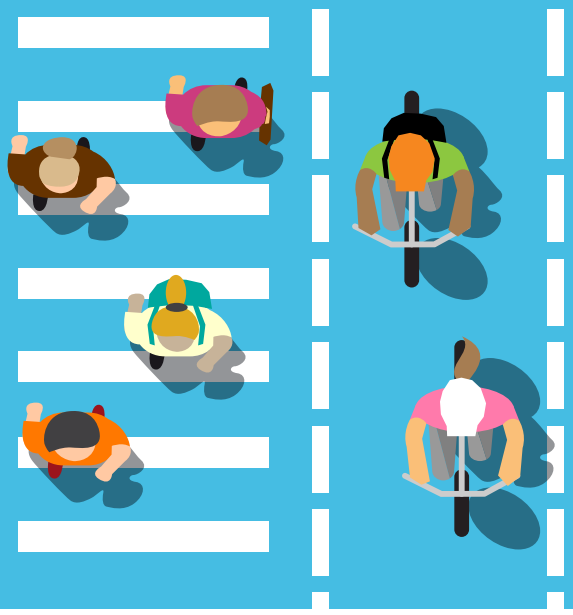
OC ACTIVE

BICYCLE & PEDESTRIAN BEST PRACTICES TOOLKIT 2018



OCTA

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INTRODUCTION

PURPOSE OF THE TOOLKIT

Walkability, bikeability, and accessibility are common elements found in healthy and vibrant communities. Communities that are walkable and accessible provide a range of benefits that improve the quality of life for residents and visitors. These benefits often include:

- **A reliable bicycle and pedestrian network with access to interesting and diverse destinations**
- **Direct and accessible connections to transit**
- **Well-maintained infrastructure that is inclusive of varying mobility needs**
- **Clear and inviting spaces, such as trails, paseos, or other public open spaces**
- **Improved public health and safety**

The OC Active Bicycle and Pedestrian Best Practices Toolkit provides local jurisdictions with a diverse range of tools and strategies for promoting and improving bicycle and pedestrian activity and safety in Orange County. The toolkit is intended to serve as a one-stop resource to a broad range of bicycle and pedestrian planning topics, tools, and strategies. The information presented in this toolkit should not be interpreted as standards, specifications, or regulations, but rather as tools and strategies for promoting more bicycle and pedestrian activity within Orange County. The strategies in this toolkit should be applied with sound professional judgement to achieve the design solutions necessary for the specific circumstances encountered.

STANDARDS/GUIDELINES

The OC Active Bicycle and Pedestrian Best Practices Toolkit draws from a variety of national, state, and local resources and is tailored to meet the unique characteristics of Orange County. Although the information presented in this toolkit provides local jurisdictions with tools and strategies for promoting more bicycle and pedestrian activity, bicycle and pedestrian infrastructure should be designed and built according to existing federal, state, and local standards. This section describes some key national, state, and local standards and guidelines that are available for the planning and design of bicycle and pedestrian infrastructure.

NATIONAL STANDARDS AND GUIDELINES

The following national resources are available:

- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Streets, 2001
- AASHTO, Guide for the Development of Bicycle Facilities, 2012
- AASHTO, Guide for the Planning, Design, and Operation of Pedestrian Facilities, 2004
- Federal Highway Administration (FHWA), Manual on Uniform Traffic Control Devices (MUTCD), 2009
- National Association of City Transportation Officials (NACTO), Urban Street Design Guide, 2013
- NACTO, Urban Bikeway Design Guide, 2011
- U.S. Access Board, American Disabilities Act Accessibility Guidelines (ADAAG), 2002
- U.S. Department of Justice, American Disabilities Act (ADA) Standards for Accessible Design, 2010

STATE STANDARDS AND GUIDELINES

The following state resources are available:

- California Department of Transportation (Caltrans) – California Manual on Uniform Traffic Control Devices (CA MUTCD), 2014
- Caltrans – Highway Design Manual, Chapter 1000: Bicycle Transportation Design, 2015
- Caltrans – Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians, 2010

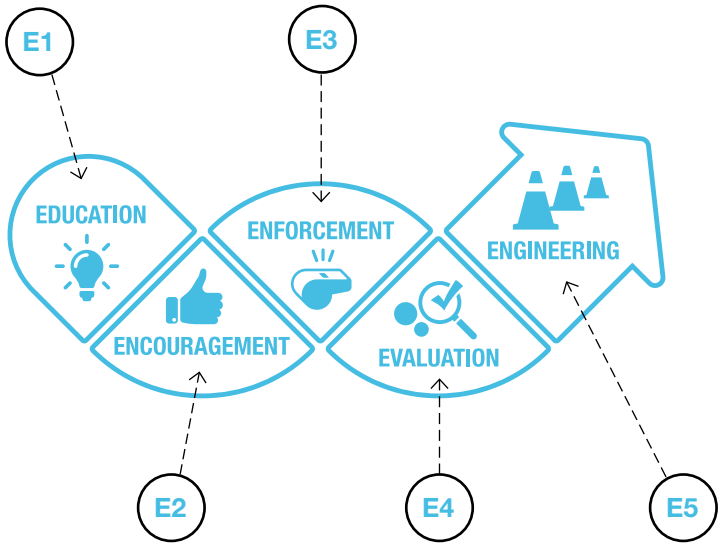
LOCAL STANDARDS AND GUIDELINES

The following local resources are available:

- Orange County Transportation Authority (OCTA) – Master Plan of Arterial Highways Guidelines (MPAH), 2017
- Orange County Council of Governments (OCCOG) – Complete Streets Initiative Design Handbook, 2016

TOOLKIT ORGANIZATION AND THE FIVE E'S

Safer bicycling and walking conditions are best achieved through a combination of strategies targeted to address both infrastructure and non-infrastructure needs. The tools and strategies discussed in this toolkit are organized around the Five E's, a universal framework and approach to improving roadway safety often used by planning practitioners. The **Five E**'s framework includes the following categories:



By focusing on the Five E's, the OC Active Bicycle and Pedestrian Best Practices Toolkit incorporates a comprehensive and holistic approach to bicycle and pedestrian planning. The subsequent sections of the toolkit discusses the benefits of each of the Five E's and includes sample tools and strategies for each E.

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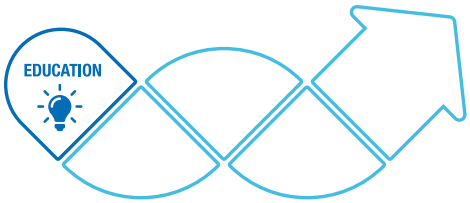


1. EDUCATION

Bicycle and pedestrian education campaigns can help local jurisdictions communicate the skills and knowledge necessary to be safe bicyclists and pedestrians. They help inform community members of traffic safety laws, facilitate safe bicycling and walking behavior and practices, and communicate common unsafe bicycle and pedestrian practices that lead to collisions. Education campaigns can include a variety of tools such as community outreach, developing local bicycle and pedestrian safety guides, hosting safe routes to school education workshops, and more.

BENEFITS

Some of the benefits of facilitating bicycle and pedestrian education campaigns include:

- Informing and reinforcing safe bicycle and pedestrian behavior and practices.
- Improving bicyclist and pedestrian safety by teaching safe biking and walking practices.
- Providing motivation to change unsafe bicyclist and pedestrian behaviors.
- Communicating traffic safety laws.
- Demonstrating that vehicles, bicycles, and pedestrians can share the road safely.
- Giving community members the skills and confidence to ride and walk.
- Providing decision makers with tools and strategies to make improvements that are appropriate for their community.

EXAMPLES

COMMUNITY OUTREACH TOOLS

Engaging community members through outreach can help communicate the importance of safe pedestrian practices and the benefits of walking. Communicating these key messages to community members can help garner support for future pedestrian infrastructure projects and polices, but local jurisdictions often have trouble with designing an effective outreach strategy that engages, encourages participation, and solicits feedback. Some successful community outreach strategies have incorporated the following tools:

- **Interactive Technologies and Tools:** Effective outreach strategies go beyond the conventional methods to engage, such as town hall meetings or open house workshops, and focus on incorporating interactive tools to make it fun. New digital technologies can help facilitate and streamline the outreach process and increase participation and interaction. Some of these interactive technologies and tools include:
  - **Poll Everywhere Surveys:** Poll Everywhere is an online service for audience polling. In a community outreach context, it allows facilitators to create poll questions that audience can answer by using their mobile phones to text their responses. Live results of each poll question can be displayed on-screen during presentations. It's a unique way to incorporate interactive and live activities during a presentation.
  - **Web-based Mapping:** Web-based mapping tools, such as ArcGIS Online, CrowdMap, and CommunityRemarks, allow community members to identify key areas on a map and leave comments. They can be useful to identifying problematic and unsafe areas, as well as communicating desired infrastructure improvements.
- **Visualization Tools:** Graphics are important to communicate key information and data to audiences in an easy to understand format. Websites, such as Street Mix, allow users to create a visual mockup of their ideal street by dragging and dropping various elements such as street trees, sidewalks, bike lanes, etc. onto its online and shareable interface.

DEVELOP LOCAL PUBLIC EDUCATION AND SAFETY CAMPAIGNS

Developing local public education and safety campaigns is a useful tool to teach safe walking tips to communities. Education and safety campaigns focus on encouraging community members to think about their existing travel choices and pedestrian behaviors, as well as helping community members make safer more informed choices. Education and safety campaigns should consider the sensitivities and different needs of different groups of people, such as children, adults, and seniors. The following are some example public education and safety tools.

- **Pedestrian Education Guides:** The Pedestrian and Bicycle Information Center developed a series of pedestrian education guides for different age and community groups. An education guide was developed for different age groups because the skills and knowledge needed to walk safely changes as people age. Each guide provides strategies and tips for educating pedestrians, highlights which key messages to convey, and provides a link for additional resources.
- **Los Angeles County Suggested Pedestrian Route to School Website:** The County of Los Angeles Department of Public Works developed its Suggested Pedestrian Route to School website, which

contains maps of suggested pedestrian walking routes for a majority of elementary schools in Los Angeles County. Each map includes key information to inform safe suggested routes to school, such as the locations of crossing guards, stop signs, crosswalks, signal lights, pedestrian bridges, and school entrances. The maps help inform parents of safe routes for children to take when walking to school.

SAFE ROUTES TO SCHOOL EDUCATION WORKSHOPS

The Safe Routes to School (SRTS) National Partnership is a nonprofit organization committed to promoting safe walking and biking to school and beyond. They often partner with local jurisdictions to provide workshops and trainings on safe routes to school, active transportation policy and programming, funding for sustainable transportation, as well as community engagement and coalition development. Each workshop and training is customizable to fit the needs of the community and can be offered in-person or online.

LEAGUE OF AMERICAN BICYCLISTS SMART CYCLING CLASSES AND LEAGUE CYCLING INSTRUCTOR (LCI) SEMINARS

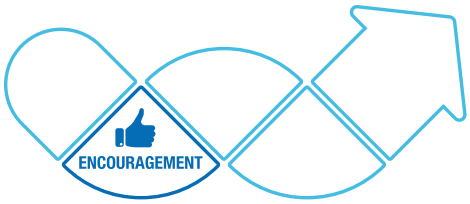
The League of American Bicyclists (LAB) provides Smart Cycling classes across the nation designed to reach people of all ages and abilities, improving skills, building confidence, and teaching others. The League's education program also offers the only nationwide bicycling instructor certification program, known as League Cycling Instructors, who are certified to teach the Smart Cycling Classes to children as well as adults.

CYCLING SAVVY CLASSES

CyclingSavvy is a program of the American Education Association, Inc. (ABEA). The course teaches the principles of "Mindful Bicycling" by empowering students to act as confident, equal road users, teaching strategies for safe integrated cycling, and providing tools to read and problem-solve a variety of traffic situations. The class consists of three 3-hour components: a bike-handling session, a classroom session, and an on-road tour.

ADDITIONAL INFORMATION

- **CommunityRemarks**
  https://communityremarks.com/
- **County of Los Angeles Department of Public Works, Suggested Pedestrian Route to School**
  http://dpw.lacounty.gov/tnl/schoolroute/
- **Orange County Bicycle Coalition, CyclingSavvy Program**
  https://www.bikeleague.org/content/become-instructor
- **Pedestrian and Bicycle Information Center, How to Educate Pedestrians and Bicyclists**
  http://www.pedbikeinfo.org/programs/education.cfm
- **Pedestrian and Bicycle Information Center, Safety Tips for Pedestrians**
  http://www.pedbikeinfo.org/community/tips_pedestrian.cfm
- **Poll Everywhere**
  https://www.polleverywhere.com/
- **Safe Routes to School National Partnership**
  https://www.saferoutespartnership.org/
- **League of American Bicyclists, League Cycling Instructor Program**
  https://www.bikeleague.org/content/become-instructor
- **League of American Bicyclists, Smart Cycling Program**
  https://www.bikeleague.org/ridesmart
- **Street Mix**
  https://streetmix.net
- **Vermont Safe Routes to School, Teaching Walking and Biking Safety Mini Guide**
  http://saferoutes.vermont.gov/sites/saferoutes/files/TeachingWalkingBikingSafety.pdf



2. ENCOURAGEMENT

Encouraging bicycle and pedestrian activity helps to generate excitement and brings awareness to the benefits of active transportation. It can also help foster public support for bikeway and pedestrian infrastructure projects and policies that are geared towards improving safety on streets. Tools to encourage bicycle and pedestrian activities include promoting national and local active transportation events, implementing local tactical urbanism events, and adopting local policies and programs that support safe and efficient active modes of transportation.

BENEFITS

Some benefits of encouraging bicycle and pedestrian activity in communities include:

- Inspiring adults and children to engage in healthy and sustainable modes of transportation.
- Demonstrating that active modes of transportation are welcome and encouraged.
- Communicating the benefits of active transportation and garnering community support for bikeway and pedestrian projects.
- Fostering a stronger sense of community.
- Promoting safer and healthier communities.

EXAMPLES

PROMOTE NATIONAL AND LOCAL ACTIVE TRANSPORTATION EVENTS

Promoting nationally recognized active transportation events, such as Walk and Bike to School Day, Pedestrian Safety Month, and Bike Month, or hosting special local events, such as walking and biking contests, can help generate excitement and encourage more bicycling and walking in communities. These events communicate and celebrate the benefits of active transportation and often inspire continued bicycle and pedestrian activity beyond the day or event.

IMPLEMENT LOCAL TACTICAL URBANISM EVENTS

Tactical urbanism is a community approach to improving the built environment and includes implementing low-cost temporary design solutions to catalyze long-term change. The goal of most tactical urbanism projects is to improve local streets and neighborhoods by implementing quick, scalable, low-cost design solutions that are temporary in hopes of garnering support for permanent infrastructure improvements and change.

- **Go Human:** The Southern California Association of Governments (SCAG) Go Human campaign is a regional campaign intended to promote and improve conditions for active modes of transportation funded by a $2.3 million grant from the 2014 California Active Transportation Program. The campaign provides funding for local jurisdictions to implement their own local tactical urbanism events to encourage active transportation. The Go Human campaign also provides information on potential strategies, case studies, enforcement strategies, and other resources that local jurisdictions can use to promote and encourage more walking and biking in their communities.
- **Re:Imagine Garden Grove:** The Re:Imagine Garden Grove event is a recent example of a tactical urbanism event funded by the Go Human campaign. The event encouraged community members to envision a car-free Garden Grove by closing select streets to vehicular traffic, creating a car-free zone. The event created a temporary 2.5 mile car-free route, prioritizing travel for pedestrians, bicyclists, and skateboarders. The Re:Imagine Garden Grove event successfully demonstrated to community members the possibilities and various design solutions available for making streets safer for pedestrians and bicyclists.
- **Go Human Riverside Artswalk Pedestrian Scrambles:** The City of Riverside partnered with SCAG's Go Human campaign to install two temporary pedestrian scrambles for a three week pilot project. Pedestrian scrambles prioritize the safe movement of pedestrians by stopping all vehicular traffic in all directions and allowing pedestrians an exclusive interval to cross an intersection in all directions, including diagonally, at the same time. The pilot project coincided with the monthly Riverside Artswalk in downtown Riverside and used the opportunity to showcase pop-up scramble crosswalks and corner sidewalk extensions that were designed and created by local artists. The temporary installations were incorporated as a part of the Riverside Artswalk and highlighted in the Riverside Artswalk map, which were distributed to visitors. Additionally, as a part of the pilot project, data was collected on how many people used the modified crosswalks, delays to vehicular traffic, and other impacts. The data collection in conjunction with feedback from community members will be used by the City in their decision to implement permanent pedestrian scrambles.

- **CicLAvia:** CicLAvia is an open streets event that occurs in cities across in Los Angeles County several times a year. Many events have been organized since 2010, providing spaces for families and friends to enjoy spaces that may have otherwise only been used primarily by automobiles. CicLAvia occurs in several different areas in order to reach the various populations of Los Angeles County.
- **SOMOS:** Similar to Los Angeles' CicLAvia, the City of Santa Ana has previously hosted the City's Sunday on Main Open Streets (SOMOS) event, closing a section of Central Santa Ana off to cars and opening it to bicyclists, walkers, and runners. The event encourages residents to attend by providing entertainment and activities along the 3.1 mile route connecting Santa Ana's vibrant downtown to its historic South Main Corridor.

ADOPTING VISION ZERO

Vision Zero is a traffic safety strategy that focuses on eliminating traffic fatalities and severe injuries, while promoting safe, healthy, and equitable mobility. Cities across the U.S. have begun developing and adopting Vision Zero initiatives in response to traffic deaths and severe injuries experienced in their communities. Vision Zero incorporates a multi-disciplinary systems approach, bringing together a variety stakeholders from different city departments, such as traffic planners and engineers, police officers, policymakers, and public health professionals, to determine appropriate solutions for eliminating traffic deaths and severe injuries. Successful solutions and strategies have included:

- Reducing speed limits
- Redesigning streetscapes
- Implementing behavior change campaigns for motorists, bicyclists, and pedestrians
- Enhancing data-driven traffic enforcement

Vision Zero initiatives represent a commitment from local jurisdictions and elected officials to prioritizing safer streets both in policy and practice.

NATIONAL BIKE MONTH

National Bike Month is held in May of each year. Established in 1956 and sponsored by the League of American Bicyclists (LAB), it encourages local jurisdictions all across the United States to develop programs and events to promote bicycling to work, school, as well as for recreation. OCTA celebrates National Bike Month with events such as the OCTA Bike Rally and the OCTA Bike Festival at the Dana Point Grand Prix. During Bike to Work Week within Bike Month, Metrolink offers free rides to passengers who bring a bike onboard the train to encourage people to bike to transit connections. In 2017, Metrolink also partnered with the Los Angeles Metropolitan Transportation Authority (Metro) to offer a free month of bike share rides to 2,000 Metrolink riders.

BICYCLE FRIENDLY COMMUNITY DESIGNATION

Through its Bicycle Friendly America (BFA) program, the League of American Bicyclists (LAB) recognizes communities that improve bicycling conditions through education, encouragement, enforcement, and evaluation programs. Communities can achieve platinum, gold, silver, or bronze status, or an honorary mention. Bicycle friendliness can indicate that a community is healthy and vibrant. Bicycle friendliness can increase property values, spur business growth, and increase tourism. Details on obtaining bike friendly community status can be found on LAB's website.

BICYCLE AND PEDESTRIAN PLANNING POLICIES AND PROGRAMS

Pedestrian planning policies can help transform the broad focus of various plan efforts into distinct actionable priorities. They help provide the direction necessary for cities to prioritize and implement projects and programs that support plan goals and objectives. Some example planning policies and programs specific to improving bicycle and pedestrian safety include:

- Implementing a pedestrian signal policy that prioritizes the safe movement of pedestrians
- Adopting a Vision Zero policy and communication strategy
- Developing a complete streets policy (as required by AB1358)
- Developing a SRTS program
- Developing a citywide wayfinding program

Local jurisdictions can also encourage and promote more bicycle and pedestrian activity by ensuring future neighborhood plans, specific plans, and corridor plans contain design standards and principles that support bicycle and pedestrian connections and activity throughout the surrounding built environment. Best practices for encouraging bicycle and pedestrian activity in these local community plans include:

- Emphasizing bicycle- and pedestrian-oriented design features and placemaking.
- Developing streetscape plans that create a comfortable, convenient, safe, bikeable, and walkable environment with bicycle and pedestrian features and amenities.
- Implementing form-based codes that emphasize bicycle- and pedestrian-scaled building facades, short block lengths, bike buffers, pedestrian buffers, and other urban design features.
- Incorporating mixed-use zones and moderate to high development densities where feasible.

ADDITIONAL INFORMATION

- **CicLAvia**
  http://www.ciclavia.org/
- **City of Santa Ana, Downtown Transit Zone Complete Streets Plan**
  http://www.ci.santa-ana.ca.us/completestreets/DowntownTransitZoneCompleteStreetPlan.asp
- **City of Santa Ana, Harbor Mixed Use Transit Corridor Plan**
  http://www.santa-ana.org/pba/planning/HarborMixedUseTransitCorridorPlan.asp
- **City of Santa Ana, SOMOS**
  http://www.ci.santa-ana.ca.us/parks/somos/
- **FHWA, Noteworthy Local Policies that Support Safe and Complete Pedestrian and Bicycle Networks, 2016**
  https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa17006-Final.pdf
- **League of American Bicyclists, Bicycle Friendly America Program**
  http://www.bikeleague.org/bfa
- **League of American Bicyclists, National Bike Month**
  https://bikeleague.org/bikemonth
- **Metrolink, National Bike Month 2017**
  https://www.metrolinktrains.com/news/metrolink-news/metrolink-celebrates-national-bike-month-with-events-and-contests-to-promote-cycling/
- **OCTA, National Bike Month 2017**
  http://www.octa.net/Bike-Month-2017/

- **Reimagine Garden Grove**
  http://ggopenstreets.com/
- **SCAG Go Human**
  http://gohumansocal.org/Pages/Home.aspx
- **Street Plans Collaborative, Tactical Urbanist's Guide to Materials and Design, 2016**
  http://tacticalurbanismguide.com/guides/tactical-urbanists-guide-to-materials-and-design/
- **Street Plans Collaborative, San Francisco Planning Department, and MJM Management, Public Space Stewardship Guide, 2016**
  http://sf-planning.org/public-space-stewardship-guide
- **Street Plans Collaborative, The Alliance for Biking and Walking, and The Fund for the Environment and Urban Life, The Open Streets Guide, 2012**
  http://tacticalurbanismguide.com/guides/the-open-streets-guide/
- **Tactical Urbanist's Guide**
  http://tacticalurbanismguide.com/
- **Vermont Safe Routes to School Walk and Roll to School Days Mini Guide**
  http://saferoutes.vermont.gov/sites/saferoutes/files/WalkandRoll.pdf
- **Vision Zero Network**
  https://visionzeronetwork.org/
- **Walk and Bike to School**
  http://www.walkbiketoschool.org/

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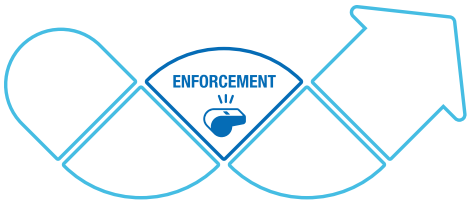


3. ENFORCEMENT

Consistent enforcement of traffic laws is an important tool local jurisdictions can use to improve bicyclist and pedestrian safety and reduce the risk of severe and fatal collisions. Enforcement activities target behaviors that impact bicyclist and pedestrian safety, such as speeding, driver impairment, and distraction. They can take on a variety of forms, such as enforcement of traffic violations, safety patrols on major arterial streets, radar speed signs, and more. Implementing enforcement activities helps to increase awareness and reduce the frequency of traffic safety problems.

Effective bicycle and pedestrian safety enforcement activities often include collaboration and coordination with multiple departments within local jurisdictions. The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) developed guides on how to enforce both bicycle safety and pedestrian safety. In the guides, the NHTSA found that effective bicycle and pedestrian safety enforcement activities tend to include some of the following components:

- Collaboration with partners in local businesses, civic organizations, and government agencies.
- Collaboration and coordination between the judiciary branch and city officials on planned traffic safety operations.
- Coordination with city engineers to ensure locations selected for traffic safety operations are suitable.
- Police officer trainings on local laws pertaining to crosswalks, pedestrians, and bicyclists, as well as training on safety program goals, objectives, and procedures.
- Incorporating bicycle and pedestrian safety operations into routine enforcement activities.

This section provides some benefits of pedestrian enforcement activities and some examples implemented in various cities both locally and nationally.

BENEFITS

Some of the benefits of implementing enforcement activities include:

- Increasing compliance with traffic safety laws.
- Improving driver, bicyclist, and pedestrian behavior.
- Reinforcing the importance of traffic codes to drivers, bicyclists, and pedestrians.
- Reducing collisions, injuries, and fatalities.
- Improving safety.
- Improving the relationship between the pedestrian/bicycling community and law enforcement.

EXAMPLES

ORANGE COUNTY SHERIFF'S DEPARTMENT BIKE AND PEDESTRIAN SAFETY ENFORCEMENT OPERATION PROGRAM

The Orange County Sheriff's Department periodically conducts bike and pedestrian safety enforcement operations which focus enforcement on collision factors involving motorists, pedestrians, and bicyclists. The Orange County's Sheriff's Department deploys extra officers to patrol locations where frequent pedestrian and bike collisions have occurred over the last three years. Patrolling officers pay special attention to drivers who speed, make illegal turns, fail to stop for stop signs and signals, fail to yield to pedestrians in crosswalks, and any other dangerous violations. Enforcement of traffic laws is not restricted to motorists. The program also enforces violations committed by pedestrians, such as crossing the street illegally or failing to yield to drivers who have the right-of-way. Funding for the bike and pedestrian safety enforcement operation program is provided by a grant from the California Office of Traffic Safety through the NHTSA.

CITY OF HUNTINGTON BEACH TICKET DIVERSION PROGRAM

The City of Huntington Beach re-launched its ticket diversion program in 2016, which provides an option for bicyclists and pedestrians to take a safety class in-lieu of paying a fine for traffic violations, authorized under the State of California's Assembly Bill 902 signed in September 2015. The safety class is a two hour class offered once a month and covers traffic laws and safety for active modes of transportation, such as walking, biking, and skateboarding. Traffic law offenders can be penalized with a fine up to $254 in the City of Huntington Beach. The cost of the class is $50, leading to a potential savings of $200 when traffic law offenders choose the traffic safety class option.

The ticket diversion program effectively encourages and promotes active transportation and safety within the city through a number of ways. First, the fines discourage violations of traffic law and second, it increases the number of people who voluntarily obtain education on traffic and safety laws for active modes of transportation.

The operation of the safety classes include cooperation from the police department and the City. To save costs, the safety classes are held at the City Council Chambers and are taught by two officers from the Huntington Beach Police Department. The classes include a presentation and videos discussing local and state laws. Additionally, costs are offset by the $50 class fee from adult participation and $15 from youth participation.

In Torrance, The South Bay Bicycling Coalition piloted a similar program along with the Redondo Beach Police Department and the traffic division of the Torrance Superior Court. Anyone who is cited in a city that cites to traffic court at the Torrance Superior Court can take the class and consequently get the citation erased from their record. The three hour safety class is taught by the South Bay Bicycling Coalition and covers the causes of bicycle crashes, rules of the road, safe-riding practices.

CITY OF SAN FRANCISCO PEDESTRIAN SAFETY ENFORCEMENT OPERATIONS

The San Francisco Police Department periodically conducts traffic safety enforcement operations that target bicycle and pedestrian safety. The operations deploy additional officers at locations where high numbers of pedestrian and bicycle collisions have occurred in the last three years. Under the program, special attention is directed towards the "Focus on the Five" traffic violations, which include: speeding, making illegal turns, failing to stop for stop signs and red lights, failing to yield to pedestrians in cross walks, as well as any other dangerous traffic violations.

The San Francisco Police Department periodically conducts three types of pedestrian safety operations to enforce traffic laws. These three types include:

- **Pedestrian Decoys:** Operations that target motorists who fail to yield to pedestrians in crosswalks. Decoy operations can involve one or more decoy officers and four to six citing officers.
- **LIDAR Speed Enforcement:** Operations that target motorists who travel at unsafe speeds through pedestrian zones. LIDAR speed enforcement operations can involve up to six officers.
- **Saturation Patrol:** Operations that target traffic violations and collision factors related to distracted driving. Saturation patrol operations can involve up to eight or more officers.

Locations for these operations are based on both complaints and frequency of incident occurrence.

ORLANDO BEST FOOT FORWARD FOR PEDESTRIAN SAFETY

Best Foot Forward is a pedestrian safety initiative launched in 2012 in Central Florida. It was formed to reduce pedestrian fatalities and injuries in the Orlando-Kissimmee-Sanford metropolitan statistical area (MSA) by 50% over a span of five years. The best foot forward coalition includes a variety of stakeholders, such as MetroPlan Orlando, Orange County Government, the City of Orlando, Orange County Public Schools, Orlando Health, the Florida Department of Transportation, LYNX, Winter Park Health Foundation, Orange Cycle, University of Miami's Walk/Safe, Healthy Central Florida, as well as police officers throughout Orange County.

The initiative began in 2012 targeting the enforcement of traffic violations at non-signalized, marked crosswalks on streets with posted speed limits of 35 mph or less. The operation included two weeks of enforcement and six weeks of data collection to measure the results. The initiative also provides training to law enforcement officers and helps to subsidize overtime costs through a 50/50 funding match.

ADDITIONAL LAW ENFORCEMENT STRATEGIES

General strategies that can help enforce good vehicle, bicycle, and pedestrian behavior as well as bridge the gap between law enforcement and users of active transportation include officer participation on a Bicycle

Advisory Committee, the implementation of Bicycle Patrol Units, and Speed Radar Trailers.

- **Officer Participation on Bicycle Advisory Committee:** The League of American Bicyclists suggests that law enforcement officials take on a role in a Bicycle Advisory Committee. Bicycle Advisory Committees help address local bicycling needs and decisions regarding bicycling in their specific communities. This type of participation increases awareness of bicyclist concerns as well as the role that law enforcement has in creating an environment where bicyclists feel welcome but are also practicing safe behavior while bicycling.
- **Bicycle Patrol Units:** The League of American Bicyclists supports the strategy of having more police officers on bikes to help increase understanding of cyclists' issues. Bike patrol officers should undergo specialized training in bicycle-related traffic laws and safety techniques. Additionally, other bicyclists are typically more accepting of bike patrol officers as they can connect with bicyclists on a different level than vehicle patrol officers in a non-confrontational manner. Bike patrol officers can also more easily move about and enforce areas that are not easily vehicle accessible, such as near clusters of buildings at college campuses, office parks, shopping centers, or at events such as street fairs and other public gatherings. As a bonus, bicycles cost less to purchase and maintain than traditional patrol cars.
- **Speed Radar Trailer:** Speed radar trailers are electronic roadside signs mounted on an unmanned trailer that tell drivers how fast their vehicle is moving and can flash when they are going too fast, along with a speed limit sign. This is especially helpful near schools, crosswalks, or bicycle/multi-use paths where there are more likely to be bicyclists and pedestrians, or areas where there are speeding problems. Although more of a short-term strategy, speed radar trailers can be effective in signaling to vehicles to be more aware of those who are traveling without a car.

ADDITIONAL INFORMATION

- **Best Foot Forward Grassroots Pedestrian Safety Initiative**
  http://www.iyield4peds.org/
- **Huntington Beach Ticket Diversion Program**
  http://gohumansocal.org/Documents/Tools/CaseStudy_HuntingtonBeach.pdf
- **League of American Bicyclists, Bicycle Friendly America Program**
  http://www.bikeleague.org/bfa
- **NHTSA, Pedestrian Safety Enforcement Operations: A How-To Guide, 2014**
  https://www.nhtsa.gov/staticfiles/nti/pdf/812059-PedestrianSafetyEnforceOperaHowToGuide.pdf
- **Pedestrian and Bicycle Information Center, The Role of Law Enforcement in Pedestrian and Bicycle Safety Programs,**
  http://www.pedbikeinfo.org/programs/enforcement.cfm
- **South Bay Bicycle Coalition, Bicycle Safety Class**
  http://www.southbaybicyclecoalition.org/bicyclesafetyclass/

4. EVALUATION

Evaluating bicycle and pedestrian planning strategies is an important tool for local jurisdictions to use to determine whether an approach is successful in improving bicycle and pedestrian conditions and safety. It involves applying appropriate performance metrics to measure the effectiveness of a strategy in meeting project and community goals. Applying performance metrics can also help local jurisdictions customize and adopt appropriate strategies that require complex design solutions specific to a given community.

BENEFITS

Evaluating active transportation planning policies, strategies, and projects with appropriate performance metrics provides a number of benefits to local jurisdictions. Some of these benefits include:

- Measuring project success in meeting community goals.
- Helping local jurisdictions prioritize projects.
- Demonstrating value and benefits of projects to community members.
- Inform smarter data-driven infrastructure investments and decisions.
- Tracking project progress over a period of time.
- Capturing datasets for other related projects.

EXAMPLES

The type of performance metrics used will vary based on the nature of the project, goals, and data available. This toolkit provides some examples of performance metrics that can be used to measure pedestrian safety, infrastructure/network quality, and access to destinations as summarized in **Table 5-1**.

Table 5-1: Sample Evaluation Metrics

PERFORMANCE CATEGORY	PERFORMANCE METRIC
SAFETY	Bicycle/Pedestrian Counts and Trends
	Bicycle/Pedestrian Injuries and Fatalities
	Traffic Speed (85th Percentile Speeds)
INFRASTRUCTURE / NETWORK QUALITY	Level of Traffic Stress
	Bicycle/Pedestrian Level of Service (PLOS)
	Presence of Bicycle/Pedestrian Facilities
	Distance between Marked Crosswalks
	Connectivity/Gap Closures
ACCESS TO DESTINATIONS	Proximity to Transit (First/Last Mile)
	Trails Connection

METRICS TO MEASURE SAFETY

Performance metrics to measure safety provide information on the well-being of active transportation users on a given network. They can also provide information on the public health of a community. Some common performance metrics used to measure bicyclist and pedestrian safety include:

- **Bicycle/Pedestrian Counts and Trends:** Conducting bicycle and pedestrian counts provides information on infrastructure usage levels. It provides information on whether bicycle and pedestrian activity is increasing or decreasing over a period of time. Low levels of bicycle and pedestrian activity can be an indicator of infrastructure and safety issues. Several resources are available describing best practices in data collection for bike and pedestrian counts. Some of these resources include guidance and best practice strategies from FHWA, SCAG, Metro, and the National Bicycle and Pedestrian Documentation Project.
- **Bicyclist/Pedestrian Injuries and Fatalities:** Analyzing bicyclist and pedestrian injuries and fatalities can provide detailed information on how safe a street or intersection is for pedestrians. It can provide insight to collision patterns in the time of day, type of accident, cause of the accident, and location. A common resource for collision data is the California Highway Patrol's (CHP) Statewide Integrated Traffic Records System (SWITRS), which provides collision data for a variety of modes as well as data on injury severity. Additionally, another useful resource is UC Berkeley's Transportation Injury Mapping System (TIMS), which organizes SWITRS data into an easy to use web-based data query and mapping application that can be integrated seamlessly with Google Maps and ArcGIS.
- **Traffic Speed (85th Percentile Speed):** Analyzing traffic speeds can provide information on a roadway's propensity for bicycle and pedestrian collisions and level of injury severity. Increases in frequency and injury severity are often found in collisions with vehicles traveling at higher speeds. The National Center for SRTS reports that crashes at speeds of 30 mph are approximately eight times more likely to kill a pedestrian than crashes at speeds of 20 mph. Obtaining data on 85th percentile speeds provides information on the average speed that 85% of vehicles do not exceed along a given corridor. Analyzing

trends in traffic speeds can also provide information on whether infrastructure design solutions have improved the safety of a corridor and reduced collision risk and potential levels of injury severity.

METRICS TO MEASURE INFRASTRUCTURE/NETWORK QUALITY

Performance metrics to measure bicycle and pedestrian infrastructure/network quality provide information on elements that impact the quality and attractiveness of the bicycle and pedestrian environment. Simply providing active transportation infrastructure does not always increase bicycle and pedestrian activity within a community. Higher quality pedestrian infrastructure, which enhances the attractiveness of biking and walking, considers elements such as bike buffers, pedestrian buffers, street trees, sidewalk widths and accessibility, safety, connectivity, distances to crosswalks, and others. Some common performance metrics used to measure bicycle and pedestrian infrastructure/network quality include:

- **Level of Traffic Stress:** The Mineta Transportation Institute developed a methodology for measuring low-stress connectivity to evaluate and guide bicycle network planning. The methodology utilizes a classification system of roadways to determine their level of traffic stress. This same methodology can be applied to the pedestrian network planning. Level of traffic stress can be used to measure the qualitative aspects of bicycle and pedestrian facilities and sidewalks by considering factors such as number of travel lanes on the roadway, traffic volumes, posted speed limits, presence/absence of bike and pedestrian buffers (street trees, on-street parking, street furniture, etc.), and others. This metric provides information on the anticipated comfort level a bicyclist or pedestrian would have biking or walking along a given corridor.
- **Bicycle/Pedestrian Level of Service (BLOS/PLOS):** BLOS/PLOS is another performance metric for measuring quality of service of a bicycle or pedestrian facility. It incorporates measures for comfort, safety, and ease of mobility. The 2010 Highway Capacity Manual (HCM 2010) includes methodologies for calculating BLOS and PLOS and includes a variety of elements in its calculation, such as traffic volumes, speed, signalized intersections, pavement conditions, and others.
- **Presence of Bicycle/Pedestrian Facilities:** Presence of bicycle and pedestrian facilities, such as bike paths of varying class types, sidewalks, crosswalks, curb ramps, and others, provide information on the presence of the infrastructure needed to facilitate bicycle and pedestrian activity. Walk audits containing checklists for these types of infrastructure items are a helpful tool to inventory and evaluate the quality of bicycle and pedestrian facilities. Organizations such as the Pedestrian and Bicycle Information Center and the American Association of Retired Persons (AARP) provide sample walk audit checklists on their websites available for use.
- **Distance Between Marked Crossings:** Marked crosswalks help facilitate safe crossings for pedestrians by improving visibility and signifying the presence of pedestrians to drivers. Longer distances between marked crossings tend to deter pedestrian activity since it increases the time it takes for a pedestrian to get from point A to point B. Distance between marked crossings can provide information on whether the roadway is providing adequate opportunities for safe pedestrian crossings.
- **Connectivity/Gap Closure:** Connectivity and gap closure can help provide information on the accessibility of a bicycle or pedestrian facility. Sidewalks with missing gaps can impede pedestrian activity for those with disabilities and can also deter those without disabilities from walking along a corridor. Similarly, bikeways with missing gaps can deter bicyclists from choosing to bike to their destination if the gap makes them feel unsafe.

METRICS TO MEASURE ACCESS TO DESTINATIONS

Biking and walking often times serves as one component of a larger multi-modal trip, thus connectivity to other infrastructure, such as transit stops, multi-purpose trails, and bikeways, greatly enhances a person's ability to access goods, services, jobs, and recreation. Some common performance metrics used to measure bicycle and pedestrian access to destinations include:

- **Proximity to Transit (First/Last Mile):** Proximity to transit provides information on a bicyclist or pedestrian's ability to get from point A to point B. Bike and pedestrian facilities that are in close proximity to transit can help improve a community's access to goods, services, jobs, and key destinations.
- **Bikeways/Trails Connection:** Pedestrian connections to existing bikeways and recreational multi-use trails can encourage more pedestrian activity and provide access to recreational destinations such as parks and open spaces.

ADDITIONAL INFORMATION

The following resources provide additional information on the evaluation of pedestrian planning projects and performance metrics.

- **AARP, Walk Audit Tool Kit, 2016**
  https://www.aarp.org/content/dam/aarp/livable-communities/documents-2016/Walk-Audit-Tool-Kit/AARP-Walk-Audit-Tool-Kit-100416.pdf
- **Caltrans, Toward an Active California State Bicycle + Pedestrian Plan Performance Measures Technical Report, 2017**
  http://www.dot.ca.gov/activecalifornia/documents/PlanElements/Final_ActiveCA_PerformanceMeasures.pdf
- **CHP SWITRS**
  http://iswitrs.chp.ca.gov/Reports/jsp/CollisionReports.jsp
- **Fehr and Peers, Active Transportation Performance Measures, 2015**
  http://www.fehrandpeers.com/active-transportation-performance-measures/
- **FHWA, Exploring Pedestrian Counting Procedures: A Review and Compilation of Existing Procedures, Good Practices, and Recommendations, 2016**
  https://www.fhwa.dot.gov/policyinformation/travel_monitoring/pubs/hpl16026/hpl16026.pdf
- **FHWA, Guidebook for Developing Pedestrian and Bicycle Performance Measures, 2016**
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/pm_guidebook.pdf
- **Mineta Transportation Institute, Low-Stress Bicycling and Network Connectivity, 2012**
  http://transweb.sjsu.edu/PDFs/research/1005-low-stress-bicycling-network-connectivity.pdf
- **National Bicycle and Pedestrian Documentation Project**
  www.bikepeddocumentation.org
- **Pedestrian and Bicycle Information Center Walkability Checklist**
  http://www.pedbikeinfo.org/pdf/community_walkability_checklist.pdf
- **SCAG, Metro, Conducting Bicycle and Pedestrian Counts: A Manual for Jurisdictions in Los Angeles County and Beyond, 2013**
  http://media.metro.net/projects_studies/call_projects/images/metroscag_bikepedcounttrainingmanual.pdf
- **UC Berkeley Transportation Injury Mapping System**
  https://tims.berkeley.edu

5. ENGINEERING

Engineering design treatments can greatly impact the environment for active transportation, by creating safer, inviting, and more accessible conditions for bicyclist and pedestrian activity. A variety of engineering tools can be applied to transform a streetscape so it can better accommodate bicyclist pedestrian safety needs. Some of these tools focus on roadway design, while others focus on bicycle and pedestrian facilities and infrastructure. This section provides brief descriptions of the benefits of implementing engineering design treatments and the tools that are available.

BENEFITS

A variety of engineering design treatments can help promote active transportation and improve safety conditions. By improving conditions for bicyclists and pedestrians, streets become safer for all users including transit riders and motorists. Some of the benefits of implementing carefully designed engineering treatments include:

- Reducing vehicular travel speeds and volumes down to a safe level.
- Improving visibility of bicyclists and pedestrians.
- Improving comfort level for bicyclists and pedestrians.
- Providing safe opportunities for crossings.
- Improving access to destinations.

EXAMPLES

This toolkit provides some examples of engineering design treatments that can be used to improve the bicycle and pedestrian environment. Although this section provides guidance on bicycle/pedestrian and roadway facility design, it is important to remember that urban streets are extremely complex and any roadway treatment must be carefully evaluated and tailored to each specific situation. Sound engineering judgment should always be applied to any roadway modification project.

The engineering design treatments discussed in this section apply to both pedestrian and bicycle environments. **Table 5-1** outlines a list of the potential treatments, beginning with treatments that apply to both pedestrian and bicycle strategies, treatments that only apply to pedestrian strategies, and treatments that only apply to bicycle strategies. The table also indicates the page number where the specific treatment is explained in more detail.

It should be noted that some of the engineering design treatments specific to bicycles on this list (beginning with Shared-Use Paths) are taken from the Bicycle Facility Toolkit in OCTA's 2016 OC Foothills Bikeways Strategy. The document details a comprehensive outline of engineering design treatments that are suitable for Orange County and are incorporated directly into this toolkit.

Table 5-1: Design Treatment Table

ENGINEERING DESIGN TREATMENT	APPLICABILITY		PAGE
	PEDESTRIAN	BICYCLE	
Traffic Calming	•	•	25
Pedestrian Lighting	•	•	26
Access to Transit	•	•	27
Driveways	•	•	28
Integration of Automated/Connected Vehicles	•	•	29
Sidewalks	•		30
Pedestrian Buffers	•		31
Integration with Bikeways	•		32
Pedestrian Intersection Treatments	•		32
Crossing Treatments	•		33
Pedestrian Signage	•		35
Senior Mobility	•		35
Bikeway Facility Types		•	36
Protected Intersections		•	37
Shared-Use Paths		•	41
Path Roadway Crossings		•	47
Separated Bikeways Design		•	51
Separated Bikeways at Intersections		•	62
Signalization		•	72
Shared Roadways		•	76
Bikeway Signing		•	79
Retrofitting Existing Streets to Accommodate Bikeways		•	82
Bicycle Support Facilities		•	85
Bikeways Maintenance		•	91

TRAFFIC CALMING

DESCRIPTION

Traffic calming measures help reduce vehicular volumes and speed down to a safe level for pedestrians and bicyclists. They include a variety of physical roadway measures that are designed to help improve safety and reduce conflicts between motorists, bicyclists, and pedestrians. It should be noted that the OCTA MPAH strictly prohibits the usage of volume control measures on MPAH streets. Local jurisdictions can, however, implement volume control measures on non-MPAH streets.

GUIDANCE/TOOLS

- **Speed Control – Horizontal Measures**
  - **Traffic Circles:** Traffic circles are raised circular islands constructed in the center of residential or local street intersections. They force a motorists to slow down in order to maneuver around them and may vary in design and materials used. The primary benefit of traffic circles is that they reduce the number of angle and turning collisions.
  - **Chicanes:** Chicanes are a series of curb extensions or road narrowings that are placed to form S-shaped curves along a segment of a roadway. Chicanes require motorists to slow down to a speed that allows them to maneuver around them. They should be placed at mid-block locations only and are the most effective on roadways where traffic volumes are equivalent on both approaches.
  - **Lateral Shifts:** Lateral shifts are a variation of a chicane, however only involves a single shift in the roadways rather than multiple shifts. Typical lateral shifts include a median island to prevent motorists from crossing the centerline and driving a straight path. Lateral shifts are applicable only at mid-block locations.
  - **Realigned Intersections:** Realigned intersections involve the reconfiguration of a T-intersection. They skew the approaches or travel paths through the intersection into curving streets and reduce vehicular speeds by limiting the ability for a motorist to drive through the intersection in a straight path.
- **Speed Control – Vertical Measures**
  - **Speed Humps:** Speed humps are rounded, raised areas placed across the roadway. They are generally 10 to 14 feet long (in the direction of travel) and are 3 to 4 inches high. The profile of a speed hump can be circular, parabolic, or sinusoidal. They are often tapered as they reach the curb on each end to allow unimpeded drainage.
  - **Speed Cushions:** A speed cushion is type of speed hump that allows larger vehicles, especially fire trucks, to straddle them without slowing down. Several small speed cushions are installed in a series across a roadway with spaces in between them.
  - **Speed Tables:** These are flat-topped speed humps often constructed with brick or other textured materials on the flat section. Speed tables are typically long enough for the entire wheelbase of a passenger car to rest on the flat section. Good for locations where low speeds are desired but a somewhat smooth ride is needed for larger vehicles. Their long flat fields give speed tables higher design speeds than speed humps.
  - Raised Intersections: A raised intersection is essentially a speed table for an entire intersection. Construction involves providing ramps on each intersection approach and elevating the entire intersection to the level of the sidewalk. They can be built with a variety of materials, including asphalt, concrete, or pavers. The crosswalks on each approach are also elevated as a part of the

treatment, to enable pedestrians to cross the road at the same level as the sidewalk. This is good for mobility impaired pedestrians but may cause problems for the sight impaired if they cannot detect the curb edge.

- Volume Control Measures
  - **Full Closure:** These are barriers placed across a street to completed close the street to through-traffic, usually leaving only sidewalks open. They are good for locations with extreme traffic volume problems and several other measures have been unsuccessful.
  - **Half Closures:** These are barriers that block travel in one direction for a short distance on otherwise two-way streets. They are good for locations with extreme traffic volume problems and nonrestrictive measures have been unsuccessful.
  - **Diverters:** These are islands located along the centerline of a street and continuing through an intersection so as to block though-movement at cross streets. They are effective at inhibiting though traffic from main streets to local streets and unsafe left turns from local streets to main streets. These diverters are often used to allow bikes and pedestrians to go through but not allow vehicles.
  - **Diagonal Diverter:** Diagonal diverters are barriers placed diagonally across an intersection, blocking through movements and creating two separate, L-shaped streets. Like half closures, diagonal diverters are often staggered to create circuitous routes through the neighborhood as a whole, discouraging non-local traffic while maintaining access for local residents.
  - **Median Barriers/Forced Turn Islands:** Median barriers or forced turn islands are raised islands designed to restrict certain turning movements at an intersection approach. They are typically implemented to eliminate undesirable turning movements that facilitate neighborhood cut through traffic. In addition to reducing volumes, forced turn islands can also help improve safety by eliminating vehicular conflict points.eliminating vehicular conflict points.

PEDESTRIAN LIGHTING

DESCRIPTION

Street lighting is an important countermeasure in bicycle and pedestrian safety. Insufficient lighting along a corridor and at crosswalks impedes a driver's ability to detect bikes or crossing pedestrians, which can cause more frequent and severe collisions. Providing bicycle and pedestrian lighting along corridors and at crosswalks helps to improve safety by increasing bicyclist and pedestrian visibility to motorists and improving the reaction time to their presence. Lighting also helps to improve personal security for a bicyclist or pedestrian that is traveling along a corridor, waiting at a bus stop, or crossing the street. It encourages more biking and walking at night, improves access to transit, and can activate a corridor.

GUIDANCE/TOOLS

- **Crosswalk Lighting**
  - Crosswalk lighting should be provided at signalized, unsignalized, and mid-block crossings, especially at:
    - Locations with a speed limit of 40 mph or greater.
    - Intersections, access points, and decision points where the roadway alignment changes.

  - o Connections to transit.
  - o Locations that attract high bicycle and pedestrian volumes, such as schools, parks, community centers, and parking lots.
  - o Pedestrian refuge islands.
- Crosswalk lighting should be installed at least 10 feet ahead of the crosswalk rather than directly overhead to increase contrast, enhance visibility, and facilitate facial communication between the bicyclist/pedestrian and the motorist.

- **Corridor Lighting**
  - Corridor lighting should be used to illuminate sidewalks and bikeways and should be installed on both sides of the street.
  - Corridor lighting should use uniform lighting levels.
  - Regular maintenance should include replacing bulbs as they approach the end of their life cycle in order to maintain proper lighting.
  - Street trees and landscaping features should be regularly pruned to ensure uniform lighting along the street and sidewalk.

ACCESS TO TRANSIT

DESCRIPTION

Because every transit rider begins and ends a transit trip by walking, the bicycle and pedestrian environment plays a critical role in attracting new riders and maintaining existing levels of ridership. The presence of high-quality infrastructure and amenities for active transportation near transit greatly enhances a person's ability to access transit services. Improving access to transit includes a wide range of strategies, such as the provision of connected and wide sidewalks, level boarding features, shelters, benches, street lighting, street trees, wayfinding, and more. The benefits of providing high-quality infrastructure and amenities for active transportation are also experienced by other modes of transportation. By providing high-quality infrastructure for active transportation, overall safety and comfort on city streets are improved to support all multi-modal connections to transit.

GUIDANCE/TOOLS

- **Sidewalks**
  - Sidewalks should be present within a quarter mile to half mile of transit stops, especially along High Quality Transit Areas (HQTA).
  - The NACTO Transit Street Design Guide recommends sidewalks should have clear pathway widths of 8 to 12 feet where transit is present.
  - Per the U.S. Access Board ADA Accessibility Guidelines, an absolute minimum clear pathway width of 3 feet is required for accessible routes at transportation facilities.
- **Bicycle Lanes**
  - Bicycle lanes should be present with one to two miles of transit stops, especially along High Quality

Transit Areas (HQTA).

- Where buses use a travel lane adjacent to a bicycle lane, both bus and bike operation comfort are enhanced by providing a buffer space between them when available. The NACTO Transit Street Design Guide recommends configuring the total width of these uses to a minimum of 15 feet total, with a desired minimum of 17 feet. Account for existing space constraints and operational characteristics on a case-by-case basis.
- Per the NACTO Transit Street Design Guide, shared bus-bike lanes may be 10-11 feet wide along segments where neither is expected to overtake the other, such as where bus volumes are moderate or where bus speeds are low. Passing at stops may be accommodated with a 13-foot shared lane.

- **Accessible Boarding Areas**
  - An accessible boarding area must be provided at all transit stops, which typically includes appropriate wheelchair waiting area widths, plus additional widths to position a wheel chair ramp.
  - Per the U.S. Access Board ADA Accessibility Guidelines, a wheelchair waiting area of 8 feet by 5 feet is required.
  - The U.S. Access Board ADA Accessibility Guidelines also requires that transit platform areas have cross slopes between 0.5% and 2% to achieve good drainage and accessibility. Landing areas should also have less than 1% cross slope.
- **Pedestrian Routes**
  - Pedestrian routes to transit should be direct and well-marked.
  - Marked crosswalks should be placed near transit stops to facilitate safe access to transit.
  - If a mid-block pedestrian crossing is provided, then it should be located behind a mid-block transit stop in order to enhance pedestrian visibility to oncoming vehicular traffic. Bus stops should be placed in front of a mid-block crosswalk by at least 5 feet, but 10 feet is preferred.
- **Lighting**
  - Transit stops should incorporate appropriate levels of lighting to enhance bicyclist/pedestrian visibility, security, and safety.
  - Transit stop lighting should be placed near passenger waiting areas, ticket-buying locations, and walkways. Street lights may not necessarily provide adequate amounts of lighting in all instances.
  - The American Public Transportation Association (APTA) recommends using multiple lights rather than single fitting to provide consistent levels of lighting and to reduce contrasts between shadow and light.
  - Avoid placing light fixtures at locations that can be blocked by street trees or other landscaping features.

DRIVEWAYS

DESCRIPTION

Various driveway designs may impede bicyclist and pedestrian access and safety. Some of these designs include overly wide and/or sloped driveways, driveways with large turning radii, multiple adjacent driveways, driveways that are not well defined, and driveways where the focus of a motorists is on finding a gap in congested traffic rather than the presence of bicyclists and pedestrians. Driveway design influences driver behavior and the safety of active transportation

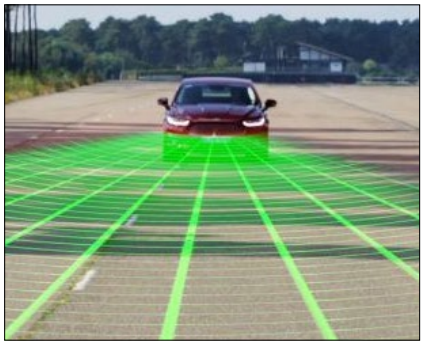
users. Careful attention to details such as the slope and design of the sidewalk intersecting the driveway as well as maintaining sight lines will help improve access and safety for bicyclists and pedestrians crossing driveways.

GUIDANCE/TOOLS

- **Turning Radii:** Some examples of driveway design improvements include narrowing driveways and tightening turning radii. Smaller driveway radii of 15 to 20 feet are recommended because they cause motorists to slow down in order to complete the turn.
- **Driveway Access:** Closing driveways or converting them to right-in-right out designs may help improve safety.
- **Sidewalks:** When sidewalks cross driveways, they should be continuous and clearly delineated across the driveway to signify the presence of bicyclists and pedestrians to motorists. Sidewalks must maintain a level with no more than 2% cross slope in order to safely accommodate wheelchair access and other mobility devices.
- **Sight Lines:** To improve visibility between motorists and active transportation users, large signs should be minimized and landscaping treatments should be properly maintained at driveways.

INTEGRATION WITH AUTOMATED/CONNECTED VEHICLES

DESCRIPTION



Emerging technologies in transportation have introduced the prospect of a widespread shift towards automated transportation. The race to implement fleets of automated/connected vehicles on city streets has begun and with it comes the impending need for proactive policy and regulation to not only guide automated/connected vehicle technology, but to also prioritize the needs of safety, equity, public health, and sustainability on city streets. The introduction of automated/connected vehicles presents a new set of challenges for designing the complete streets of tomorrow and how cities can ensure safety across all modes. Local jurisdictions must now begin to build upon the foundational principles of complete streets and Vision Zero to ensure policy, regulation, and infrastructure design catches up to the rapidly changing landscape of transportation technology.

GUIDANCE/TOOLS

- **Detection:** The detection technology implemented in automated/connected vehicles is a critical component for ensuring safety between interactions with pedestrians and bicyclists. They allow automated/connected vehicles to detect, recognize, and anticipate the movements of pedestrians and bicyclists. The same infrastructure conditions that impede a human driver's ability to detect pedestrians and bicyclists also present challenges for automated/connected vehicles. These infrastructure conditions include, low light or glare, road curvature, visually cluttered landscaping, on-street parking, and other impediments to sight lines. Local jurisdictions will need to consider policy and roadway design solutions that can provide contextual warnings and improve the detection of pedestrians and bicyclists.
- **V2X:** V2X is the terminology used to describe the wireless communication between connected vehicles, bicycles, pedestrians, infrastructure, and other road users. V2X as it relates to the bicycle/pedestrian environment represents the short-range wireless communications to inform connected vehicles of the

presence of bicyclists or pedestrians via personal beacon devices carried by bicyclists or pedestrians through their smartphone devices or other wireless communication devices. Initial research on V2X systems have theorized that they could potentially improve safety and efficiency for active transportation users by connecting to various roadway infrastructure to impact signal timing and prioritization for bicyclists and pedestrians.

- **Right-of-Way**
  - **Curbside Management:** Local jurisdictions should begin to consider curbside management strategies to reduce conflicts between transportation modes. These strategies can include separate pick-up/drop-off locations at transit stations/hubs or allowing curbs to serve different functions throughout the day, ranging from public space, pick-up/drop-off, deliveries, and other functions.
  - **Lane Widths:** Although, best practice strategies have identified lane widths of 10 feet as sufficient for accommodating vehicular traffic, many travel lanes in local jurisdictions are wider than 10 feet. As automated/connected transportation technology develops and advances, local jurisdictions will need to consider if large travel lane widths are still necessary and whether the additional right-of-way may be better suited to accommodate wider sidewalks for pedestrian travel or wider bicycle lanes for cyclists.
- **Speed:** Streets should be designed to prioritize the safety of all users. Local jurisdictions should work with auto manufacturers and transportation network companies (TNCs), such as Uber and Lyft, to ensure automated/connected vehicles are tested and programmed for safe and slow speeds when traveling in areas with high bicycle and pedestrian activity. Additionally, physical traffic calming treatments, such as traffic circles, speed humps, and others, as well as traffic signal timing can be incorporated to control travel speeds of automated/connected vehicles.

SIDEWALKS

DESCRIPTION

Sidewalks serve as the backbone to any pedestrian network and provides access to goods, services, jobs, and key destinations. In order to encourage more pedestrian activity in Orange County, sidewalks need to be safe, comfortable, well-maintained, attractive, and must be designed to accommodate mobility needs for all users regardless of age or ability. Sidewalks also present opportunities to transform streets into vibrant public spaces. Designed well, sidewalks can help activate corridors, create a sense of place, and encourage social activity.

GUIDANCE/TOOLS

- **Width:** Sidewalks should be designed to provide a minimum width of 5 feet in order to accommodate turning movements for wheelchair users and other mobility devices.
- **Location:** Sidewalks should be located on both sides of the street in all urban areas. They should also be located near major activity centers, transit stops, schools, parks and other high trip attractor locations.
- **Connectivity:**
  - The sidewalk network should be as complete as possible with minimal gaps or connectivity issues that would impede access for wheelchairs or other mobility devices.
  - Where the sidewalk network crosses multiple city boundaries, coordination efforts between cities should be made to ensure seamless connectivity.

- **Surface Conditions:** Sidewalks and the adjacent landscaping should be periodically monitored for conditions that may impact safety and impede access for wheelchairs or other mobility devices. This includes inspections for damage by tree roots, ground swelling, heat buckling, and other conditions impacting sidewalk surfaces.
- **Surface Materials:** Sidewalks should incorporate material that will not hinder the degree of access for wheelchairs or other mobility devices.
- **Clear Walkways:** Objects such as utility poles, light fixtures, and other street furniture should not restrict the width of the walkway. Walkway widths should be compliant with ADA accessibility guidelines.
- **Qualitative Design:** Sidewalk design should consider components such as lighting, shade, landscaping, and pedestrian buffers that can improve comfort level and the quality of the network.

PEDESTRIAN BUFFERS

DESCRIPTION

Incorporating appropriate pedestrian buffers from vehicular traffic enhances the quality of the overall pedestrian environment. Buffers are especially instrumental in improving pedestrian comfort levels along high volume and high speed roadways by making pedestrians feel less exposed and by providing an additional sense of protection against vehicular traffic. Buffer treatments typically include street trees, landscaping features, street furniture, on-street parking, and bikeway facilities. They are placed between vehicular travel lanes and the pedestrian walkway either on the roadway or on the sidewalk.

GUIDANCE/TOOLS

- **Street Trees/Landscaping:**
  - Street trees and landscaping features help enhance the aesthetics and quality of a corridor. They provide shade for comfort during warmer months and can divert stormwater from sidewalk surfaces to the soil.
  - Street trees and landscaping feature should be periodically monitored so they do not impede on safety or access by wheelchairs or other mobility devices. Periodic maintenance and inspections are required to ensure pathways and sight lines along sidewalks are unobstructed by street trees and other landscaping features.
- **Street Furniture:**
  - Street furniture includes elements such as parking meters, utility poles/boxes, signs, bus shelters/benches, bike racks, public art, and trash receptacles. Placement of street furniture should not impede or restrict access by wheelchairs or other mobility devices.
  - Benches should be provided along busy transit corridors, in areas of high pedestrian volume, and along blocks with a steep grade to serve as a place for rest for seniors, wheelchair users, and other others.
- **On-Street Parking:**
  - On-street parking can cause visual barriers between drivers and crossing pedestrians. Placement of on-street parking should not obstruct driver sight lines nearing crossings and intersections.
  - The FHWA does not recommend diagonal parking on high speed or high volume roadways.

- Back-in diagonal parking provides advantages over pull-in parking, such as providing trunk access from the curb rather than the street, providing drivers direct open door access to the sidewalk, and providing drivers clear sight lines when leaving the space.

- **Bikeways**
  - Incorporating on-street bikeway facilities, such as Class II and Class IV bikeways, not only provides a pedestrian buffer, but also encourages bicyclists not to ride on sidewalks and consequently reduces conflicts with pedestrians.

INTEGRATION WITH BIKEWAYS

DESCRIPTION

Bikeway facilities help to improve the pedestrian environment in a number of ways, such as encouraging lower vehicular speeds and providing a buffer between pedestrians and vehicular traffic. Despite these benefits, conflicts between bicyclists and pedestrians can arise in locations where their paths intersect, such at intersections, crosswalks, and transit stops. To reduce conflicts, design considerations should be given to safely integrate the pedestrian environment with bikeway facilities at locations where their paths intersect.

GUIDANCE/TOOLS

- To improve pedestrian visibility, marked crosswalks should be extended across on-street bicycle facilities, to communicate to bicyclists that they must yield to pedestrians. Additionally, appropriate signage should be place in advance of a crosswalk to alert bicyclists of the presence of pedestrian crossings.
- For shared off-street facilities, such as multi-use paths, pedestrians should be encouraged to stay to the right. When possible, markings or signage should be used to indicate to pedestrians to stay to the right to avoid conflicts with bicyclists.

INTERSECTION TREATMENTS

DESCRIPTION

Conflicts between pedestrians and pedestrians are often heightened at intersection crossings due to the merging of vehicular, bicycle, and pedestrian movements. Successful treatments for intersections should focus on improving the level of visibility and safety for all modes. This section explores a variety of treatments from curb extensions, refuge islands, raised intersections, signals, and others to ensure mobility and safety goals are addressed.

GUIDANCE/TOOLS

- **Curb Extensions:** Curb extensions create safer and shorter crossings for pedestrians by reducing the crossing distance for pedestrians, visually and physically narrowing the roadway, and reducing the

time pedestrians are in the street. Curb extensions provide visual cues to motorists to slow down due to the physical narrowing of the street. They also increase the visibility of pedestrians to motorists by positioning them in line with the parking lane. Curb extensions are best suited to locations with substantial pedestrian activity and where on-street parking is present.

- **Refuge Islands:** Refuge islands are raised islands that can be placed in the center of an intersection or mid-block crossing. They allow pedestrians to cross two-way streets one traffic direction at a time and they provide a protected space for pedestrians to stand and wait for an adequate gap in traffic before completing the second half of their crossing. Refuge islands are also beneficial for slower-paced pedestrians who may get caught in the middle of a roadway when the traffic signal changes prior to completing the crossing. Refuge islands are typically applied along streets where speeds and volumes make pedestrian crossings difficult or along streets with three or more traffic lanes. The FHWA recommends that refuge islands be at least 4 feet wide and be of adequate length to allow multiple pedestrians to stand and wait.
- **Raised Intersections:** A raised intersection is essentially a speed table for an entire intersection. Construction involves providing ramps on each intersection approach and elevating the entire intersection to the level of the sidewalk. They can be built with a variety of materials, including asphalt, concrete, or pavers. The crosswalks on each approach are also elevated as a part of the treatment, to enable pedestrians to cross the road at the same level as the sidewalk. This is good for mobility impaired pedestrians but may cause problems for the sight impaired if they cannot detect the curb edge.
- **Traffic Signals:** Traffic signals govern vehicular, bicycle, and pedestrian movement at intersections by allocating time and assigning right-of-way to conflicting traffic movements. Factors that should be considered to enhance pedestrian safety include:
  - Signal Prioritization: Signal priority tools, such as leading pedestrian intervals (LPI), synchronized signals for bicycles, or transit signal priority can be used to prioritize desired modes.
  - Signal Timing: Signals can be synchronized at or below targeted speeds to facilitate safe vehicular travel speeds.
- **Protected Intersections:** Protected intersections are an intersection design treatment that separates turning vehicles from crossing bicyclists and pedestrians with corner safety islands and setback bicycle crossings. The physical separation provides motorists with increased reaction times and visibility of pedestrians and bicyclists.
- **Painted Intersections:** Painted intersections typically involve a mural that is painted by the community directly onto the pavement of an intersection. They help slow down vehicular speeds by alerting them to the presence of an intersection. Painted intersections are also a tool for placemaking and enhancing a community's identity.

CROSSING TREATMENTS

DESCRIPTION

A well designed pedestrian network will enable a pedestrian to complete two important functions: walking along streets and crossing streets safely. Successful crossing treatments should consider the safety needs of all users, paying special attention to groups that are more vulnerable to collisions, such as children, the elderly, and those with disabilities. Every pedestrian crossing environment is different and crossing treatments should be carefully selected and designed to fit each individual setting.

GUIDANCE/TOOLS

- **Marked Crosswalks:** Marked crosswalks signify locations where pedestrians can cross the street and designate right-of-way for motorists to yield to pedestrians. They are often implemented at signalized locations and at locations with high levels of pedestrian and vehicular traffic. Crosswalks should be placed at signalized intersections, crossings near transit locations, trail crossings, school walking routes, and at locations that enable comfortable crossings for multi-lane roadways. Marked crosswalks are often used with additional measures to enhance safety and increase awareness of the presence of pedestrians. Marked crosswalks alone are not recommended under the following conditions:
  - Multi-lane roadways w/o a median and average daily traffic (ADT) > 12,000
  - Multi-lane roadways w/ a median and ADT > 15,000
- **High Visibility Crosswalks:** High visibility crosswalks incorporate ladder or zebra striped markings to draw more attention to the presence of pedestrians. These crosswalks are proven to be more visible to approaching vehicles and have been show to improving yielding behavior from motorists. They should be considered at locations with a history of conflicts between vehicular and pedestrian traffic and areas with high pedestrian volume.
- **Pedestrian Scrambles:** Pedestrian scrambles stop all vehicular traffic and allow pedestrians an exclusive interval to cross an intersection in all directions, including diagonally, at the same time. Pedestrian scrambles should be considered in locations where large numbers of pedestrians are expected and where there is enough space to accommodate large numbers of pedestrians to gather on the sidewalks.
- **Mid-block Crossings:** Mid-block crossings allow pedestrians to cross at locations other than intersections. They are typically considered when intersections are far apart and where there is strong evidence for pedestrian demand. An effective mid-block crossing encourages pedestrians to cross at the safest locations, makes them visible They should be located
- **Curb Ramps:** Curb ramps provide crucial access to sidewalks for people using wheelchairs and other mobility devices. As mandated by federal legislation, curb ramps must be installed at all intersections and mid-block locations where there are pedestrian crossings. Separate curb ramps for each crosswalk at an intersection should be provided to improve orientation for the visually impaired and to direct them towards the correct crosswalk. Truncated domes should also be installed as detectable warnings with curb ramps.
- **Pedestrian Signals:** Pedestrian signals indicate to pedestrians when it is permissible and safe to cross a street. They should be clearly visible at all times and must indicate to pedestrians when they can and can't cross. Newly installed traffic signals require countdown pedestrian indicators to indicate the amount of time left to cross. Pedestrian detectors, such as pushbuttons, are used to detect the presence of pedestrians that are in a position to cross.
- **Pedestrian Hybrid Beacons (formerly HAWK):** A pedestrian hybrid beacon facilitates pedestrian crossings at unsignalized locations with marked crosswalks by warning and controlling traffic. They are activated by pedestrian detectors, such as pushbuttons. Pedestrian hybrid beacons are recommended at uncontrolled crossings of multi-lane, higher speed and/or volume roadways where there is a need for pedestrian crossings without inordinate delay to vehicular traffic. They should be used in conjunction pedestrian countdown signals, crosswalks, and appropriate advance yield lines.
- **Rectangular Rapid Flash Beacons (RRFB):** RRFBs are devices that use LED flashing beacons to alert motorists of pedestrian crossings. They are activated by pedestrian detectors such as pushbuttons and are placed on both sides of the crosswalks. RRFBs should be used in conjunction with pedestrian crossing sign and supplemented with advance yield or stop pavement markings. They should not be used in conjunction with yield sign, stop sign, traffic control signal, nor should they be located at a roundabout. RRFBs are the most effective on two-lane streets, and less suited for multi-lane roadways.
- **Leading Pedestrian Interval (LPI):** LPIs provide pedestrians with a head start ranging from 3 to 7 seconds before motorists are allowed to proceed through the intersection. By providing pedestrians a

head start to cross, they help improve safety and visibility. LPIs can be programmed into traffic signals to help minimize conflicts between left or right turning vehicular traffic. A minimum head start of 3 to 7 seconds is recommended, however, intervals of 10 seconds may be appropriate in locations with long crossing distances. LPIs are recommended at locations where there are consistent conflicts between left turning or right turning vehicles and pedestrians.

SIGNAGE

DESCRIPTION

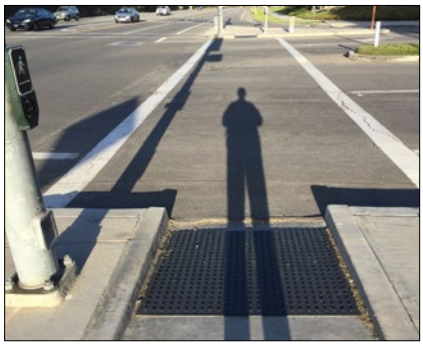
Signs are used to provide information to improve roadway safety and wayfinding. They provide information to roadway users regarding right-of-way, restricted turning movements, speed limits, and more. There are two types of signage that are useful in enhancing the pedestrian environment, regulatory and wayfinding signage. Regulatory signage is used to indicate or reinforce traffic laws and requirements of the roadway and are intended to enhance safety amongst all roadway users. Wayfinding signage is used to provide directional information to key destinations, highways, routes, and more. While signage on roadways should be used to communicate key information, careful consideration to their placement should be given to keep visual clutter at a minimum.

GUIDANCE/TOOLS

- **Advanced Yield/Stop Lines:** Advanced yield/stop lines signify to motorists where they must stop in compliance with a stop sign or signal, and are typically placed back from the crosswalk. Placing advanced yield/stop lines back from the crosswalk reduces vehicle encroachment into the crosswalk and improves visibility of pedestrians.
- **Wayfinding Signage:** Pedestrian-oriented wayfinding signage, such as maps and directional signs, help improve pedestrian circulation and enhance an area's sense of place. They help pedestrians navigate to nearby destinations, transit stops, and key routes. Local jurisdictions should consider uniformity in wayfinding signage design and theme to minimize visual clutter, develop a civic brand, and create a sense of place.

SENIOR MOBILITY

DESCRIPTION



The complexities of age-related changes make senior pedestrians more susceptible to collisions and severe injuries. These age-related changes include gradual declines in hearing, vision, balance, physical mobility and depth perception. Additionally, FHWA research found that the risk of suffering from a fatal pedestrian crash increases with age because older people are often less physically resilient. In order to improve safety and the pedestrian environment for seniors, roadway design and improvements must consider the unique and complex needs of older pedestrians. These design considerations include increasing street crossing times, audible tones at pedestrian signals, detectable warning surfaces, and more.

GUIDANCE/TOOLS

- **Pedestrian Signal Heads:** Increase street crossing times to accommodate slower walkers.
- **Refuge Islands:** Incorporate refuge islands at locations where vehicular speeds and volumes make pedestrian crossings difficult for slower walkers. They should be considered along streets with three or more traffic lanes.
- **ADA Compliance**
  - Ensure curb ramps are incorporated at pedestrian crossings to accommodate access for wheelchairs and other mobility devices.
  - Ensure sidewalks provide a minimum width of 5 feet in order to accommodate turning movements for wheelchair users and other mobility devices.
  - Ensure street furniture, street trees, and other landscaping features do not encroach upon the pedestrian pathway.
- **Treatments for Visually Impaired:** Pedestrians with visual impairments require additional navigational cues to enhance safety.
  - Detectable warning surfaces, such as truncated domes or detectable edges, should be implemented to distinguish boundary between a shared street and a conventional street.
  - Detectable warning surfaces should be consistent in materials and texture.
  - Audible tones that communicate information, such as when it is safe to cross, should be incorporated at pedestrian signals.

BIKEWAY FACILITY TYPES

DESCRIPTION

As streetscapes and infrastructure vary across regions and specific communities with varying land uses, a number of different types of bicycle facilities may be incorporated into the streetscape as appropriate. Choosing the appropriate type of facility will help to improve safety for active transportation users, manage traffic congestion, enhance economic development, and address matters of social equity.

GUIDANCE/TOOLS

The Caltrans Highway Design Manual classifies bicycle facilities into four classes of bikeways.

- **Class I Bikeways:** Also known as bike paths or shared-use paths, Class I Bikeways are facilities with exclusive right of way for bicyclists and pedestrians, away from the roadway and with minimized cross flows by vehicle traffic. These facilities support both recreational and commuting opportunities, especially along rivers, shorelines, canals, utility rights-of-way, railroad rights-of-way, within school campuses, or within and between parks. Detailed guidance for Class I Bikeway installation based on completed guidance included in the OC Foothills Bikeways Strategy can be found in Appendices A and B.
- **Class II Bikeways:** Also known as bike lanes, Class II Bikeways are established along streets, defined by pavement striping and signage to delineate a portion of a roadway for bicycle travel. Bike lanes are one-way facilities, typically striped adjacent to vehicle traffic traveling in the same direction. Buffered bike lanes provide greater separation from an adjacent traffic lane or on-street parking by using chevron

or diagonal markings. Buffered bike lanes may be desirable on streets with higher vehicle speeds or volumes. Detailed guidance for Class II Bikeway installation based on completed guidance included in the OC Foothills Bikeways Strategy can be found in Appendices C, D, and E.

- **Class III Bikeways:** Also known as bike routes, Class III Bikeways are designated routes shared with vehicles but not served by dedicated bikeways. Bike routes are established by placing signage and/or shared roadway (sharrow) markings along roadways, and are therefore generally not appropriate for roadways with high vehicle speeds or volumes. A Bicycle Boulevard is a type of bike route where bicycle travel is prioritized. These facilities are typically sites on mostly residential streets where biking or walking is the primary mode of transportation. Traffic speed and non-local vehicle access is reduced for the safety of bicyclists and pedestrians. Detailed guidance for Class III Bikeway installation based on completed guidance included in the OC Foothills Bikeways Strategy can be found in Appendices F and G.
- **Class IV Bikeways:** Also known as separated bikeways or cycle tracks, Class IV bikeways are for the exclusive use of bicycles and are physically separated from vehicle traffic with a vertical feature. The separation may include grade separation, flexible posts, inflexible barriers, or on-street parking.

PROTECTED INTERSECTIONS

DESCRIPTION

Separated bikeways at intersections can be designed as a protected intersection. These intersections provide greater separation and protection for bicyclists and minimize the number of conflict points with vehicle traffic. Protected intersection design is applicable at both signalized and stop-controlled intersections.

GUIDANCE/TOOLS

Protected intersections may require more space in the immediate vicinity of the intersection than intersections with conventional facilities. The space needed is determined by factors such as lane configuration, the presence of parking, and turning radius requirements. Key features of a protected intersection often include the following:

- **Corner Safety Island:** A corner safety island is a raised area that separates the separated bike lane from the general purpose travel lane and defines the corner radius of the intersection. The island provides comfort for waiting bicyclists and a place to queue when crossing or turning, and may manage the speed of turning vehicles when permitted turn conflicts are allowed. Turning speeds should be limited to 15 mph or less when permissive right turns across the path of through bicycles are allowed. There should be a minimum of 10 feet between the corner safety island and pedestrian sidewalk.
- **Corner Apron:** A corner apron is an optional traversable part of the corner safety island that may be needed to accommodate the wheel tracking of large vehicles. This feature helps to make geometry designed to slow driver turning speeds compatible with larger vehicles.
- **Forward Stop Bar:** The forward stop bar marks the location at which bicyclists are intended to stop and wait at a red signal indication. The location of this stop bar is purposefully further ahead of the vehicles traveling the same direction as to increase visibility of the bicyclist to the motorist.
- **Approach Taper:** The separated bike lane should shift in advance of the intersection to align bicyclists with the setback bicycle crossing. This taper should be subtle to minimize impacts to bicyclists. It is recommended to provide a taper of 1:10 (1:5 minimum).
- **Yield for Pedestrians:** Bicyclists should yield to crossing pedestrians at the location of the pedestrian

crosswalks prior to progressing to the forward stop bar waiting location. Yield line markings and signs should identify this requirement.

- **Pedestrian Safety Island:** The pedestrian safety island should be installed between the separated bike lane and general purpose travel lanes, allowing pedestrians to queue on a clearly detectable DON'T WALK signal and shorten crossing distance of the roadway. Per the MUTCD and AASHTO guidelines, the pedestrian island should be at least 4 feet wide and 6 feet long.
- **Setback Bicycle Crossing:** The bicycle and pedestrian crossings should be set back from that of the adjacent travel lanes, in line with the ends of the corner safety islands. This improves sight lines and clearly establishes priority.
- **Bicycle Signal Optimization:** Various signal phasing schemes may be used to mitigate or prevent conflict between bicyclists, pedestrians, and turning motor vehicles.

The following treatments specific to bicycles are taken from the Bicycle Facility Toolkit in OCTA's 2016 OC Foothills Bikeways Strategy, and are represented starting at page 41 of this document:

SHARED-USE PATHS

PATH ROADWAY CROSSINGS

SEPARATED BIKEWAY DESIGN

INTERSECTION TREATMENTS FOR SEPARATED BIKEWAYS

SIGNALIZATION

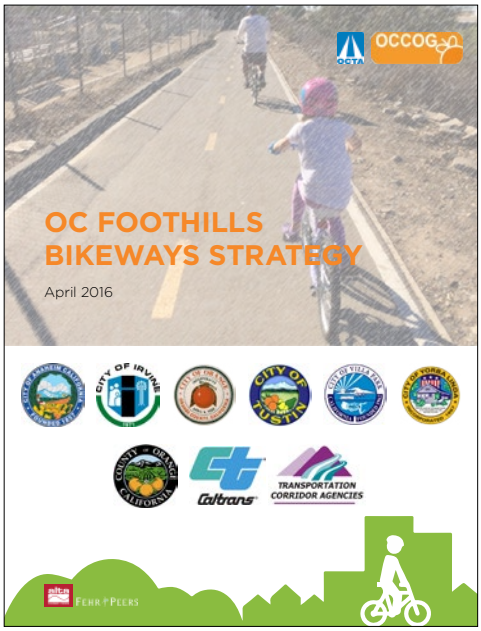
SHARED ROADWAYS

BIKEWAY SIGNING

RETROFITTING EXISTING STREETS TO ACCOMMODATE BIKEWAYS

BICYCLE SUPPORT FACILITIES

BIKEWAYS MAINTENANCE



ADDITIONAL INFORMATION

The following resources provide additional information on engineering treatments that can be used to promote and improve pedestrian activity and safety.

- **Alta Planning + Design, The Evolution of the Protected Intersection, 2015**
  https://altaplanning.com/wp-content/uploads/Evolution-of-the-Protected-Intersection_ALTA-2015.pdf
- **APTA, Bus Stop Design and Placement Security Considerations, 2010**
  http://www.apta.com/resources/standards/Documents/APTA-SS-SIS-RP-008-10.pdf
- **Caltrans, A Guide to Bikeway Classification, 2017**
  http://www.dot.ca.gov/d4/bikeplan/docs/caltrans-d4-bike-plan_bikeway-classification-brochure_072517.pdf

- **Caltrans, Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians, 2010**
  https://nacto.org/docs/usdg/complete_intersections_caltrans.pdf
- **City of Boston, Boston Complete Streets Guidelines, 2013**
  http://bostoncompletestreets.org/guidelines/
- **County of Los Angeles, Model Design Manual for Living Streets, 2011**
  http://www.modelstreetdesignmanual.com/
- **FHWA, Accessible Shared Streets: Notable Practices and Considerations for Accommodating Pedestrians with Vision Disabilities, 2017**
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/accessible_shared_streets/
- **FHWA, Achieving Multimodal Networks Applying Design Flexibility and Reducing Conflicts, 2016**
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/fhwahep16055.pdf
- **FHWA, Case Studies in Delivering Safe, Comfortable and Connected Pedestrian and Bicycle Networks, 2015**
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/network_report/
- **FHWA, Pedestrian Safety Guide and Countermeasure Selection System, 2013**
  http://www.pedbikesafe.org/PEDSAFE/index.cfm
- **FHWA, Traffic Calming ePrimer**
  https://safety.fhwa.dot.gov/speedmgt/ePrimer_modules/module3.cfm
- **NACTO, Urban Street Design Guide, 2013**
  https://nacto.org/publication/urban-street-design-guide/
- **NACTO, Blueprint for Autonomous Urbanism, 2017**
  https://nacto.org/publication/bau/blueprint-for-autonomous-urbanism/
- **NACTO, Transit Street Design Guide, 2016**
  https://nacto.org/publication/transit-street-design-guide/
- **OCCOG, Complete Streets Initiative Design Handbook, 2016**
  https://www.occog.com/occog-complete-streets/
- **OCTA, OC Foothills Bikeways Strategy, 2016**
  http://www.octa.net/pdf/20160404_OC%20Foothills%20Bikeways_Final%20Final.pdf
- **Pedestrian and Bicycle Information Center, Discussion Guide for Automated and Connected Vehicles, Pedestrians, and Bicyclists, 2017**
  http://pedbikeinfo.org/pdf/PBIC_AV.pdf
- **University of North Carolina (UNC) Highway Safety Research Center, Costs for Pedestrian and Bicyclist Infrastructure Improvements, 2013**
  http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf
- **U.S. Access Board, ADA Accessibility Guidelines, 2002**
  https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/background/adaag
- **U.S. Department of Justice, ADA Standards for Accessible Design, 2010**
  https://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards.pdf

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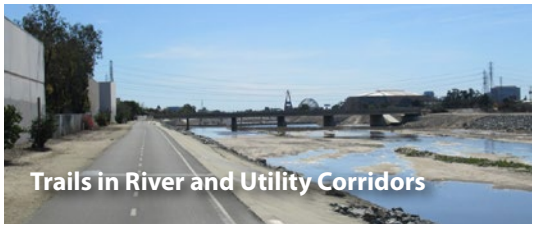
5.3 SHARED-USE PATHS

A shared use path allows for two-way, off-street bicycle use and also may be used by pedestrians, skaters, wheelchair users, joggers and other non-motorized users. These facilities are frequently found in parks, along rivers, beaches, and in greenbelts or utility corridors where there are few conflicts with motorized vehicles. Path facilities can also include amenities such as lighting, signage, and fencing (where appropriate).

Key features of shared use paths include:

- Frequent access points from the local road network.
- Directional signs to direct users to and from the path.
- A limited number of at-grade crossings with streets or driveways.
- Terminating the path where it is easily accessible to and from the street system.
- Separate treads for pedestrians and bicyclists when heavy use is expected.


General Design Practices


Trails in River and Utility Corridors


Trails in Abandoned Rail Corridors

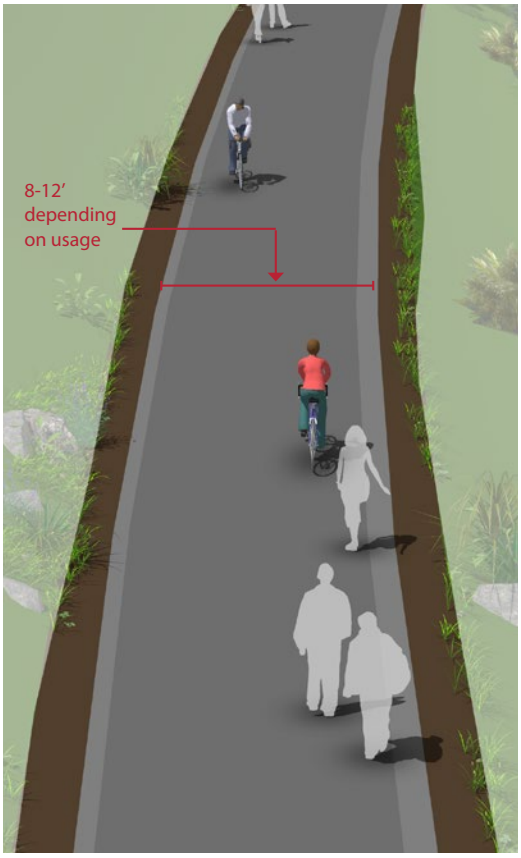

Trails in Existing Active Rail Corridors


Local Neighborhood Accessways

5.3.1 GENERAL DESIGN PRACTICES

Description

Shared use paths can provide a desirable facility, particularly for recreation, and users of all skill levels preferring separation from traffic. Bicycle paths should generally provide directional travel opportunities not provided by existing roadways.



Guidance

Width

- 8 feet is the minimum allowed for a two-way bicycle path and is only recommended for low traffic situations.
- 10 feet is recommended in most situations and will be adequate for moderate to heavy use.
- 12 feet is recommended for heavy use situations with high concentrations of multiple users. A separate track (5' minimum) can be provided for pedestrian use.

Lateral Clearance

- A 2 foot or greater shoulder on both sides of the path should be provided. An additional foot of lateral clearance (total of 3') is required by the MUTCD for the installation of signage or other furnishings.
- If bollards are used at intersections and access points, they should be colored brightly and/or supplemented with reflective materials to be visible at night.

Overhead Clearance

- Clearance to overhead obstructions should be 8 feet minimum, with 10 feet recommended.

Striping

- When striping is required, use a 4 inch dashed yellow centerline stripe with 4 inch solid white edge lines.
- Solid centerlines can be provided on tight or blind corners, and on the approaches to roadway crossings.

Discussion

Terminate the path where it is easily accessible to and from the street system, preferably at a controlled intersection or at the beginning of a dead-end street.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
Flink, C. *Greenways: A Guide To Planning Design And Development.* 1993.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

5.3.2 PATHS IN RIVER AND UTILITY CORRIDORS

Description

Utility and waterway corridors often offer excellent shared use path development and bikeway gap closure opportunities. Utility corridors typically include powerline and sewer corridors, while waterway corridors include canals, drainage ditches, rivers, and beaches. These corridors offer excellent transportation and recreation opportunities for bicyclists of all ages and skills.

Guidance

Shared use paths in utility corridors should meet or exceed general design practices. If additional width allows, wider paths, and landscaping are desirable.

Access Points

Any access point to the path should be well-defined with appropriate signage designating the pathway as a bicycle facility and prohibiting motor vehicles.

Path Closure

Public access to the shared use path may be prohibited during the following events:

- Canal/flood control channel or other utility maintenance activities
- Inclement weather or the prediction of storm conditions

Discussion

Similar to railroads, public access to flood control channels or canals may be undesirable. Hazardous materials, deep water or swift current, steep, slippery slopes, and debris all may constitute risks for public access. Appropriate fencing may be desired to keep path users within the designated travel way. Creative design of fencing is encouraged to make the path facility feel welcoming to the user.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
Flink, C. *Greenways: A Guide To Planning Design And Development.* 1993.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

5.3.3 PATHS IN ABANDONED RAIL CORRIDORS

Description

Commonly referred to as Rails-to-Trails or Rail-Trails, these projects convert vacated rail corridors into off-street paths. Rail corridors offer several advantages, including relatively direct routes between major destinations and generally flat terrain.

In some cases, rail owners may rail-bank their corridors as an alternative to a complete abandonment of the line, thus preserving the rail corridor for possible future use.

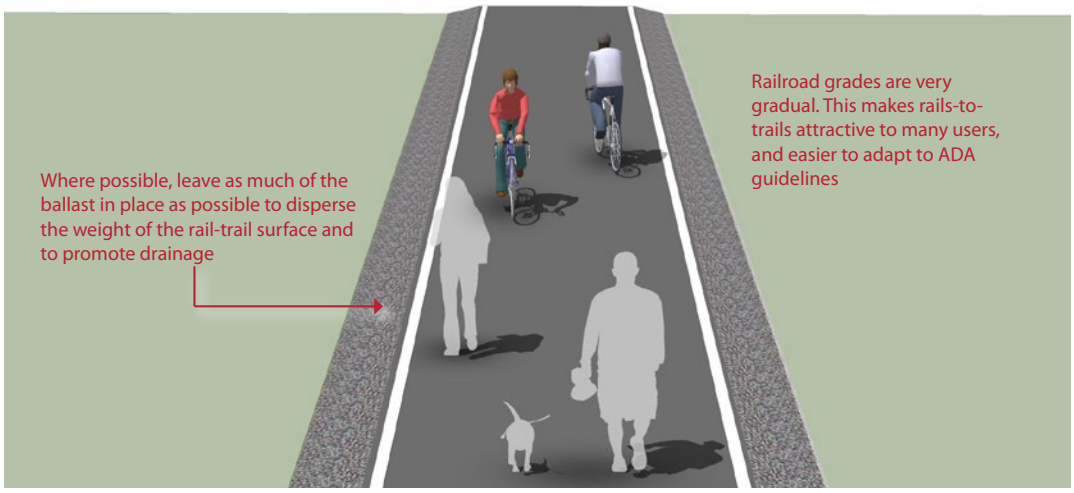
The railroad may form an agreement with any person, public or private, who would like to use the banked rail line as a trail or linear park until it is again needed for rail use. Municipalities should acquire abandoned rail rights-of-way whenever possible to preserve the opportunity for trail development.

Guidance

Shared use paths in abandoned rail corridors should meet or exceed general design practices. If additional width allows, wider paths, and landscaping are desirable.

In full conversions of abandoned rail corridors, the sub-base, superstructure, drainage, bridges, and crossings are already established. Design becomes a matter of working with the existing infrastructure to meet the needs of a rail-trail.

If converting a rail bed adjacent to an active rail line, see Shared Use Paths in Active Rail Corridors.



Discussion

It is often impractical and costly to add material to existing railroad bed fill slopes. This results in trails that meet minimum path widths, but often lack preferred shoulder and lateral clearance widths.

Rail-to-trails can involve many challenges including the acquisition of the right of way, cleanup and removal of toxic substances, and rehabilitation of tunnels, trestles and culverts. A structural engineer should evaluate existing railroad bridges for structural integrity to ensure they are capable of carrying the appropriate design loads.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
Flink, C. *Greenways: A Guide To Planning Design And Development.* 1993.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

5.3.4 PATHS IN ACTIVE RAIL CORRIDORS

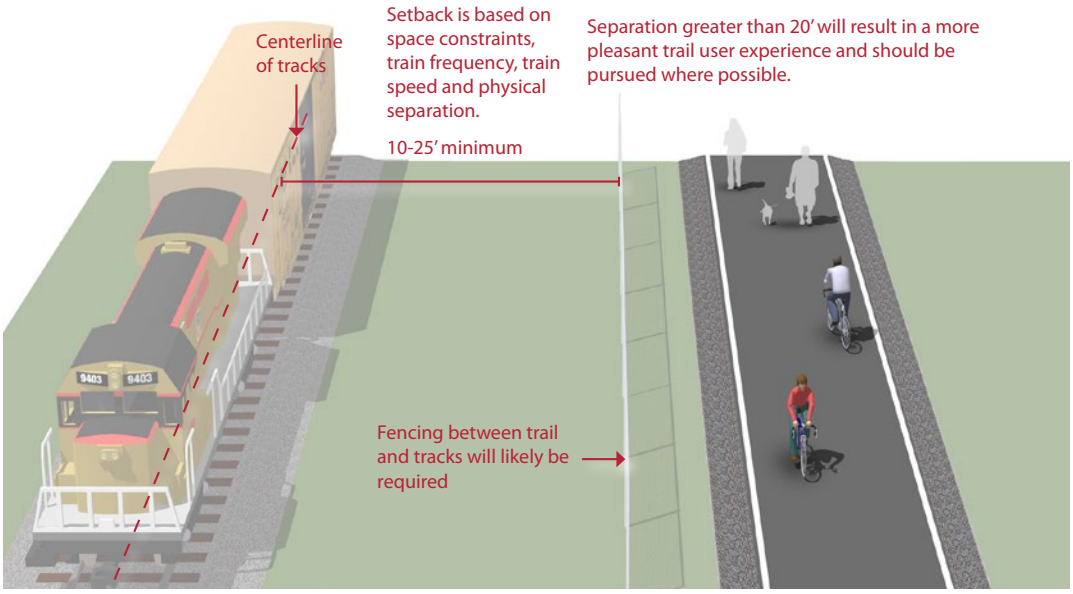
Description

Rails-with-Trails projects typically consist of paths adjacent to active railroads. It should be noted that some constraints could impact the feasibility of rail-with-trail projects. In some cases, space needs to be preserved for future planned freight, transit or commuter rail service. In other cases, limited right-of-way width, inadequate setbacks, concerns about safety/trespassing, and numerous crossings may affect a project's feasibility.

Guidance

Shared use paths in utility corridors should meet or exceed general design standards. If additional width allows, wider paths, and landscaping are desirable.

If required, fencing should be a minimum of 5 feet in height with higher fencing than usual next to sensitive areas such as switching yards. Setbacks from the active rail line will vary depending on the speed and frequency of trains, and available right-of-way.



Discussion

Railroads may require fencing with rail-with-trail projects. Concerns with trespassing and security can vary with the volume and speed of train traffic on the adjacent rail line and the setting of the shared use path, i.e. whether the section of track is in an urban or rural setting.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
FHWA. *Rails-with-Trails: Lessons Learned.* 2002.
SCRRA. *Rail-with-Trail Design Guidelines*. 2010.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

5.3.5 LOCAL NEIGHBORHOOD ACCESSWAYS

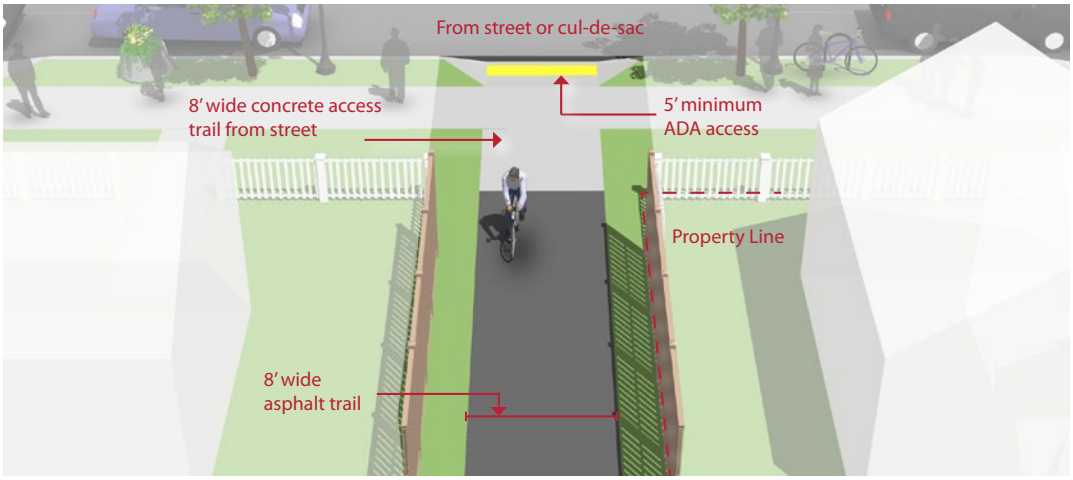
Description

Neighborhood accessways provide residential areas with direct bicycle and pedestrian access to parks, trails, greenspaces, and other recreational areas. They most often serve as small trail connections to and from the larger trail network, typically having their own rights-of-way and easements.

Additionally, these smaller trails can be used to provide bicycle and pedestrian connections between dead-end streets, cul-de-sacs, and access to nearby destinations not provided by the street network.

Guidance

- Neighborhood accessways should remain open to the public.
- Trail pavement shall be at least 8' wide to accommodate emergency and maintenance vehicles, meet ADA requirements and be considered suitable for multi-use.
- Trail widths should be designed to be less than 8' wide only when necessary to protect large mature native trees over 18" in caliper, wetlands or other ecologically sensitive areas.
- Access trails should slightly meander whenever possible.



Discussion

Neighborhood accessways should be designed into new subdivisions at every opportunity and should be required by City/County subdivision regulations.

For existing subdivisions, Neighborhood and homeowner association groups are encouraged to identify locations where such connects would be desirable. Nearby residents and adjacent property owners should be invited to provide landscape design input.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
FHWA. *Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 19: Greenways and Shared Use Paths.* 2006.
NACTO. *Urban Street Design Guide*. 2013.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

5.4 PATH ROADWAY CROSSINGS

At-grade roadway crossings can create potential conflicts between path users and motorists, however, well-designed crossings can mitigate many operational issues and provide a higher degree of safety and comfort for path users. This is evidenced by the thousands of successful facilities around the United States with at-grade crossings. In most cases, at-grade path crossings can be properly designed to provide a reasonable degree of safety and can meet existing traffic and safety standards. Path facilities that cater to bicyclists can require additional considerations due to the higher travel speed of bicyclists versus pedestrians.

Consideration must be given to adequate warning distance based on vehicle speeds and line of sight, with the visibility of any signs absolutely critical. Directing the active attention of motorists to roadway signs may require additional alerting devices such as a flashing beacon, roadway striping or changes in pavement texture. Signing for path users may include a standard "STOP" or "YIELD" sign and pavement markings, possibly combined with other features such as bollards or a bend in the pathway to slow bicyclists. Care must be taken not to place too many signs at crossings lest they begin to lose their visual impact.

A number of striping patterns have emerged over the years to delineate path crossings. A median stripe on the path approach will help to organize and warn path users. Crosswalk striping is typically a matter of local and State preference, and may be accompanied by pavement treatments to help warn and slow motorists. In areas where motorists do not typically yield to crosswalk users, additional measures may be required to increase compliance.


Marked/Unsignalized Crossings


Signalized/Controlled Crossings


Overcrossings

5.4.1 MARKED/UNSIGNALIZED CROSSINGS

Description

A marked/unsignalized crossing typically consists of a marked crossing area, signage and other markings to slow or stop traffic. The approach to designing crossings at mid-block locations depends on an evaluation of vehicular traffic, line of sight, pathway traffic, use patterns, vehicle speed, road type, road width, and other safety issues such as proximity to major attractions.

When space is available, using a median refuge island can improve user safety by providing pedestrians and bicyclists space to perform the safe crossing of one side of the street at a time.

Guidance

Maximum traffic volumes

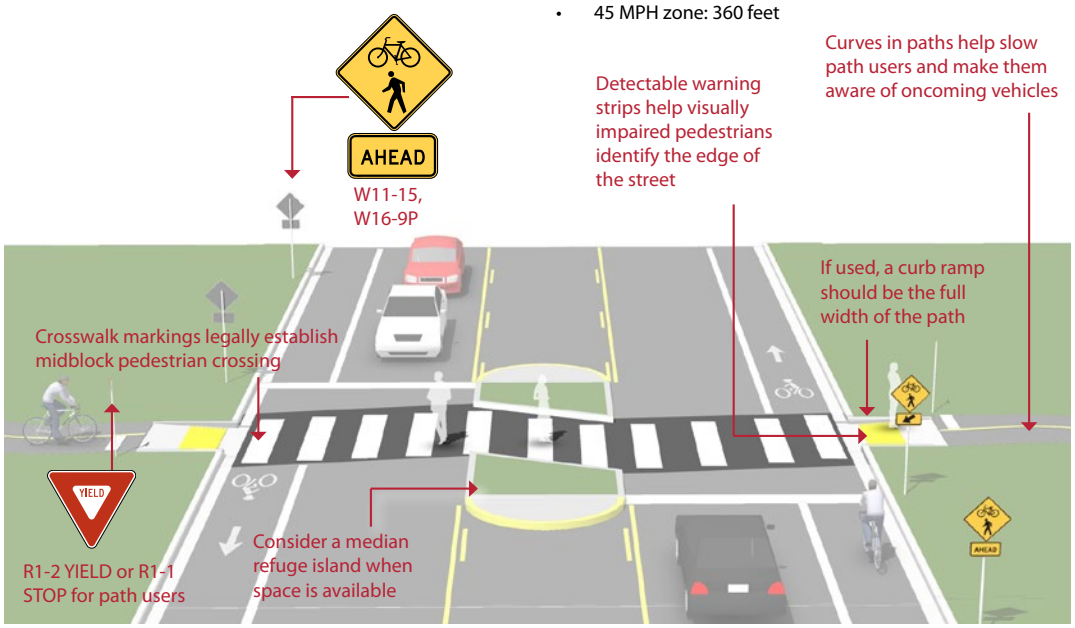
- ≤9,000-12,000 Average Daily Traffic (ADT) volume
- Up to 15,000 ADT on two-lane roads, preferably with a median
- Up to 12,000 ADT on four-lane roads with median

Maximum travel speed

- 35 MPH

Minimum line of sight

- 25 MPH zone: 155 feet
- 35 MPH zone: 250 feet
- 45 MPH zone: 360 feet



Discussion

Unsignalized crossings of multi-lane arterials over 15,000 ADT may be possible with features such as sufficient crossing gaps (more than 60 per hour), median refuges, and/or active warning devices like rectangular rapid flash beacons or in-pavement flashers, and excellent sight distance. For more information see the discussion of active warning beacons.

On roadways with low to moderate traffic volumes (<12,000 ADT) and a need to control traffic speeds, a raised crosswalk may be the most appropriate crossing design to improve pedestrian visibility and safety.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.

Materials and Maintenance

Locate markings out of wheel tread when possible to minimize wear and maintenance costs.

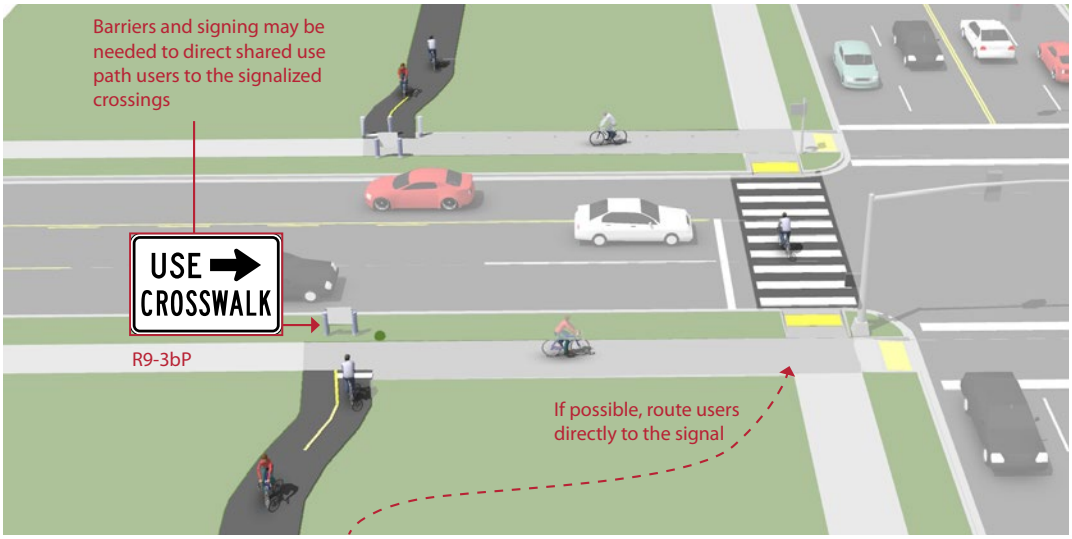
5.4.2 SIGNALIZED CROSSINGS

Description

Path crossings within approximately 400 feet of an existing signalized intersection with pedestrian crosswalks are typically diverted to the signalized intersection to avoid traffic operation problems when located so close to an existing signal. For this restriction to be effective, barriers and signing may be needed to direct path users to the signalized crossing. If no pedestrian crossing exists at the signal, modifications should be made.

Guidance

Path crossings should not be provided within approximately 400 feet of an existing signalized intersection. If possible, route path directly to the signal.



Discussion

In the US, the minimum distance a marked crossing can be from an existing signalized intersection varies from approximately 250 to 660 feet. Engineering judgement and the context of the location should be taken into account when choosing the appropriate allowable setback. Pedestrians are particularly sensitive to out of direction travel and undesired mid-block crossing may become prevalent if the distance is too great.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities.* 2004.

Materials and Maintenance

If a sidewalk is used for crossing access, it should be kept clear of snow and debris and the surface should be level for wheeled users.

5.4.3 OVERCROSSINGS

Description

Bicycle/pedestrian overcrossings provide critical non-motorized system links by joining areas separated by barriers such as deep canyons, waterways or major transportation corridors. In most cases, these structures are built in response to user demand for safe crossings where they previously did not exist.

There are no minimum roadway characteristics for considering grade separation. Depending on the type of facility or the desired user group grade separation may be considered in many types of projects.

Overcrossings require a minimum of 17 feet of vertical clearance to the roadway below versus a minimum elevation differential of around 12 feet for an undercrossing. This results in potentially greater elevation differences and much longer ramps for bicycles and pedestrians to negotiate.

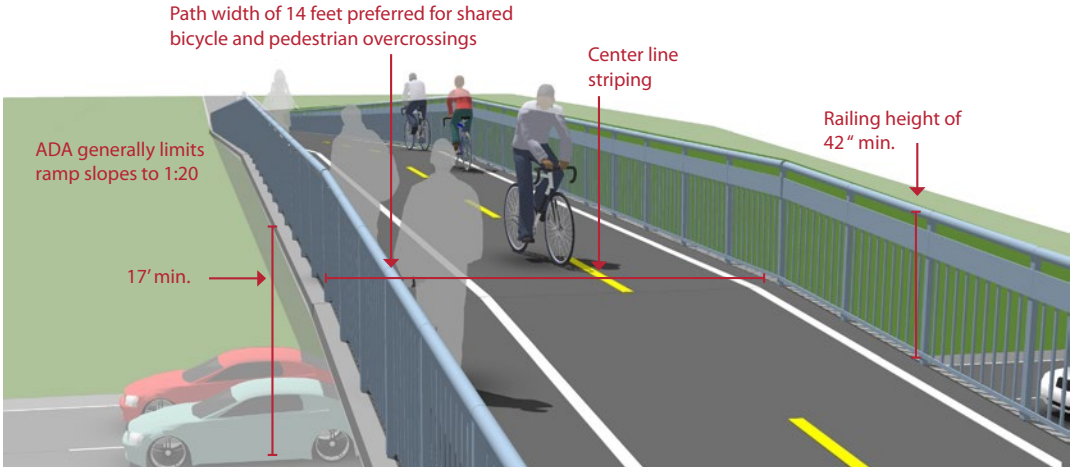
Guidance

8 foot minimum width, 14 feet preferred. If overcrossing has any scenic vistas additional width should be provided to allow for stopping. A separate 5 foot pedestrian area may be provided for facilities with high bicycle and pedestrian use.

10 foot headroom on overcrossing; clearance below will vary depending on feature being crossed.

Roadway:	17 feet
Freeway:	18.5 feet
Heavy Rail Line:	23 feet

The overcrossing should have a centerline stripe even if the rest of the path does not have one.



Discussion

Overcrossings for bicycles and pedestrians typically fall under the Americans with Disabilities Act (ADA), which strictly limits ramp slopes to 5% (1:20) with landings at 400 foot intervals, or 8.33% (1:12) with landings every 30 feet.

Overcrossings pose potential concerns about visual impact and functional appeal, as well as space requirements necessary to meet ADA guidelines for slope.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities.* 2004.

Materials and Maintenance

Potential issues with vandalism.

Overcrossings can be more difficult to clear of snow than undercrossings.

5.5 SEPARATED BIKEWAYS

Designated exclusively for bicycle travel, separated bikeways are segregated from vehicle travel lanes by striping, and can include pavement stencils and other treatments. Separated bikeways are most appropriate on arterial and collector streets where higher traffic volumes and speeds warrant greater separation.

Separated bikeways can increase safety and promote proper riding by:

- Defining road space for bicyclists and motorists, reducing the possibility that motorists will stray into the bicyclists' path.
- Discouraging bicyclists from riding on the sidewalk.
- Reducing the incidence of wrong way riding.
- Reminding motorists that bicyclists have a right to the road.


Conventional Bicycle Lanes


Buffered Bike Lanes


Bicycle Lane and Diagonal Parking


One Way Cycle Tracks

Design Needs of Bicyclists

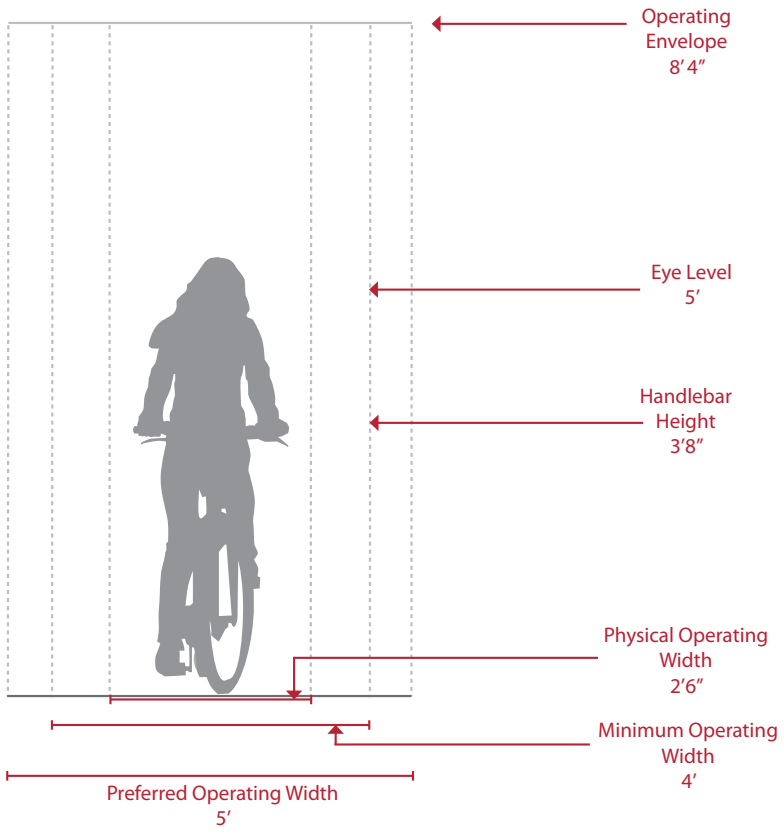
The purpose of this section is to provide the facility designer with an understanding of how bicyclists operate and how their bicycle influences that operation. Bicyclists, by nature, are much more affected by poor facility design, construction and maintenance practices than motor vehicle drivers. Bicyclists lack the protection from the elements and roadway hazards provided by an automobile's structure and safety features. By understanding the unique characteristics and needs of bicyclists, a facility designer can provide quality facilities and minimize user risk.

Bicycle as a Design Vehicle

Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The design of a bikeway should consider reasonably expected bicycle types on the facility and utilize the appropriate dimensions.

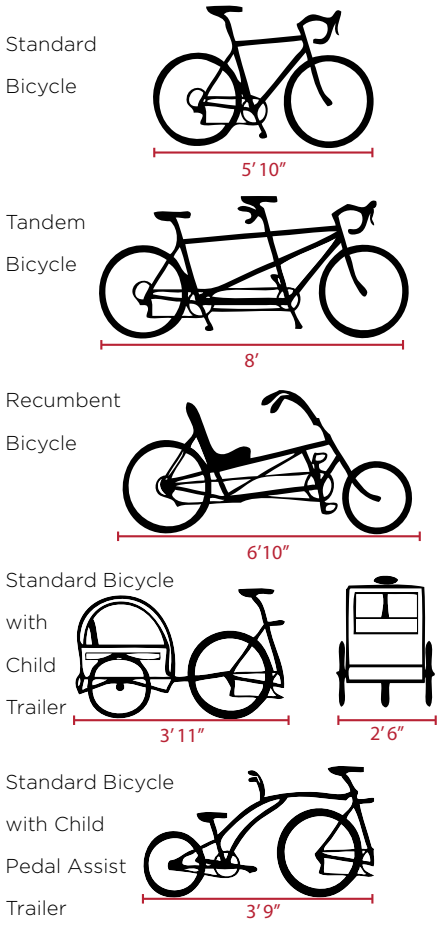
The figure below illustrates the operating space and physical dimensions of a typical adult bicyclist, which are the basis for typical facility design. Bicyclists require clear space to operate within a facility. This is why the minimum operating width is greater than the physical dimensions of the bicyclist. Bicyclists prefer five feet or more operating width, although four feet may be minimally acceptable.

Standard Bicycle Rider Dimensions



Source: AASHTO Guide for the Development of Bicycle Facilities, 4th Edition. 2012.

In addition to the design dimensions of a typical bicycle, there are many other commonly used pedal-driven cycles and accessories to consider when planning and designing bicycle facilities. The most common types include tandem bicycles, recumbent bicycles, and trailer accessories. The figure and table below summarize the typical dimensions for bicycle types.



Bicycle as Design Vehicle - Typical Dimensions

Source: AASHTO *Guide for the Development of Bicycle Facilities*, 4th Edition *AASHTO does not provide typical dimensions for tricycles.

Bicycle as Design Vehicle - Typical Dimensions

Bicycle Type	Feature	Typical Dimensions
Upright Adult Bicyclist	Physical width	2 ft 6 in
	Operating width (Minimum)	4 ft
	Operating width (Preferred)	5 ft
	Physical length	5 ft 10 in
	Physical height of handlebars	3 ft 8 in
	Operating height	8 ft 4 in
	Eye height	5 ft
	Vertical clearance to obstructions (tunnel height, lighting, etc)	10 ft
	Approximate center of gravity	2 ft 9 in - 3 ft 4 in
Recumbent Bicyclist	Physical length	8 ft
	Eye height	3 ft 10 in
Tandem Bicyclist	Physical length	8 ft
Bicyclist with child trailer	Physical length	10 ft
	Physical width	2 ft 6 in

Design Speed Expectations

The expected speed that different types of bicyclists can maintain under various conditions also influences the design of facilities such as shared use paths. The table to the right provides typical bicyclist speeds for a variety of conditions.

Bicycle as Design Vehicle - Design Speed Expectations

Bicycle Type	Feature	Typical Speed
Upright Adult Bicyclist	Paved level surfacing	15 mph
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5 -12 mph
Recumbent Bicyclist	Paved level surfacing	18 mph

*Tandem bicycles and bicyclists with trailers have typical speeds equal to or less than upright adult bicyclists.

5.5.1 BICYCLE LANE

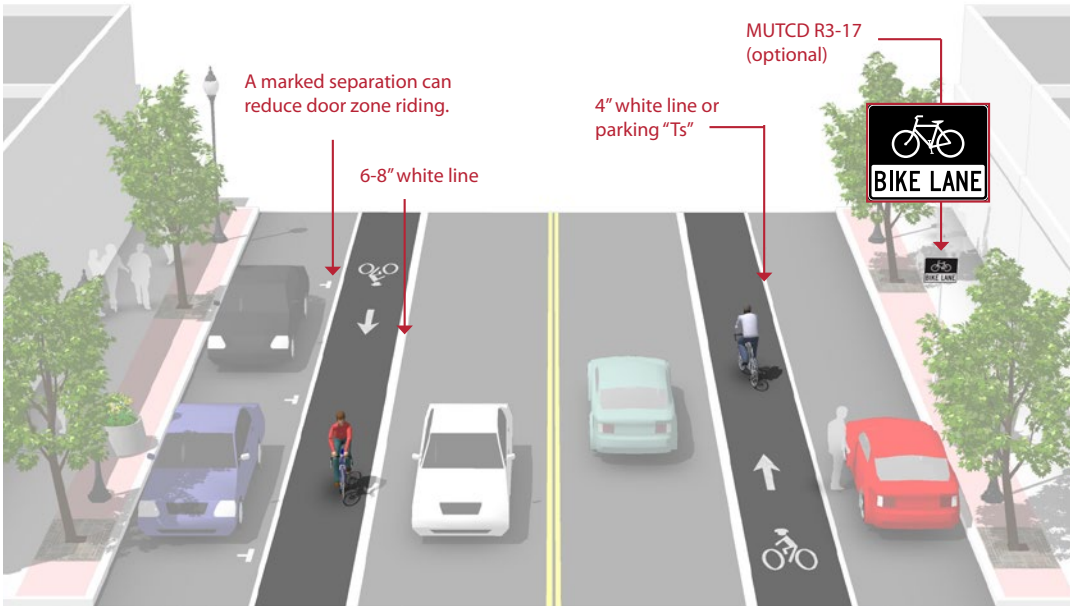
Description

Bike lanes designate an exclusive space for bicyclists through the use of pavement markings and signage. The bike lane is located adjacent to motor vehicle travel lanes and is used in the same direction as motor vehicle traffic. Bike lanes are typically on the right side of the street, between the adjacent travel lane and curb, road edge or parking lane.

Many bicyclists, particularly less experienced riders, are more comfortable riding on a busy street if it has a striped and signed bikeway than if they are expected to share a lane with vehicles.

Guidance

- 12 foot minimum from curb face to edge of bike lane.
- 14.5 foot preferred from curb face to edge of bike lane.
- 7 foot maximum for marked width of bike lane. Greater widths may encourage vehicle loading in bike lane. Configure as buffered bicycle lanes when a wider facility is desired.



Discussion

Bike lanes adjacent to on-street parallel parking require special treatment in order to avoid crashes caused by an open vehicle door. The bike lane should have sufficient width to allow bicyclists to stay out of the door zone while not encroaching into the adjacent vehicular lane. Parking stall markings, such as parking "Ts" and double white lines create a parking side buffer that encourages bicyclists to ride farther away from the door zone.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
NACTO. *Urban Bikeway Design Guide*. 2012.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

5.5.2 BICYCLE LANE AND DIAGONAL PARKING

Description

In certain areas with high parking demand such as urban commercial areas, diagonal parking can be used to increase parking supply.

Back-in diagonal parking improves sight distances between drivers and bicyclists when compared to conventional head-in diagonal parking. Back-in parking is best paired with a dedicated bicycle lane.

Conventional front-in diagonal parking is not compatible or recommended with the provision of bike lanes, as drivers backing out of conventional diagonal parking have limited visibility of approaching bicyclists. Under these conditions, shared lane markings should be used to guide bicyclists away from reversing automobiles.

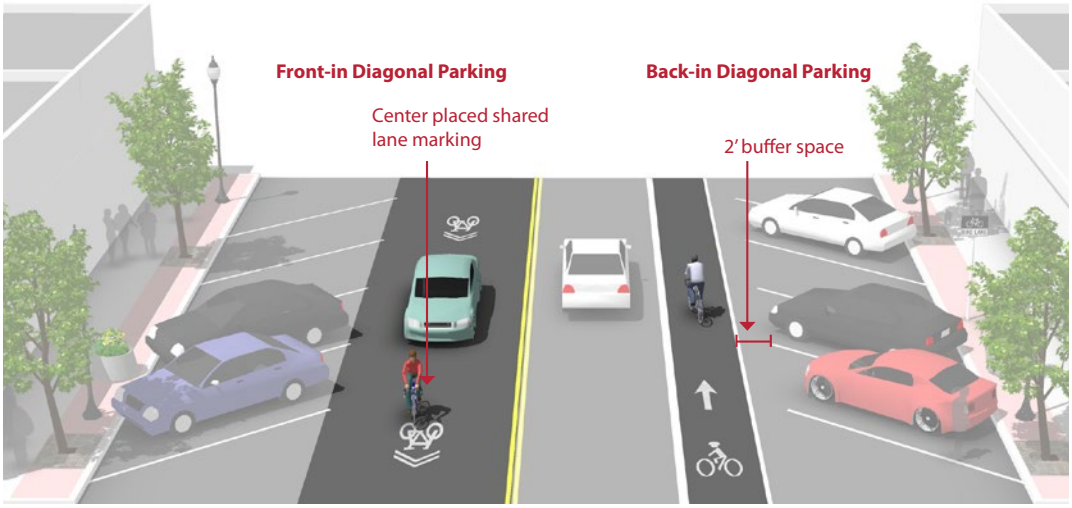
Guidance

Front-in Diagonal Parking

- Shared lane markings are the preferred facility with front-in diagonal parking

Back-in Diagonal Parking

- 5 foot minimum marked width of bike lane
- Parking bays are sufficiently long to accommodate most vehicles (so vehicles do not block bike lane)



Discussion

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

5.5.3 BUFFERED BICYCLE LANE

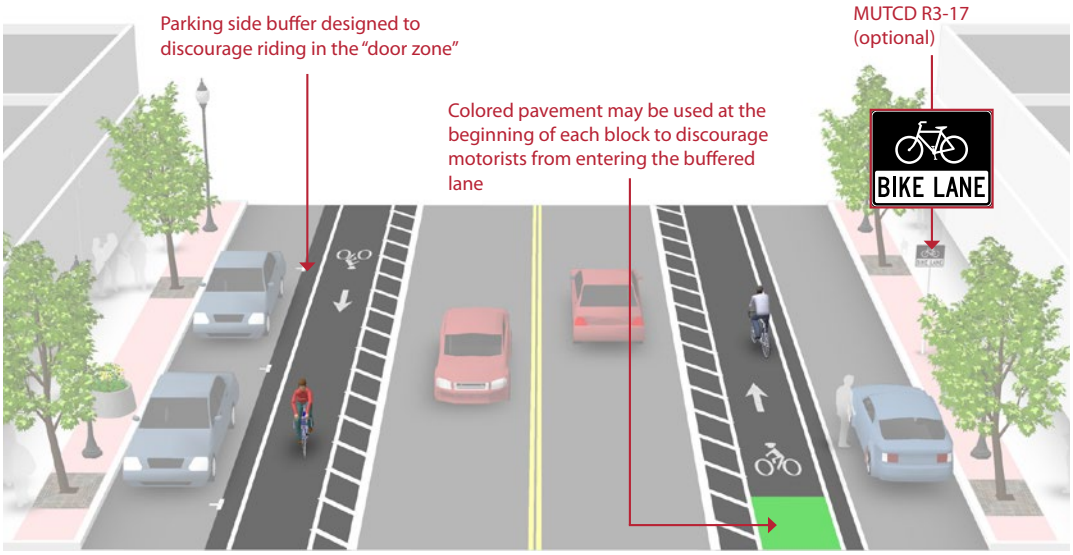
Description

Buffered bike lanes are conventional bicycle lanes paired with a designated buffer space, separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane. Buffered bike lanes follow general guidance for buffered preferential vehicle lanes as per MUTCD guidelines (section 3D-01).

Buffered bike lanes are designed to increase the space between the bike lane and the travel lane and/or parked cars. This treatment is appropriate for bike lanes on roadways with high motor vehicle traffic volumes and speed, adjacent to parking lanes, or a high volume of truck or oversized vehicle traffic.

Guidance

- The minimum bicycle travel area (not including buffer) is 5 feet wide.
- Buffers should be at least 2 feet wide. If 3 feet or wider, mark with diagonal or chevron hatching. For clarity at driveways or minor street crossings, consider a dotted line for the inside buffer boundary where cars are expected to cross.
- Buffered bike lanes can buffer the travel lane only, or parking lane only depending on available space and the objectives of the design.



Discussion

Frequency of right turns by motor vehicles at major intersections should determine whether continuous or truncated buffer striping should be used approaching the intersection. Commonly configured as a buffer between the bicycle lane and motor vehicle travel lane, a parking side buffer may also be provided to help bicyclists avoid the 'door zone' of parked cars.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices. (3D-01).* 2009.
NACTO. *Urban Bikeway Design Guide.* 2012.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

Travel Side Buffered Bike Lane on Sloat Blvd (SR-35), San Francisco (Photo: Mark Dreger)

Travel Side Buffered Bike Lane on Nimitz Blvd, San Diego (Photo: BikeSD)

Parking Side and Travel Side Buffered Bike Lane on Fifth Ave, San Diego (Photo: Paul Jamason)

Parking Side and Travel Side Buffered Bike Lane on Fifth Ave, San Diego (Photo: Paul Jamason)

Travel Side Buffered Bike Lane on PCH (SR-1), Dana Point (Photo: Google Street View)

Two-Way Buffered Bike Lane on Brink Ave, Modesto (Photo: Streetsblog)

5.5.2 CLASS IV SEPARATED BIKEWAY

Description

Protection is provided through physical barriers and can include bollards, parking, a planter strip, an extruded curb, or on-street parking. Separated bikeways using these protection elements typically share the same elevation as adjacent travel lanes.

Raised separated bikeways may be at the level of the adjacent sidewalk or set at an intermediate level between the roadway and sidewalk to separate the bikeway from the pedestrian area.

Guidance

- Separated bikeways should ideally be placed along streets with long blocks and few driveways or mid-block access points for motor vehicles. Separated bikeways located on one-way streets have fewer potential conflict areas than those on two-way streets.
- In situations where on-street parking is allowed, separated bikeways shall be located between the parking lane and the sidewalk (in contrast to bike lanes).

Discussion

Sidewalks or other pedestrian facilities should not be narrowed to accommodate the cycle track as pedestrians will likely walk on the bikeway if sidewalk capacity is reduced. Visual and physical cues (e.g., pavement markings & signage) should be used to make it clear where bicyclists and pedestrians should be traveling. If possible, separate the bikeway and pedestrian zone with a furnishing zone.

Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.
FHWA. *Separated Bike Lane Planning and Design Guide*. 2015.
Caltrans. *Design Information Bulletin #89 - Class IV Bikeway Guidance*. 2015

Materials and Maintenance

Barrier-separated and raised separated bikeways may require special equipment for sweeping and cleaning.

Two-Way Cycle Track (Separated Bikeway) along Harbor Drive, San Diego (Photo: Stephan Vance)

Two-Way Cycle Track (Separated Bikeway) Westwood Blvd, Redondo Beach (Photo: Jim Lyle)

5.6 SEPARATED BIKEWAYS AT INTERSECTIONS

Intersections are junctions at which different modes of transportation meet and facilities overlap. An intersection facilitates the interchange between bicyclists, motorists, pedestrians and other modes in order to advance traffic flow in a safe and efficient manner. Designs for intersections with bicycle facilities should reduce conflict between bicyclists (and other vulnerable road users) and vehicles by heightening the level of visibility, denoting clear right-of-way and facilitating eye contact and awareness with other modes. Intersection treatments can improve both queuing and merging maneuvers for bicyclists, and are often coordinated with timed or specialized signals.

The configuration of a safe intersection for bicyclists may include elements such as color, signage, medians, signal detection and pavement markings. Intersection design should take into consideration existing and anticipated bicyclist, pedestrian and motorist movements. In all cases, the degree of mixing or separation between bicyclists and other modes is intended to reduce the risk of crashes and increase bicyclist comfort. The level of treatment required for bicyclists at an intersection will depend on the bicycle facility type used, whether bicycle facilities are intersecting, and the adjacent street function and land use.


Colored Bike Lanes in Conflict Areas


Bike Lanes at Right Turn Only Lanes

Shared Bicycle/Right Turn Lane


Intersection Crossing Markings


Bike Boxes


Two Stage Turn Boxes

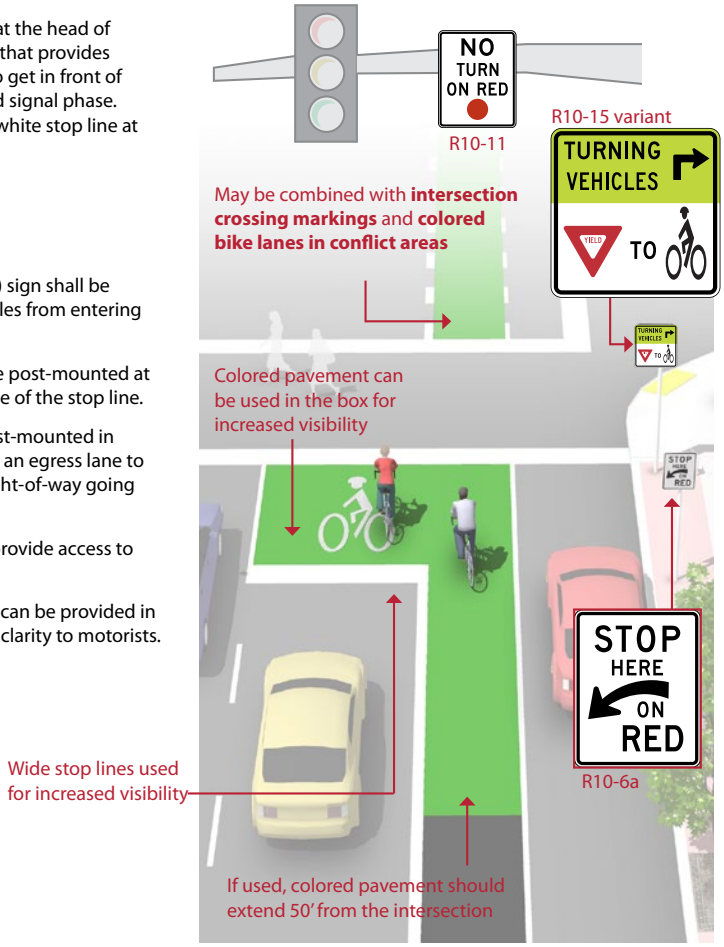
5.6.1 BIKE BOX

Description

A bike box is a designated area located at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible space to get in front of queuing motorized traffic during the red signal phase. Motor vehicles must queue behind the white stop line at the rear of the bike box.

Guidance

- 14' minimum depth
- A "No Turn on Red" (MUTCD R10-11) sign shall be installed overhead to prevent vehicles from entering the Bike Box.
- A "Stop Here on Red" sign should be post-mounted at the stop line to reinforce observance of the stop line.
- A "Yield to Bikes" sign should be post-mounted in advance of and in conjunction with an egress lane to reinforce that bicyclists have the right-of-way going through the intersection.
- An ingress lane should be used to provide access to the box.
- A supplemental "Wait Here" legend can be provided in advance of the stop bar to increase clarity to motorists.



Discussion

Bike boxes are considered experimental by the FHWA.
Bike boxes should be placed only at signalized intersections, and right turns on red shall be prohibited for motor vehicles. Bike boxes should be used in locations that have a large volume of bicyclists and are best utilized in central areas where traffic is usually moving more slowly. Prohibiting right turns on red improves safety for bicyclists yet does not significantly impede motor vehicle travel.

Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide.* 2012.
FHWA. Interim Approval (IA-14) has been granted. Requests to use green colored pavement need to comply with the provisions of Paragraphs 14 through 22 of Section 1A.10. 2011.

Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

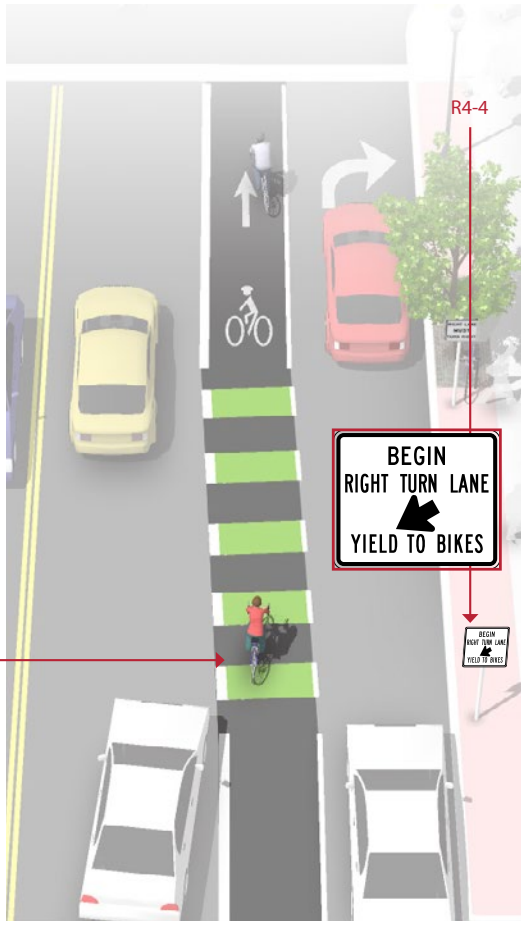
5.6.2 COLORED BIKE LANE IN CONFLICT AREAS

Description

Colored pavement within a bicycle lane increases the visibility of the facility and reinforces priority of bicyclists in conflict areas.

Guidance

- Green colored pavement was given interim approval by the Federal Highways Administration in March 2011. See interim approval for specific colored pavement standards.
- The colored surface should be skid resistant and retro-reflective.
- A "Yield to Bikes" sign should be used at intersections or driveway crossings to reinforce that bicyclists have the right-of-way in colored bike lane areas.



Discussion

Evaluations performed in Portland, OR, St. Petersburg, FL and Austin, TX found that significantly more motorists yielded to bicyclists and slowed or stopped before entering the conflict area after the application of the colored pavement when compared with an uncolored treatment.

Additional References and Guidelines

FHWA. Interim Approval (IA-14) has been granted. Requests to use green colored pavement need to comply with the provisions of Paragraphs 14 through 22 of Section 1A.10. 2011.
NACTO. *Urban Bikeway Design Guide.* 2012.

Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

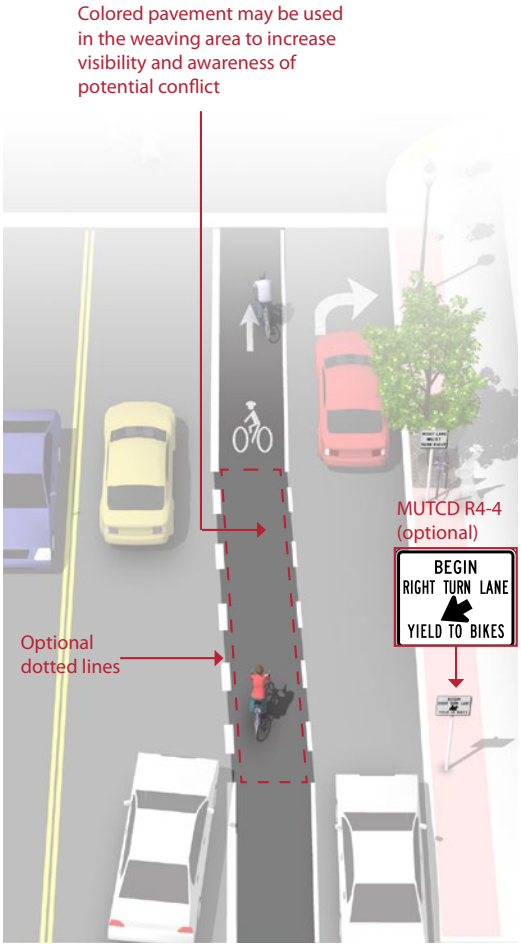
Colored Bicycle Lane in Conflict Area on 3rd St at Lime Ave, Long Beach (Photo: Streetsblog)

5.6.3 BIKE LANE AT RIGHT TURN ONLY LANE

Description

The appropriate treatment at right-turn lanes is to place the bike lane between the right-turn lane and the right-most through lane or, where right-of-way is insufficient, to use a shared bike lane/turn lane.

The design (right) illustrates a bike lane pocket, with signage indicating that motorists should yield to bicyclists through the conflict area.



Guidance

At auxiliary right turn only lanes (add lane):

- Continue existing bike lane width; standard width of 5 to 6 feet or 4 feet in constrained locations.
- Use signage to indicate that motorists should yield to bicyclists through the conflict area.
- Consider using colored conflict areas to promote visibility of the mixing zone.

Where a through lane becomes a right turn only lane:

- Do not define a dotted line merging path for bicyclists.
- Drop the bicycle lane in advance of the merge area.
- Use shared lane markings to indicate shared use of the lane in the merging zone.

Discussion

For other potential approaches to providing accommodations for bicyclists at intersections with turn lanes, please see guidance on shared bike lane/turn lane, bicycle signals, and colored bike facilities.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
NACTO. *Urban Bikeway Design Guide*. 2012.

Materials and Maintenance

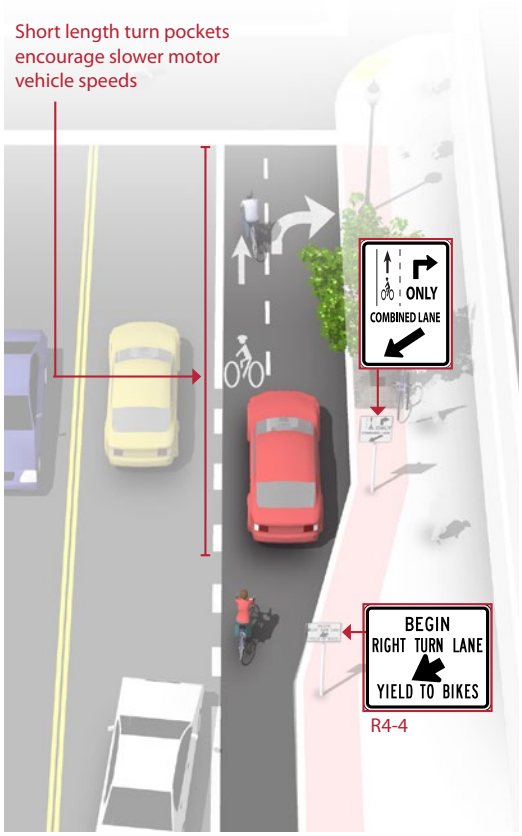
Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

5.6.4 COMBINED BIKE LANE/TURN LANE

Description

The combined bike lane/turn lane places a standard-width bike lane on the left side of a dedicated right turn lane. A dotted line delineates the space for bicyclists and motorists within the shared lane. This treatment includes signage advising motorists and bicyclists of proper positioning within the lane.

This treatment is recommended at intersections lacking sufficient space to accommodate both a standard through bike lane and right turn lane.



Guidance

- Maximum shared turn lane width is 13 feet; narrower is preferable.
- Bike Lane pocket should have a minimum width of 4 feet with 5 feet preferred.
- A dotted 4 inch line and bicycle lane marking should be used to clarify bicyclist positioning within the combined lane, without excluding cars from the suggested bicycle area.
- A "Right Turn Only" sign with an "Except Bicycles" plaque may be needed to make it legal for through bicyclists to use a right turn lane.

Discussion

Case studies cited by the Pedestrian and Bicycle Information Center indicate that this treatment works best on streets with lower posted speeds (30 MPH or less) and with lower traffic volumes (10,000 ADT or less). May not be appropriate for high-speed arterials or intersections with long right turn lanes. May not be appropriate for intersections with large percentages of right-turning heavy vehicles.

Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

Materials and Maintenance

Locate markings out of tire tread to minimize wear. Because the effectiveness of markings depends on their visibility, maintaining markings should be a high priority.

5.6.5 TWO-STAGE TURN BOX

Description

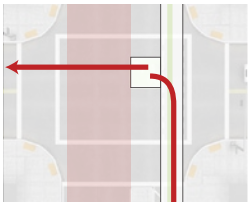
Two-stage turn queue boxes offer bicyclists a safe way to make left turns at multi-lane signalized intersections from a right side cycle track or bike lane.

On right side cycle tracks, bicyclists are often unable to merge into traffic to turn left due to physical separation, making the provision of two-stage left turn boxes critical. Design guidance for two-stage turns apply to both bike lanes and cycle tracks.

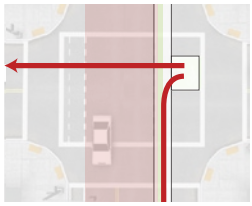
Guidance

- The queue box shall be placed in a protected area. Typically this is within an on-street parking lane or cycle track buffer area.
- 6' minimum depth of bicycle storage area
- Bicycle stencil and turn arrow pavement markings shall be used to indicate proper bicycle direction and positioning.
- A "No Turn on Red" (MUTCD R10-11) sign shall be installed on the cross street to prevent vehicles from entering the turn box.

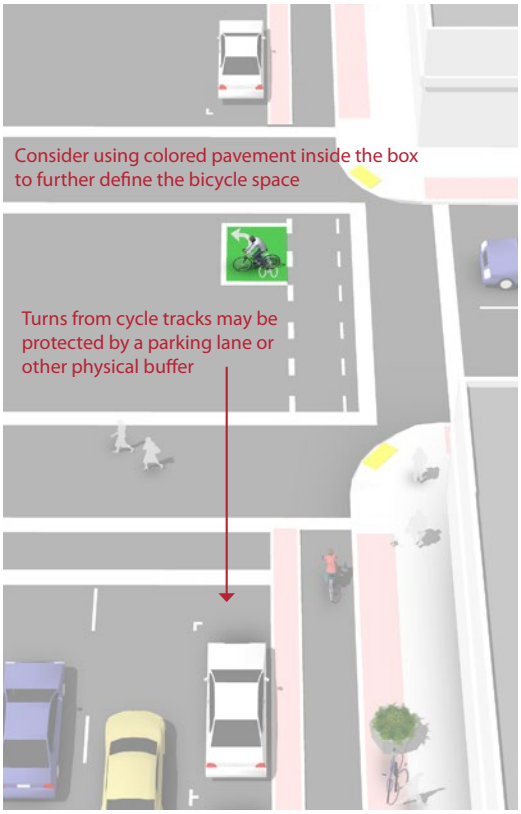
Cycle track turn box protected by physical buffer:



Bike lane turn box protected by parking lane:



Turns from a bicycle lane may be protected by an adjacent parking lane or crosswalk setback space



Discussion

Two-Stage Turn boxes are considered experimental by FHWA.

While two stage turns may increase bicyclist comfort in many locations, this configuration will typically result in higher average signal delay for bicyclists due to the need to receive two separate green signal indications (one for the through street, followed by one for the cross street) before proceeding.

Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

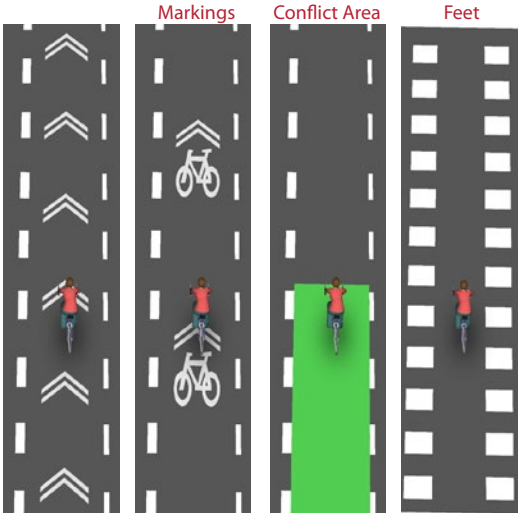
Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates.

5.6.6 INTERSECTION CROSSING MARKINGS

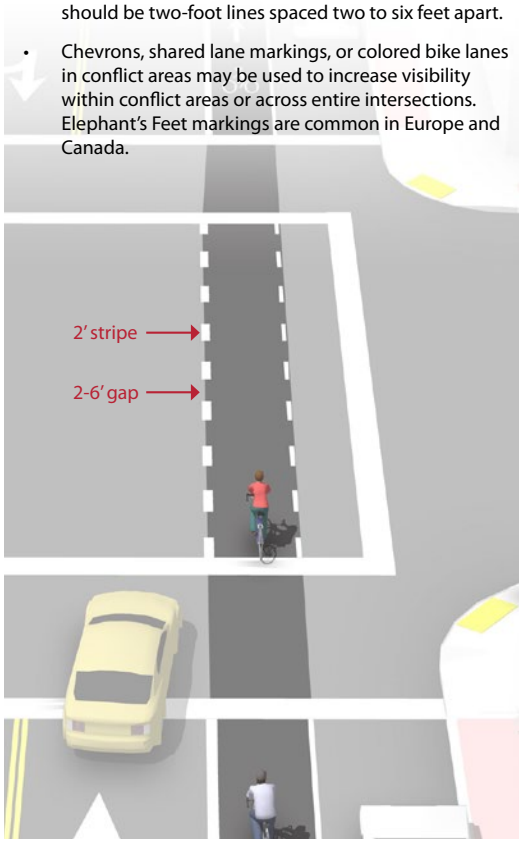
Description

Bicycle pavement markings through intersections indicate the intended path of bicyclists through an intersection or across a driveway or ramp. They guide bicyclists on a safe and direct path through the intersection and provide a clear boundary between the paths of through bicyclists and either through or crossing motor vehicles in the adjacent lane.



Guidance

- See MUTCD Section 3B.08: "dotted line extensions"
- Crossing striping shall be at least six inches wide when adjacent to motor vehicle travel lanes. Dotted lines should be two-foot lines spaced two to six feet apart.
- Chevrons, shared lane markings, or colored bike lanes in conflict areas may be used to increase visibility within conflict areas or across entire intersections. Elephant's Feet markings are common in Europe and Canada.



Discussion

Additional markings such as chevrons, shared lane markings, or colored bike lanes in conflict areas are strategies currently in use in the United States and Canada. Cities considering the implementation of markings through intersections should standardize future designs to avoid confusion.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices. (3A.06).* 2009.
NACTO. *Urban Bikeway Design Guide.* 2012.

Materials and Maintenance

Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority.

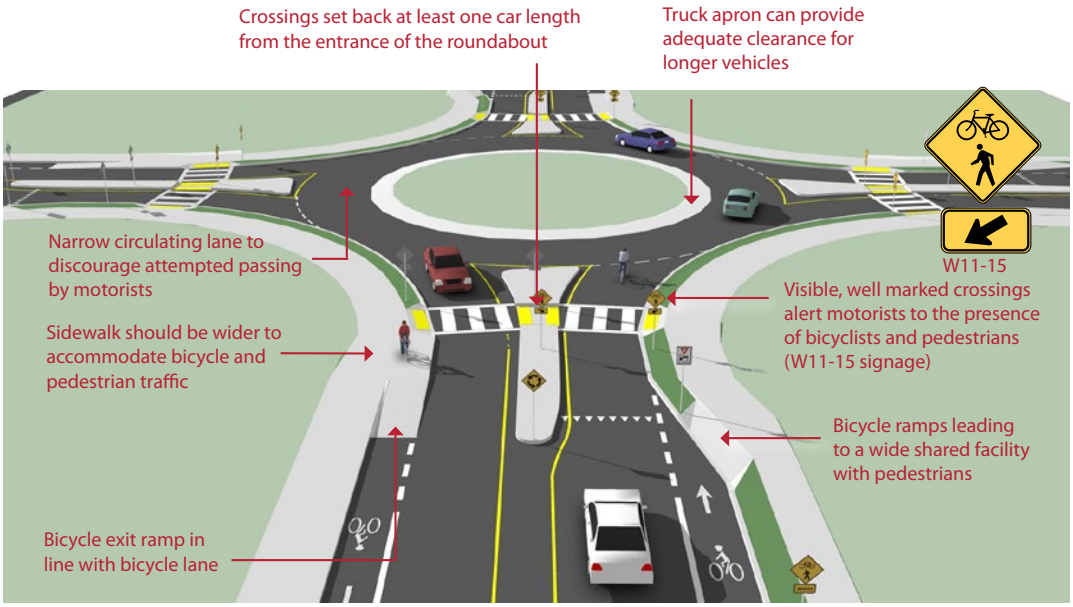
5.6.7 BICYCLES AT SINGLE LANE ROUNDABOUTS

Description

In single lane roundabouts it is important to indicate to motorists, bicyclists and pedestrians the right-of-way rules and correct way for them to circulate, using appropriately designed signage, pavement markings, and geometric design elements.

Guidelines

- 25 mph maximum circulating design speed.
- Design approaches/exits to the lowest speeds possible.
- Encourage bicyclists navigating the roundabout like motor vehicles to "take the lane."
- Maximize yielding rate of motorists to pedestrians and bicyclists at crosswalks.
- Provide separated facilities for bicyclists who prefer not to navigate the roundabout on the roadway.



Discussion

Research indicates that while single-lane roundabouts may benefit bicyclists and pedestrians by slowing traffic, multi-lane roundabouts may present greater challenges and significantly increase safety problems for these users.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.

FHWA. *Roundabouts: An Informational Guide.* 2000.
TRB. *Roundabouts: An Informational Guide, Second Edition.* NCHRP 672. 2010.

Materials and Maintenance

Signage and striping require routine maintenance.

5.6.8 BIKE LANES AT DIVERGING RAMPS

Description

Some arterials may contain high speed freeway-style designs such as merge lanes and exit ramps, which can create difficulties for bicyclists. The entrance and exit lanes typically have intrinsic visibility problems because of low approach angles and feature high speed differentials between bicyclists and motor vehicles.

Strategies to improve safety focus on increasing sight distances, creating formal crossings, and minimizing crossing distances.

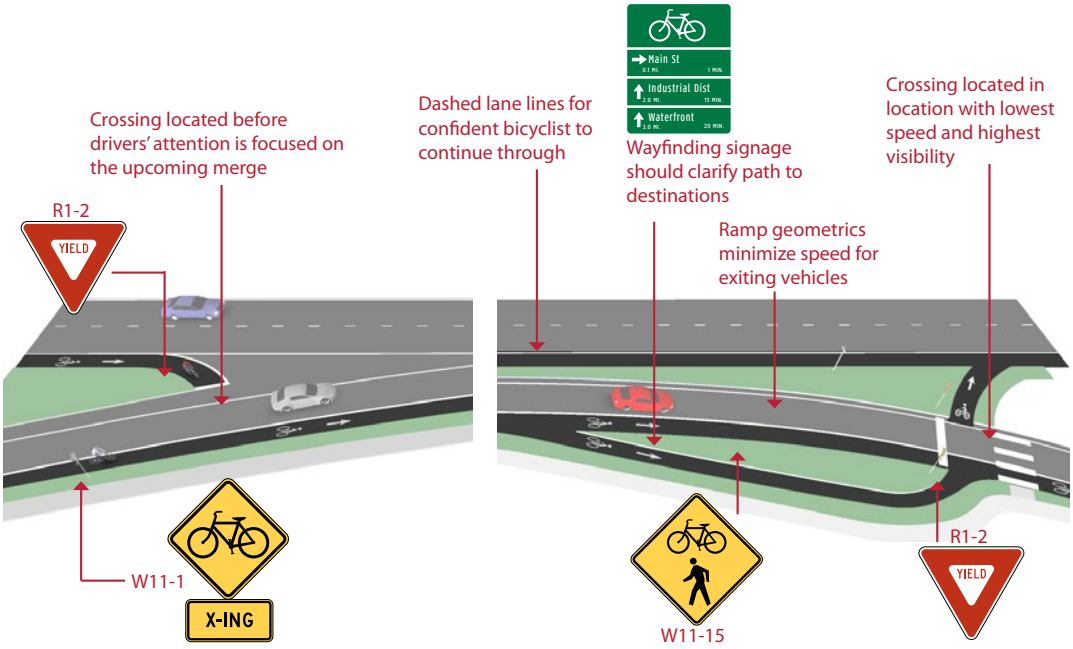
Guidance

Entrance Ramps:

Angle the bike lane to increase the approach angle with entering traffic. Position crossing before drivers' attention is focused on the upcoming merge.

Exit Ramps:

Use a jug handle turn to bring bicyclists to increase the approach angle with exiting traffic, and add yield striping and signage to the bicycle approach.



Discussion

While the jug-handle approach is the preferred configuration at exit ramps, provide the option for through bicyclists to perform a vehicular merge and proceed straight through under safe conditions.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.

FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
FHWA. *Bicycle and Pedestrian Transportation. Lesson 15: Bicycle Lanes*. 2006.

Materials and Maintenance

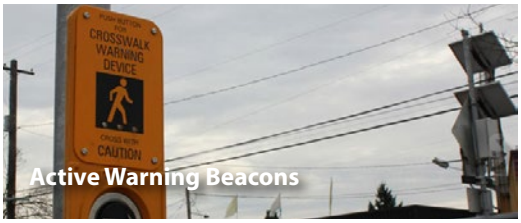
Locate crossing markings out of wheel tread when possible to minimize wear and maintenance costs.

5.7 SIGNALIZATION

Bicycle signals and beacons facilitate bicyclist crossings of roadways. Bicycle signals make crossing intersections safer for bicyclists by clarifying when to enter an intersection and by restricting conflicting vehicle movements. Bicycle signals are traditional three lens signal heads with green, yellow and red bicycle stenciled lenses that can be employed at standard signalized intersections. Flashing amber warning beacons can be utilized at unsignalized intersection crossings. Push buttons, signage, and pavement markings may be used to supplement these facilities for both bicyclists and motorists.

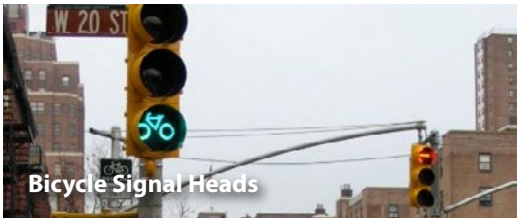
Determining which type of signal or beacon to use for a particular intersection depends on a variety of factors. These include speed limits, Average Daily Traffic (ADT), anticipated bicycle crossing traffic, and the configuration of planned or existing bicycle facilities. Signals may be necessary as part of the construction of a protected bicycle facility such as a cycle track with potential turning conflicts, or to decrease vehicle or pedestrian conflicts at major crossings. An intersection with bicycle signals may reduce stress and delays for a crossing bicyclist, and discourage illegal and unsafe crossing maneuvers.


Bicycle Detection and Actuation



Active Warning Beacons


Hybrid Beacons (HAWK)



Bicycle Signal Heads

5.7.1 BICYCLE DETECTION AND ACTUATION

Description

Push Button Actuation

User-activated button mounted on a pole facing the street.

Loop Detectors

Bicycle-activated loop detectors are installed within the roadway to allow the presence of a bicycle to trigger a change in the traffic signal. This allows the bicyclist to stay within the lane of travel without having to maneuver to the side of the road to trigger a push button.

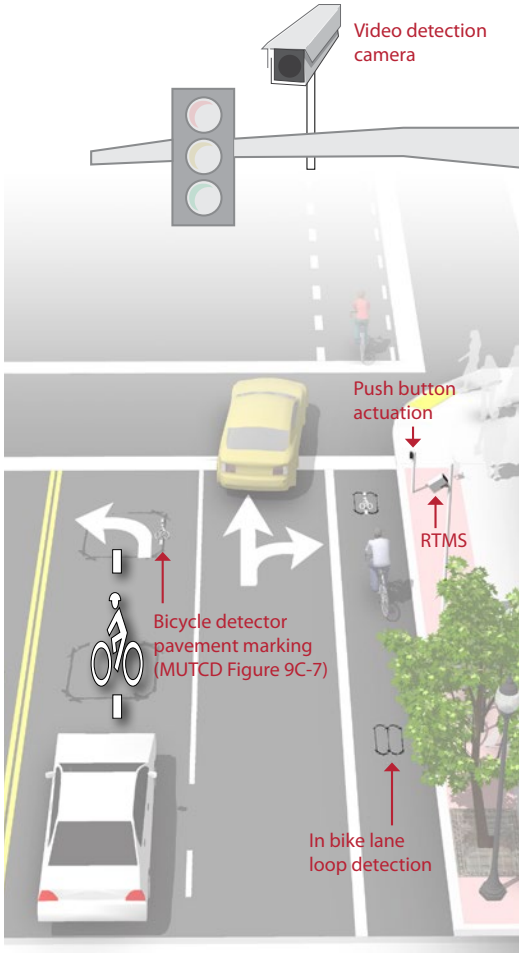
Loops that are sensitive enough to detect bicycles should be supplemented with pavement markings to instruct bicyclists how to trip them.

Video Detection Cameras

Video detection systems use digital image processing to detect a change in the image at a location. These systems can be calibrated to detect bicycles. Video camera system costs range from $20,000 to $25,000 per intersection.

Remote Traffic Microwave Sensor Detection (RTMS)

RTMS is a system which uses frequency modulated continuous wave radio signals to detect objects in the roadway. This method marks the detected object with a time code to determine its distance from the sensor. The RTMS system is unaffected by temperature and lighting, which can affect standard video detection.



Discussion

Proper bicycle detection should meet two primary criteria: 1) accurately detects bicyclists and 2) provides clear guidance to bicyclists on how to actuate detection (e.g., what button to push, where to stand).

Bicycle loops and other detection mechanisms can also provide bicyclists with an extended green time before the light turns yellow so that bicyclists of all abilities can reach the far side of the intersection.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
NACTO. *Urban Bikeway Design Guide.* 2012.

Materials and Maintenance

Signal detection and actuation for bicyclists should be maintained with other traffic signal detection and roadway pavement markings.

Bicycle Detector Pavement Marking, San Luis Obispo (Photo: NACTO)

Bicycle Detection Instruction Sign, San Luis Obispo (Photo: NACTO)

5.7.2 HYBRID BEACON

Description

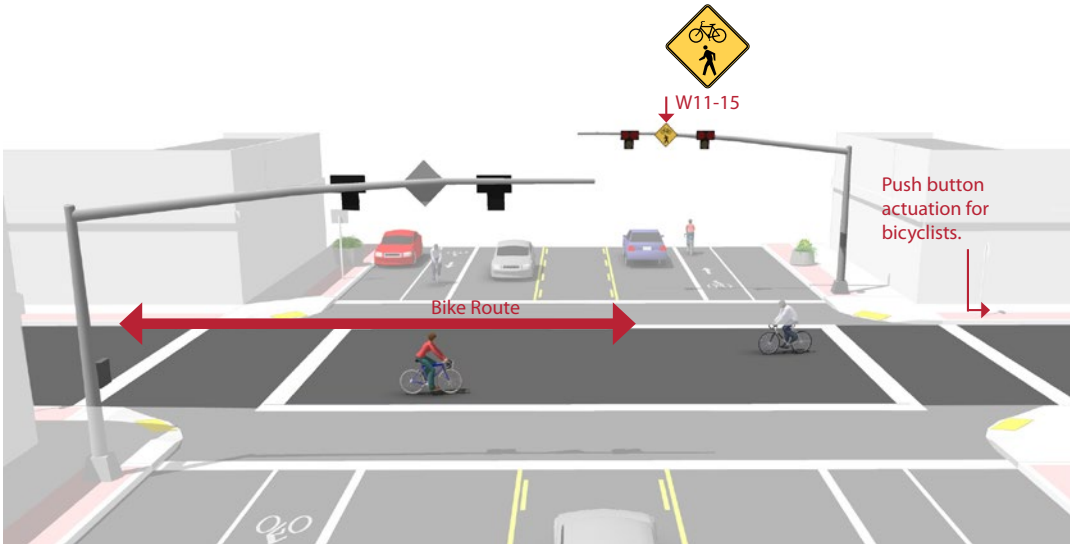
A hybrid beacon, formerly known as a High-intensity Activated CrosswalK (HAWK), consists of a signal-head with two red lenses over a single yellow lens on the major street, and pedestrian and/or bicycle signal heads for the minor street. There are no signal indications for motor vehicles on the minor street approaches.

Hybrid beacons are used to improve non-motorized crossings of major streets in locations where side-street volumes do not support installation of a conventional traffic signal or where there are concerns that a conventional signal will encourage additional motor vehicle traffic on the minor street. Hybrid beacons may also be used at mid-block crossing locations.

Guidance

Hybrid beacons may be installed without meeting traffic control signal warrants if roadway speed and volumes are excessive for comfortable user crossing.

- If installed within a signal system, signal engineers should evaluate the need for the hybrid signal to be coordinated with other signals.
- Parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk to provide adequate sight distance.



Discussion

The hybrid beacon can significantly improve the operation of a bicycle route, particularly along neighborhood greenway corridors. Because of the low traffic volumes on these facilities, intersections with major roadways are often unsignalized, creating difficult and potentially unsafe crossing conditions for bicyclists.

Each crossing, regardless of traffic speed or volume, requires additional review by a registered engineer to identify sight lines, potential impacts on traffic progression, timing with adjacent signals, capacity and safety.

Additional References and Guidelines

FHWA. *Pedestrian Hybrid Beacon Guide - Recommendations and Case Study.* 2014.
NACTO. *Urban Bikeway Design Guide.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.

Materials and Maintenance

Hybrid beacons are subject to the same maintenance needs and requirements as standard traffic signals. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

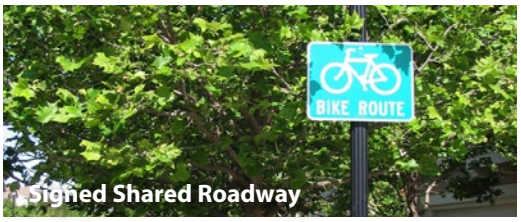
5.8 SHARED ROADWAYS

On shared roadways, bicyclists and motor vehicles use the same roadway space. These facilities are typically used on roads with low speeds and traffic volumes, however they can be used on higher volume roads with wide outside lanes or shoulders. A motor vehicle driver will usually have to cross over into the adjacent travel lane to pass a bicyclist, unless a wide outside lane or shoulder is provided.

Shared roadways employ a large variety of treatments from simple signage and shared lane markings to more complex treatments including directional signage, traffic diverters, chicanes, chokers, and/or other traffic calming devices to reduce vehicle speeds or volumes.

Neighborhood Greenways

Neighborhood greenways are a special class of shared roadways designed for a broad spectrum of bicyclists. They are low-volume local streets where motorists and bicyclists share the same travel lane. Treatments for neighborhood greenways are selected as necessary to create appropriate automobile volumes and speeds, and to provide safe crossing opportunities of busy streets.



Signed Shared Roadway


Marked Shared Roadway


Shared Roadways with Diagonal Parking


Neighborhood Greenways

5.8.1 SIGNED SHARED ROADWAY

Description

Signed shared roadways are facilities shared with motor vehicles. They are typically used on roads with low speeds and traffic volumes, however can be used on higher volume roads with wide outside lanes or shoulders. A motor vehicle driver will usually have to cross over into the adjacent travel lane to pass a bicyclist, unless a wide outside lane or shoulder is provided.

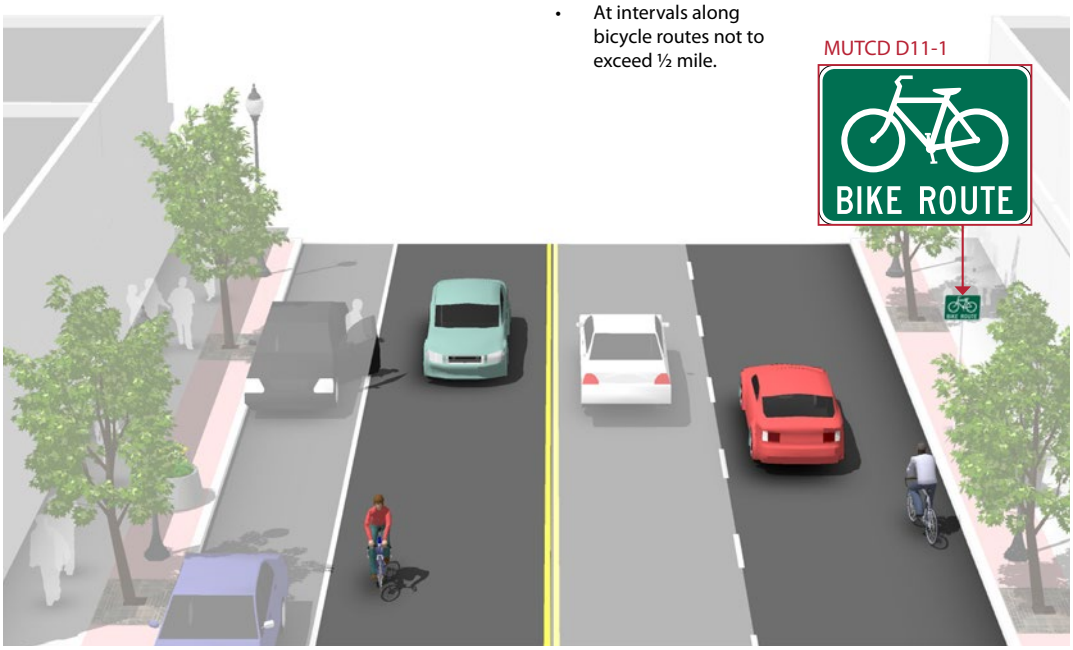
Guidance

Lane width varies depending on roadway configuration.

Bike route signage (D11-1) should be applied at intervals frequent enough to keep bicyclists informed of changes in route direction and to remind motorists of the presence of bicyclists. Commonly, this includes placement at:

- Beginning or end of Bicycle Route.
- At major changes in direction or at intersections with other bicycle routes.
- At intervals along bicycle routes not to exceed ½ mile.

MUTCD D11-1



Discussion

Signed Shared Roadways serve either to provide continuity with other bicycle facilities (usually bike lanes) or to designate preferred routes through high-demand corridors.

This configuration differs from a neighborhood greenway due to a lack of traffic calming, wayfinding, pavement markings and other enhancements designed to provide a higher level of comfort for a broad spectrum of users.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.

Materials and Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs, and will need periodic replacement due to wear.

5.8.2 MARKED SHARED ROADWAY

Description

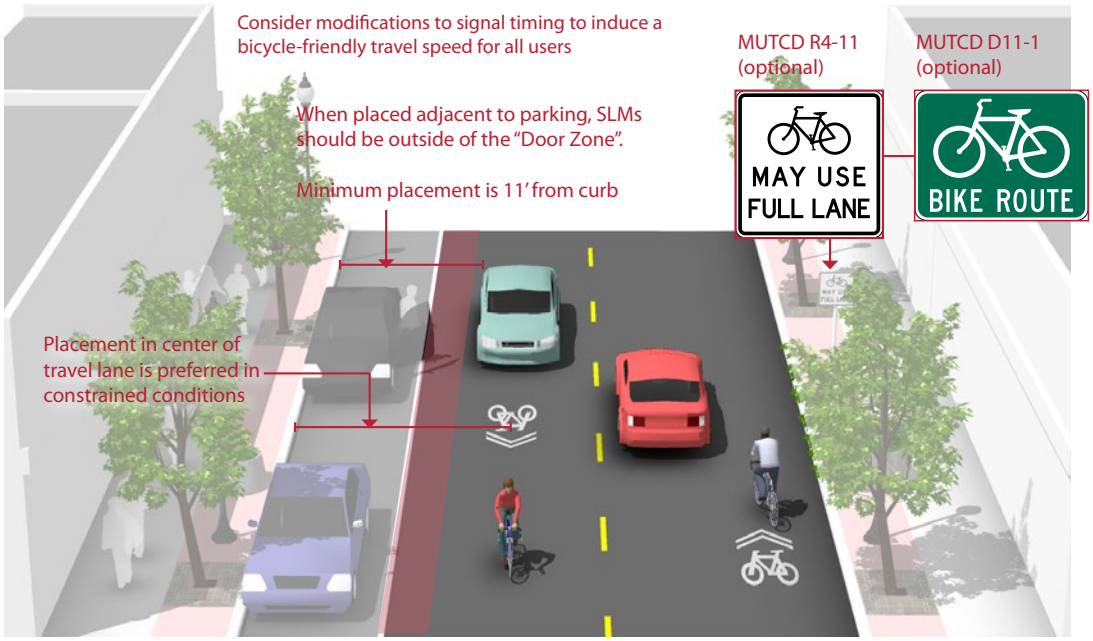
A marked shared roadway is a general purpose travel lane marked with shared lane markings (SLM) used to encourage bicycle travel and proper positioning within the lane.

In constrained conditions, the SLMs are placed in the middle of the lane. On a wide outside lane, the SLMs can be used to promote bicycle travel to the right of motor vehicles.

In all conditions, SLMs should be placed outside of the door zone of parked cars.

Guidance

- May be used on streets with a speed limit of 35 mph or under. Lower than 30 mph speed limit preferred.
- In constrained conditions, preferred placement is in the center of the travel lane to minimize wear and promote single file travel.
- Minimum placement of SLM marking centerline is 11 feet from edge of curb where on-street parking is present, 4 feet from edge of curb with no parking. If parking lane is wider than 7.5 feet, the SLM should be moved further out accordingly.



Discussion

If collector or arterial, this should not be a substitute for dedicated bicycle facilities if space is available.

Bike Lanes should be considered on roadways with outside travel lanes wider than 15 feet, or where other lane narrowing or removal strategies may provide adequate road space. SLMs shall not be used on shoulders, in designated bike lanes, or to designate bicycle detection at signalized intersections. (MUTCD 9C.07)

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
NACTO. *Urban Bikeway Design Guide.* 2012.

Materials and Maintenance

Placing SLMs between vehicle tire tracks will increase the life of the markings and minimize the long-term cost of the treatment.

5.9 BIKEWAY SIGNING

The ability to navigate through a city is informed by landmarks, natural features and other visual cues. Signs throughout the city should indicate to bicyclists:

- Direction of travel
- Location of destinations
- Travel time/distance to those destinations

These signs will increase users' comfort and accessibility to the bicycle systems.

Signage can serve both wayfinding and safety purposes including:

- Helping to familiarize users with the bicycle network
- Helping users identify the best routes to destinations
- Helping to address misperceptions about time and distance
- Helping overcome a "barrier to entry" for people who are not frequent bicyclists (e.g., "interested but concerned" bicyclists)

A community-wide bicycle wayfinding signage plan would identify:

- Sign locations
- Sign type – what information should be included and design features
- Destinations to be highlighted on each sign – key destinations for bicyclists
- Approximate distance and travel time to each destination

Bicycle wayfinding signs also visually cue motorists that they are driving along a bicycle route and should use caution. Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes. Too many road signs tend to clutter the right-of-way, and it is recommended that these signs be posted at a level most visible to bicyclists rather than per vehicle signage standards.


Wayfinding Sign Types


Wayfinding Sign Placement

5.9.1 WAYFINDING SIGN TYPES

Description

A bicycle wayfinding system consists of comprehensive signing and/or pavement markings to guide bicyclists to their destinations along preferred bicycle routes. There are three general types of wayfinding signs:

Confirmation Signs

Indicate to bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route.

Can include destinations and distance/time. Do not include arrows.

Turn Signs

Indicate where a bikeway turns from one street onto another street. Can be used with pavement markings.

Include destinations and arrows.

Decisions Signs

Mark the junction of two or more bikeways.

Inform bicyclists of the designated bike route to access key destinations. Includes destinations and arrows and distances.

Travel times are optional but recommended.

Discussion

There is no standard color for bicycle wayfinding signage. Section 1A.12 of the MUTCD establishes the general meaning for signage colors. Green is the color used for directional guidance and is the most common color of bicycle wayfinding signage in the US, including those in the MUTCD.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
NACTO. *Urban Bikeway Design Guide.* 2012.

Materials and Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs and will need periodic replacement due to wear.

5.9.2 WAYFINDING SIGN PLACEMENT

Confirmation Signs

Every ¼ to ½ mile on off-street facilities and every 2 to 3 blocks along on-street bicycle facilities, unless another type of sign is used (e.g., within 150 ft of a turn or decision sign). Should be placed soon after turns to confirm destination(s). Pavement markings can also act as confirmation that a bicyclist is on a preferred route.

Turn Signs

Near-side of intersections where bike routes turn (e.g., where the street ceases to be a bicycle route or does not go through). Pavement markings can also indicate the need to turn to the bicyclist.

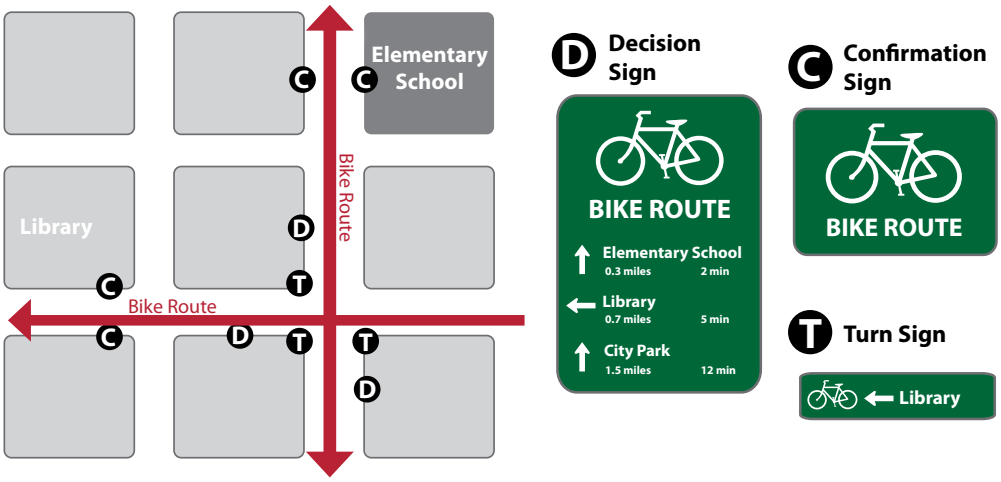
Guidance

Signs are typically placed at decision points along bicycle routes – typically at the intersection of two or more bikeways and at other key locations leading to and along bicycle routes.

Decisions Signs

Near-side of intersections in advance of a junction with another bicycle route.

Along a route to indicate a nearby destination.



Discussion

It can be useful to classify a list of destinations for inclusion on the signs based on their relative importance to users throughout the area. A particular destination's ranking in the hierarchy can be used to determine the physical distance from which the locations are signed. For example, primary destinations (such as the downtown area) may be included on signage up to 5 miles away. Secondary destinations (such as a transit station) may be included on signage up to two miles away. Tertiary destinations (such as a park) may be included on signage up to one mile away.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
NACTO. *Urban Bikeway Design Guide.* 2012.

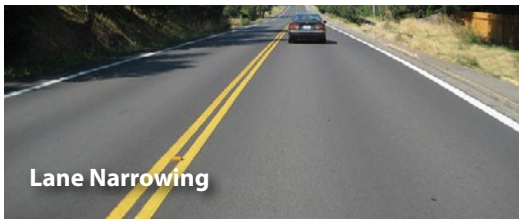
Materials and Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs and will need periodic replacement due to wear.

5.10 RETROFITTING EXISTING STREETS TO ADD BIKEWAYS

Most major streets are characterized by conditions (e.g., high vehicle speeds and/or volumes) for which dedicated bike lanes are the most appropriate facility to accommodate safe and comfortable riding. Although opportunities to add bike lanes through roadway widening may exist in some locations, many major streets have physical and other constraints that would require street retrofit measures within existing curb-to-curb widths. As a result, much of the guidance provided in this section focuses on effectively reallocating existing street width through striping modifications to accommodate dedicated bike lanes.

Although largely intended for major streets, these measures may be appropriate for any roadway where bike lanes would be the best accommodation for bicyclists.


Lane Narrowing


Lane Reconfiguration

5.10.1 LANE NARROWING

Description

Lane narrowing utilizes roadway space that exceeds minimum standards to provide the needed space for bike lanes. Many roadways have existing travel lanes that are wider than those prescribed in local and national roadway design standards, or which are not marked. Most standards allow for the use of 11 foot and sometimes 10 foot wide travel lanes to create space for bike lanes.

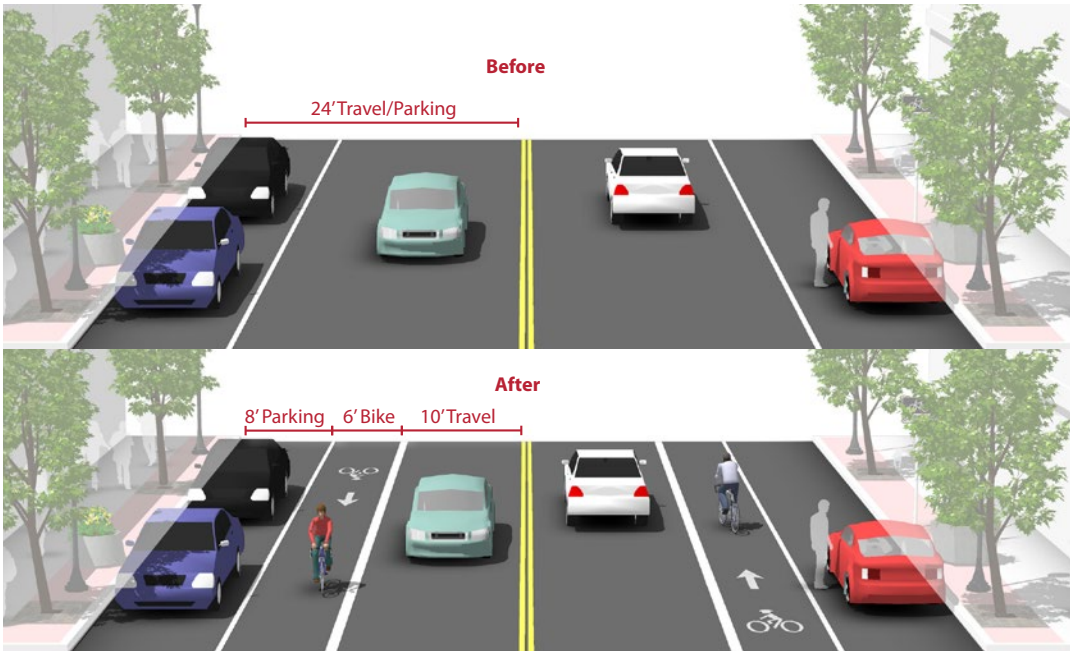
Guidance

Vehicle lane width:

- Before: 10-15 feet
- After: 10-11 feet

Bicycle lane width:

- Guidance on bicycle lanes applies to this treatment.



Discussion

Special consideration should be given to the amount of heavy vehicle traffic and horizontal curvature before the decision is made to narrow travel lanes. Center turn lanes can also be narrowed in some situations to free up pavement space for bike lanes.

AASHTO supports reduced width lanes in *A Policy on Geometric Design of Highways and Streets: "On interrupted-flow operation conditions at low speeds (45 mph or less), narrow lane widths are normally adequate and have some advantages."*

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
AASHTO. *A Policy on Geometric Design of Highways and Streets.* 2004.
NACTO. *Urban Street Design Guide.* 2013.

Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement.

5.10.2 LANE RECONFIGURATION

Description

The removal of a single travel lane will generally provide sufficient space for bike lanes on both sides of a street. Streets with excess vehicle capacity provide opportunities for bike lane retrofit projects.

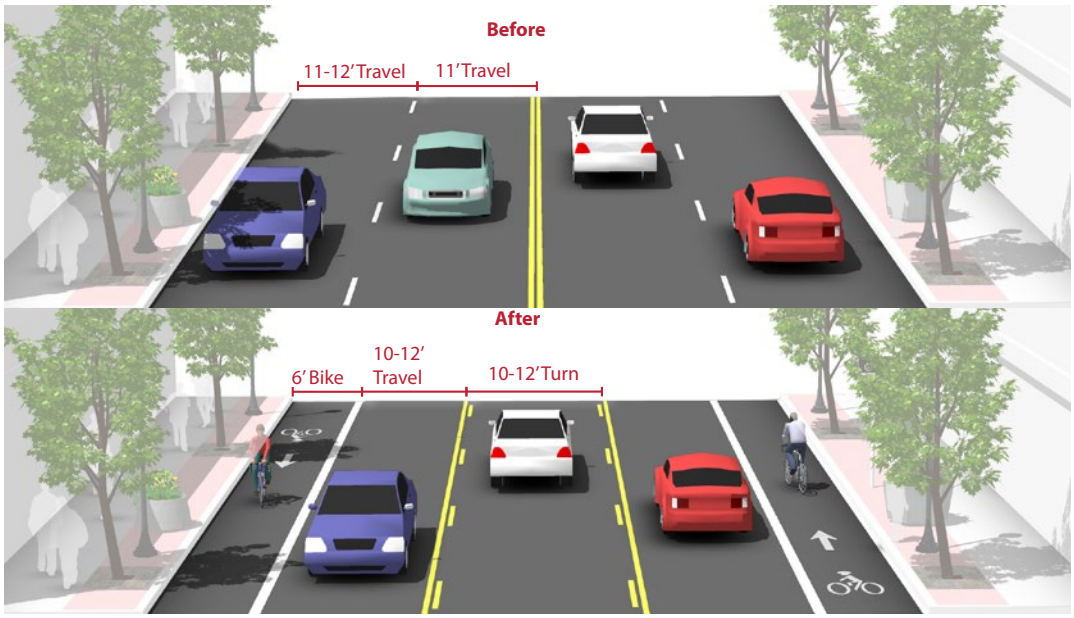
Guidance

Vehicle lane width:

- Width depends on project. No narrowing may be needed if a lane is removed.

Bicycle lane width:

- Guidance on bicycle lanes applies to this treatment.



Discussion

Depending on a street's existing configuration, traffic operations, user needs and safety concerns, various lane reduction configurations may apply. For instance, a four-lane street (with two travel lanes in each direction) could be modified to provide one travel lane in each direction, a center turn lane, and bike lanes. Prior to implementing this measure, a traffic analysis should identify potential impacts.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
FHWA. *Evaluation of Lane Reduction "Road Diet" Measures on Crashes*. Publication Number: FHWA-HRT-10-053. 2010.
NACTO. *Urban Street Design Guide*. 2013.

Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement.

5.11 BICYCLE SUPPORT FACILITIES

Bicycle Parking

Bicyclists expect a safe, convenient place to secure their bicycle when they reach their destination. This may be short-term parking of 2 hours or less, or long-term parking for employees, students, residents, and commuters.

Access to Transit

Safe and easy access to bicycle parking facilities is necessary to encourage commuters to access transit via bicycle. Providing bicycle access to transit and space for bicycles on buses and rail vehicles can increase the feasibility of transit in lower-density areas, where transit stops are beyond walking distance of many residences. People are often willing to walk only a quarter- to half-mile to a bus stop, while they might bike as much as two or more miles to reach a transit station.

Roadway Construction and Repair

Safety of all roadway users should be considered during road construction and repair. Wherever bicycles are allowed, measures should be taken to provide for the continuity of a bicyclist's trip through a work zone area.

Only in rare cases should pedestrians and bicyclists be detoured to another street when travel vehicle lanes remain open. Contractors performing work should be made aware of the needs of bicyclists and be properly trained in how to safely route bicyclists through or around work zones.


Bicycle Parking


Bicycle Access to Transit


Access through Construction Areas

5.11.1 BICYCLE RACKS

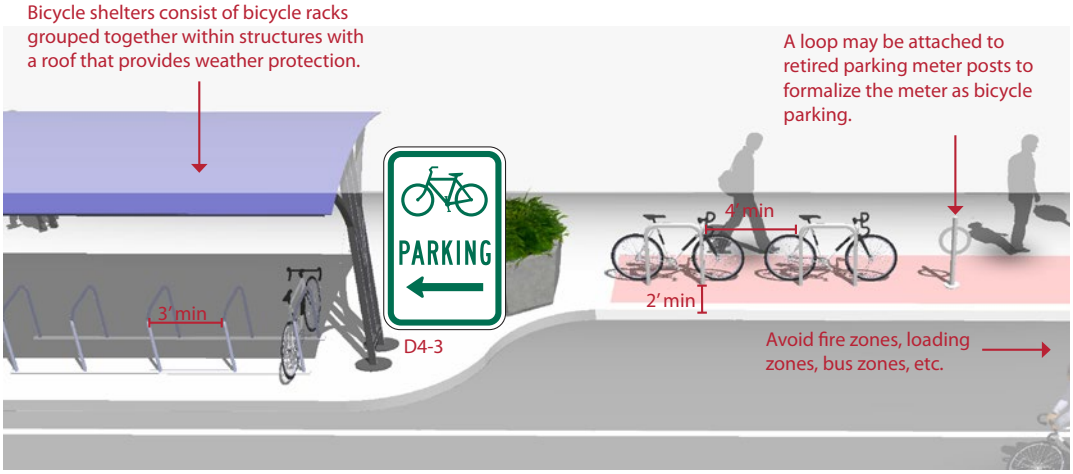
Description

Short-term bicycle parking is meant to accommodate visitors, customers, and others expected to depart within two hours. It should have an approved standard rack, appropriate location and placement, and weather protection. The Association for Pedestrian and Bicycle Professionals (APBP) recommends selecting a bicycle rack that:

- Supports the bicycle in at least two places, preventing it from falling over.
- Allows locking of the frame and one or both wheels with a U-lock.
- Is securely anchored to ground.
- Resists cutting, rusting and bending or deformation.

Guidance

- 2' minimum from the curb face to avoid 'dooring.'
- Close to destinations; 50' maximum distance from main building entrance.
- Minimum clear distance of 6' should be provided between the bicycle rack and the property line.
- Should be highly visible from adjacent bicycle routes and pedestrian traffic.
- Locate racks in areas that cyclists are most likely to travel.



Discussion

Where the placement of racks on sidewalks is not possible (due to narrow sidewalk width, sidewalk obstructions, street trees, etc.), bicycle parking can be provided in the street where on-street vehicle parking is allowed in the form of on-street bicycle corrals.

Some types of bicycle racks may meet design criteria, but are discouraged except in limited situations. This includes undulating "wave" racks, schoolyard "wheel bender" racks, and spiral racks.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
APBP. *Bicycle Parking Guide 2nd Edition.* 2010.

Materials and Maintenance

Use of proper anchors will prevent vandalism and theft. Racks and anchors should be regularly inspected for damage. Educate snow removal crews to avoid burying racks during winter months.

5.11.2 ON-STREET BICYCLE CORRAL

Description

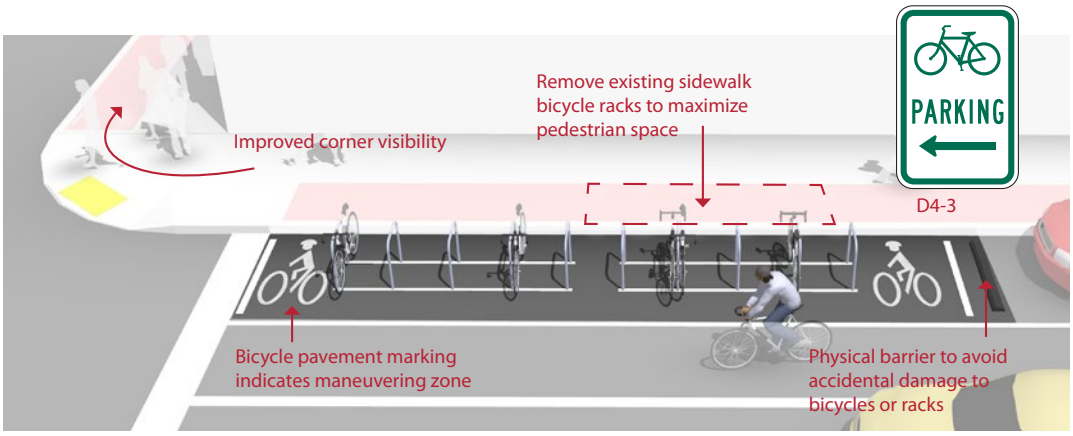
Bicycle corrals (also known as on-street bicycle parking) consist of bicycle racks grouped together in a common area within the street traditionally used for automobile parking. Bicycle corrals are reserved exclusively for bicycle parking and provide a relatively inexpensive solution to providing high-volume bicycle parking. Bicycle corrals can be implemented by converting one or two on-street motor vehicle parking spaces into on-street bicycle parking. Each motor vehicle parking space can be replaced with approximately 6-10 bicycle parking spaces.

Bicycle corrals move bicycles off the sidewalks, leaving more space for pedestrians, sidewalk café tables, etc. Because bicycle parking does not block sightlines (as large motor vehicles would do), it may be possible to locate bicycle parking in 'no-parking' zones near intersections and crosswalks.

Guidance

See guidelines for sidewalk bicycle rack placement and clear zones.

- Bicyclists should have an entrance width from the roadway of 5' – 6'.
- Can be used with parallel or angled parking.
- Parking stalls adjacent to curb extensions are good candidates for bicycle corrals since the concrete extension serves as delimitation on one side.



Discussion

In many communities, the installation of bicycle corrals is driven by requests from adjacent businesses, and is not a city-driven initiative. In such cases, the city does not remove motor vehicle parking unless it is explicitly requested. In other areas, the city provides the facility and business associations take responsibility for the maintenance of the facility. Communities can establish maintenance agreements with the requesting business. Bicycle corrals can be especially effective in areas with high bicycle parking demand or along street frontages with narrow sidewalks where parked bicycles would be detrimental to the pedestrian environment.

Additional References and Guidelines

APBP. *Bicycle Parking Guide 2nd Edition.* 2010.

Materials and Maintenance

Physical barriers may obstruct drainage and collect debris. Establish a maintenance agreement with neighboring businesses. In snowy climates the bicycle corral may need to be removed during the winter months.

5.11.3 BICYCLE LOCKERS

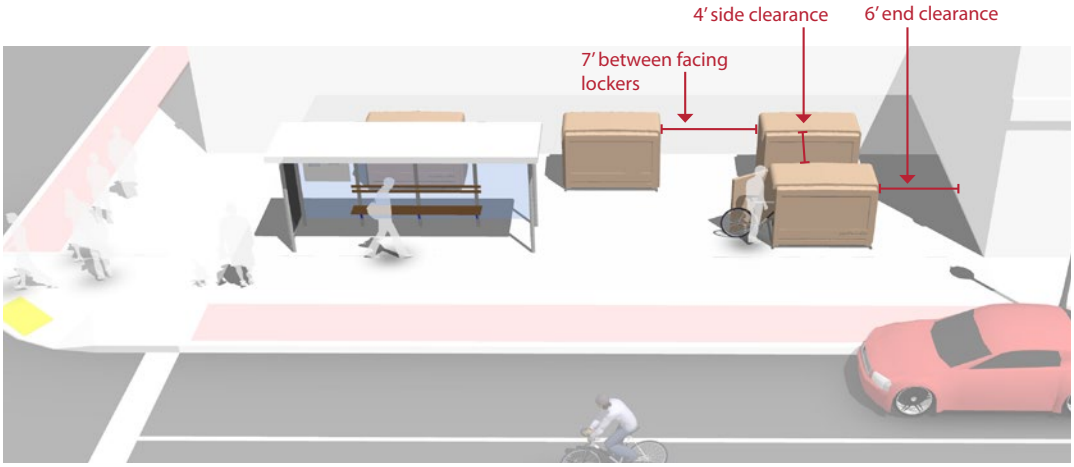
Description

Bicycle lockers are intended to provide long-term bicycle storage for employees, students, residents, commuters, and others expected to park more than two hours. Long-term facilities protect the entire bicycle, its components and accessories against theft and against inclement weather, including snow and wind-driven rain.

Bicycle lockers provide space to store a few accessories or rain gear in addition to containing the bicycle. Some lockers allow access to two users - a partition separating the two bicycles can help users feel their bike is secure. Lockers can also be stacked, reducing the footprint of the area, although that makes them more difficult to use.

Guidance

- Minimum dimensions: width (opening) 2.5'; height 4'; depth 6'.
- 4 foot side clearance and 6 foot end clearance.
- 7 foot minimum distance between facing lockers.
- Locker designs that allow visibility and inspection of contents are recommended for increased security.
- Access is controlled by a key or access code.



Discussion

Long-term parking facilities are more expensive to provide than short-term facilities, but are also significantly more secure. Although many bicycle commuters would be willing to pay a nominal fee to guarantee the safety of their bicycle, long-term bicycle parking should be free wherever automobile parking is free. Potential locations for long-term bicycle parking include transit stations, large employers, and institutions where people use their bikes for commuting and not consistently throughout the day.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
APBP. *Bicycle Parking Guide 2nd Edition.* 2010.

Materials and Maintenance

Regularly inspect the functioning of moving parts and enclosures. Change keys and access codes periodically to prevent access to unapproved users.

5.11.4 SECURE PARKING AREAS (SPA)

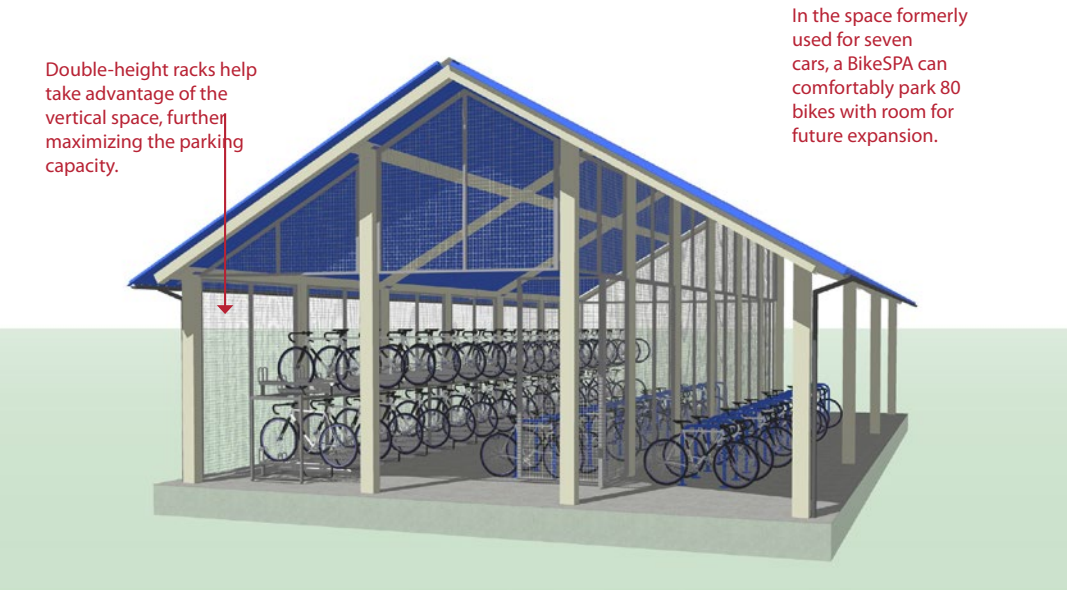
Description

A Secure Parking Area for bicycles, also known as a BikeSPA or Bike & Ride (when located at transit stations), is a semi-enclosed space that offers a higher level of security than ordinary bike racks. Accessible via key-card, combination locks, or keys, BikeSPAs provide high-capacity parking for 10 to 100 or more bicycles. Increased security measures create an additional transportation option for those whose biggest concern is theft and vulnerability.

Guidance

Key features may include:

- Closed-circuit television monitoring.
- Double high racks & cargo bike spaces.
- Bike repair station with bench.
- Bike tube and maintenance item vending machine.
- Bike lock "hitching post" – allows people to leave bike locks.
- Secure access for users.



Discussion

Long-term parking facilities are more expensive to provide than short-term facilities, but are also significantly more secure. Although many bicycle commuters would be willing to pay a nominal fee to guarantee the safety of their bicycle, long-term bicycle parking should be free wherever automobile parking is free. BikeSPAs are ideal for transit centers, airports, train stations, or wherever large numbers of people might arrive by bicycle and need a secure place to park while away.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
APBP. *Bicycle Parking Guide 2nd Edition.* 2010.

Materials and Maintenance

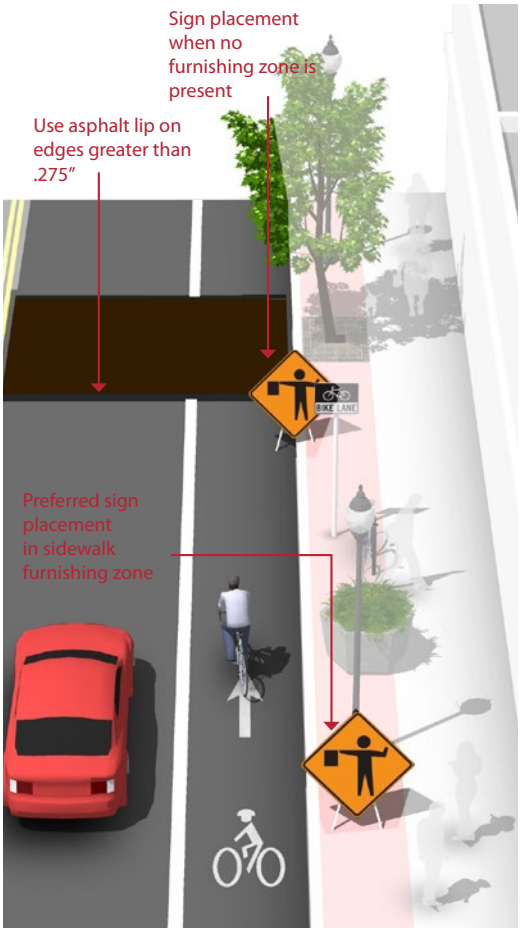
Regularly inspect the functioning of moving parts and enclosures. Change keys and access codes periodically to prevent access to unapproved users.

5.11.5 BICYCLE ACCESS THROUGH CONSTRUCTION AREAS

Description

Wherever bicycles are allowed, measures should be taken to provide for the continuity of a bicyclist's trip through a work zone area. Bicyclists should not be led into conflicts with work site vehicles, equipment, moving vehicles, open trenches, or temporary construction signage.

Efforts should be made to re-create a bike lane (if one exists) to the left of the construction zone. If this is impossible, then consider the closure of a standard-width travel lane to accommodate bicycle travel.



Guidance

Construction Signage

- Place in a location that does not obstruct the path of bicyclists or pedestrians.
- Detour and closure signs related to bicycle travel may be included on all bikeways where construction activities occur. Signage should also be provided on all other roadways.

Bicycle Travel around Steel Grates

- Require temporary asphalt (cold mix) around plates to create a smooth transition.
- Use steel plates only as a temporary measure during construction, not for extended periods.
- Use warning signs where steel plates are in use.
- Require both temporary and final repaving to provide a smooth surface without abrupt edges.

Discussion

Plates used to cover trenches tend to not be flush with pavement and have a 1"-2" vertical transition on the edges. This can puncture a hole in a bicycle tire and cause a bicyclist to lose control. Although it is common to use steel plates during non-construction hours, these plates can be dangerously slippery, particularly when wet.

Contractors performing work should be made aware of the needs of bicyclists and be properly trained in how to safely route bicyclists through or around work zones.

Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities.* 2012.
FHWA. *Manual on Uniform Traffic Control Devices.* 2009.
FHWA. *Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 21: Bicycle and Pedestrian Accommodation in Work Zones.* 2006.

Materials and Maintenance

Debris should be swept to maintain a reasonably clean riding surface in the outer 5 - 6 ft of roadway.

5.12 BIKEWAY MAINTENANCE

Regular bicycle facility maintenance includes sweeping, maintaining a smooth roadway, ensuring that the gutter-to-pavement transition remains relatively flush, and installing bicycle-friendly drainage grates. Pavement overlays are a good opportunity to improve bicycle facilities. The following recommendations provide a menu of options to consider to enhance a maintenance regimen.

Recommended Walkway and Bikeway Maintenance Activities

Maintenance Activity	Frequency
Inspections	Seasonal – at beginning and end of Summer
Pavement sweeping/ blowing	As needed, with higher frequency in the early Spring and Fall
Pavement sealing	5 - 15 years
Pothole repair	1 week – 1 month after report
Culvert and drainage grate inspection	Before Winter and after major storms
Pavement markings replacement	As needed
Signage replacement	As needed
Shoulder plant trimming (weeds, trees, brambles)	Twice a year; middle of growing season and early Fall
Tree and shrub plantings, trimming	1 – 3 years
Major damage response (washouts, fallen trees, flooding)	As soon as possible

This Section Includes:

- Sweeping
- Signage
- Roadway Surface
- Pavement Overlays
- Drainage Grates
- Gutter to Pavement Transition
- Landscaping
- Maintenance Management Plan


Sweeping


Roadway Surface


Gutter to Pavement Transition


Drainage Grates


Landscaping


Maintenance Management Plan

5.12.1 SWEEPING

Description

Bicyclists often avoid shoulders and bike lanes filled with gravel, broken glass and other debris; they will ride in the roadway to avoid these hazards, potentially causing conflicts with motorists. Debris from the roadway should not be swept onto sidewalks (pedestrians need a clean walking surface), nor should debris be swept from the sidewalk onto the roadway. A regularly scheduled inspection and maintenance program helps ensure that roadway debris is regularly picked up or swept.

Guidance

- Establish a seasonal sweeping schedule that prioritizes roadways with major bicycle routes.
- Sweep walkways and bikeways whenever there is an accumulation of debris on the facility.
- In curbed sections, sweepers should pick up debris; on open shoulders, debris can be swept onto gravel shoulders.
- Pave gravel driveway approaches to minimize loose gravel on paved roadway shoulders.
- Perform additional sweeping in the Spring to remove debris from the Winter.
- Perform additional sweeping in the Fall in areas where leaves accumulate .

5.12.2 GUTTER TO PAVEMENT TRANSITION

Description

On streets with concrete curbs and gutters, 1 to 2 feet of the curbside area is typically devoted to the gutter pan, where water collects and drains into catch basins. On many streets, the bikeway is situated near the transition between the gutter pan and the pavement edge. This transition can be susceptible to erosion, creating potholes and a rough surface for travel.

The pavement on many streets is not flush with the gutter, creating a vertical transition between these segments. This area can buckle over time, creating a hazardous condition for bicyclists.

Guidance

- Ensure that gutter-to-pavement transitions have no more than a ¼" vertical transition.
- Examine pavement transitions during every roadway project for new construction, maintenance activities, and construction project activities that occur in streets.
- Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.
- Provide at least 3 feet of pavement outside of the gutter seam.

5.12.3 ROADWAY SURFACE

Description

Bicycles are much more sensitive to subtle changes in roadway surface than are motor vehicles. Various materials are used to pave roadways, and some are smoother than others. Compaction is also an important issue after trenches and other construction holes are filled. Uneven settlement after trenching can affect the roadway surface nearest the curb where bicycles travel. Sometimes compaction is not achieved to a satisfactory level, and an uneven pavement surface can result due to settling over the course of days or weeks. When resurfacing streets, use the smallest chip size and ensure that the surface is as smooth as possible to improve safety and comfort for bicyclists.

Guidance

- Maintain a smooth pothole-free surface.
- Ensure that on new roadway construction, the finished surface on bikeways does not vary more than ¼".
- Maintain pavement so ridge buildup does not occur at the gutter-to-pavement transition or adjacent to railway crossings.
- Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.
- If chip sealing is to be performed, use the smallest possible chip on bike lanes and shoulders. Sweep loose chips regularly following application.
- During chip seal maintenance projects, if the pavement condition of the bike lane is satisfactory, it may be appropriate to chip seal the travel lanes only. However, use caution when doing this so as not to create an unacceptable ridge between the bike lane and travel lane.

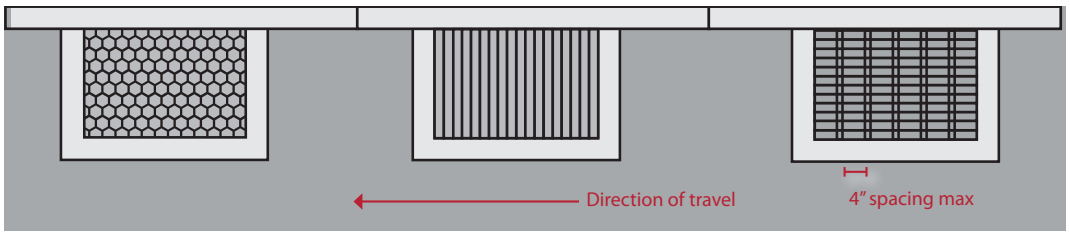
5.12.4 DRAINAGE GRATES

Description

Drainage grates are typically located in the gutter area near the curb of a roadway. Drainage grates typically have slots through which water drains into the municipal storm sewer system. Many older grates were designed with linear parallel bars spread wide enough for a tire to become caught so that if a bicyclist were to ride on them, the front tire could become caught in the slot. This would cause the bicyclist to tumble over the handlebars and sustain potentially serious injuries.

Guidance

- Require all new drainage grates be bicycle-friendly, including grates that have horizontal slats on them so that bicycle tires and assistive devices do not fall through the vertical slats.
- Create a program to inventory all existing drainage grates, and replace hazardous grates as necessary – temporary modifications such as installing rebar horizontally across the grate should not be an acceptable alternative to replacement.



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