THE MID-AMERICA REGIONAL COUNCIL
AND THE KANSAS CITY METRO CHAPTER OF THE
AMERICAN PUBLIC WORKS ASSOCIATION

BEST PRACTICES

LOCAL BIKEWAY PLANNING AND DESIGN GUIDE

2012

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1.0 INTRODUCTION

The Mid-America Regional Council (MARC) led the effort to development this guide with assistance from the Kansas City Metro Chapter of the American Public Works Association (APWA). The purpose of this document is to provide supplemental guidance to local and state governments in the planning, designing and construction of bicycle facilities. The section draws significantly on national guidelines and standards; however, because guidelines and standards periodically update, the responsibility is upon the reader to check the most current information.

This section describes a wide variety of bicycle facility accommodations and in each case provides appropriate guidance for use. The word *shall* is used wherever standards have been established. The word *should* is used to give guidance in the recommendation of appropriate use, and the word *may* is used wherever innovative treatments are discussed.

The following guide is intended to foster multi-jurisdictional uniformity in the planning, design, and construction of bikeway facilities by establishing common definitions, design guidelines and system marking devices. The Mid-America Regional Council and the Kansas City Metropolitan Chapter of the American Public Works Association developed this section jointly.

Bicycle accommodations are most easily included during new construction or reconstruction of roadways. When implementation involves retrofitting an existing roadway to better accommodate bicycle traffic, the project can become more complex. With each project, there may be unique challenges and circumstances. The process of reaching design solutions requires balancing multiple and sometimes competing factors. As a result, the goal is to reach a reasonable solution that has been vetted with stakeholders. It is impossible to cover all the possible retrofit scenarios and solutions here; however, this section provides general guidance for many common bicycle hazards and retrofit problems. Existing streets built with a curb and gutter section may be limited to re-striping to change the width of existing travel lanes, removing a travel lane or removing on-street parking.

This section has been prepared based on a thorough review of current planning guidelines, and design standards for bicycle facilities. It is consistent with professional guidelines set forth by the American Association of State Highway and Transportation Officials (AASHTO), the Manual on Uniform Traffic Control Devices (MUTCD), the Federal Highway Administration (FHWA), the Missouri Department of Transportation (MoDOT) and the Kansas Department of Transportation (KDOT). This section will require periodic updates to reflect changes in professional documents.

2.0 DEFINITIONS

The coordination of a multi-jurisdictional bikeway system is simplified by using standardized terminology. Often terms such as “bicycle lane” and “bicycle path” are used interchangeably, when, in fact, they are not equivalent. It is difficult to coordinate regionally when inconsistencies in the use and meaning of terms exist. Therefore, as local jurisdictions are developing and updating their own plans and policies, they are encouraged to use the following terms consistently with the definitions that follow.

This section is intended to provide a central location for bicycle-related definitions as defined by nationally recognized authorities. AASHTO definitions relate to planning, design and operation of bikeway facilities. The MUTCD is the national standard for all traffic-control devices installed on any street, highway, bikeway, or private road open to public. All terms are based on AASHTO or MUTCD unless otherwise noted. Text that is marked in *Italic* font indicates where additional clarification was deemed appropriate. In some cases, notes are provided to explain why AASHTO and MUTCD definitions differ. Notes are not part of the definition.

The use of AASHTO and MUTCD definitions are necessary when coordinating multi-jurisdictional systems, however; we recognize that terms such as “trail” may be more appropriate when used in a general public context.

If local jurisdictions decide to substitute a term like “path” for “trail” it is important that these terms are well defined in a plan or policy document so that it is clear how the modified term compares to AASHTO or MUTCD definitions. The following terms are listed in alphabetical order and shall be defined as follows when used in this document.

BICYCLE or BIKE — a pedal-powered vehicle upon which the human operator sits. The term “bicycle” for this publication includes three and four-wheeled human-powered vehicles, but not tricycles for children. (See References, AASHTO (1) Page 2)

BICYCLE BOULEVARD — a street segment, or series of contiguous street segments, that has been modified to accommodate through bicycle traffic but discourage through motor traffic. (See References, AASHTO (1) Page 2)

BICYCLE CARRIER — a device mounted to a motor vehicle (often a bus) which is designed to transport one or more bicycles. (MARC)

NOTE: The AASHTO definition includes only roadways designated for bicycle use, but the MUTCD definition includes all roadways where bicycle travel is legally permitted. The AASHTO definition is used throughout this document.

BICYCLE LANE or BIKE LANE — a portion of a roadway which has been designated by pavement markings and, if used, signs, for the preferential or exclusive use of bicyclists. (See References, AASHTO (1) Page 2)

BICYCLE LEVEL OF SERVICE (BLOS) — a model used to estimate bicyclists' average perception of the quality of service of a section of roadway between two intersections. (See References, (1) Page 2)

BICYCLE LOCKER or BIKE LOCKER — a secure, lockable container used for long-term individual bicycle storage. (See References, AASHTO (1) Page 2)

BICYCLE MAP — a suggested route or network of routes for cycling published in a map format. Organizations that do not have the authority to sign a bicycle route, such as a bicycle club, may publish suggested routes for cycling and in some case, local governments may publish suggested routes such as paved shoulders and wide curb lanes, which are not signed as a bike route. (MARC)

BICYCLE PATH or BIKE PATH — a pathway that is exclusively used by bicyclists, where a separate, parallel path is provided for pedestrians and other wheeled users. Most pathways are shared between bicyclists and other users: see Shared Use Path. (See References, AASHTO (1) Page 4)

BICYCLE RACK or BIKE RACK — a stationary fixture to which a bicycle can be securely attached. (See References, AASHTO (1) Page 2)

BICYCLE ROUTE — a roadway or bikeway designated by the jurisdiction having authority, either with a unique route designation or with BIKE ROUTE signs, along which bicycle guide signs may provide directional and distance information. Signs that provide directional, distance, and destination information for cyclists do not necessarily establish a bicycle route. (See References, AASHTO (1) Page 3)

BICYCLE NETWORK — a system of bikeways designated by the jurisdiction having authority. This network may include bike lanes, bicycle routes, shared use paths, and other identifiable bikeways with appropriate way finding information with or without specific bicycle route numbers. The network uses a combination of bikeway types to create a continuous and connected system. (See References, AASHTO (1) Page 3)

BIKEWAY — a generic term of any road, street, path or way which in some manner is specifically designated for bicycle travel, regardless of whether such facilities are designated for exclusive use of bicycles or are to be shared with other transportation modes. (See References, AASHTO (1) Page 3)

CYCLE TRACKS — is an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. A cycle track is physically separated from motor traffic and distinct from the sidewalk. Cycle tracks have different forms, but all share common elements—they provide space that is intended to be exclusively or primarily used for bicycles, and are separated from motor vehicle travel lanes, parking lanes, and sidewalks. In situations where on-street parking is allowed cycle tracks are located to the curb-side of the parking (in contrast to bike lanes). (See References, NACTO (3))

RAIL-TRAIL — a shared use path, either paved or unpaved, built within the right-of-way of a former railroad. (See References, AASHTO (1) Page 3)

RAIL-WITH -TRAIL — a shared use path, either paved or unpaved, built within the right-of-way of an active railroad. (See References, AASHTO (1) Page 3)

RIGHT-OF-WAY — a general term denoting land, property or interest therein, usually in a strip, acquired for or devoted to transportation purposes. AASHTO (1)

ROADWAY — the portion of the street (*or paved traveled way*), including shoulders, intended for vehicular use. (See References, AASHTO (1) Page 3)

SHARED LANE — a lane of a traveled way that is open to bicycle travel and (*motorized*) vehicular use. AASHTO (1)

NOTE: This term is a broad definition because it includes all roadways that permit bicycle travel in the traveled way including preferred bike routes but excluding shoulders because they are not intended for motorized vehicular travel and bike lanes because they are for bicycle travel only.

SHARED LANE MARKING — a pavement marking symbol that indicates an appropriate bicycle positioning in a shared lane. (See References, AASHTO (1) Page 3)

SHARED ROADWAY — a roadway that is open to both bicycle and motor vehicle travel. This may be an existing roadway, a street with wide curb lanes, or a road with paved shoulders. (See References, AASHTO (1) page 4)

SHARED USE PATH — a bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way. Shared use paths are also used (*for transportation and/or recreation*) by pedestrians, skaters, wheelchair users (*both nonmotorized and motorized*), joggers and other non-motorized users. AASHTO recommends a minimum of 10 feet width (*in rare cases, 8 feet)*. (See References, AASHTO (1) Page 4)

NOTE: The AASTHO and MUTCD definitions are nearly identical. During the update of this guide, the Access Board released accessibility guidelines for shared use paths under Americans with Disabilities Accessibility Guidelines (ADAAG). The ADAAG definition is consistent with both AASHTO and MUTCD.

SHOULDER — the portion of the roadway contiguous with the traveled way, for accommodation of stopped vehicles, emergency use and lateral support of sub-based, base and surface courses, often used by cyclists where paved. (See References, AASHTO (1) Page 4)

SIDEWALK — that portion of a street or highway right-of-way, beyond the curb or edge of roadway pavement, which is intended for use by pedestrians. (See References, AASHTO (1) Page 4)

SIDEPATH — a shared use path located adjacent and parallel to a roadway. (See References, AASHTO (1) Page 4)

NOTE: The adverb "immediately" appears after "located" and in the AASHTO definition was removed because it implies that there is no space between the roadway and sidepath. Sidepaths are within the ROW and should be separated from the travel way by open space or physical barrier. (See Section 4.1.6 Shared Use Paths and Sidepaths)

TRAVELED WAY — the portion of the roadway intended for the movement of vehicles, exclusive of shoulders. (See References, AASHTO (1) Page 4)

UNPAVED PATH — path not surfaced with a hard, durable surface such as asphalt or Portland cement concrete. (See References, AASHTO (1) Page 4)

NOTE: Most local agencies, state and federal agencies use the term "trail" to describe both paved and unpaved pathways. This term is appropriate to use but may require further definition to distinguish trail typology (paved, unpaved, equestrian, mountain bike, nature hike, etc.).

WIDE-CURB LANE – the outside lane next to the curb having a width of 13 feet or greater. A width of at least 14 feet allows a motorist to pass a bicyclist without encroaching into the adjacent lane. (See References, AASHTO (1) Page 57)

NOTE: The DRAFT AASHTO Guide for the Planning, Design, and Operation of Bicycle Facilities provides guidance wide-curb lane design. There is no singular definition found in the DRAFT; however, the definition above is derived from Chapter 4.3.1. SHARED LANES ON MAJOR ROADWAYS (WIDE CURB/OUTSIDE LANES).

3.0 DESIGNING FOR THE BICYCLE USER

The planning and design of bicycle facilities requires a clear understanding of user types, their needs and how to meet those needs while accommodating other transportation modes.

Many people are attracted to bicycling because it is a healthy, low cost affordable, energy-efficient, environmentally friendly, and relaxing form of transportation. The bicycle increases mobility, creating access to jobs, goods, services, and recreational opportunities. For many persons, bicycling is a viable transportation mode for trips that are 2 miles or less in length. When combined with transit service, trip lengths can be much longer.

The United States Department of Transportation Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations supports transportation programs and facilities that accommodate people of all ages and abilities, including people too young to drive, people who cannot drive, and people who choose not to drive. The Mid-America Regional Council conducts regional analysis population demographics to understand present and projected transportation needs. While each community is unique, the region's population is aging, and it is expected that people over age 60 will increase from 15 percent to 25 percent by 2030. Young people are expected to decline slightly as a total share of the region's population, but will increase by 78,000 over the next 20 years. A substantial number of area households require transportation options other than a personal motor vehicle. Many cannot afford to own and operate a vehicle. According to the region's 2004 Regional Household Travel Survey, 48,919 households (8.7 percent of all households) own no motor vehicle, and 227,873 households (40.8 percent of all households) have only one vehicle.

3.1 BICYCLE USER CHARACTERISTICS

Effective planning and design of bicycle facilities both on and off road requires a general understanding of the characteristics that are used to classify different types of bicycle riders. Trip purpose, physical ability, and comfort/skill level are among the most common. All of these characteristics are dynamic, causing individuals to fit into one or more profiles.

3.2 TRIP PURPOSE

Utilitarian / Nondiscretionary

The utilitarian or nondiscretionary trip includes daily destinations such as work, school and shopping. This type of trip requires the rider, when choosing a route, to consider safety, trip time, and comfort level in addition to the destination. The growth in utilitarian trips has been fueled by several factors, including personal health, cost of transportation and concern for the environment. For reasons of age or finances, an individual may not have access to an automobile making them dependent on other modes of transportation namely walking, public transit, and bicycling.

Recreational / Discretionary

The recreational or discretionary trip is made for exercise or enjoyment. The focus of this trip is not a destination but rather the activity. The bicyclist still considers safety, trip time, and comfort level, but may weigh them differently.

A bikeway network that serves both utilitarian and recreational trips is important because it affects the quality of life of all users. The differences between trip types can become blurred when the purpose of a trip is both utilitarian and recreational. A planner or designer of bicycle facilities must understand that the bikeway network of roads and pathways should serve both trip purposes.

Communities are rethinking the role that transportation plays in addressing public health, economics, and environmental stewardship. These issues are cross-cutting, and they apply to both utilitarian and recreational trips. “Active Transportation” is an approach to transportation planning and design that encourages bicycling and walking. The focus is on transportation that integrates daily physical exercise to improve the quality of life of the individual and their community. Recreation and discretionary trips also may form a daily routine that creates an active transportation lifestyle.

3.3 PHYSICAL AND COGNITIVE ABILITIES

Individual riders have a number of characteristics that affect their physical and cognitive abilities. Adults and/or children both have different levels of physical and cognitive abilities. However, children tend to be different from adults in the following ways. They:

- are more impulsive,
- lack understanding of cause and effect relationships,
- are distracted by unimportant information,
- have difficulty determining where a sound is coming from,
- have difficulty judging the speed and distance of oncoming vehicles,
- lack the peripheral vision, and
- lack physical coordination.

As adults age our physical coordination, and stamina diminish, our eyesight, hearing and cognitive abilities also diminish.

3.4 LEVEL OF USER SKILL AND COMFORT

With education, training and experience the casual rider becomes more confident, building skills that increase their comfort level. In general, the more experienced a rider is the less likely that speed and traffic volume affects their comfort level. Less experienced riders tend to prefer to travel on low-traffic residential streets or shared-use paths but may be less aware of potential risk. Public education should be provided to assist riders in choosing routes that are appropriate for their skill and equipment.

3.5 BICYCLE USER TYPES

A 1994 report by the Federal Highway Administration, Selecting Roadway Design Treatments to Accommodate Bicycles used the following general categories of bicycle user types (A, B, and C) to assist transportation planners and engineers in determining the impact of different facility types and roadway conditions on bicycles:

Advanced or (experienced) cyclists are generally using their bicycles as they would a motor vehicle. They are riding for convenience and speed and want direct access to destinations with a minimum of detour and delay. They are typically comfortable riding with motor vehicle traffic; however, they need sufficient operation space on the traveled way or shoulder to eliminate the need for them or a passing motor vehicle to shift position.

Basic or (novice) or less confident adult cyclists may also use their bicycles for transportation purposes, e.g., to go to the store or to visit friends, but prefer to avoid roads with fast busy motor vehicle traffic unless there is ample roadway width to allow easy overtaking by faster motor vehicles. Thus, basic riders are comfortable riding on a neighborhood street, shared use paths and prefer designated facilities such as bike lanes or wide curb lanes on busier streets.

Children riding on their own or with their parents, may not travel as fast as their adult counterparts but still require access to key destinations in their community, such as schools, convenience stores, and recreational facilities. Residential streets with low motor vehicle speeds, well-defined bike lanes or shared used paths can accommodate children without encouraging them to ride in the travel lane of the busy roadways. (4)

4.0 BICYCLE FACILITIES - AN OVERVIEW

The AASHTO defines "bicycle facilities" as a general term denoting improvements and provisions to accommodate or encourage bicycling, including parking and storage facilities, and shared roadways specifically designated for bicycle use. Section 4.1 describes a wide variety of bicycle facilities. Purpose, appropriate applications, and special considerations are among the topics covered professional judgment, and sound engineering practices must be used on the site-specific application of any design treatment.

Both on-street and off-street bicycle facilities and designation types are used to accommodate bicycle travel. Options included:

- Shared Roadways/Shared Lanes (on-road)

- Paved Shoulders (on-road)
- Wide Curb Lanes (on-road)
- Bicycle Routes
- Bike Lanes (on-road)
- Share Use Paths (off-road)

Note: Shared roadways, roadways with wide curb lanes or paved shoulders may or may not be designated bike routes, but all fall under the definition of bicycle facilities. AASHTO defines a bike route as a designation of a preferred route or bikeway rather than a design type.

4.1 DESIGN OF BICYCLE FACILITIES

Not all roadways equally accommodate bicycle travel. The choice of where improvements are made and which roadways are designated as part of bikeway network entails the consideration of multiple factors, including but not limited to: user needs, traffic volumes and speeds, barriers, connections to land uses, route directness, aesthetics, bikeway network density, and overall feasibility.

This document describes a wide selection of possible bicycle facility accommodations. There is no one size-fits-all bicycle facility or roadway design that suits every bicyclist and no bicycle facility design can compensate for a lack of bicycle operator skill and competency. As a result, sound planning and design principles applied within any given transportation corridor may necessitate more than one option to meet the travel and access needs of all potential users. The 2010 Highway Capacity Manual (HCM) provides a Bicycle Level of Service (BLOS) methodology that measures how safe and comfortable cyclists feel riding on roadways. More information and guidance is provided under Section 12.2. Highway Capacity Manual Multimodal LOS of this document.

Shared roadways with 12-foot or narrower travel lanes can accommodate bicycle traffic if traffic volumes speeds are low and the roadway is free of hazards. However, various treatments can improve safety for bicyclists along high-demand corridors where high-traffic volumes and speeds make it prudent to do so. Shared roadways, wide-curb Lanes, paved shoulders, bike lanes, and shared use paths can be used to accommodate bicycle traffic. Widened roadways and paved shoulders provide more operating room for bicyclists and offer several benefits to motorists, including better accommodation for trucks, buses and other wide vehicles, assisting turning vehicles, and provide additional space for emergency operations.

Designated on-road bikeways include roadways that have been signed with bike route signs, or striped with bike lanes. Shared use paths are a type of bikeway that is off-road and is covered under Section 4.1.6. Shared Use Paths and Sidepaths of this document.

The impact of designated bikeways is particularly important for Type B (novice) cyclists not adept at riding in traffic. On-street bicycle routes provide information to the bicyclists for the use of secondary streets to connect to on-street bicycle lanes, wide curb lanes and paved shoulders that offer a designated and visible space for bicyclists and can be a significant factor for route choice. Shared Use Paths can serve both transportation and recreation functions and have proven to be significant generators of bicycle use.

Due to the nature and frequency of bicycle trips made near college campuses and schools, it is particularly advantageous to provide a designated bikeway network.

4.1.1 Shared Roadways

All roadways should be accessible by bicyclist, except where prohibited on Interstates. This however does not mean that all shared roadways equally accommodate bicycle travel. AASHTO provides guidance for the conditions that a share roadway should meet to effectively accommodate bicycle travel.

There are no specific bicycle standards for

Figure 1: Shared Roadway Photo
Source: Libby Thomas Chapel Hill, NC

shared roadways, although most bicycle travel takes place on shared roadway facilities. The shared roadways function well for bicycle travel on local streets where low-volume and low-speed combine to provide a desirable BLOS.

Facility Purpose

- To provide access to the many origins and destinations dispersed throughout a community and to other bicycle facilities.
- To allow bicycles access to all streets and roadways, regardless if designated bicycle facilities are provided.

Appropriate Applications

- On local streets with low motor vehicle traffic volumes and speeds.
- On low-volume rural roads with good sight distance.
- When local streets are needed to be a part of the bikeway network to provide continuity and linkage throughout the community.

Special Considerations

Streets with shared lane conditions that are to be designated as part of a bikeway system should have hazards to bicycle travel mitigated.

Street parking should be restricted in areas of critical width to improve safety of bicyclists. Shared roadways do not usually require signage for bicyclists, unless they are links in the bikeway network. The DRAFT, AASHTO Guide for the Planning, Design, and Operation of Bicycle Facilities p. 26, indicates as a general rule that shared roadways are acceptable for bicycle use on local streets with traffic volumes of 1,000 or less AADT and traffic speeds of 30 mph or less. However, state and local agencies are encouraged to evaluate the roadway using the BLOS and to use this tool to evaluate all possible retrofit scenarios.

On narrow lanes, motorists tend to wait for a safe opportunity to encroach into the adjacent lane when passing a bicyclist. The absence of lane stripping on a local street in this case actually works to the benefit of the bicyclist. Where volumes and speeds are higher, additional lane width becomes increasing important. Bike lanes and wide curb lanes should be used to improve bicycling conditions for high-volume, high-speed roadways.

Traffic calming devices may be considered to lower traffic volumes or speeds. For guidance on the use of traffic calming to improve bicycle safety and comfort consult Section 4.3.1.5 Bicycle Boulevards.

In rural areas, the suitability of a shared roadway decreases as traffic speeds increase, especially on roads with poor sight distance. Where bicycle use or demand is potentially high, rural roads should be widened to include paved shoulders where the travel speeds and volumes are high.

The SHARE THE ROAD (STR) sign (W16-1P) may be used along shared roadways where the probability of bicycle presence is high and the shared lane width is 12 feet or less to increase awareness and improve safety. However, on roadways with high traffic and speeds, motorist may be significantly delayed while waiting for a safe opportunity to pass. In those cases, the, The BICYCLE MAY USE FULL LANE (BMUFL) sign (R4-11) may be more effective. These measures are, however not long-term solutions and are not substitutes for wide curb lanes, shoulders or bike lanes.

4.1.2 Paved Shoulders

The AASHTO Guide for the Development of Bicycle Facilities notes that in rural areas "adding or improving paved shoulders often can be the best way to accommodate bicyclists" – and they have the additional attraction of providing a variety of benefits to motorists and other road users as well. As warranted, shoulders may be designated as a bicycle route by

Figure 2: Paved Shoulders Photo
Source: FHWA

signing or/and marking for preferential use similar to bicycle lanes. A paved shoulder width should range from 4-8 feet.

A paved shoulder may or may not have a curb and gutter, but will have an edge line of demarcation. Paved shoulders may be provided on roadways for a variety of safety, operation and maintenance reasons. Most of these advantages apply to both shouldered roadways and to marked, on-street wide curb lanes and bicycle lanes on curbed roadways.

Facility Purpose

Roadways with paved shoulders have reduced accident rates, as paved shoulders:

- Provide space to make evasive maneuvers;
- Accommodate driver error by adding recovery area to regain control of a vehicle;
- Provide space for inoperative vehicles;
- Provide increased sight distance for through vehicles and for vehicles entering the roadway (e.g. in cut sections or vegetated rural areas, and in urban areas with many possible sight obstructions);
- Provide lateral clearance to roadside objects such as guardrail, signs and poles;
- Contribute to driving ease and reduced driver strain;
- Reduce passing conflicts between motor vehicles and bicyclists and pedestrians;
- Provide for storm water discharge farther from the travel lanes, reducing hydroplaning. This also reduces splash and spray to following vehicles and nearby pedestrians and bicyclists.

Roadways with paved shoulders can carry more traffic, as paved shoulders:

- Provide more intersection and safe stopping sight distance;
- Allow for easier exiting from travel lanes to side streets and roads;
- Provide greater effective turning radius for trucks;
- Provide space for off-tracking of truck's rear wheels in curved sections;
- Provide space for disabled vehicles, mail delivery and bus stops;
- Provide space for bicyclists to ride at their own pace;

- Provide space between motor vehicles and pedestrians, increasing pedestrians' level of comfort.

Roadways with paved shoulders are easier to maintain, as paved shoulders:

- Provide structural support to the pavement;
- Discharge water further from the travel lanes, reducing the undermining of the base and sub-grade;
- Provide space for maintenance operations and snow storage;
- Provide space for portable maintenance signs;
- Facilitate painting of edge lines of the travel lane.

Appropriate Applications

- On roads without curb and gutter;
- On rural roads that serve cyclists.

Special Considerations

Rumble strips can provide a safe and inexpensive way to reduce run-off the road crashes on rural shouldered highways. They can be designed to be both effective for the motorist and safe for the bicyclist.

"Rumble strips or raised pavement markers are not recommended where shoulders are used by bicyclists unless there is a maximum clear path of 0.3 m (1 ft) from the rumble strip to the traveled way, and a minimum 1.2 m (4 ft) from the rumble strip to the outside edge of paved shoulder, or 1.5 m (5 ft) to adjacent guardrail, curb or other obstacle. In addition, periodic gaps of 12 ft (3.7 m) should be provided for bicyclist every 40-60 ft to allow bicyclist to cross. (See References, AASHTO (2) Page 17)

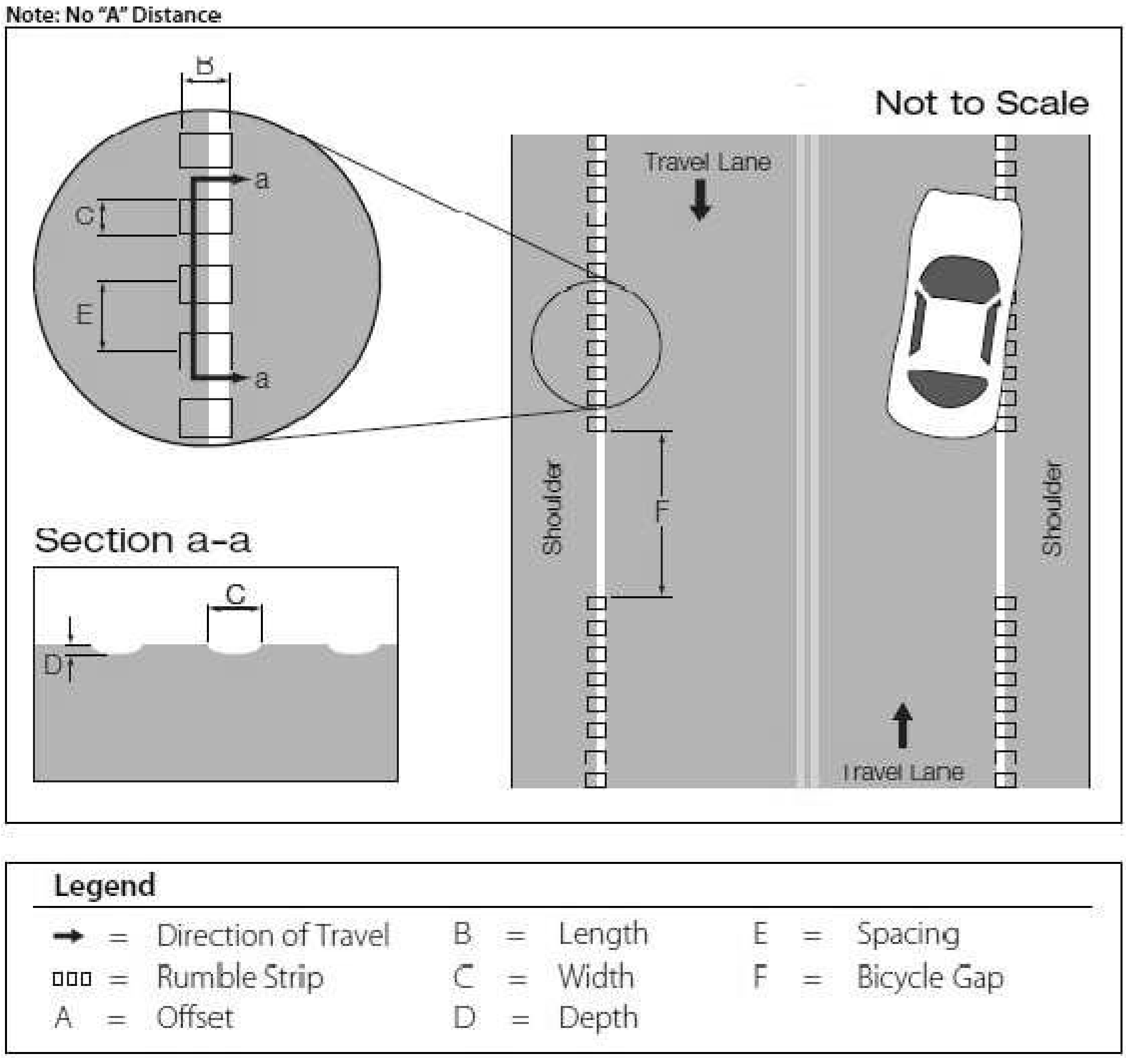


Figure 3: Edgleline Rumble Stripes Illustration
Source: FHWA Tech Advisory: Shoulder and Edgeline Rumble Stripes

It is desirable to increase the shoulder width to 5 feet or greater where, roadway grades are steep, higher bicycle use is expected, if motor vehicle speeds exceed 30 mph or the percentage of trucks, buses or recreational vehicles is high.

Small stones, sand and other debris often collect on roadway shoulders. Usually the air turbulence caused by passing traffic creates a sweeping action. For this reason, most bicyclists prefer to ride on that portion of the shoulder nearest to traffic to avoid debris. Periodic shoulder sweeping should be provided along identified bicycle routes and routes of high bicycle usage.

Rumble strips are not advisable along suburban and urban roadways. Shoulders should be paved and maintained to an equivalent surface standard as regular travel lanes. Special considerations should be made at intersections.

4.1.3 Wide Curb Lanes

Like paved shoulders or bike lanes, the wide-curb lane provides additional space for bicycle travel. In general, 14 feet of usable lane width is the recommended width for a wide curb lane because it allows a motorist to pass a bicyclist without encroaching into the adjacent lane. Additional space may be needed where grades are steep or sight line distance is poor. A curb lane that is narrower than 14 feet but at least 13 feet wide can provide marginal benefits to both bicyclists and motorists, especially on four-lane roadways where motorists encroach into the adjoining lane to pass bicyclists are not dealing with oncoming traffic. Wide curb lanes that exceed 16 feet may be misunderstood as another travel lane and are not recommended. Beyond hazard mitigation, no special design is required. Section 9.0 Principles and Approaches for Roadway Design and Retrofits, provides additional guidance on the width of lanes. (See References, AASHTO (1) Page 57)

Facility Purpose

- To improve accommodate for both bicycles and motor vehicles on roadways by providing additional operating room.
- To maintain the motor vehicle capacity of a right-hand lane when bicyclists also use it.
- To increase the roadway capacity by the number of bicyclists capable of being accommodated.
- To allow motor vehicles to pass bicycles without having to change lanes.
- To minimize both real and perceived operating conflicts between bicycles and motor vehicles.

Appropriate Applications

- Where there is insufficient room for a dedicated bicycle lane or pave shoulders.

- Where there are frequent intersecting commercial driveways or cross streets that complicate bicycle lane treatment.
- Raytown, MO, Overland Park, KS, Olathe, KS, Lenexa, KS, and Shawnee, KS, have adopted a wide curb lane configuration that includes an 11-foot inside lane and a 13-foot wide curb lane rather than two 12-foot lanes.

Special Considerations

- Wide curb lanes on roadways improve the cycling environment even though they may not be designated as a bikeway.
- A wide curb lane integrates bicycle and vehicle traffic and forces recognition and awareness on the part of motorists, particularly at intersections.
- Wide curb lanes on roadways accommodate bicycle use, but striped and signed bicycle accommodations may encourage increased bicycle use.
- Additional width 14 to 16 feet is recommended on steep grades or where drainage grates, raised reflectors or on-street parking reduces the usable width. Widths greater than 16 ft (4.8 m) encourage the undesirable operation of two motor vehicles in one lane. In this situation, a bike lane or shoulder bikeway should be provided.

4.1.4 Bicycle Routes

The signed shared roadway or bicycle route, through appropriate signing, may encompass any of the facility types or general roadway conditions discussed in this report. Bicycle routes are not an actual facility type; they are a designation of a facility or collection of bikeways, which have been improved or are considered preferred routes between origins and destinations. Wide curb lane treatments, which are typically implemented on busy arterial routes, are

Figure 4: Bicycle Route Photo
Source: Riverfront Heritage Trail, Kansas City, MO

usually not signed as designated bicycle routes. Bicycle lanes are typically preferred over wide curb lanes for arterial routes within an urban area. Paved shoulders may be designated for bicycle use with bicycle route signs.

Facility Purpose

- To provide directional assistance to bicyclists to a particular destination (e.g. park, school, or commercial district).
- To provide continuity between bicycle lanes, shared use paths or other bicycle facilities.
- To indicate to cyclists that there are particular advantages to using a route as compared with alternative routes.
- Informs motorist of preferred bicycle route indicating greater frequency of encounters.

Appropriate Applications

- Where signage is desired to guide bicyclists to their destinations.
- In order to provide directional information, a standard sign should be supplemented with arrow plates, names of routes, distances to destinations, etc.
- Designated routes may follow a combination of facility types: paved shoulders, wide curb lanes, shared use paths and general shared roadway conditions that have compatible motor vehicle volumes and speeds.

Special Considerations

Bicycle route signage is not recommended for routine use on major arterials with general shared roadway conditions, or even wide curb lane treatments. The implementation of bicycle lanes, or designation of less traveled alternative routes, are preferred treatments. If no alternative exists, "Share the Road" caution signs may be used until conditions can be improved.

For reasons of safety and liability, designated bicycle routes should meet national minimum guidelines and hazards to bicycle travel (parallel drainage grates, rough railroad crossings, etc.) should be properly mitigated before they are signed.

Retrofit Guidelines for Signing Bicycle Routes

Bicycle routes often comprise the most significant portion of a bikeway system. The bicycle route is selected based on criteria that give the bicyclists a reason to select the preferred route. AASHTO suggests that bicycle routes may be designated on local roadways with no special provision if generally; the limit is 30 mph or less, with 1,000 vehicles per day or less. Generally, bicycle routes are not recommended along roadways with high-traffic volumes above 3,000 ADT and traffic speeds above 25 mph without the provision of bike lanes, wide curb lanes or paved shoulders. After bicycle demand corridors are identified, an inventory of roadway characteristics may be used to select specific routes. The inventory might include: traffic volumes, traffic speeds, street width, presence/absence of curbs, availability of parking and parking usage, traffic control (e.g. stop sign, roundabout, traffic signal) presence at each intersection, difficulty crossing major intersections, surface quality, roadway hazards, terrain/topography, connectivity, access, destinations/attractions, directness and other relevant observations. (See References, AASHTO (1) Page 25)

Other approaches to bicycle planning and facility design includes: reducing vehicular speeds or traffic volumes to accommodate bicycles on streets that may not be wide enough for striped bike lanes. Traffic calming treatments may be used to improve safety and increase the attractiveness of a corridor. Many local residential streets are not being considered high bicycle demand corridors and the need to designate them as bikeways is unwarranted, regardless of roadway characteristics.

4.1.5 Bicycle Lanes

Bicycle lanes are designated portions of a roadway, a minimum of 4 feet wide (5 feet preferred) excluding curb and gutter that are signed, striped and marked for bicycle use. If the bicycle lane is placed between the parking area and travel lane, the minimum width should be 5 feet.

Figure 5: Bicycle Lane Photo
Source: 123rd Street, City of Leawood, KS. by MARC.

Facility Purpose

- To improve conditions for cyclists of all abilities within a given corridor.
- To encourage increased bicycle use on a given roadway by providing a greater degree of comfort and perceived safety for less-skilled cyclists.
- Movement by bicyclists and motorists becomes more predictable.
- To establish an overall channeling effect and promote an orderly flow of traffic.

Appropriate Applications

- Where significant bicycle demand is expected on arterial and collector roadways. Bike lanes should be considered on collector and arterial roadways where the combination of speed and traffic volume suggests a need.
- On-streets where lane designation is not complicated by frequent roadway intersections and commercial driveways.
- On-streets with high-traffic volumes where cyclists and motorists must frequently pass each other.
- When it is desirable to delineate the right-of-way assigned to cyclists and motorists to provide for movements that are more predictable by each.

- When the route is anticipated to serve a high number of less-experienced adult, child and recreational bicyclists.

Special Considerations

While the bicycle lane has been shown to increase overall predictability of traffic flow, the bicycle lane can erroneously increase a cyclist's confidence that motorists will not stray into his path of travel.

Bicycle lanes shall be clearly marked and signed for one-way travel, with designated facilities provided on both sides of a street or roadway, all in accordance with the Manual on Uniform Traffic Control Devices.

Road debris may collect in bike lanes due to the sweeping action of auto and truck traffic. Local agencies should budget for street sweeping to remove debris as needed.

Special consideration must be given to the treatment of bicycle lanes on roadways with on-street parking. Parking cannot coexist within the bicycle lane.

Special consideration must be given to the treatment of bicycle lanes at major intersections. Bike lanes tend to complicate left-turn movements for bicyclists at intersections. It is also difficult for bicyclists continuing straight while motor vehicular traffic is turning right.

Sufficient width from the face of the curb should be provided so bicyclists can avoid conflicts with motorists while not having to travel too close to the curb. Most new construction includes a 2-foot curb and gutter section. There is a longitudinal seam that is created where the asphalt surface of the roadway meets the concrete gutter. A minimum 4-foot bicycle lane is recommended from the edge of the gutter seam to the bicycle lane stripe. Older construction sometimes includes a 1-foot curb and gutter section where the seam has been overlaid up to the face of the curb. In this situation, a 5-foot bicycle lane may be stripped from the edge of curb face to the bicycle lane stripe. A 4-foot bicycle lane is not recommended in this instance.

4.1.6 Shared Use Paths and Sidepaths

A shared use path is a bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way. Shared use paths are also used (*for transportation and/or recreation*) by pedestrians, skaters, wheelchair users (*both non-motorized and motorized*), joggers and other non-motorized users. AASHTO recommends a minimum of 10 feet width (in rare cases, 8 feet). (See References, AASHTO (1) Page 1)

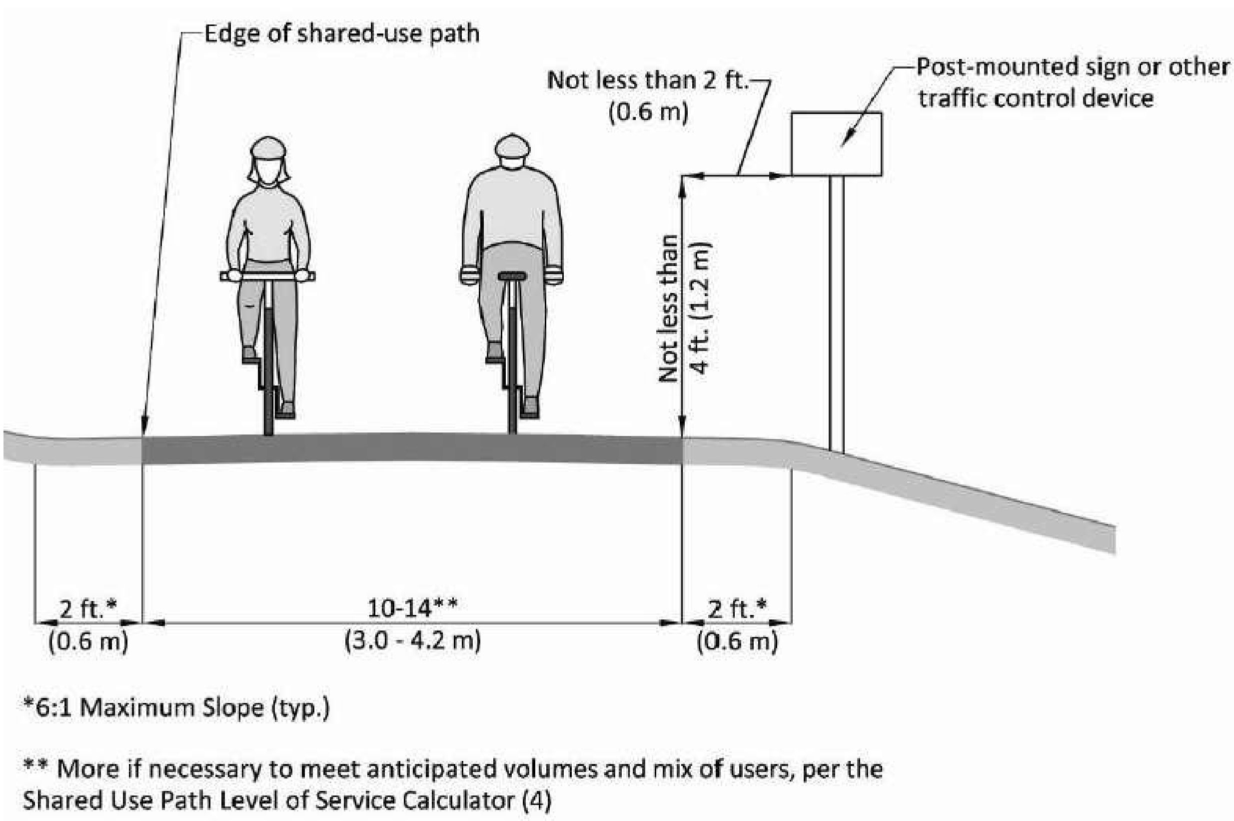


Figure 6: Share Use Path Illustration
Source: AASHTO (1) Page 135

Facility Purpose

- To serve significant generators of bicycle use, especially for Type B and C cyclists.
- To provide enjoyable recreational opportunities as well as desirable commuter routes.
- To provide system continuity and linkage in areas where no on-street facilities are available or desirable based on further evaluation.

- To supplement a network of on-road bike lanes, shared roadways, bike boulevards, and paved shoulders.

Appropriate Applications

- Where uninterrupted right-of-way is available to provide long, continuous routes for utilitarian or recreation trips.
- Within an independent right-of-way such as an abandoned railroad corridor, linear park, or greenway.
- As cut-through between buildings or connections between cul-de-sacs and other breaks in the street network.
- Within a roadway right-of-way when there is sufficient space (i.e. 10 feet) or a physical divider to enforce the concept that the path functions as a highway for bicyclists; and when few streets and driveways intersect with the path facility.
- Shared use paths should be thought of as a complementary system of off-road transportation routes for bicyclists that serve as a necessary extension to the roadway network. Shared use paths should not be used to preclude on-road bicycle facilities.

Special Considerations

- Shared use paths attract a variety of user types and therefore need to be designed to accommodate multiple users.
- Shared use paths are, by definition, physically separated from motorized traffic. Ideally, they will be grade-separated with a structure at major roadway crossings, unless the crossing roadway volumes are low, or the separation costs are excessively disproportionate to the need or probable use of the path.
- Due to safety considerations, sidewalks and walkways immediately adjacent to a roadway are not recommended for designation as bicycle routes.
- Sidepaths parallel to roadways are generally constructed when other types of bikeways are considered less desirable for bicycle travel; such as along heavily traveled metropolitan freeways or high volume and high speed roadways, or where a more desirable, safer, alternate on-street route exists and when there is a commitment to provide bike path continuity for an extended length of the corridor.

- Care must be taken to design appropriate transition areas from shared use paths to on-street bikeways that may include bicycle lanes, wide curb lanes, paved shoulders or general shared-use roadways.

Supplemental Design Details

The 1999 AASHTO Guide for the Development of Bicycle Facilities covers the design of bicycle paths, intersections and structures on pages 33-46. Chapter 5 of the DRAFT AASHTO Guide for the Planning, Design, and Operation of Bicycle Facilities covers in greater detail the design of Shared Use Paths. However, until this draft is adopted consult the 1999 Guide. The Shared Use Path design is similar to roadway design, but on a smaller scale and with typically lower design speeds.

Pavement Structure

Minimum sub-base and asphalt thickness are as recommended in a national trails design guide produced by the Rails-to-Trails Conservancy. However, standard application of this cross section is not recommended without further study. Hard, all-weather pavement surfaces are usually preferred by bicyclists over those of crushed aggregate, sand, clay or stabilized earth since these materials provide a much lower level of service and require higher maintenance. State agencies administering federal funding may add requirements to the type of surface provided if the path is intended for commuting purposes.

Each individual shared use path must be engineered and designed based upon site-specific sub grade conditions. As a rule, bicycle paths/shared use paths should be designed to support a minimum design load of 10,000 to 12,500 pounds, which is the weight of a light maintenance truck or ambulance.

Path Widths

Minimum tread widths for bike paths and shared use paths are generally accepted to be 10 feet. Per AASHTO, an 8-foot width is adequate only where the following conditions prevail:

- Bicycle traffic is expected to be low, even on peak days or during peak hours;
- Pedestrian use of the facility is not expected to be more than occasional

- There will be good horizontal and vertical alignment providing safe and frequent passing opportunities, and
- The path will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage.

A path width of 8 feet (2.4 m) may be used for a short distance due to a physical constraint such as an environmental feature, bridge abutment, utility structure, fence, etc. Warning signs that indicate the pathway narrows, per the Manual on Uniform Traffic Control Devices (MUTCD) should be considered at these locations.

Shared use paths may need to be even wider to accommodate passing situations for different users traveling at different speeds. Under certain conditions it may be necessary or desirable to increase the width to 12 feet or even 14 feet, due to high traffic, mix of path users, periodic use by maintenance vehicles, steep grades or poor sight distances.

Design Speed

Shared use paths should be designed to accommodate safe travel by the speed of faster bicyclists or in general 18 mph. When a downgrade exceeds 4% or strong prevailing tailwinds exist, 30 mph design speed is advisable. The design speed for unpaved paths is recommended at 15 mph.

The maximum super elevation rate to meet Americans with Disabilities requirements (ADA) is 3 percent, and in general, grades should be kept to a maximum of 5 percent. Where unpaved surfaces are used, the grades should be no more than 3 percent to avoid erosion and other maintenance problems.

Restriction of Motor Vehicle Traffic

As discussed in AASHTO, entrances to shared use paths sometimes need some form of physical barrier to prevent unauthorized motor vehicles from using the facilities. Any solution should take into account emergency access. Consult with your local emergency responders to find a solution that will work.

The first of two alternatives presented in the 1999 AASHTO Guide involves installing posts or bollards in the center and at either edge of the path. A 5-foot minimum spacing is recommended, as this design allows passage by pedestrians and bicyclists but restricts motor vehicle access. Posts should be at least 3-feet high and reflective for nighttime visibility. Only odd numbers of bollards should be used. Even numbered bollards can cause confusion as to which side a path user should pass. Obstruction markings should be provided on the approach.

The center barrier post may be desired to be a drop-down bollard or removable post that will allow entrance by authorized emergency and maintenance vehicles.

Figure 7: Trail Crossing Photo
Source: National Trails Partnership

In addition to reflectors or reflective tape on the barrier posts, several state and local agencies have followed California's lead in recommending 4" yellow pavement striping in an envelope around the posts to assure that their location is well marked and visible to bicyclists, day or night.

An alternative design presented by AASHTO is to split the entry way into two 5-foot paths separated by low landscaping to restrict entry to motor vehicles. One-way offsets encourage reduced speed on the approach, and quick departures. The Ohio Department of Transportation has further refined this treatment as depicted in Figure 28. This design is the preferred treatment in high volume areas where heavy path use may limit a bicyclist's view of the center bollard.

Accessibility

Shared use paths are fall under the accessibility requirements of the Americans with Disabilities Act (ADA) because pedestrians use them. Side paths in a public right-of-way that function as sidewalks should be designed in accordance with the draft Public Rights-Of-Way Accessibility Guidelines (PROWAG) , or future guidance that supersedes PROWAG. Shared use paths built in independent corridors should meet the proposed accessibility standards described in the Architectural Barriers Act Accessibility Guidelines for Outdoor Developed Areas (AGODA), or any subsequent guidance that supersedes AGODA.

Shared Use Paths Adjacent to Roadways (Sidepaths)

A sidepath is a type of shared use path, it is not a sidewalk and has special design considerations for construction and operation. MUTCD does not differentiate between Share Use Path and Sidepath nor does it have a separate definition for Sidepath. AASHTO identifies a shared use path located immediately adjacent and parallel to a roadway as a sidepath. A sidepath is designed differently than a sidewalk.

Figure 8: Sidepath Photo

Source: Adams Dairy Parkway, Blue Springs, MO by MARC.

When two-way sidepaths are located immediately adjacent to a roadway, some operational problems are likely to occur and that other types of bikeways are likely to be better suited to accommodate bicycle traffic along roadways depending on traffic conditions. (1)

A wide separation of the sidepath from the roadway is desirable to demonstrate that the sidepath functions as an independent facility. In some cases, sidepaths along highways for short sections are permissible, given an appropriate level of separation between facilities, not less than 5-foot buffer or physical barrier. Paraphrased, 1999 AASHTO Guide, p. 33-35 (2) (See Figure)

Problems with paths immediately adjacent to roadways are summarized below and discussed in greater detail in AASHTO p 33-35 & 58:

- They require one direction of bicycle traffic to ride against the flow of motor vehicle traffic, contrary to normal rules of the road.
- Bicyclists approaching and leaving the path tend to travel on the wrong side of the street, a major cause of bicycle/motor vehicle crashes.
- At intersections and driveways, motorists entering or crossing the roadway often do not notice bicyclists on adjacent paths. Likewise, motorist turning from the roadway may fail to notice bicyclist traveling in the opposite direction from the norm.
- Signs posted for roadway users cannot be seen by bicyclists traveling against traffic.
- When constructed within a narrow road right-of-way, shoulders are often sacrificed, thus decreasing the safety for roadway users.
- Many bicyclists will use the roadway instead of the shared use path because of convenience or safety. Motorists who believe bicyclists should use the sidepath may harass bicyclists using the roadway.
- Although the share use path should be given the same priority through intersections as parallel roadways. Some motorists mistakenly expect share use path users to yield at all cross streets and driveways. Requiring non-motorized users to stop or yield at every driveway is inappropriate and contrary to rules of the road.
- Stopped vehicles exiting side streets or driveways may block the bike path crossing.
- Barriers are often needed between the path and street, and may create additional obstructions and maintenance problems.
- Bicyclists using a sidepath may conflict with pedestrians and other slower path users.
- Bicyclist flow is complicated at intersections because it is contrary to the normal flow of vehicular traffic; pedestrian flow further complicates this design and creates confusion.

Additional guidance concerning sidepaths is contained in the AASTHO, DRAFT - Guide for the Planning, Design, and Operation of Bicycle Facilities, see Chapter 5: Design of Shared Use Paths.

4.2 TRAFFIC CONTROL DEVICES BIKEWAY SIGNING AND MARKING

The use of appropriate signs and pavement markings will improve the safety and general public acceptance of bicycles on public roadways. Consult the Manual of Uniform Traffic Control Devices (MUTCD) for the latest and most complete set of specifications for bicycle related signs and markings. According to the MUTCD, bicyclist traffic control devices must adhere to the following five basic requirements to perform their intended function:

- Fulfill a need.
- Command attention.
- Convey a clear, simple meaning.
- Command respect of road users.
- Give adequate time for proper response.

The local design, placement, operation, maintenance and uniformity of bicycle traffic control devices must be consistent with MUTCD standards. Uniformity of design includes location, shape, color, symbols, wording, lettering, retroreflectivity and sizes.

The following recommendations are based on input from local government agencies in the Kansas City metro area that expressed a desire for a consistent system of bicycle facility signing, recognizing that individual communities would customize signs to meet their needs.

4.2.1 Local Bicycle Routes

According to the MUTCD, a Bicycle Route Sign (D11-1) shown picture in Figure __ is intended for use where no unique designation of routes is desired. This 24" x 18" sign, green with white lettering, should be placed at intervals frequent enough to keep bicyclists informed of changes in route direction and to remind motorists of the presence of bicyclists.

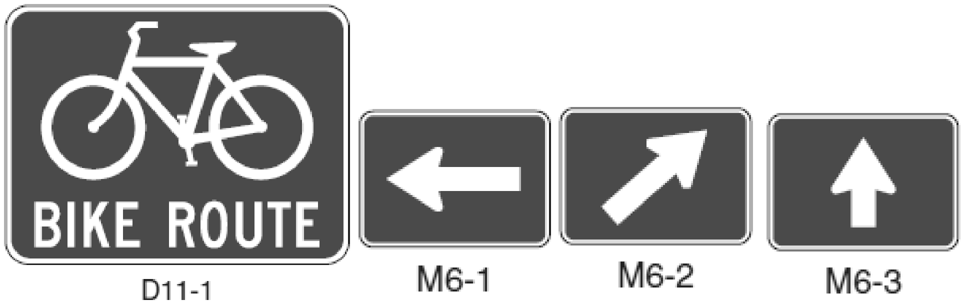


Figure 9: Bicycle Route Sign & Wayfinding Markers Illustration
Source: Chapter 9 MUTCD

Within the Kansas City region, the standard Bicycle Route Sign is recommended for use within local communities to identify local bicycle routes. To provide navigational information, supplemental plaques should be used with Bicycle Route Signs to convey the following information:

- Destination of the route
- Distance to the desired destination
- Direction of travel

As desired or deemed appropriate, supplemental plaques may also be placed above or below the D11-1 for the following purposes:

- To clarify which community a bicycle route serves
- To identify a specific route by local name

4.2.2 Regional Bikeways

An interconnected system of bikeways can be accomplished at a regional level involving multiple jurisdictions. Bicycle networks include both on-road and off-road bikeways.

The MUTCD recommends a Bicycle Route Marker (M1-9) for use where it is desired to establish a unique identification through route designation of a state, regional or local bicycle route. As presented within the MUTCD, the marker should have a numerical designation within a green background on a reflectorized white legend or border. However, due to the multiplicity of jurisdictions responsible for bikeway implementation within the Kansas City metro area, it would be difficult to coordinate a logical and meaningful numbering system across the region that could evolve and expand with new opportunities for bicycle facility construction. For this reason, and because the MUTCD allows for variance in sign design where messages other than those provided in the MUTCD are needed, the following regional signage system is proposed.

Figure 10: MetroGreen Sign Illustration

Source: Mill Creek Trail Johnson County, taken by MARC

"MetroGreen" route markers (see Figure __) are appropriate for use in the following situations:

- Multi-jurisdictional routes that connect one or more communities
- Multi-jurisdictional routes between counties or states
- Segments of the MetroGreen system

Destination (D1-1b, D1-1c, D1-2b, D1-2c, D1-3b, D1-3c) signs can also be used to establish a continuous route that link multiple jurisdictions.

4.2.3 Shared Lane Markings

Shared Land Markings (Figure #) are intended to perform any of several functions (MUTCD):
Assist bicyclists with lateral positioning in a shared lane with on-street parallel parking in order to

- Reduce the chance of a bicyclist impacting the open door of a parked vehicle,
- Assist bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to
- Travel side by side within the same traffic lane,
- Alert road users of the lateral location bicyclists are likely to occupy within the traveled way,
- Encourage safe passing of bicyclists by motorists, and
- Reduce the incidence of wrong-way bicycling

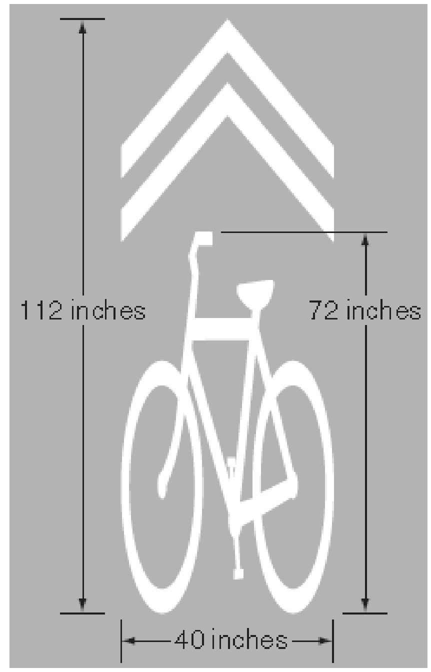


Figure 11: Shared Lane Marking Illustration
Source: See References, MUTCD (6) Section 9C.07)
.

According to the MUTCD, the Shared Lane Markings shall not be used on shoulders or in designated bicycle lanes. If used in a shared lane with on-street parallel parking, Shared Lane Markings should be placed so that the centers of the markings are at least 11 feet from the face of the curb, or from the edge of the pavement where there is no curb. If used on a street without on-street parking that has an outside travel lane that is less than 14 feet wide, the centers of the Shared Lane Markings should be at least 4 feet from the face of the curb, or from the edge of the pavement where there is no curb. If used, the Shared Lane Marking should

Figure 12: Photo Shared Lane Marking

Source: Swift Drive, North Kansas City, Missouri, taken by MARC.

be placed immediately after an intersection and spaced at intervals not greater than 250 feet thereafter. (See References, MUTCD (6) Section 9C.07)

4.2.4 Regulatory and Warning Signs

While some of the guide signs discussed above are variations of standard sign treatments, national standards recommendations for the use of regulatory and warning signs shall be followed as established in MUTCD. Regulatory signs give notice of traffic laws or regulations that bicyclists and motorists must follow. Examples include required signs and markings for bicycle lane designation (see Figure __), no parking signs, stop signs and yield signs.

Figure 13: Bike Lane Sign Illustration
Source: MUTCD R3-17

Warning signs call attention to conditions on, or adjacent to, a bikeway that is potentially hazardous to users. The use of warning signs, which are typically yellow in color, should be kept to a minimum to maximize their effectiveness.

One warning sign now being used is the “Share the Road” sign. This sub plate (W16-1), when combined with the standard W11-1 warning sign is intended to increase bicyclists’ visibility. As a warning sign, “Share the Road” signs alert motorist of the potential presence of bicycle traffic. entering the same vehicular lane space. This sign is not intended to designate a bike route. They are typically used on roadways where bicycle traffic is common. and the lane width is 12 feet or less, or where a bicycle facility is interrupted/encroached forcing cyclists into the vehicular travel lane. Its intention is not to encourage inexperienced bicyclists to ride on the roadway as a preferred route. This sign is especially useful in cities and towns where there are

Figure 14: Share The Road Sign Illustration
Source: MUTCD W11-1 and W16-1P

large numbers of bicyclists riding on streets that may be unsuitable for designation as preferred bicycle routes due to factors such as narrow lanes, high-speed traffic and/or high traffic volumes.

4.2.4.1 Bicycle May Use Full Lane Sign (R4-11)

The BICYCLE MAY USE FULL LANE sign (R4-11) may be used on roadways where the lanes are too narrow for bicyclists and motorists to operate side by side within a single lane. On roadways with significant volumes, following motorists would likely be delayed while waiting for a gap to pass the bicyclist. On such roadways, the BICYCLE MAY USE FULL LANE sign should be considered to inform users that bicyclists have the legal right to claim the lane if the right-hand lane available for traffic is not wide enough to be safely shared with overtaking motor vehicles. MUTCD guidance on the BICYCLE MAY USE FULL LANE sign is provided in section 9B.06. On roadways with frequent passing opportunities, the SHARE THE ROAD SIGN may be more appropriate. (MUTCD)

Figure 15: Bicycle May Use Full Lane Illustration
Source: MUTCD R4-11
.

4.2.4.2 Construction Zones

Construction zones can account for an inordinate amount of the safety and liability problems. This is unfortunate and unnecessary because preparing a detour plan can ensure public safety and minimizes disruption where possible.

Hazards to bicyclists may include: signs, equipment, or debris in the bikeway, blocked access without advance warning, rough pavement or gravel without advance warning, poor pavement transitions, especially when parallel to the line of travel (e.g.: metal plate edges or pavement removal/resurface areas which are not tapered). To address these hazards, it is suggested that detour signs be posted to direct bicyclists to an alternate route. Warning signs alert riders to construction or rough surfaces and debris should be removed regularly. (See Figure #)

According to the MUTCD, the Pedestrian/Bicycle Detour (M4-9a) sign should be used where a pedestrian/bicycle detour route has been established because of the closing of a pedestrian/bicycle facility to through traffic.

If used, the Pedestrian/Bicycle Detour sign shall have an arrow pointing in the appropriate direction. The arrow on a Pedestrian/Bicycle Detour sign may be on the sign face or on a supplemental plaque. The Pedestrian Detour (M4-9b) sign or Bicycle Detour (M4-9c) sign may be used where a pedestrian or bicycle detour route (not both) has been established because of the closing of the pedestrian or bicycle facility to through traffic.

Figure 16: Pedestrian/Bicycle Detour Sign Illustration
Source: MUTCD, M4-9a

4.3 INNOVATIVE DESIGN TREATEMENTS

AASHTO acknowledges that bicycle lanes tend to complicate both bicycle and motor vehicle turning movements at intersections. This problem is further complicated at intersections where the bicyclist is proceeding straight and the motorist is turning right.

This section provides guidance for innovative design treatments. Many innovative treatments involve the use of existing approved MUTCD applications. FHWA has a formal process to allow the testing of new traffic control device or a modified application of an existing device which is explained at the end of this Section.

4.3.1 Bicycle Lane and Bicycle Route Designs

Innovative bicycle design treatments are encouraged where appropriate. Several design variations have been tried in other metropolitan communities. These innovative solutions may be used to solve a problem in a particular location or overcome particular barriers to bicycling.

4.3.1.1 Contra-flow Bicycle Lanes

The objective of contra-flow bicycle lanes is to increase efficiency and safety by shortening trip distances. Contra-flow bicycle lanes have been used in some locations where there is a strong demand for bicyclists to travel against the normal flow of traffic, or to travel in both directions on a one-way street. (See Figure 17) Contra-flow bicycle lanes are especially applicable for use on one-way streets, or where the alternate route is steep, is circuitous or is hazardous.

Figure 17: Contraflow Bike Lane Photo
Source: Seattle Department of Transportation

The City of Cambridge, Massachusetts asks the following questions to evaluate potential contra-flow lane locations.

- Is safety improved because of reduced conflicts?
- Can bicyclists safely and conveniently re-enter the traffic stream at either end of the contra-flow section?
- Is the contra-flow bicycle lane short and does it provide direct access to a high-use destination point?
- Are there no or very few intersecting driveways, alleys, or streets on the side of the proposed contra-flow lane?
- Are there a substantial number of cyclists already using the street?
- Is there sufficient street width to accommodate a full-dimension bicycle lane?
- Will the contra-flow bicycle lane provide substantial savings in travel distance compared to the route motor vehicles must follow?
- Are traffic volumes acceptable?

There are multiple examples of contra-flow bicycle lanes that exist around the country. However, the contra-flow lane should be considered in only certain circumstances.

4.3.1.2 Shared Bicycle/Bus Lanes

Shared bicycle/bus lanes provide dedicated lanes for bikes and buses in areas where it is not feasible to have separate lanes for both modes. The lane is painted or paved with colored asphalt to emphasize the lane designation. The lane should be wide enough to allow cyclists to pass a stopped bus. The right lane is stenciled as a diamond lane, with supporting signage and pavement legends that designate the lane for buses and bicycles only. (See Figure 18)

Figure 18: Shared Bicycle/Bus Lane Photo
Source: Washington Street, New York City, NY taken by Mike Lydon.

Shared bicycle/bus lanes are commonly used in downtowns where it is difficult to find room for dedicated bicycle lanes. Considerations of shared bicycle/bus lanes include: bicyclists must pass stopped buses on the left whether there is a bicycle lane or not; a dedicated bicycle lane is often unnecessary; provides separation of faster and slower moving traffic; bikes and buses travel at approximately the same average speed and travel time for buses and bikes is improved as they are not hindered by congested auto traffic. Disadvantages of shared bicycle/bus lane include: there is a leap frog effect of buses and bikes; if not designed well, or if turning traffic is allowed use of the lane, benefits of the lane will be reduced. Examples currently include Tucson, AZ.; Madison, WI; Toronto, Ontario; Vancouver, BC; and Philadelphia, PA. These lanes often are used as dedicated right turn lanes. Philadelphia, PA colors this shared lane red to add emphasis.

4.3.1.3 Buffered Bike Lanes

The buffered Bike Lane provides additional lateral separation from motorized traffic. A buffered bike lane may also be considered where a bike lane of six or more feet is being provided to meet a minimum level of accommodation. At midblock locations the buffered bike lane is separated from the travel lanes by a chevron marked buffer (Figure 19). The width of the buffer will vary depending upon such conditions as motor vehicle speed, percent heavy vehicles, roadway cross slopes, and desired level of accommodations of bicycles.

Figure 19: Buffered Bicycle Lane Photo
Source: Seattle Department of Transportation

4.3.1.4 RAISED BIKE LANES

The raised bike lane offers bicyclist more positive separation from motorized traffic. The elevated lane can increase rider visibility but this design may not be practical in most urban settings. In the 1995 Oregon Bicycle and Pedestrian Plan, the Oregon Department of Transportation provides the following advantages that raised bike lanes can offer:

- A mountable curb allows cyclists to enter or leave the lane as needed for turning or overtaking;
- Motorists know they are straying from the travel lanes when they feel the slight bump created by the mountable curb; and

- A gentle slope elevates the lane. The strip is painted on the slope, which can increase the visibility of the strip. A tactile surface should be used to avoid a slippery surface. This application is dropped prior roadway intersections.

The disadvantages of this application include greater cost of construction and a narrow paving machine is required.

Figure 20: Raised Bicycle Lane Photo
Source: Unknown

4.3.1.5 Bicycle Boulevards

According to AASHTO a bicycle boulevard is a street segment, or series of contiguous street segments, that has been modified to accommodate through bicycle traffic but discourage through motor traffic. Other definitions like the one provided by the National Association of City Transportation Officials focus on low speed, low volume local street which are optimized for bicycle travel through treatments such as traffic calming and traffic reduction, signage, pavement markings and intersection crossing treatments.

Shared lane markings or share the road signs may be used along bike boulevards. Often bicycle boulevards include bicycle friendly traffic calming treatments (speed pillows, mini traffic circles) to reduce speeds of motor vehicles along the roadway. According to AASHTO bicycle boulevards often include two-way stop-controlled intersections where the number of stops for the bicyclist is minimized. Local motor vehicle access is maintained along the street but may periodicity traffic divert at key intersections. This practice prevents through motor traffic but allows free bicycle movement. The result is a low speed, low motor traffic roadway that is welcoming to bicyclists of all types.

Some portions of a bike boulevard may include bike lanes, wide-curb lanes or paved shoulders where traffic volumes are higher. Through motor vehicle traffic can be discouraged using traffic diverters at intersections. Bicycle boulevards can be created by connecting the ends of cul-de-sac roadways with bikeways. At intersections, the bicycle boulevard should be given priority over side streets. The key to a successful bicycle boulevard is creating a continuous corridor of travel that is inviting to bicyclist.

Additionally, since bike boulevards typically serve as bike routes, way finding signage should be provided. One potential obstacle to implementing bike boulevards is the crossing of major roadways. Improvements to signal timing and detection, or the provision of enhanced crossing treatments (activated beacons, raised medians) where no signals exist, will make a bicycle boulevard more appealing to cyclists.

Another challenge related to bike boulevards is the frequent opposition voiced by local residents. Those who live along the streets being altered are commonly hesitant about the bike boulevard concept. Other motorists who travel on the street may feel the same way because of altered travel patterns for the auto mode. Conversely, there are benefits to the

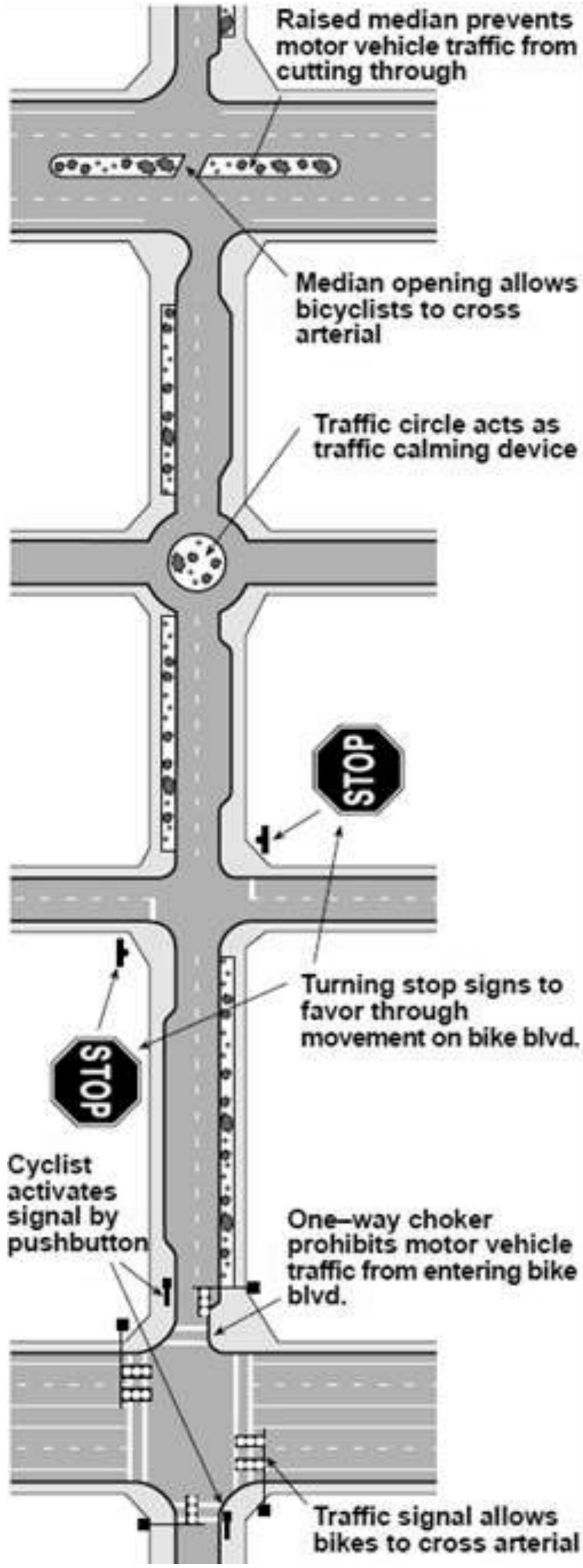


Figure 21: Bicycle Boulevard Illustration
Source: NACTO

communities because the properly applied traffic calming applications can reduce speeding and discourage cut through traffic. The Colorado Department of Transportation *Roadway Design Guide*, the suggest that designers considering the implementation of a bike boulevard should be aware of these considerations and should accordingly plan for early and sustained public outreach to the project's neighbors, communities and municipalities. (See References, CDOT (5))

4.3.1.6 Cycle Tracks

Figure 22: Cycle Track Photo
Source: Washington D.C. taken by Brent Hugh

Cycle tracks are bikeways located on the street between the general travel lanes and the sidewalk. They are distinct from shared use paths in that they are bicycle only facilities. Typically, they are separated from the general travel general travel lanes by on street parking and a physical divider. Cycle tracks at intersections can either incorporate bicycle-only signal phases or utilize "mixing zones" to merge bicycle and motor vehicle traffic. Operationally, they are very challenging particularly at their intersections with driveways and streets. Cycle tracks are applicable bikeway designs on wide, high-volume, high-speed roadways that are on major bikeway. They work best on roads with infrequent cross streets, curb cuts and long blocks. They are often applied on one-way streets.

At this time, there are no national standards for cycle tracks, but research is currently underway to identify best practices. To learn more about cycle tracks visit the NACTO site (www.nacto.org/cycletracks.html)

4.3.1.7 Reverse Angle Parking

Reverse Angle Parking or back-in angled parking is preferable to conventional head-in parking. The motor vehicle operator backs into the angle parking space. Upon exiting the space, the driver has better view of all traffic, especially cyclists. Conventional head-in parking requires the motorist to back into traffic. The approaching bicyclist are in a blind spot and it can be very hard for either the motorist and the cyclist to react in time.

Figure 23: Reverse Angle Parking Photo
Source: Columbia, MO

4.3.2 Intersection Traffic Control Treatments

4.3.2.1 Left Turn Only Bicycle Lane

Left hand turns are often a difficult maneuver for the bicyclists. Some cities have developed left turn bicycle lanes to increase safety and make the left hand turn easier. (See Figure 24) This treatment is especially useful where a signed bicycle route may jog a short distance to another through street.

Figure 24: Left Turn Only Bicycle Lane Photo
Source: flickr taken by gregraisman

4.3.2.2 Mid-block Bicycle Crossing

The objective of a mid-block crossing is to make an off-street bicycle path crossing safer and more visible. Various traffic-calming devices exist such as refuge islands and speed tables, which may be appropriately used at mid-block bicycle crossings depending on the facilities involved and type of treatment.. A mid-block crossing could be suitable for streets with faster moving traffic. Various mid-block crossing designs exist. A typical design may include two four-foot long sections of wide diagonal stripes separated by an eight-foot clear section. Reflective pavement markers are installed on the near side of the crossing in front of each diagonal strip. A bicycle logo and "XING" pavement legend are installed prior to the crossing, at a distance dependent on the roadway design speed along with a bicycle warning sign (W79). The bikeway traffic is controlled with "STOP" signs. (See Figure 25)

Figure 25: Mid-Block Crossing Photo
Source: City of Lawrence, KS

4.3.2.3 Bicycle Medians

It is possible to modify the operation of a local street to function as a through street for bicycles while restricting local access for automobiles. Bicycle medians may be installed on selected bicycle routes to limit conflicts between motorists and bicyclists and give priority to through bicycle movement. (See Figure 26)

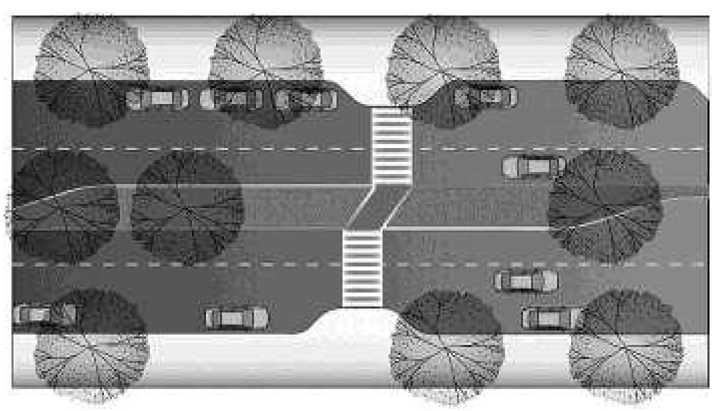


Figure 26: Bicycle Median Illustration
Source: Kimley-Horn and Associates, Inc. ITE Bicycle Medians*,* ODOT Design

4.3.2.4 Bicycle Signals

The objective of providing bicycle signalization is to separate conflicting movements and facilitate the flow of all types of traffic.

Figure 27: Bicycle Signal Photo
Source: City of Alexandria, VA

The city of Davis, California first considered using bicycle signals, which later became standard in California. There are three types of intersections where they are used: Type A, at tee intersections with high bicycle traffic along the top of the tee; Type B, at the confluence of an off-street bicycle path with an intersection; and Type C, where separated bicycle paths run parallel to arterial streets.

The city of Davis programs signal phasing provides for a minimum bicycle green time of 12 seconds and a maximum green time of 25 seconds. Additionally, a two-second all red intervals is provided at the end of this phase as opposed to only one second at the end of other phases. Pedestrian clearance intervals shall be in accordance with the MUTCD. Other treatments included with the installation of the bicycle signal heads include advance-signing warning (BICYCLE SIGNAL AHEAD). The phasing plan prohibits motorists from conflicting with bicycle and pedestrian traffic during the bike phase. (See Figure 27)

4.3.2.5 Modern Roundabouts

The modern roundabout offers safety benefits for motorists, bicyclists, and pedestrians over conventional four way intersections.

A modern roundabout has only 8 vehicle-to-vehicle conflict points and only 8 vehicle-to-pedestrian conflict points. The conventional intersection has 32 vehicle-to-vehicle conflict points and 24 vehicle-to-pedestrian conflict points.

Figure 28: Modern Roundabout Photo
Source: Overland Park, KS

If designed properly, the horizontal deflection of a modern roundabout can constrain speeds from 10 to 20 mph depending on design. As a result, bicyclists are able to match the speed of traffic.

The modern roundabout simplifies transitions between bikeway types, bicycle paths, bicycle lanes and bicycle routes.

The modern roundabout eliminates all left turn movements at an intersection by channeling traffic in a counter-clockwise direction. This vastly simplifies turning conflicts for bicyclists.

At roundabouts, bike lanes are to be terminated 100 feet in advance of the crosswalk or yield line. Bike lanes shall not be marked on the circulating roadway of the roundabout., in accordance with the MUTCD. The bicyclist should be given the option of either taking the lane as any other vehicle or transition from the bike lane termination to the sidepath. When possible the bicycle wraps at a roundabout should be constructed outside the walkway with required detectable warnings at the top of the ramp.

4.3.2.6 Railroad Crossings

When bikeways or roadways cross railroad tracks at grade, the crossing should ideally be at right angle to the rails. The bicyclist has to contend the danger of trapping a tire and approaching traffic from behind. It is best to provide a 90-degree approach because this allows the bicyclist to see approaching traffic while preparing to cross railroad tracks. This can be accomplished either as a separate path or a widened shoulder as shown in Figure 4. This will allow a bicyclist to cross railroad tracks at a right angle (90 degrees) without veering into the path of overtaking traffic. If sufficient width to allow bicyclists to cross at an angle of at least 75 degrees is not possible and where train speeds are low, commercially available flangeway fillers may enhance bicyclist operation. While AASHTO allows for a minimum of 45 degree crossing, this may be insufficient for road bikes with narrow tires. This angle also makes it more difficult to see approaching traffic. The roadway approach should be at the same elevation as the rails (1999 AASHTO Guide for the Development of Bicycle Facilities, p. 60). Warning W10-2 Skewed Crossing signs and pavement markings shall be installed in accordance to MUTCD.

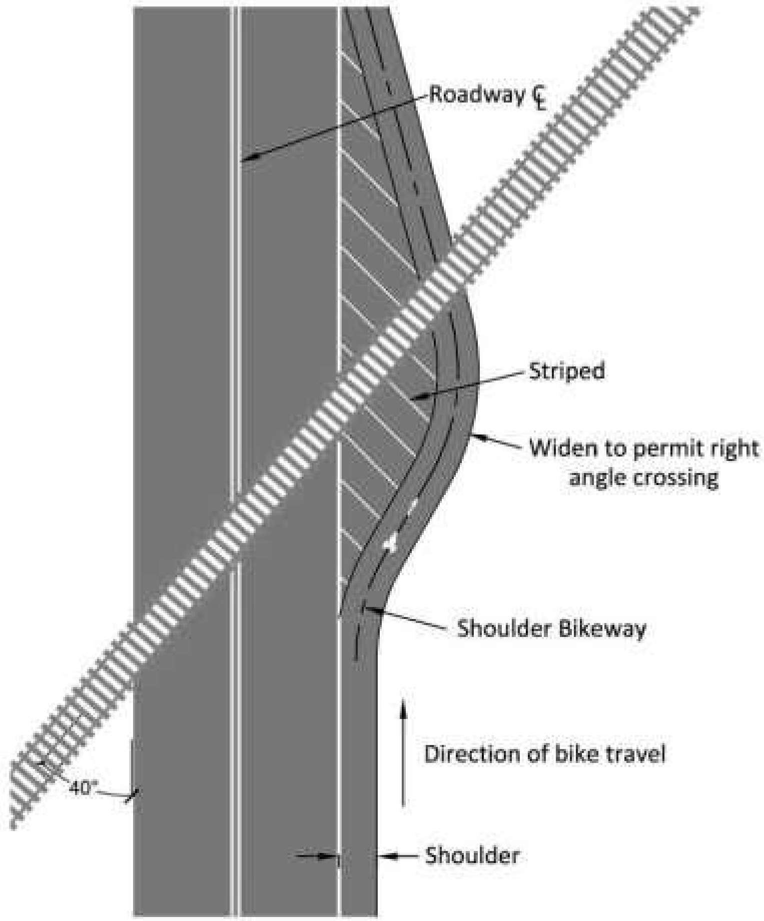


Figure 29: Skewed Railroad Crossing Illustration
Source: AASHTO (1) p. 101

4.4 EXPERIMENTAL AND INTERIM APPROVAL TRAFFIC CONTROL

TREATMENTS

From time to time, a State or local government agency may want to experiment with traffic control treatment. FHWA has a formal process to allow the testing of new traffic control device or a modified application of an existing device. Any device that is not included in or compliant with MUTCD, must be approved by FHWA for experimentation prior to trial. All requests for experimentation should originate with the State/local highway agency or toll operator responsible for managing the roadway or controlled setting where experiment will take place. That organization forwards the request to the FHWA - with a courtesy copy to the FHWA Division Office. For more information on this process visits the FHWA website mutcd.fhwa.dot.gov.

4.4.1 Bicycle Boxes (Experimental)

The objectives of the advance bicycle box are to improve the visibility of cyclists at intersections and to enable them to correctly position themselves for turning movements during the red signal phase by allowing them to proceed to the front of the queue. (See Figure 30)

Figure 30: Bicycle Box Photo
Source: City of Portland, OR

A bicycle lane leading up to a bicycle "reservoir" is located between the motor vehicle stop line bar and the crosswalk. for the bicyclist to queue at a signal. The bicycle box should be 12 to 14 feet deep. If it is shallower, bicyclists tend to feel intimidated by the motor vehicles, and if it is deeper, motorists tend to encroach. To increase its effectiveness, a bicycle stencil should be placed in the bicycle box and a contrasting surface color is strongly recommended for the reservoir and the approach bicycle lane. Instructional signs and separate cyclist signal heads can be installed in conjunction with the bicycle box. This treatment may be used at intersections with high motor vehicle and bicycle ADTs, frequent turning conflicts, and intersections with a high percentage of turning movements by both cyclists and motorists. According to the Department of Environment, Transport, and Regions of Great Britain (DETR) Traffic Advisory Leaflet 8/93, “Advance Stop Lines (ASL)s have been used successfully at sites with motor vehicle flows up to 1,000 vehicles per hour, and with two lane approaches.

A word of caution, the advance bicycle box creates legal issue if not properly designed. Right turning motorists are legally required to approach and turn right from and as near as practicable to the right edge of the roadway, thus any right turning motorist legally approaching the intersection would block the bike lane or the bike box. At signalized locations, this treatment would necessitate the prohibition of right turn on red (RTOR).

Additionally, for the cyclist who approaches intersection onor red may not get positioned in the box prior to the green phase. This will require that the bicyclist merge into traffic while signaling for a left hand turn.

4.4.2 Green Bicycle Lane (Interim Approval Granted)

Figure 31: Green Bicycle Lane Photo
Source: Seattle, WA. SDOT

AASHTO recommends that the dashed bicycle lane striping be continued throughout the right turn merge lane. A green bicycle lane treatment may be used through the transition area of a right turn lane and a bicycle lane. A variety of State and local government agencies have with the approval of FHWA experimented with green colored pavement as a traffic control device to designate locations where bicyclists are expected to operate, and areas where bicyclists and other roadway traffic might have potentially conflicting weaving or crossing movements. On

April 15, 2011 FHWA provided Interim Approval for optional use of the green colored pavement for bicycle lanes Interim Approval allows interim use, pending official rulemaking, of a new traffic control device, a revision to the application or manner of use of an existing traffic control device, or a provision not specifically described in the Manual on Uniform Traffic Control Devices (MUTCD). Appropriate MUTCD signing is also needed in these transition areas to establish right-of-way. Results of the green bicycle lane have been positive and shown to be effective.

Figure 31, shows a bicycle lane that has been painted solid through a right turn merge. This design has decreased motorist and bicyclist conflicts by giving right-of-way to the bicyclists. As bicycle lanes become more common in the Kansas City area, similar lane treatments may be called for. Refer to FHWA Policy Memorandum " MUTCD — Interim Approval for Optional Use of Green Colored Pavement for Bike Lanes (IA-14)" for information concerning conditions of Interim App

5.0 BICYCLES AND SIGNALS DETECTION

AASHTO discusses clearance intervals for traffic signal timing, and states that traffic-actuated signals should be sensitive to aluminum frame bicycles. MUTCD Section 9D.02 Signal Operations for Bicycles provides the following standards. (See References, MUTCD (6))

At installations where visibility-limited signal faces are used, signal faces shall be adjusted so bicyclists for whom the indications are intended can see the signal indications. If the visibility-limited signal faces cannot be aimed to serve the bicyclist, then separate signal faces shall be provided for the bicyclist. On bikeways, signal timing and actuation shall be reviewed and adjusted to consider the needs of bicyclists.

The following guidance is provided to assist designers in the evaluation of signal detection technologies for bicyclists. When a bicycle approaches an intersection, there are several means of detecting and facilitating its movements. Most of the innovations are passive detection devices such as loop detectors and infrared, radar or video detection systems. Other methods are activated, such as the bicycle push-button, similar to that used by pedestrians. Existing technology are being repurposed for bicycle and pedestrian detection. This section is intended to provide practitioners with a range of options.

There are a wide variety of sensor detection technologies which if installed, calibrated and maintained can effectively detect a bicycle. Sensor technologies covered include inductive-loop detectors, magnetometers, video image processors, and microwave radar sensors. Typical applications include traffic signal control, incident detection, and gathering of vehicle volume and classification data to meet State and Federal reporting requirements. These devices are installed either below, above or adjacent to the roadway. For more information, refer to the Traffic Detector Handbook, Publication Number: FHWA-HRT-06-108, May 2006. This resource describes the installation and operation of these sensors in more detail.

5.1 INDUCTIVE LOOP DETECTORS ILD

Inductive Loop Detectors (ILDs) are effective in detecting bicycles provided that the sensors are adjusted properly, the bicycle is magnetically detectable, and the bicyclist passes through the detection zone. A recent FHWA study concluded that the settings and location where a cycle crosses the loop, not the design and installation, are mainly responsible for the poor detection of bicyclist. Research findings recommend use a sensitivity setting of 6 for the loop amplifier wherever possible. The MUTCD Detector Pavement Marking is recommended to communicate positioning.

There are three general types of ILD applications, diagonal quadruple loop quadripole loop and standard loop. Researchers have found that the diagonal and quadripole loop designs are the most effective. .

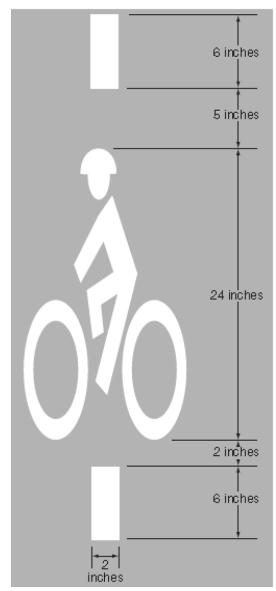
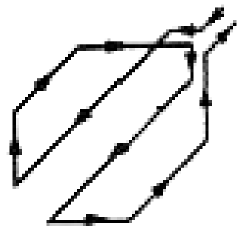


Figure 32: Inductive Loop Detector Symbol Illustration
Source: MUTCD

This pavement marking to the right shows the cyclist precisely where to ride or stop on the pavement to have the magnetic sensor detect the cyclist and request a green signal indication..

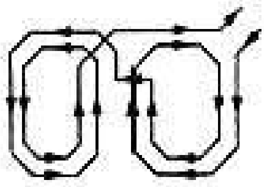
Diagonal Quadripole Loop



Diagonal Quadripole Loop

Due to the sensitivity over the entire width of the loop, the diagonal quadruple is the preferred option for shared roadway situations where the exact location of the bicycle cannot be easily predicted.

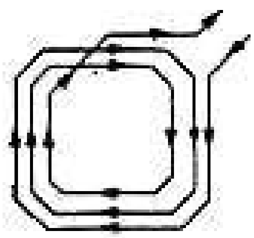
Quadripole Loop



Quadripole Loop

The recommended loop type for use within bicycle lanes is the quadruple. This design detects most strongly over the center wires and is relatively insensitive to vehicles in adjacent lanes.

Standard Loop



Standard Loop

Standard loops are least desirable for detecting bicycles because they are most sensitive over the wires that form the outer edge of the loop. Unless bicyclists know exactly where to position themselves over the loop, they will not be detected.

Figure 33: Inductive Loop Detectors Illustration

Advantages of this technology:

- It is a reliable and proven technology

Disadvantages of this technology:

- The calibration of this technology for bicycle detection is challenging.
- Retrofitting is expensive

5.2 VIDEO DETECTION

Video image processors are used to activate treatments such as signal timing specifically needed to assist bicyclists to cross at signalized intersections. This system is useful at signalized intersections where there are dedicated bicycle lanes. The video system uses detectors drawn in video images to sense the presence of bicycles in bicycle lanes at signalized intersections.

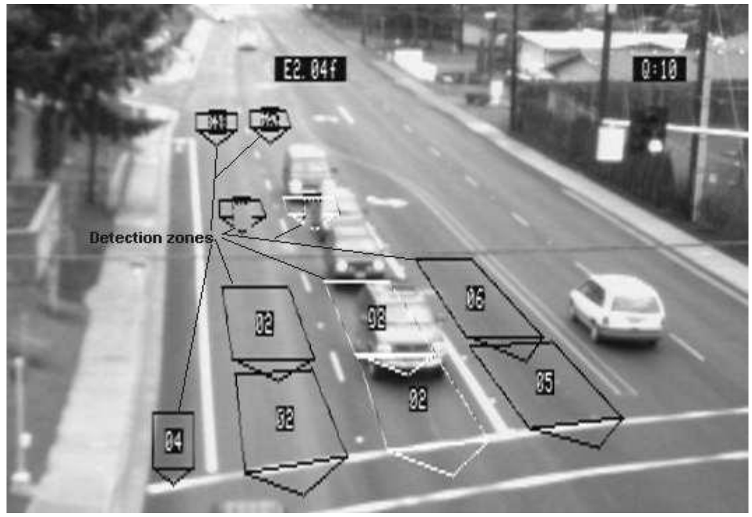


Figure 34: Video Layout Image
Source: City of Salem, OR

Figure 34 shows the layout of bicycle lane loops drawn in a video image on the approach to a signalized intersection. The computer system is capable of sensing up to 60 different detection zones within a single intersection for a cost comparable to loop detectors buried within the pavement. The loops to detect motorized vehicle traffic are also shown. Areas labeled 04 are bicycle lane detection zones.

Advantages of this technology:

- Special signal timing can be activated to allow bicyclists sufficient time to cross the intersection. This treatment enhances safety for this mode of transportation.
- It will detect bicycles that do not contain iron, unlike loop detectors.
- It is not affected by asphalt work and may be used to help direct traffic during construction.
- Easily adjustable and cost effective solution.

Disadvantages of this technology:

- Weather conditions such as thick fog and blinding sunlight, as well as shadows can reduce the effectiveness of the camera.

5.3 REMOTE TRAFFIC MICROWAVE SENSOR DETECTION (RTMS)

Microwave sensors detect bicycles at signalized intersections using frequency modulated continuous wave radio signals that detect objects in the roadway. This method can detect slow moving or stopped vehicles unlike Doppler. It is also marked with a time code, which gives information on how far away the object is. This technology can also be used to count vehicles. Many new systems have storage and data download capabilities to remote locations.

Advantages of this technology:

- Can detect slow moving or stopped objects.
- Not affected by extremes in light or temperature, weather conditions such as fog that may obstruct video cameras, or road/utility work.
- RTMS can detect bicycles that do not contain iron.
- The waves refract around large vehicles so smaller vehicles are still “visible.”

Disadvantages of this technology:

- Microwave systems may be more expensive than standard loops.

5.4 BICYCLE PUSH BUTTON/BAR

The bicyclist activates the signal by pushing a bar or button similar to those used for pedestrians, but the button is installed in a location convenient for bicyclists and the signal timing is set appropriately for bicyclists. The sign plate located above the push button/pad/bar indicates that it is not for the use of pedestrians. (See Figure 35) The larger the surface of the button, the easier it is for cyclists to use, thus a push pad is preferential to a push button, and a push bar is preferential to a push pad, as it can be actuated without removing one’s hands from the handlebars.

Advantages of this technology:

- Allows separate signal timings for different user needs

- Usually less expensive than other detection treatments

Disadvantages of this technology:

- Location of push button does not, in most cases, allow the bicyclist to prepare appropriately for through or left turning maneuvers at the intersection.
- Forces the bicyclist to stop completely to actuate the signal.

Figure 35: Bicycle Push Button Photo
Source: flickr by Richard Drdul

Fine-tuning existing traffic detection systems may also improve bicycling conditions. Signal timing should include a minimum green time that allows cyclists to remount their bikes and travel across the intersection, and a yellow/red time that provides a safe bicycle clearance interval. Generally, 2 – 3 seconds added to the minimum automobile green time is appropriate; a yellow interval of 3.0 to 6.0 seconds offers sufficient time for a cyclist to come to a complete stop or enter the intersection legally; and an all-red clearance interval greater than 2.0 seconds is needed to clear bicycles from most intersections.

6.0 BICYCLES ON BRIDGES, VIADUCTS AND OVERPASSES

The U.S. DOT Policy Statement, Accommodating Bicycle and Pedestrian Travel: A Recommended Approach, states: "A bridge that is likely to remain in place for 50 years should be built with sufficient width for safe bicycle and pedestrian use in anticipation that facilities will be available at either end of the bridge even if that is not currently the case." Design bridges with sidewalks and shoulders or bike lanes on both sides of the structure. Viaducts and overpasses/underpasses should also be designed to accommodate bicyclists and pedestrians.

Bridges, viaducts and overpasses should accommodate bicycles, even where bicycle accommodation is not available on the approach roadway. The exception to this is roadways where bicycle access is prohibited. Shoulder improvements associated with bridge projects (approach shoulders) should include bicycle accommodations, such as paved shoulders or bike lanes.

The type of bicycle accommodation should be determined in consideration of the road function, length of the bridge or tunnel (i.e., potential need for disabled vehicle storage), and the design of the approach roadway. In most cases (except for those cited below), the bicycle facility will be separated from the pedestrian facility (sidewalk). In cases where a bridge on a controlled access freeway impacts a non-controlled access roadway (e.g. an overpass/underpass that impacts an existing surface roadway), the project should include the necessary access for bicycles on the non- limited access roadway, including such elements as bike lanes, paved shoulders, wide sidewalks, and bicycle crossings at associated ramps. Access from adjoining streets should be as direct as possible to reduce out-of-the-way detours for bicyclists, and designs should endeavor to minimize conflict points at entrances and exits.

Bridges, viaducts and overpasses must be properly designed to provide safe, accessible approaches, with sufficient space for bicyclists to navigate ascents and descents, and safe riding surfaces that take into consideration expansion grate design and seam placement that minimize hazards to bicyclists. Bridges should also be well-lit.

Figure 36: Sidepath Along Bridge Photo
Source: Kansas City, MO taken on Heart of Amercia Bridge by MARC.

In locations where bicyclists will operate in close proximity to bridge railings or barriers, the railing or barrier should be a minimum of 42 inches (1.05 m) high. On bridges where bicycle speeds are likely to be high (such as on a downgrade), and where a bicyclist could impact a barrier at a 25 degree angle or greater (such as on a curve), a higher 48- inch (1.2 m) railing should be considered. If the shoulder is sufficiently wide so that a bicyclist does not operate in close proximity to the rail, lower rail heights are acceptable.

On bridges with a continuous span over 1/2 mile (0.3 km) in length and speeds that exceed 45 mph, consideration should be given to providing a shared use path separated from traffic with a concrete barrier, preferably on both sides of the bridge. If there are often sudden changes in roadway geometry that will significantly reduce travel lane widths and negatively impact bicyclists' safety and comfort, the preferred solution is to provide shoulders or bike lanes by narrowing travel lanes.

6.1 UNDER BRIDGES

Major river bridges should be designed to allow bicyclists and pedestrians to travel along the rivers and under the bridges. Several options are available for accommodating bicyclists on bridges or on roads that cross under bridges. In urban and suburban areas, a 4-ft striped area (unmarked or marked as bike lanes) should be included in the basic design. Alternatively, wide outside lanes should be provided.

As with bridges and overpasses, safe accommodation should be made for bicyclists to use roadway underpasses to prevent impediment to free movement across freeways, railways, and other barriers. Access from adjoining streets should be as direct as possible to reduce out-of-the-way detours for bicyclists, and designs should endeavor to minimize conflict points at entrances and exits. Absence of bicycle facility on approaches should not prevent bicycle accommodation within the underpass.

New roadway tunnels and underpasses should incorporate planning to accommodate bicyclists. General design standards for bicycle facilities should apply, but consideration should be given to providing significant extra width for shy distance from walls or other barriers. Bicyclist speeds will be affected by grade, and extra width may also be needed on steep grades. Adequate vertical clearance should also be provided.

6.2 TRANSITION AREAS

Abrupt changes in the pavement width of the right travel lane or shoulder should be discouraged. While skilled bicyclists will ride in a straight line by guiding off the lane stripe, many riders will unpredictably move right or left as the lane or shoulder widens or narrows. Where bike lanes, wide curb lanes or paved shoulders are discontinuous across bridges or through other squeeze points such as interchanges, share the road signs may be appropriate. Activated beacons associated with the STR assembly may enhance their effectiveness.

Special transition problems frequently occur at bridges and structures, either when traffic lanes merge to cross a narrow bridge, or when a narrow roadway approaches a new, wider bridge. In the first situation, warning may be provided to both bicyclists and motorists by using the standard MUTCD W5-2 “Narrow Bridge” sign in advance of any bridge or culvert having a roadway clearance less than the width of the approach pavement.

Figure 37: Narrow Bridge Sign Illustration
Source: MUTCD, W5-2

An additional treatment for unavoidable obstacles such as narrow bridges is to use zebra warning striping on the bridge shoulders, as recommended by the New Jersey DOT and depicted in Figure 38 to the left. The stripes function to divert motor vehicle traffic away from the bridge parapet thus providing additional operating space on the right-hand side of the bridge for cyclists.

For the second situation, safe bicycle passage may be accommodated in the transition from a wide structure to a narrow roadway by continuing the extra operating width of the bridge shoulders or wide outside lanes for at least 100 feet on either side of the bridge. If on- or off-ramps or intersections are present, the paved shoulder or wide curb lane treatment should continue at least as far as the ramps or intersection.

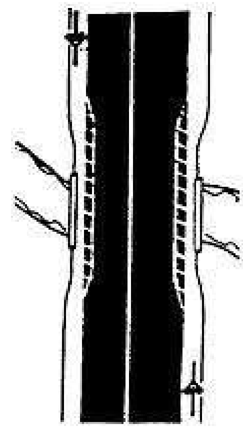


Figure 38: Narrow Bridge Illustration
Source: MUTCD, W5-2

The best way to avoid transition problems is to design adequate width into the bridge during construction. Several new bridges in the greater Kansas City area have accommodated bicycle traffic in this way and at the same time improved conditions for motorists.

7.0 STREET UTILITIES

A critical step to making the Kansas City regional area a more bicycle-friendly region is to embrace the concept that every street is a bicycling street.

To varying extents, bicycles will be ridden on all roadways where they are permitted. All new roadways except those where bicyclists will be legally prohibited, should be designed and constructed under the assumption that they will be used by bicyclists. (See References, AASHTO (2) Page 1)

Planners should investigate the opportunity to make at least minor or marginal improvements to bicycle travel. Designing, constructing and retrofitting roadways to better accommodate bicycle use means mitigating basic hazards to bicycle travel. These potential hazards include wheel-eating drainage grates, railroad crossings, unresponsive traffic signals, general spot improvements and enhanced maintenance practices. For the most part, the mitigation of hazards is inexpensive and can be accomplished within routine maintenance and improvement schedules and budgets.

Hazard mitigation and roadway maintenance practices are addressed in the 1999 AASHTO Guide for the Development of Bicycle Facilities on pages 60, 64 and 73.

7.1 DRAINAGE GRATES AND UTILITY COVERS

Drainage grate inlets are potential problems to bicyclists. Parallel bar drainage grates are the worst design because they tend to trap bicycle tires.

Utility covers and drainage grates should be installed to be flush with the pavement. New roadway construction should consider the use of curb inlets as opposed to gutter pan drop inlets.

Most state transportation departments and many local governments have eliminated use of the parallel bar drainage grate and instead substitute bicycle-friendly and hydraulically efficient inlets such as those depicted in Figure 39.

On new construction, curb inlets are preferred to grate inlets wherever possible. When grate inlets are installed, they should not be of the parallel-bar design.

Figure 39: Bicycle Safe Drainage Grates Photo
Source: FHWA-SA-09-024

A program for identifying and replacing existing parallel-bar grates should be a high-priority of any local jurisdiction that seeks to mitigate hazards to bicyclists. At a minimum, the temporary correction recommended by AASHTO should be undertaken in popular bicycling corridors. This interim solution involves welding steel cross straps perpendicular to the parallel bars at 4” center-to-center maximum spacing to provide a maximum safe opening between the straps, or retrofitting the grates with prefabricated cross bars or welded wire fabric. The welded bars or retrofitting with prefabricated cross bars should be installed flush with the pavement to avoid creating a new hazard for cyclists. Obstruction warning markings should be placed on the pavement in advance of grates that are not bicycle friendly.

The previously discussed hazards should be mitigated on all roads to be used by bicyclists. As stated in AASHTO, "The majority of bicycling will take place on ordinary roads with no dedicated space for bicyclists. Bicyclists can be expected to ride on almost all roadways." Therefore, hazard removal should occur on all roadways except for freeways where bicycle travel is prohibited by law.

8.0 BIKEWAY TRANSITIONS

A bikeway network is made up of all facility types and wayfinding signs. Transitions between designs are critical to create seamless connections. Transitions between facility types should be functional and intuitive. A corridor may have transitions from a shared roadway marked with shared lane markings to a narrower lane that is signed with BICYCLE MAY USE FULL LANE sign or share the road sign, to a paved shoulder to a bike lane, to a shared use path. Transitions are necessary to provide connectivity the bikeway network.

9.0 PRINCIPLES AND APPROACHES FOR ROADWAY DESIGN AND RETROFITS

Existing roadways may be retrofitted to improve bicycle accommodations by either widening the roadway or by reconfiguring the existing roadway. On busier or higher-speed rural roads, paved shoulders can be added to improve comfort for bicyclists. On urban (curbed) roadways, it may be possible to better accommodate bicyclist by reconfiguring travel lanes. AASHTO (1)

There are a number of retrofitting approaches that should be considered with trying to improve conditions for bicyclist. Below are some of the most common approaches.

Widen Roadway

- During reconstruction projects the widening of roadway may be an option to incorporate wide curb lanes or bike lanes.

Reduce Travel Lane Width

In some situations, the travel lane width may be reduced allowing for the reallocation of roadway pavement to an outside wide curb lane or bike lane. Practitioners should consult the AASHTO, A Policy on Geometric Design of Highways and Streets, for further guidance.

Reduce Number of Travel Lanes

In situations where there are four lanes of traffic (two in each direction), and a significant number of left-turn movements, consider the possibility of re-striping for a continuous left-turn lane, two travel lanes .with the remaining pavement to provide some form of improved bicycle accommodation in each direction.

Remove Parking Lanes

A roadway's primary function is to move people and goods. It is not to store stationary vehicles. In some cases, parking may only be needed on one side to accommodate residences and/or businesses. Parking can sometimes be narrowed to 7 ft adjacent to a bicycle lane, particularly in areas where traffic calming is being considered. A strategy to add bicycle lanes is to convert diagonal parking to parallel parking. If angle parking is desired consider reverse angle parking as an option to improve safety for cyclist. (See Section 4.3.1.7 Reverse Angle Parking)

Removal of Obstructions

Some older paved or landscaped traffic islands/medians reduce roadway width unnecessarily. If not needed for access control, removal and replacement of raised median islands with pavement markings can often add several feet of useable width. Relocating utility poles, guardrails and other obstructions away from the edge of the roadway can create additional width.

Generally, the safety of motorists and bicyclists is not compromised with the modifications listed above, as the total pavement width stays the same or is wider. In many cases, safety is enhanced as motor vehicle lanes are offset away from curbs, all travel lanes are better defined, and parking is removed. Adding bicycle lanes, wide curb lanes or paved shoulders often can improve sight distances and increase turning radii at intersections and driveways.

Not all existing roadway conditions will be as simple to retrofit as those listed above. In many instances, unique and creative solutions will have to be found. Width restrictions may only allow for wider curb lanes (13 to 16 feet) to accommodate bicycles and motor vehicles.

It is also important that every effort be made to ensure bikeway continuity. Practices such as directing bicyclists onto sidewalks should be avoided, as they may introduce unsafe conditions.

9.1 BIKE LANE RETROFITS

The built roadway system contains a host of design variations that simply cannot be accounted for in this document. The examples below provide potential solutions to retrofitting selected roadways. As with all design treatments, jurisdictions must evaluate traffic conditions and roadway characteristics on a case-by-case basis. None of the examples below should be implemented until a traffic study verifies the appropriateness of the change.

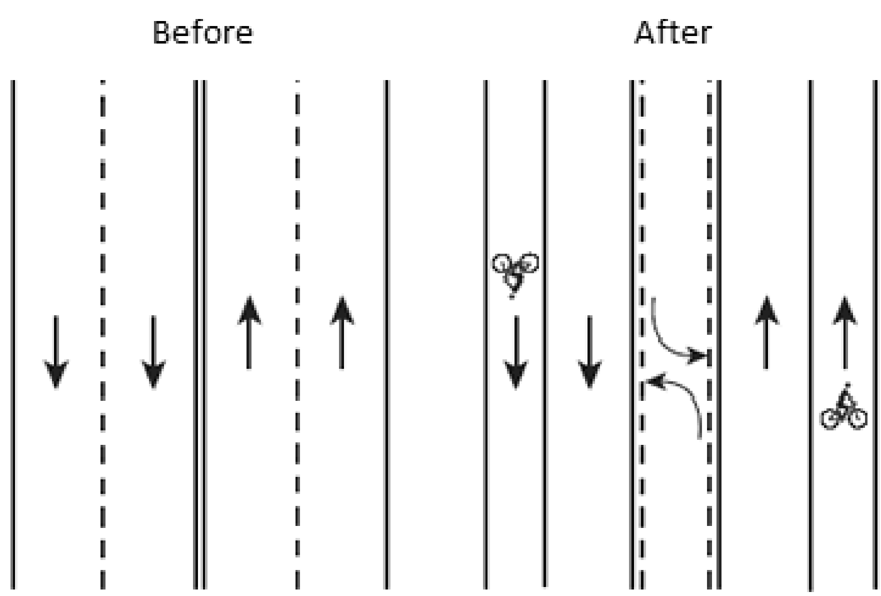


Figure 40: Arterial Road Diet Illustration
Four-lane arterial roadway re-stripped from four travel lanes each 11' reduced to two travel lanes each 11', with a 12' center turn lane and two 5' bike lanes. (Not to scale)

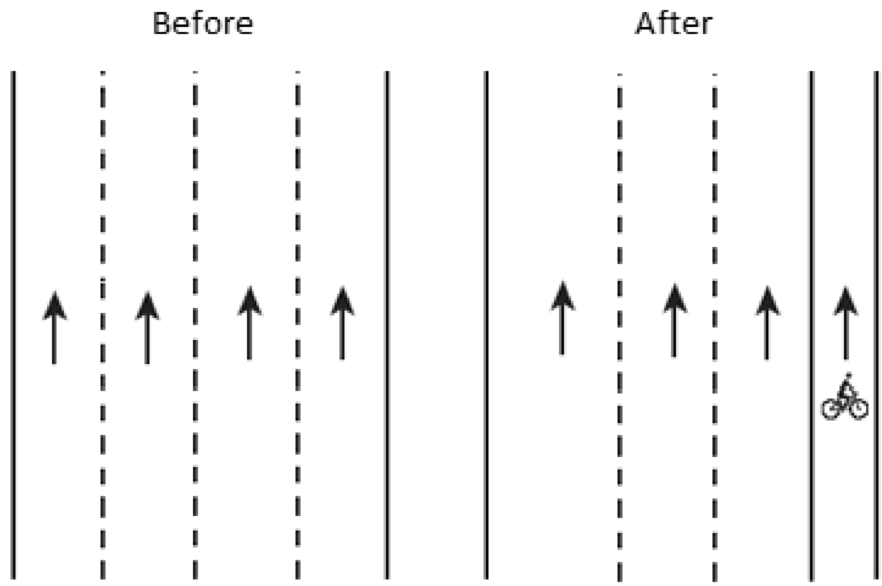


Figure 41: Arterial Road Diet Illustration
Four-lane arterial roadway re-stripped from four 11’ one way travel lanes to one 14’ lane, two 12’ lanes and one 6’ bike lane. (Not to scale)

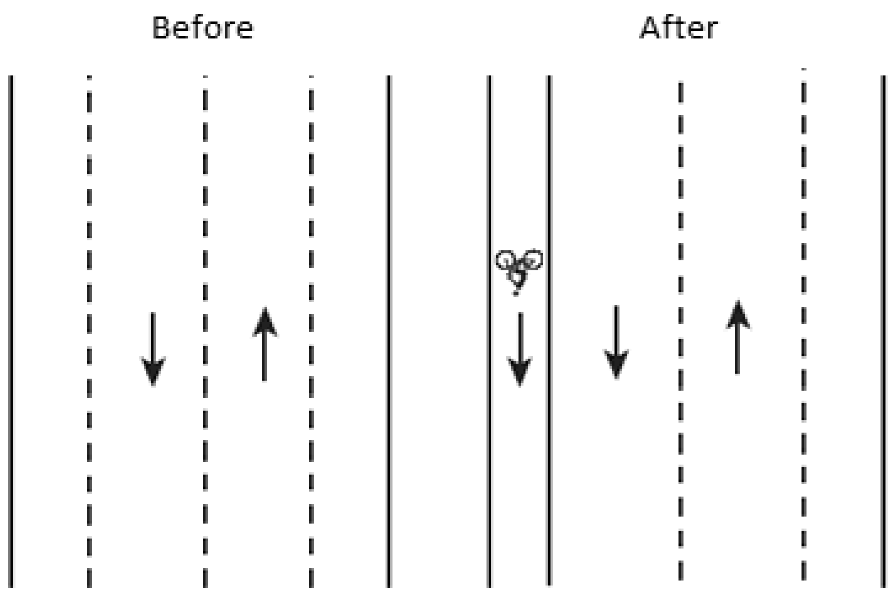


Figure 42: Collector Road Diet Illustration
Two-lane collector roadway re-stripped from two 12’ travel lanes with two 10’ parking lanes to two 12’ travel lanes with two 6’ bike lanes and one 8’ parking lane. Parking is removed on one side of a two way street. (Not to scale)

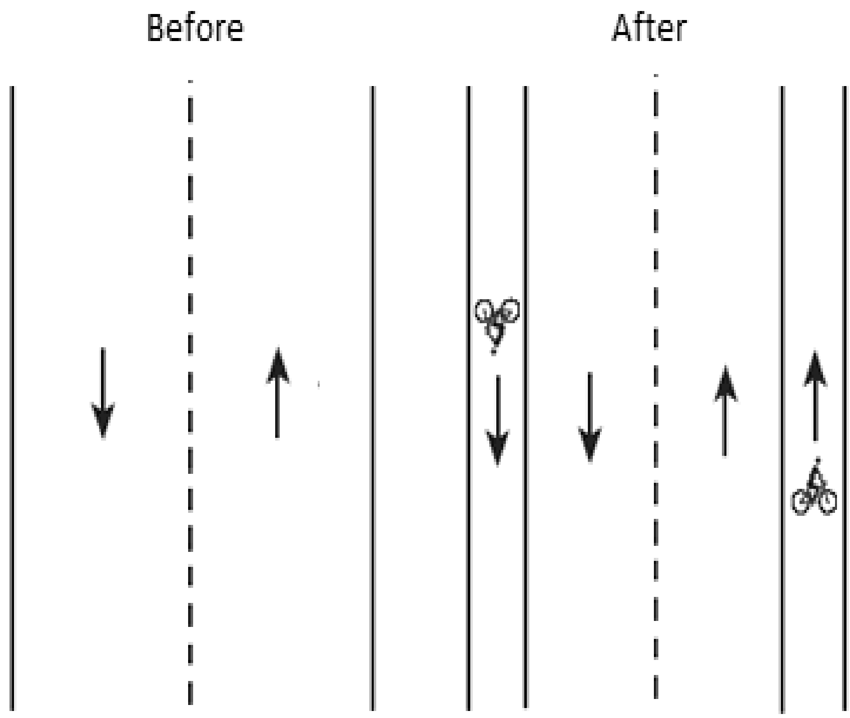


Figure 43: Collector Road Diet Illustration
Two-lane collector roadway re-stripped from two 16' to two 12' travel lanes and two 4' bike lanes. (Not to scale)

10.0 BICYCLE PARKING

Bicycle parking is recognized as part of the vital infrastructure system essential to encourage bicycle transit as a viable transportation choice. This section discusses the need for bicycle parking accommodations not only as it relates to destinations but also as public transportation. In recent years, the public transit providers have begun adding bicycle racks on buses so that riders can approach their final destination through a multi-modal public transit system. As access to various destinations improves and cycling is encouraged, bicycle parking becomes an ever-larger component.

Responsibility of the implementation of bicycle parking improvements is the responsibility of both government and private enterprise. The Mid-America Regional Council encourages local jurisdictions to consider adopting bicycle ordinances to address new development.

Bicycle parking needs vary by type and duration of use and location. There are many useful types of facilities on the market, which all fall generally into three categories (discussed below). Several of the following factors are common to all acceptable bicycle-parking installations:

- Good support of the bicycle
- Security - capacity to lock the frame and both wheels
- Ease of use
- Durability
- Visibility of site
- Convenience to destination
- Compatibility with site conditions
- Attractiveness

Several of the following designs cannot be recommended for most public locations:
Racks that are very low to the ground do not properly support the bicycle, are difficult to attach a locking device to and pose a potential tripping hazard to pedestrians.

Variations of the traditional "school rack" generally only support the front wheel and therefore do not provide stability or security to the rear components of the bicycle. This lack of durability may allow bicycles to fall over and would require a longer chain or cable to secure all components of the bicycle. Some bicycle rack models are not capable of accommodating all types of bicycles i.e. wider wheels of "mountain bikes."

10.1 CLASS I

Class I parking structures provide long term, high security parking protection from theft, vandalism and weather; bicycle lockers or attended covered parking are example (See Figure 45). Bicycle lockers are generally rectangular enclosures with the capacity for storage of one or two bicycles. Materials currently in use for locker construction include particleboard, fiberglass, galvanized steel and stainless steel. Fiberglass and steel are the most durable. Frame and hardware construction should be durable and designed appropriately for the weather conditions of the Kansas City region.

Bicycle lockers provide the highest level of security for bicycles and are appropriate for use where daylong or longer storage is needed on a regular basis. Bicycle lockers are generally rented and/or reserved in advance for any period typically varying from one month to one year, therefore, some program of maintenance must also be implemented. This class requires the most land area of any bicycle parking facility.

Figure 44: Class I Bicycle Parking Photo
Source: City of Blue Springs, MO

10.2 CLASS II

Class II parking provides medium security protection against theft but not against weather or vandalism. Both wheels and the frame are secured to the rack or post with a simple user supplied lock, but without the need for cables or chain (See Figure 46). Several companies market bicycle-parking racks that allow all three major components of the bicycle - back wheel, front wheel, and frame - to be locked, without the removal of the front wheel. The users must usually only supply the appropriate padlock or U-lock. These racks usually have either attached cables or moving parts that enclose the bicycle parts. They generally are designed to provide stable support for the bicycle. The proper use of these devices is not always immediately apparent, so their installation is best reserved where repeat and longer-term use is anticipated.

Figure 45: Class II Bicycle Parking Photo
Source: Unknown

These facilities provide a very high level of security for the bicycle, although accessories and some components are still vulnerable to theft or vandalism. This type of design is a good choice for places of employment, schools, transit access points and any other location where bicycles may be left for several hours with minimum supervision.

10.3 CLASS III

Class III parking provides minimum-security "bicycle racks" or fixed objects that protect against theft but only in conjunction with a user-supplied cable, chain and lock. Racks are more likely to cause damage to bikes due to crowding. Many varieties of stands and racks fall into the Class III category of bicycle parking. Many types of hitching posts, rails, inverted "U's," and "ribbon" racks are commercially offered. As a cost saving measure, some municipalities and private employers have designed, constructed and/or fabricated variations of this type. The popular "ribbon" rack is used extensively for its attractiveness and ease of installation. Common properties of Class III facilities include its support of the bicycle with or without the front wheel removed, visual aesthetics and post or pipe dimensions which will allow use of a U-lock.

Figure 46: Class II Bicycle Parking Photo
Source: City of Memphis, TN .

These facilities are recommended for short-term parking, although in combination with other amenities (such as shelter from the weather) they can be adequate for long-term storage. The various posts and inverted U designs have the advantage of maximum sitting flexibility. They can be grouped or provided for one or two bicycles, as necessary.

10.4 SHORT-TERM VS. LONG-TERM BICYCLE PARKING

Provide short-term bicycle parking for shoppers, customers, messengers and other visitors who generally park for two hours or less. Class II or III facilities are appropriate in this case. A good rule of thumb is that short-term parking should be located within 50 feet of a main entrance of the destination with an adequate number of spaces. It is a good idea to distribute short-term parking where there is more than one building on a site, or where a building has more than one main entrance; distribute the parking to serve all buildings or main entrances.

Provide long-term bicycle parking for employees, students, residents, commuters and others who generally stay at a site for several hours. This parking is typically more secure and weather-protected than short-term parking. Class I or II bicycle parking facilities are most appropriate for long-term parking.

Figure 47: Long-term Bicycle Parking Photo
Source: League of American Bicyclist

10.5 BICYCLE PARKING LOCATION

The location of bicycle parking should be determined first. This location should meet the needs of potential users. Lack of adequate bicycle parking facilities and fear of theft are major deterrents for all bicyclists. The visibility of parking and ability of the rack to secure the bike are two important considerations.

Locate bicycle parking near destinations in convenient locations. High priority destinations include recreational destinations, schools, and universities, places of employment and commercial/retail centers. Conversion of auto parking spaces to bicycle parking allows six to eight bicycles to park in the space as one car. Do not block access or face the facility in the wrong direction.

Additional Considerations

There are several additional features of bicycle parking improvements that can increase their attractiveness to users. Weather protection (roof or canopy) can greatly enhance any Class II or III facility, which is for commuting or other long-term uses. Placing facilities in high traffic areas or where they are visible to an attendant will improve security.

11.0 MAINTENANCE AND OPERATION PRACTICES

General

A plan for operation, maintenance and policing of bicycle facilities should be established prior to facility construction. This plan should include who is responsible for maintenance, the practices that will be used and the frequency of maintenance operations. Due to the nature of the vehicle, bicycle tires often have more sensitivity to pavement debris and bumps than an automobile. It is important to keep this in mind when planning a bicycle facility.

Sweeping

Shoulders and other bicycle facilities should be kept free from gravel, sand, glass, leaves, and other roadway debris. Sand or gravel are often used to increase vehicle traction in snow and ice conditions. Where possible, maintenance policies should consider using salt or other environmentally friendly products that do not accumulate on roadways and bicycle facilities. If sand or gravel must be used, the bicycle facilities should be swept as soon as possible after the storm event. Bicycle facilities in wooded or waterway areas should be regularly cleared of leaf debris. Sweeping should be required after the completion of all surface maintenance repairs.

Surface Repairs

Hazards to bicycle travel include gaps in longitudinal paving joints, potholes, bumps and other pavement surface irregularities, which may be eliminated through maintenance repairs. Bicycle facilities should be regularly inspected for surface irregularities and corrected as soon as possible. When making repairs, care should be taken to eliminate longitudinal joints from the traveled bikeway. Surface repairs can be minimized by building the pavement to high standards.

Pavement Overlays

When overlaying pavement, it is necessary to 1) extend the overlay for the full width of the pavement and the bicycle facility or 2) end the pavement overlay at the shoulder or bike lane stripe to prevent pavement ridges in the middle of the bike travel area. If option 2 is selected, care should be taken to not leave a ridge between the automobile lane and the bicycle facility. When overlaying pavements, no more than ¼" elevation change between a grate or utility cover and the surrounding pavement surface should be allowed.

Vegetation

Vegetation around bicycle facilities should be pruned to allow 8' vertical clearance and 2' horizontal clearance on either side of a bicycle facility. Proper sight distances should be maintained wherever a bicycle facility intersects with automobile access points. Localities might consider adopting ordinances requiring adjacent landowners to prune vegetation encroaching into the bicycle facility clearance area.

Signs and Markings

Signs should be regularly inspected to ensure legibility and retro-reflectivity. A regular replacement program should be followed for signs that are damaged or lose legibility. Pavement markings should also be regularly updated to allow automobile and bicycle operators to know where bicycle facilities are located.

Snow Clearance

Wherever possible, maintenance jurisdictions should keep bicycle facilities and sidewalks free of snow piles and stored snow. If a shared use path is used by commuters, it is recommended that this facility also be free of snow.

Maintenance Reporting

Bicycle facility operators should consider having a reporting mechanism in place that allows facility users to report maintenance concerns. The City of Kansas City uses their "3-1-1 Action Center" for people to request maintenance concerns. These concerns are then handled by their Bicycle Pedestrian Coordinator. A reporting mechanism could include phone, internet, and/or postcards to allow citizens to easily report concerns. Concerns should be addressed as soon as possible to prevent future problems.

Additional best practices for maintenance and operations can be found in Chapter 7 of the DRAFT AASHTO Guide for the Planning, Design, and Operation of Bicycle Facilites.

12.0 TECHNICAL ANALYSIS TOOLS AND MODELS

This section convers a number of important tools and modals developed assist designers in the planning, programming and continued evaluation of bikeway facilities.

12.1 BICYCLE COUNTS

State and local governments are increasing efforts to collect counts of bicyclists and pedestrians on roadways and pathways. Collecting baseline data is needed to measure benefits and prioritize investments for walking and bicycling, and transit service links. The primary intended uses for the data include but are not limited to:

- Trend analysis – document the number of people bicycling or walking over time and changes in demand
- Demographic analysis – develop correlations between bicycle and pedestrian activity and population characteristics
- Air-quality analysis – evaluate the air-quality benefits of investments towards bicycle and/or pedestrian infrastructure
- Crash analysis – develop exposure measures
- Validate and calibrate models – compare with real world counts with predictive models

Manual Counts - Communities that perform manual counts are strongly encouraged to follow the methodology recommended by The National Bicycle and Pedestrian Documentation Project. In order to estimate existing and future bicycle and pedestrian demand and activity, agencies nationwide have begun to conduct counts and surveys in a consistent manner. By following the similar methodology, data collected may be comparable between communities and over time.

Automated Counts -Some communities may decide to collected counts with automated technologies. There are some advantaged to this approach. For example, automated counts can be conducted over longer durations that allow for more robust analysis of variations in daily, weekly, or monthly changes. This approach may be more cost effective in reducing personnel cost. A variety of technologies are used for both pedestrian and bicycle counts.

For more information about manual or automated bicycle counts please visit (bikepeddocumentation.org) . Several resources are available for free download.

12.2 HIGHWAY CAPACITY MANUAL MULTIMODAL LOS

The Highway Capacity Manual (HCM) 2010 incorporates a multimodal Level of Service LOS approach that includes: Auto, Transit, Bicycle and Pedestrian levels of service. LOS is reported separately, by mode, for given system elements. The *bicycle LOS* is based on extensive research. Bicycle LOS applications report intersections, roadway segments, roadway facilities and off-street facilities. The HCM integrates consideration of all modes when performing facility analysis.

There are no stand-alone Pedestrian, Bicycle, Transit chapters in the HCM 2010. Volume 1, Chapter 5 Quality and Level of Service Concepts of the HCM delves into overarching concepts. An all modes approach allows analysis of roadways from a “complete streets” perspective.

The bicycle LOS score model is based on comfort of bicyclist related to separation from traffic, motorized traffic volumes, traffic speeds, volume of heavy-vehicles, and pavement quality. The bicycle LOS score contained in the HCM 2010 is a state-of-the-art tool. The bicycle LOS score for roadways (urban streets) combines LOS along roadway segments and LOS through intersections.

Volume 3, Chapter 23 Off-Street Pedestrian and Bicycle Facilities address the quality of service from the user’s perspective. The HCM 2010 defines off-street pedestrian, bicycle facilities as exclusive to non-motorized modes (except ADA mobility devices), and separated from the roadway. Sidepaths and sidewalks are excluded from this definition because they tend to operate within the area of influence of a roadway. In general, facilities beyond 35 feet of separation are considered off-street. The off-street LOS calculates bicycle and pedestrian modes separately. Data inputs required for off-street facilities include hourly pedestrian and bicycle demands by direction, and average pedestrian and bicycle speeds.

The Sidepath Suitability Score covered under item D offers a different type of quality of service measure and may be used along with the HCM 2010 off-street LOS or separately.

12.3 THE BICYCLE LEVEL OF SERVICE (BICYCLE BLOS)

An alternative to the HCM 2010 bicycle LOS score is the Bicycle Level of Service (BLOS) Model (14) published Real-Time Human Perceptions: Toward a Bicyclist Level of Service in Transportation Research Record 1578. The BLOS Model provided the research necessary for the development of the HCM 2010 bicycle LOS score. This research may be downloaded without charge from many locations on the internet.

The BLOS Model is statically-calibrated mathematical equation that is an accurate method of evaluating bicycling conditions of roadways. It uses the same measurable traffic and roadway factors that transportation planners and engineers use for other travel modes. The statically precision, of the BLOS Model reflects the effect of bicycling “suitability” or “compatibility” based on discrete roadway variables that are often readily available. The BLOS Model requires standard geometric and operational data inputs:

- roadway width,
- bike lane widths,
- share lane widths,
- traffic volume,
- pavement surface conditions,
- traffic speed and type, and
- on-street parking,

Variables may be isolated to measure the relative effect of factors, which is particularly useful when balancing an all modes approach to new construction or reconstruction projects.

Applications

The Bicycle LOS Model is used by planners, engineers, and designers throughout the US and Canada in a variety of planning and design applications.

Applications include:

Conducting a benefits comparison among proposed bikeway/roadway cross-sections
Identifying roadway restriping or reconfiguration opportunities to improve bicycling conditions
Prioritizing and programming roadway corridors for bicycle improvements
Creating bicycle suitability maps
Documenting improvements in corridor or system-wide bicycling conditions over time

There is no standard or minium BLOS. However, one practical application of this tool is to set desired BLOS based on an bikeway network of identifed roadways. Through a process of planning and project programming roadways can be identified and then priortized for improvement.

The BLOS Model is applicable for use on urban, suburban and rural roads in North America. It is widely used by Metropolitian Planning Organizations (MPO) like the Mid-America Regional Counicl (MARC), State Departments of Transportation, large and small cities a like.

Bicycle Level-of-Service Categories

The Bicycle LOS score resulting from the final equation is pre-stratified into service categories "A","B", "C", "D", "E", and F" ("A" is best, and "F" is worst), according to the ranges shown in Table 1. These ranges reflect users' perception of the road segments level of service for bicycle travel. This stratification is in accordance with the linear scale established during the referenced research (i.e., the research project bicycle participants' aggregate response to roadway and traffic stimuli). The BLOS Model is particularly responsive to the factors that are statistically significant. An example of its sensitivityto various roadway and traffic conditions is shown on the following page.

The BLOS Model represents the comfort level of a hypothetical “typical” bicyclist. Some bicyclists may feel more comfortable and others may feel less comfortable than the BLOS grade for a roadway. A poor BLOS grade does not mean that bikes should be prohibited on a roadway. Rather, it suggests to a transportation planner that the road may need other improvements (in addition to shoulders) to help more bicyclists feel comfortable using the corridor.

Table 1: BLOS Grades

LEVEL-OF-SERVICE	Bicycle LOS Score
A	≤ 1.5
B	> 1.5 and ≤ 2.5
C	> 2.5 and ≤ 3.5
D	> 3.5 and ≤ 4.5
E	> 4.5 and ≤ 5.5
F	and ≤ 5.5

12.4 SIDEPATH SUITABILITY SCORE

Sidepath facilities are common and popular bikeway applications throughout the United States and internationally. Major arterials in suburbs, where development patterns and functional class hierarchy often limits connectivity to higher speed and traffic volume roadways. Section 4.1.6 Shared Use Paths Adjacent to Roadways (Sidepaths) provides a summary of operational challenges for motorist and path users that stem from intersection conflict points, sight visibility, normal traffic flow and facility priority.

The Sidepath Suability Score is based on an algorithm. Typical applications include:

- Evaluate existing sidepaths
- Determine whether a new sidepath would be an appropriate option
- Suggest safety improvements for existing or planned sidepaths

The model has not been statically validated. It is simply an estimate of the relative importance of key terms, checked by observation during the North Aurora (Illinois) Non-Motorized

Transportation Plan development. (12) Six factors are considered below. The assumption is made that bicyclist will travel in both directions on the sidepaths, even though those riding against the flow of parallel traffic are at higher risk.

Intersection Traffic Score. The volume and speed of traffic significantly affect the risk of collision with turning vehicles. Determine the Intersection Traffic Score (ITS) from the following:

ITS = Spd * Vol *[R+(2A)+(4B)] / M;

Where:
R = Number of residential intersections (driveways) on the sidepath segment,
A = Number of minor commercial intersections and streets (<1000 ADT),
B = Number of major commercial intersections and streets (≥1000 ADT),
M = Length of segment in miles
Spd = Speed limit factor, for the parallel street: ≤ 30 mph = 1, 35-40 = 2, ≥ 45 = 3.
Vol = Traffic ADT factor, parallel street: ≤2,000 = 1; 2,000-10,000 = 2; ≥10,000 = 3.

Add the appropriate number of suitability points for the ITS.

Intersection Traffic Score ITS	Points
0	0
1-40	1
41-80	2
81-120	3
121-160	4
161-200	5
201-240	6
> 240	7

Continuity. Discontinuities (major gaps, or sidepath ends) may force cyclists to ride through grass, etc., and enter the roadway awkwardly. Often cyclists will avoid sidepaths with these gaps. Add 4 points if major discontinuities exist.

Curb cuts. Uncut curbs compromise cyclist movement and attention at intersections. Add 3 points if any intersections are lacking curb cuts.

Pedestrian use. Sidewalks and sidepaths are used by both bicyclists and pedestrians. Insufficient width increases user conflict. (However, extra width encourages higher cyclist speeds – which is a problem at incorrectly-designed intersections.) Add points according to the following pedestrian use chart:

Rare pedestrian use	Occasional pedestrian use	Often pedestrian use
0-5' = 1 point	0-5' = 2 points	0-5' = 4 points
>5' = 0 points	6-7' = 1 point	6-7' = 2 points
	>=8’ - 0 points	>=8’ - 1 point

Crosswalks. Visible crosswalks can help make motorists more aware of non-motorized traffic. Sometimes 2 parallel painted stripes are sufficient. At busier intersections, ladderstyle crosswalks and other techniques enhance visibility. Add 2 points if crosswalks are necessary but absent. Add 1 point if there are some crosswalk markings, but more visibility is warranted for that intersection type. Add 0 points for appropriately marked crossings. Take the average crossing for the segment.

Intersection sidepath/road separation. AASHTO recommends that sidepaths be brought close to the parallel road at intersections, so motorists more easily see and consider bicyclists during their approaches. The intersecting road’s vehicular stop line should be in back of the sidepath crossing – cyclists must not weave through stopped traffic when crossing. Add 5points if the crossing goes through stopped traffic. Add 3 points if the crossing is not brought “close enough” to the parallel road. Add 1 point when the crossing is brought close to the road. (Paved shoulders and bike lane crossings would add 0 points.) Again, take the average crossing for the segment. Add together all the points for the sidepath suitability score. Ranges of suitability are: Points 0-7 8-9 10-11 12 or more

Add together all the points for the sidepath suitability score. Ranges of suitability are:

Table 2: Sidepath Suitability Score

Suitability Score	Suitability
<= 7	High
8-9	Medium
10-11	Low
>= 12	Not suitable

12.5 SPEED-VOLUME MATRIX (SVM)

The Speed-Volume Matrix (SVM) appeared in the first publication of this guide. It is based on a report that was issued by the Pedestrian and Bicycle Information Center, Highway and Safety Research Center of the University of North Carolina, titled “Bicycle Facility Selection: A Comparison of Approaches”. The authors of this research provided a comparison of approaches from more than 20 national, state, and local manuals. The SVM compares North America examples including areas in the mid-west. The SVM does not supplant engineering judgment; it augments the professional’s ability to make informed decisions. The SVM is not a standard but rather intended for quick assessment when more rigorous analysis is not possible. The BLOS Model should be used for where advanced analysis is required.

Table 3: Speed Volume Matrix

	20 mph and less	*25 mph*	*30 mph*	*35 mph*	*40 mph*	*45 mph and over*
Standard Lane	<2,000	<2,000	<1,000	<1,000	<1,000	-----
Wide Curb Lane	2,000-10,000	2,000-9,000	2,000-8,000	2,000-7,000	2,000-6,000	<1,000
Bike Lane or Paved Shoulder	>10,000	>2,000	>2,000	>2,000	>1,000	>1,000
Shared Use Path	anytime	anytime	anytime	anytime	anytime	anytime

Note: Use average operating speed and annual average daily traffic (AADT).

12.6 BIKEWAY TREATMENT AND ROADWAY FUNCTIONAL CLASSIFICATION

The roadway functional classification system was introduced by the Federal Highway Administration (FHWA) late in the 1960s, and developed guidelines for local governments and planning organizations to use in maintaining the functional classification system in their own jurisdictions is the process by which roadways are ranked according to the type of service they provide. The mix of access, mobility, and trip length determines a roadway’s functional class. This system works to channelize traffic within a network of roadways in a logical and efficient manner. Consult the FHWA Functional Classification Guidelines, Criteria, and Procedures for further reading. (16)

The next table provides general guidance to local jurisdictions when selecting identifying possible bikeway design treatments based on roadway functional class. Roadway operational characteristics such as average speed and average traffic volume relate to functional class but do not define it. On one end, high-level roadways such as interstates and freeways have high mobility, restricted access, and tend to serve long distance trips. High traffic volumes and speeds typically characterize these roadways. On the other end, local roadways have low mobility, unrestricted access and tend to serve short distance trips. Low traffic roadways are typically characterized by low traffic and low speeds. In general, lower the roadway classification produces higher bicycle level of service. However, most utilitarian related trips require travel on major and minor arterials.

This table uses the FHWA defined roadway classification system; local jurisdiction classifications may vary. The table below is not a standard but rather a general guide for bikeway network planning. The BLOS Modal should be use where advanced analysis is required.

Table 4: Bikeway Treatment & Roadway Functional Class

	Paved Shoulder	Bicycle Lane	Wide Curb Lane	Standard Lane	Shared Use Path
Interstate	NP	NP	NP	NP	PS
Urban Expressway	PS*	NP	NP	NP	PS
Principal Arterial	PS	PS	PS	NR	PS
Urban Principal Arterial	PS	PS	PS	NR	PS
Minor Arterial	PS	PS	PS	NR	PS
Urban Minor Arterial	PS	PS	PS	NR	PS
Collector	PS	PS	PS	NR	PS
Local	PS	PS	PS	PS	PS

KEY: NP = Not Permitted NR = Not Recommended PS = Possible Solution

NOTE: An asterisk (*) indicates that this solution may be considered when all other reasonable alternatives treatments are not practical and routing is necessary to provide continuity of bicycle routes. An example of this would be major river bridges (such as the Heart of America Bridge over the Missouri River).

12.7 PEDESTRIAN AND BICYCLE CRASH ANALYSIS TOOL (PBCAT)

The PBCAT version 2.0 is a software product developed by the Federal Highway Administration that can be used to develop and analyze a database containing details associated with crashes between motor vehicles and pedestrians or bicyclists. The database is typically built using detailed crash reports, which are generated by law enforcement agencies. PBCAT is a valuable tool, because in addition to identifying crash locations, it identifies the crash type (among a list of common reasons for crashes) and recommended countermeasures. During project planning, BCAT can help to identify specific locations where additional design measures may be needed to increase bicycle safety. More information on the PBCAT consult the Pedestrian and Bicycle Information Center website (www.bicyclinginfo.org) .

12.8 GEOGRAPHIC INFORMATION SYSTEM (GIS)

Geographic Information Systems (GIS) is powerful tool for the collection, management and analysis of large quantities of data. The GIS uses relational database, which are link to geo-referenced features. This tool is particularly useful for bikeway planning and management. For example, it is possible to generate a an existing Bicycle Level of Service Map and future BLOS map based on projected operational and geometric assumptions. GIS can be used to store and track bicycle count information. GIS can be used to track the development of bikeways progress over time. Through relational database, it is possible to import data from other sources. Communities may use aerial photography to collect geometric data about roadways including, shoulder widths, lane widths, bike lanes and presence of sidepaths. In some cases field data collection may be required. Crash data can be analyzed to identify of locations of concern and further study. Other important datasets may include bus service routes to identify preferred location for bike lanes, public bicycle parking, and bikeway transit stops. GIS may be used to evaluate bikeway in relation to existing and planned land use and population density.

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