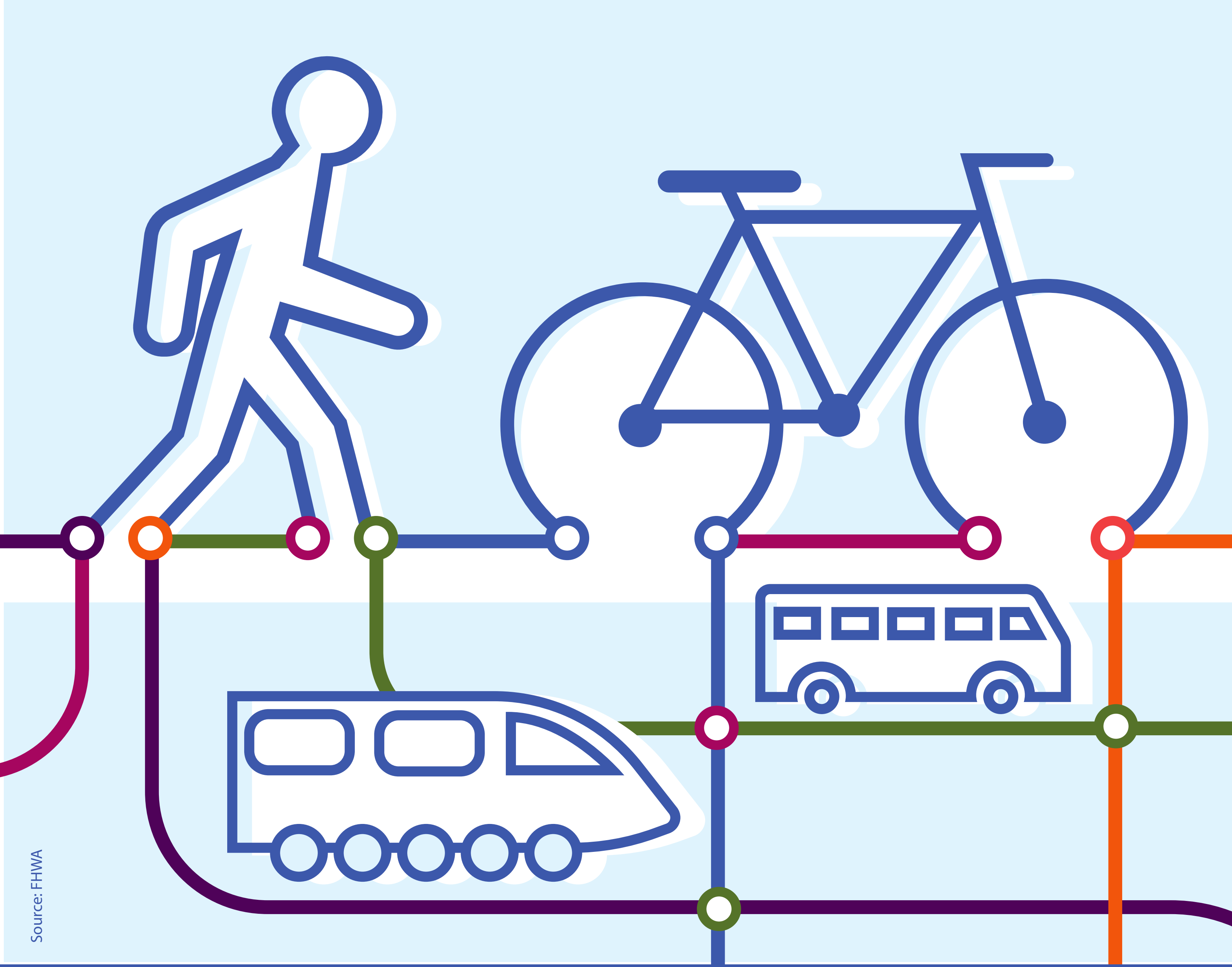

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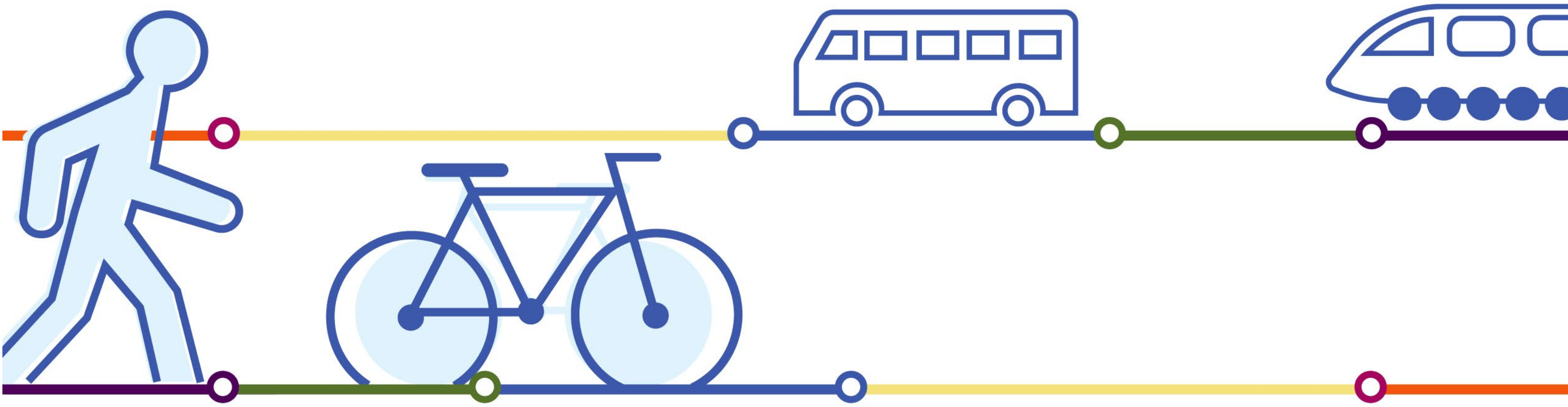
Improving Safety for Pedestrians and Bicyclists Accessing Transit

U.S. Department of Transportation
Federal Highway Administration

U.S. Department of Transportation
Federal Transit Administration

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

FHWA-SA-21-130



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SI* (MODERN METRIC) CONVERSION FACTORS

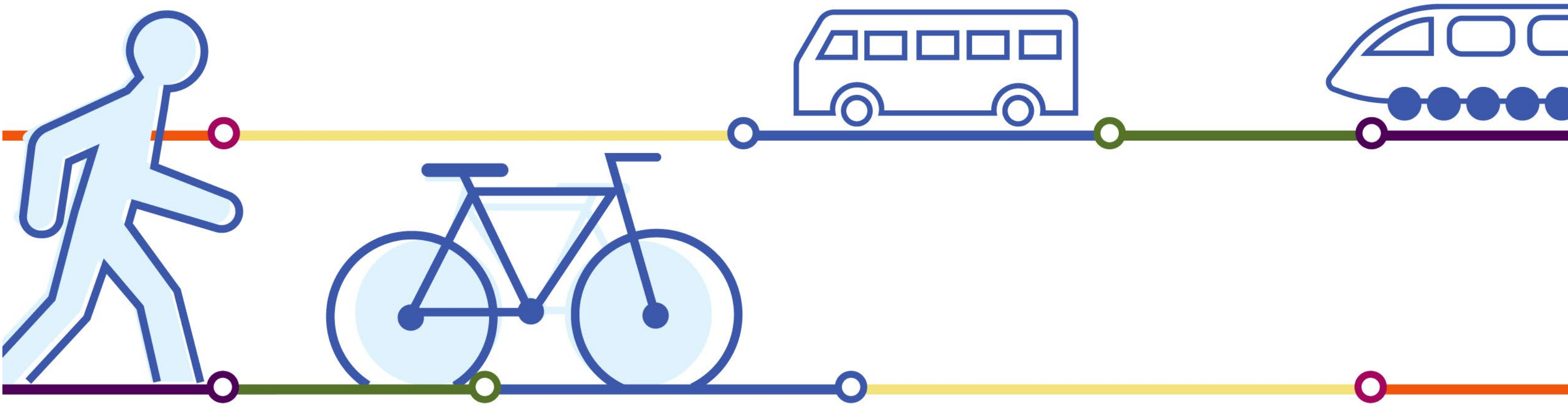
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)



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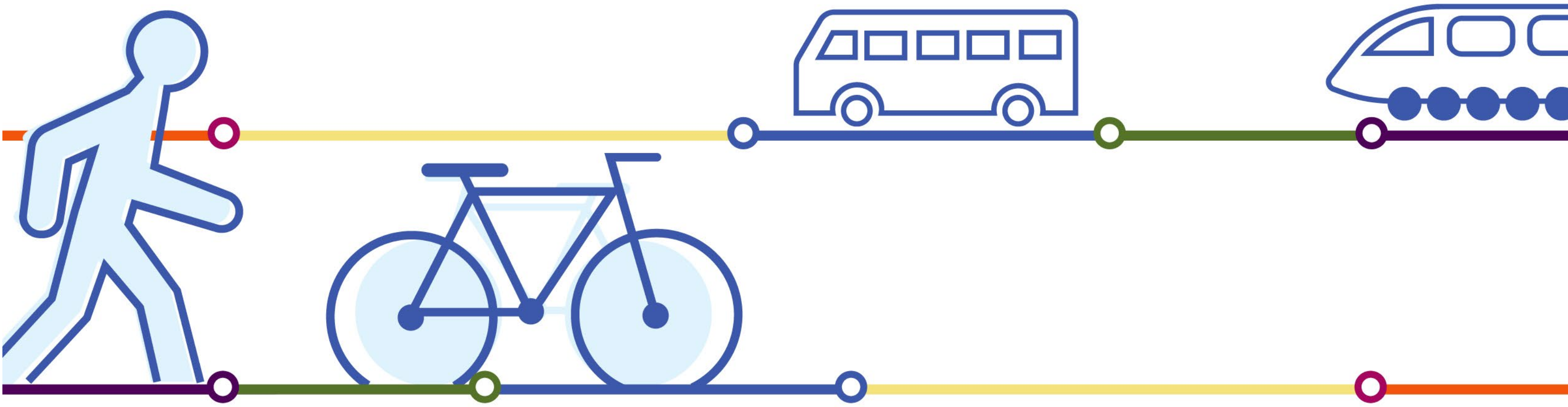

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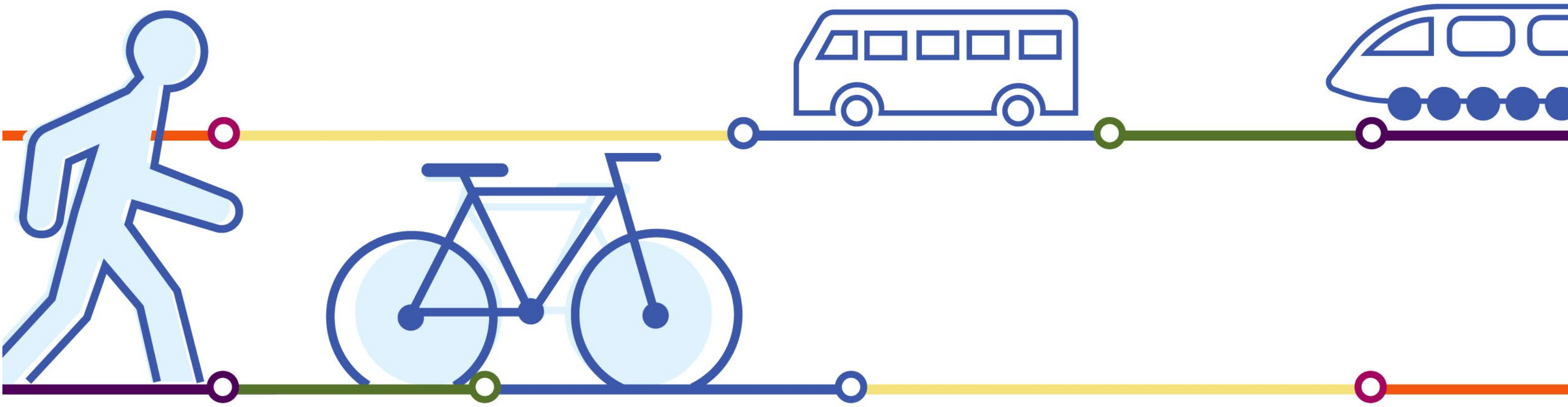


Acronyms

AADT – annual average daily traffic

AASHTO – American Association of State Highway and Transportation Officials

ADA – Americans with Disabilities Act

ADAAG – Americans with Disabilities Act Accessibility Guidelines

APC – automated passenger counter

APS – accessible pedestrian signals

APTA – American Public Transportation Association

AREMA – American Railway Engineering and Maintenance of Way Association

AVL – automatic vehicle location

BIPOC – Black, Indigenous, and people of color

CFR – Code of Federal Regulations

CTA – Chicago Transit Authority

DVRPC – Delaware Valley Regional Planning Commission

DOJ – Department of Justice

ERF – electronic registering fareboxes

eTOD –equitable transit-oriented development

FHWA – Federal Highway Administration

FRA – Federal Rail Administration

FTA – Federal Transit Administration

HSM – Highway Safety Manual

HVE – high visibility enforcement

IA – Interim Approval

IT – information technology

IoT – Internet of Things

ITE – Institute of Transportation Engineers

LED – light-emitting diode

LPI – leading pedestrian intervals

MaaS – mobility as a service

MCDOT – Montgomery County Maryland Department of Transportation

MPH – miles per hour

MUTCD – Manual on Uniform Traffic Control Devices for Streets and Highways

NACTO – National Association of City Transportation Officials

NCHRP – National Cooperative Highway Research Program

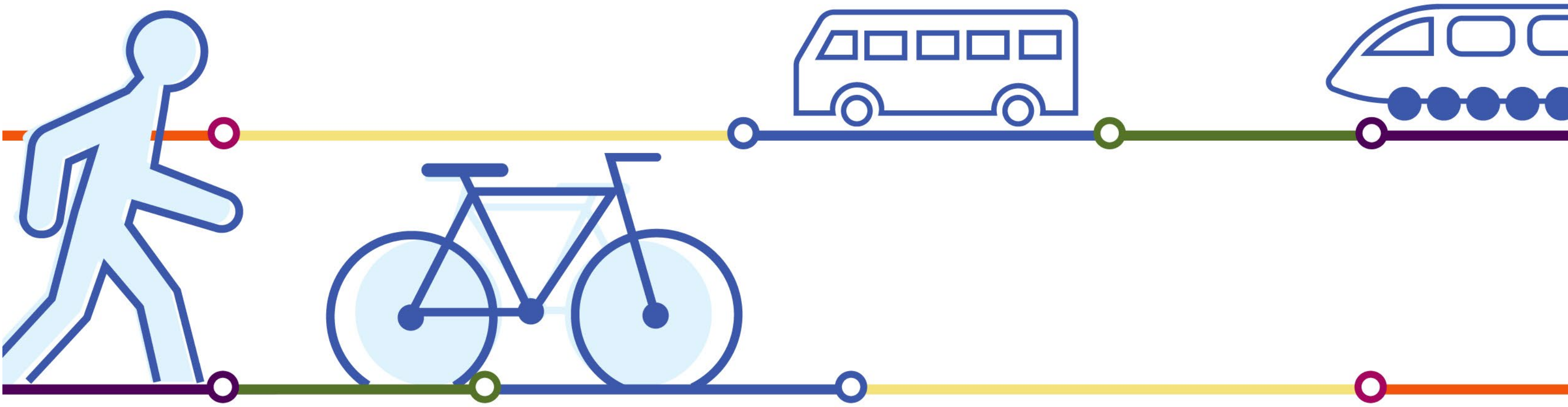
NHTS – National Household Travel Survey

NHTSA – National Highway Traffic Safety Administration

ODOT – Oregon Department of Transportation

PHB – pedestrian hybrid beacon

PBCAT – Pedestrian and Bicycle Crash Analysis Tool



PROWAG – Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (U.S. Access Board, 2011)

PSAP – Pedestrian Safety Action Plan

RRFB – rectangular rapid-flashing beacon

RSA – road safety audit

RTA – Regional Transportation Authority

SCAG – Southern California Association of Governments

SDH – social determinants of health

SFMTA – San Francisco Municipal Transit Authority

STEP – Safe Transportation for Every Pedestrian Program

TAM – transit asset management

TCRP – Transit Cooperative Research Program

TDM – transportation demand management

TNC – transportation network company

TOD – transit-oriented development

VDOT – Virginia Department of Transportation

WABA – Washington Area Bike Association

1 Introduction

Transit provides mobility options to people of all backgrounds, reduces harmful emissions, and supports equitable economic development. The physical safety of transit passengers while using and accessing transit facilities is crucial to the success of a transit system. Every transit passenger travels some distance by foot or mobility device, whether it is driving to a park-and-ride lot and then walking or rolling to the transit station, or walking, rolling, or bicycling directly to the stop. The roadways used to access transit facilities should be Complete Streets, which are safe and feel safe for all roadway users. This can be achieved by planning, implementing, and evaluating equitable streets and networks that prioritize safety, comfort, and connectivity to destinations for all people who use the street network. This guide provides agencies with a thorough look at pedestrian and bicyclist safety considerations in accessing and using transit

About this Guide

This guide builds on the 2008 Federal Highway Administration (FHWA) publication, *Pedestrian Safety Guide for Transit Agencies* (Nabors et al., 2008). Since the guide's publication in 2008, some aspects of transit have stayed the same:

> "Public transportation provides people with mobility and access to employment, community resources, medical care, and recreational opportunities in communities across America. It benefits those who choose to ride, as well as those who have no other choice".
> -FHWA, 2002, p. 14-2

Other aspects of using and accessing transit—including the types of modal choices available at our fingertips —have changed drastically. This guide is intended to not only reflect those changes, but also address the safety of a variety of vulnerable road users, such as pedestrians, bicyclists, and micromobility users, who are similarly susceptible to severe injury or fatality if involved in a crash. Additionally, there are some transit riders who have unique needs and are more likely to use transit. For example, across all ethnicities, women have both a lower access to private motorized vehicles and lower driver's license attainment than men. Communities of color represent the majority of transit riders (60 percent) and also tend to have longer distances to travel to their places of work (American Public Transportation Association, 2017). Additionally, individuals with disabilities have lower vehicle ownership rates than those without disabilities and are more likely to use transit for their mobility needs (Bureau of Transportation Statistics, 2018). Agencies should implement elements of Complete Streets, which consider the needs of all users when thinking about how to improve safe access to transit. This guide contains specific considerations about how agencies can help to make sure that all people: 1) are considered, 2) feel safe and welcomed accessing these facilities, and 3) can have the confidence that these spaces were planned and designed with them in mind.

Who is this Guide for?

This guide is intended for transit agencies, State and local roadway owners, and regional organizations involved with planning and designing transit stops and the roadway, pedestrian, and bicycle facilities that provide access to transit.

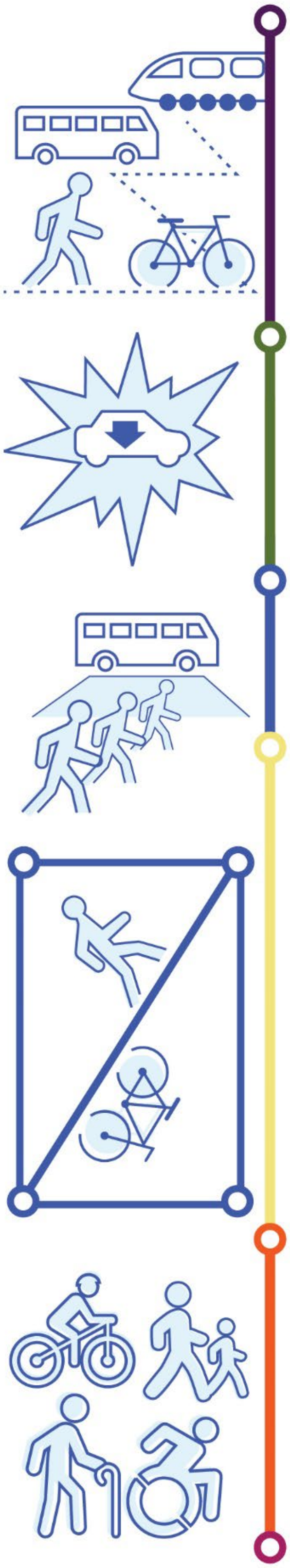
What Does it Contain?

The guide contains wide ranging topics related to pedestrian and bicyclist safety and access to transit and is organized as follows:

- Chapter 1 provides an introduction and overview of the guide.
- Chapter 2 discusses the fundamentals of pedestrian and bicyclist safety as related to access to transit, including the various types of passengers and how they access transit facilities. The chapter also describes crash contributing factors for pedestrians and bicyclists accessing transit.
- Chapter 3 contains information on the various tools that analysts can use to identify issues related to pedestrian and bicyclist safety and access to transit, including potential data sources and how to analyze data.
- Chapter 4 outlines ways to enhance pedestrian and bicyclist safety, ranging from internal actions, such as organizational improvements and training programs, to partnerships with public and private entities.
- Chapter 5 focuses on design and operational measures to improve pedestrian and bicyclist safety. The chapter is broken up into two groupings: 1) factors affecting the route to access transit and 2) factors affecting pedestrian and bicyclist safety at the transit stop. The section on accessing transit includes bicyclist and pedestrian facilities and special considerations such as light rail crossings. The transit stop/station design section analyzes how certain types of station placements and designs can impact access to the stop along with pedestrian and bicyclist safety.
- Chapter 6 discusses steps to overcome barriers to accessibility, including how to change driver behavior near transit stops and how to design facilities in a constrained right-of-way.

How to Use this Guide

This guide provides a comprehensive understanding of how to address pedestrian and bicyclist safety concerns related to accessing transit. Throughout the guide, the core principles for pedestrian and bicyclist safe access to transit (as shown on the following page) are explored. Certain sections, such as The Fundamentals and Tools for Identifying Pedestrian and Bicyclist Safety Issues, provide a foundational understanding of pedestrian and bicyclist safety and are applicable to all readers. Other sections, such as the Approaches to Enhancing Pedestrian and Bicyclist Safety in **chapter 4**, and Design and Operational Measures in **chapter 5,** maybe more applicable to specific roles or agencies. For example, within **chapter 5**, the Transit Access section is likely more applicable to roadway owners and the Transit Stop/Station section may be more applicable to transit agencies.



The core principles for pedestrian and bicyclist safe access to transit are:

The physical safety of transit passengers while using and accessing transit facilities is crucial to the success of the transit system. Every transit passenger travels some distance, whether it is driving and then walking or rolling from a park-and-ride lot, or walking, rolling, or cycling a longer distance to the transit stop.

Transit use can decrease an area's overall motor vehicle crashes by decreasing single occupancy vehicle trips. Roadway owners can provide pedestrians and bicyclists comfortable access to transit to encourage transit use.

Transit stops are pedestrian and bicyclist generators and deserve special attention to reduce the risk of nonmotorized crashes.

Pedestrian and bicycling routes to access transit should reflect a connected network of roadway, sidewalk, and bicyclist facilities. Considerations for the network include:

> **Directness**. The pedestrian and bicyclist network should be direct between key destinations, but also appropriate for characteristics of the surrounding conditions. An agency should understand pedestrian and bicyclist "desire lines", or their preferred route, and seek to accommodate pedestrians and bicyclists in these locations.

> **Continuity and connectivity**. The pedestrian and bicyclist network should not have gaps or abrupt changes besides the beginning and end terminals of a facility.

> **Comfort**. The perceived risk and level of comfort may influence a pedestrian's or bicyclist's behavior. Factors affecting comfort levels can include degree of separation from vehicular traffic, lighting, roadway condition, and, for bicyclist's, confidence in ability. Where possible, agencies should provide pedestrians and bicyclists with increased separation from motor vehicles. Additionally, pedestrians, particularly disabled pedestrians, may not feel as comfortable waiting, boarding, and alighting a transit vehicle if they are sharing that space with bicyclists or micromobility users. Methods to alert and slow bicyclists and micromobility users include pavement markings and signage to designate how the space should be used.

Transit stops can enhance safety of riders but should be usable and welcoming to everyone. Transit stop amenities are more than just features to enhance the comfort of transit riders. They can help to improve pedestrian and bicyclist safety by enhancing both conspicuity and visibility of passengers, and also drivers' awareness of potential increases in pedestrian and bicyclist activity. The provision and design of amenities can also help to improve the organization and flow of people around the transit stop. For instance, the provision and design of bicycle and scooter racks, lockers, and parking can impact the safety and accessibility of the transit stops and routes to the stops.

2 Background

In pedestrian safety, the phrase, "Everyone is a pedestrian at some point in their day," is often used. This phrase is especially true when we think of how people access transit. Regardless of how a person began their trip, they walk, roll, or bicycle to access transit. Because of this, agencies should understand pedestrian and bicyclist characteristics and needs when planning and designing transit systems to help to create safe, comfortable, and connected networks by incorporating attributes of a Complete Street.

The Fundamentals

There are certain vital pieces of information that serve as a basis for understanding how to improve pedestrian and bicyclist safety with regard to accessing transit. These pieces include understanding *who* generally uses transit and *what* their needs are. To entice new or more consistent ridership, agencies should consider the distance pedestrians and bicyclists are willing to travel to access transit stops. These are not the only considerations when it comes to behavior, as certain types of groups may have extra needs or wants. Age, gender, race, physical ability—to name a few—all play a role in how infrastructure and transit should be planned and integrated to enhance safety.

Who Uses Transit?

There are differences in trip purposes, modes, and timing that vary among genders, ages, health status, geography, income, and other factors. The following are observations about the similarities and differences in pedestrian, bicyclist, and transit trips from the National Household Travel Survey (NHTS):

- In a typical day, roughly 1 in 6 Americans (17 percent) reported taking a walk or riding a bicycle (NHTS, 2020).
- People who reported better health and higher levels of physical activity were more likely to report a trip by walking or biking (NHTS, 2020).
- Women and men reported an equal proportion of nonmotorized travel (NHTS, 2020).
- Those aged 40 to 64 reported the largest proportion of nonmotorized trips, while the smallest proportion was those aged 16 to 24 (NHTS, 2020).
- People who live in higher density areas were more likely to travel by walking or biking as compared to those living in lower density areas (i.e., urban versus suburban versus rural areas).
- Persons younger than 20 years old were less likely to take transit, whereas those 65 and older took more transit trips, and both of these trends were led by females compared to males (NHTS, 2019).
- Compared to previous NHTS surveys, both higher income households ($75,000-$100,000) and lower income households (<$10,000) have increased transit ridership with increases in trips of more than 50 percent and 36 percent, respectively (NHTS, 2019). Figure 1 shows the percent difference in transit trips by income level between 2009 and 2017.

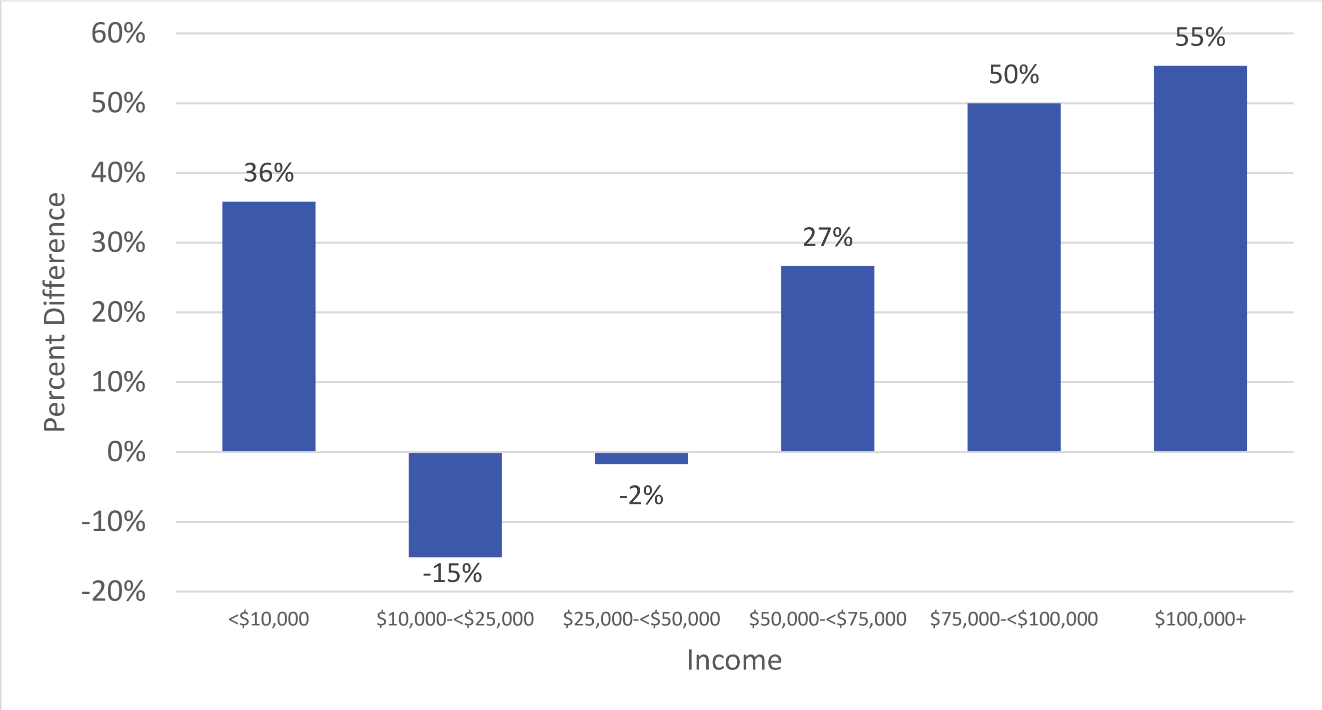


Figure 1. Graphic. Percent difference in number of transit trips by income between 2009 and 2017 (adapted from NHTS, 2020).

A survey on transit ridership conducted by American Public Transportation Association (APTA) found that when looking at transit trips through reported race and ethnicity (as shown in figure 2), White participants made up 40 percent of transit trips, while Black, Hispanic, Asian, and "Other" participants made up roughly 60 percent in 2017 (APTA, 2017). As a comparison, Black, Hispanic, Asian, and "Other" participants comprise just 37 percent of the population.

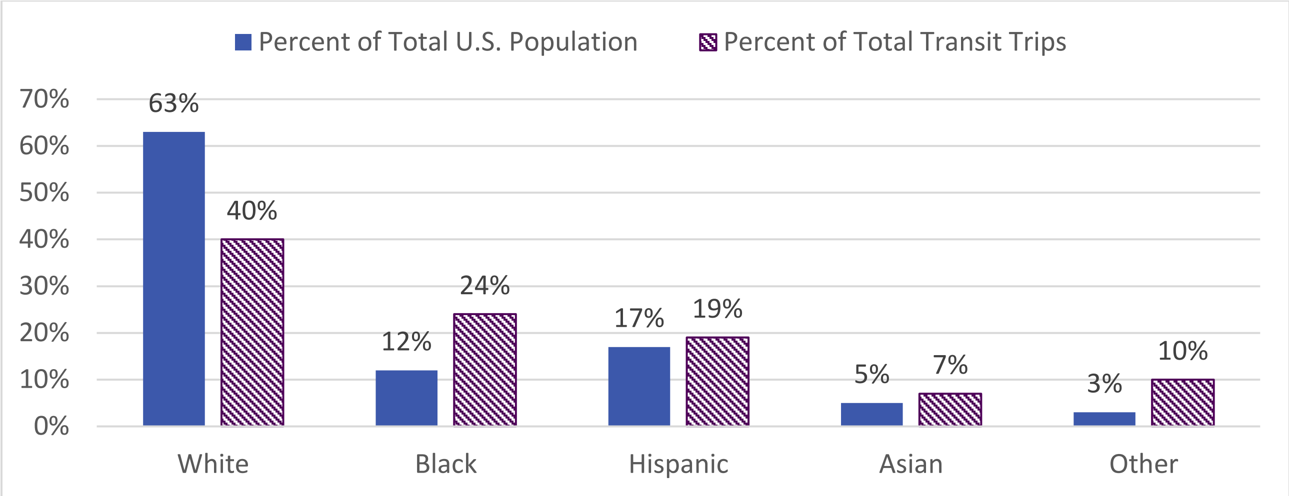


Figure 2. Graphic. Ethnic composition of riders and of the population in the United States in 2017 (adapted from APTA, 2017).

Figure 3 shows the results of the 2017 NHTS with the percent of trips by mode and time of day (NHTS, 2020). Each mode percentage is independent of one another, meaning that the sum of the data points for each hour per mode will sum to 100 percent of the trips. For example, roughly eight percent of all pedestrian and bicyclist trips, seven percent of auto trips, and six percent of transit trips were taken in the 2 pm hour.

To summarize, peak travel by mode—in terms of proportion of daily trips by those modes—were as follows:

- Walking/Bicycling: the morning peak is at 8 am and midday peak is between 12 pm and 3 pm, which represent approximately 7 percent to 8 percent of walking/bicycling trips per peak.
- Auto: the morning peak is at 7 am and afternoon peak is between 3 pm and 5 pm, which represent approximately 6 percent to 8 percent of auto trips per peak.
- Transit: the morning peak is at 7 am and afternoon peak is at 5 pm, which represent approximately 10 percent of transit trips per peak.

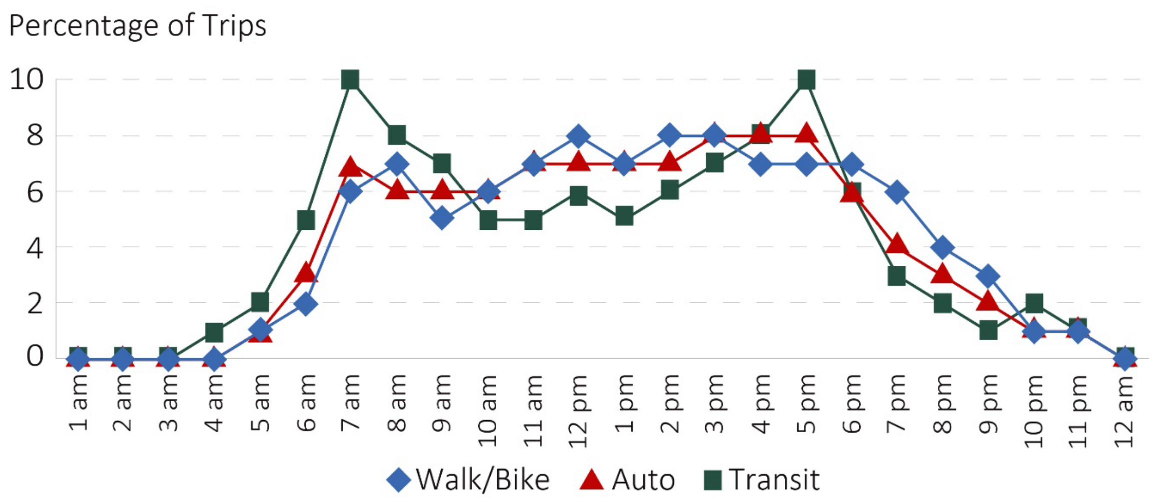


Figure 3. Graphic. Comparison of travel mode by time of day (NHTS, 2020).

Distance Pedestrians and Bicyclists Are Willing to Travel to Transit

The typical distance pedestrians and bicyclists are willing to travel to transit stops—referred to as walksheds, bikesheds, or access sheds—is dependent on several factors including the type of transit service, presence and quality of supporting multimodal networks, land use context, and mobility of the user. Research has shown that most transit riders walk ¼ mile or an equivalent of 5 minutes to reach their bus stop, walk ½ mile to reach Bus Rapid Transit (BRT) (Ryus et al., 2013), and walk ¾ mile or 15 minutes when accessing commuter rail (El-Geneidy et al., 2014). As a matter of policy, the Federal Transit Administration (FTA) considers the catchment areas of ½ mile

Walksheds and bikesheds for transit can widely vary depending on access to facilities, individual speed, and those with unique mobility needs.

for pedestrians and 3 miles for bicyclists (Federal Register, 2011). Some agencies use a smaller bikeshed distance; the American Public Transportation Association (APTA) (2018) recommends planning on a bikeshed distance of 1 to 3 miles. While these walkshed and bikeshed distances are reflective of the average, there is wide variation among different user groups and in different locations, particularly when considering access to facilities, individual speed, and those with unique mobility needs. In general, agencies can improve pedestrian and bicyclist safety by providing accessible and convenient pedestrian facilities within ¼- to ½-mile of transit stops and stations and 1 mile of heavy rail stations and providing bicyclist facilities within 1 to 3 miles of transit stops and stations.

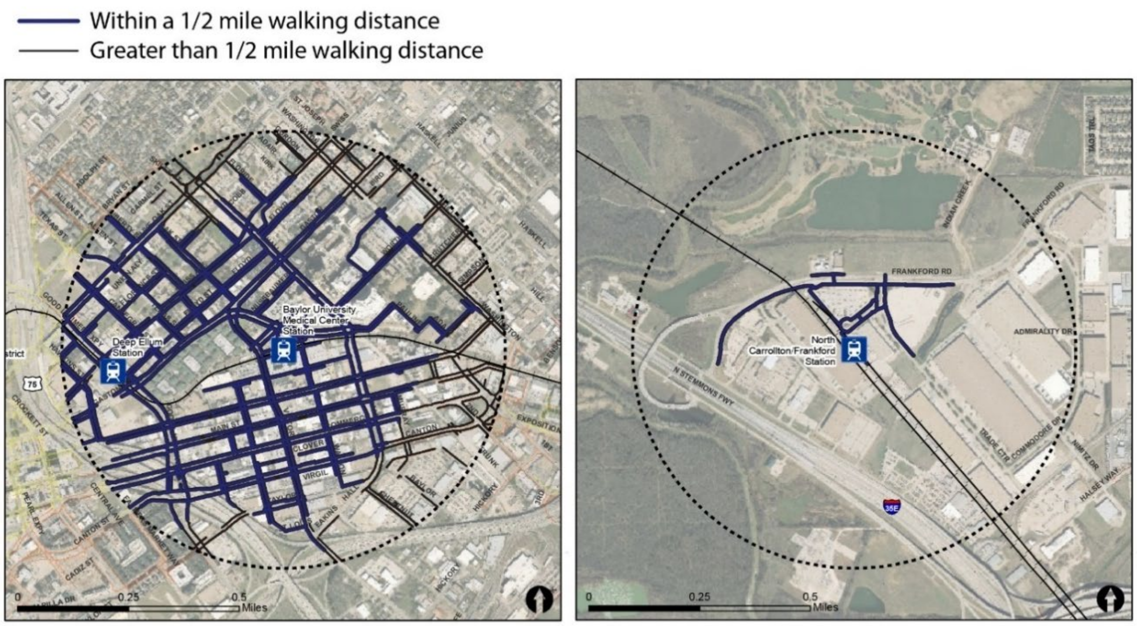


Figure 4. Graphic. Examples of ½-mile walksheds for two Dallas area rapid transit rail stations (FTA, 2017).

The actual amount of walking or bicycling that is possible within that walkshed or bikeshed is a direct reflection of the quality of the multimodal network. A basic ½-mile buffer or radius around a transit stop may not accurately reflect the actual walking distance to transit for areas without sidewalk, non-grid roadway networks, or both (figure 4). In figure 4, the image on the left shows a much more robust pedestrian network than the one on the right. This might indicate that the likelihood of people walking to transit is higher for the network on the left versus on the right, which has limited options to walk to the transit stop.

Additionally, the quality of bicyclist and pedestrian facilities can also influence their use; sidewalks directly on the back of the curb and on-road bicycle lanes along higher speed arterials are high stress facilities. Research has shown that low stress bicyclist facilities can increase bicyclist mode share, as supported in case studies conducted in King County, Washington and the East Village in New York City (American Planning Association, 2015). Bicyclist infrastructure improvements such as protected bicycle lanes, lighting, and bicycle racks were all features that survey participants stated would encourage them to bicycle more. In addition, more walkable environments were predictive of people choosing to walk rather than drive to transit (Park et al., 2015). This was the finding in a case study out of Mountain View, California where factors such as sidewalk amenities, traffic impacts, street scale and enclosure, and landscaping elements were used in a mode choice model. The station in the case study had 340 available parking spaces daily yet found that improved sidewalk amenities and pedestrian friendly traffic conditions increased the chance of people choosing to walk to transit.

An individual transit passenger's mobility can also influence their effective distance to transit. Those individuals with slower walking speeds, such as seniors, those with mobility devices, and caregivers with strollers or wheelchairs, may be discouraged from accessing transit if they have to travel farther distances or when those facilities are space constrained and designed for faster pedestrians. Additionally, riders with disabilities may not be able to access fixed route transit stops if there are sidewalk gaps or if pedestrian facilities—such as sidewalks and traffic signals—are not accessible. Transit agencies and roadway owners should analyze and evaluate their pedestrian and bicyclist networks and strive for them to be Complete Streets that are accessible, comfortable, and connected access to transit for users of all abilities.

Finally, rural and suburban land uses can present their own challenges in accessing transit. In rural areas, there may be limited sidewalk and bicyclist networks to reach transit, and many riders may live beyond a ½-mile distance to a fixed route stop. Passengers may be forced to walk along roadways or on shoulders, increasing their crash risk. Paratransit and on-demand transit services may help overcome access and lack of pedestrian and bicyclist facilities in rural areas. However, these on-demand transit services have unpredictable demand with regards to both pick-up and drop-off locations and the timing of requests. This presents additional challenges with how and where to design facility improvements given that system users can request a ride to/from any location within the network. Given this uncertainty, it is impractical to maintain pedestrian and bicyclist facilities within the entire on-demand transit operating zone, meaning that some pedestrians and bicyclists may have routes to or from their pick-up/drop-off location that could be missing sidewalks, marked crosswalks, bicyclist facilities, or pedestrian signals.

Even in denser suburban land uses, curvilinear and disconnected street networks and sidewalk gaps can increase the walking and bicycling distance to transit. Also, pedestrians and bicyclists may cross arterial roadways with high traffic volumes and speeds to access transit in suburban environments, which can increase crash risk and discomfort. **Chapter 3** describes how transit agencies can evaluate bicyclist and pedestrian access to stations and stops.

Delaware Valley Regional Planning Commission Transit Station Evaluation Tool

The Delaware Valley Regional Planning Commission (DVRPC) developed the web-based RideScore tool to evaluate commuter rail, trolley, and subway stations outside of the City of Philadelphia's core for bicycle facility improvements. RideScore, shown in figure 5, calculates a value for each station based on 10 variables, including proximity to on-road bicycle facilities, population and employees within 1 mile, nearby shared-use paths and trails, and intersection density within ½ mile (a measure of walkability and street connectivity). The tool integrates typical walking and bicycling distances to transit—among other variables—to support DVRPC and local agencies in better coordinating transit and bicycle facility improvements to increase ridership.

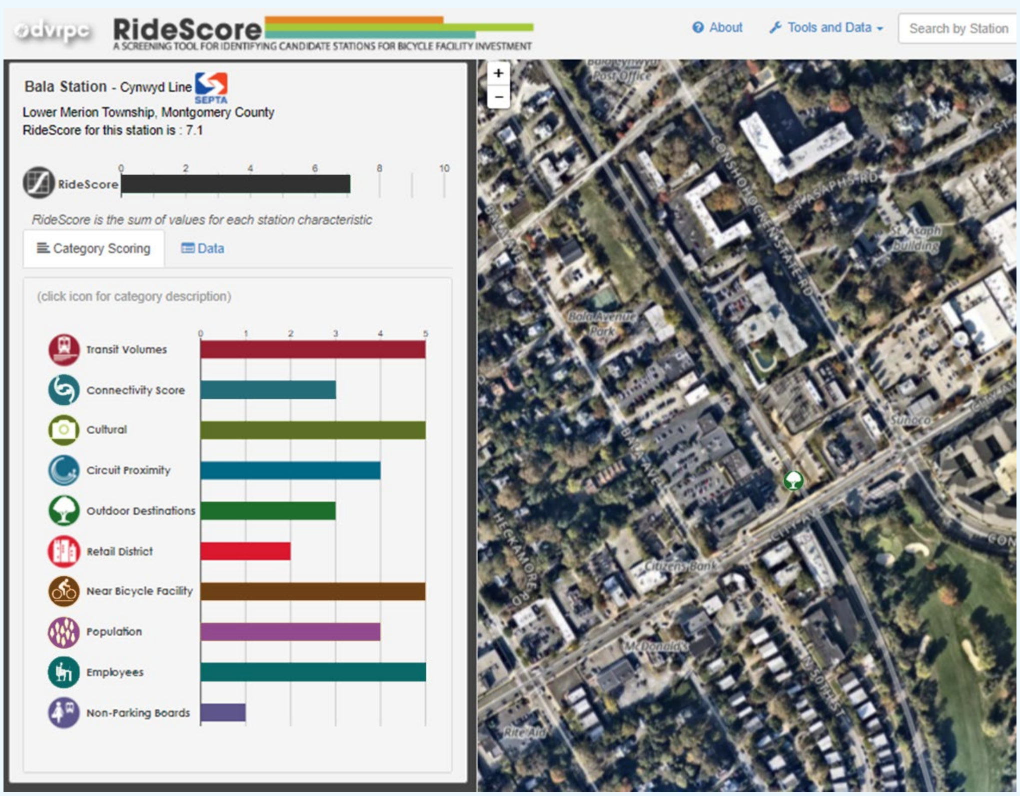


Figure 5. Graphic. Online RideScore tool for identifying candidate transit stations for bicyclist facility investment (DVRPC, n.d.).

Pedestrian and Bicyclist Characteristics and Behavior

Some of the primary considerations for pedestrians and bicyclists include travel speeds, spatial needs, and mobility needs/factors. In addition to providing a clear and accessible route, there are other more nuanced needs related to mobility factors, user confidence, demographic characteristics, and cognitive abilities to consider. Table 1 summarizes some of the needs that planners and designers may want to consider for pedestrians and bicyclists in accessing and using transit.

Table 1. Considerations for pedestrians and bicyclists accessing transit.

Transit User Group	Considerations
General	• Need safe, accessible, and connected pedestrian and bicyclist facilities that are connected to the transit facility. • Generally prefer to use the most direct route to and from the transit facility. • May feel unsafe travelling to/from, or waiting at, transit stops (especially at night or in isolated locations)(Whitfield et al., 2018; Lubitow et al., 2019). • May not understand traffic flow or travel patterns. • May have difficulty with orientation and understanding traffic signs. • May have difficulty judging speed of approaching vehicles. • May be more affected by surface irregularities in the pavement and changes in slope or grade. • Children may have difficulty seeing (and being seen by) drivers of all types of vehicles, including buses because of decreased detection of threats within their peripheral vision (David et al., 1986) and shorter stature than adults.
Bicyclists	• Need safe and connected bicyclist facilities within the bikeshed leading to the transit facility. • May have a child or additional luggage on the bicycle, which can make the bicycle heavier and more cumbersome to handle. This can impact the ability to stop quickly, make sharp turns, or load into bicycle parking or a transit vehicle. • May need more space or time when boarding transit to load their bicycle on the transit vehicle (such as loading onto a train or securing it to the front of the bus). • Certain styles and types of bicycles—such as electric bicycles or cargo bicycles—may not fit onto transit vehicles or could be difficult to load due to the weight of the bicycle. • Some riders may not be physically capable of lifting the bicycle onto transit vehicle racks. • Adequate and secure storage areas for bicycles are needed at the transit facility if the traveler is not continuing by bicycle for the remainder of their trip, if the transit vehicle does not have space for their bicycle, or if the transit agency has policies against bringing the bicycle onto transit.
Pedestrians	• Need accessible and connected pedestrian facilities within the walkshed leading to the transit facility. • May have a child (possibly with a stroller) or luggage (such as a suitcase or grocery cart) and need more space to maneuver and store/secure items. • May have difficulty deciding where and when it is safe to cross the street. • May need more time to cross a street due to walking speed. • May have reduced vision and hearing acuity that affect their awareness of oncoming traffic or transit. • May need pedestrian signal information provided in multiple formats (audible, tactile, and visual). • May need accommodations at transit stops, such as additional seating or lean bars.

Within the broader community, there is a spectrum of types of bicyclists with varying levels of comfort and skill. Figure 6 illustrates one method for categorizing bicyclists as related to their confidence and tolerance of traffic stress (Dill & McNeil, 2016).

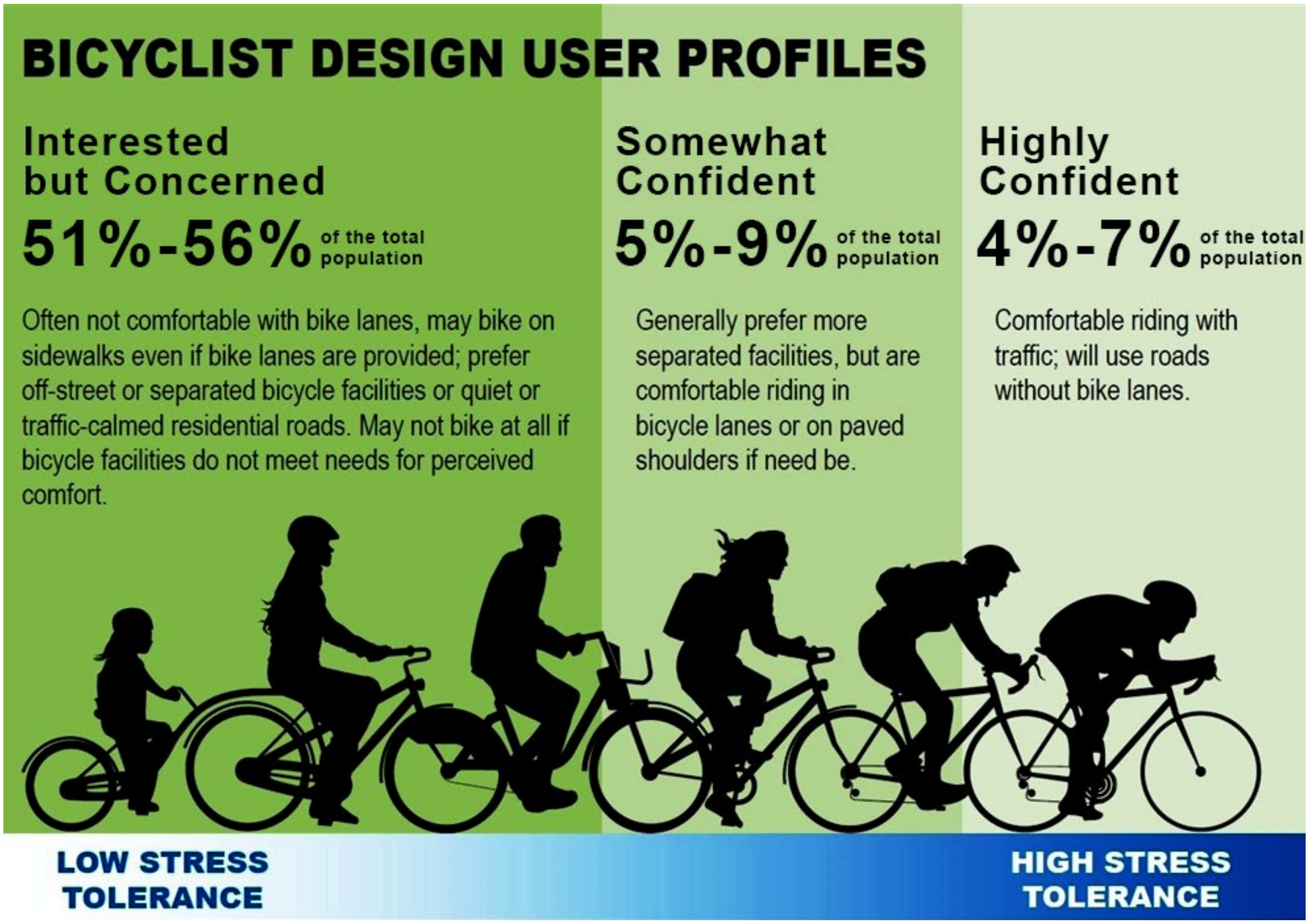


Figure 6. Graphic. Bicyclist user profiles (adapted from Dill & McNeil, 2016).

Understanding common pedestrian and bicyclist behaviors is essential to promoting pedestrian safety near transit. Pedestrians typically take the most direct line possible to minimize the distance and time they walk to reach their destination. Placing roadway crossing facilities at the most direct crossing locations can make the crossing attractive to pedestrians. Poorly designed environments often result in pedestrians using informal paths through properties and crossing roadways at locations without pedestrian safety enhancements. Providing convenient and direct pedestrian connections can help to make sure the facilities are used as intended, ultimately enhancing pedestrian safety.

Bicyclists often ride in the road because sidewalk riding may be illegal, and they can avoid slower pedestrian traffic. If designated bicyclist infrastructure does not exist, many potential bicyclists may choose to ride on the sidewalk or avoid bicycling altogether. This scenario puts pedestrians at risk who now share the walkway with higher speed bicyclists, and it also puts the bicyclists at risk for crashes with motorized vehicles as drivers may not see them as they cross a driveway or intersection. Alternatively, bicyclists may still choose to ride in the roadway but could be exposed to the risk of a crash with motorized vehicles—particularly on higher speed, higher volume, multilane roadways. Connected bicyclist infrastructure provides a more comfortable and safer method for bicyclists to reach transit facilities.

Pedestrians and bicyclists who are at risk of missing their transit connection may act in ways that increase their chances of being involved in a crash. These may include:

- Running or bicycling faster to catch transit.
- Crossing against signals or at locations that do not have marked crossing facilities or safety enhancements.
- Bicycling on roads where they feel less comfortable (due to the number of lanes and speed or volume of vehicles).
- Walking or bicycling between stopped or parked vehicles, including buses.
- Stepping into the street to pass other transit riders that are waiting at a transit stop.

The safety treatments listed in **chapter 5** can help reduce pedestrian and bicyclist crash risk when accessing, waiting for, and using transit services.

Crash Factors for Pedestrians and Bicyclists Accessing Transit

While investigating crashes—in this context transit-related crashes involving pedestrians or bicyclists, or crashes involving pedestrians and bicyclists who are traveling to or from transit—patterns and trends in the data can help agencies better understand crash risk and determine associated crash factors. In addition to crash statistics, agencies can evaluate other data, such as transit logistics or traffic volume, to assess the risk for pedestrians and bicyclists accessing transit.

In 2019, pedestrian crashes accounted for 17 percent of all traffic fatalities, but only 3 percent of the total number of people injured, thus emphasizing the more severe outcome of crashes involving pedestrians (National Center for Statistics and Analysis, 2020). With 82 percent of pedestrian and 78 percent of bicyclist fatalities occurring in urban settings (NHTSA, 2019), and given that transit ridership is highest in urban areas, urban agencies should pay particular attention to the safety of pedestrians and bicyclists traveling to and from transit facilities.

Transit stops are traffic generators—particularly for pedestrians and bicyclists. These locations deserve special attention to reduce the pedestrian and bicyclist crash risk.

Transit service by its nature operates in a multimodal environment that presents crash risks for pedestrians and bicyclists. Analyses of pedestrian crashes in Seattle, Los Angeles, Toronto, and Charlotte have shown that pedestrian crossings near transit stops have higher crash risks (Craig et al., 2019). Similarly, the National Cooperative Highway Research Program (NCHRP) *893 Systemic Pedestrian Safety Analysis* found that the presence of transit stops and the number of stops along a roadway segment are both associated with elevated pedestrian crash risk

(Thomas et al., 2018). Other transit activity measures, such as the number of buses stopping along a segment and the increasing numbers of passengers boarding or alighting at a stop, were also associated with an increase in pedestrian crash risk. Transit agencies can mitigate high risk locations and partner with other agencies to implement safety improvements for accessing transit stops.

Table 2. Summary of identified potential roadway and traffic risk factors for pedestrian and bicyclist crashes (adapted from Monsere et al., 2017).

Risk Factors	***Bicyclist***	***Pedestrian***	***Both***
Horizontal curves	x	x	x
Presence of bus stops	x	x	x
Number of driveways	x	x	x
Presence of median	x	x	x
Traffic volume	x	x	x
Number of lanes	x	x	x
Posted/vehicle speed	x	x	x
Percent heavy vehicles	x	x	x
Lighting	x	x	x
Lane width	x	x	x
Presence of bicycle lanes	x	-	-
Presence of bicycle paths	x	-	-
Presence of parking	x	-	-
Vertical grade (slope)	x	-	-
Width of bicycle lanes	x	-	-
Average sidewalk width	-	x	-
Distance to the closest marked crosswalk or intersections	-	x	-
Maximum number of crossing stages	-	x	-
Number of traffic directions	-	x	-
Paved shoulder	-	x	-
Presence of marked crosswalk	-	x	-
Presence of paved sidewalk	-	x	-
Total road width	-	x	-
Pedestrian delay	-	x	-

Note: dashed line indicates the item is not applicable to the category.

The Oregon Department of Transportation (ODOT) analyzed pedestrian and bicyclist crashes to improve its methodology for identifying and prioritizing high risk locations. As part of the process, ODOT produced a literature review that identified the key risk factors for both modes (table 2, showing combined roadway and traffic characteristics)(Monsere et al., 2017). ODOT identified the proximity to transit stops as a risk factor for both modes. ODOT incorporated many of the risk factors into crash occurrence and crash severity models for intersections and segments and evaluated their statistical significance for the State’s crash data and roadway network. The number of transit lines through an intersection was a significant variable for both pedestrian and bicyclist crash occurrence models. Other State departments of transportation (DOTs) can replicate the analysis process to find those risk factors applicable to their roadway networks.

The use of crash types to organize and analyze pedestrian and bicyclist crashes can support a transit agency's response to safety issues through identification of precrash actions and potential countermeasures. The Pedestrian and Bicycle Crash Analysis Tool (PBCAT) provides a pedestrian and bicycle crash typing tool with definitions for both pedestrian and bicyclist crashes (Thomas et al., 2021). The tool provides the following optional, special circumstances screening questions related to transit:

- Was the non-motorist struck crossing in front of a transit bus stopped at a marked bus stop?
- Was the non-motorist struck while going to, from, or waiting at a transit bus stop, regardless of the circumstances?
- Was the non-motorist struck by a transit bus pulling into or away from the curb or loading area?

While there are no specific crash types for transit within PBCAT, most—if not all—of the pedestrian and bicyclist crash types are relevant to understanding crashes for people traveling to and from transit. **Chapter 5** includes operational and design improvements to reduce bicyclist and pedestrian crashes near transit stops.

3 Tools for Identifying Pedestrian and Bicyclist Safety Issues

To improve pedestrian and bicyclist safety, agencies should first understand what safety issues are present and where best to focus their time and effort. This chapter includes a variety of tools for identifying pedestrian and bicyclist safety issues as related to both access to transit and also more broadly. The tools include some that involve the public, such as direct feedback and transit stop assessments, while others rely on professionals and data analysis, such Road Safety Audits (RSAs) and transit stop balancing. The chapter also provides an overview of pedestrian and bicyclist data analysis and potential sources of data.

Direct Feedback

There are mechanisms for gathering direct feedback from transit users and providers, including conducting surveys, questionnaires, and listening sessions. Agencies may find it useful to gather feedback from unique user groups, such as the disability community, schools, older adults, or other users. Transit agencies typically host **advisory committees**—possibly with an accessibility focus and comprised of persons with disabilities and seniors, or with more general rider advisory committees. Advisory committees can serve a range of purposes, from facilitating regular communication between the disability community and a transit agency to providing input for a specific activity, such as the design of one transit stop (Easter Seals Project Action, 2012).

Another way of gathering information is **crowd sourcing locations and issues** using clickable maps. This information can help to visualize and catalog safety issues, such as near miss locations. Pedestrian and bicyclist crashes are oftentimes underreported, so crowd sourcing additional information can complement crash data analysis. In the Washington, DC area, the Washington Area Bike Association (WABA) created a web-based reporting form for those involved in a bicyclist crash, witnessed a bicyclist crash, or experienced a near miss incident. Because the data includes accounts from witnessed events and near misses, the data can provide more insight into areas of risk than relying solely on emergency responder reported injury and fatality crash data. However, as crowdsource data is self-reported, data quality is compromised as the reports lack a unified format and standard (Mardan and Zhu, 2019).

Internally, agency staff can provide direct feedback through **operator safety assessment reviews**. Transit agencies invest in both initial and refresher safety training for their operators, and their feedback can be invaluable in identifying safety concerns and risks. When there is an incident, transit agencies investigate the incident, attempt to determine the root cause, and record their findings for future trend analysis. These trend analyses can lead to actions to prevent future incidents, ranging from targeted training to modifications in transit routes, stops and facilities, and equipment.

Transit Stop Assessment Tools

This section provides tools to evaluate the safety and accessibility of transit stops for pedestrians and bicyclists. The tools include transit stop checklists, RSAs, pedestrian and bicyclist catchment area facility inventories, and transit stop balancing.

While the chapter presents tools for transit agencies to use, agency partners such as local, regional, and State agencies; public interest and community groups; university researchers; and nonprofit organizations may also benefit from the tools.

Transit Stop Checklists

Transit stop checklists assist transit agencies or residents with assessing conditions at transit stops. The checklists have most commonly been used for bus stops. However, they can also apply to all other types of transit, such as streetcars, shuttle services, or any other fixed route service. Checklists typically document:

- Pedestrian and bicyclist facility presence and condition near the transit stop.
- Roadway crossing treatments near the transit stop (crosswalks, curb ramps, pedestrian/bicycle signals).
- Path of access between the pedestrian and bicycle facilities and transit stop boarding area.
- Readability of transit stop signs.
- Obstructions at the transit stop.
- Transit stop shelter and amenities, including bicycle parking, seating, lighting, etc.
- Compliance with the Americans with Disabilities Act (ADA) standards (boarding and alighting area, etc.).

This type of checklist can help to facilitate a conversation between transit riders, the owner of the roadway, and the transit agency, providing a mechanism for decision-makers to understand the needs, preferences, and concerns relating to transit stop access. The checklist is not necessarily a standards check, although an agency could tailor the checklist for use in that manner. Appendix A provides an example bus stop checklist from San Francisco Municipal Transit Authority (SFMTA).

RSAs

While transit stop checklists may help an agency understand some of the pedestrian and bicyclist needs and potential safety issues, an RSA is a more robust process that is conducted with a team of professionals with a variety of skillsets, including:

- Roadway safety.
- Bicyclist and pedestrian safety and infrastructure.
- Roadway design.
- Traffic operations.
- Transit planning and operations.
- ADA specialist/disability advocacy organizations.
- Law enforcement and emergency services.

Transit agencies or roadway owners may decide to initiate an RSA to investigate community concerns, evaluate a crash spot or high injury corridor, provide an additional perspective on safety improvements, or any combination thereof. During the audit, the RSA team may rely on prompt lists, which outline potential issues for consideration.

The RSA can be conducted during several stages of a roadway project including preconstruction (planning, preliminary design, final design), construction (work zone traffic control plan, preopening), and post construction (including existing roads open to traffic). While the RSA team typically does not possess the authority to change a design that is being audited, it can highlight safety concerns and recommend measures that can reasonably be implemented within the project’s timeline and budget.

Appendix A provides an excerpt of the prompt lists from the FHWA *Pedestrian and Bicyclist Road Safety Audit (RSA) Guide and Prompt Lists* (Goughnour et al., 2020).

Access to Transit RSA Case Studies

In 2016, FHWA published *Improving Access to Transit Using Road Safety Audits: Four Case Studies* (Goughnour et al., 2016). The report (figure 7) discusses the RSA process and highlights four case study examples of RSAs that sought to improve access to transit. The four locations were:

- City of Asheville, North Carolina.
- Orange County, Florida.
- City of Springfield, Oregon.
- City of Tucson, Arizona.

These locations had a high frequency of pedestrian, bicyclist, and transit crashes; high transit ridership; or were locations where planning for changes to transit service were underway. During the RSAs, some of the common conditions that appeared to present challenges to transit users were:

Figure 7. Graphic. FHWA *Improving Access to Transit Using Road Safety Audits: Four Case Studies* (Goughnour et al., 2016).

- Lack of ADA compliant accessible routes and transit stops.
- Driver behavior and lack of yielding to pedestrians at marked and unmarked crosswalks.
- Lack of pedestrian crossing measures along routes to transit stops, including pedestrian signals and crosswalks.
- Pedestrians crossing mid-block to use the most direct route or intentionally crossing away from intersections due to safety concerns.

The case studies include photographs, a project background, and key RSA findings and suggestions. These case studies will help Federal, State, Tribal, and local agencies better understand conditions that affect transit access and how to effectively address safety in the RSA process.

Facility Inventories

A successful transit system provides access to riders of all abilities. To that end, transit agencies can review areas within which a pedestrian or bicyclist is expected to access a transit stop/station, known as a walkshed, bikeshed, or access shed. Agencies can use geographic information system (GIS) tools to map out pedestrian network access for all users to stops within a certain distance threshold—typically ¼ to ½ mile for pedestrians and 1 to 3 miles for bicyclists—to reveal gaps in pedestrian and bicyclist facilities. Since a transit agency's control generally begins and ends at the transit stop or station, the agency will need to work with local and State roadway owners to implement solutions to fill those gaps.

The facility inventory within the walkshed and bikeshed relies on quality data. Pedestrian and bicyclist facility data can vary drastically in terms of availability, quality, and format (e.g., not all data are in GIS and it may be challenging to convert to GIS format). Transit agencies should consider working with local governments to confirm that the data collection and asset inventories meet their needs. For example, many jurisdictions may collect data on sidewalk assets and conditions; however, these datasets may not contain crosswalks, curb ramps, or pedestrian signals (and accessibility provisions), which are critical to understanding pedestrian access to transit. For bicyclists, agencies may have an accurate inventory of facilities such as trails, dedicated or separated lanes, or shared lanes, but not differentiate between the bicyclist experience for those facilities.

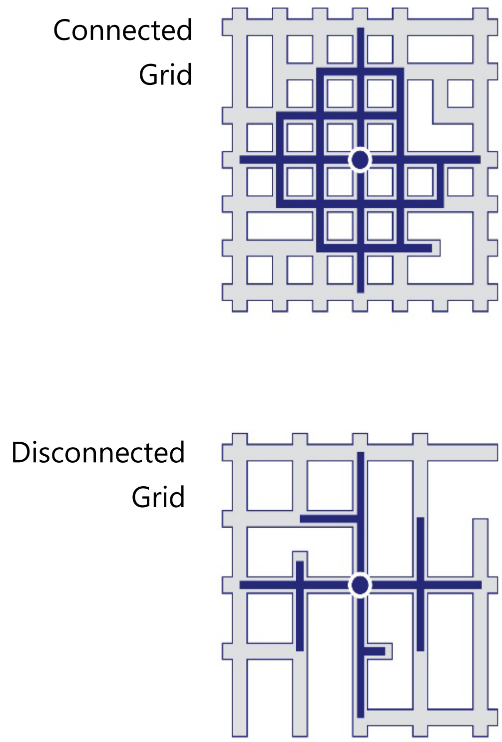


Figure 8. Graphic. TriMet pedestrian plan walkshed analysis (TriMet, 2020).

In 2020, TriMet of Portland, Oregon, embarked on a pedestrian plan to identify priorities for improving walking and rolling (bicycling, wheelchairs, etc.) access to transit as well as identify opportunities for cooperation between the agency and the owner of the right-of-way. The transit walksheds were defined as ¼ mile of the network distance (i.e., an existing viable route using the existing pedestrian network) as shown in figure 8 (TriMet, 2020). The plan used mapping, GIS analyses, and community and agency input to create a project list and recommended strategies. As part of the mapping exercise, TriMet developed one region-wide inventory of planned improvements and determined which projects would expand transit walksheds, allowing more people to walk and roll to transit stops and stations. TriMet also reported that the project analysis did not include crossing infrastructure or crossing gaps, because regionwide data was not available.

Transit Stop Balancing

The balancing, and oftentimes consolidation, of transit stops allows transit agencies to optimize transit stop spacing and performance with minimal affects to ridership and service areas. Over time, a transit agency may find that its routes include stops that are underutilized, numerous duplicative stops, and stops that are that too closely spaced (given the land use context). After internal analysis and robust public engagement, a transit agency may decide to consolidate or remove stops to reduce delays associated with acceleration and deceleration, door opening and closing times, traffic signal delays, and transit vehicle reentry into the travel lane (Ryus, 2016). Together, these changes can reduce transit travel times and may also allow the transit agency to focus on the provision of amenities at stops, upgrades for ADA compliance, and safety improvements. However, the transit agency should incorporate robust community outreach as part of any transit stop consolidation effort to make sure that stops are convenient, particularly in areas with low vehicle ownership and especially for those pedestrians with mobility challenges, as shown in figure 9 (TransitCenter, 2018).

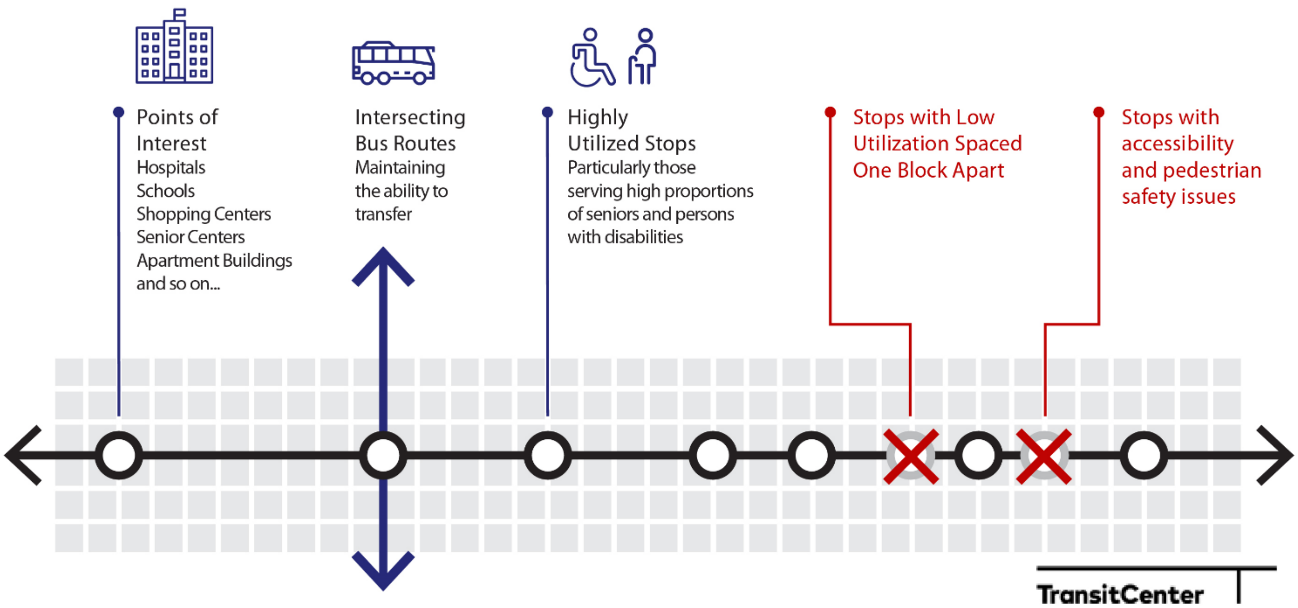


Figure 9. Graphic. Guide to balanced stop spacing (TransitCenter, 2018).

Indianapolis Transit Stop Balancing and Relocation for Safety

The Indianapolis Public Transportation Corporation (IndyGO) completed a system-wide bus stop balancing program in October 2020 to improve its system performance (figure 10). IndyGO updated its service standards in 2019, and stop spacing was one of the agency's defining features across its rapid, frequency, and basic service categories. The revised stop spacing standards recognized that wider spacing would increase the likelihood that bus stops would be located closer to signalized and enhanced crossing locations, thereby creating a safer pedestrian environment. The maximum added walk time for transit riders was kept to 5 minutes (¼ mile) or less.

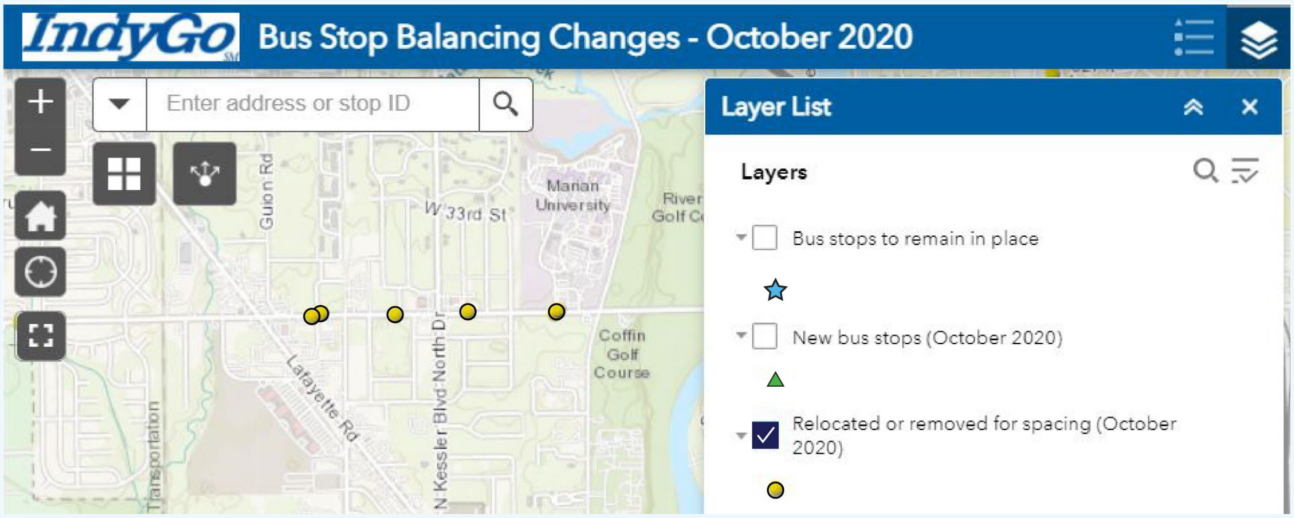


Figure 10. Graphic. IndyGO bus stop balancing program (IndyGO, 2020).

Estimating First-Mile/Last-Mile Access

Generally, transit trips using fixed route services, by their nature, require another mode to access both the origin and destination stops or stations. Agencies can use modeling as an estimate for the first-mile/last-mile access and should take into account a number of factors, including:

- Transit boardings and alightings at each station or stop.
- Pedestrian and bicycle network connectivity to the station or stop, including the street network, sidewalk network, and bicyclist network, typically within ¼ mile to 3 miles of the station or stop.
- Parking availability for vehicles and bicycles at the station or stop.
- Surrounding population and employment.
- Surrounding land use development, including transit-oriented development (TOD).

While first-mile/last-mile access is thought of in terms of the physical distance, some research suggests that an access time of 5 to 10 minutes is the more direct measure perceived by travelers, regardless of the mode chosen (Miami-Dade Transportation Planning Organization, 2018). Rapid transit offering a high frequency of departures (for example, a heavy rail line) tends to include a larger first-mile/last-mile access area than a slower, less frequent mode (for example, a local bus route).

Other factors that can increase first-mile/last-mile access include provisions for first-mile/last-mile modes at stops or stations, such as bikeshare, e-scooters, and vehicle pick-up/drop-off access; as well as wayfinding information, both at the station or stop and throughout the surrounding area to the station or stop.

Los Angeles First/Last Mile Strategic Plan

In March 2014, the Los Angeles County Metropolitan Transportation Authority (Metro) and the Southern California Association of Governments (SCAG), released the Metro First/Last Mile Strategic Plan (LA Metro, 2016). Metro and SCAG recognized that while public transit services may provide the core portion of a trip, passengers complete the first and last portion on their own through walking, biking, or other means, as shown in figure 11. The plan's goal is to better coordinate infrastructure investments to facilitate the first and last trip portions from station areas, extending the reach of transit and ultimately increasing ridership. To achieve this goal, the plan introduces the Pathway, a proposed county-wide, transit access network designed to reduce the distance and time it takes people to travel from their origins to stations and from stations to their ultimate destinations. The Pathway results in a series of active transportation improvements along specific access routes that seamlessly connect passengers with intermodal facilities, such as bicycle share, car share, bus stops, or regional bikeways.

Since adopting the plan in 2016, Metro now partners with local communities and stakeholders to develop a set of community-supported improvements along the key pathways that respond to the unique conditions of each station area. Improvements include:

- Crosswalks, bulb-outs, street trees, and landscaping.
- Signal timing for pedestrians and bicyclists.
- Bicycle lanes, bicycle parking, and bicycle share stations.
- Wayfinding signage to key destinations and connections.
- Real time transit information signs and kiosks.

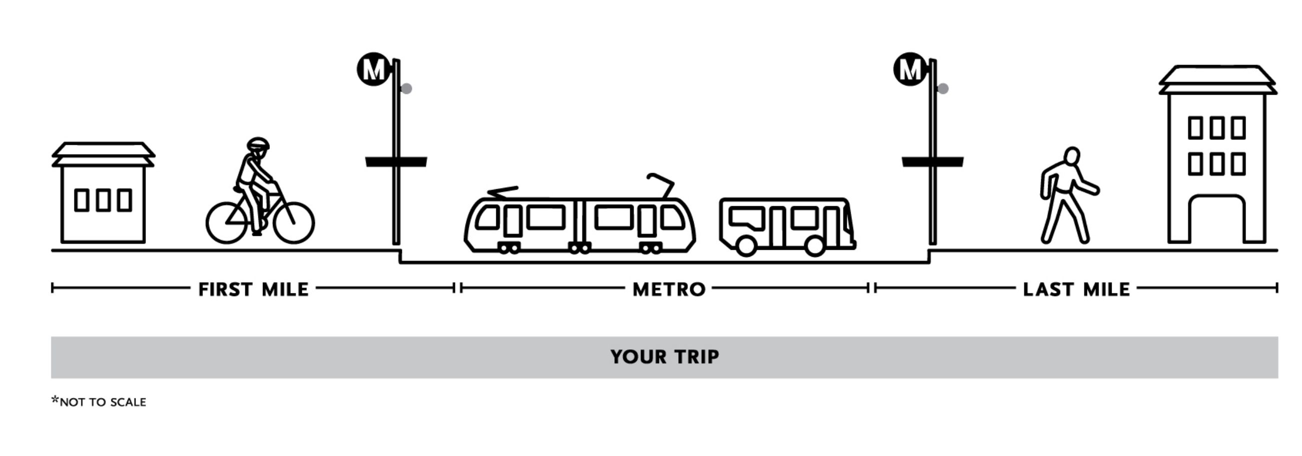


Figure 11. Graphic. Depiction of first/last mile from Los Angeles' Strategic Plan (LA Metro, 2016).

Observing Pedestrian and Bicyclist Behavior

Transit agencies can gather useful information about pedestrian and bicyclist access to transit by observing pedestrian and bicyclist behavior near stops and stations. For pedestrians, observers can note activity, such as pedestrians:

- Using recreational trails or informal pathways or walking in the roadway where sidewalks do not exist.
- Waiting too close or too far from the roadway due to inadequate bus stop placement.
- Crossing roadways at unmarked, midblock locations or at unmarked crosswalks at intersections.
- Running across roadways to catch the bus.
- Stepping out into the street to be seen by transit operators, or boarding and alighting in the roadway, due to obstructions such as queued or parked vehicles.
- Competing for seating or shelter space at a bus stop.
- Experiencing crowding conditions due to high passenger demand with queues limiting space to maneuver on the sidewalk.

From a bicyclist perspective, observers should note activity, such as:

- Bicycles locked on trees, lampposts, or handrails alluding to lack of bicycle storage options.
- Bicyclist-bus leapfrogging (i.e., passing each other multiple times) when traveling in the same direction.
- Bicyclist path obstruction because of bus boarding and alighting.
- Bicyclist conflicts or near misses with transit passengers boarding and alighting.
- Bicyclists swerving to avoid obstacles (e.g., debris, cracks, and potholes) in the roadway or at the transit stop.

For drivers, observers can note activity, such as:

- Speeding.
- Making sudden movements to pass or turn in front of a bus.
- Not yielding to crossing pedestrians or bicyclists.

Transit agencies can use the results of these observations to improve transit stop locations, transit stop and roadway design, or service schedules. They can also provide information to schools and other organizations to develop targeted education messages, confer with local police on ideas for targeted enforcement of driver and pedestrian behaviors, and coordinate with local transportation engineers on improvements to crosswalks, sidewalks, bicyclist facilities, roadway striping, and signage.

Agencies can also use observations of pedestrian and bicyclist behavior to highlight the importance of Complete Street improvements and convey the experience of accessing the local transit system to transit agency staff, governmental agency staff, developers, and politicians.

The Minneapolis-St Paul Area Metro Council Bicycle and Pedestrian Connections to Transit Infrastructure Study

The Minneapolis-St Paul Area Metro Council Bicycle and Pedestrian Connections to Transit Infrastructure Study (Metropolitan Transit, 2009) was tasked with identifying infrastructure improvements for connections for walking and bicycling to transit. As part of this study, the Council developed a toolkit of improvements in three categories, including legal access (ADA curb access for transit and pedestrian curb cuts and ramps), safety (bicycle lanes, crosswalks, pedestrian hybrid beacons, median refuge islands, sidewalks, lighting, etc.), and facilities (benches, bicycle lockers, shelters, etc.).

Essential Considerations

Because public transportation provides open door service to all who wish to travel, agencies should anticipate a wide range of users who access transit service and take advantage of connections to pedestrian and bicyclist facilities. Many of these relate to the types of origins and destinations served by the immediate transit route, but planners and designers should keep in mind that transit systems function as networks, so different passenger markets and needs can be served anywhere on these systems.

Since some transit users are dependent on transit for the majority of their trips, including for basic products and services such as groceries and medical care, agencies should consider the barriers that can impede these trips. For example, the Safe Routes to School National Partnership identified the following barriers for people using transit to access grocery shopping (Safe Routes to School National Partnership, 2017):

- Transit routes may not directly connect grocery and market locations with those where people live and work.
- Transit schedules may not serve individual shopping schedules.
- Transfers and total travel time may cause passengers to worry about making it home in time to store perishable food items.

In this example, people may choose to take the most direct route to and from the market and transit stop due to the heavy load they are carrying or because of the perishable items. This may result in unexpected crossings, walking in the roadway, and other risky behaviors by transit riders. Section 2.3.2 of the FTA ADA Circular notes that transit agencies are responsible for clearing obstructions that create accessibility barriers in areas directly controlled by the transit agency's organization. An example of this is removing snow at bus stops over which the transit agency has direct control. For the area surrounding the transit stop, the FTA encourages coordination with other public entities or private property owners, as noted in the guide, *Effective Snow Removal for Pathways and Transit Stops* by the National Aging and Disability Transportation Center (National Aging and Disability Transportation Center, 2016).

Other examples of potential obstructions include shared micromobility devices such as dockless scooters and bicycles. Although micromobility users are provided guidance on where to leave the devices when the trip is finished, they are sometimes parked in locations that block the sidewalk or transit stop. The National Association of City Transportation Officials (NACTO) recommends that cities require micromobility operators to keep the public right-of-way clear by removing any devices obstructing walkways within a designated timeframe (NACTO, 2019). Edmond, Oklahoma, has only one micromobility operator, but provides the operator's phone number and email for public contact to request the removal of any device inappropriately located (City of Edmond, n.d.).

Inaccessibility of a bus stop and surrounding pedestrian environment can impact demand for ADA complementary paratransit for a rider who could otherwise use the fixed route service. It is often more cost effective to make and keep the bus stop and sidewalk accessible than to provide ADA paratransit on an ongoing basis. Incorporating elements of a Complete Street, including accessibility improvements, also improves mobility for many other riders, including those who are pushing strollers, pulling wheeled luggage, etc.

Safety Data Analysis

There are many ways that data analysis can help to better understand and quantify bicyclist and pedestrian safety with respect to transit access. For example, the discussion on *Estimating First/Last Mile Access* earlier in **chapter 3** discussed how agencies can use data to improve access. Similarly, agencies can incorporate many data sources into their analysis to identify and mitigate specific risk factors—such as the previously mentioned observational data in *Observing Pedestrian and Bicyclist Behavior* in **chapter 3**.

Traditional safety data focuses on crash data, roadway data, and traffic volume data. These data can help to identify infrastructure and exposure factors that increase the risk of pedestrian and bicyclist crashes. Beyond these traditional datasets, agencies may want to use other data to understand the needs of pedestrians and bicyclists accessing transit. Examples include pedestrian catchment area facility inventories discussed earlier in **chapter 3**, crowdsourced data, survey findings, and observational data. While some data sources are readily available—such as socioeconomic data from the census and transit ridership—others are oftentimes lacking. For example, pedestrian and bicyclist volume data may be sporadically collected and not cover the entire network. Because of that, pedestrian and bicyclist crash exposure and demand are not easily quantifiable. Similarly, there are not typically readily available geocoded data layers for common origins and destinations, such as schools, hospitals, and cultural centers.

This section focuses on pedestrian and bicyclist crash data analysis, the use of health outcome data, and other new transit specific data sources.

Pedestrian and Bicyclist Crash Data Analysis

There are two basic approaches to identifying and treating locations to help reduce future crashes and injuries:

1. The **high-crash** location approach. These locations may also be referred to as "crash clusters" or "hot spots". This approach is reactive and assumes that crashes will continue to occur in the same locations as they have historically.
2. The **systemic**, or risk-based, approach. This approach identifies locations with elevated crash risks. As severe and fatal crashes can be random in nature, this approach proactively identifies high-risk locations so that they can be treated before a crash occurs.

Regardless of the method chosen, agencies may find that crash analysis for pedestrians and bicyclists is challenging. The following are some of the challenges that agencies may encounter:

- Pedestrians and bicyclists are much more likely to be killed or seriously injured in crashes involving motor vehicles than vehicle occupants or drivers. However, as a proportion of total crashes, pedestrian and bicyclist crashes can be relatively rare. This means that across an entire network, the fatality and serious injury risk for pedestrians and bicyclists may be relatively high, but it may be challenging to identify specific high-crash locations. The potential lack of high-crash locations could support a systemic or risk-based approach for the analysis.
- The types of data needed for robust pedestrian and bicyclist safety analysis are often incomplete or unavailable. Specifically, many agencies may not have robust infrastructure inventories (e.g., sidewalk presence and quality, locations for marked crosswalks, etc.) and may lack comprehensive pedestrian and bicyclist counts (or exposure data). Similarly, the level of detail available for pedestrian and bicyclist crashes, compared to motor vehicles, is often lacking. For example, in a crash involving two motorized vehicles, a crash type might be recorded as an "angle crash" and within the attributes, it is noted that one driver was traveling straight and the other was making a right-turn. For a similar crash between a bicyclist and a motorized vehicle, the crash may be categorized as a "bicycle crash" with the attributes as "failure to yield". Only upon reading the full crash narrative may the exact movements be understood.

To overcome these challenges, analysts can rely on surrogate measures to help understand typical characteristics of roadways, such as posted speed limit and number of lanes, or the use of socioeconomic data, such as vehicle ownership, to help identify areas with more walking, bicycling, and transit usage. With this analysis, transit agencies and roadway owners can work together to develop informed plans that will reduce the risk of crashes by improving pedestrian and bicyclist facilities and connections to transit.

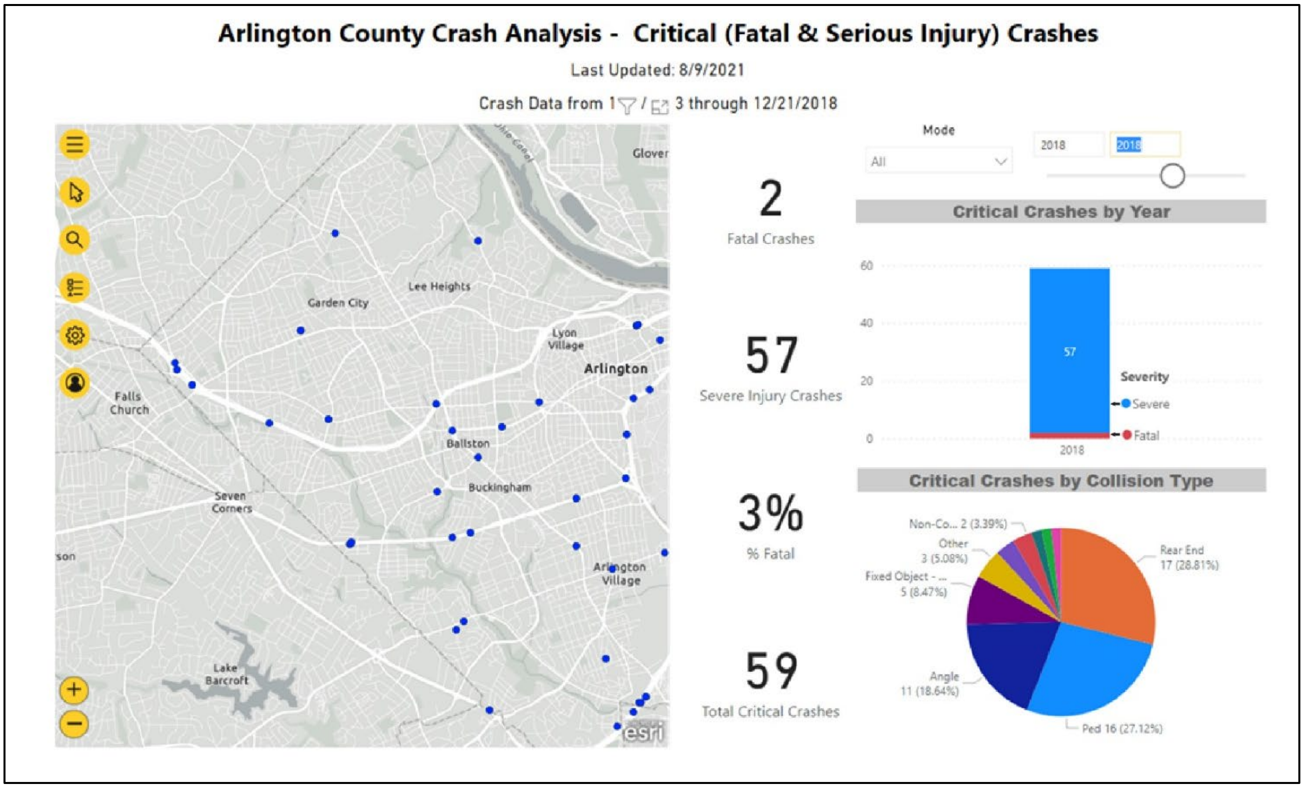


Figure 12. Graphic. Example of the interactive maps that support Arlington, Virginia's Vision Zero program (Arlington County, 2021).

It can also be helpful to publish the crash data analysis so that other organizations and individuals can understand crash risks and become partners in helping to improve transportation safety. This approach is a key component of Vision Zero programs that aim to eliminate all traffic fatalities and severe injuries. Figure 12 provides an example of interactive crash analysis maps developed by Arlington County, Virginia (Arlington County, 2021).

The following are useful resources when conducting pedestrian and bicyclist crash data analysis:

- American Association of State Highway and Transportation Officials (AASHTO) *Highway Safety Manual* (HSM) (AASHTO, 2010).
- FHWA *Synthesis of Methods for Estimating Pedestrian and Bicycle Exposure to Risk at Areawide Levels and on Specific Transportation Facilities* (Turner et al., 2017).
- FHWA *Guide for Scalable Risk Assessment Methods for Pedestrians and Bicyclists* (Turner et al., 2018).
- FHWA *Guidebook on Identification of High Pedestrian Crash Locations Bicyclists* (Fitzpatrick et al., 2018).
- National Cooperative Highway Research Program (NCHRP) Project 17-73 *Systemic Pedestrian Safety Analysis* (National Academies of Sciences, 2018).
- NCHRP 07-17 Pedestrian and Bicycle Transportation Along Existing Roads—ActiveTrans Priority Tool Guidebook (National Academies of Sciences, 2015).

VDOT Pedestrian Safety Program

The Virginia Department of Transportation (VDOT) has been working to improve pedestrian safety throughout the Commonwealth. In 2018, VDOT developed a Pedestrian Safety Action Plan (PSAP) (Virginia Department of Transportation, 2018). VDOT updated the PSAP as newer data became available, including a statewide transit data layer and a dataset called the Health Opportunity Index. VDOT used the transit layer to better identify collocated transit facilities with those areas of severe and fatal pedestrian crash risk. Additionally, the Health Opportunity Index provided insights on areas with poor health outcomes. A Bayesian spatial analysis indicated that the Health Opportunity Index and pedestrian fatalities were strongly correlated and therefore was a good additional indicator of locations with elevated pedestrian crash risk. Ultimately VDOT uses their plan to help direct funds to improve pedestrian safety at locations shown in figure 13 through infrastructure improvements like the ones mentioned in this guide.

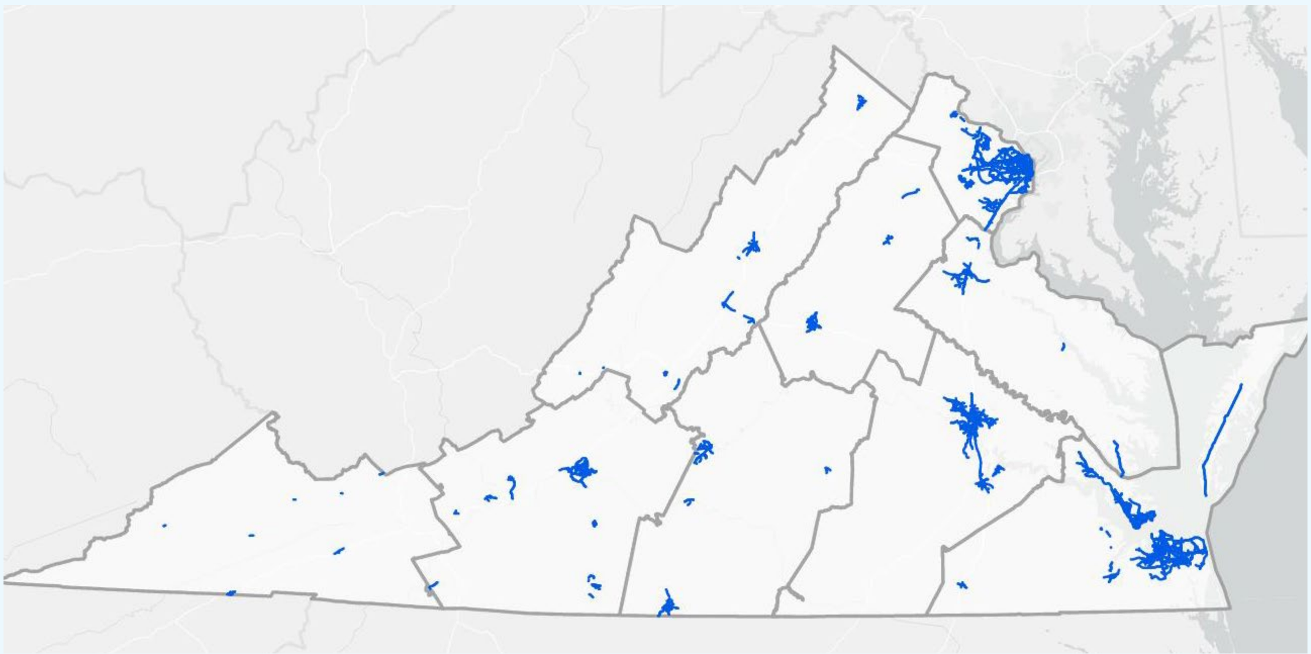


Figure 13. Graphic. Geographic distribution of VDOT priority PSAP corridors (Virginia Department of Transportation, 2018).

Health Outcome Data

As illustrated through the Virginia example, it is important that the data analysis includes health figures, social determinants of health (SDH), and social equity data sets. SDH are defined by the Center for Disease Control and Prevention (CDC) as "conditions in the places where people live, learn, work, and play that affect a wide range of health and quality-of-life-risks and outcomes (CDC, 2021)."

Healthy People 2030 uses a place-based framework that lists five areas of SDH (U.S. Department of Health and Human Services, n.d.):

- Healthcare access and quality.
- Education access and quality.
- Social and community context.
- Economic stability.
- Neighborhood and the built environment.

Providing resources and mitigation strategies to enhance quality of life can have a significant influence on population health outcomes. The incorporation of Complete Streets policies and roadway designs, that provide safer transportation options and access to multiple modes of transportation, can better the neighborhood and built environment, help reduce emissions and air pollution, and increase physical activity amongst users.

Social equity is described as "just and fair inclusion into a society in which all can participate, prosper, and reach their full potential. Unlocking the promise of the nation by unleashing the promise in us all (Policy Link, n.d.)." A focus on social equity can be put in place to confirm all neighborhoods have access to transportation and are not adversely affected by increased air pollution, noise pollution, or safety hazards by being near highways, busy roads, or overpasses.

Fairfax County, Virginia Social and Racial Equity Policy

Fairfax County, Virginia, adopted a social and racial equity policy, titled "One Fairfax" (Fairfax County, 2017). The policy covers multiple safety sectors and has one goal dedicated to transportation defined as "a multimodal transportation system that supports the economic growth, health, congestion mitigation, and prosperity goals of Fairfax County and provides accessible mobility solutions that are based on the principles associated with sustainability, diversity, and community health (Fairfax County, 2017)." The County also included goals for better transportation in the County's strategic plan and mitigation strategies to improve the transportation system and highlight accessibility and equity.

States and localities can analyze the overall safety of a street or transportation network and change social equity and SDHs for the better. A focus on safety can lead to improved situations, including installing safer crossings, enhanced access to transit, and infill of sidewalk gaps or missing connections to key destinations. According to the National Highway Traffic Safety Administration (NHTSA), the pedestrian fatality rate for seniors (65 years or older) per 100,000 population was roughly 25-percent higher than the total pedestrian fatality rate (2.29 versus 1.84, respectively) (NHTSA, 2019). A report from the Govenors Highway Safety Association (GHSA) in 2020 found that from 2015 to 2019, Black, Indigenous, and people of color (BIPOC) pedestrian deaths accounted for 48 percent of all pedestrian deaths, while only 38 percent of the total U.S. population is BIPOC (see figure 14) (Retting, 2021).

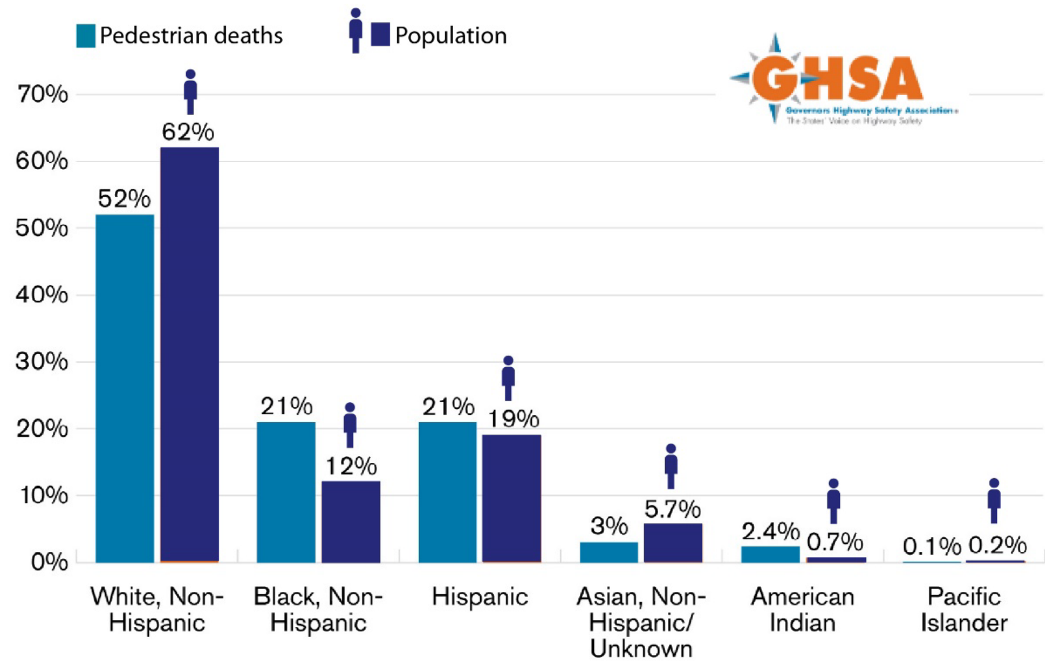


Figure 14. Graphic. Percent of total pedestrian fatalities and population by race, 2015-2019 (Retting, 2021).

Emerging Data Sources

Emerging sources of data are constantly evolving. This section highlights some potential emerging data sources for transit planning and crash analysis.

Collision Avoidance Warning System

Collision avoidance warning system is an emerging technology that agencies can use on transit vehicles that are designed to detect and prevent potential collisions before the event occurs. Specially, through a set of camera detectors installed on the bus, these systems provide coverage of blind zones where vulnerable road users may be hidden from the driver's view and alerts drivers to avoid potential collisions. Several transit agencies in Washington State have piloted these technologies on revenue service and found during the pilot that no equipped buses were involved in any collisions with bicyclists or pedestrians. It should be noted that because these collision events are rare, further tracking of these technologies is needed. A powerful biproduct of these technologies is that they integrate with Automatic vehicle location (AVL) systems to provide the exact location for where crashes and near-misses occurred, providing planners with a rich dataset to understand the most conflict prone areas along a bus route (Kern, 2017; Lutin et al., 2017; NHTSA, n.d.; Samsara, 2021).

System Ridership Data

With potentially hundreds or even thousands of transit stops maintained by a single transit agency, it may be difficult to know where an agency should focus resources and energies to improve the pedestrian and bicyclist experience. Fortunately, ridership data generated using automated passenger counters (APCs) or electronic registering fareboxes (ERFs) can be applied to prioritize and focus resources. An APC is an electronic device that records boarding and alighting data on a transit vehicle. Similarly, ERF systems are electronic devices that automatically generate payment records when the fare is paid. ERF data is often considered to be more accurate but, unlike APC data, ERFs typically do not provide information on where passengers might alight a vehicle. Many APC systems also indicate where transit vehicle ramps deploy to help understand transportation needs related to access, or where bicyclists board (Florida DOT, 2019).

Transit Vehicle Location Data

With the growth of smartphones, transit planners have more data at their fingertips than have ever been available before. Many transit vehicles are equipped with AVL technology, which interacts with the Global Positioning System satellites to accurately track vehicle location in real-time. Not only can transit riders use AVL data (through transit websites and phone applications) to plan their trips by noting arrival times and where vehicles are in the network, this data can also be translated into urban analytics, providing insight on travel patterns and modal choice on the street level with a few clicks of a mouse. Agencies can leverage AVL data to understand key pedestrian and bicyclist corridors along a transit network and strategize where agencies should focus their inter-modal conflict management and treatment (Streetlight Data, n.d.).

Tools for Crash Investigations

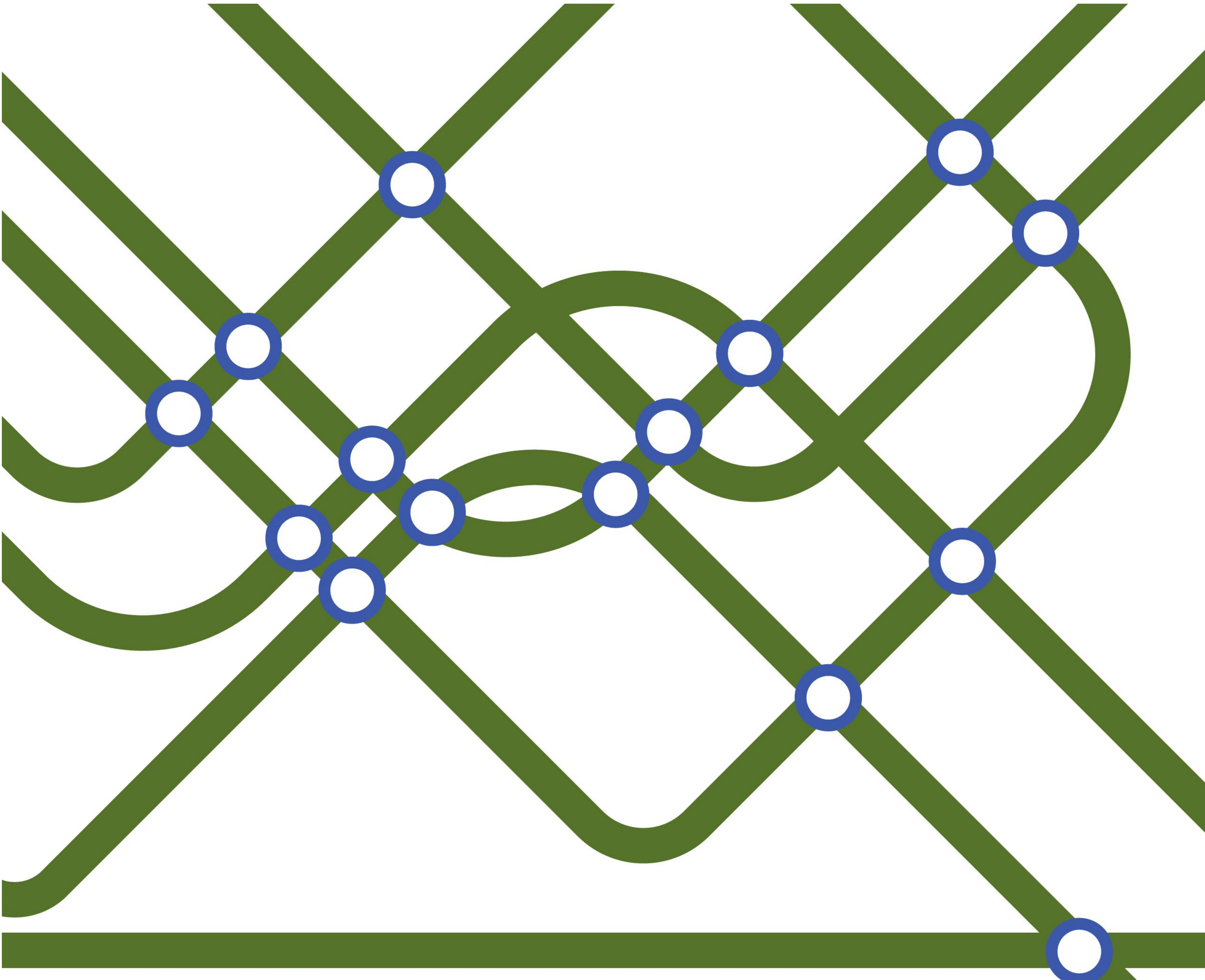
Due to evolution in technology, particularly related to video, transit agencies can leverage onboard camera recordings and event data recorders to review and reconstruct crashes after they occur and subsequently inform potential roadway and operations design improvements (Axiomtek, 2014). Event data recorders are devices that can capture (U.S. DOT, 2019):

- Vehicle speed.
- Whether the brake was activated in the moments before a crash.
- Crash forces at the moment of impact.
- Information about the state of the engine throttle.
- Air bag deployment timing and air bag readiness prior to the crash.
- Whether the vehicle occupant’s seat belt was buckled.

Inward and outward facing cameras can help to improve operational safety, control and reduce risk, and strengthen crash investigations (APTA, 2019). FTA suggests that all regional transit authorities (RTAs) implement these cameras on rail transit vehicles (FTA, 2020a).

None of these technologies are mandatory but can be extremely beneficial for agencies in cases of disputed crashes and improving overall driver safety—potentially reducing behaviors such as distracted driving—and improving an overall understanding of crashes.

Over the years, devices have improved to be more rugged: successfully handling continuous vibrations and all-weather conditions. Camera technology have also improved in pixel size and resolution offering better, more detailed video. Agencies can directly integrate video recordings in a cloud-based environment, making expensive information technology (IT) equipment unnecessary. Faster internet speeds and fiberoptics speeds as well as optimized data formats allow for quicker transfer speeds, making this information more accessible than ever.



4 Approaches to Enhancing Pedestrian and Bicyclist Safety

Transit agencies and roadway owners both play critical roles in improving the safety of pedestrians and bicyclists. Beyond conducting analyses and designing transit stops to support safer pedestrian and bicyclist access, transit agencies can take internal actions to create awareness about safety. Transit agencies and roadway owners can also partner with organizations to improve safety conditions for passengers. The following section, *Internal Actions*, discusses strategies transit agencies can implement independently, and with community partners, to foster safer conditions for pedestrians and bicyclists.

Internal Actions

Transit agencies have the authority to independently implement pedestrian and bicyclist safety initiatives, such as organizational improvements and modifying services and facilities. Even with limited resources, transit agencies can take steps to improve pedestrian and bicyclist safety and access.

Transit agencies each take different approaches to creating a culture of safety. While methods vary, a key theme across many transit agencies is to establish accountability at all levels of the agency so that members contribute to a safety mindset (Staes et al., 2017). Another common theme is to apply multiple mitigation measures to promote safety. In a survey of transit agencies, most reported that they generally take a holistic approach to safety management by developing comprehensive safety programs with multiple strategies for addressing safety; they did not rely on a single measure alone to prevent safety risks (Staes et al., 2017). One key component to a comprehensive safety program is to foster a strong internal culture of safety. Critical elements of a strong safety culture include the following:

1. Leadership is clearly committed to safety.
2. Open and effective communication exists across the organization.
3. Employees feel personally responsible for safety.
4. The organization practices continuous learning.
5. The work environment is safety conscious.
6. Reporting systems are clearly defined and not used to punish employees.
7. Decisions demonstrate that safety is prioritized over competing demands.
8. Employees and the organization work to foster mutual trust.
9. The organization responds to safety concerns fairly and consistently.
10. Safety efforts are supported by training and resources.

These ideas are explored further within the realms of organizational improvements, transit operator training programs, internal agency documentation and policies, transit services and facilities, and transit vehicle safety features.

Transit Agency Organizational Improvements

Transit agencies can make organizational changes that have long-term positive effects on pedestrian and bicyclist safety and convenience. Some potential actions include the following:

- Work with agency leadership to send a strong and public message about the importance of safety, particularly that of reducing crash risks.
- Review and update policies to make sure that they provide adequate support for improving accessibility, safety, and reducing crash risks.
- Look for opportunities to formalize the relationship with partner agencies to share data, identify safety issues, and implement improvements.
- Establish a bus stop coordinator position within the agency to work with local and State transportation departments and the public to review transit agency policies and operations. The coordinator should work with transit agency staff on route planning, scheduling, transit stop facilities, and coordination with other organizations.
- Work with the bus stop coordinator or other staff person to make them aware of construction activities planned for bus stops or areas surrounding the transit facility. The coordinator can work with roadway agencies and their contractors to assure that the agency provides adequate, accessible alternative routes for pedestrians and bicyclists during construction periods.
- Work with agency staff to elevate the awareness of transportation safety issues—particularly those actions or situations that have a higher risk for fatal or severe injury crashes—in their day-to-day responsibilities.
- Provide periodic training on pedestrian and bicyclist safety to agency staff, consultants, and operators to improve the quality of transit service and the safety record of bus and train operators.
- Provide transit agency representation on metropolitan and regional planning organization decision-making boards and committees.

Transit Operator Training Programs

Transit operator training programs have helped transit agencies reinforce stated safety metrics and foster a culture of safety among staff. These can include:

- Offering annual or ongoing refresher safety training, in addition to new bus operator training and remedial training. The refresher trainings commonly address safety policies and procedures, defensive driving, and distracted driving. The training can also include information specific to pedestrian and bicyclist crash risks and roadway designs they might encounter in their operating area. Refresher trainings may also reduce driver complacency, which is a hazard.
- Providing training through a variety of mediums to support different learning styles. Many transit agencies deliver training through computer-based/online training, video training, simulation training, and instructor-led sessions (Staes et al., 2014).

- Instructing operators on how to assess their individual ability to operate buses and trains and report safety concerns that they see on their routes. Operators can face schedule-related fatigue, which can slow their response times and increase their odds of being involved in a crash. They can also help to improve safety through their firsthand observations. If a transit driver frequently notices particular driver, pedestrian, or bicyclist behaviors, they can report it and the transit agency can work with roadway owners to mitigate the crash risks.

King County, Washington Metro Fostering a Culture of Safety

In December of 2017, King County, Washington Metro launched 'Walk safe,' a pedestrian awareness campaign (King County Metro, 2017). This campaign had educational messages for transit users, but also included training for transit operators. Recognizing the difficulties in seeing pedestrians in dark conditions, the campaign reminded drivers to be vigilant for crossing pedestrians. Figure 15 includes one of the graphics used during the campaign.

Figure 15. Graphic. King County Metro, 'Walk Safe' campaign (King County Metro, 2017).*

*Graphic created by Doug Hansen, King County Metro

Omnitrans Transit Operator Training Programs

Omnitrans, the transit provider for the San Bernardino Valley, has been recognized as a leader in the world of transit safety. Notably, the agency received APTA's 2019 Bus Safety and Security Excellence Award for creating an amateur radio service and placing an emphasis on technological improvements to foster a better safety culture within the agency (Perrero, 2019). Among a number of other items aimed at further improving safety, Omnitrans placed a focus on transit operator training.

In 2014, Omnitrans began training employees with a bus simulator purchased through a Workforce Development grant and Partnership at California State University, San Bernardino. The simulator allows trainees to experience a variety of scenarios, conditions, and hazards. Between 60 and 70 operators per year can learn or practice safe driving habits and behavior without ever hitting the road. Additionally, all operators are provided with Safety Management Systems training, in line with the Public Transportation Agency Safety Plan, for greater understanding of the principles and components.

Beyond initial and reoccurring training, Omnitrans places a high value on maintaining a culture of safety post training. The agency does so through strong safety standards, recognition of good practice, and a rewards system. Omnitrans believes that safety begins internally, and that safety is a goal worth investing in—through both time and in money.

Internal Agency Documentation and Policies

Many transit agencies already have a written safety policy or similar type of document that states the agency's safety goals and procedures to achieve those goals. A survey of 30 transit agencies in 2012 sought to determine who had this type of documentation. Of the respondents, 28 responded affirmatively and two abstained (Goodwill et al., 2012). In more recent years, the prominence of crashes—particularly pedestrian and bicyclist crashes—has resulted in increased awareness of safety concerns. Transit agencies and roadway owners can build off established safety programs and reevaluate their agency's documentation and policies to better understand and formalize actions that improve pedestrian and bicyclist safety. Some examples of potential improvements include:

- Collect an inventory of assets, along with a condition assessment of each, per the 2016 requirement by the FTA for transit agencies to develop a transit asset management (TAM) plan (FTA, n.d.[*]). Enhancements to the inventory data can also be combined with transit station audits so that pedestrian and bicyclist safety and accessibility improvement needs can be identified and prioritized.
- Incorporate pedestrian and bicyclist features into standard plans and standard designs for transit stops, stations, and other transit facilities. Include these features in cost estimates and programming details from project conception through construction and maintenance.

[*] The requirements for transit operators to develop a TAM plan are found at 49 CFR 625.25.

- Conduct pedestrian safety audits at transit stops and surrounding areas on a regular basis (examples provided in **chapter 3**).
- Develop or update TOD guidelines to ensure accessible pedestrian facility design, including sidewalks, pedestrian crossing facilities, and warning and wayfinding signs. Frequently, transit agencies will partner with local governments who are responsible for administering land use laws and regulations. FTA's Pilot Program for TOD Planning provides examples of ways to develop TOD guidelines (FTA, n.d.a).
- Establish agency performance metrics around pedestrian and bicyclist safety and accessibility. This should use some form of evaluating multimodal analysis to account for pedestrian, bicyclist, and transit rider impacts beyond traffic effects. For new developments, require developers to complete a selected form of multimodal analysis rather than relying on a traditional traffic impact analysis. Transit agencies are also required to report safety incidents, including where transit vehicles have struck a person or another vehicle (FTA, 2021).
- Consider incorporating incentive and reward programs as an additional tool to improve safety. Incentive programs should be used in conjunction with an existing safety management program and are especially effective with management support (Staes et al., 2017). According to the National Safety Council, incentives can motivate and engage employees through positive and proactive reinforcement, rather than penalizing employees after a mistake is made (Rojas, 2018). This is especially important as transit operators typically maneuver large vehicles and if they were in a crash with a pedestrian or bicyclist, if could lead to a severe or fatal injury.
- Encourage transit operators to reach out about potential crash issues—whether it has to do with transit routing and vehicles or roadway user behavior, design, or operations.
- Develop a Complete Streets policy or guidance document that features information on how to plan, design, and implement a Complete Street. The document may include, but is not limited to, elements such as design guidance, prioritization methods, equity considerations, implementation procedures, and evaluation strategies.

Transit Asset Management Plans

"Every agency must develop a TAM plan if it owns, operates, or manages capital assets used to provide public transportation and receives federal financial assistance under 49 U.S.C. Chapter 53 as a recipient or subrecipient. Each transit provider must designate an Accountable Executive (49 CFR 625.5) to ensure appropriate resources for implementing the agency's TAM plan and the Transit Agency Safety Plan.

Each TAM plan should:

- Outline how people, processes, and tools come together to address asset management policy and goals.
- Provide accountability and visibility for furthering understanding of leveraging asset management practices.
- Support planning, budgeting, and communications to internal and external stakeholders."
    - FTA website on transit asset management plans (FTA, n.d.b).

City of Denver, Colorado: Improving Transit Safety & Connections

Denver Moves: Transit Plan is Denver's first citywide transit plan (City of Denver, 2019). The plan creates a local transit vision and framework for improving the quality of transit options in order to make transit more reliable, frequent, and convenient. The plan recommends:

- Investments in key corridors in Denver that will result in high quality and reliable transit.
- A network of frequent transit service corridors, to provide service that arrives more often, all day, every day.
- Improvements in pedestrian and bicycle infrastructure and amenities to make it easier and safer for people walking and biking to get to transit.
- Promoting transit supportive land use and developments instills a "sense of place" at transit stations and stops in Denver.
- Continued support for affordable fare programs, fare payment technology to make transit more affordable easier to use, and programs that promote and encourage the use of transit.

Figure 16. Graphic. Denver's big moves and strategies. (City of Denver, 2019)

Part of what drove the plan implementation is that the current transportation system does not meet the City's needs. The number of employees traveling in and out of Denver is increasing, as is congestion. The City also recognizes that transportation options influence where people live with more people wanting to move to a city if it had more and better options for getting around. This also supports a shift in driving where younger adults are driving less and older adults are looking to age-in-place.

Bicyclist and pedestrian access to transit stops and stations is oftentimes a deciding factor in choosing transit and in Denver, can be challenging. According to the plan, 9 percent of the sidewalks within a ½ mile of light rail and a ¼ mile of bus stops are missing, and 28 percent are deficient in width (i.e., less than 4-feet wide).

The *Denver Moves: Transit Plan* vision and implementation strategies and actions, as summarized in figure 16, help support ongoing growth and local mobility needs by improving transit and connecting more people to more places, sustaining Denver as a healthy and vibrant community.

Transit Services and Facilities

While transit agencies are reliant on State and local roadway owners to make changes to the roadway network, transit agencies can typically modify their services and facilities with just an agreement from the roadway owner. However, some transit agencies may require a permit from the roadway owner for the installation of any improvements. Alternatively, sometimes the improvements fall within the transit agency's property or an easement with a private property owner. These types of changes have the potential to improve pedestrian and bicyclist safety and access.

Service improvements may include:

- Changing bus routes and stop locations to reduce walking and cycling distances or facilitate transfer.
- Improving coordination between bus and rail schedules to allow for easier transfers and shorter waiting time.

Facility modifications may include:

- Moving bus stops to shorten walking distances, reduce street crossings, or improve safety at street crossings for pedestrians accessing transit at each stop.
- Improving signage, seating, shelter, or lighting at bus stops.
- Increasing maintenance frequency and thoroughness.

Transit agencies can make several modifications to their services and facilities that can improve safe pedestrian and bicyclist access. These include locating bus stops convenient to signalized crosswalks, establishing off-street transfer centers, and positioning transit amenities such as shelters to ensure clear sightlines for oncoming motorists.

Transit agencies also provide guidance to local governments and developers on how to enhance pedestrian and bicyclist access to transit, as well as how to incorporate transit within developments to shorten walk distances. Examples of recently updated transit agency design manuals and guidebooks include:

- Capital Metropolitan Area Transit Authority (2020).
- Maryland Transit Administration (2019).
- Monterey Salinas Transit (2020).
- San Diego Metropolitan Transit System (2018).

In some cases, transit agencies establish partnerships to implement their guidelines, such as the Chicago Area Regional Transportation Authority's Access to Transit program (see case study for more information).

Refer to **chapter 5** for additional detail on specific engineering modifications for transit facilities.

Chicago Area Regional Transportation Authority's (RTA) Access to Transit

In 2012, the Chicago area's RTA introduced its Access to Transit program to provide funding support for small scale projects that improve pedestrian and bicyclist access to transit, such as those shown in figure 17. Municipalities and counties that have plans that specifically recommend bicyclist and/or pedestrian access improvements to transit are eligible to apply for funding through this competitive program. To be eligible, applicants must demonstrate that their proposed projects will lead to increased ridership, improved access to existing transit services, and will contribute to reduce vehicle emissions (RTA, 2021). Communities with lower tax bases/median incomes can apply for funding for Phase 1 engineering for access to transit projects.

RTA uses a combination of local and Federal Congestion Mitigation Air Quality funds for the Access to Transit program. To date, the program has supported 28 projects totaling $13 million in funding (RTA, 2021). Projects range from bus stop improvements to pedestrian crossings to bicycle parking.

Figure 17. Photograph. A before and after photo of an RTA Access to Transit project that included the addition of a crosswalk, walk signal, and curb cuts to improve access to a stop on PACE's Harlem Ave. route in Palos Heights, IL (RTA, 2021).

Transit Vehicle Safety Features

Advances in motorized vehicle safety features have been rapidly integrated into our daily lives. Agencies have incorporated similar advances into transit vehicles. The following are some examples of design features that can reduce the risk of collisions with pedestrians and bicyclists.

Bus warning lighting – additional lighting including strobes and light-emitting diode (LED) light bars either on the sides or front/top that light when the bus begins moving or is turning (Pecheux et al., 2008).

Bus turning announcements – bus annunciator suppliers include a pedestrian warning system where the bus announces through exterior speakers when it is making a turn, such as, "Caution! Bus is turning (Clever Devices, 2021)!"

Rail features – between-car-barriers, such as those shown in figure 18, are designed to protect visually disabled passengers from mistaking the space between railcars as a doorway and inadvertently stepping off the platform between cars and falling to the track bed (FTA, 2019).

Figure 18. Photograph. Examples of between-car-barriers for light rail (FTA, 2019).

Collision avoidance and blind spot detection – many personal vehicles are already equipped with this type of technology that alerts drivers to a potential collision or object within the vehicle's blind spot. Transit vehicles are similarly becoming equipped with these as well. This can aid the transit operator in preventing crashes, particularly with pedestrians and bicyclists who are less visible than larger, motorized vehicles.

Transit vehicle security systems – these systems can include video cameras, covert microphones, silent alarms, and AVL to monitor and respond to situations onboard vehicles and along transit routes. These technologies can be used in combination to pinpoint a vehicle's location during an incident and assist in providing a real-time or recorded comprehensive view of an incident (U.S. DOT, n.d.).

Partnerships

Partnership, coordination, and cooperation between various organizations in the public and private spheres are critical to improving the safety and efficiency of a transit system or broadening its appeal to a wider base. Due to the nature of existing planning, governing, and economic structures, planning network extensions or any other changes to transit operations likely involves local, regional, State, and possibly Federal coordination—not to mention input from the public. When new development is planned, either based on or including transit networks, public/private partnerships are often sought after to help fund projects, improve efficiency, or generate interest from the public. The following describes some opportunities for partnerships among public agencies and public-private organizations that will enhance pedestrian and bicyclist safety when accessing transit.

Community Pedestrian Safety Committee – Howard County, Maryland Transit & Pedestrian Safety Advisory Group

In 2021, Howard County, Maryland's County Council established a Transit and Pedestrian Advisory Group to advocate for pedestrians and transit users, directly advising the County's Office of Transportation (Howard County, 2021). The group, per County law, is comprised of a member of the Multimodal Transportation Board, two Howard County students, two Howard County residents (one a paratransit passenger and another a fixed-route passenger), two people selected by the Howard County Public School System (one of whom must be a high-school principal), and one representative from the following six possible organizations (Howard County, 2021):

1. The Howard County Association of Community Services.
2. The Commission on Aging.
3. The Commission on Disability Issues.
4. The Howard County Department of Recreation and Parks.
5. The Howard County Police Department.
6. The Howard County Council.

The group of selected citizens is required to meet at least four times each year, two of which must be joint sessions with the Bicycle Advisory Group and two which must be held separately. During the meetings, the group is required to designate time for public comments on relevant issues (Howard County, 2021).

Public Agency Partnerships

Partnerships between transit operators and local, regional, State, and Tribal agencies are critical to transit planning for various reasons. From a policy perspective, there is an inherent need for partnership between transit operators and various levels of government. Since 2016, the FTA and FHWA require transit operators to use a performance-based planning approach and develop a TAM plan (FTA, 2020b[1]). Ultimately, the development of a TAM necessitates partnership and coordination between transit agencies and different levels of government, particularly metropolitan planning organizations and State DOTs (FTA, n.d.[2]).

[1] The requirements for a performance-based approach are found at 23 CFR Part 450.206(c) and the requirements for transit operators to develop a TAM plan are found at 49 CFR Part 625.25.

[2] The requirements for transit operators to coordinate with metropolitan, statewide and non-metropolitan planning processes are found at 49 CFR Part 625.45(e).

As transit operators themselves do not own the roadways, partnerships with local municipalities or regional agencies are necessary to prioritize space for transit vehicles (Transit Center, 2018a). Furthermore, changes in land-use over time can generate the need for more transit in particular areas. The reintroduction of TOD in many areas involves coordination between transit agencies and local planning agencies to ensure transit provides service to these developments. In rural and Tribal areas, public transit is crucial for people to reach basic services like hospitals, post offices, or voting precincts (Kaseko et al., 2014). Partnerships with local municipalities are also important for overcoming the "first-mile/last-mile" challenge, as the two can work together to develop better bicyclist and pedestrian infrastructure to connect with existing transit networks (Advocacy Advance, 2014).

MaineDOT Pedestrian Safety Campaigns and Coordination with Transit Agencies

MaineDOT has been working with transit agencies around Maine to improve safety through its Heads Up program. MaineDOT is using the program to address safety through:

- Education and behavior change – involving the media, providing information, hosting local forums, and conducting outreach to specific groups.
- Engineering – improving pavement markings, traffic signals, and signage.
- Enforcement – both positive and punitive.

One aspect of the education component involved messaging on transit vehicles. MaineDOT met with the transit agencies, who agreed to place the messaging on the buses if MaineDOT printed the posters. As a result, transit vehicles throughout the State included messaging on pedestrian safety.

Figure 19. Photograph. Two examples of MaineDOT pedestrian safety posters on transit vehicles (VHB, 2019).*

*These images are not publicly available. VHB provided permission and shared for the purposes of this project.

Metro Transit Minneapolis – Better Bus Stops

Beginning in 2014, Metro Transit Minneapolis partnered with a host of local organizations to deploy the Better Bus Stops project (Farrington & Schwartz, 2017). The purpose was twofold: invest in capital infrastructure and engage with the community. For the capital investments, the project sought to improve bus stop shelters, shelter lighting, heaters, and pedestrian access. Figure 20 shows a bus stop improved through this project, with solar power added to improve lighting. The Community Engagement Team was comprised of various local partners to reach underrepresented communities in planning, decision making, and implementation processes on and in proximity to transit-oriented corridors (Farrington & Schwartz, 2017). Focusing on areas of concentrated poverty according to 2010 Census results, the final area of emphasis included 28 Minneapolis neighborhoods.

The main goal of the public engagement process was to empower the community to drive the decision-making process. The team did so by developing a set of 'essential questions' to determine how and where to install improvements, desired features, historical significance of nearby structures, the aesthetics and orientation of shelters, and a place for miscellaneous feedback for Metro Transit to improve regional equity. Beyond these questions, a variety of other methods were used to provide information and acquire feedback: online file sharing, Q&A sessions, information sessions, bus stop facilities games, various surveys, tours, and other pop-up engagement sessions (Farrington & Schwartz, 2017).

By the end of the project, Metro Transit deemed the community engagement portion of the project a success, and the goals set out at the beginning were met. In total, an estimated 7,000 people participated throughout the engagement (Farrington & Schwartz, 2017). Metro Transit closed the engagement period with greater knowledge of what the community needed, and the project led to better transparency, documentation, and trust which they hope to create opportunities in the future.

Figure 20. Photograph. A Metro Transit stop, improved through the Better Bus Stops initiative (Farrington & Schwartz, 2017).

Public/Private Partnerships

The synergy of public/private partnerships can oftentimes lead to developments that are attractive to residents who might choose to live, work, or shop in these areas. To facilitate efficient and safe transit operations, it is critical that transit agencies be given an opportunity to weigh in on site design for private developments prior to finalizing project design.

To achieve this, land review authorities, depending on applicable laws and regulations, may be able to use the following tools to enable collaboration with transit agencies:

- Give transit agencies an opportunity to weigh in on development design as part of site plan review. For example, the City of San Diego mandates that copies of any site plan requiring a discretionary permit from the city be sent to the transit agency for review, thus allowing the transit agency to influence the project's design and request rights-of-way for transit facilities.
- Invite transit agencies to help develop design guidelines and standards for developers.
- Invite transit agencies to help formulate TOD guidelines. Transit agencies can help promote TOD through many means, for example, by using agency-held land, underwriting land costs, assisting in land assembly, providing financial incentives, and working out shared parking agreements (Hess and Lombardi, 2004).
- Develop transit accessibility checklists.
- Work with transit agencies to provide technical assistance estimating impact fee or developer fee reductions due to the inclusion of transit and pedestrian-oriented design features.

One potential byproduct of these developments is that local residents may not feel as comfortable accessing the transit facilities and may feel like they are trespassing on a private development. For these developments to serve the public—and they are by nature of being centered around transit access—it should be a clear and stated goal of the project that all feel welcomed and comfortable using walking and biking through the development to use the transit facilities. In San Francisco, the Bay Area Rapid Transit's (BART's) TOD Guidelines state that, "A successful, pedestrian friendly station area should be comfortable and inviting to the surrounding community (Thorne-Lyman, 2017)."

To this end, some agencies are developing Equitable Transit-Oriented Development (eTOD) plans. As the Chicago eTOD plan explains,

> "Equitable TOD (eTOD) is development that enables all people regardless of income, race, ethnicity, age, gender, immigration status or ability to experience the benefits of dense, mixed-use, pedestrian-oriented development near transit hubs. eTOD elevates and prioritizes investments and policies that close the socioeconomic gaps between neighborhoods that are predominately people of color and those that are majority white. eTOD projects and processes elevate community voice in decision making processes and in realizing community-focused benefits such as affordable housing, public health, strong local businesses, and environmental sustainability, to name a few. When centered on racial inclusion and community wealth building, eTOD can be a driver of positive transformation for more vibrant, prosperous, and resilient neighborhoods connected to opportunities throughout the city and region (City of Chicago, n.d.)."

Danbury, Connecticut Transit Oriented Development

The New England Chapter of Congress for New Urbanism recently awarded the Danbury, Connecticut TOD Plan with its 2020 Urbanism Award (Center for New Urbanism New England Chapter, 2020). The Danbury project, as shown in figure 21, represents how innovative land use, urban design, economic, and transportation planning can revitalize a downtown area. The plan for Danbury's downtown includes an enhanced multimodal transit and rail station that will address current and future bus operator needs, create synergies between the bus and rail systems, and support TOD and downtown revitalization.

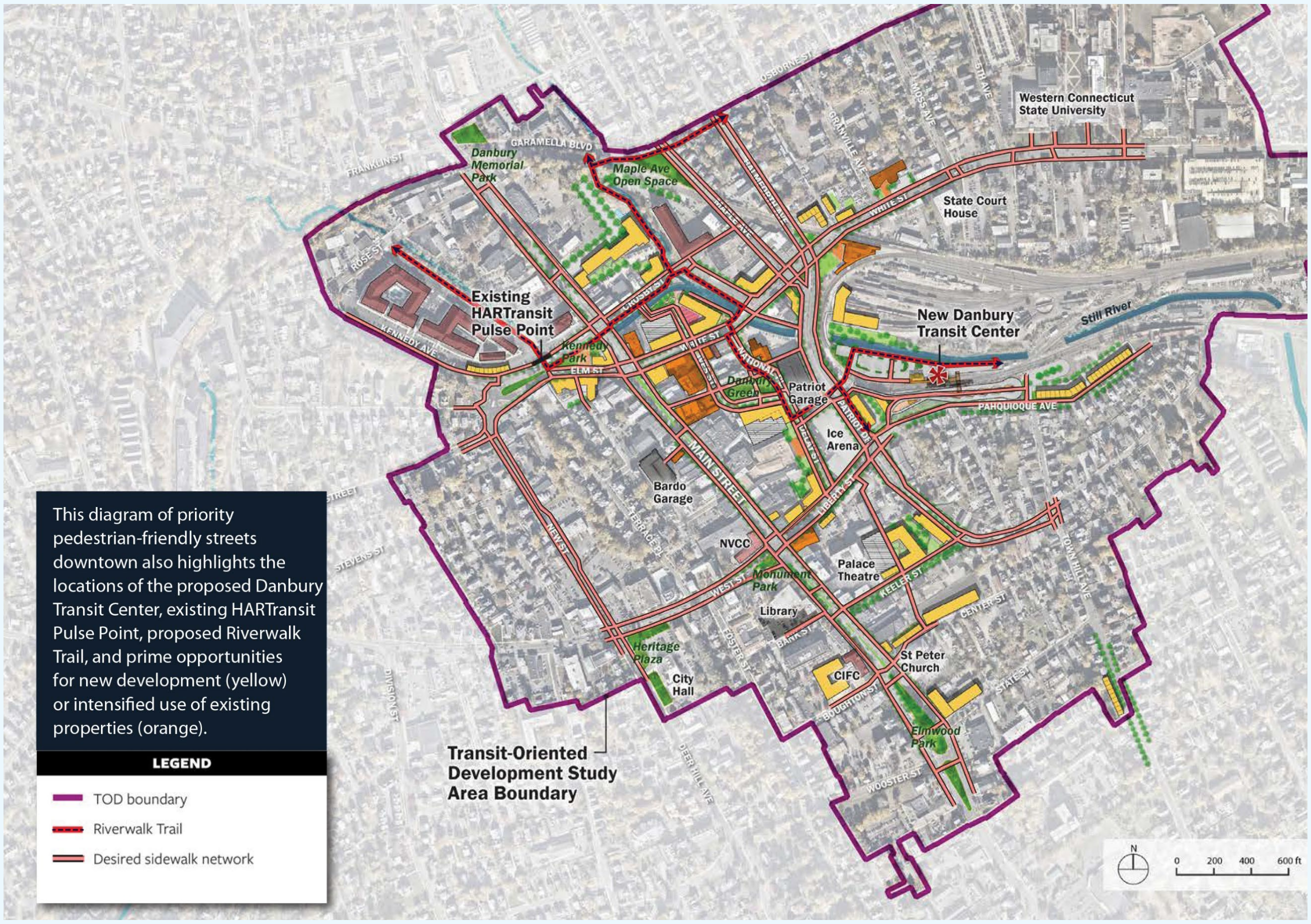


Figure 21. Graphic. Map of the Danbury TOD Plan with priority pedestrian-friendly streets (Goody Clancy).*

* This image is not publicly available. Goody Clancy provided permission and shared for the purposes of this project.

Mobility as a Service

Public/private partnerships can also provide agencies with the opportunity to take advantage of new services, such as Mobility as a Service (MaaS). MaaS can be thought of as a "tool", but at its heart, involves coordination among transportation services and options, including public and private entities. The definition of MaaS continues to evolve, but one used by the United Nations captures its breadth as:

> "…a user-centric transportation management system, using intelligent mobility distribution systems and IoT (Internet of Things) applications, in which all transport modes service operators and infrastructure providers are connected under a single platform, which supplies mobility options to travelers providing real time traffic information, service conditions and operator arrangements, and delivering on-line ticketing and payment options (Dimitriou et al., 2020)".

U.S. transit systems are beginning to use MaaS to offer their customers more options to address their complete trips between origin and destination. Several transit systems are expanding the use of their fare media to include bicycle share, such as Los Angeles Metro's TAP card, which is valid for payment across 26 regional transit providers and for Metro Bike Share (TAP, n.d.). Transit systems are also partnering with private software providers to offer comprehensive trip planning and fare payment for complete trips. An example is Kansas City's RideKC's partnership with Transit App (RideKC, 2021). RideKC's passengers can also use RideKC Bike bikeshare, and can plan and pay for their complete trips using the Transit App.

5 Design and Operational Measures

There are a variety of actions that transit agencies and their partner organizations can implement to improve safety for pedestrians and bicyclists when accessing transit. These actions include engineering (physical infrastructure) and operational efforts.

The design of sidewalks, curb ramps, bicyclist facilities, shared paths, and transit stops contribute to a passenger's experience and both actual safety (tied to crashes) and perceived safety (makes people feel safer) on the transit system. Well-connected sidewalks installed in areas with regular transit service provide a safer option for transit patrons as opposed to walking in the street while traveling to or from a stop or station. Connected and continuous bicyclist facilities provide visibility at intersections, incorporate transit access, and are designed for the intended user profiles. In addition, transit agencies and roadway owners can improve roadway and transit crossing safety with an appropriate combination of facilities, such as marked crosswalks, pedestrian refuge islands, warning signs, pedestrian signals, and potentially grade separation.

The following design and operational measures and improvements are categorized into two themes:

1. **Transit access** – designing the pedestrian and bicyclist routes to transit facilities.
2. **Transit stop/station** – locating and designing transit stops and stations to provide safe and accessible facilities for pedestrians and bicyclists.

These distinctions are intended to help transit agencies consider the barriers and safety issues for pedestrians and bicyclists when traveling to and from the stop, as well as the experience at the stop, whether transferring routes, waiting, or accessing another mode. Routes that provide transit access should incorporate Complete Streets elements, while the location of transit stops and stations should consider the safety and comfort of people using transit services.

Transit Access

Safe access to transit services is paramount to supporting transit use and multimodal networks. **Chapter 1** noted pedestrians may be expected to travel ½ mile and bicyclists may be expected to travel 3 miles to reach a transit stop or station, though this may vary based on facilities, individual speed, and those with unique mobility needs. There are also emerging transportation services and micromobility technologies such as scooters, e-bikeshare, and Transportation Network Companies (TNCs) to support first-mile/last-mile access to transit. **Chapter 5** explores the design of transit stops and stations in more detail. Key components for safely accessing transit include inclusion of Complete Streets features into sidewalk and bikeway facility design, transit stop integration, and roadway and rail crossings.

Pedestrian Facility Design

Good pedestrian facility design should account for the needs of all potential users, including all ages, genders, and abilities. When applied appropriately, this design concept known as "universal design" ensures the built environment is usable and can be shared by all people, thus eliminating the need for specialized design.

The U.S. Department of Justice's (DOJ) ADA Title II regulations require that a public entity's newly constructed facilities be made accessible to and usable by individuals with disabilities to the extent that it is not structurally impracticable to do so (28 CFR 35.151(a)). The DOJ's regulations also require that, when an existing facility is altered, the altered facility be made accessible to and usable by individuals with disabilities to the maximum extent feasible (28 CFR 35.151(b)). The U.S. Department of Transportation's (DOT) regulations under Section 504 of the Rehabilitation Act of 1973 (Section 504) include similar requirements for entities that receive Federal financial assistance from DOT (49 CFR Part 27).

In 2010, the DOJ adopted enforceable accessibility standards under the Americans with Disabilities Act titled "2010 ADA Standards for Accessible Design" (U.S. DOJ, 2010). These standards incorporate the 2004 ADA Accessibility Guidelines (2004 ADAAG) issued by the U.S. Access Board. The standards primarily address accessibility requirements for buildings and sites, but they also apply to newly constructed or altered curb ramps at intersections (28 CFR 35.151(i)). Recipients of Federal financial assistance from DOT must also comply with DOT's Standards for Accessible Transportation Facilities, which require placement of detectable warnings on curb ramps (49 CFR 27.3(b); 49 CFR Part 37, Appx. A).

In 2011, the U.S. Access Board published a Notice of Proposed Rulemaking (NPRM) in the Federal Register to invite comment on the Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (U.S. Access Board, 2011). The intent of this effort was to provide comprehensive accessibility guidelines for pedestrian facilities in the public right-of-way that would ultimately be adopted as enforceable standards by the DOT and DOJ. The Access Board published a Supplemental Notice of Proposed Rulemaking in 2013 to add draft guidelines for shared use paths, (i.e., paths serving a transportation purpose and used by pedestrians, bicyclists, and sometimes others)(U.S. Access Board, 2013). The proposed PROWAG, including the shared use path provisions, have not been finalized or adopted as of this writing and are not enforceable federal requirements. In the absence of enforceable standards for most pedestrian facilities in the public rights-of-way, public entities have some degree of flexibility in determining how they will comply with the general accessibility obligation under title II of the ADA and Section 504. Transit agencies should consult with their local and State governments to determine if they have adopted the proposed PROWAG as a local standard with respect to pedestrian facilities in the public right-of-way.

While keeping the legal framework for accessible design in mind, transit agencies may find the following resources useful to consider for pedestrian facility design:

- Institute of Transportation Engineers (ITE) *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* (Henderson et al., 2010).
- AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* (AASHTO, 2021).
- AASHTO *A Policy on Geometric Design of Highways and Streets, 7th Edition* (commonly referred to as the "Green Book") (AASHTO, 2018).

Creating safe and accessible places for pedestrians to travel along roadways can encourage more people to use transit systems. It is critical to ensure that sidewalks and other pedestrian pathways have appropriate width, surface, buffer (i.e., separation from motor vehicle traffic), lighting, and signage along roadways as described in the following sections.

Sidewalk Width

Sidewalks should be wide enough to accommodate the expected levels of pedestrian traffic. Narrow sidewalks that cannot accommodate the volume of foot traffic may encourage pedestrians to walk in the roadway or take alternate routes, increasing the potential for conflict with motor vehicles. Although the proposed PROWAG suggests a minimum clear width (i.e., lateral space available for pedestrian travel for the length of a corridor) of 4 feet for sidewalks in the public right-of-way, it is desirable to provide a sidewalk clear width of at least 5 feet to accommodate two people walking side-by-side or two wheelchair users to pass each other, as shown in figure 22.

Wider sidewalks can help to meet the needs of pedestrians. When large groups of pedestrians are present on the sidewalk, and sufficient space is not provided, pedestrian traffic will move slowly, causing some people to walk in the street, or cross to the other side of the street, increasing their crash risk. Even in less crowded areas, pedestrians may walk in the street if the sidewalk is not wide enough, or they may decide to cross the street at an undesirable location to reach a sidewalk with less traffic. To make the most of the width available, street furniture (e.g., benches, bicycle racks, trash cans), utilities, and street trees should be located out of the pedestrian path and instead placed in the buffer zone (i.e., between the street and the sidewalk) or in the frontage zone (i.e., between the sidewalk and right-of-way line).

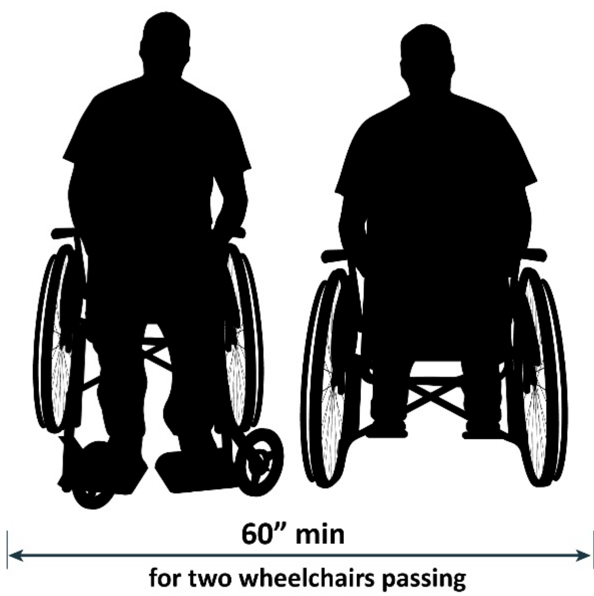


Figure 22. Graphic. Space needed for two wheelchairs passing (Goughnour et al., 2020).

Sidewalk Surface

The full clear width of a sidewalk should be firm, stable, and slip resistant (U.S. Access Board, 2011, proposed PROWAG R302.7). The accessible route of a sidewalk should be clear of obstructions, including overhanging branches, utility poles, and signs (U.S. Access Board, 2011, proposed PROWAG R210 and R402).

Sidewalk Buffer

A buffer is a space provided between the pedestrian walkway and the vehicular travel lanes. This buffer enhances both pedestrian comfort and safety. Depending on the type of buffer, it can separate pedestrians from passing vehicles that can present issues such as large mirrors that overhang onto the curb, wind, and splashing water during rain events. The buffer can be landscaped with materials such as grass, flowers, shrubs, or trees, which also provide shade and visually narrow the roadway for drivers, potentially encouraging slower speeds (Ewing, n.d.; Landis et al., 2001). Similar to trees, on-street parking can also serve as a buffer between moving vehicles and pedestrians and can also encourage slower vehicular traffic.

Additional Sidewalk Considerations

There are several other additional considerations when designing sidewalks, including the following:

- Driveway crossing design is important for providing safe, accessible sidewalks. The full sidewalk width should be carried across driveways with minimal change in grade or cross slope. Reducing corner radii encourages drivers to turn more slowly, allowing them to see and stop for crossing pedestrians.
- Ample, consistent, and uninterrupted lighting creates a safe and secure environment for all pedestrians, including customers accessing transit (FHWA, 2021). The FHWA *Lighting Handbook* includes more information about lighting considerations for crosswalks and railroad grade crossings, among other locations (Lutkevich, McLean, and Cheung, 2012). The supplementary *Informational Report on Lighting Design for Midblock Crossing* illustrates lighting layouts at intersection and midblock locations (Gibbons et al., 2008).
- Directional signage installed around heavily-used transit stops helps direct passengers to local points of interest. Signage scaled for pedestrians may be more easily seen by people walking. Graphic elements can help pedestrians to better understand the intent, even those who cannot read English.
- Visual obstructions, such as parked cars, large shrubs, or utility boxes can impair the ability of drivers to see pedestrians at crosswalks. Avoiding installing these obstructions, or relocating them, will improve driver-pedestrian sight distance.
- Curb ramps and detectable warning surfaces are needed to provide an accessible connection between sidewalks and streets.
- Accessible pedestrian signals (APS) provide information on pedestrian signal phases to blind or low-vision pedestrians in audible and vibrotactile formats. These devices indicate when to cross at signalized intersections.

Bicyclist Facility Design

Planning and designing a comprehensive multimodal network to provide access to transit includes considering the variety of types of bicyclists, such as those shown in figure 6, and their needs. Bicyclist facilities that are designed to reduce level of traffic stress and serve the broadest population of rider—through vehicle speed regulation and separation from traffic— have been shown to increase cycling rates by 5 to 15 percent (Schultheiss et al., 2019). Transit agencies also benefit from integration of bicyclist facilities into transit stop and station design; APTA reports that agencies can help manage parking demand, build customer goodwill, expand transit reach, increase ridership, and create safer and more convenient connections to fixed route service when integrating bicyclist facilities (APTA, 2018). There are several considerations for transit agencies to accommodate bicyclists in stop design and multimodal and route network planning. This section explores those considerations; however, the following documents provide additional information on the bicyclist facility planning, design specifications, and integration with other roadway users:

- FHWA *Separated Bike Lane Planning and Design Guide* (Goodman et al., 2015).
- FHWA *Bikeway Selection Guide* (Schultheiss et al., 2019).
- FTA *Manual on Pedestrian and Bicycle Connections to Transit* (FTA, 2017).
- AASHTO's *Guide for the Development of Bicycle Facilities* (AASHTO, 2012).

Facility Type Considerations

When transit agencies and roadway owners coordinate on the placement of transit routes, stops, and bicyclist facilities, the transportation network will better serve the needs of transit users. Limited right-of-way, on-street parking, loading zones, motor vehicle and transit vehicle speeds, transit service frequency, and driveways are common constraints to the location of both transit stops and bicyclist facilities. For example, it is recommended that mixing zones for transit stops and separated bicycle lanes only occur where four buses per hour or fewer serve the stop to reduce bus/bicyclist conflicts and support an uninterrupted facility (Goodman et al., 2015). Design decisions for both modes will affect transit passenger and bicyclist comfort, accessibility, and safety.

Transit agencies and roadway owners can better accommodate the needs of bicyclist and transit riders when they consider the interaction of the bikeway type, intended bicycle design user, and how to mitigate potential conflicts between transit vehicles and bicycles. Because the default position for both transit stops and bicyclist facilities is against the curb, managing interactions through signage, pavement markings, and separation is key to reducing conflicts. Table 3 illustrates that as the bicycle design user expands to include more potential users, there is a greater need for separation for both the bicyclist facility and the transit stop (e.g., separated bicycle lane and floating stop).

Table 3. Bikeway type and transit interactions (adapted from Schultheiss et al., 2019).

Bikeway Type	Design User	Potential Conflicts with Transit (Location and Behavior)	Reduce Transit Conflicts
Shared Lane	• Highly confident users	• Entire segment/travel lane • Transit stop areas • "Leapfrog" passing • Limited visibility	• Improve signage • Reduce road speeds • Evaluate potential for dedicated bicyclist facilities • Evaluate parallel routes for transit or bicyclists
Traditional Bicycle lane	• Highly confident users • Somewhat confident users	• Potential encroachment into bicycle lane • Entering and exiting bicycle lane at transit stop locations • "Leapfrog" passing	• Modify pavement markings to indicate mixing zone • Evaluate potential for buffered or separated bicyclist facilities • Evaluate parallel routes for transit or bicyclists
Buffered Bicycle lane	• Highly confident users • Somewhat confident users	• Entering and exiting bicycle lane at transit stop locations • "Leapfrog" passing	• Evaluate the need for a floating transit stop versus mixing zone • Evaluate potential for vertical separation of bicyclist facility
Separated Bicycle lane and Two-way Separated Bicycle Lanes	• Highly confident users • Somewhat confident users • Interested but concerned users	• Bicyclist conflicts with boarding and alighting transit users	• Implement floating transit stop • Route bikeway behind transit stop • Implement shared transit bicycle lane stop

Shared Bus-Bicycle Lanes

Shared bus-bicycle lanes are lanes reserved for transit vehicles and bicyclists, and they are indicated by pavement markings and signage. While shared bus-bicycle lanes can provide lateral separation for bicyclists from general traffic and expand the on-street bikeway network, NACTO reports that they are not high comfort bicyclist facilities and are not suitable for routes with high bus volumes or bus lanes with operating speeds above 20 miles per hour (mph) (NACTO, 2016). Pavement markings and signage should clearly indicate permitted users, and special attention should be paid to transit vehicle and bicyclist passing areas near stops.

The City of Chicago launched a pilot project in 2018 and 2019 to create dedicated bus-bicycle lanes on Halsted Avenue to decrease transit delay and accommodate bicyclist travel during bridge reconstruction (Chicago Transit Authority, 2019). The City and Chicago Transit Authority (CTA) partnered to install plastic bollards and pavement markings to create the ½-mile shared lane. Transit service improved and surveys of bicycle users found that bicyclists felt safer riding in the shared lane compared to prior conditions and most felt generally safe interacting with transit vehicles.

Roadway Crossings

Pedestrians and bicyclists often cross the road when traveling to and from transit stops or transferring to other routes. The types of crossing treatments and their applications to improve access and reduce crash risk are dependent on roadway characteristics, intersection layout, and multimodal network facilities. This section includes a summary of potential crossing enhancements for both pedestrians and bicyclists.

Marked Crossings

Marked crossings can include bicycle lane extension pavement markings for bicyclists, or crosswalks for pedestrians or bicyclists. According to Uniform Vehicle Code (UVC) § 1-118, a model example of State and local laws, the definition of a crosswalk is,

> "That part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs, or in the absence of curbs, from the edges of the traversable roadway; and in the absence of a sidewalk on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the existing sidewalk at right angles to the centerline (UVC, 2000)."

Uniform Vehicle Code

The basis for many of our traffic laws is the UVC (UVC, 2000). The UVC is a set of motor vehicle laws, originally designed by the National Committee on Uniform Traffic Laws and Ordinances, as a comprehensive example for individual State motor vehicle and traffic laws (National Committee on Uniform Traffic Laws and Ordinances, 1992). The UVC was born out of the need for uniformity in traffic regulation throughout the United States. Although many State and local governments have adopted the UVC as the basis for legislation and regulation related to the operation of motor vehicles on public roadways, some State and local statutes may vary. It is the responsibility of every road and transit agency to know and follow the applicable laws when designing for pedestrian and bicyclist access to its stations. Oftentimes these laws provide minimum requirements, and it is incumbent on the designers and planners to understand the flexibility to plan and create facilities beyond the minimum design standards to best meet the needs of their users.

State and local agencies may not use this exact UVC definition, and it is not required under FHWA regulations, but many agencies have similar laws regarding unmarked crosswalks. Although intersections may have legal crossing locations without a marked crosswalk, crosswalk pavement markings can be used to indicate preferred crossing areas for pedestrians and to help make drivers more aware of pedestrians crossing the roadway. Marked crosswalks are commonly denoted by standard crosswalk markings (two parallel lines) or high-visibility crosswalk markings (thick white bars parallel to the direction of travel, both “continental” and “ladder” style crosswalks). Other crosswalk treatments include stamped asphalt or pavers or raised pavement surfaces (raised crosswalks). It is critical that drivers approaching a crosswalk can easily see the crosswalk treatment. High-visibility crosswalks are the most visible to drivers and have demonstrated a 48-percent reduction in pedestrian crashes when compared to previous parallel line markings (Chen et al., 2013).

Accessible curb ramps should be provided at both ends of crosswalks wherever the roadway crossing is at a different level than the adjacent sidewalk (U.S. DOJ, 2010). Bicycle lane extension markings can be used to visually denote the bicycle lane routing through the intersection. Within signalized intersections, “No Turn on Red” (MUTCD R10-11 sign) restrictions or channelizing devices (FHWA, 2009, MUTCD Chapter 3H) such as flexible delineators or tubular markers, should be used to prevent vehicles from entering the bicyclist queuing area.

Marked crosswalks and bicycle lane extensions are commonly used to identify preferred locations for crossings. However, in many cases, particularly on multi-lane roads with high speeds and traffic volumes, marked crosswalks alone are not sufficient to assure safe crossings. MUTCD provisions state that:

New marked crosswalks alone “should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph and either:

- The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an ADT of 12,000 vehicles per day or greater: or
- The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater (FHWA, 2009, p. 384).”

Where these conditions exist, additional measures should be included to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, or otherwise provide active warning of pedestrian presence (FHWA, 2009).

The FHWA Safe Transportation for Every Pedestrian Program (STEP) *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* provides additional information on the types of countermeasures to pair with marked crosswalks at uncontrolled and midblock locations (FHWA, 2018). The STEP Guide recommends crossing improvements based on the posted roadway speed, daily volumes, and roadway configuration. For multi-lane, higher speed, and higher volume roadway conditions, the guide recommends substantial crossing improvements like a pedestrian refuge island, Rectangular Rapid-Flashing Beacon (RRFB), and Pedestrian Hybrid Beacon (PHB). These improvements are in addition to visibility improvements such marked crosswalks, lighting, and crossing warning signs.

Detailed engineering analysis will help to determine the appropriate combination of treatments for a pedestrian/bicyclist crossing (FHWA, 2018). These infrastructure improvements can make crossings safer and more convenient for transit customers and can help reduce pedestrian and bicyclist crashes.

Agencies may consider the following types of safety treatments to improve crossings near transit (the next sections provide additional information):

- Refuge islands.
- Curb extensions.
- Reduced corner radii.
- Raised crossings.
- RRFBs or PHBs.
- Modifying motor vehicle travel lanes.
- Warning and Regulatory signs.
- Pedestrian and bicycle signals.
- Two-stage bicycle turn box.
- Leading pedestrian and bicyclist intervals.
- Turning movement restrictions.

Refuge Islands

Refuge islands allow pedestrians and bicyclists to cross one direction of motor vehicle traffic at a time and on particularly long crossings, the islands can provide pedestrians and bicyclists with a place of refuge to pause and rest (figure 23). These treatments have been shown to reduce pedestrian crashes by 32 percent (Zeeger et al., 2017). This is especially important for slow moving pedestrians who need longer gaps to cross at unsignalized crossings or who may not be able to fully cross the street in the time provided at a signalized intersection.

Figure 23. Graphic. Pedestrian refuge island concept featuring pedestrian regulatory and warning signs (FHWA, 2018a).

Islands that are 6-feet (preferably 8 feet) long in the direction of pedestrian travel can provide sufficient refuge space for pedestrians with disabilities, people with strollers, bicyclists, and others, such as the island shown in figure 23. The *AASHTO Guide for the Development of Bicycle Facilities* recommends that the island area should be increased to 10 feet when it is intended to accommodate both pedestrians and bicyclists with trailers (AASHTO, 2012). Also, the cut-through should be the full width of the crosswalk and include detectable warning surfaces as long as a two-foot minimum gap can be provided between detectable warning surfaces (U.S. Access Board, 2011, proposed PROWAG, R208.2).

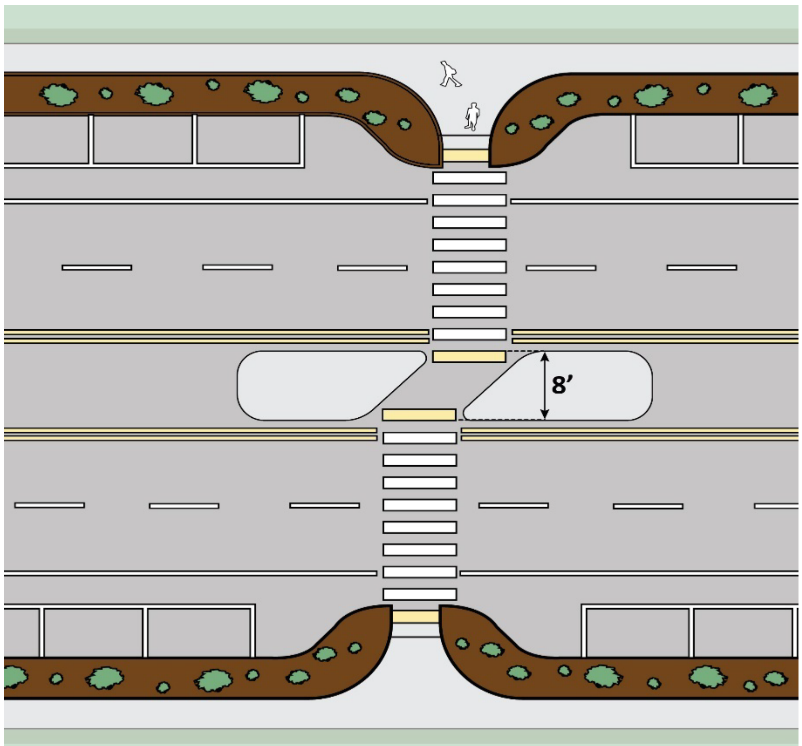


Figure 24. Graphic. Dimension showing pedestrian refuge island crossing width (VHB, 2021).*

Curb Extensions

Curb extensions (or curb bulbouts) can be used on roadways with on-street parking to shorten pedestrian crossing distances and increase the visibility of pedestrians at roadway crossings (figure 25). By narrowing the curb-to-curb width of a roadway, curb extensions may also help reduce motor vehicle speeds and improve pedestrian safety. Curb extensions at bus stop locations can help preserve on-street parking because fewer parking spaces need to be removed for buses to pull to the curb. They may also improve transit operations by enabling a bus to pull to the curb more easily and board and alight passengers more quickly. Locating bus stops on curb extensions may have the additional benefit of providing increased clear width on sidewalks by locating the shelter out of the pedestrian travel way. More information on this concept is provided in the *Bus Bulbout* section of this chapter.

* This image is not publicly available. VHB provided permission and shared for the purposes of this project.

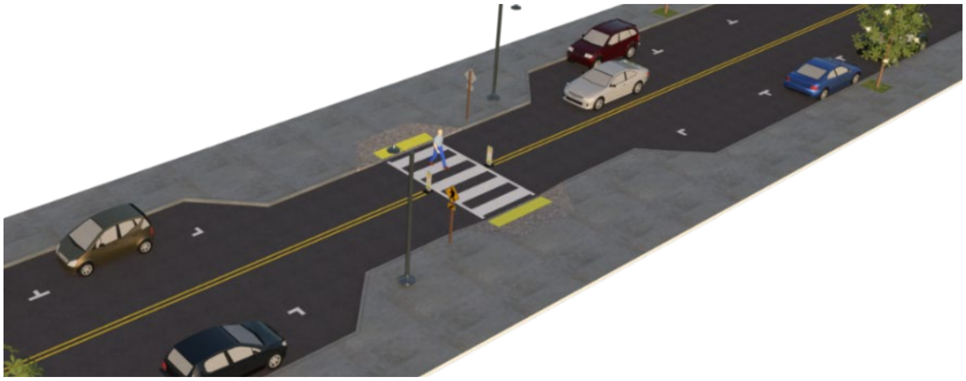


Figure 25. Graphic. Concept demonstrating curb extensions on both sides of crosswalk (VHB, 2018).*

Reduced Corner Radii

Wide intersection corner radii allow motorists to make high-speed turning movements. Reducing the corner radii can help reduce the speed of turning vehicles, improve sight distance between motorists and crossing pedestrians and bicyclists, and shorten the crossing distance for pedestrians and bicyclists (figure 26). It is important to evaluate surrounding land uses and the traffic composition on the roadway when considering this treatment. If a curb radius is too small, trucks and buses may drive on the curb to turn, which can endanger waiting pedestrians and bicyclists. An analysis of the traffic and turning movements should be conducted to determine the impacts of this treatment on all types of vehicles, including transit, motor vehicles, bicyclists, and pedestrians.

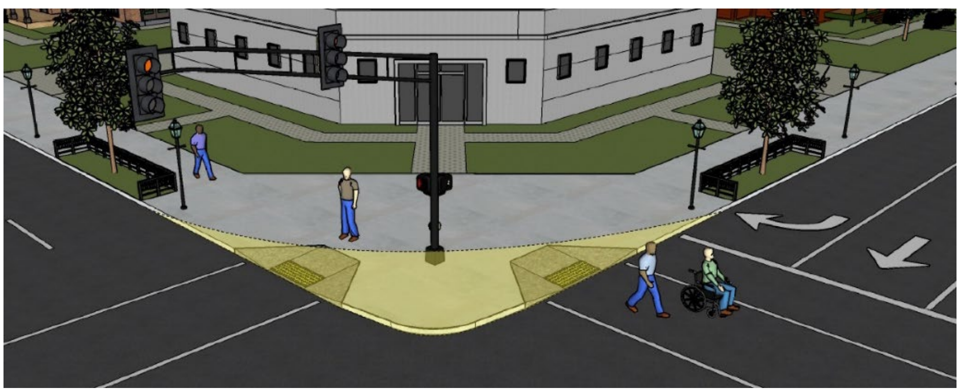


Figure 26. Graphic. Concept showing reduced corner radii (VHB, 2021).*

Raised Crossings

Raised crossings are ramped speed tables that span the entire width of the roadway, often placed at midblock crossing locations, though they are sometimes placed at stop-controlled intersections, channelized turn lanes, or roundabouts (figure 27). Raised crossings reduce vehicle speeds, promote driver yielding, enhance the conspicuity of crossing pedestrians and bicyclists, and can reduce pedestrian crashes up to 45 percent (Thomas et al., 2016). Raised crosswalks are typically installed on 2-lane or 3-lane roads with speed limits of 30 mph or less and annual average daily traffic (AADT) below

* This image is not publicly available. VHB provided permission and shared for the purposes of this project.

9,000 vehicles per day. Transit agencies may have concerns about the placement of raised crosswalks along transit routes and near stops. FHWA's *Traffic Calming Primer* notes that raised crosswalks are better suited for neighborhood circulators and local bus service and not generally appropriate for high frequency transit routes such as BRT, express, and limited stop service (unless the posted speed is 30 mph or less) (FHWA, n.d.). Additionally, while raised crossings improve pedestrian and bicyclist safety at crossings, it is recommended that transit stops are not located near a raised crosswalk to prevent rider instability from transitioning to standing or sitting as the transit vehicle crosses over the raised crosswalk.

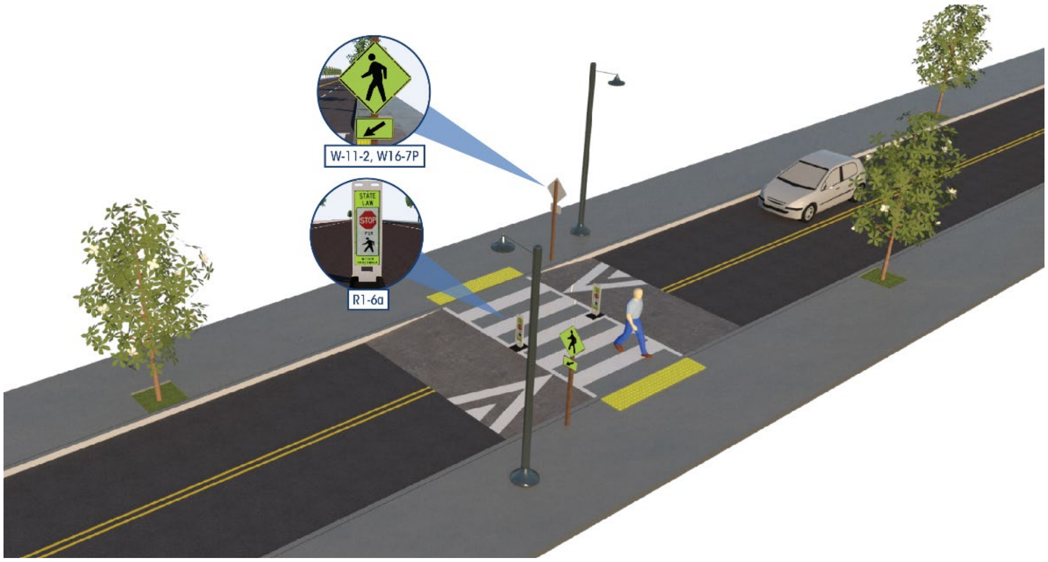


Figure 27. Graphic. Raised crosswalk featuring pedestrian warning signs (FHWA, 2018b).

Rectangular Rapid-Flashing Beacons (RRFBs) and Pedestrian Hybrid Beacons (PHBs)

Both RRFBs and PHBs are pedestrian actuated devices that indicate a pedestrian is attempting to cross the roadway. RRFBs are sign conspicuity enhancements that draw a motorist's attention to a pedestrian, school, or trail crossing sign when activated through a push button or passive detection. The warning sign and crosswalk markings inform the motorists to YIELD or STOP depending on the State or local law. A PHB is a "hybrid" beacon that includes traffic signal indications and pedestrian signals to control the movements of motorists and pedestrians. While these are not traffic signals, they have been shown to demonstrate high levels of motor vehicle yielding that persists over time. Accessible pedestrian signals may be used with PHBs and Audible Information Devices may be used with RRFBs to communicate crossing opportunities to pedestrians with vision disabilities.

RRFBs include two rectangular shaped yellow indications, each with an LED-array-based light source, that flash with high frequency when activated (figure 28). They are placed on both sides of the marked crossing at locations like midblock, trail crossing, and other uncontrolled crossing locations. When a median is present, the left side of the RRFB should be placed in the median. RRFBs may be used on multilane roadways, and the FHWA *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* provides application guidance based on speed, number of lanes, and vehicle volumes (FHWA, 2018). RRFBs can reduce pedestrian crashes by 47 percent (Zeeger et al., 2017).

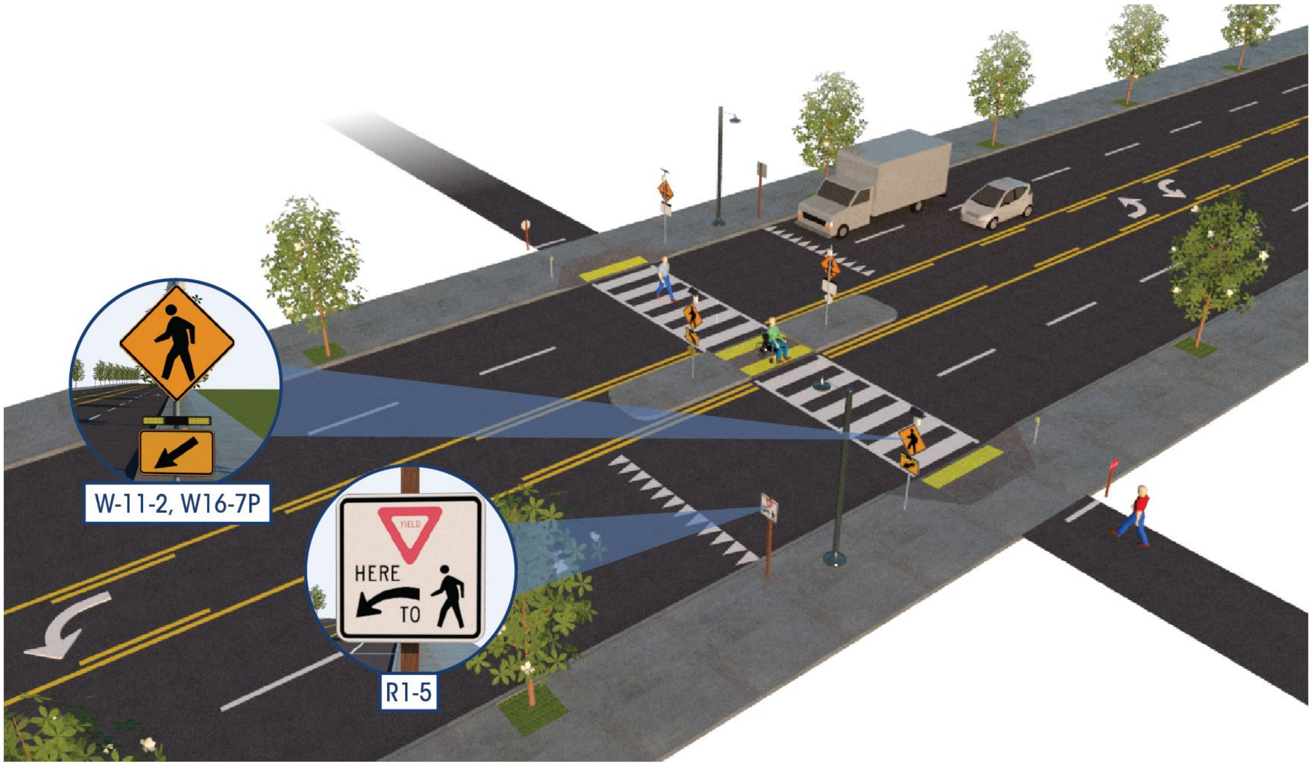


Figure 28. Graphic. RRFB featuring pedestrian refuge island (FHWA, 2018c).

A PHB consists of two red lenses above a single yellow lens that rest in the dark until activated by a pedestrian. Once activated, it then displays a sequence of flashing and steady signal indications to control motor vehicle and pedestrian movements (figure 29). PHBs are candidate improvements for uncontrolled crossing locations that are multilane roadways with volumes above 9,000 AADT and speeds at 40 mph and above. PHBs can reduce pedestrian crashes by 55 percent (Zeeger et al., 2017). The MUTCD includes provisions on the pedestrian crossing levels, placement near intersections, and required accompanying signage and pavement markings (FHWA, 2009, MUTCD Chapter 4F).

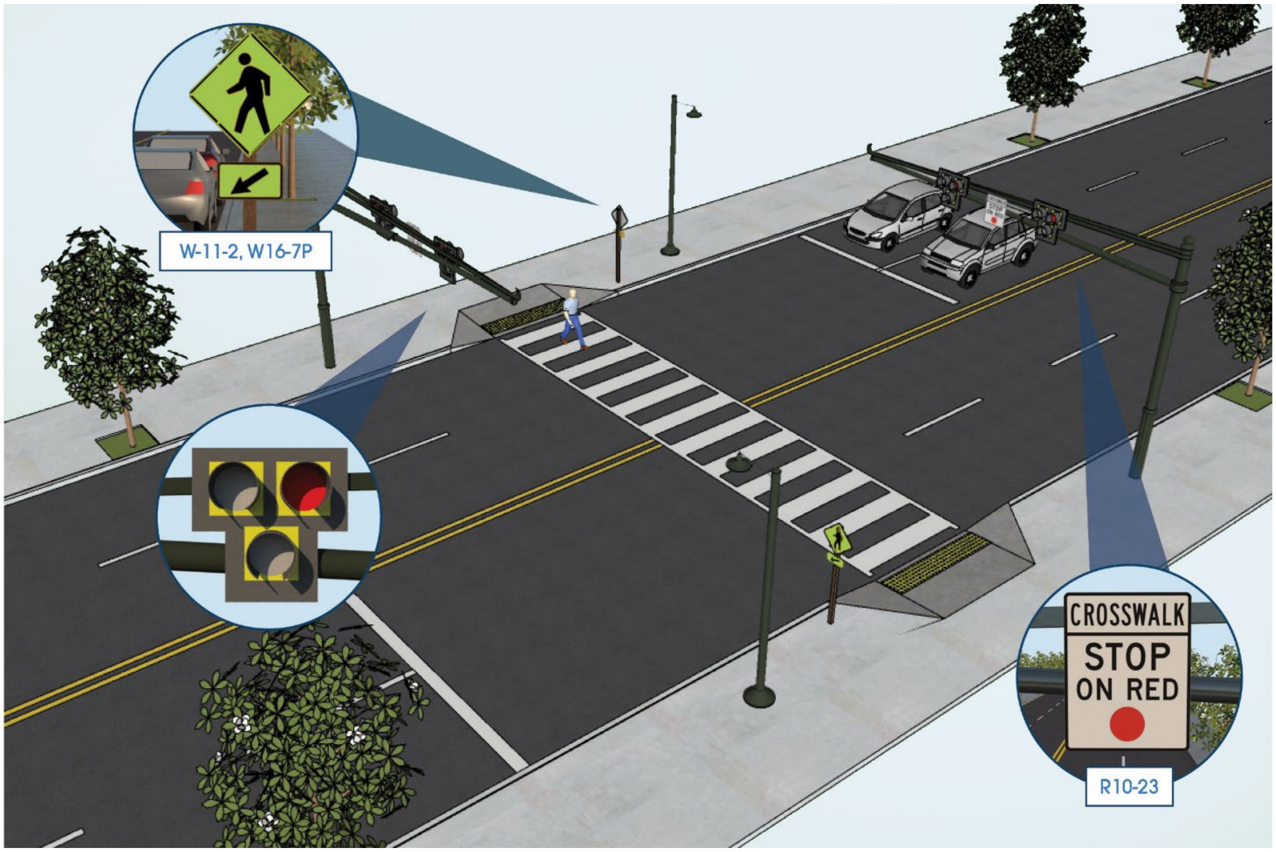


Figure 29. Graphic. PHB featuring pedestrian regulatory and warning signs (FHWA, 2018d).

Modifying Motor Vehicle Travel Lanes

Pedestrian and bicyclist safety and access near transit stations can be improved by modifying lane configurations, narrowing widths, or removing lanes. This is also referred to as a road diet. Narrowing travel lanes can provide more space for sidewalks, shoulders, buffers, and bicycle lanes and may reduce motor vehicle speeds on some roadways. Removing travel lanes can be accomplished by eliminating through-travel lanes or replacing a center-turn lane with raised median islands or a median strip. Road diets can provide space for on-street parking, shared-use facilities, transit lanes, and bicyclist facilities with increased separation from traffic. Road diets have been shown to reduce total crashes by 19 percent in urban areas and 47 percent in suburban areas (Pawlovich, 2006).

Removing travel lanes often involves tradeoffs between travel modes within a roadway corridor. For example, reducing a road from four lanes to two lanes may increase overall vehicle delay when a transit vehicle stops in the lane for passengers. Transportation agencies should coordinate with transit agencies to evaluate the impact on transit stop access and performance, as well as the effects on all modes, including automobiles, bicyclists, and pedestrians and on parallel streets. FHWA's *Road Diet Information Guide* provides additional information for analyzing road diet candidates and potential improvements (Knapp et al., 2014).

Regulatory and Warning Signs

Regulatory and warning signs can increase driver awareness of pedestrians and bicyclists, especially in areas where they may not be expected (see figure 30). These signs can include:

- A bicyclist crossing sign (MUTCD W11-1) warning where a bicyclist may be crossing the roadway (FHWA, 2009, MUTCD Section 2C.49).
- A pedestrian crossing sign (MUTCD W11-2) warning where a pedestrian may be crossing the roadway (FHWA, 2009, MUTCD Section 2C.50).
- In-street or overhead pedestrian crossing signs (MUTCD R1-6, R1-6a, R1-9, and R1-9a) alert drivers of the requirement to stop or yield to pedestrians crossing (FHWA, 2009, MUTCD Section 2B.12).

Signs should be used judiciously according to the MUTCD, “Regulatory and warning signs should be used conservatively because these signs, if used to excess, tend to lose their effectiveness" (FHWA, 2009, MUTCD section 2A.04).

Figure 30. Graphic. Concept featuring pedestrian warning and regulatory signs (W11-2, W16-7PL, and R1-6A) (FHWA, 2018e).

Pedestrian and Bicycle Signals

Pedestrian and bicycle signals can clarify right of way for pedestrians, bicyclists, and motorized vehicles. Pedestrian signals should be provided at signalized intersections near transit stops and alert pedestrians—and bicyclists crossing within the crosswalk—to the appropriate time to cross the intersection. Using APS would allow the signal to communicate information in non-visual formats to pedestrians with vision disabilities. Bicycle signals only control bicyclist movements and should be considered at intersections with high bicyclist volumes and transitions between bicyclist facilities (Sanders et al., 2020). Agencies may request approval for use of bicycle signals from FHWA under the conditions of Interim Approval 16 (MUTCD IA-16). Figure 31 illustrates the guidance from the Massachusetts DOT for the placement of bicycle signals at one-way separated bicycle lanes (MassDOT, 2015). Specific phasing should be determined on a case-by-case basis.

Accompanying pedestrian countdown signal heads, such as those shown in figure 32, are beneficial at intersections with high pedestrian crossing volumes or long crossing distances, and they have been shown to reduce pedestrian crashes by 70 percent when replacing "Walk/Don't Walk" signals (Van Houten et al., 2012). Countdown signal heads indicate the number of seconds remaining for pedestrians to complete crossing the street before opposing traffic is allowed to proceed.

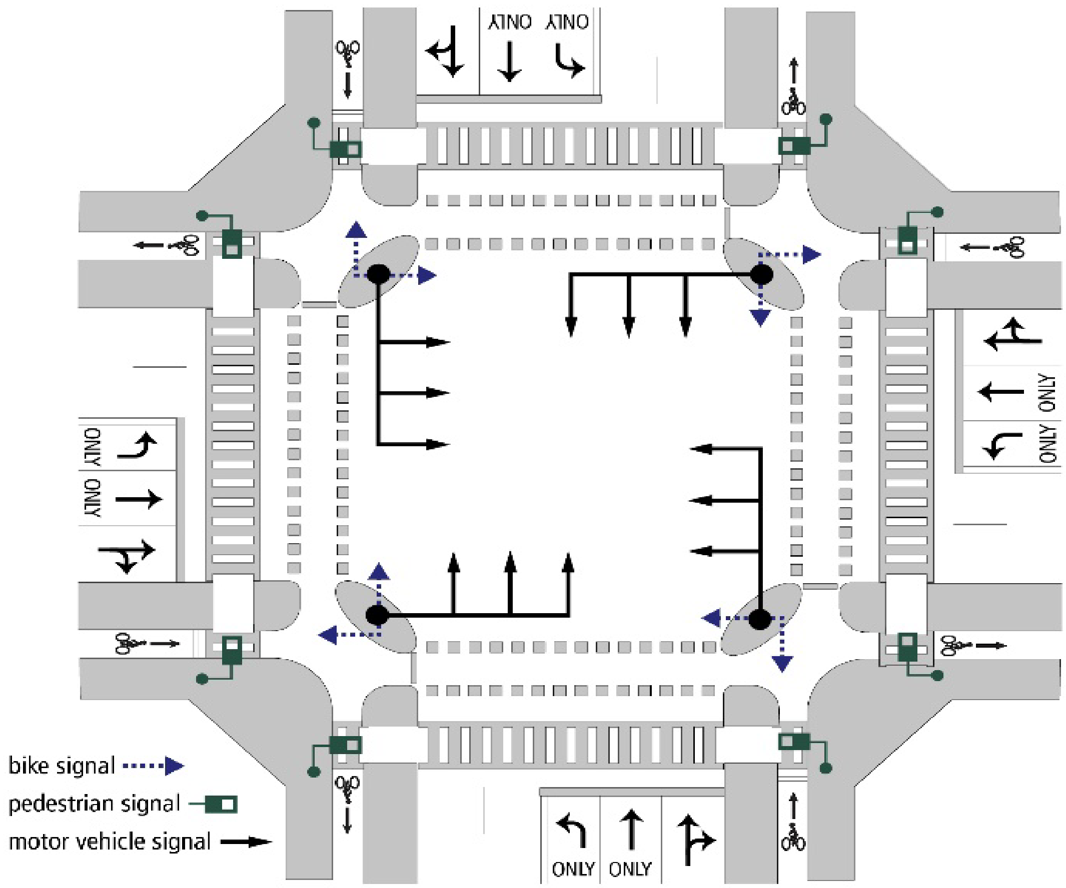


Figure 31. Graphic. Typical signal face locations for motor vehicles, bicyclists, and pedestrians for separated bicycle lanes (MassDOT, 2015).

Signal phasing should balance the available crossing time with the wait time between crossing phases. Long wait times may increase the prevalence of pedestrians and bicyclists crossing against the traffic signal. Pedestrian signals can also be combined with traffic signals that restrict vehicles from making turning movements that could impair pedestrian safety. Standards and guidance for pedestrian signal timing are included in the MUTCD (FHWA, 2009, MUTCD Section 4E.10).

At busy midblock crossings, pedestrian- or bicyclist-activated traffic signals may be considered in lieu of RRFBs and PHBs for regulating vehicular traffic. Extensive provisions and standards for pedestrian signal warrants are provided in the MUTCD (FHWA, 2009, MUTCD Section 4C).

Figure 32. Graphic. Concept demonstrating pedestrian and bicycle signals (VHB, 2021).*

Two-Stage Bicycle Turn Box

Depending on the intersection configuration and vehicular volumes, a two-stage turn box may be installed to facilitate bicyclists making two-stage left-turns (figure 33). The turn box should be placed between the crosswalk and the bicycle lane extension so that it is out of the path of vehicular travel. It should also be aligned with the receiving bicycle lane so that the bicyclist is able to travel straight into it from the turn box. As seen in figure 33, this allows the bicyclist to wait for the green signal in the new direction of travel, in front of vehicles waiting at the stop line. The turn box also provides a space for bicyclists to wait that is adjacent to the crosswalk, minimizing potential conflicts between pedestrians and bicyclists. There should also be a no-turn-on-red restriction, using an R10-11, R10-11a, or R10-11b sign, for any turning movements that cross over the bicycle box, per the FHWA Interim Approval for the Optional Use of Two-Stage Bicycle Turn Boxes (MUTCD-IA-20). A turn queue box may be placed within a sidewalk or within the parking lane at T- or offset intersections.

* This image is not publicly available. VHB provided permission and shared for the purposes of this project.

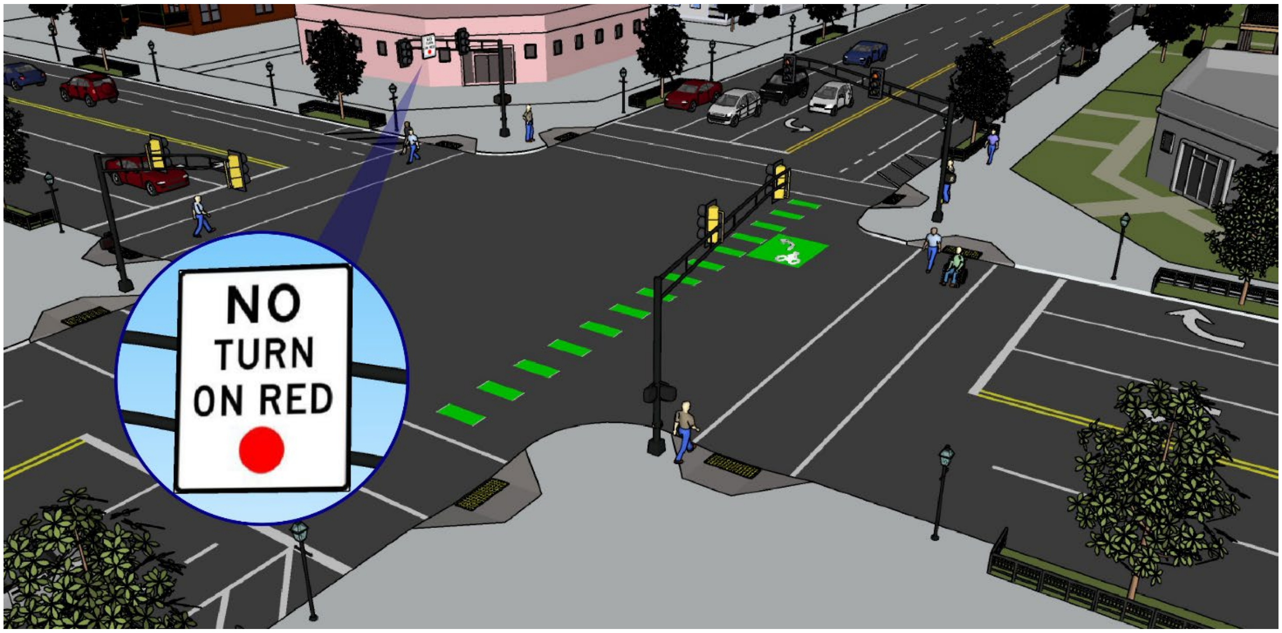


Figure 33. Graphic. Concept demonstrating a two-stage left-turn bicycle box (VHB, 2021).*

Leading Pedestrian and Bicyclist Intervals

Leading Pedestrian Intervals (LPIs) and Leading Bicyclist Intervals (LBIs) are low-cost adjustments to signal timing that release the pedestrian WALK or bicycle signal phase 3- to 7-seconds before vehicles are given the green indication (figure 34). An LPI can also be used as an LBI when a “BIKES MAY USE PEDESTRIAN SIGNAL” sign (MUTCD R9-5) is present (FHWA, 2009). APS should be included to communicate pedestrian signal information in non-visual formats to pedestrians with vision disabilities. The LPI/LBI increases the visibility of crossing pedestrians and bicyclists and reduces conflicts with turning vehicles. LPIs have been shown to reduce pedestrian crashes by 13 percent at intersections (Goughnour, et al., 2018). To increase effectiveness, these treatments can be combined with a right-turn-on-red restriction for motorized vehicles. LPIs and LBIs may be deployed where there is a history of pedestrian crashes with turning vehicles, elevated pedestrian and bicyclist crossing volumes, vulnerable populations who need more time to cross, and intersections with poor visibility. Standards and provisions for the LPI may be found in the MUTCD (FHWA, 2009, MUTCD Section 4E).

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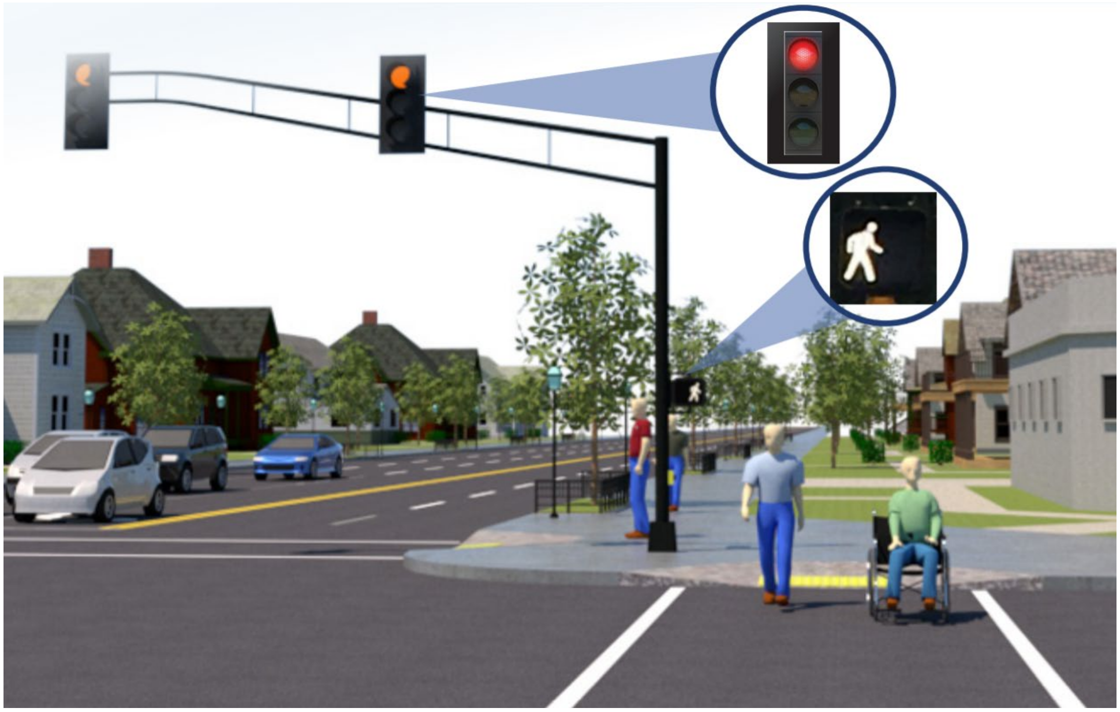

Figure 34. Graphic. Concept demonstrating an all-red signal during the LPI phase (FHWA, 2019).

Turning Restrictions

Turning restrictions at signalized intersections can reduce turning vehicle conflicts with pedestrians and bicyclists by prohibiting turning during times or at locations with frequent pedestrian crossings or vulnerable populations like near schools and parks. Time-based restrictions may span periods with high turning vehicle and pedestrian conflicts, such as peak AM and PM travel times. However, right-turn-on-red restrictions, illustrated in figure 35, are often installed in conjunction with LPIs and deployed in a targeted manner to avoid motor vehicle noncompliance. These restrictions are usually posted using a "NO TURN ON RED" sign from the R10-11 series of the MUTCD (R10-11, R10-11a, or R10-11b sign)(FHWA, 2009). Right-turn-on-red prohibitions have been shown to reduce all crashes by 2.6 percent (Harkey et al., 2008).

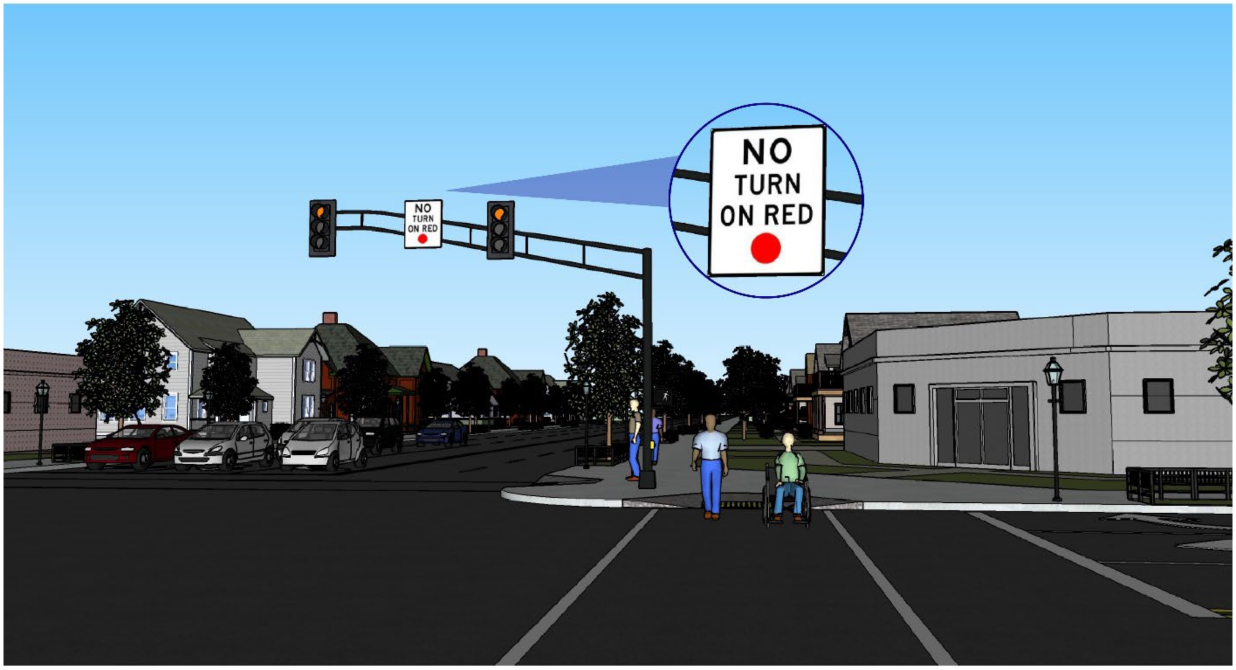

Figure 35. Graphic. Concept demonstrating the "No Turn on Red" restriction (VHB, 2021).*

Rail, Light Rail, and Streetcar Crossings

Crossing design is critical in locations where pedestrians and bicyclists cross rails—whether those are from rail, light rail, or streetcars. "Risky or inattentive behavior" has been noted as a primary factor in pedestrian-rail collisions (TCRP, 2007). Some of the specific factors related to pedestrian-rail crashes include:

- “Rushing to catch trains or get across intersections.
- Ignoring audible and visual warnings at crossings.
- Distractions, such as cell phones and headsets.
- Not paying attention in transit malls.
- Intoxication (Ogden and Cooper, 2019).”

The most important crossing features for bicyclists are (1) the crossing angle and the presence of a gap on either side of the track rail and (2) the crossing smoothness. Crossing angles of 30 degrees or less are considered exceptionally risky for bicyclists to maneuver, particularly when wet. Significantly skewed crossing angles pose challenges mainly due to the risk of bicycle tires slipping into the track rails while crossing over them and could also create issues with sight lines prior to crossing over the tracks. Additional measures are available if the crossing angle is less than 60 degrees (Walsh et al., 2004). Crossings that have significant skew or complex geometries may necessitate an active traffic control system or may need to be closed to highway traffic (Ogden and Cooper, 2019). As bicyclist routes are

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oftentimes planned for the same roadways, streetcar crossings can increase the potential for conflicts between the two modes.

Most current standards and requirements for railroad at-grade warning systems are tailored to motor vehicle traffic and will need to be tailored to expected pedestrian and bicyclist traffic. FHWA's *Highway-Rail Crossing Handbook* provides guidance about pedestrian crossings (Ogden and Cooper, 2019). The MUTCD (see Parts 5 and 8), American Railway Engineering and Maintenance of Way Association (AREMA) Signal Manual (see Section 3.3.10) (FHWA, 2009; AREMA, 2021), and Code of Federal Regulations 49 (49 CFR Part 234) provide additional guidance (FRA, 2002). Different standards apply to at-grade crossings of light rail or streetcar tracks, which often have no gates or warning devices.

Per the Federal Railroad Administration (FRA), 49 CFR 234.225, railroads shall provide a minimum of 20 seconds of warning time, with the active devices (bells, flashing lights, barricades, etc.) fully deployed 5 seconds before the arrival of a transit vehicle (FRA, 2002). This gives pedestrians a minimum of 15 seconds to complete crossing the tracks. Longer crossings may necessitate additional warning time built into the train detection system. The proposed PROWAG suggests that pedestrian facilities that cross railroads at-grade be accessible to and usable by pedestrians with disabilities (U.S. Access Board, 2011).

At-grade crossings with multiple tracks can present additional dangers to pedestrians who may assume that a warning has been deployed for a train that is currently stopped on one of the tracks when in reality, a second train is also coming on another track. Separate warnings may be necessary for these locations to help alert pedestrians of the full extent of the danger of the at-grade rail crossing. Additionally, transit operating rules can incorporate guidance on hold-short, adjacent track occupancy, or stop-and-proceed rules to help prevent collisions at stations when multiple transit vehicles are present.

Safety treatments can be categorized as either active or passive traffic control systems. Active traffic control systems are those that engage in advance of or during a train crossing, such as four-quadrant gate systems, automatic gates, flashing-light signals, traffic control signals, actuated blank-out and variable message signs, and other active traffic control devices. Passive traffic control systems, consisting of signs and pavement markings only, identify and direct attention to the location of a grade crossing and advise road users to slow down or stop at the grade crossing as necessary to yield to any rail traffic occupying, or approaching and in proximity to, the grade crossing.

Traditional crossbucks, gates, or flasher/bell assemblies are useful for warning pedestrians of oncoming vehicles, but all these devices are considered "supplemental" and are typically deployed as part of an engineering decision or a diagnostic team review. The MUTCD indicates flashing light signals with a Crossbuck sign and audible device should be used where there is inadequate clearing sight distance, or where light rail speeds exceed 35 mph (FHWA, 2009, MUTCD Chapter 2). While these traditional devices have been reliable and effective in the past, some newer devices such as digital voice announcements, have been granted MUTCD permission to experiment.

Other potential safety treatments include the following:

- **Stop lines, edge lines, and dynamic envelope pavement markings** – Stop lines let pedestrians and bicyclists know where to safely stop in advance of the train and edge lines help keep pedestrians and bicyclists along the route. Detectable warning surfaces provide similar cues to pedestrians with vision disabilities. Dynamic envelope pavement markings indicate the required clearance for the train or light rail transit equipment, accounting for any overhang due to loading of the vehicle, lateral motion, or suspension failure. These markings, shown in figure 36 and figure 37, help pedestrians and bicyclists visualize the actual space the train may need and avoid conflicts with the passing vehicle.

- **Refuge areas** – Refuge areas should be considered between tracks and roadway travel lanes rather than placed between two sets of tracks, as shown in figure 38 (FHWA, 2009). If a refuge area is not physically feasible, additional pedestrian signal heads, signing, and detectors or flashing light signals could be installed (FHWA, 2009, MUTCD Section 4E.08).
- **Fencing, gates, and channelization** – Fences can be used to discourage pedestrians from crossing rail tracks in undesignated locations and used to guide pedestrians to designated grade crossings. Z-Crossings can force pedestrians to look in the direction of an oncoming train. Swing Gates are passive devices that require pedestrians to open before crossing, causing them to pause their movements, and better understand their surroundings including the possibility of oncoming trains. Gate Skirts can help deter pedestrians from crossing the right-of-way when the crossing warning systems are engaged (Ogden and Cooper, 2019).
- **Two-stage left-turn box** – This is a treatment that can be used at any intersection—with or without the presence of rail—and helps bicyclists to make left-turns in two stages. This design, shown in figure 40 encourages bicyclists to cross the tracks at a right angle, which can help to reduce the chance of a bicyclist from slipping on the rails or getting caught in the tracks.
- **Flanges** – Bicycle and wheelchair wheels can become trapped in the flangeway opening, or the gap between the side of the rail and the roadway surface. As such, measures to reduce the flange gap should be implemented (U.S. Access Board, 2011, proposed PROWAG R302.7.4).

  The gap on the outside of the rail, also known as the "field flangeway", can be remedied relatively easily using fillers made of rubber or polymer. The primary function of fillers is to keep water and debris out, but they can also eliminate the outside gap almost entirely. The gap on the inside of the rails, also known as the "gauge flangeway," must be kept open since it is where the train wheels, or "flange", travel to keep the train on the tracks (49 CFR 213.357). To allow for this flange, ADA standards recommend that public crossings have a maximum gauge flangeway width of 2.5 inches to allow individuals in wheelchairs to cross the tracks (U.S. DOJ, 2010). In general, light rail and streetcars need only a narrow flange and heavy rail needs a wider flange. The fillers for gauge flangeways are designed to accommodate this gap requirement and provide space for the wheel flange. The only exception to this is for low-speed rail (where the vehicle may be entering a freight yard), where the gauge flangeway can be filled completely, these may only be used in low-speed applications (Williams et al., 2004; AASHTO, 2012).
- **Grade-separated crossings** – Railroad tracks with high-speed and high-frequency train service may necessitate pedestrian tunnels or overpasses with accessible grades to create a safe crossing for pedestrians.
- **Signalization of crossings** – In circumstances where streetcar, pedestrian, and bicyclist crossings have less than ideal sight distance, the crossings can be controlled through a traffic signal.

- **Surveillance, education, and enforcement** – Enforcement can help reduce the number of pedestrians trespassing (e.g., walking along railroad tracks).

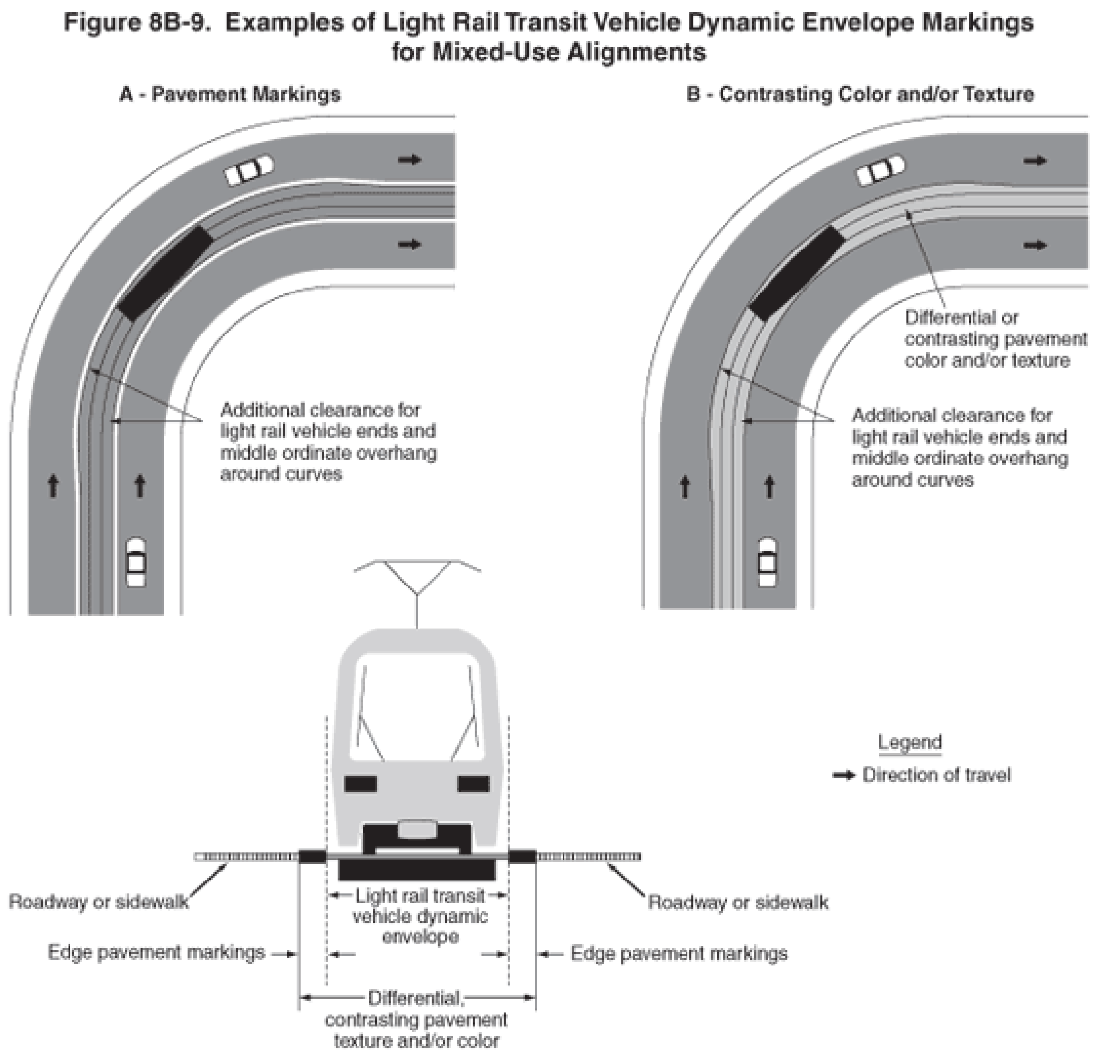

Figure 36. Graphic. Example of light rail transit vehicle dynamic envelope markings for mixed-use alignments. (FHWA, 2009, MUTCD Figure 8B-9).

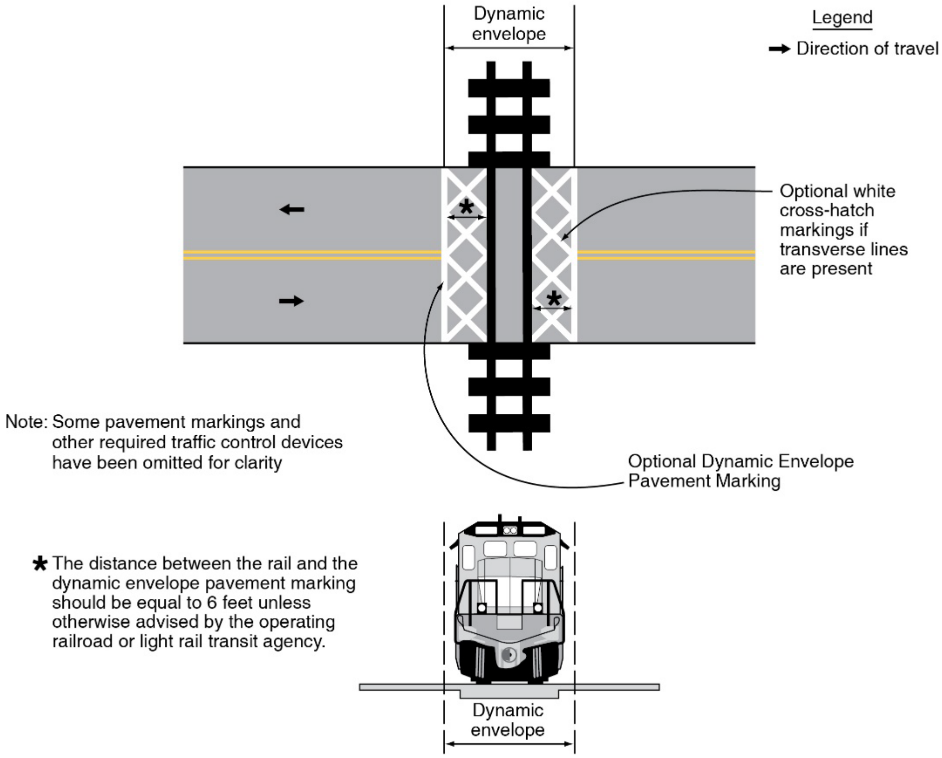

Figure 37. Graphic. Example of dynamic envelope pavement markings at grade crossings. (FHWA, 2009, MUTCD Figure 8B-8).

Figure 38. Photograph. Example of a pedestrian refuge island and channelization between tracks with fencing for channelization in Murray, UT (Wikimedia Commons, 2009).*

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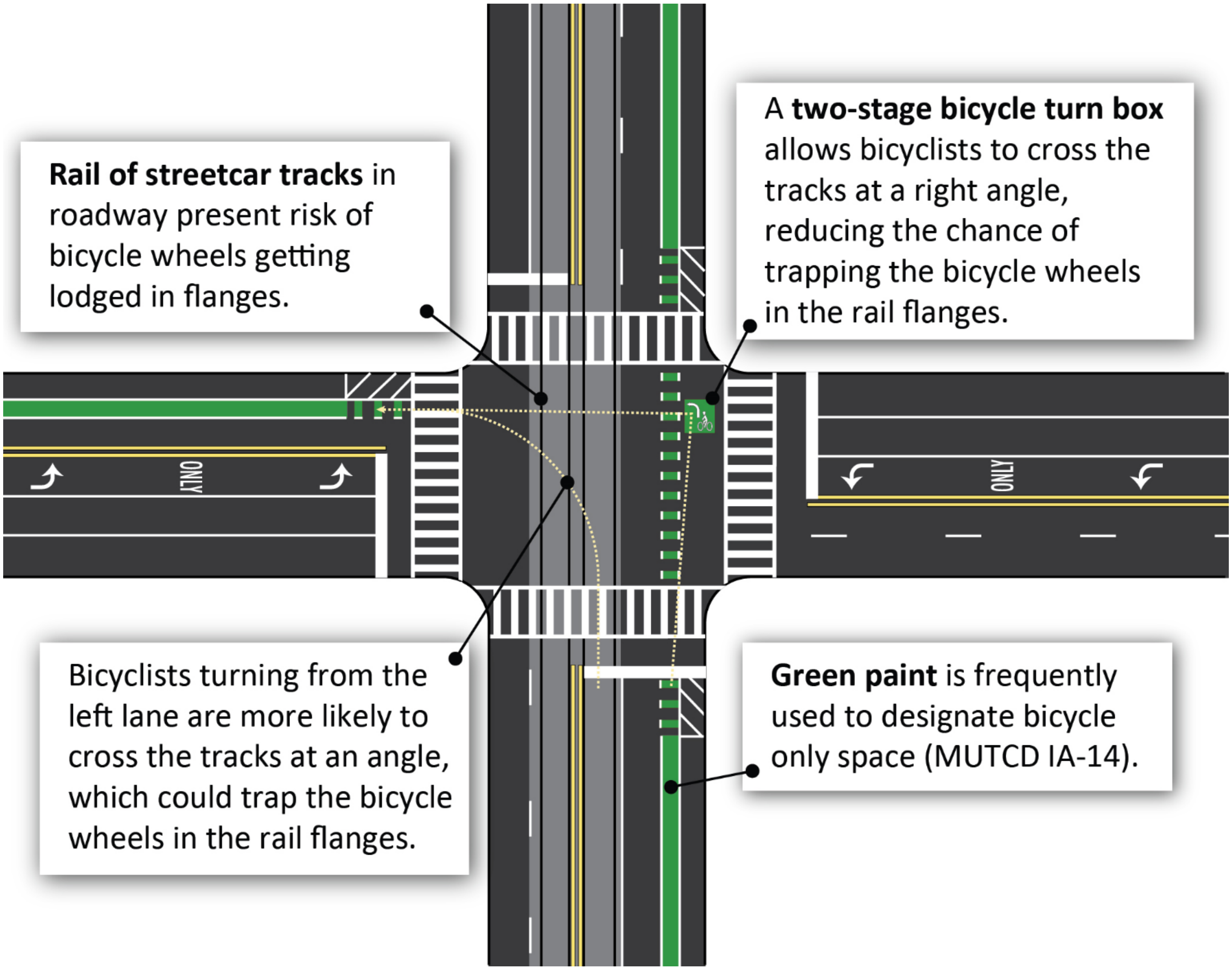


Figure 39. Graphic. Two-stage left turn for bicyclists crossing rail or streetcar tracks. (VHB, 2021).*

[*] This image is not publicly available. VHB provided permission and shared for the purposes of this project.

Oregon DOT compiled a list of rail crossing bicyclist and pedestrian safety treatments as compared to the relative cost to implement and impact on a variety of factors (Goodchild et al., 2017). Table 4 shows the summary of active treatments and table 5 shows the summary of passive treatments.

Table 4. Overview of active rail crossing treatments (adapted from Goodchild et al., 2017).

Treatments	**Cost**	**Maintenance**	**Weather**	**I t Quiet Zone**	**Light Emission**	**Duration**	**Compliance**	**R t Behavior**
Flashing Light Signals	$$	$$	M	--	L	L	L	H
Bells	$	$	--	--	--	L	L	H
Vehicle Automatic Gates	$$	$	--	--	--	H	--	M
Wayside Horn System	$$	$	M	L	--	L	--	M
In-Pavement Marker System	$$-$$$	$$	M	--	M	L	--	M
Pre-Signal/Traffic Lights	$$$	$$	M	--	H	--	--	L
Variable Message Sign/Blank-Out Signs	$$	$	H	--	--	--	--	M
Dynamic Speed Monitoring Display (DSMD)	$	$	H	--	--	--	H	H
Pedestrian Automatic Gates	$$	$$	L	--	--	--	--	M
Pedestrian Hybrid Beacon	$$	$	M	--	--	M	M	H
Active and Automatic Rectangular Rapid Flash Beacon (RRFB)	$	$$	L	--	M	H	H	L

Legend for Active Treatments

Low	Medium	High
L	M	H
$	$$	$$$

Table 5. Overview of passive rail crossing treatments (adapted from Goodchild et al., 2017).

Treatment	Cost	Maintenance	Day Visibility/Audibility	Night Visibility/Audibility	Sight Distance	Weather	ADA	Duration	Compliance	Behavior
Crossbucks	$	$	M	L	M	H	--	L	L	M
Railroad Crossing Advance Sign	$	$	M	L	M	H	--	--	--	M
Look Both Ways	$	$	M	L	M	H	--	L	--	M
Pavement Marking	$	$$	M	L	M	H	H	L	--	H
Tactile Warning	$	$$	H	L	M	M	M	L	--	H
Dynamic Envelope	$$	$$	H	M	M	M	H	L	M	M
Conflict Paint	$	$	H	M	H	M	--	L	H	L
Glow in Dark Paint	-	-	H	H	H	M	--	L	H	L
Rumble Strips	$	$	M	L	L	L	L	M		M
Speed Bumps	$	$	H	M	M	M	L	L	H	M
Speed Humps	$	$	H	L	H	L	L	L	--	L
Speed Kidney	$	$	H	M	M	M	L	L	H	M
Speed Cushion	$	$	H	M	M	M	L	L	M	M
Speed Table	$	$	H	M	M	M	L	L	H	L
Grade/Hill	$$	$	H	L	L	L	L	M	--	M
Curves	$$	$	H	L	H	L	H	M	--	L
Raised Crosswalk	$	$	H	L	M	H	H	L	M	L
Bollards	$	$	H	M	H	M	--	M	H	M
Bicycle Rail or Lean Rail	$	$	H	L	M	L	--	--	H	L
Lighting	$	$	--	H	H	M	--	--	H	M
Mirrors	$	$	H	L	M	H	--	L	--	M
Pedestrian Refuge	$$	$	H	M	M	L	M	L	--	M
Channelization (Paving/Delineation)	$$$	$$	H	M	H	L	--	M	--	L
Channelization (Z-Crossing)	$$$	$	H	M	H	L	H	L	--	M
Manual Gates	$	$	H	M	H	L	H	L	--	M
Pedestrian overcrossing, undercrossing	$$$	$	H	M	M	L	M	M	H	L
Quick/Temporary Curb	$	$	H	M	H	M	H	M	--	M
Pedestrian Crossing Flags	$	$	M	L	M	H	H	L	L	H

Legend for Passive Treatments

Low	Medium	High
L	M	H
$	$$	$$$

Special Considerations

Transit agencies can be aware of special scenarios, such as Wide and Ultra-Wide crossings and Long and Ultra-Long Angle crossings.

Wide and Ultra-Wide Crossings are those with the following characteristics:

- Wide Crossings (>30 feet and <60 feet) are generally more than two tracks.
- Ultra-Wide Crossings (≥60 feet) are generally more than four tracks.

Wide and Ultra-Wide Crossings pose additional threats to pedestrians, especially older adult pedestrians. Whereas the MUTCD defines the standard pedestrian walk rate from 3.0 to 3.5 feet per second (FHWA, 2009, MUTCD Section 4E.06), distances greater than 60 feet would not allow persons to clear the grade crossing before the minimum required 20 seconds warning time. Some risk can be mitigated through:

- Extended preemption/warning timing exclusively for pedestrians or all road users.
- Refuge islands where space exists between tracks outside of the foul area (figure 38).
- Some combination of both, along with other safety treatments listed in this chapter.

Long and Ultra-Long Angle crossings are those with the following characteristics (Ogden and Cooper, 2019):

- Long Angle Crossing (Acute or Obtuse) (<90 degrees and ≥45 degrees).
- Ultra-Long Angle Crossing (Acute or Obtuse) (<45 degrees).

Long and Ultra-Long Angle crossings pose similar threats to pedestrians to those of Wide and Ultra-Wide Crossing (figure 40). Some risk can be mitigated by:

- Creating perpendicular crossings within the same grade crossing.
- Adding additional pedestrian/bicyclist channelization.
- Adding additional flashing light signals/warning bells/automatic gates.

Figure 40. Photograph. Example of Long Angle Crossing with shortened pedestrian and bicycle lane crossing (top right), Federal Energy Regulatory Commission (FERC) crossing at 19th St NW & N Miami Ave, Miami, FL (Nearmap, 2021).

Transit Stop/Station

It is essential for transit stops and stations to have good linkages to the existing pedestrian and bicyclist network through the use of sidewalks, bicyclist facilities, curb ramps, and crosswalks. Placing transit stops and stations on and near Complete Streets help to meet the needs of all users, regardless of age and ability. Bus activity should be a consideration when combining transit corridors with on-street bicyclist facilities. For example, heavy transit corridors may not be preferable corridors for shared or on-street bicyclist facilities. In those instances, there may be a suitable alternative route for the bicyclist facilities. Considerations for the placement of bicyclist facilities on transit corridors include pedestrian boarding and alighting space and transit operations effects on bicyclist comfort and safety (Schultheiss et al., 2019). Options for minimizing bicyclist conflicts with transit could include appropriate signage, pavement markings, bus bulbs, or separated bicycle lanes on the left side of a one-way street.

In selecting and designing transit stop locations, agencies may consider operating factors such as ridership and reliability. At the same time, agencies can consider factors that affect transit rider safety. Further, they can install amenities and design stops that meet both the needs of transit rider safety and the transit vehicle operation. The following section explores various factors related to transit stop placement and design that can impact pedestrian and bicyclist safety.

Transit Stop Placement

Transit stop placement has a direct impact on pedestrian and bicyclist safety and this section discusses enhancements and considerations for transit stop placement. If a transit agency is not able to relocate a transit stop, other measures to improve safety, such as those described in **chapter 6** should be considered.

Connected routes provide pedestrians and bicyclists with the opportunity to connect to transit without having to extend routes or increase the need to cross the roadway. This is particularly important for pedestrians with disabilities. By understanding pedestrian and bicyclist “desire lines”, the transit agency and roadway owners can understand how the transit stop will integrate with those desired routes.

Transit stop placement and design can help to encourage positive sight lines for transit operators, pedestrians, and bicyclists alike while also encouraging safe crossing behaviors for transit users. For example, as shown in table 6, a far side bus stop encourages pedestrians to cross behind the bus but can create sight distance issues for motor vehicles traveling in the opposite direction of the bus. A nearside stop allows passengers to access the bus closest to the crosswalk but can obscure curbside signals and cause sight distance issues for drivers and pedestrians. A midblock transit stop can reduce congestion at passenger waiting areas and minimize sight distance problems at intersections. However, unless a complimentary mid-block crosswalk is provided, this stop location can increase the distance to the nearest intersection crosswalk and the potential for pedestrians and bicyclists to cross away from a marked crosswalk.

Transit stop spacing has a major impact on the overall transit system performance and safety. Looking at the network of bus stops, agencies might find that over time additional stops have been added (FTA, 2015). While this can increase convenience for transit riders, it may be difficult for roadway agencies to provide enhanced safety measures for pedestrians and bicyclists with several stops in close proximity.

Additionally, if buses stop in the travel lane, this may lead to erratic and risky movements by frustrated motor vehicle drivers who attempt to maneuver around the bus. All of this could lead to an increased risk of crashes. Transit agencies can periodically reexamine the location of stops to determine locations of higher value to riders.

Table 6. Comparative analysis of bus stop locations (adapted from FTA 2015).

Stop Type	Advantages	Disadvantages
Near Side	• Minimizes interference when traffic is heavy on far side of intersection • Allows passengers access to buses closest to the crosswalk • Intersection available to assist in pulling away from curb • Prevents double stopping • Allows buses to service passengers while stopped at red light • Provides driver with opportunity to look for oncoming traffic including other buses with potential passengers	• Conflicts with right-turning vehicles are increased • Potentially obscures curbside traffic control devices and crossing pedestrians • Potentially obscures sight distance for crossing vehicles stopped to the right of the bus • Potentially blocks the through lane during peak periods by queuing buses • Increases sight distance problems for crossing pedestrians
Far Side	• Minimizes conflicts between right-turning vehicles and buses • Provides additional right turn capacity by making curb lane available for traffic • Minimizes sight distance problems on approaches to intersection • Encourages pedestrians to cross behind the bus • Accommodates shorter deceleration distances for buses • Creates gaps in traffic flow for buses reentering the flow of traffic at signalized intersections	• Potentially blocks intersections during peak periods by queuing buses • Potentially obscures sight distance for crossing vehicles • Increases sight distance problems for crossing pedestrians • Interferes with bus operations and all traffic in general when stopping after a red light • Potentially increases number of rear end crashes since drivers do not expect buses to stop again after stopping at a red light
Midblock	• Minimizes sight distance problems for vehicles and pedestrians • Minimizes pedestrian congestion in passenger waiting areas • Reduces conflicts with different movements of vehicles (vehicles turning right and left) and can eliminate turning lanes	• Necessitates additional distance for no parking restrictions • Encourages patrons to cross street at midblock (jaywalking) • Increases walking distance for patrons crossing at intersections

In addition to the stop placement considerations previously mentioned, BRT stop placements come with unique considerations. BRT stops may look like a curb side stop served by a local bus route and should be designed on local bus route principles. However, BRT platforms are sometimes located at-grade in the median between travel lanes. Because of this, it is important to consider surrounding traffic speeds, surrounding bicyclist facilities and connections, pedestrian refuge space, connections to crosswalks, pedestrian control devices and timing, and transfer activity.

Understanding the potential transfers between transit and other modes, such as bicycle share, can help transit agencies when orienting transit stops. Placing stops on the same quadrant of the intersection eliminates the need for pedestrians to cross the road to transfer.

Transit Stop Design

There are several safety considerations to keep in mind when designing transit stops and stations. NACTO's *Transit Street Design Guide* (NACTO, 2016) provides several design principles to improve safety. The first principle is that stations serve as gateways to the transit system. As these are the first and last places riders interact with while using transit, it is important to design stops in ways that make them feel invited, safe, and comfortable, which are all factors that can help boost ridership.

Transit stops should also facilitate movement and ease interactions. This second design principle, and the design elements discussed in this chapter, can increase the safety and efficiency of intersection crossings and rider transfers. In-lane stops and integrating platform heights with vehicles are other tactics used to enhance safety and efficiency of a transit system. Boarding islands and bulbs provide a direct path for users to board without any maneuvers from the transit vehicle. In addition to creating shorter, safer paths for pedestrians, these designs also increase sidewalk space and vehicle predictability—particularly at bicyclist-bus conflict locations.

The last two principles are simple, but crucial: universal design is equitable design and design for safety. The first part emphasizes the benefits from designing stops for all users—a stop that is accessible for all, regardless of abilities or age, creates a better experience for each rider. The second part, design for safety, considers all elements affecting riders: prioritization of direct and convenient walking access to transit stops, low delay pedestrian crossings, human scale lighting, transparent structures, weather protection, among

Flexible Funds for Safety, Complete Streets, and Enhanced Transit - Transportation Planning Capacity Building Program

Many Federal-Aid Highway Programs support bicycle lanes, better pedestrian walkways, trails, lighting, and other projects that enhance safety. However, some State Departments of Transportation (DOTs), cities, and Tribes may not use these funds for small-scale safety and access improvements due to processes and requirements more suitable to large-scale highway projects. Transferring, or flexing, funds from Federal Highway programs to the Federal Transit program facilitates federal investments at the local level for measures that improve access, particularly for underserved groups. (See FAQs for the full list of eligible activities and FTA's flex funding page for additional uses: https://www.planning.dot.gov/flex.aspx).

others. Designers should make sure that all the stop facilities still provide accessible boarding and alighting space free of conflicts with other users, and accessible amenities. Figure 41 illustrates proposed key dimensions for accessible bus stops. The following sections describe design elements that enhance safety for pedestrians and bicyclists.

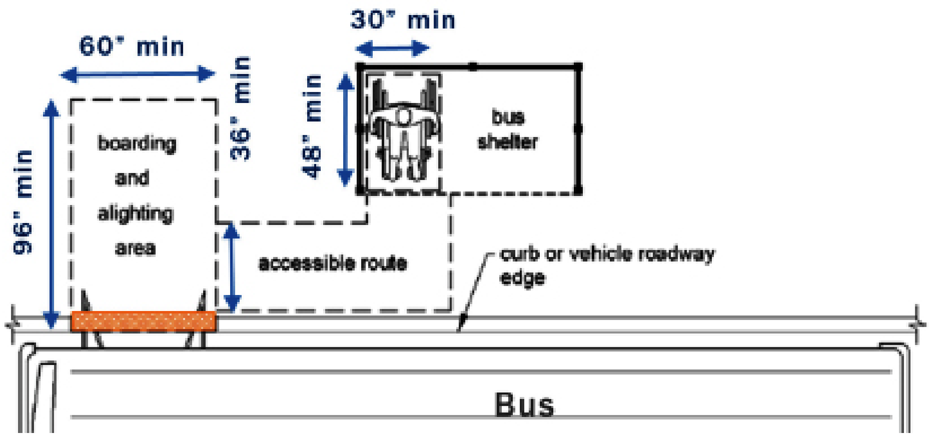


Figure 41. Graphic. Accessible bus stop boarding and alighting area, and shelters (U.S. Access Board, n.d.).

Curbside Stops

Curbside stops are the most common types of bus stops where the bus zone is located in the road, usually in a parking or loading lane area or stopping directly in the bus lane when neither of those are present. Passengers board and alight directly from the sidewalk. This is the lowest cost transit stop type and only involves signage and an accessible boarding and alighting area. In many situations, this may be the only type of design feasible. This design may encourage impatient drivers to make last minute lane changes or drive aggressively due to delays from stopping buses, particularly with frequent and closely spaced stops. This concept is similar to that of figure 42, but does not involve the bus pulling out of the travel lane.

Curbside Pullouts

Also known as “bus bays,” “bus pockets,” or “bus turnouts,” curbside pullout stops allow buses to pull out of the travel lane (figure 42). The space for the pullout is typically taken from on-street parking. The actual stop design is similar to that of a curbside stop. These stops are typically most useful in locations where there are higher traffic volumes and speeds or longer bus dwell times. These stops can increase travel time for transit passengers due to the merge back into traffic. Further, if the pullout is blocked by parked vehicles, buses may stop in the lane—requiring passengers to board from the street, which may prevent some disabled passengers from boarding the bus.

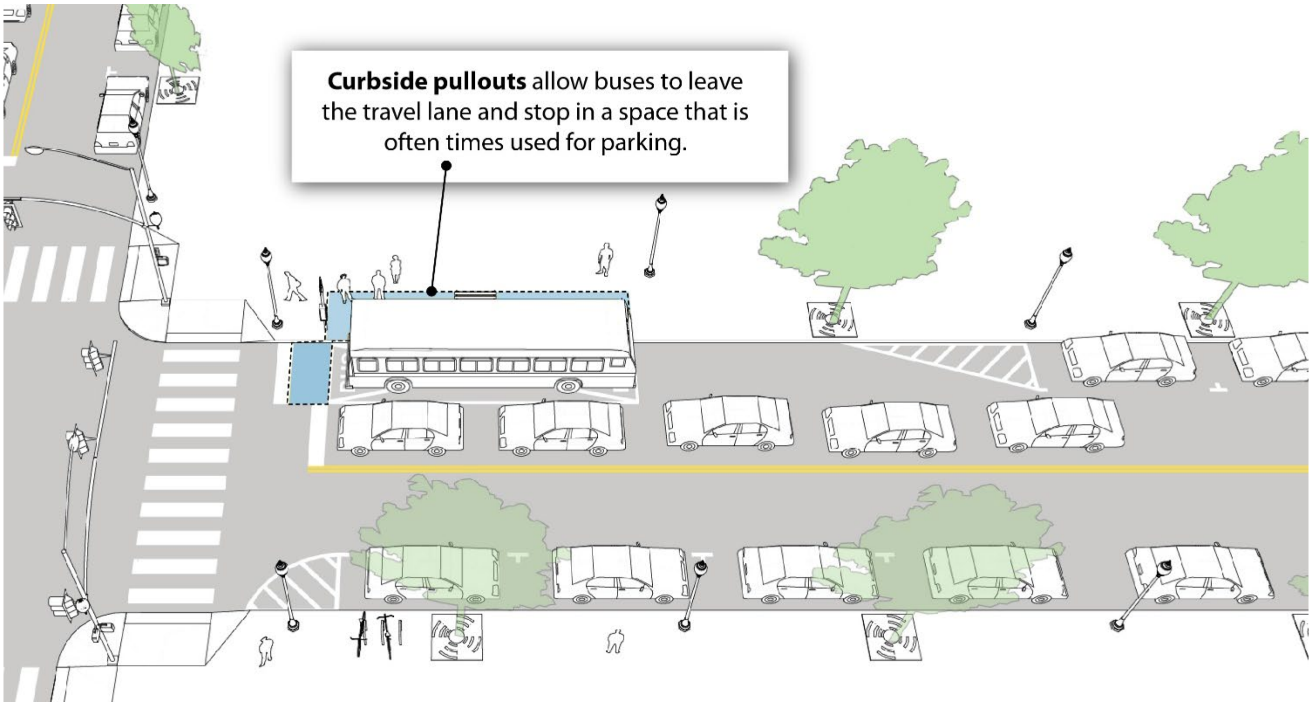


Figure 42. Graphic. Concept demonstrating a curbside pullout (adapted from NACTO, 2016).

Bus Bulb Outs

Like traditional curb extensions, bus bulb outs are an extension of the curb that move the bus stop area out to the edge of the travel lane (figure 43). These are possible in areas with on-street parking or wide lanes. It frees up sidewalk space by the transit stop and provides a space for riders to queue in the curb extension. In locations with constrained space, this feature may also provide space for amenities, such as a shelter or bicycle racks, that may not have been possible otherwise. Other safety benefits include narrowing of the roadway (which can lead to traffic speed reductions), reduced crossing distances for pedestrians and bicyclists, and enhanced conspicuity of transit riders or individuals waiting to cross the street.

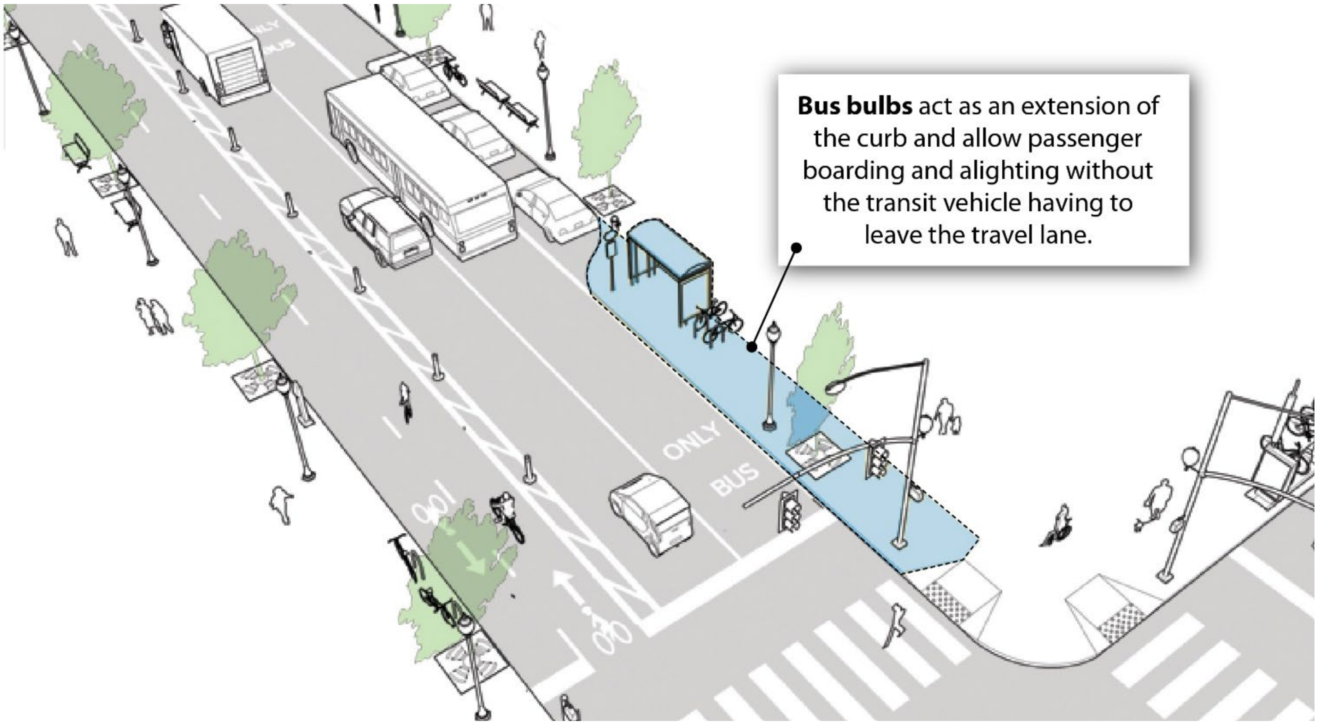


Figure 43. Graphic. Concept demonstrating a bus bulb (adapted from NACTO, 2016).

Floating Transit Stops

There are two types of floating transit stops, which typically serve buses or streetcars: one that is located to the left of a travel lane, and the other is located to the left of an on-street bicyclist facility such as a separated bicycle lane. These two configurations are shown in figure 44 and figure 45. These types of stops provide a refuge area for both transit riders and pedestrians crossing the street. The placement of the transit stop away from the curb and the bicyclist facility against the curb reduces conflicts between transit vehicles and bicyclists "leapfrogging" one another as transit vehicles pull into a stop, are passed by bicyclists, and then pass bicyclists after reentering the travel lane (FTA, 2017).

Pedestrians can more easily reach the transit stop when the floating transit stop is placed at controlled intersections than when it is not. To limit crossings away from the marked crosswalk, railings should be installed on the right side of the island, along the through vehicular lane (NACTO, 2016). For those with bicyclist facilities to the right of the transit stop, pedestrian crossings to and from the floating bus stop should be prioritized over the bicyclist movement per Chapter 11 of the UVC (UVC, 2000). This may be realized through the use of a raised crosswalk spanning the bicycle lane between the curb and floating bus stop, a high visibility marked crosswalk, pedestrian railings, and a yield or stop line with accompanying signage to alert bicyclists of pedestrians in crosswalks (Porter et al., 2016). Colored pavement markings may be used to designate space exclusive to transit or bicyclists. Figure 44 shows transit lanes with red paint, which requires approval under Interim Approval 22 (MUTCD IA-22), and figure 45 shows bicycle lanes with green paint, which requires approval under Interim Approval 14 (MUTCD IA-14).

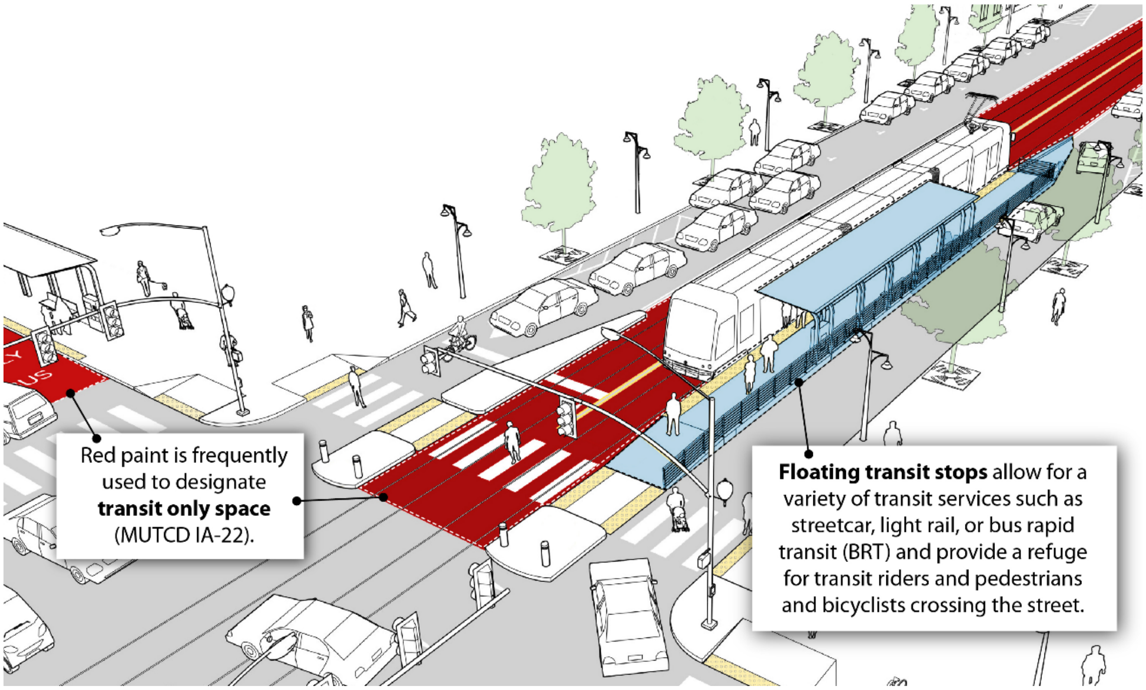


Figure 44. Graphic. Concept demonstrating an exclusive floating transit stop (adapted from NACTO, 2016).

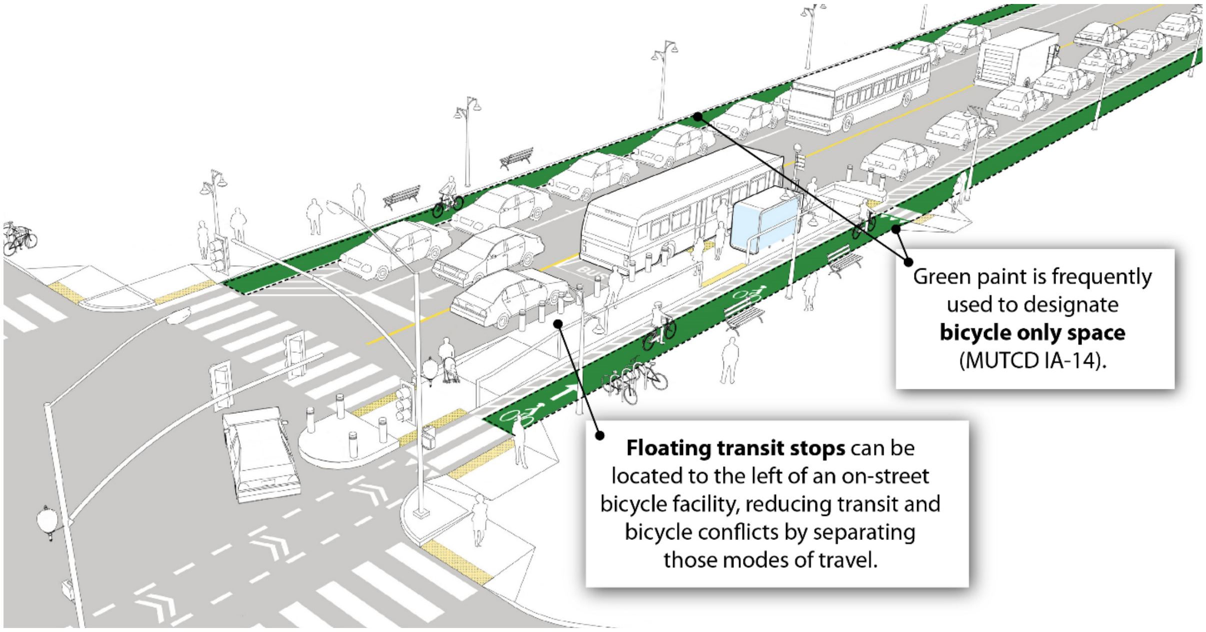


Figure 45. Graphic. Concept demonstrating floating transit stop with an adjacent bicycle lane (adapted from NACTO, 2016).

In both designs, a floating transit stop island of at least 8-feet wide in the direction of pedestrian crossing can provide pedestrians protection in the crosswalk. Including curb ramps, detectable warning surfaces, and channelization where appropriate would make the crossing accessible to all users (U.S. Access Board, 2011). In addition, providing an 8-feet long space, measured perpendicular to the curb, would provide an accessible boarding and alighting area (U.S. Access Board, 2011). For islands with bicycle lanes located to the right, placing transit shelters at least 10 feet from crosswalks would help to maintain visibility between bicyclists and people exiting the transit stop (NACTO, 2016).

In Maryland, the Montgomery County DOT (MCDOT) prioritized inclusive engagement with the visually disabled community to improve successive versions of its floating bus stops. MCDOT installed the first generation of floating bus stops in 2017 to integrate with separated bicycle lanes. These initial stops included truncated domes, header curbs, and sidewalk curbing with a 45-degree angle edge to prevent bicycle pedal strikes. However, these first stops did not have high contrast visual surfaces between the bicycle lane and platform, which are helpful for low vision transit riders. The next generation of floating bus stops were developed through tailored workshops with the visually disabled community and the use of tactile graphics (Montgomery County DOT, 2021). New transit stops incorporate numerous advances for accessibility: a level crossing at the front, located at a signal to simplify crossings; railings along the back and transverse railings at the ends; high contrast color differences; header curb; and high visibility crosswalks. The floating stops, as shown in figure 45, also incorporate treatments to increase bicyclist yielding to pedestrians and lower speeds such as flex posts to narrow the lane, vertical and horizontal deflection, and "rumble strips" from thick pavement markings. Bicycle signals can also be used to provide dedicated phases for pedestrians and bicyclists.

Median Stop

A median transit stop is where a transit stop is placed in the center of the roadway, separating travel lanes that are in opposing directions. These are high capacity stops that are used for buses, BRT, light rail, and streetcars and due to their placement, make transit prominent and readily apparent to all roadway users. As with floating transit stops, this type of transit stop typically provides ample space for queued passengers and transit stop amenities, and it provides the added benefit of serving stops in both travel directions.

The stop may be designed for either left- or right-side boarding. If the transit platform is in the center with the transit vehicles running on the outside, this is left-side boarding. If transit vehicles run through the center with platforms on both the right and left sides, this is right-side boarding. These two configurations are illustrated in figure 46 and figure 47.

The minimum suggested platform width for right-side boarding is 8 feet. However, since left-side boarding allows for platforms serving two travel directions, the minimum suggested platform width is 10 feet (in constrained conditions), with a preferred width of 12 feet. If the left-side boarding platform only serves one direction, the suggested minimum width is 9 feet (NACTO, 2016). As with the floating transit stop, providing an 8-feet long space, measured perpendicular to the curb, would provide an accessible boarding and alighting area (U.S. Access Board, 2011).

Since passengers cross the street to access the transit facilities, the use of LPIs and lagging left-turn only phases can help prioritize pedestrian movements at signalized intersections. There is still a risk of passengers darting into the street when a transit vehicle is approaching. Therefore, transit agencies may consider treatments such as fencing to address safety concerns and discourage this type of behavior. As passengers may cross travel lanes when entering and exiting stops, intersection design and signalization should prioritize pedestrian movements to eliminate turn conflicts. Protection at the edge of the median provides a physical barrier for crossing and waiting pedestrians.

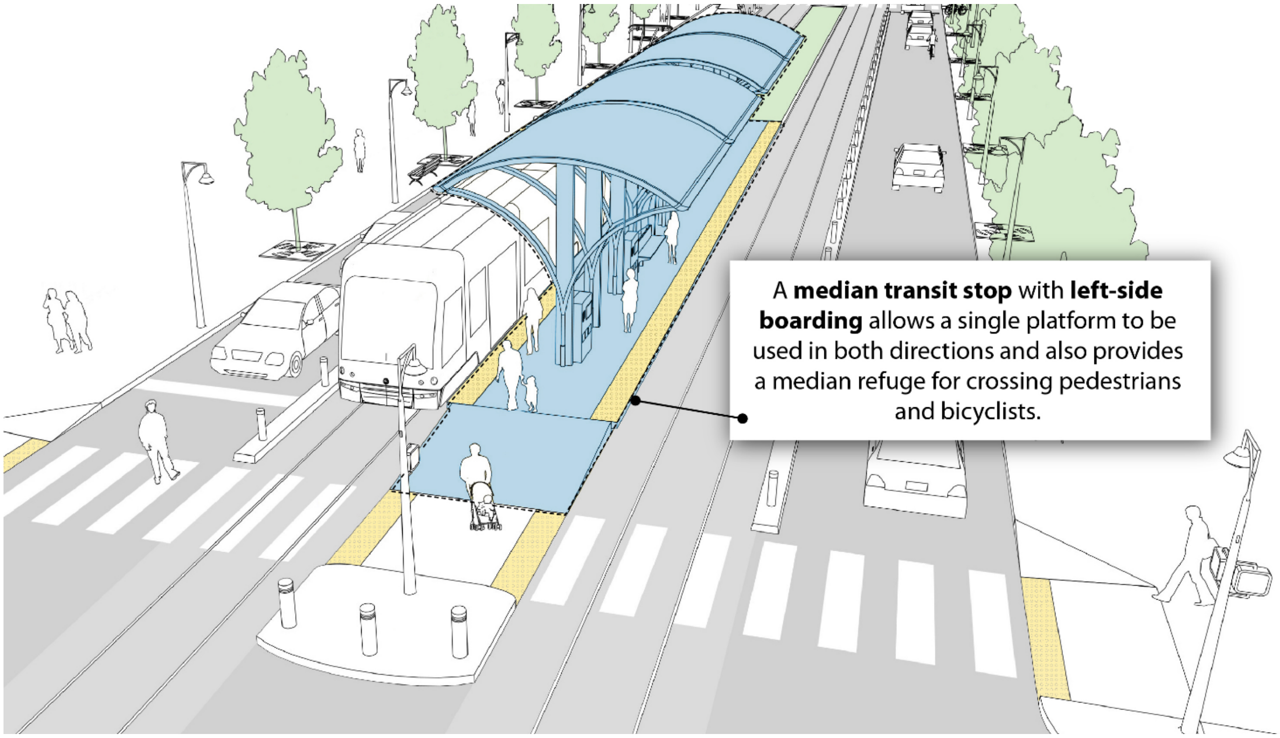


Figure 46. Graphic. Concept demonstrating left side boarding used in both directions (adapted from NACTO, 2016).

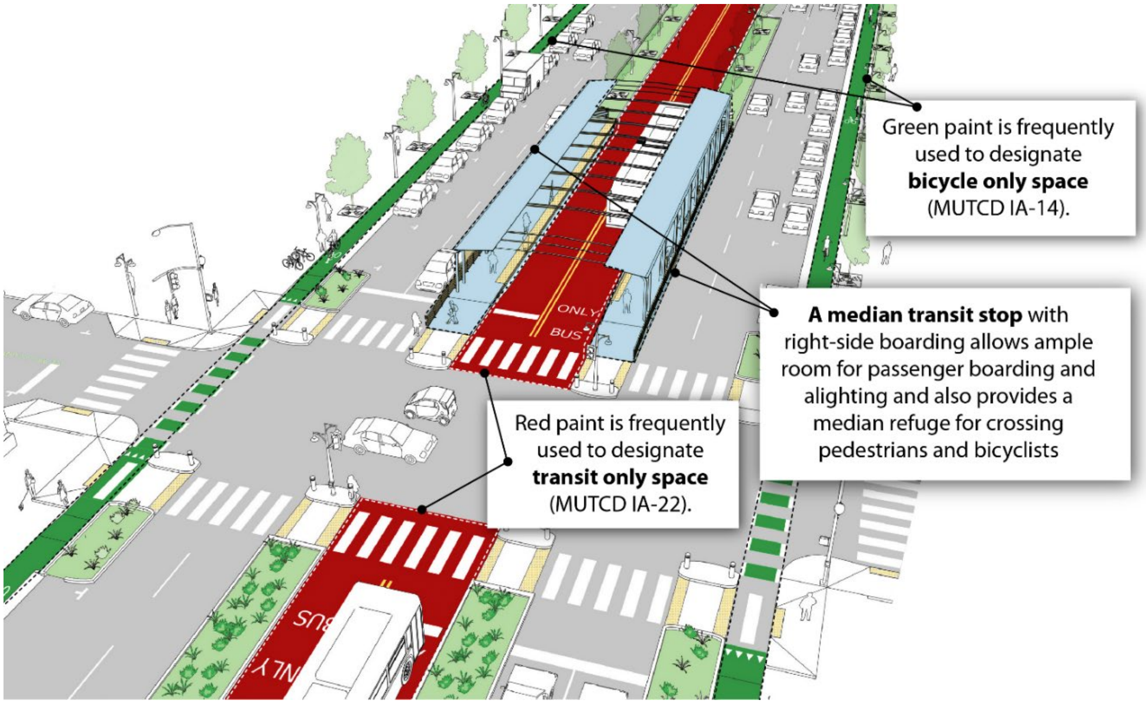


Figure 47. Graphic. Concept demonstrating right side boarding with exclusive transit lanes (adapted from NACTO, 2016).

Lighting

Lighting is a critical component to any transit stop design. As the stops are pedestrian and bicyclist generators, it is important to make sure pedestrians and bicyclists are visible to drivers and each other. The lighting at transit stops should be "pedestrian-scale," meaning that it is placed lower than typical street lighting (mounted at a height of 20 feet or less) and is designed to illuminate the sidewalk and other pedestrian spaces. Lighting can provide a visual reminder for drivers of potential pedestrian activity and can also be used to increase the general comfort and personal safety of passengers at transit stops.

Table 7 includes recommended design criteria as presented in FHWA Report SA-21-087, *Pedestrian Lighting Primer* (FHWA, 2022). Recommended design criteria vary depending on the expected level of pedestrian activity. The classifications of low, medium, and high pedestrian activity are as follows:

- **Low Pedestrian Activity** (10 or fewer pedestrians per hour): Areas with very low volumes of pedestrians during hours of darkness. Examples may include suburban streets with single family dwellings, very low-density residential developments, and rural or semi-rural areas.
- **Medium Pedestrian Activity** (11-100 pedestrians per hour): Areas where lesser numbers of pedestrians are expected during hours of darkness. Examples may include downtown office areas, libraries, apartments, neighborhood shopping, industrial, parks, and streets with nearby transit lines.
- **High Pedestrian Activity** (over 100 pedestrians per hour): Areas with significant numbers of pedestrians expected during hours of darkness. Examples may include downtown retail areas, theaters, concert halls, stadiums, and transit terminals.

Table 7. Recommended pedestrian lighting levels (FHWA, 2022).

Pedestrian facility characteristics	Average Illuminance	Average Luminance	
		Rural	**Urban**
Intersection crosswalk	30 lux vertical	*	*
Midblock crosswalk	20 lux vertical	*	*
Facility adjacent to roadway with low to medium pedestrian activity	2 lux vertical	*	1 cd/m^2
Facility adjacent to roadway with high pedestrian activity and/or school zones	10 lux SC	1 cd/m^2	2cd/m^2

**Use minimum maintained average pavement luminance criteria from RP-8-18.*

Note: Values are for roadway scale luminaire heights (6.5m or 20 feet or higher). For pedestrian scale lighting (6.5m in height or lower), add 2 vertical lux and 0.5 cd/m^2 to the criteria to overcome increased glare resulting from the use of a lower mounting height.

Transit Stop Amenities

Transit stop amenities are items that are not required for passengers to access transit, but move transit from the most basic, functional role to an experience that is more inclusive and enjoyable. To be more inclusive, amenities should be placed carefully to maintain the accessibility of the transit shelter and stop for those with disabilities. Providing bicyclist amenities at transit stops, stations, and on vehicles can help to expand transit ridership by integrating other modes and extending the reach of first-mile/last-mile transit connections (APTA, 2018). While these improvements may not reduce crash risk directly, they can improve the sense of personal safety and protection of property (FTA, 2017). In Minneapolis, Metro Transit undertook a public outreach process to find out what types of amenities passengers valued and what factors were important in transit stop placement. They used the feedback to develop transit shelter and amenities guidance, as shown in figure 48.

Bus Stop Amenities Survey: *What did we learn?*

Priorities for shelter and bus stop features:

- Signage and information
- Benches
- Shelters
- Lighting
- Heaters
- Safe street crossings
- Maintenance at bus stops and shelters

Priorities for where to locate shelters:

- Where many people wait for the bus.
- Near hospitals, healthcare clinics, social service centers, senior housing, housing and services for people with disabilities, where children are waiting.
- Where residents don't have a car, where residents have lower income.

Transit Shelter & Amenities Guidance:

Adding a shelter

Metro Transit considers adding shelters at bus stops as funding and maintenance resources allow based on this criteria:

- ✓ Stops that are major transfer points
- ✓ Neighborhoods with higher number of households without a car
- ✓ Some locations that may meet the criteria for a shelter may not have space to fit a shelter.

Removing a shelter

A shelter may be *permanently* removed if:

- ✓ There are consistently fewer than 15 average daily boardings
- ✓ Changes in roadways or property boundaries that make it so the site cannot fit a shelter
- ✓ There are site problems, such as inadequate clearance around the shelter for pedestrians or traffic safety issues

A shelter may be *temporarily* removed if:

- ✓ It is located in a construction zone, such as a street construction project or development of property
- ✓ There is ongoing vandalism or documented public safety issues. Persistent vandalism takes maintenance staff time away from other needs, and temporarily removing the shelter interrupts the pattern of behavior

Improving a shelter

- ✓ Metro Transit may add lighting or heating to a shelter, if it meets the criteria and electricity is available or easily added. Lighting and heating are not standard features in shelters due to the high costs of installing and maintaining them.
- ✓ Lights are considered where there are higher boardings during evening or overnight hours, especially where there are documented personal security concerns
- ✓ Heaters are considered if there at least 100 average daily boardings

Figure 48. Graphic. Minneapolis Shelter Guidelines Development (Metro Transit, 2015).

The following transit amenities have the greatest potential for improving the transit riding experience. Each of these amenities should be placed out of the sidewalk and not block pedestrian circulation, even when occupied, or access to the shelter and transit stop for people using mobility aids. Shelters should be accessible to individuals with disabilities (U.S. Access Board, 2011). For example, those using mobility aids need to have the necessary space to access the ramp or lift on the transit vehicle.

Seating/resting areas – These structures can take the form of benches to seats attached to the transit stop sign pole to leaning posts. They provide a spot for passengers to wait and can be critical for those disabled individuals with additional needs, older adults, pregnant, young, or those facing challenges that may not be visible. These should be placed in a location that is convenient to the stop so that passengers can see approaching transit vehicles.

Shelters – These structures provide some sort of protection from the weather, like shade from the sun and protection from rain and snow. Some shelters provide shields in the front to protect waiting passengers from water splashed from passing vehicles. Shelters are generally located conveniently near the stop so that passengers can see approaching transit vehicles.

Bicycle parking – This can include bicycle racks, lockers, parking, and security. Bicycle parking is important because bicycles fulfill many transit riders' first and last mile needs—helping them to get to the transit station but allowing them to leave the bicycle there if they chose/could not take it on the transit vehicle.

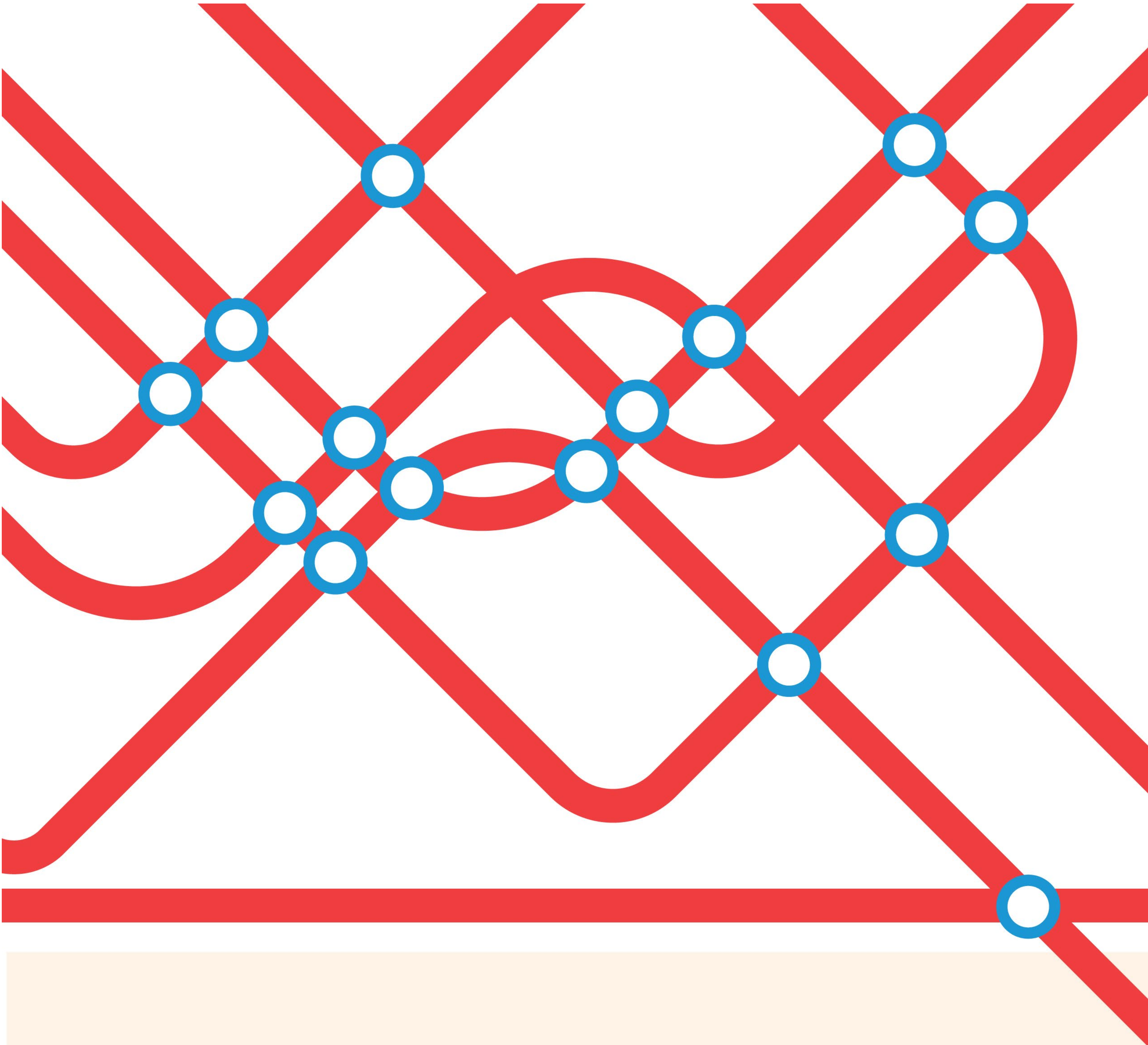
- *Bicycle racks* are a structure where riders can secure their bicycles. Bicycle racks can be simple in design but are also the most vulnerable of all the bicycle parking options.
- *Bicycle lockers* offer a more secure parking option. These are locked containers that hold individual bicycles and are accessed with a key. Because they are compartmentalized, the lockers prevent theft and shelter bicycles from the weather.
- *Bicycle parking and security* are also a more secure form of bicycle parking. This type of parking includes a room for bicycle storage and may include video surveillance.

Mobility Hubs and Micromobility

Mobility hubs are co-located modes of transportation such as shared use mobility devices (e.g., bicycle share, electric scooters), ridesharing options, and electric vehicle charging, as illustrated in figure 49. The hubs are typically connected through some form of digital infrastructure that allows people to link trips together on various modes with the ease of using an application on their phone.

Co-locating services helps to close the gaps in an individual trip and provides flexibility in modal choice. It also helps to solve the first-mile/last-mile problem of how to connect people from their origins and destinations to transit stops, which could increase transit ridership. For pedestrians and bicyclists, mobility hubs could mean a reduction in crashes with motorized vehicles due to reductions in the volume of vehicular traffic. This might also mean an increase in pedestrian and bicyclist volumes or sharing space with other micromobility options, such as electric scooters. Most electric scooters are to be operated in the street or in bicyclist facilities, as indicated in the rental agreements and backed by State and local laws. However, these devices oftentimes are operated on the sidewalks, where they travel at much higher speeds than pedestrians. The speed discrepancy could lead to crashes between the two. Additionally, while sidewalks might provide a nice smooth surface for operating electric scooters, sidewalks and curb ramps were not designed for the speeds that are possible on electric scooters. Another potential impact of micromobility devices includes device placement in public right-of-way when they are no longer in use. Although micromobility users are provided guidance on where to leave the devices when the trip is finished, they are sometimes left obstructing sidewalks, curb ramps, or transit stops. Improving bicyclist facilities to include buffers or physical barriers from vehicular travel lanes could help minimize potential among bicyclists, pedestrians, and micromobility users.

Figure 49. Graphic. Visualization of mobility hub services (CoMoUK, 2019).



6 Overcoming Barriers to Safe and Accessible Transit

Transit agencies can adopt numerous changes to reduce accessibility barriers for current and potential transit riders. These include addressing driver behavior near transit stops, co-locating mobility options, incorporating technological solutions that benefit all riders, addressing sidewalk maintenance options, and resilience planning for emergency response. Together, these advances support transit use by more people of all ages and abilities and help agencies to grow and adapt to changing conditions and needs.

Changing Driver Behavior Near Transit Stops

Pedestrian and bicyclist safety near transit stops is a critical issue for overcoming access to transit. As identified in **chapter 2**, proximity to transit stops is a risk factor for both pedestrians and bicyclists. Transit agencies can implement programs and physical improvements—or work with partner agencies—to reduce the risk of injury to riders.

One option to reduce crash risk at transit stops is the initiation of a High Visibility Enforcement (HVE) program to encourage increased yielding to pedestrians and bicyclists and safer passing. An HVE is often a multiphase campaign of both education to community members and enforcement of driver yielding at targeted locations by law enforcement. The education on yielding and passing laws precedes the enforcement phase, and it may include radio ads, TV commercials, and outreach to schools and community groups. Enforcement then occurs where motorists are ticketed for failure to yield to pedestrians in crosswalks; this activity may be conducted in waves, first with warnings, and then followed by traffic citations. Research on HVE in Saint Paul, Minnesota found that while motorist yielding was lower at crossing locations near transit stops compared to other locations, yielding rates increased and passing behaviors (that would create multiple threat crash situations) decreased following the HVE campaign (Craig et al., 2019).

Other improvements like parking restrictions to improve pedestrian and bicyclist visibility can modify driver behavior and reduce conflicts near transit stops. For example, FHWA collected case studies along transit corridors that illustrate how removing or restricting parking improves sight lines for transit operators and motorists and expands bicyclist and pedestrian facilities (Goughnour et al., 2016). Many of these modifications are also described in **chapter 5**.

Co-locating Mobility Options

Co-locating mobility options provides riders with a seamless transition between modes and the ability for cohesive trip planning from start to finish. However, limited right-of-way, drainage structures, street trees, and parking can limit transit stop placement and connectivity to other modes. These constraints may look different in rural and urban areas. For example, the lack of sidewalks, designated places to cross the street, and waiting areas are more pronounced in rural areas (Boyle, 2015). However, urban areas may not have sufficiently wide sidewalks or transit landing pads, which is the boarding and alighting area, that accommodates all users, including those with mobility devices.

When siting or improving transit stops, transit agencies may consider taking the following actions to address physical constraints:

- Engage and coordinate early on with local municipalities, counties, and States for developing Better Bus Stop programs, and addressing missing pedestrian and bicyclist facilities and transit stop design (Boyle, 2015).
- Communicate the importance of transit and proactively seek out the relevant agencies to both help them understand and clarify the transit agency's space needs so they can be appropriately balanced with the other competing space demands (Boyle, 2015).
- Prioritize accessibility.
- Develop a customized bus stop design and location guidance document so that the agency can be more effective in communicating its needs with local jurisdictions and developers and permit flexibility when needed. Guidelines can also support decision making for when to provide amenities at a given stop (Boyle, 2015).
- Consider bus stop balancing for stops with safety and accessibility issues (Miatkowski and Hovenkotter, 2019). Transit agencies may consider removing low performing stops or those with safety concerns to prioritize improvements at nearby stops with greater right-of-way for amenities, improving crossing locations, and connecting pedestrian and bicyclist facilities.
- Consider the tradeoffs to other modes, such as parking removal or lane reconfigurations, to accommodate transit stops. For example, a floating stop may be preferred for the co-location of a separated bicycle lane along a higher frequency route. The floating stop would remove fewer parking spots than a mixing zone (e.g., 40 feet versus 80 feet for the bus zone) and would reduce conflicts for bicyclists but would come at higher financial costs.
- Reassess mobility policies to create mode-agnostic mobility goals, such as those that promote reducing fatal and serious injuries for all road users and access to healthy food options (Evenhouse et al., 2019). These types of policies could support more comprehensive management of limited right-of-way. For example, this could include prioritizing the integration of active transportation like bikeshare with transit stops or the targeted removal of parking stops to allow for marked enhanced crossings to transit.

WMATA Principles for Bus Stop Design Principles

As part of its Metrobus Customer Experience Plan, the Washington Metropolitan Area Transit Authority (WMATA) developed several resources to improve transit access including an asset inventory, bus stop guide, and wayfinding strategy. The Bus Stop Amenity Reference Guide provides guidance to partner agencies and jurisdictions on the elements for basic, enhanced, and transit center stops (WMATA, 2019). The resource includes thresholds for when to include features such as lighting and shelters and when to consider optional bus stop enhancements.

The WMATA bus stop guidance also establishes objectives and principles for supporting bus stop development and providing partner agencies the flexibility needed to address constrained environments. First, the guide's objectives include maximizing customer comfort and safety, ensuring that bus stops are easily identifiable, creating a predictable waiting experience, and striving for accessibility and equity. These are intended to influence the outcomes of stop placement and co-located amenities. Second, the guide recognizes the constraints of the built environment and proposes the following two principles that should inform all bus stops (WMATA, 2019):

- **Flat** – the grade of sidewalks, crosswalks, and curbs should conform with ADAAG guidelines to facilitate wheelchair movement to and around the bus stop area.
- **Clear** – crosswalks, sidewalks, and any paths used by customers to access the bus stop and its amenities should be unobstructed to allow free movement.

Together, the guide's objectives, principles, example design drawings, and guidelines help inform the discussion among transit practitioners on constraints and tradeoffs without compromising the essential elements of access.

Technological Solutions to Route Planning

The use of technology can support improved transit route planning, increased access to transit, and the co-location of other mobility services. Transit agencies typically know when people board the bus with fareboxes but may not have accurate information on where riders alight. Similarly, a fare card that can be used for transit and other mobility options could provide insight into ridership data on multimodal trips. AVL and Automatic Passenger Counters (APCs) are common among medium and large transit agencies to help gather alighting data. Route, trip, and segment level data can assist transit planners in optimizing route planning and design (Byala et al., 2021). This information can complement rider intercept surveys in determining demand for new and underserved routes.

Transit agencies are also using "big data" to enhance the route planning process. In a survey of its member transit agencies, the APTA reported that some agencies are analyzing ridership data from mobile fare apps to track trips and transfers across regional transit agencies to support improved service planning (Dickens and Hughes-Cromwick, 2019). Additionally, location-based cell phone data is also used to help identify potential transfer and connection points between routes and determine route patterns (Dickens and Hughes-Cromwick, 2019). The use of "big data" from regional travel demand models and purchased sources can help illustrate where demand for travel exists that would not be known through traditional community outreach and surveys.

Route planning can also integrate connections with modes and services to improve access and mobility for riders. These connections can include payment coordination with TNCs, co-located mobility hubs, transfers to demand response transit (DRT), and coordination for first-mile/last-mile connections (Byala et al., 2021). Forms of DRT include microtransit, paratransit, subsidized rideshare programs, and fixed deviated route services, all of which operate according to a rider request via mobile applications or phone calls to a call center. Microtransit is a form of DRT that involves using vehicles, such as vans and shuttles, to move multiple riders from their respective origins and destinations simultaneously along a dynamically generated route within a designated region or zone. For example, Montgomery County, Maryland started a microtransit pilot service to help fill the first-mile/last-mile connection to and from two local light rail stations (Montgomery County DOT, 2021).

Finally, outreach to riders in the route planning process is essential, especially to disadvantaged and diverse populations. For example, during route planning for the greater Baltimore area BaltimoreLink bus service, engagement with low-income residents illustrated that riders and potential riders were more willing to walk to high frequency transit if their issues of personal safety at night were addressed (Byala et al., 2021).

Addressing Sidewalk Maintenance

Sidewalks are an essential part of the pedestrian transportation network. In many jurisdictions in the United States, individual property owners are required to maintain the portion of sidewalk within their property. Because of this, it can be challenging to preserve a connected, accessible, and continuous network of sidewalks. Some homeowners may not have the funds to repair cracked or damaged sidewalks. In the case of abandoned properties, it may be difficult to track down a responsible party and hold them accountable for the upkeep. Some agencies are exploring options to mitigate these issues, either through cost-sharing programs, grant programs, or taking over the cost of maintenance. The following are a listing of example agency programs to help defray the burden of sidewalk maintenance from individual property owners, ultimately helping to maintain an accessible and continuous surface for pedestrians.

Agencies with cost-sharing programs for sidewalk maintenance:

- City of San Diego, California (The City of San Diego, 2021):
    - The City pays for 50 percent of the eligible replacement cost and the property owner pays the remaining 50 percent. The fee is based on a per square foot cost and is the same for all neighborhoods throughout the city.
- The City of Naperville, Illinois (City of Naperville, 2021):
    - The City dictates that public sidewalk maintenance is the responsibility of the adjacent property owner. The City has implemented a cost sharing sidewalk program to assist property owners in the upkeep of public sidewalks located throughout the city.

- For sidewalks adjacent to residential properties, the City pays 60 percent and the resident pays 40 percent.
- For sidewalks adjacent to multifamily and commercial properties, the cost is split 50-50 between the City and property owner.
- For multifrontage residential lots, the City pays 60 percent for the shorter frontage and 75 percent of the longer frontage; the homeowner pays the balance.

- St. Louis, Missouri (City of St. Louis, 2021):
  - Property owners are required to maintain their sidewalks in good repair. The City offers owners a cost sharing option through the 50-50 sidewalk program.
- Salt Lake City, Utah (Salt Lake City, n.d.):
  - The repair or replacement of deteriorated sidewalk, drive approach, and curb and gutter in the public way is the responsibility of the adjacent private property owner. Property owners can hire a contractor to accomplish the necessary concrete repairs, which requires a permit to work in the public way, or property owners can take advantage of the 50-50 concrete program.
- City of San Antonio, Texas Sidewalk Rebate Program (City of San Antonio, 2021):
  - Any residential sidewalk within the city limits can be considered under the program.
  - An eligible project scope and rebate estimate will be provided by the property owner conducting repairs.
  - Once repairs are finished, the adjacent property owner submits their completed rebate forms and the copy of invoice (or receipt) from the contractor itemizing work and costs. Once repairs have been inspected and approved, the property owner will receive a rebate check by mail for the eligible amount of the repair cost, not to exceed $3,000.

Roadway agencies that have a grant program for sidewalk maintenance:

- The City of Madras, Oregon (The City of Madras, n.d.a; The City of Madras, n.d.b):
  - The City recognized the cost to repair sidewalks due to damage caused by street trees was causing a significant financial burden to businesses. They created the Downtown Sidewalk Repair Grant to help defray those costs.
  - Eligible Uses of Grant Funds:
    1. Applications will only be accepted for commercial properties in the downtown where there is a street tree planted.
    2. Property owners may only apply for one grant for one property in a calendar year.
    3. First time applicants will be given priority over previous applicants.
    4. Applications must be received and approved by the City prior to any work being performed. Retroactive applications will not be accepted.

Cities that maintain their own sidewalks:

- Austin, Texas (Smart Cities Dive, n.d.; City of Austin, n.d.):
    - The City took over responsibility for sidewalk maintenance in the mid-1990s, but did not have a funding strategy that could generate enough revenue to ensure a high level of accessibility. By providing a Federal regulatory framework, the ADA helped reframe how the City repairs and replaces sidewalk through the development of a new sidewalk program that uses a scoring system to rate sidewalks by condition and prioritizes them based on the repairs needed to provide accessibility. Details in Austin's Sidewalk Master Plan state that ADA compliance is a requirement for any project to attain funding.
- Washington D.C. (Smart Cities Dive, n.d.):
    - City residents can report any sidewalk that needs service, specifying the location, type of pavement, and severity of the problem. The City ensures an investigation within 10 days but warns that more labor-intensive repairs depend on available resources.

Resilience Planning for Emergency Response

In the case of emergencies—weather, public health, or other situations—transit agencies may alter or reduce service. Because of this, it is important for roadway owners and transit agencies to work together to develop a relationship and framework that allows them to adapt quickly to the changing environment.

This type of resilience planning can include changing routes or stop locations and/or modifying the way services are provided. By engaging in resilience and scenario planning, stakeholders can work together to come up with contingency plans. These plans should consider how people will access the transit stops, the space needed at that transit stop, the need for service changes, and how people will access new routes (FTA, 2021).

It is important to note that some forms of transit may be more adaptable than others. For example, rail services and stations are fixed so the types of changes possible are more limited. However, because of their singular use—that of serving transit riders—they may be less impacted by changes due to emergencies. Buses are an example of a much more adaptable form of transit. They can easily be rerouted due to flooding and roadway closures. However, communicating changes in a rapidly evolving situation can be challenging. Sometimes changes can be communicated through websites or mobile applications. In the absence of these tools, riders may be notified via a posting at the transit stop. In that event, it may be necessary for the transit agency to work with the roadway owner to make sure that riders have access to the new transit stop location. This could include the creation of temporary walkways along roadways such as those found in work zones or warning signs to drivers notifying them of new/temporary transit stops. ATSSA provides a checklist (included in Appendix A) for pedestrian facilities in work zones that might be helpful for transit agencies and roadway owners to consider if a temporary route change is necessary.

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7 Appendix A

RSA Prompt List Excerpt

(Source: FHWA Pedestrian and Bicyclist Road Safety Audit (RSA) Guide and Prompt Lists)

Appendix B: Prompt List

Location	Physical Environment / Infrastructure					
	Presence/Placement	Quality/Condition	Connectivity/ Consistency	Visibility	Lighting	Transit
Universal Considerations for Study Area	• Do facilities address ped and bike needs, including those with disabilities? • If future changes are proposed to the transportation system or surrounding land use, will those needs still be met?	• Are ped and bike facilities in good condition and accommodate users with disabilities?	• Are safe, continuous, and convenient ped and bike routes provided throughout the study area?	• Do obstructions block the view of roadway users? • What obstructions block the view of pedestrian and bicycle facilities (e.g., crosswalks, traffic control devices, signs)? • Does the sun create visibility issues at certain times of day?	• Are ped and bike facilities well-lit? • Can peds and bikes be seen by motorists during dark conditions?	• How does transit infrastructure interact with ped and bike facilities?
Along Street (including driveways)	• How are peds and bikes accommodated on both sides of the road? • Are facilities shared, separate, or buffered? • What is the comfort level for users? • Are ped and bike facilities appropriate for the adjacent land use? • Do parked vehicles obstruct ped paths? • Does parking adversely affect bike safety?	• Are the bike/ped facilities in good condition and well-maintained? • Are there obstacles (e.g. utility poles or signs) in the pedestrian travel path? • Are the sidewalks wide enough for two people to walk together? • Does vegetation or debris infringe on pedestrian or bicyclists facilities? • Is the pavement free of obstacles (e.g., potholes, drainage grates, longitudinal joints)?	• How are peds accommodated at driveways/ access points? • Are ped walkways continuous? • Are bike routes continuous?	• Are there obstructions blocking the driver's view of peds and bikes? • Are driveways designed with peds and bikes in mind (e.g., less driveway density, access management, proper signage, pavement markings)?	• Are sidewalks and bicycle facilities adequately lit?	• Are there sufficient boarding areas (5 feet along curb, 8 feet perpendicular to curb line) and visibility at transit stops? • Do ped and bike facilities connect to transit stops?

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Pedestrians Checklist and Considerations for Temporary Traffic Control Zones

(Source: ATSSA)

Pedestrian Considerations: Updated Checklist for Temporary Traffic Control Zones

Header Images: FHWA, Getty

For those who plan, design, construct, and maintain temporary traffic control (TTC) zones in the public right-of-way, there are several resources that provide requirements and guidance on accommodating pedestrians as part of the TTC setup. Chapter 6D of the *2009 Edition of the Manual on Uniform Traffic Control Devices* contains provisions for pedestrian and worker safety. Title II of the Americans with Disabilities Act of 1990 (ADA) prohibits discrimination on the basis of disability. Since no Federal standard governing work zones has been adopted under the ADA, agencies have some degree of flexibility in determining how they will comply with the general accessibility requirements under Title II of the ADA. Public entities may turn to different resources for guidance when determining how to ensure accessibility. Two resources often referenced are the *"2011 Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way"* and the *"2013 Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way; Shared Use Paths,"* proposed regulations published by the U.S. Access Board.

This updated checklist summarizes existing resources and provides work zone pedestrian access considerations for the planning, design, and construction phases of a project. It is intended for use by planners, designers, inspectors, and other construction personnel, including those responsible for utility and maintenance work.

Pedestrian Considerations during Planning and Design

Source: ATSSA

Planning

- ☐ Project scoping activities include provisions for accessible, detectable, safe, convenient travel paths for pedestrians that replicate, as nearly as possible, the most desirable characteristics of the existing sidewalks or footpaths throughout all phases of construction.
- ☐ Temporary facilities replicate, as nearly as practical, the accessibility features present in the existing pedestrian facility, when the existing facilities are disrupted, closed, or relocated in a TTC zone.
- ☐ The project avoids pedestrian conflicts with work site vehicles, equipment, operations, and mainline traffic.
- ☐ The project considers and mitigates pedestrian impacts caused by TTC activities, including access to significant generators such as schools, senior centers, transit stops, and shopping areas.
- ☐ Project staff meet with local community organizations (i.e., local ADA[1] advocates or city ADA coordinators) through open houses to address concerns and needs.
- ☐ Project includes project-specific outreach products in accessible formats for individuals with disabilities.

[1] ADA: Americans with Disabilities Act.

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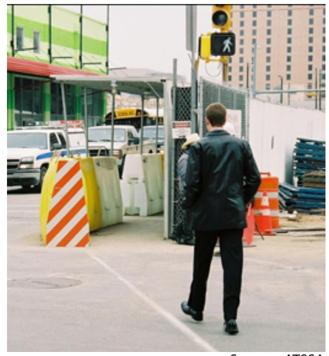
Pedestrian Considerations: Updated Checklist for Temporary Traffic Control Zones

Design



Source: ATSSA

- ☐ The design provides for advance pedestrian information, transition information, project information, points of contact, and ingress and egress directions for pedestrians, including pedestrians with a variety of disabilities (e.g. mobility, vision, hearing, cognitive).
  - Consider a proximity-activated 'audible sign' to give notice of a detour route and provide other applicable project-specific details.
- ☐ The project maintains accessible pedestrian access to businesses, residences, transit stops, and other access points.
- ☐ The project provides temporary nighttime lighting for pedestrian walkways throughout the TTC zone.
- ☐ The project signs each Temporary Pedestrian Access Route (TPAR)[2] at intersections rather than mid-block locations. Agencies define the TPAR as an ADA compliant route that guides pedestrians through or around the work zone. Pedestrians must be warned in advance of changed conditions and their options for alternate routes, and temporary routes must be accessible.
- ☐ Detour routes are accessible, detectable, and clearly communicated by signs and TTC devices.
- ☐ Temporary or alternate routes include accessible devices to delineate and allow detection of the pedestrian path and include curb ramps as needed.
- ☐ The design includes paths that separate pedestrians from vehicular traffic, with similar lengths to the original pedestrian routes.
- ☐ The design includes covered walkways, where needed, to protect pedestrians from falling debris hazards.
- ☐ The design maintains access to existing transit stops or includes the relocation of transit stops with an accessible path to temporary boarding and alighting areas.
- ☐ The project features are completely documented, including all aspects considered, and all information is saved in the permanent project record file.
- ☐ To avoid discriminating against individuals with disabilities, the project should include the following provisions.
  - The project provides an alternate route when existing pedestrian facilities are disrupted, closed, or relocated in a TTC zone. Temporary facilities replicate the accessibility features present in the existing pedestrian facility.
  - The project uses water-filled barriers, concrete barrier, or other longitudinal channelizing devices that are detectable for pedestrians with visual disabilities (see sections 6G.05, 6F.63, 6F.68, and 6F.71 of the MUTCD). Detectable devices have a solid toe rail covering an area 1.5 to 6 inches above the ground. Note that the use of caution tape stretched between traffic control devices is not adequate and not acceptable. Avoid encroachment into pedestrian facilities by signs, the legs of stands, or barricades.
  - Additional devices communicate traffic control messaging to individuals with visual or other disabilities, such as audible information devices or accessible pedestrian signals.

[2] See draft MNDOT guidelines for illustrations of TPAR features:

http://www.dot.state.mn.us/trafficeng/workzone/ADA/DRAFT-TPARGuidelines.pdf

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Pedestrian Considerations: Updated Checklist for Temporary Traffic Control Zones

Design Recommendations:

- Provide a minimum sidewalk width of 4 feet (a 5 foot width is desirable), erect parallel or perpendicular curb ramps with raised sides and slopes not exceeding 12:1, and provide passing space (a minimum 5 foot by 5 foot space every 200 feet where full 5 foot temporary sidewalks are not feasible). Cross slopes for ramps must not exceed 1:48 (2%).
- Maintain a firm, stable, and slip resistant surface to eliminate barriers to wheelchair use and to avoid tripping hazards (elevation changes greater than ¼"). Surface openings are to be no more than ½" in the direction of travel. Ensure all grade breaks are flush and include detectable warning surfaces where the temporary sidewalk meets the street.

Pedestrian Considerations in the Field

Construction/Maintenance/Utility

☐ Public notices for construction projects include information about pedestrian closures and detours with specific outreach to organizations representing people with disabilities.

☐ Construction phasing considers continuous access through or around the impacted area. For example, removing curb ramps at all four corners of an intersection simultaneously will reduce access.

☐ TPARs are readily accessible and usable by individuals with disabilities, to the maximum extent feasible, and infeasible items are documented.

☐ The path is maintained and clear of debris and other items that may obstruct pedestrian access. Temporary routes and ramps are stable with non-slip surfaces.

☐ At intersections, pedestrian access is controlled, and traffic control devices provide advance notification of sidewalk closures and guidance to safe crossing locations including audible messages.

☐ The pedestrian signal head is clear of visual obstructions such as fencing and/or equipment.

☐ Additional signing/markings are installed, and transit stops are added or relocated, as necessary.

☐ Physical barriers separate pedestrians from vehicular traffic, and protective features are installed as needed. Pedestrians are protected from the work space with barricades detectable by cane, and barricades are continuous, stable, and non-flexible.

Field Device Criteria: Consider barricades with a solid toe rail covering an area 1.5 to 6 inches above the ground. The top of the barricade should be 36" to 42" in height with diagonal strips having at least 70% contrast. Also see MUTCD references listed above for additional detail.

☐ Signs are adequately placed so that pedestrians are not confronted with mid-block obstacles on or above the TPAR. Signs and other devices mounted lower than 7 feet above the TPAR do not project more than 4 inches into the accessible path. Information on signs is communicated to pedestrians with visual or other disabilities.

☐ Temporary traffic signals are modified or installed, including pedestrian signals and push buttons, as necessary. Ensure pedestrian clearance times adequately account for walking speeds and travel distances. Ensure that push buttons are accessible to pedestrians with disabilities.

☐ Inspections include pedestrian accommodations during construction, and an appropriate timeline for inspection is being followed.

☐ Traffic control devices and the pedestrian area are in well-maintained and safe condition and are accessible, clean, sturdy, firm, smooth, continuous, detectable, and do not pose tripping hazards.

Helpful Resources

2011 Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way: https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines

2013 Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way; Shared Use Paths: https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/shared-use-paths/supplemental-notice

Accessible Design for the Blind: www.accessforblind.org

Accessible Sidewalks Video Series: https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/guidance-and-research/accessible-sidewalks-video-series

Source: ATSSA

Accommodating Pedestrians in Work Zones Webpage: https://www.workzonesafety.org/topics-of-interest/accommodating-pedestrians/

ADA Best Practices Tool Kit for State and Local Governments: https://www.ada.gov/pcatoolkit/toolkitmain.htm

ADA Best Practices Tool Kit for State and Local Governments, Chapter 6, Curb Ramps and Pedestrian Crossings: https://www.ada.gov/pcatoolkit/ch6_toolkit.pdf

ADA Best Practices Tool Kit for State and Local Governments Chapter 6, Addendum: Title II Checklist: https://www.ada.gov/pcatoolkit/ch6_chklist.pdf

Applying the Americans with Disabilities Act in Work Zones: A Practitioner Guide: https://www.workzonesafety.org/training-resources/fhwa_wz_grant/atssa_ada_guide/

FHWA Pedestrian and Bicycle Safety Website: https://safety.fhwa.dot.gov/ped_bike/

Minnesota DOT Guidance for Temporary Pedestrian Access Route Facilities and Devices: http://www.dot.state.mn.us/trafficeng/workzone/ADA/DRAFT-TPARGuidelines.pdf

MUTCD Part 6: Temporary Traffic Control: https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/part6.pdf

Temporary Facilities Advisory Report: https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/background/access-advisory-committee-final-report/x03-temporary-facilities-and-construction

U.S. Access Board (http://www.access-board.gov)

U.S. Access Board Guide to the ADA Standards - Chapter 4: Ramps and Curb Ramps: https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/guide-to-the-ada-standards/chapter-4-ramps-and-curb-ramps

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