Chapter 7: Multimodal Project Design – Approaches for Different Modes

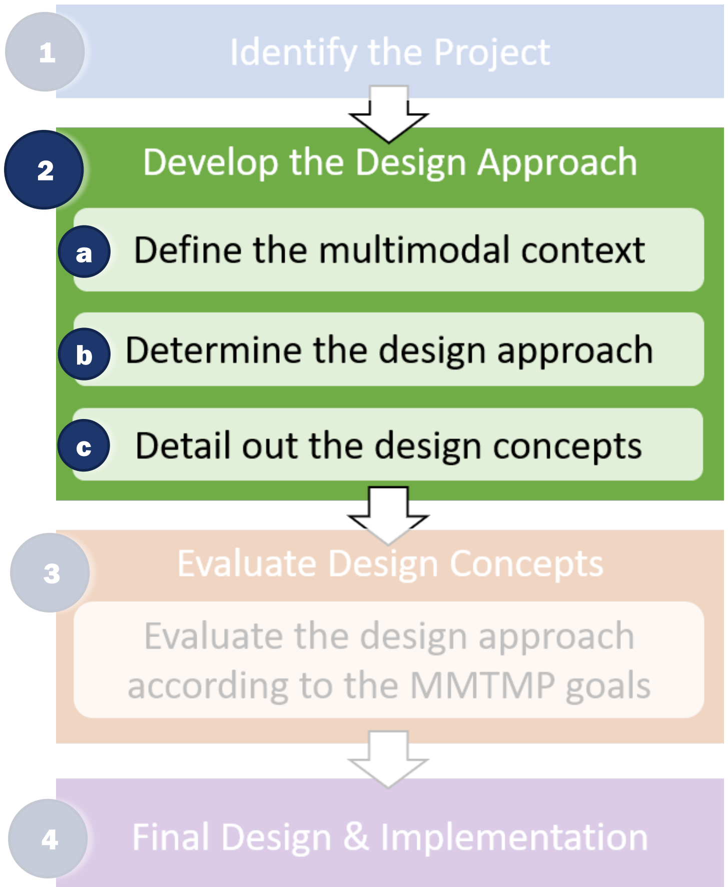
This chapter continues exploring the Multimodal Project Design Framework, focusing specifically on Step 2b: *Determining the Design Approach* and Step 2c: *Detailing Out the Design Concepts*. It provides specific guidance and considerations for bicyclist, scooter, and transit modes. It also provides an example of how to use the Multimodal Project Design Framework on a hypothetical multimodal corridor.

Step 2b: Determining the Design Approach

After the multimodal context has been defined, the next step is to determine the design approach – the way in which each mode will be accommodated within the street. The design approach is heavily dependent upon the Modal Emphasis of the corridor and also depends on a variety of other factors.

This section focuses on types of facilities for bicyclist/scooter and transit modes. It defines the various types of facilities that may be appropriate in different circumstances for potential design approaches. It also provides design considerations for each potential design approach. The following sections are organized by the possible combinations of Bicycle/Scooter Modal Emphasis, Transit Modal Emphasis, and both.

The Multimodal Project Design Framework



Steps 2b and 2c of the Multimodal Project Design Framework are the focus of this chapter.

Design Approaches for Corridors with Bicycle/Scooter Modal Emphasis

The preferred bicycle facility for a corridor with Bicycle/Scooter Modal Emphasis is largely determined by the speed and volume of vehicles on the corridor. As the speed and volume of traffic increases, so does the need for physical separation between bicycle riders and vehicles.

There are three design approaches to accommodating bicycle riders on Norfolk's streets.

- Shared Lanes
- Conventional Bicycle Lanes
- Separated Bicycle Lanes

Shared Lanes

Shared lanes describe a configuration where bicycle riders share a general vehicle travel lane with motorized vehicles. This configuration may be the preferred approach on low-speed, low-volume streets. Some shared lanes can be considered "bicycle boulevards," where treatments such as shared lane pavement markings (aka sharrows), wayfinding signs, and traffic calming features are implemented to prioritize bicycle travel.[i] Generally, shared lanes have the lowest comfort at higher vehicle speeds and volumes, but they require the least amount of space within the corridor cross-section.

Conventional Bicycle Lanes

A conventional bike lane is a dedicated lane separated from the general vehicle travel lane by paint. Sometimes, additional striping provides a buffer between the travel lane and the bike lane. This is called a "buffered bicycle lane" and is considered a conventional bike lane. Conventional bicycle lanes more clearly require motorists to yield to bicyclists and have a higher level of forgiveness than shared lanes, but conflicts may occur anywhere within the facility because of the lack of a vertical separation element.

Separated Bicycle Lanes

A separated bicycle lane is one that is separated from vehicular traffic by a vertical separation element, which may include curbs, planters, bollards, flexible delineators, or parked cars. A separated bike lane can be located on the street or entirely outside of the roadway.

A shared lane design approach is where bicyclists share a lane with motorized vehicles. Shared lanes may have shared lane markings, also called "sharrows." Shared lane markings are not considered to be a bicycle facility; they are a pavement marking. Austin, TX. Image Source: NACTO

A conventional bicycle lane is a bicycle lane that is not vertically separated from vehicle travel lanes. Conventional bicycle lanes may be directly adjacent to the vehicle travel lane or may have a painted buffer. Fairfax, CA. Image Source: NACTO

Separated bicycle lanes are separated from vehicle travel lanes by vertical elements such as curbs, planters, bollards, flexible delineators, or parked cars. New York City, NY. Image Source: NACTO

Separated bicycle lanes reduce the potential for sideswipe, overtaking, and hit-from-behind crash types. They provide higher levels of safety and comfort than conventional bicycle lanes and increase predictability by constraining the location of conflict points.

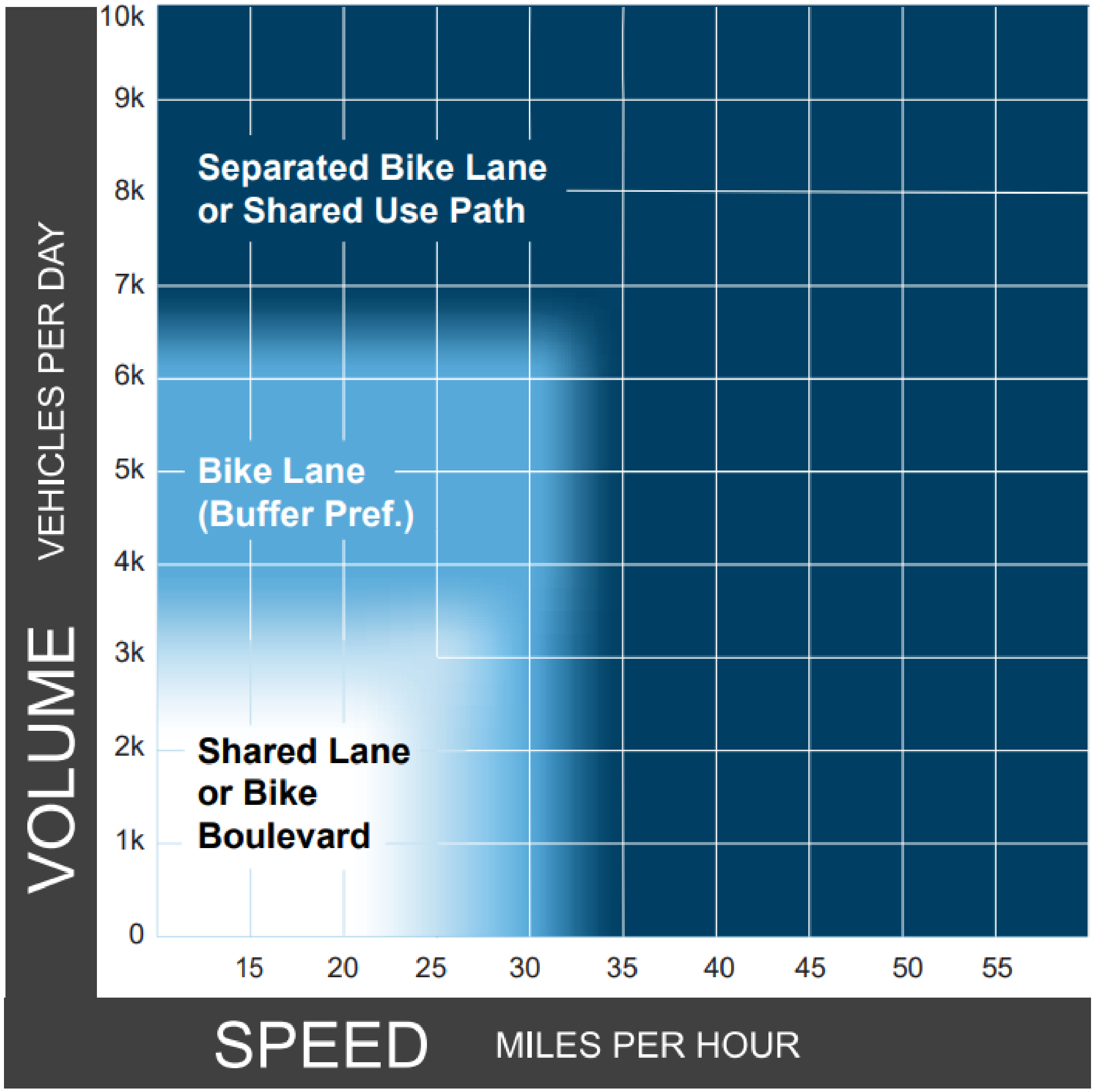
Considerations for Choosing a Design Approach for Bicycle/Scooter Modal Emphasis

The Federal Highway Administration published its *Bikeway Selection Guide* in 2019, and it further defines and compares these types of bicycle design approaches.

The FHWA Bikeway Selection Guide provides guidance for identifying the preferred design approach that meets the safety and comfort needs of the "Interested but Concerned" bicyclist type, as shown **Figure 7-1**. Generally, the higher the speed and volume of a road, the more protective the preferred design approach.

The following paragraphs describe the federal guidance, which is based on a comprehensive literature review and recent safety studies. However, this is guidance for the optimal treatment not considering existing site conditions. It is important to recognize that Norfolk's rights of way are frequently constrained, and implementing this guidance on many of Norfolk's streets will require lane repurposing or road and building reconfigurations to acquire additional right-of-way.

FIGURE 7-1: FHWA GUIDANCE FOR PREFERRED BIKEWAY TYPES FOR URBAN, URBAN CORE, SUBURBAN, AND RURAL TOWN CONTEXTS



This reference chart from the Federal Highway Administration's 2019 Bikeway Selection Guide shows the optimal design approaches that meet the safety and comfort needs of the "Interested but Concerned" type of bicyclist, depending on traffic speed and volume. Norfolk's constrained rights-of-way and built out conditions will often make achieving these design approaches extremely difficult. However, when new streets are being planned, there may be an opportunity to implement these optimal approaches more fully. Image Source: FHWA

Assessing these types of approaches, particularly for converting travel lanes, is discussed in greater detail in Chapter 8: Multimodal Project Evaluation.

The FHWA guidance reflects the types of facilities that have been shown to best meet the safety and comfort needs of the majority of bicyclists. If the best approach is not feasible due to site conditions, the section below describes how to identify the next best option, which may be a higher-stress facility that serves only the "Highly Confident" bicyclist types or may be an alternate route. These are often tough choices with hard tradeoffs. The following guidance is intended to inform a discussion about these tradeoffs, recognizing that there are often no easy solutions.

Shared lanes can be a positive and affordable solution when designed correctly and used in the correct context.[ii] Shared lanes are most appropriate on roadways where the difference between bicyclist and motorist travel speeds is very low.[iii] Generally, shared lanes are considered the preferred design approach on local streets with operating speeds less than 25 mph and traffic volumes are less than 3,000 vehicles per day. Injury and fatality crash risks rise sharply for vulnerable users when motor vehicle speeds exceed 25 mph.[iv]

Exposure Level: High	Exposure Level: High to Medium	Exposure Level: Medium to Low	Exposure Level: Low

CONVENTIONAL BIKE LANES AND SHARED LANES

Bike lanes and shared lanes require bicyclists to share and negotiate space with motor vehicles as they move through intersections. Motorists have a large advantage in this negotiation as they are driving a vehicle with significantly more mass and are usually operating at a higher speed than bicyclists. This creates a stressful environment for bicyclists, particularly as the speed differential between bicyclists and motorists increases. For these reasons, it is preferable to provide separation through the intersection.

SEPARATED BIKE LANES WITH MIXING ZONES

One strategy that has been used in the U.S. at constrained intersections on streets with separated bike lanes is to reintroduce the bicyclist into motor vehicle travel lanes (and turn lanes) at intersections, removing the separation between the two modes of travel. This design is less preferable to providing a protected intersection for the same reasons as discussed under conventional bike lanes and shared lanes. Where provided, mixing zones should be designed to reduce motor vehicle speeds and minimize the area of exposure for bicyclists.

SEPARATED BIKE LANES THROUGH ROUNDABOUTS

Separated bike lanes can be continued through roundabouts, with crossings that are similar to, and typically adjacent to, pedestrian crosswalks. Motorists approach the bicycle crossings at a perpendicular angle, maximizing visibility of approaching bicyclists. Bicyclists must travel a more circuitous route if turning left and must cross four separate motor vehicle path approaches. Yielding rates are higher at single-lane roundabouts.[1]

PROTECTED INTERSECTIONS

A protected intersection maintains the physical separation through the intersection, thereby eliminating the merging and weaving movements inherent in conventional bike lane and shared lane designs. This reduces the conflicts to a single location where turning traffic crosses the bike lane. This single conflict point can be eliminated by providing a separate signal phase for turning traffic

bicycle → motor vehicle → conflict area ●

Intersections are points in the bicycle network where bicyclists are most vulnerable. Bicycle lanes that convert back to shared lanes at intersections provide little if any safety benefits. Separated bike lanes with mixing zones and through roundabouts provide moderate levels of protection. Fully protected intersections offer the highest level of safety for bicyclists and scooter riders. Image Source: MassDOT Separated Bike Lane Planning & Design Guide

However, shared lanes may be appropriate on streets with speed limits up to and including 35 mph[v] for the "Somewhat Confident" and "Highly Confident" types of bicyclists. The FHWA Bikeway Selection Guide indicates as motorized traffic volumes increase above 6,000 vehicles per day, it becomes increasingly difficult for motorists and bicyclists to share roadway space.

Shared lanes typically require no additional width within the corridor cross-section. In fact, providing wide outside curb lanes are generally not recommended, as research has shown they result in decreased bicyclist safety and are associated with higher rates of wrong-way bicycling.[vi]

Conventional bicycle lanes, including buffered bicycle lanes, generally improve bicyclist safety, but there are different factors that can influence the degree to which they reduce crashes.[vii] Bicyclists are most vulnerable at intersections. The majority of conflicts and crashes in urban areas between bicyclists and motorists are related to motor vehicle turning at intersections.[viii] Bicycle lanes that transition back to shared lanes at intersections provide little if any safety benefits at these most vulnerable points within the bicycle network. Conventional bicycle lanes with a buffer are the preferred design approach for corridors with Bicycle/Scooter Modal Emphasis whose posted speeds are between 25 and 35 mph and traffic volumes are between 3,000 and 7,000 vehicles per day.

On roadways where traffic volumes exceed 7,000 vehicles per day or where posted speeds exceed 35 mph, the preferred design approach is a vertically separated bicycle lane to accommodate the safety and comfort needs of the "Interested but Concerned" type of bicyclist.

For example, a bicyclist traveling at 10 mph on a roadway with 10,000 vehicles per day will be passed by a motor vehicle during the peak period once every four seconds, which is far too frequent for most bicyclists to feel comfortable.[ix]

Conventional bicycle lanes on streets with traffic volumes above 7,000 vehicles per day or speeds greater than 35 mph will serve the "Highly Confident" and "Somewhat Confident" types of bicyclists, but networks consisting of only non-separated bicycle facilities only have bicycle mode shares of 2 to 3 percent in the United States. Low-stress networks that provide separated facilities on these higher volume and higher speed streets are associated with bicycling rates of 5 to 15 percent in the U.S.[x]

*Federal guidance on an optimal design approach for accommodating bicyclists is outlined in **Figure 7-1**. The preferred design approaches in this chart are designed to meet the safety and comfort needs of most bicyclists and provide facilities for bicyclists of all ages and abilities.*

When the Preferred Design Approach is Infeasible

When the preferred design approach outlined in the chart in **Figure 1** is be infeasible due to right-of-way or other constraints, a *next best facility* should be identified, as well as a parallel route that would serve the same trip and provide a low-stress option.

For example, if a separated bike lane or shared use path is the preferred design approach based on traffic speeds and volumes, but this configuration is not feasible, then buffered bike lanes should be considered the next best option. The next best option may still be an appropriate solution to accommodate the safety and comfort needs of the "Highly Confident" and "Somewhat Confident" bicyclists directly on the project corridor.

As explained later in this chapter, one option for corridors with both Bicycle/Scooter and Transit Modal Emphasis may be to provide a shared multimodal lane where buses, bicyclists, and scooters can operate in the same lane, where car and truck traffic is prohibited.

In some cases. where the preferred design approach is not feasible, it is important to designate a *parallel route* that may be less direct than the accommodation directly on the project corridor but offers a more comfortable and safe facility.

It should be noted that even the provision of a next best option or the designation of a parallel route may prove infeasible in the near- and mid-term. When planning for bicycle improvements in the near- or mid-term, it is important to remember that this Master Plan and associated maps portray the long-term vision of connectivity, and it may take numerous incremental improvements to achieve the long-term vision.

Design Approaches for Corridors with Transit Modal Emphasis

Facility selection for corridors with Transit Modal Emphasis is driven by bus performance and traffic conditions on the corridors. In general, corridors where high traffic congestion or other friction factors cause slow bus speeds or unreliable bus travel times may need dedicated bus facilities. On the other hand, streets where traffic patterns result in low or consistent delays can likely accommodate buses in general travel lanes.

There are three design approaches to accommodating buses on corridors with Transit Modal Emphasis.

- General Travel Lanes
- Targeted Transit-Priority Elements
- Dedicated Transit Lanes

General Travel Lanes

The most common bus facility is a general-purpose travel lane where buses drive in the same lane as other vehicles. On streets where buses operate in the general travel lane, bus performance depends on the traffic conditions of the street.

Targeted Transit-Priority Elements

Under this approach, bus-priority interventions are targeted at points along a corridor to speed up buses. Transit Signal Priority (TSP) is one type of intervention often used in this approach. TSP allows traffic signals to detect approaching buses and change their timing so that buses move through intersections faster. Another type of intervention in this category is bus queue jumps. Queue jumps are installed at intersection approaches and allow buses to bypass the line of cars waiting at the intersection. Targeted transit-priority elements can significantly improve transit performance without making major corridor-long changes to a street.

Dedicated Transit Lanes

Buses can be given their own lane so that they are totally separated from traffic along the entire corridor. This approach gives the biggest boost to bus performance, but it also has the highest impact on other modes. There are several bus lane design options available, including curbside, offset (to the left of the parking lane), center-running (along a median), and a full transit-only street.

Queue jumps and transit signal priority are two types of targeted transit priority elements that can be implemented at high congestion spots along a corridor. Queens, New York. Image Source: NYCDOT

Dedicated transit lanes provide a separate lane for buses throughout an entire corridor. This approach gives the biggest boost to bus performance, but requires the most space within the cross-section. Washington, D.C.. Image Source: NACTO

Considerations for Choosing a Design Approach for Transit Modal Emphasis

Dedicated transit lanes provide for the most reliable transit operations, since buses are completely separate from vehicle traffic. However, they require an entire lane in the cross-section, which may be difficult to achieve. They may not be necessary on roads where there are few bus routes or where bus routes run infrequently.

Conversely, buses in shared lanes with traffic require no or minimal additional space within the cross-section. However, buses in shared lanes will get stuck in traffic, which on roads with heavy congestion can produce unreliable bus travel times.

Bus performance is one key factor to determining the preferred design approach for a corridor with transit modal emphasis. The frequency of buses and the space available within the cross-section are other important factors. **Table 7-1** outlines the design considerations for choosing a preferred design approach for corridors with transit modal emphasis.

There is considerable overlap between the design considerations, and this is intentional. There are often many other factors in circumstances that need to be considered, such as funding constraints, timeframe, and other demands on roadway space that will influence the selection of the preferred design approach.

Table 7-1: Design Considerations for Transit Modal Emphasis

		Design Considerations		
		Frequency of Buses	Performance of Buses	Impact to Roadway
Design Approach	General Travel Lanes	Appropriate where bus frequency is low (no more than 1 bus every 15 minutes).	Appropriate where buses operate with minimal delays and have reliable travel times.	No additional lanes needed. Buses operate in general travel lane.
Design Approach	Targeted Transit Priority Elements	Appropriate where bus frequency is moderate or high.	Appropriate to address delays in specific areas.	Additional lane may be needed at intersections.
Design Approach	Dedicated Transit Lanes	Appropriate where bus frequency is high (at least 1 bus every 15 minutes).	Appropriate where there are corridor-long delays or unreliable travel times.	Additional lane needed for entire length of the corridor.

When choosing a design approach for corridors with transit modal emphasis, it is important to consider the frequency of buses, bus performance, and the impact to the roadway.

Design Approaches for Corridors with Bicycle/Scooter Modal Emphasis and Transit Modal Emphasis

Some corridors in Norfolk are designated with both Bicycle/Scooter and Transit Modal Emphasis. To determine the preferred design approach on these corridors, you would first determine the preferred design approach for each mode separately.

You may determine that the preferred design for the bicycle/scooter modes is a separated bicycle lane and the preferred design for the transit mode is a dedicated transit lane. However, two separate facilities for bicycle/scooter and transit modes may not be necessary, or right-of-way constraints may make providing two separate facilities infeasible.

There are two potential design approaches in this circumstance, each with distinct considerations:

- Combined Bus and Bicycle Lane
- Separate Bus and Bicycle Lanes

Combined Bus and Bicycle Lane

A shared bus-bicycle lane (also called a "multimodal lane") is a single lane that is dedicated to only buses, bicycles, and scooters. Private vehicles like cars and trucks are typically not permitted in this lane, except for right turns at intersections in some configurations. The shared bus-bike lane provides an improvement in bus travel time and separates bicycle and scooter riders from general traf fic. This approach is appropriate where bus frequency is not very high and where there is enough street width available for a wide bus-bicycle lane. If bicycle volumes are very high, bus performance will be reduced. If bus volumes are very high, the facility will not be as comfortable for bicycle riders. Several cities have implemented shared bus-bike lanes across the U.S. Careful design of bus stops and intersections is critical to minimizing conflicts between buses and bicyclists/scooter riders and this is discussed in the following section.

Separate Bus and Bicycle Lanes

This design approach provides two separate lanes - one dedicated to buses and another dedicated to bicyclists and scooter riders. This is the ideal design approach and is preferred where either bus or bicyclist/scooter rider volumes are high.

A combined lane for buses and bicyclists in Philadelphia, PA. Image Source: NACTO


Separate dedicated lanes for buses and bicyclists in New York City, NY. The dedicated bus lane is on the right side of the street. The dedicated bike lane is on the left. Image Source: NACTO

Considerations for Choosing a Design Approach for Bicycle/Scooter and Transit Modal Emphasis

The frequency of buses, speed of buses, and space available within the cross-section are three major considerations for determining which design approach is preferred and feasible. **Table 7-2** outlines these considerations for both potential design approaches.

Separate bus and bicycle lanes may be the preferred design approach, but they require the most space within the corridor cross-section.

Generally, combined bus-bike lanes may be appropriate on corridors with few bus routes or where bus routes are infrequent and where bus speeds do not exceed 20 mph. When bus speeds exceed 20 mph or where buses are more frequent than 1 bus every 5 minutes, separate bus and bicycle lanes may be preferred.

The volume and demand of bicyclists and scooter riders is another consideration. Generally, combined bus and bicycle lanes work well when buses are infrequent, and bicyclist and scooter rider volumes are low. If buses become more frequent, the combined lane can begin to feel less comfortable for bicyclists and scooter riders. Conversely, if bicyclist and scooter rider volumes increase, the combined lane can work less efficiently for buses.

TABLE 7-2: DESIGN CONSIDERATIONS FOR CORRIDORS WHERE THE PREFERRED DESIGN APPROACH FOR BICYCLISTS/SCOOTER RIDERS IS A SEPARATED LANE AND THE PREFERRED DESIGN APPROACH FOR TRANSIT IS A DEDICATED TRANSIT LANE

		Design Considerations		
		Frequency of Buses	Speed of Buses	Impact to Roadway
Design Approach	Combined Bus and Bicycle Lane	Ideal where bus frequency is no more than 1 bus every 15 minutes. Potentially feasible where bus frequency is as often as 1 bus every 5 minutes.	Appropriate where bus speed is limited to 20 mph.	16-ft lane desired. Potentially feasible with a 12-ft lane.
	Separate Bus and Bicycle Lanes	Appropriate where bus frequency is more than 1 bus every 5 minutes.	Appropriate where bus speed is higher than 20 mph.	18.5-ft is the minimum width needed to accommodate a dedicated bus lane and a separated bike lane that do not share the same space. More width may be needed.

On corridors where the preferred design approach for bicyclists and scooter riders is a separated bicycle lane and the preferred design approach for transit is a dedicated transit lane, , examine the frequency of buses, speed of buses, and impact to the roadway to determine if bicycle/scooter and bus modes can share the same lane or if separate facilities are needed.

Considerations for Bus Stops Along Bicycle/Scooter Facilities

Regardless of whether dedicated facilities are provided for bicyclists or buses, conflicts between bicyclists and buses most often occur at bus stops and intersections. This is true even on streets where bicyclists, buses, and general traffic all share the same lane.

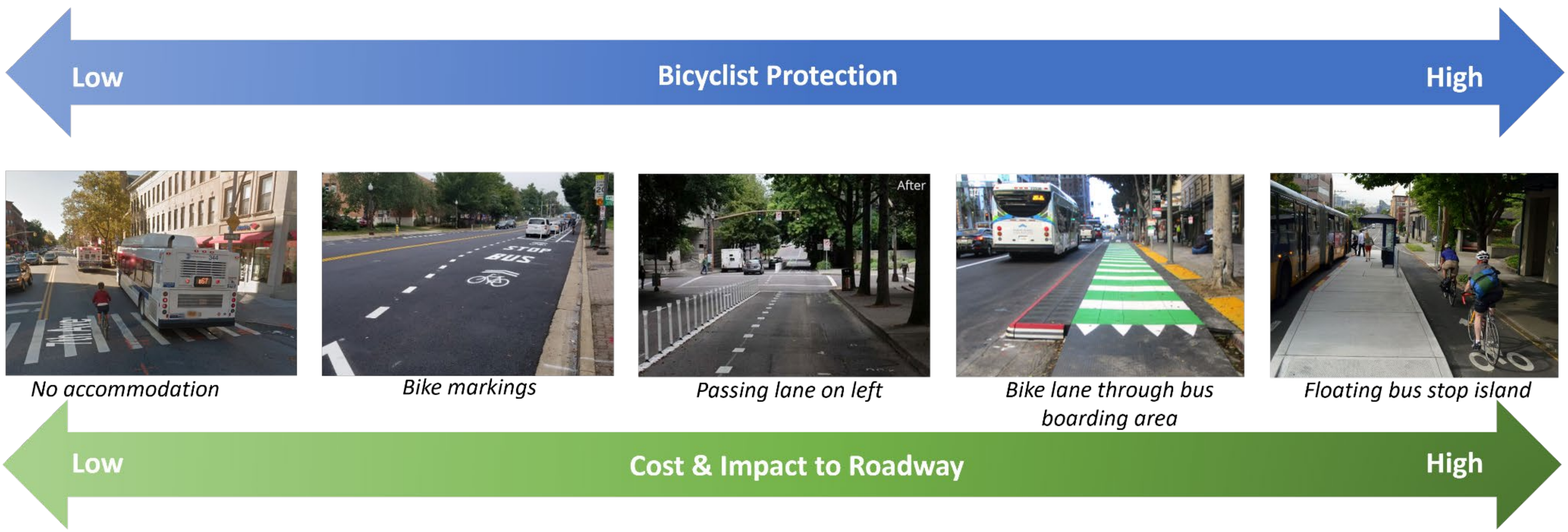
Bus stops can be designed to limit potential conflicts, and there are a variety of treatments available that provide a range of separation and protection, as shown in the figure below. These treatments can be applied to any design approach, whether dedicated facilities for either buses or bicyclists are provided along the length of the corridor.

The design approaches in the figure below range from simple configurations that provide little separation between the modes but require little if any additional space to complex designs that provide significant separation.

Generally, the lower the cost and space needed, the less the separation between bicyclist and bus conflicts.

Designs for intersections to maximize bicyclist protection are discussed under the Design Considerations for Bicyclist/Scooter Modal Emphasis section.

Design Approaches for Bus Stops Along Bicycle/Scooter Facilities



There are a variety of design approaches for bus stops along bicycle/scooter facilities that provide a range of separation between bicyclist and bus conflicts. Generally, the more separation provided, the more space is needed within the right-of-way and the higher the cost to implement.

Table 7-3 outlines several considerations for determining the preferred design approach for a bus stop along a bicycle/scooter facility.

A general rule of thumb is that the busier the bus stop and the higher the bicycle volumes, more separation is needed.

Table 7-3: Design Considerations for Bus Stops along Bicycle/Scooter Facilities

		Design Considerations			
		Bus Boardings and Alightings	Volume of Bicyclists and Scooter Riders	Impact to Bicyclists and Scooter Riders	Impact to Roadway
Design Approach	No accommodation	Appropriate where bus stop activity is low.	Appropriate where bike volume is low.	Provides minimal protection.	No additional lane width needed.
	Bike markings in bus stop	Appropriate where bus stop activity is low or moderate.	Appropriate where bike volume is low or moderate.	Provides minimal protection.	No additional lane width needed.
	Bike passing lane on the left	Appropriate where bus stop activity is moderate or high.	Appropriate where bike volume is moderate or high.	Provides some protection.	5 ft of additional lane width needed.
	Bike lane through bus boarding area	Appropriate where bus stop activity is moderate or high.	Appropriate where bike volume is moderate or high.	Provides high protection.	Additional width needed in the amenity or sidewalk element.
	Floating bus stop	Appropriate where bus stop activity is high.	Appropriate where bike volume is high.	Provides highest protection.	Additional roadway width needed to provide boarding island and bike lane.

This table outlines the design considerations for the various approaches for bus stop design along bicycle/scooter facilities.

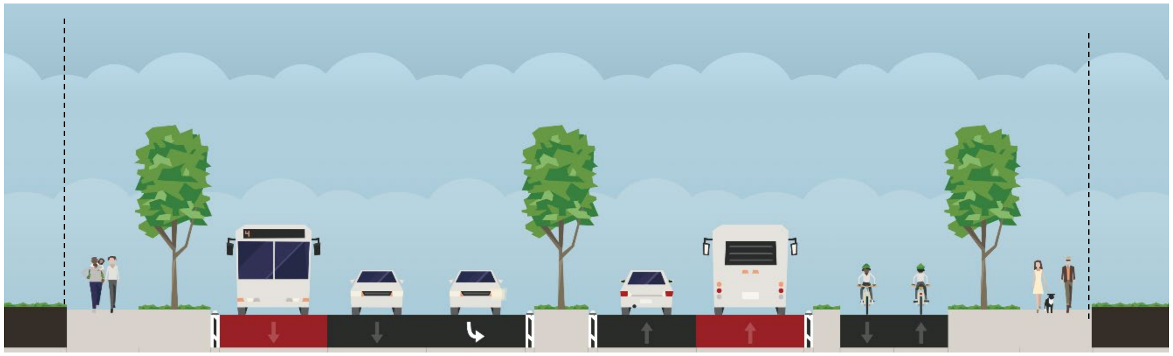
Wrap-Up on Step 2b: Determining the Design Approach

The previous sections have described a variety of design considerations for corridors with Bicycle/Scooter Modal Emphasis, Transit Modal Emphasis, and both that designers should consider in Step 2b: Determine the Design Approach.

The outcome of Step 2b is one or more preferred or desired design approaches for the corridor that spell out how each mode could be accommodated within the corridor cross-section, if feasible.

For example, one preferred design approach may be to provide dedicated transit lanes and a separated bicycle facility. This preferred design approach may require additional right-of-way and may be considered the long-term or vision design approach that could be feasible when an area redevelops. Another preferred design approach may be to provide a combined bus-bike lane without moving curbs by converting one general travel lane to a "multimodal lane." This preferred design approach may be considered a shorter-term design approach. Both preferred design approaches may be advanced into the next step.

This point in the process is a good time for another touchpoint with stakeholders and the public, especially when more than one design approach is being considered.



Several preferred design approaches may result from Step 2b: Determining the Design Approach. This illustration shows an example of a long-term or vision design approach for a multimodal corridor that requires additional right-of-way to provide dedicated bus lanes and separated bicycle facilities.

A less costly near-term preferred design approach may consist of restriping the lanes within the existing curbs to convert a general travel lane to a combined bus-bike lane.

The next step – Step 2c: Detailing Out the Design Approach – further fleshes out the design approaches into a design concept, which is described in the next section.

Step 2c: Detailing Out the Design Concept

After determining the preferred design approach, the next step is to detail out the design approach into a design concept with specific dimensions for each corridor element.

The design concept may be a corridor cross-section illustration with widths for each element within the cross-section, or it may be a plan view concept along a corridor including treatments for each segment and intersection.

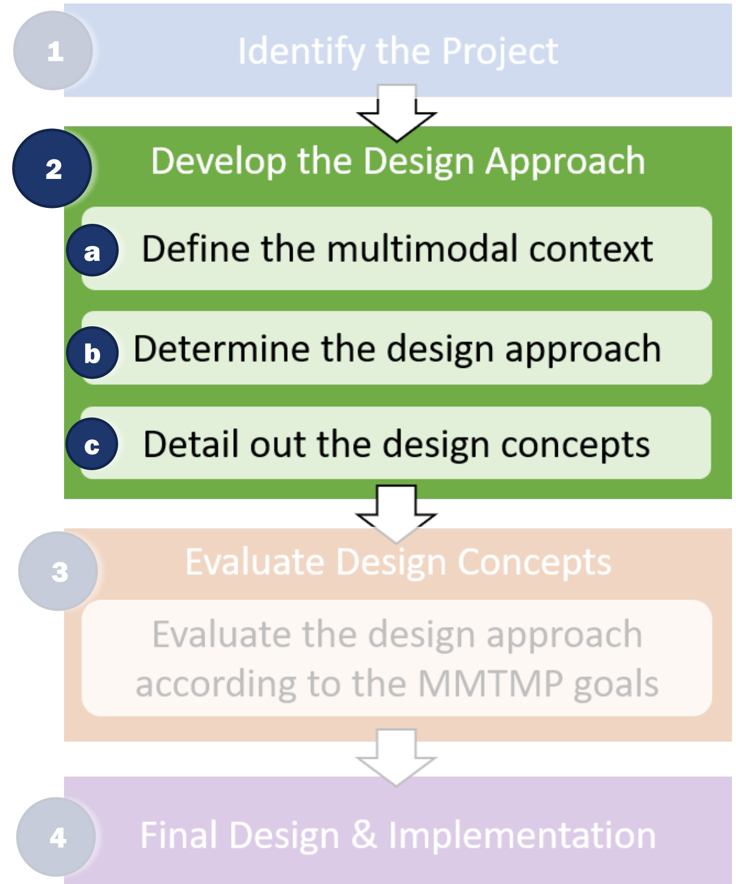
In this step, designers use the *Corridor Matrix* to determine the dimensions of each corridor element.

*The **Corridor Matrix** provides optimal and minimum standards for each Corridor Element.*

The design standards in the Corridor Matrix, provided in Appendix C, are shown as a range between two values – *optimal* and *minimum*. This range allows designers the flexibility to select a dimension for each corridor element anywhere within the range, depending on whether that corridor element should be optimized, minimized, or somewhere in between.

The Corridor Matrix comes from DRPT's Multimodal System Design Guidelines. The optimal and minimum values were developed based on the latest industry standard guidance from the American Association of State Highway Transportation Officials, the Congress for New Urbanism the Federal Highway Administration, the Institute for Transportation Engineers, and the National Association of City Transportation Officials. The Virginia Department of Transportation's (VDOT) Road Design Manual incorporates the Multimodal System Design Guidelines, including the Corridor Matrix and standards therein, by reference.

The Multimodal Project Design Framework



Steps 2b and 2c of the Multimodal Project Design Framework are the focus of this chapter.

The Corridor Matrix provides a range of dimensions for each Multimodal Corridor type and each Transect Zone. The Multimodal Corridor type and Transect Zone for the project corridor will have already been defined in prior steps in the corridor design framework.

The selection of a dimension for each corridor element will use the design considerations previously discussed in this chapter.

On corridors with Pedestrian Modal Emphasis, the sidewalk through element should be optimized as much as is feasible.

On corridors with Bicycle/Scooter Modal Emphasis, the preferred design approach should be consistent with the guidance for facility selection to provide a low-stress facility that serves bicyclists of all ages and abilities, and implemented if feasible. If not, the next best option should be considered, and a parallel route should be designated.

On corridors with Transit Modal Emphasis, the preferred design approach should provide a dedicated transit lane if needed and if feasible. If not, the outside travel lane width should be optimized for bus operations.

On corridors where it is not feasible to obtain the minimum dimension for one or more corridor elements, planners and designers should identify and assess opportunities and tradeoffs. These may include eliminating on-street parking or other curbside use, converting a general travel lane to another purpose, selecting a next best option for one or more

Corridor Element Key ⇩		CORRIDOR MATRIX Multimodal System Design Guidelines - 2020 Update					
	Corridor Type ⇨	Boulevard					
	Intensity ⇨	T-5		T-4		T-3	
	Context Zones & Corridor Elements ⇩	OPTIMAL	MINIMUM	OPTIMAL	MINIMUM	OPTIMAL	MINIMUM
	Building Context Zone						
A	BUILDING FRONTAGE ELEMENT	5 ft	3 ft	5 ft	2.5 ft	7 ft	1.5 ft
	Location of off street parking	rear	rear	rear	rear	rear	rear
	Typical building entry locations	front	front	front	front	front	front
	Roadway Edge Zone						
B	SIDEWALK THROUGH ELEMENT	10 ft	6 ft	8 ft	6 ft	6 ft	6 ft
C	AMENITY ELEMENT	8 ft	6 ft	8 ft	6 ft	8 ft	6 ft
	Surface Treatment for Amenity Element	Paved with tree wells		Paved with tree wells		Paved with tree wells	
	Roadway Zone						
D	CURBSIDE ACTIVITY ELEMENT						
	PARALLEL PARKING ONLY	8 ft both sides	None	8 ft both sides	None	8 ft both sides	None
	FLEX ZONE: variable parallel parking, pick-up + drop-off, light delivery	10 ft [1]	8 ft	10 ft [1]	8 ft	10 ft [1]	8 ft
E	BICYCLE ELEMENT*						
	Non-Separated Conventional Bike Lane	5 - 8 ft [2]	4 - 5 ft [2]	5 - 8 ft [2]	4 - 5 ft [2]	5 - 8 ft [2]	4 - 5 ft [2]
	Non-Separated Buffered Bike Lane	9 - 10 ft [2]	6 - 8 ft [2]	9 - 10 ft [2]	6 - 8 ft [2]	9 - 10 ft [2]	6 - 8 ft [2]
	Further Guidance for Non-Separated Facilities	NACTO Urban Bikeway Design Guide		NACTO Urban Bikeway Design Guide		NACTO Urban Bikeway Design Guide	
	Separated Bike Lane (one-way)	10 ft [2]	6.5 - 8 ft [2]	10 ft [2]	6.5 - 8 ft [2]	10 ft [2]	6.5 - 8 ft [2]
	Separated Bike Lane (two-way)	15 ft [2]	9.5 - 11 ft [2]	15 ft [2]	9.5 - 11 ft [2]	15 ft [2]	9.5 - 11 ft [2]
	Further Guidance for Separated Facilities	FHWA Separated Bike Lane Planning and Design Guide		FHWA Separated Bike Lane Planning and Design Guide		FHWA Separated Bike Lane Planning and Design Guide	
F	TRANSIT ELEMENT						
	Shared Transit Lane	12 ft	11 ft	12 ft	11 ft	12 ft	11 ft
	Considerations	Low congestion		Low congestion		Low congestion	
	Dedicated Transit Lane	12 ft	11 ft	12 ft	11 ft	12 ft	11 ft
	Considerations	High congestion		High congestion		High congestion	

The Corridor Matrix is a series of tables with optimal and minimum dimensions for each element within a corridor cross-section, according to the latest industry guidance. It is used to detail out a design concept with specific dimensions for each corridor element. The full Corridor Matrix is provided in Appendix C.

travel modes, redesignating one or more modal emphases to a less direct alternative route, and/or acknowledging that additional right-of-way is needed which will increase the project cost, likely extend the project timeline, and may encounter pushback from adjacent property owners. All of these options have benefits and disadvantages, and there are rarely any easy solutions.

However, the advantage of using the Multimodal Project Design Framework is that it informs these tough discussions and difficult decisions by putting the tradeoffs into the context of the larger multimodal transportation system.

The following section provides an example of how to use the Multimodal Project Design Framework on a hypothetical multimodal corridor.

Multimodal Corridor Design Example

In this hypothetical example, the project corridor is a four-lane minor arterial in a suburban employment center that serves 15,000 vehicles per day and has a 35-mph posted speed limit.

The existing corridor cross-section is shown in **Figure 7-2.** It consists of 88 feet from the back edge of each sidewalk, with individual corridor elements:

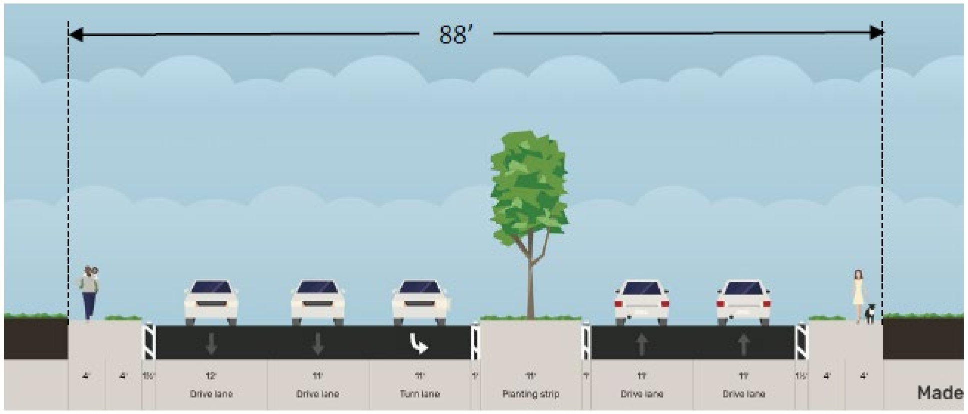
- 4-ft wide sidewalks on both sides
- 4-ft wide buffer/amenity element on both sides
- 1.5-ft wide curb and gutter on both sides
- One 12-ft wide outer southbound travel lane
- One 11-ft wide inner southbound travel lane
- Two 11-ft wide northbound travel lanes
- A 22-ft wide curbed median with 1-ft of pavement on either side that transitions at intersections to an 11-ft wide turn lane with an 11-ft wide median

Step 1: Identify the Project

There are two timeframes envisioned for this project corridor.

The near-term timeframe envisions making changes within the existing edges of curb that would align with the city's repaving schedule.

FIGURE 7-2: MULTIMODAL CORRIDOR DESIGN EXAMPLE – EXISTING CONFIGURATION



The existing configuration of the hypothetical example contains two general travel lanes in each direction, a wide median, and substandard sidewalks on each side.

The long-term timeframe envisions expansions beyond the curb and the possibility of acquiring additional right-of-way on one side where current building are set far back from the edge of the road. The long-term vision for this area involves large scale redevelopment that would increase both residential and non-residential densities.

Step 2: Develop the Design Approach

Step 2a: Define the Multimodal Context

The project corridor is a major spine through a future Multimodal Center, but the area context is generally suburban today. It lacks a connected grid with parallel streets.

In the Multimodal System Plan, the project corridor is identified as a future Boulevard. Boulevards are a type of Placemaking corridor that have the highest multimodal capacity to accommodate multiple motorized and non-motorized modes.

The Multimodal System Plan identifies this corridor as having Pedestrian, Bicycle/Scooter, and Transit Modal Emphasis. The Transect Zone is identified as T-4.

Because this corridor is designated with all three modal emphases, and there is a lack of connected parallel streets, it is a good example of how the limited right-of-way will be a challenge to accommodating all modes. However, we know from the Multimodal System Plan that this is a key corridor for all of these modes, and the tradeoffs will need to be assessed and weighed carefully.

Step 2b: Determine the Design Approach

The design approach spells out the way in which each mode will be accommodated within the street. This portion of the hypothetical example examines each mode individually at first.

Determining the Preferred Design Approach for Pedestrians

As explained in Chapter 4, pedestrian safety is the top priority for all Multimodal Corridors. The project corridor currently has 4-ft wide sidewalks, which are considered to be substandard.

The long-term timeframe envisions expansions beyond the curb. In the long-term timeframe, the preferred design approach will include optimizing the sidewalk width.

However, in the short-term timeframe, the current sidewalk is outside of the pavement between the curbs that would be included in the city's regular repaving schedule. Although the current sidewalk is substandard, it is provided continuously along both sides of the street.

Expanding the sidewalk width will not be considered within the project extents of the short-term timeframe. However, the design of the project will involve ensuring there are marked crosswalks at all signalized intersections, and the project team will perform an analysis of crosswalk frequency to determine if there are any segments where the distance between marked crossings exceeds 600 feet.

Determining the Preferred Design Approach for Bicyclists and Scooter Riders

Because of the project corridor's Bicycle/Scooter Modal Emphasis designation, we know that this corridor is a key connection for bicyclists and scooter riders, and that it is important to identify a preferred design approach that will provide a low-stress facility that serves bicyclists of all ages and abilities.

The project corridor serves 15,000 vehicles per day and has a posted speed limit of 35 mph. 15,000 vehicles per day is well above the 7,000 vehicles per day general threshold above which the preferred design approach is a vertically separated bicycle lane to meet the safety and comfort needs of all bicyclist types. A shared lane design approach on a roadway with this high volume of traffic would only accommodate only the most confident bicyclists.

The preferred design approach for bicyclists and scooter riders at this point in the process is a separated bicycle lane.

Determining the Preferred Design Approach for Transit

The project corridor has Transit Modal Emphasis, meaning it is a critical connection for transit and has a high potential for generating transit trips.

Current bus service on this corridor includes two routes, but at relatively low frequency. In the peak hour, the bus frequency is 1 to 2 buses every 15 minutes. However, it is envisioned that as this area redevelops, more frequent transit service will be provided in the future. It is also anticipated that with redevelopment, future demand will change. This corridor today experiences periods of low reliability in the morning and evening rush hours, which impacts bus on-time performance.

At this point in the process, the preferred design approach for transit is somewhat flexible. The low bus frequency indicates general travel lanes may be appropriate, but the disruption to bus travel time reliability and the anticipated need for high bus frequencies in the future indicate that targeted transit priority elements or dedicated bus lanes could be preferred, especially in the future.

Considering a Combined Bus and Bicycle Lane

Because there is relative flexibility in the preferred design approach for transit, the consideration of a combined bus and bicycle lane occurs in a somewhat iterative process, and it is explained in the following step.

Considerations for bus stops would also be preliminarily considered at this point in the process, but they are not included as part of this hypothetical example.

Step 2c: Detail Out the Design Approach

Although Steps 2b and 2c are explained discretely in this chapter, in practice they are applied in an iterative process of examining the available right-of-way, identifying the optimal and minimum dimensions for each corridor element, trying out various combinations of corridor element dimensions, and weighing the tradeoffs.

Detailing Out the Design Concept for the Short-Term Timeframe

In this hypothetical example, the constraints of the short-term timeframe present only a few options for reconfiguring the pavement within the existing curbs. Again, note this is a hypothetical example, and the tradeoffs explained here may not apply in all situations.

One option that may have been identified preliminarily would be to narrow each lane to 10-ft wide to provide an on-street bicycle lane. However, this would only provide at most six feet of width – enough for a conventional non-buffered bicycle lane on one side of the street, and that still would require modifications to the median, which is not a part of the short-term project scope.

Removing the turn lane is not considered an option because it alternates throughout the corridor, and the turn lane is critical for avoiding gridlock at the traffic signals, and again, would require modifications to the median.

The project team quickly realizes providing any bicycle accommodation beyond a shared lane will require converting one of the two general travel lanes in each direction to a facility that provides dedicated space for bicyclists without mixing with general traffic.

At this point, a traffic study would typically be conducted, but as explained in Chapter 7, the third step in the Multimodal Project Design Process proposes to modify the traditional traffic engineering evaluation to focus on how well a potential design concept will meet the city's vision and goals for multimodal transportation, not just how much a design concept will increase vehicular delay or worsen vehicular level of service.

After discussing the tradeoffs, the project team may decide in this hypothetical example that because the project corridor serves a critical connection for bicyclists and scooters, it is most important to provide a dedicated facility for bicyclists and scooter riders, and the city may be willing to accept increased vehicular delays, which would occur at select pinch points on the project corridor.

The project team at this point decides to move forward with a preferred design approach of a dedicated bicycle facility, but it is important to note that the resulting design concept and tradeoffs would be shared with stakeholders and the public as part of the public process in the subsequent phases of the Multimodal Project Design Framework.

The project team consults the Corridor Matrix and sees that the optimal width of 10 ft for a one-way separated bike lane is possible to achieve on both sides of the street with the repurposing of the outer general travel lanes.

Because the preferred design approach for the short-term timeframe now consists of only one general travel lane in each direction, the project team revisits the design considerations for the preferred approach for transit. The additional vehicular delay will further worsen bus on-time performance if buses continue to operate in the remaining general travel lane.

The low bus frequency of 1 to 2 buses every 15 minutes in the peak period is consistent with the design considerations for a combine bus and bicycle lane, and bus speeds along the project corridor are below 20 mph because of the frequency of bus stops and intersections.

The project team now examines the feasibility of lane width. Unfortunately, the 16-ft desired lane width is not feasible within the existing curbs. However, the project team determines it is possible to achieve 12-ft widths for the combined bus-bike lanes on both sides of the street. This will require narrowing the remaining northbound general travel lane from 11-ft to 10-ft wide.

The resulting preferred design concept for the short-term timeframe is shown in Figure 7-3. It consists of:

- One 12-ft wide combined bus-bike lane on both sides of the street
- One 11-ft wide southbound general travel lane

- One 10-ft wide northbound general travel lane
- The median, turn lane, sidewalks, and buffer/amenity elements remain the same as in the existing configuration.

Detailing Out the Design Concept for the Long-Term Timeframe

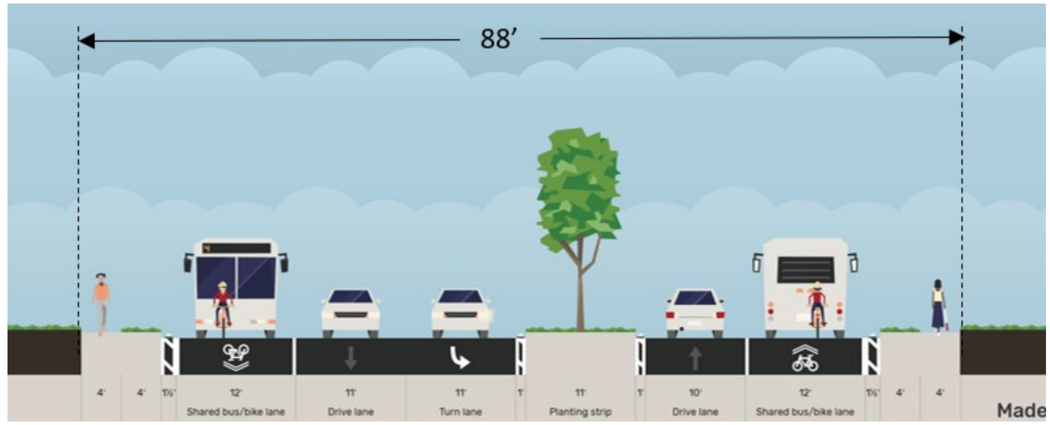
As explained previously, the long-term timeframe anticipates large scale redevelopment of the area and possible expansion of the roadway on the right side where current buildings are set far back from the edge of the road.

With the proposed expansion of the corridor width and the ability to modify the elements beyond just the pavement, the design concept for the long-term timeframe, shown in **Figure 7-4**, expands the sidewalk width to the optimal dimension of 8-ft wide for a T-4 Boulevard. It also expands the amenity element to 8-ft wide, which provides additional opportunities for tree planting or other green amenities.

Some of the width of the median is transferred to a two-way separated bicycle facility on the right side.

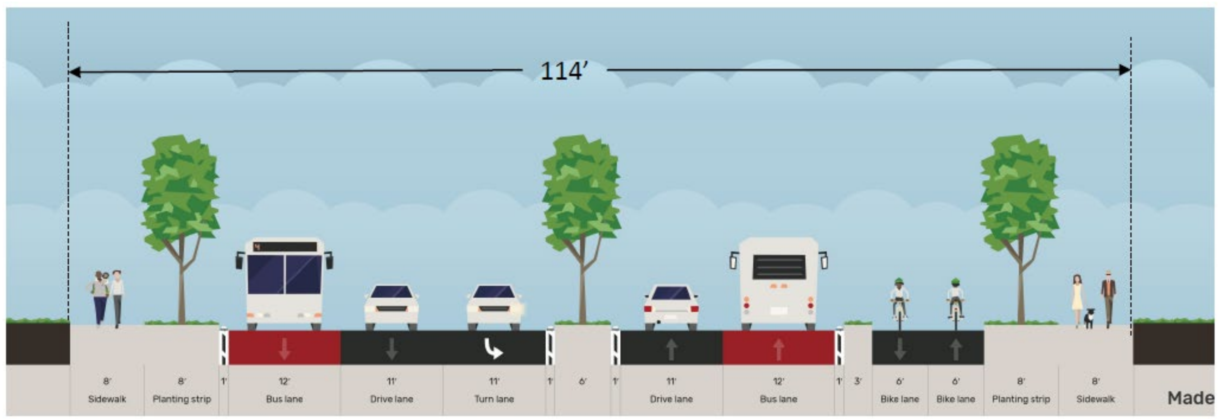
In this design concept, the dedicated bus lane remains on both sides of the street in anticipation of more frequent bus service in the future. This is consistent with the Boulevard's function of providing the highest multimodal capacity. However, flexibility may remain in this long-term design concept, such

FIGURE 7-3: MULTIMODAL CORRIDOR DESIGN EXAMPLE – SHORT-TERM DESIGN CONCEPT



The design concept for the short-term timeframe changes the configuration of the pavement within the existing curbs to provide a combined bus-bike lane on both sides of the street, demonstrating a reconfiguration possible within the general resurfacing and repainting maintenance schedule, without reconstructing curbs..

FIGURE 7-4: MULTIMODAL CORRIDOR DESIGN EXAMPLE – LONG-TERM DESIGN CONCEPT



The design concept for the long-term timeframe assumes large scale redevelopment and expands cross-section beyond the existing curbs to provide separate dedicated transit lanes and a two-way separated bicycle facility. It also expands the sidewalk width to the optimal dimension and expands the width of the amenity zone to allow for tree planting.

that if this configuration were to be constructed, but bus frequency were not yet increased, this design concept could be tweaked to show the bus lane operating as a shared lane for buses and general traffic.

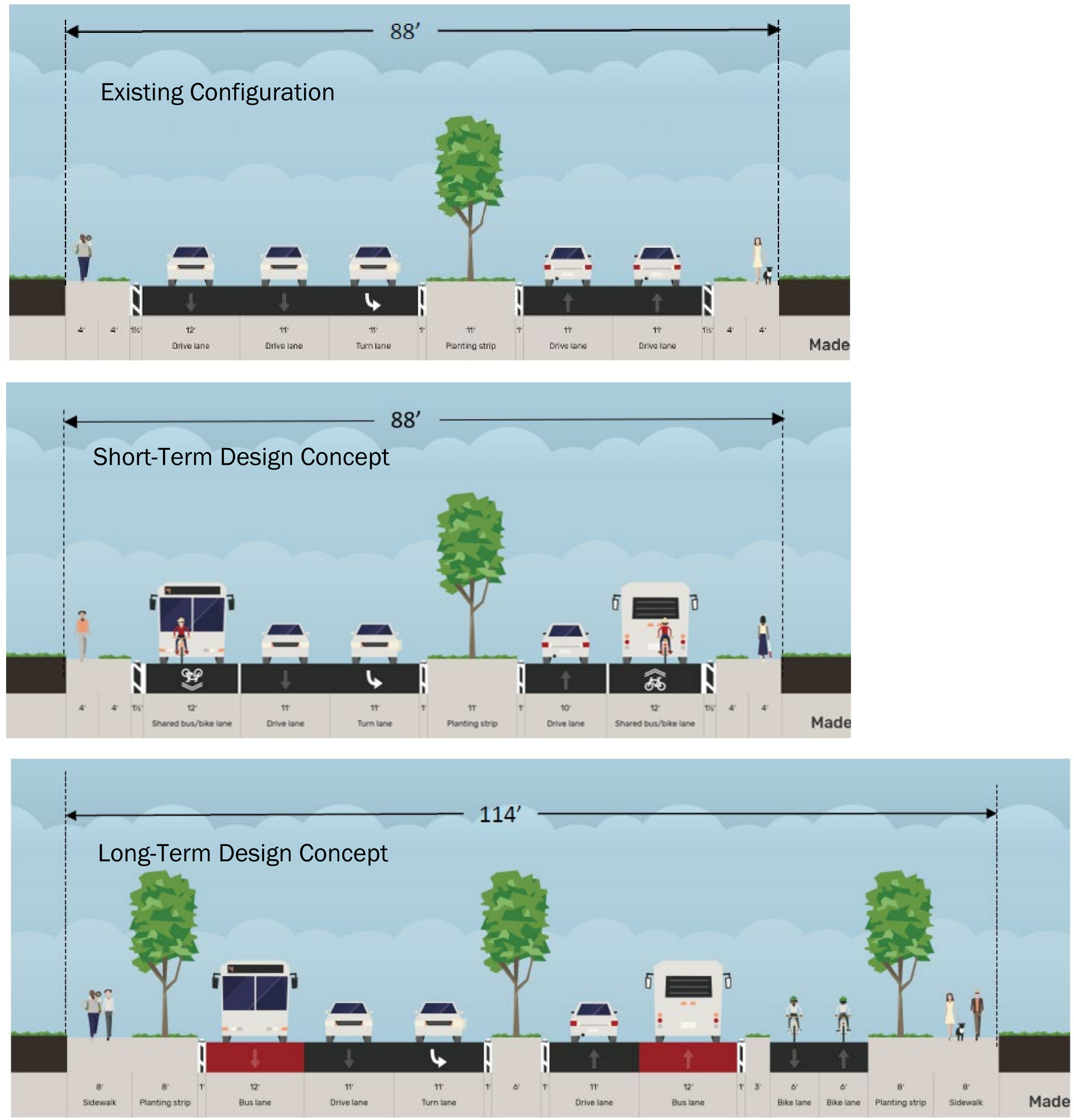
Next Steps

The outcome of this second step in the Multimodal Project Design Framework is shown altogether in **Figure 7-5**.

This second step resulted in two design concepts – one for the near-term timeframe that is constrained within the existing curbs, and another for the long-term timeframe that expands beyond the existing right-of-way.

The two resulting design concepts are now ready to be advanced to Step 3: *Evaluate Design Concepts*. This third step of the Multimodal Project Design Framework is described in Chapter 8.

FIGURE 7-5: MULTIMODAL CORRIDOR DESIGN EXAMPLE – DESIGN CONCEPTS SHOWN TOGETHER



The outcome of the second step of the Multimodal Project Design Framework is one or more design concepts with specific dimensions for each element in the corridor cross-section.

[i] Definitions of bikeway facility types are based on the FHWA 2019 Bikeway Selection Guide.
[ii] FHWA, 2019. *Bikeway Selection Guide.*
[iii] NACTO *Urban Bikeway Design Guide.* *https://nacto.org/publication/urban-bikeway-design-guide/bikeway-signing-marking/shared-lane-markings*
[iv] USDOT Literature Review on Vehicle Travel Speeds and Pedestrian Injuries, 1999.
[v] The Manual on Uniform Traffic Control Devices suggests shared lane markings be restricted to roadways with operating speeds of 35 mph or less. The NACTO Urban Bikeway Design Guide provides similar guidance that shared lane markings are generally not appropriate on streets with a speed limit above 35 mph.
[vi] FHWA, 2019. *Bikeway Selection Guide.*
[vii] FHWA, 2019. *Bikeway Selection Guide.*
[viii] Massachusetts Department of Transportation, 2015. *Separated Bike Lane Planning and Design Guide*. https://www.mass.gov/lists/separated-bike-lane-planning-design-guide.
[ix] FHWA, 2019. *Bikeway Selection Guide.*
[x] FHWA, 2019. *Bikeway Selection Guide.*