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FHWA Course on Bicycle and Pedestrian Transportation

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COURSE OVERVIEW

Planning for bicycle and pedestrian travel is a somewhat new field of study, and yet it also involves planning and engineering techniques that have been around for many years. This coursebook provides the reader with current information on pedestrian and bicycle planning and design techniques, as well as practical lessons on how to increase bicycling and walking through land use practices, engineering measures, and a variety of other urban and rural design procedures.

This manual can be used to train future professionals, including planners, engineers, landscape architects, and other designers, in a variety of disciplines . Emphasis is placed on the importance of developing an interdisciplinary team approach to planning and implementing bicycle and pedestrian programs, and of the role played by each profession represented in this course.

This coursebook was developed by the USDOT Federal Highway Administration for use in graduate-level courses in non-motorized transportation planning and design. Several of the lessons address both bicycle and pedestrian issues, while others address one particular aspect of pedestrian or bicycle design. The coursebook is arranged into three sections:

Introductory Topics

Lessons cover the history of non-motorized transportation, current levels of bicycling and walking, and factors that influence the choice of bicycling or walking.

Planning Section

Lessons cover a wide range of planning issues, including pedestrian and bicycle crash types, how to prepare a local bicycle or pedestrian plan, adapting suburban communities to encourage bicycle and pedestrian travel, traditional neighborhood design, and revising local zoning and subdivision regulations to encourage bicycle- and pedestrian-friendly development.

Design Issues

The lessons in this section cover an extensive range of issues in non-motorized transportation design. Traffic calming, pedestrian accommodations at intersections, on-road bicycle facility design and trail design are among the topics addressed, with various levels of detail.

Students are advised to consult standard engineering texts for specific details regarding the analytical basis and methodiological techniques for traditional transportation analysis procedures such as transportation modeling, traffic engineering, safety analysis, facility design, and project construction.

A variety of sources are cited and included in this document via references. Technical and commentary excerpts were selected from pertinent references for inclusion in this coursebook based on the relevancy of the material to the overall context of pedestrian and bicycle transportation. Some of these references were written from an advocate's perpective and may contain information that is opinion rather than fact. Inclusion of referenced material in this document does not constitute an endorsement of these individual views. Rather, this material has been included for the purpose of presenting diverse and relevant viewpoints with respect to planning and design of pedestrian and bicycle facilities.

L E S S O N 1

The Need for Bicycle and Pedestrian Mobility

1.1 Purpose

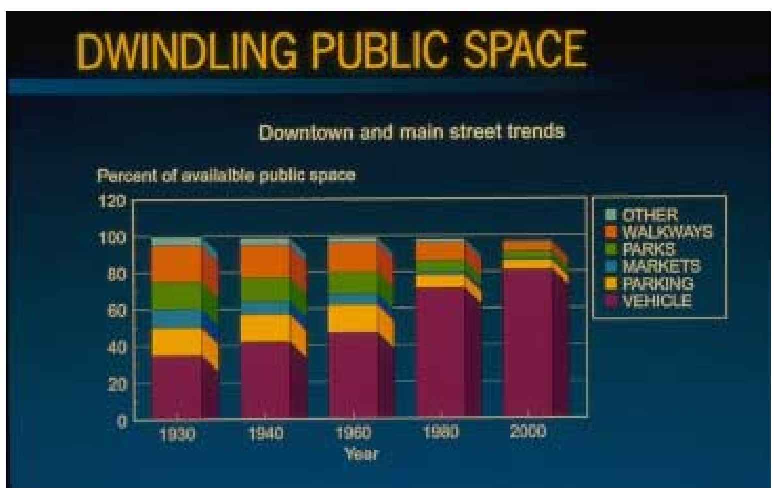
This lesson explores the history of community design and its effect on bicycle and pedestrian travel. It explains the intricate relationship between transportation systems and land use, and how this relationship has evolved in the United States. This session also discusses the importance of planning for non-motorized transportation modes as viable alternatives to the use of private automobiles, as it relates to quality of life, economic factors, health, safety and welfare. Finally, the lesson explores the new emphasis on bicycle and pedestrian planning that has resulted from national legislation and grassroots support in local communities.

1.2 How Cities Grow: An Historical Perspective

Perhaps more than any other factor, transportation modes have influenced the way cities grow and the forms they take. Before the advent of the automobile, cities were more compact and smaller in terms of area and population.

Travel between cities was arduous. Transport of goods and materials was limited, generally, to short distances. People walked, rode horses or burros, or traveled in animal-drawn carts. Trips for work, shopping, socializing, and business were limited to walking distance for most people.

The introduction of the bicycle was a major innovation and substantially extended the range people could travel. Even today, the bicycle is a major mode of transportation in some countries of the world, such as China. It is used to haul heavy loads, pull trailers, and provide everyday transport. In these countries, the cost of driving is prohibitive for the average citizen. Per capita income is low and the price of motor vehicle fuel and services is very high. Studies have shown that as per capita income rises, people switch to private motor vehicle ownership and the extent of walking and bicycling decreases.



In the United States, 20th century cities reflect the influence of motor vehicles as the dominant transportation mode.

In the United States of the 20th century, cities reflected the influence of the motor vehicle as the dominant transportation mode. Although many cities have historic city centers, which date from pre-auto days, density, land use mixes, pedestrian scale and architectural "quaintness" are not replicated in newer areas. In central cities, they are preserved and showcased as relics of earlier times.

People visit them for the unusual experience of leaving their cars behind and walking around. Only within the confines of large, modern suburban shopping malls can they experience anything like this close to home.

People usually get in their cars to go to school, to work, or to buy groceries. They drive to health clubs and exercise. They drive out of town to go hiking. They carry bicycles on their cars to meet friends and go for a bike ride.

A lot of this is just plain habit. People don't think about walking or bicycling as being easy to do. Some of it, however, is a response to:

- Cities that concentrate all commercial development at major intersections, and that "buffer" these uses from nearby homes in ways that may screen out the lights and noise, but that also prevent pedestrian access. People can walk or bike to the shopping center, but only if they travel far out of their way and use major arterial streets. Under these conditions, mothers hesitate to send little Susie to the store on her bicycle for a loaf of bread.

- Cities with subdivision ordinances and street design standards that require wide streets and sometimes do not require sidewalks. The concept of "traffic calming"–where motor traffic within neighborhoods is slowed and put on an equal footing with non-motorized street users–is considered a somewhat dubious innovation.

- It isn't easy to use public transportation in suburban locations. Effective public transit requires a higher density of users. Suburban schedules provide service at infrequent intervals. It is usually faster to drive than to take the bus.

- Streets are designed without giving serious consideration to their potential use by bicyclists and pedestrians. The possibility of someone actually walking around outside the neighborhood is not always accommodated in design. Too often, bridges, underpasses, and roadways do not include sidewalks and other facilities that make walking easier. Street cross-sections, signal actuation, median designs, and maintenance practices do not often account. Even where special lanes or other facilities are not provided, modest improvements can be made to facilitate bicycle and pedestrian travel. Often, the improvements also result in improved traffic operations.

- Often, barriers to bikes and pedestrians are put up because designers just don't stop to think. Bikes and pedestrians are generally not allowed at drive-up windows for bank tellers, restaurants, dry cleaners, and similar establishments. They have to go inside through another entrance. Parking garages may allow direct access into adjoining office buildings…but what if the pedestrian wants to park a

Streets should be designed with serious consideration to their potential use by bicyclists and pedestrians.

bicycle…or walk up a ramp to the street? Construction zones may put pedestrians and bicyclists at risk. Snow removal may pile snow along the curb, forcing bicyclists to the middle of traffic lanes. The list goes on and on.

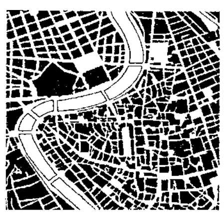
Suburban land use planning encourages separation of land use, such as in this housing development.

- Suburban land use planning encourages low density and separation of land use types. Employment centers are separate from residential areas; residential developments are predominantly low-density, single-family. Buffer zones with townhouses, patio homes, and garden apartments may separate the subdivisions from offices or shopping. Land is relatively cheap and developers can provide an affordable version of the "American Dream."

- Suburban streets are newer, wider, usually built for higher-speed traffic than they are in older parts of town. Speed limits are higher. Traffic is lighter and so people can zip around easily at about 10 miles per hour over the speed limit. People perceive these streets as dangerous for bicycling and they lack the skills and confidence to ride on them.

- Over time, cities have tended toward larger blocks of land, fewer small streets and lanes, and aggregation of land uses. Think about it. Every time a pedestrian comes to a corner, he or she has the opportunity to change directions, to enjoy a different view and browse along a different street facade. Long, continuous blocks diminish the number of choices. Many small blocks have more "surface area" than a few large ones…more windows to look in, more doors, more architectural variety.

Venice, Italy
1,500 intersections per square mile



Rome, Italy
500 intersections per square mile (Downtown)

Los Angeles
160 intersections per square mile

Irvine, California
15 intersections per square mile

SOURCE: *Great Streets*

Allan Jacobs, Chair of the Department of City and Regional Planning at the University of California at Berkeley, presented an intriguing look at the phenomenon at the 1989 Pedestrian Conference in Boulder and later in his book, *Great Streets*. Jacobs' examined intersections as variables that make significant contributions to the "walkability" of cities. Jacobs prepared diagrams showing typical one-mile-square areas of cities throughout the world – all on the same scale to allow easy comparison (see examples, drawings represent 1square mile).

Research has shown that even low to moderate levels of exercise can have tremendous benefits.

He asked people to look at these and tell him which diagram looked like it represented a place where they would like to be dropped off to spend an afternoon walking (the cities were unidentified). People selected areas where blocks were small, with streets that did not follow a regular, grid alignment.

Jacobs also noted that street patterns tend to become simplified over time. In central Boston, in the 1890's, there were more than 430 intersections and 276 city blocks. Now, there are about 260 intersections and 170 city blocks. The blocks have become larger; there are fewer businesses and people are walking less. Is there a relationship? (*Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*, FHWA-HI-96-028, *1996*)

1.3 Modern Suburban Travel

Most modern suburban communities in the United States are not designed for bicycle and pedestrian travel. This was not always the case. In communities across the country that were built prior to 1950, there are remnants of walkable, bikable streets where destinations are closer to residential areas. In fact, many of these older neighborhoods are the hottest real estate property in town. More and more people are beginning to appreciate well-designed communities such as these, where bicycling is enjoyable and the streets are lined with trees and sidewalks (the trend toward neo-traditional neighborhood design reflects this–see Lesson 6). The following provides one view of how suburban residential design has changed in America:

"Over the last 40 years, as automobiles replaced streetcars, the need for locating houses close to the streetcar stop disappeared. Retail business concentrated near the residential subdivisions and apartment complexes. . . Curbs and sidewalks, symbols of a pedestrian and streetcar-oriented world, became expansive and unnecessary features in this new, low-density environment. House lots became wider to accommodate garages, and houses themselves were set back from the street to reduce the noise and nuisance of passing cars."

(Richard K. Untermann, *Linking Land Use and Transportation,*University of Washington, 1991)

1.4 Benefits of Bicycling and Walking

Increased levels of bicycling and walking would result in significant benefits in terms of health and physical fitness, the environment, and transportation-related effects. Research has shown that even low to moderate levels of exercise, such as regular bicycling or walking, can reduce the risk of coronary heart disease, stroke, and other chronic diseases; help reduce health care costs; contribute to greater functional independence in later years of life; and improve quality of life at every stage. A recent British Medical Association study concluded that the benefits in terms of life years gained from the increased physical activity of bicycling far outweigh any possible negative effects in life-years lost from injuries or fatalities.

Replacing automobile trips with non-motorized and non-polluting bicycling or walking trips would yield significant environmental benefits. According to *Plan B, The Comprehensive State Bicycle Plan for Minnesota*, public savings from reduced pollution, oil importation, and congestion costs alone have been estimated at between 5 and 22 cents for every automobile-mile displaced by bicycling or walking. Increased use of these non-motorized transportation modes can help urban areas reduce their levels of ozone and carbon monoxide to meet air quality standards required under the 1990 Clean Air Act Amendments.

Efforts to facilitate bicycling and walking can also result in more general transportation benefits besides offering additional travel options for those who are unable to drive or who choose not to drive for all or some trips. Roadway improvements to accommodate bicycles, such as the addition of paved shoulders, have been shown to reduce the frequency of certain types of motor vehicle crashes. Urban area congestion can be reduced. Measures to reduce vehicle speeds, which can encourage greater pedestrian activity in residential or downtown shopping and business areas, also impact positively on motor vehicle safety. Greenways along waterways, railway lines, or other public rights-of-way yield recreational, educational, environmental, and aesthetic benefits in addition to providing corridors for walking and bicycling transportation. A general enhancement of the "livability" of our cities parallels a truly intermodal transportation system in which bicycling and walking are valuable components.

Given these many benefits, it is not surprising that a recent Harris Poll showed that while 5 percent of respondents currently walk or bicycle as their primary means of transportation, two-and-a-half times this number would prefer to meet their transportation needs by walking or bicycling if better facilities were available. Survey results may overestimate actual behavior, but they do indicate areas to be addressed.(*National Bicycling and Walking Study,* FHWA Publication No. FHWA-PD-94-023, 1991)

1.5 Government Commitment and Support

Support for bicycling and walking must be found within the Federal Government, and State and local government offices. Whereas individuals and private organizations can accomplish much in increasing public awareness, identifying needs, etc., it is primarily government that is responsible for creating safer and more appealing places to bicycle and walk. This is accomplished not only through direct improvements to the roadway environment, but also through planning, policymaking, and other government activities. Support and commitment at every level of government are thus the keys to significant increases in the use of bicycling and walking as modes of transportation.

As noted in FHWA's 1991 *National Bicycling and Walking Study*, the U.S. Federal Government is firmly committed to supportibg bicycling and walking. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) made significant additional commitments to the future of bicycling and walking transportation in the United States.

States responded to the challenges of the ISTEA legislation, and many are already ahead of its requirements. As mandated, bicycle and pedestrian coordinators have been identified in all 50 States,

Multi-use trails have been built as part of major highway improvement projects in Florida.

and a number of States are in the process developing bicycle and pedestrian plans. Metropolitan Planning Organizations (MPOs) and individual communities are also beginning to respond to the mandates and opportunities of the ISTEA legislation.

Together, these events offer strong encouragement for the future of bicycling and walking transportation in the United States. As stated on the cover of a recent brochure produced by the Bicycle Federation of America, "There has never been a better time to promote bicycling than now."

TEA-21 Funding Sources for Bicycle and Pedestrian Projects

Bicycle and pedestrian projects are broadly eligible for funding from almost all the major Federal-aid highway, transit, safety, and other programs. Bicycle projects must be "principally for transportation, rather than recreation, purposes" and must be designed and located pursuant to the transportation plans required of States and Metropolitan Planning Organizations.

National Highway System funds may be used to construct bicycle transportation facilities and pedestrian walkways on land adjacent to any highway on the National Highway System, including Interstate highways.

Surface Transportation Program (STP) funds may be used for either the construction of bicycle transportation facilities and pedestrian walkways, or non-construction projects (such as maps, brochures, and public service announcements) related to safe bicycle use and walking. The Transportation Equity Act for the 21st Century (TEA-21) adds "the modification of public sidewalks to comply with the Americans With Disabilities Act" as an activity that is specifically eligible for the use of these funds.

Ten percent of each State's annual STP funds are set aside for ***Transportation Enhancement Activities (TEAs).*** The law provides a specific list of activities that are eligible TEAs and this includes "provision of facilities for pedestrians and bicycles, provision of safety and educational activities for pedestrians and bicyclists," and the "preservation of abandoned railway corridors (including the conversion and use thereof for pedestrian and bicycle trails)."

Another 10 percent of each State's STP funds are set aside for the ***Hazard Elimination and Railway-Highway Crossing programs***, which address bicycle and pedestrian safety issues. Each State is required to implement a Hazard Elimination Program to identify and correct locations that may constitute a danger to motorists, bicyclists, and pedestrians. Funds may be used for activities including a survey of hazardous locations and for projects on any publicly owned bicycle or pedestrian pathway or trail, or any safety-related traffic-calming measure. Improvements to railway-highway crossings "shall take into account bicycle safety."

Congestion Mitigation and Air Quality Improvement Program funds may be used for either the construction of bicycle transportation facilities and pedestrian walkways, or non-construction projects (such as maps, brochures, and public service announcements) related to safe bicycle use.

Recreational Trails Program funds may be used for all kinds of trail projects. Of the funds apportioned to a State, 30 percent must be used for motorized trail uses, 30 percent for non-motorized trail uses, and 40 percent for diverse trail uses (any combination).

TEA-21 provides a variety of funding opportunities for on-road bike lanes, trails, sidewalks, and bridges that accommodate bicycles and pedestrians.

Provisions for pedestrians and bicyclists are eligible under the various categories of the ***Federal Lands Highway Program*** in conjunction with roads, highways, and parkways. Priority for funding projects is determined by the appropriate Federal Land Agency or tribal government.

National Scenic Byways Program funds may be used for "construction along a scenic byway of a facility for pedestrians and bicyclists."

Job Access and Reverse Commute Grants are available to support projects, including bicycle-related services, designed to transport welfare recipients and eligible low-income individuals to and from employment.

High-Priority Projects and Designated Transportation Enhancement Activities identified by TEA-21 include numerous bicycle, pedestrian, trail, and traffic-calming projects in communities throughout the country.

Federal Transit Program

Title 49 U.S.C. (as amended by TEA-21) allows the ***Urbanized Area Formula Grants, Capital Investment Grants and Loans***, and ***Formula Program for Other Than Urbanized Area*** transit funds to be used for improving bicycle and pedestrian access to transit facilities and vehicles. Eligible activities include investments in "pedestrian and bicycle access to a mass transportation facility" that establishes or enhances coordination between mass transportation and other transportation.

TEA-21 also created a ***Transit Enhancement Activity*** program with a 1-one percent set-aside of **Urbanized Area Formula Grant** funds designated for, among other things, pedestrian access and walkways, and "bicycle access, including bicycle storage facilities and installing equipment for transporting bicycles on mass transportation vehicles."

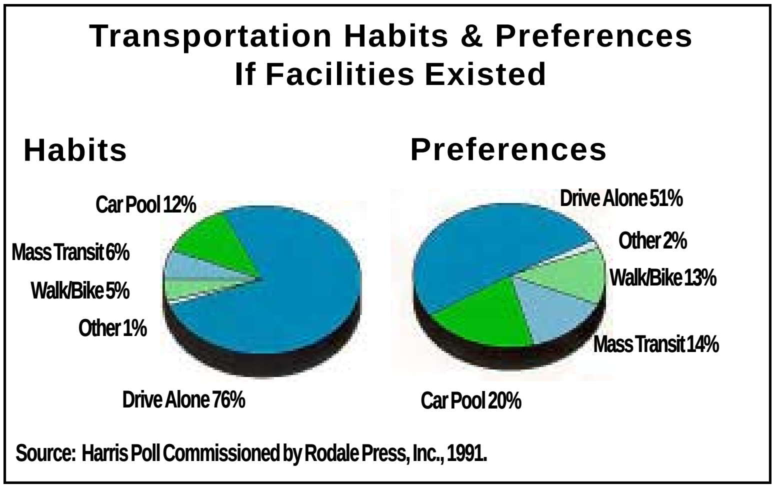
Highway Safety Programs

Pedestrian and bicyclist safety remain priority areas for ***State and Community Highway Safety Grants*** funded by the Section 402 formula grant program. A State is eligible for these grants by submitting a Performance Plan (establishing goals and performance measures for improving highway safety) and a Highway Safety Plan (describing activities to achieve those goals).

Research, development, demonstrations, and training to improve highway safety (including bicycle and pedestrian safety) is carried out under the **Highway Safety Research and Development (Section 403) program**. (*A Summary of Bicycle and Pedestrian Provisions of the Federal-Aid Program,* FHWA-PD-98-049, 1998).

1.6 Public Support for Bicycling and Walking

Regardless of the commitment of Federal, State, and local governments to bicycling and walking transportation, and regardless of the "walkability" or "bicycleability" of our cities and towns, the full potential of bicycling and walking as transportation modes will not be realized if the public is unwilling to recognize and embrace them as viable transportation options. Both government and the private sector can play key roles here by working to increase public



awareness of bicycling and walking and actively promoting their use. Programs to increase employee use of non-motorized transportation, including innovative Transportation Demand Management plans, police-on-bikes, and U.S. Postal Service employees on bicycles, all can help to legitimize non-motorized transportation.

If recent survey results are any indication, the public already strongly supports increased travel options. The 1991 Harris Poll cited earlier showed that 46 percent of adults age 18 and older — 82 million Americans — had ridden a bicycle in the previous year. Of these:

- 46% stated they would sometimes commute to work by bicycle if safe bicycle lanes were available;
- 53% would if they had safe, separate, designated paths on which to ride;
- 45% would if their workplace had showers, lockers, and secure bicycle storage; and
- 47% would if their employer offered financial or other incentives. (*Pathways for People,* 1992).

Similarly, 59 percent of the respondents reported that they would walk, or walk more, if there were safe, secure designated paths or walkways, and 55 percent would if crime were not a factor. Overall, 5 percent of respondents reported that either walking or bicycling was their primary means of transportation; but given adequate facilities, 13 percent would prefer to meet their transportation needs by walking or bicycling. Respondents also indicated that they want their government to enhance their opportunities to walk and bicycle. (*Pathways for People,* 1992)

Another indication of the public's desire for increased opportunities to bicycle and walk can be found in the overwhelmingly positive responses to the *Federal Register* notice soliciting comments for the National Bicycling and Walking Study. Most of the respondents clearly indicated a desire to walk and bicycle more if appropriate facilities were provided. (*National Bicycling and Walking Study,* FHWA-PD-94-023, 1991)

1.7 Transportation and Planning Trends

Thus far, this lesson has described the challenges and potential for increasing non-motorized travel in the United States. Renewed interest and financial support for bicycling and walking has led to improvement projects in nearly every city in the country. Although progress is slow and the problems often seem insurmountable, several trends in transportation planning point to a promising future for bicycling and walking. This section presents an overview of current trends and their implications for non-motorized travel, with examples from communities throughout the United States.

1. New land use, transportation, and environmental trends point to a promising future.
In general, both the public and the professional community are becoming dissatisfied with the status quo. New energy, funding, and political support are being given to programs that reduce reliance on the private motor vehicle and encourage bicycling and walking. Here are a few examples of these trends:

a. Seattle, Portland, San Diego, and Los Angeles move to develop effective transit systems.

- Voters in Los Angeles taxed themselves heavily to start rebuilding the once-famous transit system. Initial sections are open and operating.
- Trips into downtown Seattle have shifted heavily toward use of transit and bicycling, with improved facilities and strong support from

political bodies. Increases in walking trips from the nearby Capital Hill District are also reported.

- San Diego, starting with $60 million, gained high-volume ridership overnight when it introduced its 16-mile “Red Line” and the Tijuana Trolley.

- Portland is reclaiming views of mountain landmarks with successful introduction of an extensive system of buses and light rail.

- Many other cities, including Honolulu, Orlando, and Minneapolis are now increasing emphasis on transit and transit planning.

b. Traditional Neighborhood Design (TND) and Neo-Traditional Town Planning are hot trends on the planning scene.
Neo-traditional planning is a topic of debate and disagreement within the planning community. Advocates of “traditional” plans propose a nostalgic approach. They look to historic designs for small communities where traffic was light, people knew their neighbors, and land use encouraged walking and bicycling.

A great deal of experimentation is taking place in the United States at this time. Florida alone has 15 neo-traditional communities on the drawing board. Projects to retrofit existing neighborhoods in conformance with traditionalist precepts have been proposed in Bellingham, Washington; Stuart, Florida; and projects in California, Texas, Alaska, Virginia, Maryland, North Carolina, and Georgia. See Lesson 6 for more information on this concept.

c. Traffic-calming strategies can reduce the speed of and emphasis on motor vehicles.
Traffic calming employs physical measures to slow down motorists through changes to the horizontal and vertical alignment of the road and giving greater design priority to pedestrians, bicyclists, and community amenities. Traffic-calming measures are becoming standardized in communities throughout the country. See Lesson 11 for a full explanation of the fundamental traffic-calming techniques.

d. Transportation Demand Management (TDM) proves popular.
Whereas the early 1980s saw engineers experimenting with ways to push more vehicles through an existing and expanding transportation network, the trend in the 1990s has turned toward getting people to make fewer single-occupant auto trips. Using the TDM concept, employers, government agencies, and others direct their energies into convincing the public to use the auto for solo trips less and less. This is done through pricing incentives (recouping the true cost of parking, for example); subsidies to more efficient transportation modes; helping people overcome perceived hurdles; pushing for improved land use policy; and flexible work hours.

Can TDM really work? In Australia, it does. In many ways, Australia is similar to the United States: highly suburbanized, auto-crazy, with similar land use patterns and levels of auto ownership. The parallels, however, only go part way. In Australia, gasoline consumption and trips per household are half of U.S. figures. What can be learned from this example? Australian cities, while similar to U.S. cities in many ways, also have important differences. The following

Traditional Neighborhood Design incorporates design features that encourage walking and bicycling.

attributes are part of urban form and transportation systems in Australia:

- Strong neighborhoods with neighborhood centers.
- Neighborhood schools within 1/4-mile walking distance for most children.
- Pedestrian access is required between adjacent neighborhoods.
- Local Area Traffic Management (LATM) providing safe motor vehicle speeds and operations through neighborhoods.
- Parking that is limited and frequently market-priced. Only one parking space per 10,000 square feet of floor area is required in Sydney.
- Convenient transit transfers are provided.
- Transit service is fast and convenient.
- Few freeways go into the Central Business Districts (CBDs); no new lanes are built on existing freeways.
- Major activities are located in mixed-use centers accessed by a multi-modal transportation system.
- There is a strong intermodal transportation system.
- Decision-making is flexible and more decentralized than in the United States; flexible block grants are allowed through general policy.

e. Transportation Management Associations (TMAs) and Commuter Assistance Centers (CACs). Many cities or regions are setting up fully staffed organizations, with trained professionals who focus on getting people out of single-occupant vehicles. Some cities, such as Los Angeles, have dozens of TMAs. Florida already has 17 such associations with more than 40 expected to start up over the next several years.

Each association is funded by local government, employers, and others with a strong interest in reduced parking demand, and future reductions in traffic-induced transportation costs. Many TMAs and CACs encourage bicycling and pedestrian/transit trips.

2. New tools are available for bicycle and pedestrian programs

A new wave of post-interstate highway construction is surging across America. A resounding demand by the public, responded to by Congress, has set a dynamic direction for future transportation planning and construction. The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) and the 1998 Transportation Equity Act for the 21st Century (TEA-21) provided tremendous funding infusions for bicycle and pedestrian facilities.

Many cities or regions are setting up fully staffed organizations, with trained professionals who focus on encouraging alternative transportation.

a. New funding sources have become available.

- **State, regional, and local entities will all be involved in determining the ultimate use of federal transportation funds.**

  This, in itself, is a hopeful sign for non-motorized transportation. Agencies, in many cases, have supported, but have not been able to fund, improved transit, increased choice of transportation modes, and non-motorized transportation facilities and programs.

Enhancement monies.
Ten percent of the total Surface Transportation Program funds are earmarked for "enhancement" activities. Provision is made allowing use of these funds for pedestrian, bicyclist, trail, and preservation programs.

Clean Air Act.
The second generation of the Clean Air Act, passed in 1991, has put teeth into the original Act and now requires cities with the poorest air quality records to make significant improvements. Substantial penalties are specified for non-compliance.


The availability of bike lockers at rail stations is important to encourage commuting.

Transit funding is no longer given only token recognition.
Transit programs and intermodal efficiency are emphasized in ISTEA and TEA-21. Indeed, the term "intermodal," found throughout the new legislation, reflects a tangible commitment to a balanced transportation system.

Indirectly, Federal support for transit can benefit bicycling and walking. People have to walk or ride to and from bus stops and transit stations. Consideration is being given to improving access to transit and encouraging adoption of local policy, standards, and ordinances that can result in better conditions. Similarly, more and more cities are accommodating bicycles on buses, ferries and trains. Phoenix, Arizona has a model program. The intermodal emphasis encourages such linkages, along with provision of bicycle lockers, shower facilities, "loaner" or low-priced rental bikes at downtown transit stations, and benefits for bicyclists.

Environmental emphasis.
Cities with the lowest air quality and largest populations are allocated a portion of the federal transportation funds for reduction of auto emissions. Since the greatest reductions will be through displacement of single-occupant vehicle trips, funds may be used for related non-motorized transportation programs.

- **Other Environmental Improvement Funds.** Other Federal and State legislation has been enacted to further improvement of air quality, noise reduction, water quality, and other pollution (e.g., hazardous wastes). Substantial funding is available.

- **Growth Management Act(s).** A number of States are considering requirements for urban containment, urban infill, implementation of TDM strategies, and other measures to reduce urban sprawl and associated costs. Florida recently entered the second phase of its nationally recognized growth management legislation. TDM practices are now encouraged on additional highway and roadway miles. Developers in Florida have supported this new policy, since TDM has proven to be less expensive than the cost of building additional traffic lanes.

- **Other legislation.** California has passed a series of initiatives aimed at not only cleaning up the air, but also at significant alterations of transportation habits. California businesses must now achieve a significant reduction in auto trips or pay substantial fines. Other States, such as Oregon and Washington, are studying these measures and may propose similar legislation. The California policy is expected to benefit bicyclists, pedestrians, and transit users, since use of alternative transportation modes is encouraged.

b. New, federally sponsored research shows increased support for bicycling and walking programs.
Led by the Federal Highway Administration and National Highway Traffic Safety Administration, the Federal government has initiated a broad range of research and other studies addressing bicycle and pedestrian transportation.

The National Bicycling and Walking Study provides a comprehensive look at ways to encourage bicycling and walking in the United States. The Study mirrors the ISTEA legislation.

The Study is also expected to have a significant influence on State and local policy. Combined with other research now underway. It can be expected that our knowledge about many aspects of pedestrian and bicycle transportation will be greatly advanced over the next few years.

c. Professional associations are increasingly pro-walking and pro-bicycling.
Associations such as the American Association of State Highway and Transportation Officials (AASHTO), Transportation Research Board (TRB), the Institute of Transportation Engineers (ITE), and the American Society of Civil Engineers (ASCE) are putting more and more positive energy into support of bicycle and pedestrian transportation.

They are working to educate their members about design planning construction practices and related issues. ITE, for example, has published manuals on traffic calming, supports traditional neighborhood design and is adding new chapters on walking and bicycling solutions to its major handbook and other publications. New organizations are forming to focus exclusively on alternative transportation systems.
In addition, engineers and planners in the bicycle and pedestrian field have established their own professional organization - The Association of Pedestrian and Bicycle Professionals (APBP). This new organization promotes excellence in the emerging professional discipline of pedestrian and bicycle transportation.

d. Greater public involvement in decisionmaking is encouraged.
It is expected that the public will become much more involved in transportation planning and policy, especially on the local and State levels. ISTEA and a general trend toward citizen activism are leading to the formation of bicycle advisory councils (BACs) and pedestrian advisory councils (PACs) in many areas. Combined with existing community organizations, clubs, and advocacy networks, they will play increasing roles in transportation and land use decisions.

e. Facilities on greenways and other recreation areas can help meet transportation needs.
ISTEA and TEA-21 allow use of highway funds for bicycle and pedestrian facilities that have transportation purposes. Today, only purely recreational facilities, such as closed-loop trails that have no possible transportation use, are excluded from funding consideration.

The availability of funds for recreation transportation facilities dovetails with the increasing emphasis and funding for preservation and enhancement of greenbelts and with the “Rails to Trails” movement utilizing abandoned rail rights-of-way. State initiatives, such as Arizona’s Heritage Fund add to the pot by funding trails and other recreation, preservation, and conservation projects. In some cities, trail systems provide continuous, scenic and grade-separated access to most major destinations using canal banks, flood control channels, river corridors, parks, and greenbelts. Built to the current design standards, these trails can serve many types of users for many different trip purposes.

f. Voters having repeatedly shown their support for bicycle and pedestrian facilities.

Here are a few examples:

- Seattle voters recently approved a $120 million bond issue for purchasing land and constructing urban trails. The measure passed with the greatest voter turnout for any election and won by the widest margin in decades.

- In Pinellas County, Florida, with the backing of the Friends for the Pinellas Trail, voters approved a controversial, 10-year, $100 billion transportation bill. The approval margin was razor thin. Neighboring Hillsborough County (Tampa) rejected a similar bill—also by a narrow margin. All the local analysts gave credit for the Pinellas win to the citizens group that backed the trail and encouraged voter turnout.

- In 1990, Arizona voters gave approval by almost a two-to-one margin to the Arizona Heritage Fund. This was an exceptionally strong showing, considering the fact that only 3 of the 13 ballot propositions that year were approved. Of the 3, the Heritage Fund received the most votes. The Fund takes about $20 million annually from lottery profits and divides it between State Parks and the Arizona State Game and Fish Departments.

The money is used for parks, trails, preservation of historic and cultural sites, and wildlife conservation. About $500,000 was allocated for trails in the first funding year. Among criteria used in selecting projects for funding are the trail's accommodation of a variety of users and its potential to provide linkages to other trails and destinations.

3. Pedestrians are increasingly being considered in planning and design.

With the encouragement of planning gurus such as William Whyte (*City — Rediscovering the Center, The Social Life of Small Urban Spaces*) and the late Donald Appleyard (*Livable Streets*), a generation of professionals sympathetic to the need for "a sense of place," "people places," "activated streets," and "livable cities" has come of age. Old buildings are being preserved.

Once-deteriorating downtowns are being rediscovered and revitalized, often with a strong pedestrian emphasis. Design review requirements and urban design guidelines are being incorporated into ordinances and adopted into planning documents.

The roles that engineers, planners, architects, and landscape architects can play in creating streets, plazas, parks, and other public spaces that offer amenity, interest, variety, and a feel for the special, unique qualities of a given city are starting to be appreciated.

The need for coordination, for working with other professional disciplines as well as with citizen groups, city maintenance departments, police officers, school officials, and others is being realized and addressed in the planning process. To create pedestrian and bicyclist-friendly cities takes cooperation and a "big picture" approach backed by the power to put forward adoptable recommendations with policy or regulatory status.

Revitalization of America's downtowns is occurring throughout the country.

a. Livable cities' success stories.
Although the "livable cities" movement is still in its early days, many U.S. cities have already logged considerable accomplishments:

- **Washington, D.C.**, had the vision of transforming the city into an inviting pedestrian environment. The effort took years. It was complex and, ultimately, rewarding. Today, our Nation's Capital owes much of its success to coordinating the opening of the Metro system with construction of pedestrian facilities. A special police force was hired for security and parking control. Fast-moving traffic on key streets was slowed through implementation of a series of strategies that included eliminating one-way streets. Right turns on red lights were reinforced through pro-pedestrian policy. On some streets, all traffic in a given direction is now required to turn.

  Sidewalks were widened and given decorative pavement in many cases. Medians were added. All this occurred over the past 15 years. The result is dramatic. The pedestrian improvements are complemented by our Nation's best and most complete transit system. All this took place in a city where 90 percent of the work force commutes in and out daily.

- **Boston — Harvard Square.** For the first time in its history, Harvard Square has been redesigned as a major public gathering place. Transit vehicles, which were below ground 20 years ago and later brought up to the surface, were retreated once again to quiet underground busways enhanced with public art. Although the Square, from a pedestrian viewpoint, is not perfect, it represents a splendid re-dedication of land to public use by pedestrians. Other commons (with underground parking), Newberry Street, and Faneuil Hall Marketplace provide exemplary pedestrian environments.

- **Savannah, Georgia and Charleston, South Carolina.** Still in the process of rebuilding following widespread destruction by hurricane Hugo, these cities offer powerful examples of good pedestrian planning and public spaces. Airy waterfront piers, one with citizen porch swings that are so popular that they never stop swaying, show a positive outgrowth from a devastating natural disaster.

- **Honolulu, Hawaii — Kalakala Street, Waikiki.** One of the most dramatically transformed streets, Kalakala has gone from noisy, sooty gray ugliness to a bright, breezy, and fragrant street with a 50/50 ratio of automobile to pedestrian space. The street is lively, the scale is right, and people throng.

- **Victoria, Vancouver, Canada.** It's only a few miles from the U.S. border and it's an ideal downtown. The character of historic streets has been recaptured. Alleys create a fine-grained network that enables pedestrians to avoid many intersections. In the heart of it all is a mall that contributes to the ambiance, rather than detracts from it. At the insistence of the public, mall developers were required to provide ground-level retail, to pave the streets with rich detail, and to design for interaction and architectural interest. The result works beautifully.

- **Portland, Oregon — Pioneer Square.** This active downtown gathering space is paved with inscribed bricks sponsored by citizens at $35 a piece. The Square is an ideal place to see and be seen. Its form creates an irregular, theatrical setting with a variety of elevations, vantage points, perches, and perspectives. It's an informal urban theater, with lunchtime crowds creating their own entertainment. There is a strong link to the city's transit system, which approaches the Square via a transit mall where cars are allowed, but not encouraged. Nearby, is Freeway Park, with its famous Halprin sculpture-fountain.

b. There is a new emphasis on bicyclist and pedestrian safety and on safety-related research.
Nationally, pedestrians and bicyclists account for 14 to 15 percent of all traffic fatalities. In urban areas, this figure is even higher. As more and more people walk and ride bicycles, it is important that safety improvements and programs keep pace.

Accordingly, the Federal Highway Administration and National Highway Traffic Safety Administration have dedicated funds to identifying and prioritizing bicycle and pedestrian research needs. Research projects are being carried out by a team headed by the University of North Carolina's Highway Safety Research Center.

c. The need to train professionals about bicycling and walking has been recognized.
Traffic engineers and urban planners rarely receive adequate training related to non-motorized transportation. Only one out of a hundred highway professionals has taken a college course on non-motorized transportation and these courses were offered in overseas colleges. None are offered in the United States on a regular basis. The planner or engineer who today is being told to go out there and make things right for bikes and pedestrians has to rely on personal experience, courses such as this one, self-education, and luck.

This is a global problem. Recent Chinese transportation reports and magazine articles, written in a country where fewer than one in 10,000 people travel by car, address ONLY motorized transportation modes. The word "bicycle" is not mentioned. Worldwide, the status of the automobile has dominated professional practice.

Bicycles are often seen as having low status, associated with the poorer classes or underdeveloped nations. Even in bicycle-friendly Copenhagen and Amsterdam, pedestrian and bicycle officials talk about difficulties in dealing with planners and engineers who think only in terms of motorized solutions.

The Federal Highway Administration has given high priority to training professionals involved in bicycle and pedestrian transportation. Development of college-level courses and other training, combined with future revision of professional reference documents and activities planned by organizations such as the American Society of Civil Engineers and the American Planning Association will, over time, make professionals better-equipped to deal with non-motorized transportation modes.

d. There is a new awareness of risk management strategies related to bicycling and walking.
The courts are becoming *de facto* bicycle and pedestrian facility designers. There continue to be very sizeable settlements ($2 to $15 million) against government entities that neglect the basics of design for bicycles and pedestrians.

Although some highway professionals and city officials now are reluctant to build new facilities for fear of legal action, they should be aware that they can also be sued for failure to take action.

Many court settlements are for failure to act, failure to maintain, failure to operate properly, failure to perform to accommodate <u>all</u> users of existing streets, highways, and paths. The transportation professional with no formal training in walking and bicycling accommodation is put at a serious disadvantage.

e. The public involvement process is becoming more inclusive.
Design and research have historically focused on vocal, adult citizens. Children, the elderly, the poor, and the disabled seldom stand up at city council or planning commission hearings to advocate policy and improvements that could make it easier for them to get around.

Children account for a large percentage of bicycle and pedestrian crashes and yet relatively little sophisticated crash research was done in the United States until adults took to bicycling and walking, started to get hurt, and complained about it. Children are not involved in decisionmaking. They don't know who to complain to. They can't drive. Their writing skills are still developing. They must depend on others for resources and transportation.

The same basic situation can be applied to the elderly, the poor, and the disabled. Their numbers are increasing. They are dependent on walking and bicycling for mobility. They are disproportionately at-risk when dealing with traffic and in potentially hazardous situations. ALL must be considered in research, planning, and design.

f. The bicycle and pedestrian industries are becoming more aware of the need to educate and to deliver safety messages.
The bicycle and pedestrian associations and industries have historically had little active involve-

The elderly, children, and the poor are the least likely to be accommodated by today's dominant transportation modes.

ment in safety and education programs. With a few notable exceptions, bicycle manufacturers and support industries, safety associations, and others who should know better have not been proactive in efforts to promote safety.

Advertisements and bicycle safety films show bicyclists wearing helmets. Increasingly, bicycle dealers provide information about safety, maintenance, and ways to develop good riding skills. Some offer training and literature, and refer bicyclists to clubs where they can ride with experienced bicyclists and become part of the "bicycle culture" of the community.

g. The U.S. bicycle and pedestrian programs—getting back on track.
The 1970s saw a surge of funding for bicycle programs and research. A few projects were completed. Starting in the 1980s, however, almost 100 percent of the safety money was channeled into a few, auto-related areas.

In 1988, Florida canvassed all 50 Governor's Highway Safety Representatives in the United States and leaders in State departments of transportation. It was found that all of them felt that there was not a pedestrian problem and, therefore, there was no need to do anything about it. One said, "There is no money for funding—so how can there be a problem?" In the 1980s, more than 90,000 pedestrians and bicyclists were killed.

During this time, few States spent money on bicycle and pedestrian crash-reduction programs, even though a full decade of research from the 1970s pointed out the need and showed how to approach solutions.

Fortunately, bicycle and pedestrian transportation is experiencing a resurgence of interest, funding, and research. Lessons learned over the past 20 years are being tested and applied to new thinking about design, education, enforcement programs, and the positive roles bicycling and walking can play in realigning our thinking about cities. There is increasing awareness of the need to improve air quality, to decrease traffic congestion, and to revive a sense of "community." People are giving a fresh look at the efficiency and pleasure of leaving the car in the garage and heading out on two wheels or two feet to go about their business. As transportation tends toward the human scale, a new urban form–finer-grained, more richly detailed, and community-oriented– will evolve. In time, the new transportation will build a new kind of city.

This course session has introduced many issues, ideas, attitudes, and planning tools. It presents a broad-brush overview. Additional detail on many of these topics are explored in depth during other training course sessions.

1.8 Exercise: A Pictorial Essay

Part 1
Take photographs of both good and bad locations to bicycle and walk in your community. Photographs can document conditions in several locations or within one particular development (commercial or residential). Your photo log should capture the overall environment (such as streetscape), specific barriers and/or good features, and general land wuse relationships to the transportation facility. Prepare a short write-up for each photograph explaining the

problems or positive features you inventoried.

Part 2
Using the specific locations you documented in Part 1, conduct an evaluation of engineering issues related to the following facility design aspects:

1. Need for bicycle/pedestrian facilities–How would you establish the need for facilities (either existing or proposed improvements)? What data would you collect? What type of analysis procedures or comparisons would be useful in assessing need? If you documented existing facilities in your photographs, how would you evaluate effectiveness to those detractors that would suggest that money spent on facilities for pedestrian and bicycles is a waste of resources. Please develop some proposed guidelines, within the context of effective and reasonable public policy, for use by a local agency in addressing issues related to bicycle and pedestrian facilities.

2. Incorporation of needed facilities in new design –Describe how any deficiencies you noted in your photo logging exercise could have been addressed if pedestrian and/or bicycle facilities were included in the original design and construction. Tabulate and evaluate the associated impacts. If you documented existing designs, describe and quantify impacts associated with accommodating pedestrians and/or bicycles in the facility(ies) you photographed.

3. Incorporation of needed facilities in retrofit design–Assuming that you documented deficient locations for pedestrian and bicycle travel, list and describe possible ways to rectify and retrofit existing facilities so that these locations can more readily accommodate pedestrian and/or bicycle travel modes.

In time, the new transportation era will build a new kind of city.

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L E S S O N 2

Bicycling and Walking in the United States Today

2.1 Purpose

It is generally acknowledged that non-motorized travel modes are not being used as extensively as they could be in the United States. This lesson describes current levels of bicycle and pedestrian activity, and specifically examines the reasons why bicycling and walking are not used more extensively as travel modes. Patterns of pedestrian and bicycle travel are explored, particularly as they relate to design issues and allocation of right-of-way space.

In order to adequately plan and design for bicycles and pedestrians, it is important to understand current patterns of travel as well as the desire for increased mobility. Although children, older adults, and the disabled make up a large percentage of the population (up to 37 percent of most States), their needs are seldom adequately considered in transportation system planning and design. This lesson discusses bicycle and pedestrian travel from the perspectives of these user groups. (FHWA-PD-94-023, *National Bicycling and Walking Study*)

2.2 Current Levels of Bicycling and Walking

A number of surveys confirm that bicycling and walking are activities enjoyed by increasing numbers of Americans of all ages:

- A 1982-1983 Nationwide Recreation Survey reported that 28 percent of respondents had bicycled during the past 3 months, up from just 9 percent in 1960.
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- According to a National Sporting Goods Associations survey, exercise walking drew 71.3 million participants in 1990, making it one of the fastest growing participant sports. (NSGA, 1991)
- A Harris Poll conducted in December 1991 found that nearly half (46 percent) of American adults age 18 or older had bicycled within the past year. The same survey reported that 73 percent of adults had walked outdoors specifically for

Bicyclists and pedestrians need to be accommodated with safe and convenient modes of transportation.

exercise. More than half had walked on at least 10 occasions during the last mild weather month, and 17 percent had walked on 30 or more occasions. (*Pathways for People, 1992*)

Bicycling and walking are clearly popular activities, whether for sport, recreation, exercise, or simply for relaxation and enjoyment of the outdoors. As the following surveys indicate, however, their potential as modes of transportation is just beginning to be realized.

Nationwide Personal Transportation Survey

The primary source of information on utilitarian as well as recreational bicycling and walking in the United States is the Nationwide Personal Transportation Survey (NPTS). The survey is conducted approximately every 7 years. The first three were home interview surveys; the 1990 survey was done by telephone. The survey is conducted throughout the year and includes information on the travel of persons age 5 and older.

The 1990 NPTS interviewed 48,385 persons living in 22,317 households (Research Triangle Institute, 1991). Each respondent was asked to provide information on all travel during a recent 24-hour period, including the purpose of the trip, distance traveled, and travel mode. Information was collected for each segment of multi-modal trips, such as a walk to a bus stop or bicycle ride to a rail station.

Results revealed that only one out of five trips involved travel to or from work, and less than 2 percent involved on-the-job travel. The largest portion of trips (42 percent) are family or personal business travel, which includes trips to the grocery store, to the doctor or dentist, or to transport a child to school. Social or recreational travel accounts for another quarter of trips. This category includes visits to friends or relatives, trips to a park or sporting event, as well as “pleasure driving” and vacation trips. Overall, 7.2 percent of all trips were by walking and 0.7 percent by bicycling.

The percentage of bicycling trips is essentially the same as reported in the 1983 NPTS results, while the percentage of walking trips is down slightly from 8.5 percent previously recorded (Klinger and Kuzmyak, 1986). The 1990 survey also showed walking to be a frequent component of multi-modal trips, although these accounted for only 1 percent of all trips. All totaled, an estimated 18 billion walking trips and 1.7 billion bicycling trips were made in 1990. (Research Triangle Institute, 1991)

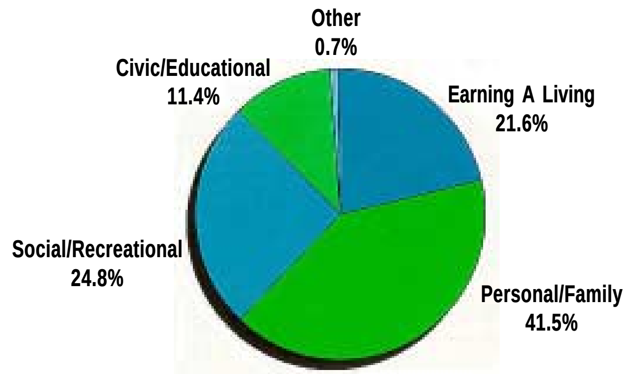
More than half of the bicycle trips and a third of the walking trips were for social or recreational purposes. Family and personal business travel, along with school and church-related travel, were also significant contributors.

Average length of a travel trip was 0.6 mile for walking, and 2.0 miles for bicycling. As expected, non-motorized modes were used to a greater extent in central city areas, with their higher densities and compactness, than in the suburbs or rural areas. More than 11 percent of all trips in central cities were by walking or bicycling.

U.S. Census Survey

A second source of information on utilitarian bicycling and walking is the U.S. Census “Journey to Work” survey. The survey is conducted every 10 years and is targeted toward participants in the work force age 16 or older. It is important to note that the U.S. Census survey only reports on travel to and from work, excluding trips to school, shopping, and other frequent destinations. Data are collected for a one-week period during the last week in March, making it likely that bicycling and walking trips are underreported for many parts of the country due to cold weather. Moreover, only the predominant transportation mode is requested, so that occasional bicycling and walking trips as well as bicycling and walking trips, made to access transit or other travel modes, are not recorded.

Daily Trips by Purpose for All Travel Modes



Source: *Nationwide Personal Transportation Survey*, 1990.

With these limitations in mind, in 1990, an estimated 4.5 million people (4.0 percent of all workers) commuted to work by walking, and just under one-half million (0.4 percent) commuted by bicycle. These are national averages; some cities had much higher percentages of people walking or bicycling to work. It should be noted, however, that the overall percentages for 1990 are down slightly from the 1980 Census results, which showed 5.3 percent of persons commuting by walking and 1.4 percent by bicycling.

Opportunities for Growth
Madison, Wisconsin; Portland and Eugene, Oregon; Davis, California; and Boulder, Colorado are all places that enjoy relatively high levels of bicycling and walking for transportation as well as recreation and fitness. These and other U.S. "success stories" will be documented in later chapters of this report. Considering these successes, as well as the high levels of bicycling and walking in many European cities, it is clear that the transportation potential of walking and bicycling in the United States has barely been tapped.

As examples, in Delft, The Netherlands, bicycles are used for 43 percent of all travel trips, and in Muenster, Germany, they are used for more than a third of all trips (*The National Bicycling and Walking Study Case Study No. 16: Study of Bicycle and Pedestrian Programs in European Countries,* FHWA-PD-92-037, 1992). Like the United States, Japan is a highly motorized society; in Tokyo, however, non-motorized transportation constitutes one-fourth of all travel. *(Case Study No. 17)*

These cities and many others in Europe, Asia, and other parts of the world provide strong evidence that bicycling and walking are more than just good ways of staying fit and enjoying the outdoors. They are modes of travel that can reduce the need for automobile trips and play an important role in the overall transportation system. (*National Bicycling and Walking Study,* FHWA Publication No. FHWA-PD-94-023, 1991)

2.3 Factors Influencing the Decision to Bicycle or Walk

Many factors influence choice of travel mode and, in particular, the decision to bicycle or walk. These factors operate at different levels in the decision process. A recent analysis identified a three-tiered hierarchy of factors categorized according to initial considerations, trip barriers, and destination barriers. (*The National Bicycling and Walking Study Case Study No. 1: Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes,* FHWA-PD-93-041, 1992)

Initial Considerations
Many people may never seriously consider the transportation options of bicycling and walking. Overcoming the status quo of automatically relying on a car to travel the 3 miles to work or three blocks to the drugstore is an important first step in broadening the base of bicyclists and walkers. Activities such as "Bike to Work" days have been successfully employed in many communities to increase awareness of bicycling and walking as viable means of transport.

Distance, or its companion factor, time, is often sited as a reason for not bicycling or walking. According to 1990 NPTS results, the average length of a travel trip is 9 miles. Trips to work are slightly longer, while shopping and other utilitarian trips are shorter. More importantly, 27 percent of travel trips are 1 mile or less; 40 percent are 2 miles or less; and 49 percent are 3 miles or less. All of these trips are within reasonable bicycling distance, if not within walking distance.

Individual attitudes and values are also important in the decision to bicycle or walk. People may choose not to bicycle or walk because they perceive these activities as "uncool," as children's activities, or as socially inappropriate for those who can afford a car. Others may have quite different values, viewing bicycling and walking as beneficial to the environment, health, economical, and free from the problems of contending with traffic or finding parking. These and the many other benefits of bicycling and walking described in the previous section are key motivators for many persons not only to begin bicycling and walking, but also to continue to do so on a regular basis.

Individual perceptions (and mis-perceptions) also play a role in the decision process. Safety concerns such as traveling at night must be addressed. Although walking and bicycling can be accomplished at low levels of exertion, some people perceive that these activities are beyond their capabilities (*The National Bicycling and Walking Study Case Study No. 4: Measures to Overcome Impediments to Bicycling and Walking*, FHWA-PD-93-031, 1992). While a very small proportion of the population may not have the physical capabilities to walk to a destination or ride a bicycle, for most people, these activities are well within their abilities, and as stamina and skill increase, such activities become easier and more enjoyable.

Finally, there are situational constraints that, while they may not totally preclude the decision to bicycle or walk, do require additional planning and effort. Examples include needing a car at work, having to transport items that are heavy or bulky, and needing to drop off children at day-care. While these situations may make it more difficult to bicycle or walk, they often can be overcome with advance planning. More analysis of these issues would be useful. If bicycling and walking are not appropriate for one particular trip, a number of trips in which bicycling and walking are viable options are usually present during the course of a day or week.

Trip Barriers

Even with a favorable disposition toward bicycling and walking, reasonable trip distances, and absence of situational constraints, many factors can still encourage or discourage the decision to bicycle or walk. One of the most frequently cited reasons for not bicycling or walking is fear for safety in traffic (Case Study No. 4). Given the prevailing traffic conditions found in many urban and suburban areas –narrow travel lanes, high motor vehicle speeds, congestion, lack of sidewalks, pollution, etc.–many individuals who could meet their transportation needs by bicycling or walking do not, simply because they perceive too great a risk to their safety and health.

Perceptions of safety as well as actual safety problems must be addressed at the local level. Locational constraints such as lack of alternatives to high-speed, high motor vehicle volume roadways must be carefully handled. Adequate facilities can help overcome many of these safety concerns, whether they be sidewalks for walking, smooth shoulders, wide curb lanes, bicycle lanes, or off-road paths for the enjoyment of both bicyclists and walkers. Traffic-calming measures are another way to enhance bicycle and pedestrian safety and accommodation.

Even communities with well-designed bicycling and walking facilities can still have problems with access and linkage.

Traffic safety can also be improved through education and law enforcement activities. Training opportunities that help bicyclists feel more competent riding in traffic, campaigns that remind motorists to "share the road," and efforts to cite motorists who fail to yield to pedestrians at intersections are just a few examples.

Even communities with well-designed bicycling and walking facilities can still be plagued by problems with access and linkage. A beautifully designed and constructed off-road facility is useless to the bicyclist or pedestrian who cannot traverse a narrow bridge or cross a freeway to get to it. Similarly, facilities that do not connect neighborhoods to shopping areas or downtown businesses may never achieve their intended purpose of increased use of non-motorized travel modes. Directness of the route and personal safety and security considerations are also important factors in people's decisions to bicycle or walk.

Environmental factors could also be considered in this category of trip barriers. Examples include hilly terrain, extreme temperatures, high humidity, and frequent or heavy rainfall. Like many of the other trip barriers cited, these are to a great extent subjective and have been dealt with by those already engaging in these activities, any of whom have effectively overcome these difficulties. For potential users, these issues must be addressed and overcome if that is possible.

Destination Barriers

Facility and infrastructure needs do not stop with arrival at the work site or other destination. Many bicyclists are discouraged from becoming bicycle commuters because once at work they have no place to safely park their bicycle and no place where they can shower and change (although if the trip is made at lower levels of exertion, showering and changing clothes may not be necessary). The absence of showers and changing facilities can also serve as a barrier to those wanting to incorporate a walk or run into their daily work commute or lunch break.

Secure bicycle parking deserves special attention. The availability of parking is a prerequisite for automobile use; the same holds true for bicycling. Bicyclists are further burdened by the possibility of theft or damage to their bicycles. A Baltimore survey of bicyclists reported that 25 percent had suffered theft, with 20 percent of those giving up bicycling as a result. In New York City, bicycle theft numbers in the thousands annually. Even when parked securely, bicycles are frequently exposed to damage from rain and other environmental conditions. Secure parking areas for bicycles are necessary before bicycle use will increase.

Law enforcement officials can increase motorists awareness of pedestrian safety by penalizing city motorists who fail to yield to pedestrians.

Destination barriers can also take a less tangible form, such as a lack of support from employers and co-workers. Such support can be particularly important for sustaining a long-term commitment to bicycling or walking. In some cases, this support may be tangible, such as a discount on insurance costs or reimbursed parking expenses. In other cases, it may be less tangible, but equally important, such as allowing a less formal dress code or establishing a policy of "flextime." The latter might allow employees to adjust their work schedules so that, for example, they do not have to commute during the heaviest traffic times or in darkness.

To summarize, a variety of factors enter into an individual's decision to bicycle or walk for utilitarian purposes. Some of these, such as trip distance, must be considered at the very outset of the decision process. Others, such as route selection, parking, and response from co-workers, come into play later in the process. It must be addressed if current levels of bicycling and walking are to be increased. (*National Bicycling and Walking Study,* FHWA-PD-94-023, 1991)

Secure bike parking is necessary before bicycle use will increase.

2.4 Potential for Increasing Bicycling and Walking

What is the potential for increasing bicycling and walking in the United States? Can the relatively high levels of bicycling and walking found in cities such as Davis, California and Madison, Wisconsin be duplicated in other communities? Can U.S. cities approach the high usage levels found in some European and Asian cities?

Clearly, if aggregate levels of bicycling and walking are to be increased, changes must occur to remove the barriers previously discussed. This section identifies a variety of factors that impact on the potential of bicycling and walking as viable transportation modes in the United States. Together, they form a basis for the action plans presented in the remainder of the report.

Public Support for Bicycling and Walking
As mentioned in the previous chapter, the public already strongly supports increased travel options. The 1991 Harris Poll cited earlier showed that 46 percent of adults age 18 and older — 82 million Americans — had ridden a bicycle in the previous year. Of these:

- 46 percent stated they would sometimes commute to work by bicycle if safe bicycle lanes were available.
- 53 percent would if they had safe, separate designated paths on which to ride.
- 45 percent would if their workplace had showers, lockers, and secure bicycle storage.

A 1991 Harris Poll showed that 82 million Americans had ridden a bicycle in the previous year.

- 47 percent would if their employer offered financial or other incentives. (*Pathways for People,* 1992)

Other Considerations

Other factors can also significantly impact on the potential for bicycling and walking in the United States. Of particular relevance are: (1) the linkage of bicycle and pedestrian travel to transit, (2) the expansion of recreational bicycling and walking to more utilitarian uses, and (3) the potential impact of bicycle design technology.

A fleet of bicycles await their owners at this Dutch bus terminal.

The transit connection.

An important outgrowth of the ISTEA legislation is the creation of an Office of Intermodalism within the U.S. Department of Transportation. This office has primary responsibility for coordination between the different modes of transportation. In the past, intermodal research, planning, and programs attracted relatively little attention in the United States, in part because transportation agencies are organized along modal lines. The recent legislation offers new opportunities and strong encouragement for transportation agencies to work together to improve pedestrian and bicyclist access to public transportation. (*The National Bicycling and Walking Study Case Study No. 9: Bicycle and Pedestrian Policies and Programs in Asia, Australia, and New Zealand,* FHWA-PD93-016, 1992)

The potential for bicyclist and pedestrian integration with transit is enormous. According to 1990 NPTS data, 53 percent of all people nationwide live less than 2 miles from the closest public transportation route. The median length of an automobile trip to access a park-and-ride lot for public transit is 2.3 to 2.5 miles; and for a kiss-and-ride trip in which a passenger is dropped off, median trip length ranges from 1.3 to 1.6 miles. (Case Study No. 9)

Since these short-distance "cold-start" motor vehicle trips generate significant pollution, improved bicyclist and pedestrian access to transit can also reap environmental benefits. A 1980 Chicago area transportation study found bike-and-ride to be by far the most cost-effective means of reducing hydrocarbon emissions. Results of recent studies indicate that if only 0.5 percent out of every 200 workers living less than 2 miles from a transit route and currently commuting by auto could be attracted to bike-and-ride travel, nationwide gasoline savings of 20 to 50 million gallons would be realized annually. The conversion of only 10 percent of park-and-ride commuters to bike-and-ride could result in gasoline savings of more than 2.2 million gallons annually. (Case Study No. 9)

While much potential remains unrealized, the bicycle-transit link is gaining momentum:

- In Phoenix, Arizona, the first major city to use bus bicycle racks systemwide, there are an estimated 13,000 bicyclist boardings per month.

- In the first 3 months of Portland, Oregon's Tri-Met program, more than 700 bicyclists bought permits to allow bicycles on buses and light rail.

- Pierce Transit in Washington allows bicycles to travel inside transit vehicles.

- In California, surveys show that one-third to two-thirds of bicycle locker users at park-and-ride lots drove alone to their final destination before switching to bike-and-ride. In San Diego, the average bicyclist rides 3.6 miles to access a locker prior to traveling another 11 miles by transit.

Trails serve a variety of purposes — environmental conservation, habitats for wildlife, and educational resources, as well as preservation of the rail corridors themselves. But beyond these uses, they also serve as a valuable system of urban corridors for bicycling, walking, and other forms of non-motorized transportation.

Despite the tremendous growth in the Rails-to-Trails program over the past two decades, the market remains virtually untapped. Only about 2 percent of the total mileage of track abandoned in this century has been converted to trails. Nearly 150,000 miles of abandoned track remain available for development, and much of this is located in urban areas. The rails-to-trails movement thus holds tremendous potential for recreational as well as utilitarian bicycling and walking.

Recreational bicycling and walking. The popularity of bicycling and walking as recreational activities, as well as healthy forms of outdoor exercise, is well documented. Over the past decade, both activities have enjoyed widespread and growing participation by the American public. The distinction between recreational bicycling and walking and utilitarian bicycling and walking is not always clear-cut. One approach is to classify a bicycle or walking trip as "utilitarian" only if it would otherwise have been made by an alternative mode of transport, such as a car or bus (the "mode substitution" test). By this definition, the age of the person and the nature of the facility on which the travel takes place do not enter into consideration. If a child rides a bicycle, even on the sidewalk, down the street to a friend's house, this is a legitimate transportation trip.

The blending of recreational and transportation trip purposes and facilities is perhaps best evidenced by the Rails-to-Trails movement. The idea behind the movement beginning in the mid-1960's was simple: to convert abandoned or rail corridors into public trails (Nevel and Harnik, 1990). The first trails were little more than unpaved and ungraded stretches of "scrap land" used primarily by hikers and casual walkers. However, over time, they evolved into more finely tuned facilities, often paved, and immensely popular with the new breed of mountain-bike riders and joggers. Today, there are nearly 3,000 miles of such linear greenways, with an estimated 27 million users each year.

The kinds of grassroots efforts that make rails-to-trails conversions a reality are typical of the actions of bicyclists across the country, who over the past two decades have been organizing in a variety of ways to improve their acceptance and safety on the roadway. From national groups such as the 23,000-member League of American Bicyclists (LAB) and 25,000-member Adventure Cycling Association, to State-level bicycle advisory boards and local bicycle clubs, there is already in place an extensive network of resources to support current efforts to increase levels of utilitarian bicycling. While pedestrians have not organized themselves to the same extent as bicyclists, the potential exists here as well, as evidenced by *Prevention* magazine's 70,000+-member America Walks and local groups such as Walk Boston.

According to the Bicycle Federation of America, there are already an estimated 131 million recreational bicyclists and walkers. These people have demonstrated their ability to travel under their own power. They have also experienced firsthand the fitness, health, psychological, and other benefits of bicycling and walking. This population will be instrumental in achieving the goal of doubling the percentage of utilitarian bicycling and walking.

The primary question that remains is how to convert more of these recreational bicyclists and walkers to persons using these modes for utilitarian travel. The 1991 Harris Poll suggests that at least part of the answer lies in improving existing facilities for bicycling and walking, building sidewalks and designated bicycle facilities, installing secure bicycle parking at destinations, etc. (*Pathways for People*, 1991). Other surveys support this conclusion (Robinson, 1980). However, it is uncertain to what extent a person's professed intention to bicycle or walk if certain facilities are made available will correspond to actual changes in their travel behavior should these improvements be realized. Nevertheless, recreational bicyclists and walkers represent a strong candidate pool of potential bicycling and walking commuters.

Indications that efforts to increase overall levels of bicycling and walking transportation will succeed come from analyses of successful efforts in this country and abroad. Much of the remainder of this report is devoted to documenting these successes and showing how the results can be expanded to other areas.

Bicycle design technology.
Another factor that may affect the potential of bicycling is the continued development of the bicycle itself, along with the many accessories that accompany it. The resurgence of bicycling in the 1980's may be partially credited to the development of mountain bikes. Technological innovations and highly functional design have made this type of bicycle "user-friendly" and versatile for a wide range of people and uses. New bicycle designs –some of which are just now appearing–that are appropriate for facilitating transit interface, short-distance cargo carrying, and easy use by all segments of society, may further broaden ridership. Perhaps an even more "intelligent" bicycle design can contribute to a significant increase in utilitarian bicycle trips. (*National Bicycling and Walking Study*, FHWA-RD-94-023, 1994).

2.5 Need for Action: Pedestrians and Bicyclists at Risk

An increasing percentage of the U.S. population is affected if pedestrians and bicyclists are not accommodated in transportation facilities and programs. Children, older adults, and people with disabilities make up a substantial portion of the population–up to 37 percent in some States. To maintain independence and mobility, these people walk and ride bicycles.

Age groups affected.
More than other age groups, children and older adults (age 66+) rely on walking or bicycling as their primary transportation mode. They have few options in most cases. They must achieve mobility within the physical limitations associated with old age and with the early stages of children's physical development:

- Children have not yet acquired the skills needed for traffic safety. Their physical development in terms of such things as peripheral vision and ability to discern the source of sounds is incomplete.
- Older adults have the experience and basic skills, but often move around more slowly than they used to, have poor eyesight, hearing loss and a range of other disabilities. Despite these limitations, they are out there biking and walking around. They haven't got much choice if they are to retain some degree of independence.

Bicycle and pedestrian crashes. Children and older adults are highly overrepresented in bicycling and pedestrian crash statistics. Approximately 6,500 pedestrians and 900 bicyclists are killed each year as a result of collisions with motor vehicles. As a group, pedestrians and bicyclists comprise more than 14 percent of all highway fatalities each year. Pedestrians account for as much as 40 to 50 percent of traffic fatalities in some large urban areas.

Children have not yet acquired the skills needed for traffic safety.

Populations at both ends of the age spectrum are increasing as one wave of Baby Boomers nears retirement age and a new Boom is said to be in the works. Clearly, there is a need for action. (*Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*, FHWA-HI-96-028, 1996)

2.6 References

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L E S S O N 3

Bicycle and Pedestrian Planning Overview

3.1 Purpose

Communities throughout the United States have begun to recognize both the potential for bicycle and pedestrian travel and the barriers that must be overcome. In order to address these issues, many communities have begun to develop master plans for bicycle and pedestrian mobility, often as part of the local Comprehensive Plan or Transportation Improvement Program, or through other regional planning efforts.

The renewed effort to plan for bicycle and pedestrian mobility was given a tremendous boost by the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, and was reaffirmed in 1998 by the Transportation Equity Act for the 21st Century (TEA-21). This new era of transportation legislation brought an array of planning requirements to States and Metropolitan Planning Organizations (MPOs). This lesson provides an overview of ISTEA and TEA-21 planning issues, and presents a variety of model master planning processes that can be used at various levels of government.

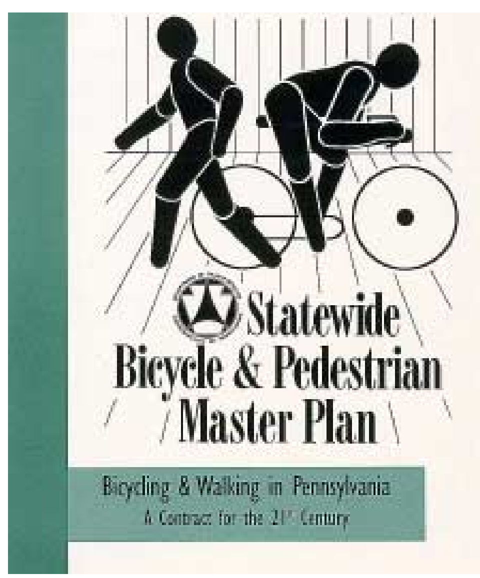
3.2 Federal Requirements for Planning

ISTEA requires preparation of non-motorized elements within State and metropolitan transportation plans.

In addition, each State and each MPO is required to incorporate appropriate provisions for bicycling and walking into the State Transportation Improvement Program (STIP) and Transportation Improvement Programs (TIP).

In addition, each State is required to establish a Bicycle and Pedestrian Coordinator position in its State department of transportation.

ISTEA offers substantial incentives for taking bicycling and walking seriously as alternative transportation modes. There is a wide variety of ISTEA funding programs with potential application to bicycling and walking.



State plans vary considerably in detail and planning approach.

Preparing Plans That Meet Federal Requirements
Information is available on Federal, State, and, in some areas, local levels to assist in preparation of bicycle and pedestrian transportation plans.

1. Technical guidance from FHWA/FTA.
The Federal Highway Administration and Federal Transit Administration have issued Technical Guidance for Bicycle and Pedestrian Planning at the State and MPO levels in order to meet Federal requirements.

Some communities combine the elements of on-road bikeways, trails, and sidewalks into a single plan.

- Any regionally significant bicycle or pedestrian project funded by or requiring an action by FHWA or FTA must be included in the Metropolitan Transportation Improvement Program (TIP).

- Bicycle and pedestrian elements of transportation plans should include:

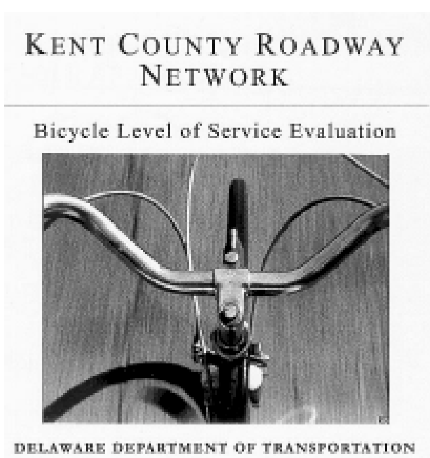
(1) Vision and goal statements and performance criteria.
(2) Assessment of current conditions and needs.
(3) Identification of activities required to meet the vision and goals.
(4) Implementation of the bicycle and pedestrian elements in statewide and MPO transportation plans and transportation improvement programs.
(5) Evaluation of progress, using performance measures developed in (1).
(6) Public involvement as <u>required</u> by TEA-21 and the FHWA/FTA planning regulations.
(7) Transportation conformity requirements for air quality, where necessary.

In brief, the Technical Guide includes the following key points relevant to State and metropolitan area transportation planning for bicycles and pedestrians.

- Plan elements should include goals, policy statements, and specific programs and projects whenever possible.

- The Plan should identify financial resources necessary for implementation.

- Bicycle and pedestrian projects may be on- or off-road facilities. Off-road trails that serve valid transportation purposes as connections between origins and destinations are considered as eligible projects consistent with the planning process.



2. State and metropolitan area planning guidelines.
State and MPO transportation planning guidelines vary considerably in terms of format, level of detail, and planning approach. In some States, the plans are prepared by staff and, in others, with primary input from consultants. Some States have developed detailed guidelines for preparation of bicycle and pedestrian plans and programs, while others provide little guidance in this area. Some have initiated a rigorous process of working with local and regional entities to make sure that the STIP is responsive to community needs, while others take a more hands-off approach.

3. Preparing regional plans.
The ISTEA planning process has the potential to be a major stimulus to intermodal cooperation and work among diverse local entities and disciplines. Working together to set priorities and select projects on a metropolitan basis can help bring communi ties within the region closer together as common

objectives are defined and mutually agreeable selection criteria are established.

Regional planning process issues. Issues that typically arise during the regional planning process include:

- Interpreting the meaning of an “eligible” project under the various ISTEA programs.
- Providing guidelines for preparation of regional plans so information is formatted for ease of incorporation into State-level planning.

Recommended Action Plan for State and Local Governments

Action Item 1:
Organize a bicyclist/pedestrian program

Action Item 2:
Plan and construct needed facilities

Action Item 3:
Promote bicycling and walking

Action Item 4:
Educate bicyclists, pedestrians, and the public

Action Item 5:
Enforce laws and regulations

Many entities need to organize their roles and objectives as part of the local planning effort.

- Dealing with implementation and funding realities — Who coordinates implementation of a multi-jurisdictional plan? What about Traffic Management Organizations (TMOs)? How can applications and funding commitments be met?
- Conflicting standards and philosophies among the regional entities–each county or town may have somewhat different ideas about bicycle and pedestrian transportation and a different set of facility and street standards.
- Reconciling potential conflicts between local and regional perspectives.
- Keeping a broad perspective on plans and programs rather than concentrating only on facility project selection. (Drake, *Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*)

3.3 Preparing Local Pedestrian Plans

Cities and town with good bicycle and pedestrian plans can have a far greater impact on the regional and State-level planning processes. It is advantageous for the local entity to format its plan to meet State and regional guidelines so it can easily be folded into STIP, TIP, and specific bicycle/pedestrian plans.

It is beneficial if neighboring communities can work together to coordinate recommendations and create linkages. Implementation of local programs and facility construction can have far greater use if they extend beyond the city limits to adjoining communities.

In order to do well in the “ISTEA Derby,” the local entity must demonstrate a commitment to providing matching funds and meeting required deadlines, and should come equipped with specifics of projects, cost-estimates, and other information— to add to the regional planning process. The city that does its homework has the best chance of securing the funds.

1. Pedestrian planning strategy.
Planning for pedestrians should begin with a thorough understanding of existing local conditions. Therefore, it is advisable to start a pedestrian program by developing a project checklist to help identify possible problems, existing environmental constraints, and/or program features.

Next, proceed to implement improvements through the use of interactive and responsive programs. For the most part, such programs can be managed as part of an agency’s routine function.

For example, if the project checklist suggests installing accessible curb ramps at intersections, find

Many communities are making traffic calming a top priority.

out what curb-cut standard (if any) the street department currently uses. If a poor or sub-optimal design is being used, there are several steps that can be followed to improve safety for pedestrians. These include:

- Changing the curb-cut standard (or design guidelines) for new construction.
- Having the street department use the new standard whenever they replace or modify a current installation.
- Budgeting a reasonable amount of money for annual curb-cut installation, based on public requests and a quick prioritization of the street system (e.g., streets near schools, social service offices, popular transit stops, and senior centers).

2. Project priorities.
One approach in setting priorities for pedestrian improvements is to identify what would encourage people to walk more often and then orient efforts toward improving conditions for pedestrians in this direction. During the development of the bicycle and pedestrian plan for Louisiana, citizens were asked what could be done to make it easier to get around by foot. The responses were ranked as follows:

1. More sidewalks	61.93%
2. More off-road trails	57.80%
3. Destinations close to home and work	33.94%
4. Education for motorists	30.28%
5. Enforcement of bicyclist/motor vehicle laws	28.44%
6. More benches, water fountains, etc.	28.44%
7. More crosswalks	27.06%
8. Slower traffic on local roads	21.56%
9. Better transit service	15.14%

Another approach that can help determine where to start is to see what America's most progressive "pedestrian-friendly" communities are doing. Pedestrian activities in these communities typically include:

- Providing a community-wide walkway network that is continuous and safe.
- Providing curb ramps at intersections.
- Installing curb bulbs.
- Calming neighborhood streets.
- Rewriting work-zone policies.
- Reconfiguring arterials.

Some projects are modest in scope, while others can be major undertakings.

While each of these projects and programs may be part of a larger comprehensive planning effort, each can be implemented singly. Also, implementation can be accomplished in phases and in sequences that best reflect local realities.

For example, if it would be easy to install key pedestrian signals, but far more difficult to retrofit sidewalks on a bridge across a major river, the former should be done immediately and the latter as funding and political support materialize.

If the zoning ordinance is currently being revised, adding pedestrian considerations like mixed-use zoning or reduced commercial frontage requirements might be considered. Thus, it is both possible and desirable to pick and choose those projects and programs from the list that have local appeal and are doable. Such an approach makes it possible to get things going almost immediately and to start making a real difference in the community, often at minimal expense.

Of course, some projects are expensive. For instance, if there is a need for a grade-separated pedestrian crossing of a freeway, such a project can easily cost upwards of $300,000 to $500,000. Planning for such an expenditure can take several years and may involve grant applications or implementation through the Transportation Improvement Program (TIP) process and the use of any one of several categories of Federal funds. Meanwhile, many small, but important, changes can be made as the community works its way toward pedestrian-friendliness.

Pedestrian signals that are consistent in their design and actuation are important.

Many local programs have found that small initial successes build momentum, allowing more ambitious work to follow. In one western community, for instance, installation of several "test" traffic circles on residential streets — a project that took several days of work and less than $5000 to accomplish–helped build support for an on-going program installing such circles all over town.

3. Program/Project list.
The list below briefly describes pedestrian programs or projects in categories that relate to the time-honored "Four E's"–engineering, education, encouragement, and enforcement. While not every conceivable pedestrian program or project is included, the following checklist contains the most important.

a. Engineering.

Walkways:
Typical concerns: Sidewalks are often broken, missing, or not continuous.

Possible Solutions: Require sidewalk installation or replacement as a condition of development.

Intersections:
Typical concerns: 14 percent of fatal crashes in urban areas occur in the central business district (CBD). Two-thirds of CBD injuries occur at intersections.

Possible solutions: Create guidelines for intersection design to make pedestrians as visible as possible and their actions as predictable as possible.

Crosswalks:
Typical concerns: Pedestrians "dart out" or cross vehicular roadways at random locations.

Possible solutions: Create a program to install crosswalks, bulbouts (flared curbs), and refuge islands to encourage pedestrians to cross streets and roads at predictable, as well as convenient, locations. Bulbouts and refuge islands also reduce exposure time for pedestrians at crossings and increase green time for vehicles.

Curb ramps:
Typical concerns: Wheelchair users can't cross street or must use a nearby driveway.

Possible solutions: Create an annual curb ramp program to install ramps where requested.

Creative intersection design can greatly increase motorists' awareness of pedestrian safety.

Curb bulbs and curb radii:
Typical concerns: Wide streets are more difficult to cross than narrow ones and expose pedestrians to traffic dangers for a longer period of time.

Possible solutions: Use curb bulbs to narrow streets at important crossings and include the specifications in standard designs.

Signal timing and push buttons:
Typical concerns: Pedestrian signals are often inconsistent in their timing and actuation methods.

Possible solutions: Follow a consistent policy of push-button installation and signal timing whenever traffic signals are installed or modified.

Pedestrian half-signals:
Typical concerns: Where residential streets meet arterial streets at unsignalized intersections, pedestrians may have great difficulty crossing.

Possible solutions: Install pedestrian half-signals near schools, hospitals, social service offices, and senior citizen centers.

Signing and marking:
Typical concerns: When pedestrian signing and marking is used in the wrong location, in the wrong manner, or for the wrong purpose, it can lead to a false sense of security for pedestrians.

Possible solutions: Evaluate high-risk locations and install consistent pedestrian crossing controls.

Pedestrian amenities:
Typical concerns: Streetscape is devoid of amenities and street furniture that facilitate and encourage walking.

Possible solutions: Develop and install a system of amenities and street furniture, taking care not to limit sight distance or restrict the width of normal pedestrian paths.

Reconfiguring arterial streets:
Typical concerns: High arterial street speeds are often associated with high risks of pedestrian fatalities.

Possible solutions: Change the channelization to provide median refuges and slow traffic down.

Bridges:
Typical concerns: Without adequate sidewalks, pedestrians may have to walk in the roadway or avoid a walking trip all together.

Possible solutions: Make sure sidewalks are included in all major renovation projects.

Traffic calming:
Typical concerns: Too often, through traffic diverts to residential streets in order to avoid arterial street congestion.

Possible solutions: Install a set number of traffic circles per year in response to neighborhood requests.

Maintenance:
Typical concerns: Badly maintained sidewalks or those cluttered with portable signs and newspaper stands can lead to pedestrian injuries.

Possible solutions: Enact clear and fair laws governing the use of sidewalks for private purposes. Establish and implement an ongoing maintenance program. Remove all hazards. If a hazard cannot be removed, erect barriers or clear warning signs.

b. Education.

Public awareness campaigns:
Typical concerns: Safety and acceptance of walking as a legitimate travel mode are serious concerns for pedestrians.

Possible solutions: Construct public awareness and education campaigns that target safety problems and change attitudes for the better.

c. Encouragement.

Trip-length reduction:
Typical concerns: Even with adequate sidewalks and crosswalks, if destinations are out of reach, few people will walk for utilitarian purposes.

Possible solutions: Encourage mixed-use development through incentives such as increased density or additional height.

Group B (basic) bicyclists value designated bike facilities such as bike lanes.

Walking-route maps:
Typical concerns: Knowing how to reach nearby destinations on foot is a major step to encouraging walking.

Possible solutions: Develop an interest in a series of neighborhood and regional walking maps.

Walking events:
Typical concerns: Just getting started is often the biggest barrier to increased pedestrian activity.

Possible solutions: Facilitate the organization and promotion of special walking events to celebrate foot travel and encourage novices to give walking a try.

d. Enforcement.

Construction zones:
Typical concerns: Work sites often “take over” pedestrian space, forcing people to walk in the street or through construction debris.

Possible solutions: Require clear consistent work zone controls as part of the building permit process.

Land use development requirements:
Typical concerns: Having to cross large parking lots to reach a nearby store negates the value of curbside sidewalks; it can be unsafe and a discouragement for walkers.

Possible solutions: Require safe pedestrian access to new and renovated buildings.

Enforcement:
Typical concerns: Motorists often ignore pedestrians in crosswalks and pedestrians often ignore crosswalks.

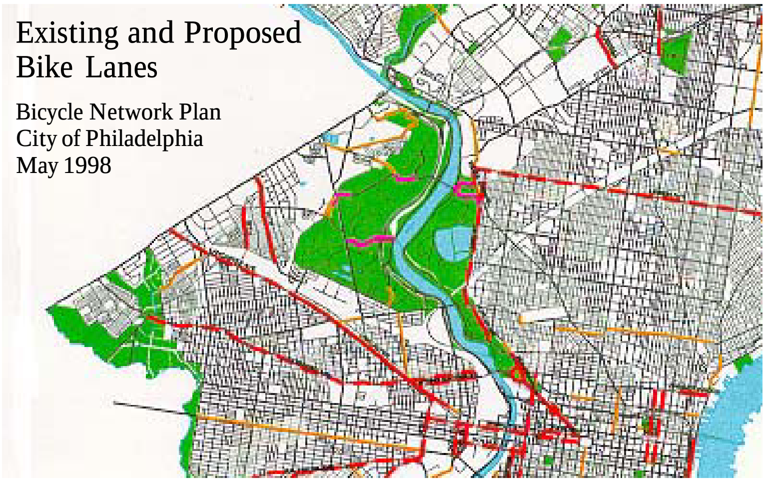
Possible solutions: Enforce pedestrian-related traffic laws, focusing first on key crash locations.

3.4 Local Bicycle Planning

Transportation planning is a process for making decisions about the development of transportation facilities. This includes providing accurate information about the effects that proposed transportation projects will have on the community and projected users. Bicycle planning is no exception. However, because much of the information necessary to reach sound decisions about providing for safe, efficient bicycle use is already available as a by-product of the normal operation of the road system, the bicycle planning process is a specific application of the overall transportation planning process.

This is especially true in the case of Group A bicyclists–the more experienced and proficient bicyclists that comprise about 5 percent of bicycle users in the United States. These bicyclists are able to operate on the roadway in most traffic conditions and favor the directness and right-of-way preference given to roads with a high functional classification. The planning process used to develop or improve roadways for motorists is equally valid for this type of bicyclist.

There are, however, some important design features to be taken into account to best accommodate Group A bicyclists, and for this reason, planners and engineers should refer to the American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* (1999) during the planning process for streets and highways. Group A riders should be anticipated and provided for on all roadways where bicycles are not excluded by statute or regulation, regardless of functional classification.



The situation is very different for Group B/C bicyclists (bicyclists of average skill and experience, and children). While these bicyclists value many of the same roadway features as Group A bicyclists (i.e., accessibility and directness), they also value other characteristics such as designated bicycle facilities and lower traffic volumes.

Group B/C bicyclists typically prefer to ride on neighborhood streets and/or designated bicycle facilities. The location of these facilities is best determined through a planning process that seeks to determine where designated facilities are needed and the type of bicycle facilities that should be provided to accommodate and encourage Group B/C bicyclists.

Developing a Bicycle Network Plan

The following discussion details a planning process intended to identify a network of routes where special bicycle facility treatments should be employed to meet the needs of Group B/C bicyclists.

Many model planning processes could be used to select routes and design facility treatments to accommodate Group B/C bicyclists. Chapter 1 of the AASHTO Guide contains several suggestions for establishing a bicycle planning program. The following process is but one example It consists of six steps:

1. Establish performance criteria for the bicycle network.
2. Inventory the existing bicycle facility and roadway system.
3. Identify desired bicycle travel lines and corridors.
4. Evaluate and select specific route alternatives.
5. Select appropriate design treatments.
6. Evaluate the finished plan against the established performance criteria.

Establish Performance Criteria for the Bicycle Network

Performance criteria define the important qualitative and quantitative variables to be considered in determining the desirability and effectiveness of a bicycle facility network. These can include:

- **Accessibility:** This is measured by the distance a bicycle facility is from a specified trip origin or destination, the ease by which this distance can be traveled by bicycle, and the extent to which all likely origins and destinations are served. Some communities (e.g., Arlington, VA) have adopted a criterion of having a bicycle facility within 1 mile (1.61 km) of every residence. More importantly, no residential area or high-priority destination (school, shopping center, business center, or park) should be denied reasonable access by bicycle.

- **Directness**: Studies have shown that most bicyclists will not use even the best bicycle facility if it greatly increases the travel distance or trip time over that provided by less desirable alternatives. Therefore, even for Group B/C bicyclists, routes should still be reasonably direct. The ratio of directness to comfort/ perceived safety involved in this trade-off will vary depending on the characteristics of the bicycle facility (how desirable is it?), its more direct alternatives (how unpleasant are they?), and the typical user's needs (in a hurry?, business or pleasure trip?).

- **Continuity:** The proposed network should have as few missing links as possible. If gaps exist, they should not include traffic environments that are unpleasant or threatening to Group B/C riders, such as high-volume or high-speed motor vehicle traffic with narrow outside lanes.

- **Route Attractiveness:** This can encompass such factors as separation from motor traffic, visual aesthetics, and the real or perceived threat to personal safety along the facility.
- **Low Conflict**: The route should present few conflicts between bicyclists and motor vehicle operators.
- **Cost:** This would include the cost to both establish and maintain the system.
- **Ease of Implementation:** The ease or difficulty in implementing proposed changes depends on available space and existing traffic operations and patterns.

Inventory Existing System

Both the existing roadway system and any existing bicycle facilities should be inventoried and evaluated. The condition, location, and level of use of existing bicycle facilities should be recorded to determine if they warrant incorporation into the proposed new network or if they should be removed. If existing bicycle facilities are to be used as the nucleus of a new or expanded network, the inventory should note which improvements to the existing portions of the network may be required to bring the entire new network up to uniform design and operations standards.

A simple inventory of the roadway system could be based on a map of the annual average daily traffic (AADT) counts on each road segment within a community or region. A more complex inventory could include factors such as the number of traffic lanes, the width of the outside lane, the posted speed limit or actual average operating speed, the pavement condition, and certain geometric and other factors (e.g., the frequency of commercial driveways, grades, and railroad crossings).

Identify Bicycle Travel Corridors

Predicting bicycle travel corridors for a community is not the same as identifying the routes that bicyclists currently use. Instead, travel corridors can be thought of as “desirable lines” connecting neighborhoods that generate bicycling trips with other zones that attract a significant number of bicycling trips.

For motor vehicle traffic, most peak morning trips are made between residential neighborhoods and employment centers. In the evening peak hours, the opposite is true. In the evening or on weekends, the pattern of trip generation is much more dispersed as people travel to shopping centers, parks, and the homes of friends or relatives.

Estimating these trip flows for an entire city can be a complex, time-consuming effort requiring significant amounts of raw data and sophisticated computer models. Fortunately, transportation planning for bicycles is much simpler. Unlike traditional transportation planning that attempts to predict travel demands between future zones on as-yet unbuilt streets and highways, bicycle planning attempts to provide for bicycle use based on existing land uses, assuming that the present impediments to bicycle use are removed. These desire lines are, in fact, well represented by the traffic flow on the existing system of streets and highways.

The underlying assumption is that people on bikes want to go to the same places as do people in cars (within the constraints imposed by distance), and the existing system of streets and highways reflects the existing travel demands of the community. Furthermore, most adults have a mental map of their community based on their experience as motor vehicle operators. Thus, they tend to orient themselves by the location of major streets and highways.

Again, it is important to note that the resulting map may not be a representation of where bicyclists are now, but is instead a reflection of where bicyclists wish to go. The actual travel patterns of Group B/C bicyclists are heavily influenced by their perception of the bicycling environment they face. Uncomfortable or threatening bicycling conditions will cause these bicyclists to alter route choice from their most preferred alignment, choose a different travel mode, or not make the trip at all. Thus, the task of the transportation planner for bicycling is to ask, “Where are the bicyclists now?” and “Where would they be if they could go where they preferred?”

Although this use of existing traffic flows is a useful overall predictor of bicyclists' desire lines, a few special situations may require adjustments to the corridor map:

- Schools (especially colleges and universities) and military bases can generate a disproportionately large share of bicycle trips. This is especially true for campuses where motor vehicle parking is limited.

- Parks, beaches, libraries, greenways, rivers and lakesides, scenic roads, and other recreational facilities attract a proportionately higher percentage of bicycle trips.

Evaluate and Select Specific Route Alternatives
The corridor identification procedure identifies desire lines for bicycle travel between various locations. The next step is to select specific routes within these corridors that can be designed or adapted to accommodate Group B/C bicyclists and provide access to and from these locations. The aim is to identify the routes that best meet the performance criteria established in the first step of this planning process.

Typically, this step and the selection of appropriate design treatments are highly interactive processes. The practicality of adapting a particular route to accommodate Group B/C bicyclists may vary widely depending upon the type of design treatment selected. For example, a less direct route may become the best option if comparatively few inexpensive and easily implemented design improvements are required.

Therefore, steps 4 and 5 should be approached as an iterative loop in which both route selection and design treatment are considered together to achieve a network that is highly advantageous to the user, is affordable, has few negative impacts on neighbors and other non-users, and can be readily implemented.

In summary, the selection of a specific route alternative is a function of several factors, including:

- The degree to which a specific route meets the needs of the anticipated users as opposed to other route options.

- The possible cost and extent of construction required to implement the proposed bicycle facility treatment.

- The comparative ease of implementing the proposed design treatment. For example, one option may entail the often unpopular decision to alter or eliminate on-street parking while another does not.

- The opportunity to implement the proposed design treatment in conjunction with a planned highway construction or reconstruction project.

A more inclusive list of factors to be considered in the selection of a specific route is presented in the AASHTO Guide.

Select Appropriate Design Treatments
Guidelines for selecting an appropriate design treatment are presented in lesson 3 of this manual. In overview, the principal variables affecting the applicability of a design treatment are:

- **The design bicyclist.** Is the proposed route projected to be used primarily by Group A bicyclists, or is it intended to also serve as part of a network of routes for Group B/C bicyclists?

- **The type of roadway project involved on the selected route.** Is the roadway scheduled for construction or reconstruction, or will the incorporation of design improvements be retrofitted into existing geometrics or right-of-way widths?

- **Traffic operations factors.** The most significant traffic operations factors for determining the appropriateness of various design treatments are:
  - Traffic volume.
  - Average motor vehicle operating speeds.
  - Traffic mix.
  - On-street parking.
  - Sight distance.
  - Number of intersections and entrances.

Evaluate the Finished Network Plan Using the Established Performance Criteria
Will the proposed network meet the criteria established at the start of the planning process? If it does not meet most of these criteria, or inadequately

meets a few critical goals, either the proposal will require further work, or the performance criteria must be modified. In the latter case, the planning process as a whole should be reviewed to determine if previously discarded routes should be reconsidered. There may now be more preferred options in light of the newly modified criteria.

This reality check is important. Many well-considered proposals fail when it is determined that the finished product no longer meets its established objectives. (Drake, *Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*, 1996).

Several factors will determine the final design treatment used; two of the foremost are cost and controversy.

3.5 Using Analytical Tools in the Planning Process

Bicycle planners have traditionally relied on anecdotal evidence to prove that bicycle facilities are needed within specific roadway corridors. In the case of a typical urban arterial with heavy traffic and relatively high speeds, planners rightfully argue that demand is not accurately reflected by the number of bicyclists currently riding within the road right-of-way. They maintain that due to impedances, there exists a pent up, or latent, travel demand within the corridor.

However, when challenged to quantify this latent demand, many planners are at a loss as to how to respond. Some bicycle planners attempt to employ the “desire lines” technique–a vintage 1930’s planning tool that has become obsolete with today’s environment of linked urban tripmaking patterns and expectations of sophisticated travel demand models. Other planners have relied on the “if you build, it they will come” philosophy of response - one that requires a leap of faith that many policymakers aren’t ready to take except in rare circumstances.

Today’s trend toward quantitative analysis puts more pressure than ever on transportation planners to justify public expenditures “by the numbers.” Increasingly, competition among projects for priority within metropolitan area Transportation Improvement Programs requires a numerical basis to demonstrate that all projects can reach measurable objectives. Furthermore, in the case of the increasingly popular method of providing facilities by development exactions, local governments have been issued a “wake-up call” by the U.S. Supreme Court through its 1994 *Dolan vs. Tigard* decision. That decision has underscored the need for local governments to clearly demonstrate, or quantify, how a proposed bicycle facility will offset traffic caused by new land developments. Clearly, in today’s transportation planning environment, bicycle planners must use analytical methods in order to do their jobs successfully.

While millions of dollars and decades of research have gone into travel demand models for motor vehicles and transit, bicycle travel demand models are virtually non-existent. However, a recently developed analytical tool, the Latent Demand Score (LDS) Model, can help planners to quantitatively evaluate bicycle travel demand on a systemwide basis. The LDS Model measures the relative amount of bicycle travel that would occur on a road segment if there were no bicycle travel impedances. It employs a simplified, probabilistic gravity model technique to quantify the proximity and magnitude of bicycle trip attractors and/or generators. Applied on a segment-by-segment basis and in conjunction with a bicycle Level of Service (LOS) analysis, the LDS model can provide a clear, reasonable, and relatively

Streets and roadways can be analyzed to determine the relative level of service they provide to bicyclists.

low-cost method of determining which roads are the best candidates for bicycle facility improvements. And until significant federal funding for the development and calibration of a bicycle travel demand forecasting model is mad available, the LDS Model will be the model of choice for cutting-edge bicycle transportation planners. The following sections outline the LDS Model technique.

Technical Review: The Latent Demand Score (LDS) Model

The LDS Model was developed to provide transportation planners with the ability to quantify latent bicycle travel demand. The LDS Model differs from the classic four-step highway travel demand model in the following way: where the highway's gravity model requires extensive network coding and algorithms to simulate travel between its trip generators and attractors, the LDS Model quickly estimates the probability of bicycle travel on individual road or street segments based upon their proximity, frequency, and magnitude of adjacent bicycle trip generators and/or attractors. The LDS Model uses many parameters similar to those in the highway model. The steps of the LDS Model are:

1. Establish trip-making thresholds for the bicycle trip attractors and generators for the four trip purposes: home-based work, home-based shopping, home-based recreational/social, and home-based school trips. The attractors/ generators include: home-based work markets, home-based markets per census block group, commercial employment per traffic analysis zone, public parks (stratified in to minor, staffed, and major), and elementary and middle schools' student population (within their transportation exclusion zone).

2. Geocode and/or map the attractors/ generators and record (in the database), for each segment, the number of indicators, stratifying according to proximity using Geographic Information System (GIS) software.

3. Compute the Trip-Making Probability Summation (TPS):
   a. Calibrate for the urban area the Trip Probability vs. Distance (impedance) curves for each trip purpose.
   b. Multiply, for each distance stratification, the number of indicators by their distance impedance.
   c. Sum, for each trip purpose, its value for the segment.

4. Normalize the Demand Indicator Values (DIV) to reflect their relative trip generation (ADTs) by:
   a. Estimating the average independent variable of each attractor/generator.
   b. Calculating the average trip generation of each attractor/generator using the *ITE Trip Generation Manual*.

5. Multiply the DIV by its trip generation and then multiply the product by the Demand Category Constant determined by the respective trip purpose's share in the study area.

6. Calculate the segment's Latent Demand Score by summing the DIVs.

The LDS Model uses readily available demographic data, employing simplified geocoding and data input for spreadsheet-based gravity computations. It is important to note that the LDS Model estimates the relative latent demand of bicycle travel on each segment of a road network. It provides a clear indication of the relative level of desired bicycle use should a bicycle facility be provided on the road segment.

Case Study: Application of the LDS Model in Birmingham, Alabama

In Birmingham, Alabama the LDS Model was used as one component of a comprehensive Bicycle, Pedestrian and Greenway Plan for a large two-county region. The plan was funded with Congestion Mitigation and Air Quality (CMAQ) funds and serves as part of the MPO's Long Range Transportation Plan. The project was conducted by the Birmingham Regional Planning Commission (BRPC).

One important task for this project was to prioritize facility development. The planning process included a Route Planning Charette for local planners, engineers, citizens and elected officials that resulted in a "ultimate needs list" of on-road and off-road corridors for bicycle and pedestrian facility development. The needs list, which included more than 900 different corridor segments, was further refined through a needs assessment, as defined in the steps below:

Step 1: Assess the Current Level of Service

During the first step, a bicycle level of service (BLOS) analysis was computed for the on-road route system identified in the Route Planning Charettee. The BLOS model, based upon the Interaction Hazard Score of IHS Model (*Landis, Transportation Research Record 1438*) quantified the bicyclists' perception of hazard level of interacting with motor vehicles. The resulting BLOS score was scaled into categories A, B, C, D, E, or F, with "A" representing the best conditions and "F" representing the worst conditions.

Step 2: Estimate Latent Demand

The LDS Model, as described above, was used to measure potential bicycle travel activity for each on-road and off-road segment. For the Birmingham Area plan, latent demand was estimated for four trip types:

- Home-based work.
- Home-based shopping.
- Home-based recreational/social.
- Home-based school trips.

An impedance variable was added to the model to account for the effect of grade on travel demand, because steep hills are commonplace throughout the region. In addition, the LDS Model's distance impedances were stratified to account for the different average trip distances in rural versus suburban and urban areas.

Step 3: Compute Analytical-Based Priority

By combing the results of the BLOS and LDS Models, an analytical score was produced for each segment of the proposed route system. A road segment with poor bicycling conditions, but a high latent demand ranked higher on the priority list than a road with a similar level of demand, but relatively good conditions for bicycling. Off-road future segments were ranked only with the latent demand.

Step 4: Measure Public Priority

During two public meetings held in January 1996, participants were asked to identify the routes that they felt should have the top priority. The attendees were given five votes each (more than 150 citizens participated in this process). The results were tallied and public priorities for the route system were established

$$LDS = \sum_{n=1}^{4} TTS_n \times \frac{\sum_{n=1}^{4}(GA_n \times \overline{TG_n})}{(GA_n \times \overline{TG_n})} \times \left[\overline{TG_n} \sum_{d=1}^{j} P_{nd} \times ga_n\right]$$

n	=	bicycle trip purpose (e.g., work, personal/business, recreation, school)
TTS	=	trip purpose share of all bicycle trips
GA	=	number of generators or attractors per trip purpose
TG	=	average trip generation of attractor or generator
P	=	effect of travel distance on trip interchange, expressed as a probability
ga	=	number of generators or attractors within specified travel distance range
d	=	travel distance range from generator or attractor

Form of Latent Demand Score Model equation.

Step 5: Compute Final Needs Ranking

The final needs ranking for the proposed route system was computed as a combination of the analytical score and public priority. The results of the final needs ranking were divided into three Needs Levels: A, B, and C, and stratified by jurisdiction.

Step 6: Designation of the Short-Term and Long-Term Route Plans

The Long-Range Route Plan is composed primarily of routes that were scored as Level A on the final needs assessment. Level B and Level C routes are included on this plan as needed to form necessary regional connections. The Short-Range Plan includes routes that are deemed critical for immediate improvement and/or areas already planned for improvement (thus making bicycle/pedestrian facility development less expensive).

As a regional plan, funding and construction for routes identified on the Short- and Long-Range Plans will require partnerships between local governments and the Birmingham Regional Planning Commission. This MPO is committed to allocating a portion of the region's Surface Transportation Funds (above and beyond Enhancement Funds) for bicycle and pedestrian facility construction and programs. While each route on the route plan is eligible for funding, a high level of competition among local governments is expected in the years to come.

Conclusion

Together, the Latent Demand Score and Bicycle Level of Service Models are effective bicycle system planning and roadway facilities prioritization tools that:

- Are adaptable to a variety of software.
- Use data available in virtually all metropolitan areas.
- Use objectively collected field data.
- Can be easily updated.
- Can be used for "fingertip" policy testing of traffic calming or other alternatives.
- Generate easily understood results.

Numerous metropolitan areas throughout the United States are using these models to successfully develop their bikeway network in today's challenging planning environment. (*Pro-Bike/Pro-Walk 1996 Conference Proceedings, Article #70,* "Using the Latent Demand Score Model to Estimate Use")

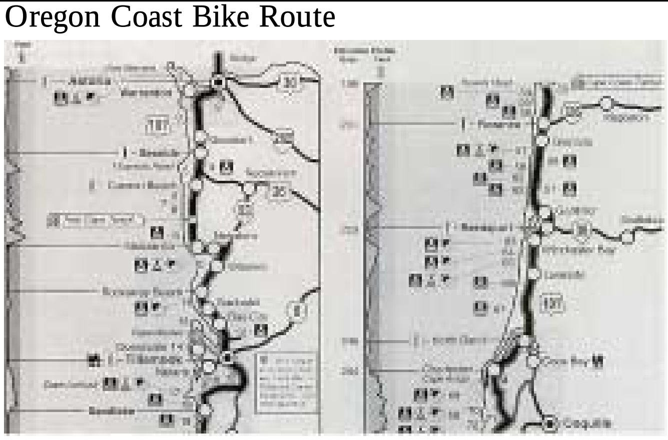
3.6 Mapping

Consistency in bicycle maps enables users to readily understand symbols and colors when they visit a new area. A system of unified codes and symbols is also useful to planners, designers, and engineers.

There are four basic types of bicycle maps:

- Urban bicycle facility maps.
- County, State, or regional bicycling guides.
- Bicycling tour guides.
- City or county planning maps.

Oregon Coast Bike Route



Oregon Coast Bike Route map provides a clear and easily read map for all users.

The first three types are used mainly by bicycle riders; the fourth is used by a wide variety of interested parties.

Urban Bicycle Map

Used primarily by local utilitarian bicyclists, newcomers, and visitors, this type of map is intended to help cyclists choose routes they feel comfortable bicycling on, and to encourage first-time riders to make certain trips by bicycle.

All streets should be shown. A simple color code indicates the presence and type of bicycle facilities. It also warns bicyclists of roads they should use with caution. The accompanying text should provide information on the proper use of bikeways, traffic laws, and safety tips.

Other useful information includes enlargements of difficult intersections, steep hills, weather data, parking facilities, bike shops, important destinations, and landmarks, etc. However, too much detail creates a cluttered effect; simplicity makes it easier to find needed information.

CODE:

Blue	Bike Lanes
Purple	Multi-Use Paths
Red	Caution Areas
Black	Local Streets (shared roadways)

Bicycle Guide
The intended audience is recreational and touring riders interested in medium- to long-distance trips. The major concerns when choosing a route are traffic volume and roadway conditions. Color coding indicates bicycle level of service; a solid line indicates the presence of shoulders wide enough for bicycle travel.

The map should include State highways and county roads. The level of detail is less than that on an urban map. Other information to be included are distances, grades, weather data (especially prevailing wind directions), and camping facilities. Text should be used for information on local history, landmarks, viewpoints, etc.

Description of loop tours is useful to riders planning day trips. Local bicyclists should ride the loops in order to assess conditions. A written description of the route listing landmarks and turns is helpful.

Since bicycle trips often cross jurisdictional boundaries, counties are encouraged to coordinate regional maps, covering a natural geographical area within easy reach of several population centers.

Shoulders:
Black lines indicate shoulders 1.2 meters (4 feet) or wider on both sides of the roadway.

Grades:

1 Chevron	2-4% grade
2 Chevrons	4-6% grade
3 Chevrons	Greater than 6% grade

Bicycling Tour Guide
The intended audience is bicyclists on an extended tour. The format can be fold-out maps, strip maps, or brochures. Various agencies can cooperate to produce maps for long-distance bicycle tours that traverse several jurisdictions.

If a loop or one-way tour is best when bicycled in one direction only, this should be emphasized in the text (for example, it is best to ride the Oregon Coast Bike Route from north to south, to take advantage of prevailing winds).

Points of interest are important, as are distances, grades, campgrounds, availability of water, and details about different areas. A written description of the route listing landmarks and turns is useful, as well as an elevation profile.

Other Useful Tips
Good maps are clear and simple, as too many symbols and details create confusion. Only needed information should be included:

- For urban maps, all city streets should be shown, as well as schools, public agencies, and other common destinations. But not every street needs to be coded for bicycling purposes: most residential streets and minor collectors function well as shared roadways and should be left open on the map.

- For bicycling guides, too much topographical detail obscures the information that is really useful.

- For tour guides, inclusion of all roadways in the vicinity creates a confusing, web-like effect. Only the roads on the tour need to be included, along with roads that connect the route to other localities (for riders who wish to join or leave the route at intermediate points). Insets of urban areas are useful.

It is usually better to create a new map. If available graphics capabilities don't allow this, existing maps can be used by adding and deleting information.

Other important considerations are:

- Symbols and text should be oriented in a direction consistent with the way a map is going to be held (if possible, north at the top).

- Descriptive text should be placed as close as possible to the relevant map segment (especially important for tour guides). (*Oregon Bicycle and Pedestrian Plan*)

3.7 References

AASHTO, *Guide for the Development of Bicycle Facilities*, 1999.

Bicycle Federation of America, *Pro-Bike/Pro-Walk Resource Book (1996 Conference Procedings),* Article #70, "Using the Latent Demand Score Model to Estimate Use," 1996.

Birmingham Regional Planning Commission, *Birmingham Area Bicycle, Pedestrian and Greenway Plan - Final Report*, 1996.

City of Philadelphia, *Bicycle Facility Design Standards*, 1998.

Drake and Burden, *Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*, NHI Course #38061, FHWA-HI-96-028, 1996.

Bruce W. Landis, "Bicycle System Performance Measures: The Interaction Hazard and Latent Demand Score Models," *ITE Journal*, Vol. 66, No. 2, pp. 18-26.

L E S S O N 4

Pedestrian and Bicycle Crash Types

4.1 Purpose

Many professionals involved in pedestrian and bicycle programs have never received training that focuses on crash causation. Everyone–from traffic safety specialists to traffic engineers, planners, educators, and law enforcement personnel–can benefit from an understanding of how crashes occur and how to avoid them.

This lesson provides an understanding of crash characteristics, crash rates, exposure, and a grounding in crash typing. The most significant crash types will be explained and associated with contributing factors and typical errors made. The concepts of corridor and site crash analysis and team problem-solving will be emphasized. Discussion will include special conditions–especially nighttime crashes, those involving impaired drivers, pedestrians and bicyclists, and high-speed roadways.

4.2 What Is a Crash?

The word "crash" may be new to some people as a way to describe the event in which a bicyclist or pedestrian greets the ground, a motor vehicle, or any other solid object in a way that can result in bodily harm and/or property damage. Historically, these were called "accidents." The term "accident" implies heavy doses of chance, unknown causes, and the connotation that nothing can be done to prevent them.

Crashes are preventable. Bicyclist and pedestrian "crashes" are not random events. They fall into a pattern of reoccurring crash types and occur because the parties involved make mistakes. The mistakes can be identified and counteracted through a combination of education, skill development, engineering, and enforcement measures so crashes can be substantially reduced.

4.3 The Crash Avoidance Process

Whether you are a pedestrian, bicyclist, or motorist, you generally go through a similar sequence of actions leading from searching for and recognizing a potential crash situation to taking steps to avoid it.

The steps in this sequence are described below. If any of these steps are overlooked by either party, a crash may result.

Step 1: Search – Both driver and bicyclist or pedestrian scan their environment for potential hazards.

Step 2: Detect – One or both parties (bicyclist, pedestrian, or motor vehicle) sees the other.

Step 3: Evaluate – The threat of collision is recognized, along with the need for action to avoid it.

Step 4: Decide – Assess risk and select the actions necessary to avoid a collision. This may involve judging location, closing speed, direction of travel, position in traffic, likely behavior, and other factors.

Step 5: Action – This step involves the successful performance of the appropriate action(s) to avoid a collision.

4.4 Number of Bicycle and Pedestrian Crashes

Approximately 6,500 pedestrians and 900 bicyclists are killed each year as a result of collisions with motor vehicles. As a group, pedestrians and bicyclists comprise more than 14 percent of all highway fatalities each year. Pedestrians account for as much as 40 to 50 percent of traffic fatalities in some large urban areas. The 1994 General Estimates System (GES) data indicate that 90,000 pedestrians and 60,000 bicyclists were injured in this type of crash. Many more injuries are not reported to record-keeping authorities. A study by Stutts, et al. (1990) showed that fewer than two-thirds of bicycle-motor vehicle crashes serious enough to require emergency room treatment were reported on State motor vehicle crash files.

4.5 Summary of Bicycle and Pedestrian Crash Characteristics

In the 1996 study conducted by the Federal Highway Administration (*Pedestrian and Bicycle Crash Types of the Early 1990's*, FHWA-RD-95-163), 5,000 pedestrian and 3,000 bicycle crashes in 5 States were studied extensively in order to code crash types, determine the specific factors associated with the crash types, and to identify how countermeasures could be used to reduce the frequency of crashes. The following is a summary of the findings of the study.

Pedestrian-Motor Vehicle Crash Sample Summary

1. Compared to their representation in the overall U.S. population, young persons (under 25 years of age)

were overrepresented in pedestrian crashes with motor vehicles, while older adults (ages 25 to 44) and the elderly (age 65+) were underrepresented. Elderly pedestrians in crashes, however, were more than twice as likely to be killed (15 percent versus 6 percent) compared to young persons.

2. Collisions with motor vehicles led to serious and fatal injuries to pedestrians in more than 33 percent of the crashes.

Forty-one percent of pedestrian crashes occur at intersections.

3. Alcohol or drug use was noted in about 15 percent of pedestrian crashes overall, but increased to 31 percent for pedestrians in the 25 to 44 age group. Alcohol/drug crashes were also more frequent on weekends and during the hours of darkness.

4. Pedestrian crashes occurred most frequently during the late afternoon and early evening hours, times when exposure is probably highest and visibility may be a problem.

5. About two-thirds of the crashes were categorized as urban. Fifteen percent of the pedestrian crashes reported occurred on private property, primarily in commercial or other parking lots. The elderly were overrepresented in commercial parking lot crashes, young adults in non-commercial parking lot crashes, and children under age 10 in collisions occurring in driveways, alleys, or yards.

6. Nearly 60 percent of the road-related crashes occurred on two-lane roadways. Serious and fatal injuries to pedestrians were directly proportional to speed limit and number of lanes.

7. Forty-one percent of crashes occurred at roadway intersections, and an additional 8 percent occurred in driveways or alley intersections.

8. The pedestrian was judged to be solely at fault in 43 percent of the crashes. Running into the road, failure to yield, alcohol impairment, stepping out from between parked vehicles, and walking or running in the wrong direction (with traffic) were the most frequently cited pedestrian contributing factors. Younger pedestrians were more likely to be at fault.

9. Motor vehicle drivers were judged to be solely at fault in 35 percent of the crashes. Driver hit and run and failure to yield were the most frequently cited driver contributing factors, followed by improper backing, safe movement violations, and exceeding safe speed. Only 3 percent of motor vehicle drivers striking pedestrians were judged to have been impaired by alcohol.

10. More than three-fourths of pedestrian crashes fell into one of the following eight crash-type categories: vehicle turn/merge (9.8 percent), intersection dash (7.2 percent), other intersection (10.1 percent), midblock dart/dash (13.3 percent), other midblock (13.2 percent), not in roadway/waiting to cross (8.6 percent), walking along roadway (7.9 percent), and backing vehicle (6.9 percent). These and the other seven major crash-type categories discussed in this report varied with respect to the pedestrian, driver, locational/environmental, and roadway factors that characterized them. It is critically important

A memorial to a bicyclist killed at a busy intersection in Newark, DE.

for individual States and communities to develop a better understanding of the particular traffic situations endangering their residents.

Bicycle-Motor Vehicle Crash Sample Summary

1. The basic bicycle-motor vehicle crash patterns are similar to those seen in the late 1970's. Intersections, driveways, and other junctions continue to be locations where about three-fourths of the crashes occur. Emerging facilities should be designed with this fact in mind.

2. Compared with their representation in the overall U.S. population, young bicyclists under the age of 15 (and particularly ages 10 to 14) were overrepresented in crashes with motor vehicles, while older adults (ages 25 to 44) and the elderly (age 65+) were under- represented. However, bicyclists older than age 44 were overrepresented with regard to serious and fatal injury.

3. Collisions with motor vehicles led to serious and fatal injuries to bicyclists in just over 18 percent of the crashes.

4. Alcohol or drug use was noted in about 5 percent of bicycle crashes overall, but increased to 15 percent for bicyclists in the 25 to 44 age group. This may be an emerging problem. Alcohol-drug crashes were more frequent on weekends and during hours of darkness.

5. About two-thirds of the bicyclist crashes occurred during late afternoon and early evening hours. Exposure is likely quite high during these hours, and visibility can be a problem.

6. About two-thirds of the crashes were categorized as urban. About 7 percent occurred on private property. Bicyclists less than 10 years old were somewhat overrepresented in crashes in housing-related parking lots, driveways, alleys, and private roads.

7. About 60 percent of the road-related crashes occurred on two-lane roadways. Roads with narrower lanes and roads with higher speed limits were associated with more than their share of serious and fatal injuries to bicyclists.

8. Bicyclists were judged to be at fault in about half of these crashes with motor vehicles. Bicyclists need training about how to ride in traffic. Failure to yield, riding against traffic, stop sign violations, and safe movement violations were the most frequently cited bicyclist contributing factors. The likelihood of the bicyclist being responsible for the crash was greatest for the younger bicyclists. When the crash-involved bicyclist was older, the motor vehicle driver was more likely to be at fault.

9. Motor vehicle drivers were judged to be solely at fault in 28 percent of the cases. Failure to yield, hit and run, and failure to see the bicyclists were the most frequently cited driver contributing factors.

10. The bicycle-motor vehicle crashes were divided into the three main categories as such:

Parallel-path events	36 percent
Crossing-path events	57 percent
Specific circumstances	7 percent

11. The most frequent parallel-path crashes were motorist turn/merge into bicyclist's path (12.2 percent), motorist overtaking the bicyclist (8.6

percent), and bicyclist turn/merge into motorist's path (7.3 percent). The most frequent crossing-path crashes were motorist failed to yield to bicyclist (21.7 percent), bicyclist failed to yield at an intersection (16.8 percent), and bicyclist failed to yield midblock (11.8 percent). These six individual crash types accounted for almost 80 percent of all bicycle-motor vehicle crashes.

Project Summary and Recommendations

1. Much of what is reported in this study seems strongly connected to basic walking, riding, and driving patterns — in other words, related to exposure. Future studies of pedestrians and bicyclists and related facilities should be planned with this need in mind.

2. As a measure of accountability, it is recommended that local and State pedestrian-bicycle coordinators continually track crashes in their jurisdictions. A simplified crash typing procedure that coordinators can easily use should be prepared and disseminated.

3. With the current increased interest in both bicycling and walking, crash investigators on the State and local levels should be urged to report completely on any bicyclist and pedestrian crashes, particularly for roadway-related variables.

4. A systemwide approach will be necessary to make safety gains as well as reach the goals of the National Bicycling and Walking Study (Federal Highway Administration, 1994), namely: (1) to double the number of trips made by bicycling and walking, and (2) to reduce by 10 percent the number of bicyclists and pedestrians injured or killed in traffic collisions. Engineering, education, and enforcement approaches are vital to improved safety. There is a continuing need to establish the mindset that bicyclists and pedestrians are worthy and viable users of our transportation system.

4.6 Common Pedestrian and Bicycle Crash Types

This portion of the lesson presents information specific to pedestrian and bicycle crashes. It looks at the number, types, and characteristics of these crashes. The information was generated through a study conducted by the Highway Safety Research Center at the University of North Carolina (published by the Federal Highway Administration in June 1996). The study purpose was to update 1970's era crash data to reflect more recent crash types, with particular attention to roadway and locational factors so that designers can reduce crash frequency through engineering methods and other interventions. See the following pages for examples.

Pages 4-6 through 4-9: Eight most common pedestrian crash types.

Pages 4-10 through 4-13: Eight most common bicycle crash types.

4.7 Exercise: Design a Countermeasures Program

Part 1
Design a program that specifically provides countermeasures aimed at reducing one (or more) common bicycle and/or pedestrian crash types. Countermeasures can include physical changes to the bicycle/pedestrian environment (engineered and constructed solutions), or education programs aimed at a particular audience that may be susceptible to certain crash types. Be specific about what the program would include, and how it would be implemented throughout a community. Include an explanation of how you would propose to evaluate the effectiveness of your program.

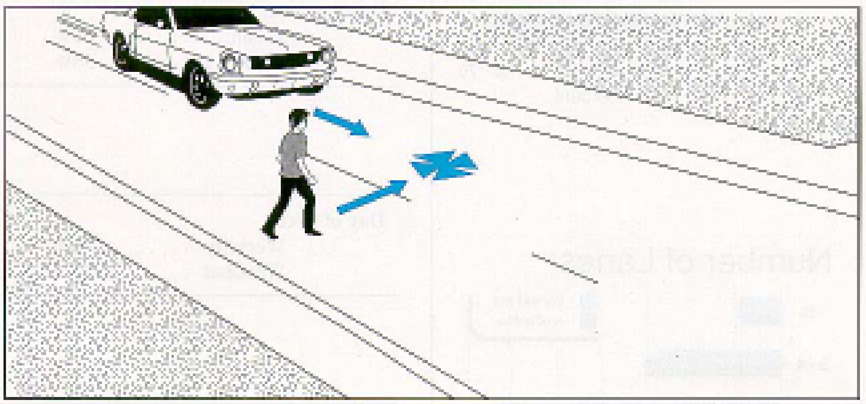
Part 2
Using the data provided for the case study location, Piedmont Park in Atlanta, Georgia, developed some conclusions regarding the crash data obtained through the State department of transportation (DOT) for 1995, 1996, and 1997 (see Figures 4.3 to 4.8). Cross-tabulations of crashes by time of day, location, and causation factors are helpful in gaining insight into safety problems and possible countermeasures. Data available for these type evaluations are often limited due to the low percentage of reported pedestrian accidents and bicycle crashes. However, important information can be obtained by a thorough analysis of available data.

Figure 4.1: Eight of the Most Common Pedestrian Crash Types. Source: *Pedestrian Crash Types - A 1990's Informational Guide*, 1997.

Midblock—Other

Frequency: 548 cases; 10.8% of all crashes
Severity: 49% resulted in serious or fatal injuries

Description: The crash occurred at midblock, but does not conform to any of the specified crash types.



Vehicle Turn/Merge

Frequency: 497 cases; 9.8% of all crashes
Severity: 18% resulted in serious or fatal injuries

Description: The pedestrian and vehicle collided while the vehicle was preparing to turn, in the process of turning, or had just completed a turn (or merge).

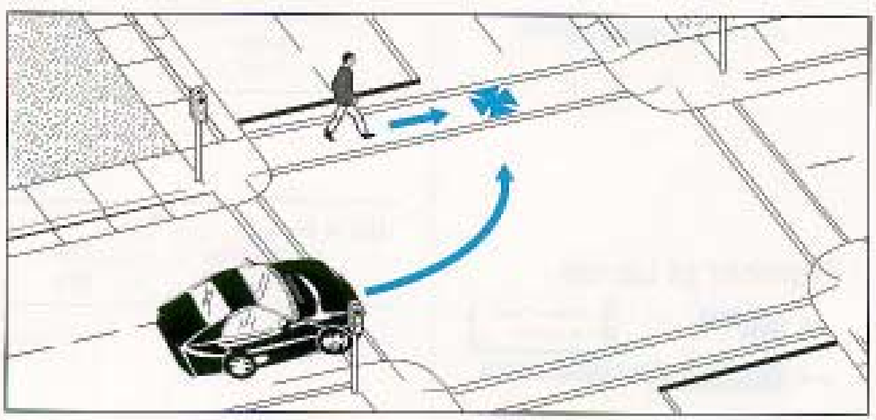
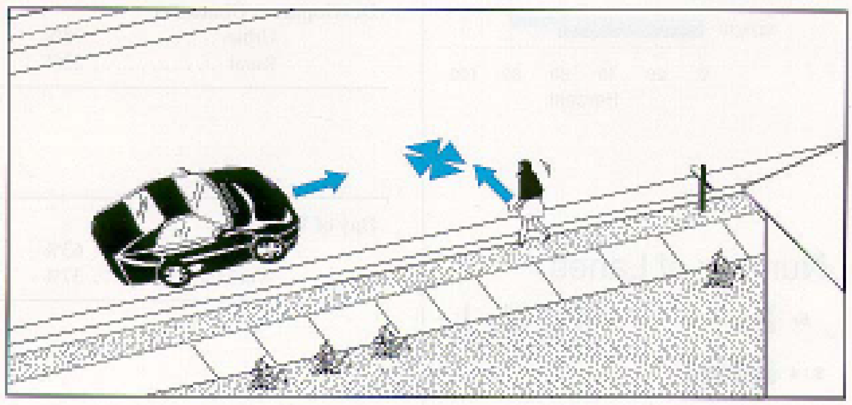


Figure 4.1: Eight of the Most Common Pedestrian Crash Types (continued).

Midblock Dash

Frequency: 442 cases; 8.7% of all crashes
Severity: 37% resulted in serious or fatal injuries

Description: At midblock location, the pedestrian was struck while running and the motorist's view of the pedestrian was not obstructed.



Not In Roadway

Frequency: 404 cases; 7.9% of all crashes
Severity: 28% resulted in serious or fatal injuries

Description: The pedestrian was struck when not in the roadway. Areas included parking lots, driveways, private roads, sidewalks, service stations, yards, etc.

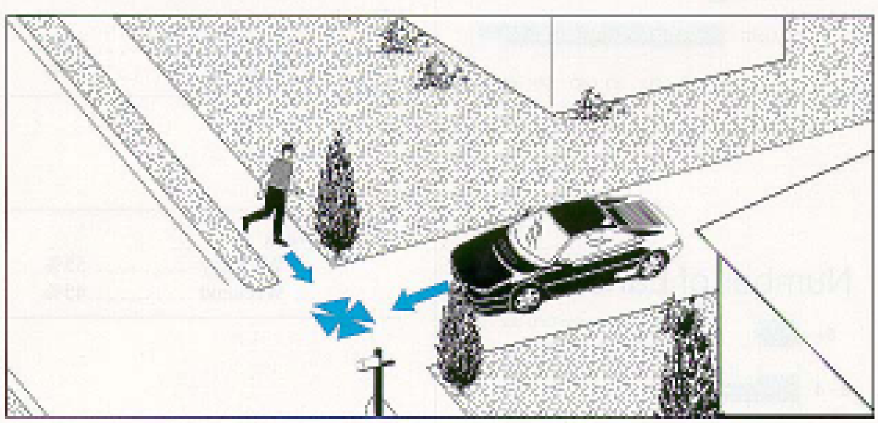
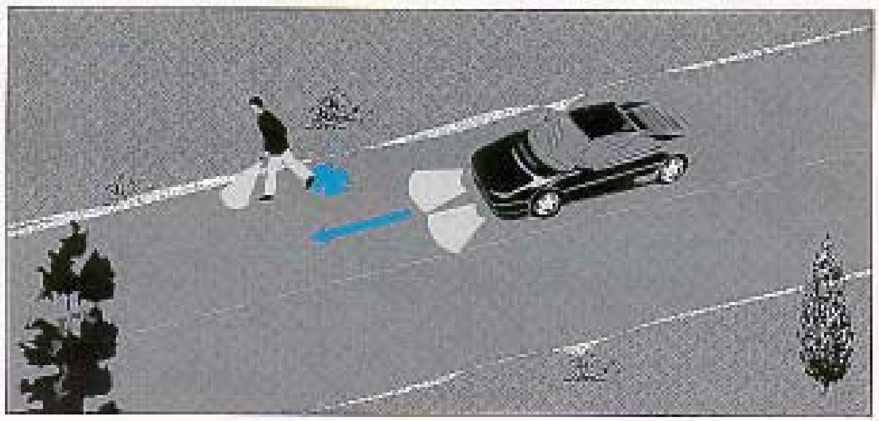


Figure 4.1: Eight of the Most Common Pedestrian Crash Types (continued).

Walking Along Road

Frequency: 375 cases; 7.4% of all crashes
Severity: 37% resulted in serious or fatal injuries

Description: The pedestrian was struck while walking (or running) along a road without sidewalks. The pedestrian may have been: hitchhiking (15 cases), walking with traffic and struck from behind (257 cases) or from the front (5 cases), walking against traffic and struck from behind (76 cases or from the front (7 cases), walking along a road, but the details are unknown (15 cases).



Intersection Dash

Frequency: 363 cases; 7.2% of all crashes
Severity: 34% resulted in serious or fatal injuries

Description: The pedestrian was struck while running through an intersection and/or the motorist's view of the pedestrian was blocked until an instant before impact.

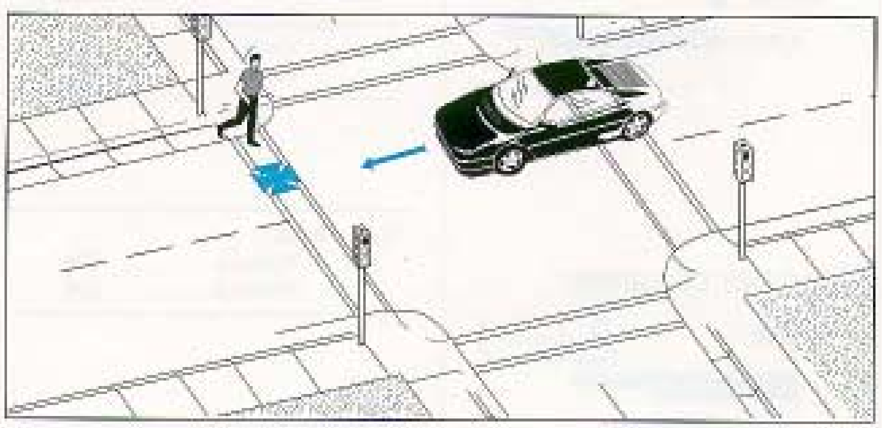
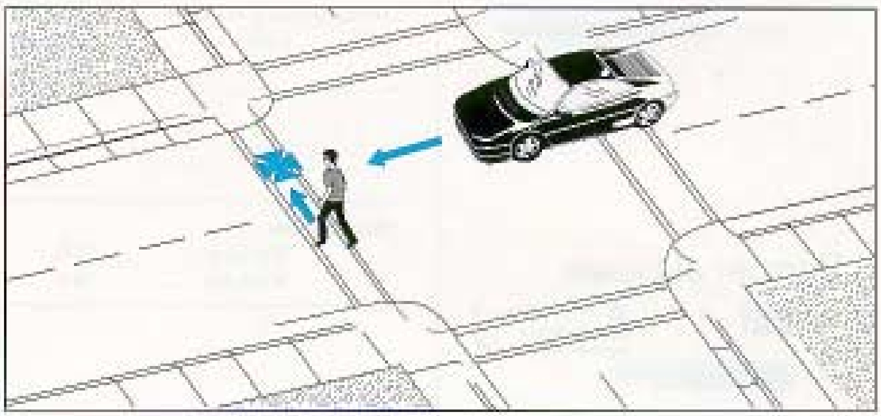


Figure 4.1: Eight of the Most Common Pedestrian Crash Types (continued).

Intersection—Other

Frequency: 364 cases; 7.2% of all crashes
Severity: 42% resulted in serious or fatal injuries

Description: The crash occurred at an intersection but does not conform to any of the specified crash types.



Backing Vehicle

Frequency: 351 cases; 6.9% of all crashes
Severity: 23% resulted in serious or fatal injuries

Description: The pedestrian was struck by a vehicle that was backing.

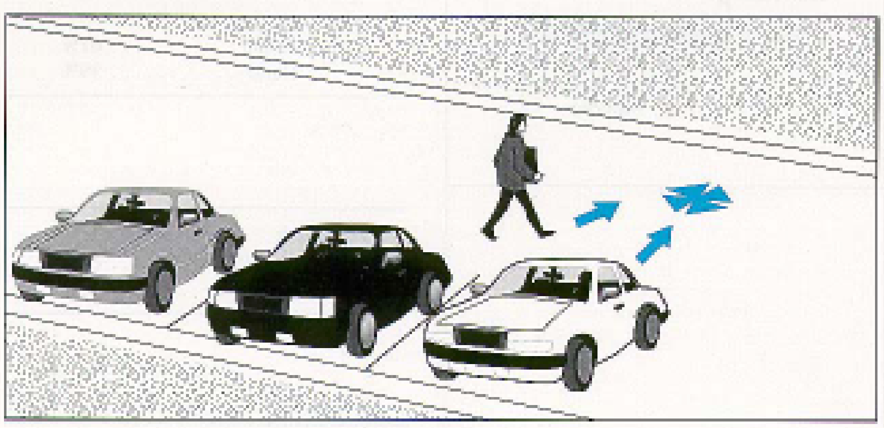
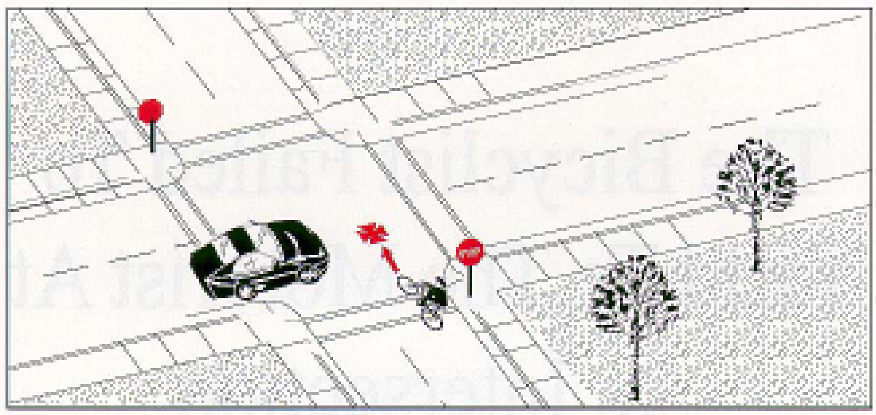


Figure 4.2: Eight of the Most Common Bicycle Crash Types. Source: *Bicycle Crash Types - A 1990's Informational Guide*, 1997.

Ride Out At Stop Sign

Frequency: 290 cases; 9.7% of all crashes
Severity: 23% resulted in serious or fatal injuries

Description: The crash occurred at an intersection at which the bicyclist was facing a stop sign or flashing red light.



Drive Out At Stop Sign

Frequency: 277 cases; 9.3% of all crashes
Severity: 10% resulted in serious or fatal injuries

Description: The crash occurred at an intersection which the motorist was facing a stop sign.

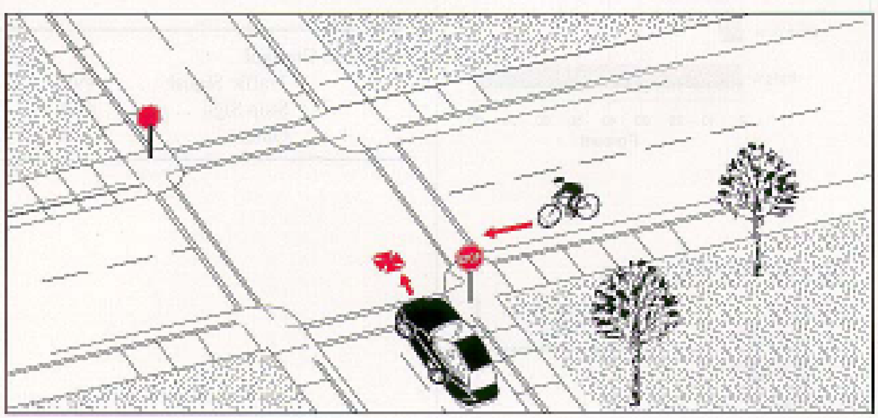
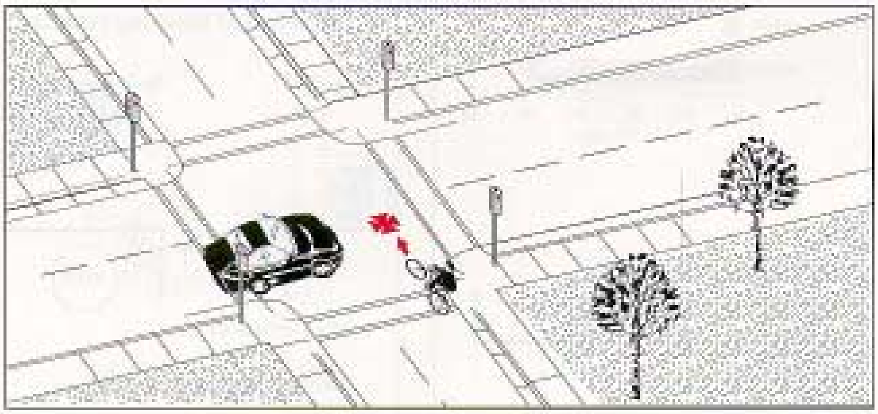


Figure 4.2: Eight of the Most Common Bicycle Crash Types (continued).

Ride Out At Intersection—Other

Frequency: 211 cases; 7.1% of all crashes
Severity: 16% resulted in serious or fatal injuries

Description: The crash occurred at an intersection, signalized or uncontrolled, at which the bicyclist failed to yield.



Drive Out At Midblock

Frequency: 207 cases; 6.9% of all crashes
Severity: 7% resulted in serious and fatal injuries

Description: The motorist was entering the roadway from a driveway or alley.

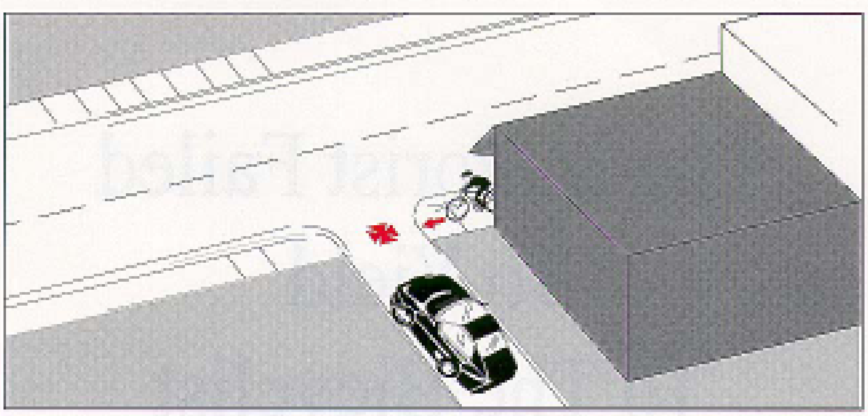
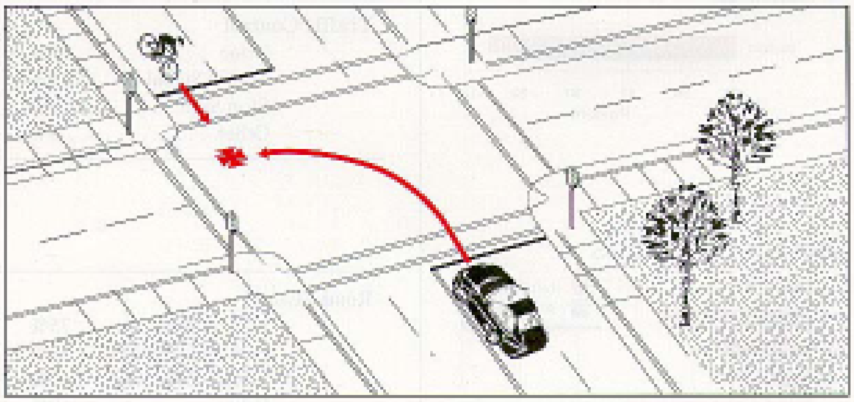


Figure 4.2: Eight of the Most Common Bicycle Crash Types (continued).

Motorist Left Turn—Facing Bicyclist

Frequency: 176 cases; 5.9% of all crashes
Severity: 24% resulted in serious or fatal injuries

Description: The motorist made a left turn while facing the approaching bicyclist.



Ride Out At Residential Driveway

Frequency: 153 cases; 5.1% of all crashes
Severity: 24% resulted in serious or fatal injuries

Description: The bicyclist entered the roadway from a residential driveway or alley.

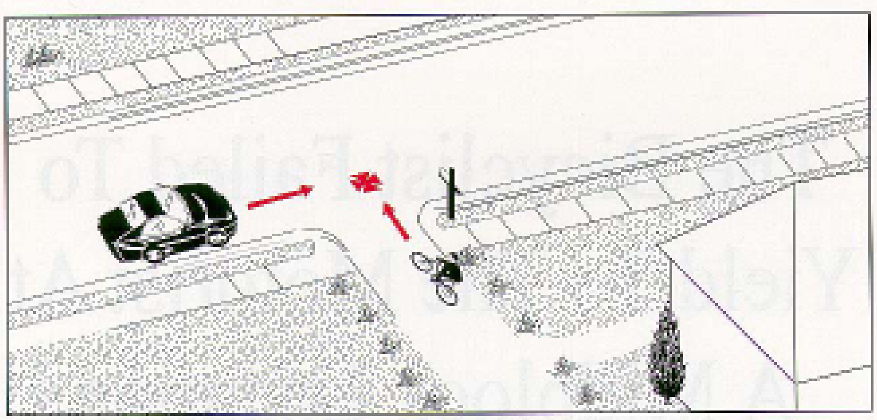
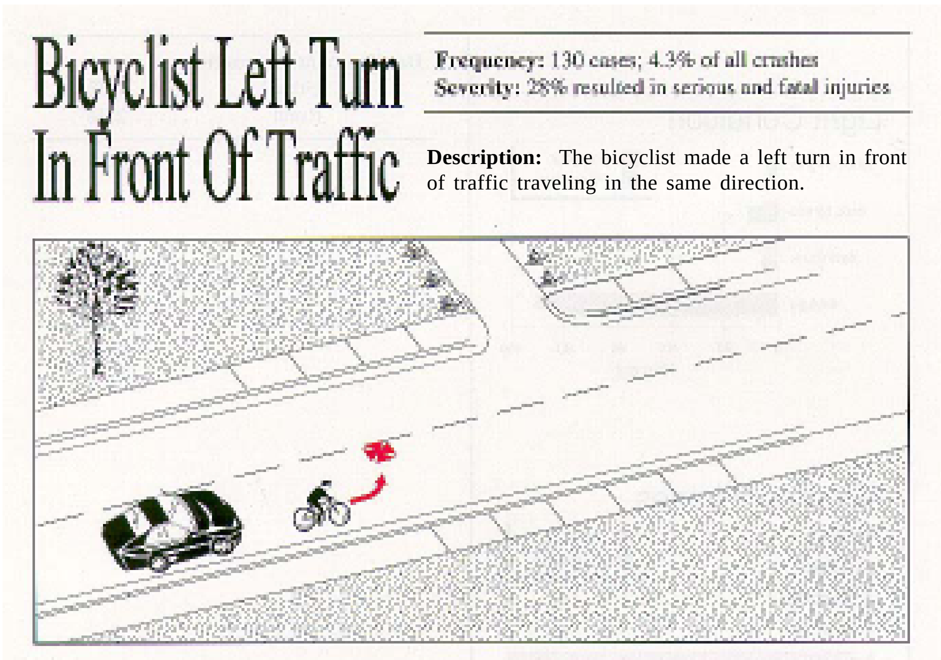
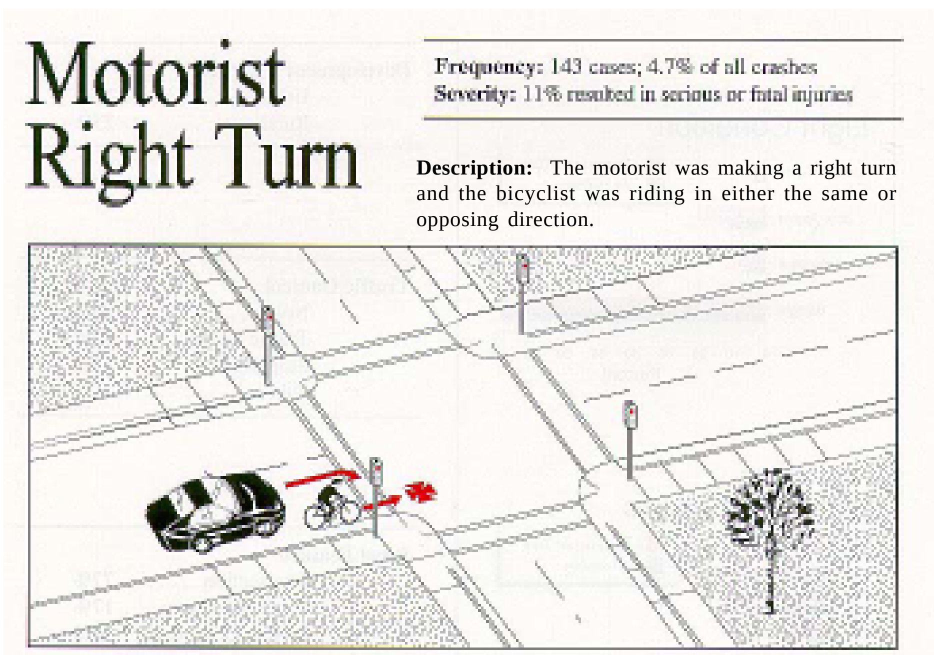


Figure 4.2: Eight of the Most Common Bicycle Crash Types (continued).





For the purpose of providing some general background on the case study location, the following descriptive information is provided:

- Piedmont Park is a large public park located approximately 3 miles north of the central business district in the midtown area of Atlanta.
- The park is surrounded on all sides by densely populated residential neighborhoods.
- Very little parking is available within the park and most park users arrive by foot, roller blades, skateboard, or bicycle.
- The park has extensive walking, running, and bicycling trails, and these are the primary uses of the park. In addition, there are numerous festivals and special events.
- Access to the park from surrounding neighborhoods is via surface streets, most of which have narrow (4-foot- to 5-foot-wide) sidewalks.
- The park is bound on all sides by heavily traveled arterial roadways that commonly experience significant peak-hour congestion.
- Two transit stations are located within walking distance near the park and frequent pedestrian access to and from the park is linked with the stations. Typical sidewalk and crosswalk treatments are used along surface streets (10th St. and 14th St.) to connect with the transit stations. Bicycles are allowed on transit fixed-rail vehicles during all operational periods.

Data provided for conducting a case study evaluation of pedestrian and bicycle conditions at Piedmont Park include the following information:

- Bicycle Crash Locations (Figure 4.3).
- Pedestrian Accident Locations (Figure 4.4).
- Site Location Map (Figure 4.5).
- Tabulation of Pedestrian Accident Data (Figure 4.6).
- Tabulation of Bicycle Crash Data (Figure 4.7).
- Usage Data Collected at Major Park Entrances (Figure 4.8).
- Summary of Major Roadways (Figure 4.9).

Part 3

Obtain pedestrian accident and bicycle crash data from your State DOT for a particular roadway or area of interest. You should obtain a minimum of 3 years of data in order to conduct your analysis of factors similar to those discussed in the Piedmont Park case study location. Although local city agencies sometimes maintain crash data, the State DOT is the most reliable source of available data. Most States maintain their crash data in a computerized database system and sorts of the data can be conducted on various field entries to list crashes associated with either pedestrians or bicycles. These types of crashes will only constitute a very small amount of the total crashes occurring along a roadway and it may be useful to receive a full listing of all the crashes associated with your location of interest. DOT's may only maintain data along the more significant roadways and often do not include subdivision/residential streets.

Most DOT personnel are very helpful and willing to work to get you the data you need. You should clearly explain your intentions, location of interest, and type of data that you would like to obtain. Submitting a request in writing is typically required so that your data request can be efficiently processed through their system. In addition to the crash data, you may need other information that will allow you to decode the crash data and to physically link the crash to a location on the roadway network. An accident/crash investigation manual is usually available that lists all of the coded entries used in creating aggregated crash tabulations. Also, a roadway features log is typically available to link milepost listings to physical map features such as intersections, bridges, and street names. In the initial phases of conducting an analysis of crashes, it is seldom necessary to access the actual crash reports. It is much more useful to utilize aggregated crash records that are available through the crash data system. Allow ample time for DOT personnel to accommodate your request within their day-to-day workload. Generally, data can be received in 2 to 3 weeks after submitting a request.

4.8 References

Text and graphics for this section were derived from the following sources:

Drake and Burden, *Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*, NHI Course #38061, FHWA-HI-96-028, 1996.

Federal Highway Administration, *Bicycle Crash Types: A 1990's Informational Guide,* FHWA-RD-96-163, 1997.

Federal Highway Administration, *Pedestrian and Bicycle Crash Types of the Early 1990's*, Technical Summary, FHWA-RD-95-163, 1996.

Federal Highway Administration, *Pedestrian Crash Types: A 1990's Informational Guide,* FHWA-RD-96-163, 1997.

Figure 4.3

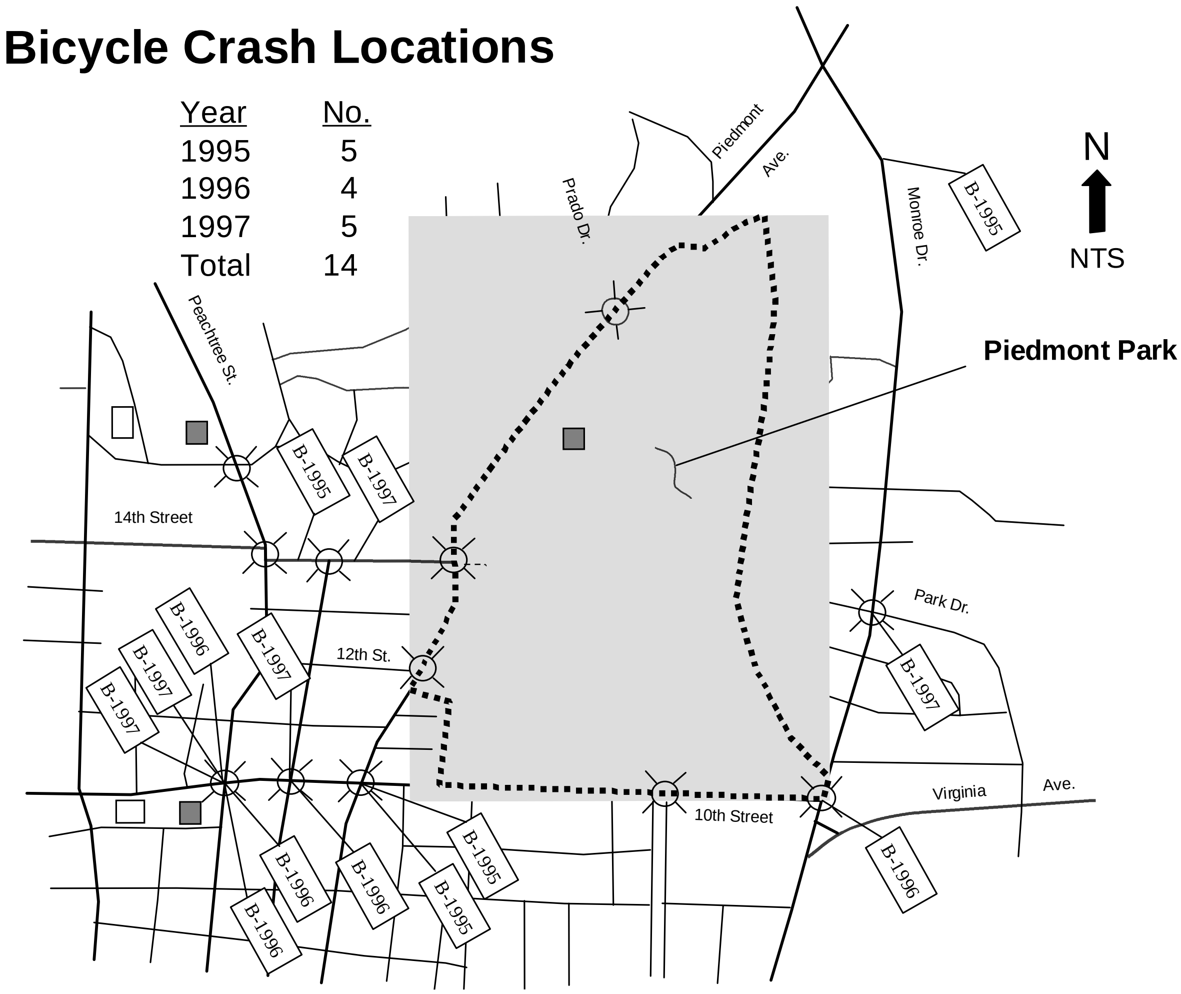

Bicycle Crash Locations
Year No.
1995 5
1996 4
1997 5
Total 14
N
NTS
Piedmont Park
Piedmont
Ave.
Prado Dr.
Monroe Dr.
Peachtree St.
14th Street
12th St.
10th Street
Park Dr.
Virginia
Ave.
B-1995
B-1995
B-1997
B-1996
B-1997
B-1997
B-1997
B-1997
B-1996
B-1996
B-1996
B-1995
B-1995
B-1996

Figure 4.4

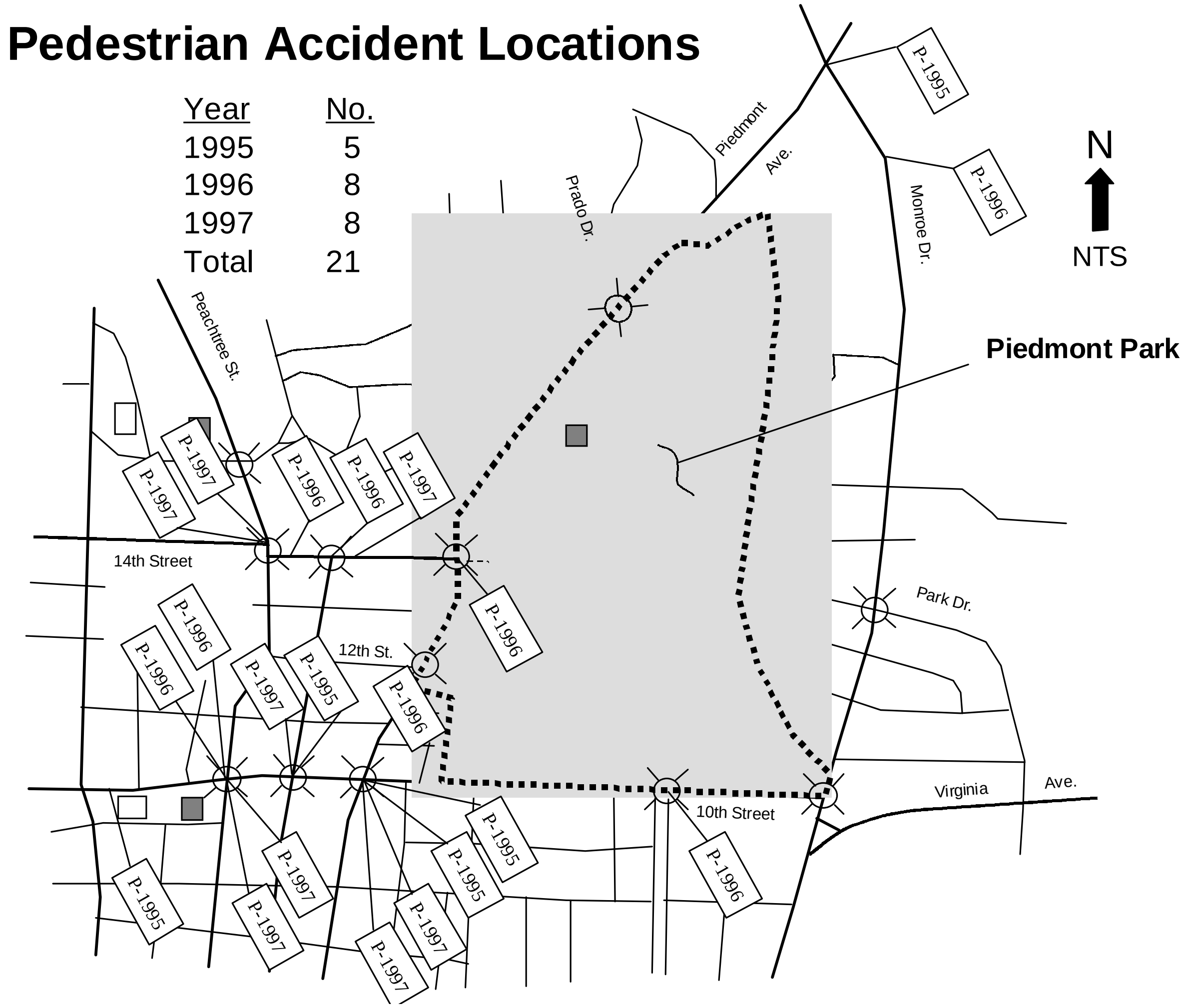

Pedestrian Accident Locations
Year No.
1995 5
1996 8
1997 8
Total 21
Piedmont Ave.
Prado Dr.
Monroe Dr.
N
NTS
Piedmont Park
Peachtree St.
14th Street
12th St.
Park Dr.
Virginia Ave.
10th Street
P-1995
P-1996
P-1997

Figure 4.5

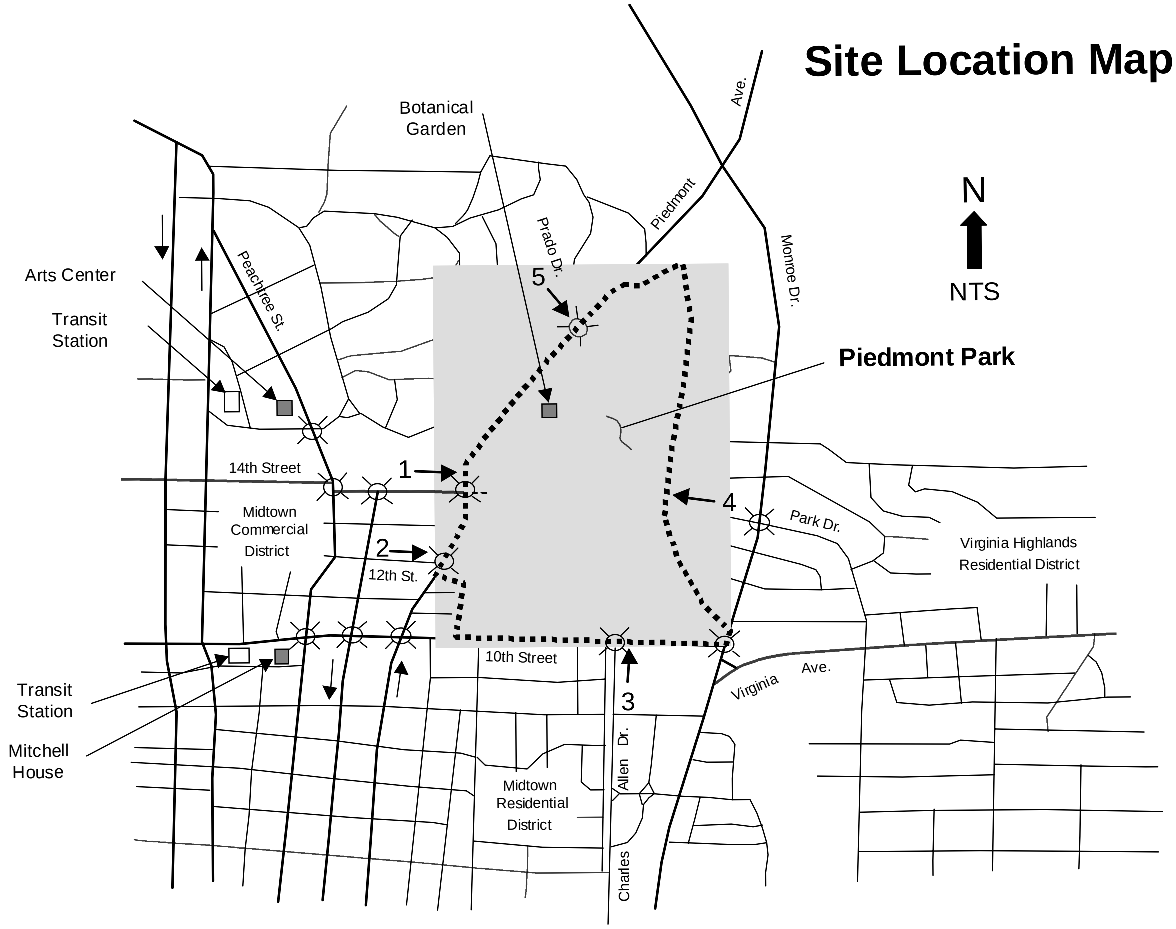

Site Location Map
N
NTS
Botanical
Garden
Arts Center
Transit
Station
Peachtree St.
Prado Dr.
Piedmont
Ave.
Monroe Dr.
Piedmont Park
14th Street
Midtown
Commercial
District
12th St.
10th Street
Park Dr.
Virginia Highlands
Residential District
Virginia
Ave.
Transit
Station
Mitchell
House
Midtown
Residential
District
Allen Dr.
Charles
1
2
3
4
5

Figure 4.6:

Piedmont Park Vicinity – Atlanta, Georgia
Tabulation of Pedestrian Accident Data

No.	Route Roadway	Mile Post	Time	Month	Day	Year	Severity	Location	Type	Light Condition	Surface Condition
1	10th Street	1.78	23:29	06	13	1997	Injury	Intersection	Pedestrian	Dark-Lighted	Dry
2	10th Street	1.78	13:54	08	25	1997	Injury	Intersection	Pedestrian	Daylight	Dry
3	10th Street	1.87	23:01	06	19	1997	Injury (2)	Intersection	Pedestrian	Dark-Lighted	Dry
4	10th Street	1.99	19:19	02	06	1997	Injury	Intersection	Pedestrian	Dark-Lighted	Dry
5	10th Street	1.99	17:26	07	08	1997	Injury	Intersection	Pedestrian	Daylight	Dry
6	14th Street	0.06	15:00	04	04	1997	Injury	Intersection	Pedestrian	Daylight	Dry
7	14th Street	0.06	18:00	03	03	1997	Injury	Intersection	Pedestrian	Daylight	Dry
8	14th Street	0.00	9:30	06	10	1997	Injury	Intersection	Pedestrian	Daylight	Dry
9	Monroe Drive	5.71	16:12	09	21	1996	Injury	Roadway Segment	Pedestrian	Daylight	Wet
10	10th Street	2.43	15:45	09	07	1996	Injury	Intersection	Pedestrian	Daylight	Dry
11	10th Street	1.78	19:50	07	04	1996	Injury	Intersection	Pedestrian	Daylight	Dry
12	10th Street	1.78	22:05	07	13	1996	Injury	Intersection	Pedestrian	Dark-Lighted	Dry
13	10th Street	2.01	21:30	06	29	1996	Injury	Roadway Segment	Pedestrian	Dark-Lighted	Dry
14	14th Street	0.00	17:10	08	05	1996	Injury	Intersection	Pedestrian	Daylight	Dry
15	14th Street	0.06	13:00	03	13	1996	Injury	Intersection	Pedestrian	Daylight	Dry
16	Piedmont Avenue	1.01	22:20	04	25	1996	Injury	Intersection	Pedestrian	Dark-Lighted	Dry
17	Monroe Drive	5.97	23:06	02	10	1995	Injury	Intersection	Pedestrian	Dark-Lighted	Wet
18	10th Street	1.64	18:20	01	11	1995	Injury	Roadway Segment	Pedestrian	Dusk	Dry
19	10th Street	1.87	17:25	02	08	1995	Injury	Intersection	Pedestrian	Daylight	Dry
20	10th Street	1.99	21:00	10	17	1995	Injury	Intersection	Pedestrian	Dark-Lighted	Dry
21	10th Street	1.99	02:23	01	21	1995	Injury (2)	Intersection	Pedestrian	Dark-Lighted	Dry

Crash data provided by Georgia Department of Transportation.

Figure 4.7

Piedmont Park Vicinity – Atlanta, Georgia
Tabulation of Bicycle Crash Data

No.	Route Roadway	Mile Post	Time	Month	Day	Year	Severity	Location	Type	Light Condition	Surface Condition
1	Monroe Drive	5.14	19:00	09	17	1997	Injury	Intersection	Angle Intersecting	Daylight	Dry
2	10th Street	1.78	12:20	03	14	1997	Injury	Intersection	Angle Intersecting	Daylight	Dry
3	10th Street	1.78	17:32	08	29	1997	Injury	Intersection	Angle Intersecting	Daylight	Dry
4	10th Street	1.87	17:43	03	11	1997	Injury	Intersection	Head On	Daylight	Dry
5	14th Street	0.00	18:10	12	17	1997	Injury	Intersection	Angle Intersecting	Dark-Lighted	Dry
6	Monroe Drive	4.85	01:15	05	05	1996	Injury	Intersection	Rear End	Dark-Lighted	Dry
7	10th Street	1.78	15:33	12	18	1996	PDO	Intersection	Sideswipe Same Dir	Daylight	Dry
8	10th Street	1.78	18:30	12	27	1996	PDO	Intersection	Angle Intersecting	Dark-Lighted	Dry
9	10th Street	1.87	21:45	02	09	1996	PDO	Intersection	Angle Intersecting	Dark-Lighted	Dry
10	Monroe Drive	5.81	17:15	09	02	1995	PDO	Roadway Segment	Angle Intersecting	Daylight	Dry
11	10th Street	1.78	12:22	02	23	1995	Injury	Intersection	Angle Intersecting	Daylight	Dry
12	10th Street	1.99	16:40	09	29	1995	Injury	Intersection	Angle Intersecting	Daylight	Dry
13	10th Street	1.99	17:50	08	03	1995	Injury	Intersection	Angle Intersecting	Daylight	Dry
14	14th Street	0.00	17:45	09	11	1995	Injury	Intersection	Rear End	Daylight	Dry

PDO = Property Damage Only
Crash data provided by Georgia Department of Transportation.

Figure 4.8

Piedmont Park Vicinity – Atlanta, Georgia
Human Powered Transportation (HPT) Modes
HPT Usage Data Collected at Major Park Entrances

			Total for all intersection movements (1)			
No.	**Entrance Location**	**Time of Day**	**Bicyclists**	**Rollerbladers (2)**	**Pedestrians (3)**	**Total HPT Activity**
1 (4)	Piedmont Ave. at 14th St.	4:25 4:40 pm	3	2	22	27
1 (4)	Piedmont Ave. at 14th St.	5:00 5:15 pm	2	3	29	34
2	Piedmont Ave. at 12th St.	4:40 4:55 pm	6	4	12	22
3	10th St. at Charles Allen Dr.	5:20 5:35 pm	3	6	42	51
4	Park Ave. at Elmwood Dr.	5:40 5:55 pm	7	5	18	33

Notes:

1. Conditions were sunny and clear, temperature approximately 90 degrees F. Count duration was for a total of 15 minutes for each spot count location.
2. Count tabulations include occasional skateboarders.
3. Count tabulations include joggers and people with baby strollers.
4. Piedmont Ave. at 14th St. was counted twice, to evaluate peaking characteristics.

Figure 4.9

Piedmont Park Vicinity – Atlanta, Georgia
Summary of Major Roadways

No.	Roadway	Mileposts	No. of Lanes	Speed Limit	1997 ADT	Total Length (miles)
1	Piedmont Avenue					1.28
	Section 1	0.65 to 1.01	3 (one way)	35 mph	11,700	
	Section 2	1.01 to 1.93	4	35 mph	26,400	
2	10th Street	1.56 to 2.68	4	35 mph	20,420	1.12
3	14th Street					0.29
	Section 1	0.00 to 0.23	4	35 mph	22,400	
	Section 2	0.00 to 0.06	4	35 mph	17,500	
4	Monroe Drive	4.85 to 5.97	4	35 mph	20,500	1.12

L E S S O N 5

Adapting Suburban Communities for Bicycle and Pedestrian Travel

5.1 Purpose

That suburban activities require the use of a car and generate large amounts of traffic is well known. The overwhelming majority of suburban areas in the United States are oriented only to automobile travel. Most suburbs do not accommodate bicyclists and pedestrians, and they rarely provide good access to transit (with a few exceptions). With all this in mind, however, it is necessary to expand walking and bicycling travel opportunities in the suburbs without eliminating the car. Suburbs were organized around automobile travel and, in many instances, won't function well without it.

This session explores methods of redesigning suburban communities to better accommodate non-motorized transportation. It discusses how the suburbs developed, the hierarchy of the street system, and appropriate modifications that can accommodate and encourage bicycling and walking. This session is mostly oriented toward suburban planning considerations – with reference to other sections that focus on design issues such as traffic calming and walkway/bikeway design.

5.2 Introduction

Before the automobile became a part of most American households, many people who now live in suburbs were city dwellers who relied on walking for their transportation close to home and on streetcars, trolleys, or trains for longer trips. The streetcar and railroad lines generally ran from cities to outlying neighborhoods where houses and businesses clustered near major stops. People usually walked from their homes to public transportation, much as they walked from home to the business district to do their shopping.

Once more and more people were able to afford their own cars, dependence on streetcars, trolleys, and trains diminished as did the need to live near them. Since land farther away from the city was less expensive, people from city neighborhoods began to

see the fulfillment of their dream of owning a detached home with land around it. When developers of these homes learned that people would be willing to drive a little farther to buy even less expensive land, leap-frogging began. Leap-frogging is the practice of developing less expensive land farther from the city while leaving vacant more expensive land closer to the city. Developers of schools, businesses, and parks also sought the least expensive land. Thus, the result was scattered facilities and communities with no central focus. Because suburban building became so scattered, streetcar and rail transit were inappropriate, ending usually at the city's edge, and the car became the main means of transportation for suburban residents.

Inadequate maintenance of sidewalks makes a short walk difficult to maneuver.

That suburban activities require the use of a car and generate a large amount of traffic is well known. In suburban commercial areas, heavy traffic starts early in the morning and lasts for the entire day until the end of evening rush hour. Traffic is heavy because of the many trips from store to store made by shoppers who find driving between stores easier than walking or bicycling, even though distances may be short enough for these activities. Because of the active, internally generated traffic, walking and bicycling are not safe, or pleasurable, or convenient. Consequently, before viable pedestrian improvements can be made, all-day peak traffic must be corrected.

Major pedestrian improvements will come as land-use changes reduce the distances between daily activities. These land-use changes include increasing density and mixing land use, two actions residents of suburbs often believe are inappropriate for suburban lifestyles. That point may soon be moot, as increased density and mixed uses in suburbs are on the upswing. Now, apartments and commercial developments are being built along arterials and on land by-passed by leap-frogging. The pattern of development in many suburbs is infilling. This present pattern is now providing more opportunities for infill development to be designed to accommodate pedestrians and bicyclists as well as to take advantage of bus transportation. While converting to accommodate pedestrians and bicyclists is more difficult than downtown, low-density development does allow improvements not possible in built-up neighborhoods.

Lack of sidewalks and parked cars along the road's edge create unsafe conditions for bicyclists and pedestrians.

Three typical pedestrian problems — safety, function, and pleasure — need to be addressed. Safety problems are real or perceived conflicts as people cross streets or walk where there are no sidewalks. Since suburban drivers cover longer distances and drive faster, the dangers are magnified. The absence of pedestrians on suburban streets dulls drivers' awareness and further aggravates the problem of safety.

Functional pedestrian problems are found wherever there is little or no walking space, lack of sidewalks, parked cars along the road's edge, wide driveways, few benches, and barriers. Beyond this, another functional problem is the lack of destinations within a reasonable walking distance. Problems that create unpleasant environments for pedestrians and bicyclist are: walking next to noisy, fast moving cars; poor vistas; few rest stops; streetscapes with little interest to someone who is not driving; vacant lots or large parking lots that are visually dull and potentially unsafe.

Sidewalks with a landscape strip should be installed to minimize exposure to vehicular traffic.

Abandoning the Street

The long driving distances necessary to serve low-density areas increase the speed and volume of suburban traffic, making streets busy and uncomfortable places. To counter this, an "inside-out" development pattern–the opposite of the prevalent urban development patterns–has evolved. While most urban communities focus on and utilize the street suburban communities turn their backs to the street, and focus human activities on internal gardens, courtyards, and open spaces. Typically, car parking separates front doors from the sidewalk, and makes using the car seem most natural. Unfortunately, the interior spaces are seldom interconnected, so walking or bicycling for long distances in them is not possible.

The shift was from the urban grid pattern to a suburban road "hierarchy." The grid typical for many cities allows free choice of routes, but doesn't necessarily distinguish between high or low volumes of traffic or between streets that are or aren't good to raise families on. The hierarchy changed that, with its system of roads from arterials carrying high traffic volumes to cul-de-sacs with virtually no vehicular traffic. The secret lies in not interconnecting streets, which positively directed through traffic to arterials. Cul-de-sacs soon became the favored street to live on.

Grid patterns developed when travel by foot was important. As the grid was infinitely divisible, it created a fine-grain network that benefited foot traffic. The hierarchy developed to accommodate the automobile, recognizing that cars can easily travel extra distances, and that as traffic disperses, certain roads should carry more or less traffic than others. Pedestrians, unfortunately, cannot easily travel longer distances, and are the losers.

The hierarchy, in its conceptual form, includes a separate pedestrian system "internal" to the road system that purportedly ensures pedestrian access to different parts of the community. Unfortunately, the internal system was not provided in most cases, and when it was, it didn't lead to the places people wanted to reach because they were located on the roads. Internal circulation spaces were often unsafe because there was so little foot traffic and the varied ownership made access dependent on private property rights. A strategy of: (1) linking internal spaces where possible and (2) making the street usable for pedestrians and bicyclists will enhance suburban living for many people.

5.3 Users

To begin, the planner should determine where people want or need to travel; the routes they might travel; and who these people (the users of improved facilities) are. The most likely users of improved sidewalks and bicycle routes are:

- Children who must be driven to school, play, and other activities. Their lives would be improved with safe walks and bikeways leading to schools, and across busy arterials, to shops and recreational facilities.

Utilities and the lack of curb cuts makes this intersection very unsafe, limits the mobility of pedestrians, and does not allow for handicapped access.

- Parents who have to drive children would appreciate safe sidewalks and bikeways so their children can move around the community by themselves. Parents too could benefit from walking and bicycling along improved routes. A fully developed bicycle system might eliminate the need for families to own the second or third car.

- Older people, who may not drive, but have time to walk or bicycle, may be able to carry out some of their daily chores, enjoy the out-of-doors, and exercise all on the same trip. Even though an older suburban population is emerging, this age group has all but been ignored in planning. Improved bicycle and walking facilities coupled with smaller, affordable houses may help older residents continue to live in their communities.

- Commuters who live within 4 to 5 miles of work may be able to bicycle the distance, saving money while benefiting from physical exercise. Those living further may be able to walk or bike to bus or carpool stops.

- Recreationists, particularly those who regularly walk, jog, or bicycle, would benefit from improved routes and separation from fast-moving traffic.

5.4 A Strategy

Eventually, entire suburban communities should be accessible, safe, and comfortable for all pedestrians and bicyclists. While that will take time and will require changes in land use, it is possible to prioritize improvements to be made in the foreseeable future. These improvements might include the following:

- Facilities that serve the largest group of existing pedestrians.
- Facilities that correct the most dangerous, frequently used places.
- Facilities at the busiest locations.
- Facilities designed to attract new users.
- Bicycle facilities.

5.5 Present Suburban Land Uses

Suburban land uses affecting pedestrians can be divided into three categories. First, there are individual tract subdivisions, planned as units, with a sense of order derived from the in-road systems. Access is limited to one or two points. Most are single-family residential, though some warehousing, shopping, and medical developments exhibit the same characteristics. The distinguishing characteristics are that each subdivision is a recognizable unit, planned as a whole, and can be re-planned to better serve the pedestrian.

The second type of land use is the linear arterial, which unites the community through cars. While the roadway portion of arterials most likely was engineered, land-use planning was never done for the apartments, warehouses, offices, and businesses that line arterials. However, arterials with these activities form the backbone of most suburban communities, serving both long-distance driving and local business transactions. Arterial strips often convey a sense of the community's image or identity. While this image is presently seldom distinguishing or pleasant, it could be improved with pedestrian-/ bicycle-related amenities.

Arterials are obvious locations for bicycle and pedestrian improvements since these roads pass most community facilities and are the only direct and relatively long through roads in the suburban community. However, most arterials have pedestrian safety and environmental problems that must be overcome. If these problems are too great, it may be possible to improve a route parallel to the arterial, but one block removed.

The landscape island acts as a barrier for pedestrian access.

The third general type of suburban land use is by-passed land, forgotten during initial development as entrepreneurs leap-frogged out to find cheaper land. These lands infill more slowly and more haphazardly than planned subdivisions, and are likely to have many owners and a variety of land uses, though perhaps not as many as along arterials. By-passed lands may be the easiest to adapt to pedestrians and bicycle-related improvements, as they have the highest densities, have mixed land uses, and are close to a variety of services.

5.6 Safety Problems

The most dangerous places for pedestrians are along suburban roads without sidewalks and intersection treatment. These roads are usually arterials located near schools, bus stops, businesses, or parks. Intersections of residential streets and arterials that have no sidewalks or signals also contribute to risk. Moreover, bus stops have often been located where there are no sidewalks, contributing further to pedestrian hazards.

Develop safe route maps to improve school access safety. As noted, the majority of pedestrian accidents occur to young people, many of them traveling to and from school.

To reduce accidents, develop a school trip map, combining the expertise and resources of the police, engineering and school departments, and local parents.

The safe route maps should be developed by walking each access street to identify the safest walking routes and dangerous intersections. The program should develop and distribute handout maps, correct dangerous situations, and continue an ongoing evaluation of the selected routes.

5.7 Planning With the Car in Mind

It is necessary to extend walking and bicycling potential in the suburbs *without* eliminating the car. Suburbs were organized around automobile travel and, in many instances, won't function well without it. Yet, the car needn't always be dominant and uncontrolled.

Increased car usage has constrained its own flexibility because roads have become more crowded and fuel costs have risen. Extending pedestrian and bicycle access within a community may eliminate some need for the car, allowing increased flexibility

This developer never considered the benefits of pedestrian access.

for those who have to drive. Walkways should be planned for physical and psychological safety from the auto, yet allow direct and easy access to all types of activities. Most walkways should be planned *in conjunction with roads,* so pedestrians can reach all developments that are located along the road.

Main building entrances should be oriented on the façade facing a transit street.

5.8 Planning for Pedestrian and Bicycle Routes

Because there are so many safety problems related to pedestrians in the suburbs, improvements to make bicycling safe may, on balance, prove to be a better *initial* investment than improvements for pedestrians. Bicycles can travel 5 to 6 miles with relative ease, serving kids going to school, commuter trips, and many shopping activities. Initial bicycle improvements are inexpensive if striping, shoulder widening, and curb cuts are done. Striping and lane alteration could provide space for bicyclists on existing roads, giving them the same access as motorists, and might cost only 5,000 to 10,000 dollars per mile.

Conceptual planning is relatively simple. It consists of determining the general direction that walkways should take. These satisfy conditions discussed earlier, focusing on shops, schools, cultural attractions, and work and play places. Designing the exact route is the complex part. While many people might articulate the desirability of pedestrian routes, few will agree to have their street changed, to reduce parking, or to pay for a widened pedestrian area. Design, then, should be based first on routes that exist, before establishing new ones. Privacy, views, access, and local character must be understood and incorporated in the design.

Suburban areas typically consist of many small residential developments, each abutting a major road. These major roads lead to services such as shopping, schools, and parks. Pedestrian and bicycle safety problems usually do not exist inside individual suburban developments (unless they are large), but they increase on the major roads. The first consideration is: Should these major arterial streets be organized and developed for non-otorized traffic or do they have insurmountable auto-related problems that suggest finding an alternative route?

Origin/Destination information is necessary in the suburbs not so much because of the crush of users, but to see where users come from and where they go. Simple pedestrian and bicycle volume counts seldom yield enough information about where people are going or come from, the reason for the trip, and any special pedestrian and bicycle needs that should be met. This kind of data may be best obtained through observation of an origin/destination survey that should include the following information:

1. The location of major pedestrian and bicycle generators, such as parking facilities, transit stations, and major residential developments (i.e., where people are coming from).

Without sidewalks pedestrians are left to wander in the middle of the street.

2. The location of main pedestrian and bicycle attractions such as shopping centers, office and public buildings, schools, theaters, colleges, hospitals, and sports stadiums (i.e., where people are going).

3. Existing and potential pedestrian and bicycle routes between major destinations.

4. Time periods in which major pedestrian and bicycle flow occurs.

Landscaping can be used to channel and organize the traffic flow in parking lots, as well as provide pedestrian refuge areas.

Some new questions to consider:

- Do existing pedestrian and bicycle routes satisfy the heaviest travel demand? Can a need for new routes be clearly identified?

- Do existing routes require improvement to resolve circulation problems?

- Which areas seem to be preferred locations for development of new activities to generate pedestrian and bicycle movement. Note: Each activity stimulates more pedestrian movement.

- If new commercial developments are proposed, where will pedestrians and bicyclist travel from to reach them? Will this require adjustments to the existing network?

Sidewalks

Since destination points were scattered and sidewalks were expensive to construct, early suburban communities had no sidewalks. Later, some communities required developers to install sidewalks. In most suburbs, there is a patchwork of sidewalks that stop and start, but often aren't linked. In some developments where sidewalks were required, developers constructed them adjacent to the curb, which virtually enlarges the roadway, and places pedestrians next to traffic or parked cars. However, separation from the street, by planting strips with trees, lawn, or shrubs protects pedestrians from cars, reduces the apparent road width, and is essential in new construction. While landscape development increases the short-term cost, it makes walking safer and more pleasant for years to come.

Sidewalk width should vary to adjust to physical conditions and pedestrian volume. Sidewalks near schools and stores need more width to accommodate more people. Anyplace where there is a view, the sidewalk should be widened and a bench and landscaping added. Should a tree be in the way of the walk, it could be made to curve around the tree. In places, a walk may be as narrow as 3 feet, although that serves only one person. Four feet of width barely allows two people to pass, while 5 feet is more comfortable and is considered a standard sidewalk width by many communities. Moreover, a sidewalk along one side is sufficient for most low-density communities. (Reference Lesson 13 for more information on sidewalk design and Lesson 11 for information on traffic calming.)

Suburban Connections to Transit

The location of commuter bus stops, particularly "flyer" park-and-ride stops, should be marked, as well as any difficult pedestrian/bicycle access problems, such as busy streets to cross or walk along. Opportunities such as short cuts that make access easier should be noted as well. The planner should try to envision how pedestrian/bicycle routes could connect bus stops to residential developments in the community. Since the success of suburban transit depends partly on the adequacy of sidewalks and the ease with which people can walk to bus stops, it is

Medians and crosswalks should be placed at destination locations such as this shopping center.

essential that safe sidewalks, separated from traffic, lead to each bus stop from nearby developments.

Summary of Sidewalk Requirements
Walkways that are to be sufficiently safe, convenient, secure, and cause the least nuisance to residents must:

1. Traverse the shortest routes possible between homes and community facilities.
2. Be segregated from arterial roads and busy residential streets by a wide planter or parking lane.
3. Have gradients below 8 percent, and ideally, below 5 percent (particularly where elderly and disabled people live and walk).
4. Be busy, well-lit, and overlooked by dwellings and passing traffic.
5. Have curbs or other barriers to prevent vehicles from using the sidewalk or planting strips.
6. Offer some protection from rain, wind, or snow.
7. Be sufficiently wide to allow easy flow of pedestrian and bicycle traffic.

5.9 Existing Retail/Office Developments

Entrances to many commercial and retail centers are oriented toward automobile travel. Bicycle and pedestrian access to storefronts is not only difficult and awkward, but often unsafe. For the purpose of this discussion, a shopping center is used as an example of how to retrofit existing developments to accommodate pedestrians. The same principles apply to other types of developments, such as office complexes and multi-family housing.

An average shopping center or "strip mall" is separated from the roadway by a wide parking lot that averages between 90 to 150 meters (300 to 500 feet) in depth. There are often no pathways linking store entrances to the sidewalks along the street, and sometimes there are no sidewalks on the street to be linked. Parking lots with multiple entryways allow traffic to circulate in different directions, creating hazards and confusion for walkers and cyclists. Drive-throughs at banks and fast-food restaurants in out-parcel developments add to pedestrian safety problems and encourage people to drive between different destinations on the site.

Storefronts do little to encourage walking. They are often barren and devoid of windows, and are therefore visually unappealing to a pedestrian. If they exist, walkways between stores are often narrow and uncovered, and pedestrian amenities such as benches are rare. Pedestrian connections between developments are not provided, encouraging shoppers to get back in their automobiles to access adjacent developments.

Although the problems with shopping centers are numerous, they can be redeveloped to better serve pedestrians. As older shopping centers undergo renovations, they should be redesigned to serve customers who arrive via transit, automobile, bicycle, and on foot. Specific methods include:

- Maximize pedestrian and transit access to the site from adjacent land uses.

- Provide comfortable transit stops and shelters with pedestrian connections to the main buildings; transit stops and pedestrian drop-offs should be located within reasonable proximity to building entrances —preferably no more than 225 meters (750 feet), and ideally much closer than that.

- Provide attractive pedestrian walkways between the stores and the adjacent sites.

- Ensure that fencing and landscaping does not create barriers to pedestrian mobility.

Improve the Layout of Buildings and Parking Lots:

- Increase the density of existing sites by adding new retail buildings in the existing parking lots, with offices or multi-family housing around the perimeter of the site.

- Locate parking lots on the sides and to the rear of buildings, with major retail being situated closer to the street.

- Rework entrances and orient buildings toward pedestrian and transit facilities instead of parking lots.

- Arrange buildings on site to reduce walking distance between each building and between the nearest transit facility.

- Provide covered walkways around and between buildings, if possible.

Improve Pedestrian Circulation and Safety Measures on Site:

- Connect all buildings on site to each other via attractive pedestrian walkways, with landscaping and pedestrian-scale lighting. Provide covered walkways where possible.

- Minimize pedestrian/auto conflicts by consolidating auto entrances into parking lots.

- Separate roads and parking lots from pedestrian pathways through the use of grade changes.

- Implement safety measures at pedestrian crossings, warning signage, tight corner radii, and other measures (see section of this workbook on Traffic Calming).

5.10 Exercise

Describe 10 to 15 ways in which you would propose to retrofit a nearby residential development (or one that you grew up in) to make bicycling and walking viable forms of transportation. Elaborate on each idea, explaining how it would work and why it would improve the livability of the community.

5.11 References

Text and graphics for this lesson were derived from the following sources:

Oregon Chapter of the American Planning Association, *Oregon Transportation Rule: Recommendations for Pedestrian, Bicycle and Transit-Friendly Ordinances*, 1993.

Pennsylvania Department of Transportation, *Pennsylvania Statewide Bicycle and Pedestrian Plan: Pedestrian Planning Guidelines*, 1996.

Richard K. Untermann, *Accommodating the Pedestrian*, Van Nostrand Reinhold Company, Inc., New York, 1984.

For more information on this topic, please refer to:

Florida Department of Transportation, *Florida Pedestrian Planning Guidelines*, 1995.

Traffic Engineering Council Committee TENC-5A-5, Institute of Transportation Engineers, *Design and Safety of Pedestrian Facilities–A Recommended Practice of ITE*, 1998.

L E S S O N 6

Neo-Traditional Neighborhood Design

6.1 Purpose

Traditional Neighborhood Design (TND) (also called "New Urbanism" and "Neo-Traditional Neighborhood Design") is a town planning principle that has gained acceptance in recent years as being one solution to a variety of problems in suburban communities throughout the country. Traditional neighborhoods are more compact communities designed to encourage bicycling and walking for short trips by providing destinations close to home and work, and by providing sidewalks and a pleasant environment for walking and biking. These neighborhoods are reminiscent of 18th and 19th century American and European towns, along with modern considerations for the automobile.

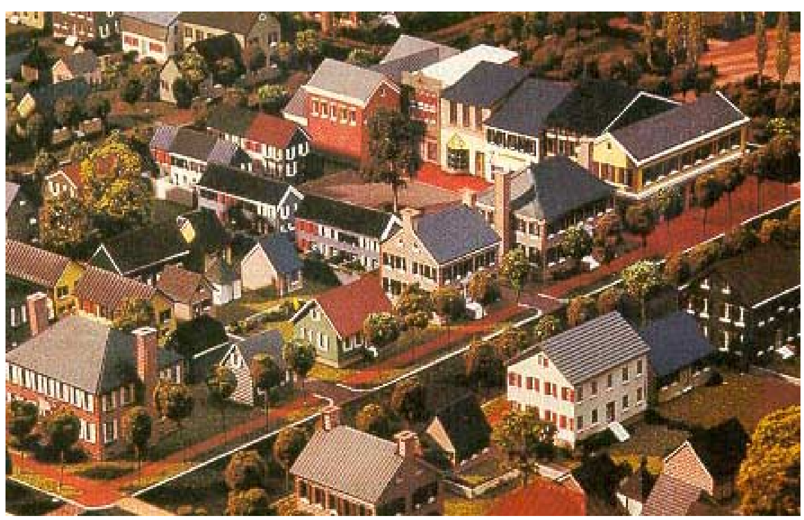
This lesson includes an informative article on TND/New Urbanism that appeared in the May 1994 edition of *Engineering News Record*. It is written from an engineering perspective, but it also describes the cooperative spirit that must exist between planners, architects, and engineers to make TND work.

6.2 "Putting Brakes on Suburban Sprawl"

Engineering News Record *article, May 1994. Reprinted with permission.*

New urbanists are zealots. They proselytize their antidote to alienation — new old-style towns — with a missionary's fervor. And after a frustrating first decade bucking an automobile-driven society unfriendly to their peripatetic ways, they are beginning to make great strides.

With several neo-traditional neighborhoods built, public planners are taking notice. Some are even adjusting general plans and zoning for compact walkable mixed-use towns. Suburban traffic engineers and public works officials are no longer simply recoiling at the prospect of pedestrian-friendly street patterns with narrower, gridded and tree-lined streets.



Village model showing gridded streets and clustered buildings of different types proposed for Haymount [Virginia] development. (Photo and caption,* ENR, *May 9, 1994.)

And market surveys are convincing skeptics that suburban residents are content living in a town that by design nurtures both community consciousness and the individual spirit.

"Contemporary suburbanism isolates and separates," says Paul Murrain, an urban planner based in Oxford, U.K. Consumers are recognizing "in their hearts" the better quality of life offered by new urbanism, he adds.

Though new urbanism is also intended for cities cut to pieces by highways, it is more the planner's answer to suburban sprawl and the breakdown of community caused by a post-World War II obsession with the automobile. Apart from nearly total dependence on the car, the typical suburb, with its looping or dendritic street pattern and dead-end cul-de-sacs, "is laid out so that it can't grow," says Andres Duany, partner in Andres Duany & Elizabeth Plater-Zyberk Architects and Planners (DPZ), Miami. "It chokes on itself in very short order."

New urbanism allows travel from one destination to another without using collector roads. (Photo and caption,* ENR*, May 9, 1994.)

"Suburban sprawl is riddled with flaws," Duany continues. Unfortunately, "all of the professions [involved in development] have sprawl as their model."

Even those who do not subscribe to new urbanism see a need for change. "We are finally recognizing we should plan communities, not structures," says Carolyn Dekle, executive director of the South Florida Regional Planning Council, Hollywood.

"New urbanism is a return to romantic ideas of the past and does not respond to current lifestyles," says Barry Berkus, principal of two California firms, B3 Architects, Santa Barbara, and EBG Architects, Irvine. "But it is part of a knee-jerk, but needed, reaction to irresponsible planning that produced monolithic neighborhoods without character."

Duany, both charismatic and outspoken, and his cerebral wife Plater-Zyberk are in new urbanism's high priesthood. To focus attention on their goals, DPZ and several others created the Congress for the New Urbanism last year. The second meeting is set for May 20 to 23 in Los Angeles. "We need all the converts we can get," says Duany, because, "inadvertently, one thing after another prevents it." Among these are fear of change and criticism that the new urbanism model is too rigid – robbing the individual residents of choice.

Regardless of criticism, converts are beginning to spill out of the woodwork. "Before my conversion, I was a schlock developer," confesses John A. Clark, of the Washington, DC, company that bears his name. "Most of my stuff was so bad it makes your teeth ache."

Then in 1988, after reading about neo-traditional development, the movement's original name, "the light bulb went off," says Clark. He called Duany and soon enlisted DPZ in the campaign for Virginia's Haymount.

There are other tales of conversion. "We were Duanied," says Karen Gavrilovic, principal planner in the Loudoun County Planning Dept., Leesburg, VA. Last year, the county adopted a comprehensive general plan based on new urbanism, which just won an American Planning Association award.

Until new urbanism becomes mainstream, the approvals process for each community tends to be tortuous and therefore expensive. “The thing that must change is the cost of establishing new communities,” says Daniel L. Slone, a lawyer with Haymount’s counsel, McGuire Woods Battle & Boothe, Richmond. “It will take the cooperation and leadership of planners, politicians, and environmental and social activists.”

Superhighways–Have they done more harm than good?

Approvals are complicated. The approach “raises hundreds of land-use questions” that must be answered, says Michael A. Finchum, who as Caroline County’s director of planning and community development, Bowling Green, VA, is involved with Haymount.

“Anything new is of concern,” especially to lenders and marketers, agrees Douglas J. Gardner, project manager for developer McGuire Thomas Partners’ Playa Vista, a new urbanism infill plan sited at an old airstrip in Los Angeles (*ENR*, 10/04/93, p. 21). But Gardner sees planning obstacles as surmountable and blames Playa Vista’s 5-year approval time on a trend toward a “more rigorous regulatory framework” for all types of developments.

Fabric

New urbanism combines aspects of 18th and 19th century American and European towns with modern considerations, including the car. As in Loudoun County, the model can be applied on any scale — to a city, a village, or even a hamlet. In West Palm Beach, FL, which is drafting a new urbanist downtown plan, it is superimposed on an existing urban fabric. Though most of the architecture so far has been traditional, any vernacular is possible.

Like a bubble diagram, neighborhoods should overlap at their edges to form larger developed areas, interconnected by streets, public transit, and bicycle and footpaths. Regional mass transit and superhighways enable workers to commute to remote job centers.

To make new urbanism work on a wider scale, San Francisco-based Calthorpe Associates promotes urban growth boundaries and future development around regional transit. But localities are afraid they will lose control, so most States have not authorized regional governance, says Peter A. Calthorpe. The result is “fractured development, no regional transit, and no attention to broader environmental and economic issues,” he says.

There are many proposed new urbanism projects, but less than a dozen are built. Most, not yet 5 years old, have yet to reach build-out. The more well known are DPZ’s Kentlands in Gaithersburg, MD; architect-planner Calthorpe’s Laguna West in Sacramento; architect Looney Hicks Kiss’ Harbor Town in Memphis; and DPZ’s Seaside, a northern Florida vacation-home town.

Retrofits are possible, but more difficult. Subdivisions, with multiple landowners and streets that are nearly impossible to link, are the most troublesome. Office park and shopping center makeovers, such as Mashpee Commons on Cape Cod, are easier because the cost of a parking garage to free up surface lot space for development can often be financially justified, says Duany.

The optimal new urbanism unit is 160 acres. Typically, the developer provides the infrastructure. The town architect establishes and oversees the plan and designs some structures. But other architects are

Street Design	Standard	New Urbanism
Basic layout	Dendritic	Interconnected grid
Alleys	Often discouraged	Encouraged
Design speed	Typically 25-30 mph	Typically 20 mph
Street width	Generally wider	Generally narrower
Curb radii	Selected to ensure in-lane turning	Selected for pedestrian crossing times and vehicle types
Intersection geometry	Designed for efficiency, safety, vehicular speed	Designed to discourage through traffic, for safety
Trees, landscaping	Strictly controlled	Encouraged
Street lights	Fewer, tall, efficient luminaires	More, shorter, closely spaced lamps
Sidewalks	4-ft minimum width,outside right of way or to undulate	5-ft minimum, within ROW and parallel to street
Building setbacks	15 ft or more	No minimum
Parking	Off-street preferred	On-street encouraged
Trip generation	Developed from a sum of the users	Developed from a reduced need for vehicular trips

ENR, *May 9, 1994.*

also involved. Public buildings and space, including a community green, are located near the center, as are many commercial buildings.

Mix

Under new urbanism, there is often no minimum building setback. Lot widths are typically multiples of 16 feet, and are 100 feet deep. There are a variety of residential buildings–apartment buildings, row houses, and detached houses–usually mixed with businesses. Finally, there are alleys lined by garages and secondary buildings, such as carriage houses and studios.

All elements are planned around "the distance the average person will walk before thinking about getting in the car," says Michael D. Watkins, Kentlands' town architect in DPZ's Gaithersburg office. That's a maximum 5-minute walk–a quarter mile or 1,350 feet-from a town center to its edges.

New urbanists maintain that a family will need fewer cars. Duany likes to point out that it costs an average of $5,500 per year to support each car, the equivalent of the annual payment on a $55,000 mortgage.

Sidewalks are usually 5 feet wide instead of 4. Streets, designed to entice, not intimidate, walkers, are typically laid out in a hierarchical, modified grid pattern. The broadest are 36 feet wide; the narrowest, 20 feet. On-street parking is encouraged and counted toward minimum requirements. Vehicle speed is 15 to 20 mph, not 25 to 30 mph. Curb return radii are minimized so that a pedestrian crossing is not daunting. Superhighways are relegated to the far outskirts of town.

In a grid, traffic is designed to move more slowly, but it is also more evenly distributed so there are fewer and shorter duration jams, says Duany. In the typical suburb, broad commercial streets, called collectors, have become wall-to-wall traffic, while loop and cul-de-sac asphalt typically remains under-used.

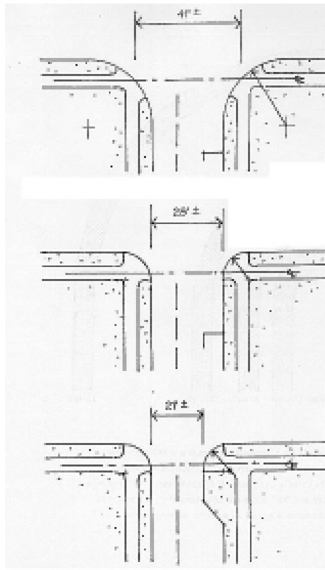
Berkus objects to the grid, except to organize the town center. The "edges should be organic" for those who perceive "enclaves" as safer and more secure places to live, he says.

Bernardo Fort-Brescia, principal of the Miami-based Arquitectonica, also thinks the undulating street and cul-de-sac should be offered. "There are no absolutes," he says.

The firm's plan for Meerhoven, a new town proposed for Holland, reflects many new urbanist concepts in a modern vernacular. "Nothing is faked to appear old," says Fort-Brescia. Every element has a function based on modern lifestyles. For example, the town lake is sized for triathlon swimming and perimeter marathon runs. But pedestrians and bikers are encouraged. And mass transit will whisk commuters to jobs elsewhere.

Arquitectonica is fortunate–there are no intractable standards in the way of its plan. But in the United States, new urbanists say their biggest roadblocks are existing street design standards geared to traffic volume and efficient movement, and zoning that prohibits small lots and mixing building types. For example, firefighters and sanitation officials want to have a street wide enough for trucks to turn corners without crossing the centerline.

"Public works will view your proposal with suspicion" because in new urbanism, traffic is no longer the driving force behind street design, says Frank Spielberg, president of traffic engineer SG Associates Inc., Annandale, VA.



Effects of curb return radii on pedestrian crossing distance. Source: Wilmapco, Mobility-Friendly Design Standards, Wilmington Area Planning Council, Nov. 1997.

In addition to ITE's manual, which already contains residential street guidelines, there are American Association of State Highway and Transportation Officials standards. They support compact projects, "but only if you already know where to look," says C.E. Chellman, CEO of White Mountain Survey Co., a land surveyor-engineer in Ossippe, NH, and editor of ITE's draft guidelines.

Chellman says transportation officials often forget that ITE and AASHTO standards are not binding codes. Officials are reluctant to use judgment, he says.

Spielberg, sympathetic to new urbanism, but cautious about traffic issues, says there are still questions: Lower expected traffic volume justifies narrow streets, but is actual traffic volume lower? How long would it take to convince residents they need fewer cars? Will traffic be retained within the project, which would relieve the developer of adjacent road upgrades?

Some engineers simply take issue with the specifics driving new urbanism. Skokie, IL-based traffic engineer Paul C. Box, who wrote the existing ITE residential street guidelines, claims lowering the speed limit is against human nature. He says on-street parking is dangerous because children get hit running out between parked cars. He is against narrower through streets and the bicycle as transpor-

Traffic engineers have been working for 40 years to accommodate the proposals of architects and planners, maintains Spielberg, chairman of the Washington-based Institute of Transportation Engineers'(ITE) 5-year-old committee on traffic engineering for neo-traditional development. Now that the approach is changing, "traffic engineers will respond," he says.

Reform

"Surprisingly, traffic engineers, the most recalcitrant of all, are the first to reform," agrees Duany. ITE plans to publish neo-traditional street design guidelines late this year or early in 1995.

Retrofits are difficult, say new urbanists. Shopping centers are simplest because parking garages can replace surface lots. Mashpee Commons before and after. (Photo and caption,* ENR, *May 9, 1994.)

tation unless separate bike paths or lanes are constructed, which he says is too costly. He also thinks undulating sidewalks are safer than those along the street.

Until there is a body of research to support it, mainstream lenders and commercial interests will continue to shy away from new urbanism, says James Constantine, principal of Community Planning Research Inc., Princeton, NJ. In February, Constantine released data from a survey of "active" home-buyers attending the Home Builders Association of Memphis show at Harbor Town last September. Of 123, "a whopping two-thirds" said they'd "like" to live in a neo-traditional neighborhood, he says. The only market resistance was to small lots and minimal setbacks, he adds.

John H. Schleimer, president of Market Perspectives, Carmichael, CA, says even home-buyers surveyed recently who bought elsewhere "like" the idea of community and the option of walking places. But many said they paid the same price for bigger homes on larger lots.

Haymount's Clark isn't rattled: "Someone who wants to live on a mansion-size lot and 'commit cul-de-side' has to go elsewhere. That's why there is vanilla and chocolate."

By Nadine M. Post

Typical suburban neighborhoods offer few route choices for trips.

6.3 Street Design for Traditional Neighborhoods

Neo-traditional neighborhoods have begun to appeal both to community designers and home-buyers alike. It is important, however, to consider that neo-traditional street design fundamentally differs from standard suburban street design. In recent years, many neighborhoods have been built across the country that claim to be neo-traditional that are, in fact, missing critical features.
The magazine article in this section provides a good overview of the concepts of neo-traditional neighborhood design. This section provides more specific details on neo-traditional street design, and explains how it is different from standard suburban street design.

Basic Street Layout

Standard suburban street design is characterized by a hierarchical, tree-like pattern that proceeds from cul-de-sacs and local streets to collectors to wide arterials. The organization of the network collects and channels trips to higher capacity facilities. The use of streets in residential areas for inter-community and through-traffic is minimized by limiting access by constructing few perimeter intersections, reducing interconnections between streets, and by using curving streets and cul-de-sacs in the development. Where this layout is successfully designed and constructed, automobiles are the most convenient choice for short, as well as long, trips. The street layout forces longer, less direct auto travel when street connections are missing.

The hierarchical street layout reflects the guiding principle that streets on which residences front should serve the least traffic possible. At best, only vehicles traveling to or from the homes on a given street would ever appear on that street. There would be little or no "through-traffic," hence the prevalence of cul-de-sacs. Traffic from residential streets is quickly channeled through the street hierarchy to collectors and then to arterials. Only arterials, fronted primarily by stores, offices, or apartments, provide direct connectivity between land uses and other neighborhoods.

By contrast, Neo-Traditional Neighborhood Design (NTND) calls for an interconnected network of streets and sidewalks to disperse vehicular trips and to make human-powered modes of travel (such as walking and biking) practical, safe, and attractive for short trips. Motorists, pedestrians, and public officials will find the regular pattern more understandable.

Neo-traditional neighborhoods have narrower, tree-lined streets.

The street pattern in an NTND can also have a hierarchy, with some roadways designed to carry greater traffic volumes. A basic assumption of NTND planning, however, is that neighborhood streets that serve local residential trips can also safely serve other neighborhood trips and some through-traffic. For example, a street with 40 homes would need to carry about 20 vehicle trips during the peak hour. The effective capacity of this street could easily be 200 vehicles per hour without a significant effect on safety or environmental quality. By limiting the access to the street as in standard suburban design, 90 percent of its effective capacity is wasted. Nearby arterials must make up the difference.

By eliminating dead ends and designing all streets to be interconnected, neo-traditional neighborhoods provide multiple route choices for trips. By using narrow streets and by constructing more of them, more, yet smaller, intersections are created. In concept, therefore, overall network capacity is increased, traffic is dispersed, and congestion is reduced in neo-traditional communities. While this rationale seems intuitively correct, it must be carefully applied. Land use and density are not constant across a neo-traditional community. Larger traffic generators will attract larger numbers of vehicles that may require multi-lane streets and intersections.

Use of Alleys

Planners discourage alleys in standard suburban residential areas. In a typical suburban development, an alley behind homes serves no function because garages and their driveways are accessed from the street.

However, in Neo-Traditional Neighborhood Design, alleys give neighborhood planners design flexibility by permitting narrow lots with fewer driveways on local streets. Fewer driveways also mean more affordable, smaller home sites and more space for on-street parking, especially if the home-owners use the alleys for their own vehicular access, parking, and utilitarian activities. Alleys provide space for underground or unattractive overhead utilities while freeing streets for trees and other plantings. Alleys also can be used for trash storage and collection and emergency vehicle access. NTND projects do not have alleys everywhere, but where they do, traffic safety may improve. Alleys eliminate residential driveways and the need for backing up onto the street, which would otherwise occur and is inherently unsafe.

Street Design Speed

Design speeds for suburban neighborhood streets range from a minimum of 25 or 30 mph to 45 mph. The design speed recognizes the type of facility (local, collector, or arterial), and it allows for a standard 5- or 10-mph “margin of safety” above the 85th percentile speed, which is usually the posted speed. Often, the signing of wide streets for 25 to 35 mph simply results in more speed violations. It is not unusual for neighbors to complain of speeding traffic on neighborhood streets and to request actions to slow the traffic. Stop signs, speed bumps, “Children at Play” signs, and the like may have to be used to slow vehicles from the original design speed of the street.

Neo-traditional neighborhoods re-create commercial densities reminiscent to pre-World War II era downtowns.

neighborhood, drivers are more likely to expect pedestrians and avoid them in emergency situations.

Street Width

In suburban neighborhoods, street type, width, and design speed are based on projected vehicle volumes and types. The larger the vehicle permitted on the street according to local regulations, the wider the street. The focus is on motorized vehicles, often to the exclusion of pedestrians, other transportation modes such as bicycles, and other considerations of the community environment.

Neo-Traditional Neighborhood Design projects attempt to control vehicle speeds through careful design of streets and the streetscape. Minimum NTND street design speeds are 15 to 20 mph. On-street parking, narrow street widths, and special design treatments help induce drivers to stay within the speed limits. T-intersections, interesting routes with lots of pedestrian activity, variable cross-section designs, rotaries, landscaped medians, flare-outs, and other treatments may be used.

At slower speeds, the frequency of vehicular accidents may decline, and those that do occur may be less severe. What is not clear is whether or not the frequency of pedestrian-vehicle accidents also decreases with speed. Indeed, more than 70 percent of all pedestrian traffic collisions occur in locations where speeds may be low (NHTSA, 1989). Pedestrian accident types are often associated with darting out from between parked cars, walking along roadways, crossing multi-lane intersections, crossing turn lanes, dashing across intersections, backing-up vehicles, ice cream vending trucks, and bus stops.

For NTND projects, the goal is to create more “active” streetscapes, involving more of the factors that slow drivers. These include parked cars; narrow street width; and eye contact between pedestrians, bicyclists, and drivers. The overall impact of these elements of design is enhancement of the mutual awareness of drivers and pedestrians. Thus, many professionals believe that in a neo-traditional

Ideal suburban lane widths per direction are 12 feet, while exclusive turn lanes may be 10 feet or less. Depending on whether or not parking is permitted, two-lane local street widths vary from 22 to 36 feet, while two-lane collector streets vary from 36 to 40 feet. In many suburban jurisdictions, the minimum street width must accommodate cars parked on both sides, an emergency vehicle with its outriggers, and one open travel lane. These “possible uses” instead of “reasonably expected uses” lead to a worst-case design scenario, an excessively wide street, and probable higher travel speeds.

In contrast to suburban street design, the width of NTND streets is determined by the projected volumes and types of all the users of the street, including pedestrians. The actual users of the street and their frequency of use help determine street width. In addition, NTND-type standards come into play. The basic residential NTND street has two lanes, one for each direction, and space for parking on at least one side. The resulting minimum width may be as narrow as 28 to 30 feet. Design considerations, however, may preclude parking in some areas, perhaps to provide space for bicyclists.

If neo-traditional communities encourage narrower streets with parking, then vehicles will naturally slow and stop for parking maneuvers and for larger approaching or turning vehicles that may encroach on the other lane. The NTND concept is that drivers must be more watchful (as they usually are in central business district (CBD) areas) and, once more watchful, drivers expect to and do stop more frequently.

To alert drivers to the relative change in importance between vehicles and pedestrians, they must be warned at entrances to the NTND. This warning must be more than signs. Narrower streets; buildings closer to the street; parked cars; smaller signs;and the generally smaller, much greater visual detail of a pedestrian-scale streetscape all serve as good notice to the visitor.

Curb Radii

Curb radii in suburban neighborhoods match expected vehicle type, turning radius, and speed to help ensure in-lane turning movements if possible. In order to accommodate the right-hand turning movements of a tractor trailer (WB 40) and larger vehicles, no matter what their frequency of street use, suburban streets typically have minimum intersection curb radii of 25 to 35 feet. Some jurisdictions require 50 feet or more. What such large curb radii do for smaller, more predominant vehicles is to encourage rolling stops and higher turning speeds. These conditions increase the hazards for crossing pedestrians. The large curb radii effectively increase the width of the street, the pedestrian crossing time, and the exposure of pedestrians to vehicles.

NTND curb radii are usually in the range of 10 to 15 feet. They depend on the types of vehicles that most often use the street, not the largest expected vehicle. The impacts on pedestrians, parking spaces, and turning space for larger vehicles are also considered. The smaller the curb radii, the less exposure a crossing pedestrian has. Furthermore, an additional parking space or two may extend toward the intersection with small curb radii, or if parking is prohibited, additional room for turning vehicles is created.

Intersection Geometry

Many manuals detail conventional intersection design and analysis for suburban developments (AASHTO, 1990). Such intersections are designed for an environment in which the automobile is dominant. Hence, traffic engineers attempt to maximize intersection capacity, vehicle speed, and safety. They also aim to minimize vehicle delay and construction cost. As a result of the hierarchical approach to street system design, which carries traffic from narrow local streets to larger collectors and arterials, intersection size and complexity grow with the streets they serve. Drivers of these streets expect an ordered structure and any anomalous designs present safety problems.

In Neo-Traditional Neighborhood Design, the concept of connected patterns of narrow, well-designed streets is intended to improve community access in spite of low design speeds. The numerous streets provide more route choices to destinations and tend to disperse traffic. In concept, the more numerous, smaller streets also mean smaller, more numerous, less congested intersections. Again, due to slower vehicular speeds, greater driver awareness, and the desire for vista terminations, some NTND intersection designs are typically different from suburban designs.

Street Trees and Landscaping

Subdivision standards and roadway design practice strictly control the size and location of street trees and other plantings. Some local regulations may even prohibit trees and other plantings near the street. These guidelines originated with the precedent of the "forgiving roadway" that arose through tort actions. They generally place trees far from the edge of high-speed roads to reduce the chance of serious

Trees and landscaping form an essential element of the streetscape in NTND projects.

accidents if vehicles swerve off the road. For suburban streets with lower design speeds and space for parked cars, trees can be closer to the street.

Trees and landscaping form an essential element of the streetscape in NTND projects. The relationship of vertical height to horizontal width of the street is an important part of creating a properly configured space or “outdoor room.” On some streets that feature single-family housing, the design may call for setting the houses back somewhat from the street. In neighborhoods and along streets such as this, the trees form an important part of that street. While providing shade and lowering street and sidewalk temperatures, they create a sense of closure in a vertical plane. Along streets that contain townhouses and stores with apartments above them, actual full-sized trees become less important, while smaller trees and landscaping remain essential elements.

Street Lighting

Suburban neighborhood design calls for large, efficient luminaires on high poles spaced at relatively large distances. Their purpose is not only to illuminate the nighttime street for safer vehicle operation, but also to improve pedestrian and neighborhood security.

Street lighting in traditional neighborhoods serves the same purposes as that in suburban neighborhoods. However, the intensity and location of the lights are on a more pedestrian scale. Smaller, less intense luminaires are often less obtrusive to adjacent properties and allow the nighttime sky to be seen. They only illuminate the streetscape as intended.

Sidewalk Width and Location

Sidewalks in suburban neighborhoods typically have a minimum width of four feet. While they may lie parallel to the street, they may also meander within the right-of-way or lie entirely outside of it.

NTND designers try to keep walking as convenient as possible, and this results in shorter distances when sidewalks remain parallel to the street. The focus is on a safe and pleasant walking experience. The typical minimum sidewalk width is 5 feet because this distance allows two pedestrians to comfortably walk side-by-side. Walking distances should be kept as short as possible, and, in traditional neighborhoods, horizontally meandering or vertically undulating designs are avoided even though these features may add interest. Neither should a pedestrian route be perceived as longer than the same driving route, nor should it create undue mobility problems for visually impaired pedestrians or people who use wheelchairs.

Building Setbacks

Conventional front setbacks are 15 feet or more for several reasons. Setbacks allow road widening without having to take a building and compensating its owner. They help sunlight reach buildings and air to circulate. In addition, side and rear setbacks afford access by public safety officials.

Traditional designs have no minimum setback and, indeed, maximums may be specified by some policymakers. The goal is to integrate residential activity and street activity and, for example, to allow the opportunity for passers-by to greet neighbors on their front porches. Furthermore, the walls of nearby buildings help to vertically frame the street, an important aesthetic dimension.

Pedestrian push buttons should be conveniently placed. Be sure existing site features are not obstacles to reaching the button.

Suburban parking lots in retail developments are vast–and are rarely full.

NTND projects are intensely planned and closely regulated as to types and ranges of use and location. Such planning affords the otherwise unusual opportunity to have a good degree of understanding about the future traffic demands for a street, and to design for those needs. Furthermore, to minimize the need for future widening, NTND streets have adequate rights-of-way, typically not too dissimilar to "standard" requirements, and the buildings do not encroach on the right-of-way. Within the right-of-way, the typical NTND street will have a planting strip of 6 feet or so on each side, and parking lanes on both sides of the street (sometimes striped, sometimes unstriped), both of which provide opportunities for some widening without a great deal of effort if a future wider street is needed.

Parking

The importance of parking for suburban projects cannot be over-emphasized because nearly all trips are by car. Off-street parking is preferred; indeed, large parking lots immediately adjacent to the street give a certain status to retail and commercial establishments. Sometimes, suburban parking is allowed on the street in front of smaller stores. Because of the importance of vehicle access in suburban development, city ordinances typically establish minimum parking criteria.

Neo-traditional design encourages on-street parking by counting the spaces toward maximum parking space requirements. The parking is usually no more than one layer deep. If the adjacent development contains residential and other uses, parallel parking is recommended. In commercial areas, 90-degree head-in and diagonal parking are permitted. Parking lots are usually built behind stores. As a result, the street front is not interrupted by a broad parking area.

On-street parking is a concern for some traffic engineers. The concern is that "dart-out" accidents (where pedestrians, especially children, dart-out from between parked vehicles into the traffic stream) will increase if on-street parking is encouraged. The proponents of NTND projects argue that a row of parked vehicles enhances pedestrian activity by creating a buffer between pedestrians and moving traffic, that the overall street design slows moving traffic so that any accidents that do occur are less severe, and that the active streetscape makes drivers more alert to pedestrians. There is also some evidence that children in conventional neighborhoods are susceptible to driveway backing accidents. On-street parking, therefore, must be limited to streets where the design fosters low speeds (20 mph or less) for moving traffic.

6.4 References

Text and graphics for this lesson were taken from the following sources:

Institute of Transportation Engineers, *Neo-Traditional Neighborhood Street Design*, 1995.

Nadine M. Post, "Putting Brakes on Suburban Sprawl," *Engineering News Record*, May 9, 1994, pp. 32-39.

Wilmington (DE) Area Planning Council, *Wilmapco Mobility-Friendly Design Standards*, Nov. 1997.

For more information on this topic, refer to:

Office of Transportation Engineering and Development, *Pedestrian Design Guidelines Notebook*, Portland, OR, 1997.

"Made to Measure: How to Design a Livable Street the New England Way," *Planning Magazine*, June 1996.

Town of Cornelius, NC, Land Development Code, *Traditional Neighborhood District*, 1996.

L E S S O N 7

Using Land-Use Regulations to Encourage Non-Motorized Travel

7.1 Purpose

Land use and transportation have an extremely complex interrelationship. Often times, problems with the transportation system are blamed on faulty land-use policies and vice versa—problems with sprawling land uses are blamed on transportation policies. In fact, the problems typically do not have simple cause-and-effect solutions. This lesson takes a look at ways in which land-use regulations can be improved to support an intermodal transportation system that encourages access by walking, bicycling, and transit.

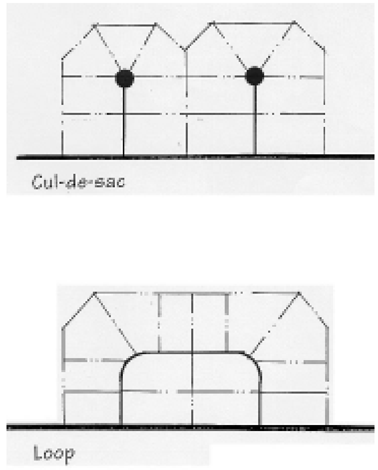
Most communities in the United States have land-use regulations that primarily support automobile access to local destinations. Substantial changes to zoning laws and subdivision regulations will be necessary in many communities in order to accomplish fundamental improvements to the transportation system. In addition to ordinances that require bicycle parking and sidewalks, even more basic changes are needed to automobile parking requirements, street design standards, allowable land-use densities, and transit-oriented developments.

Revising regulations that have been in place for many years can be a daunting task – either for planners who are trying to re-model a development ordinance or for engineers who are trying to change street design standards to accommodate bicycle and pedestrian travel. This chapter provides some examples of the types of provisions that are included in new policies on the State and local levels in order to accommodate and encourage bicycle and pedestrian travel.

7.2 Pedestrian-Oriented Land Use

One of the most important factors in a person's decision to walk or bike is the proximity of goods and services to homes and workplaces. A recent study

for the Federal Highway Administration confirms this: 33 percent of survey respondents cited distance as the primary reason for not walking. The most conducive land use for pedestrian activity is one with a higher density mix of housing, offices, and retail. Studies have also shown that more people walk in areas that are able to achieve higher densities of either housing or employment, despite lower densities of other uses such as retail. One study of the Puget Sound Region in Washington State defines high density as 50 to 75 employees per acre, or 9 to 18 residents per acre.



Loops are preferred to cul-de-sacs. Source: Wilmapco, Mobility-Friendly Design Standards, Wilmington Area Planning Council, 1997.

Zoning and Subdivision Regulations
Pedestrian and bicycle travel is often an afterthought in the development process. The results are impassable barriers to pedestrian travel, both within and between developments. The examples below show how local zoning ordinances can be amended to require more attention to the needs of pedestrians and bicyclists.

- **Subdivision Layout**
  Residential subdivision layout (including Planned Unit Developments) should provide safe, convenient, and direct bicycle and pedestrian access to nearby (within ¼ mile for walking and 2 miles for bicycling) and adjacent residential areas; bus stops; and neighborhood activity centers, such as schools, parks, commercial and industrial areas, and office parks.

- **Cul-de-Sacs**
  Cul-de-sacs have proven to be effective in restricting automobile through-traffic; however, they can also have the effect of restricting bicycle and pedestrian mobility unless public accessways are provided to connect the cul-de-sac with adjacent streets. Trail connections between cul-de-sacs and adjacent streets should be provided wherever possible to improve access for bicycles and pedestrians.

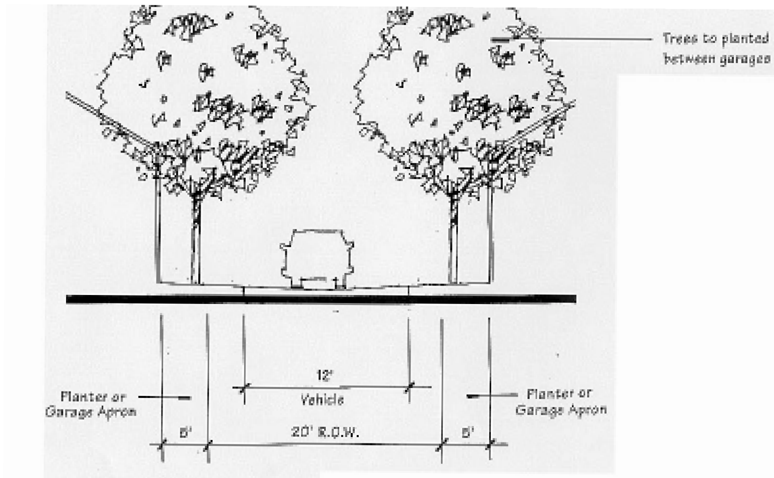
- **Future Extension of Streets**
  During subdivisions of properties, streets, bicycle paths, and sidewalks should be designed to connect to adjacent properties that are also likely to be subdivided in the future, so that a secondary system of roads and sidewalks develops over time. When subdivisions are built with only one outlet to a main thoroughfare, the result is heavy traffic congestion and difficult intersections for both motorists and pedestrians.

Low-density single-use zoning creates trip distances that are too far to make walking a viable transportation option.

- **Inclusion of Bicycle and Pedestrian Facilities in Piecemeal Development**
  This is intended to ensure that pedestrian and bicycle facilities are included in projects that occur in a piecemeal fashion. For projects in which only part of the land owned by the applicant is proposed for development, a sketch plan showing the tentative locations of streets, bicycle facilities, and public accessways should be submitted for the entirety of the land owned. "Stub-outs" should be constructed

for bicycle and pedestrian facilities on-site, and the next construction phase should be designed to connect to this network.

- **Internal Bicycle/Pedestrian Circulation for Commercial and Business Developments.**
  Adequate provisions should be made for bicycle and pedestrian circulation between buildings and related uses on development sites (the Americans With Disabilities Act (ADA) also contains regulations for on-site circulation).



Typical alley: Ordinances should be modified to allow for rear-lot access.

- **Lot Coverage**
  Zoning codes should be amended to raise the allowable lot coverage along bus routes to encourage intensification of uses and more efficient use of land in these areas.

- **Parking in High-Density Residential Developments**
  In some high-density residential areas, existing regulations require off-street parking, and at the same time, a reduced lot frontage. This results in homefronts that primarily consist of garage doors. Ordinances should be modified to allow for rear-lot access (alleyways) or other innovative solutions in these areas.

- **Parking Reductions**
  Parking codes should be modified to allow for a "reduced parking option" for developments that are located on bus routes and which provide facilities that encourage bicycling and walking. In general, shopping center parking lots should not be designed to handle volumes that occur only once or twice per year, but rather more typical volumes.

- **Compliance with design standards**
  Bicycle and pedestrian facilities should be designed to meet local and statewide design standards.

Community Visioning
Many communities throughout the country are conducting extensive revisions to their zoning and subdivision regulations in light of new planning techniques that improve transportation and community design.

New rules that would allow parking reductions and higher density developments are likely to be controversial. Public education for citizens and elected officials is essential in order to gain popular support for these new regulations.

The City of Portland, Oregon recently conducted an extensive revision of local zoning and subdivision regulations, using a successful technique that encouraged involvement from citizens and local elected officials. The city conducted a well-publicized Visual Preference Survey™, allowing local citizens to establish a vision for their ideal community environment by comparing photographs of different styles of urban, suburban, and rural development. When shown side-by-side, photographs of suburban strip development were rated far lower than those showing more compact, mixed-use districts. (*Picture This. . . The Results of Visual Preference Survey*, 1993)

Development Review Process
Land developers should be asked to submit a "Pedestrian and Bicycle Mobility Plan" early during the site plan review process. This plan should provide an inventory of all existing and proposed

land uses adjacent to the site, and illustrate a logical circulation plan for pedestrians and bicycles within the development and between adjacent land uses. The questions below can help design professionals create site plans that are sensitive to the needs of pedestrians.

SITE PLAN CHECKLIST

Overall System

- Does the plan meet ADA standards?
- Are utilitarian paths direct? Do they provide for connections to pedestrian magnets nearby? Can pedestrians take advantage of "shortcut paths" that encourage walking instead of driving?
- Does the pedestrian system consider the type and probable location of future development on adjacent or nearby parcels of land? Is there flexibility to provide direct connections to adjacent parcels; should that be desired in the future?
- Are building entrance areas convenient to the pedestrian? Are they clearly evident through either design features, topography, signing, or marking?
- Are walkways along the street buffered from traffic as much as possible?

Safety and Security

- Are crossings of wide expanses of parking lot held to a minimum?
- Are pathways generally visible from nearby buildings and free from dark, narrow passageways?
- Is adequate pedestrian-scale lighting provided for nighttime security?
- Are sight lines at intersections adequate for pedestrian visibility? Are pedestrians able to see on-coming traffic, given typical speeds?
- Do pathways lead to road crossing points with the least conflict?
- In general, are pedestrian/vehicle conflict points kept to a minimum?
- Are pedestrians given adequate time to cross the road at intersections?

7.3 Commercial Development Design Guidance

The physical layout of a development can often make the difference in a person's choice to walk between stores or to adjacent developments. Careful attention should be given to the location of buildings as well as the configuration of parking lots. Several provisions can ensure a better walking environment in commercial and office developments:

- **Building Setbacks**
  Buildings should not automatically be separated from the street by parking lots — this discourages pedestrian access and primarily serves those who arrive by automobile. A maximum setback requirement of 15 to 25 feet can help to encourage pedestrian activity. Parking, driving, and maneuvering areas should not be located between the main building entrance and the street. Parking lots should be located on the side and rear yards of the property whenever possible.

  For developments with multiple buildings, direct pedestrian access to public transit should be provided by clustering buildings near bus stops.

- **Building Orientation and Facades**
  Main building entrances should be oriented with the facade facing the street designated as a bus route. Entrances and paved walkways should lead directly to a bus stop. Visual stimulation is very important to pedestrians — long, blank walls with no openings onto the street discourage walking. Building facades should maintain continuity of design elements, such as windows, entries, storefronts, roof lines, materials, pedestrian spaces and amenities, and landscaping. Parking garages on streets with bus service should have ground-floor street frontage developed for office, retail, or other pedestrian-oriented uses.

- **On-Site Walkways**
  For developments with multiple buildings and/or outparcels, all building entrances on the site should be connected by walkways to encourage walking between buildings and to provide a safe means of travel for pedestrians. Sidewalks

between the building edge and parking lots should allow pedestrians safe and convenient access to building entrances without having to walk within driving aisles of parking lots.

- **Pedestrian Access Between Adjacent Developments**
  Sidewalks should connect uses on the development site to adjacent activity centers to encourage walking instead of driving between uses. Barriers such as fences or vegetation should not be placed so as to hinder access between developments.

- **Lighting**
  Pedestrian-scale lighting should be designed to light the walkway, thereby increasing pedestrian safety. Pedestrian lighting should be used in addition to lighting provided for motorists' safety. *Timesaver Standards for Landscape Architecture* (Harris and Dines, 1988) includes an excellent chapter on desirable lighting levels for pedestrian facilities, and specifies the following levels of illumination for sidewalks:

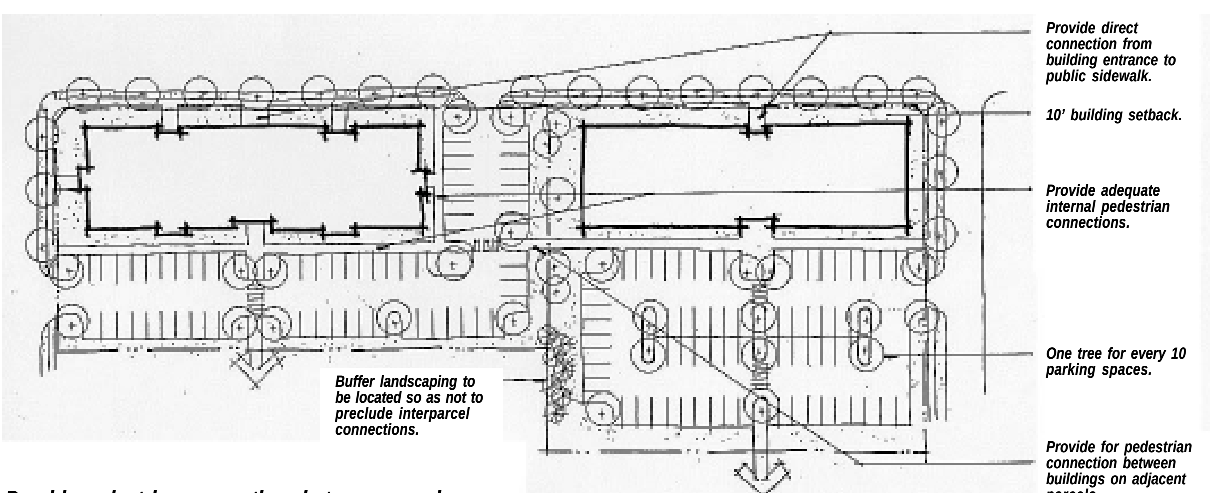
Location of lighting	***Lux (lx)***	***Footcandles (fc)***
Sidewalks		
Along Roadsides:		
Commercial areas	**10**	**0.9**
Intermediate areas	**6**	**0.6**
Residential areas	**2**	**0.2**
Sidewalks Distant From Roadsides:	**5**	**0.5**
Pedestrian Tunnels:	**40**	**4.0**

- **Improvements Between the Building and the Street**
  Design elements in the area between the building and the street are critical to successful pedestrian spaces. The streetscape should provide visual interest for the pedestrian. The area should be landscaped if project budgets allow.

- **Parking Lot Design**
  Parking lots with fifty or more spaces should be divided into separate areas with walkways and landscaped areas in between that are at least 10 feet in width. Pedestrian paths should be designed with minimal direct contact with traffic. Where pedestrian paths cross the traffic stream, raised speed tables that slow cars, while providing an elevated pedestrian walkway, should be provided. Additional recommendations for pedestrian-oriented parking lots:

a. Location
   Keep parking on one or two sides of the shopping center, away from the side that will generate the most pedestrian access. This pedestrian access point could be an office park, outparcel shopping or restaurant, or a residential area.

b. Direct Pedestrian Paths
   Provide a direct pedestrian path from parking lots and parking decks to the buildings they serve. Clearly delineate this path with striping, different paving materials, or by situating the path through the center of a series of strategically placed parking islands.



Provide pedestrian connections between parcels.

c. Use of Landscaping
Landscaping can be used to channel and organize the traffic flow in parking lots, as well as to provide pedestrian refuge areas. Avoid open parking lots that allow cars to move in any direction.

d. Bicycle Parking
Provision of bicycle parking at destinations is crucial–without it, bicycling becomes far less convenient. Bicycle parking ordinances can help to improve the situation (see Lesson 22 for a full description).

7.4 Guidance on Designing Residential Communities That Encourage Walking

Suburban neighborhood design can be modified to encourage bicycling and walking. It is not necessarily more expensive to build these communities; however, they require more careful design on the part of the developer. These types of pedestrian-friendly neighborhoods are worth the effort. Recent studies suggest that homes sell quickly in these communities. (See Lesson 6 for a more complete description of traditional neighborhood development.)

A pedestrian-oriented neighborhood should include the following aspects (list below is taken from the *ITE Journal*, January 1992 edition, pp. 17-18, "Neo-Traditional Neighborhood Design and Its Implications for Traffic Engineering"):

- Streets that are laid out in well-connected patterns on a pedestrian scale so that there are alternative automobile and pedestrian routes to every destination. A cul-de-sac pattern generally limits connectivity and is therefore discouraged.

- A well-designed street environment that encourages intermodal transportation. These streets should include pedestrian-scale lighting, trees, sidewalks, and buildings that are within close walking distance to the sidewalk.

- Residential and internal commercial streets should be relatively narrow in order to discourage high-speed automobile traffic.

- On-street parallel parking is recommended where it can be used as a buffer between pedestrians and motor traffic. Parked cars also serve to slow down the passing traffic, helping to balance the overall use of the street.

- Bicycles are considered an integral part of the transportation mode mix, and the design of the streets includes appropriate facilities for them.

- The buildings are generally limited in size, and building uses are often interspersed—that is, small houses, large houses, outbuildings, small apartment buildings, corner stores, restaurants, and offices are compatible in size and are placed in close proximity.

- In addition to streets, there are public open spaces, around which are larger shops and offices, as well as apartments.

- Larger communities should provide a neighborhood center (providing small-scale commercial and office uses) within a 5- minute walking distance (roughly a 0.25-mile radius) for the majority of residents in the neighborhood.

7.5 Street Design Standards

In New Castle County, Delaware, the regional planning agency and the Delaware Department of Transportation have teamed up to further define the precise design standards that should apply to local and collector streets. Following the references are the results of a study that was conducted in 1997-1998 to revise State design standards (see next page).

7.6 References

Text and graphics for this section were derived from the following sources:

American Planning Association, *Oregon Transportation Planning Rule*, 1993.

Birmingham Regional Planning Commission, *Walkable Communities in the Birmingham Area*, 1996.

Madison (WI) City Code, Madison, Wisconsin.

Wilmington (DE) Planning Council, *Mobility-Friendly Design Standards*, 1997.

For more information on this topic, refer to:

Town of Davidson, NC, *Davidson Land Plan*, (The Regulating Plan and Code), Oct. 1995.

Maryland Office of Planning, *Managing Maryland's Growth, Modeling Future Development on the Design Characteristics of Maryland's Traditional Settlements*, 1994.

WILMAPCO - MOBILITY FRIENDLY DESIGN STANDARDS STUDY
DELAWARE DESIGN / POLICY GUIDELINES FOR LOCAL & COLLECTOR STREETS

Purpose of Study:

This study supports the long-range transportation goals of the Delaware Department of Transportation, Town of Middletown, New Castle County and WILMAPCO. These goals include increasing mobility and accessibility by providing people with a range of travel options. Transportation improvements should be integrated into the social fabric of communities to help create livable neighborhoods and provide an expanded network of connections within and between communities. Mobility friendly design standards support travel by pedestrian, bike and transit modes along with reduced vehicle speeds within communities. The goal is to provide an excellent transportation and land use system that is sustainable and provides access and mobility options.

Street Design Criteria:

As part of this study, the consultant team is exploring opportunities to provide flexibility in neighborhood street design through reduced lane widths and other geometric design criteria. The benefits of this approach include:

- Safety: slow speeds and safe connections between travel modes.
- Traffic Calming: narrower streets with tighter curve radii result in cars driving slower.
- Enhanced Pedestrian Environment: less paving and slower moving traffic creates a more pedestrian and bicycle friendly environment, thus allowing short trips by walking or biking instead of by auto.
- Lower construction and maintenance costs.
- Reduced storm water runoff.

Application:

DelDOT Blue Book (Rules and Regulations for Subdivision Streets - 1981)

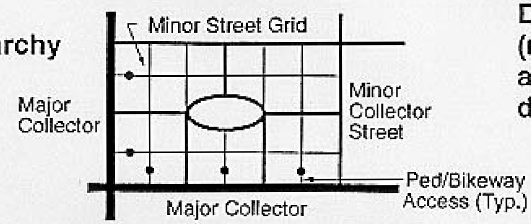
- minor streets: less than 50 homes (less than 500 trips/day)
- minor collector streets: 50 to 300 homes (500 to 3,000 trips/day)

DELAWARE DEPARTMENT OF TRANSPORTATION

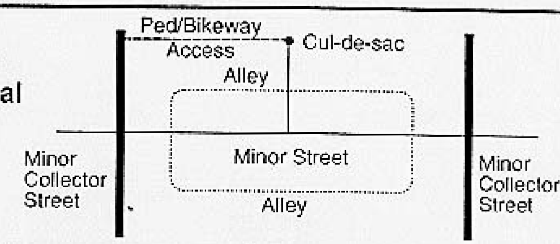
WILMAPCO

Figure 7.1

Plan Elements:
(traditional hierarchy of subdivision street grid)



Detail Layout:
(minor street with alleys for individual driveway access)



	DelDOT	AASHTO	ITE	ASCE	RECOMMENDED	COMMENTS
✦ **Network Design** (the conceptual approach to the hierarchy of functional layout of street systems)						
Minor Streets Minor Collector Streets	Not specified	Reference FHWA; "Highway Functional Classification: Concepts, Criteria and Procedures" (1974)	Curvilinear designs with interconnections as direct as possible	Linear or curvilinear design/short distances to collectors	Short interconnected streets/direct routes/loops preferred to cul-de-sacs Consider Network Connectivity Index of 1.4 as desired minimum target	The goal is to provide greater mobility options for pedestrians and bicyclists
✦ **Block Lengths** (distance along centerline of street between centerlines of connector cross streets)						
Minor Streets Minor Collector Streets	Not specified	While not specified, spacing of minor arterial streets may vary from 1/8 to 1/2 mile in CBD and 2 to 3 miles in suburban fringes	Limited number of intersections	Minimum number of intersections	200' to 500' (blocks longer than 500' require midblock crosswalks and pass-throughs based on walkability.)	
✦ **Design Speed** (selected speed used to define geometric features; posted speed is typically 5 to 10 MPH below Design Speed.) Desirably, this speed reflects adjacent residential and commercial activity)						
Minor Streets	25 mph	20 to 30 mph	20 mph (hilly) 25 mph (rolling) 30 mph (level)	20 mph	20 mph (desired operating speed is 20 mph) Require engineering study to support 20 mph-otherwise need to change statutes.)	Design speed and desired operating speed: 20 mph
Minor Collector Streets	30 mph	30 mph or greater	25 mph (hilly) 30 mph (rolling) 35 mph (level)	25 mph (hilly) 30 mph (rolling) 35 mph (level)	25 mph (desired operating speed is 25 mph)	Design speed and desired operating speed: 25 mph

Figure 7.1 (continued)

Plan Elements continued

	DelDOT	AASHTO	ITE	ASCE	RECOMMENDED	COMMENTS
✦ Minimum Horizontal Curve Radius (measured at centerline of street)						
Minor Streets	150'	100' min.(desirably as large as possible)	100' (hilly) 180' (rolling) 300' (level)	100' to 150' (access street) 150' to 300' (subcollector)	90' when curve is unsigned 45' when curve is signed as a traffic calming measure.	Additional engineering analysis to be conducted by DelDOT
Minor Collector Streets	300'		180' (hilly) 300' (rolling) 480' (level)	300' to 500'	150' minimum 90' when curve is signed as a traffic calming measure	Vertical curve issues to receive further study by DelDOT
✦ Intersection Design (desirable configuration for intersections with collector / arterial streets)						
Minor Streets	T-Intersection 90°	Type is primarily determined by the number of intersecting legs, the topography, the traffic pattern, and the desired type of operation	T-Intersections (4-way intersections also acceptable)	T-Intersections (4-way intersections and roundabouts are also acceptable)	T-Intersections or 4-way Provide: Intersections with roundabout or other traffic calming measures	Consider permitting "L" curves, i.e. 90° turns for loop or U shaped roadways. Loops preferred to cul-de-sacs. Consider permitting 60° for local streets. Reference recently released ITE manual-Traditional Neighborhood Development - Street Design Guidelines, June 1997.
Minor Collector Streets	T-Intersection 90°				Roundabouts or 2-way stops or 4-way stops	Roundabouts are appropriate for locations with heavy minor street delay, heavy turning traffic, intersections with unusual geometry, where major roads intersect at a "Y" or "T" junction, or where u-turns are necessary. They are inappropriate for locations where a signal interconnect system is necessary, or queuing from adjacent intersections would back up into the roundabout.
✦ Minimum Curb Return (radius of curb at street intersection)						
Minor Streets Minor Collector Streets	25'	15' minimum 25' desirable 30' (collector)	20' (local-local) 25' (local-collector) 30' (collector-collector)	15' to 20' (local-local) 25' to 30' (local-collector)	10' (local-local) 15' (local-collector with parking lanes) 20' (collector-collector with parking lanes) 40' (local-collector without parking lanes) 40' (collector-collector without parking lanes)	40' radius adds 9 seconds to pedestrian crossing (40' radius vs. 20' radius). Further consideration required regarding curb return radii / school buses. See page 2 of 10.

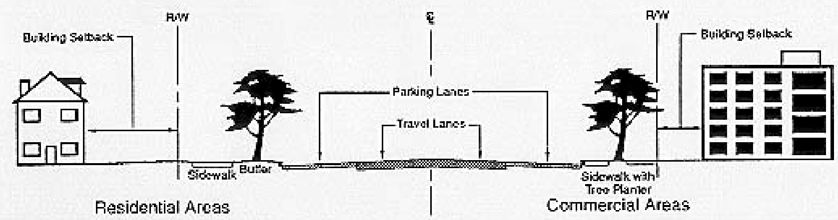
Figure 7.1 (continued)

Plan Elements continued

	DelDOT	AASHTO	ITE	ASCE	RECOMMENDED	COMMENTS
✦ **Maximum Cul-de-Sac Length** (measured along centerline of cul-de-sac from centerline of intersecting street)						
Minor Streets / Minor Collector Sts.	500' to 1,000' (depending on density)	Not specified	700' to 1,500' (depending on density)	500' to 1,000'	250' preferred to 500' maximum serving no more than 30 units with cut throughs provided at cul-de-sac heads for peds / bikes	
✦ **Minimum Driveway Spacing** (measured along centerline of street between centerlines of connecting driveways)						
Minor Streets	200' (narrower lots call for shared driveways)	Not specified, although desirably as far removed from intersections as practicable		50' (narrower lots call for rear access via alleys)	50' (narrower lots call for alley access or shared driveways)	
Minor Collector Streets	250'					
✦ **Minimum Driveway Width** (out to out dimension of paved surface)						
Minor Streets / MinorCollector Sts.	12' standard (not minimum)	Not specified (but returns should not be less than 3' radius)	10' minimum 18' (for 2-car garage on street)		8' to 16' (single-family) 18' (multi-familty	

Figure 7.1 (continued)

Typical Section Elements



	DelDOT	AASHTO	ITE	ASCE	RECOMMENDED	COMMENTS
✦ ROW Width (total width of publicly owned land available for transportation, drainage, landscaping, and utility accommodation uses)						
Minor Streets	50' (minor streets) 26' under special circumstances	50' (with 26' roadway section) 66' (commercial areas with on-street parking)	50' (low density) 60' (medium and high densities)	24' (access street) 42' to 46' (subcollectors)	42' or 49' = 20' or 27' roadway (no parking or one side) + 5' planting strip + 5' sidewalk + 8" top of curb Traffic calmed environment - bicycles accommodated on shared facility.	44' or 51' total ROW including 1' offset from back of sidewalk
Minor Collector Streets	60' (minor collectors)	40' to 60'	70' (low & medium densitlies) 80' (high density)	52' to 56'	51' or 58' = 29' or 36' roadway (parking one side or both sides) + 5' planting strip, 5' sidewalk, 8" top of curb. If frontage on local collector 10' planting strip required each side, increasing R.O.W. by 10'. Larger R.O.W. allowed if a boulevard type median is provided. Designated bicycle accommodations provided based on traffic volume, speed and road section - see FHWA publication used by DelDOT. A local and/or regional analysis should be prepared to identify the destinations that bicycle users may seek.	53' or 60' total ROW including 1' offset from back of sidewalk
✦ Pavement Width (width of paved surface; curb face to curb face if curbs provided)						
Minor Streets	22' (minor streets)	26' (OK for less when ROW is severely limited)	20' to 28' (low density) 28' to 34' (medium density) 36' (high density)	22' to 24' (local access street) 26' (subcollectors)	18' roadways (2@9') 2' offsets to curb face (2@1') 20' total - - - - - 18' roadways (2@9') 7' parking lanes 2' offsets to curb face (2@1') 27' total	
Minor Collector Streets	32' (minor collectors)		24' to 36' (low and medium densities) 40' (high densities)	36'	20' roadways (2@10') 7' parking lane 2' offsets to curb face (2@1') 29' total - - - - - 20' roadways (2@10') 14' parking lanes 2' offsets to curb face(2@1') 36' total	

Figure 7.1 (continued)

Typical Section Elements continued

	DelDOT	AASHTO	ITE	ASCE	RECOMMENDED	COMMENTS
✦ **Lane Width** (width of travel and parking lanes; centerline and edge lines typically not painted)						
Minor Streets	11' (minor streets)	10' (travel lanes - use 11' where feasible; minimum in residential areas 9') 7' (parking lanes - use 9' in commercial areas)		10' (travel lanes- without parking on both sides) 12' (travel lanes- with parking on both sides) 8' (parking lanes)	9' travel lanes (min) 7' parking lanes	"Bulb-outs" at intersections encouraged DelDOT to establish parking setback from intersections
Minor Collector Streets	11'-4" with curb (minor collectors)	10' (travel lanes) 7' (parking lanes - residential) 8' (parking lanes - commercial)			10' travel lanes (min) 7' parking lane (striped)	"Bulb-outs" at intersections encouraged DelDOT to establish parking setback from intersections
✦ **Pavement Edge Treatment** (choices include barrier (i.e. vertical face) or mountable curbs, and no curbs)						
Minor Streets	Mountable or barrier curbs (none at low densities i.e. 1/2 acre lot size & >100' frontage & >60' building setback)	Urban areas - curbs used extensively Rural areas - exercise caution in use of curbs Normally vertical curbs	None or roll-type curbs (low density) Vertical curb (medium and high densities)	Vertical or roll-type curbs at higher densities	8" vertical curbs (whenever sidewalk provided). Vertical curbs stop vehicles from parking on landscaped buffer strip	
Minor Collector Streets					8" vertical curbs (plus ADA entrance)	

Figure 7.1 (continued)

Typical Section Elements continued

	DelDOT	AASHTO	ITE	ASCE	RECOMMENDED	COMMENTS
+ Sidewalk Warrants (i.e. when and where to provide paved surface for pedestrian conveyance)						
Minor Streets	Not required by DelDOT-New Castle County requires on at least one side of all local streets with 10+ dwellings and densities of > 1 unit/acre and on both sides of minor collectors	Both sides in commercial areas, at least one side in residential areas.	Only at medium and high densities	Not required on access streets. One side of subcollectors.	2 units or more / acre sidewalks both sides; less than 2 units/acre to 1 unit/acre sidewalks one side; greater than 1 acre lots - no side walks All cul de sacs - sidewalks both sides	
Minor Collector Streets	Not required by DelDOT-New Castle County requires on at least one side of all local streets with 10+ dwellings and densities of > 1 unit/acre and on both sides of minor collectors	Both sides in commercial areas, at least one side in residential areas.	Both sides	Both sides	Both sides	
+ Sidewalk Widths (width of paved surface)						
Minor Streets Minor Collector Sts.	Not specified by DelDOT (New Castle County requires 5')	4' (8' or more may be needed in commercial areas)	4' to 6'	4' minimum with planting strip 6' without planting strip	5' (with buffer strip) 8' (without buffer strip) (at least 40 sq. ft. per person at peak times)	
+ Planting Buffer / Utility Strip (area between edge of pavement / curb and sidewalk or right of way line)						
Minor Streets	Not specified	12' (desirable)	5' to 6'	3' to 5' desirable	5' minimum Zero permitted for commercial uses with minimum 8' sidewalk	
Minor Collector Sts			10'	3' to 5' desirable	10' minimum, if lots front on residential collector streets	

Figure 7.1 (continued)

Typical Section Elements continued

	DelDOT	AASHTO	ITE	ASCE	RECOMMENDED	COMMENTS
✦ Alley Width (width of paved surface)						
Minor Streets	Not specified	16' to 20' in residential areas	20' (alleys allowed but discouraged)	12' (pavement) 16' (right-of-way) (recommended when lot widths are less than 50' wide)	12' (alleys or shared driveways are recommended when lot widths are less than 50') 12' paved width acceptable provided 20' open R.O.W. available Encourage utility placement along alleys.	
✦ Tree / Obstacle Clearance (distance from back of curb)						
Minor Streets	Clear zone - 2' in urban areas with barrier curb	1.5'		3'	2.5' from back of curb to centerline of tree One tree per 40 linear feet of right-of-way frontage, 2½" - 3" caliper and DelDOT clear zone requirements. Mature height restrictions to be established based on species to avoid conflicts with overhead utilities.	
Minor Collector Streets	Clear zone - 2' in urban areas with barrier curb	1.5' with vertial curbs (where no curbside parking) 2' with vertical curbs (where curbside parking)		3'	2.5' from back of curb to centerline of tree 5.0' if access fronts on the collector street	

L E S S O N 8

Tort Liability and Risk Management

8.1 Purpose

This lesson provides a working understanding of risk management principles, tort liability, and techniques for monitoring and evaluating existing facilities and programs. Key definitions are provided, along with information on litigation trends, exposure evaluation methodologies, successful risk-reduction strategies, and case study examples. Students will study examples that illustrate the importance of considering human performance in planning and design and of the role facilities play in creating predictable behavior. An understanding of tort liability and risk management issues will alert the designer to the need for evaluation and monitoring on an on-going basis and for creating built-in feedback systems. More and more lawsuits are being settled against government entities that adopt a "do nothing" posture. Identifying potential risks, doing something and then evaluating the results as part of a systematic program is proving to be a more defensible approach.

8.2 Introduction

To an increasing degree, issues of risk management and tort liability are becoming major determinants of planning, engineering, and implementation programs for bicyclists and pedestrians. Agency concerns about potential liability can either lead to innovation and substantially improved facilities and programs or they can lead to a "do nothing" approach. Ignoring risks does not make them go away. Taking systematic steps to identify and evaluate risks and to develop an effective risk management program are essential measures, even if your agency cannot afford to remedy all problems immediately.

Without a well-conceived and implemented risk management program, the courts become the de facto policy-makers.

Highway engineers, designers, and planners must consider the needs of the pedestrian and bicyclist. Design of streets, bridges, surface conditions,

maintenance, and operations must be all viewed differently with the increasing importance of bicycling and walking to people of all ages.

The very young, the old, and the disabled, in particular, must rely heavily on walking and bicycling for everyday transportation and exercise. Highway and recreational facility systems that fail to incorporate fully the needs of all users increase the likelihood of potential court settlements in favor of those who are excluded.

The needs of all users, young and old, should be incorporated into highway and recreation facilities.

all too easy to blame mishaps on "the bureaucrats" and to take them to court if the opportunity arises. When someone travels a roadway or a trail on a regular basis and a crash occurs, they generally look beyond themselves for someone to blame. It is tempting to pin responsibility on the faceless public agency most directly involved in design, maintenance, regulation, or operation of the facility. People may not only file lawsuits, but also become publicly critical of the agency and its programs. They become less likely to endorse budget increases and bond issues. If asked to serve as jurors in tort cases, they recall the negative experiences and perceptions and may filter facts through this bias.

Since most highway professionals are not routinely trained to design for the specific requirements of pedestrians and bicyclists, mistakes are common. The result is increased risk, which is often not identified until crashes occur. Training is especially important since many engineers and planners do not bicycle or walk extensively under the conditions for which they design.

8.3 Liability — An Issue of Increasing Importance

Just how significant is the liability issue? Hasn't this whole thing possibly been exaggerated? How much money is really involved? What do YOU think?

The total dollar amount of claims against U.S. highway agencies in a typical year is between $50 and $60 billion.

1. Planning, engineering, and public perception. Most of us know that planning and highway professionals work hard to address traffic problems, improve safety, save money, keep people and goods on the move, and meet many other praiseworthy goals on behalf of the public. Does the public we serve really understand the parameters within which we work? Does it support our objectives? Does it know the limitations we face – the schedules, budgets, and political pressures? Does it care?

Building and maintaining the public's confidence in the work of government is a constant struggle. It is

Implementing an aggressive and well-publicized risk management program can help head off these problems. An effective first line of defense is to build and maintain public confidence; to protect budget allocations for needed public works projects; and to foster a spirit of cooperation, not confrontation, between public and private sector parties.

Today, the newspapers and electronic news media frequently headline court settlements against public agencies that have allegedly failed to use good judgment or carry out their professional responsibility on behalf of public health, safety, and welfare. Some settlements now soar as high as $10 to $14 million for a single injury. Even minor lawsuits – which may be settled for as little as $5,000 – may require $10,000 to defend.

2. Governments can be sued for what they do. The examples that follow illustrate conditions that can lead to pedestrian and bicyclist injury. In these first two cases, the government was sued for an injury to a pedestrian or bicyclist on a facility that was specifically built to accommodate bicycling and walking.

Example:
An attorney was riding a bicycle on a sidewalk that years earlier was marked as a bicycle path. He did

not slow down when approaching a residential driveway on a semi-blind corner. He ran into a motorist exiting the driveway, hitting the car in the middle of the front-door panel.

Consequence:
Bicyclist sues motorist and the condominium owners for $750,000.

Lessons Learned:
The bicyclist will have a tough time proving that he was not guilty of contributory negligence in this case. Since he hit the middle of the car, it can be argued that he had plenty of discovery time had he been paying attention and riding in a reasonable and prudent manner. The car was moving very slowly, stopping to check for traffic and entering the street. The bicyclist's view of the driveway was partially blocked by a perimeter wall around the condo complex.

Signing any sidewalk as a bicycle path increases the likelihood of tort settlements even years later. By designating a sidewalk for bicycle use, you send the message that it is "safe" to ride there. Sidewalk facilities have built-in "booby traps" for the unsuspecting.

Sight-distance problems at intersections with streets, driveways, and alleys are common on sidewalk facilities. Most local zoning ordinances allow construction of rear and side yard walls to a height of 6 feet on the rear and side property lines. Since sidewalks are often located very close to rear or side property lines, especially in residential areas, walls on these property lines seriously limit sidewalk views for intersecting motorists.

Motorists expect pedestrians on sidewalks, not bicycles moving 10 times as fast. Bicyclists, with the wind in their ears, on two-wheeled vehicles, are not as sensitive to noise cues as pedestrians and not as maneuverable. It takes them much longer to react and stop.

Since sidewalks have historically been regarded as "pedestrian zones," the pedestrian movement pattern of two-way traffic prevails. Bicyclists using the sidewalk often think this applies to them too, and ride against traffic. They don't see stop signs at cross-streets (located to be seen by motorists on the other side of the street) and they are not part of the normal scanning pattern for motorists.

A person waiting to turn right will scan to the left for oncoming traffic, wait, and then move quickly to take advantage of a gap. At first, he may take a quick look right to see if a pedestrian is coming, but he seldom looks back. A fast-moving bicyclist can easily escape detection and a crash can result. For these and other reasons, sidewalks are not recommended for designation as bicycle facilities.

Example:
A wheelchair user is traveling along a sidewalk. The sidewalk is discontinuous, with an unpaved stretch of about 150 feet. To get around this, the wheelchair user moves into the street, going against traffic, gets stuck in sand on the shoulder of the road and falls over. He can't get up until a passer-by helps him, setting him upright and pushing him through 150 feet of sand to the continuation of the paved sidewalk. The wheelchair is damaged and the person is injured.

Consequence:
Pedestrian sues City, claiming negligence, and wins.

Lessons Learned:
Consider <u>ALL</u> users. Examine your community for these sorts of hazards and institute an aggressive retrofit program. The City was said to have led the

In order to see around obstructions near the corner, motorists often pull out beyond them, THEN stop to look for traffic. More often than not, this puts them right across the sidewalk.

wheelchair-bound person "into a trap." A continuous paved surface should be provided or warning sign posted well in advance.

3. Governments can be sued for what they do not do. "Do nothing" is not a viable option. In the two examples that follow, injuries occurred because a government did not take action to correct a potentially hazardous situation. More and more governments are being sued for failing to recognize public needs and take actions to meet them.

Example:
A pedestrian is walking along the sidewalk on a one-way street, facing the flow of traffic approaching a signalized intersection. Because the traffic signals are positioned to be seen by oncoming (one-way) motor traffic, the pedestrian can see neither the signal nor the "walk/don't walk" sign. He hesitates until he thinks he has a green light and then steps out into traffic. After getting partway across, he realizes that he has made a mistake, turns around suddenly, is hit and injured.

Consequence:
The pedestrian sues the City and wins. The City did not provide pedestrian-oriented traffic controls.

Lessons Learned:
Consider **<u>ALL</u>** users. Examine your community for these sorts of omissions and institute an aggressive retrofit program.

Example:
On a bridge that provides the main linkage to downtown, the surface is badly broken up, the pavement is deteriorated on the decking, and seams have been slurried over, leaving dangerous ridges. This bridge is known to be heavily used by bicycles and the City has written to the State three times asking that the bridge be repaired due to the potential hazard. Because of these and other hazards, bicyclists cannot ride too near the curb and crowd the motorists in narrow lanes. The State has not responded, despite repeated requests for action.

A semi-tractor trailer left his "Jake brake" on. As he approached the bridge, he released his foot, activating the brake, which caused a loud noise. A 23-year-old woman bicycling across the bridge heard the noise behind her and moved over closer to the curb. The trucker once again activated the brake, causing another loud noise as he approached the bicyclist. The bicyclist panicked, rode into the curb, fell, and was killed by the truck.

Consequence:
The bicyclist's family and the truck driver's insurance company both sued the State.

Lessons Learned:
Because of the letter written by the City and the length of time the condition had been present, the State settled out of court. In addition to the poor pavement conditions, it was found that the bridge sloped slightly to the right and the State had, over time, let the centerline of the roadway drift toward the right. The right-hand lane was 13 feet wide, while the left-hand lane width was 17 feet. The bicyclist was forced to share a dangerously narrow lane with both hazardous pavement conditions and heavy truck traffic.

The lesson here is to take action promptly in response to identification of hazards, even if it means only the interim measure of posting warning signs until the correction can be made.

4. Trends in tort settlements.
America is experiencing an increase in tort liability claims. The public and its officials can and should demand fairness in settlements; however, it is unlikely that we will see a dramatic reduction in charges and complaints. Trends indicate just the opposite:

Transportation system programs should be based on defensible standards.

- More lawsuits are being filed.
- Legal action is becoming broader in its scope — suing non-profits, families of those affected, as well as agencies and individuals.
- Government, well-insured corporations and professionals continue to be favored targets due, in part, to their perceived "deep pockets" and ability to pay.
- There is a tendency toward increased liability in areas that once had some degree of immunity.
- There is a continuing rise in the size of claims.

Insurance companies often settle rather than defend. People with a litigious bent are encouraged by the knowledge that insurance companies often settle quickly rather than bear the time and cost of defending themselves against relatively low-dollar claims. The courts are, in this way, taken out of the process. The knowledge that even a frivolous lawsuit may net someone $50,000 to $100,000 is a strong incentive to sue! It's a crazy world, but risk management is here to stay. It is important that agencies and organizations understand it and structure their actions accordingly.

The Impact of These Trends
The issue of risk management is becoming a major factor in decisions about implementation of capital projects and programs. The high costs associated with risk management have, in some cases, meant that things just don't get built or programs don't get funded. Decision-makers are getting gun-shy. Ignoring the problem, however, won't make it go away. As we stated earlier, governments are just as often sued for what they don't do as for the actions they do take.

The best approach is to develop a strong, pro-active program to plan, design, build, maintain, and operate a fully balanced transportation system that responds to the needs of all potential users. The program must be based on a diligently applied set of defensible standards and a public process that allows involvement by all affected parties. An agency's ability to demonstrate that it is aware of potential problems and is taking systematic steps to address them is very important.

8.4 Some Basic Definitions

To negotiate the legal minefields successfully, a working knowledge of some basic terms is useful. What, really, is a tort? What is proximate cause? Negligence? Sovereign immunity? Additional discussion of related concepts follows:

1. Tort.
Definition: A wrongful act, not including breach of contract or trust, that results in injury to another person's property or the like and for which the injured party is entitled to compensation.

When an individual is harmed by another party without criminal intent, he or she may be able file a tort claim. The tort claim must be based on establishing that the party had a duty to perform relative to the injured individual and that this duty was not performed with ordinary care, in a reasonable and prudent manner. An injury resulting from a breach of contract or trust does not fall within the definition of a tort.

Example and Discussion:
A 32-year-old mother of three was permanently disabled when she lost control of her bicycle, went off a multi-use path into a drainage ditch, and fell. Her back was severely injured when she struck a rock on the far side of the ditch.

It was found that the bicyclist was not warned of the potential hazard and thus was surprised by it. Once she went off the path, there was a trap in the recovery area. The assumption that design for low-speed use only was acceptable was found not to be valid. The City was responsible to design for expected speeds and could have been found at fault in this case.

How could the path have been designed to minimize the chances of this type of accident?

The path was originally designed as a pedestrian walkway and later designated as a "bike path" without modifying it to bring it into conformance with AASHTO or other accepted design standards for multi-use facilities.

When it was built, the path met current standards for pedestrian use. The cost of rebuilding it to accommodate bicycles was thought to be excessive by the City Council and signs were simply added to the existing path.

The rationale for this action was that the path was meant for recreational use and that improving it to AASHTO standards would encourage high-speed bicycling that would endanger pedestrians. It was thought that the narrow width and tight turns would force bicyclists to ride slowly and use caution.

The woman injured in the crash approached the turn in the path at a reasonable speed. Her view of the ditch was blocked by tall shrubs at the edge of the path. The horizontal radius of curvature for the path was far below AASHTO standards for a reasonable design speed. The path was designed for a maximum speed of 11 mph, while AASHTO recommends a 20-mph design speed on level terrain, with a 125-foot stopping sight distance.

The edge of the path dropped off directly into a culvert, with no shoulder provided.

Swinging a little wide on the turn and having no available recovery area, her tire dropped off the edge of the path into the culvert, and her bicycle flipped, sending her flying to the far side of the drainage ditch.

If the substandard radius on the curve had not caused a loss of control, and if the bicyclist had been able to see how tight the curve would become, and if the culvert had not been in the curve alignment, then the crash might not have occurred. The substandard design, then, is viewed as the proximate cause of the injury. Proximate cause must be proven to establish negligence in court.

The City maintained that it was not designing for the high-speed bicyclist, but for the novice recreational rider who would not go fast.

The courts found this position to have contributed to the cause of the accident.

This "contributory negligence" often results in rulings against settlements favorable to the defense.

How could the path have been designed to minimize the chances of this type of accident? Designers need to anticipate use by all types and ages of travelers – motorists, pedestrians, bicyclists; young, old, disabled, or hale and hearty. Only by understanding pedestrian and bicyclist behavior, perceptions, and operations as well as most traffic engineers understand motorists can these problems be avoided in the future.

2. Negligence.
Definition: An act or omission within the scope of the duties of an individual, agency, or organization that leads to the harm of a person or of the public; the failure to use reasonable care in one's actions.

To prove negligence, the plaintiff's attorney must prove each of these conditions:

- The defendant has a duty to use reasonable care:
  Do the defendant's <u>duties</u> include responsibility for some element of the accident (site, vehicle, etc.)?

- The defendant did not responsibly carry out that duty (was negligent):
  Did the defendant exercise ordinary care performing his or her duty in a reasonable and prudent way?

- The defendant's failure to carry out that duty (negligence) was directly responsible for the injury ("proximate cause").

- The plaintiff was not guilty of contributing to the cause of the accident through contributory negligence.

- The plaintiff incurred damages resulting from the crash.

How is a judgment of negligence against government won?

It is not easy to prove negligence within the context of the four conditions specified above. However, negligence must be proven if a judgment is to be won. The example that follows is taken from an actual case where negligence was alleged.

Example:
The Florida Department of Transportation was charged and tried in a civil court with negligence as a result of the bicyclist falling on the bridge (Miller v. FDOT).

How Did the Injury Happen?
The bicyclist's wheel fell into a bridge counterweight slot. The rider was pitched forward, sustaining serious facial injuries on the grating. The rider was a professional model and an experienced bicyclist. She brought a tort charge against the State, which had to be defended.

How Would You Rrule?
The bridge was built more than 30 years ago, before bicycling became popular. There was no designated bicycle facility on the bridge. The bicyclist was riding to the far left of the lane. Was this a legal location for the bicyclist? Was this position within a narrow lane a logical location? Did the bicyclist have sufficient discovery time to see and avoid the slot? Could an adult with 8 years of bicycling experience, and who served as a ride leader, and who had been over this route a dozen times previously, have anticipated this danger? Considering your answers to these questions, can the five conditions necessary for negligence be proven?

How Did the CourtsRule?
In this case, the court ruled against Florida DOT and the case was settled for $250,000. It was argued that FDOT was negligent for the following reasons:

- FDOT had a duty to design, operate, and provide maintenance services for the bridge. The open counterweight slot constituted a maintenance condition. The government had a duty to maintain and operate a safe road for all users. Florida DOT, furthermore, had a duty to warn the public of an unsafe condition, and had failed to do so. It was argued that the agency knew that bicyclists used this bridge, and that there had been previous bicycling crashes on this grating and associated with this slot.

- The open slot had been previously reported as needing correction; but the correction had not been made. It was, therefore, argued that FDOT had not carried out its duty in a responsible manner. Even though the correction had not been made, it could have warned bicyclists of a potential hazard.

- The slot was the proximate cause of the crash. The bicycle wheel fell through the slot and precipitated the crash.

- The bicyclist may have significantly contributed to the crash (been guilty of contributory negligence): (a) she was riding in both an illegal and illogical place on the roadway; (b) she was riding too fast for bridge conditions; (c) she rode this route at least weekly and should have been aware of the hazard; (d) she was riding directly behind another bicyclist so she did not see the slot until it was too late to take evasive action; and (e) she was an expert bicyclist with 8 years of experience who served as a ride leader and officer in a bicycle club that used this route weekly; as a leader, she had a responsibility to know and alert others to potential hazardous conditions along the route.

- The bicyclist, a professional model, suffered severe facial damage. The damage claims were found to be real and significant. A $250,000 settlement was awarded.

3. Ordinary Care.

Definition: Courts base settlements on the level of care that a reasonably experienced and prudent professional or other individual would have taken in the same or a similar event or action. This level of care is referred to as "ordinary care."

"Ordinary care" is distinguished legally from "extraordinary care," which parties are not expected to meet. Standards for separating "ordinary" from "extraordinary" are based on the expectation that 85 percent of travelers operate in a responsible manner (the 85^{th} Percentile Rule).

Highway professionals are charged to design, operate, and maintain highways for the reasonably prudent traveler.

Example:

In a private development, a bicyclist transporting a child crashed into a second bicyclist, also transporting a child. One was approaching a blind corner leading into an underpass from a lateral path providing street access to a greenbelt path. Because of limited clearances within the underpass, the bicyclist rode toward the middle of the underpass. He did not see the other bicyclist (approaching through the underpass from the opposite direction) in time to avoid a crash.

The case was settled against the developer.

The project designer did not offer the same level of care for the bicyclist and pedestrian as was offered to the motorist. The needs of all potential users must be given equal weight.

It was argued in court that motorists on the bridge were given the advantage of full design, signing, and operations treatments based on AASHTO standards, but the bicyclists in the underpass below were left to "fend for themselves" in an abandonment of design principles.

4. Sovereign Immunity.

An agency that has full "sovereign immunity" is not required to pay settlements. Partial immunity puts a cap on how much can be awarded or limits exposure to certain areas, such as maintenance and operations.

a. Limited Immunity.

Today, most States and some counties have limited immunity. Florida, as an example, has a maximum settlement amount of $250,000 per incident. If the courts award a settlement in excess of this amount, the plaintiff has to appeal before the legislature for the difference.

Very few States still have full sovereign immunity, where a plaintiff must request a waiver to win a government settlement. Some States allow lawsuits, but specify that they must be filed within a short period of time following the injury or limit the amount of the suit.

The same level of design, planning, and maintenance should be offered for the bicyclist and pedestrian as is done for the motorist.

To date, few lawsuits have been won against the Federal Government, although many suits are filed.

An example of this type of case is Coleman v. USA, where the National Park Service is being sued for a bicycle crash that occurred when a bicyclist crossed the centerline of a roadway to pass other riders during a large, mass bicycle ride. In moving left to pass, he hit a concrete seam along the center of the road at an oblique angle. His wheel caught the seam and he went down. Although this case is still pending, the Park Service is saddled with the expense of a defense.

b. **What is Your Liability Limit?** Many governments have partial immunity, others have sovereign immunity. Consultants and corporations have no immunity. Non-profit corporations are losing the immunity they once had. Individuals seldom have immunity.

c. **Design decisions may have protection, but maintenance and operations do not**.
Certain actions have full or partial immunity from legal action. As a general rule, governments still enjoy some immunity in the area of design, although this, too, is eroding.

There is little immunity for actions related to operations or maintenance. Lawsuits relating to signing, warnings, surface conditions, poor maintenance, and similar factors are among the most difficult cases to defend.

A systematic assessment of potential liability is the first step toward a proactive position.

Example:
A well-educated adult bicyclist, riding in the correct direction on a bicycle lane, suddenly swerved left into the traffic lane, where he was hit broadside by a car going 55 mph. He was thrown 120 feet, landed on his head and, sustained severe brain injuries.

Who Was Sued?
In this case (Boyd v. Illinois), the lawsuit was filed against the bicycle manufacturer and the construction company, since the State of Illinois refused liability under legislative immunity.

Why Did the Bicyclist Lose Control?
The bicycle lanes are on a highway bordered by steep cliffs on one side and a river on the other. On the river side of the highway, maintenance of the lane is so poor that many bicyclists opt to ride against traffic, along the cliffside lane, where the surface is in much better condition. They prefer to take their chances with oncoming traffic rather than risk a fall from broken pavement and the ever-present gravel, dirt, and debris along the river. The cliffside bicycle lane is routed within the narrow zone between curb and motorway. This zone traps a two- to three-foot-wide pile of debris and sediment, especially after storms, leaving a perilously narrow strip for bicycle movements. The bicyclist in the example lost control when a wrong-way cyclist suddenly challenged him for his narrow portion of the lane.

Poor design (curbing and low-grade surfacing and construction quality) in this case led to a poor maintenance condition on both sides of the highway. The extremely poor maintenance on the river side led to an operations problem when bicyclists routinely elected to ride against traffic to maintain their stability rather than cope with the dangerously deteriorated pavement along the river.

8.5 Identifying Your Level of Exposure

1. The General Process.
Given the trends discussed earlier, it makes sense to adopt a proactive position. By developing a realistic assessment of the degree to which your agency may be exposed to potential liability problems, you will have taken an important first step toward developing a practical risk-reduction strategy. It is important that this assessment be systematic, keyed to anticipate and counteract a wide range of legal actions and that it involve all affected public and private parties.

a. Document the scope of your specified duties.

b. For each type of duty, prepare a detailed list of the actions involved in carrying it out.

c. Do some homework. Research the crashes and lawsuits that have occurred in your community.

d. For each action, document or develop a reasonable standard or set of criteria to be followed, taking into account their impact on all potential users.

e. Systematically evaluate your present programs and facilities according to the criteria and standards defined for each action.

f. Set priorities for action.

This process should provide a good idea of the strong and weak points of your programs and facilities and an overall picture of your level of exposure. By working thoughtfully through a systematic analysis of what it takes to carry out your assigned duties and a realistic assessment of how well programs and facilities measure up to accepted standards, you will probably learn a great deal and establish a strong direction for subsequent development of a practical risk-reduction strategy.

2. Scottsdale, Arizona Case Study.

Let's look for a moment at a recent case study from the City of Scottsdale, Arizona. Scottsdale has historically been a leader in the provision of bicycle facilities. Since the early 1970's, an extensive and popular multi-use pathway system has evolved–a north-south spine through the most populous part of the city. The paths are used by many commuters, but were designed primarily as recreational facilities. They are now 15 to 20 years old. Some portions were built to standards that are now outdated or are more appropriate to pedestrians than to bicyclists. Use of the paths has increased, along with potential conflicts and the diversity of users. There have been crashes and lawsuits filed.

In 1989, Scottsdale voters approved $214,000 in bond money for bicycle path improvements. This amount was not enough to bring the pathway system into complete conformance with current standards, but it was an important first step. The City commissioned a study to provide the City with a fully justified basis for developing a risk-reducing improvement program within available funding limitations.

Specifically, the study provided:

- Detailed documentation of existing conditions.
- Review of applicable standards and criteria.
- Analysis of existing conditions in the context of these standards.
- Priorities for implementation.
- A recommended action program.

The *Scottsdale Bicycle Path Improvement Study* focused on giving the City a <u>useful</u> tool for reducing risk along its pathway system through a prioritized set of recommended improvement projects.

3. Is Ignorance REALLY Bliss?

The comment is sometimes heard that if all these potential hazards are identified, then the agency's liability may <u>increase</u> since the agency can be shown to have been aware of the hazards without correcting them. Are you really less vulnerable if you <u>don't</u> know what the problems are?

In a word, the answer is "NO." Its not <u>quite</u> as simple as that, but here is a summary:

a. What if you don't know about a potentially hazardous condition and an injury occurs?

The success of your defense may, in part, depend on how discoverable the condition was. The question is often asked, "Did the agency have time to discover its error?" If a crash happened during the first week this condition existed, there might be a strong defense since there was not sufficient time to discover the error. If 2 years had gone by before the crash, most courts would rule that there was plenty of time for the agency to discover the condition and correct it.

If It's Broken – Fix It
Sometimes a condition is so patently unfair to the public that an injured party will bring a suit where he or she would normally accept most blame. For more than 15 years, bicyclists have been fighting governments that have tried to keep them out of the roadway. If a pedestrian were injured by a bicyclist on a sidewalk, one or both parties might file a case against the government for forcing the bicyclist into a space that does not provide reasonable and prudent sight distances, operational widths, and, which now violates many laws, design standards, and accepted practices.

Example:
Difficult Maintenance Conditions (Walden v. Montana). A bicyclist descending an interstate ramp into Great Falls, Montana, was slipstreaming two fellow bicyclists at high speed. At the pinch point, where the guardrail and the lane narrow, the bicyclist came alongside his friend. The friend moved out from the guardrail, forcing the cyclist into the seam separating the travel lane from the ramp lane. Hitting the lateral seam, the cyclist crashed, landing on his head at more than 35 mph.

Was Montana responsible for maintaining a concrete/asphalt joint to meet the needs of the bicyclist on an interstate?

This case was tried and won for the defense, and upheld in the State supreme court. The bicyclist contributed significantly to his own injury. The highway department had a serious uncorrectable groundwater problem that made it difficult to maintain a better joint. The joint met AASHTO standards for preventing tire scuffing and vehicle deflection problems at such a location. Signing the specific nature of the hazard for a bicyclist, who would normally stay on the 10.0-foot shoulder, was not required to meet the standard of ordinary care, which requires highway professionals to design, operate, and maintain highways for the reasonably prudent traveler.

b. What if you have been made aware of a potentially hazardous condition and an injury occurs before you have taken steps to correct the condition?

Agencies have a responsibility to fix problems, but the courts tend to favor good will and intent to find solutions, even if some conditions are too expensive to fix immediately.

Again, a great deal will depend on the length of time that has passed between identifying the condition and the injury. If it can be shown that a reasonably short period has elapsed and that the agency or other party is taking positive steps toward correcting the condition, the defense position will be improved.

If a city, for example, conducts a study to identify areas of potential risk along a recreational trail system and does not have sufficient funds to immediately make all corrections indicated by the study, all is not lost!

If a crash occurs and the city can demonstrate that it has a well-documented program of risk reduction and that it has taken some interim steps (such as warning signs and markings) to alert trail users to potential risk areas, its defense is strengthened. If it had not identified potential risks and taken steps toward risk reduction, the city's defense would have been substantially weakened.

Signing a hazardous condition has long been recognized as an important interim treatment for many conditions. Failing to sign a known condition is difficult to defend.

Signing and warning offers two types of benefits: (1) People are more cautious, so the number of crashes and injuries are reduced; and (2) The attempt to alert the public about a potentially hazardous condition generates good will and makes it more difficult for a plaintiff's attorney to argue that the plaintiff was surprised by the condition. Signing should make use of international symbols, and follow standard signing and marking practices found in the MUTCD (*Manual on Uniform Traffic Control Devices*).

c. What if you have identified a potentially hazardous condition and have taken steps to correct it?

What if you have trimmed shrubs that blocked sight distances, widened a tight turn to meet AASHTO standards, and added rideable shoulders to a path and STILL someone loses control and is injured? Assuming the agency responsible for the path has carried out its duties using ordinary care in a responsible way, it would be more difficult to prove negligence. The burden of responsibility may well shift to the bicyclist or other injured party whose contributory negligence may have led to the accident.

8.6 Cases That Lead to Quick Settlements Against a Government

Now that we have discussed methods for evaluating risk, common design errors, and general ways of strengthening your legal position, it may be useful to look at some of the most common lawsuits—the ones government employees stay up nights worrying about because they are usually settled quickly in favor of the injured party. Some of the most important pitfalls to be avoided are:

a. Open drainage grates in the travelway.

Lawyers refer to these as "waiting traps." Much research has been devoted to analysis and design of bicycle-safe, hydraulically efficient drainage grates. Temporary solutions are simple and cost-effective. If the grate cannot be replaced immediately, it can be rotated 90 degrees or temporary strips can be welded across it. It can be marked as a potential hazard.

This pedestrian signal would not be accessible to all users. How can a child reach this to cross the street safely?

b. Paths that end suddenly at "bad" locations with no transition or escape route provided.

In court, you will hear that these sorts of paths "lead the customer into a trap." All facilities should be ended logically, with a reasonable warning ("Path Ends"), a transition to an alternate route and some design precautions taken so the inattentive path user is not launched off a cliff, slammed into a barricade around a blind corner, or otherwise penalized too harshly.

c. Inadequate curve radii.

Many designers are not aware that <u>speed</u>, not vehicle design, is the sole determinate of the proper radius of curvature. A bicycle and car going the same speed, say 20 mph, each need a 95-foot horizontal radius for turning. If anything, the bicycle needs a slightly wider path in a curve, since bicyclists lean into a turn, taking up slightly more space. Design speeds of 20 mph on flat terrain and 30 mph for grades up to 4 percent are recommended by AASHTO guidelines.

d. Long-term, severe surface irregularities.

The longer that surface irregularities such as broken pavement, potholes, raveled edges, bumps, seams, and gutter edge build-up are left unattended, the greater the potential exposure and the more difficult it becomes to convince a jury that you did not know the condition existed. The jury will be convinced that the condition was discoverable, and you may be found negligent.

e. Poor sight distances

Like motorists, bicyclists need time to identify and react to potential hazards, such as tight turns, obstructions in the travelway and intersecting motor vehicles, pedestrians, and other bicyclists. At least 6 seconds of discovery is needed to allow adequate reaction time, mechanical set-up, and braking to a stop. At 20 mph (29.33 feet/second), this is a distance of 176 feet. Walls and vegetation most often block views, but sometimes, sight distances can also be limited by steep hills (cresting sight distance) or curves on steep grades. Identify these problem areas. Install warning signs and/or remove obstructions.

All facilities should end logically, with a reasonable warning, and an alternative route, so that the user is not suddenly "trapped."

f. Roadway design, planning, operation, and maintenance that do not consider bicycle and pedestrian use.

It is no longer acceptable to plan, design, or build roadways that do not fully accommodate use by bicyclists and pedestrians. The bicycle is seeing increased use for transportation and the health benefits of walking are receiving greater attention. There have now been more than 20 years of experience with designing for bicycles in the Unite States, with millions of dollars devoted to research and planning. With every passing year, the courts become less and less sympathetic to agencies that have not understood the message: bicyclists and pedestrians are here to stay. Make sure your staff is knowledgeable about planning, design, and other aspects of non-motorized travel. Be sure to take all modes into account.

Courts have become less and less sympathetic to agencies that do not consider the needs of bicyclists and pedestrians.

g. Bridges and underpasses that are hazardous to bicycles and pedestrians.

Like motorists, bicyclists need to cross bridges to get to some destinations. Bridges are expensive to build and difficult to retrofit for bicycling.

Example:
A bicyclist descended a steep grade at high speed in low-light conditions, hit the depressed drainage area next to the sharp guardrail, and lost control. The cyclist, drafting a friend at 17 mph, was contributing significantly to his risk.

Although settled out of court, FDOT had to consider the appearance of the many protruding rails, posts, and other conditions that would have been seen by a jury.

Risk Management Tip: Pay close attention to bridges. Bridges have many surface conditions, maintenance problems, and operations problems that must be dealt with. A facility of any length is only as safe as its weakest link — often the bridge.

h. Poor maintenance of off-street facilities.

Many agencies have been successfully sued when people slop on gravel, sand, grass clippings, standing water, deteriorating pavement, and similar conditions. Bicycles are particularly sensitive to litter, debris, and other materials. An aggressive maintenance program is essential for all designated facilities. Develop a method for identifying and correcting problems in a timely manner.

Spot Maintenance and Improvement Programs:

Many communities have implemented a special annual fund to attend to pedestrian and bicycling facilities spot improvements. They have asked bicyclists and others to alert them to any poor maintenance conditions. This fund and response system allows the cities to respond to a hazardous condition within 48 hours of discovery.

8.7 References

Text and graphics for this section were taken from Drake and Burden, *Pedestrian and Bicyclists Safety and Accommodation Participation Workbook,* NHI Course No. 38061, FHWA-HI-96-028, 1996.

For more information on this topic, refer to:

American Association of State Highway and Transportation Officials, *Guide for the Development of Bicycle Facilities*, 1991.

American Association of State Highway and Transportation Officials, *A Policy on Geometric Design and Highways and Streets,* 1990 edition.

Betty Drake, *Scottsdale Bicycle Path Improvement Study,* Gruen Associates and Baker Engineers, 1991.

Federal Highway Administration, *Manual on Uniform Traffic Control Devices (MUTCD),* 1988 edition.

L E S S O N 9

Bicycle and Pedestrian Connections to Transit

9.1 Purpose

Bicycling and walking typically account for one-fourth to one-half of all personal trips in European cities, as well as the vast majority of all public transportation access trips, even in lower density suburban areas. This stands in sharp contrast to the United States, where the share of personal trips made by non-motorized means fell in recent decades to less than 10 percent, and where automobile park-and-ride accounts for a major share of suburban transit access (FHWA-PD-93-016, *The National Bicycling and Walking Case Study No. 17: Bicycle and Pedestrian Policies and Programs in Asia, Australia, and New Zealand*, 1993).

The U.S. Congress emphasized connections between transit and bicycle and pedestrian facilities in the Transportation Equity Act for the 21st Century (TEA-21), providing several funding sources for bicycle and pedestrian improvements through the Federal Transit Program. In one example, TEA-21 created a Transit Enhancement Activity program with a 1-percent set-aside of Urbanized Area Formula Grant funds designated for, among other things, pedestrian access and walkways, and "bicycle access, including bicycle storage facilities and installing equipment for transporting bicycles on mass transportation vehicles."

This lesson discusses the history of bicycle and pedestrian access to transit in the United States, and provides an overview on how bicycling and walking is being integrated with transit. Case studies from the United States and Europe describe successful projects.

9.2 Introduction

In city after city, transit agencies are discovering that bicycles and transit are agood combination. The popularity of linking bicycles with transit is demonstrated in Phoenix, for example, where a 1997 study found that there are more than 2,100 daily users of bike-on-bus racks.

In Aspen, Colorado, bus operators must often turn away bicyclists in the summer mountain biking season; in Austin, Texas, and Seattle, Washington, transit agencies recently decided to equip their entire

fleet of city buses with bike racks. And on the West Coast, a manufacturer of bus racks for bicycles reports sales in 80 transit agencies in more than 30 States. (*National Bicycle and Pedestrian Clearinghouse Technical Assistance Series, No.1*, 1995)

Lack of adequate bike parking is a common problem at urban subways.

9.3 Overview of the Problem

While U.S. transit authorities have expended considerable planning and engineering efforts to meet pedestrian needs in the interiors of transit stations, in many cases, little attention has been devoted to either the pedestrian or bicycling environment to and from stations. Poorly developed inter-jurisdictional and interagency cooperation often impedes consideration of the door-to-door experience of using public transportation. It is not unusual for several different agencies to maintain independent control over the various facilities that are used by someone walking or cycling to and from a single transit stop.

Unless these agencies agree to cooperate together in assessing, planning, and enhancing non-motorized transit access, major impediments to pedestrian and bicycle access may persist or grow in severity. Local and State governments with the authority to manage, maintain, and construct pedestrian and bicycle facilities and roads should cooperate with transit agencies and interested citizens in developing action programs to reduce barriers to bicycle and pedestrian access to transit.

METRO of Seattle, Washington, for example, is working to integrate non-motorized access to transit from the beginning in plans for new regional transit services, rather than as an "add-on" to already designed transit projects. In December 1991, METRO published a *Non-Motorized Access Study*, which was a study conducted to assess the potential of and make recommendations for incorporating bicycle and pedestrian access into the system plan for Seattle's Regional Transit Project. The Regional Transit Project examines two future rapid-transit alternatives for the region — a transitway alternative (bus and high-occupancy vehicle (HOV) facilities) and a rail system alternative (light rail). The study notes:

"The potential commuter travel shed surrounding a transit line can be increased by adding station and vehicle amenities to allow easier interface between bicycles and the transit system."

Among the study's key findings are the following:

According to 1990 NPTS data, 53 percent of all people nationwide live less than 2 miles from the closest public transportation route.

- Approximately 1 million people live within a 2-mile (desirable biking distance) radius of the proposed rapid-transit system stations (a significant potential transit market).
- Agencies that have made improvements for bicycle access to stations see substantial increases in bicycle ridership at those stations.
- Transit vehicle (bus and rail) modifications and facility access requirements can be accommodated at relatively modest capital costs. (FHWA-PD-93-012, *The National Bicycling and Walking Case Study No. 9: Linking Bicycle/Pedestrian Facilities With Transit*, 1992)

9.4 Pedestrian Access to Transit

Walking is the most environmentally friendly and low-cost way to get people to and from public transportation. When given sidewalks or traffic-calmed streets to walk along, safe and convenient ways to cross streets, and a comfortable and attractive environment, most people are willing to walk farther to reach public transportation.

In the United States, however lack of attention to pedestrian needs beyond the bounds of the transit station seems fairly common. The location of park-and-ride lots is often not amenable to non-motorized access. One transit agency commented that all of their park-and-ride lots are located near freeways and/or shopping areas where residential housing is quite far away and there are no paths or sidewalks located near the park-and-ride lots.

Some U.S. transit and transportation agencies, however, are showing a growing and promising awareness of the need to focus on the larger environment that surrounds and leads to transit stations and bus stops:

Charlotte

The City of Charlotte, North Carolina, began a project in 1981 to encourage walking and bicycle access to bus transit along its heavily traveled Central Avenue Corridor, which contains seven intersections at Level of Service (LOE) E or F during the peak hours. To help address bicycle access needs, 20 bicycle racks and 3 lockers were installed at key bus stops. Pedestrian access was improved by installing 114 pedestrian signals and 115 push buttons at key intersections, and sidewalks were constructed with curb-cut ramps.

Los Angeles

The Southern California Rapid Transit District (SCRTD) has developed an interactive computer demonstration of the sidewalk "level of service" effects of pedestrian overcrowding. This was used in a successful effort to mitigate a plan by the Los Angeles Department of Transportation to take sidewalk space away from a rail station area that will serve the intersection of the RED and BLUE rail transit lines. SCRTD has also completed a plan to improve pedestrian access to the Hill Street Metro portals, including wider sidewalks, pedestrian shortcuts to key destinations, trees, and a pedestrian walkway connecting the Museum of Contemporary Art with the newly installed "Angel's Flight" cable railway.

Houston

METRO of Houston recently entered into a program to implement sidewalks along major roads to provide access to their transit facilities.

Sacramento

All-light rail transit (LRT) stations in Sacramento, CA, except one which is located in a freeway right-of-way, provide at-grade pedestrian and bicycle access. Some 17 of the system's 28 stations are within three blocks of a city or county trail facility. Linkages at most stations are via residential or connector streets with low traffic volumes, presenting fewer problems for people on foot or bicycle. Four LRT stations are located on pedestrian/transit malls.

Portland, Oregon

Portland offers an outstanding example of linking pedestrian facilities to public transportation. Reallocating street space downtown to transit and pedestrians has helped keep the central business district healthy, retaining a much higher share of regional retail activity than in other cities where downtown area has declined. *(NBWS Case Study No. 9)*

9.5 How Are Bicycles Being Integrated With Transit?

A variety of facilities and services are being provided: bike racks on buses; provisions for the transport of bicycles on light- and heavy-rail transit, commuter rail, and long-distance trains; bike parking at transit stations; design improvements at transit stations (curb cuts, signing, and lighting); links to transit centers (bike lanes, multi-use trails, and widened roadway shoulders); and bicycle-ferry programs.

A thorough discussion of the issues surrounding the implementation of bicycle-transit integration is found in two documents: *Linking Bicycle and Pedestrian*

The preferred style of bike rack mounts to the front of the bus.

Facilities With Transit, National Bicycling and Walking Study, Case Study 9; and *Integration of Bicycles and Transit*, Transportation Research Board (TRB), 1994.

1. Transit Agency Concerns: Safety, Schedule Delays, and Equipment.

Schedule Adherence.
The TRB study shows that most transit agencies are not experiencing problems with schedule delays; new bike-on-bus rack design has minimized dwell times for loading and removal.

Safety and Protection of Transit Property.
The TRB study has also shown that the impact of bicycle-transit integration has been minimal on the personal safety of bicyclists, operators, or the public, and on transit agency property. Bike racks on the fronts of buses have not proven to interfere with driving. Rail operators attribute their positive safety record to a permit process used by most agencies that educates bicyclists about the program and ensures that they will not have a detrimental impact on the system.

Equipment Procurement.
Much of the equipment needed for bicycle-transit integration is now easily obtainable. With regard to equipment procurement, transit agency personnel must take into consideration design criteria, technical specifications, and capital costs.

2. Bicyclist Concerns: Fares, Permits/Fees, Restricted Hours, Parking, and Access.

Many bicyclists contend that time-restricted access lowers use among everyday bicyclists. For example, in Washington, DC, a lack of early morning access for the bike-on-rail program leaves unserved those commuters who could use their bikes for egress from Metrorail stations to job sites and schools. Programs that require permits discourage use by tourists, other visitors, and local residents who may be casual users.

Additional fares for transporting bikes also creates a disincentive for use, however most transit systems have not instituted such fares. (*National Bicycle and Pedestrian Clearinghouse Technical Assistance Series, No. 1*, 1995)

9.6 Bike-on-Bus Programs

Bike-on-bus programs are functionally similar to bike-on-rail programs, but often operate in much lower density corridors than rail transport. By expanding a bus line's access and egress service area, bike-on-bus programs can attract many passengers who would not otherwise be able to use transit for their trip, particularly to reach suburban destinations where transit coverage is often sparse.

There are three means of accommodating bicycles on buses — rear-mounted racks, front-mounted racks, and allowing bikes inside the bus. Rear-mounted racks were the earliest type of systems, but preferences appear to have shifted toward front-mounted racks. At least three transit systems now use rear-mounted racks — San Diego Transit, Humboldt Transit Authority in northern California, and the Santa Cruz Transit District in California. Two agencies that previously used rear-mounted racks– North County Transit in northern San Diego County and Windham Regional Transit in Willimantic, CT– have changed their policies; the former to front-mounted racks and the latter to a policy that permits bikes inside the buses.

Most U.S. bike-on-bus services do not require a permit, in contrast to most U.S. bike-on-rail services. While most U.S. transit systems accommodate bikes only on designated routes, a few cities, such as Phoenix, AZ, Aspen, CO, and Sacramento, CA, have no route restrictions and have opened their entire system to carrying bicycles.

Some transit agencies allow bicyclists to carry their bikes onto trains and buses.

The City of Phoenix began a 6-month bike-on-bus demonstration program from March through August 1991 to assess potential use of the service. Bicycle racks were mounted on the front of buses operating on three routes that were selected based on criteria developed in coordination with the bicycle community. Two-thirds of the $15,000 program cost came from a grant by the Arizona Department of Environmental Quality. During the demonstration program, 5,500 bicycle trips were taken and ridership steadily increased. At the end of the first month, 153 riders had used the service. By the end of the third month (May), this jumped to 1,109 riders per month and by the end of the 6 months, there were 1,404 riders per month. Phoenix Transit reported no safety problems associated with the new service. The service not only attracted increasing numbers of bicyclists, but also attracted to transit people who did not previously use buses. A Bike Rider Survey found that the vast majority (90 percent) of the bus riders used the bike racks for commuting. An evaluation of the demonstration concluded:

"From the response received, it would not be a stretch to say that the program was overwhelmingly popular among transit riders and [was] hailed as an excellent idea by bike riders. For bus patrons it is an added option, for bike riders it is an opportunity, and for public transit it is another step toward reducing the number of vehicles traveling on the road."

As a result of the successful demonstration, the Phoenix Transit bike-on-bus program was expanded system-wide in July 1992. By 1997, all 463 buses in the Phoenix system were equipped with front-mounted bike racks, each of which carried two bikes. A survey in 1997 found that there were 2,146 daily users of the bike racks within Phoenix alone (not including use outside of Phoenix).

Although most transit agencies offering bike-on-bus services have relied on various devices outside the bus, a few agencies have decided that added hardware is unnecessary and have allowed bicycles inside their buses. Westchester County Department of Transportation (WCDOT), located near New York City, simply adopted a permissive "welcome aboard" policy toward bicyclists and other potential users beginning in the late 1970s. The space provided for wheelchair-bound passengers could be used by those traveling with baby carriages, shopping carts, bulky packages, or bicycles. This policy applied only

to handicapped-accessible Advanced Design Buses and only in non-peak periods. Wheelchair users were given priority over bicycles at all times. No problems had been reported with the service.

9.7 Bike-on-Rail Programs

The first American commuter rail system permitting bicycles in passenger coaches in recent years was the Southern Pacific Railroad (SP), serving San Francisco and San Jose. A 4-month demonstration project in 1982, sponsored by the California Department of Transportation (Caltrans), allowed cyclists to secure their bicycles in the aisles of the rail cars at no charge during non-peak hours. No permit was required. Southern Pacific's management, however, showed little enthusiasm for the project and demanded payment of $73,000 by Caltrans to indemnify SP for potential accidents. While there were no schedule delays, injuries, or inconveniences to other passengers during the 4-month demonstration, lack of publicity and a short program duration resulted in low bicycle use–only about 100 users per week. SP management's demand for costly insurance payments — more than $100 per bicycle trip — resulted in the program being dropped.

Connections between transit systems and bike networks and pedestrian trails make it obvious how convenient these options of travel are.

At the time of the Caltrans demonstration project, only two other North American rail systems had carried bicycles for more than 1 year: BART, the rail rapid transit system in the San Francisco Bay Area and Port Authority Trans-Hudson (PATH) in New Jersey, which started its bike-on-rail program in 1962. BART's program enjoyed strong public support; by 1980, BART had issued more than 9,000 bike-on-rail permits. Community support and the excellent safety record of the program prompted BART to relax restrictions on the bike-on-rail service and permits were made available through the mail. By 1984, the number of permits had more than tripled to 28,000; this had grown to 71,000 permits by 1992.

BART's success prompted other rail systems to institute bike-on-rail programs. Today, they exist on many commuter rail, and heavy and light rail transit (LRT)systems in cities across the country, and other transit agencies are planning bike-on-rail service.

New light rail systems that have opened in some U.S. cities in recent years are integrating bicycles with their systems, providing bicycle parking at stations, and permitting bike-on-rail service. These include LRT systems in Santa Clara County, San Diego, Sacramento, and Los Angeles, CA and Portland, OR. In mid-1992, Portland initiated a more comprehensive bike-on-transit program, including bikes on the LRT and on regional buses, and increased bicycle parking facilities at stations.

Bicycle stencils on outside and inside doors of Danish State Railways, local "S-Tog" trains indicate those doors where bikes may be brought on board the train.

Permits

Most U.S. transit authorities with bike-on-rail service require a bicyclist to obtain a valid permit. Costs for the permit generally range from $3 to 5 and are valid for varying lengths of time. Some systems, especially those with newer programs, require annual permit renewal, while on other systems, permits may be valid for 3 to 5 years, and on some, for an unlimited period. While the permit process provides a means of assessing use of the system and ensures that bicyclists are familiar with the program rules and regulations, permits severely constrain demand, generally excluding tourists and potential occasional users. A few simple billboards or signs in transit vehicles and near stations, as found in Europe, would provide an alternative means of communicating rules of operation.

It is notable that not a single European bike-on-rail program requires a permit for the carriage of bicycles. A large number of rail systems across Europe allow bicycles on trains. Some offer this service for free, while others charge a fare supplement for the bicycle. Eliminating permits allows them to attract a larger pool of users, generate added revenues, and avoid the often considerable costs associated with permit administration. Santa Clara County Transit, in California, is the first U.S. transit agency to take a more European attitude toward the bicycle, allowing them on board without a permit, at no extra charge.

Time Restrictions

The U.S. bike-on-rail services are almost all restricted to times outside the weekday peak hours. The exceptions are BART in San Francisco and the commuter rail system in Boston, MA, which allows bicycles to be carried during peak hours in the "reverse commute" direction only. Restrictions on most systems prohibit bicycles on rail weekdays before 9:00 a.m. or 9:30 a.m. in the morning (some allow bikes before 6:00 a.m.) and from 3:00 p.m. or from 3:30 to 6:30 p.m. Weekend policies vary, with some systems having no restrictions and some blocking out certain hours when there is substantial shopping, work, or recreational travel. Several European bike-on-rail systems, including Oslo and Amsterdam, have no time restrictions on the time when bicycles can be brought on board. Without any restrictions, bicyclists, using their own common sense, tend to naturally avoid bringing bicycles into rail cars during crowded rush hours. Santa Clara County Transit again leads the United States in adopting the most European attitude toward bike-on-rail, allowing two bicycles per car in peak hours, and four per car in non-peak hours.

Rail Car Design Constraints

Restrictions on the number of bikes permitted on each rail transit system vary. Some systems permit two bicycles/car and others allow bicycles only on the last car of the train, with a maximum of four bicycles/train. In Santa Clara County, the bike-on-rail program is so popular that the number of bikes far exceeds the limit. Passengers are expressing concerns about access problems caused by bicycle overcrowding and efforts are under way to try to resolve this.

Rail transit system restrictions on the number of bicycles permitted are based in part on rail car designs in this country, in which bicycle accommodation has not been a consideration. On the MARTA system in Atlanta, and on other systems, bicyclists hold their bikes in a fold-up seat area near the backdoor of the rail car.

In California, design of the new "California Car," mandated and funded by Proposition 116, requires accommodation of a reasonable number of bicycles carried on board by passengers for both inter-city and commuter applications. The California Car is a bi-level car that superficially resembles Amtrak's Superliner, but with significant design differences, including bicycle storage on the lower level of the car. The new rail car, which will be used on State-sponsored Amtrak and local commuter rail services, is a promising new development in the United States. Its specifications could be adapted by other rail agencies to enhance bicycle-rail linkage.

9.8 Bicycle Parking Facilities at Transit Stations

Cities and transit authorities across the country are beginning to recognize the crucial role of secure bicycle parking at transit stations in promoting increased bicycle access to transit. A number of the Nation's commuter rail and rail transit systems are investing in bicycle parking, but many lack a more comprehensive strategy that looks at the environment beyond the station. Frequently, the quality of the parking provided is inadequate, leaving most bicycles vulnerable to theft and vandalism. The majority of suburban bus transit systems, which could expand service area and ridership through bicycle-transit interface, appear to pay little, if any, attention to bicycle parking facilities at bus stops.

There is wide variation in the use of bicycle racks and lockers between rail stations and also between

As in Vasteras, Sweden, cycle parking in the downtown area is essential to the encouragement of cycle commuting as well as leisure travel to the city's center.

transit systems. A crucial factor appears to be the degree to which the environment leading to the station is bicycle-friendly and the quality of the bicycle parking provided. In areas where separate bicycle paths or bike lanes on streets have been implemented, facilitating connection to rail or bus services, the ease and safety of access by bicycle is greatly enhanced. Access to many stations is on streets where little or no thought has been given to bicycle safety, curtailing the extent of bicycle access. The degree to which a transit agency actively promotes its bicycle parking facilities, and more broadly, promotes the environmental and social benefits of bicycle access vs. auto access, also impacts upon the use of bicycle lockers and racks.

The Economics of a Guarded Bicycle Parking Garage in Germany

Since July 1989, in Wunstorf, Germany, near Hannover, local authorities, working with a private bicycle shop owner, have developed a "Bicycle Station" to provide 320 guarded bicycle parking spaces at the railway station, along with bicycle rental and repair services. In the first 22 months of operation, the number of bicycles parked at the rail station increased fourfold to about 160 each day, with growth continuing at a rate of 20 to 30 percent per year. Since the second year of operation, some 60 to 90 bicycles were rented each month in the warmer months of the year, mostly on weekends.

The facility and rental bicycles are in public ownership, but operations are handled under a private franchise contract. User fees for parking have been set at US$1.85 per week, $5.60 per month, or $56 per year for those with a weekly, monthly, or yearly railway pass, respectively; without a railway pass, parking fees are one-third higher. Single-use parking costs US$0.75 per day. The vast majority of users buy monthly parking cards to obtain the discount they offer.

Bicycle parking fees comprise two-thirds to three-fourths of the revenues in any given month, with bicycle repair work comprising most of the remainder, except in the warmer months, when bicycle rentals, mostly for recreational use, provide up to a fifth of revenues. The franchise operator is guaranteed minimum receipts by the local authorities of US$750 per month, but as of May 1991, monthly revenues from the operation were US$1,650 and were continuing to increase at a steady pace, so this guarantee was not being exercised.

Total cost of the operation is about US$8,900 per month. The government provides a fixed subsidy of about US$7,100 per month (or about US$22 per bicycle parking space) and the franchise operator pays the remaining costs of about US$1,800. The franchise operator is responsible for the cost of providing a bicycle mechanic, insurance, and maintenance of rental bicycles, and a portion of utilities and building insurance, while the government supports other costs as a means of encouraging the use of transit and bicycles. With a continuation of the fixed contract subsidy, the franchise operator was anticipated to achieve profitability in his activities at the Bicycle Station by the end of 1991.

The Bicycle Station is open 108.5 hours per week and is staffed by three people over the course of a typical day. Labor costs comprise 83 percent of the costs of operation. A study that examined the possibility of semi-automating the bicycle parking garage using a system found in Japan and the Netherlands estimated that the full cost of conversion would be about US$121,000 to provide a 168-bicycle capacity system, or $720 per unit capacity.

9.9 Access to Transit Centers

The success of a bicycle-transit integration program may hinge on the quality of bicycle access to and from the transit facility. Multi-use trails, rail-trails, on-road bike lanes, widened shoulders, and sidewalks often provide critical transportation linkages from neighborhoods and business or commercial districts to transit centers. Trails that parallel rail corridors, or rails-with-trails, offer another way to link the two modes. *(NBWS Case Study No. 9)*

9.10 Why Link Bicyclists With Transit Services?

Integration enhances travel potential for both modes of travel by offering a number of advantages that each mode alone cannot provide:

- Bike-on-transit service enables bicyclists to travel farther distances and overcome topographical barriers.
- Bike-on-transit services to recreational destinations during off-peak periods can increase overall transit ridership and increase efficient use of capacity.
- Bicycle-to-transit services (trails, on-road bike lanes, and bike parking) enlarge transit's catchment area by making it accessible to travelers who are beyond walking distances from transit stations.

Integration lowers air pollutant emissions from trips taken on public transit. Outside of central business districts, most commuters using rail transit and park-n-ride lots arrive by auto; and typical trip lengths are 3 to 6 km (5 to 10 miles). For an auto trip of 11 km (7 miles), nearly 90 percent of the emissions occur in the first 1.6 km (1 mile), known as the "cold-start" stage.

In most situations, encouraging auto commuters to drive to rail or bus transit produces little air quality improvements. However, converting transit access trips from auto to bike, or converting car commutes to bike-n-ride transit trips, can produce significant emission reductions. (FHWA-PD-93-012, 1993)

Integration reduces the cost of constructing automobile park-n-ride lots, which vary from $1,500 to $20,000 per space. The cost of providing bicycle parking and storage facilities averages $50 to $500 each.

In rural communities, integration offers touring bicyclists and other tourists auto-free access to popular recreation destinations such as trails and parks and provides rural bicycle commuters the means for inter-city or inter-town commuting. (FHWA-PD-93-012, 1993)

9.11 What Are the Key Elements of Successful Programs?

Demonstration Projects

Many successful programs began with a limited demonstration phase, then expanded to a broader, or even system-wide, operation. Demonstration projects tend to focus on identifying and solving specific technical and operational aspects of the service, and usually lead to wider program implementation.

Bicycle shelters used in Germany allow a bike to be parked for 4 days before being moved to a long-term parking area, allowing commuters to leave bikes over the weekend.

Advisory Committees
This committee should include non-agency organizations and individuals who have experience in bicycle advocacy in their community, an interest in bicycle-transit programs, knowledge of user needs and constituency characteristics, and some expertise in bicycle and/or transit issues.


A pedestrian and bicycle bridge near the Freiburg rail station carries thousands of people each day.

Marketing and Promotion
A bike-transit program must vigorously market and promote in order to be effective: a brochure describing the agency's program, a telephone number for information, and drawings or photographs of equipment to help users understand operating procedures.

The Tri-Met in Portland, Oregon, distributed 4,000 brochures directly to the local bicycle advocacy group's membership. In Philadelphia, the Southeastern Pennsylvania Transit Authority (SEPTA) prepared a pamphlet highlighting eight scenic and cultural destinations for bicycle touring that were accessible by its local rail systems. Bike-to-Work Days and bicycle fairs, or offers of free test rides, have also proven to be effective in promoting new programs.

Are Federal Funds Available for Bicycle-Transit Integration?
The Rails-To-Trails Conservancy has documented the use of Intermodal Surface Transportation Efficiency Act (ISTEA) funds in the development of dozens of bicycle-transit integration facilities. ISTEA/TEA-21 programs being used include the Congestion Mitigation and Air Quality Improvement Program, Surface Transportation Program, and the Transportation Enhancements Program. Through the Federal Transit Program in TEA-21, several funding sources are available for bicycle and pedestrian access improvements.

9.12 Exercise

Choose a local transit station (or individual transit stop) and determine the potential catchment area. Design a program for increasing bicycle and pedestrian access to the transit station, including both design improvements and education/promotion efforts. For physical improvements, include both the immediate vicinity, as well as connections to origins that lie in the catchment area.

Alternate Exercise
Choose a nearby transit stop or park-n-ride station and ride a bike or walk to it. Document the problems along the way, as well as those you experience when you arrive at the station/stop. Given your knowledge of the community, what would it take to get people to bicycle and walk to this site?

9.13 References

For an analysis of the state of the practice, see *Integration of Bicycles and Transit*. Write: TRB, National Research Council, 2101 Constitution Ave., NW, Washington, DC 20418, $12.

The FHWA reports listed below are available through the FHWA Report Center, 9701 Philadelphia Court, Unit Q, Lanham, MD, 20706. Telephone: (301) 577-0818, Fax: (301) 577-1421.

Federal Highway Administration, *National Bicycle and Pedestrian Clearinghouse Technical Assistance Series*, No. 1, 1995.

Federal Highway Administration, *National Bicycling and Walking Study–Case Study No. 9: Linking Bicycle/Pedestrian Facilities With Transit*, FHWA-PD-93-012, 1993.

Federal Highway Administration, *National Bicycling and Walking Study - Case Study No. 17: Bicycle and Pedestrian Policies and Programs in Asia, Australia, and New Zealand*, FHWA-PD-93-016, 1993.

To learn more about successful bicycle-transit integration services, contact the following:

1) Bicycle Parking
BART, San Francisco
Leo Rachal
(510) 464-6169

2) Bike-on-Bus
METRO, Seattle
Robert Flor
(206) 684-1611

3) Commuter Rail
Metro North
New York City
Metro Area
Kyle McCarthy
(212) 340-4916

4) Heavy Rail
WMATA
Washington, D.C.
Sharonlee Johnson
(202) 962-1116

5) Light Rail
Tri-Met
Portland, Oregon
Linda Williams
(503) 238-4884

6) Long-Distance Rail
Amtrak
Steve Roberts
(202) 906-2091

L E S S O N 10

Off-Road Trails

10.1 Purpose

Off-road facilities can provide low-stress environments for bicycling and walking that are separate from motor vehicle traffic. They can be great places for novice and child bicyclists to try out their riding skills prior to taking trips on urban streets. While they have many positive features, design of off-road trails must be done with the same care and attention to recognized guidelines as design of bike lanes on roadways. In addition, trails are often extremely popular facilities that are in high demand among rollerbladers, bicyclists, joggers, people walking dogs, and a variety of other users. The resulting mix and volume of non-motorized traffic can create dangerous conditions that should be anticipated during the design phase.

The discussion that follows addresses the types and design requirements of different trail users, and provides a brief overview of design issues and guidelines. More detail on multi-use trail design and engineering is provided in national guidelines set by AASHTO and the MUTCD.

10.2 Multi-Use Trails

Only in very few instances is a trail used exclusively by one type of user. People routinely walk on “bicycle paths” and mountain bicyclists have been known to use “equestrian trails.” In most cases, it must be assumed that trails will be shared by all types of users of all ages and abilities.

These different trail users have different objectives, which can result in conflict. Some use the trail to get to work. Others use it to walk the dog, jog, or stroll with their children. By understanding the needs of these users and designing trails to accommodate expected levels and types of use, you can build a trail system that plays an important role in the community or region’s transportation and recreation network for years to come.

Trail user conflicts are an issue when on wide trails like this coastal trail in Santa Barbara, CA.

10.3 Trail Design Information Resources

The following resources are recommended as sources of specific information on trail design and construction:

Conflicts on Multiple-Use Trails, Roger Moore, Federal Highway Administration, FHWA-PD-94-031, 1994.

Greenways – A Guide to Planning, Design and Development, The Conservation Fund, Charles Flink and Robert Searns, 1993.

Guide for the Development of Bicycle Facilities, American Association of State Highway and Transportation Officials, 1999.

Manual on Uniform Traffic Control Devices (MUTCD), USDOT, latest edition (for signing and pavement marking on trails).

Public Trail Access: A Guide to the Protection of Arizona's Trails, Arizona State Parks, Arizona State Committee on Trails, 1995.

Rails-With-Trails: Sharing Corridors for Recreation and Transportation, Brillot and Winerich, Rails-to-Trails Conservancy, 1993.

Signs, Trails and Wayside Exhibits — Connecting People and Places, Suzanne Trapp, Michael Gross, and Ron Zimmerman, UWSP Foundation Press, University of Wisconsin – Stevens Point, Wisconsin 54481, 1994.

Trail Design, Construction and Maintenance Guidelines, Arizona State Parks, Arizona State Committee on Trails, 1995.

Trails for the Twenty-First Century – Planning, Design and Management Manual for Multi-Use Trails, Edited by Karen–Lee Ryan, published by the Rails-to-Trails Conservancy, 1400 Sixteenth Street, N.W., Suite 300, Washington, D.C. 20036, (202) 331-9696.

10.4 Trail Types

Among the many types of trails are the following:

- Urban trails and pathways.
- Rail-trails.
- Trails in greenways.
- Interpretive trails.
- Historic trails.
- Rural trails.
- Primitive trails.

All of these can be designed for use by pedestrians (including joggers, casual strollers, hikers, in-line skaters, and others), people with disabilities, bicyclists, and equestrians. What distinguishes one type of trail from another is, primarily, its context.

Trails can be designed to include year-round activities such as cross-country skiing, sledding, and snowmobiling where appropriate. (Erie Canal Trail, Syracuse, NY)

Consideration of trails in this course lesson will focus primarily on urban trails and pathways, including rail-trails and trails in greenways.

10.5 Rail-Trails

More than 10,000 miles and 1,000 trails are now in place nationwide, and well over 100,000 miles of future rail abandonments make this one of the most important programs. Abandoned rails provide:

Trails are rarely successful without the support and approval of adjacent property owners and the community.

- Natural corridors, often to the heart of a city.
- Excellent access.
- Rail-banking possibilities (the rails, or at least transit, will come back).
- Bridges, tunnels, easy grades, and views.
- A link from the past to the future.

Railway and Utility Companies as Trail Partners

Today, there are many active rail, utility, and other corridors where a bit of imagination and lots of negotiation can lead to successful shared corridors. Building partnerships has led to excellent trail links and full-length trails.

Issues in building partnerships include:

- Seattle, Portland and many West Coast areas have shared corridors with rail lines.
- Utilities have often bought abandonments and most are likely partners.
- Resolution of issues related to legal protection, tort liability, and contracts to address partnership concerns about liability.
- Provision of physical separation between rail lines, canals, or utility facilities.
- If a utility or other partner's use of the facility (e.g., for maintenance work) has potential conflict with trail use, provide an alternative route during times when trail use will be restricted.

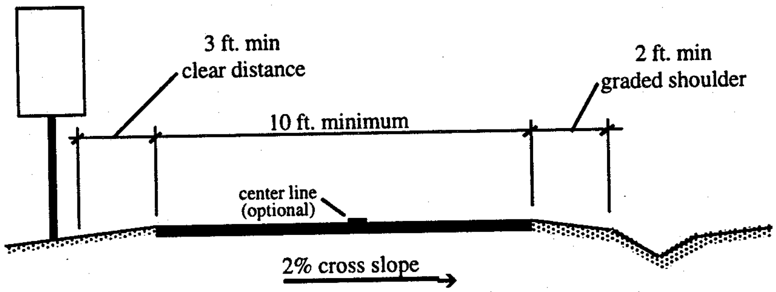
The Rails-to-Trails Conservancy (Tel: (202) 331-9696, Fax: (202) 331-9680) offers a wide variety of training and information resources related to trails within rail rights-of-way. Especially recommended is *Rails-With-Trails: Sharing Corridors for Recreation and Transportation*, by Michael Brillion and Julie A. Winterich, available through the Rails-to-Trails Conservancy.

10.6 Trail Design Issues

National guidelines for the design of multi-use trails are provided by AASHTO's *Guide for the Development of Bicycle Facilities* (1991). Nearly one-third of the guide is devoted to trail design, and the requirements are quite detailed. The reader is cautioned that the following section of this manual is intended to provide further depth only on design issues that the AASHTO Guide does not fully cover. The AASHTO Guide should be used as a companion text to this chapter.

Location and Use

Multi-use trails are physically separated from motor vehicle traffic (except at crossings with



Typical cross-section for multi-use trails. Source: NCDOT

streets) and are built either within an independent right-of-way (such as a utility or railroad right-of-way), or along specially acquired easements across private lands. Trails cater to a variety of users, including bicyclists, pedestrians, joggers, rollerbladers, and horseback riders. Possible conflicts between these user groups must be considered during the design phase, since bicyclists often travel at a faster speed than other users.

Multi-use trails can help bicyclists and walkers avoid congested urban areas, although they sometimes do not provide access to important destinations in congested areas. Off-road trails offer a convenient and pleasant alternative, as well as an opportunity for a novice bicyclist to get some riding experience in a less threatening environment. Although multi-use trails usually attract a higher percentage of Group B (basic) and Group C (child) bicyclists, Group A (advanced) bicyclists can also benefit from their use.

Trail Width and Traffic Control

The minimum width for two-directional trails is 3 meters (10 feet); however 3.7-meter to 4.3-meter (12 to 14 feet) widths are preferred where heavy traffic is expected. Due to the popularity of off-road trails, centerline stripes should be considered for paths that generate substantial amounts of pedestrian traffic, and speed limits or cautionary signs should be posted. Trail etiquette signing should clearly state that bicycles should give an audible warning before passing other trail users.

Bicycle Paths Adjacent to Roadways

In the past, "bicycle sidepaths" (bikeways immediately adjacent to roadways) were developed with the concept of separating bicyclists from roadways in order to reduce opportunities for conflict. It is now widely accepted that bicycle paths immediately adjacent to roads actually cause greater conflicts. These sidepaths create the following problems (excerpt from AASHTO's *Guide for the Development of Bicycle Facilities,* 1991):

1. Unless paired (on both sides of the road), they require one direction of bicycle traffic to ride against motor vehicle traffic, contrary to normal rules of the road.

2. When the bicycle path ends, bicyclists going against traffic will tend to continue to travel on the wrong side of the street. Likewise, bicyclists approaching a bicycle path often travel on the wrong side of the street in getting to the path. Wrong-way travel by bicyclists is a major cause of bicycle/automobile accidents and should be discouraged at every opportunity.

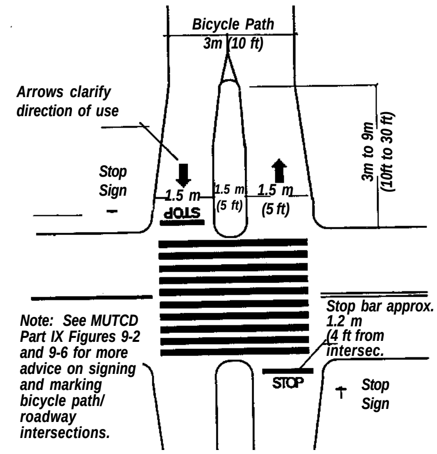
3. At intersections, motorists entering or crossing the roadway often will not notice bicyclists coming from their right, as they are not expecting contra-flow vehicles. Even bicyclists coming from the left often go unnoticed, especially when sight distances are poor.

4. When constructed in narrow roadway rights-of-way, the shoulder is often sacrificed, thereby decreasing safety for motorists and bicyclists using the roadway.

5. Many bicyclists will use the roadway instead of the bicycle path because they

have found the roadway to be safer, more convenient, or better maintained. Bicyclists using the roadway are often subjected to harassment by motorists who feel that, in all cases, bicyclists should be on the path instead.

6. Bicyclists using the bicycle path generally are required to stop or yield at all cross-streets and driveways, while bicyclists using the roadway usually have priority over cross-traffic, because they have the same right-of-way as motorists.



Alternative approach to trail/roadway intersections. Source: NCDOT

7. Stopped cross-street motor vehicle traffic or vehicles exiting side streets or driveways may block the path crossing.

8. Because of the closeness of motor vehicle traffic to opposing bicycle traffic, barriers are often necessary to keep motor vehicles out of bicycle paths and bicyclists out of traffic lanes. These barriers can represent an obstruction to bicyclists and motorists, can complicate maintenance of the facility, and can cause other problems as well.

For these reasons, the AASHTO Guide further states that there should always be a minimum of 1.5 meters (5 feet) between the trail and the roadway.

Trail/Roadway Intersection Design
Trail/roadway intersections can become areas of conflict if not carefully designed. For at-grade intersections, there are usually several objectives:

1. Site the crossing area at a logical and visible location. When at all possible, trails should be designed to meet roadways at existing intersections. If alternate locations for a bicycle path are available, the one with the most favorable intersection conditions should be selected. Mid-block crossings should not be sited in close proximity to major intersections with other highways.

2. Warn motorists of the upcoming crossing. Warning signs and pavement markings that alert motorists of the upcoming trail crossing should be used in accordance with the MUTCD.

3. Maintain visibility between trail users and motorists. Vegetation, highway signs, and other objects in the right-of-way should be removed or relocated so that trail users can observe traffic conditions and motorists can see approaching trail users. Every effort should be made to locate mid-block crossings on straight sections of roadway, rather than near curves where sight distance is limited.

This trail provides suffiicient warning for both motorists and bicyclists of the approaching mid-block crossing. There is also a push-button signal to ensure that they can cross safely.

4. Inform trail users of the upcoming intersection. Signs and pavement markings on the trail can provide advance warning of upcoming intersections, especially in areas where the intersection is not clearly visible 75 meters (250 ft) in advance.

Intersections and approaches should be on relatively flat grades. In particular, the bicyclist should not be required to stop at the bottom of a hill. Additional guidance on trail/roadway intersections is provided by AASHTO's *Guide for the Development of Bicycle Facilities.*

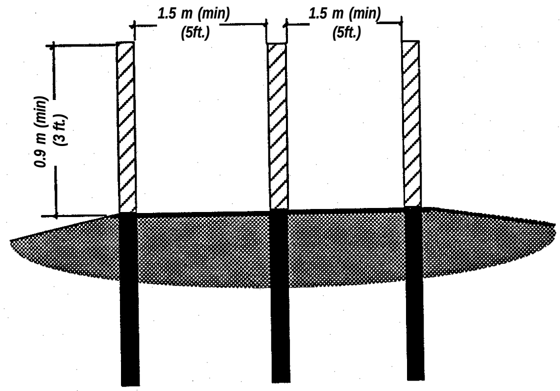
The need for parking should be anticipated during the master planning process for the trail system. Adequate parking at trailheads is necessary so that trail users do not park on the shoulder of the road near intersections, blocking the sightlines of both motorists and trail users.

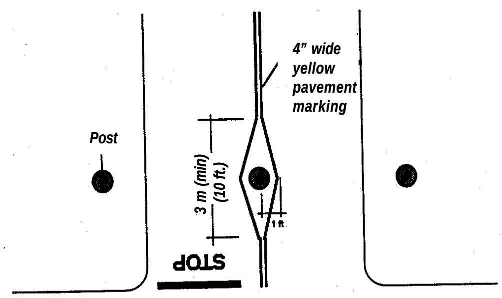
For high-speed multi-lane arterials and freeways, the only viable solution may be a grade-separated crossing. Overpasses can be extremely expensive and marginally successful if users are expected to climb long entrance ramps. Underpasses should be of adequate width and should be well lit with vandalism-resistant fixtures. Approach ramps for grade-separated crossings must meet ADA or ANSI standards.

Restricting Motor Vehicle Access

Unauthorized motor vehicle access is an issue at some trail/roadway intersections. Trail bollards are the most effective method of limiting unwanted motor vehicles. However, much care should be taken in their use because they present an obstacle when located in the travel path of bicycles and pedestrians. Centerline pavement striping should be used to increase the visibility of bollards located in the center of the trail, as shown in the detail on this page.

Bollards should be painted a bright color and permanently reflectorized to maintain their visibility. Bollards should be sited 9 meters (30 feet) in advance of the intersection, so that cyclists can fully concentrate on maneuvering





Reflectorized post barrier used to keep motor vehicles off bicycle paths and marking plan. Source: **California Highway Design Manual,** ***Caltrans, 1987.***

through the bollards and still have time to prepare for the upcoming intersection.

Bollards should be 0.9 meter (3 feet) tall, and can be constructed of a variety of materials. Several commercial manufacturers offer bollards that can be unlocked and removed to allow emergency vehicle or maintenance access.

Pavement Design

Typical pavement design for off-road multi-use trails should be based on the specific loading and soil conditions for each project. Trails designed to serve bicycle transportation purposes should be composed of a hard surface, such as asphalt or concrete, and should be designed to withstand the loading requirements of occasional maintenance and emergency vehicles.

In some circumstances, given an extremely stable trail bed (such as a rail-trail) and excellent drainage conditions, a soft-surface trail may be acceptable. Careful consideration should be given to the amount of traffic the specific trail will generate, as these surfaces tend to deteriorate with heavy use. These trails must also meet the standards set by AASHTO's *Guide for the Development of Bicycle Facilities* (1999).

One important concern for asphalt multi-use trails is the deterioration of trail edges. Installation of a geotextile fabric beneath a layer of aggregate base course can help to maintain the edge of the trail. It is also important to provide a 0.6 meters (2 feet) wide graded shoulder to prevent trail edges from crumbling.

10.7 References

Text and graphics for this lesson were derived from the following sources:

AASHTO, *Guide for the Development of Bicycle Facilities*, 1999.

City of Philadelphia, *Bicycle Facility Design Standards*, 1998.

Drake and Burden, *Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*, NHI Course #38061, FHWA-HI-96-028, 1996.

Also see Section 10.3 of this lesson for a listing of trail design publications.

LESSON 11

Traffic Calming

11.1 Purpose

Traffic calming is a traffic management approach that evolved in Europe and is now being implemented in many U.S. cities. The following definition is quoted from *An Illustrated Guide to Traffic Calming* by Hass Klau (1990):

"*Traffic calming* is a term that has emerged in Europe to describe a full range of methods to slow cars, but not necessarily ban them, as they move through commercial and residential neighborhoods. The benefit for pedestrians and bicyclists is that cars now drive at speeds that are safer and more compatible to walking and bicycling. There is, in fact, a kind of equilibrium among all of the uses of a street, so no one mode can dominate at the expense of another."

This chapter explores the principle of traffic calming and provides a variety of studies, design details, and photographs of areas where traffic calming has been effectively used in the United States and in Europe. Along with the advantages of traffic calming, the text describes mistakes that practitioners have sometimes made in implementing traffic-calming techniques.

11.2 Traffic-Calming Objectives

The most fundamental traffic-calming goal is to reduce the speed of vehicular movement. With reduction of speed, the following objectives can be realized:

1. **Improved "feel" of the street.**
   This objective calls for increased community involvement in and "ownership" of the street. If people feel more comfortable on the street, they are more likely to walk or bicycle there and to

engage in other street-oriented activities with their neighbors. A key aspect of achieving this objective is reducing the perceived threat of danger from motor traffic.

Traffic-calming devices are used to break up long uninterrupted street vistas that encourage speeding.

2. **Enhanced aesthetic values and a sense of nature.** Several traffic-calming techniques, such as street landscaping, pedestrian amenities, and reclamation of roadway areas can serve as community open space. Not only do these techniques make the neighborhood more attractive, but they also break up long, uninterrupted street vistas conducive to speeding and convey the message that "this is a pedestrian place."

3. **Reduced crime.** It's harder to make a speedy getaway if a fleeing felon has to deal with speed humps, woonerfs, and traffic circles. It's harder to get away without being spotted if there are "eyes on the street" – if the street is a positive, community focus.

4. **Equitable balance among transportation modes.** With reduced motorist speeds, safety is improved. Pedestrians and bicyclists have more time to detect and avoid motor vehicles. Traffic calming sends the message that "motor vehicles don't exclusively OWN the roadway" – that other modes have equal rights. Studies that evaluate traffic-calming improvements show increased levels of walking, bicycling, and transit use following installation.

5. **Increased safety/decreased severity of injury in traffic crashes.** With reduced speeds comes a significant reduction in the number and severity of crashes involving motor vehicles. Traffic-calming facility evaluations uniformly show fewer crashes, fewer fatalities, and less severe injuries.

6. **Improved air quality and noise levels.** Slower moving vehicles make less noise and, generally, emit fewer pollutants.

7. **Decreased fuel consumption.** With more trips made by walking, bicycling, and transit, and with slower traffic speeds, fuel consumption reductions of 10 to 12 percent have been reported.

8. **Continued accommodation of motor vehicle traffic.** An important objective is the continued accommodation of motor vehicle traffic. Although traffic calming shifts the balance among travel modes, this shift should not result in severely restricted traffic volumes or in shifting traffic problems from the traffic-calmed area to other streets.

11.3 Traffic-Calming Issues

When any new traffic management approach is introduced, issues, concerns, and questions are bound to arise. Design decisions related to traffic can have far-reaching consequences. Lives, economic well-being, and urban livability are directly affected.

Professional engineers, planners, government, and the public all are aware of and sensitive to proposals for changes in the traffic environment. Roadway congestion, air quality, traffic safety, street crimes, and the high cost of new improvements are among the most-widely debated issues in America today. New design ideas are, and should be, subjected to rigorous testing and evaluation before being accepted as part of the standard engineering and transportation planning tool kit. Traffic calming is not a panacea for urban transportation woes, but it can have significant benefits in many situations.

Traffic calming can be termed as engineering and other physical measures designed to control traffic speeds and encourage driving behavior appropriate to the

In considering the application of traffic-calming techniques, what specific issues are likely to arise? The discussion on the following pages focuses on traffic-calming issues. (Note: Studies and statistics referenced are cited in FHWA Case Study Nos. 19 and 20, *National Bicycling and Walking Study*.)

1. Traffic safety.
The Issue: Encouraging people to walk, play, and bicycle in and next to the streets is just asking for trouble. They will have a false sense of security and accidents will increase. They will develop bad habits that may increase their when they leave the neighborhood.

Comment: Traffic-calming measures have been implemented in many European cities. In the Netherlands and Germany, extensive research has been conducted to evaluate the safety and impact of traffic-calming techniques and devices.

2. Impact on traffic volumes, distribution, and operations.
The Issue: Traffic calming will never work on anything except very low-volume residential streets. It will substantially reduce the amount of traffic that a street can handle efficiently and this is counterproductive. We need to move vehicles, not restrict them. Furthermore, if we slow traffic on one street, the traffic will simply be diverted to another street. The net result will be increased congestion and more problems overall.

Comment: A 5-year German Federal Government evaluation of traffic calming and follow-up research found:

- Little change in overall traffic volumes.
- Reduction in average vehicle speeds by almost 50 percent.
- Average increase in motorist trip time of only 33 seconds.

3. Lack of proven design standards.
The Issue: There are no uniform, accepted, and legally defensible standards to follow. If we want to try traffic calming, where can we get specific information about design?

Comment: Many U.S. cities are now developing and testing design guidelines for traffic-calming improvements. Although uniform, national standards have yet to evolve, valuable experience is being gained. The list of references at the end of this lesson provides a starting point for further exploration of specific design approaches.

4. Liability.
The Issue: These traffic-calming ideas may be accepted in Europe, but they haven't really been tried here. Are we opening the door to all kinds of legal problems if somebody crashes on a traffic circle or a speed table and sues us?

Comment: When considering the use of any new design approach, concerns about liability can be

Emergency vehicle access should always be considered when incorporating traffic-calming measures.

addressed somewhat through performance of "due diligence" on the part of the engineer, planner, or other professionals involved in the design. Research into the experiences of other U.S. cities, European standards, and evaluation studies should be thorough and followed up with a first-hand look if possible. Construction of a pilot project or other testing of proposed designs can benefit, as can on-going and systematic evaluation of the improvements once installed.

5. Emergency and service vehicle access.
The Issue: Construction of speed bumps, neck-downs, medians, and traffic circles will increase response times for emergency vehicles and may restrict access for garbage trucks, delivery vans, and other large vehicles.

Comment: Studies in Berkley and Palo Alto, CA, show that traffic management measures (e.g., traffic diverters, bicycle boulevards) have not impaired police or fire emergency response times.

- The Seattle Engineering Department works closely with its Fire Department to design and field-test traffic circles on a site-specific basis to ensure good emergency access.

6. Impacts on bicycling.
The Issue: Pavement texturing, speed tables, wider sidewalks, "bulb-outs" at corners and similar improvements may make things better for pedestrians, but may have a negative impact on bicycling.

Comment: A 5-year German Federal Government evaluation of traffic calming and follow-up research found doubling of bicycle use over a 4-year period.

- Implementation of traffic management strategies in the downtown area of the Dutch City of Groningen contributed to a substantial increase in bicycling and walking. Bicycle use is now well over 50 percent of all trips.
- Studies of traffic-calming areas in Japan show increases in both bicycle and pedestrian traffic volumes along most routes.

(Note: *Cyclists and Traffic Calming*, a Technical Note publication of the Cyclists Touring Club (see references, end of lesson), includes extensive information on adapting traffic-calming techniques for bicycling.

11.4 Traffic-Calming Devices

Traffic calming has many potential applications, especially in residential neighborhoods and small commercial centers. Traffic-calming devices can be grouped within the following general categories:

- Bumps, humps, and other raised pavement areas.
- Reducing street area where motor traffic is given priority.
- Street closures.
- Traffic diversion.
- Surface texture and visual devices.
- Parking treatments.

Frequently, a combination of traffic-calming devices is used. Examples of such combinations will be discussed briefly, including:

- The woonerf.
- Entry treatments across intersections.
- Shared surfaces.
- Bicycle boulevards.
- Slow streets.

- Channelization changes.
- Traffic calming on a major road.
- Modified intersection design.

1. Bumps, humps, and other raised pavement areas.
This category includes all traffic-calming devices raised above pavement level. Drivers must slow down when they cross these devises or suffer an uncomfortable KER-BUMP or (KER-BUMP-KER-BUMP), running the risk of spilled coffee and a severe jolt to their tailbones. Although people often gripe about the inconvenience of having to slow down for these devices, they don't have much choice. Their effectiveness at slowing traffic cannot be disputed. They are sometimes referred to as "Silent Policemen."

Speed bumps can be combined with curb extensions and a winding street alignment. Signing and pavement markings should clearly identify the bump.

Included in this category are:

- Speed bumps.
- Speed humps.
- Raised crosswalks.
- Raised intersections.

The following are brief descriptions of each, with definitions, comments, and examples:

Speed Bumps
A speed bump is a raised area in the roadway pavement surface extending transversely across the travel way, generally with a height of 3 to 6 inches and a length of 1 to 3 feet.

Design Considerations:
- Most effective if used in a series at 300- to 500- foot spacing.
- Typically used on private property for speed control – parking lots, apartment complexes, private streets, and driveways.
- Speed bumps are not conducive to bicycle travel, so they should be used carefully.

Speed Humps
A speed hump (or "road hump") is a raised area in the roadway pavement surface extending transversely across the roadway. Speed humps normally have a minimum height of 3 to 4 inches and a travel length of approximately 12 feet, although these dimensions may vary. In some cases, the speed hump may raise the roadway surface to the height of the adjacent curb for a short distance.

The humps can be round or flat-topped. The flat-topped configuration is sometimes called a "speed table." Humps can either extend the full width of the road, curb-to-curb, or be cut back at the sides to allow bicycles to pass and facilitate drainage.

Design Considerations:
- If mid-block pedestrian crossings exist or are planned, they can be coordinated with speed hump installation since vehicle speeds will be lowest at the hump to negotiate ramps or curbs between the sidewalk and the street.
- The hump must be visible at night.
- Speed humps should be located to avoid conflict with underground utility access to boxes, vaults, and sewers.

Speed humps slow traffic speeds on residential streets.

- Speed humps should not be constructed at driveway locations.

- Speed humps may be constructed on streets without curbs, but steps should be taken to prevent circumnavigation around the humps in these situations.

- Adequate signing and marking of each speed hump is essential to warn roadway users of the hump's presence and guide their subsequent movements.

- Speed humps should not be installed in street sections where transit vehicles must transition between the travel lane and curbside stop. To the extent possible, speed humps should be located to ensure that transit vehicles can traverse the hump perpendicularly.

- A single hump acts as only a point speed control. To reduce speeds along an extended section of street, a series of humps is usually needed. Typically, speed humps are spaced at between 300 and 600 feet apart.

Example:
Bellevue, Washington has installed speed humps in residential neighborhoods (labeled as speed "bumps" below, although broader than the typical speed bump). The City uses a 12-foot-wide hump, 3 inches high at the center. The design allows for little or no discomfort at speeds of 15 to 25 mph, but will cause discomfort at higher speeds. The humps are marked clearly, distinguishing them from crosswalks. White reflectors enhance nighttime visibility.

Bellevue found that the speed humps reduced traffic speeds and volumes. The humps, in general, received strong public support, and residents favored their permanent installation.

The following concerns were raised regarding the speed hump installation:

- Concern about restricted access and increased response time for emergency vehicles. The Bellevue Fire Department asked that the humps be installed on primary emergency access routes.

- Concern about aesthetics of signing and markings at the traffic humps. Residents raising the concerns, however, felt that the speed reductions compensated for the appearance of the humps.

- Concern about the effectiveness of the humps in reducing motor vehicle speeds along the length of a street, not at just two or three points. The distance between speed humps was found to have an impact on traffic speeds. The City found that maximum spacing should be approximately 500 feet.

The Bellevue Department of Public Works concluded that speed humps were effective speed-control measures on residential streets and recommended their use be continued. The table on the following page summarizes "before" and "after" data related to the Bellevue speed humps:

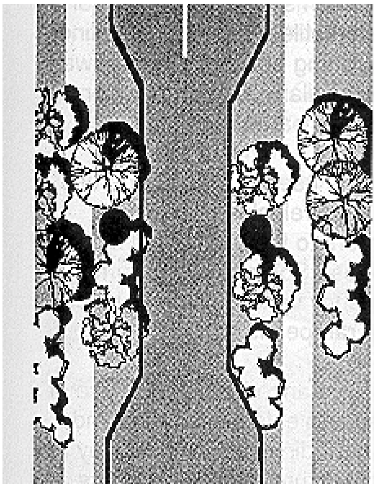
Raised Crosswalks
Raised crosswalks are essentially broad, flat-topped speed humps that coincide with pedestrian crosswalks at street intersections. The crosswalks are raised above the level of the roadway to slow traffic, enhance crosswalk visibility, and make the crossing easier for pedestrians who may have difficulty stepping up and down curbs.

Raised crosswalks can both slow motor traffic and give pedestrians a continuous-level surface at the crossing. Changes in texture and color help define the edges of the crossing.

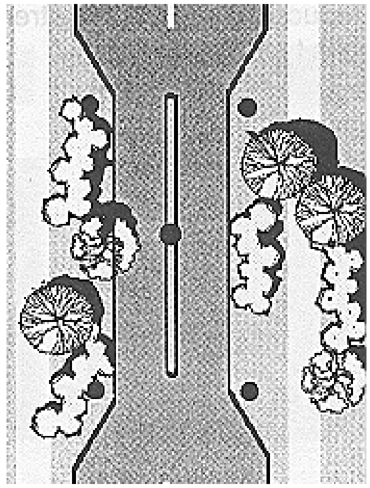
Table 2. Bellevue Speed Humps Findings

LOCATION	STREET TYPE/ WIDTH	# OF HUMPS	HUMP SPACING	SPEED LIMIT	Before:		After:	
					85TH % SPEED	VPD	85TH % SPEED	VPD
Somerset Drive SE	Two-way, 40 feet wide local residential neighborhood street	2	340'	25 mph	39 mph	795	27 mph	541 (VPD increased to 746 when the hump was reduced from 3/4" to 3")
Highland Drive SE	Two-way, 35 feet wide neighbor-hood collector	3	220'	25 mph	36 mph	1,700	25 mph	No change because no alternative route exists
166th/ 162nd Avenue SE	Two-way, 36 feet wide local residential street; walk to school route	2 2	600' 580'	25 mph 25 mph	37 mph 37 mph	655 472	24 mph 27 mph	.017 .017
SE 63rd Street	Two-way, 35 feet wide local residential street temporarily serving as a connection between two minor arterials	2 3	1,000' 500'	25 mph	36 mph	2,456	27 mph	2,802
Yarrow Bay neighbor-hood	Primarily a neighborhood connector	2	400		39 mph	3,685 1,641	25 mph	2,931 1,653

Source: FHWA Case Study No. 19.



ONE-LANE SLOW POINT



TWO-LANE SLOW POINT

Design Considerations:

- Can be constructed of brick, concrete block, colored asphalt or cement, with ramps striped for better visibility.
- Raised crosswalks are applicable:

(1) On roadways with vehicular speeds perceived as being incompatible with the adjacent residential land uses.
(2) Where there is a significant number of pedestrian crossings.
(3) In conjunction with other traffic-calming devices, particularly entry treatments.
(4) On two-lane or fewer residential streets classified as either "local streets" or neighborhood collector streets."
(5) On roadways with 85th percentile speeds less than 45 mph.

Intersection Humps/Raised Intersections
Intersection humps raise the roadway at the intersection, forming a type of "plateau" across the intersection, with a ramp on each approach. The plateau is at curb level and can be enhanced through the use of distinctive surfacing such as pavement coloring, brickwork, or other pavements. In some cases, the distinction between roadway and sidewalk surfaces is blurred. If this is done, physical obstructions such as bollards or planters should be considered, restricting the area to which motor vehicles have access.

Design Considerations:

- Ramps should not exceed a maximum gradient of 16 percent.
- Raised and/or textured surfaces can be used to alert drivers to the need for particular care.
- Distinctive surfacing helps reinforce the concept of a "calmed" area and thus plays a part in reducing vehicle speeds.
- Distinctive surfacing materials should be skid-resistant, particularly on inclines.
- Ramps should be clearly marked to enable bicyclists to identify and anticipate them, particularly under conditions of poor visibility.
- Care must be taken so the visually impaired have adequate cues to identify the roadway's location (e.g., tactile strips). Color contrasts will aid those who are partially sighted.

2. Reducing street area where motor traffic is given priority.
This category of traffic-calming techniques includes all those that reduce the area of the street designated exclusively for motor vehicle travel. "Reclaimed" space is typically used for landscaping, pedestrian amenities, and parking.

Discussed here are:
- Slow points.
- Medians.
- Curb extensions.
- Corner radius treatment.
- Narrow traffic lanes.

Slow Points (neck-downs, traffic throttles, pinch points)
Slow points narrow a two-way road over a short distance, forcing motorists to slow and, in some cases, to merge into a single lane. Sometimes these are used in conjunction with a speed table and coincident with a pedestrian crossing. The following are advantages and disadvantages of both one-lane and two-lane slow points:

(1) One-lane slow point.
One-lane slow points restrict traffic flow to one lane. This lane must accommodate motor traffic in both travel directions. Passage through the slow point can be either straight through or angled.

Advantages:
- Vehicle speed reduced.
- Most effective when used in a series.
- Imposes minimal inconvenience to local traffic.
- Pedestrians have a reduced crossing distance, greater safety.

Disadvantages:
- Reduced sight distances if landscaping is not low and trimmed.
- Contrary to driver expectations of unobstructed flow.
- Can be hazardous for drivers and bicyclists if not designed and maintained properly.
- Opposing drivers arriving simultaneously can create confrontation.

(2) Two-lane slow point.
Two-lane slow points narrow the roadway while providing one travel lane in each direction.

Advantages:
- Only a minor inconvenience to drivers.
- Regulates parking and protects parked vehicles as the narrowing can help stop illegal parking.
- Pedestrian crossing distances reduced.
- Space for landscaping provided.

Disadvantages:
- Not very effective in slowing vehicles or diverting through traffic.
- Only partially effective as a visual obstruction.

Design Considerations:
- Where slow points have been used in isolation as speed control measures, bicyclists have felt squeezed as motorists attempt to overtake them at the narrowing. Not all bicyclists have the confidence to position themselves in the middle of the road to prevent overtaking on the approach to and passage through the narrow area.
- To reduce the risk of bicyclists' being squeezed, slow points should generally be used in conjunction with other speed control devices such as speed tables at the narrowing. Slower moving drivers will be more inclined to allow bicyclists through before trying to pass. Where bicycle flows are high, consideration should be given to a separate right-of-way for bicyclists past the narrow area.
- A textured surface such as brick or pavers may be used to emphasize pedestrian crossing movement. Substituting this for the normal roadway surface material may also help to impress upon motorists that lower speeds are intended.
- Such measures should not confuse pedestrians with respect to the boundary of the roadway area over which due care should still be taken. In particular, where a road is raised to the level of the adjacent sidewalk, this can cause problems for those with poor sight. However, a tactile strip may help blind people in distinguishing between the roadway and the sidewalk; similarly, a color variation will aid those who are partially sighted.
- Slow points can be used to discourage use of the street by large vehicles. They can, however, be barriers to fire trucks and other emergency

This traffic-calming measure uses a landscaped median to narrow the travel lanes.

vehicles. Some designs permit access by emergency vehicles by means of lockable posts or ramped islands.

- Slow points can enhance the appearance of the street. For example, landscaped islands can be installed, intruding into the roadway to form a narrow "gate" through which drivers must pass. Landscaping enhances the neighborhood's sense of nature and provides a visual break in views along the street.

This median provides a diagonal waiting area for bicyclists, including a railing to hold onto.

- Used in isolation, roadway medians do not have a significant impact in reducing vehicle speeds. For the purpose of slowing traffic, medians are generally used in conjunction with other devices, such as curb extensions or roadway lane narrowing.

Several caveats apply:

- To achieve meaningful speed reductions, the travel lane width reduction must be substantial and visually obvious. The slowing, however, is temporary; as soon as the roadway widens again, traffic resumes its normal speed.

- Slow points are generally only sanctioned where traffic flows are less then 4,000 to 5,000 vehicles per day. Above this level, considerable delays will occur during peak periods.

- Clear signing should indicate traffic flow priorities.

Slow Point Examples:

Medians
Medians are islands located along the roadway centerline, separating opposing directions of traffic movement. They can be either raised or flush with the level of the roadway surface. They can be expressed as painted pavement markings, raised concrete platforms, landscaped areas, or any of a variety of other design forms. Medians can provide special facilities to accommodate pedestrians and bicyclists, especially at crossings of major roadways.

Design Considerations:
- Medians are most valuable on major, multi-lane roads that present safety problems for bicyclists and pedestrians wishing to cross. The minimum central refuge width for safe use by those with wheelchairs, bicycles, baby buggies, etc. is 1.6 meters (2 meters is desirable).

- Where medians are used as pedestrian and bicyclist refuges, internally illuminated bollards are suggested on the medians to facilitate quick and easy identification.

- Bicyclists have been put at risk of being squeezed where insufficient room has been left between a central median and the adjacent curb. Experience shows that most drivers are unlikely to hold back in such instances to let bicyclists go through first. This threat is particularly serious on roads with high proportions of heavy vehicles.

- The contradiction between the need to reduce the roadway width sufficiently to lower motorist speeds, while at the same time leaving enough room for bicyclists to ride safely, must be addressed. This may be achieved by reducing the roadway width to the minimum necessary for a bicyclist and a motorist to pass safely (i.e., 3.5 meters).

There are three suggestions:

- Introducing color or texture changes to the road surface material around the refuge area reminds motorist that a speed reduction is intended.

- White striping gives a visual impression that vehicles are confined to a narrower roadway than that created by the physical obstruction — adjacent areas exist that vehicles can run over, but these are not generally apparent to approaching drivers.

- In some cases, provide an alternate, cut-through route for the bicyclists.

Curb Extensions

The sidewalk and/or landscaped area on one or both sides of the road is extended to reduce the roadway to a single lane or minimum-width double lane. By reducing crossing distances, sidewalk widening is used to facilitate easier and safer pedestrian movement.

Reducing roadway width results in vehicle speed reductions. When curb extensions are used at intersections, the resultant tightened radii ensure that vehicles negotiating the intersection do so at slow speeds.

A 7-foot radius allows for a slow and safe turn. As the radius increases, so does the speed of the vehicle.

Design Considerations:

- Can be installed either at intersections or mid-block.
- May be used in conjunction with other traffic-calming devices.
- Curb extensions are limited only to the degree that they extend into the travelway. Curb extensions cannot impede or restrict the operation of the roadway.
- Successful bicycle facilities need a clear separation from sidewalk and street pavement, with adequate distances from parked cars to avoid opening doors. Cross-traffic should be slowed to allow bicyclists better continuity and safety.
- Narrowing certain streets can, at the same time, create safer bicycle facilities, but care should be taken that bicyclists are not squeezed by overtaking vehicles where the road narrows. Encouraging motorists to let the bicyclists through first by using complementary traffic-calming techniques such as speed tables and cautionary signing or leaving sufficient room for both to pass safely at the narrowing would be appropriate measures.
- If it is expected that a motorist should be able to pass a bicyclist, the minimum desirable width is 3.5 meters.
- Curb extensions can be employed to facilitate bicycle movement where a segregated multi-use trail crosses a busy street.

Corner Radius Treatment

Corner radii of intersection curbs are reduced, forcing turning vehicles to slow down. Efforts to accommodate trucks and other large vehicles have historically led to increased corner radii at intersections.

The following results have been observed:

- Large vehicles (trucks, vans, etc.) turn the corners easily.
- Other vehicles turn faster than with a reduced radius corner.
- Pedestrian crossing distances are increased by up to 4 feet, depending on the radius.
- Pedestrian safety is decreased, due to higher speeds.
- The sharper turns that result from the reduced radii require motorists to reduce speed, increasing the time available to detect and take appropriate actions related to pedestrians at the crossing.

Advantage:

- Can result in increased safety for pedestrians by reducing crossing distances and slowing the speed of turning vehicles.

Disadvantages:

- May result in wide swings in turning movements of large vehicles.

The design of street closures should provide specific parking areas to discourage obstruction of bicycle and pedestrian traffic.

- May affect response times for emergency vehicles.

Design Consideration:
- To slow traffic, a corner radius of approximately 7 feet is recommended.

Narrow Traffic Lanes
Especially in residential areas, wide streets may not be necessary or desirable. Wide traffic lanes encourage faster motor vehicle speeds. Consideration should be given to the review of cross-sections for all street classifications to determine whether roadway lane widths can be reduced (within AASHTO guidelines) so more area can be dedicated to bicycle and pedestrian use and associated traffic-calming facilities.

Advantages:
- Additional area for landscaping, and pedestrian facilities.
- Reduced vehicle speeds and increased safety.

Disadvantage:
- On-street parking may be restricted.

Design Consideration:
- Cross-section approaching the reduced-width street should also be slowed.

Example: City of Portland, Skinny Street Program
The City of Portland requires most newly constructed residential streets to be 20 or 26 feet wide, depending on neighborhood on-street parking needs. In the past, residential streets were required to be as wide as 32 feet. To achieve a variety of benefits, the City reduced residential street widths. The City's Fire Bureau participated in the development of this standard to ensure access for emergency vehicles.

3. Street closures.
Three types of street closures are described in the following discussion:
- Complete street closures.
- Partial street closures.
- Driveway links.

(Caution: Street closures must be considered in an area-wide context or traffic problems may simply shift to another nearby street).

Complete Street Closures
Street closures, generally on residential streets, can prohibit through-traffic movement or prevent undesirable turns. Street closures may be appropriate where large volumes of through-traffic or "short-cut" maneuvers create unsafe conditions in a residential environment.

Design Considerations:
- Where proposals are likely to lead to a reduction in access, prior consultation with residents at early stages of planning and design is especially important to minimize opposition.

- The benefits of exempting bicyclists should be carefully considered in all cases.

- Bicycle gaps should be designed to minimize the risk of obstruction by parked vehicles. Painting a bicycle symbol and other directional markings on the road in front of the bicycle gap has proven to be effective.

- Bollards can reduce the parking obstruction.

- Bollards should be lighted or reflectorized to be visible at night.

- The design of bicycle gaps should permit good visibility of adjacent roads.

- Signing should acknowledge the continued route as a through one for bicyclists.

- Clearly defined parking can reduce the problem of parked cars blocking the closure and bicycle gap.

- Police and fire departments should be consulted early in the design process to determine emergency access requirements. Often, removable bollards, crash gates, and card or key-operated gates can satisfy these requirements, combined with parking restrictions. A 20-foot-wide clear path is needed for emergency access.

- Tree planting, benches, and textured paving can enhance appearance.

- Street closures are recommended only after full consideration of all expected turning and reversing movements, including those of refuse trucks, fire trucks, and other large vehicles.

Partial Street Closures
Access to or from a street is prohibited at one end, with a no-entry sign and barrier restricting traffic in one direction. The street remains two-way, but access from the closed end is permitted only for bicyclists and pedestrians.

Design Considerations:

- Bicycle and pedestrian exemptions should be provided as a general rule, designed to minimize the likelihood of obstruction by parked vehicles.

- All signing should acknowledge the continued existence of the route as a through one for bicyclists and pedestrians.

Driveway Links
A driveway link is a partial street closure, where the street character is significantly changed so it appears to be a private drive. Typically, the roadway is narrowed and defined with textured or colored paving. A ribbon curb or landscaping may be used to delineate roadway edges. "Reclaimed" roadway area is converted to pedestrian facilities and landscaping.

This is a very effective method of changing the initial impression of the street. If done right, drivers will not be able to see through. It appears as a road closure, yet allows through traffic.

The driveway link can provide access to small groups of homes and is especially applicable to planned residential developments. The "go slow" feel of the driveway link is enhanced by design standards that eliminate vertical curb and gutter and use a relatively narrow driveway cross-section. A ribbon curb may be used to protect roadway edges.

4. Traffic diversion.
Traffic diversion is one of the most widely applied traffic-calming concepts. It includes all devices that cause motor vehicles to slow and change direction to travel around a physical barrier. Physical barriers used to divert traffic in this fashion can range from traffic circles to trees planted in the middle of the road. The discussion that follows provides information on: traffic diverters, traffic circles, chicanes, and "tortuous" street alignments as traffic-calming devices.

Traffic Diverters
Traffic diverters are physical barriers installed at intersections that restrict motor vehicle movements in

Diagonal road closures/diverters limit vehicular access, but allow emergency vehicles to enter through removable bollards.

selected directions. The diverters may be designed to prevent right- or left-hand turns, to block straight-ahead travel and force turns to the right or left, or create a "T" intersection. In all cases, paths, cut-throughs, or other provisions should be made to allow bicyclists and pedestrians access across the closure.

Traffic diverters can take many forms. Here are two examples:

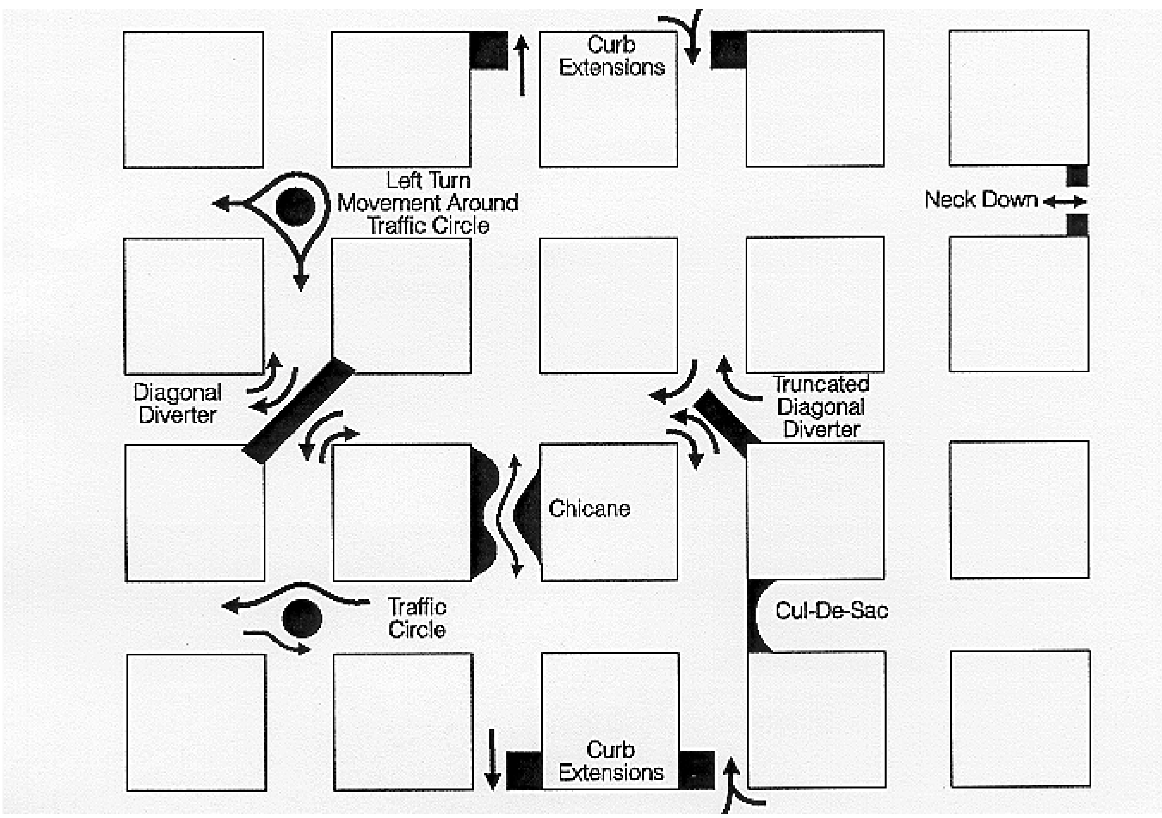
(1) Diagonal road closure/ diversion.
Straight-through traffic movements are prohibited. Motorists are diverted in one direction only.

The splitter islands should be raised and landscaped to prevent left-turning vehicles from taking a short cut to avoid driving around the outside of the island.

Advantages:
- Through-traffic is eliminated.
- Area for landscaping is provided.
- Conflicts are reduced.
- Pedestrian safety is increased.
- Can include a bicycle pathway connection.

Disadvantages:
- Will inconvenience residents in gaining access to their properties.
- May inhibit access by emergency vehicles unless street names are changed.
- Will move through traffic to other streets if not back to the arterial.

Example:
Eugene, Oregon has used diagonal diverters with positive community response. Eugene installs the



Example of an integrated traffic-calming plan.

diverters on a temporary basis to get neighborhood feedback before making a permanent installation. Two types of diagonal diverters are used — some are landscaped, while others are just guardrails. Both types have openings for bicycles. These have been supported by nearby residents.

Traffic circles can be designed to accommodate large vehicles and emergency access without undue restrictions.

Seattle installed truncated diagonal diverters, which allow right-turn movements around one end of the diverter. The Engineering Department found that these diverters were disruptive to neighborhood traffic and has focused instead on installation of traffic circles to control neighborhood traffic problems. Problems experienced with diverters included: (1) travel time and distance increased for all users; (2) local residents were diverted to other streets; (3) visitors and delivery services were often confused and delayed; and (4) emergency vehicle response times were potentially increased.

(2) Turning-movement diverters.
This type of diverter is designed to prevent cut-through traffic at the intersection of a neighborhood street with a major street or collector. It prevents straight-through movements and allows right turns only into and out of the neighborhood.

Advantages:
- Effective at discouraging cut-through traffic.
- Relatively low cost.
- Creates sense of neighborhood entry and identity.

Disadvantages:
- Limits resident access. Should be installed as part of overall neighborhood circulation improvements to ensure reasonable convenience for residents.

- Motorists may try to override the diverter to make prohibited turns unless vertical curbs, barriers, landscaping, or other means are used to discourage such actions.

Traffic Circles
Small traffic circles (center island approximately 4 meters in diameter) can be used as traffic-calming devices at intersections, reducing vehicle speeds. A roundabout is a channelized intersection at which all traffic moves counterclockwise around a central traffic island. These islands may be painted or domed, mountable elements may be curbed, and may include landscaping or other improvements.

Advantages:
- Crashes reduced by 50 to 90 percent when compared to two-way and four-way stop signs and other traffic signs by reducing the number of conflict points at intersections.

- Effective in reducing motor vehicle speeds. Success, however, depends on the central island being sufficiently visible and the approach lanes engineered to deflect vehicles, preventing overrun of the island. Overrunnable roundabouts on straight roads are less likely to produce the desired speed reduction.

Roundabout Accident Study
In 1989, a survey of crashes at mini-roundabouts examined years of crash data for 447 sites in England, Wales, and Scotland.

Key survey findings were:
- Mini-roundabouts were most commonly used on streets with speed limits of 30 mph or less.

Where possible, cyclists should be provided with cycle slips which enable them to bypass speed humps.

- Mini-roundabouts were found to have a far lower overall accident rate than that of signalized intersections with equivalent speed limits.

- Looking only at crashes involving bicycles, the study showed that four-arm mini-roundabouts have about the same involvement rate (accidents per million vehicles of that type entering the intersection) as do conventional, four-legged, signalized intersections.

Comparative Accident Rates:

Signalized intersections:
2.65 accidents/intersection/year
34 accidents per 100 million vehicles
20% resulted in serious or fatal injury

Roundabouts:
0.83 accidents/intersection/year
20 accidents per 100 million vehicles
19% resulted in serious or fatal injury

Both types of intersections compared have 30-mph speed limits and are four-legged intersections.

Splitter islands are the islands placed within a leg of the roundabout, separating entering and exiting traffic and designed to deflect entering traffic. They are designed to prevent hazardous, wrong-way turning movements.

These islands are important design elements and should be provided as a matter of routine, wherever feasible. Without splitter islands, left-turning motorists have a tendency to shortcut the turn to avoid driving around the outside of the central island. The islands should, preferably, be raised and landscaped. If this is not possible, painted island markings should be provided.

Design Considerations:

- Roundabouts should preferably have sufficiently raised and highly visible centers to ensure that motorists use them, rather than overrunning.

- Clear signing is essential.

- Complementary speed reduction measures such as road humps on the approach to roundabouts can improve safety.

- The design of roundabouts must ensure that bicyclists are not squeezed by other vehicles negotiating the feature. Yet, where possible, adequate deflection must be incorporated on each approach to enforce appropriate entry speeds for motor vehicles.

Example: Seattle Neighborhood Traffic Control Program

The Seattle Engineering Department (SED) has experimented since the 1960's with a variety of neighborhood traffic control devices. The major emphasis of the SED Neighborhood Traffic Control Program is installing traffic circles (roundabouts) at residential street intersections. City staff report that about 30 circles are built each year. A total of approximately 400 circles have been installed to date. Each circle costs about $5,000 to $6,000.

In Seattle, a traffic circle is an island built in the middle of a residential street intersection. Each circle is custom-fitted to the intersection's geometry; every circle is designed to allow a single-unit truck to maneuver around the circle without running over it. A 2-foot concrete apron is built around the outside edge of the circle to accommodate larger trucks. Large trucks, when maneuvering around the circle, may run over the apron. The interior section of the circle is usually landscaped.

SED coordinates the design and construction of each circle with the Seattle Fire Department and school bus companies.

Traffic circles are installed at the request of citizens and community groups. Because there are more requests than funding to build them, SED has created a system for evaluating and ranking the requests. Before a request can be evaluated, a petition requesting a circle must be signed by 60 percent of the residents within a one-block radius of the proposed location. Then, the intersection's collision history, traffic volume, and speeds are studied.

Chicanes

Chicanes are barriers placed in the street that require drivers to slow down and drive around them. The barriers may take the form of landscaping, street furniture, parking bays, curb extensions, or other devices.

The Seattle Engineering Department has experimented with chicanes for neighborhood traffic control. It has found chicanes to be an effective means of reducing speed and traffic volumes at specific locations under certain circumstances. A demonstration project at two sets of chicanes showed:

- Reduction of traffic volumes on the demonstration streets.
- Little increase in traffic on adjacent residential streets.
- Reduced motor speeds and collisions.
- Strong support for permanent installation of chicanes by residents (68 percent).

Design Considerations:

- Consideration should be given to safe bicycle travel. Bicycle bypasses and signs to indicate directional priority are suggested.

- A reduction in sight lines should not be used in isolation to reduce speeds, as alone, this could be potentially dangerous. A reduction in sight lines may be appropriate to avoid excessive land taking or as a reinforcing measure only where other physical features are employed that reduce speed.

- Chicanes offer a good opportunity to make environmental improvements through planting. However, preference should be given to low-lying or slow-growing shrubs to minimize maintenance and ensure good visibility.

- Measures should be employed to ensure that chicanes are clearly visible at night.

- Where full closure or speed humps are not feasible, chicanes may be used to reduce traffic speeds. Many different layouts are possible, including staggered parking (on alternating sides of the road).

Tortuous Roads

Roads can be designed to meander or jog sharply, slowing traffic and limiting views to discourage speeding. This technique can incorporate use of cul-de-sacs and courtyards.

Design Considerations:

Tortuous roads are generally planned as part of the design stage of a new road layout, rather than being superimposed on an existing layout. The siting of buildings is used to create a meandering road.

These pavement markings at a median refuge not only delineate the crossing for motorists, but also cue pedestrians about the location of the roadway edge.

- Designers should be aware of the need for accessibility to residential properties, both in terms of servicing and the needs of the individual. Tortuous roads will prove to be unpopular if they severely restrict accessibility.

- Where traffic is deliberately diverted onto a tortuous route — to avert town center congestion, for example — consideration should be given to maintaining as direct a route as possible for bicyclists.

- Tortuous roads (a.k.a. serpentines) are under study, but have not yet been approved for use in Portland. If approved, they would be limited for use on two-lane or fewer residential streets.

- Road design is limited by AASHTO standards for transition taper lengths.

- This traffic-calming device may require significant parking removal and should be used where parking removal is not an issue.

5. Surface texture and visual devices.
This category of traffic-calming devices includes signing, pavement marking, colored and textured pavement treatments, and rumble strips. These devices provide visual and audible cues about the traffic-calmed area. Colors and textures that contrast with those prevailing along the roadway alert motorists to the need for alertness, much as conspicuous materials increase bicyclist and pedestrian visibility. Signs and pavement markings also provide information about applicable regulations, warnings, and directions.

Signing and Pavement Markings
Installation of directional, warning, and informational signs and pavement markings should conform to MUTCD guidelines, as applicable. Traffic-calming devices may be new to many people in the United States and the signs and markings will help minimize confusion and traffic conflicts.

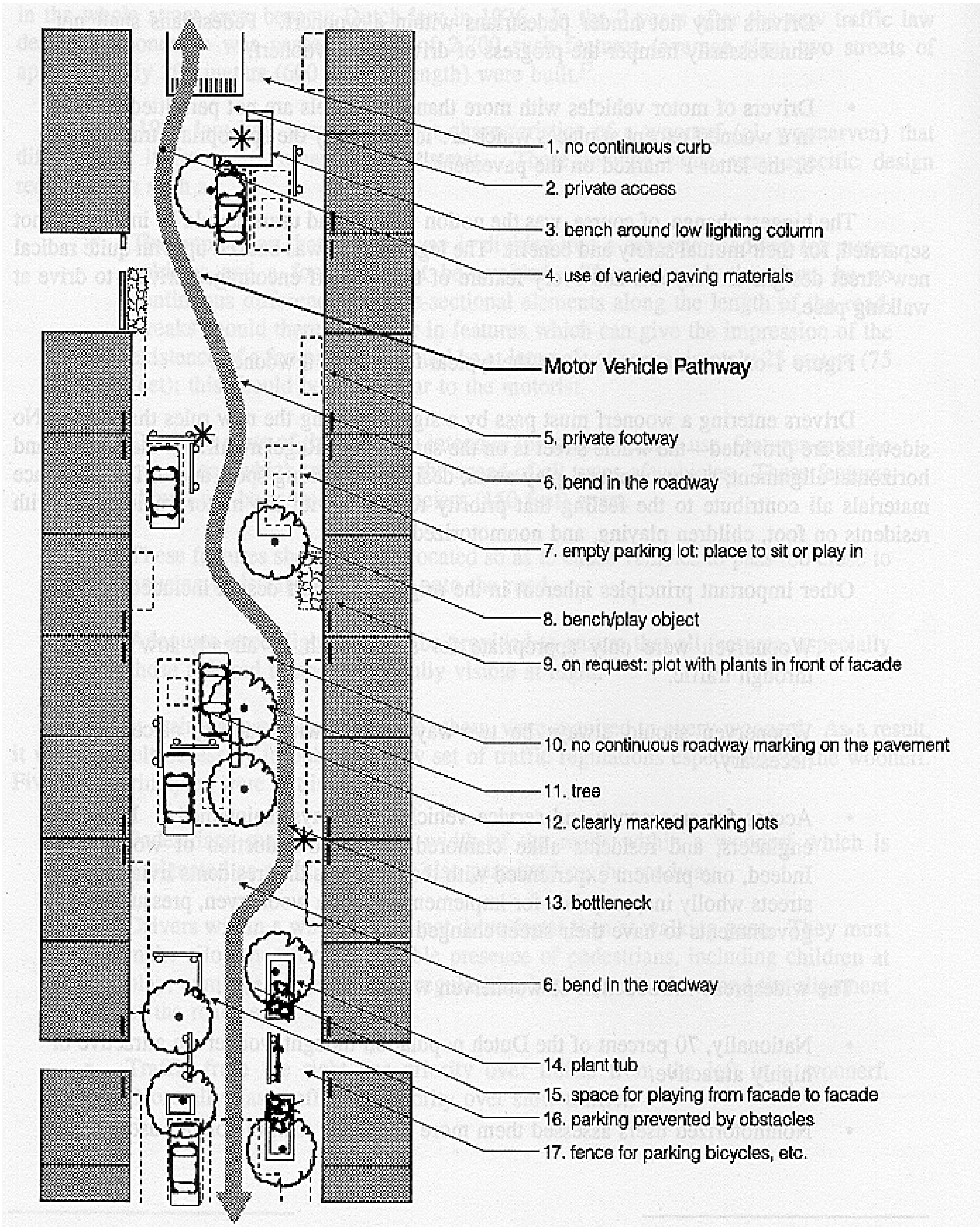
Design Considerations:

- A part of the sign/pavement marking approach to mitigating traffic in residential areas includes painting of stripes/lines on the roadway and other patterns that are designed to have a psychological impact on drivers. Although such patterns are basically intended to slow vehicles rather than reduce traffic, they should make passage over residential streets less desirable than if the roadway were untreated, in effect, encouraging the use of alternative routes.

- Many of the patterns tried have had only marginal success. In a few cases, the average speed increased slightly. A pattern that is successful is that of painting transverse bands. Painted lines are applied to the road at decreasing intervals approaching an intersection or “slow-down” point. They are intended to give the impression of increasing speed and motorists react by slowing down.

Pavement treatments can be applied to the entire traffic-calmed area or limited to specific street uses. The texture or color should be a noticeable contrast to the approaching roadways if speeds are to be reduced.

Pavement Texturing and Coloring
The use of paving materials such as brick, cobbles, concrete pavers, or other materials that create variation in color and texture reinforces the identity of the area as a traffic-restricted zone.



Model of a "woonerf."

Design Considerations:

- The choice of materials should ensure that they do not pose a danger or deterrent to bicyclists. Cobbles present special difficulties, particularly for vehicles with narrow wheels and without the benefit of suspension. Such treatment is particularly discouraging for bicyclists on steep slopes, making it harder to maintain momentum when riding uphill. Thus, as a general rule, cobbles should not be employed. Similarly, pavers with chamfered edges impair a bicyclist's stability and should be avoided.

- The color and texture of the street surface are important aspects of the attractiveness of many residential streets. The variation from asphalt or concrete paving associated by most people with "automobile territory" signals to the motorist that he or she has crossed into a different, residential zone where pedestrians and bicyclists can be expected to have greater priority.

Putting the Design Techniques to Work: Selected Examples of Traffic Calming

Most traffic-calmed streets utilize a combination of the devices just discussed. The following are some examples: the woonerf, entry treatments, shared streets, and other techniques (bicycle boulevards, modified street design, modified intersection design, channelization changes, traffic calming on a major road, slow streets, transit streets, and pedestrian zones).

The distinction between sidewalks and roadway is blurred in woonerfs.

1. The woonerf.

A woonerf (or "living yard") combines many of the traffic-calming devices just discussed to create a street where pedestrians have priority and the line between "motor vehicle space" and "pedestrian (or living) space" is deliberately blurred (see the model of a woonerf). The street is designed so motorists are forced to slow down and exercise caution. Drivers, the Dutch say, do not obey speed limit signs, but they do respect the design of the street.

The woonerf (plural — woonerven) is a concept that emerged in the 1970's as increased emphasis was given by planners to residential neighborhoods. People recognized that many residential streets were unsafe and unattractive and that the streets, which took up a considerable amount of land area, were used for nothing but motor vehicle access and parking. Most of the time, the streets were empty, creating a "no-man's land" separating the homes from one another.

The Dutch, in particular, experimented extensively with street design concepts in which there was no segregation between motorized and non-motorized traffic and in which pedestrians had priority.

A law passed in 1976 provided 14 strict "design rules" for woonerfs and resulted in construction of 2,700 such features in the following seven years.

The woonerven were closely evaluated, with the/ following findings:

- Injury accidents were reduced by 50 percent.

- Vehicle speeds were reduced to an average of 8 to 15 mph (13 to 25 km/h).

- Nationally, 70 percent of the Dutch population thought woonerven to be attractive or highly attractive.

- Non-motorized users assessed woonerven more positively than motorized users.

- Feedback from residents living on woonerfs was very positive. They appreciated the low traffic volumes and absence of cut-through traffic, but considered the larger play areas and other improvements to the street environment to be even more important benefits.

Woonerf Design Principles:
Following evaluation of the woonerven, the Dutch law was amended (July 1988) to allow greater design flexibility, replacing the design rules with six basic principles.

(1) The main function of the woonerf shall be for residential purposes. Thus, roads within the "erf" area may only be geared to traffic terminating or originating from it. The intensity of traffic should not conflict with the character of the woonerf in practical terms: conditions should be optimal for walking, playing, shopping, etc. Motorists are guests. Within woonerven, traffic flows below 100 vehicles per hour should be maintained.

(2) To slow traffic, the nature and condition of the roads and road segment must stress the need to drive slowly. Particular speed-reduction features are no longer mandated, so planners can utilize the most effective and appropriate facilities.

(3) The entrances and exits of woonerven shall be recognizable as such from their construction. They may be located at an intersection with a major road (preferable) or at least 20 meters (60 feet) from such an intersection.

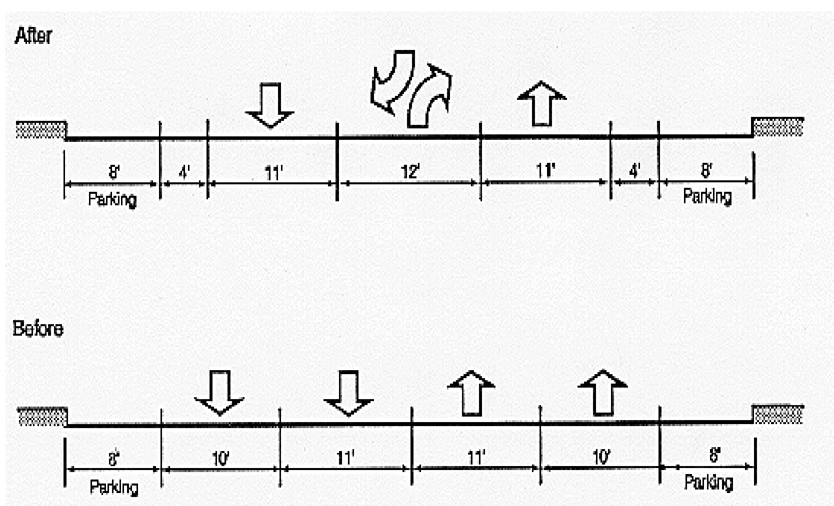
(4) The impression shall not be created that the road is divided into a roadway and sidewalk. Therefore, there shall be no continuous height differences in the cross-section of a road within a woonerf. Provided this condition is met, a facility for pedestrians may be realized. Thus, space can be designated for pedestrians and a measure of protection offered, for example, by use of bollards or trees.

(5) The area of the road surface intended for parking one or more vehicles shall be marked at least at the corners. The marking and the letter "P" shall be clearly distinguishable from the rest of the road surface. In shopping street "erfs" (winkelerven), special loading spaces can be provided, as can short-term parking with time limits.

(6) Informational signs may be placed under the international "erf" traffic sign to denote which type of "erf" is present.

2. Entry treatment across intersections.
Traffic-calming devices can be combined to provide an entry or "gateway" into a neighborhood or other district, reducing speed though both physical and psychological means. Surface alterations at intersections with local streets can include textured paving; pavement inserts; or concrete, brick, or stone materials. At the entry, the surface treatment can be raised as high as the level of the adjoining curb. Visual and tactile cues let people know that they are entering an area where motor vehicles are restricted.

Eugene, Oregon installs curb extensions at entrances to neighborhood areas, usually where a residential



The conversion of a 58-foot roadway. Elimination of one travel lane in each direction creates space for bicyclists.

street intersects an arterial. The curb extension is placed to prevent motor vehicle traffic from cutting through the neighborhood. The curb extension is signed as a neighborhood entrance or exit. Most of the street remains two-way, but one end becomes a one-way street. Compliance by motor vehicles is mostly good. Bikes are allowed to travel both ways at all curb extensions.

3. Bicycle boulevards.
The City of Palo Alto, California has moved beyond spot traffic-calming treatments and has created bicycle boulevards — streets on which bicycles have priority.

The purpose of a bicycle boulevard is to provide:

- Throughway where bicycle movements have precedence over automobiles.
- Direct route that reduces travel time for bicyclists.
- Safe travel route that reduces conflicts between bicyclists and motor vehicles.
- Facility that promotes and facilitates the use of bicycles as an alternative transportation mode for all purposes of travel.

The Palo Alto bicycle boulevard is a 2-mile stretch of Bryant Street — a residential street that runs parallel to a busy collector arterial. It was created in 1982 when barriers were fitted to restrict or prohibit through motor vehicle traffic, but to allow through bicycle traffic. In addition, a number of stop signs along the boulevard were removed. An evaluation after 6 months showed a reduction in the amount of motor vehicle traffic, a nearly twofold increase in bicycle traffic, and a slight reduction in bicycle traffic on nearby streets.

The City also found that anticipated problems failed to materialize and concluded that a predominately stop-free bikeway — on less traveled residential streets — can be an attractive and effective route for bicyclists. The bicycle boulevard bike traffic increased to amounts similar to those found on other established bike routes.

The bicycle boulevard continues to function as a normal local city street, providing access to residences, on-street parking, and unrestricted local travel. The City received complaints about the visual appearance of the initial street closure barriers (since upgraded with landscaping), but is unaware of any other serious concerns of nearby residents.

Plans for the extension of the bicycle boulevard through downtown Palo Alto were approved by the City Council in the summer of 1992. Included in this extension was the installation of a traffic signal to help bicyclists cross a busy arterial.

4. Channelization changes.
The Seattle Engineering Department is changing some of its streets from four lanes to two lanes. with a center left-turn lane. These channelization changes can provide extra room for bicycle lanes or a wide lane for cars and bikes to share.

Numerous comments from users of some of those streets say motor vehicle speeds seem to have decreased. One street in particular, Dexter Avenue North, is a popular commuting route to downtown Seattle for bicyclists.

Traffic counts on the street show bicyclists make up about 10 to 15 percent of the traffic at certain times during the day. The rechannelization had little or no effect on capacity, reduced overtaking accidents, and made it easier for pedestrians to cross the street (by providing a refuge in the center of the road).

11.5 Exercise

Do one of the following exercises:

1. Choose a site-specific location (such as two to three blocks of a local street) where fast traffic or short cuts are a problem. Conduct a site analysis to determine problems. Prepare a detailed site solution that incorporates several traffic-calming devices. Illustrate with drawings and describe the anticipated changes in traffic speed.

2. Prepare a traffic-calming solution for an entire neighborhood or downtown area that illustrates an area-wide approach to slowing traffic. Conduct a site analysis to determine problem areas. Illustrate your solutions and describe the anticipated changes in traffic speed and flow.

11.6 References

Text and graphics for this lesson were derived from the following sources:

Federal Highway Administration, *National Bicycling and Walking Study–Case Study No. 19: Traffic-Calming, Auto-Restricted Zones, and Other Traffic Management Techniques–Their Effects on Bicycling and Pedestrians,* 1994.

Federal Highway Administration, *Pedestrian & Bicyclist Safety and Accommodation–Participation Handbook*, NHI Course #38061, 1996.

Hass Klau, *Illustrated Guide to Traffic Calming*, Institute of Transportation Engineers, 1990.

For more information on this topic, refer to:

J. Cleary, *Cyclists and Traffic Calming*, Cyclists Touring Club, Godalming, U.K., 1991.

R. Ewing and Kooshian, “U.S. Experience With Traffic Calming,” *ITE Journal*, August 1997, pp. 28-33.

Cynthia Hoyle, *Traffic Calming*, Planning Advisory Service Report No. 456, American Planning Association, 1995.

Institute of Transportation Engineers, *Recommended Guidelines for the Design and Application of Speed Humps*, 1993.

National Cooperative Highway Research Program (NCHRP), *Research Synthesis on Roundabouts*, NCHRP Synthesis 264.

Traffic Calming in Practice– An Authoritative Sourcebook With 85 Illustrative Case Studies (available through ITE), Landor Publishing, London, 1994.

LESSON 12

Pedestrian and Bicycle Facilities in Work Zones

12.1 Purpose

When construction zones encroach on sidewalks or crosswalks, pedestrians may suddenly find themselves having to make detours that may be unsafe, difficult to navigate, or both. They may be forced to choose between picking their way through the construction site or walking in a busy street. This can be especially dangerous for the elderly and handicapped, who rely on well-maintained, well-marked sidewalks for safe mobility. Adding to the problem is when projects are built in phases and when construction zones change weekly or even daily.

Bicyclists also experience difficulties when traveling through construction zones, particularly when roadway space is constrained and when pavement conditions are rough. In some instances, sudden pavement changes in construction zones can represent a severe hazard to bicyclists.

This lesson describes typical problems and solutions that improve conditions for bicyclists and pedestrians in work zones.

12.2 Possible Solutions

It is important to develop and implement construction zone policies to eliminate unexpected obstacles for pedestrians and bicyclists and make transitions as safe and smooth as possible. The following concerns should be addressed:

- Advance warning and guidance signs.
- Adequate illumination and reflectorization.
- Channelizing and barricading to separate pedestrians from traffic.
- Wheelchair accessibility.
- Preventing visually impaired pedestrians from entering work zones.
- Warning bicyclists about surface irregularities and maintaining areas where bicyclists can pass through construction zones.
- Circumstances requiring temporary walkways and/or bikeways.

Utility work in bike lanes can often be accomplished without blocking the entire lane.

Contractors should be allowed flexibility as long as requirements are met. It's often difficult to plan ahead as many traffic control decisions are made daily in the field. All parties involved should be made aware of the needs of pedestrians and bicyclists and be made responsible for ensuring safe and continuous passage.

12.3 Implementation Strategies

Developing a workable policy for bicycle and pedestrian access through construction zones requires the cooperation of traffic engineers, construction inspectors, crew chiefs, contractors, and advocates. The policy should apply whenever construction or maintenance work affects pedestrian or bicycle access, whether the work is done by private firms or city, county, or State crews.

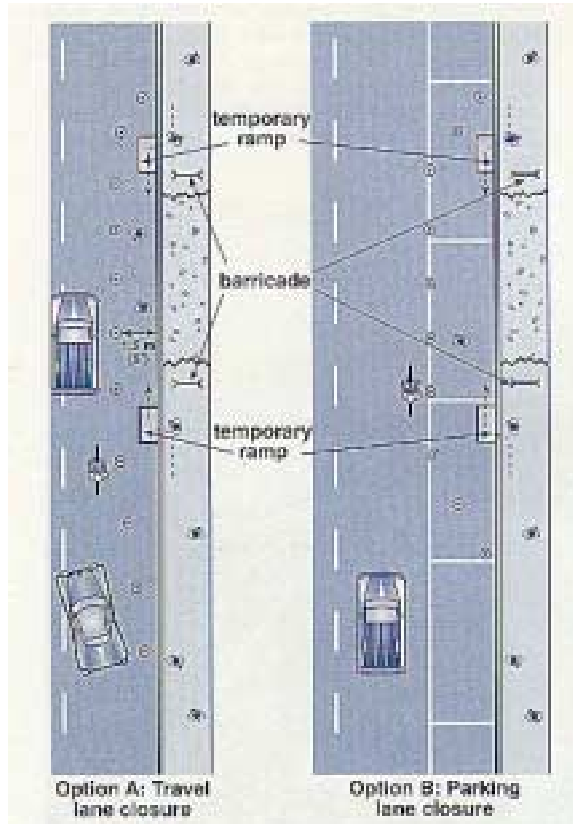
Link to construction permits: Make sure that permits required for street construction or construction projects that encroach upon sidewalks or crosswalks are contingent upon meeting bicycle and pedestrian access policies. Give contractors copies of the standards when they apply for a permit. What is needed are standards or a policy that is readily available. These can be incorporated into contracts, agreements, or specifications.

Train in-house work crews: Many road, pavement, maintenance, or utility projects use permanent city crews to do the work. Educate crew chiefs and crews to ensure that they understand and follow the policy.

Enacting pedestrian and bicycle access policies for work zones is not expensive. The main costs involve developing the policy, training crews and construction inspectors, and imparting information to contractors. On-going costs involve work site inspection.

12.4 Planning and Design Considerations

While the 1988 MUTCD's pedestrian guidelines apply to pedestrian traffic around work zones, the absence of specific guidance on pedestrian access around construction zones leaves local agencies with a great deal of flexibility. Keep in mind that the MUTCD's silence on this subject may lead some in an agency to balk at establishing hard and fast regulations.



Creating passageways for pedestrians during construction.
(Cone taper not to scale. See MUTCD for standard lane closure.)

Rural Highway Construction

Construction operations on rural highways affect mostly touring and recreational bicyclists; pedestrians are seldom encountered in rural settings.

On low-volume roads or through short construction zones, standard traffic control practices are usually adequate. Bicyclists can ride through without impeding traffic. Their needs can be met by maintaining a paved surface and removing temporary signs, debris, and other obstructions from the edge of the roadway after each day's work.

On high-volume roads or through long construction zones, enough paved roadway width should be provided for motor vehicles to safely pass bicyclists.

Flaggers and pilot cars should take into account the bicyclists' lower speeds. When bicyclists are coming through, radio messages can be relayed to other flaggers.

On highways with very high traffic volumes and speeds, and where construction will restrict available width for a long time, it may be advisable to provide a detour route for bicyclists where possible. The detour should not be overly circuitous. Directional signs should guide bicyclists along the route and back onto the highway.

Urban Roadway Construction
Through-bicycle movement must also be maintained. Bicyclists can share a lane over a short distance. On longer projects and on busy roadways, a temporary bike lane or wide outside lane may be provided. Bicyclists should not be routed onto sidewalks or onto unpaved shoulders.

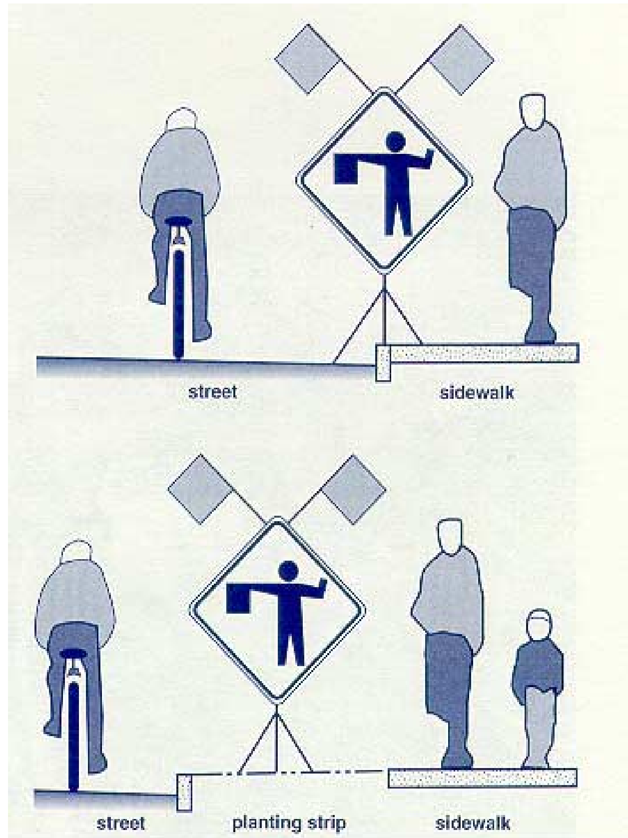
Debris should be swept to maintain a reasonably clean riding surface in the outer 1.5 or 1.8 meters (5 or 6 feet) of roadway. Bicyclists have a low tolerance for surface grade changes and excessive bumps should be avoided.

The placement of advance construction signs should obstruct neither the pedestrian's nor the bicyclist's path. Where this is not possible, placing signs half on the sidewalk and half on the roadway may be the best solution.

Pedestrian Issues: Seattle Example
The Engineering Department of the City of Seattle has developed specific policies for pedestrian access, control, and protection in work zones. These policies are detailed in the City's *Traffic Control Manual for In-Street Work* (4th edition, 1994). The purpose of the manual is "to set forth the basic principles and standards to be observed by all those who perform work in public streets so as to provide safe and effective work areas and to warn, control, protect, and expedite vehicular and pedestrian traffic."

Before any in-street work is commenced, all persons performing work within the street right-of-way must first obtain a permit by submitting and receiving approval of a traffic control plan.

To protect pedestrians, the manual describes procedures for erecting protective barricades, fencing, and bridges, together with guidance devices

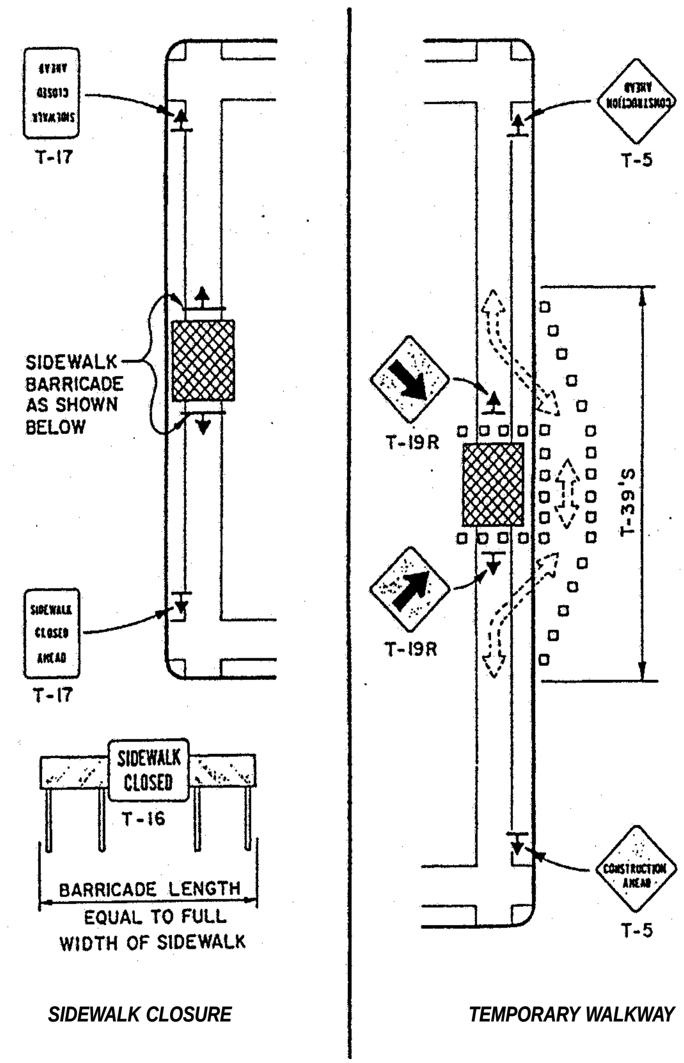


Construction sign placement.

and signs. Whenever passageways or walkways are affected by construction, access for pedestrians and disabled persons is ensured. Access to recommended school crossings must be maintained at all times. Where walkways are necessarily closed by construction, alternate walkways, including temporary curb ramps, must be provided. Where alternate walkways are not feasible, signs are required at the limits of construction and in advance of the closure at the nearest crosswalk or intersection to divert pedestrians across the street. Pedestrians must never be diverted into a portion of the street concurrently used by moving vehicular traffic. Where required, fixed pedestrian ways using fences and canopies shall be considered. Adequate illumination and reflectorization is required during hours of darkness.

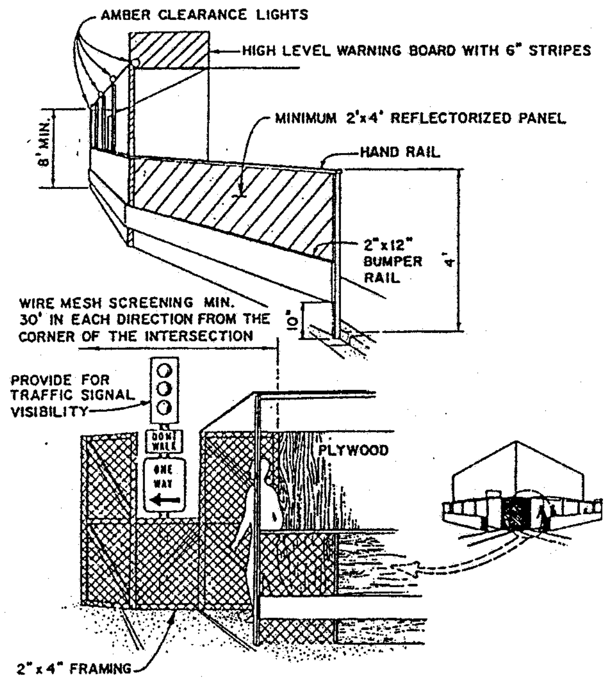
The diagrams on the pages 12-4 and 12-5 are excerpted from Seattle's *Traffic Control Manual for In-Street Work*.

Figure 12-1: Pedestrian Control in Work Zones

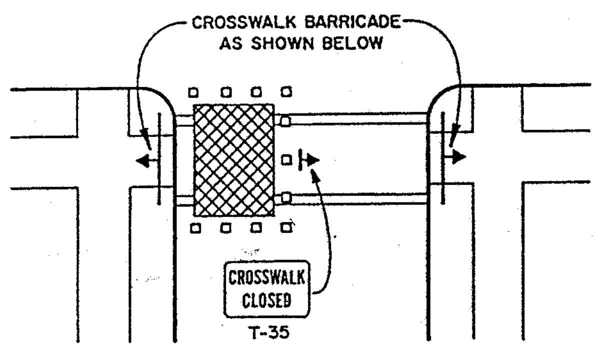


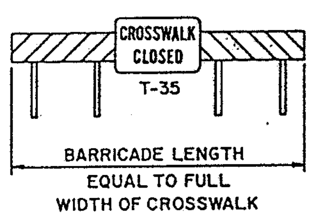
PEDESTRIAN CONTROL
Source: *Traffic Control Manual for In-Street Work*, Seattle Engineering Department

Figure 12-2: Pedestrian Control in Work Zones



PEDESTRIAN PROTECTION





PEDESTRIAN CONTROL

Source: *Traffic Control Manual for In-Street Work*, Seattle Engineering Department

12.5 References

Text for this section was derived from the following sources:

Oregon Department of Transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

John Williams, *Implementing Pedestrian Improvements at the Local Level*, FHWA.

L E S S O N 1 3

Walkways, Sidewalks, and Public Spaces

13.1 Purpose

No single design feature can ensure that a streetscape will be attractive to pedestrians. Rather, the best places for walking combine many design elements to create streets that “feel right” to people on foot. Street trees, separation from traffic, seating areas, pavement design, lighting, and many other factors should be considered in locations where pedestrian travel is accommodated and encouraged. This lesson provides an overview of these design elements, with examples of successful streetscapes throughout the United States.

13.2 Basic Urban Sidewalk Requirements

All urban sidewalks require the following basic ingredients for success: adequate width of travel lanes, a buffer from the travel lane, curbing, minimum width, gentle cross-slope (2 percent or less), a buffer to private properties, adequate sight distances around corners and at driveways, shy distances to walls and other structures, a clear path of travel free of street furniture, continuity, a well-maintained condition, ramps at corners, and flat areas across driveways. Sidewalks also require sufficient storage capacity at corners so that the predicted volume of pedestrians can gain access to and depart from signalized intersections in an orderly and efficient manner.

Minimum Width of Sidewalks

Sidewalks require a minimum width of 5.0 feet if set back from the curb or 6.0 feet if at the curb face. Any width less than this does not meet the minimum requirements for people with disabilities. Walking is a social activity. For any two people to walk together, 5.0 feet of space is the bare minimum. In some areas, such as near schools, sporting complexes, some parks, and many shopping districts, the minimum width for a sidewalk is 8.0 feet. Thus, any existing 4.0-foot-wide sidewalks (permitted as an AASHTO minimum) often force pedestrians into the roadway

in order to talk. Even children walking to school find that a 4.0-foot width is not adequate.

Desirable Sidewalk Width
The desirable width for a sidewalk is often much greater. Some shopping districts require 12, 20, 30, and even 40 feet of width to handle the volumes of pedestrian traffic they encounter. Pennsylvania Avenue in Washington, D.C. has 30-foot sidewalk sections to handle tour bus operations, K Street in Washington, D.C. has 20=foot sections to handle transit off-loading and commercial activity, the commercially successful Paseo de Gracia boulevard in Barcelona, Spain has 36 to 48 feet in most sections.

Designers must pay close attention to minimums, and only use variances below these levels for short sections. On the other side of the width equation, overly ample sidewalk widths are rarely justified. It is essential to work out the peak volumes of transit discharge, the likely commercial appeal of an area, and the influence of large tour buses and other factors when designing public space.

Chapter 13 of the *Highway Capacity Manual* covers the topics of sidewalk width and pedestrian level of service.

For two people to walk abreast, 5 feet is the bare minimum for sidewalk width.

Be sure to calculate the commercial need for outdoor cafes, kiosks, corner gathering spots, and other social needs for a sidewalk. Sidewalk widths have not been given sufficient attention by most designers. When working in a commercial area, designers should always consult property owners, chambers of commerce, and landscape architects to make certain that the desired width is realistic. Corner or mid-block bulb-outs can be used to their advantage for creating both storage space for roadway crossings and for social space.

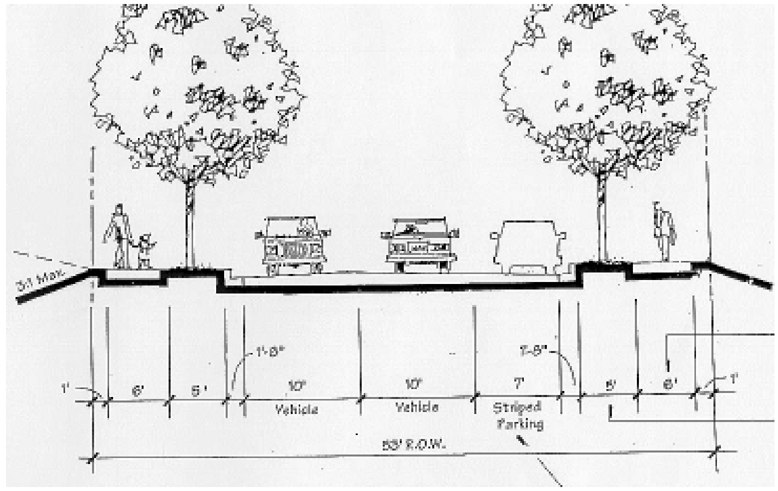
The safety needs of motorists and bicyclists in the roadway must be considered when determining the desirable widths of adjacent sidewalks. There is compelling evidence that generous lane width (12-foot) standards applied to downtown and commercial streets are counterproductive and lead to faster traffic.

AASHTO specifically permits 10- or 11-foot travel lanes on arterials in commercial districts, and also permits turning lanes to be restricted to 10 feet. Truck volumes and the volume of bicycles must also be factored into this equation. As a general rule, when speeds are at or near bicycle speeds (15 to 20 mph), then bike lanes may not be as essential as the appropriate width of sidewalk. The designer is reminded that in Central Business Districts (CBD), the pedestrian volume may be 50 to 90 percent of total traffic. When these needs are not met, the commercial and social success of the community is lessened, and safety may be compromised.

Including ammenities such as newspaper stands and kiosks along corners creates lively, more defined spaces; however, they should not interrupt the flow of pedestrian traffic.

Paving Materials
Although most sidewalks are made of concrete, in some instances, asphalt can provide a useful surface. On trails, joggers and some others prefer asphalt. As a general rule,

however, the long life of concrete, and the distinct pattern and lighter color are preferred. Paver stones can also be used, and in some applications, they have distinct advantages (see section later in this lesson).



The width of a natural buffer provides the essential space needed for situations such as protecting pedestrians from out-of-control vehicles.

Border Areas and Buffers

A border area should be provided along streets for the safety of motorists and pedestrians as well as for aesthetic reasons. The border area between the roadway and the right-of-way line should be wide enough to serve several purposes, including provision of a buffer space between pedestrians and vehicular traffic, sidewalk space, snow storage, an area for placement of underground utilities, and an area for maintainable esthetic features such as grass or other landscaping. The border width may be a minimum of 5 feet, but desirably, it should be 10 feet or wider. Wherever practical, an additional obstacle-free buffer width of 12 feet or more should be provided between the curb and the sidewalk for safety and environmental enhancement. In residential areas, wider building setback controls can be used to attain these features. (AASHTO, *A Policy on Geometric Design of Highways & Streets*, 1990)

The preferred minimum width for a nature strip is 5 to 7 feet. A nature strip this wide provides ample storage room for many utilities. The width provides:

- An essential buffer between an out-of-control motorist and a pedestrian.
- Improved sight distances at driveways.
- Adequate width for landscaping and street trees.

A tree set back from the roadway 4.0 feet meets minimum AASHTO standards for fixed objects when a barrier curb is used (30 mph or less), and is adequate for most species. The area is ample for most snow storage. When this preferred minimum cannot be achieved, any width, down to 4.0 feet or even 2.0 feet, is still beneficial.

Nature strips, especially in downtown areas, may be a good location to use paver stones for easy and affordable access to underground utilities. In downtown areas, nature strips are also a convenient location for the swing-width of a door, for placement of parking meters, hydrants, lampposts, and other furniture.

Another way to achieve border width and the needed buffer from traffic is to provide bike lanes. This 5-foot space creates a minimal safe width to the sidewalk, even when at the back of the curb; reduces the effects of noise and splashing; and provides a higher level of general comfort to the pedestrian.

On-street parking has two distinct advantages for the pedestrian. First, it creates the needed physical separation from the motorist. Second, on-street parking has been shown to reduce motorist travel speeds. This creates an environment for safer street crossings.

On the back side of sidewalks, a minimum width buffer of 1to 3 feet is essential. Without such a buffer, vegetation, walls, buildings, and other objects encroach on the usable sidewalk space. With just several months of growth, many shrubs will dominate a sidewalk space. This setback is essential, not only to the walking comfort of a pedestrian, but to ensure essential sight lines at each residential and commercial driveway.

Placement of Street Furniture/Shy Distances

Pedestrians require a shy distance from fixed objects, such as walls, fences, shrubs, buildings, parked cars, and other features. The desired shy distance for a

Parked cars can also serve as a buffer between the sidewalk and the street.

pedestrian is 2.0 feet. Allow for this shy distance in determining the functional width of a sidewalk.

Note that attractive windows in shopping districts create momentary stoppage of curious pedestrians. This is a desired element of a successful street. These window watchers take up about 18 to 24 inches of space. The remaining sidewalk width will be constrained. This is often desirable on sidewalks not at capacity. But if this stoppage forces pedestrians into the roadway, the sidewalk is too narrow.

Newspaper racks, mail boxes, and other street furniture should not encroach into the walking space. Either place these items in the nature strip, or create a separate storage area behind the sidewalk, or in a corner or mid-block bulb-out. These items need to be bolted in place.

Parking meters on a narrow sidewalk create high levels of discomfort. In a retrofit situation, place meters at the back of the walk, or use electronic parking meters every 50 or 100 feet.

Parking garages on commercial district walks are ideally placed away from popular walking streets. If this cannot be done, keep the driveways and curb radii tight to maximize safety and to minimize the discomfort to pedestrians.

Grade

If possible, grade should be kept to no more than 5 percent, and, terrain permitting, avoid grades greater than 8 percent. When this is not possible, railings and other aids can be considered to help elder adults. The Americans With Disabilities Act (ADA) does not require designers to change topography, but only to work within its limitations and constraints. Do not create any man-made grade that exceeds 8 percent.

Stairs

Since falls are common with poorly designed stairs, every effort should be made to create a slip-free, easily detected, well-constructed set of stairs. The following principles apply: Stairs require railings on at least one side, and they need to extend 18 inches beyond the top and bottom stair. When an especially wide set of stairs is created, such as at transit stations, consider rails on both sides and one or two in mid-stair areas. Avoid open risers, and use a uniform grade with a constant tread to rise along the stairway length. All steps need to be obvious. Stairs should be lit at night. A minimum stairway width is 42 inches (to allow two people to pass). The forward slope should be 1 percent in order to drain water. Stairs in high nightlife pedestrian centers can be lit both above and at the side.

Landscaping

"Landscaping should be provided for esthetic and erosion control purposes in keeping with the character of the street and its environment. Landscaping should be arranged to permit sufficiently wide, clear, and safe pedestrian walkways. Combinations of turf, shrubs, and trees are desirable in border areas along the roadway. However, care should be exercised to ensure that guidelines for sight distances and clearance to obstructions are observed, especially at intersections." (AASHTO, *A Policy on Geometric Design of Highways & Streets*, 1990)

Landscaping can also be used to partially or fully control crossing points of pedestrians. Low shrubs in commercial areas and near schools are often desirable to channel pedestrians to crosswalks or crossing areas.

Sidewalks must be graded and placed in areas where water will not pond or where large quantities of water will not sheet across.

Rural Sidewalks
Sidewalks along rural roadway sections should be provided as near the right-of-way line as is practicable. If a swale is used, the sidewalk should be placed at the back of the swale. If a guardrail is used, the sidewalk must be at the back of the guardrail. There will be times in near-urban spaces where the placement of sidewalks is not affordable or feasible. Wide paved shoulders on both sides of the roadway will be an appropriate substitute in some cases. However, the potential for growth in near-urban areas requires that rights-of-way be preserved. When sidewalks are placed at the back of the right-of-way, it may be necessary to bring the walkways forward at intersections in order to provide a roadway crossing where it will be anticipated by motorists. Security issues are also important on rural area sidewalks, so street lighting should be given full consideration. This lighting can act as part of the transitional area alerting higher speed motorists that they are arriving in an urban area.

Bridge Sidewalks
Bridge crossings are essential to pedestrians and bicyclists. Whenever possible, the sidewalks should be continued with their full width. Sidewalks on bridges should be placed to eliminate the possibility of falling into the roadway or over the bridge itself. Sidewalks should be placed on both sides of bridges. Under extreme conditions, sidewalks can be used on one side only, but this should only be done when safe crossings can be provided on both ends of the bridge. When sidewalks are placed on only one side, they should be wider in order to accommodate large volumes of pedestrian traffic.

Corners
Management of land on the corner is essential to the successful commercial street. This small public space is used to enhance the corner sight triangle; to permit underground piping of drainage so that street water can be captured on both sides of the crossing; to provide a resting place and telephone; to store pedestrians waiting to cross the roadway; and to provide other pedestrian amenities. Well-designed corners, especially in a downtown or other village-like shopping district can become a focal point for the area. Benches, telephones, newspaper racks, mailboxes, bike racks, and other features help enliven this area. Corners are often one of the most secure places on a street. An unbuilt corner, in contrast, is often a magnet for litter and it erodes the aesthetics of the street.

13.3 Street Lighting

For both safety and security reasons, most sidewalks require street lighting. Lighting is needed for both lateral movement of pedestrians and for detection by motorists when the pedestrian crosses the roadway. As a general rule, the normal placement of street luminaries, such as cobra heads, provide sufficient lighting to ensure pedestrian movement. However, in commercial districts, it is often important to improve the level of lighting, especially near ground level. Successful retail centers often use low street lamps in addition to or in lieu of high angle lamps. Some designs permit both the high angle highway lamp and the low angle street lamp on the same pole.

Pedestrians on a pedestrian-oriented street design (shopping district) require three sources of lighting. The first is the overall street lighting, the second is the low placement of lamps (usually tungsten) that reach between and below most trees, and the third is

the light emitted from stores that line the street. The omission of any one of these lights can result in an undesirable effect, and can reduce the desire to walk or shop at night.

Lights are needed in all areas where there are crosswalks or raised channel islands. Lighting can be either direct or can be placed to create a silhouette effect. Either treatment aids the motorist in detecting the pedestrian.

Pedestrians are less attracted to a commercial zone, or any area where there are dark spots. The potential to be victimized keeps many pedestrians from traveling through an area at night. Thus, lighting from shops, street lamps, and highway luminaries are essential to the success of a commercial district. Even one dark spot along a block may force some pedestrians to the opposite side of the street.

13.4 Sidewalk Placement

Sidewalks are recommended on both sides of all urban arterial, collector, and most local roadways. Although local codes vary, AASHTO and other national publications insist that separation of the pedestrian from motorized traffic is an essential design feature of a safe and functional roadway.

Although the AASHTO Policy on Geometric Design of Highways and Streets (Greenbook) does not fully address the issue of sidewalk placement, in lightly developed areas, the Greenbook does recommend that rights-of-way be preserved on all arterial and collector roadways. Although AASHTO and many other organizations suggest that some short sections of local streets can have sidewalks on one side only, the designer should consider that single-side sidewalks can create unwanted motorist/pedestrian conflicts.

Priority Construction of Sidewalks

Many communities, such as Tallahassee, Florida, have small ($250,000), but significant, sidewalk construction funds set aside for community development and pedestrian safety. When prioritizing missing sidewalks, it is important to provide sidewalks to fill gaps on arterials and collectors at the following locations:

- Schools (within 1/4 mile).
- To all transit stops.
- Parks, sports arenas.
- Shopping districts, other commercial areas.
- Recreational corridors.
- Retirement homes.
- Medical complexes/hospitals.
- All public buildings.

Costs and Benefits of Sidewalks

A typical neighborhood lot sidewalk of 5 feet and two street border trees raise the cost of the undeveloped lot by 1to 3 percent. In comparison, residential lot streets with sidewalks and trees often show an increased property value of $3,000 to $5,000.

Pedestrians on a pedestrian-oriented street (shopping district) require three sources of lighting.

13.5 Ambiance, Shade, and Other Sidewalk Enhancements

The above discussion provides a basis for meeting the most basic needs of a pedestrian. In many parts of a city, it is essential to create highly successful walking corridors. The following elements are often found to be desirable to achieve robust commercial activity and to encourage added walking versus single-occupant motor vehicle trips. One or two very attractive features create a highly successful block ... and one or two highly offending or unsafe conditions will leave one side of the street nearly vacant.

The designer of this pre-WW II neighborhood in Birmingham, AL knew the value of street trees.

Trees

It is hard to imagine any successful walking corridor fully void of trees. The richness of a young or mature canopy of trees cannot be matched by any amount of pavers, colorful walls or other fine architecture, or other features. Although on higher speed roads (40 mph and above) trees are often set at the back of the sidewalk, the most charming streets are those with trees gracing both sides of a walkway. This canopy effect has a quality that brings pedestrians back again and again. If only one side can be achieved, then on low-speed roadways, again the trees are best if placed between the walkway and the curb. A 4-foot setback from the curb is required.

In older pre-WW II neighborhoods, trees were often placed every 25, 30, or 35 feet apart. It is essential to keep trees back far enough from the intersection to leave an open view of traffic. With bulb-outs, this can often allow trees near the corner.

Paver Stones

Colorful brick, stone, and even tile ceramics are often used to define corners, to create a mood for a block or commercial district, or to help guide those with visual impairments. These bricks or pavers need to be set on a concrete pad for maximum life and stability.

Paver stones can also be used successfully in neighborhoods. Denmark is one of many European countries that use concrete 1-meter-square paver stones as sidewalks. These stones are placed directly over compressed earth. When it is time to place new utilities, or to make repairs, the paver stones are simply lifted, stacked, and replaced when the work is complete.

Awnings

Retail shops should be encouraged to provide protective awnings to create shade, protection from rain and snow, and to otherwise add color and attractiveness to the street. Awnings are especially important in hot climates on the sunny side of the street.

Outdoor Cafes

There are many commercial actions that can help bring back life to a street. Careful regulation of street vendors, outdoor cafes, and other commercial activity, including street entertainers, help enliven a place. The more activity, the better. One successful outdoor cafe helps create more activity and, in time, an entire evening shopping district can be helped back to life. When outdoor cafes are offered, it is essential to maintain a reasonable walking passageway. The elimination of two or three parking spaces in the street and the addition of a bulbed-out area can often provide the necessary extra space when cafe seating space is needed.

Alleys and Narrow Streets

Alleys can be cleaned up and made attractive for walking. Properly lit and planned they can be secure and inviting. Some alleys can be covered over and made into access points for a number of shops. The tasteful and elegant Bussy Place alley in Boston was a run-down alley between buildings. With a roof overhead and a colorful interior with escalators, this

Alleys can be made attractive and can serve as access points to shops.

alley is now the grand entry to a number of successful downtown shops. Other alleys become attractive places for outdoor cafes, kiosks, and small shops.

Victoria, on Vancouver Island, British Columbia, has a host of 30 or more alleys that channel a major portion of its pedestrian traffic between colorful buildings and quaint shops. Some alleys that were originally hard-wood bricks are now polished and provide a true walk through history.

The expansion of a mid-block set of crossings can help make these alleyways a prime commercial route and can lessen some of the pedestrian activity on several main roads.

Kiosks

Small tourist centers, navigational kiosks, and attractive outlets for other information can be handled through small-scale or large-scale kiosks. Well-positioned interpretive kiosks, plaques, and other instructional or historic place markers are essential to visitors. These areas can serve as safe places for people to meet and can generally help with navigation.

Play Areas and Public Art

Public play areas and interactive art can help enliven a corner or central plaza. One especially creative linear space in Norway provided a fence and a 40-foot-long jumping box. Children were invited to see how far they could jump, and compare their jump with record holders, kangaroos, grasshoppers, dogs, and other critters.

Pedestrian Streets, Transit Streets, and Pedestrian Malls

A number of European cities are reclaiming streets that are no longer needed for cars. Cars still have access to many of these streets before 10:00 a.m. and after midnight. Other streets in both the East and West are being converted to transit and pedestrian streets (e.g., 15th Street Mall in Denver). These conversions need to be made with a master plan so that traffic flow and pedestrian movements are fully provided for. There are many streets in America that have been temporarily converted to pedestrian streets and later, following a lack of use, were then converted back to traffic. There are many instances where it is not possible to generate enough pedestrian traffic to keep a street “alive.” Under these conditions, the presence of on-street auto traffic creates security for the pedestrian.

13.6 Pedestrian Plazas

Many plazas constructed in the recent past have been too large and uncomfortable for pedestrians, serving more to enhance the image of the building on the lot. Some of these are products of zoning laws that encouraged plaza construction in exchange for increased building height. However, bonus systems haven’t ensured that the “public space” will actually be a public benefit. Decisions have been based on inches and feet, instead of on activity, use, or orientation. The result has been a number of plazas with problems: some are windswept, others are on the shady side of buildings, while others break the continuity of shopping streets, or are inaccessible because of grade changes. Most are without benches, planters, cover, shops, or other pedestrian comforts. To be comfortable, large spaces should be divided into smaller ones. Landscaping, benches, and wind and rain protection should be provided, and shopping and eating should be made accessible.

It has been demonstrated that *no* extra room should be provided. In fact, it is usually better to be a bit crowded than too open, and to provide many smaller spaces instead of a few large ones. It is better to have places to sit, planters, and other conveniences for pedestrians than to have a clean, simple, and "architectural" space. It is better to have windows for browsing and stores adjacent to the plaza space, with cross-circulation between different uses than to have the plaza serve one use. It is better to have retailers rather than offices border the plaza. And, finally, it is better to have the plaza be a part of the sidewalk instead of separated from the sidewalk by walls.

Small protected spaces provide separation from noise and traffic.

- Enclose a plaza on one or two sides.
- Plan for at least 20 percent of the plaza to be landscaped.
- Provide seating in the sun and make it readily accessible to the public.
- Develop shops and stores along the plazas, excluding large banks, travel agents, and offices that attract few pedestrians.
- Do not use large expanses of blank wall.

Where is the best place for a plaza? Plazas ideally should be located in places with good sun exposure and little wind exposure, in places that are protected from traffic noise and in areas that are easily accessible from streets and shops. A plaza should have a center as well as several sub-centers.

The planner should inventory downtown for spaces that can be used for plazas, especially small ones. Appropriate spaces include: space where buildings may be demolished and new ones constructed, vacant land, or streets that may be closed to traffic or may connect to parking.

New stores can sometimes be set back 8 to 10 feet from the street to allow plaza space in exchange for increased density.

Some suggestions for planners and developers of plazas include the following:

- Limit plaza size to create small, human-scaled spaces. A maximum size of 2,500 square feet is appropriate, with several small plazas being better than one large one.
- Plan for prevailing sun angles and climatic conditions, using as a rule of thumb a minimum of 20 percent of daily sunshine hours on March 21.
- Encourage the use of bandstands, public display areas, outdoor dining space, skating rinks, and other features which attract crowds. In cold or rainy areas, a covered galleria would benefit pedestrians more than an open plaza.
- Integrate indoor and outdoor space to make it more useful. Plan spaces to be small and informal in character and quality so as to be inviting, comfortable, and non-oppressive.

In some European countries, streets have been turned over to pedestrians.

- Avoid sunken plazas, since access is difficult and people feel uncomfortable in them. Keep them level or just slightly below sidewalk grade. For instance, at Rockefeller Center in New York City, the lower level originally had shops, that failed and were converted to the now famous ice skating rink. Most people view the rink from above, while only users go below.

- Avoid architectural and geometrical bench arrangements. Instead, consider where and how most people would prefer to sit. One reason so-called "undesirables" frequent many plazas is that benches are not usable by pedestrians. Movable chairs, heavy enough not to be stolen, but light enough to move, are recommended so that people can choose where they want to sit and what arrangement they prefer.

Streets with a raised median will usually have lower pedestrian crash rates.

13.7 Exercise: Design a Pedestrian Space

Part 1
Choose an existing public space that currently does not encourage walking and redesign it to better accommodate pedestrians. Your plan should be developed at a conceptual level. You should prepare a plan view drawing with enough information to identify major existing features, proposed improvements, and impacts. Profile and cross-section view drawings are also helpful in presenting particular details required to construct your proposed improvements. Aerial photographs and U.S. Geological Survey topographic maps often provide a good background for overlaying proposed improvements.

Part 2
Conduct a pedestrian capacity analysis for the Piedmont Park case study location (as described in Exercise 3.8 of Lesson 3) using procedures described in the *Highway Capacity Manual*. The four major park entrances, as indicated on the Site Location Map, should be evaluated to determine the pedestrian level of service (LOS). In order to conduct this evaluation, the following assumptions should be utilized:

- Expand 15-minute pedestrian counts included in the park usage data to represent hourly volumes.

- All of the pedestrian volume at each of the four entrances accesses the park on existing 5-foot-wide feet wide sidewalks.

Utilize and document other assumptions as necessary in order to conduct the LOS analysis. Be sure to evaluate the sensitivity of values related to your assumptions.

Determine the existing level of service for pedestrians at the four major park entrances. Do the sidewalks need to be widened? In addition, evaluate pedestrian level of service under the following scenarios:

- Average weekday pedestrian traffic is anticipated to double in 5 years, will 5-foot-wide sidewalks be adequate?

- Special events will generate pedestrian volumes five times those measured for an average weekday.

13.8 References

Text and graphics for this lesson were derived from the following sources:

Florida Department of Transportation, *Florida's Pedestrian Planning and Design Guidelines,* 1997.

Oregon Department of Transportation, *Oregon's Bicycle and Pedestrian Plan*, 1995.

Richard Untermann, *Accommodating the Pedestrian*, 1984.

Wilmington Area Planning Council, *Mobility-Friendly Design Standards*, 1997.

For more information on this topic, please refer to:

AASHTO, *A Policy on Geometric Design of Highways & Streets*, 1990.

Institute of Transportation Engineers, *Design and Safety of Pedestrian Facilities*, 1998.

Office of Transportation Engineering and Development, *Pedestrian Design Guidelines Notebook*, Portland, OR, 1997.

L E S S O N 14

Pedestrian Signing and Pavement Markings

14.1 Purpose

Traffic engineers use a wide variety of road signs and pavement markings. Some are used to alert motorists to pedestrian activity and to direct pedestrians to defined crossings. Problems are created, however, when pedestrians assume that signs and paint will protect them from cars. Drivers, on the other hand, often ignore pedestrian signs and markings because they seldom see many pedestrians. As a result, signs and paint may lull pedestrians into a false sense of security.

This lesson provides an overall philosophy for the use of signs and pavement markings, as well as details on how these traffic control measures should be employed. Crosswalk markings at intersections are covered in more detail in Lesson 15.

14.2 Introduction

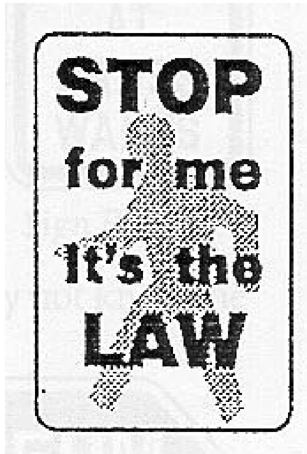
Signing is governed by the *Manual on Uniform Traffic Control Devices* (MUTCD), which provides specifications on the design and placement of traffic control signs installed within public rights-of-way. The MUTCD encourages a conservative use of signs (Sections 2A-1, 2A-6, 2B-1, and 2C-1). Signs should only be installed when they fulfill a need based on an engineering study or engineering judgment. In general, signs are often ineffective in modifying driver behavior, and overuse of signs breeds disrespect.

Used judiciously and located with consistency, signs and markings can be effective. Jurisdictions should develop clear guidelines for use and should avoid overreliance on signs and paint to control motorist behavior. This may mean altering and/or relocating existing signs and markings. It may be best to eliminate markings and signs that have proven to be ineffective or deleterious to pedestrian safety. There is ongoing debate and studies in progress to determine whether markings (especially written messages) improve pedestrian safety, whether crosswalks are useful at mid-block locations, and whether signs contribute to visual overload for motorists and breed disrespect for messages.

14.3 Planning and Design Considerations

The MUTCD outlines guidelines governing signs and pavement markings. At the same time, it does not prohibit creative regulatory design.

The MUTCD does not define criteria for crosswalk location or striping options. Much is left to engineering judgment. As a result, there is leeway in adapting guidelines to specific signing and marking policy needs.



Seattle is developing a new sign aimed at educating and reminding motorists of the 1990 crosswalk legislation supported by citizens that requires motorists to stop for pedestrians in a crosswalk. The sign will be installed at locations where crosswalk or pedestrian signs are not appropriate. It is designed to be relocated after 4 to 6 weeks to another location. Coordination with the Seattle Police Department will ensure enforcement. Initially, Seattle will place four 760-millimeter x 900-millimeter (30-inch x 36-inch) signs in different locations around the city.

Colors for signs and markings should conform to the color schedule recommended by the MUTCD to promote uniformity and understanding from jurisdiction to jurisdiction. For the background color of signs, use:

- YELLOW - General warning.
- RED - Stop or prohibition.
- BLUE - Service guidance.
- GREEN - Indicates movements permitted, directional guidance.
- BROWN - Public recreation and scenic guidance.
- ORANGE - Construction and maintenance. warning
- BLACK - Regulation.
- WHITE - Regulation.

For pavement markings, use:

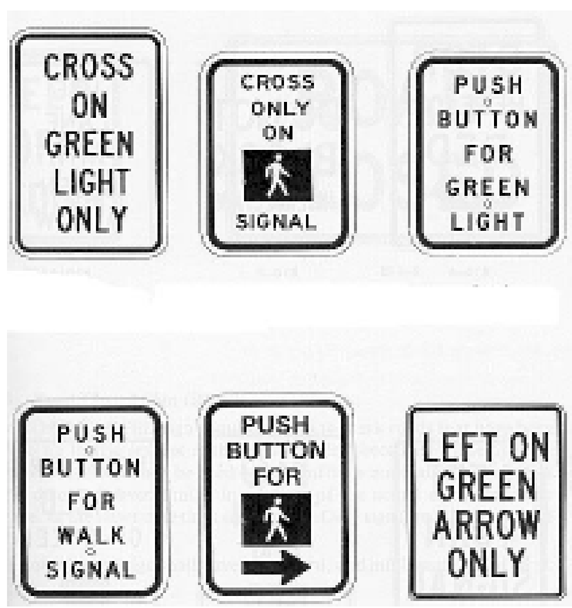
- YELLOW - Centerline stripes.
- WHITE - All other pavement stripes and markings, including edge stripes, lane markings, and crosswalks.

14.4 Regulatory Signs

These signs are used to inform motorists or pedestrians of a legal requirement and should only be used when the legal requirement is not otherwise apparent. They are generally rectangular in shape, usually consisting of a black legend on a white background, and shall be reflectorized or illuminated. Many motorist signs, including stop signs, yield signs, turn restrictions, and speed limits, have a direct or indirect impact on pedestrians.

The NO TURN ON RED (R10-11a) sign may be used in some instances to facilitate pedestrian movements. *The Manual on Uniform Traffic Control Devices* (MUTCD) lists six conditions when "no turn on red" may be considered, three of which are directly related to pedestrians or signal timing for pedestrians. Considerable controversy has arisen regarding pedestrian safety implications and right turn on red operations, ranging from a study by Zador, which indicated a significant increase in pedestrian accidents with right-turn-on-red, to studies by AASHTO and McGee, which concluded that right turn on red does not create a pedestrian safety problem.

The use of NO TURN ON RED signs at an intersection should be evaluated on a case-by-case basis. Less restrictive alternatives should be considered in lieu of NO TURN ON RED. Also, supplementary



signs, such as WHEN PEDESTRIANS ARE PRESENT or WHEN CHILDREN ARE PRESENT may be placed below the NO TURN ON RED sign.

There are occasions when no-turn-on-red restrictions are beneficial, and specific recommendations relating to pedestrians include:

- Part-time restrictions should be discouraged; however, they are preferable to full-time prohibitions when the need only occurs for a short period of time.

- Universal prohibitions at school crossings should not be made, but rather restrictions should be sensitive to special problems of pedestrian conflicts, such as the unpredictable behavior of children and problems of the elderly and persons with disabilities. Pedestrian volume, as such, should not be the only criterion for prohibiting right turns on red.

Pedestrians are restricted from continuing straight and are encouraged to cross to the left to avoid a vehicular merge lane.

There are a number of regulatory signs directed at pedestrians, which include:

- Pedestrians prohibited signs (R5-10a, R5-10b, R5-10c, R5-10a, and R9-3a) to prohibit pedestrian entry at freeway ramps.

- Pedestrian crossing signs (R9-2, R9-3a, and R9-3b) are used to restrict crossings at less safe locations and to divert them to optimal crossing locations. Various alternatives include the USE CROSSWALK (with supplemental arrow) sign, which may be used at signalized intersection legs with high conflicting turning movements or at mid-block locations directing pedestrians to use an adjacent signal or crosswalk. The signs have most applicability in front of schools or other buildings that generate significant pedestrian volumes.

- Traffic signal signs (R10-1 through R10-4) include the pedestrian push=button signs or other signs at signals directing pedestrians to cross only on the green light or WALK signal. Pedestrian push-button signs should be used at all pedestrian-actuated signals. It is helpful to provide guidance to indicate which street the button is for (either with arrows or street names). The signs should be located adjacent to the push button and the push buttons should be accessible to pedestrians with disabilities.

Other signs may be used for pedestrians at traffic signals to define the meaning of the WALK, DON'T WALK, and flashing DON'T WALK signal indications. The decision to use these signs (or alternatively, stickers mounted directly on the signal pole) is strictly engineering judgment and is primarily for educational purposes. As such, their use may be more helpful near schools and areas with concentrations of elderly pedestrians–two high-risk areas. This information may also be effectively converted into brochures for distribution and ongoing educational purposes.

14.5 Warning Signs

Warning signs are used to inform unfamiliar motorists/pedestrians of unusual or unexpected conditions. Warning signs predominantly fall under the permissive category ("may" condition), and when used, should be placed to provide adequate response times. Warning signs are generally diamond-shaped with black letters or drawings on a yellow background and shall be reflectorized or illuminated. Overuse of warning signs breeds disrespect and should be avoided.

This pedestrian warning sign is fluorescent yellow green (FYG) allowing it to be more visible.

The warning sign predominantly used to warn motorists of possible pedestrian conflicts is the Advance Pedestrian Crossing sign (W11-2). This sign should be installed in advance of mid-block crosswalks or other locations where pedestrians may not be expected to cross. This significantly minimizes their use at most urban intersections since pedestrian crossings are an expected occurrence. This sign may also be selectively used in advance of high-volume pedestrian crossing locations to add emphasis to the crosswalk. The advance pedestrian crossing sign provides more advance warning to motorists than crosswalk markings, and on some occasions, may be used when crosswalk markings do not exist. Where there are multiple crossing locations that cannot be concentrated to a single location, a supplemental distance plate may be used (NEXT XXX FEET). The advance pedestrian crossing signs should not be mounted with another warning sign (except for a supplemental distance sign or an advisory speed plate) or regulatory sign (except for NO PARKING signs) to avoid information overload and to allow for an improved driver response. Care should be taken in sign placement in relation to other signs to avoid sign clutter and to allow adequate motorist response. The MUTCD specifies a 30-inch x 30-inch sign size. However, it may be helpful to use a larger (36-inch x 36-inch) sign on higher speed or wider arterial streets.

The Pedestrian Crossing sign (W11A-2) is similar to the Advance Pedestrian Crossing sign, but has the crosswalk lines shown on it. This sign is intended to be used at the crosswalk, which is the only warning sign not used in advance of the condition being warned (except for large arrow signs and object markers). Because of its placement and the motorist's inability to distinguish and comprehend the subtle difference between the two signs (W11-2 versus W11A-2), its usefulness is limited. When used, it should be preceded by the advance warning sign and should be located immediately adjacent to the crossing point. To help alleviate motorist confusion, a black-and-yellow diagonally downward pointing arrow sign may be used to supplement the pedestrian crossing sign (W11A-2).

The Playground sign (W15-1) may be used in advance of a designated children's play area to warn motorists of a potentially high concentration of young children. This sign should generally not be needed on local or residential streets where children are expected. Furthermore, play areas should not be located adjacent to high-speed major or arterial streets, or if so, should be fenced off to prevent children from darting into the street.

According to the *Traffic Control Devices Handbook*, CAUTION–CHILDREN AT PLAY or SLOW CHILDREN signs should not be used since they may encourage children to play in the street and may encourage parents to be less vigilant. Such signs also provide no guidance to motorists in terms of a safe speed, and the sign has no legal basis for determining what a motorist should do. Furthermore, motorists should expect children to be "at play" in all residential areas, and the lack of signing on some streets may indicate otherwise. The signs are unenforceable and act as another roadside obstacle to pedestrians and errant motorists. Use of these non-standard signs may also imply that the involved jurisdiction approves of streets as playgrounds, which may result in the jurisdiction being vulnerable to tort liability.

School Warning signs include the advance school crossing signs (S1-1), the school crossing sign (S2-1), SCHOOL BUS STOP AHEAD (S3-1) sign, and others. School-related traffic control devices are discussed in detail in Part VII (Traffic Controls for School Areas) of the MUTCD. A reduced speed limit sign with flashing lights can be installed ahead of the actual crossing. The lights are set to flash during school hours, alerting drivers that a lower speed limit is in effect when the flashers are operating. Another sign and light combination is SCHOOL SPEED LIMIT XX, where the speed limit is illuminated during school hours.

Flashing lights, school crossing signs, and a 20-mph speed limit should give motorists plenty of advance warning of the crossing area up ahead.

The MUTCD allows for the development of other specialty warning signs based on engineering judgment for unique conditions. These signs can be designed to alert unfamiliar motorists or pedestrians of unexpected conditions and should follow the general criteria for the design of warning signs. Their use should be minimized to retain effectiveness and should be based on engineering judgment.

14.6 Directional Signs

Directional signs for pedestrians are intended to assist people who are new to the area or to assist residents who may not know the most direct route to a destination by foot. Use distances meaningful to pedestrians, such as the number of blocks or average walking time.

14.7 Pavement Word and Symbol Markings

The MUTCD allows for the use of pavement word and symbol markings such as SCHOOL XING or PED XING, as motorist warning devices (Section 3B-20). These may be helpful on high-volume or high-speed streets with unusual geometrics (such as vertical or horizontal curves) in advance of a pedestrian crossing area. Markings should be white and placed to provide an adequate motorist response. Their use should be kept to a minimum to retain effectiveness. Consideration should be given to snow conditions that may obliterate the markings during portions of the year in some regions of the country and the agency's ability to maintain these pavement markings. If used, the word or symbol markings should generally be used in each approach lane (except for the SCHOOL message).

Some agencies have also attempted to communicate with pedestrians by using pavement word markings such as LOOK BOTH WAYS or other symbols to encourage pedestrians to look for vehicles and to enter the road cautiously.

All pavement word and symbol markings require periodic maintenance and replacement after resurfacing. If used, it is advisable to maintain an inventory of stencils for periodic checking and refurbishment.

14.8 Exercise

The need to develop and detail pedestrian signs and pavement markings in a manner in which these

"Look Right" or "Look Left" are painted on the street next to the curb in the United Kingdom to remind pedestrians which direction in which to look for oncoming traffic before stepping into the street.

provisions can be constructed within the normal field of highway construction is an extremely important issue. Signs and pavement markings for a proposed roadway project are specified through a detailed system of standard drawings, specifications, and bid item numbers. An example plan view drawing demonstrating this method for highway-related signs and pavement markings using Caltrans (California Department of Transportation) specifications is provided for reference in Figure 14-1.

Engineers use the standards to ensure uniform construction and contractors use the standards to develop construction cost estimates for their bids. The use of these procedures in developing designs is a critical link in the continuum of planning, designing, and constructing transportation facilities. Construction of pedestrian and bicycle facilities should make full use of this well-established system. Most State DOT's have a variety of specifications that pertain to pedestrian and bicycle facilities. Specific standard drawings pertaining to bicycle and pedestrian facility construction as taken from the Caltrans Standard Plans document are summarized below.

Develop a plan to install pedestrian signs and pavement markings that uses nomenclature and reference standards from your State DOT. Estimate the quantity of each construction item needed and develop an engineer's construction cost estimate. You will need to utilize the following resources:

- Standard Drawings (periodically published document).
- Standard Specifications (periodically published document).
- Bid Item Numbers (typically a published list).
- Statewide Average Bid Summary (typically assembled several times a year).

14.9 References

Text and graphics for this section were derived from the following sources:

Federal Highway Administration, *Implementing Pedestrian Improvements at the Local Level*, 1998.

ITE, *Design and Safety of Pedestrian Facilities–A Recommended Practice of ITE*, Washington, DC, 1998.

Manual on Uniform Traffic Control Devices, USDOT, 1988.

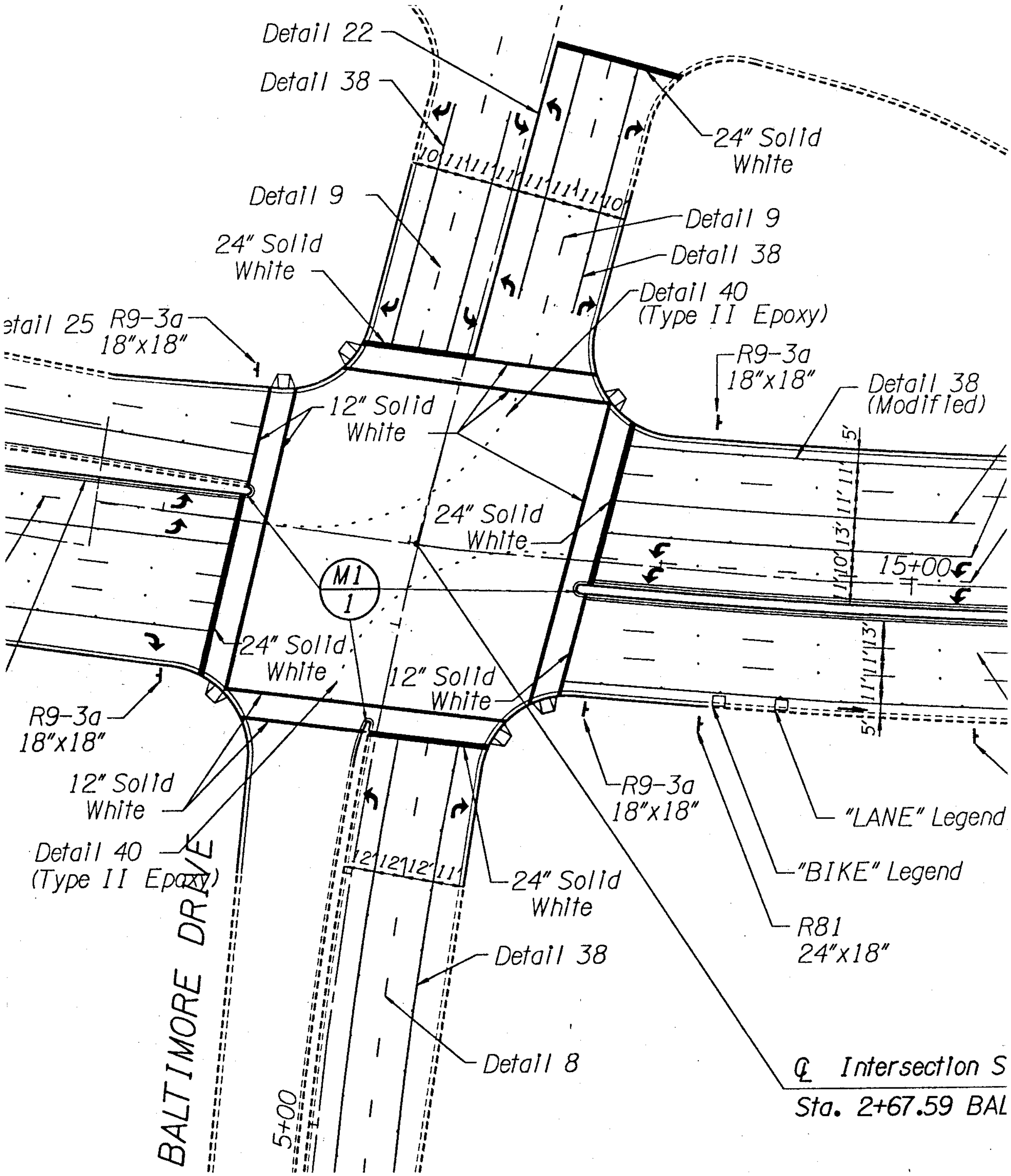
For more information on this topic, refer to:

Florida Department of Transportation, *Florida Pedestrian Facility Planning and Design Guidelines*, 1996.

Oregon Department of Transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

Pennsylvania Department of Transportation, *Pennsylvania Pedestrian Planning and Design Guidelines* and *Pennsylvania Community Design Systems*, 1996.

Figure 14-1:
Example Signing and Marking Plan
S.R. 8, Fletcher Parkway Construction Plans
Le Mesa, California



L E S S O N 15

Pedestrian Accommodations at Intersections

15.1 Purpose

Walkways provide mobility along a linear path. But eventually, people need to cross roads and streets at intersections. These intersections, where the paths of people and vehicles come together, can be the most challenging part of negotiating a pedestrian network. If pedestrians cannot cross the street safely, then mobility is severely limited, access is denied, and walking as a mode of travel is discouraged.

This lesson provides an overview of several design features that are critical in order to provide for pedestrian access at intersections. Much research has been done on this topic in the past, and several design manuals provide more detail, including the *Manual on Uniform Traffic Control Devices*, AASHTO's *Policy on the Geometric Design of Highways and Streets*, and ITE's *Design and Safety of Pedestrian Facilities among others*.

Text for this lesson was taken from the Institute of Transportation Engineers' 1998 publication, entitled *Design and Safety of Pedestrian Facilities–A Recommended Practice*. Reprinted with permission.

15.2 Introduction

In urban areas, two-thirds of the pedestrian injuries occur at central business district (CBD) intersections. Overall, the "intersection dash," where a pedestrian enters the street at an intersection and is seen too late by a driver of a motor vehicle is the third most prevalent pedestrian accident type, accounting for 7.2 percent of all pedestrian crashes.

The solution is to design and build intersections that:

- Encourage pedestrian use in lieu of mid-block crossing locations.
- Make pedestrians as visible as possible.
- Make pedestrian actions as predictable as possible.
- Slow vehicular traffic.

Reduced sight distances can present a serious problem for pedestrians who wish to cross the street.

A good place to start is to develop design guidelines for intersections that are responsive to the needs of pedestrians, which can be followed whenever new intersections are built or when existing intersections are being improved or reconstructed.

Important intersection issues include consideration of the following:

1. **Improved pedestrian conspicuity.** Ways to alert motorists to the possible presence of pedestrian activity at intersections include providing painted crosswalks in the roadway, moving pedestrians out from behind parked cars through the use of bulb-outs, and improving both horizontal and vertical sight distances through the removal of extraneous curbside clutter such as newspaper boxes, redundant utility poles, or overgrown vegetation. The use of traffic-calming devices such as raised intersections tells drivers that the area is not designed for rapid through movement, but rather it is an area where pedestrians can be expected. Drivers must exercise caution when approaching raised intersections and be ready to yield right-of-way to pedestrians. Another way to slow drivers is to design right-turn slip lanes with exit angles between 50 and 60 degrees.

2. **Predictability of pedestrian actions and movement.** Pedestrian movement can be controlled and made more routine and visible through the use of crosswalks and signalization.

3. **Distance and time that pedestrians have to cross a roadway.** Both the distance and time it takes pedestrians to cross a street can be shortened through the use of curb bulbs, medians, and refuges.

Use of colored crosswalks and median refuges makes this intersection more pedestrian-friendly.

Bulb-outs reduce crossing distances for pedestrians.

4. **Ease of movement from walkway to street level and vice versa.** Curb ramps facilitate the transition from walkways to streets. Raised intersections can make it easier to meet the Americans With Disabilities Act (ADA) requirements as a crosswalk becomes a natural extension of a walkway and the need for curb ramps is eliminated.

Improving intersections for pedestrians involves the coordination and integration of a number of design elements, including crosswalks, curb ramps, curb bulbs, turning radii, signalization.

When designing intersections:

- Take vertical as well as horizontal sight distances into account.

- Refer to AASHTO's *1994 Policy on Geometric Design of Highways and Streets* (also known as the "Green Book") for formulas relating to storage space needed for pedestrians.

- Prohibit parking near intersections.
- Use curb bulbs, curb ramps, and signalization.
- Limit right-turn-on-red movements in areas of high pedestrian volumes.
- Keep crosswalks at right angles to turning roadway terminals and slip lanes.
- Keep right turns below 15 mph and left turns below 20 mph.
- Locate crossing close to the parallel street; 0.6-meter (2-feet) offset is standard.
- Use stop lines for motorists; keep stop lines behind crosswalks.

15.3 Crosswalks

Typical Concerns
Of the 61 different pedestrian accident types, the midblock "dart-out" type — where a pedestrian may suddenly appear between parked cars or otherwise cross a vehicular way at a random location — accounts for 13.3 percent of all pedestrian accidents. In three-quarters of these cases, the crash occurs in the curbside lane. One-third of mid-block dart-outs result in a serious injury or a fatality.

Possible Solutions
One solution is to create an ongoing retrofit program to establish crosswalks in locations that encourage pedestrians to cross in certain locations, and that also provide motorists with ra easonable expectation of where pedestrians might cross a roadway. Crosswalks are one tool that municipalities can use to accomplish both goals. Other tools include curb bulbs and medians (as discussed in this lesson).

Important crosswalk concepts and issues include:

1. Creating reasonable expectations where pedestrians may cross a roadway. A crosswalk creates a visible indication for both motorists and pedestrians as to where pedestrians may be expected to cross a roadway.

2. Predictability of pedestrian actions and movement. When combined with signalization (as well as curb bulbs and refuge islands, where appropriate), crosswalks can help to control pedestrian movement and make them more routine.

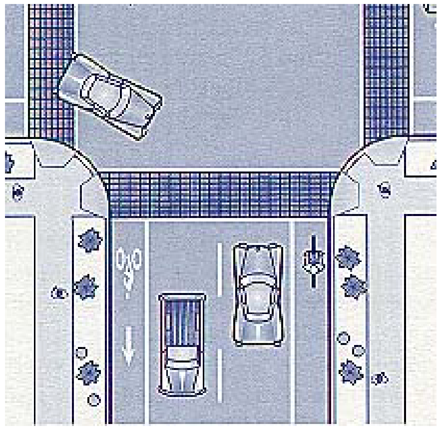
3. Knowing when and where crosswalks are appropriate. As noted in the Oregon *Bicycle and Pedestrian Plan,* some studies have found that pedestrians may develop a false sense of security when crossing a road in marked crosswalks. Other studies have found that motorists are more likely to stop for pedestrians in marked crosswalks, especially where pedestrian right-of-way laws are enforced.

   It is important that the proper use of crosswalks is backed up by State law. Vermont is one State where State law gives pedestrians conditional right-of-way when using marked crosswalks. As long as "traffic control signals are not in operation, the driver of a vehicle shall yield the right of way, slowing down or stopping, if necessary, to a pedestrian crossing the roadway within a crosswalk" *(Vermont Statutes Annotated, 1; 23, §1051(a)).* Where this law is reinforced by signage in the crosswalk itself, reminding drivers of the State law and their responsibility to stop, some town select board officials have said that drivers' habits markedly favor pedestrians. The onus is on the pedestrian to safely enter a crosswalk. Vermont law continues, "No pedestrian may suddenly leave a curb or other place of safety and walk or run into the path of a vehicle which is so close that it is impossible for a driver to yield" *(Vermont Statutes Annotated, 1; 23, §1051 (b)).*

4. Where crosswalks might be located. Generally, marked crosswalks are located at all open legs of signalized intersections. They may also be provided at other locations. When used with curb bulbs, signage, and illumination, the visibility of pedestrian crossings can be enhanced.

Although expected at intersections, the installation of crosswalks at mid-block locations may also be desirable under some conditions, such as when medians or refuge islands are used.

The Institute of Transportation Engineers recommends that certain conditions may not warrant the installation of marked crosswalks, such as when the hourly peak pedestrian volume is very low (<25 pedestrians per peak 4 hours) or when traffic volume is very low (<2,000 Annual Average Daily Traffic [AADT]). At all other locations, or where predominately young, elderly, or handicapped pedestrians may be found, crosswalks are recommended.



Textured crossings, using non-slip bricks or pavers, can raise a driver's awareness through increased noise and vibration.

5. Implement a vigorous enforcement program. Convince law enforcement authorities to actively monitor crosswalk behavior, enforce crosswalk laws, and prosecute crosswalk scofflaws. Create and implement a public relations program to increase public awareness about the rights and responsibilities of crosswalk use. Emphasize crosswalk laws through the use of informational signage at crosswalk locations.

Implementation Strategies

1. Develop and adopt a crosswalk policy and design guidelines. Decide where crosswalks shall be used, and when policies and ordinances are changed or updated, make sure a crosswalk policy is implemented. Likewise, develop "standard" crosswalk designs for the public works department to follow.

2. Piggy-back on capital and/or maintenance projects. Look for opportunities to install crosswalks whenever intersections are changed or upgraded, or when roadways are resurfaced.

3. Use crosswalks to connect sidewalks and curb ramps at intersections. Coordinate crosswalk painting with new or existing curb ramp locations.

4. Establish an annual crosswalk improvement program. Schedule crosswalk replacement or repainting so that crosswalk markings never become deteriorated or less visible to motorists. The duty of a driver to yield right of way to a pedestrian in a crosswalk may be compromised if the driver could not see the crosswalk or one did not exist. Furthermore, the municipality may be liable for failing to exercise due care toward maintaining the crosswalk for pedestrians, especially if the municipality knew or should have known of a crosswalk deficiency.

Resources and Scheduling

Crosswalks are relatively inexpensive to install. Obtaining authorization to install them, on the other hand, could take months or longer.

Evaluation

An informal traffic study can determine if the crosswalk program is enhancing pedestrian safety. Especially monitor locations of high pedestrian use. Review crash statistics on a regular basis.

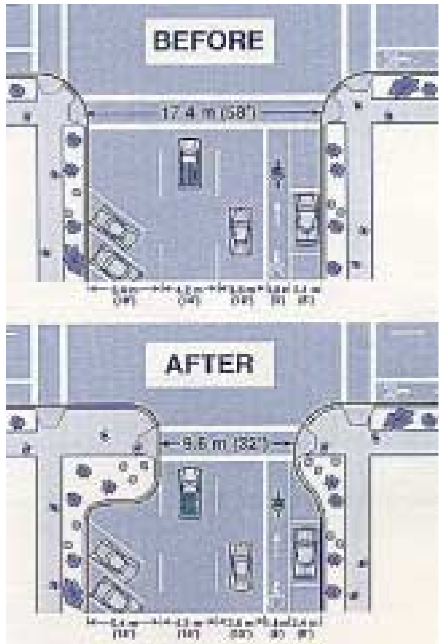
Planning and Design Considerations

When planning and designing crosswalks, consider these recommendations:

- Place crosswalks across the full width of the pavement.
- Use crosswalks at all signalized intersections.
- Use crosswalks at non-signalized intersections with discretion.
- Place crosswalks in locations where they are visible and where they are not obscured by parked cars or signs.
- Illuminate mid-block crosswalks that are not expected by motorists.
- Use two white parallel lines 0.2 meters to 0.6 meters (0.5 feet to 2 feet) wide, spaced at a 1.8-meter (6-feet) minimum, or the width of the approaching sidewalk if it is greater, to define a crosswalk area.

- Use special markings such as striped ("zebra") longitudinal lines or diagonal cross-hatching for added visibility and to emphasize a crossing.
- Consider textured crossings, using non-slip bricks or colored pavers, to increase a driver's awareness through increased noise and vibration.
- Use crosswalks at the corners of skewed intersections.

Where warranted, the lighting levels in pedestrian areas should meet those recommended by the Illuminating Engineering Society (IES).



Also known as bulbs, neck-downs, flares, or chokers, curb extensions reduce the pedestrian crossing distance and improve the visibility of pedestrians by motorists.

15.4 Curb Bulbs and Curb Radii

Typical Concerns
Walking across a wide street takes longer than crossing a narrow street. As a result, pedestrians are exposed for a longer length of time to the threat of being hit by a vehicle when crossing a wide street. Another problem pedestrians face when trying to cross a street is visibility. Parked cars may make it difficult for them to see oncoming vehicles and vice versa.

Also, when streets intersect at an acute or obtuse angle, or have a large curb radius, motorists can make turns at relatively high speeds. By contrast, 90-degree intersections and corners with tight curb radii tend to slow motorists down. The problem with obtuse angles is particularly bad when a vehicle on an arterial street turns onto a residential street. Pedestrians crossing the residential street adjacent to the arterial may not expect high-speed turning traffic or they may have their backs turned toward the turning cars.

Possible Solutions
The solution is to shorten the crossing distance for pedestrians. One way to effectively shorten the pedestrian crossing distance on streets where parking is permitted is to install curb bulbs, also known as curb extensions and chokers. Curb bulbs project into the street, usually for a distance equal to the depth of a typical parallel parking space, making it easier for pedestrians to see approaching traffic and giving motorists a better view of pedestrians. When motorists are better able to see pedestrians, they have a greater opportunity to stop before a crash can occur.

Decreasing crossing distances for pedestrians also provides these motor vehicle capacity benefits:

- At signalized intersections, it decreases the length of the pedestrian phase.
- At unsignalized intersections, it reduces the time a right-or-left turning vehicle has to wait for a pedestrian to cross before exiting the roadway.

Reduced sight distances can present a serious problem for pedestrians who wish to cross the street.

When designing curb bulbs at intersections where there is low truck traffic, consider making the corner radius as small as possible. This will have the effect of slowing down right-turning motor vehicles. Where truck traffic is present, a tight corner radius may make the turn difficult to negotiate for these vehicles. Furthermore, the constant overriding of the curb and sidewalk by rear wheels of trucks may ultimately cause damage to the curb or sidewalk or cause injury to pedestrians.

Simultaneously installing curb bulbs and changing curb radii is frequently possible since both involve moving the curb and gutter into the improved portion of the street right of way.

Where acute or obtuse intersections are encountered, such as where a residential street meets an arterial, creating an intersection that is closer to 90 degrees may also provide opportunities to reduce curb radii and create curb bulbs.

Implementation Strategies
Typically, curb bulbs and curb radius changes are appropriate at a limited number of intersections. Consequently, over time, most intersections that need improvements may be upgraded for pedestrians in this fashion. As with other pedestrian improvements, the key is to develop a strategy and stick to it over a period of years. Here's how to get started:

1. Determine arterial and residential street specifications. Include curb bulbs and/or smaller curb radii in standard plans and specifications for public and private road projects. A change in one or more local ordinances may be required or specifications may sometimes be implemented by administrative rule.

2. Start an annual program to install curb bulbs and adjust the curbs at obtuse-angle intersections. Develop project selection criteria to select the projects that will do the most to enhance safety. Some areas to be considered include:

   a. Locations where residential streets meet arterial streets at an obtuse angle.
   b. Locations that are on routes used by school children or the elderly.
   c. Downtown or neighborhood shopping areas with high pedestrian volumes.
   d. Projects nominated by neighborhood associations.

Resource Requirements and Scheduling
The cost of installing curb bulbs and changing the curb radii can vary considerably, depending on whether drain grates have to be moved and/or whether there are other issues that have to be addressed. For example, it may be necessary to move the conduit for a signal or relocate utility poles and light and/or sign standards.

Decide if the work is to be done by the public works department or a private contractor. In general, if only a few bulbs are involved, it may be cheaper and faster to have town or city crews do the work. If there is a lot of work to be done, it may be cheaper to use a private contractor. The key is to let the public know how long it will take to install a bulb and then deliver promptly.

Evaluation
Visit project sites to determine if good locations have been selected and the best design(s) is being used. Check crash records, do speed studies of cars making turns, look at the curbs to see if trucks or buses are driving over them, and ask pedestrians if they feel safer. Be a good listener and observer, and make modifications where needed.

Pedestrian push buttons should be conveniently placed. Be sure existing site features are not obstacles to reaching the button.

Planning and Design Considerations
Transportation agencies have increased curb radii over the years to keep trucks and buses from running over curbs and striking pedestrians standing on the corner; such changes also increase capacity. Unfortunately, curb radii have been increased at intersections that do not have large truck traffic or buses (e.g., in residential neighborhoods). The following are guidelines for curb bulbs and small curb radii:

- On arterial streets, install curb bulbs only where permanent parallel parking is next to the curb. Curb bulbs should protrude a minimum of 2 meters (6 feet) into the roadway. Ideally, they should project the full depth of adjacent parking stalls, usually 5.5 meters to 6 meters (8 feet to 9 feet). Curb bulb projections prevent the parking area next to the curb from becoming a travel lane.

- A curb radius of 3 meters to 4.5 meters (10 ft to 15 ft) should be used where residential streets intersect other residential streets and arterial streets.

- A curb radius of 6 meters (20 feet) should be used at the intersections of arterial streets that are not bus or truck routes.

- A curb radius of 7.5 meters to 9 meters (25 feet to 30 feet) should be used at the intersections of arterial streets that are bus and/or truck routes.

- Curb bulbs should not extend too far into the street to present a bottleneck for bicycle travel. As a minimum, a 4.3-meter (14-foot) travel lane should be maintained.

15.5 Signal Timing and Push Buttons

Problem Statement
The public is often baffled by pedestrian signal timing and push buttons; such pedestrian features seem to vary not only from jurisdiction to jurisdiction, but also from intersection to intersection. Walk/Don't Walk timing lengths often appear arbitrary–especially the Walk and flashing Don't Walk phases. Part of the problem stems from the fact that many walkers do not know that the flashing Don't Walk is intentionally displayed before an average person can completely cross the street. Another part of the problem may result from timing cycles that are simply too fast for slow walkers such as older pedestrians or people who are handicapped.

Another aspect of the problem may be due to the absence of pedestrian push buttons or because a call button is obscured or difficult to reach. At many intersections that do have push buttons, the Don't Walk phase is so long that pedestrians feel their push-button request has not been recognized by the signal system. All of these problems encourage disrespect for pedestrian signals, promote increased jaywalking, and create conflicts with motorists.

Solution Statement
Develop policies governing pedestrian signal timing and push-button actuation to ensure fair treatment for pedestrians. Make signal timing as consistent as possible, and adopt a clear pedestrian push-button warrant. Develop a desired level of service for pedestrian waiting and push-button response times and evaluate signalized intersections to see if the pedestrian level of service at signalized intersection falls within an acceptable range.

Major issues related to pedestrians and signalized intersections include:

- Seemingly arbitrary length of Walk and flashing Don't Walk cycles.
- Pros and cons of lengthening flashing Don't Walk to accommodate slower pedestrians.
- Safety trade-off of shortened pedestrian phase implemented to enhance vehicular right turns
- Fairness of laws that allow motorists to enter an intersection on the yellow while prohibiting pedestrians from doing so during flashing Don't Walk.
- Trade-off between motor traffic delays and pedestrian delays at actuated pedestrian crossings.
- Integrating pedestrian recall and pedestrian actuation in a way pedestrians will understand.

Implementation Strategies
Making signalized intersections consistent with stated policies won't happen overnight; consider it as part of a long-term commitment to pedestrian safety. Whatever strategy is employed, use field observations to see how pedestrians react to signal timing and push buttons. Comparing a variety of configurations will help. It is possible for workable and consistent policies to be developed.

Annual Program: A comprehensive program should be established to evaluate and prioritize improvements. It should not be hard to locate those areas needing attention. In all likelihood, the public works department probably maintains a file filled with complaints from citizens.

New Signal or Signal Timing Projects: Review the pedestrian signal timing plan for any intersections undergoing signal modification or adjustments. Keep aware of signal work, providing appropriate suggestions. This will help signal engineers become more sensitive to pedestrian needs.

Resource Requirements
The peculiarities of many intersections means that a strictly policy-driven approach may not be possible. As a result, trained personnel will be needed to evaluate signal timing and actuation at many specific locations. Most of the work will be done by agency crews unless there is a large enough backlog to justify going out to bid.

Evaluation
Monitor intersections with modified signal timing and push buttons, and compare them with unaltered intersections. Crash reductions and/or fewer pedestrian complaints will be good indicators of whether the new policies are working. Develop a level of service for pedestrian push buttons and apply accordingly

Planning and Design Considerations
Consider these features when providing signals that are responsive to pedestrians:

- Signals must fulfill a need, gain attention, convey a clear and simple meaning, and command the respect of road users, as well as provide adequate time for response.
- Average walking speed should be calculated at 1.2 meters (4 feet) per second; 1.1 meters (3.5 feet) per second is becoming more common; 0.9 meters (3 feet) per second should be used where there is a high frequency of older pedestrians; and people with mobility impairments move as slow as 0.8 meters (2.5 feet) per second.
- Many pedestrians stop watching for lights and, instead, look for gaps to cross streets when their delay exceeds 30 seconds.
- Place pedestrian signal heads at each end of the crosswalk.

- Place the push button at the top of and as near as possible to the curb ramp and clearly in line with the direction of travel. This will improve operations as many pedestrians push all buttons to ensure that they hit the correct one.

- Use a push-button box that gives pedestrians a visible acknowledgment (indicator light comes on at push-button box) that their crossing request has been received. Where medians exist, place additional push buttons in medians. If signal head on opposite side of the street is more than 18.3 meters (60 feet) away, place additional pedestrian signal heads in medians.

- Place pedestrian signals in channelized islands.

- Visually impaired people need audio support at key signalized intersections.

- Audio signals are available using different sounds — from pleasant (cuckoo or tinkling bell sounds preferred) to obnoxious (avoid raspy-sounding buzzers).

- Walk Phase: Allow time for pedestrians to search and start walking. For coordinated signal systems, extend to full green time minus flashing.

- Don’t Walk Phase (pedestrian clearance interval): Avoid shortening the Walk phase to improve the flow of right-turning vehicles.

- Flashing Don’t Walk Phase (pedestrian clearance interval): Included in the full green time. Calculated as part of the crossing time. Crossing time equals distance divided by 0.8 meters to 1.2 meters (2.5 feet to 4 feet) per second, depending on customer base.

Pedestrian push buttons are often provided at locations with intermittent pedestrian volumes to call for the WALK message and/or extend the crossing interval.

- Steady Don’t Walk Phase: Equal time for yellow clearance and all-red signal. Pedestrians should be out of the street.

The MUTCD has many suggestions regarding push-button placement and pedestrian signal timing. However, in many other areas of pedestrian activity, it leaves a great deal to engineering judgment.

15.6 Pedestrian Refuge Islands

Pedestrian refuge islands are defined as the areas within an intersection or between lanes of traffic where pedestrians may safely wait until vehicular traffic clears, allowing them to cross a street. Refuge islands are commonly found along wide, multi-lane streets where adequate pedestrian crossing time could not be provided without adversely affecting the traffic flow. These islands provide a resting area for pedestrians, particularly those who are wheelchair-bound, elderly, or otherwise unable to completely cross an intersection within the provided signal time. These refuge islands also provide a safety area for pedestrians caught in the street when a signal changes.

Refuge islands provide a safety area for pedestrians who cannot cross the entire street on one cycle.

When evaluating whether a refuge island is needed, both crossing time and safety must be considered. For example, in suburban areas with long distances between intersections and traffic signals, a large proportion of pedestrian crossings occur at unsignalized intersections and at mid-block locations. However, with a median, a pedestrian would only have to look in one direction to cross to the median, and in the opposite direction to complete their crossing from the median to the far side of the street. Pedestrians crossing an undivided, multi-lane street may experience delays 10 times longer than the delay incurred crossing a street with a median as shown by the pedestrian crossing delay curves provided in NCHRP Report 294A.

The effect of refuge islands and medians on pedestrian safety is unclear. Studies have reported both increases and decreases in accidents after pedestrian islands have been installed. There is a substantial lack of definitive information on this subject. However, a 1978 study in western Australia indicated that the rate of pedestrian accidents at a four-lane unsignalized intersection was reduced to 11.5 percent of its original level when raised median islands were installed.

Refuge islands can be beneficial under certain conditions and inconsequential or even harmful under others. The typical conditions where refuge islands are most beneficial include:

- Wide, two-way streets (four lanes or more) with high traffic volumes, high travel speeds, and large pedestrian volumes.

Streets with raised medians usually have lower pedestrian crash rates.

- Wide streets where the elderly, people with disabilities, and children cross regularly.

- Streets with insufficient green signal phasing time for safe pedestrian crossings.

- Wide, two-way intersections with high traffic volumes and significant numbers of crossing pedestrians.

- Low-volume side-street traffic demands with insufficient green time to cross (i.e., low side-street volumes in combination with high main street volumes may warrant short green times for the side street, which, in turn, does not allow enough time for the pedestrian to cross the entire street).

The typical conditions where refuge islands are least beneficial or possibly harmful include:

- Narrow streets and/or streets where substandard-width refuge islands are used.

- Instances in which a high turning volume of large trucks exist.

- Conditions under which the roadway alignment obscures the island, thereby making it likely that vehicles will drive onto the island.

- Areas where the presence of a safety island will severely hamper snowplowing.

In areas where refuge islands are beneficial, the advantages to pedestrians are many, including:

- Reducing pedestrian crossing time by splitting crossing distances (i.e., providing staged crossing of pedestrians), thereby reducing the green time required for the pedestrian crossing phase.

- Providing pedestrians with a resting place when crossing wide roads or intersections.

- Providing a pedestrian storage area.

- Increasing the capacity of the intersection with a near-side island that provides a better location for the stop bar.

- Loading and unloading transit riders (although curbside locations provide a better alternative).

- Providing a location for traffic control (shorter mast arms) and utility pole installations.

Pedestrian refuge islands can create a safer crossing for wide streets.

The disadvantages of pedestrian refuge islands include:

- A false sense of security or safety to pedestrians.
- Street sweeping or snowplowing problems.
- Damage to vehicles if struck.
- Installation costs will be higher.
- Generally, more right of way is required.

Recommended Practice
Pedestrian refuge islands may be installed at intersections or mid-block locations as deemed appropriate by engineering studies. Refuge islands should be considered during the design of complex intersections or streets rather than after construction has been completed. They must be visible to motorists at all times and should be delineated by curbs, guideposts, signs, or other treatments. Refuge islands should be designed to minimize the potential hazard to motorists and pedestrians alike.

Island Design Features
Pedestrian refuge islands must be designed in accordance with the AASHTO policy and the MUTCD requirements. Design considerations should include:

- Areas at traffic signals where the total length of crosswalk cannot be readily traveled in one pedestrian phase. Special consideration should be given to intersections where a large number of elderly pedestrians and/or people with disabilities will be present. Special consideration should also be given to complex or irregularly-shaped intersections where islands could provide a pedestrian with the opportunity to rest and become oriented to the flow of oncoming traffic.

- Raised curbs with cut-through ramps at pavement level or curb ramps for wheelchair users. Cut-through ramps should be graded to drain quickly and should also have special provisions to assist the visually impaired in identifying the refuge island. Islands with ramps should have a level area at least 48 inches long at the same level as the top of the raised median to provide a level area for wheelchair users.

- Areas at least 6 feet wide from the face of the curb to the face of the curb. The minimum width should not be less than 4 feet wide from the face of the curb to the face of the curb. The island should not be less than 12 feet long or the width of the crosswalk, whichever is greater. The minimum island size should be 50 square feet.

- An approach nose, offset from the edge of the traffic lane, appropriately treated to provide motorists with sufficient warning of the island's presence. This can be achieved in various ways, such as illumination, reflectorization, marking, signage, and/or size.

- Pedestrian push buttons and signage adjacent to crosswalks.

- Guidestrips for the blind.

- Placement on wide (four lanes or more) streets with high traffic volumes.

- No obstruction to visibility by such features as foliage, barriers, or benches.

- Barriers that may be necessary to keep pedestrians from stepping into traffic at improper locations.

Refuge islands provide pedestrians with a resting place when crossing roads or intersections.

15.7 Exercise: Urban Intersections

The need to develop and detail pedestrian intersection improvements in a manner that can be constructed within the normal field of highway construction is an extremely important issue. Pedestrian accommodations at intersections include both traffic signal and pavement marking improvements. An exercise covering pavement marking issues was previously addressed in Exercise 14.8. With regard to signalization at intersections, pedestrian improvements typically include pedestrian signals, pedestrian push buttons, conduit/wiring, mounting brackets, and pedestrian poles. Traffic signal improvements are specified through a detailed system of standard drawings, specifications, and bid item numbers. An example plan view drawing demonstrating this method for specifying traffic signal improvements using Georgia Department of Transportation standards is provided for reference in Figure 15-1.

Develop a plan to install pedestrian signals and related improvements for an intersection in your community. The plan should be developed using nomenclature and reference standards from your State DOT. A list of standard drawings pertaining to pedestrian facility construction from Caltrans (California Department of Transportation) was previously provided in Exercise 14.8. If possible, you should obtain an intersection drawing from your local traffic engineering department. This drawing typically shows the location of existing roadway features, travel lanes, signal equipment, and utilities. In addition to preparing a plan of proposed improvements, develop an estimate of quantities needed for each construction item and prepare an engineer's construction cost estimate. You will need to utilize the following resources:

- Plan view drawing of local intersection.
- Standard drawings (periodically published document).
- Standard specifications (periodically published document).
- Bid item numbers (typically a published list).
- Statewide average bid summary (typically assembled several times a year).

15.8 References

"A Comparison of the Pedestrian Safety of Median Islands and Marked Crossings," *Western Roads*, Western Australia, August 1978.

American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* Washington, DC, 1990.

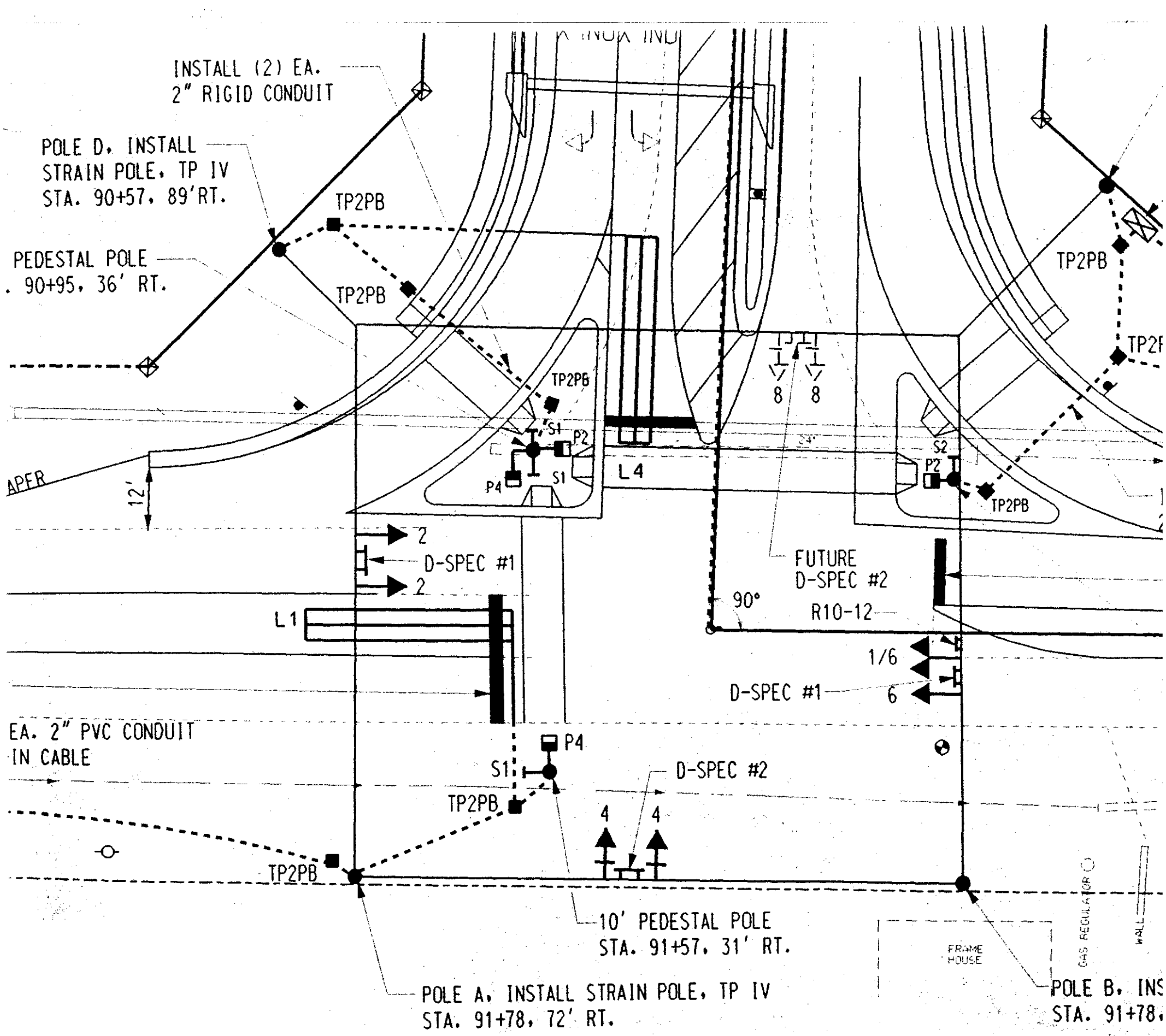
Federal Highway Administration, *Manual on Uniform Traffic Control Devices*, Washington, DC, 1988.

ITE, *Design and Safety of Pedestrian Facilities–A Recommended Practice of ITE*, Washington, DC, 1998.

National Cooperative Highway Research Program, Transportation Research Board, *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas*, NCHRP Report 294A, Washington, DC, June 1987.

Figure 15-1:

Example Traffic Signal Plan.
Sugarloaf Parkway Construction Plans
Lawrenceville, Georgia



LESSON 16

Mid-Block Crossings

16.1 Purpose

Designers often assume that pedestrians will cross roadways at established intersections. Observation of pedestrian behavior clearly indicates that people routinely cross at mid-block locations. Pedestrians will rarely go out of their way to cross at an intersection unless they are rewarded with a much improved crossing — most will take the most direct route possible to get to their destination, even if this means crossing several lanes of high-speed traffic.

Well-designed mid-block crossings can actually provide many safety benefits to pedestrians when placed in proper locations. This chapter discusses those benefits and explains several basic design principles for mid-block crossings.

16.2 Introduction

For most of this century—since pedestrians and motorists began competing for space—safety campaigns have directed pedestrians to walk to intersections to cross roadways. This is helpful advice, especially in downtown locations where signalization is frequent, where cycle lengths are short, where blocks are long, and where intersections are small and compact. But with the advent of the modern suburb, blocks are much longer, signalization is even less frequent, some intersections are very wide, and vehicle speeds are much higher than downtown. Under these conditions, crossing at intersections becomes less practical and often more dangerous.

Today's designer is challenged to find workable crossing points to aid pedestrians across high-speed roadways. When convenient and manageable crossing points are not identified, most pedestrians cross at random, unpredictable locations. In making random crossings, they create confusion and they add risk to themselves and drivers.

This chapter addresses two ways to facilitate non-intersection crossings: medians and mid-block crossings. By placing medians along multi-lane roadways, the designer helps channel pedestrians to the best locations: where gaps are more frequent; where lighting is improved; and where motorists have the best chance to search, detect, recognize, and respond to the presence of pedestrians. Where there are medians, the pedestrian still may cross at random locations, but due to the increased frequency of acceptable gaps and greatly reduced conflicts, the pedestrian is inclined to find a longer gap and then walk (not rush) across the roadway.

Midblock crossings are easily located on low-volume, low-speed roadways, such as short collectors through neighborhoods.

Mid-block crossings are an essential design tool. All designers must learn the best placement, geometrics, and operations of mid-block crossings.

16.3 Medians and Refuge Islands — Powerful Safety Tools

A median or refuge island is a raised longitudinal space separating the two main directions of traffic. Median islands, by definition, run one or many blocks. Refuge islands are much shorter than medians, and are a length of 31 to 76 m (100 to 250 ft). Medians and refuge islands can be designed to block side-street or driveway crossings of the main road and block left-turning movements. Because medians reduce turning movements, they have the ability to increase the flow rate (capacity) and safety of a roadway.

Medians are now an essential tool to minimize the friction of turning and slowing vehicles. Medians maximize the safety of the motorist and pedestrian. Medians have been extensively studied by the Georgia and Florida Departments of Transportation. Based on more than 1,000 centerline miles (1,600 km) of conversion from two-way left-turn lanes (TWLTL's) to raised medians, motorist crashes were reduced dramatically. It has also been shown through FDOT (Florida Department of Transportation) research that pedestrians are at high risk while standing in TWLTL's.

Mid-block crossings can be kept simple and are easily located on low-volume, low-speed roadways, such as short 40- to 48-km/h (25- to 30-mph) collectors through neighborhoods. When collectors are longer and handle more traffic and higher speeds, medians or refuge islands are helpful, and sometimes essential. On multi-lane minor and major arterials, refuge islands or raised medians are essential. However, when used, crosswalks must be placed with great care in these locations, especially once travel speeds exceed 64 km/h (40 mph).

16.4 Advantages of Medians

Medians separate conflicts in time and place. The pedestrian faced with one or more lanes of traffic in each direction must determine a safe gap in two, four or even six lanes at a time. This is a complex task requiring accurate decisions. Younger and older pedestrians have reduced gap acceptance skills compared to pedestrians in other age groups. Pedestrians typically have poor gap assessment skills at night. Many may predict that a car is 61 meters (200 feet) off when, in fact, it is only 31 meters (100 feet), far too close to attempt a crossing.

At times, it may be necessary to block mid-block access. These shrubs are dense enough to divert pedestrians to adjacent intersections.

Medians Allow More Frequent Gaps
Medians not only separate conflicts, they also create the potential for acceptable gaps. On a standard-width four-lane roadway with a center left-turn lane (20 m or 64 feet wide, with five 12-foot lanes plus two 24-inch gutter pans), it takes an average pedestrian traveling 1.2 meters (4 feet) per second nearly 16 seconds to cross. Finding a safe 16-second gap in four moving lanes of traffic may be difficult or impossible. In any event, this may require a wait of 3 to 5 minutes. Faced with a substantial delay, many pedestrians select a less adequate gap, run across the roadway, or stand in the center left-turn lane hoping for an additional gap. If a raised median is placed in the center, the pedestrian now crosses 7.9 m (26 ft). This requires two 8-second gaps (see Figures 16-1 and 16-2). These shorter gaps come frequently. Based on traffic volume and the platooning effects from downstream signalization, the pedestrian may be able to find an acceptable gap in a minute or less.

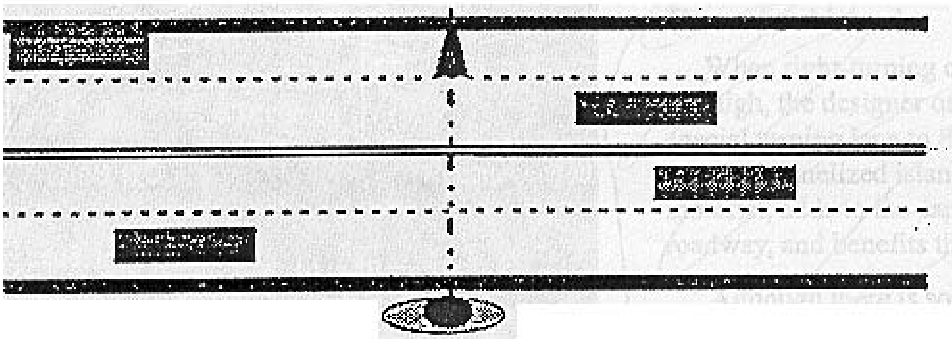
Medians Are Cheaper to Build
The reduced construction cost of a median vs. a center left-turn lane comes as a surprise to many designers. Grass medians allow natural percolation of water, thus reducing drainage and water treatment costs. Medians do not require a base or an asphalt. Curbing is essential in urban sections where medians are typically raised above the level of the street. In general, however, medians average a 5-to 10-percent reduction in materials and labor costs compared to a center left-turn lane.

Medians Are Cheaper to Maintain
While there is only a slight savings in cost to build a raised median versus a center left-turn lane, there is a substantial savings in maintenance. A study for Florida DOT compared 6.44 km (4.0 miles) of median versus center left-turn lane maintenance costs and found that medians save an average of 40 percent of maintenance costs based on a 20-year roadway life. More frequent resurfacing, such as every 7 to 9 years would show much greater savings. This, too, surprises many designers. During the full life of the roadway asphalt, a raised median saves costs associated with the sweeping of accumulated debris, the repainting of lines, the replacement of raised pavement markers, and the resurfacing of the lane. The raised median requires infrequent cutting of grass and occasional litter clean up. If the median is dedicated by agreement or permit to the community for landscaping, then the cost to the State highway department drop to near zero.

16.5 Design Considerations for Medians

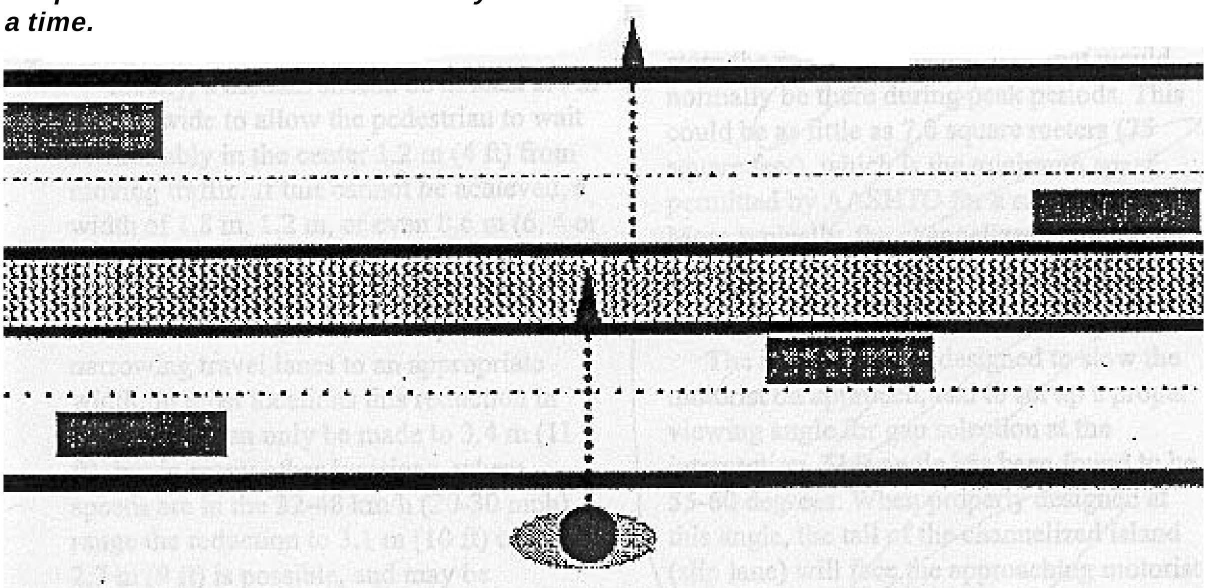
Ideally, a median should be at least 2.4 meters (8.0 feet) wide to allow the pedestrian to wait comfortably in the center, 1.2 m (4 ft) from moving traffic. A wider median is necessary if it must also serve the purpose of providing a left-turn bay for motor vehicle traffic at intersections. If the desired 2.4 meters (8.0 feet) cannot be achieved, a width of 1.8 meters (6 feet), 1.2 meters (4 feet), or even 0.6 meters (2 feet) is better than nothing. To find the needed width, especially in a downtown or other commercial environment, consider narrowing travel lanes to an

Figure 16.1. Mid-block crossing without median — the pedestrian must look in both directions.



- ***Requires one 16-second gap.***
- ***Pedestrian must look in both directions and find a gap in both directions. The wait will be considerable because statistically, two 8-second gaps are more likely than one 16-second gap.***

Figure 16.2. Mid-block crossing without median — the pedestrian needs to look in only one direction at a time.



- ***Requires two 8-second gaps.***
- ***Pedestrian only has to look in one direction.***

appropriate width. In most locations, this reduction in travel lanes can only be made to 3.4 meters (11 feet), but in many other locations, where speeds are in the 32-to 48-km/h (20- to 30-mph) range, the reduction to 3.1 meters (10 feet) or even 2.7 meters (9 feet) is possible, and may even be desirable.

Medians typically have an open flat cut and do not ramp up and down due to the short width. If the island is sufficiently large, then ADA-approved ramps (1:12 grade) should be used. It is best to provide a slight grade (2 percent or less) to permit water and silt to drain from the area.

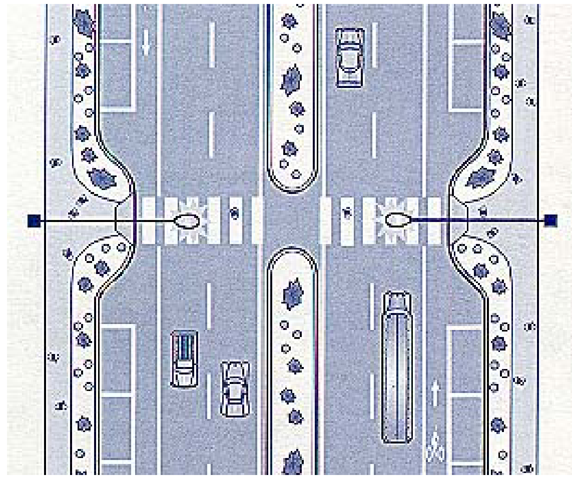
16.6 Mid-Block Crossings by Roadway Classification

Mid-block crossings are located and placed according to a number of factors, including roadway width, traffic volume, traffic speed and type, desire lines for pedestrian movement, and adjacent land use. Guidance for median placement on various types of roadways appears below.

Local Roads
Due to their low traffic speed and volume, local roadways rarely have median treatments. Some exceptions may apply, especially around schools and hospitals, where traffic calming is desired, and in other unique locations.

Collector Roads
Two-lane collector roads occasionally have medians or refuge islands to channel pedestrians to preferred crossing locations. Used in a series, these refuge islands have a strong visual presence and act as significant devices to slow motorist travel through the corridor. A 16-km/h (10-mph) speed reduction (from 64 km/h to 48 km/h [40 mph to 30 mph]) has been achieved. Pedestrians crossing at these mid-block refuge islands with marked crosswalks (who also make their intent to cross known) achieve a nearly 100-percent favorable response from motorists.

When collector roads are widened to four lanes (not recommended), raised medians may be essential. A boulevard-style street with tree canopies is recommended. This canopy effect helps reduce travel speeds.



Mid-block crossing curb extensions may be considered where there are pedestrian generators on both sides of the road.

Multi-Lane Arterial Highways With Four Lanes
Suburban crossings of four-lane roadways are greatly improved when medians and mid-block crossings are used (see figure above). On lower volume roadways, it is best to not use signalization.

Signalization may be helpful or even essential under the following conditions:

- On higher volume roadways.
- Where gaps are infrequent.
- In a school zone.
- Where elderly or disabled pedestrians cross.
- Where speeds are high.
- When a number of other factors are present.

Multi-Lane Arterial Highways With Six or More Lanes
On multi-lane arterials with six or more lanes, merging is occurring, lane-changing increases, and there is a greater tendency for motorists to speed and slow. This creates highly complex conditions to be interpreted by the pedestrian.

At mid-block, where vehicle speeds are high, signalization may be the only practical means of helping pedestrians to cross unless it is part of a signal coordination scheme. At high speeds, and with infrequent signal calls, high numbers of rear-end crashes can be anticipated. It is best not to allow urban area roadways to achieve high corridor speeds. This is especially true in areas where land use supports higher densities. The higher the speed, the greater the engineering challenge to cross pedestrians safely.

If a pedestrian crossing is needed, the designer must increase the devices used to alert the motorist. The standard pedestrian crossing and advanced crossing symbols with 0.9- x 0.7-meter (36- x 26-inch) signs are an absolute minimum for speeds of 64 km/h (40 mph) or greater. Pavement word symbols can be used as further enhancement. An enhanced crosswalk marking such as a zebra or ladder-style crossing should be considered. Large overhead signs, flashing beacons, bulb-outs, and even flashing overhead signs have been successfully used in some locations.

16.7 Mid-Block Crossing Design

The design of mid-block crossings makes use of warrants similar to those used for standard intersections. Stopping sight distances, effects of grade, cross-slope, the need for lighting, and other factors all apply. The design considerations for medians are covered earlier in this lesson. However, there are a number of added guidelines that must be followed.

Connect Desire Lines

All other factors considered, pedestrians and bicyclists have a strong desire to continue their intended path of travel. Look for natural patterns. A parking lot on one side connecting a large office complex on another virtually paints the desired crossing location. Use of a high-angle video time-lapse camera to map pedestrian crossings quickly paints this location, if it is not already well known.

Lighting

Motorists need to see pedestrians standing waiting to cross and those that are crossing. Either direct or backlit lighting is effective. Some overhead signs, such as in Portland, Oregon and Seattle, Washington, use overhead lights that identify the pedestrian crossing and also shine down on the actual crosswalk.

Grade-separated crossings at mid-block or intersection grade-separated crossings are effective in a few isolated locations. However, due to their cost and their potentially low use, engineering studies should be conducted by experienced designers. If given a choice, on most roadways, pedestrians generally prefer to cross at grade.

16.8 Mid-Block Signals

The placement of mid-block signals is called for in some locations. The warrants provided in the *Manual on Uniform Traffic Control Devices* (MUTCD) should be followed. But even more caution needs to be provided for signalized mid-block locations. Pedestrians feel frustrated if a signal is holding them back from crossing when there is an ample gap. Many will choose to cross away from the crossing, while others will dutifully push the activator button, not get an immediate response, and cross when there is a sufficient gap. A few seconds later, the approaching motorists must stop at a red signal for no reason, which can encourage motorist disrespect for the signal in the future.

Thus, the best signal setup for a mid-block crossing is a hot (nearly immediate) response. As soon as the pedestrian call actuator button is pushed, the clearance interval should be activated. This minimal wait time is a strong inducement for pedestrians to walk out of their way to use the crossing. Hot responses can often be used if the nearby signals are not on progression, or a hot response may be permitted in off-peak hours. Mid-block signals should be part of a coordinated system to reduce the likelihood of rear-end crashes and double cycles, i.e., two pedestrian cycles per one vehicle cycle at intersections to reduce pedestrian delay.

If a mid-block signal system is used, it is important to place a pedestrian push button in the median. There will be times when some pedestrians start too late, or when older pedestrians lack time, even at 0.9 meters (3.0 feet) per second to cross. In these rare instances, the pedestrian needs to reactivate the signal.

16.9 Exercise

Choose an urban site that would be a good candidate for a mid-block crossing with a pedestrian refuge island. Document the reasons that people often cross at this site (or would cross, given the opportunity). Photograph the site and prepare a sketch design solution.

16.10 References

Text and graphics in this lesson were derived from:

Florida Department of Transportation, *Florida Pedestrian Planning and Design Guidelines*, 1996.

For more information on this topic, refer to:

ITE, *Design and Safety of Pedestrian Facilities — A Recommended Practice of ITE*, 1998.

Oregon Department of Transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

L E S S O N 17

Pedestrians With Disabilities

17.1 Purpose

There are 43 million people in the United States with disabilities. Virtually all are pedestrians at one time or another. People with disabilities hold jobs, attend school, shop, and enjoy recreation facilities. Anyone can experience a temporary or permanent disability at any time, due to age, illness, or injury. In fact, 85 percent of Americans living to their full life expectancy will suffer a permanent disability. Design deficiencies frequently can be overcome by an agile, able-bodied person. However, when age or functional disabilities reduce a person's mobility, sight, or hearing, a good design is very important.

The Americans With Disabilities Act (ADA) was enacted by Congress on July 26, 1990 to prohibit discrimination against people with disabilities. This civil rights law ensures that a disabled person will have full access to all public facilities throughout the United States. The law has specific requirements for pedestrian facilities on private as well as public property, such as sidewalks and pedestrian accommodations within the right of way of streets and highways.

Eighty-five percent of Americans who live to their full life expectancy will suffer a permanent disability.

This section provides an overview of basic accessibility requirements that most often come into effect when designing pedestrian facilities in the public right of way. A complete set of standards can be found in the *Americans With Disabilities Act Accessibility Guidelines*, developed by the Access Board.

Although these standards are not covered in this section, ADA guidelines also apply to parking lots, passenger loading zones, steps and stairways, bus loading areas, and a variety of other features in of public rights of way.

17.2 Introduction

For traffic engineering purposes, a disability can be classified in one or more of three functional categories: mobility impairments, sensory deficits, or cognitive impairments. A person with a mobility impairment is limited in his/her method or ability to move about because of a physical disability or circumstance. This includes people who use wheelchairs and those with braces, crutches, canes, and walkers. It also includes persons with balance or stamina problems. Pregnant women are in this category as well.

While sensory deficits are most often associated with blindness or deafness, partial hearing or vision loss is much more common. Other persons have lost sensation in some part of their body. Color blindness, especially of red and green, is also a sensory deficit.

Cognitive impairments refer to a diminished ability to process information and make decisions. This includes persons who are mentally retarded or who have a dyslexic type of learning disability. In the United States, those who are unable to read or understand the English language are also in this category.

Based on tests conducted by the Veterans Administration, the level of energy expended by a wheelchair user is about 30 percent higher than that needed by a pedestrian walking the same distance. Moreover, a person on crutches or with artificial legs uses 70 percent more energy to go the same distance. If a person using a wheelchair travels a full city block and finds no curb cut, doubles back and travels that same distance in the street, it is the equivalent of an ambulatory person going four extra blocks. This illustrates the importance of removing physical barriers from our street network.

17.3 The Americans With Disabilities Act (ADA)

The Americans With Disabilities Act was signed into law on July 26, 1990. This civil rights law ensures that a disabled person will have full access to all public facilities throughout the United States. It is important to be not only in compliance with the letter of the law, but also with the spirit of the law. A prioritized plan for improvements should be in place with resources allocated to those locations where there is the greatest need. A primary concern for public agencies is providing access to public transit and to public buildings and facilities. In most cases, this will involve removing barriers to wheelchair access along sidewalks, installing accessible wheelchair ramps, and improving access to bus stops, as well as other features to accommodate pedestrians with various disabilities.

Dimensions and rules in the chapter are based on current standards set by the Architectural and Transportation Barriers Compliance Board, the Uniform Federal Accessibility Standards (UFAS), and the American National Standards Institute (ANSI) codes at the time of writing of this document. These rules may be updated from time to time, and local codes that are more strict should supersede these codes.

Sidewalks

Wheelchairs require a 0.9-meter (3-feet) minimum clearance width for continuous passage, so sidewalks should have a minimum clearance width of at least 1.5 meters (5 feet). They should be paved with a smooth, durable material. Sidewalks should be built and maintained in urban areas along all major arterial streets, in commercial areas where the public is invited, and at all transit stops and public areas. It is desirable to have paved sidewalks on both sides of all streets in urban and suburban areas to provide mobility for disabled (as well as non-disabled) pedestrians. A planting strip, which serves as a buffer between on-street vehicles and pedestrians on the sidewalk, can be especially beneficial to visually impaired pedestrians on the sidewalk and to wheelchair users. Sidewalks should be kept in good condition, free from debris, cracks, and rough surfaces.

Curb cuts are a critical design consideration for persons in wheelchairs.

To the extent practicable, sidewalks should have the minimum cross-slope necessary for proper drainage, with a maximum of 25 millimeters (1 inch) of fall for every 1.2 meters (4 feet) of width (2 percent). A person using crutches or a wheelchair has to exert significantly more effort to maintain a straight course on a sloped surface than on a level surface.

There should be enough sidewalk cross-slope to allow for adequate drainage. The maximum cross-slope should be no more than 2 percent)1:50) to comply with ADA requirements. Driveway slopes should not encroach into the sidewalk, and a 1.8-meter (6-foot) setback will generally prevent this encroachment.

Driveway slopes should not encroach into the sidewalk.

Where the sidewalk is located adjacent to the street, it should be rerouted sufficiently away from the street (to the back of the right of way or on an easement, if necessary), out of the driveway slope.

Ramps

Ramps are defined as locations where the grade exceeds 5 percent along an accessible path. Longitudinal grades on sidewalks should be limited to 5 percent, but may be a maximum of 1:12 (8.3 percent), if necessary. Long, steep grades should have level areas at intermittent distances (every 30 ft), since traversing a steep slope with crutches, artificial limbs, or in a wheelchair is difficult and level areas are needed for the pedestrian to stop and rest. In areas where it is impossible to avoid steep grades, an alternative route (such as an elevator in a nearby building) should be provided. However, the ADA does not require accommodations in all locations where natural terrain prevents treatment.

When grades exceed 5 percent, special textures and handrails may be required. Handrails are used by persons in wheelchairs to help pull themselves up and are used by other persons for support. Specifications for ADA-approved handrails can be found in the *Americans With Disabilities Handbook*. Informational signs, indicating alternative routes or facilities, can be placed at the base of the grade or in a guidebook for the area. Arrangements may be made with the local transit authorities to transport persons with disabilities at reduced (or no) fares where steep grades or other obstacles prohibit or severely impede access.

Street Furniture

Street furniture, such as benches and bus shelters, should be out of the normal travel path to the extent possible. For greater conspicuity, high-contrast colors, such as red, yellow, and black, are preferable. The following guidelines should be considered in the positioning of street furniture:

- Street furniture should not hang lower than 2.0 meters (6.7 feet) over a walking area.
- No object mounted on a wall or post or free standing should have a clear open area under it higher than 0.7 meters (2.3 feet) off the ground.
- No object higher than 0.7 meters (2.3 feet) attached to a wall should protrude from that wall more than 100 millimeters (4 inch).
- No protruding object should reduce the clear width of a sidewalk or walkway path to less than 0.9 meters (3 feet).

Another common problem for wheelchair users is the placement of street furniture next to on-street parking, which can make exiting a car or lift-equipped vehicle difficult. One remedy is to relocate the street furniture toward the end of the parking space instead of the center, or at the back of the sidewalk furthest from the curb. At least 1.5 m (5 ft) of clear space width along the sidewalk is needed to allow for exiting a vehicle. Other objects, such as streetlight poles, may be more difficult to move, so consideration may be given to relocating the handicapped parking space or reserving extra handicapped parking spaces.

Pedestrian Push Buttons
Some individuals may have difficulty operating pedestrian push buttons. In some instances, there may be a need to install a larger push button or to change the placement of the push button. Pedestrian push buttons should always be easily accessible to individuals in wheelchairs, and should be no more than 1.05 meters (42 inches) above the sidewalk. The force required to activate the push button should be no greater than 2.2 kg (5 lb).

A pavement grinding project left an exaggerated lip at this curb cut.

Pedestrian push buttons should be located next to the sidewalk landing, the top of the ramp, and adjacent to the appropriate crosswalk ramp. If there are two push buttons at a corner (one for each crosswalk), the push buttons should be located on separate poles and adjacent to their respective ramps.

Curb Cuts and Wheelchair Ramps
The single most important design consideration for persons in wheelchairs is to provide curb cuts. New and rebuilt streets with sidewalks should always have curb cuts at all crosswalks. It is desirable to provide two curb cuts per corner. These also benefit others with mobility limitations, elderly pedestrians, and persons pushing strollers, carts, etc. A “roll” curb (i.e., one with a sloped rather than a vertical curb face) is a barrier and will not allow for wheelchair access. Curb cuts should be at least 1.0 meter (3 ft-4 inches) wide at the base, with flared sides that do not exceed a slope of 2.33 percent and ramps that do not exceed 8.33 percent.

The ramps should be flared smooth into the street surface. Ramps should be checked periodically to make sure large gaps do not develop between the gutter and street surface. There may be a need to remove accumulations of asphalt at the edge of the curb radius.

Single ramps located in the center of a corner are less desirable than a separate ramp for each crosswalk to accommodate disabled pedestrians and should not be built for newly constructed or reconstructed sidewalks. Separate ramps provide greater information to visually impaired pedestrians in street crossings, especially if the ramp is designed to be parallel to the crosswalk. Crosswalk markings should be located so that a pedestrian in a wheelchair should not have to leave the crosswalk to enter or exit the street. In some cases, a wider ramp may be used to accommodate pedestrians in wheelchairs.

Ramps or cut-through islands should be provided for marked or unmarked crosswalks at median (or frontage road) islands. Cut-throughs should be designed to provide proper drainage and to avoid ponding.

Drainage is important. Standing water can obscure a drop-off or pothole at the base of a ramp and makes the crossing messy. Storm-drain inlets should be clear of the crosswalk. If this is not possible, the openings in the grate should be no larger than 13 millimeters (0.5 inch) in width.

17.4 Exercise

To help you realize how challenging visual and mobility impairments can be, you will get a chance to travel in a wheelchair, and then as a blindfolded pedestrian.

For safety, the following rules apply to this *activity:*

- Always have your protector (partner) with you.
- Only travel in the area designated for this activity.
- Always lean backwards when going down a ramp (wheelchair).
- Always lean forward when going up a ramp (wheelchair).

- The protector should be in front of the wheel-chair when going downhill, and behind the wheelchair when going uphill.
- Do not hold onto the blind person or push the wheelchair.
- Talk to the blind person to let them know you are there, and only warn of dangers (do not direct).

17.5 References

Text and graphics for this lesson were derived from the following sources:

Drake and Burden, *Pedestrian and Bicyclist Safety and Accommodation Participant Workbook*, NHI Course #38061, FHWA-HI-96-028, 1996.

Florida Department of Transportation, *Pedestrian Planning and Design Guidelines*, 1997.

The following Federal agencies are responsible for providing information about the Americans With Disabilities Act (ADA). The agencies and organizations are sources for obtaining information about the law's requirements and informal guidance for complying with the ADA. They are not sources for obtaining legal advice or legal opinions about your agency's rights or responsibilities under the ADA.

Architectural and Transportation Barriers Compliance Board
1331 F Street, NW, Suite 1000
Washington, DC 10004-1111
1-800-872-2253 (voice and TDD)

Equal Employment Opportunity Commission
1801 L Street, NW
Washington, DC 20507
Questions and Documents:
1-800-669-3362 (voice)
1-800-800-3302 (TDD)

Federal Communications Commission
for ADA documents and general information:
202-632-7260 (voice)
202-632-6999 (TDD)

President's Committee on Employment of People With Disabilities Information Line:
800-232-9675 (voice and TDD)

U.S. Department of Justice
Civil Rights Division
Public Access Section
P.O. Box 66738
Washington, DC 20035-6738
202-514-0301 (voice)
202-514-0383 (TDD)

U.S. Department of Transportation
Federal Transit Administration
400 7th Street, SW
Washington, DC 20590
202-366-1656 (voice)
202-366-2979 (TDD)

Office of the General Counsel
202-366-9306 (voice)
202-755-7687 (TDD)

The island above does not provide a cut-through. Note that the older woman is having difficulty, whereas the other pedestrians are already crossing.

L E S S O N 18

Shared Roadways

18.1 Purpose

There are a variety of ways to accommodate bicycles on roadways. In many cases, a few simple construction projects can make a big difference, such a replacing unsafe drain grates, filling pot-holes, or maintaining roadway shoulders so that they are free of debris. The next few lessons explore design solutions for several types of on-road bicycle facilities, as well as other general improvements that can be made to make bicycling on roadways safer and easier.

Lessons 18 through 20 cover the following bicycle facility types:

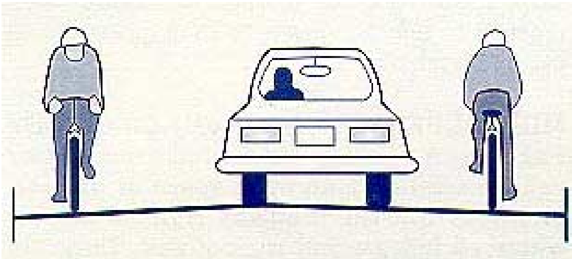
- Shared roadways.
- Shoulder bikeways.
- Wide curb lanes.
- Bike lanes.
- Bike routes.
- Bike boulevards.

The text and graphics for this lesson were derived from the *Oregon Bicycle and Pedestrian Plan*, a statewide planning policy and design manual published by the Oregon Department of Transportation in 1995. Oregon has been a leader among the States in bicycle facility development. More detailed information on facility design is provided in AASHTO's *Guide for the Development of Bicycle Facilities* (1999).

18.2 Shared Roadways

Since bicyclists are legally able to use all roadways, all roads are technically classified as "shared roadways" (with the exception of controlled-access freeways in some States). AASHTO defines a shared roadway as "a roadway which is not officially designated and marked as a bicycle route, but which is open to both bicycle and motor vehicle travel. This may be an existing roadway, street with wide curb lanes, or a road with paved shoulders." (AASHTO, 1998)

In the United States, most shared roadways have no provisions for bicycle travel and are, therefore, perceived as unsafe by many bicyclists. However, there are some design measures that can be taken to



Shared roadway.

ensure that shared roadways accommodate bicyclists safely and efficiently. This lesson describes several design options for shared roadways, including wide curb lanes, shoulder bikeways, and bicycle boulevards. There is also a discussion of practices to be avoided, such as sidewalk bikeways.

Bike lanes are another design treatment preferred by many bicyclists — they are addressed separately in Lessons 19 and 20.

There are no specific bicycle standards for most shared roadways; they are simply the roads as constructed. Shared roadways function well on local streets and minor collectors, and on low-volume rural roads and highways. Mile per mile, shared roadways are the most common place for people to ride.

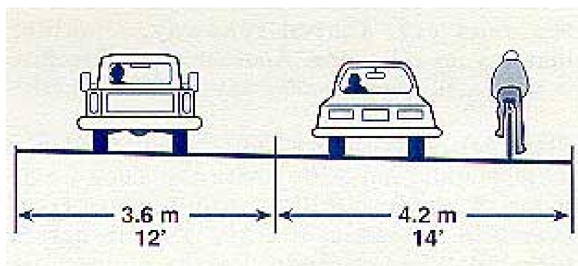
Shared roadways are suitable in urban areas on streets with low speeds — 40 km/h (25 mph) or less — or low traffic volumes (3,000 average daily traffic (ADT) or less, depending on speed and land use).

In rural areas, the suitability of a shared roadway decreases as traffic speeds and volumes increase, especially on roads with poor sight distances. Where bicycle use or demand is potentially high, roads should be widened to include shoulder bikeways if the travel speeds and volumes on the roadway are high.

Many urban local streets carry excessive traffic volumes at speeds higher than they were designed to carry. These can function as shared roadways if traffic speeds and volumes are reduced. There are many traffic-calming techniques that can make these streets more amenable to bicycling on the road.

18.3 Wide Curb Lanes

A wide curb lane may be provided where there is inadequate width to provide bike lanes or shoulder



Wide curb lane.

bikeways. This may occur on retrofit projects where there are severe physical constraints and all other options have been pursued, such as removing parking or narrowing travel lanes. Wide curb lanes can often be installed by narrowing inner lanes on a multi-lane arterial, thereby re-allocating roadway space so that the outside (curb) lanes are wider (see Lesson 20 for roadway retrofit solutions). Wide curb lanes are not particularly attractive to most cyclists, they simply allow motor vehicles to pass cyclists within a travel lane.

To be effective, a wide lane must be at least 14 ft wide, but less than 16 ft wide.

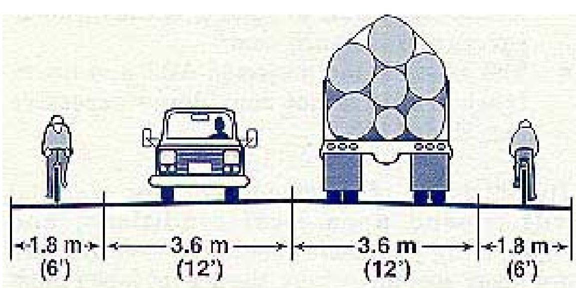
To be effective, a wide lane must be at least 4.2 meters (14 feet) wide, but less than 4.8 meters (16 feet) wide. Usable width is normally measured from the curb face to the center of the lane stripe, but adjustments need to be made for drainage grates, parking, and the ridge between the pavement and gutter. Widths greater than 4.8 meters (16 feet) encourage the undesirable operation of two motor vehicles in one lane. In this situation, a bike lane or shoulder bikeway should be striped.

18.4 Shoulder Bikeways

Paved shoulders are provided on rural highways for a variety of safety, operational, and maintenance reasons:

- Space is provided for motorists to stop out of traffic in case of mechanical difficulty, a flat tire, or other emergency.
- Space is provided to escape potential crashes.
- Sight distance is improved in cut sections.
- Highway capacity is improved.
- Space is provided for maintenance operations, such as snow removal and storage.
- Lateral clearance is provided for signs and guardrail.
- Storm water can be discharged farther from the pavement.
- Structural support is given to the pavement.
- Paved shoulders provide an excellent place for bicyclists to operate if they are adequately maintained.

Width Standards
In general, the shoulder widths recommended for rural highways in AASHTO's *Policy on Geometric Design of Highways and Streets* serve bicyclists well, since wider shoulders are required on heavily traveled and high-speed roads and those carrying large numbers of trucks.



Shoulder Bikeway: Min 3.5 meters (5 feet) against curb, parking, or guardrail; 1.2 meters (4 feet) against the open shoulder.

When providing shoulders for bicycle use, a width of 1.8 meters (6 feet) is recommended, however even 0.6 meters (2 feet) of shoulder width will benefit more experienced riders. A 1.8-meter (6-foot) wide shoulder allows a cyclist to ride far enough from the edge of the pavement to avoid debris, yet far enough from passing vehicles to avoid conflict. If there are physical width limitations, a minimum width of 1.2 meters (4 feet) from the longitudinal joint between a monolithic curb and gutter and the edge of travel lane may be adequate.

On steep grades, it is desirable to maintain a 1.8 meter (6-foot) wide shoulder (minimum — 1.5-meters or 5 feet), as cyclists need more space for maneuvering.

Pavement Design
Many existing gravel shoulders have sufficient width and base to support shoulder bikeways. Minor excavation and the addition of 75 to 100 millimeters (3 to 4 inches) of asphaltic concrete is often enough to provide shoulder bikeways. It is best to widen shoulders in conjunction with pavement overlays for several reasons:

- The top lift of asphalt adds structural strength.
- The final lift provides a smooth, seamless joint.
- The cost is less, as greater quantities of materials will be purchased.
- Traffic is disrupted only once for both operations.

When shoulders are provided as part of new road construction, the pavement structural design should be the same as that of the roadway.

On shoulder-widening projects, there may be some opportunities to reduce costs by building to a lesser thickness. A total of 50 to 100 millimeters (2 to 4 inches) of asphalt and 50 to 75 millimeters (2 to 3 inches) of aggregate over existing roadway shoulders may be adequate if the following conditions are met:

- There are no planned widening projects for the road section in the foreseeable future.

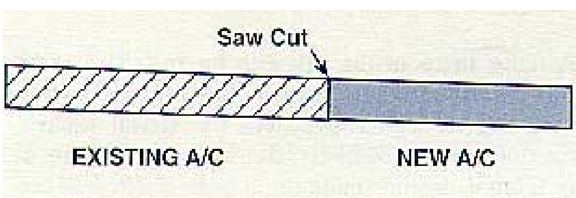
- The existing shoulder area and roadbed are stable and there is adequate drainage or adequate drainage can be provided without major excavation and grading work.

- The existing travel lanes have adequate width and are in stable condition.
- The horizontal curvature is not excessive, so the wheels of large vehicles do not track onto the shoulder area (on roads that have generally good horizontal alignment, it may be feasible to build only the insides of curves to full depth.
- The existing and projected ADT and heavy truck traffic is not considered excessive (e.g., less than 10 percent).

The thickness of pavement and base material will depend upon local conditions, and engineering judgment should be used. If there are short sections where the travel lanes must be reconstructed or widened, these areas should be constructed to normal full-depth standards.

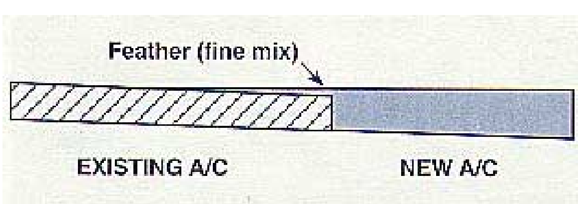
The Joint Between the Shoulders and the Existing Roadway

The following techniques should be used to add paved shoulders to roadways where no overlay project is scheduled:



Saw-cut joint.

1. Saw Cut: A 0.3-meter (1-foot) saw cut inside the existing edge of the pavement provides the opportunity to construct a good tight joint. This eliminates a ragged joint at the edge of the existing pavement (see figure below).

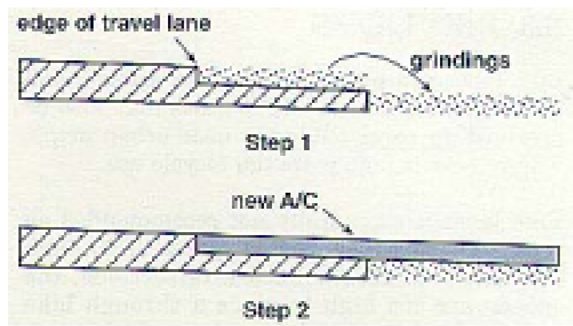


Asphalt feathering.

2. Feathering: "Feathering" the new asphalt onto the existing pavement can work if a fine mix is used and the feather does not extend across the area traveled by bicyclists.

3. Grinder: Where there is already some shoulder width and thickness available, a pavement grinder can be used to make a clean cut at the edge of the travel lane, grade the existing asphalt to the right depth, and cast aside the grindings in one operation, with these advantages:

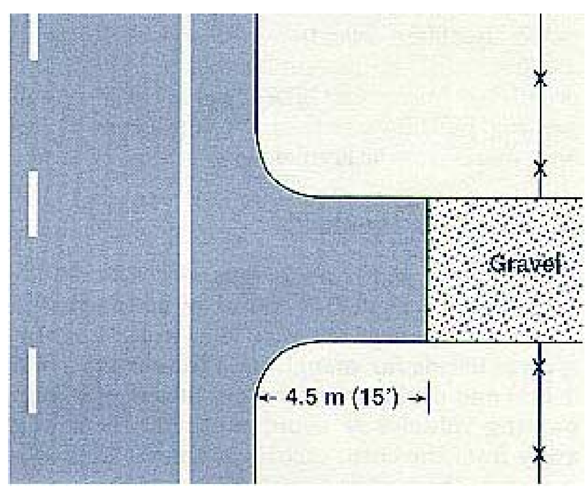
- Less of the existing pavement is wasted.
- The existing asphalt acts as a base.
- There will not be a full-depth joint between the



Grinding out existing asphaltic concrete (A/C).

travel lane and the shoulder.
- The grindings can be recycled as base for the widened portion.

New asphalt can then be laid across the entire width of the shoulder bikeway with no seams.



Paved driveway apron.

Gravel Driveways and Approaches
Wherever a highway is constructed, widened, or overlaid, all gravel driveways and approaches should be paved back 4.5 meters (15 feet) to prevent loose gravel from spilling onto the shoulders.

18.5 Bike Routes

Bike routes are specially designated shared roadways that are preferred for bicycle travel for certain recreation or transportation purposes. AASHTO's *Guide for the Development of Bicycle Facilities* cites the following reasons for designating bike routes:

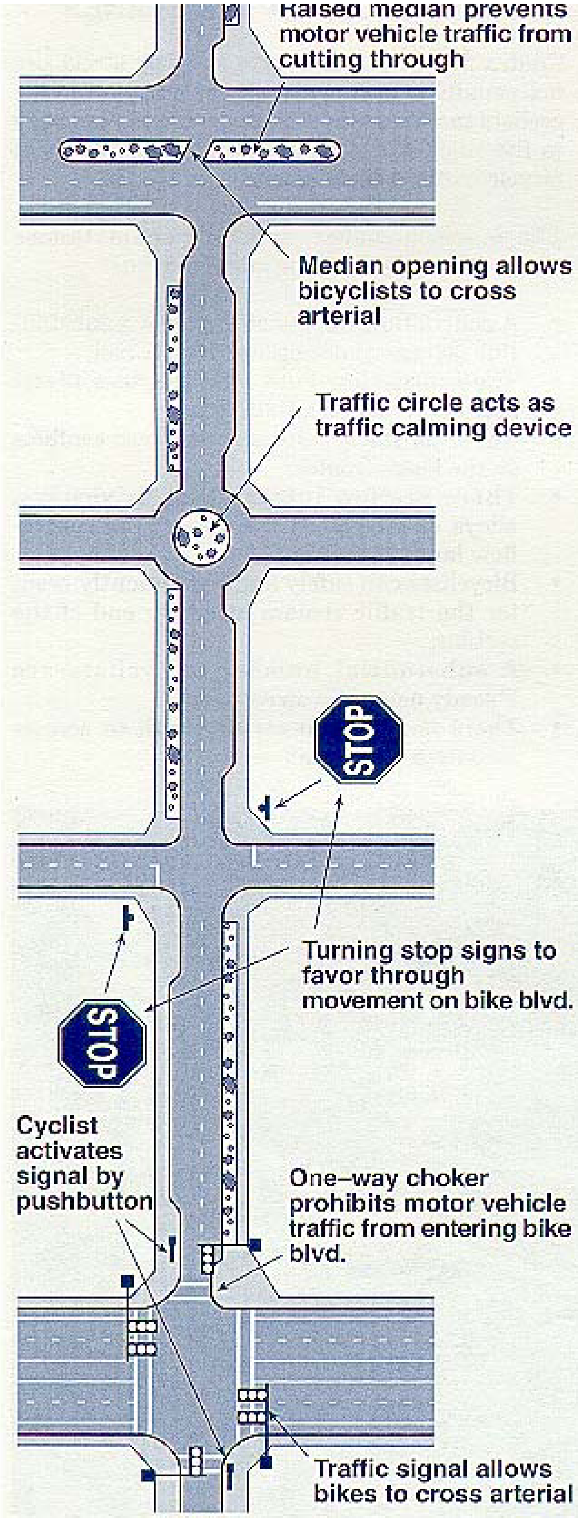
- The route provides a linkage to other bicycle facilities, such as bike lanes and multi-use paths.
- The road is a common route for bicyclists through a high-demand corridor.
- The route is preferred for bicycling in rural areas due to low traffic volumes or paved shoulder availability.
- The route extends along local neighborhood streets and collectors that lead to internal neighborhood destinations, such as a park or school.

Bike route signs may also be used on streets with bike lanes, as well as on off-road trails. Regardless of the type of facility or roadway they are used on, it is recommended that bike route signs always include destination, direction, and distance information.

The signing of shared roadways indicates to bicyclists that there are particular advantages to using these routes compared to alternate routes. This means the responsible agencies have taken action to ensure that these routes are suitable as shared routes and will be maintained.

Routes should be considered for signing only if some of the following criteria are met:

- The route provides through and direct travel in bicycle demand corridors.
- The route connects discontinuous segments of bike paths and bike lanes.
- An effort has been made to adjust traffic control devices (stop signs, signals) to give greater priority to bicyclists on the route, as opposed to alternative streets. This could include placement of bicycle-sensitive detectors on the right-hand portion of the road or where bicyclists are expected to ride.
- Street parking has been removed or restricted in areas of critical width to provide improved safety.
- Surface imperfections have been corrected (e.g., utility covers have been adjusted to grade, bicycle-proof drainage grates have been installed, potholes have been filled, etc.).
- Maintenance of the route will be at a higher standard than that of other comparable streets (e.g., more frequent street sweeping).
- The street provides wider curb lanes than other parallel roads.
- Shoulder or curb-lane widths meet or exceed accepted standards for bicycle facilities (14-ft-wide curb lanes, minimum of 4-ft-wide shoulders).



Elements of a bike boulevard, including street crossings.

18.6 Bicycle Boulevards

The bicycle boulevard is a refinement of the shared roadway concept–the operation of a local street is modified to function as a through-street exclusively for bicycles, while maintaining local access for automobiles. Traffic-calming devices reduce traffic speeds and through trips. Traffic controls limit conflicts between motorists and bicyclists, and give priority to through-bicycle movement.

Advantages of Bicycle Boulevards

- Opportunity — Traditional street grids offer many miles of local streets that can be converted to bicycle boulevards.
- Low cost — Major costs are for traffic control and traffic-calming devices.
- Traffic-calming techniques are increasingly favored by residents who want slower traffic on neighborhood streets.
- Bicycle travel on local streets is usually compatible with local land uses.
- Bicycle boulevards may attract new or inexperienced cyclists who do not feel comfortable on arterials and prefer to ride on lower traffic volume streets.
- Bicycle boulevards can improve conditions for pedestrians, with reduced traffic and improved crossings.

Disadvantages of Bicycle Boulevards

- They are often located on streets that do not provide direct access to commercial land uses and other destinations; some cyclists may have to negotiate a hostile street environment to complete a portion of their trip.
- If improperly implemented, they can cause traffic diversion onto other streets.
- Failure to provide arterial crossings can result in unsafe conditions for bicyclists.
- Traffic signals may be expensive or unacceptable for the traffic conditions.

Successful bicycle boulevard implementation requires careful planning with residents and businesses to avoid unacceptable impacts.

Elements of a Bicycle Boulevard

- Selection of a direct and continuous street, rather than a circuitous route that winds through neighborhoods. Bike boulevards work best on a street grid system.
- Turn stop signs toward intersecting streets so bicyclists can ride with few interruptions.
- Place motor vehicle traffic diverters at key intersections to reduce traffic volumes (the diverters must be designed to allow through-bicycle movement).
- Place traffic-calming devices on streets to lower traffic speeds.
- Place directional signs to route cyclists to key destinations, to guide cyclists through difficult situations, and to alert motorists of the presence of bicyclists.
- Provide protection where the boulevard crosses high-volume arterials:

   1. Use signals where a traffic study has shown that a signal will be safe and effective to ensure that bicyclists can activate the signal. Signal loops should be installed where bicyclists ride, supplemented with a push button that won't require dismounting.

   2. Use median refuges with gaps wide enough to allow bicyclists to pass through (minimum 2.4 meters [8 feet]). The median should be wide enough to provide a refuge (minimum 3 meters [10 feet]). The design should allow bicyclists to see the travel lanes they must cross.

18.7 Practices To Be Avoided

The Oregon Department of Transportation has more than 20 years of experience designing bikeways, and has also learned from local city and county experiences. Some practices have proven to be poor ones:

Sidewalk Bikeways
Some early bikeways used sidewalks for both pedestrians and bicyclists. While in rare instances this type of facility may be necessary, or desirable for use by small children, in most cases, it should be avoided.

Sidewalks are not suited for bicycling for several reasons:

- Bicyclists face conflicts with pedestrians.
- There may be conflicts with utility poles, sign posts, benches, etc.
- Bicyclists face conflicts at driveways, alleys, and intersections: A bicyclist on a sidewalk is generally not visible to motorists and may emerge unexpectedly. This is especially true of bicyclists who ride opposing adjacent motor vehicles.
- Bicyclists are put into awkward situations at intersections where they cannot safely act like a vehicle, but are not in the pedestrian flow either, which creates confusion for other road users.

Bicyclists are safer when they are allowed to function as roadway vehicle operators, rather than as pedestrians.

Where constraints do not allow full-width walkways and bikeways, solutions should be sought to accommodate both modes (e.g., narrowing travel lanes or reducing on-street parking). In some urban situations, preference may be given to accommodating pedestrians. Sidewalks should not be signed for bicycle use – the choice should be left to the users.

Extruded Curbs
Raised concrete curbs create an undesirable condition when used to separate the motor vehicle lane from a bike lane or paved shoulder: Either one may hit the curb and lose control, with the motor vehicle crossing onto the bikeway or the cyclist falling onto the roadway.

At night, the curbs cast shadows on the lane, reducing the bicyclist's visibility of the surface. Extruded curbs make bikeways difficult to maintain and tend to collect debris. They are often hit by motor vehicles, causing them to break up and scatter loose pieces onto the surface.

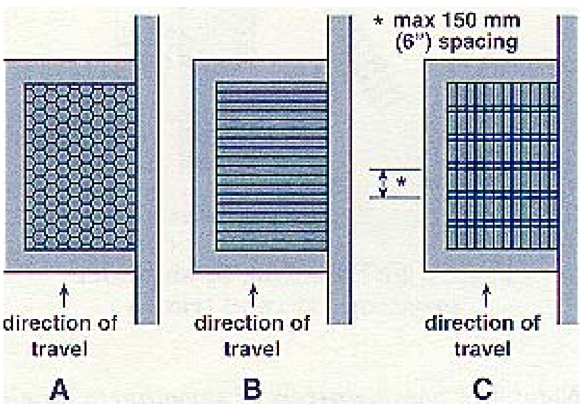
Reflectors and Raised Pavement Markers
These can deflect a bicycle wheel, causing the cyclist to lose control. If pavement markers are needed for motorists, they should be installed on the motorist's side of the stripe, and they should

have a beveled front edge.

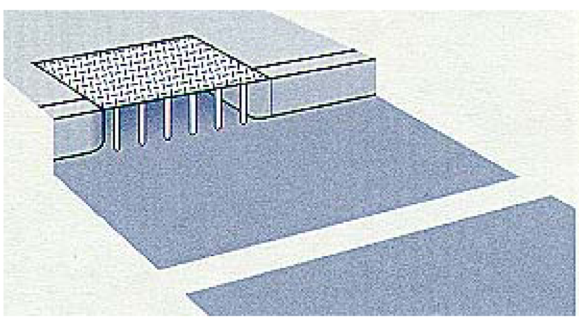
18.8 Other Design Considerations

Drainage Grates

Care must be taken to ensure that drainage grates are bicycle-safe. If not, a bicycle wheel may fall into a slot in the grate, causing the cyclist to fall. Replacing existing grates (See A and B in figure below [preferred methods]) or welding thin metal straps across the grate perpendicular to the direction of travel (C, alternate method) is required. These should be checked periodically to ensure that the straps



Bicycle-safe grates.



Inlet flush in the curb face.

remain in place.
Note: Grates with bars perpendicular to the roadway must not be placed at curb cuts, as wheelchairs could get caught in the slots.

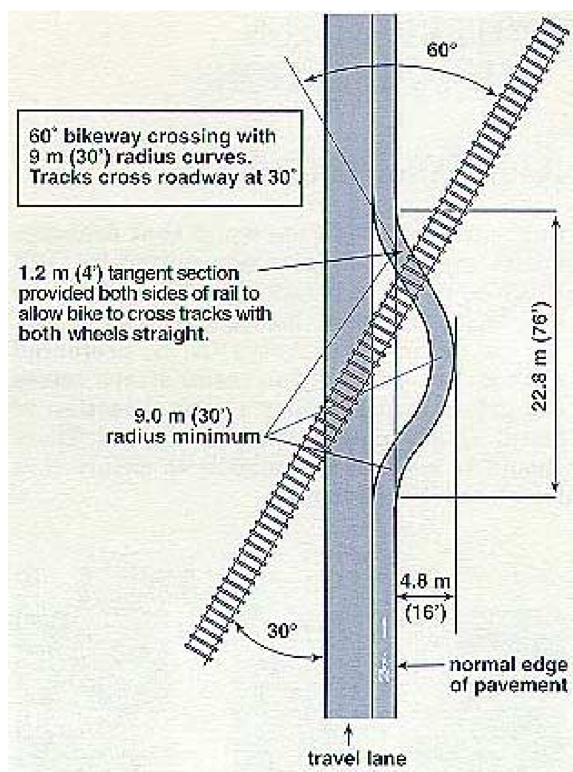
The most effective way to avoid drainage grate problems is to eliminate them entirely with the use of inlets in the curb face (see figure above).

If a street-surface grate is required for drainage, care must be taken to ensure that the grate is flush with the road surface. Inlets should be raised after a pavement overlay to within 6 mm (1/4 inch) of the new surface. If this is not possible or practical, the pavement must taper into drainage inlets so they do not cause an abrupt edge at the inlet.

Railroad Crossings

Special care must be taken wherever a bikeway intersects railroad tracks. The most important improvements for bicyclists are smoothness, angle of crossing, and flange opening.

Smoothness: Concrete performs best under wet conditions and, when laid with precision, provides a smooth ride. Rubberized crossings provide a durable, smooth crossing, although they tend to become slippery when wet. If asphalt pavement is used, it must be maintained in order to prevent a ridge buildup next to the rails. Timber crossings



Bike lane or shoulder crossing railroad tracks.

wear down rapidly and are slippery when wet.

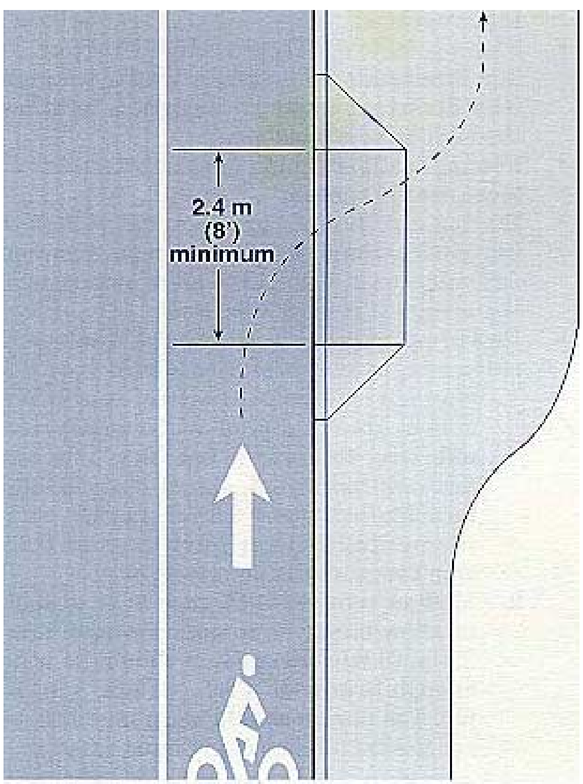
Angle of Crossing: The risk is kept to a minimum where the bikeway crosses the tracks at a 90° angle. If the skew angle is less than 45°, special attention should be given to the bikeway alignment to improve the angle of the approach, preferably to 60° or greater, so cyclists can avoid catching their wheels in the flange and losing their balance.

Flange Opening: The open flange area between the rail and the roadway surface can cause problems for cyclists, since it can catch a bicycle wheel, causing the rider to fall. Flange width must be kept to a minimum.

Note: *The **combination** of smoothness, angle, and flange opening create conditions that affect cyclists. By improving smoothness and flange opening, the angle becomes less critical.*

Sidewalk Ramps on Bridges

These can help cyclists if the bridge sidewalks are wide enough for bicycle use (minimum 1.2 meters [4 feet]). They should be provided where motor vehicle traffic volumes and speeds are high, the bridge is fairly long, and the outside traffic lanes or shoulders on the ridge are narrow.

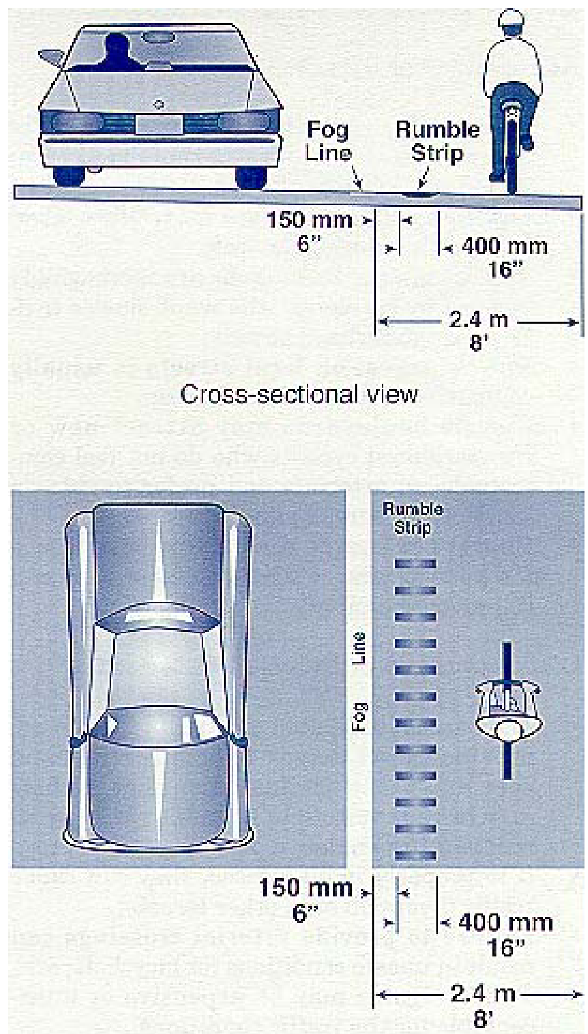


Ramp provides access to sidewalk.

Rumble Strips

Rumble strips are provided to alert motorists that they are wandering off the travel lanes onto the shoulder. They are most common on long sections of straight freeways in rural settings, but are also used on sections of two-lane undivided highways.

Bicycles are allowed on some freeways and expressways and on most primary and secondary roads. Many bicyclists prefer to ride on the shoulder, outside the travel lane and out of the truck and automobile traffic stream. One of bicyclists' main concerns about rumble strips is the ability to control the bicycle when the rider needs to travel across or



Bicycle-friendly rumble strip.

along the rumble strip for such maneuvers as a left turn or to avoid debris or an obstacle on the paved shoulder. Travel to the right of the rumble strip is generally most beneficial for the bicyclist as long as that area is free of debris and obstacles and the travel path is wide enough to comfortably accommodate the bicycle. A newer rumble strip design is more bicycle-friendly: 400-millimeter (16-inch) grooves are cut into the shoulder, 150 millimeters (6 inches) from the fog line. On a 2.4-meter (8-foot) shoulder, this leaves 1.8 m (6 feet) of usable shoulder for bicyclists. Some highway agencies have instituted policies that prohibit the use of shoulder rumble strips on roads designated as bike routes or where there is insufficient remaining paved shoulder room to accommodate bicycle travel. Others evaluate the use of rumble strips on a case-by-case basis and often opt to install them only at locations with a history of run-off-road crashes.

Several options are being considered to address the concerns of the bicycle traveler. The selection of a particular shoulder rumble strip design or revisions to current designs may provide part of the solution. For example, milled shoulder rumble strips are narrow and usually require less space on the shoulder than other types of strips. The narrower width of the strip allows more shoulder room for the bicyclist to maneuver on the right side of the shoulder.

Other designs being used and investigated use a skip pattern of rumble strip that provides a smoother travel path throughout portions of the strip for bicyclists to move to the left when needed. Also, some highway agencies are providing an aid to cyclists and all travelers in general by posting roadside signs, such as RUMBLE STRIPS AHEAD, alerting the traveler to the presence of the shoulder rumble strip.

18.9 Exercise

Choose a local street that would be a good candidate for a bicycle boulevard. The street segment should be several blocks in length, and should include at least one crossing of a major arterial. Prepare a conceptual design plan for the street segment, showing the location of signing, traffic signals, on-street parking, and traffic-calming features. Your design should be shown in plan view, and should be accompanied by a narrative explaining the purpose of special design features.

18.10 References

Text and graphics for this section were derived from the following sources:

American Association of State Highway and Transportation Officials, *Guide for the Development of Bicycle Facilities* (Review Draft), 1997.

Federal Highway Administration Website, Office of Highway Safety, Rumble Strip Web page, 1999.
Oregon Department of Transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

For more information on this topic, refer to:

USDOT, *Manual on Uniform Traffic Control Devices* (latest version).

L E S S O N 19

Bicycle Lanes

19.1 Purpose

The AASHTO *Guide for the Development of Bicycle Facilities* defines a bike lane as “a portion of a roadway which has been designated by striping, signing, and pavement markings for the preferential or exclusive use of bicyclists.” As levels of bicycling have increased in the United States, there has been a growing amount of support for bike lanes on urban and suburban roadways. Bike lanes are a preferred facility type in European countries, and in North America, nearly every major city has made an effort in recent years to install bicycle lanes, either as “pilot projects” (to test their success) or, in many cases, on larger networks of intercon-necting roadways. Several small towns have led the way in establishing networks of bicycle lanes, particularly college towns where there are high levels of student bicycle commuters (e.g., University of California at Davis and University of Texas at Austin).

As a relatively new feature in the roadway cross-section, bike lane design has been the topic of much study in recent years. Bike lane design can be quite challenging in situations where the existing urban traffic patterns are complex and cross-sections are already constrained by heavy traffic volumes. Designers throughout the country develop new and better solutions each year. This section includes excerpts from several sources, including Oregon’s *1995 Bicycle and Pedestrian Plan* and Philadelphia’s *Bicycle Network Plan.*

Note: The Europeans have pioneered innovative bike lane design solutions. Lesson 22 includes a description of European approaches that have been successful.

As with the other bicycle facility design issues covered in this manual, bike lane design is covered in

some detail by the AASHTO *Guide for the Development of Bicycle Facilities.* This text should be referenced for additional information.

19.2 Bicycle Lane Widths and Construction Standards

Bicycle lanes serve the needs of all types of cyclists in urban and suburban areas, providing them with their own travel lane on the street surface. The minimum width of a bike lane should be 1.5 meters (5 feet) against a curb or adjacent to a parking lane. On streets where the bike lane is adjacent to the curb and the curb includes a 1-foot to 2-foot gutter pan, bike lanes should be a minimum of 4 feet wide (width does not include the gutter pan, since bicyclists are typically unable to use this space).

Wider bike lanes are recommended on streets with higher motor vehicle speeds and traffic volumes, or where pedestrian traffic in the bike lane is anticipated. Width measurements are taken from the curb face to the bicycle lane stripe.

Since bicyclists usually tend to ride a distance of 0.8 meters to 1.1 meters (2.5 feet to 3.5 feet) from the curb face, it is very important that the pavement surface in this zone be smooth and free of structures. Drain inlets and manholes that extend into this area cause bicyclists to swerve, having the effect of reducing the usable width of the lane. Where these structures exist and the surface cannot be made smooth, bike lane width should be adjusted accordingly. Regular maintenance is critical for bike lanes (see text in this section).

Bike lanes should be constructed to normal full-depth pavement standards since motor vehicles will occasionally cross them, or may use them as a breakdown area.

19.3 Unmarked Lanes

Where the minimum widths listed above cannot be met, it may be possible to provide an unmarked lane. Studies have shown that the bicyclist's perceived level of comfort is higher when a striped area is provided; therefore, this method can raise the bicycle level of service for the street. An unmarked lane is a striped area of 0.6 m (2 ft) wide or more that contains no markings or signing that would denote it as a bike lane. "Share the Road" signs may be used to caution motorists to be alert for bicyclists.

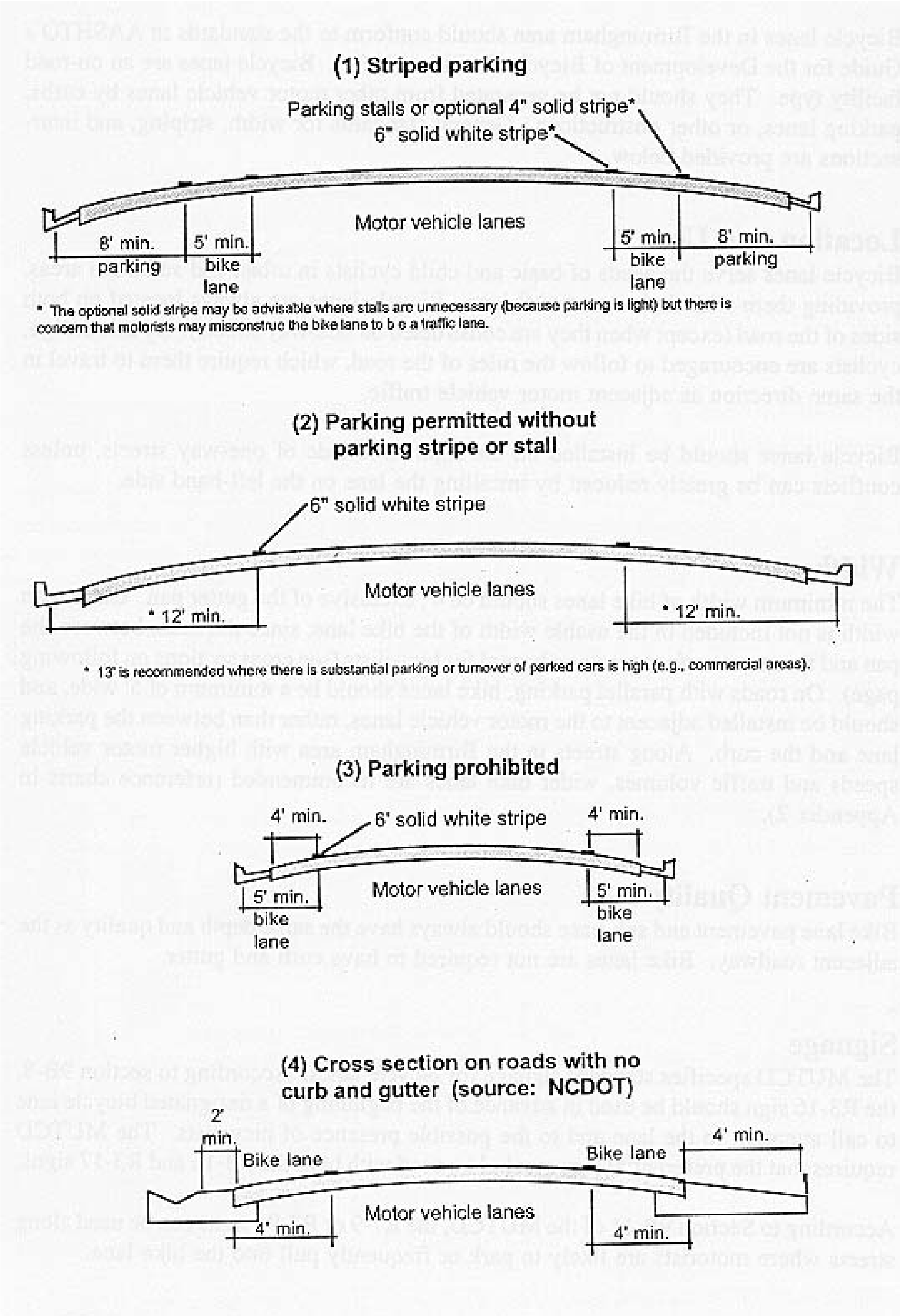
It is important to recognize that this is a temporary solution. Particularly on busy streets, narrow unmarked lanes will not adequately serve the needs of the majority of bicyclists.

19.4 Location Within the Street Cross-Section

Bicycle lanes are always located on both sides of the road on two-way streets. Since bicyclists must periodically merge with motor vehicle traffic, bike lanes should not be separated from other motor vehicle lanes by curbs, parking lanes, or other obstructions. Two-way bike lanes on one side of two-way streets create hazardous conditions for bicyclists and are not recommended.

On one-way streets, bicycle lanes should be installed on the right-hand side, unless conflicts can be greatly reduced by installing the lane on the left-hand side. Left-side bicycle lanes on one-way streets may also be considered where there are frequent bus or trolley stops, unusually high numbers of right-turning motor vehicles, or if there is a significant number of left-turning bicyclists.

As a temporary solution, striping narrow lanes through intersections may be an option where space is limited.



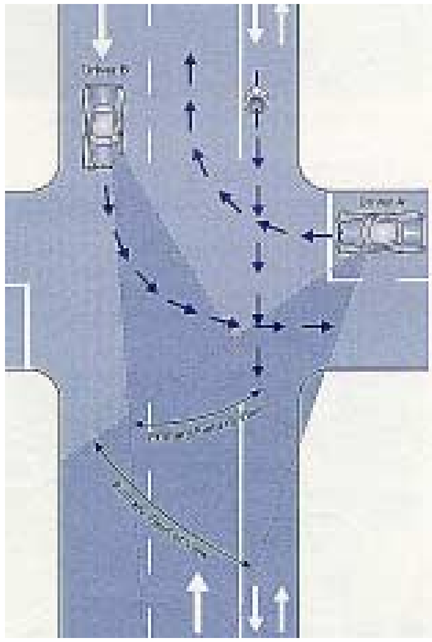
Bicycle lanes provided under different types of conditions. **Source: AASHTO Guide for the Development of Bicycle Facilities, 1991.**

19.5 Practices To Be Avoided

Two-Way Bike Lane
This creates a dangerous condition for bicyclists. It encourages illegal riding against traffic, causing several problems:

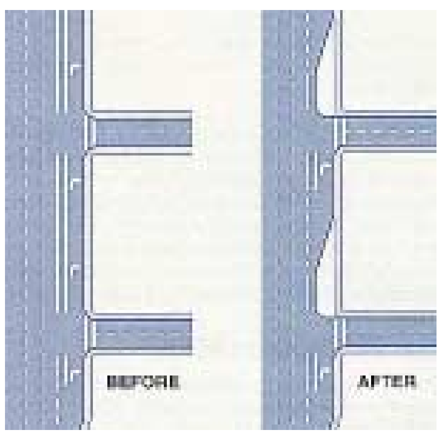
- At intersections and driveways, wrong-way riders approach from a direction where they are not visible to motorists.
- Bicyclists closest to the motor vehicle lane have opposing motor vehicle traffic on one side and opposing bicycle traffic on the other.
- Bicyclists are put into awkward positions when transitioning back to standard bikeways.

If constraints allow widening on only one side of the road, the centerline stripe may be shifted to allow for adequate travel lanes and bike lanes:



In both cases above, a wrong-way bicyclist is not in the driver's main field of vision.

Continuous Right-Turn Lanes
This configuration is difficult for cyclists: Riding on the right puts them in conflict with right-turning cars, but riding on the left puts them in conflict with cars merging into and out of the right-turn lane. The best solution is to eliminate the continuous right-turn lane, consolidate accesses, and create well-defined intersections.



Continuous right-turn lane reconfigured to standard approaches.

19.6 Contra-Flow Bike Lanes

Contra-flow bike lanes on a one-way street are not usually recommended. They may encourage cyclists to ride against traffic, which is contrary to the rules of the road and a leading cause of bicycle/motor vehicle crashes.

There are, however, special circumstances when this design may be advantageous:

- A contra-flow bike lane provides a substantial savings in out-of-direction travel.
- The contra-flow bike lane provides direct access to high-use destinations.
- Improved safety because of reduced conflicts on the longer route.
- There are few intersecting driveways, alleys, or streets on the side of the contra-flow lane.
- Bicyclists can safely and conveniently re-enter the traffic stream at either end of the section.
- A substantial number of cyclists are already using the street.
- There is sufficient street width to accommodate a bike lane.

A contra-flow bike lane may also be appropriate on a one-way residential street recently converted from a two-way street (especially where this change was made to calm traffic).

For a contra-flow bike lane to function well, these special features should be incorporated into the design:

Contra-flow bike lanes can provide direct access to high-use destinations.

- The contra-flow bike lane must be placed on the right side of the street (to motorists' left) and must be separated from oncoming traffic by a double yellow line. This indicates that the bicyclists are riding on the street legally, in a dedicated travel lane.

- Any intersecting alleys, major driveways, and streets must have signs indicating to motorists that they should expect two-way bicycle traffic.

- Existing traffic signals should be fitted with special signals for bicyclists; this can be achieved with either loop detectors or push buttons (these should be easily reached by bicyclists without having to dismount).

Note: Under no circumstances should a contra-flow bike lane be installed on a two-way street, even where the travel lanes are separated by a raised median.

19.7 Bike Lane Pavement Markings

The *Manual on Uniform Traffic Control Devices* (MUTCD) section 9C addresses standard bike lane markings. The stripe between the bicycle lane and the adjacent motor vehicle lane should be a 100-millimeter (4 inch) wide white line (minimum width). Six- to eight-inch-wide lines provide an even clearer division of space, and are highly recommended.

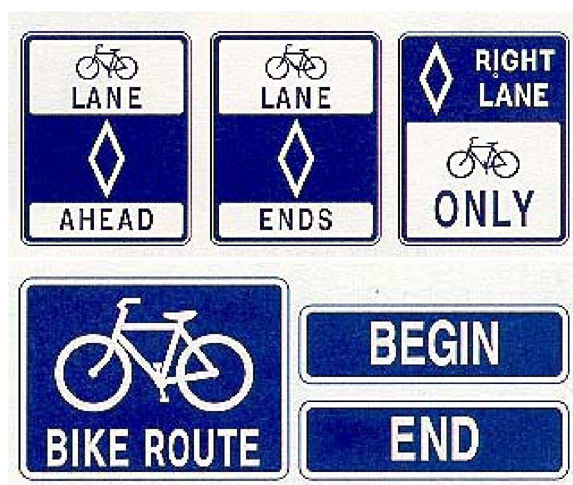
Where parking is allowed next to a bike lane, the parking area should be defined by parking space markings or a solid 100 millimeter (4 inch) wide stripe.

Care should be taken to use pavement striping that is durable, yet skid-resistant. Reflectors and raised markings in bike lanes can deflect a bicycle wheel, causing a bicyclist to lose control. If reflective pavement markers are needed for motorists, they should be installed on the motorist's side of the stripe, and have a beveled front edge.

While the 1988 edition of the MUTCD recommends the use of the diamond-shaped preferential lane symbol in conjunction with bike lane signs, this symbol is often confusing for both the bicyclist and motorist. For this reason, subsequent editions of the MUTCD will probably eliminate the use of the diamond in bike lanes. The new standard pavement markings for bicycle lanes are the bicycle symbol (or the words BIKE LANE) and a directional arrow.

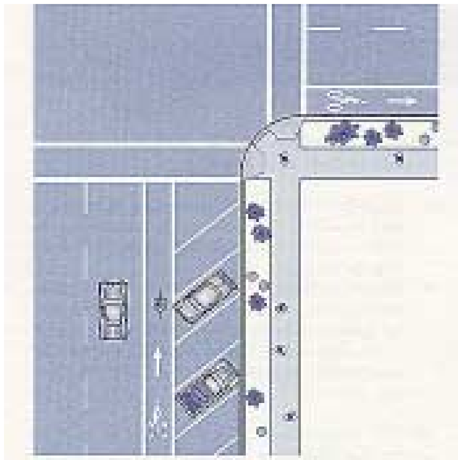
19.8 Bike Lane Signing

The *Manual on Uniform Traffic Control Devices* (MUTCD) section 9B addresses standard bike lane signing. According to section 9B-8, the R3-16 sign should be used in advance of the beginning of a



Bike lane signs should be replaced with bike lane stencils, with optional NO PARKING signs where needed.

designated bicycle lane to call attention to the lane and to the possible presence of bicyclists. In locations where bicycle lanes are ending, the same R3-16 sign should be used, with the word ENDS substituting for the word AHEAD. The R7-9 or R7-9a signs should be used along streets where motorists are likely to park or frequently pull into the bike lane.



Bike lane next to diagonal parking, 8-inch stripe should separate the areas.

19.9 Diagonal Parking

Diagonal parking causes conflicts with bicycle travel: Drivers backing out have poor visibility of oncoming cyclists and parked vehicles obscure other vehicles backing out. These factors require cyclists to ride close to the center of a travel lane, which is intimidating to inexperienced riders.

Where possible on one-way streets, diagonal parking should be limited to the left side, even if the street has no bike lane; on one-way streets with bike lanes, the bike lane should be placed adjacent to parallel parking (preferably on the right).

Bike lanes are not usually placed next to diagonal parking. However, should diagonal parking be required on a street planned for bike lanes, the following recommendations can help decrease potential conflicts:

- The parking bays must be long enough to accommodate most vehicles.
- A 200-millimeter- (8-inch-) wide stripe should separate the parking area from the bike lane.
- Enforcement may be needed to cite or remove vehicles encroaching on the bike lane.

19.10 Bike Lane Design at Intersections

Intersections With Bus Stops

If there is a bus stop at the near side of the intersection, a broken line should extend the length of the bus stop (no less than 15 meters [50 feet]), and the solid white line should resume on the far side of the intersection, immediately after the crosswalk. If a bus stop is located on the far side of the intersection, the solid white line on the far side of the intersection should be replaced with a broken line for a distance of at least 24 meters (80 feet) from the crosswalk (at this intersection, a broken line would still be required on the near side if there is right-turning traffic).

Intersections With Right-Turn Lanes

In general, right-turn lanes should be used only where warranted by a traffic study, as they present problems for both bicyclists and pedestrians:

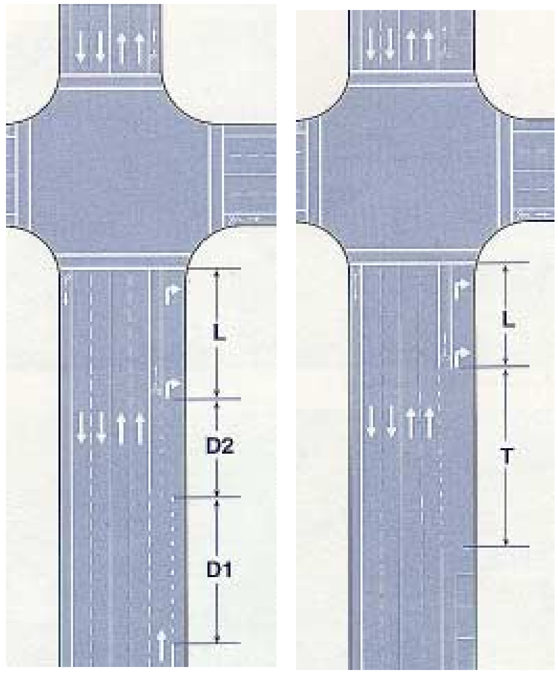
- If right-turning cars and through bicyclists must cross paths.
- If the additional lane width adds to the pedestrian crossing distance.
- If right-turn moves are made easier for motorists, which may cause inattentive drivers to not notice pedestrians on the right.

The through bike lane to the left of a right-turn lane should be striped with two 100-millimeters- (4-in-) wide stripes and connected to the preceding bike lane with 0.9-meter (3-foot) dashes and 2.7-meter (9-foot) spaces. This allows turning motorists to cross the bike lane. A legend must be placed at the beginning of the through bike lane. Sign R4-4, BEGIN RIGHT TURN LANE, YIELD TO BIKES, may be placed at the beginning of the taper in areas where a through bike lane may not be expected.

Not all intersections can be widened to provide a right-turn lane. A bike lane to the left of right-turning cars should still be provided. One common configuration occurs where a right-turn lane is developed by dropping parking (see figure at right).

Another configuration occurs where a lane is dropped and turns into a right-turn lane.

Note: This is a difficult movement for bicyclists as they must merge left and find a gap in the traffic stream:



Above left: Bike lane left of right-turn lane developed by dropping a travel lane. Above right; Bike lane left of right-turn lane developed by dropping parking.

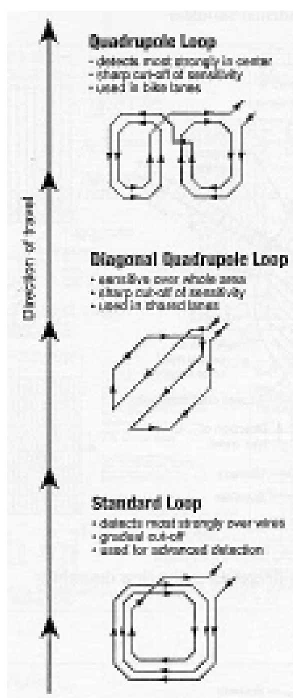
Offset Intersections
Care should be taken to ensure that motorists are not inadvertently encouraged to ride in the bike lane because of offset travel lanes. At intersections with offset lanes, dashed offset lane markings should continue through the intersection to direct traffic flow (MUTCD Section 3B-7).

Traffic Signal Actuation
It is highly recommended that new on-road bicycle facilities include traffic signals that detect bicycles for all actuated signal systems. *The Traffic Detector Handbook* (FHWA-IP-90-002) recommends several bicycle-sensitive loop configurations (loops are wires installed beneath the pavement surface that detect the presence of vehicles) that effectively detect bicycles. The quadrupole loop is the preferred solution for bike lanes, and the diagonal quadrupole loop is preferred for use in shared lanes.

One solution for existing intersection signals that do not respond to bicycles is to install a special pavement marking over the exact spot that a bicycle must stand in order to "trip" the signal.

Exception #1: Heavy Right Turns
If the major traffic movement at an intersection is to the right, and the straight through move leads to a minor side street, then the bike lane may be placed on the right and wrapped around the curve, assuming that the majority of cyclists will desire to turn right too. This often occurs where a highway is routed over local streets and the route is indirect.

Exception #2: Tee Intersections
At a Tee intersection, where the traffic split is approximately 50 percent turning right and 50 percent turning left, the bike lane should be dropped prior to the lane split to allow cyclists to position themselves in the correct lane. Where traffic volumes are very high, a left- and right-turning bike lane should be considered.



Different loop configurations: The quadrupole loop is recommended for bike lanes.

Expressway Interchanges
Expressway interchanges often present barriers to bicycle circulation. Designs that encourage free-flowing motor vehicle traffic movements are the most difficult for pedestrians and bicyclists to negotiate.

At-Grade Crossings
Interchanges with access ramps connected to local streets at a right angle are easiest for bicyclists to negotiate. The intersection of the ramp and the street should follow established urban intersection designs. The main advantages are:

- The distance that pedestrians and bicyclists must cross at the ramps is minimized.
- Signalized intersections stop traffic.
- Visibility is enhanced.

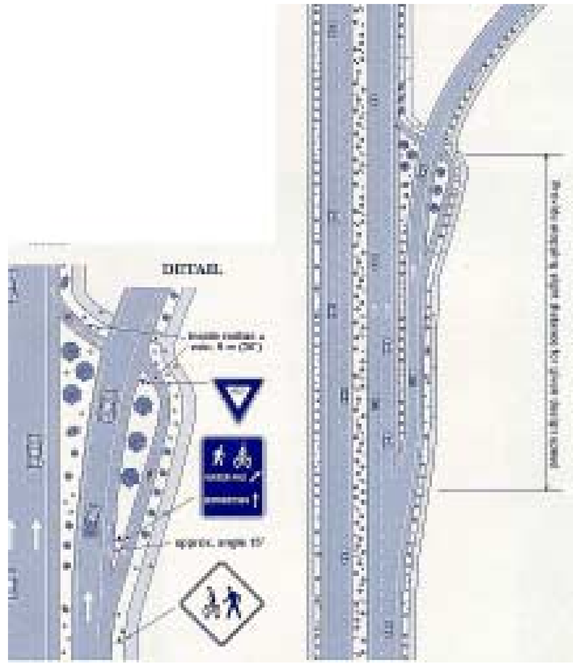
If these configurations are unavoidable, mitigation measures should be sought. Special designs should be considered that allow pedestrians and bicyclists to cross ramps in locations with good visibility and where speeds are low.

Grade-Separated Crossings
Where it is not possible to accommodate pedestrians and bicyclists with at-grade crossings, grade separation should be considered. Grade-separated facilities are expensive; they add out-of-direction travel and will not be used if the added distance is too great. This can create problems if pedestrians and bicyclists ignore the facility and try to negotiate the interchange at grade with no sidewalks, bike lanes, or crosswalks.

In some instances, a separate path can be provided on only one side of the interchange, which leads to awkward crossing movements. Some bicyclists will be riding on a path facing traffic, creating difficulties when they must cross back to a bike lane or shoulder (clear and easy-to-follow directions must be given to guide bicyclists' movements that are inconsistent with standard bicycle operation).

To ensure proper use by bicyclists, structures must be open, with good visibility (especially underpasses).

Other Innovative Designs
These concepts are presented as examples of innovative solutions to bike lane design at freeway interchanges and intersections.

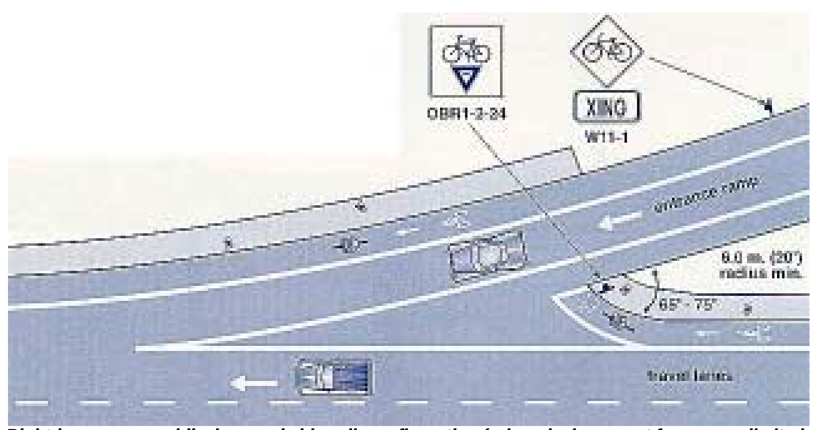


Exit ramp configuration for bike lane and sidewalks (urban design — not for use on limited-access freeways).

Traffic entering or exiting a roadway at high speeds creates difficulties for slower moving bicyclists. The following designs help alleviate these difficulties:

Right-Lane Merge
It is difficult for bicyclists to traverse the undefined area created by right-lane merge movements, because:

- The acute angle of the approach creates visibility problems.



Right-lane merge — bike lane and sidewalk configuration (urban design — not for use on limited-access freeways).

- Motor vehicles are often accelerating to merge into traffic.

- The speed differential between cyclists and motorists is high.

The following design guides bicyclists in a manner that provides:

- A short distance across the ramp at close to a right angle.

- Improved sight distances in an area where traffic speeds are slower than farther downstream.

- A crossing in an area where drivers' attention is not entirely focused on merging with traffic.

Exit Ramps
Exit ramps present difficulties for bicyclists because:

- Motor vehicles exit at fairly high speeds.
- The acute angle creates visibility problems.
- Exiting drivers often do not use their right-turn signal, confusing pedestrians and bicyclists seeking a gap in the traffic.

The exit ramp design on the previous page guides bicyclists in a manner that provides:

- A short distance across the ramp, at close to a right angle.

- Improved sight distances in an area where traffic speeds are slower than farther upstream.

- A crossing in an area where the driver's attention is not distracted by other motor vehicles.

Dual Right-Turn Lanes
This situation is particularly difficult for bicyclists. Warrants for dual turn lanes should be used to ensure that they are provided only if absolutely necessary.

The design for single right-turn lanes allows bicyclists and motorists to cross paths in a predictable manner, but the addition of a lane from which cars may also turn adds complexity: Some drivers make a last minute decision to turn right from the center lane without signaling, catching bicyclists and pedestrians unaware.

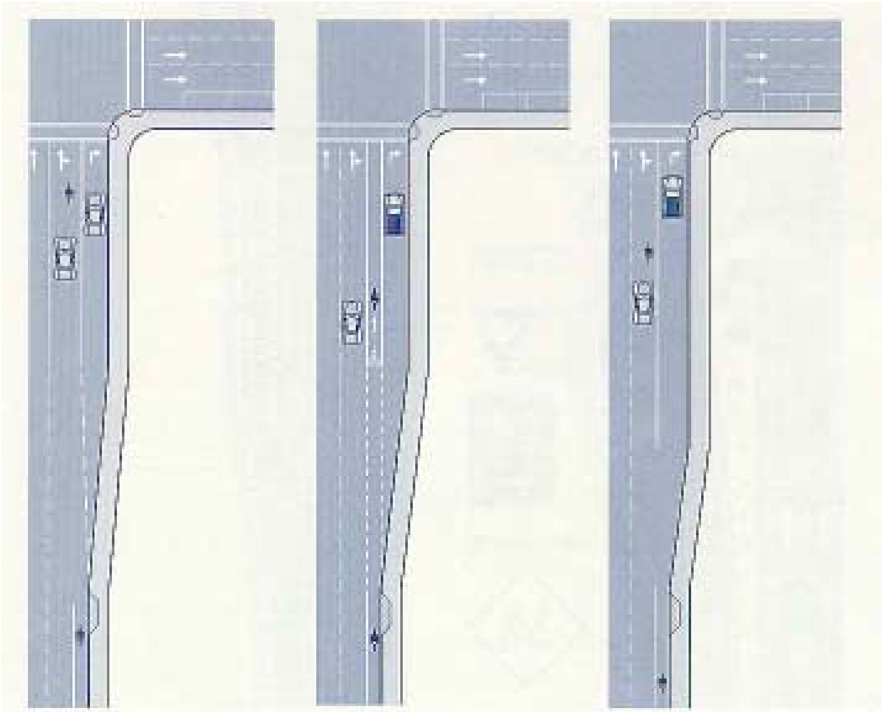
Bicyclists and motorists should be guided to areas where movements are more predictable, so bicyclists and motorists can handle one conflict at a time, in a predictable manner. A curb cut provides bicyclists with access to the sidewalk, for those who prefer to proceed as pedestrians.

- Design A (see Figure 19-13) encourages cyclists to share the optional through-right-turn lane with motorists.

- Design B guides cyclists up to the intersection in a dedicated bike lane.

- Design C allows cyclists to choose a path themselves (this design is the AASHTO recommendation–simply dropping the bike lane prior to the intersection).

A. B. C.

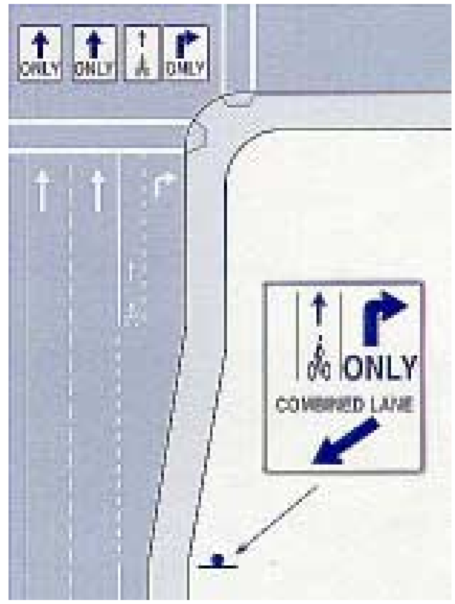


Bike lane through dual right-turn lanes.

A fourth design places an island between the right-turn lane and the optional through-right turn lane. This creates a more conventional intersection, separating the conflicts. This design is also better for pedestrians, as the island provides a refuge.

Engineering judgment should be used to determine which design is most appropriate for the situation.

Right-Turn Lane Without Room for a Bike Lane
On bike lane retrofit projects where there is insufficient room to mark a minimum 1.2-meter (4-foot) bike lane to the left of the right-turn lane, a right-turn lane may be marked and signed as a shared-use lane to encourage through-cyclists to occupy the left portion of the turn lane. This is most successful on slow-speed streets.



Joint use of a right-turn lane for through-bicyclist.

19.11 Exercise

Redesign a local intersection to include bike lanes. Choose an intersection with a moderate level of complexity, and assume that curb lines can be moved at will in order to achieve your design. Prepare a report and graphics that show existing conditions and recommended modifications. Signalization changes (if necessary) should also be explained, as well as any advance striping and signing needed on the intersection approaches.

19.12 References

Text and graphics in this lesson were derived from the following sources:

Oregon Department of Transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

Philadelphia Department of Streets, *Philadelphia Bicycle Facility Design Guidelines*, 1998.

For more information on this topic, refer to:

AASHTO, *Guide for the Development of Bicycle Facilities*, latest edition.

ITE Technical Committee 6A-55, *Review of Planning and Design Standards for Bicycle Facilities*, 1997.

USDOT, *Manual on Uniform Traffic Control Devices*, Section 9, latest edition.

L E S S O N 20

Restriping Existing Roads With Bike Lanes

20.1 Purpose

While bike lanes are desired in many urban locations, designers face the reality that most urban streets are surrounded by built-up environments, and are already constrained by large volumes of automobile traffic. Finding the extra width for bike lanes is often very difficult in retrofit situations, unless plans call for a roadway widening project. For downtown central business districts, roadway widening for bike lanes is not usually a desired option, since it could cause problems for pedestrians by further reducing sidewalk space.

Retrofitting urban streets to include bike lanes has become a new area of study, and several States and local governments have developed innovative solutions. This lesson includes excerpts from the 1995 *Oregon Bicycle and Pedestrian Plan*, as well as an article published in the *Pro Bike/Pro Walk '96 Conference Proceedings* by Chuck Fisher, the Bicycle/Pedestrian Planner for the City of Salem, Oregon.

20.2 Introduction

To accommodate bicyclists on busy roadways in urban areas, bike lanes generally serve bicyclists and motorists best. Many roadways in urban areas were originally built without bike lanes. These roadways often act as deterrents to bicycle travel and may cause conflicts between bicyclists and motorists.

The needs of cyclists can be accommodated by retrofitting bike lanes onto many existing urban roadways using the following methods:

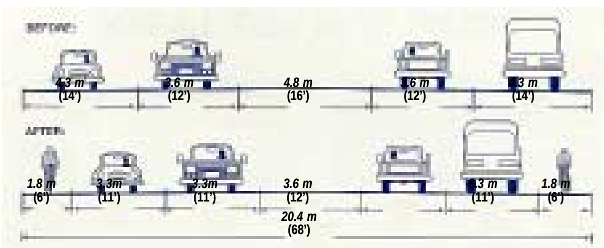
1. Marking and signing existing shoulders as bike lanes.
2. Physically widening the roadway to add bike lanes.
3. Restriping the existing roadway to add bike lanes.

Method #1 is simple, and bike lane marking standards are outlined in Lesson 19. Method #2 involves reconstruction (standards also outlined in Lesson 19). In many instances, existing curb-to-curb width allows only Method #3 to be considered.

Where existing width doesn't allow full standards to be used, it may be possible to modify portions of the roadway to accommodate bike lanes. Most States use the following standards: 4.2-meter (14-foot) center turn lanes, 3.6-meter (12-foot) travel lanes, 1.8-meter (6-foot) bike lanes, and 2.4-meter (8-foot) parking lanes.

These guidelines should be used to determine how the roadway can be modified to accommodate bike lanes without significantly affecting the safety or operation of the roadway. Reduced travel-lane widths are within AASHTO minimums.

It is important to use good judgment, and each project should be reviewed by a traffic engineer.

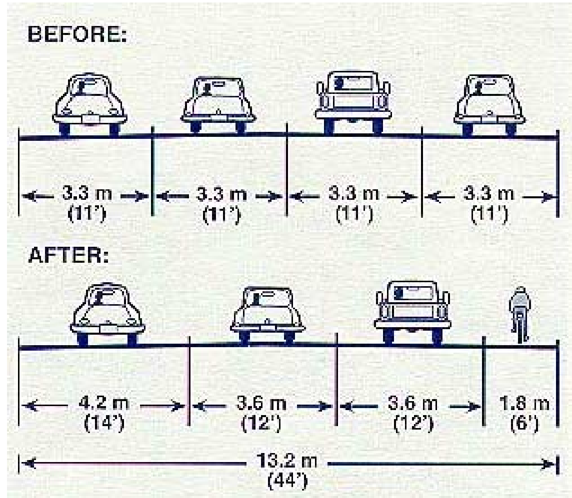


Reduced travel-lane widths.

20.3 Reduce Travel-Lane Widths

The need for full-width travel lanes decreases with speed:

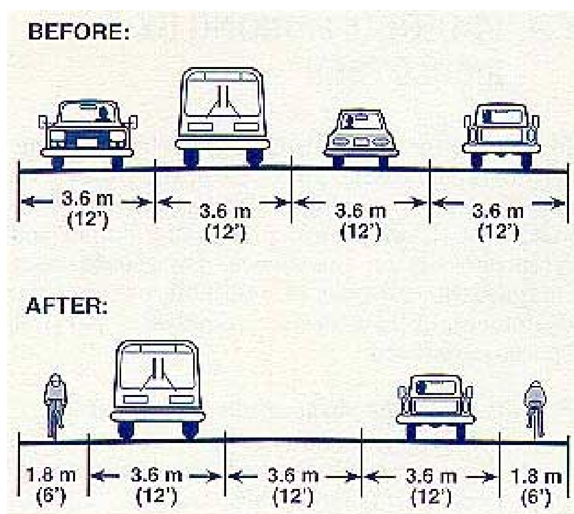
- Up to 40 km/h (25 mph): Travel lanes may be reduced to 3 or 3.2 meter (10 or 10.5 feet).
- 50 to 65 km/h (30 to 40 mph): 3.3-m (11-foot) travel lanes and 3.6-meter (12-foot) center turn lanes may be acceptable.
- 70 km/h (45 mph) or greater: Try to maintain a 3.6-meter (12-foot) outside travel lane and 4.2-meter (14-foot) center turn lane if there are high truck volumes.



Travel lanes reduced from four to three on a one-way street.

20.4 Reduce Number of Travel Lanes

Many one-way couplets were originally two-way streets. This can result in an excessive number of travel lanes in one direction. A study will determine if traffic can be handled with one less lane.
On two-way streets with four travel lanes and a significant number of left-turn movements, restriping for a center turn lane, two travel lanes, and two bike lanes can often improve traffic flow.



Travel lanes reduced from four to two, with center turn lane.

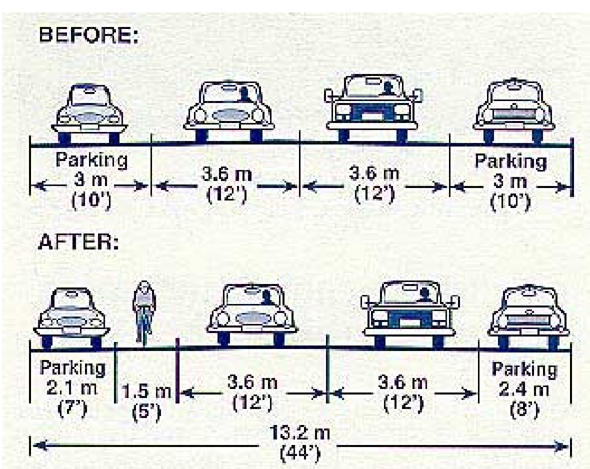
20.5 Reconsider the Need for Parking

A roadway's primary function is to move people and goods rather than to store stationary vehicles. When parking is removed, safety and capacity are generally improved. Removal of parking will require negotiations with the local governing body (such as the city council), affected business owners, and residents.

To stave off potential conflicts, careful research is needed before making a proposal, including:

- Counting the number of businesses/residences and the availability of both on-street and off-street parking.
- Selecting which side would be less affected by removal (usually the side with fewer residences or businesses, or the side with residences rather than businesses in a mixed-use neighborhood).
- Proposing alternatives such as:
  1. Allowing parking for church or school activities on adjacent lots during services or special events.
  2. Shared use by businesses.
  3. Constructing special parking spaces for residents or businesses with no other options.

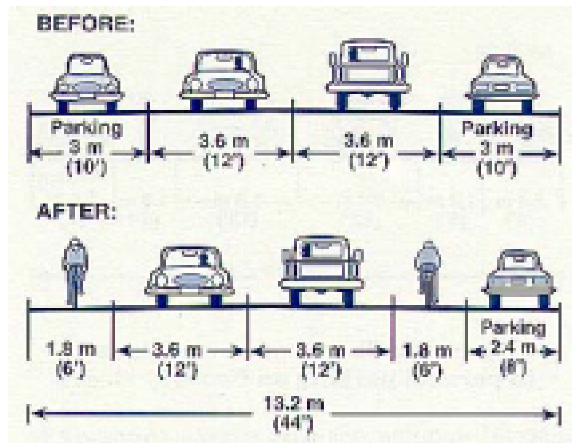
Rather than removal of all on-street parking, several other options can be pursued:



Narrowing parking on a one-way street.

Narrow Parking Lane
Parking can be narrowed to 2.1 meters (7 feet), particularly in areas with low truck parking volumes, since today's cars are smaller.

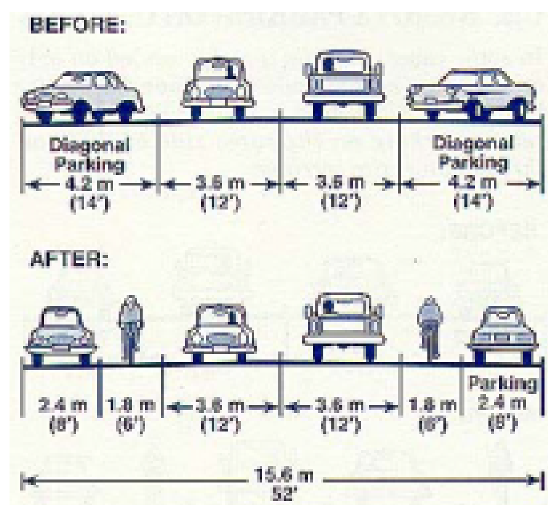
Remove Parking on One Side
In some cases, parking may be needed on only one side to accommodate residences and/or businesses.



Parking removed on one side of a two-way street.

Note: It is not always necessary to retain parking on the same side of the road through an entire corridor.

Change From Diagonal to Parallel Parking
Diagonal parking takes up an inordinate amount of roadway width relative to the number of parking spaces provided. It can also be hazardous, as drivers



Changing from diagonal to parallel parking on a two-way street.

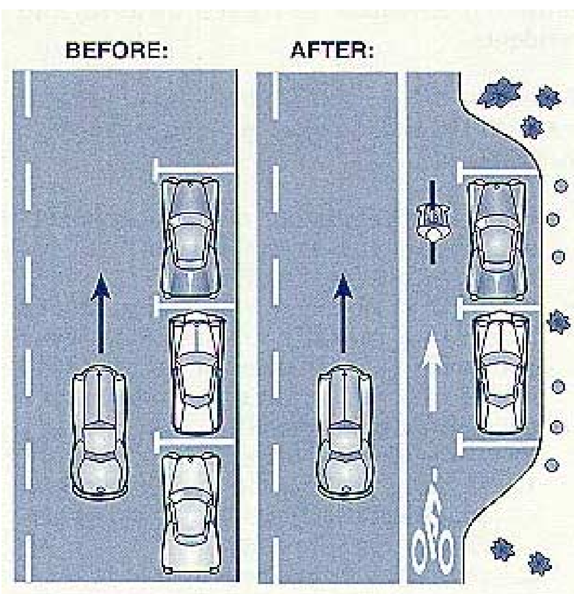
backing out cannot see oncoming traffic. Changing to parallel parking reduces availability by less than one-half.

Special Note: On one-way streets, changing to parallel parking on one side only is sufficient; this reduces parking by less than one-fourth.

Prohibit Parking by Employees
Most business owners cite the fear of losing potential customers as the main reason to retain on-street parking. Many cities have had success with ordinances prohibiting employees from parking on the street. This could help increase the number of available parking spaces for customers, even if the total number of parking spaces is reduced.

Special Note: One parking place occupied by an employee for 8 hours is the equivalent of 16 customers parking for half an hour, or 32 customers parking for 15 minutes.

Replacing Lost Parking
Where all of the above possibilities of replacing parking with bike lanes have been pursued, and residential or business parking losses cannot be sustained, innovative ideas should be considered to provide parking, such as with off-street parking.

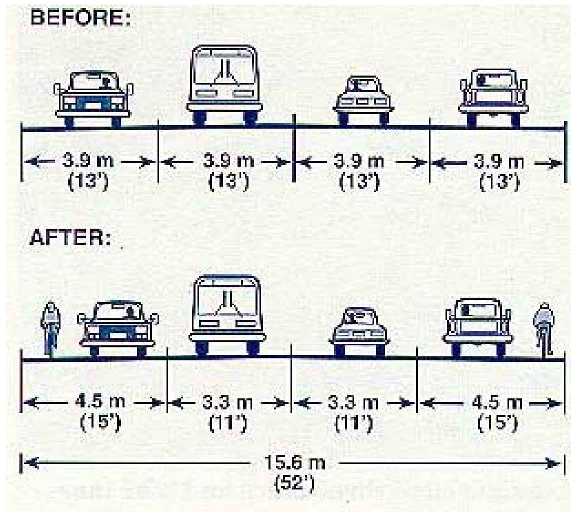


Providing parking when there are no reasonable alternatives.

Other uses of the right of way should also be considered, such as using a portion of a planting strip, where available.

20.6 Other Considerations

Not all existing roadway conditions will be as simple to retrofit as those listed previously. In many instances, unique and creative solutions will have to be found.



Restriping for wide curb lane.

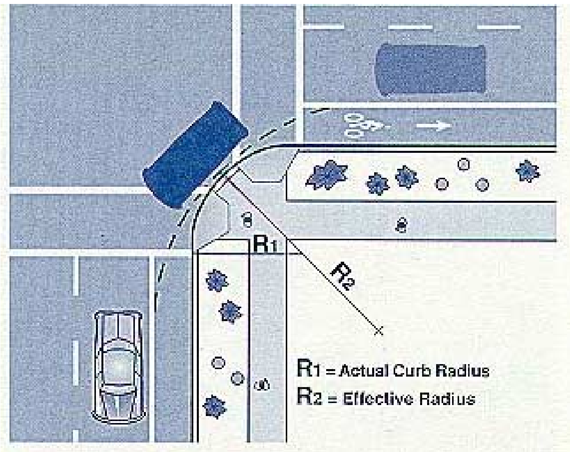
Width restrictions may only allow for a wide curb lane (4.2 to 4.8 meters [14 to 16 feet]) to accommodate bicycles and motor vehicles.

Bike lanes must resume where the restriction ends. It is important that every effort be made to ensure bike lane continuity. Practices such as directing bicyclists onto sidewalks or other streets for short distances should be avoided, as they may introduce unsafe conditions.

Other minor improvements at the outer edge of the roadway should be made in conjunction with bike lane restriping, including:

- Existing drainage grates, and manhole and utility covers should be raised flush to the pavement prior to striping a bike lane.

- Minor widening may be required to obtain adequate width.



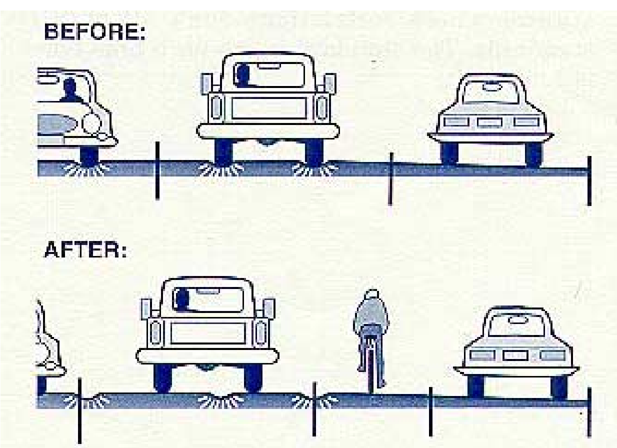
An effective radius at intersections is increased with bike lanes.

- Removal or relocation of obstructions away from the edge of the roadway may gain some usable width. Obstructions can include guard-rails, utility poles, and sign posts.

20.7 Additional Benefits

Safety Benefits
Safety is enhanced as travel lanes are offset from curbs, lanes are better defined, and parking is removed or reduced. Adding bike lanes can often improve sight distance and increase turning radii at intersections and driveways.

Pavement Benefits
Restriping travel lanes moves motor vehicle traffic over, which can help extend the pavement life, as traffic is no longer driving in the same well-worn ruts.



Motor vehicles no longer drive in wheel ruts after restriping.

20.8 Bike Lane Widths

While it is important to maintain standards for bicycle facilities, there may be circumstances where restrictions don't allow full standards. The standard width for a bike lane is 1.8 meter (6 feet).

Minimum widths are:

- 1.5 meters (5 feet) against a curb or adjacent to a parking lane.
- 1.2 meters (4 feet) on un-curbed shoulders. A 1.2-meters (4-feet) curbed bike lane may be allowable where there are very severe physical constraints.

20.9 Retrofitting Bicycle Lanes While Mitigating On-Street Parking Demand

Retrofitting bike lanes into a city's built environment is perhaps a bicycle coordinator's most difficult challenge. This is especially true when the removal of existing on-street parking is involved. Some would cry that street space is not for the storage of vehicles and should instead accommodate only moving traffic. However, if as planners we are promoting in-fill and neotraditional development that is designed to encourage people to work and shop near their homes, we cannot at the same time remove on-street parking from older neighborhoods that have no alternatives. If we do, it is likely that the mom-and-pop store on the corner will close, and neighbors will be forced to jump in their cars to grab a quart of milk.

The first step in the evolution of this process was identifying which streets would make the best connections for bicyclists. Not unlike directions from a down-east farmer, Salem's (Oregon) bikeway system has long been characterized as "you can't get there from here." This is due primarily to the lack of connectivity between the outer areas' bicycle facilities and the downtown core. Particularly lacking are connecting bicycle lanes within 2 miles of downtown, the area most likely served by increased bicycle ridership.

Retrofitting these older neighborhoods with bike lanes and removing all on-street parking would probably have created a political firestorm. Recognizing this, the City of Salem staff developed policies and methodologies that allowed for the mitigation of on-street parking demand.

Policy Language
The policy language is contained within the Goal, Objective, and Policies of the Salem Transportation System Plan's Bicycle System Element:

Policy 1.2 - Mitigation of On-Street Parking Loss Due to Future Bicycle Facility Projects. Where new bicycle facilities require the removal of on-street parking spaces on existing roadways, parking facilities shall be provided that mitigate, at a minimum, the existing on-street parking demand lost to the bike project. This policy does not apply to street widening or major reconstruction projects.

The key phrase in the policy is the mitigation of parking demand, not supply. As part of the update of the Transportation Plan, the staff developed criteria for ranking potential bike projects. Working with this list, the staff determined which projects were to be included for the next construction/striping season. A process was then put into motion that included many of the criteria developed by the City of Portland.

In Practice
First and foremost, the staff surveys the existing on-street parking demand on the facility. Other data collection includes existing cross-sections and on-street parking supply. Analysis activities included sketching cross-section design, locating alternative on-street parking locations, and initial project cost estimates.

Public Involvement
At this point, the staff begins a public involvement process that includes neighborhood meetings, letters to abutting property owners, public workshops to determine alternatives, on-street sign notification, Citizens Advisory Traffic Commission meetings, and final approval by the City Council.

Some of the alternatives presented by the staff at the meeting workshops include restriping the road to accommodate parking on one side versus two. Neighbors are asked to help determine on which side of the street parking should remain, given that only half the parking supply is required to meet the demand. A variation on this is alternating the parking from side to side. For instance, if a six-block area requires parking on one side, a solution might be to allow parking on one side for three blocks then alternating to the other side for three blocks.

Another alternative, especially if there is only a small amount of parking mitigation required, for say, that mom-and-pop store, is to build parking bays. Similar to bus pull-outs, these add the necessary room to accommodate parking in what was the planting strip, between the curb and sidewalk.

20.10 Exercise

Choose a local urban street that would be a good candidate for a bike lane retrofit project. Redesign a two-block section of the roadway to include bike lanes (sketch drawings will be sufficient). Present at least two options for retrofitting the street, and include solutions that would require further traffic studies. Indicate proposed dimensions for travel lanes, parking lanes, and bike lanes. If removal of parking is one of your solutions, describe the public involvement process you would go through to achieve agreement from adjacent property owners and businesses.

20.11 References

Text and graphics for this section were derived from:

Oregon Department of Transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

Chuck Fisher, "Retrofitting Bicycle Lanes While Mitigating On-Street Parking Demand," *Pro Bike/Pro Walk 1996 Conference Proceedings*.

For more information on this topic, refer to:

AASHTO, *Guide for the Development of Bicycle Facilities*, 1999.

L E S S O N 21

Bicycle Facility Maintenance

21.1 Purpose

This lesson describes maintenance programs and activities that are critical to successful bikeways, and recommends a step-by-step approach to solving common maintenance problems.

Bicycles and bicyclists tend to be particularly sensitive to maintenance problems. Most bicycles lack suspension systems and, as a result, potholes that motorists would hardly notice can cause serious problems for bicyclists. In addition, since bicyclists often ride near the right margin of the road — sometimes as required by traffic law — they use areas that are generally less well maintained than the main lanes. On higher speed roads, the passage of motor vehicle traffic tends to sweep debris to the right, where most bicyclists travel. In addition, ridges, such as those found where a new asphalt overlay does not quite cover the older roadway surface, can catch a wheel and throw a bicyclist to the ground.

Aside from these general problems, special bicycle facilities often need more maintenance than they receive. On trail systems, for example, vegetation is often allowed to overgrow the pavement edge, effectively narrowing the usable surface. And soil treatments that are commonly used under new roadbeds are sometimes ignored on trail projects; as a result, the surfaces are quickly destroyed by intruding plants.

21.2 Solution Overview

For the most part, satisfying bicycling maintenance requirements is a matter of slightly modifying current procedures. For example, if street-sweeping crews pay a bit more attention to the right edge of the road, it can benefit bicyclists greatly.

In addition, using maintenance-friendly design and construction techniques can reduce the need for special — and sometimes costly — treatments later.

For example, when paving a street bordered by unpaved alleys and driveways, paving into those alleys and driveways 10 to 20 feet (depending on grades and other features) can keep entering traffic from dragging gravel and other debris onto the paved surface.

Finally, special bicycle facilities such as bike lanes or trails may require enhanced maintenance. This cost, along with a clear understanding of who has responsibility for maintenance, should be part of every project budget.

21.3 Objectives

1. **To maintain roadways and bikeways to a relatively hazard-free standard.**

- By sweeping pavement edges and paved shoulders with sufficient care.
- By patching surfaces as smoothly as possible and by requiring other agencies or private companies to do likewise whenever they dig up a road or trail.
- By making sure pavement overlay projects feather the new surface into the existing one or otherwise do not create new linear joints.
- By replacing such hazards as dangerous grates or utility covers as the opportunity arises.
- By patching potholes in an expeditious manner.
- By routinely cutting back all encroaching vegetation, especially on trails or popular bike routes.

2. **To encourage bicyclists to report maintenance problems and other hazards.**

- By developing a “bicycle spot improvement” form and distributing copies throughout the bicycling community.
- By making sure returned forms are acted upon in a timely fashion.

3. **To design and build new roadways and bikeways in such a way as to reduce the potential for accumulation of debris.**

- By using edge treatments, shoulder surfaces, and access controls that reduce the potential for accumulation of debris.
- By using materials and construction techniques that increase the longevity of new trail surfaces.

4. **To include maintenance costs and clearly spelled-out maintenance procedures in all bicycle facility projects.**

- By including reasonable estimates of the maintenance costs in the project budget.
- By establishing clear maintenance responsibilities in advance of construction.

21.4 Implementation Strategies

Improving bicycle-related maintenance requires action on several fronts. First, maintenance policies used by all relevant agencies should be reviewed and changed, if necessary. Second, designers should be encouraged to “think maintenance” when they design: low-maintenance requirements should be the rule rather than the exception. And, finally, an outreach effort should be implemented to: (1) encourage bicyclists to report maintenance problems, and (2) identify existing maintenance problems, particularly on special bicycle facilities or popular bicycling routes.

21.5 Sub Tasks

1. **Identify key implementors.**
   Implementation requires working closely with those agencies and personnel responsible for maintaining the current infrastructure, as well as those charged with designing and building new facilities. For roadway maintenance, this may mean the local street department or the State transportation agency’s district maintenance division. For trails, it may mean local, State, or Federal parks or lands agencies.

   New facility design can involve local engineering and parks planning agencies, as well as State and Federal officials, depending on jurisdiction. It may be, for example, that a new arterial street being built in the local community is actually designed by engineers working at the State capital.

2. **Review existing policies and practices.**
   In some cases, an agency’s policies, standards, and guidance are included in formal documents that have gone through an approval process or

that have been issued by department supervisors. Examples of these may be standard sweeping schedules and priority streets for snow removal. Conducting a review of these may be relatively simple once copies have been obtained.

On the other hand, some practices may simply be matters of how a particular person handles a specific task. For instance, one street sweeper may leave more of the right roadway edge unswept than did another sweeper. Identifying important areas in which practices vary from standard procedure — or in which standard procedures do not exist — can help in determining needed improvements in such areas as policy development, communication, and employee training.

Extending the paved area to include the shoulder would keep gravel and debris off of the paved surface and prevent problems for bicyclists.

3. **Review results in the field and solicit comments from users.**
In some cases, policies may seem reasonable in theory, but may break down in practice. For this reason, it is important to see how well the facilities work. Checking out the street and trail system from the saddle of a bicycle can help uncover previously unknown problems. For instance, an agency may have a policy of sweeping arterial streets every 2 weeks. But field experience may show that certain arterials are subject to greater accumulations of debris from nearby land uses. Increasing the frequency of sweeping on such streets — particularly if they are popular bicycling streets — may be necessary.

   In addition, soliciting comments from users can help identify problems that would otherwise be overlooked. Because of their intimate knowledge of surface conditions, bicycle users can often pinpoint specific locations and needs. To get information, send news releases to local bicycle groups, as well as the media, asking for help. In all likelihood, users will welcome the opportunity to contribute.

4. **Recommend appropriate changes in policies and practices.**
Based on the reviews and comments discussed above, develop modified versions of policies and practices where warranted; for important topics not previously covered, develop new guidance for adoption. Work with the appropriate agencies to make sure the changes are understood and implemented.

5. **Create an ongoing spot improvement program.**
As mentioned earlier, soliciting comments from users can help an agency find specific problem locations. Institutionalizing this process, in the form of a "spot improvement program," can provide ongoing input and, in many cases, help identify problems before someone gets hurt. In addition, such a program can dramatically improve the relationship between an agency and the bicycling public. Spot improvement programs are good policy and good public relations.

   To this end, set aside a modest annual budgetary allocation for user-requested spot improvements. Create mail-back postcards for distribution to local bicycle shops and user groups. As cards come in, check out the locations identified and take action as necessary.

6. **Evaluate progress.**
As the work proceeds, keep track of successes and failures, as well as the schedule of routine maintenance activities. Identify changes that

Bike lane maintenance is particularly important.

have or have not been made to policies and determine if additional effort is needed. On an annual basis, ask the bicycling public for comments on maintenance issues in general, and the spot improvement program in particular. In addition, keep track of the numbers and kinds of problems identified and how they were dealt with. Finally, determine if the program budget is appropriate to the task.

21.6 Resource Requirements

For the most part, bicycle-related maintenance tasks involve work an agency already does; little additional effort will be required. It may simply mean adding popular bicycling routes to the priority sweeping route network, for example. In some instances, however, additional equipment may be needed. For example, maintaining a particular trail may require purchasing special equipment–perhaps a small sweeper or a special attachment for a tractor.

21.7 Schedule

In regions with harsh winters, special effort should be made to clear the winter's accumulation of road sand and other debris early in the spring. Also, the periods following high winds and flooding may require special attention.

21.8 Specifications

Typical Maintenance Concerns
The following are some of bicyclists' most common maintenance concerns and some common solutions:

Surface problems: For potholes and other surface irregularities, patch to a high standard, paying particular attention to problems near bicyclists' typical travel alignments. Require other agencies and companies to patch to a similarly high standard; if repairs fail within a year, require remedial action.

Debris (sand, gravel, glass, auto parts, etc.) near the right edge of the road: Sweep close to the right edge. If necessary, use vacuum trucks to remove material, especially if it accumulates adjacent to curbs. Pay particular attention to locations such as underpasses, where changes in lighting conditions can blind bicyclists to surface hazards.

For debris or surface irregularities on curves or at intersections, pay special attention to the areas between the typical paths of turning and through motor vehicle traffic; often these fill with debris and are in typical bicyclist trajectories. In addition, areas where debris washes across the paved surface should receive special attention; for example, eliminating the source of the problem by providing better drainage is ultimately a more cost-effective solution than increased sweeping.

Chip seal gravel: Many local agencies use chip seal to extend the lives of their roadways. However, the technique, which involves laying down a coating of oil and a layer of crushed rock, often leaves deep piles of gravel just to the right of the typical travel paths of motor vehicles. To reduce the impact on bicyclists, remove excess gravel as soon as possible and suggest alternative routes as detours.

Ridges or cracks: These should be filled or ground down as needed to reduce the chance of a bicyclist catching a front wheel and crashing. Pay particular attention to ridges or cracks that run parallel to the direction of travel. One common location to check is where a merging lane is provided just beyond an intersection. Because traffic must merge left to continue traveling straight, the bicyclist will be crossing the joint between the merge lane and the through lane at a very shallow angle.

Encroaching vegetation: Trim back bushes and tree branches adjacent to trail edges to allow at least a 2-foot clearance between the edge of the pavement and the vegetation, paying particular attention to the insides of curves.

Grasses adjacent to trail edges: Tall grasses should be mowed regularly to expose any potential hazards that might otherwise be hidden from a cyclist's view. In addition, vegetation should be prevented from breaking up the edge of pavement and encroaching on the trail surface.

Signing and marking trails: Because they are often unique, trail signs may be subjected to frequent theft or vandalism. Regular inspections should be conducted to ensure that signs are still in place and in good condition; this is particularly true of regulatory and warning signs.

Trail markings: Generally, trails have a few simple markings (e.g., a yellow centerline); however, these should be repainted when necessary. Centerlines, for example, help encourage bicyclists to keep to their side of the trail and perform a very useful function.

On-road bicycle signs: Special bicycle signs (regulatory, warning, or information) should be maintained in the same way that other roadway signs are. Pay particular attention to bike route signs at decision points, warning signs at special hazard locations, and regulatory signs on popular bike-lane streets.

On-road bicycle markings: Bicycle lane striping should be renewed at the same time that other stripes are painted. The same goes for bike-lane pavement markings (e.g., diamond markings). Some markings may suffer from more wear-and-tear than others and deserve special attention. For instance, pavement markings that indicate the "hot spot" for traffic signal loop detectors may be in a location where car tires routinely pass; as a result, they may wear out faster than other markings.

21.9 References

Text and graphics for this lesson were derived from:

Federal Highway Administration, D*esigning for Bicycles at the Local Level*, 1997.

For more information, please refer to:

AASHTO, *Guide for the Development of Bicycle Facilities*, 1999.

AASHTO, *Maintenance Manual*, 1987.

Rails to Trails Conservancy, *Trails for the 21st Century*, 1994.

L E S S O N 22

Bicycle Parking and Storage

22.1 Purpose

Bicycle parking is one of the most important investments in order to improve and encourage bicycle travel in urban areas. This lesson describes how to develop a successful bicycle parking program, including implementation strategies, resource requirements, and design considerations.

22.2 Problem Overview

Providing secure bicycle parking is a key ingredient in efforts to encourage bicycling at the local level. Many bicycle journeys end somewhere other than the bicyclist's home and, as a result, the bicyclist must park his or her bicycle. And for those who live in apartment complexes, college dormitories, or other high-density settings, the issue of where to leave a bike while at home is also a serious issue. In short, at one time or another, most bicyclists have experienced the frustration of finding no secure place to leave their bikes.

Some have experienced the even greater frustration of returning to find their bicycles stolen. In fact, statistics compiled by the Federal Bureau of Investigation show that between 1988 and 1992, an average of approximately 450,000 bicycles were reported stolen each year. These figures are low, according to the Lock Smart Campaign, which estimates that roughly twice as many are stolen, but never reported. They suggest that, with an average cost of $380 per bike, the financial loss to American bicyclists amounts to $450 million dollars per year.

While providing secure bicycle parking is not the entire solution to the problem of theft, it certainly can help and it can increase bicyclists' comfort in leaving their bicycles unattended. As a result, many bicycle owners may be encouraged to make bicycle trips that they might otherwise forego.

22.3 Solution Overview

Bicycle parking can be provided in a wide variety of settings using three basic approaches: bicycle racks (open-air devices to which a bicycle is locked), bicycle lockers (stand-alone enclosures designed to hold one bicycle per unit), and bicycle lock-ups (site-built secure enclosures that hold one or more bicycles).

This trail provides many site amenities, including short-term bike parking.

For short-term parking, bicycle racks work well. At sites that require long-term parking for a variety of potential users, lockers are the devices of choice. For long-term parking for a limited number of regular and trustworthy users, bicycle lock-ups can solve the problem.

22.4 Objectives

1. **To provide well-located secure bicycle parking at popular destinations in business districts and at other public sites:**

- Install bicycle parking at public centers.
- Install bicycle parking on public rights of way in neighborhood commercial and downtown business districts.
- Encourage private businesses to provide bicycle parking for their customers.
- Install bicycle parking at transit stops and in parking garages.
- Encourage the installation of high-security bicycle parking at existing worksites, schools, and high-density residential developments .

2. **To require new commercial, public, and high-density residential developments to include plans for bicycle parking:**

- Adding provisions to local zoning regulations requiring bicycle parking as part of new developments, particularly commercial, public, and high-density residential developments.
- Make these requirements part of the process of getting a building permit.

At community destination points such as schools, ample bike parking should be provided.

22.5 Implementation Strategies

Implementing bicycle parking in a community requires a combination of three primary strategies:

1. Acquire and install bicycle parking devices on public rights of way or at public destinations (e.g., city hall, libraries, and parks).
2. Encourage businesses to provide bicycle parking for their customers.
3. Alter zoning regulations to ensure that bicycle parking is provided in new developments.

Typically, the first strategy helps “prime the pump” for the second; and the third strategy helps ensure long-term improvements in newly developed areas.

22.6 Subtasks

Encourage private businesses to provide bicycle parking for their customers.

1. Identify key implementors.
Each of the three implementation strategies requires the cooperation of a different group of constituencies. To put bicycle parking in public places requires the cooperation of agencies who control the land involved. Sidewalks may be controlled by the streets or public works department, while parks and recreation may have responsibility for public open spaces and recreational sites. There may be an agency (similar to the Federal Government's General Services Administration) in charge of all public property. Or agencies that run specific services (e.g., the library, public health clinics) may control their own sites.

Encouraging businesses to install bicycle parking requires the cooperation of such groups as the Chamber of Commerce, downtown business associations, and shopping center managers. In addition, agencies that routinely deal with businesses should be enlisted as outlets for any literature developed as part of the program.

Altering zoning regulations to require consideration of bicycle parking in new developments requires close cooperation with planning and zoning agency staff, as well as the assistance from appointed zoning boards and builders' associations. Typically, regulations are revised on a schedule; therefore, the opportunity to revisit parking requirements may or may not be imminent.

2. Structure the program.
In some communities, a reactive program that simply fills orders and answers questions can prove to be successful. This would be most likely in a "bicycle town" with a high degree of interest in bicycling matters. However, in many places, such a passive approach would result in little response. Business owners and managers of large employment centers or residential complexes often see bicycles as clutter and a "problem" to be eliminated rather than as a solution to traffic congestion or air quality problems. As a result, a successful bicycle parking program should include elements of marketing and promotion.

With the help of the key players identified in Subtask 1, create three ad hoc task groups covering each of the three primary thrusts. The groups should create the ground rules and materials necessary for the following tasks:

Task Group 1: Public Bicycle Parking
- Install bicycle parking at public centers.
- Install bicycle parking on public right of way.
- Install bicycle parking at transit stops and in parking garages.

Task Group 2: Private Bicycle Parking
- Encourage private businesses to provide bicycle parking for their customers.
- Encourage installation of high-security bicycle parking at worksites, schools, and high-density residential developments.

Task Group 3: Zoning Regulation Revision
- Add provisions to local zoning regulations requiring bicycle parking.
- Make these requirements part of the process of getting a building permit.

3. Choose appropriate bicycle parking devices.
As one of the first tasks, assemble packets of information on available bicycle parking devices, along with the pros and cons of each device. In a joint meeting(s) with all three task groups, adopt a set of criteria and decide which devices are to be

Zoning ordinances should include provisions for bicycle parking that indicate how many spaces are required within specific districts.

endorsed. A set of possible criteria are listed in the Specifications section below. Next, give each task group its marching orders. They are as follows:

New ordinances should address the following: (examples taken from existing ordinances in Ann Arbor, MI; Madison, WI; Denver, CO; and San Francisco City/County, CA):

- Bike parking ordinances should clearly indicate how many bicycle parking spaces are required, either as a function of the type of development (retail, office, residential, etc.) or as a standard percentage of the required off-street automobile parking. For example, the City of Denver requires that off-street automobile parking facilities of 20 spaces or more provide bicycle parking equal to 5 percent of the automobile parking space requirement.
- Bicycle racks that support the bike by the wheel should not be permitted.
- Bicycle racks should be located at least as close to the building entrance as the nearest non-handicapped parking space.

The requirements can also address lighting of bicycle racks, requirements to retrofit existing public buildings, and protection from the elements.

4. Tasks for Task Group 1: Public Bicycle Parking. Task Group 1 should set criteria for installing bicycle parking devices on sidewalks, as well as at public destinations. For sidewalks, criteria could include such items as minimum width of sidewalk, rack position on sidewalk and proximity to other street furniture and vegetation, and number per block or number per site. For public sites, they could include proximity to the main entrance, and minimum number of bicycle parking spaces per installation (perhaps keyed to type of facility served).

Next, they should create an agreed-upon step-by-step procedure for planning and installation. This should include initial identification of the potential site, discussion with relevant agency personnel, determination of the specific site's needs (number of parking devices and location), cost analysis and budgeting, procurement, installation, and follow-up.

To support this activity, they should create a project sheet for rack installation that includes places for the source of the request (if any), signatures of any required agency personnel, a schematic diagram of the site, installation date, and any comments.

Next, they should estimate the total bicycle parking need for public places, given a list of potential sites. Estimates can be conservative and based to some extent on existing bicycle traffic, as long as participants realize that latent demand may be significant. For this reason, phased installation may be particularly appropriate.

For sidewalks, a base number of racks to be installed during the fiscal year (e.g., 100, 500, 1000) should be decided upon, along with a map showing priority areas. For instance, downtown might be a top-priority area, neighborhood commercial areas could be second, and strip development areas might be third.

Finally, the Task Group should set an annual budget for the program and decide how the bicycle parking should be paid for. Potential sources include a wide variety of Federal transportation programs, as well as local funding opportunities.

5. Tasks for Task Group 2: Private Bicycle Parking.
Task Group 2 should assemble a packet of information for potential private-sector bike parking providers. The packet should include a cover letter describing the importance of bicycle parking to businesses and giving any organizational endorsements for the program; a list of available parking devices, along with information on how to order them and which are best suited for which settings; tips on deciding how many bikes need to be accommodated; and tips on locating and installing the devices.

The Task Group should also work out details of any promotional activities that will need to be planned. For instance, they should develop a list of groups to talk with, determine who should be responsible for reaching each one, and start making contacts. To this end, the Task Group should develop a standard presentation, possibly including slides and handouts.

6. Tasks for Task Group 3: Zoning Regulation Revision.
The Task Group should start by identifying passages in the existing zoning codes where motor vehicle parking is discussed. They should find out when the regulations are going to be modified and use that in determining their schedule of work. They should next assemble sample bicycle parking laws from other communities. Based on the sample laws, they should create a draft revision to the regulations and circulate it for comment. Once comments have been received and considered, they should forward a final draft revision for action at the proper time.

Location Criteria
The location criteria are a mix of those developed by the Cities of Denver and Seattle for placing bicycle racks:

- Racks should be located within 50 feet of building entrances (where bicyclists would naturally transition into pedestrian mode).

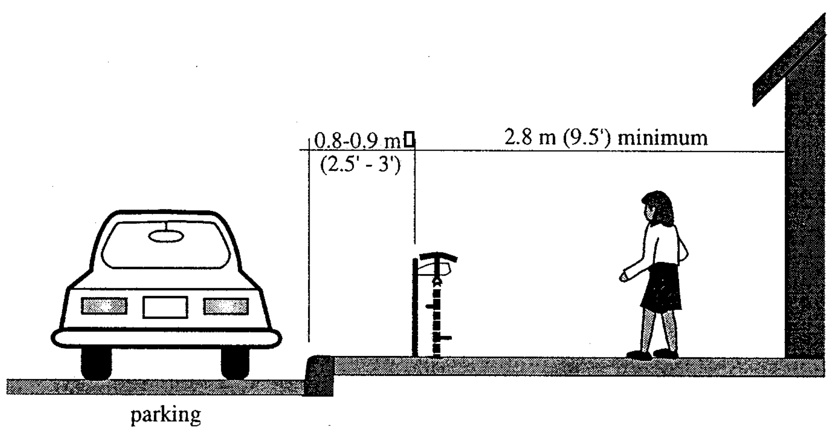
- Racks should be installed in a public area within easy viewing distance from the main pedestrian walkway, usually on a wide sidewalk with 5 or more feet of clear sidewalk space remaining (a minimum of 24 inches of clear space from the parallel wall, and 30 inches from the perpendicular wall).

- Racks are placed to avoid conflicts with pedestrians. They are usually installed near the curb and at a reasonable distance from building entrances and crosswalks.

- Racks can be installed at bus stops or loading zones only if they do not interfere with boarding or loading patterns and there are no alternative sites.

7. Implement the program.
With the program set up, materials at the ready, and initial funding identified, implementation of the program can begin. Routine responsibilities for the various tasks should be taken care of by the agencies identified through the previous steps. Oversight of the program may require the attention of a project coordinator. This may be a task delegated to a member of the planning department or public works staff.

8. Evaluate progress.
As the work is proceeding, keep track of successes and failures. Early on, get the word out to the bicycling public that: (1) the program exists, and (2) they should submit comments and ideas for potential parking sites. Keep a record of how many parking



Philadelphia's standard for bike rack placement in business districts.

devices have been installed, how many comments have been received, how many information packets have been sent out, what proportion of public places has adequate bicycle parking, how well the parking is working (e.g., whether the public likes it, whether it holds up well to vandalism), and how successful the zoning regulations appear to be (once they are adopted). Use this feedback in fine-tuning the program and determining future levels of funding.

This is surely a location in need of adequate bicycle parking.

22.7 Resource Requirements

For the most part, bicycle parking requires basic equipment: racks and lockers. These can be ordered or fabricated in large or small quantities. Ordering in quantity can save money as long as storage needs can be satisfied until installation can be accomplished. Once a community gets actively involved in bicycle parking installation, it is quite possible that local sources will emerge. For instance, in some communities, welding shops make and sell approved bike racks on a routine basis. This not only helps agencies satisfy a growing bicycle parking demand, but it can lead to the development of new local industries.

22.8 Schedule

Installing bicycle parking at public places and on sidewalks can begin with little delay. Encouraging businesses to install bicycle parking, being more of a marketing and promotion activity, involves building interest over time and may not pay off for several years. Even longer term are the results of changes in zoning ordinances. At the same time, these changes can lead to the greatest overall effect.

22.9 Specifications

It is important to choose a bicycle rack design that is simple to operate. Bicycle racks should be designed to allow the use of a variety of lock types. It may be difficult initially to determine the number of bicycle parking spaces needed: Bicycle racks should be situated onsite so that more racks can be added if bicycle use increases.

There are three general types of bicycle rack designs. The following is information on each style (derived from the April 1996 issue of *Pro Bike News*).

Class I Bicycle Parking
This category includes bike lockers or locked/ guarded storage areas that provide high-security protection.

Street trees in Central Business Districts often become de facto bike racks.

Advantages:
High-security storage, ideal for long-term storage.

Disadvantages:
Expensive. Average cost per bike: Starter unit is $3,300, additional units are $1,600 each.

Class II Bicycle Parking
This category includes racks that secure both wheels and bicycle frame, which usually have moving parts and provide medium security with a user-supplied lock.

Advantages:
Medium security, great when coupled with covered protection from the elements.

Disadvantages:
Moving parts, complex design, may not work with the common U-lock.

Average cost per bike: $65to $150.

Class III Bicycle Parking
The most common type of Class III rack is the inverted "U" or rail rack.

Bike lockers should be made available in areas where long-term parking is necessary.

Advantages:
Simple design, affordable, can be manufactured by a local welder. Supports frame as well as wheel.

Disadvantages:
Offers low level of security for long-term parking.

Average cost per rack: $75 installed (if purchased in quantities of 50 or more).

22.10 Sample Bike Parking Ordinance From Madison, Wisconsin

A growing number of communities have included bicycle parking requirements in their development regulations. By so doing, they ensure that bicycle parking is included in the normal course of development. This example is from the Madison City Code.

Purpose
To provide adequate and safe facilities for the storage of bicycles.

1. Bicycle parking facilities shall be provided as required for all new structures and uses established as provided in Sec. 28.11(2)(a)1 or for changes in use as provided in Secs. 28.11(2)(a)2 and 3; however, bicycle parking facilities shall not be required until the effective date of this paragraph. Notwithstanding Secs. 28.08(1)(i) and 28.09(5)(a), bicycle parking facilities shall be provided in all districts, including districts in the Central Area.

2. In the residential district, accessory off-street parking facilities provided for the uses listed herein shall be solely for the parking of passenger automobiles and bicycles of patrons, occupants, or employees and not more than one truck limited to a 1-ton capacity.

3. Required bicycle parking spaces shall be at least 2 feet by 6 feet. An access aisle of at least 5 feet shall be provided in each bicycle parking facility. Such space shall have a vertical clearance of at least 6 feet.

4. Accessory off-street parking for bicycles shall include provisions for secure storage of bicycles. Such facilities shall provide lockable enclosed lockers or racks, or equivalent structures in or upon which the bicycle may be locked by the user. Structures that require a user-supplied locking device shall be designed to accommodate U-shaped locking devices. All lockers and racks must be securely anchored to the ground or the building structure to prevent the racks and lockers from being removed from the location. The surfacing of such facilities shall be designed and maintained to be mud- and dust-free.

Bicycle racks should be situated on site so that more racks can be added if bicycle use increases.

5. Bicycle parking facilities shall be located in a clearly designated safe and convenient location. The design and location of such a facility shall be harmonious with the surrounding environment. The facility location shall be at least as convenient as the majority of automobile parking spaces provided.

6. Bicycle parking facility spaces shall be provided in adequate number as determined by the Zoning Administrator. In making the determination, the Zoning Administrator shall consider, when appropriate, the number of dwelling units or lodging rooms, the number of students, the number of employees, and the number of automobile parking spaces in accordance with the following guidelines.

   (a) In all cases where bicycle parking is required, no fewer than two spaces shall be required.

   (b) After the first 50 bicycle parking spaces are provided, additional bicycle parking spaces required are 0.5 (one-half) space per unit listed.

   (c) Where the expected need for bicycle parking for a particular use is uncertain due to unknown or unusual operating characteristics of use, the Zoning Administrator may authorize that construction and provision of not more than 50 percent of the bicycle parking spaces be deferred. Land area required for provision of deferred bicycle parking spaces shall be maintained in reserve.

22.11 References

Text and graphics for this section were derived from the following sources:

City of Philadelphia Bicycle Parking Specifications, 1998.

Institute of Transportation Engineers, *Implementing Bicycle Improvements at the Local Level*, ITE LP-471, Washington, DC, 1999.

Madison City Code, Madison, WI.

Pro-Bike News, April 1996.

For more information on this topic, refer to:

Bicycle Federation of America, *Source Book of Designs, Manufacturers, and Representatives*, 1992.

Bikecentennial, *Technical Notes:* Bike Parking Location; Choosing Parking Devices; A Simple Bike Rack Design; Bike Parking Ordinances, 1987-89.

Ellen Fletcher, *Bicycle Parking*, 1990.

Off-Street Bicycle Parking Guidelines

Land Use	Bike Space
Dwellings/lodging rooms	1 per dwelling unit or 3 lodging rooms
Clubs/lodges	1 per lodging room plus 3% of person capacity
Fraternities/sororities	1 per 3 rooms
Hotels/lodging houses	1 per 20 employees
Galleries/museums/libraries	1 per 10 automobile spaces
Colleges/universities/ junior high and high schools	1 per 4 employees plus 1 per 4 students
Nursery/elementary schools	1 per 10 employees, plus students above second grade
Convalescent and nursing homes/institutions	1 per 20 employees
Hospitals	1 per 20 employees
Places of assembly, recreation, entertainment, and amusement	1 per 10 automobile spaces
Commercial/manufacturing	1 per 10 automobile spaces
Miscellaneous/other	To be determined by the Zoning Administrator based on the guide lines for the most similar use listed above

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Source: *Madison City Code*, Madison, WI

L E S S O N 23

European Approaches to Bicycle and Pedestrian Facility Design

23.1 Purpose

Much has been written in recent years regarding many of the successful non-motorized programs in western Europe, including The Netherlands, Germany, England, and Switzerland. This lesson includes excerpts from a 1994 Federal Highway Administration report entitled *FHWA Study Tour for Pedestrian and Bicyclist Safety in England, Germany, and The Netherlands*, specifically those sections that describe innovative European approaches to bicycle and pedestrian facility design.

23.2 Pedestrian Facilities

1. Zebra crossings (England, see figure 23-1 below) include zebra crosswalk stripes across the road with dashed lines used to mark the crosswalk on both sides. "Belisha Beacons" (poles with fashing orange lights - see photo below) are placed on each side of the crosswalk. These crossings are installed at selected mid-block locations (never at intersections). At zebra crossings, pedestrians have the right of way, and drivers must yield (i.e., slow or stop) to pedestrians in the crosswalk. Zebra crossings are preceded by zigzag pavement markings next to the curb on the vehicle approach.

2. Pelican crossings (England) are mid-block crossings controlled by traffic signals and push-button pedestrian signals. The push-button hardware lights up and conveys specific messages to pedestrians during each interval, as shown in Figure 23-2. A walking green man symbol and a standing red man are displayed, as shown in Figure 23-3. A flashing green man indicates pedestrian clearance. A flashing green man on the pedestrian approach concurrent with flashing amber and red balls on the vehicle approach precedes the green ball indication on the vehicle approach. Instead of zebra crosswalks, pelican crossings have dashed (not solid) parallel lines to mark the crosswalk. As with zebra crossings, pelican crossings are not used at intersections, but are installed only at selected mid-block locations.

3. Toucan crossings (England, see figure 23-4) are shared crossings for pedestrians and bicyclists (cyclists "too can" cross together) at selected

Figure 23-1. Zebra crossing with belisha beacons in London.

crossings at the intersection of roadways with pedestrian and bicycle paths. The preferred layout includes a tactile warning surface, audible beepers or tactile rotating knobs, push-buttons with WAIT displayed in each corner of the crossing, infrared lamp monitoring, and vehicle detection on all approaches. The desirable crosswalk width is 4 meters; the minimum acceptable width is 3 m. Signal indications include standing red man, walking green man, and green bicycle. The flashing amber with the red ball indication is not used for the vehicle approach. Crosswalk lines are delineated by white squares.

Figure 23-2. Pedestrian push-button hardware in Great Britain gives feedback regarding when to cross.

Figure 23-3. Pedestrian green man (WALK) and red man (DON'T WALK) signal displays.

4. Puffin (<u>P</u>edestrian <u>U</u>ser-<u>F</u>riendly <u>IN</u>tersection) crossings (England), generally installed at intersections, consist of traffic and pedestrian signals with red push-button devices and infrared or pressure mat detectors. After a pedestrian pushes the button (or stands on the mat), a detector verifies the presence of the pedestrian. This helps eliminate false signal calls associated with children playing with the signal button or people who push the button and then decide not to cross. If a pedestrian is present at the end of a vehicle cycle, the red traffic signal is indicated to motorists, and pedestrians see the green man (i.e., WALK display). A separate motion detector extends the green interval (if needed) to ensure that slower pedestrians have time to cross safely. If a pedestrian pushes the button, but fails to wait for the green man symbol, the detector will sense that no pedestrian is waiting and will not stop motor vehicle traffic needlessly.

Puffin crossings are recent developments and are said to improve pedestrian safety and reduce unnecessary vehicle delay. Since the motion detector can detect only those pedestrians walking within the crosswalk lines, physical barriers are used on the curbs to channel pedestrians into the crosswalks. At some crossings, tactile surfaces have been introduced that guide a visually impaired person to the crosswalk. Puffin crossings are currently used at 27 demonstration sites in England. One official stated that they expect to eventually replace all pelican and toucan crossings with puffin crossings if they are found to be effective based on the number of pedestrian accidents, vehicle delays, detector and equipment adequacy, and other factors.

Figure 23-4. Toucan crossings in Great Britain provide separate pedestrian and bicyclist signals where trails cross roadways.

5. Pedestrian messages (England), such as LOOK RIGHT or LOOK LEFT (see figure 23-5), are painted on the street next to the curb to remind pedestrians which direction to look for motor vehicle traffic prior to stepping into the street. These messages are used extensively in London, where many tourists visit. (Many U.S. tourists are accustomed to looking left for traffic before stepping off the curb and looking right for traffic when standing at a pedestrian island in the middle of a two-way street.)

FIGURE 23-5. Pedestrian pavement messages and refuge islands.

6. Traffic signals (The Netherlands). Pedestrian signal displays include a standing red man (i.e., DON'T WALK) and a walking green man (i.e., WALK). A flashing green man (i.e., you may walk, but the red man display will follow soon) follows the steady green man phase. Pedestrian push buttons are also used at some crossing locations (see figure 23-6). Pedestrian signals are placed at arterial intersections with high volumes of pedestrians and motor vehicles. They are installed near the vehicle traffic signal.

A flashing yellow indicator has been tested in The Netherlands (along with legal regulations) in some simple situations instead of a solid red ball for pedestrian signals. The symbol used for the yellow indicator is a triangle with an exclamation point inside it. The flashing yellow tells pedestrians that they may cross at their own risk, but other traffic has priority. The zebra crosswalk markings are removed at such locations to avoid suggesting that pedestrians have priority in crossing. The pedestrian green is an exclusive movement and, therefore, should be conflict-free. The motivations for testing this symbol include the following:

FIGURE 23-6. Pedestrian barriers (separators) are used extensively in London to channel pedestrians to preferred crossing locations.

- Whether the pedestrian signal phase is actuated or pre-timed, pedestrians are allowed to choose between crossing with the green indication or crossing during the flashing yellow indication during an appropriate gap in traffic.
- Since the red indication is replaced by a flashing yellow, the situation allows for 100-percent compliance by pedestrians. Pedestrians no longer cross against the red indication because there is no longer a red indication.
- At actuated locations, less time is consumed by exclusive pedestrian movements. Since pedestrians know that it is legal to cross whenever they want, they may not bother to call for the pedestrian green.
- The Dutch also state that the use of flashing yellow indicators enhances the status of the red indication. Red indications will only be used at complex crossing locations.

The disadvantages found with the triangle signal include the following:

- It is unknown whether pedestrians understand that they do not have the right of way while they are crossing during the flashing yellow indication. However, it appears that turning traffic must give way to pedestrians; therefore, an exclusive turn arrow cannot be combined with a flashing yellow pedestrian indication.

Figure 23-7. Pedestrian mall in Munster, Germany.

- It is safer for pedestrians to cross with the green indication in conflict-free situations. The situation of crossing during a flashing yellow pedestrian indication is still the same as crossing during a red indication. It is difficult to explain it to children and to convince them that they should wait for the green while they see others crossing at times when the light is yellow or red. Many elderly persons feel safer crossing in groups rather than alone. Following the crowd, an older person may end up at the tail end of the group, exposed to oncoming vehicles and unable to sprint to safety.

Another device tested in The Netherlands was a "pedestrian sender." This device provides a means for signal preemption for vulnerable pedestrians, including the visually and mobility impaired The pedestrian sender is similar to the emergency beepers used by the elderly and impaired to call for help. This device influences the traffic controller by doubling the pedestrian green time, activating an acoustic signal, and preventing conflicting traffic movements. No information about providing a directional indication to the vulnerable pedestrian was available. The results of a questionnaire indicated great enthusiasm for the pedestrian sender. The survey also indicated no misuse of the device.

While pedestrian improvements in Delft were said to lag behind bicycle facilities, pedestrian signals were installed at selected intersections in that city. A green man, yellow triangle, and red man were used for the WALK, DON'T START (clearance), and DON'T WALK intervals, respectively. Zebra-striped crosswalks are commonly used at pedestrian crossings.

7. Pedestrian zones (Germany), which can also be used by cyclists during off-peak hours (i.e., evenings), have been established on many downtown streets. Not only are there fewer conflicts with pedestrians during off-peak hours, but it was claimed that the presence of pedestrian and bicycle traffic helped eliminate crime and added an element of personal safety. The pedestrian mall shown in figure 23-7 allows bus, bike, and taxi travel throughout the day. In Freiburg, on Kaiser Josef, a pedestrian street, cars and bicycles are not permitted. Streetcars and pedestrians have exclusive use of the street.

FIGURE 23-8. Some bicycle paths parallel roadways, such as this one in Groningen, The Netherlands.

23.3 Bicycle Facilities

1. The Netherlands.
The general philosophy in The Netherlands is to separate bicyclists from motor vehicles whenever speeds increase to greater than 30 km/h. According to one official, bicycle paths are safer than bike lanes between intersections. At intersections, however, a separate bicycle path will generally have a higher number of accidents. Separate bicycle paths (see figure 23-8) are considered desirable under heavy motor vehicle traffic

conditions, but undesirable along streets with low volumes of motor vehicles. Their general approach to bicycle facilities is to avoid making them too sophisticated.

Bike lanes are typically wide enough for two cyclists to ride side-by-side. The bike lanes are generally reddish in color, with visible (and well-maintained) white bicycle symbol markings (see figure 23-9). Bike lanes are typically located between the motor vehicle lane and the sidewalk and are sometimes part of the sidewalk. Sometimes, problems occur with motor vehicles parked on the bicycle lane. Bike lanes are sometimes marked through intersections, as shown in figure 23-10.

Figure 23-9. Typical bicycle lanes in The Netherlands are often reddish in color and wide enough for two cyclists to ride side-by-side.

Bicycle Signals

In The Netherlands, separate bicycle signals are commonly used at arterial intersections that have bike lanes and high volumes of bicyclists and motor vehicle traffic. The bicyclist signals are vertical red, amber, and green bicycle symbols mounted on a pole, as shown in figure 23-11. They are located either next to the vehicle signal head (i.e., using the same 20-centimeter diameter signal face as the vehicle signal) or at a lower level (1 meter high) using a smaller size signal face (7 to 7.5 centimeter).

The signal indications are all steady (i.e., no flashing indications), and there is typically an advance green phase for bicyclists, with a simultaneous red phase for right-turning motor vehicles. According to one local official, levels of compliance with the signal are generally not very high.

In some cities, such as The Hague and Groningen, a special bicycle phase allows bicyclists in the bike lane to proceed straight before motor vehicles (i.e., right-turning traffic) are allowed to proceed. Motor vehicles are not allowed to turn right on red in The Netherlands, although bicyclists are allowed to do so in certain cities and locations. Bicycle lanes are not typically placed to the right of parked cars, since motorists cannot see bicyclists as easily. It is common for bicycle lanes to end before intersections. Mixing traffic before an intersection promotes anticipation and interaction among road users at the crossing. Otherwise, automobile drivers turning right often are not fully aware of bicyclists and moped riders coming from an adjacent bicycle lane.

Bicycle Rental

Renting a one- or three-speed bicycle in The Netherlands is relatively inexpensive, costing approximately 10 guilders (about US$6) per day or about 50 guilders (US$30) per week. Bicycle rental shops are located throughout towns and cities, commonly at train stations. Information on bicycle rentals is provided at local hotels.

2. Germany

On-street bike lanes are installed on the street level and are typically painted red or installed with a red pavement surface. This type of facility is generally

Figure 23-10. Bike lanes are sometimes marked through intersections.

less expensive to install than off-street facilities. Off-street bike lanes are sometimes installed on the sidewalk level, as shown in figure 23-12. Generally marked with a distinctive red color (which contrasts with the gray stone used for pedestrian walkways and the clear zones between the street and bike path), these lanes provide a greater separation between bicyclist and motor vehicles. When a parking lane exists, this separation allows room to open car doors without obstructing the bike path.

Figure 23-11. Bicycle signal used in Amsterdam.

As observed in Munster, bike paths are typically 1.6 meter wide (one direction on each side of the street), and the separation between cars and the bike path is generally 0.7 meters wide. Some areas are narrower in cases where sufficient room does not exist. This type of facility was originally promoted in the 1940's as a means to eliminate the "hindrance" to cars that was caused by bikes. They are now retained to separate cars and bicyclists for safety purposes.

Bike tracks are generally paths through the countryside and are signed routes. They are generally not paved.

Bus lanes that can also be used by bikes require a width of 4.5 meters or more to allow buses to easily and safely overtake cyclists when necessary. As shown in figure 23-13, these facilities are signed and marked with a bus and bike symbol.

Intersection improvements that facilitate bike travel include an advance stop line that allows bicyclists to exit sidewalk paths to turn left in front of motorized traffic. This allows a safer path for left-turning cyclists, provides better visual contact between bikes and cars, and allows cyclists to be away from vehicle exhaust. This design has been found to be safer than the traditional weave condition. Other signal treatments include special advance green signals for cyclists, and, in some cases, signals timed for bicycle traffic (based on a signal progression of approximately 9 mph). It was also observed during site visits that traffic signal heads in Munster had one green cycle signal head and two red cycle signal heads. This was done to improve the visibility of the red cycle signal.

Bike parking lockers and sheltered spaces are offered at some park-and-ride or park-and-bike lots at transit stations (see figure 23-14). Each bike locker can hold two bikes and provides better security for more expensive bicycles than at bicycle shelters. The rental fee for bike lockers is 20 deutsche marks US$11.70) per month, which is much less expensive than car parking. This particular lot has 108 car parking spaces, and is on the outskirts of the built-up area of the city. The construction cost is much less for bike parking facilities than for car parking. Furthermore, about 10 to 12 bikes can be parked in a single car parking space.

Figure 23-12. Off-street bicycle/pedestrian path in Germany.

Bike parking at the train station facilitates train-bike combination trips. Bikes are parked in monitored areas and can be parked for 4 days before being moved to a long-term parking area. This allows train commuters to leave their bikes at the train station over the weekend. The City of Munster is also planning a 4,000-space underground bicycle parking facility at the train station.

Separate signal heads for bicyclists, as well as separate distinctive signal heads for trolleys, are used where exclusive bus lanes exist (using vertical or horizontal white lines as bus signal displays). This often results in three sets of signal heads side-by-side (car, trolley, and bike).

Figure 23-13. Lane used for buses and bicyclists only.

Installing bike racks at corners also helps intersection visibility. The study team was shown an intersection where car parking at the intersection had previously created a visibility problem for motorists on the side street. The problem occurred even after NO PARKING signs were posted. Installing bike racks at the corner physically prevented car parking and opened up sight distances for side-street traffic.

Bicycle lanes with continuous lane markings are reserved solely for bicyclists. If the lane is dashed, cars and trucks may use the space only when no bicycle is present.

3. Great Britain.
A variety of bicycle fatalities occur in Great Britain, particularly in smaller cities such as York and Cambridge, England, which have extensive networks of bicycle lanes and paths. Bicycle lanes are commonly narrow; some were observed by a study team to be 3 feet wide or less in many cases, as shown in figure 23-13. Along some city streets, contra-flow bike lanes exist, that is, one-way bicycle lanes move in the opposite direction to one-way motor vehicle traffic (see figure 23-15). Double yellow lines next to the curb mean no parking.

Figure 23-14. Illustration of bike shelters used in Germany.

Bicycle trails are found in some areas of Great Britain, which allow for long-distance cycling separate from motor vehicles (see figure 23-16). Entrances onto these trails are designed to prevent most types of motor vehicles (including motorcycles) from entering (see figure 23-17). Such barriers cause some problems for bicyclists who enter or exit the trail. Bicyclists are also allowed to use an extensive network of exclusive bus lanes throughout London. In York, an abandoned rail line became an excellent bicycle facility using the existing bridges and underpasses. A 1,000-mile cycle route network for London is planned over the next several years.

23.4 References

Text and photographs for this section were taken from:

FHWA Study Tour for Pedestrian and Bicyclist Safety in England, Germany, and The Netherlands, FHWA-PL-95-006, 1994.

Figure 23-15. Contra-flow bicycle lane in Cambridge, England.

Figure 23-16. Bicycle trail on an abandoned railroad right of way south of York, England.

Figure 23-17. Entrance to bicycle trail is designed to restrict entry by motor vehicles.

L E S S O N 24

Education, Encouragement, and Enforcement

24.1 Purpose

When bicycle and pedestrian programs began in the late 1960's, the emphasis was strictly on providing facilities. As communities gained experience and began to identify other needs, the concept of the comprehensive "4-E" program emerged, combining the elements of engineering, education, enforcement, and encouragement.

The past 30 years have seen a great deal of growth and much creativity in the field. Communities with long-standing bicycle and pedestrian programs have developed a wide variety of programs to educate local citizens, encourage more bicycling and walking, and enforce the rules of the road. This is in contrast to a far greater number of communities that have begun building new facilities–through the funding infusions of the Intermodal Surface Transportation Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21),but have not begun to establish support programs in the areas of education, enforcement, and encouragement.

This lesson explores the fundamental features of education, enforcement, and encouragement programs for bicycling and walking, providing examples of successful programs from around the country.

24.2 Comprehensive Programs — Why They're Important

Historically, providing for bicyclists meant providing bicycle facilities. This was the focus during the early phase of program development in the United States, but by the late 1970s, it was replaced in some progressive communities such as Boulder, CO, and Madison, WI, with a more comprehensive 4-E approach, which combined engineering and planning

A mock-up of a miniature downtown area enables these children in Greensboro, NC, to learn pedestrian safety.

with enforcement, education, and encouragement. By then, it had become clear that simply providing a bicycle- and pedestrian-friendly road or trail environment, as important as it is, cannot solve all bicycle and pedestrian problems. Some safety problems, for example, may be more easily solved through programs than through facilities. In order to understand the importance of the other elements of a comprehensive program, consider the following two examples:

Example 1: A person decides to ride her bicycle to work. Between home and the office, there is a road with bicycle-friendly design features (e.g., wide outside lanes, bicycle lanes, etc.). While riding, she barely misses a 10-year-old wrong-way rider coming at her, is almost cut off by a motorist turning left in front of her, and finally finds no place to securely park her bicycle at the office. She locks her bike to the leg of a newspaper rack and goes into the office. When she leaves work, the sun has gone down; she has no bike lights. She calls a taxi to take her and her bicycle home.

Analysis: While she was able to take advantage of one element of a comprehensive program (the on-road facilities), the lack of other elements caused her serious inconvenience and danger. Youngsters need to learn which side of the road to use and the traffic laws should be enforced; motorists should learn to watch for bicyclists and to yield to them just as they would to other motorists. These common bicyclist and motorist errors lead to many crashes and may be addressed through education, enforcement, and awareness programs. Secure and convenient bicycle parking should be provided at all popular destinations as a routine matter. In some communities, this is dealt with in the parking ordinance.

Example 2: A person gets in his car on a sunny summer afternoon to drive to a nearby store. The store is less than a mile away and he is buying a quart of milk. There are sidewalks, but he doesn't even think of walking. He drives there, buys his milk, and drives home. In so doing, he contributes to air quality and congestion problems. And he wastes gasoline.

Analysis: While the existence of sidewalks or places to walk is important, it does not necessarily convince people to walk if they habitually take a car for every trip. The average American household generates 10 auto trips per day and many of them are short-distance errands. Breaking the driving habit requires effort and understanding. A good awareness campaign, including media spots and other elements, can help develop that understanding and encourage people to make the effort to walk for short trips. Walking takes little extra time compared to driving for very short distances. When one considers the costs (environmental, economic, personal health) of driving, and the exercise and health benefits of walking, walking is often preferable.

These two hypothetical examples point out the importance of going beyond the old focus on facilities alone to include other aspects as well. They suggest the potential roles that

The lack of education and awareness among bicyclists and motorists can be addressed through new programs aimed at both adults and children.

agencies such as the police department, the school district, and private parties such as the local television station and newspaper can play in improving the bicycling and walking situation in a community.

It is important to keep in mind that some elements may not contribute directly to increased numbers of nonmotorized travelers. However, these elements are important for other reasons, primarily safety.

24.3 Successfully Mixing the 4-E's

How, exactly, can a successful mix of engineering, enforcement, education, and encouragement be determined? The answer is that participants from a wide range of agencies and groups must get involved in the process. The Geelong, Australia, model is a good one to illustrate this point. The Geelong Bike Plan Team included members from the enforcement community, roads department, safety agencies, school system, and bicycling community. In assembling their comprehensive program, the project managers enlisted the help of those who would, ultimately, be responsible for implementing it.

This is the process suggested here. A "bike-pedestrian plan task force" should be assembled to mold and steer the program. The following structure is suggested for the task force. While the same department may be represented on several subcommittees, this would not necessarily require different individuals. Individual members should deal with those aspects within their areas of expertise.

Task Force Structure

Subcommittees:

Steering Committee
Physical environment
Education and awareness
Encouragement
Data collection

Physical Environment
Public works (traffic engineering, streets)
Planning (transportation, land use)
Parks and recreation (parks planning)
Cyclists and pedestrians
College campus planning

Education and Awareness
Parks and recreation (programming)
School district (elementary and junior high)
High school and college
Health
Cyclists and pedestrians

Enforcement
Police (traffic)
Cyclists and pedestrians

Determining the Scope of a Comprehensive Program

Because so little is known about the bicycling and walking situations in most communities, it is difficult to predict in advance what level of expenditure and program activity will be needed to implement a comprehensive program. Until the needs have been identified and the problems assessed, the necessary scope of the program will probably remain unknown. However, the basic approach suggested here is to make bicycle and pedestrian considerations part of the normal process of governing. In many cases, this may require little extra expense.

The most successful bicycle and pedestrian education programs for children are implemented through local school systems.

For example, if a police officer stops a bicyclist for running a red light, this should not be seen as a new or extra duty. It is simply part of traffic enforcement and it will pay the community back in terms of decreased crash rates. Similarly, adding pedestrian- or bicycle-related questions to a transportation needs survey will not necessarily require large amounts of money. It allows transportation planners to do a better job of planning for the community's travel needs and can pay off in reduced motorized travel demand. Finally, changing from a dangerous drainage grate standard to a bicycle-safe design costs no more, but can reduce an agency's potential liability.

There will be some projects (e.g., a new bicycle bridge) that require a significant expenditure of funds. However, if the need for a project is clearly documented through surveys and studies, it can take its place in the Transportation Improvement Program. In such an arena, its strengths and weaknesses can be weighed against those of other potential projects.

Steps in the Process
There are four primary steps in the process of mixing the elements of engineering, education, enforcement, and encouragement to create a comprehensive bicycle-pedestrian program.

First, it is important to develop an understanding of the local bicycling and walking situations. This means looking closely at non-motorized travel in the community, determining its limitations and potential, as well as current levels of use and safety problems. This understanding forms the basis for the work that follows.

The second step is to set realistic goals and objectives. These should be based on data from the information-gathering step and they should be measurable and achievable.

Third, participants should address those goals and objectives through the development of an action plan. The plan should be a blueprint for the community's work in all the elements of the comprehensive program. It should include phasing and funding considerations.

Fourth, as work on the action plan progresses, it should be evaluated based on its effects on the goals and objectives. Without an evaluation process, it is impossible to determine the effects of one's work. With evaluation, one can judge and document success, correct errors, and fine-tune the program.

24.4 Elements of a Good Education Program

- **Provide instruction in lawful, responsible behavior among bicyclists, pedestrians, and motorists.**

1. Teach important bicycling and walking skills to youngsters.

Approach: Using information gathered from the user studies as well as the crash studies, work with school administrators and teachers to identify target ages for key educational messages. Review course options and identify opportunities for implementing bicycling and walking curricula for the target ages.

Result: A program of instruction that effectively reaches the target audience.

Examples: Missoula, MT's school district has included bicyclist education in its core curriculum since 1980; the program is taught by physical education instructors. Boulder's bicycle-pedestrian program staff includes a full-time education person in charge of implementing curricula in cooperation with the local school system. Madison's program works with the local schools to do the same.

2. Teach important bicycling and walking skills to adults.

Approach: Using information gathered from the user studies as well as the crash studies, work with college and high school administrators and teachers to identify key educational messages. Review course options and identify opportunities for implementing bicycling and walking curricula for the target ages.

Result: A program of instruction that effectively reaches the target audience.

Examples: Effective cycling instructors in Seattle, WA and Tucson, AZ, among other communities, have offered adult courses through the local junior colleges. Missoula and several other communities have offered cycling classes to traffic law violators through the local municipal court systems.

3. Include bike and pedestrian information in driver training.

Approach: Using information from the crash studies, work with local driver training instructors and violators to identify key messages for delivery to new drivers, as well as those required to take remedial driving courses. Assemble a model curriculum unit and deliver it to all local instructors.

Result: A model curriculum and delivery mechanism for reaching drivers during training.

New and returning university students should be included in training programs. It is during the first few weeks of classes that most crashes occur.

Examples: The Gainesville, FL Bicycle Coordinator taught 14- and 15-year-old driver education students how to share the road with bicycles. The coordinator brought copies of bicycle/automobile crash reports to illustrate her points. She then divided the class into groups, each with an accident report. Groups analyzed how the crashes happened and how they could have been avoided.

- **Deliver important safety messages through various print and electronic media.**

1. Determine which safety messages are most important for which audiences.

Approach: Using information gathered from the crash studies, identify important messages for the whole range of target audiences.

Result: A prioritized list of messages identified as to their target audiences.

Examples: The Gainesville program determined that one of the audiences most in need of attention was the college student population. Key safety messages for these bicyclists were identified.

Education programs should target adult bicyclists and motorists.

2. Create a process for effectively delivering those messages.

Approach: Work with the local media and other groups to determine how best to reach the audiences identified above, given the resources available.

Result: A long-term strategy for delivering selected messages to key target audiences.

Examples: In 1986, Madison, WI's bicycle program created an ambitious bicycle helmet campaign, working with local bicycling groups and the media. They did before-and-after studies of both helmet wearing rates and their success in delivering their messages. In Gainesville, FL, officials commissioned a safety specialist to create college student-oriented bicycling comic strips for publication in the campus newspaper and for printing as brochures.

24.5 Elements of a Good Enforcement Program

- **Improve existing traffic laws, as well as their enforcement.**

1. Review and, if necessary, modify laws that affect bicyclists and pedestrians.

Approach: In cooperation with the police department and city attorney, review local and State bicycle and pedestrian laws and compare with the current version of the Uniform Vehicle Code and Model Traffic Ordinance. Focus, in particular, on those regulations that may unnecessarily restrict bicycle or pedestrian traffic or that seem out-of-date when compared to the national models.

Result: A report listing suggested changes to local and State traffic laws.

Examples: Palo Alto, CA, after reviewing potential crash problems and liability concerns, decided to allow bicycle traffic on a key expressway. In doing so, they opened a new route for fast cross-town travel.

2. Enforce laws that impact bicycle and pedestrian safety.

Approach: Using information from the crash studies, determine which traffic violations are implicated in the most common serious car/bike and car/pedestrian crashes. Working with the police department, traffic court, and city attorney, develop a plan for enforcing the key laws.

Result: A plan for equitable enforcement of bicycle, pedestrian, and motor vehicle traffic laws.

Examples: Since the mid-1980's, Madison, WI's police department has used a "bicycle monitor" program, staffed by specially deputized university students, to enforce bicycle traffic laws. Seattle's department aggressively polices crosswalks and routinely gives motorists tickets for violating pedestrian rights of way. Missoula's bicycle patrol routinely gives tickets to motorists who violate the law.

3. Review and, if necessary, modify procedures for handling youthful violators.

Approach: In cooperation with the police department, develop procedures for handling young bicycle and pedestrian law violators.

Result: A set of procedures for dealing with young bicyclists and pedestrians.

Philadelphia, PA police officers use bicycles to patrol city streets.

Examples: For years, Dallas operated a youth court for young bicyclists caught violating traffic laws. The City of Santa Barbara, CA, a pioneer in bicycle enforcement, developed a campaign that included special tickets for youngsters, a publicity campaign, and a training film for officers. Missoula, MT has a special warning ticket for youngsters: one copy goes to the violator, one is mailed to the parents, and one is kept at the police station.

- **Reduce the incidence of serious crimes against non-motorized travelers.**

1. Develop a strategy for reducing the number of bikes stolen and increasing the proportion of recovered bikes.

Approach: Based on the police department's bike theft study, develop a strategy for reducing the impact of bike theft rings and other sophisticated thieves. Also consider a means to inform the public of simple steps they can take to keep their bikes from being stolen.

Result: A plan for reducing bike theft in the community.

Examples: Missoula, MT used their 1982 bicycle theft study as the basis for TV spots, appearances on news shows, news releases, brochures and posters, all of which promoted using high-security locks. They also developed a computerized bicycle registration procedure that has helped identify and return many licensed bikes to their owners.

2. Develop a strategy for reducing assaults on bicyclists and pedestrians.

Approach: Based on the study of bicyclist and pedestrian harassment and assault, develop a standard procedure for dealing seriously with these complaints.

Result: Policies and procedures for dealing with bicyclist and pedestrian assault and harassment.

Examples: For years, the Missoula bicycle program has worked with the city attorney's office on a case-by-case basis to resolve complaints of bicyclist harassment. Their efforts resulted in irresponsible motorists receiving numerous warnings and citations.

- **Use non-motorized modes to help accomplish other unrelated departmental goals.**

1. Implement non-motorized patrols in appropriate areas.

Approach: Based on the experiences of other communities, determine the need and potential of non-motorized patrols in the community and develop an implementation plan.

Result: A plan for funding and creating non-motorized police patrols in the community.

Examples: Seattle, WA has pioneered the mountain bike patrol as a way of dealing with street crime. Begun in 1987, the patrol has grown to more than 100 officers and the founders have given training seminars to police departments all over the country. Each year, hundreds of mountain bike officers gather for a national conference sponsored by the League of American Wheelmen; many also attend the annual "Beat the Streets" patrol competition hosted by the City of Seattle.

24.6 Elements of a Good Encouragement Program

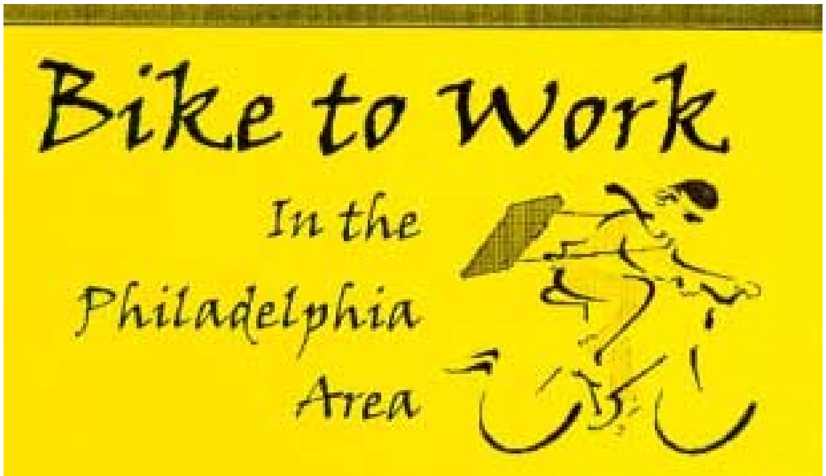
- **Reduce or eliminate disincentives for bicycling and walking and incentives for driving single-occupant motor vehicles.**

1. Add non-motorized options to agency motor pools.

Approach: Identify all agency motor pools and determine which can be modified to include bicycles. In addition, consider which trips can be efficiently taken on foot. Create a plan of action for adding non-motorized options where possible. Promote the approach as a model for other local employment centers.

Result: A plan for using non-motorized modes in satisfying agency transportation needs.

Examples: The City of Seattle recently created a "non-motorized pool," adding bicycles to the motor vehicles available for employee use. The bikes are proving to be extremely popular.



Promotional flyers can give safety tips, rules, and specific laws, and contacts and resources in the area.

2. Require companies and agencies to produce balanced transportation plans for their workforce's commuting needs.

Approach: Review city policies and practices, as well as those of private companies and other large employers, that reward driving private automobiles or discourage walking or bicycling. Work with all appropriate agencies and companies to modify those provisions.

Result: A set of proposed options (policies, ordinances, programs) that address institutional biases against bicycling and walking.

Examples: In Palo Alto, CA, a transportation plan for Stanford University suggested helping staff purchase bicycles if they would use them for commuting to work. The City reimburses those who use their bicycles for work-related trips. The university campus in Davis has, for many years, severely restricted motor vehicle parking. This has been identified as one of the major factors in encouraging students and faculty to ride bikes to the campus.

- **Provide ways for non-participants to receive a casual introduction to bicycling and walking.**

1. Include entry-level bicycling and walking activities in local recreational programming.

Approach: Identify existing programs or groups that could become sponsors for introductory-level bicycling and walking activities. Based on user studies, create a list of potential activities and match them with groups willing to offer sponsorship.

Result: A schedule of introductory-level non-motorized recreational activities.

Examples: Eugene, OR's recreation department sponsored a variety of recreational rides and workshops for novice adult riders through their network of parks. The Chesterfield County Parks Department in Richmond, VA, sponsors an annual "Peanut Ride," which visits peanut farms in the area, allowing participants to learn more about local agriculture while getting exercise.

2. Promote utilitarian non-motorized transportation through introductory fun events.

Approach: Through a combination of promotional events and media publicity, encourage citizens to walk or ride in place of driving.

Result: An annual series of promotions supporting non-motorized travel.

Examples: Boulder's annual Bike Week has become a major event over the years, encompassing a schedule of senior citizen rides, bike polo, business challenges, bicycle parades, and non-polluter commuter races. During their Bike to Work Day in 1992, approximately 7,000 people rode bicycles to work.

3. Offer key target audiences detailed information on utilitarian non-motorized travel.

Approach: Based on the user studies, determine which audiences are most likely to bicycle or walk; further determine their detailed informational needs and create a plan for getting that information to the target audience.

Result: A plan for giving detailed useful information to key target audiences.

Examples: The Ann Arbor, MI, program has run seminars at local hospitals and other employment centers, helping participants learn how commuting by bicycle might work for them. In Los Angeles, the El Segundo Employers Association, in cooperation with the Southern California Association of Governments, has produced maps, pamphlets, and seminars to promote non-motorized transportation among their workers.

Local agencies can work together to promote bicycling and walking, transportation, and safety.

- **Use electronic and print media to spread information on the benefits of non-motorized travel.**

1. Develop and disseminate a limited set of simple, but important, pro-bicycling and pro-walking messages.

Approach: Based on the user studies, determine the educational needs of bicyclists and walkers, assemble a list of the most important messages, and create a media campaign to get them across. Include the experiences of current non-motorized travelers as a way of personalizing the messages and lending added credibility.

Result: A media campaign promoting the benefits of bicycling and walking directed at key target audiences.

Examples: San Diego has used bus-mounted advertising to promote the benefits of non-motorized travel. Seattle, in cooperation with a local TV station, has created a series of local promotional television spots.

24.7 Conclusion

A comprehensive bicycle-pedestrian program directed toward the goal of increasing safe travel by non-motorized modes must combine the efforts of many people. No one office can do it all. Officials in public works, planning, enforcement, education, and recreation agencies all have a role and must work together to achieve the desired end.

In order to measure future success, it is important to first determine current conditions. Since non-motorized travel is so seldom measured, we know little about it. With data on use, user attitudes and behavior, safety, and security problems, it is possible to begin assembling an achievable set of goals and objectives. These goals and objectives should be used to guide the development and implementation of an action plan. The plan should include physical elements such as roadway improvements and trail systems, as well as non-physical elements such as enforcement and educational programs.

Evaluating the elements of the action plan is a critical step in determining future direction and past success. Success should be measured both in terms of services delivered and effects achieved. Evaluation must be seen as a key ingredient to implementation, rather than as an extra duty to be performed if there is time or money.

Combining these steps into a comprehensive program will allow a community to achieve and measure success.

24.8 References

Text and graphics for this lesson were derived from:

Federal Highway Administration, National Bicycling and Walking Study, *Case Study 11: Balancing Engineering, Education, Law Enforcement, and Encouragement,* 1994.