TN TDOT Department of Transportation




TDOT PROJECT SCOPING GUIDE

SEPTEMBER 2024

Preface

The Project Scoping Guide (PSG) supports the Tennessee Department of Transportation (TDOT) Project Delivery Network (PDN) by informing specific stages of the project development process and provides guidance for development of project deliverables and documentation. The PSG integrates a performance- and context-based planning and design approach and becomes a primary resource for planning and design guidance and criteria within the five contexts (Rural, Rural Town, Suburban, Urban, and Urban Core). The PSG aligns with a Federal Highway Administration (FHWA) Safe System Approach (SSA) by emphasizing a broad, all-encompassing framework for creating safer public spaces and supports project teams with developing and implementing projects that improve the safety performance of the transportation system.

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Introduction and Overview

The *Project Scoping Guide (PSG)* supports the Tennessee Department of Transportation (TDOT) Project Delivery Network (PDN) by informing specific stages of the project development process and provides guidance for development of project deliverables and documentation. Chapter 1 creates a roadmap for how each of the *PSG* chapters links to the PDN to support decision-making and documentation at each stage.

The *PSG* integrates a performance- and context-based planning and design approach and becomes a primary resource for planning and design guidance. The information presented aligns with a Safe System Approach by emphasizing a broad, all-encompassing framework for creating safer public spaces. *(1)*

1.1 PURPOSE OF THE GUIDE

The purpose of the *PSG* is to:

- Support project teams with executing Stage 0 and Stage 1 of the PDN by providing information to develop the Concept Report in Stage 0 and the Project-Specific Design Criteria Document in Stage 1;
- Outline a decision-making framework for executing design flexibility and evaluating tradeoffs for the range of users within the five contexts (Rural, Rural Town, Suburban, Urban, and Urban Core);
- Outline roadway design criteria for geometric design elements for each facility type within each of the five contexts;
- Support project teams with developing and implementing projects that improve the safety performance of the transportation system;
- Provide project-specific design information to the TDOT Project Notebook that informs Stage 2 of the PDN; and
- Establish a primary resource for design guidance for various modes of travel.

The *PSG* is a resource for TDOT project managers, planners, designers, engineers, and technical staff. It may also be useful for local agencies and consultants outside of TDOT that are involved in developing roadway designs for TDOT-funded and/or managed projects and work permitted within TDOT's right-of-way.

The guidance in the *PSG* pertains to local, collector, and arterial roadways. Freeways and expressways are not included, except for grade-separated crossings over/under freeways and crossroads at interchanges. Project teams should continue to refer to the TDOT *Roadway Design Guidelines* for design guidance related to freeways and expressways. The *Roadway Design Guidelines* will also continue to be a resource for design details beyond the information provided in the chapters of the *PSG.* Additional references to the *Roadway Design Guidelines* are provided throughout the *PSG* as applicable.

1.1.1 Project Types

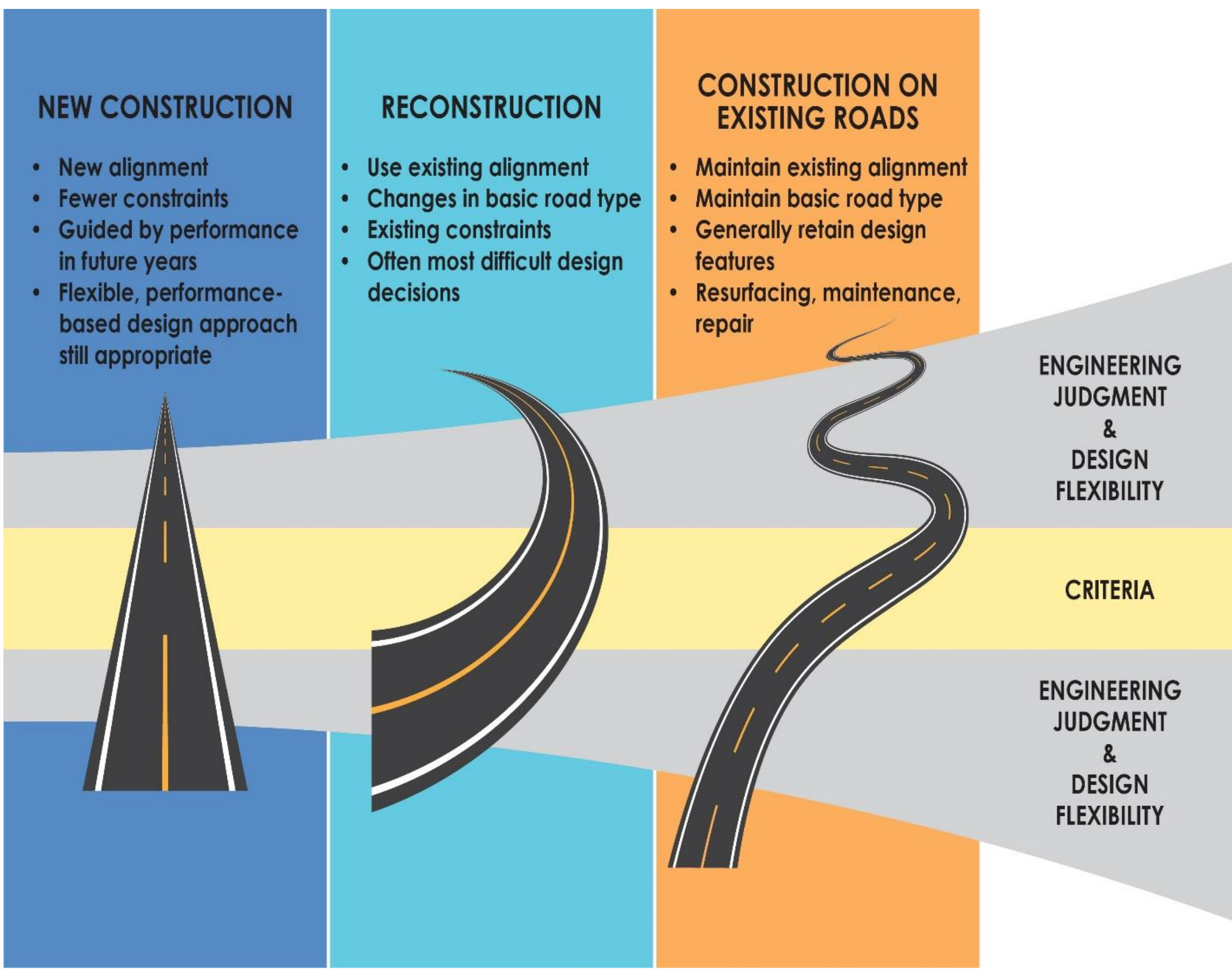
The design guidance and criteria presented in the *PSG* apply to the planning and design of all project types, including, but not limited to, the following designations, as defined in the American Association of Highway Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets* (*Green Book)*:

- **"New construction projects** are those that construct roads on new alignment where no existing roadway is present… New construction projects can often use traditional design criteria because there are often fewer constraints in construction on a new alignment than in projects on existing roads… The design of new construction projects is not guided by the performance of an existing road, but the forecast performance of the design alternatives in future years may strongly influence design decisions. Thus, a flexible, performance-based approach to design is appropriate even for new construction projects." *(2)*
- **"Reconstruction projects** are projects that utilize an existing roadway alignment (or make only minor changes to an existing alignment) but involve a change in the basic roadway type. Changes in the basic roadway type include widening a road to provide additional through lanes or adding a raised or depressed median where none currently exists, and where these changes cannot be accomplished within the existing roadway width (including shoulders)… Retaining the existing alignment means that existing constraints in the current roadway environment will influence design decisions… Reconstruction projects often create the most difficult design decisions because a new facility type is being adapted to an existing alignment and needs to fit within the existing community context." *(2)*
- "**Construction projects on existing roads** are those that keep the existing roadway alignment (except for minor changes) and do not change the basic roadway type. Such projects are classified for design purposes by the primary reason the project is being undertaken or the specific need being addressed. The typical project needs addressed by road and street improvement projects on existing roads include repair infrastructure condition, reduce current or anticipated traffic operational congestion, reduce current or anticipated crash patterns" *(2)*. The projects include resurfacing, maintenance, and bridge repair.

This includes both TDOT and local government projects fully or partially funded with state or federal funds and projects within TDOT's transportation network or right-of-way. Local agencies managing projects that include state or federal funding must comply with the *PSG* pursuant to Local Government Guidelines Manual.

The project type affects the range of planning and design solutions and what dimensional values and features can be considered. Different project types have varying considerations for design flexibility, roadway user integration, and existing and future land uses. New construction projects are likely to have fewer constraints and may have the ability to more closely integrate the specific design criteria. Reconstruction projects may be constrained by existing features, requiring more design flexibility and evaluation of various tradeoffs. Construction on an existing alignment focuses on the primary purpose of the project and requires design flexibility to address the range of needs while understanding the original goals. Figure 1-1 illustrates the range of project types and how the design flexibility and design criteria may be influenced based on each type.

Figure 1-1 Project Types and Range of Design Flexibility



1.1.2 Roadway Users

A roadway should meet the needs of the people who desire to use it, whether traveling on foot, in a wheelchair, on a bicycle or scooter, or in a vehicle. The early planning stages of the design process should identify and consider the unique needs of the expected and desired current and future users. More information on this topic is provided in Chapter 3 of the *PSG*.

Understanding user needs helps project teams assess and evaluate alternatives. The following roadway users should be considered for all TDOT planning and design projects. Chapter 4 of the *PSG* provides additional information on pedestrians, bicycles, and transit users.

- **Pedestrians** include people traveling on foot or using a personal assistive device. The AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* notes that there is no single "design pedestrian," as "pedestrians exhibit a wide range of physical, cognitive, and sensory ability." *(3)* Some have significant mobility disabilities, and many pedestrians have temporary mobility disabilities at some point during their lives. Pedestrian trips include both utilitarian trips and recreational trips. Some pedestrians do not have other options available (e.g., lack of access to a vehicle or transit service), while others choose to walk for exercise or enjoyment.
- **Bicyclists** have a range of ages and abilities, with varying comfort and skill levels. Roadways should be designed to meet the needs of a range of cyclists. The AASHTO *Guide to Bicycle Facilities* indicates that "bicyclists should be expected on roadways, except where prohibited, and on shared use paths. Safe, convenient, well-designed, well-maintained facilities, with low-crash frequencies and severities, are important to accommodate and encourage bicycling." *(4)*
- **Micromobility users** are defined by the Federal Highway Administration (FHWA) as "any small, low-speed, human- or electric-powered transportation device, including bicycles, scooters, electric-assist bicycles (e-bikes), electric scooters (e-scooters), and other small, lightweight, wheeled conveyances" *(5)*. When integrating micromobility, projects should consider managing interactions between micromobility users and other users and verifying that micromobility parking does not hinder sidewalk accessibility. For TDOT facilities, scooters are considered the same type of user as a bicyclist for planning and design considerations.
- **Motorcyclists** have unique needs that, when considered during the design process, can lead to improved safety outcomes. FHWA notes that, "Motorcyclists are at significantly greater risk of fatalities and injuries when involved in a crash compared to passenger vehicle drivers" *(6)*. Design considerations related to roadside barriers, pavement surface and maintenance, and pavement markings should be included in project decision-making to improve motorcyclist safety.

- **Motor vehicle drivers** are the most common users of most roadways. As noted in the AASHTO *Green Book*, "in the past, many roadways were designed and built primarily to serve the mobility needs of motor vehicles (automobiles, trucks, and buses), with some consideration of other transportation modes. In recent years, the focus of road design has shifted to consistently consider the needs of all transportation modes, including pedestrians and bicyclists." Motor vehicles is a broad category, typically including "passenger cars, motorcycles, sports utility vehicles, light trucks (such as pickup trucks), and recreational vehicles." *(2)*

- **Transit** includes buses, trains, local shuttles, trolleys, and paratransit. Transit vehicles reflect a range of sizes and design characteristics. For example, transit buses have a variety of wheelbase lengths and different distances between the bumpers and axles, impacting turning radius and the swept path of the bus. Where a roadway serves transit vehicles, special consideration may be needed to provide adequate width and turning radii, incorporate transit stops and anticipated pedestrian crossings, and provide designated transit lanes, if appropriate.

- **Trucks** include a broad range of vehicle types. AASHTO has established vehicle classifications that categorize trucks based on the number of axles and units or trailers *(2)*. Standard trucks are typically allowed on a roadway without any special permit, where trucks that are larger or heavier require permits to travel on the roadway system and are referred to as oversize or overweight trucks. Typically, truck volumes are higher on higher classification roadways, like freeways and arterials, with more limited truck activity on lower order roadways like collectors and local roads.

  TDOT also uses several additional designations and classifications for roadways where higher truck activity is expected and freight is a priority. As noted in the *Tennessee Statewide Multimodal Freight Plan*, "Tennessee's roadways and highways are a key element in the state's freight system, serving both the long-distance movement of goods as well as last-mile connections… The State of Tennessee, through TDOT, maintains a State Route System that provides primary connectivity throughout the state and contains many major routes within urban areas" *(7)*. In addition, "truck designated roadways in the state of Tennessee are cataloged as part of the National Highway Freight Network (NHFN), which… serves as the principal means of designation major freight routes on a statewide basis for Tennessee" *(7)*.

  In order to "provide access to industrial areas and to facilitate the development of expansion and industry within the State of Tennessee," TDOT has developed the State Industrial Access (SIA) program, which designates Industrial Highways based on eligibility criteria and an application process *(8)*. The SIA program provides funding and technical assistance to support Industrial Highways. Understanding expected truck activity and needs may influence design decisions for a roadway. As noted in the AASHTO *Green Book*, "For example, residential streets are typically designed to accommodate fire trucks, garbage trucks, school buses, and snowplows; larger trucks that may be present only occasionally, such as moving vans, are not primary considerations in design" *(2)*.

- **Connected and automated vehicles (CAVs)** are vehicles able to communicate with each other and roadside infrastructure to make driving decisions automatically, are currently under development. CAVs have the potential to change how vehicles interact with each other, the roadway, and other users. Predictions vary significantly as to when CAVs will be commercially available and how quickly consumers will adopt them, but vehicles without connectivity and with lower levels of automation like adaptive cruise control and braking are already on the roadways. Based on how CAVs develop, they may require certain design features to operate effectively, like specific lane and shoulder widths, pavement markings, separation from pedestrians and bicyclists, or enhanced lighting.
- **Other** roadway users may be present based on the surrounding land uses or communities, such as animal-drawn vehicles, school-aged children, or older adults.

1.2 HOW TO USE THE GUIDE

The *PSG* is a resource for establishing design performance criteria and guidance based on design year context to support flexibility in design decision-making on TDOT projects. By understanding the key principles, guidance, and applications in each chapter of the *PSG*, project teams should be able to plan, design and implement projects that integrate the needs, safety, and mobility of the full range of roadway users. Table 1-1 provides an overview of each chapter in the *PSG*.

Additional details and supplemental information that support the primary chapter content are included in appendices at the end of the *PSG*.

Table 1-1: Chapter Overview

Chapter Title	Chapter Description and Key Guidance
Chapter 1 Introduction and Overview	Chapter 1 introduces the *PSG*, describes its purpose and intended audience, and provides an overview of each chapter. It includes an overview of TDOT policies and practices as well as other relevant resources that should be considered while using the *PSG*.
Chapter 2 Decision-Making Framework and Documentation	Chapter 2 focuses on a performance-based design approach and a delivery process that supports decision-making from planning through design. This chapter provides a connection to the PDN stages and documentation procedures for TDOT.
Chapter 3 Identifying Design Year Context	Chapter 3 describes TDOT's five context classifications and offers guidance for how to identify a specific project's design year context. This chapter includes preliminary design expectations for each context classification and supports context identification and documentation as part of the Concept Report in Stage 0.
Chapter 4 Multimodal Planning and Design	Chapter 4 provides fundamental principles and guidance for planning and designing for various modes of travel. This includes information on pedestrian, bicycle, and transit opportunities and specific design guidance for a range of facility types. This chapter supports project teams in understanding roadway user needs and design elements to be documented in the Concept Report in Stage 0 and the Active Transportation Review in Stage 0.
Chapter 5 Intersection Planning and Design	Chapter 5 includes information to support project teams in intersection control evaluations (ICE) and intersection design. This connects to information covered in the TDOT *Highway System Access Manual (HSAM)* and includes information specific to pedestrian and bicycle safety evaluation (TDOT *20-Flag Intersection Evaluation Guide*) at intersections. This chapter supports project teams with understanding traffic control options and selecting traffic control in Stage 0.
Chapter 6 Context Design Guidance and Criteria	Chapter 6 describes street realms and highlights specific opportunities for the design elements within each realm as they relate to various contexts. This chapter provides summary tables with design guidance and criteria for TDOT contexts, including target speed ranges by context. This includes information to help project teams identify and evaluate trade-offs while assessing a project's operations, safety, and design. Chapter 6 supports PDN Stage 1 by confirming the context determined in Stage 0 and provides information for the Project-Specific Design Criteria Document needed in Stage 1. The outcomes of this support Stage 2. The TDOT Project Notebook will use this information for Stage 2.
Chapter 7 Case Studies	Chapter 7 presents case studies to demonstrate how to apply a performance-based design approach to a range of projects and evaluate design decisions based on context. This chapter includes application information to support project teams in evaluating tradeoffs and making decisions within each stage of the PDN.

1.3 KEY TERMINOLOGY AND DEFINITIONS

This section presents the specific qualifying words used throughout the *PSG* and gives definitions for key terminology. **Appendix A** provides additional information about *PSG* terminology, including a glossary of terms and a list of acronyms.

1.3.1 Qualifying Words

Many qualifying words are used throughout design projects and within the *PSG*. For consistency and uniformity in the application of various design criteria, the following definitions apply:

- **Should, Recommend:** An advisory condition. The project team is strongly encouraged to follow the criteria and guidance presented in this context unless there is reasonable justification not to do so. The decision made by the project team should be documented.
- **May, Could, Can, Suggest, Consider:** A permissive condition. The project team is allowed to apply individual judgment and discretion to the criteria when presented in this context.
- **Standard:** A statement of minimum required practice. An exception from the standard may be granted through the Design Exception/Waiver/Deviation process (discussed in Chapter 2) and requires approval.
- **Criteria:** A term that is typically applied to design values, usually with no suggestion as to the criticality of the design value.
- **Guidance:** A statement of recommended but not mandatory practice in typical situations, with deviations allowed if engineering judgment or an engineering study indicates they are appropriate. The verb "should" is typically used. The verbs "shall" and "may" are not used in guidance statements. Guidance statements are sometimes modified by options.
- **Option:** A statement of practice that is a permissive condition and carries no requirement or recommendation. Option statements sometimes contain allowable modifications to a standard or guidance statement. The verb "may" is typically used. The verbs "shall" and "should" are not used in option statements.
- **Support:** An informational statement that does not convey any degree of mandate, recommendation, authorization, prohibition, or enforceable condition. The verbs "shall," "should," and "may" are not used in support statements.
- **Policy:** Indicates TDOT practice, which TDOT generally expects the project team to follow, unless otherwise justified. TDOT policies are adopted through a formal process with the Policy Committee.
- **Desirable, Preferred:** An indication that the project team should make every reasonable effort to meet the criteria and that they should only use a less desirable or less preferred design after due consideration of the desirable or preferred design.

- **Minimum, Maximum, Lower, Upper (Limits):** Representative of generally accepted limits within the design community, but not necessarily suggesting that these limits are inflexible.
- **Typical:** Indicates a design practice that is most often used in application. However, this practice does not necessarily represent the desirable treatment at a given site.
- **Acceptable:** Design criteria that do not meet desirable values but are considered reasonable and safe for design purposes.

1.3.2 Key Terminology

The following key terms are used consistently throughout the *PSG:*

- **Context Classifications:** Five TDOT contexts (Rural, Rural Town, Suburban, Urban, and Urban Core) that broadly identify the various built environments along TDOT roadways based on existing or future land use characteristics, development patterns, and roadway connectivity. The term context and context classification are used interchangeably throughout the *PSG*.
- **Roadway User:** Pedestrian, bicyclist, micromobility user, motorcyclist, motorist, transit user, freight handler, or other individual traveling on, crossing, or accessing a roadway.
- **Functional Classification (Facility Type):** The process by which streets and highways are grouped into classes, or systems, according to the character of service they are intended to provide. The *PSG* focuses on local, collector, and arterial roadways.
- **Multimodal:** The different types of roadway users traveling through the transportation system and considered collectively. The Office of Active Transportation, within the Local Programs & Community Investments Division, oversees the active transportation reviews as part of the PDN.
- **Performance-Based Design Approach:** A decision-making approach for guiding and documenting planning and design decisions that emphasizes the outcomes from decisions as the primary measure for design effectiveness and project success.

1.4 TDOT PROJECT DEVELOPMENT PROCESS

The TDOT Project Delivery Network (PDN) is a scalable process for those involved in the delivery and management of TDOT projects. The PDN facilitates consistency and transparency through the project delivery process, enabling project teams to improve reliability and efficiency. The PDN outlines the stages, activities, tasks, deliverables, and links to references to accomplish these ends. The PDN supports project teams to achieve the following:

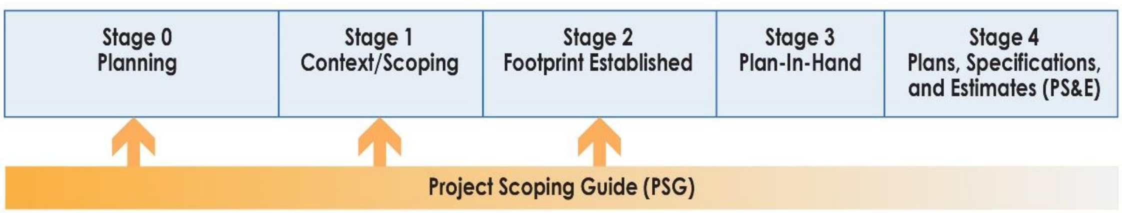
- Maintain consistency via a logical progression of activities throughout the planning, environmental, and design stages.

- Clearly define the construction scope of work and programmed amount at the beginning of the project.
- Streamline steps and procedures throughout the project development process.
- Define key project deliverables and activities to build a schedule a project manager and team can follow to deliver the project.
- Identify opportunities for multidisciplinary collaboration throughout each stage of the process.
- Provide a systematic quality assurance process for key deliverables. *(9)*

The PDN outlines milestones and activities for each discipline within each stage of a project.

The *PSG* primarily supports milestones, activities, and documentation in Stages 0, 1 and 2 across multiple disciplines. While the *PSG* can continue to inform later stages of the PDN, Stages 3 and 4 primarily implement the information established earlier in the process. Figure 1-2 illustrates the PDN stages primarily supported by the *PSG*.

Figure 1-2 TDOT PDN Alignment with the Project Scoping Guide



Chapter 2 provides additional details on how the *PSG* supports the milestones, activities, and deliverables within the PDN.

1.5 TDOT POLICIES

TDOT has specific statewide policies that guide project development and implementation to verify that overall department goals and objectives are met. The information presented in the *PSG* is meant to align and support the overarching TDOT policies that should be considered and incorporated into the project decision-making. Additional TDOT Policy and Procedure information for each TDOT Division can be found on the internal TDOT website. External TDOT users can request additional information about TDOT policies and refer to information provided in the Local Government Guidelines Manual.

1.6 ACCESSIBILITY

TDOT's Multimodal Access Policy is intended to promote the inclusion of multimodal facilities in all transportation planning and project development activities at the local, regional, and statewide levels, and to develop a comprehensive, integrated, and connected multimodal transportation network. *(10)*

As noted in TDOT's Multimodal Access Policy, "pedestrian facilities shall be designed and built to accommodate persons with disabilities in accordance with Americans with Disabilities Act (ADA) access standards. Sidewalks, shared use paths, street crossings (including over- and under-crossings) and other infrastructure shall be constructed so that all pedestrians, including those with disabilities, can travel independently." *(10)*

The Public Right-of-Way Accessibility Guidelines (PROWAG) provide minimum recommendations for the public right-of-way by the U.S. Department of Justice and the U.S. Department of Transportation. PROWAG applies to newly constructed facilities as well as alterations and additions to public facilities in the public right-of-way and will be mandatory once adopted by the Department of Justice and Department of Transportation under Title II of the ADA. *(11)*

For additional resources and guidance, refer to the TDOT ADA Office.

Chapter 4 provides guidance on TDOT's accessibility requirements by project type, key milestones for verifying accessibility throughout the design documentation process, and additional information on PROWAG.

1.7 NATIONAL POLICIES

The following national policies and legislation influence TDOT's planning and design practice. Additional information about each policy is provided in Appendix B.

- Fixing America's Surface Transportation (FAST) Act Design Flexibility and Multimodal Guidance
- Infrastructure Investment and Jobs Act (IIJA)
- U.S. Department of Transportation (USDOT) Policy Statement on Bicycle and Pedestrian Accommodation
- FHWA Design Flexibly Guidance
- FHWA Bicycle and Pedestrian Facility Design Flexibility
- FHWA Strategic Agenda for Pedestrian and Bicycle Transportation
- FHWA Safe System Approach

1.8 STATE AND NATIONAL RESOURCES

Statewide and national publications related to the *PSG* are described in the following sections to support project teams throughout the project delivery process.

1.8.1 TDOT Resources

TDOT has additional resources to support and guide project implementation. Project teams should maintain a current understanding of the following key resources to verify any future changes to TDOT policies and practices.

PROJECT DELIVERY NETWORK (PDN)

As described in Section 1.4, the Project Delivery Network (PDN) is an overarching guide that provides direction for implementing projects on TDOT facilities. The PDN is supported by other TDOT resources such as the *PSG, Roadway Design Guidelines,* and *HSAM* that provide specific guidance for various milestones, activities, and deliverables throughout the PDN stages.

ROADWAY DESIGN GUIDELINES

The *Roadway Design Guidelines* verify consistency in roadway design practices for TDOT projects across the state. The *Roadway Design Guidelines* outline the current recognized design standards for new construction or reconstruction of existing highways while giving due regard to topography, natural conditions, road material availability, and prevailing traffic conditions.

The *PSG* and *Roadway Design Guidelines* together provide the information project teams need to plan, design, and implement a roadway project. The *PSG* focuses on design principles, selection and placement of facility types, and context-based design criteria for cross-sectional elements. The *Roadway Design Guidelines* supply additional design details related to standard drawings and standard details (e.g., how to design a curb ramp) as well as information on preparing roadway plans.

STANDARD DRAWINGS AND STANDARD SPECIFICATIONS

TDOT Standard Drawings ensure consistency in TDOT projects across the state. Standard Drawings contain standard notes and details and are referenced in the contract plans. This reduces repetition within the plans and prevents the designer from copying the commonly used notes and details into every set of plans. Standard Drawings help reduce both the number of drawings in project plans and the time it takes to prepare project plans.

The *Standard Specifications for Road and Bridge Construction (Standard Specifications)* lay out TDOT's standards for work methods and construction materials. The *Standard Specifications* are part of all construction contracts and set criteria for bidding, awarding, and executing the contract.

HIGHWAY SYSTEM ACCESS MANUAL (HSAM)

The *Highway System Access Manual (HSAM)* establishes a procedure to guide project teams in selecting intersection or interchange configurations and control. It also sets required design criteria related to intersection spacing, intersection design, driveway design, medians, and turn lanes. The *HSAM* is divided into three volumes. The first volume gives an introduction, including a summary of existing best practices in corridor agreements, specific requirements and content for TDOT corridor agreements, and land development regulation guidance. The second volume offers guidance for evaluating intersections and interchanges, including scoping, the Capacity Analysis for Planning of Junctions (CAP-X) workflow, Safety Performance for Intersection Control Evaluation (SPICE), and life-cycle cost analysis. The third volume includes the required geometric design criteria, including spacing, access geometrics, driveway geometrics, medians, U-turns, the deviation process when *HSAM*'s criteria cannot be met, and considerations for private developments.

TRAFFIC DESIGN MANUAL

The *Traffic Design Manual* was prepared in conjunction with TDOT's *Roadway Design Guidelines* to aid in developing construction plans involving traffic signals, roadway lighting, signs, pavement markings, and minor intersection improvements. The purpose of this manual is to present the concepts and standard practices related to traffic control system design in Tennessee. The *Traffic Design Manual* provides additional details about specific design elements and other aspects of the overall construction plan set.

COLLECTION OF TRANSPORTATION PLANS

TDOT has developed a Collection of Transportation Plans from throughout the state that can support statewide planning decisions. This includes local agency, regional, corridor, specific area, and other plans that may include local community visions and goals for the transportation network and roadway users. Information from these plans can help guide identification of design year context, described in Chapter 3 of the *PSG,* and may inform other design decisions related to roadway projects within or adjacent to the project area.

ADDITIONAL TDOT RESOURCES

Additional TDOT resources that may support and inform project decisions include:

- Tennessee Strategic Highway Safety Plan
- Statewide Active Transportation Plan
- Tennessee Vulnerable Road User Safety Assessment
- Transportation System Management and Operations Program Plan
- 25-Year Long-Range Transportation Policy Plan
- Local Programs Documents
- Statewide Planning Studies

1.8.2 National Resources

There are national resources beyond TDOT-specific publications that can help a project team identify, plan, and design context-based projects for the range of roadway users. To verify current design practice and national perspectives and to supplement the information in the *PSG*, project teams should review and use relevant publications from AASHTO, FHWA, the National Cooperative Highway Research Program (NCHRP), the National Association of City Transportation Officials (NACTO), and the along United States Access Board. The most recent versions of the following publications should be used for reference, as needed:

- AASHTO, *A Policy on Geometric Design of Highways and Streets (Green Book)*
- AASHTO, *Roadside Design Guide*
- AASHTO, *Guide for the Development of Bicycle Facilities*
- AASHTO, *Guide for the Planning, Design and Operation of Pedestrian Facilities*
- AASHTO, *Highway Safety Manual (HSM)*
- FHWA, *Manual on Uniform Traffic Control Devices (MUTCD)*
- NCHRP, Web-Only Document 320: Aligning Geometric Design with Roadway Context
- NCHRP, Research Report 1022: *Context Classification Application: A Guide*
- NCHRP, Research Report 1036: *Roadway Cross Section Reallocation: A Guide*
- NCHRP Research Report 948: *Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges*
- NCHRP, Research Report 1087: *Guide for Intersection Control Evaluation*
- NACTO, *Urban Bikeway Design Guide*
- NACTO, *Urban Street Design Guide*
- NACTO, *Transit Street Design Guide*
- U.S. Access Board, Public Right of Way Accessibility Guidelines (PROWAG)

1.9 TORT LIABILITY

Tort liability and risks are often seen as impediments to implementing design flexibility and there is a misperception that "designing to standards" inherently improves safety performance and eliminates the risk of lawsuits. Project teams should understand fundamental elements of tort liability to make informed decisions and learn how to manage risk by documenting the project evaluation and decision-making process. NCHRP Legal Digest 57: *Tort Liability Defense Practices for Design Flexibility* provides additional information on tort liability related to design guidance and standards *(12)*. In addition, NCHRP Legal Research Digest 83: *Guidelines for Drafting Liability Neutral Transportation Engineering Documents and Communications Strategies* can support project teams in understanding how to develop design documentation that manages risk *(13)*.

Project teams must exercise engineering judgment when making planning and design decisions that meet desired outcomes within a project's context. Engineering judgment includes evaluating available pertinent information—as well as the application of appropriate standards, guidance, and practices contained in the *PSG* and other TDOT resources—to decide the applicability of standards and criteria, design, and implementation of various projects. The *MUTCD* notes that "Engineering judgment shall be exercised by a professional engineer with appropriate traffic engineering expertise, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer." *(14)*

Documenting the decision-making process when selecting the design for new or reconstructed roadways is an effective way to manage risk. This includes documenting design considerations and alternatives that were evaluated based on clearly outlined project goals. Chapter 2 of the *PSG* provides a framework that guides project teams through decision-making and outlines how design decisions are documented in the PDN. The guidance provided in the *PSG* allows for a diverse range of potential designs. Therefore, the discretionary decisions of project teams must be documented as part of specific stages of the PDN to provide the justification and evidence necessary to manage tort liability.

1.10 REFERENCES

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Tennessee Department of Transportation

Project Scoping Guide

Chapter 2 – Decision-Making Framework and Documentation

September 2024

TN TDOT Department of Transportation

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Chapter 2

Decision-Making Framework and Documentation

Chapter 2 focuses on a performance-based approach to TDOT's Project Delivery Network (PDN) that supports decision-making from planning, concept development, evaluation and selection, and design.

Performance-based design is a decision-making approach that helps agencies better manage transportation investments and serve system-level needs with limited resources by focusing on system-wide performance. Identifying the desired project outcomes and understanding the context and primary roadway users can help project teams determine appropriate performance measures to evaluate the trade-offs of various design decisions.

Completing these steps early in the PDN can guide the planning phase and refine the range of alternatives considered. By reviewing and confirming project goals throughout the PDN, the project team can validate that the alternative chosen reflects the original project goals and serves the intended roadway users.

This chapter integrates national perspectives to outline a decision-making framework for projects that is linked to the stages of the PDN. It also identifies how TDOT will integrate design documentation into the decision-making framework to document project decisions and outcomes. Applying performance-based design and documenting decisions within the PDN is critical to successfully delivering projects.

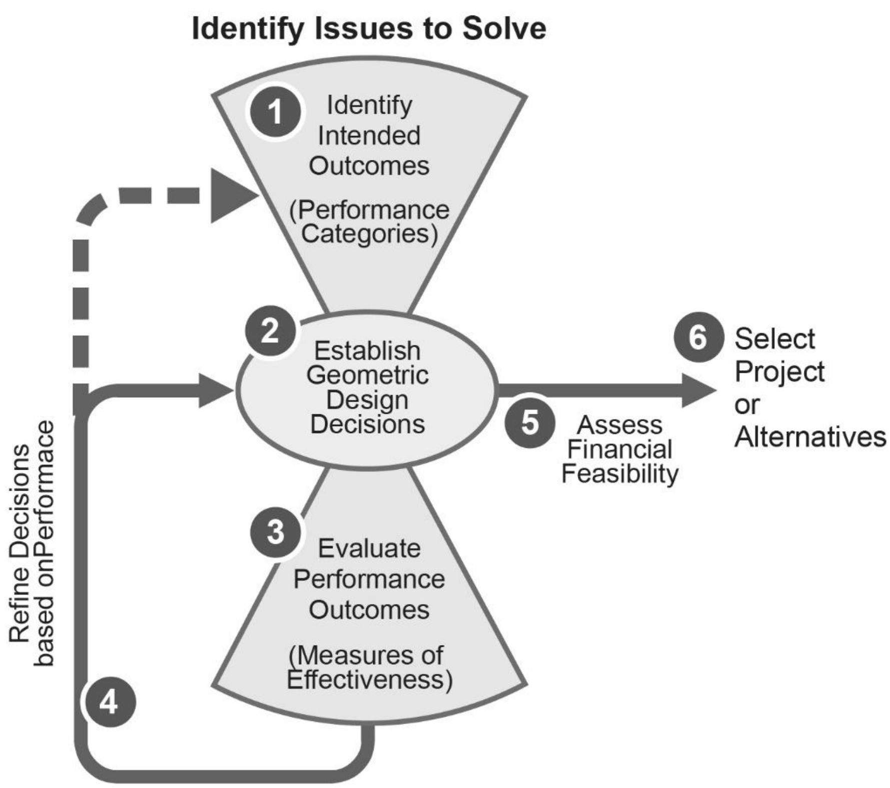
2.1 PERFORMANCE-BASED DESIGN APPROACH

A performance-based approach enables project teams to make informed decisions about the performance trade-offs of alternative solutions. This is especially helpful when developing solutions in fiscally- and physically-constrained environments. Supported at the national level by the Federal Highway Administration (FHWA) and the American Association of State Highway Transportation Officials (AASHTO), performance-based design focuses on the outcomes of design decisions as the primary measure of design effectiveness. *(1, 2)*

Performance-based design follows six basic steps, described below and shown in Figure 2-1.

1. Identify intended project outcomes by which performance can be measured, such as safety, livability, economic development, or environmental sustainability.
2. Establish geometric design decisions, such as design criteria and preliminary design.
3. Evaluate the performance of the geometric design in comparison to the desired project outcomes.
4. Iterate design and outcomes to optimize based on the evaluation results.
5. Evaluate benefits/costs to determine the value of the geometric design compared to the project outcomes.
6. Select or advance project(s) or alternatives based on viability within the project context.

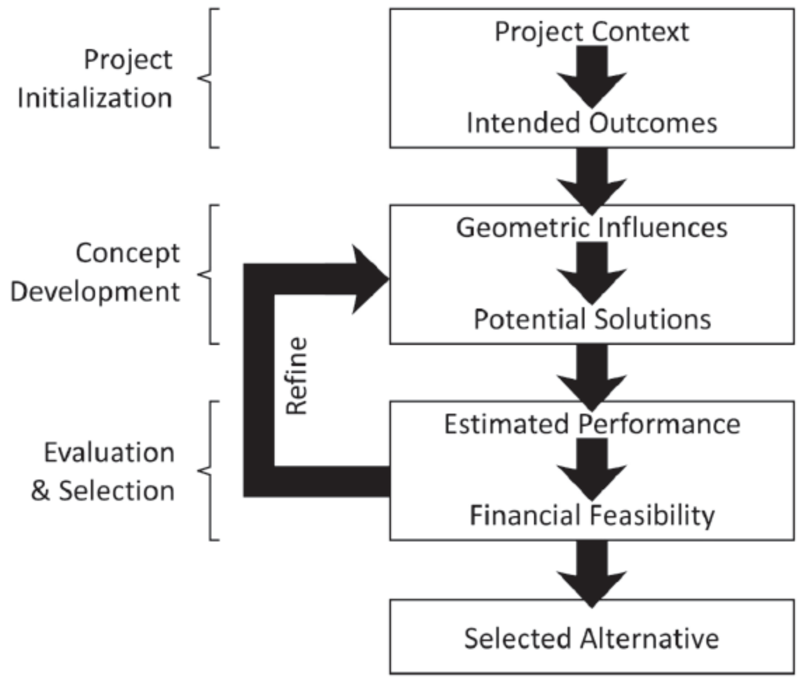
Figure 2-1 Performance-Based Analysis Model



Source: NCHRP Report 785, Exhibit 1-1 (3)

Performance-based design can be applied to various stages of the PDN. Figure 2-2 provides a basic framework that can be tailored to specific projects. The project initiation, concept development, and evaluation and selection align with Stage 0 and Stage 1. These early stages focus on project teams identifying project goals, documenting the context and user needs, developing and evaluating concepts, and working towards defining the project criteria that are used to establish the project footprint in Stage 2.

Figure 2-2 Performance-Based Analysis Application Framework



Source: NCHRP Report 785, Exhibit 5-1 (3)

2.1.1 Community Engagement and Public Outreach

Community engagement and public outreach are important for identifying the desired outcomes and performance measures that are used in a performance-based design approach to select a project alternative.

The TDOT Community Relations and Communication Division is responsible for enhancing and improving communication between TDOT and its stakeholders/customers and for providing the public with accurate and timely information. In addition, TDOT's Office of Community Transportation (OCT) can support project teams in connecting with local agencies that may be involved in and/or impacted by the project.

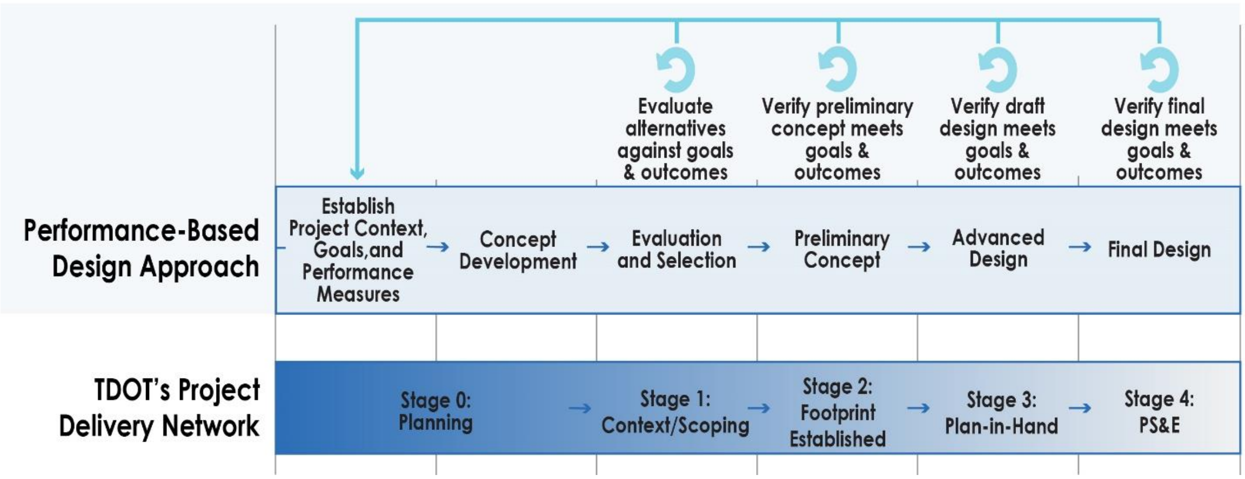
These resources support project teams in identifying and implementing effective outreach approaches. By engaging the appropriate resources early in project development, project teams can communicate clearly with stakeholders and integrate community goals throughout the planning, design, and construction processes. Understanding how the project can impact stakeholders can lead to project efficiency and positive community collaboration.

Community input is requested in Stage 0 and may be gathered through coordination with local agency staff during the site visits as part of Stage 0. Community input should inform the goals and performance measures that are established as part of Stage 0 and documented in the Concept Report (see Section 2.2).

2.1.2 Connection to the TDOT PDN

Figure 2-3 illustrates how a performance-based design approach can be integrated into TDOT's existing design process outlined in the PDN. As shown, the approach is intended to be iterative, so that at each stage the design is reviewed to ensure it supports the project goals and outcomes.

Figure 2-3 Performance-Based Design Approach



As shown in Figure 2-3, each stage of the PDN progresses through the overarching performance-based design approach.

- **Stage 0: Planning**—Develop an initial project vision and initiate conceptual layout (for some project types) or single-line sketch, which is summarized in the Concept Report. Context, goals, and performance measures will be identified in Stage 0 and then may be refined in Stage 1.
- **Stage 1: Context/Scoping**—Confirm critical project goals and intended outcomes, identify alternatives, and outline project-specific design criteria based on the selected alternative. This includes establishing the line and grade package that outlines major roadway design elements (including horizontal and vertical alignments) to inform other disciplines.
- **Stage 2: Footprint Established**—Develop the roadway functional plans, including refined typical sections.
- **Stage 3: Plan-in-Hand**—Complete all plans, specifications, and estimates (PS&E).
- **Stage 4: PS&E**—Finalize the project's PS&E.

2.2 ESTABLISHING PROJECT GOALS AND PERFORMANCE MEASURES *(PDN STAGE 0 AND 1)*

As part of Stage 0 and Stage 1, the project team will establish goals and performance measures that will set the foundation for design decisions throughout the project. Understanding the project type, project catalyst, and prior community engagement will be key elements of identifying goals and performance measures. As described in Chapter 1, Section 1.1.1 of the *PSG,* different project types will have varying levels of design flexibility and constraints. The project catalyst can help the project team understand the fundamental reasons for the project, such as safety performance, operational capacity, or land use development. Community engagement can help inform the goals and performance measures to verify the project optimizes the positive impact to the surrounding area.

2.2.1 Goals

Collaborating with local agencies and engaging the community can help a project team determine project goals early in the process. This will establish the vision and context for the future community within the project's limits. The TDOT Collection of Transportation Plans can be a starting point for identifying previous goals and future planning decisions. In addition, each project is an opportunity to identify new plans that may be added to the TDOT Collection of Transportations Plans to expand this resource.

The project goals should be a brief list of succinct points that speak to the community's priorities and vision as they relate to transportation and the associated land use goals of the study area. The goals should consider the range of existing and anticipated social, economic, and environmental conditions while also reflecting the roadway designation. Goals can be visionary and focused on the future but should be stated in plain, non-technical language and understood by community members. At a minimum, the goals should address:

- **Vision of the Place**: The vision will incorporate the existing context with the desired future land use pattern and growth. For example, the project team may expect the study area to maintain a Rural context, or may anticipate the mix of uses to increase, resulting in a new Suburban context. The role of the place in the region (e.g., employment center, residential enclave, neighborhood retail, regional shopping area, etc.), community values (e.g., safety, economic development, community character) and environmental and cost impacts should be considered. Community engagement and input early in the project is key to establishing a vision.
- **Desired Role of the Facility**: The desired role of the facility will draw heavily on the transportation characteristics outlined in the Concept Report and Project-Specific Design Criteria Document as well as regional and local vision and goals for the study area, vetted by stakeholders. For example, a facility could function as a regional commuting facility with longer-distance trips or a local-serving roadway with mostly shorter trips.

- **Major Users of the Facility**: The context and the role of the facility will inform who the roadway users are. Based on existing and future transportation needs and land use conditions, the project team can define who the major users of the facility are now and in the future. These users may include pedestrians, bicyclists, transit users, freight traffic, motorists, etc., and should also include demographic groups based on major land uses around the facility (e.g., elderly, school children, tourists, retailers, employees, disadvantaged communities, etc.).

As previously described, goals should be documented early in the PDN process as part of the Concept Report in Stage 0 and confirmed at key project milestones. This will verify that design decisions align with the project's original intent and support existing and future roadway user needs within the study area. Table 2-1 outlines example project goals based on different project.

Table 2-1: Example Project Alternatives and Associated Goals

Example Projects	Example Project Goals
Project A: A five-mile, two-lane arterial roadway connects an established metropolitan area and growing suburban development. The area is currently rural but is transitioning from a sparsely developed rural community to suburban development as growth from the metropolitan core expands. The roadway winds through a forested area with natural features including a water crossing and several large mature trees near the roadway. Improvements are being considered on the roadway to address a recent increase in crashes and to better serve all users and ongoing development. Residents on the corridor are concerned about maintaining the character of the roadway and current aesthetic.	• Provide increased safety and access for pedestrians and bicyclists along the corridor. • Accommodate future vehicular traffic anticipated on the corridor. • Enhance long-term livability for the local community. • Preserve existing natural features.
Project B: The crash rate at the intersection of a four-lane state arterial and two-lane local street has been identified as higher than similar intersection types by the state and local agency. The state arterial is programmed for routine maintenance. The local agency wants to explore possibilities for improving safety and pedestrian access at this intersection.	• Improve intersection safety for all users. • Identify opportunities for improved pedestrian and bicyclist crossings at the intersection. • Leverage public investment (resurfacing along the state arterial) to help encourage private redevelopment. • Limit impacts to adjacent utilities and right-of-way.
Project C: A two-mile state arterial about 10 miles from a downtown Urban Core has been identified as a potential redevelopment corridor by the local agency. TDOT wants to improve mobility and access for all users along this five-lane roadway and has partnered with the local agency to develop a corridor plan that serves a range of users.	• Improve transit access and mobility. • Accommodate regional traffic moving along the corridor. • Enhance connectivity and access for walking and bicycling to connect activity areas along the corridor, including safe crossing opportunities. • Leverage local and state public investment to spur economic development. • Preserve and enhance existing residential neighborhoods surrounding the area.

PDN Documentation: Project goals are identified and documented in the Final Concept Report in Stage 0. Project goals are confirmed and documented in the Draft Project Commitment Document in Stage 1 and Final Project Commitment Document in Stage 2.

2.2.2 Performance Measures

For each project, performance measures evaluate an alternative's ability to respond to the specific needs of the facility's users. Performance measures should relate directly to the project's documented goals. Therefore, performance measures should be identified after defining the project's goals and desired outcomes and before alternatives are developed.

In general, project-level performance measures should:

- **Reflect Project Goals and Desired Outcomes**: Balanced measures of success account for project goals and how these goals fit into the larger transportation network (i.e., local versus commuter oriented). An effective set of measures describes the experience of each anticipated user and assesses the likelihood of achieving desired outcomes. Projects typically have a wide range of goals and, therefore, need to consider a variety of performance measures.
    - For instance, an agency may identify a roadway improvement project focused on improving mobility and safety for a growing number of users while also striving to minimize impacts to an adjacent wetland. Performance measures should address the goals of mobility, safety, and environmental preservation. Measures could include variations in travel time (mobility), the frequency and severity of crashes (safety), and the project footprint (environmental preservation).
    - For instance, a community may want to implement bicycle lanes on a TDOT arterial while minimally impacting traffic mobility and limiting utility conflicts. Bicycle level of traffic stress (LTS) could be used to measure impacts to bicyclists, while the vehicle volume-to-capacity (v/c) ratio could be considered for traffic mobility. The project footprint and number and type of utility conflicts could be used to assess the overall impact to the adjacent right-of-way and utilities.
- **Be Understandable and Easy to Communicate**: With competing interests over potential transportation projects, measures of success should communicate to all those involved. They should be readily measurable using available data and explainable in a way that can be understood by non-technical stakeholders and members of the public. While some measures require relatively complex calculations (such as v/c ratio), other simpler measures can still produce a good deal of understanding with minimum analysis.
    - For instance, measures that describe the reliability and mobility of traffic could be as simple as evaluating the travel time between various destinations for each alternative. Measures related to assess the pedestrian environment can be as simple as determining the number of crossings per mile, the type of pedestrian signals provided, and the presence of Americans with Disabilities Act (ADA) compliant ramps. While it may seem that having more data and conducting more analysis would lead to the "correct" result, a simple and easily understandable set of evaluation criteria that truly reflect the context and project goals may lead to better stakeholder buy-in and the ultimate success of the project.

- **Be Consistent and Objectively Measurable**: To effectively support decision-making, each measure needs to be objective and applicable to all alternatives.
    - For example, a measure specific to traffic signal performance, like percentage of vehicles arriving on green, would not be consistently measurable when comparing a signalized corridor to a roundabout corridor.
- **Help Differentiate Between Alternatives**: In aggregate, the selected set of measures needs to help differentiate performance among the alternatives to inform decision-making. Each individual measure does not need to differentiate—in some cases, all alternatives under consideration will fulfill a goal (and related measure) to the same degree. However, within the set of measures, one or more must be measurably different between the various alternatives.
- **Be Specific to the Plan**: Effective measures of success should be developed for specific plans and studies and not simply "copied and pasted" from previous studies with similar attributes.
    - For example, while v/c ratio is generally used for many traffic-related roadway considerations, a study exploring ways to improve pedestrian safety on a corridor may focus on the number and spacing of pedestrian crossings instead.
    - For example, a project focused on realigning the roadway to improve safety performance may consider measures associated with speed reduction, crash type, and overall project footprint.

Relevant performance measures may be selected from a range of categories to help the project team meaningfully differentiate among alternatives, as shown in Table 2-2. The selection of these performance measures will likely be applied differently depending on the context classification, project vision, and project-specific characteristics.

Table 2-2: Examples of Performance Categories and Measures

Performance Category	Example Performance Measure
Safety	• Conflict point analysis • Pedestrian and bicycle intersection evaluation (TDOT *20-Flag Intersection Evaluation Guide*) • Vehicle speeds • Crossing distances • Crash history (severity and type of crash) • Calibrated safety performance functions (*Highway Safety Manual*) • Crash reduction factors
Mobility/Traffic Operations	• Average Daily Traffic (ADT) threshold values • Capacity Analysis for Planning of Junctions (CAP-X) • Volume-to-capacity (v/c) ratio • Travel delay • Corridor travel time • Travel time reliability (review of available existing data and estimated microsimulation data) • Level of service (LOS) • Queue lengths (50th or 95th percentile) • Design vehicle
Footprint	• Right-of-way • Property acquisition impacts • Utility conflicts • Access management issues
Structural Capacity	• Design life • Ability to widen the structure
Design Roadway User	• Pedestrian and bicycle quality of service • Connectivity • Type of pedestrian and bicycle facilities
Financial Investment	• Life cycle cost • Construction cost • Benefit-to-cost ratio
Environmental Considerations	• Vehicle miles traveled (VMT) • Congested vehicle miles traveled • Greenhouse gas emissions • Other emissions and particulate matter • Transit accessibility • Mode share • Impacts to wetlands or other environmentally-sensitive areas
Other Site-Specific Considerations	• Livability • Walkability • Economic revitalization • History (e.g., protection of a tree) • Heritage

Specifically identifying performance measures in the design roadway user service category, Table 2-3 lists potential project-level performance measures that could be considered for each mode. This list is not intended to be exhaustive or prescriptive. It draws from industry best practices, including latest guidance and research from FHWA, such as the FHWA *Guidebook for Developing Pedestrian and Bicycle Performance (4)* and the Environmental Protection Agency (EPA) *Guide to Sustainable Transportation Performance Measures (5)*, as well as the TDOT *Highway System Access Manual – Volume 1*.

Table 2-3: Examples of Project-Level Performance Measures by Mode

Mode	Project Level Performance Measures
Vehicular	• Maximum volume-to-capacity (v/c) ratio • Travel-time reliability (review of available existing data and estimated microsimulation data) • Peak and off-peak travel time • Estimated potential reduction in crashes using crash reduction factors • Number of major crashes per year • Number of high-crash locations • Length of vehicle queues • Average or 85th percentile travel speed • Intersection delay
Freight	• Volume-to-capacity (v/c) ratio • Travel-time reliability (review of available existing data and estimated microsimulation data) • Peak and off-peak travel time • Ability to serve freight origins and destinations • Loading zone availability • Average and 85th percentile travel speed
Bicycle	• Bicycle level of traffic stress (LTS) • Percent of roadway served by an exclusive bicycle facility • Percent of roadway with bicycle facilities meeting current standards • Estimated potential reduction in crashes using crash reduction factors • Number of crashes involving bicyclists • Forecast volumes of bicyclists (various methods available)
Pedestrian	• Pedestrian level of traffic stress (LTS) • Sidewalk coverage and connectivity • Sidewalk width and effective width • Pedestrian space • Average distance between marked crossings • Percentage of ADA-compliant pedestrian crossings • Average pedestrian delay at intersections • Presence of pedestrian refuge islands • Number of street trees and percentage of shade • Level of pedestrian-scale street lighting • Estimated potential reduction in crashes using crash reduction factors
Transit	• Number/percent of ADA-compliant transit stops • Number of residents/jobs within a quarter mile of stop locations (or within a half a mile of high frequency transit) • Anticipated transit delay due to stop location (in-lane stops and far-side stops typically reduce delay) • Presence or degree of transit priority treatments (where appropriate) • Sidewalk width • Proximity of marked street crossings to transit stop locations • Average travel speed

Table 2-4 offers an example of how to tie performance measures to project goals for Project Alternative A presented in Table 2-1.

Table 2-4: Example of Tying Performance Measures to Project Goals

Project Goals	Performance Category	Performance Measures
Provide increased safety and access for pedestrians and bicyclists along the corridor.	Safety and Design Roadway User	• Expected change in travel speeds • Anticipated change in crashes • Pedestrian assessment • Bicyclist assessment
Accommodate future vehicular traffic anticipated on the corridor.	Operations	• Design year volume-to-capacity (v/c) ratio • Design year level of service (LOS) • Expected change in travel time reliability
Enhance long-term livability for the local community.	Livability	• Community feedback on how well the design alternatives maintain the character of the existing roadway.
Preserve existing natural features.	Environmental Impacts	• Level of impact to environmental features • Number of trees impacted

Establishing and applying performance measures has the greatest influence on project outcomes when they are incorporated early in project scoping and alternatives identification. The performance measures should be revisited and reevaluated throughout the project development process to ensure the design continues to align with the original desired outcomes.

TDOT PDN Documentation: Performance measures are identified as part of the Final Concept Report in Stage 0.

2.3 CONCEPT DEVELOPMENT *(PDN STAGE 0)*

The next step in the process is to develop alternative concepts. The alternatives are intended to represent a range of options and may be refined through the evaluation process. As discussed in Chapter 3, the context informs the types of users and the intensity of uses within each context. For almost every project, roadway user needs can be addressed in multiple ways. The alternatives developed to respond to these needs should explore a variety of methods and means for meeting them.

Sometimes, due to limited right-of-way or physical constraints, difficult choices must be made about how to serve different users along a roadway while limiting impacts to other project elements (e.g., utilities). Where it is not possible to provide a high-quality facility for each mode along all TDOT roadways, it may be necessary to rely upon parallel networks to provide additional travel options that serve all users.

The network approach requires close coordination between TDOT and local agencies. For example, the analysis of an alternative that prioritizes on-street parking over a dedicated bicycle facility should be informed by local vision, availability of parallel routes, and the local agency's willingness to invest in and maintain parallel facilities. The project team may find this information documented in local plans. Further, the evaluation of this alternative (and others) could also be informed by collecting data about the on-street parking use—who is using it, utilization rates, turnover rates, and side street parking availability. Finally, the decision must also be informed by technical analysis of bicycling trip origins and destinations and the need for bicycling connectivity, safety data, and user input.

TDOT PDN Documentation: Project alternative concepts are initially identified in the Final Concept Report in Stage 0 and further refined in Stage 1 as part of the Draft Project Commitment Documentation.

2.4 EVALUATION AND SELECTION *(PDN STAGE 1)*

In many cases, there may not be one clear-cut alternative that equally serves users at the same level. Selecting a well-vetted set of performance measures will frame a discussion and provide information for the project team, TDOT, the public, and local agencies to understand the trade-offs among the alternatives. The selected alternative is reviewed against the project goals and intended outcomes again when the preliminary design and final design are developed to ensure it is still consistent with the initial purpose of the project.

Some potential ways to help evaluate the trade-offs for this example between on-street parking and a bicycle facility may include considering the:

- Number of people served by each facility (e.g., parking spaces on a block used by 50 customers per day; bicycle lane used by 200 people per day);
- Availability of alternative facilities to serve each use (e.g., whether there is a nearby low-stress route for bicyclists or available parking on side streets or in parking lots);
- Relative impacts on safety, comfort, and convenience of users (e.g., asking motorists to park and walk an extra block to access destinations, versus asking bicyclists to ride in mixed traffic or out of direction on an alternate route);
- Economic impact (e.g., understanding potential economic impacts of convenient on-street parking space versus a bicycle facility to adjacent businesses); and
- Community priorities and goals (e.g., desire to provide convenient vehicle parking versus desire to implement travel demand management strategies to encourage bicycling).

Developing a clear and simple approach for evaluating, categorizing, or scoring alternatives can allow project teams to verify that the project goals and performance measures are adequately integrated and assessed to select the most appropriate and viable alternative.

Table 2-5 illustrates an example of how the performance measures from Table 2-4 related to safety can be evaluated with "low," "medium," and "high" improvement ratings.

A similar approach can be executed for other project goals and various performance measures. Chapter 7: Case Studies provides additional examples of how to evaluate alternatives.

Table 2-5: Example Improvement Ratings for Safety Performance Measures

Project Goal	Performance Measure	Improvement Rating		
		Low	Medium	High
Provide increased safety and access for pedestrians and bicyclists along the corridor.	Expected change in travel speeds	Project includes **0-1 treatments** with documented effectiveness at speed **reduction**.	Project includes **2 treatments** with documented effectiveness at speed **reduction**.	Project **includes 3 or more treatments** with documented effectiveness at speed **reduction**.
	Anticipated change in crashes	Project is **not** anticipated to reduce crashes.	Project provides a **moderate** value crash reduction factor.	Project provides a **high** value crash reduction factor.
	Pedestrian assessment	Project provides a facility of **minimum** width.	Project provides a wider facility with **horizontal separation**.	Project provides a wider facility with **vertical separation**.
	Bicycle assessment	Project provides a facility of **minimum** width.	Project provides a wider facility with **horizontal separation**.	Project provides a wider facility with **vertical separation**.

Using the measures and categories from Table 2-5, Table 2-6 illustrates the summary results from evaluating two alternatives. This is meant to demonstrate one method for how trade-offs between alternatives can be communicated to decision-makers and stakeholders. A similar approach could be used for other performance measures beyond safety and instead of "improvement ratings," a scoring (e.g., 0, 1, 2, 3, etc.) or other method could be used.

Table 2-6: Summary of Safety Performance Measures Evaluation

Project Goal	Performance Measure	Improvement Rating	
		Alternative 1	Alternative 2
Provide increased safety and access for pedestrians and bicyclists along the corridor.	Expected change in travel speeds	High	Medium
	Anticipated change in crashes	High	High
	Pedestrian assessment	High	Medium
	Bicycle assessment	Low	High

If design decisions, project team discussions, and alternative evaluations lead to any changes in the performance measures or project goals, this information and the project team decisions should be clearly documented (See PDN for documentation and deliverables) and justified for review by the project team, who would either confirm the decisions or provide alternate direction on how to proceed. The alternate direction could include:

- Additional or further modification to the project team revisions;
- Rejection of the revisions and return to original project goals; or
- Decision to change the project scope and reinitiate the process of goals development.

After a consensus has been reached, the preliminary design decisions and trade-offs should be well documented with stakeholder support.

TDOT PDN Documentation: Alternative evaluation and selection occurs in Stage 1 and the selected alternative is documented in the Stage 1 Scope of Work Document. The Final Project Commitment Document developed in Stage 2 includes the final alternative that will move forward in the project.

2.5 DESIGN PHASE *(PDN STAGE 2)*

As a project moves into the design phase, project teams should give careful consideration to preserving the goals and desired outcomes of the project. Additional constraints may become apparent throughout the design phase that require project elements to be revisited and refined. For example, the project team may discover during final project design that it is infeasible or significantly more costly than anticipated to provide a key element of the agreed-upon preliminary design.

If changes are made to the preliminary concept, advanced design, or final design that are not aligned with the project context and intended outcomes, the project team should revisit the context and goals and adjust the design as needed. This iterative process verifies that if changes are made during the design process, the design is still consistent with the project purpose.

Project teams should clearly document changes and justifications for their decisions. These decisions should also be vetted with key local stakeholders engaged in the beginning of the PDN. If the local stakeholders and project team cannot agree on a path forward, it may be necessary, and ultimately less costly, to stop the development of the final design and return to an earlier step in the process. This may include revising project goals or developing and evaluating new project alternatives.

TDOT PDN Documentation: The design elements and criteria are documented in the Project-Specific Design Criteria and Scope of Work Document in Stage 1 and also inform the Draft Project Commitment Document in Stage 1. The Final Project Commitment Document in Stage 2 includes the final project design criteria that will be carried through the design phase.

2.6 DOCUMENTING DESIGN DECISIONS

The performance-based design approach includes key documentation milestones to verify decisions are carried from the earliest stages through final design and construction. The TDOT PDN outlines specific deliverables that align with this approach and each stage of the PDN process. The *PSG* provides direction for developing information related to specific deliverables within the PDN, including:

- **Stage 0: Planning**
  - Draft and Final Concept Report
  - Begin Decision-Making Worksheet
- **Stage 1: Context/Scoping**
  - Draft Project Commitment Document
  - Scope of Work Document
  - Project-Specific Design Criteria Document
- **Stage 2: Footprint Established**
  - Signed Project Commitment Document
  - Functional Plans
  - Design Exceptions/Deviations/Waivers

Other documentation occurs in Stages 3 and 4, which is not a focus for the *PSG.* Figure 2-4 illustrates how the documentation aligns with the PDN stages and supports an overarching performance-based design approach. Table 2-7 summarizes the PDN stages and associated deliverables executed by each discipline.

Figure 2-4 Performance-Based Design Decision Framework with TDOT Documentation

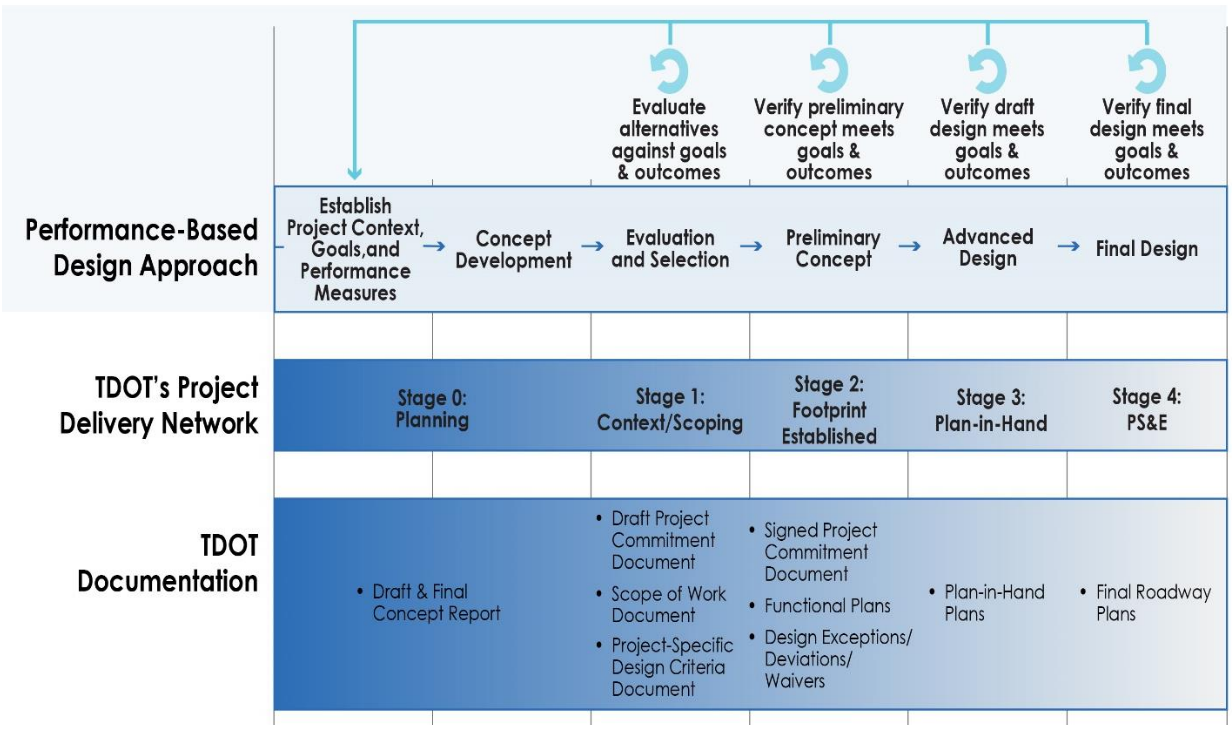


Table 2-7: Project Delivery Network Activities and Deliverables Related to the *PSG*

Stage 0: Planning	Stage 1: Context/Scoping	Stage 2: Footprint Established	Stage 3: Plan-in-Hand	Stage 4: PS&E

• Provide Roadway Desktop Review
• Initiate Concept Report
  o Gather data to inform concept report (e.g., traffic data, crash data)
  o Outline project purpose and goals
  o Identify performance measures
  o Identify context
  o Complete IIE Analysis and Summary Form
  o Identify alternatives
  o Identify long-range planning documentation
  o Identify public outreach needs
• Begin Decision-Making Worksheet
• Conduct Active Transportation Review and develop Active Transportation Considerations and Recommendations
• Conduct public outreach
• Develop Draft Concept Report
  o Document goals, context, performance measures
  o Concept layout or single-line sketch (if applicable and dependent on project type)
  o IAR documentation
  o Document public outreach input
• Finalize Concept Report
	• Set up project
	• Develop Draft Project Commitment Document (PCD)
	• Verify Concept Report is integrated into documentation and decision-making
	• Initiate roadway design and typical sections
	• Develop Project-Specific Design Criteria Document based on design year context
	• TDOT Project Notebook
	• Verify all information (e.g. roadway, geotechnical, multimodal) is included in Project Commitment documentation
	• Confirm multimodal compliance as part of Environmental Review based on Stage 0 recommendations
	• Verify ADA compliance with multimodal recommendations
	• Identify potential drainage and maintenance requirements based on multimodal recommendations
		• Complete Project Commitment Document (PCD)
		• Verify Concept Report is integrated into documentation and decision-making.
		• Verify multimodal information is included in Project Commitment documentation.
		• Develop Functional Design Plans
		• Verify criteria align with footprint established
		• Identify and complete Design Exceptions/Deviations/Waivers
			• Manage Plan-In-Hand
			• Complete Plan-in-Hand Design
			• Verify design aligns with original goals and criteria
			• Acquire right-of-way
				• Manage PS&E
				• Finalize construction documents

Deliverables				
• **Draft Concept Report** • **Final Concept Report**	• **Draft Project Commitment Document (PCD)** • **Scope of Work Document** • **Project-Specific Design Criteria Document**	• **Signed Project Commitment Document (PCD)** • **Functional Design Plans, including refined typical sections.** • **Design Exceptions/Deviations/Waivers**	• **Plan-In-Hand Plans and associated documentation**	• **Draft and Final Roadway Plans** • **Final Construction Plan**

2.7 DESIGN EXCEPTIONS/DEVIATIONS/WAIVERS

Despite the range of flexibility for the controlling elements of a design, there are situations in which accepted design criteria are not applicable or where design exceptions, deviations, or waivers are needed for circumstances in the field that cannot reasonably be met within the project footprint.

When appropriate, the design exception, deviation, or waiver process allows use of criteria or standards other than the accepted values. Design exceptions, deviations, or waivers can be opportunities to add design practicality or value and are not necessarily considered violations of TDOT policy.

Project teams should follow the specific design exception, deviation, or waiver process required for the specific discipline. The *Roadway Design Guidelines (RDG)* and *Highway System Access Manual (HSAM)* are the primary resources for these processes, but some projects and disciplines may require additional processes. Design exceptions, deviations, and waivers are typically completed as part of Stage 2 of the PDN.

2.8 REFERENCES

1. Federal Highway Administration (FHWA). "Performance-Based Practical Design." https://www.fhwa.dot.gov/design/pbpd/ (as of November 3, 2023).
2. American Association of State Highway Transportation Officials (AASHTO). *A Policy on Geometric Design of Highways and Streets (Green Book)*, Seventh Edition. Washington, D.C., 2018.
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Tennessee Department of Transportation

Project Scoping Guide

Chapter 3 – Identifying Design Year Context

September 2024

TN TDOT Department of Transportation

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Chapter 3

Identifying Design Year Context

TDOT is at the forefront of bridging land use with transportation and incorporating context classifications into the planning and design decision-making process and project documentation. Identifying and documenting context is an integral step in the Project Delivery Network (PDN) as one of the key outcomes of the Concept Report in Stage 0: Planning.

Chapter 3 describes TDOT context classifications and the process to select the design year context for projects within the different Tennessee communities. This chapter also provides background on the national transportation industry context-based design practice, which aligns with the American Association of State Highway Transportation Officials' (AASHTO) *A Policy on Geometric Design of Highways and Streets (Green Book)* and other related national initiatives.

A context identification process helps the project team understand how land use, the surrounding roadway environment, and users can impact design decisions. This approach enables the project team to be more flexible and determine "appropriate design dimensions based on project-specific conditions and existing and future roadway performance more than on meeting specific nominal design criteria," as the *Green Book* notes *(1)*. Also, a roadway's context, in addition to its facility type, informs the types of expected roadway users. This overall process allows project teams to make design decisions that support all future roadway users.

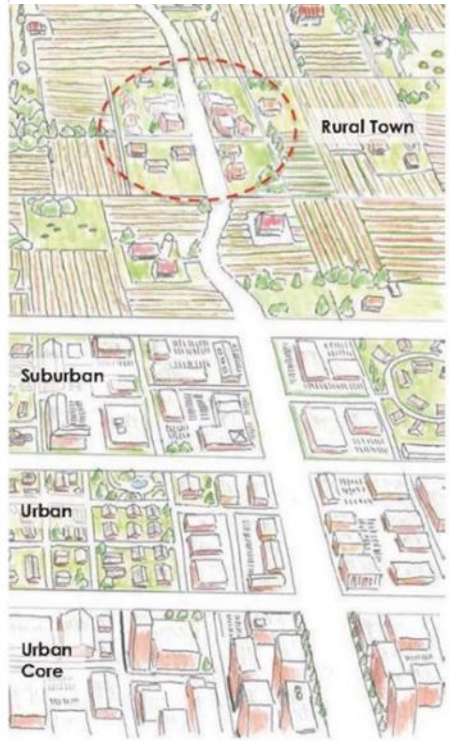
TDOT's context identification process considers both the existing and future design year context to inform project decisions. However, the focus of this chapter is design year context to verify project implementation aligns with long-term goals and plans to support all users of TDOT's transportation network.

3.1 TDOT CONTEXT CLASSIFICATIONS

TDOT's context classifications are consistent with those presented in the *Green Book* and based on research conducted as part of National Cooperative Highway Research Program (NCHRP) Research Report 855: *An Expanded Functional Classification System for Highways and Streets (2)* and NCHRP Research Report 1022: *Context Classification Application: A Guide (3)*, as presented in Figure 3-1. Definitions for each context in TDOT's *Highway System Access Manual (HSAM)* speak to development density, setback, land use, and, in some cases, on-street parking and pedestrian facilities, as defined below *(4)*.

- **Rural:** Areas with the lowest density, few houses or structures (widely dispersed or no residential, commercial, or industrial uses), and usually large setbacks.
- **Rural Town:** Areas with low density but diverse land uses with commercial main street character, potential for on-street parking and sidewalks, and small setbacks.
- **Suburban:** Areas with medium density, mixed land uses within and among structures (including mixed-use town centers, commercial corridors, and residential areas), and varied setbacks.
- **Urban:** Areas with high density, mixed land uses and prominent destinations, potential for some on-street parking and sidewalks, and mixed setbacks.
- **Urban Core:** Areas with highest density, mixed land uses within and among predominately high-rise structures, and small setbacks.

Figure 3-1 Context Classifications



Source: Figure 1-9, Highway System Access Manual. Originally from NCHRP Research Report 855 (1)

The five TDOT context classifications are broad but may not fit every location. Subsequent sections of this chapter will offer guidance to the project team as they determine the appropriate context based on predominant land use, modal expectations, roadway function, and other major considerations.

3.1.1 Determining Context

Context is based on existing and future anticipated conditions along the roadway. Site characteristics can be evaluated through a combination of a site visit, reviewing internet-based aerial and street-level imagery, analyzing maps, consulting with the local agency, and reviewing land use plans.

Project teams should coordinate with TDOT Planning Division to obtain the latest information for identifying context classification throughout the state.

For projects with a long design life that require consideration of future transportation demand projections, the project team should consider future land use when determining context. The assumptions related to future land use should be coordinated with TDOT Long Range Planning Division staff to verify approach and coordination. The project team should begin this process by reviewing existing plans, such as long-range plans or corridor studies, if available. The TDOT Collection of Transportation Plans may include regional, local, or other area plans that can inform the context identification process.

Projects with a relatively short design horizon, such as resurfacing, safety, or bridge repair projects, may only need to consider existing conditions to determine context. Proposed developments with approved permits should be considered part of the existing conditions. However, the project team should look for opportunities to support future land use and expected users and address gaps in the bicycle and pedestrian network, where feasible and possible with appropriate funding.

In some cases, the context may differ on each side of the roadway. In these situations, the project team should determine the appropriate context based on predominant land use, modal expectations, roadway function, or other major considerations.

NCHRP Research Report 1022: *Context Classification: A Guide* is a national resource available to support project teams in identifying context and establishing expectations for roadway users, such as speed and appropriate travel modes. *(3)*

Table 3-1 provides typical characteristics of the five context classifications. Project teams can use this as a starting point for determining context along state roadways. Some roadways may have characteristics of a variety of contexts, such as land use that is suburban but block sizes and access control that is more rural, as an example. Noting what context the existing conditions and future desired outcomes for the roadway and surrounding area fall under for each column in the table, along with engineering judgment, can help identify the most appropriate context classification. In some cases, the context may not be expected to change between existing conditions and the design year. In other cases, the desired context in the design year may be different than what currently exists, and project teams can consider how the roadway and surrounding area may transition over time. For example, a project may be in an area that is rural but transitioning to Suburban context as growth from the metropolitan core expands, so the design year context may be identified as Suburban.

Table 3-1: Potential Existing and Future Characteristics of Contexts for TDOT Roadways

Context Classification	Land Use[1]	Density of Structures[1]	Building Setback[1]	Block Size[2]	Access Control[1]	Parking Location[2]	Pedestrian Activity	Bicycle Activity	Transit	Utilities	Landscaping
Rural	Agricultural, natural resource preservation, and outdoor recreation uses with some isolated residential and commercial	Lowest (few houses or structures)	Usually large setbacks	Undefined blocks	Limited access, varied direct vehicle access to land uses, limited pedestrian and bicycle access	Mostly off-street parking	Limited	Limited	Limited	Overhead utilities with varied setback	Unlikely within right-of-way
Rural Town	Primarily commercial uses along a main street, with some mixed residential neighborhood and commercial clusters	Low to medium (single-family houses and other single-purpose structures)	On-street parking and sidewalks with predominately small setbacks	Small to medium blocks	High access opportunities for all users	On-street parking	Likely	Limited	Limited	Overhead utilities with varied setback	Unlikely
Suburban	Mixed residential neighborhood and commercial clusters (includes town centers, commercial corridors, big box commercial, and light industrial)	Low to medium (single- and multifamily structures and multistory commercial)	Varied setbacks with some sidewalks and mostly off-street parking	Medium to large blocks, not well defined	Low to moderate access opportunities for all users	Mostly off-street parking	Varied	Varied	Potential	Overhead utilities with minimal setback	Likely
Urban	Mixed residential and commercial uses, with some institutional and industrial and prominent destinations	High (multistory, low-rise structures with designated off-street parking)	On-street parking and sidewalks with mixed setbacks	Small to medium blocks	High access opportunities for all users	On-street parking and structured parking	Likely	Likely	Likely	Most utilities underground, light poles likely adjacent to the roadway	Likely
Urban Core	Mixed commercial, residential, and institutional uses within and among predominately high-rise structures	Highest (multistory and high-rise structures)	Small setbacks with sidewalks and pedestrian plazas	Small, well-defined blocks	High access opportunities for pedestrians and bicycles, limited parking may limit access for vehicles	Restricted on-street parking and structured parking	Likely	Likely	Likely	Most utilities underground, light poles likely adjacent to the roadway	Likely

1 Inclusion of Density of Structures, Building Setback, Permeability, and Land Use as described in NCHRP Research Report 1022 (3)
2 Inclusion of Block Size and Paring Location as described in the AASHTO Green Book (1)
3 Inclusion of Natural Environment, Community Characteristics, and Social Demographics as described by NCHRP Web-Only Document 320 (5)

Additional considerations for natural environment, community characteristics, and social demographics can also be integrated into the decision-making process for understanding the existing context and identifying the design year context, as shown in Table 3-2.

Table 3-2: Potential Existing and Future Natural Environment, Community Characteristics and Social Demographics of Land Use Contexts for TDOT Roadways

Context Classification	Natural Environment (Sensitivity and Access)[1]	Community Characteristics[1]	Social Demographics[1]
Rural	High likelihood of environmentally sensitive areas. Consider the potential need for environmental mitigation.	Community considerations are typically oriented away from the road facilities. Access to parklands, public lands.	Agriculture and resource oriented.
Rural Town	Consider potential need for treating and managing environmental mitigation to address impacts.	Considerations for community gathering areas. Historic buildings, bridges, water towers.	Considerations for personal safety and security.
Suburban	Consider potential need for treating and managing environmental mitigation to address impacts.	Community considerations are typically oriented away from the road facilities.	Considerations for personal safety and security.
Urban	Consider parks, greenways. Considerations for air quality, greenhouse gas, and water quality.	Considerations for community gathering areas. Historic buildings, bridges, water towers.	Considerations for personal safety and security—pedestrian facilities, parking.
Urban Core	Consider parks, greenways. Considerations for air quality, greenhouse gas, and water quality.	Considerations for community gathering areas. Historic buildings, bridges, water towers.	Considerations for personal safety and security—pedestrian facilities, parking.

1 Inclusion of Natural Environment, Community Characteristics, and Social Demographics as described by NCHRP Web-Only Document 320 (5)

3.1.2 TDOT Context Examples

The following Tennessee examples for each context are intended to help the project team visualize each context and compare project-specific characteristics. The Google Earth images below serve as a reference when selecting the context classification for each project location.

RURAL

Areas with lowest density, few houses or structures (widely dispersed or no residential, commercial, or industrial uses), and usually large setbacks. Examples of a Rural context are shown in Figures 3-2 through 3-5.

Figure 3-2 SR 100, Centerville—Rural Context

Figure 3-3 SR 100—Rural Context

Source: Google Maps

Figure 3-4 E Emory Rd (SR 331), Corryton—Rural Context

Figure 3-5 E Emory Rd (SR 331)—Rural Context

Source: Google Maps

RURAL TOWN

Areas with low density but diverse land uses with commercial main street character, potential for on-street parking and sidewalks, and small setbacks. Examples of a Rural Town context are shown in Figures 3-6 through 3-9.

Figure 3-6 Signal Mountain Rd (TN 27), Chattanooga—Rural Town Context

Figure 3-7 Signal Mountain Rd (TN 27)—Rural Town Context

Source: Google Maps

Figure 3-8 S Main Street (SR 013), Lobelville—Rural Town Context

Figure 3-9 S Main Street (SR 013)—Rural Town Context

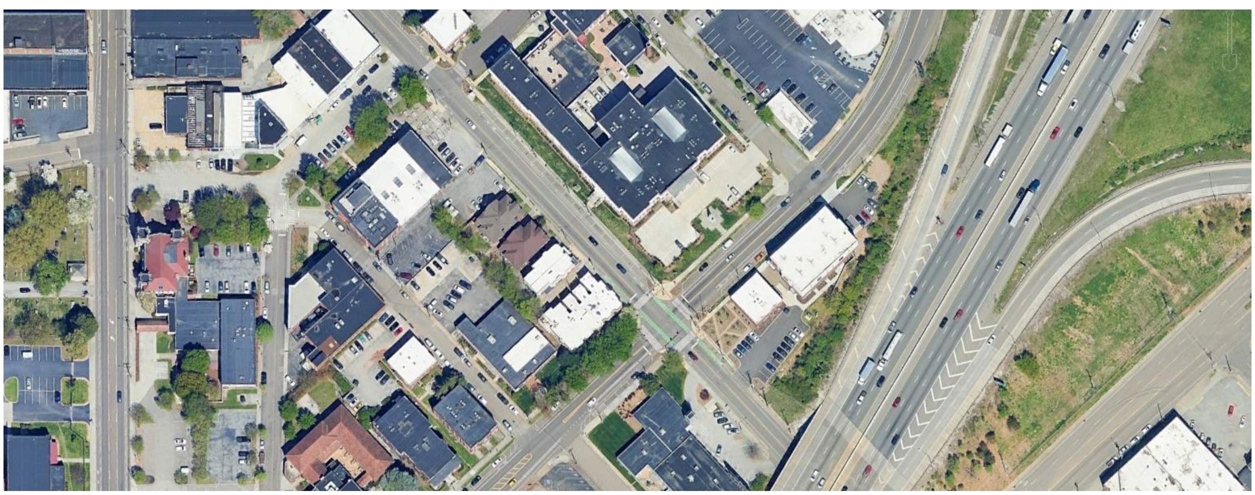
Source: Google Maps

SUBURBAN

Areas with medium density, mixed land uses within and among structures (including mixed-use town centers, commercial corridors, and residential areas) and varied setbacks. Examples of a Suburban context are shown in Figures 3-10 through 3-15.

Figure 3-10 E Fifth Avenue (SR 06025), Knoxville—Suburban Context

Figure 3-11 E Fifth Avenue (SR 06025)—Suburban Context



Source: Google Maps

Figure 3-12 S 2nd Avenue (SR 011), Lewisburg—Suburban Context

Figure 3-13 S 2nd Avenue (SR 011)—Suburban Context

Source: Google Maps

Figure 3-14 E Main Street (SR 024), Lebanon—Suburban Context

Figure 3-15 E Main Street (SR 024)—Suburban Context

Source: Google Maps

URBAN

Areas with high density, mixed land uses and prominent destinations, potential for some on-street parking and sidewalks, and mixed setbacks. Examples of an Urban context are shown in Figures 3-16 through 3-19.

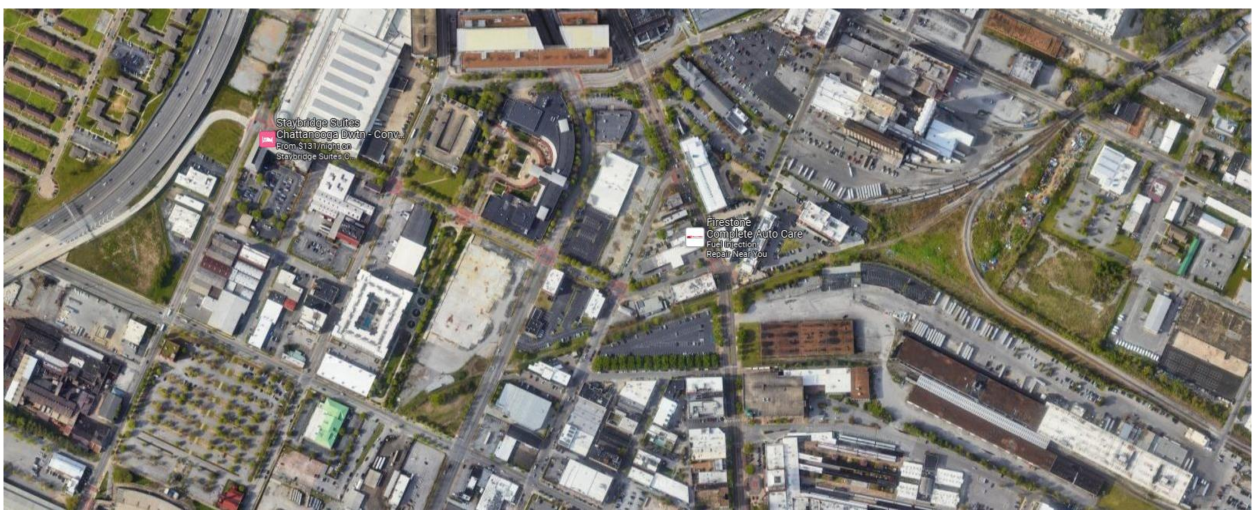
Figure 3-16 W Main Street (SR 03776), Knoxville—Urban Context

Figure 3-17 W Main Street (SR 03776)—Urban Context

Source: Google Maps

Figure 3-18 Martin Luther King Boulevard (SR 316), Chattanooga—Urban Context

Figure 3-19 Martin Luther King Boulevard (SR 316)—Urban Context



Source: Google Maps

URBAN CORE

Areas with highest density, mixed land uses within and among predominately high-rise structures, and small setbacks. Examples of an Urban Core context are shown in Figures 3-20 through 3-23.

Figure 3-20 West End Avenue (SR 1), Downtown Nashville—Urban Core Context

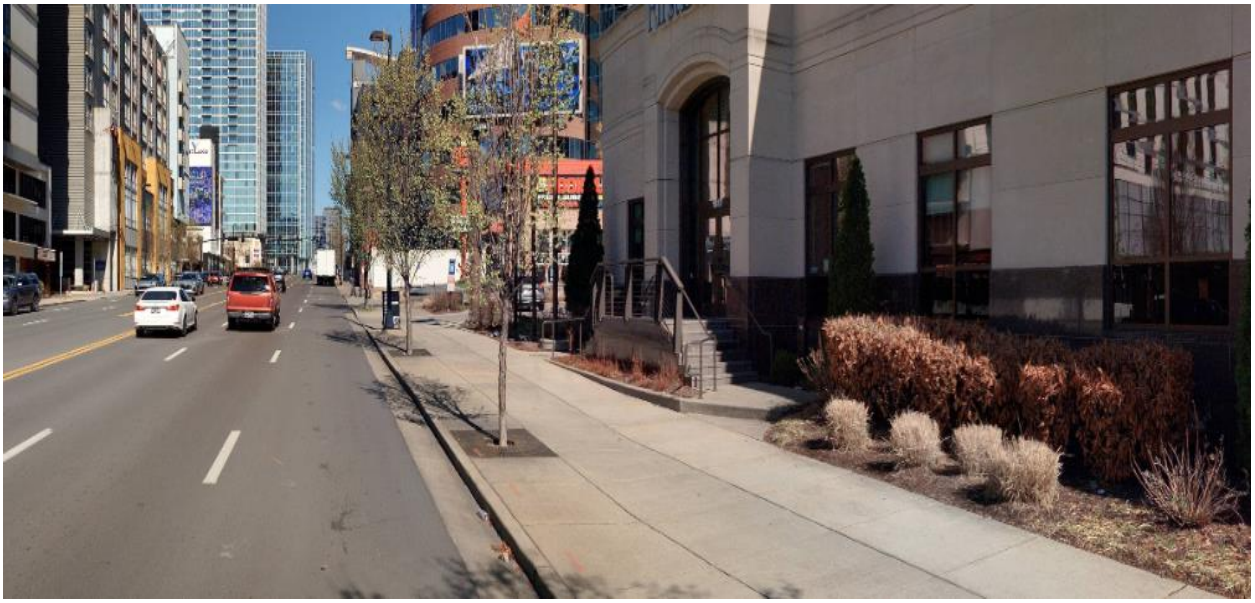
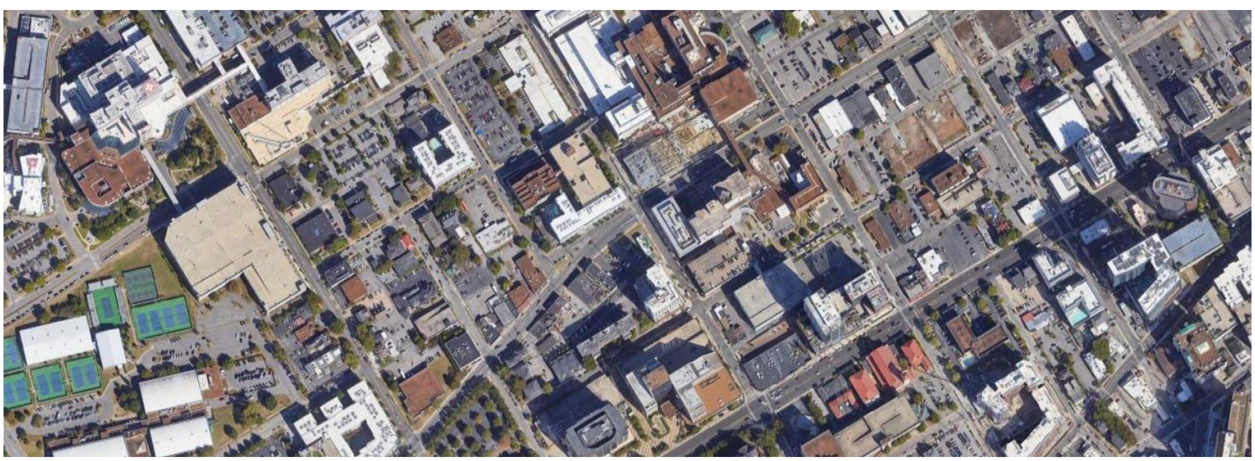


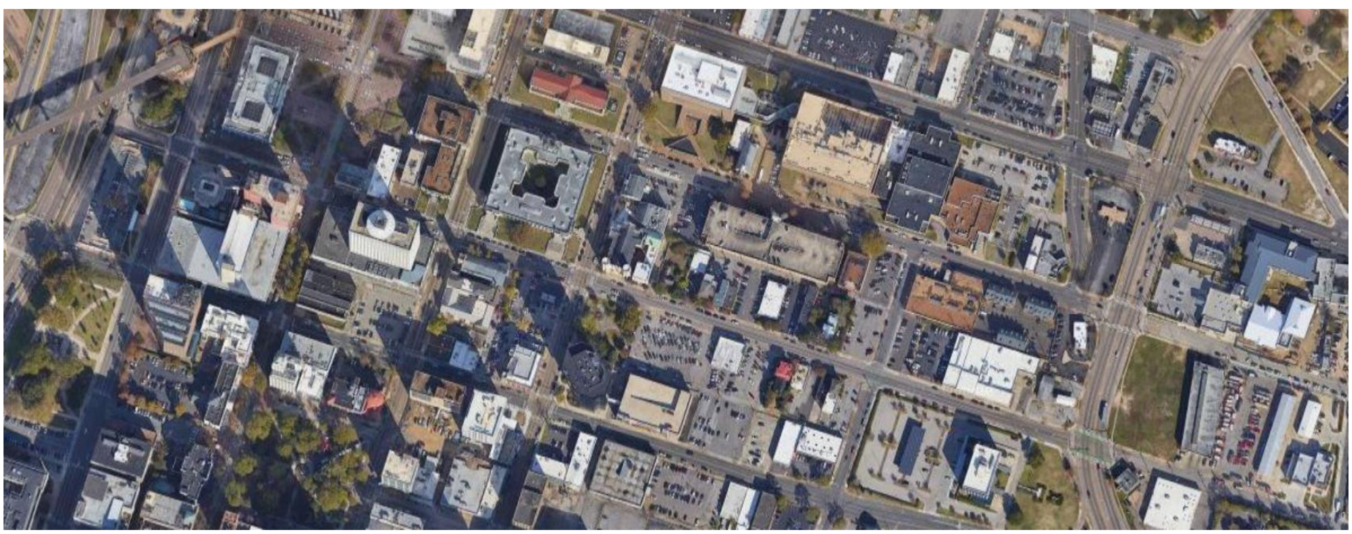
Figure 3-21 West End Avenue (SR 1)—Urban Core Context



Source: Google Maps

Figure 3-22 North B.B. King Boulevard (SR 3), Downtown Memphis—Urban Core Context

Figure 3-23 North B.B. King Boulevard (SR 3)—Urban Core Context



Source: Google Maps

3.1.3 Modal Integration

Context can help the project team identify the types of roadway users and the intensity of use that can be expected within each context. Understanding the roadway users and their needs will influence the design elements.

For example:

- In an **Urban Core** context, the project team should expect more pedestrians, bicyclists, and transit riders than in other contexts. Therefore, slower vehicle speeds, shorter signal spacing, shorter crossing distances, and other design elements such as bicycle facilities, on-street parking, and wide sidewalks should be considered as strategies to improve safety and comfort for anticipated users (pedestrians, bicyclists, and transit riders).
- In a **Suburban** context, while the project team should expect higher volumes of vehicles and freight, bicyclists and pedestrians are also likely to be present and enhanced facilities should be integrated for bicyclist and pedestrian safety and comfort. Greater separation between vehicles and bicyclists and pedestrians may be provided in a Suburban context because vehicle speeds and volumes are higher.

The design elements for the facility will change as it transitions into different contexts. Table 3-3 summarizes the potential presence of each user type in different contexts to support planning and design decisions. It should be used to reflect the desired goals are for roadway users in the future design year, not just to document current experiences. This table is intended to be a starting point and not dictate decisions for roadway users in the context.

Table 3-3: General Modal Integration in Different Contexts

Context	Motorist	Freight	Transit	Bicyclist	Pedestrian
Urban Core	Low	Low	High	High	High
Urban	Medium	Low	High	High	High
Suburban	High	High	High	Medium	Medium
Rural Town	Medium	Medium	Varies	High	High
Rural	High	High	Low	Low	Low

High: Highest level facility should be considered and prioritized over other modal treatments.
Medium: Design elements should be considered; trade-offs may exist based on desired outcomes and user needs.
Low: Incorporate design elements as space permits.

Specific modal expectations should be established on a project-by-project basis for the future design years of a project. Although some modes may be expected to appear less frequently, they must still be accommodated as all modes may be present in all contexts. For example:

- Roadways in an **Urban Core** context are designed to emphasize safety and comfort for transit users, bicyclists, and pedestrians, but still accommodate vehicles and freight deliveries. This could mean designing intersections in the Urban Core with smaller corner radii, which lowers vehicle speeds and reduces the crossing distance, providing greater safety and comfort for pedestrians.
- Roadways in a **Rural** context are designed to emphasize mobility for vehicles, but should still consider the safety and comfort of bicyclists and pedestrians, who may be present in lower volumes but are more vulnerable to severe crashes. TDOT's research study, *Addressing Traffic Safety to Reduce Pedestrian Injuries and Fatalities in Tennessee* (6), notes that pedestrian crashes are more severe in rural areas compared to urban areas, with a greater proportion of crashes in rural areas being fatal.

Chapter 4: Multimodal Planning and Design includes additional user guidance for each context.

3.2 CONNECTION TO OTHER ROADWAY CLASSIFICATIONS

3.2.1 Connection to Facility Type

TDOT's transportation system divides roadways into four functional classifications (facility types): local, collector, arterial, and freeway. This guide focuses on local, collector and arterial roadways, as defined below. Information and guidance for freeways is provided in the TDOT *Roadway Design Guidelines*.

- **Local:** A low-volume road that provides access to individual properties, such as homes, businesses, and institutions.
- **Collector:** A street that collects traffic from local streets and directs it towards arterials. Collectors are usually located within residential or commercial areas and are designated as secondary routes for intracity travel.
- **Arterial:** A major thoroughfare that supports higher-capacity transportation through urban and suburban areas. Arterials are designated as primary routes for regional or intercity travel.

For location-specific information about how TDOT facilities are classified, refer to the online TDOT functional classification map.

Understanding the function of the facilities within the transportation network will remain important; however, context is the driver for design decisions. A roadway facility type describes the role it plays within the overall transportation network. Context classifications influence the qualities and characteristics (e.g., features, elements, design dimensions) of a facility type. For example, an arterial serves a specific function in the network (functional classification), but the geometric design features and dimensions of the arterial are based on the context.

3.2.2 Connection to TDOT Roadway Designations

TDOT also uses roadway designations, including:

- **Freight Route:** The network of highways that have been identified as critical in supporting the movement of freight across the state. The TDOT Statewide Multimodal Freight Plan provides additional information on TDOT's guiding principles and goals related to statewide freight *(7)*.
- **State Industrial Access (SIA) Program and Industrial Highways:** In order to "provide access to industrial areas and to facilitate the development of expansion and industry within the State of Tennessee," TDOT has developed the State Industrial Access (SIA) program, which designates Industrial Highways based on eligibility criteria and an application process *(8)*. The SIA program provides funding and technical assistance to support Industrial Highways.
- **National Highway System:** The network of highways within the United States, including within Tennessee, that support the national economy, defense, and mobility, including the Interstate Highway System and other roads that serve airports, seaports, railroad terminals, military bases, etc.
- **State Highway System:** The network of TDOT-maintained roadways that supplements the National Highway System to provide statewide coverage.

When identifying and documenting the future design year context, these designations should be documented as well, as they affect modal expectations and regional travel. Roadways designated as freight routes and those that are a part of the National and State Highway Systems are anticipated to have higher numbers of freight carriers.

3.3 DOCUMENTING CONTEXT

Documenting the design year context is an important element of the PDN process. Although it is important for the project team to document the existing context, the focus should be on the context anticipated in the design year to verify the project is aligned with future goals and plans for the area. The project team should coordinate with local agencies to confirm the design year context at the start of a project. As previously described in Section 3.1.1., the project team should review long-range planning documentation to see if context was previously established and documented.

The context is primarily documented as part of the Concept Report developed in Stage 0 of the PDN process. The Project Commitment Document in Stage 1 confirms and documents the design year context. The context can inform the Stage 0 Multimodal Considerations and Recommendations document that is integrated into the Concept Report. The Scope of Work document also notes the context and references the Concept Report for additional documentation. Chapter 2 of this guide provides additional information on the documentation and stages of the PDN and describes how context is documented within each stage.

The process established in the PDN allows for context and other roadway characteristics or designations to be documented early in the project development process in order to select the appropriate context-based design guidance and criteria. This information will be carried through subsequent stages of the PDN process.

3.4 CONTEXT DESIGN CONSIDERATIONS

This section outlines how the contexts, modal expectations, and roadway characteristics can be applied together. Table 3-4 provides general design guidance based on context. More specific guidance for design elements within each context is included in Chapter 4 and Chapter 6.

Table 3-4: Designing Based on Context, Considering Roadway Designations and Activity of Different Modes

Context	Travel Lanes	Turn Lanes	Shy Distance	Median	Roadside Features	Bicycle Facility	Sidewalk	Target Pedestrian Crossing Spacing Range (feet)[1]	On-street parking
Rural	Start with minimum widths, wider by roadway characteristics	Balance crossing width and operations depending on desired use	Consider roadway characteristics, desired speeds	Flush or depressed medians are optional.	Roadside ditches	Start with separated bicycle facility, consider roadway characteristics	Continuous and buffered sidewalks or shared-use path	600+/-, varies based on adjacent land use	Not typical
Rural Town	Start with minimum widths, wider by roadway characteristics	Balance crossing width and operations depending on desired use	Consider roadway characteristics, desired speeds	Flush or raised medians are optional and may be used as pedestrian crossing refuge	May vary between curb and gutter and ditches	Start with separated bicycle facility, consider roadway characteristics	Continuous and buffered sidewalks or shared-use path, sized for desired use	250-550 (1-2 blocks)	Consider on-street parking if space allows
Suburban	Start with minimum widths, wider by roadway characteristics	Balance crossing width and operations depending on desired use	Consider roadway characteristics, desired speeds	Flush or raised medians are optional and may be used as pedestrian crossing refuge	Curb and gutter	Start with separated bicycle facility, consider roadway characteristics	Continuous and buffered sidewalks or shared-use path	600+/-, varies based on adjacent land use	Not typical
Urban	Start with minimum widths, wider by roadway characteristics	Minimize additional crossing width at intersections	Minimal	Flush or raised medians are optional and may be used as pedestrian crossing refuge	Curb and gutter	Start with separated bicycle facility, consider roadway characteristics	Ample space for sidewalk activity (e.g., sidewalk cafes, transit shelters)	250-550 (1-2 blocks)	Consider on-street parking if space allows
Urban Core	Start with minimum widths, wider by roadway characteristics	Minimize additional crossing width at intersections	Minimal	Flush or raised medians are optional and may be used as pedestrian crossing refuge	Curb and gutter	Start with separated bicycle facility	Ample space for sidewalk activity (e.g., sidewalk cafes, transit shelters)	250-550 (1-2 blocks)	Varied, consider impacts to bicycles, transit, and loading/unloading areas.

[1] Intersection spacing should follow guidance provided in TDOT Highway System Access Manual (HSAM) Volume 3 (4). Intersections are typically too far apart for pedestrian permeability, therefore, mid-block crosswalks will likely be required to achieve recommended crossing spacings.

3.5 REFERENCES

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Project Scoping Guide

Chapter 4 – Multimodal Planning and Design

September 2024

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Chapter 4

Multimodal Planning and Design

Chapter 4 provides fundamental principles and guidance for multimodal planning and design, with a focus on pedestrians, bicyclists, and transit. It outlines specific needs associated with different user types and key factors to consider when selecting the appropriate multimodal facilities for a project. It supports project teams in understanding multimodal user needs and design elements, a key component of the Active Transportation Review and Concept Report in Stage 0: Planning of the Project Delivery Network (PDN).

As discussed in Chapter 3 of the *Project Scoping Guide* (*PSG*), design year context, modal expectations, and roadway characteristics all influence the design process. The various users on a roadway may have different needs based on factors like land use, functional classification, street patterns, and behaviors of other users on the roadway. What works well for a pedestrian in one context might not work well in another context. For example, wider sidewalks may be needed in the Urban Core context, which, compared to a Suburban context, has higher levels of pedestrian activity and amenities that support adjacent commercial uses. Greater separation between bicyclists and vehicles may be appropriate on an arterial in a Suburban context where vehicle volumes and speeds are higher compared to a collector in an Urban or Urban Core context.

This chapter does not include design details (e.g., how to design a curb ramp or drainage facilities) or design values (e.g., recommended sidewalk or buffer widths). Instead, it presents overarching principles and metrics for evaluating multimodal facilities to help project teams take a performance-based design approach. References are made throughout to design details available in Standard Drawings, the *Roadway Design Guidelines*, and other TDOT manuals, as well as design values in Chapter 6 of the *PSG*.

4.1 ACCESSIBILITY POLICIES

TDOT's Multimodal Access Policy is intended to promote the inclusion of multimodal facilities in all transportation planning and project development activities at the local, regional, and statewide levels and to develop a comprehensive, integrated, and connected multimodal transportation network. *(1)*

The Public Right-of-Way Accessibility Guidelines (PROWAG) provides guidance from the U.S. Department of Justice and the U.S. Department of Transportation for the public right-of-way *(2)*. PROWAG applies to newly-constructed facilities as well as to alterations and additions to public facilities in the public right-of-way *(3)*.

For additional resources and guidance, refer to the TDOT Americans with Disabilities Act (ADA) Office.

4.1.1 Accessibility Requirements by Project Type

Wherever pedestrian facilities are intended to be a part of a transportation system, federal regulations (28 CFR Part 35) require that those pedestrian facilities meet or exceed Americans with Disabilities Act (ADA) guidelines *(4)*. All new construction or alteration of existing transportation facilities (reconstruction projects) must be designed and constructed to be accessible to and usable by persons with disabilities.

All projects shall review and evaluate existing pedestrian access and connectivity within the project's scope. Projects shall address and correct deficiencies that do not meet ADA, PROWAG, and TDOT requirements.

All Local Program projects shall follow the same guidance based on project type. Projects developed and led by local agencies shall follow the same guidance, based on Federal Highway Administration (FHWA)-required ADA elements.

When altering existing facilities, it may not be possible to fully meet applicable accessibility requirements. In these cases, consult with the TDOT ADA Coordinator to develop a workable solution that meets accessibility requirements to the maximum extent feasible. Design Exceptions/Deviations/Waivers may be necessary to justify and document requirements that are not met. Chapter 2 provides additional information on this process.

Accessibility requirements for each project type include:

- **New Construction:** Pedestrian needs shall be assessed and included in new construction projects. All pedestrian facilities included in new construction projects must meet accessibility requirements to the extent structurally practicable.
- **Reconstruction:** Any project that affects or could affect the usability of a pedestrian facility is classified as a reconstruction project. Reconstruction projects shall evaluate existing pedestrian circulation, accessibility, and connectivity. Any deficiencies should be identified, documented, and included in the project scope. Reconstruction projects shall not decrease, or have the effect of decreasing, the accessibility of a pedestrian facility or an accessible connection to an adjacent building or site below the ADA accessibility requirements in effect at the time of the alteration. The following requirements also apply:
    - All existing pedestrian facilities disturbed by construction must be replaced; replacement facilities must meet current ADA, PROWAG, and TDOT requirements to the maximum extent feasible.
    - If pedestrian facilities are present, curb ramps are required at intersections and other pedestrian crossings.
    - Existing curb ramps should be evaluated to determine whether curb ramp design elements meet current accessibility criteria. Curb ramps that do not meet accessibility criteria must be modified or replaced to meet applicable accessibility requirements.

This may also trigger modification of other adjacent sidewalk facilities to incorporate transitional segments so specific elements of a curb ramp will meet accessibility criteria.

  - Installation of crosswalk markings and applicable signs is required at intersections, midblock crossings, and other uncontrolled crossings deemed necessary.
  - Existing crosswalks (marked or unmarked) should be evaluated to determine whether crosswalk design elements meet the accessibility criteria for a legal pedestrian access route. Crosswalk slopes may need to be modified to meet the required accessibility standards to the maximum extent feasible.
  - Within construction limits, any existing connection from a pedestrian access route to a crosswalk (marked or unmarked) that is missing a receiving curb ramp must have a curb ramp installed that meets ADA, PROWAG, and TDOT accessibility requirements to the maximum extent feasible.
  - Intersections with at least one corner served by a public sidewalk or a pedestrian access route shall have curb ramps or flush landings at all corners of the intersection. This requirement must be met regardless of whether or not the receiving end of the crosswalk is located within the project's limits.

- **Construction on Existing Alignment,** including repair, resurfacing, maintenance, and bridge repair: Resurfacing work on any leg of an intersection requires upgrading the entire intersection to meet ADA, PROWAG, and TDOT requirements. Existing pedestrian signals and pushbuttons do not require upgrade during resurfacing, but the pedestrian facilities must be accessible and consider any new curb ramps or sidewalks. If there are any pedestrian signals present during resurfacing, all corners must have curb ramps and provide refuge for pedestrians to the maximum extent feasible. Resurfacing the full intersection will trigger ADA improvements. If there are no existing pedestrian facilities on any approach, installing curb ramps is not required. Section 4.3.3 provides information on types of pedestrian facilities. In addition, the TDOT *Roadway Design Guidelines* provides design information.

  Roadway maintenance activities are not considered alterations and do not require simultaneous improvements to pedestrian accessibility under the ADA. When portions of sidewalk or curb ramps are disturbed as part of maintenance activities, verify that any replacement meets all applicable ADA guidelines.

- **Signalization Projects:** Any new signal or signal improvement project that involves altering pedestrian facilities or making changes to intersection functions that impact pedestrian facilities (e.g., adding lanes or pedestrian refuge islands) must upgrade all pedestrian facilities. If any portion of the pedestrian facilities are altered or disturbed, the project team shall evaluate the entire intersection and upgrade it to meet ADA requirements (e.g., sidewalk, curb ramps, pedestrian signals or pushbuttons).

ADA improvements are triggered when pedestrian signal operations, pedestrian software (the controller's internal logic), or ITS software affecting pedestrian signal operations are altered. Replacing the pedestrian signal head or making permanent signal timing adjustments will trigger ADA requirements if the modification affects pedestrian intervals, signal phases, cycle length, or sequence to include longer walk times or longer clearance times. This also includes programming parameters to extend the walk indication (Rest in Walk) when coordinated signalization is used. The project team must bring all pedestrian facilities, including curb ramps, pedestrian pushbuttons, and pedestrian signal heads, into full ADA compliance.

Vehicular signal controller or software alterations or vehicular signal head replacements do not trigger the requirement to bring all pedestrian facilities at the intersection into full ADA compliance.

4.2 PEDESTRIAN AND BICYCLE SAFETY AND EXPERIENCE

There are a variety of metrics for assessing pedestrian and bicycle safety and comfort. This section covers some common tools and describes key factors that influence a pedestrian's or bicyclist's experience, including vehicle speed, separation, and exposure.

4.2.1 Safety

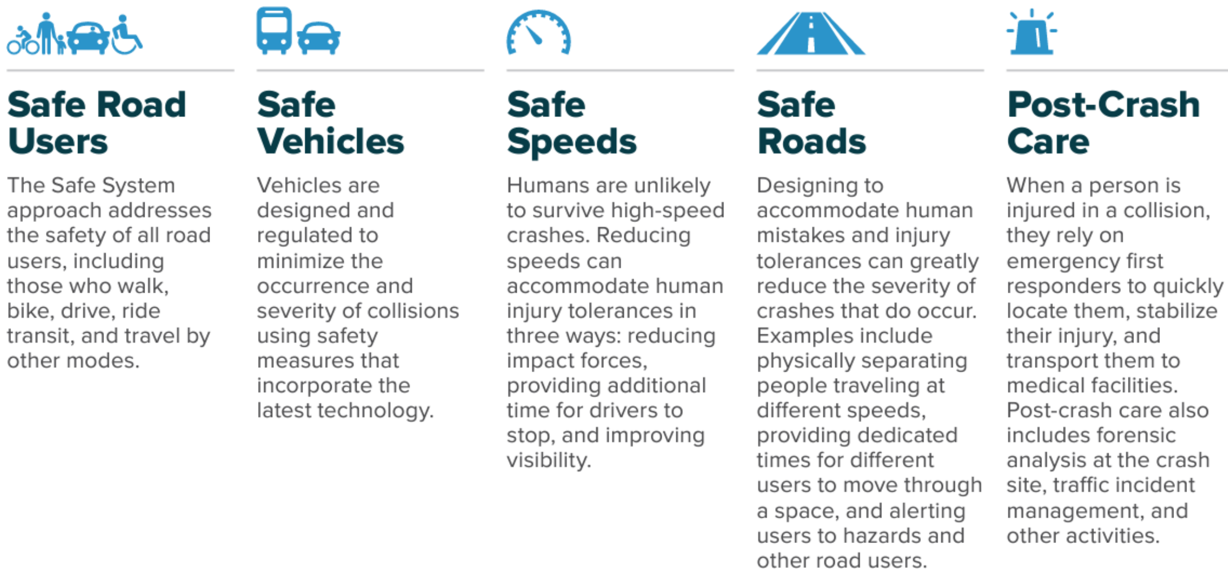
Safety is TDOT's highest priority for all users, including pedestrians and bicyclists. Pedestrians and bicyclists are overrepresented in traffic fatalities *(5)* and are often referred to as vulnerable roadway users, as they are at a higher risk of injury or death in a collision.

A proactive approach to pedestrian and bicyclist safety includes strategies such as:

- Using the *Highway Safety Manual (HSM)* to quantify and predict crash frequency and severity. However, the tools for multimodal safety analysis in the *HSM* are limited and may not cover all desired analyses. *(6)*
- Conducting an engineering analysis to identify potential crash causes and countermeasures, including road safety audits, field visits, and speed studies.
- Calculating the Pedestrian and Bicyclist Intersection Safety Indices, which are scores reflecting the relative safety of a site. *(7)*
- Using design guidelines that prioritize separation and space for pedestrians and bicyclists as well as lower vehicular speeds where modes interact.
- Following a Safe System Approach (SSA) that aims to minimize crash risk by removing conflict points, separating road users, lowering traffic speeds, and reducing conflict angles *(8)*. As shown in Figure 4-1, a Safe System Approach considers all road users and seeks to design roadways that reduce the severity of crashes that do occur.
- Providing access for all ages and abilities, considering design year context, roadway classification, and demand.

- Conducting a Design Flag Assessment to identify design features that affect safety for pedestrians and bicyclists, as described in National Cooperative Highway Research Program (NCHRP) Research Report 948: *Guide for Pedestrian and Bicycle Safety at Alternative Intersections and Interchanges (9)*. This methodology is further described in Chapter 5 of the *PSG* and the TDOT *20-Flag Intersection Evaluation Guide*.

Figure 4-1 Key Principles of Safe System Approach



Source: FHWA (8)

4.2.2 Level of Traffic Stress (LTS)

Level of traffic stress (LTS) is a tool for quantifying the level of comfort a bicyclist or pedestrian feels when using a facility. The bicycle LTS methodology classifies road segments into four levels based on traffic characteristics and whether bicycles are in mixed traffic, bicycle lanes, or on separated paths. Classifications for intersection approaches consider conflict between bicycles and right-turning traffic.

Pedestrian LTS, similar to bicycle LTS, offers four levels of traffic stress to classify sidewalk segments, intersection approaches, and intersection crossings. It considers inputs like sidewalk condition and width, buffer type and width, bicycle lane and parking widths, number of lanes and posted speed, illumination presence, land use, and crossing data.

General definitions of each LTS are provided in Table 4-1.

Table 4-1: Bicycle and Pedestrian Level of Traffic Stress Definitions

Level	Definition
LTS 1	Presents little to no traffic stress and requires little attention to the traffic situation. Provides a relaxing, comfortable experience for most users. Suitable for almost all bicyclists and pedestrians. Motor vehicles are separated from bicyclists and pedestrians or traveling at a low speed and volume.
LTS 2	Presents little traffic stress and is therefore suitable for most adults but may require more attention to the traffic situation than might be appropriate for young children. Provides separation from motor vehicles, an exclusive facility next to a well-confined traffic stream, or a shared roadway with a low-speed differential between bicyclists and motor vehicles.
LTS 3	Presents moderate stress, with most adults willing to use the facility but with some level of discomfort. Includes exclusive facilities adjacent to moderate-speed traffic with small to no buffers and shared lanes with moderately low-speed traffic.
LTS 4	Presents high traffic stress and likely only used by adults with limited other choices. Typical locations include high speed, multilane roadways with no or narrow sidewalks or bicycle lanes and buffers.

Source: Adapted from Mineta Transportation Institute's Low-Street Bicycling and Network Connectivity (10) and the Oregon Department of Transportation's Analysis and Procedures Manual (11)

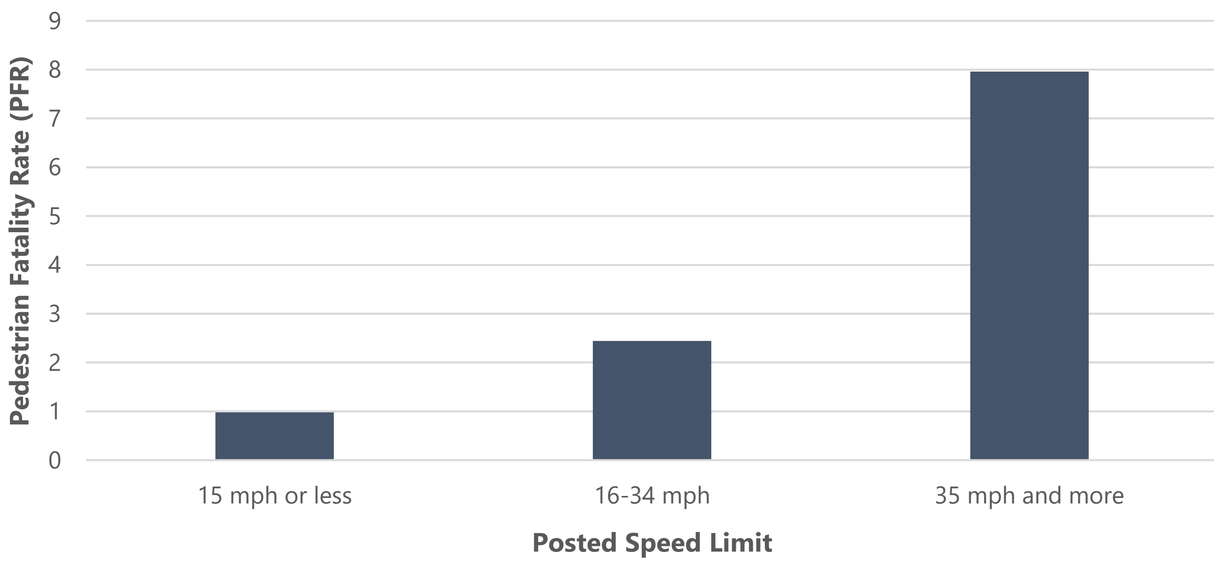
More information on bicycle and pedestrian LTS, as well as other performance measures, is available in FHWA's *Guidebook for Measuring Multimodal Network Connectivity. (12)*

4.2.3 Speed

It is important to design roadways for desired vehicle speeds, considering the roadway's design year context, functional classification, and intended users. Speed contributes to nearly 30 percent of all traffic fatalities and "greatly influences the severity of pedestrian crashes," according to FHWA *(13)*. Safe Speeds is one of the five pillars of a Safe System Approach. This pillar recognizes that "the correlation between speed and injury crashes has been well documented through scientific literature on traffic safety, and achieving lower speeds has been proven to save lives and reduce serious injuries" *(14)*. As a vehicle's speed increases, the driver's peripheral vision decreases and stopping distance increases. This combination contributes to an increase in crash risk *(15)*.

The University of Tennessee and Vanderbilt University conducted a study using pedestrian crash data from 2009 through 2019. The "results show a significant overall increase in pedestrian crash severity in Tennessee from 2009 to 2019 concerning fatal outcomes… Roads with higher speeds, multiple lanes, and straight maneuvers also report a higher proportion of fatalities than the involvement." The study included an assessment of pedestrian fatality rate (PFR), which is the number of pedestrian deaths per 100 pedestrians involved in crashes. It found that the PFR for crashes on roadways with higher posted speed limits is substantially higher compared to crashes on roadways with lower posted speed limits, as shown in Figure 4-2 *(16)*.

Figure 4-2 Pedestrian Fatality Rate and Posted Speed Limit



Source: The University of Tennessee and Vanderbilt University (16)

On higher-speed roads (considering speeds 35 mph and more based on Figure 4-2), the speed differential between vehicles and bicyclists or pedestrians should be a major factor in determining multimodal facility selection along a corridor. An increased speed differential makes it more challenging for pedestrians to judge gaps between vehicles when crossing a road or motorists to judge the distance required to pass a cyclist. Along corridors with higher speed differentials between users, facilities for each user should be separated by buffers or other physical elements. Aside from safety implications, there is a direct correlation between speed differential and user comfort for all modes.

Chapter 6 of the PSG provides more information on speed, including recommended target speed by design year context and resources for achieving the desired target speed.

4.2.4 Separation

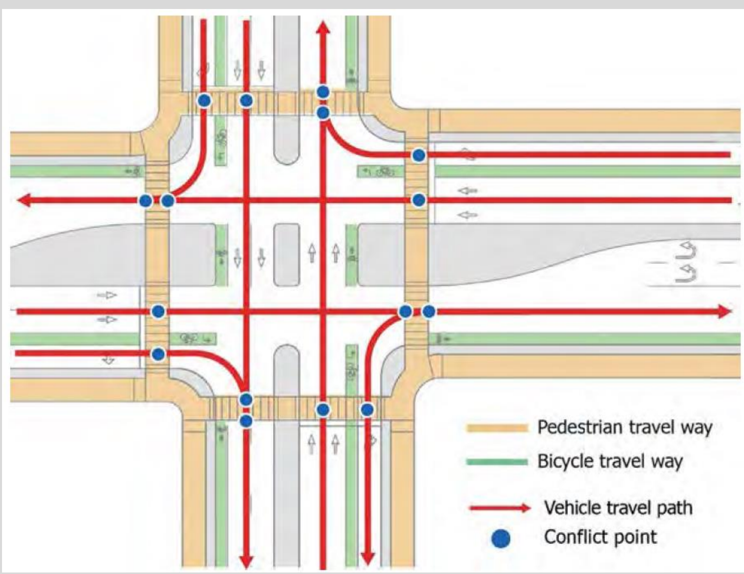
Providing separation between different types of users increases both safety and comfort. Physical separation from vehicular travel lanes is the preferred way to increase safety for pedestrians and bicyclists and is typically most important when vehicle volumes and speeds are higher. Separation can be accomplished with shared-use paths, separated bicycle lanes, and buffers between the roadway and sidewalks. Where these features are not feasible or where bicyclists prefer on-road facilities, marked bicycle lanes can help reduce the time or distance in which bicyclists are exposed to risk. Marked bicycle lanes can be supplemented with methods that slow motor vehicles down, roadway lighting, and warning signs that increase awareness of the presence of bicyclists. Key design considerations for bicycle facilities are cross-section width and control at driveways and intersections.

Separation is also recommended between pedestrians and vehicles, with the type and width of buffer recommended based on the design year context, roadway classification, intended users, and other site characteristics.

4.2.5 Exposure

Larger intersections, especially those with yield-controlled or free movements, can reduce safety performance and may be uncomfortable for pedestrians and bicyclists. Limiting pedestrian and bicycle exposure by reducing crossing distances and controlling interactions with vehicles, especially with high-speed or high-volume traffic movements, generally provides a better experience for pedestrians and bicyclists. According to NCHRP Research Report 948: *Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges*, "Smaller intersections are more likely to reduce the exposure to conflicts and require shorter clearance times and crossing distances for all modes. A smaller intersection footprint with fewer legs generally increases safety and efficiency" *(9)*. Conducting a conflict point analysis can help inform decision-making by evaluating the number of potential conflicts across different design scenarios, as shown in Figure 4-3. The TDOT *20-Flag Intersection Evaluation Guide* provides additional information and guidance for applying this methodology.

Figure 4-3 Pedestrian-Vehicle Conflict Points at a Median U-Turn Intersection (MUT)



"Pedestrians crossing an MUT intersection encounter fewer distinct conflicting traffic streams than at a conventional intersection. At a conventional intersection, pedestrians cross the street with one-stage or two-stage crossing during the adjacent street's vehicle phase. At an MUT intersection, left-turns are removed from the main intersection and occur away from the intersection, thus removing potential pedestrian exposure to left-turning vehicles." *(9)*

Source: NCHRP Research Report 948, Exhibit 6-10 (9)

4.2.6 Key Resources

A variety of national and state-specific resources exist to help project teams quantitatively evaluate pedestrian and bicycle facilities and make informed design decisions. Key resources are shown below and described further in **Appendix C**.

- TDOT Multimodal Prioritization Tool
- NCHRP Research Report 926: *Guidance to Improve Pedestrian and Bicyclist Safety at Intersections*

- NCHRP Research Report 948: *Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges*
- NCHRP Research Report 834: *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook*
- AASHTO, *Highway Safety Manual* (*HSM*)
- FHWA, Crash Modification Factor (CMF) Clearinghouse
- FHWA, *Improving Intersections for Pedestrians and Bicyclists Informational Guide*
- FHWA, *Pedestrian and Bicyclist Intersection Safety Indices User Guide*
- FHWA, *Safe System Approach for Speed Management*
- FHWA, *Integrating Speed Management within Roadway Departure, Intersections, and Pedestrian and Bicyclist Safety Focus Areas*
- National Association of City Transportation Officials (NACTO), *Urban Bikeway Design Guide*
- NACTO, *Urban Street Design Guide*

4.3 PEDESTRIAN DESIGN

This section describes principles of pedestrian design and how to integrate these principles into roadway design to achieve pedestrian safety and comfort objectives. It describes the types of pedestrian facilities and considerations for selecting the most appropriate facility given various options and trade-offs. Specific design values related to pedestrians are provided in Chapter 6. Traffic control devices related to pedestrians are further described in Appendix D and in the TDOT *Roadway Design Guidelines*.

4.3.1 General Principles

Pedestrian travel is a vital transportation mode. Used at some point by everyone, it is a critical link to everyday life for many. To verify facilities and provide access for all users, project teams should be aware of the various physical needs and abilities of pedestrians. Key considerations include:

- **Walking speeds:** A design speed of 3.5 feet per second is typically assumed, but lower speeds may be appropriate in locations with a higher population of young children, older adults, or people with disabilities.
- **Spatial needs:** The amount of width needed by pedestrians varies according to the expected type and volume of users, as well as adjacent land uses. More width is needed for pedestrians to pass each other or walk side-by-side, as well as for people in wheelchairs or pushing strollers, as shown in Figure 4-4.

- **People with disabilities:** Designing for pedestrians with disabilities, including mobility and vision disabilities, should be a key focus. According to NCHRP Research Report 948, "The range of different pedestrian disabilities has practical implications for the design of sidewalk widths, grades, cross slopes, refuge island widths, pushbutton placement, accessible signals, and curb ramps to comply with requirements set forth by the Americans with Disabilities Act (ADA)." *(9)*

Figure 4-4 Sidewalk in Nashville, TN (Urban Context)

Wider sidewalks serve a range of uses, including providing for pedestrians walking side-by-side and pulling luggage. In addition, they may provide space for outdoor dining areas, signage, and landscaping.

Source: TDOT

Recognizing the factors that influence a pedestrian's experience is an important part of the design process and providing facilities that meet the needs of users. The AASHTO *Guide for the Planning, Design, and Operations of Pedestrian Facilities* identifies the following factors as key in the decision to walk *(17)*:

- **Distance and density:** "Distance is the primary factor in the initial decision to walk… Most people are willing to walk 5 to 10 minutes at a comfortable pace to reach a destination" *(17)*. Walking distance is influenced by land use patterns, crossing opportunities, and population density. Typically, areas with frequent pedestrian destinations, a mix of land uses, and shorter block lengths have higher levels of pedestrian use.
- **Route directness:** "Pedestrian routes should provide access to destinations without the need for pedestrians to travel excessively out of their way" *(17)*. Providing frequent crossing opportunities, convenient pedestrian connections, and a robust network can increase pedestrian use.

- **Personal safety and security:** Design features can have a big impact on both perceived and actual pedestrian safety. Influential elements include walkway width, separation from vehicles, crossing distance, block length, lighting, vegetation, and land use.
- **Personal comfort and environmental attractiveness:** "A decision to walk can be influenced by the comfort, convenience, and visual interest of the route, as well as the presence of other potential destinations along the route" *(17)*. Providing shade, benches, attractive buildings, and landscaping typically makes a route more appealing.

4.3.2 Elements of Design

The design of a pedestrian facility is influenced by the design year context, functional classification and characteristics, user needs, and site-specific constraints. Basic elements of pedestrian facility design are described below and illustrated in Figure 4-5. Additional design elements are included in the TDOT *Roadway Design Guidelines*.

- **Conflict points:** Pedestrians face conflicts with other users, including motor vehicles and bicyclists, at driveways, crossings, and intersections. Key pedestrian elements at these locations include curb ramps, grade, lighting, speed control, and sight distance.
- **Walkway width:** The walkway width has a significant influence on capacity and the ability of the route to serve users in wheelchairs, pushing strollers, or traveling in groups. The walkway width is also influenced by adjacent roadway uses. Where a walkway is immediately adjacent to a building face or other obstruction, additional width is needed to provide a shy distance between pedestrians and fixed objects.
- **Separation or buffer:** Separation between pedestrians and motor vehicles is desirable for pedestrian safety and comfort. Buffers create a visual and sound barrier between pedestrians and moving traffic. Separation can be created by bicycle lanes, shoulders, on-street parking, landscaping, or street furniture (e.g., seating, waste receptacles, drinking fountains, mailboxes). Landscaping can also improve a roadside's aesthetics, provide shade, and intercept stormwater.

Figure 4-5 Sidewalk and Pedestrian Crossing in Dickson, TN (Urban Core Context)

Landscaping and on-street parking provide a buffer between pedestrians and vehicles and shorten the crossing distance for pedestrians. A wider sidewalk offers space for pedestrian-scale lighting, benches, and waste receptacles, while also providing a comfortable space for users in wheelchairs, pushing strollers, or traveling in groups.

Source: TDOT

4.3.3 Types of Pedestrian Facilities

Sidewalks, shared streets, and shared-use paths (discussed in Section 4.5) are the typical pedestrian facilities used throughout Tennessee. Roadway shoulders are not considered an appropriate pedestrian facility. The comfort and utility of a pedestrian facility is based on factors like width, separation from traffic, vehicle speeds and volumes, obstructions, and pedestrian volumes.

- **Sidewalks:** Sidewalks provide space for pedestrians along a roadway. Sidewalks are typically provided on both sides of a roadway and ideally separated from vehicle traffic by a buffer or positive protective device where a buffer is not feasible. Sidewalk width is based on the design year context and anticipated pedestrian volumes and users. In Urban and Urban Core contexts, the sidewalk may also provide for a frontage zone with street furniture, bus stops, or micromobility hubs. Although most sidewalks are on roadways with curbs, sidewalks can also be provided on roadways without curbs, typically in Suburban, Rural, or Rural Town contexts. Separation between the roadway and sidewalk can improve pedestrian safety and comfort, especially where vehicle volumes and speeds are higher. Sidewalks can be broken into three general zones: the frontage zone, the pedestrian zone, and the buffer zone. Chapter 6 provides additional information and guidance for each zone. The TDOT *Roadway Design Guidelines* provides additional information on sidewalk design.
- **Shared streets:** Shared streets, sometimes called woonerfs, are used by pedestrians, vehicles, and bicyclists without designated separate space for different users. Typically, shared streets are used where vehicle speeds and volumes are very low or when there are severe constraints that limit the ability to provide separate spaces for different users.

Design elements can help maintain low vehicle speeds and volumes and reinforce the intended use of the roadway, as shown in Figure 4-6. For example, "street furniture, including bollards, benches, planters, and bicycle parking, can help define a shared space, subtly delineating the traveled way from the pedestrian-only space." *(15)*

Figure 4-6 Shared Street in Nashville, TN (Urban Core Context)

Source: Google

Shared streets can take a variety of forms, and often include flexibility so that the use can vary. This shared street uses bollards to distinguish the pedestrian plaza from the roadway, with the option for pedestrians to spill out into the shared roadway during special events. The unique streetscape encourages slower vehicle speeds, while still providing for the occasional larger delivery vehicle.

4.3.4 Pedestrian Facility Selection

Selecting the appropriate type of pedestrian facility and determining key design features like width and separation involves considering a variety of factors, including:

- Pedestrian safety based on speed, separation, and exposure (e.g., conflict points)
- Design year context, functional classification, and vehicle speeds and volumes
- Anticipated volume and type of pedestrians (e.g., older adults or school-age children)
- Available right-of-way and potential constraints (e.g., buildings or sensitive environmental lands)
- Overall cross section elements (i.e., what is happening next to the pedestrian facility), including desired bicycle facility type and width
- Crossing locations and types

Typically, when considering pedestrian options, the project team should seek to provide a wide sidewalk or shared-use path with separation or a wide buffer from vehicle traffic. In constrained environments, it may be necessary to provide a curb-tight sidewalk. On local roadways with low speeds and low traffic volumes, a shared street (woonerf) may be appropriate. Section 3.4 of the *PSG* provides general design direction for pedestrian facilities based on design year context. Chapter 6 of the *PSG* provides more specific design direction based on design year context and functional classification, including potential pedestrian facility types; widths for the frontage zone, pedestrian zone, and buffer zone; and target pedestrian crossing spacing range.

A performance-based design approach should be used to confirm that planned pedestrian facilities meet the desired outcomes, as described in Chapter 2. Chapter 2 also provides information on developing goals and performance measures, including pedestrian-specific performance measures.

Figure 4-7 illustrates the six steps of a performance-based design approach applied to pedestrian facility selection.

Figure 4-7 Performance-Based Design Approach to Pedestrian Facility Selection

Step 1. Identify intended project outcomes by which performance can be measured

For selecting a pedestrian facility, outcomes identify the desired users of the facility, set a target level of traffic stress or effective width, or highlight specific goals, such as creating an aesthetically inviting space. Community outreach can help inform goals and pedestrian needs. Identify performance metrics that can be used to evaluate the alternatives compared to the project goals, as described in Section 4.2 and Chapter 2.

Step 2. Establish geometric design decisions, such as design criteria and preliminary design

Using the guidance in Section 3.4 and considering the factors listed above, identify potential pedestrian facilities. Next use the guidance in Chapter 6 to select design criteria, including facility width and separation.

Step 3. Evaluate the performance of alternatives compared to desired project outcomes

Evaluate the pedestrian facility alternatives identified using the goals and metrics developed in Step 1.

Step 4. Iterate design alternatives based on the evaluation results.

If the alternatives identified do not achieve the desired project outcomes, identify what changes are needed and reconduct the evaluation.

Step 5. Evaluate benefits and costs to determine the value of the geometric design compared to the project outcomes.

In some cases, there may be multiple feasible alternatives that achieve project outcomes. A benefit and cost assessment can provide more information to help make a decision.

Step 6. Select or advance alternatives based on viability within the project context.

Reconsider the alternatives given project context and other objectives beyond the desired pedestrian experience, like livability, economic development, and environmental sustainability.

Selecting pedestrian facilities starts early in TDOT's Project Delivery Network (PDN) as part of the Concept Report and Multimodal Considerations & Recommendations in Stage 0: Planning. This is also when context and other considerations are used to assess modal integration and design considerations, as described in Chapter 3. Specific design criteria—like facility type, width, and separation—are identified, evaluated, and summarized in the Project-Specific Design Criteria Document in Stage 1 of the PDN. As functional design plans are developed in Stage 2, they are verified to ensure the pedestrian facility and design still meets the identified goals and outcomes.

PDN Documentation associated with pedestrian design include:

Concept Report: Develops an initial project vision, conceptual layout, and cross section, including pedestrian facilities (type, with, buffer).

Active Transportation Considerations & Recommendations: Informs the Concept Report and ensures the project complies with TDOT's Multimodal Access Policy, incorporates recommended multimodal elements, and is coordinated with related existing or planned multimodal projects.

Project-Specific Design Criteria Document: Establishes criteria including design speed, lane and shoulder widths, sight distance, design vehicle, and potential design exceptions or waivers.

Chapter 6 provides additional details, including recommended width of the facility and buffer. Where a location is constrained, project teams may need to evaluate trade-offs and apply design flexibility. The project team may need to identify what changes would be required to achieve the preferred pedestrian facility and then evaluate each alternative against the modal priorities and objectives for the project. Community outreach should help inform the pedestrian-related goals for the project, specific user needs, and preferred pedestrian facility type.

4.4 BICYCLE DESIGN

This section describes the principles of bicycle design and how to integrate those principles into roadway design to achieve bicyclist safety and comfort objectives. It describes the types of bicycle facilities and considerations for selecting the most appropriate facilities given various options and trade-offs. Specific design values related to bicycles are provided in Chapter 6. Traffic control devices related to bicycles, including bicycle signals, bicycle boxes and green colored pavement, are further described in **Appendix D** and in the TDOT *Roadway Design Guidelines*.

4.4.1 General Principles

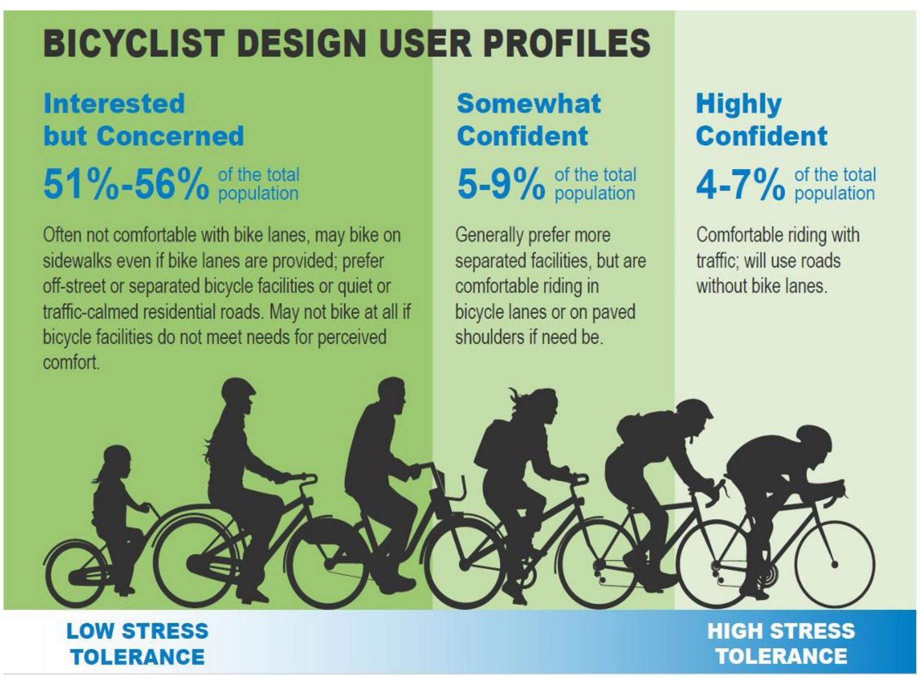
"Bicyclists should be expected on roadways, except where prohibited, and on shared-use paths. Safe, convenient, well-designed, and well-maintained facilities with low crash frequencies and severities are important to integrate and encourage bicyclists" *(18)*. Tennessee's Statewide Active Transportation Plan, *Making Connections: Actions to Improve Walking, Bicycling, and Rolling in Tennessee,* notes two strategies for addressing safety: reducing conflict points between people and motorists and reducing the speed of vehicles in appropriate contexts. The plan notes that bicycle planning is focused on providing bicycle facilities that meet the needs of people of all ages and abilities and suggests metrics like LTS to assess facility comfort *(19)*.

To design efficient and effective bicycle facilities, it is important to understand the following range of bicycle user types and principles of bicycle network design:

- **User Types:** Bicyclists include a wide variety of users with a mix of trip purposes, abilities, speed, preferences, and risk tolerance. While bicycling has grown in popularity, perceptions of safety and tolerance for traffic stress are highly influential in determining if and where a bicyclist will ride. The FHWA *Bikeway Selection Guide* identifies three categories of bicyclists, shown in Figure 4-8 *(20)*. These categories are useful for anticipating design needs.

  Much of the national bicycle design guidance recognizes that not all bicyclists are comfortable on the same types of facilities, and designing for a wide range of users means creating low-stress facilities through separation from high motor vehicle volumes and speeds.

Figure 4-8 Bicyclist Design User Profiles



Note from source: The percentages above reflect only adults who have stated an interest in bicycling.
Source: FHWA Bikeway Selection Guide (20)

- **Network Design:** Bicycle facilities are best thought of from a network perspective and as "part of a broader planning process that accounts for roadway and traffic characteristics of all modes, including freight, transit, personal vehicles, emergency access, bicyclists, and pedestrians." *(20)* To have utility, a bicycle facility needs to be part of a broader network that connects users safely to their destinations. This includes considering parallel routes and how those may contribute to the network. The FHWA *Bikeway Selection Guide* identifies seven principles of bicycle network design:

  1. **Safety**: The frequency and severity of crashes are minimized and conflicts with motor vehicles are limited.
  2. **Comfort**: Conditions do not deter bicyclists due to stress, anxiety, or safety concerns.
  3. **Connectivity**: All destinations can be accessed using the bicycling network, and there are no gaps or missing links.
  4. **Directness**: Bicycle distances and trips times are minimized.
  5. **Cohesion**: Distances between parallel and intersecting bicycle routes are minimized.
  6. **Attractiveness**: Routes direct bicyclists through lively areas, and personal safety is prioritized.
  7. **Unbroken Flow**: Stops, such as long waits at traffic lights, are limited, and street lighting is consistent. *(20)*

4.4.2 Elements of Design

Bicycle facility design is influenced by design year context, roadway type and characteristics, user needs, and site-specific constraints. Basic elements of bicycle facility design are described below, and additional details are included in the TDOT *Roadway Design Guidelines*.

- **Shy Distance:** Shy distance refers to the space between the bicycle facility and curb. When there are vertical objects adjacent to the bicycle facility (landscaping, signage, waste receptacles, bicycle parking, etc.), bicyclists will shy away from the curb to avoid interference with their handlebars or pedals. Because this reduces the rideable space, additional width is needed to achieve the desired rideable width. Along roadways with curb and gutter, the width of the bicycle facility should not include the gutter.
- **Conflict Points:** Bicyclists face conflicts with motor vehicles at driveways and intersections. Key elements at these locations include lighting, speed control, and sight distance. Green colored pavement in designated bicycle lanes and in extensions of designated bicycle lanes through intersections and other traffic conflict areas may be used to draw attention to the presence of bicyclists, as illustrated in Figure 4-9.
- **Width:** Typically, wider bicycle facilities are needed on roadways with higher motor vehicle volumes or speeds. Bicycle facility width is also influenced by context and functional classification.

- **Separation or Buffer:** Separation between the bicycle facility and roadway may be provided by a vertical element (e.g., landscaping, on-street parking, or curb) or horizontal element, like striping. Providing separation between bicyclists and motor vehicles makes the bicycle facility more attractive to a wider range of users.

Additional design elements, such as green colored pavement and bicycle boxes, are described in **Appendix D.**

Figure 4-9 Bicycle Lane in Nashville, TN(Urban Core Context)

Source: TDOT

Green pavement is used to draw attention to the bicycle lane, with dashed green pavement used through signalized intersections to highlight the space for bicyclists through the intersection. The red striping indicating the fire lane also distinguishes the gutters and shy distance between the bicycle lane and curb. A striped buffer separates the bicycle lane from vehicle traffic. Vehicles are expected to operate at a low speed in the dense urban environment with frequent intersections and high activity levels.

4.4.3 Types of Bicycle Facilities

The many different types of bicycle facilities used throughout Tennessee provide varying levels of comfort based on facility users. The following sections provide guidance for each type.

SEPARATED BICYCLE LANES

A separated bicycle lane, also referred to as a cycle track (one way or two way) or protected bicycle lane, is a facility for bicyclists that is located within or directly adjacent to the roadway and is physically separated from motor vehicle traffic by a curb, median, on-street parking, or other vertical element. If on-street parking is used to separate the bicycle lane from vehicle travel, a striped buffer is required between on-street parking lanes and bicycle lanes to reduce the risk of a bicyclist being hit by the opening door of a parked car. This type of facility provides the most protection from motor vehicle traffic and can improve safety performance and bicyclist comfort. In some cases, micromobility users such as scooters may also use this facility.

Raised medians or curbs are generally the preferred way to create physical separation between the bicycle lanes and motor vehicle lanes, as shown in Figure 4-10. Delineator posts or other lower-cost vertical elements may be used, especially in retrofits, to limit cost and drainage impacts. "One-way separated bike lanes, especially those with a physical curb, have been shown to reduce injury risk and increase bicycle ridership due to their greater actual and perceived safety and comfort," according to the FHWA *Bikeway Selection Guide*. *(20)*

Figure 4-10 Two-Way Separated Bicycle Lanes in Memphis, TN (Urban Context)

A raised curb is used to separate a two-way bicycle lane from vehicle traffic. Green pavement helps draw attention to the space, with a center stripe, bicycle symbols and arrows indicating two-way bicycle traffic. A wide landscaping strip separates the bicycle lane from the sidewalk.

Source: Google

Separated bicycle lane design guidelines are provided in FHWA's *Separated Bike Lane Planning and Design Guide* to communicate best practices, advance design guidance, and encourage flexible solutions to bicycle mobility *(21)*. Signs and pavement markings associated with separated bicycle lanes must comply with the *MUTCD*.

> "Vertical elements in the buffer area are critical to separated bike lane design. These separation types provide the comfort and safety that make separated bike lanes attractive facilities. The selection of separation type(s) should be based on the presence of on-street parking, overall street and buffer width, cost, durability, aesthetics, traffic speeds, emergency vehicle and service access, and maintenance."
>
> —FHWA, *Separated Bike Lane Planning and Design Guide* (*21)*

Separated bicycle lanes may be one way (either in the direction of vehicle travel or contraflow) or two-way. Where separated bicycle lanes are contraflow or two-way, additional consideration is needed to ensure motorists are aware of approaching bicyclists. Potential design treatments include:

- Where two-way bicycle facilities are provided on one-way streets, locate facilities to the right of vehicle lanes where motorists are more likely to expect bicyclists.
- Provide protected intersections for bicyclists with the use of separate phases where there are high volumes of turning vehicles.
- Use raised crossings and/or reduced corner radii to slow turning vehicles.
- Provide clear sightlines between different users.
- Use marked crossings and regulatory signs to draw attention to bicyclist movements.

Wider separated bicycle lanes accommodate greater volumes of bicyclists. Wider bicycle lanes can also provide space for freight bicycles (bicycle designed to haul cargo in addition to transporting the rider) that may be present in Urban Core contexts and require additional design considerations (e.g., wider lanes, wider curb radii, and parking spaces). Narrower widths are sometimes used in constrained locations. However, narrow widths may inhibit passing and side-by-side riding, which are important to providing a comfortable bicycling environment that appeals to people of all ages and bicycling abilities. More guidance on preferred widths of separated bicycle lanes is provided in Chapter 6 of the *PSG*.

BUFFERED BICYCLE LANES

Buffered bicycle lanes are conventional bicycle lanes paired with a designated buffer space that separates the bicycle lane from the adjacent motor vehicle travel lane or parking lane. Buffer space is created with pavement markings. When a buffer is placed between the traveled way and bicycle lane, as shown in Figure 4-11, the bicyclist is separated from motor vehicles, which can improve safety performance. Buffers are required to be placed between on-street parking lanes and bicycle lanes to reduce the risk of a bicyclist being hit by the opening door of a parked car.

Figure 4-11 Buffered Bicycle Lane in Nashville, TN (Suburban Context)

A striped buffer is provided between the bicycle lane and vehicle travel lanes. The bicycle lane is indicated with pavement markings and signage. The *MUTCD* indicates that where buffers are greater than 3 feet wide, chevron or diagonal markings should be applied. In this location, diagonal markings are used in the buffer space.

Source: TDOT

Compared to conventional bicycle lanes, buffered bicycle lanes have the following advantages:

- They provide greater shy distance between bicyclists and motor vehicles.
- They offer space for faster bicyclists to pass slower bicyclists without having to encroach into the motor vehicle travel lane.
- They allow greater space for bicycling without making the bicycle lane appear so wide that it might be mistaken for a motor vehicle travel lane or a parking lane.
- They appeal to a wider range of bicyclists and encourage bicycling.
- They allow space for future vertical separation to be installed if not feasible at the time of buffer installation.

CONVENTIONAL BICYCLE LANES

Conventional bicycle lanes designate exclusive space for bicyclists immediately adjacent to vehicle traffic, as shown in Figure 4-12. This type of facility is typically not preferred due to the lack of separation between bicycles and motor vehicles, increasing exposure for the bicyclists and decreasing safety performance and bicyclist comfort. Typically, pavement markings and/or signs are used to designate bicycle lanes. Roadway Standard Drawings MM-PM-2 through MM-PM-5 should be referenced for bicycle lane signs and pavement markings. Any deviation from these standard drawings requires approval by the TDOT Engineering Division.

Figure 4-12 Conventional Bicycle Lane in Nashville, TN (Suburban Context)

Source: TDOT

A conventional bicycle lane provides no horizontal or vertical separation between bicyclists and motor vehicles. As shown, the width of the bicycle lane does not include the shy distance between the bicycle lane and curb. Bicyclists typically avoid riding near the curb, especially where there are drainage facilities or changes in the pavement surface.

The level of comfort of bicycle lane users is based on:

- Vehicle volumes and speeds
- Bicycle lane width
- Percentage of heavy vehicles (e.g., trucks) present on the roadway
- Presence of on-street parking and parking space turnover (due to interactions with vehicles entering and exiting parking spaces and with drivers potentially opening their doors into the bicycle lane)
- Proximity to curbs or other vertical elements, such as guardrails, signs, landscaping, and waste receptacles
- Pavement smoothness and quality, including presence of gutter seams, drainage inlets, and utility covers
- Presence and design of transit stops
- Intersection treatments, such as bicycle boxes, crossing markings, and two-stage turn queue boxes
- Shade from direct sunlight

SHARED LANE

A shared lane provides space for both bicyclists and motor vehicles. Because experience for bicyclists is highly impacted by vehicle volume and speed, shared roadways are generally only appropriate where speeds are 25 miles per hour and less and traffic volumes are lower.

Research has shown that on-street parking can significantly impact bicyclist safety in shared lanes. According to the FHWA *Bikeway Selection Guide*, "While parked vehicles may calm traffic in some scenarios, bicyclists riding alongside parked vehicles in shared lane scenarios are more exposed to being injured or killed when a vehicle operator opens their car door into their operating path." *(20)*

Shared lane markings (also called sharrows) may be used to tell bicyclists where to ride in the roadway to avoid the door zone of parked cars and to alert drivers to expect bicyclists, as shown in Figure 4-13. The position of the marking is detailed in Roadway Standard Drawing MM-PM-2. Based on the *MUTCD*, shared lane markings should not be placed on roadways with a posted speed of 40 mph or greater *(22)*.

Other design treatments that may be used on shared roadways include:

- Signs to tell drivers they are expected to share the roadway.
- Wayfinding signs for bicyclists.
- Traffic calming to slow vehicle speeds or prioritize bicycle travel.
- Volume management strategies to reduce and discourage through vehicle traffic, such as restricted movements at intersections.
- Transitions to a bicycle lane on sections with steep grades to enable slower bicyclists to travel outside of the space for motor vehicles.
- Enhanced crossing treatments for bicyclists at intersections of streets with higher motor vehicle speeds and volumes.

Figure 4-13 Shared Lane in Nashville, TN (Suburban Context)

Sharrows indicate to bicyclists where to ride to avoid the door zone of parked cars, and also provide another indication to drivers to expect bicyclists. Sharrows and pavement markings may also be used to direct bicyclists at intersections with vehicle restrictions. Restricting vehicle movements at intersections along a key bike route can limit vehicle volumes and provide a more comfortable environment for bicyclists.

Source: TDOT

PAVED SHOULDERS

Many state highways in Rural or Rural Town contexts are used by bicyclists for commuting between cities. In Rural Towns, the state highways are also used by bicyclists for commuting within the city. Providing and maintaining paved shoulders along these routes can improve convenience and safety for both bicyclists and motorists. Shoulder improvements that facilitate bicycle travel include widening shoulders, improving roadside maintenance (including periodic sweeping), and removing surface obstacles that are incompatible with bicycle tires, such as drain grates. Additional shoulder improvements include:

- **Bicycle-Friendly Rumble Strips**: The presence and design of rumble strips on shoulders influences the safety and comfort of bicyclists. Where bicycle activity is expected, adequate space should be provided between the rumble strips and outside edge of the shoulder, as shown in Figure 4-14. Additional details are provided in Standard Drawings TM-15 and TM-16. In addition, MM-PM-2 shows bicycle lanes, rumble strips and pavement markings.
- **Guardrails or Barriers**: If a guardrail or barrier is adjacent to the shoulder, additional width is needed to account for the shy distance needed by bicyclists.
- **Intersections**: Shoulders sometimes taper at intersections to provide space for vehicle turn lanes, but this change can leave the expected interaction between bicyclists and vehicles undefined. Transitioning shoulders to a bicycle lane design through an intersection can help define the intended space for bicyclists.

Figure 4-14 Paved Shoulders on State Route 96 in Williamson County, TN (Rural Context)

State Route 96 serves as a state bicycle route. Where rumble strips are used, adequate space should be provided between the rumble strips and outside shoulder for bicyclists to ride comfortably.

Source: TDOT

4.4.4 Bicycle Facility Selection

The FHWA *Bikeway Selection Guide* provides a resource to "help practitioners consider and make informed trade-off decisions relating to the selection of bikeway types" *(20)*. The guide is consistent with a performance-based design approach, and it "incorporates and builds upon [FHWA's] support for design flexibility to assist transportation agencies in the development of connected, safe, and comfortable bicycle networks that meet the needs of people of all ages and abilities" *(20)*. The guide outlines three primary steps in bicycle facility selection, shown in Figure 4-15.

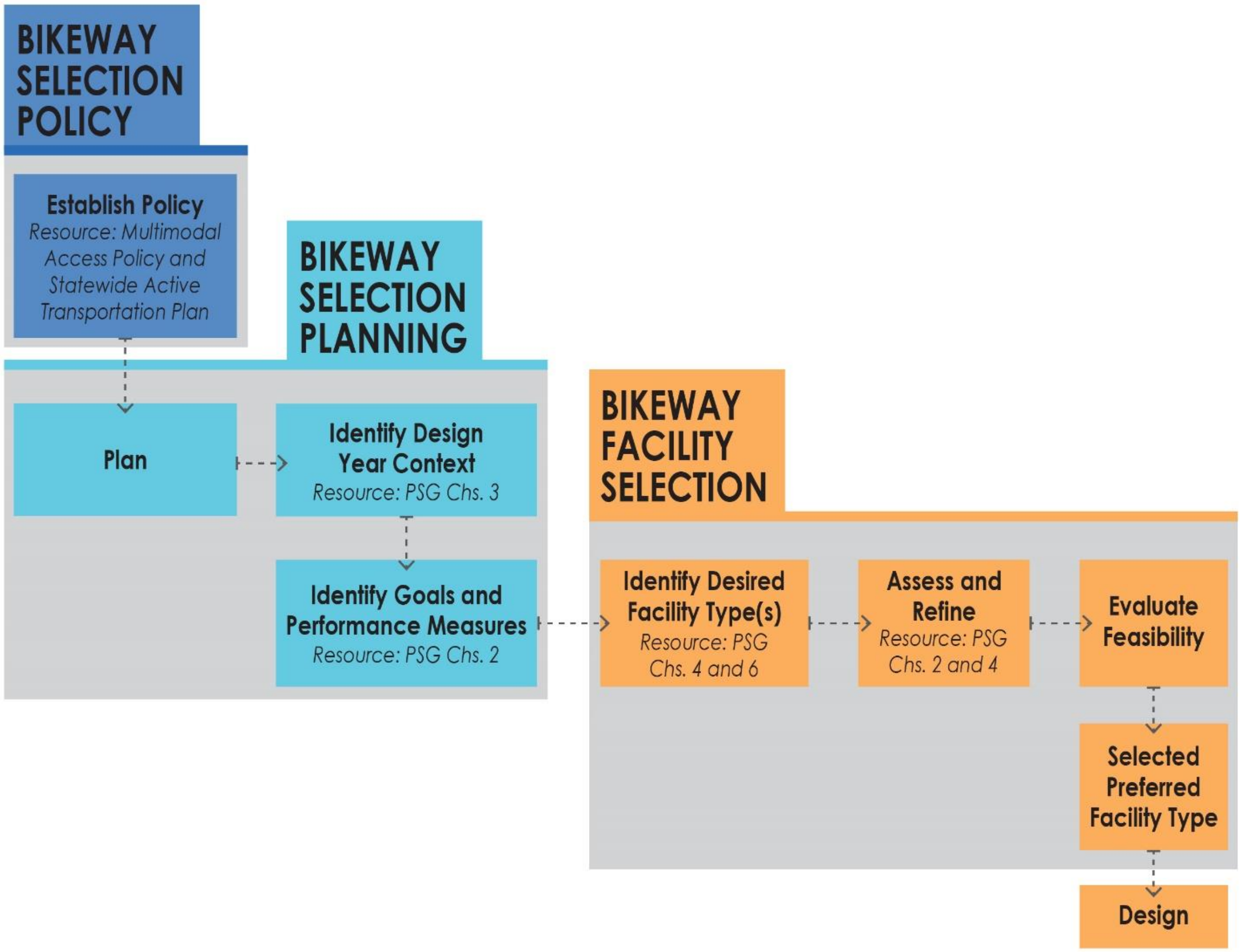
Figure 4-15 Bikeway Selection Steps

Step 1: Bikeway Selection Policy	•Policies can set goals and expectations for the bicycle network. •Policies can establish design considerations based on context or other factors. •TDOT resources: *Multimodal Access Policy* and the *Statewide Active Transportation Plan*
Step 2: Bikeway Selection Planning	•Includes identifying a project's purpose, context, role in the overall network, and design user. •Involves a broader planning process that considers "roadway and traffic characteristics for all modes" as well as "community goals and priorities." *(20)* •TDOT resources: Chapters 2-4 of the *PSG*
Step 3: Bikeway Facility Selection	•Uses a context-sensitive approach to identify the desired facility type for a corridor, which is then refined based on real-world conditions. •Considers design year context, functional classification, vehicle volumes and speeds, target users, and constraints. •TDOT resources: Chapters 4 and 6 of the *PSG*

Source: Adapted from FHWA Bikeway Selection Guide (20)

This section focuses on Step 3: Bikeway Facility Selection. A variety of national resource documents include recommendations on how to select the bikeway type for a facility, with vehicle volumes and speeds as the most often-used metrics. TDOT uses the decision-making flow chart shown in Figure 4-16 and guidance in the *PSG* and TDOT Standard Drawings for selecting and designing the preferred bikeway type.

Figure 4-16 Decision-Making Flow Chart for Bicycle Facility Selection



Source: Adapted from Figure 8 in the FHWA Bikeway Selection Guide (20)

Identifying the desired bikeway type can be challenging and requires considering a variety of factors, including:

- **Design Year Context and Functional Classification:** What is the design year context and functional classification of the roadway?
- **Target Users:** Who should feel safe and comfortable using the bicycle facility?
- **Vehicle Traffic:** What are the vehicle volumes and speeds on the roadway?
- **Network:** What is the broader bicycle network in the area and desired travel paths between origins and destinations?

Chapter 6 of the *PSG* provides tables by design year context that indicate what bicycle facility types to consider based on functional classification. Where multiple options are provided, the project team should consider the facility type needed based on the target users, vehicle traffic, and bicycle network. Typically, separated bicycle facilities are preferred where feasible to provide the greatest level of comfort for all users, especially when vehicle volumes and speeds are higher. In addition, TDOT's Standard Drawings provide further guidance on bicycle facility type based on design year context, vehicle speed, and vehicle volumes.

As shown in Figure 4-16, once the desired bikeway type is identified, it may need to be refined based on constraints and feasibility. A performance-based design approach, as described in Chapter 2 of the *PSG*, should be used to evaluate tradeoffs and confirm the selected bikeway type carried through the design process is consistent with the project context, goals, and performance measures. Chapter 2 includes example bicycle-focused performance measures that may be used to ensure the project meets the intended goals and outcomes.

Table 4-2: Potential Bicycle Facility Types in Different Contexts

Context	Potential Facility Types
Rural[1]	Shared-use path Shared lane
Rural Town	Separated bicycle lane Buffered bicycle lane Conventional bicycle lane Shared lane
Suburban	Separated bicycle lane or shared-use path Buffered bicycle lane Conventional bicycle lane Shared lane
Urban	Separated bicycle lane Buffered bicycle lane Shared lane
Urban Core	Separated bicycle lane Buffered bicycle lane Shared lane

[1]Bike Routes may also be present on state highways in Rural contexts.
Note: Chapter 6 of the PSG provides recommended buffer widths by design year context and functional classification. The shared lane section in Section 4.4.3 provides additional guidance on when to consider a shared lane.

4.5 SHARED-USE PATHS

A shared-use path is a combined pedestrian and bicycle facility located within an independent right-of-way or the street right-of-way and physically separated from motor vehicle traffic by an open space or barrier. Most shared-use paths are designated for two-way travel and are designed for both daily commuting and recreation. Some paths may be long and connect communities, parks or natural areas, and popular destinations. Other paths may be short and serve a discrete purpose. Shared-use paths that have an independent alignment (separate from the roadway) may be considered in all contexts and when it crosses the roadway it may require additional crossing treatments. If the shared-use path is parallel and adjacent to the roadway, they are not recommended in Urban or Urban Core contexts due to greater pedestrian conflicts as well as driveway and intersection conflicts with two-way travel.

4.5.1 General Principles

Shared-use paths can vary significantly in purpose, character, and design. In general, principles for shared-use paths include:

- Path design should consider expected users and their key characteristics like transport modes, speeds, ages, trip purposes, and abilities. Shared-use paths may be used by walkers, runners, people with mobility devices, bicyclists, skaters, other micromobility users, and equestrians. Some users may be on the path for exercise or recreation. Other users may be on the path to reach a destination and will be more focused on speed and efficiency.
- The quality of the user's experience is shaped by how crowded the path is, what speed the person is going compared to other users, how often they have to stop or cross a roadway, how smooth the path surface is, what amenities are available, and the surrounding aesthetic elements like landscaping or artwork.
- Shared-use path design is similar to roadway design, but on a smaller scale and with lower typical design speeds. The design speed for a shared-use path is 18 mph. Common design elements include cross slope, drainage, curvature, and sight distance.
- ADA and PROWAG accessibility requirements apply to shared-use paths.
- Wayfinding and signage may be appropriate, especially at intersections and near key destinations, as shown in Figure 4-17.
- Shared-use paths should be integrated with the broader pedestrian and bicycle networks, with intentional connections to other routes and facilities.
- Additional space and design elements may be required near major destinations, crossings, or intersections to integrate more users on the path.
- Path design should communicate expected user behaviors, such as slowing at intersections or yielding between users. Education and enforcement strategies may also be helpful to verify users know how to safely use the paths.

Figure 4-17 Signage on Greenway in Farragut, TN (Suburban Context)

Sources: TDOT

Distinctive signage can be used along a shared-use path to help users find and stay on the path. Wayfinding signage can include simple maps, arrows, and the distance to nearby destinations. It is especially helpful at path intersections. The MUTCD has additional information about signing for shared-use paths.

4.5.2 Elements of Design

Design elements for a shared-use path are similar to those for pedestrian or bicycle facilities and are influenced by design year context, user needs, and site-specific constraints. Basic elements of design for shared-use paths are described below and additional information is provided in the TDOT *Roadway Design Guidelines*.

- **Path width:** The width of a shared-use path is based on expected users, site-specific constraints, and whether the path is delineated by direction or user type. This is shown in Standard Drawing MM-TS-2.
- **Separation or buffer:** Shared-use paths may be adjacent to roadways. In these cases, separation is provided by landscaping, on-street parking, or other vertical elements. If a path is located within the clear zone of a roadway, especially along a higher-speed roadway, crashworthy barriers should be considered in the buffer. For bridges, there is typically an additional one foot of space between the shared-use path and the parapet. This is shown in Standard Drawing MM-TS-2.

Figure 4-18 Shared-Use Path along State Route 397 in Williamson County, TN (Rural Context)

The shared-use path provides adequate width for several bicyclists to ride side by side, or a bicyclist to pass another path user. A wide landscape strip provides separation from vehicle traffic.

Source: TDOT

4.5.3 Route Selection

A shared-use path may be an appropriate facility in areas where it is desirable to physically separate pedestrians and bicyclists from vehicle traffic and there is not adequate space or a need to physically separate pedestrians and bicyclists from each other. Shared-use paths are common in sparsely-developed contexts where right-of-way is constrained. Shared-use paths may be located on one or both sides of the roadway. In some cases, a sidewalk may be provided on one side of the roadway and a shared-use path on the other side. Shared-use paths are not preferred in contexts with increased access points that may create conflicts with the users on the paths, such as Rural Town, Urban Core, and Urban contexts.

Considerations when evaluating the appropriateness of a shared-use path include:

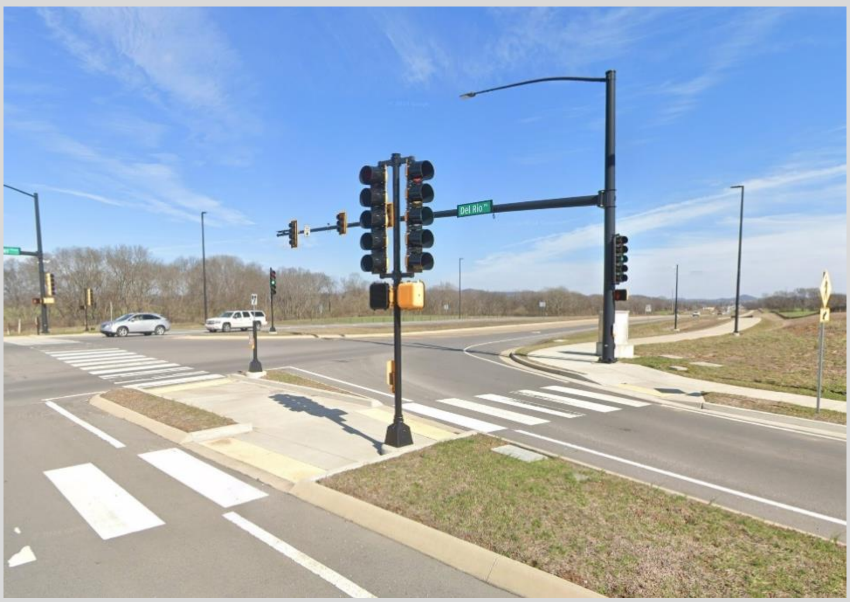
- Shared-use paths are typically comfortable for all ages and abilities of riders.
- Shared-use paths are well suited to continuous corridors where there are not frequent destinations, crossings, or expected stops.
- High pedestrian volumes, driveways, sharp turns, crossings or frequent stops, and large speed differentials in users degrade a bicyclist’s experience on a shared-use path.
- Where pedestrian or bicycle volumes are high, separation between modes is desirable.

Shared-use paths may not be ideal on corridors with frequent intersections or crossings and are better suited to longer corridors. Where a shared-use path crosses a roadway or intersection, vehicles or path users may be required to yield or stop via a sign, beacon, or traffic signal.

Consider the following at conflict points:

- Design treatments can be used on the approaches to intersections or crossings to signal to users they may need to slow or stop. Treatments include path narrowing, curvature, signage, raised bars, and detectable warning surfaces.
- Ensure sight distance is provided for all users and clearly define who has the right-of-way.
- Consider volume, speed, and the broader network to determine whether path users or vehicle users are stopped.

Figure 4-19 Shared-Use Path at Signalized Intersection in Franklin, TN (Suburban Context)



Curves are used on both sides of the intersection to slow approaching bicyclists. A double yellow center strip is used on the path near the intersection to separate users by direction, and visually narrow the path to encourage lower speeds. Path users cross the roadway during the pedestrian signal phase, with green crosswalk markings used to draw attention to the path.

Source: TDOT

4.5.4 Mixing Users

Shared-use paths may include pavement markings or signage indicating designated space for pedestrians and bicyclists (shown in Figure 4-20), or users may be expected to share the full width of the path and yield to one another. If pedestrians and bicyclists are separated, the space for bicyclists may be further separated based on direction.

Separating pedestrians and bicyclists may be desirable where higher bicycle speeds are expected, as speed differentials between users can degrade the comfort, safety, and experience of path users. Slower path users may be startled by faster path users, and faster path users may be frustrated by slower users or expect certain yielding behavior. Where recreational riders are anticipated or there are longer gaps between intersections or required stops, bicyclists may reach higher speeds. Where a shared-use path is shorter in length or requires frequent turns and stops, bicycle speeds may be lower. Design elements may be used to control user speeds, including tread surfacing, curves, path narrowing, and gateways.

In cases with high volumes of pedestrians and bicycles mixing, it may be appropriate to provide a wider overall width for the shared-use path to create more space for pedestrians and bicycles to navigate comfortably.

Figure 4-20 Shared-Use Path on Bridge over River in Nashville, TN (Urban Context)

Pavement markings and a center stripe may be used to indicate space for bicyclists and pedestrians, with arrows used to indicate directionality. Especially on grades, the speed differential between pedestrians and bicyclists may be greater, so separation may be more desirable.

Source: TDOT

4.6 CROSSINGS

Crossings are a key part of pedestrian and bicycle networks and can have a significant impact on user comfort and safety. Crossings introduce potential conflicts between different users and the potential for severe crashes.

> According to a study by the University of Tennessee and Vanderbilt University, "Midblock crossings have become more dangerous and have contributed more significantly to fatal crashes in recent years… The driver continuing straight… and striking a pedestrian crossing midblock, has one of the most substantial chances of increasing severity." In light of this, the study recommends a "focus on improving midblock crossings with proven interventions," specifically reducing speeds; increasing crossing opportunities, especially on transit corridors; and installing countermeasures like beacons, islands, and lighting. *(16)*

This section presents general principles around crossings and provides design guidance for a variety of crossing types at midblock crossings and intersections.

4.6.1 General Principles

NCHRP Research Report 926: *Guide to Improve Pedestrian and Bicyclist Safety at Intersections*, provides key design principles around pedestrian and bicyclist safety at crossings and intersections, including:

- **Assume people will bicycle and walk**: Provide bicycle and pedestrian infrastructure between and at intersections and consider bicyclists and pedestrians as part of the design process.
- **Minimize and manage conflict points by prioritizing safety**: Consider and minimize conflict points as feasible. Separated facilities, like separated bicycle lanes and sidewalks, exclusive pedestrian phasing, and bicycle signals, help to minimize conflicts.
- **Minimize travel time and delay**: Consider how design decisions will impact the experience of bicyclists and pedestrians. Prohibiting crossings, using longer cycle lengths, requiring multi-stage crossings, and designing longer block lengths can all increase delay for bicyclists and pedestrians, and may result in a lack of compliance with traffic control devices.
- **Minimize exposure to conflicts**: Minimize the amount of time and distance where bicyclists and pedestrians have the potential for conflict with motor vehicles by keeping crossings and merging distances as short as feasible, as shown in Figure 4-21.
- **Control speeds and minimize speed differential at conflict points**: Where there is potential for conflict between users, control speeds considering the context and intended users.
- **Prioritize comfort**: Provide low-stress, comfortable crossings that consider the impact the physical experience has on the user.
- **Provide and convey a predictable, reasonable path**: Use design treatments to emphasize expected behaviors and help users understand where and how they should travel.
- **Manage sight lines and visibility**: Ensure there is clear visibility between the different users at an intersection or crossing. Daylighting intersections and crossings by setting back on-street parking and limiting visual obstructions, while encouraging slower speeds, can improve sightlines and opportunities for different users to see each other.
- **Ensure accessibility**: Intersections and crossings should be accessible for all users and consistent with ADA and PROWAG requirements. *(23)*

Figure 4-21 Marked Crossing at Intersection in Knoxville, TN (Urban Context)

Bulb-outs shorten the crossing distance for pedestrians and make pedestrians waiting to cross more visible to motorists. Parking restrictions increase sight lines and the ability of different users at the intersection to see each other.

Source: TDOT

4.6.2 Elements of Design

The design of a pedestrian and bicycle crossing is influenced by the location (midblock, uncontrolled intersection, traffic signal, roundabout, etc.), design year context, roadway type and characteristics, user needs, and site-specific constraints. Basic design elements are discussed below and illustrated in Figure 4-22, and additional information is provided in the TDOT *Roadway Design Guidelines*. TDOT Roadway Standard Drawings T-M-4, T-M-4A, and T-M-4B provide details for crosswalk markings.

- **Crosswalk Markings:** Marked crosswalks typically include longitudinal markings (sometimes called "piano keys") to emphasize the crosswalk location. On high-speed and/or high-volume facilities, longitudinal markings may make the location more visible to motorists. Longitudinal crosswalk markings shall be used on all midblock crossings.
- **High-Visibility Crosswalk Markings**: This type of marking uses reflective materials to bring additional emphasis to priority crossings. They can be used at intersections or midblock and are typically applied at locations with moderate to high vehicle volumes and speeds. They can be paired with other types of traffic control or crossing treatments, which may increase their effectiveness.
- **Crosswalk Marking Architectural Features:** Asphalt or concrete are the proper materials to use for the walking surface. A different look can be achieved by using stamped patterns. Crosswalks may be textured on the edges but should maintain a five-foot smooth section in the middle and must be marked with transverse (parallel) reflective pavement marking.

- **Curb Extensions/Bulb-Outs:** Curb extensions, usually in the form of a bulb, can be used at an intersection or midblock crossing to shorten the crossing distance for pedestrians while narrowing the vehicle path. They are typically used on roadways with curbs and on-street parking or shoulders. In general, curb extensions should extend the width of the shoulder or parking lane, with the curb face approximately one foot from the edge line of the through travel lane.
- **Curb Ramps:** Curb ramps are used to transition pedestrians or bicyclists between different grades and are typically required at crossings, except where the crossing is raised to be even with the sidewalk or pedestrian facility. Perpendicular design curb ramps are required. Parallel, blended transition, and lowered-corner curb ramps are appropriate for areas with right-of-way constraints and must be approved through the Design Exception/Deviation/Waiver process.
- **Detectable Warning Surfaces:** Detectable warning surfaces (truncated domes) are used to alert pedestrians with vision impairments that they are approaching a roadway crossing, conflict, or change in grade. Detectable warning surfaces are used with curb ramps, pedestrian refuge islands, railroad crossings, commercial driveways, raised crossings, and blended transitions. Additional design guidance for curb ramps and detectable warning surfaces are provided in the MM-CR-Series Roadway Standard Drawings and Chapter 3 of the *Roadway Design Guide*.
- **Crossing Island/Pedestrian Refuge:** A crossing island in the median, also called a pedestrian refuge, can improve pedestrian safety by providing a protected area where pedestrians can stop while crossing the roadway. Crossing islands can also be used to facilitate bicyclist crossings where bicycle routes cross more major roadways. The island reduces exposure for pedestrians and/or bicyclists by allowing a two-stage crossing that only requires them to cross vehicular traffic coming from one direction at a time. Crossing islands can be used at intersections or midblock crossings.
- **Raised Crossing:** A raised crossing brings the level of the roadway even with the sidewalk, shared-use path, or other pedestrian/bicycle facility, providing a level pedestrian and/or bicyclist path. The crossing acts as a speed table, requiring vehicles to slow and improving safety for pedestrians and/or bicyclists crossing the roadway. Pedestrians and/or bicyclists cross at close to a constant grade so curb ramps are not typically needed; however, detectable warnings are still required.
- **Lighting**: Crossing illumination can significantly impact a pedestrian or bicyclist's sense of comfort and security. Proper lighting also helps ensure that users waiting to cross are visible to motorists. Lighting for crossings should be mounted at a lower, pedestrian-friendly level for crossing areas with high nighttime pedestrian activity, such as shopping districts, transit stops, schools, community centers, and other major pedestrian generators or areas with a history of pedestrian crashes.

Figure 4-22 Midblock Crossing at Night in Knoxville, TN (Urban Context)

Source: *TDOT*

A crossing island/pedestrian refuge increases visibility of the midblock crossing and enables pedestrians to cross one direction of vehicle traffic at a time. Curb ramps and detectable warning surfaces are provided on the crossing island. Lighting illuminates the crossing and improves visibility of pedestrians at night.

4.6.3 Marked and Unmarked Crossings

According to PROWAG *(2)*, a crosswalk is defined as follows:

> "That part of a *roadway* that is located at an intersection included within the connections of the lateral lines of the *pedestrian circulation paths* 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 *pedestrian circulation path* on one side of the *roadway*, the part of a *roadway* included within the extension of the lateral lines of the *pedestrian circulation path* at right angles to the center line; or at any portion of a *roadway* at an intersection or elsewhere distinctly indicated as a *pedestrian* crossing by pavement marking lines on the surface.
>
> *Crosswalks* at intersections may be marked or unmarked" *(2)*

The *MUTCD* provides a similar definition. The definitions of a crosswalk in PROWAG and the *MUTCD* are similar but are slightly different from the current Tennessee Code Annotated (TCA), which defines crosswalk in §55-8-101 as "A. 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; or B. Any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface" *(24)*.

One distinct difference is the inclusion of the line in PROWAG, "in the absence of a pedestrian circulation path on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the pedestrian circulation path at right angles to the center line" *(2)*. This difference could lead to different interpretations on when an unmarked crosswalk is created. Since TDOT has adopted both PROWAG and the *MUTCD*, it has been decided that the state is bound by the definition of a crosswalk in PROWAG and the *MUTCD*. Generally speaking, this means that where a sidewalk along a roadway approaches an intersection, the extension of that sidewalk across the intersecting roadway is a crosswalk. During projects that trigger ADA improvements, these crosswalks should be identified to ensure that these locations meet PROWAG and TDOT ADA requirements.

UNMARKED CROSSWALKS

Unmarked crosswalks are legal pedestrian routes but not marked with signage or pavement markings. Pedestrians have the same right-of-way at unmarked crosswalks as they do at marked crosswalks. While all crosswalks have the same ADA accessibility requirements per PROWAG, leaving some crosswalk locations unmarked may be acceptable or even preferable on some roadways based on engineering judgment. While all crossings controlled by a stop sign, yield sign, or a signal should have marked crosswalks, uncontrolled crossings may not require a marked crosswalk if conditions meet the minimum safety standards.

Projects teams can coordinate with the TDOT Office of Active Transportation to determine if and where to place pedestrian crossings but should also be aware of unmarked crosswalks that are not currently ADA/PROWAG accessible. Project teams should consider the impacts at intersections with incomplete or asymmetrical pedestrian circulation.

Certain intersection legs may not meet the definition of unmarked crosswalks. Project teams should start by aiming to make the intersection fully accessible and confirm the need for crossings based on the design year context, environmental constraints, and project-specific characteristics. If crossings are not able to be integrated into the project, justification should be documented, and Design Exception/Deviations/Waivers may be required.

Project teams should coordinate with the Office of Active Transportation and ADA Office to identify the most appropriate pedestrian facilities and confirm crosswalk locations and types are integrated into the planning and design process.

MARKED CROSSWALKS

Controlled (signal, stop, or yield) pedestrian crossings on state routes shall have crosswalk pavement markings and stop bar or yield marking with signs in accordance with the *MUTCD*. Marked crosswalks at controlled pedestrian crossings on non-state routes are recommended.

Crosswalks may also be marked at uncontrolled intersections (intersections without a signal, or a stop or yield control) or at uncontrolled approaches (e.g., on a major roadway where an intersecting minor street is stop controlled but the major roadway has no traffic signal or stop control).

Marked crosswalks at uncontrolled locations (intersections or midblock) may be considered based on the need accompanying the safety performance assessment for both pedestrians and vehicles. If crossings are not able to be added, pedestrians should be guided to other routes for crossing.

Based on the *MUTCD, Section 3C.02, Application of Crosswalk Markings,* "At uncontrolled approaches, an engineering study should be performed before a marked crosswalk is installed. The following criteria should be considered: total number of approach lanes, the presence of a median, the distance from adjacent signalized intersections or other controlled crossings, projected pedestrian and bicyclist volumes, pedestrian and bicyclist paths of travel, pedestrian ages and abilities, pedestrian and bicyclist delays, location and frequency of transit stops, average daily traffic (ADT), speed limit or the 85th-percentile speed, the horizontal and vertical geometry of the crossing location, the possible consolidation of multiple crossing points, the availability of street lighting, and other appropriate factors." *(22)*

Additional guidance on selecting crossing treatments and countermeasures is in Section 4.6.5.

CLOSING CROSSWALKS

Existing crosswalks may not meet desired objectives for pedestrian safety and comfort. When this happens, designers should first look to improve safety at the crossing utilizing proven countermeasures such as pavement markings, advance warning signs, improved street lighting, and strategies to reduce vehicle speeds and posted speed limits. In rare circumstances, a particular pedestrian crossing should be closed. Closing a sidewalk or pedestrian crossing is a last resort and should be pursued only when the crosswalk has a history of safety issues and when other efforts at safety improvement were attempted and found to be ineffective. The act of removing crosswalk pavement marking or choosing not to install ADA curb ramps is insufficient to consider a crossing as closed. The following requirements apply when it is determined that closing the crosswalk is the only safe alternative:

- Provide a physical barrier and signs to indicate that the crossing is prohibited for all users.
- Provide a reasonable alternate route that all pedestrians can use. The route should include multiple countermeasures for safe pedestrian crossing. Most importantly, the route should be located within a reasonable distance from the closed crossing.

4.6.4 Crossing Treatments

Beyond crosswalk markings, there are additional treatments that can improve safety performance and comfort for users crossing the roadway. The following sections outline the potential benefits, constraints and applications of rectangular rapid flashing beacons (RRFBs), pedestrian hybrid beacons (PHBs), pedestrian signals, and grade-separated crossings.

RECTANGULAR RAPID FLASHING BEACON (RRFB)

Figure 4-23 RRFB at Midblock Crosswalk in Nashville, TN

Source: TDOT

An RRFB includes signs and warning beacons with rectangular-shaped LED indications that flash rapidly when activated. As described in the *MUTCD*, RRFBs "provide supplemental emphasis to pedestrian, school, and trail warning signs at marked crosswalks across uncontrolled approaches" (22). They can increase motorist yielding rates and reduce pedestrian crashes by making crossings more visible and attracting motorists' attention.

Benefits

- Provides a visible warning to motorists at eye level.
- Increases motorist yielding behavior at crossing locations compared to round yellow flashing beacons.
- Allows motorists to proceed after yielding to pedestrians and bicyclists.
- Provides a lower cost treatment that can also be solar powered to eliminate the need for an additional power source.

Constraints

- Flashing beacons must be activated by pedestrians or bicyclists.
- Motorists may not understand the flashing lights of the RRFB (yellow device - warning), so compliance may be lower than with a traffic signal.

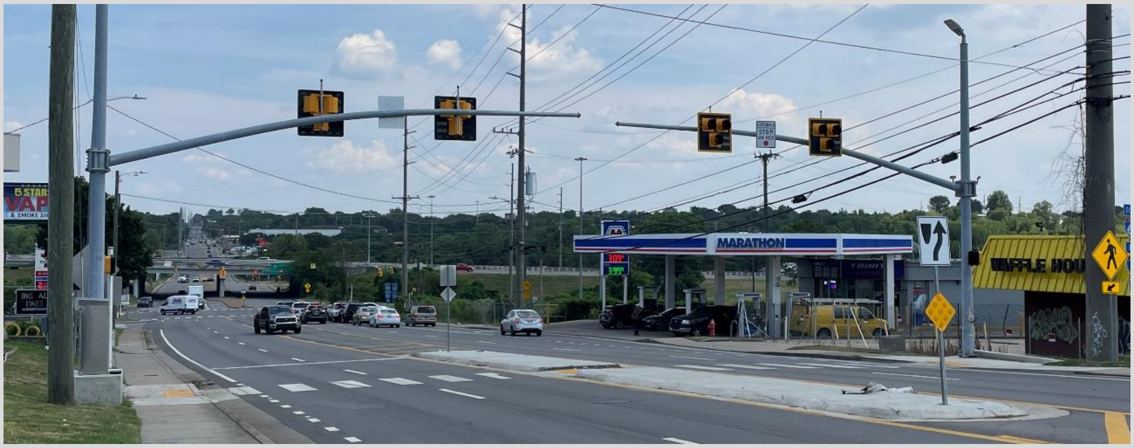
Applications

- Midblock or uncontrolled crossings with medium to high pedestrian or bicycle demand and/or medium to high traffic volumes.
- Locations where shared-use paths intersect with roadways.

The *MUTCD* provides more information on the design and operation of RRFBs (22).

PEDESTRIAN HYBRID BEACON (PHB)

Figure 4-24 PHB at Shared-Use Path Crossing W. Trinity Lane in Nashville, TN (Urban Context)



Source: TDOT

A PHB is a pedestrian-activated signal that is unlit when not in use (rests in dark). It begins with a yellow light alerting drivers to slow and then displays a solid red light requiring them to remain stopped while pedestrians cross the street. Finally, the beacon shifts to flashing red lights to signal that motorists may proceed after pedestrians have completed their crossing. This treatment often leads to improved safety performance and comfort for pedestrians and bicyclists compared to other treatments.

Benefits

- Results in higher motorist yielding behavior at crossing locations compared to other treatments such as the RRFB.
- High pedestrian compliance due to very short wait times.
- Improves pedestrian safety and reduces pedestrian-involved crashes by 69 percent. *(25)*
- Red signal indication provides a clear message to motorists that a complete stop is required.

Constraints

- Must be activated by pedestrians or bicyclists.
- More costly than other crossing treatments.
- Local agencies are responsible for maintaining the PHB, which requires additional coordination.

Applications

- Midblock crossings with high pedestrian or bicycle crash risk and need for intervention (as determined by the Multimodal Priority Tool), high pedestrian or bicycle demand, and/or high traffic volumes.
- Locations where a full traffic signal is not warranted or appropriate.
- Locations where shared-use paths intersect with roadways.

Chapter 4J of the *MUTCD* provides more information on the use and operation of PHBs, including guidelines for installing PHBs based on pedestrian volumes, vehicle speeds and volumes, and crosswalk length. *(22)*

PEDESTRIAN SIGNALS

Figure 4-25 Pedestrian Signal on Shelby Avenue in Nashville, TN

Source: Google

Pedestrian signals are pedestrian-actuated and function similarly to a standard traffic signal. They typically rest in green for mainline vehicular traffic unless actuated by a pedestrian waiting to cross, at which point a sequence of steady yellow and red is displayed to stop vehicles on the mainline while pedestrians cross. Signals can also be used by bicyclists and on bicycle routes can be designed to be actuated by waiting bicyclists.

Benefits

- Results in high motorist yielding behavior at crossing locations.
- Can be designed to be actuated by waiting bicyclists.

Constraints

- Must be activated.
- More costly than other crossing treatments.

Applications

- Midblock crossings with high pedestrian or bicycle demand and/or high traffic volumes.
- Locations where shared-use paths intersect with roadways.
- Previously stop-controlled intersections where pedestrian and bicyclist volumes warrant a signal.
- This type of treatment is not used frequently by TDOT compared to other treatments such as PHBs.

GRADE-SEPARATED CROSSINGS

Figure 4-26 Big River Crossing in Memphis, TN

Source: TDOT

A grade-separated crossing is a bridge (overcrossing), or a tunnel (undercrossing) designed to carry pedestrians, bicyclists, and other non-motorized users over or under a roadway or other barrier to travel, such as a waterway or railroad crossing.

Benefits

- Provides physical separation from motor vehicle traffic, attracting users of all comfort and ability levels.
- Minimizes crash risk and can provide a safe crossing of any type of facility, including railroads and limited-access highways.

Constraints

- Grade-separated crossings can be very expensive.
- Depending on topography, may require significant additional space to make grade changes.
- Long undercrossings have the potential to present safety and security issues, so they require lighting.
- Significant delays to pedestrians, bicyclists, and other non-motorized users, decreasing convenience and level of service.

Applications

- Crossings of limited access highways, multilane roadways, railroads, or bodies of water.
- Shared-use paths often have grade-separated crossings to provide comfortable and safe crossings for users of all levels.

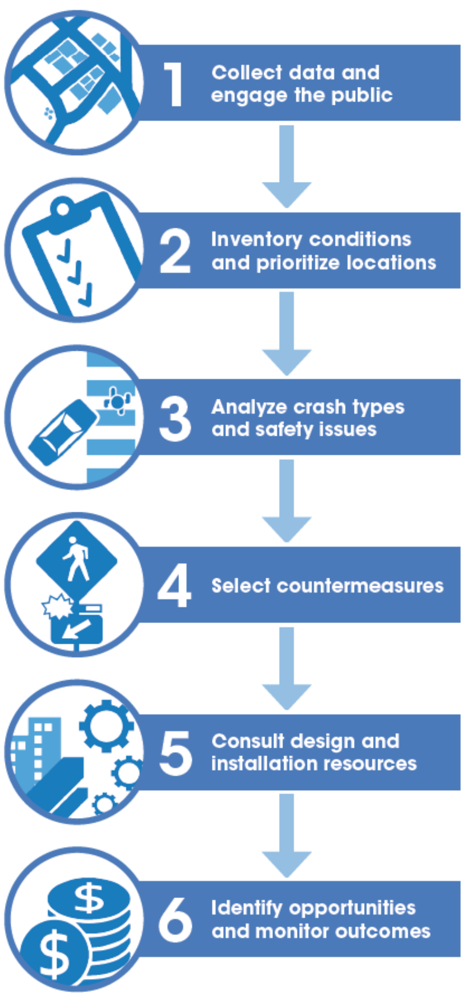
In some cases, it may be worthwhile to provide both a grade-separated crossing and at-grade crossing. For example, if a grade-separated crossing requires out-of-direction travel, some users may not tolerate the additional travel time or distance and prefer a higher-stress, at-grade crossing.

4.6.5 Crossing Selection

Selecting the appropriate pedestrian or bicycle crossing treatment requires careful consideration of the desired safety outcomes, design year context and site-specific conditions, which will influence right-of-way, driver expectations, infrastructure needs, and pedestrian behavior. There is currently a significant amount of national guidance on selecting crossing treatments, most of which focuses on vehicle volume, speed, roadway configuration, pedestrian volume, and proximity to other crossings. However, considering context and accounting for future pedestrian demand are also critical for serving intended users. TDOT generally uses the approach presented in FHWA's *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* (*STEP Guide*), with an added focus on context and other key factors *(26)*. TDOT's Vulnerable Road Users Safety Assessment is consistent with this approach and can be used by project teams to apply a simplified selection process.

The *STEP Guide* presents six steps for selecting crossing treatments and related countermeasures at uncontrolled crossing locations. While geared towards existing locations, guidance can also be applied to new roadways *(26)*. The six steps are illustrated in Figure 4-27.

Figure 4-27 Process for Selecting Crossing Treatments and Countermeasures



Source: FHWA STEP Guide (26)

This section focuses on step 4 of the process, "select countermeasures." The *STEP Guide* provides a framework for initially identifying crossing treatments and countermeasures based on roadway and traffic characteristics, shown in Figure 4-28. The *STEP Guide* notes that the selection process should be informed by additional considerations, such as pedestrian volume, operational speeds, land use context, and other site features. *(26)*

Figure 4-28 Framework for Initial Selection of Crossing Treatments and Countermeasures

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	❶ 2 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6 7 9	① 5 6 7 9	① 5 6 ❾
3 lanes with raised median (1 lane in each direction)	❶ 2 3 4 5	❶ ❸ 5 7 9	① ❸ 5 ❼ ❾	① 3 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❼ ❾	① ❸ 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❾
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	❶ 2 3 4 5 6 7 9	❶ ❸ 5 6 7 9	① ❸ 5 6 ❾	① 3 4 5 6 7 9	① ❸ 5 6 ❼ ❾	① ❸ 5 6 ❾	① ❸ 4 5 6 7 9	① ❸ 5 6 ❾	① ❸ 5 6 ❾
4+ lanes with raised median (2 or more lanes in each direction)	❶ ❸ 5 7 8 9	❶ ❸ 5 7 8 9	① ❸ 5 8 ❾	① ❸ 5 7 8 9	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 8 ❾
4+ lanes w/o raised median (2 or more lanes in each direction)	❶ ❸ 5 6 7 8 9	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 8 ❾

Given the set of conditions in a cell,

- \# Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1. High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2. Raised crosswalk
3. Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4. In-Street Pedestrian Crossing sign
5. Curb extension
6. Pedestrian refuge island
7. Rectangular Rapid-Flashing Beacon (RRFB)**
8. Road Diet
9. Pedestrian Hybrid Beacon (PHB)**

Source: FHWA STEP Guide (26)

A performance-based design approach can be used to evaluate potential crossing treatments and countermeasures identified using the framework in Figure 4-28. This approach uses the identified purpose and need to select performance measures to consider when comparing different alternatives, including:

- **Safety:** What is the crash history at the crossing location? What are the vehicle speeds and volumes? What yielding behavior is anticipated with the alternatives?
- **Consistency with context:** Is the alternative consistent with the design year context?
- **Accessibility:** Does the alternative meet the needs of all expected users?
- **Feasibility/Cost:** Is there adequate right-of-way for the alternative? What is the cost to install and maintain the alternative?
- **Operations:** How does the alternative impact all roadway users, including motorists, bicyclists, and pedestrians?
- **Network Connectivity:** How far is the location from other crossing opportunities? What role does the crossing play in the overall pedestrian and bicycle networks?
- **Demand:** What volume of pedestrians and bicyclists currently use the crossing or are expected to in the future? What latent demand may there be which is not currently served? What pedestrian or bicycle generators may be served by the crossing?

Chapter 2 of the *PSG* provides additional guidance on applying a performance-based design approach to design decisions, as well as documentation of decisions.

4.6.6 Spacing Requirements and Considerations

The AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* notes that "pedestrians have a strong desire to cross streets at locations close to their intended path—that is, they do not want to go out of their way any more than necessary to reach their destination." *(17)*

To determine the appropriate spacing of pedestrian and/or bicycle crossings, a variety of factors should be considered, including:

- Design year context
- Network characteristics, including frequency and spacing of intersections and bicycle and pedestrian routes
- Pedestrian and bicycle destinations (e.g., transit stops, schools, parks, shopping areas, employment centers, etc.)

Decision-making for identifying the appropriate crossing spacing should include:

- Considering both existing and projected demand and desire lines.
- Recognizing that frequent crossings enhance walkability.

- Understanding that increased pedestrian travel time and delay influence pedestrian decisions (especially among young children) on when to cross, thus affecting overall safety performance.
- Understanding the desired outcomes around user quality of service and safety performance.

Table 4-3 provides ranges for pedestrian crossings based on context. Ranges are given instead of specific distances to allow flexibility, acknowledging that a number of other factors may influence the desired spacing for a specific location.

Table 4-3: Target Pedestrian Crossing Spacing by Context

Context	Target Pedestrian Crossing Spacing Range (feet)[1]
Rural	600+/-, varies based on adjacent land uses
Rural Town	250-550 (1-2 blocks)
Suburban	600+/-, varies based on adjacent land uses
Urban	250-550 (1-2 blocks)
Urban Core	250-550 (1-2 blocks)

Note: Intersection spacing should follow guidance in TDOT Highway System Access Manual (HSAM) Volume 3.

4.6.7 Crossings at Intersections

The principal objective when designing intersections or interchanges for pedestrian and bicycle mobility and safety performance is to provide a visible, distinct, predictable, and clearly designated path leading to and through the intersection while managing potential conflicts between all other roadway users.

General principles to enhance crossings at intersections for pedestrians and bicyclists is provided in the AASHTO *Guide for the Development of Bicycle Facilities* and *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. Key considerations include:

- Avoid free-flow turning movements by motor vehicles or provide appropriate crossing treatments for pedestrians and bicyclists.
- Include pedestrian-scaled lighting to enhance crossings.
- Integrate crossings that are direct, logical, and the shortest distance to reduce exposure to motor vehicles.
- Signal timing and actuation should support bicycle and pedestrian detection and navigation through the intersection.

Consider access management to reduce conflict points near the intersection. Chapter 5 provides additional design guidance related to intersections.

SIGNALIZED INTERSECTIONS

Traffic signals direct the movement of pedestrians, bicyclists, transit, freight, and motor vehicles at an intersection. The intersection design and signal timing influence the delay users experience moving through the intersection as well as their safety and comfort. Project teams should consider all users and examine the trade-offs of different design decisions.

For example, adding a separate turn lane may reduce vehicle delay and crash risk for turning vehicles while increasing the crossing distance, travel time, and exposure for pedestrians and bicyclists. In this case, a pedestrian refuge island may need to be integrated to support pedestrians crossing the longer distance of the intersection. Additionally, trade-offs may need to be considered for signal timing at the intersection. Longer cycle lengths may accommodate a higher vehicle volume through an intersection while increasing delay for pedestrians. It is important to evaluate traffic signals in the overall context of the street network and through each user's perspective.

NCHRP Report 812: *Signal Timing Manual,* Second Edition, suggests an eight-step, outcome-based process for developing signal timing *(27)*. The second step is to identify users and the third to establish user and movement priorities. This enables project teams to select operational objectives and then develop timing strategies aligned with those objectives. While project team priorities and user needs may vary by project, safety for all roadway users should remain as the top priority.

Key considerations related to pedestrians, bicyclists, and transit vehicles at traffic signals include:

- **Pedestrian Features:** Pedestrian pushbuttons, marked crosswalks, and pedestrian signals should be provided at all locations with existing or planned sidewalks, and within all Suburban, Urban, or Urban Core contexts. Pedestrian pushbuttons and signals shall be used where there are existing or proposed marked crosswalks. If marked crosswalks are not present and will not be added, pedestrian signals are not required.
- **Accessible Pedestrian Signals (APS) and Countdown Pedestrian Displays**: Based on PROWAG and ADA compliance, APS should be installed and include audible and vibrotactile indications of the *WALK* interval. Installing these devices may require improvements to existing sidewalks and curb ramps to ensure ADA and PROWAG compliance.
- **Cycle lengths:** When developing a signal cycle plan, the designer should weigh the effects on all users: pedestrians, bicyclists, transit vehicles, and/or motorists. Longer cycle lengths may be acceptable to optimize vehicular traffic movements, however, shorter cycle lengths may be appropriate in Urban and Urban Core contexts with high pedestrian and/or bicyclist activity.
- **Flash operation:** Many municipalities in Tennessee operate their signals in a scheduled flash mode late at night and into the early morning. If pedestrian activity is expected during the night, this should not be done, especially on multilane routes. Traffic controllers cannot accept a pedestrian pushbutton call when operating in flash mode.

- **Upgraded features:** When a project's limits begin or end at an intersection, all approaches to the intersection must be upgraded with similar active transportation features, so pedestrians and bicyclists can more safely traverse the intersection. If curb ramps are installed, they must be installed in all quadrants of an intersection with curb. If the vehicular lanes are modified, the signal heads will typically need to be replaced or shifted, along with possible modifications to the signal cabinet.

Table 4-4 summarizes signal timing strategies and treatments based on four needs of pedestrians and cyclists.

Table 4-4: Pedestrian and Bicycle Signal Timing Strategies and Treatments

Need	Pedestrians	Bicyclists
Safety and comfort	• Exclusive pedestrian phase • Leading pedestrian interval • No turn on red • Protected-only left turn	• Exclusive bicycle phases • No turn on red • Protected-only left turn • Flashing bicycle crossing warning
Minimizing delay	• Shorter cycle length • Maximizing walk interval length • Pedestrian recall	• Shorter cycle length • Signal progression
Ease of Use and Information	• Countdown pedestrian display • Call indicator • Independently mounted push-button • Pedestrian recalls	• Call indicator • Bicycle wait countdown
Accessibility	• APS • Crossing times that support lower crossing speeds • Pedestrian recalls	• Minimum green and change interval settings

Additional guidance on traffic signals and signal timing is available in the *MUTCD*, ITE's *Traffic Engineering Handbook*, TDOT's *Traffic Design Manual*, NCHRP Report 812: *Signal Timing Manual,* Second Edition, and NCHRP Research Report 969: *Traffic Signal Control Strategies for Pedestrians and Bicyclists.*

ROUNDABOUTS

Roundabout intersections reduce the number of conflict points between motorists, pedestrians, and bicyclists and are intended to be designed to lower motor vehicle speeds to improve a driver's ability to react and yield to other users. Crossing locations are set back from the roundabout circulatory roadway to separate the driver decisions at the crosswalk from the driver decisions at the circulatory roadway. In most cases, crossings are designed to be made in two stages, crossing one direction of conflicting traffic at a time with a raised pedestrian island refuge between opposing directions of conflicting traffic. Pedestrians circulate the perimeter of the intersection and should be guided to the correct crossing locations by a detectable buffer between the sidewalk and circulatory roadway. Bicycles can travel through the roundabout in a variety of ways, such as:

- Within the center of the motor vehicle lane.
- In bicycle lanes at the same grade but laterally buffered from motor vehicle lanes.
- In physically separated bicycle one-way or two-way facilities, sometimes known as cycle tracks or protected bicycle lanes (shown in Figure 4-29).
- In shared-use paths with pedestrians, separated from the roadway.

Figure 4-29 Roundabout with Separated Pedestrian and Bicycle Facilities in Bend, OR (Suburban Context)

There are a variety of options for bicycle facilities at a roundabout. Bicycle lanes may transition to separated bicycle facilities at the roundabout, with marked crossings adjacent to pedestrian crossings.

Source: Kittelson & Associates, Inc.

Various crossing treatments can be integrated into the roundabout intersection to improve safety and comfort for those crossing and navigating through the intersection. Multilane roundabouts in Urban or Urban Core contexts with sidewalk facilities on both sides of the roadway require a pedestrian push-button with RRFB, PHB, or raised crossing to improve user safety.

Figure 4-30 Roundabout PHB in Oakland County, MI (Suburban Context)

Pedestrian hybrid beacons are provided at the multi-lane roundabout entries and exits to provide for pedestrian safety and accessibility. This location in Oakland County, Michigan was the first permanent installation of PHBs at a roundabout.

Source: Lee Rodegerdts

Crosswalk and/or bicycle facilities must be included at roundabouts in locations with existing pedestrian or bicycle infrastructure or that will connect to pedestrian or bicycle networks, either today or in the future. In Rural, Rural Town, Urban, or Urban Core contexts where current pedestrian and bicycle traffic volumes are low or these users may not be present, projects should include measures to accommodate future needs or demands. These may include:

- Rough grading the roundabout perimeter to accommodate future sidewalks, landscaping buffer strip, shared-use paths, etc.
- Installing pedestrian and bicycle curb ramps or lowered curb at logical future locations along perimeter curbing.
- Providing cut-throughs (gaps) at the splitter islands for future crosswalks.
- Obtaining adequate right-of-way to accommodate future measures, including lighting.
- Installing conduit across all legs and splitter islands in the event that roadway lighting or accessible pedestrian beacons or signals are required.

Sidewalk facilities at roundabouts must be designed to meet ADA, PROWAG and should be designed to meet TDOT standards. Additional information on roundabout designs and crossings is provided in NCHRP Research Report 1043: *Guide for Roundabouts*.

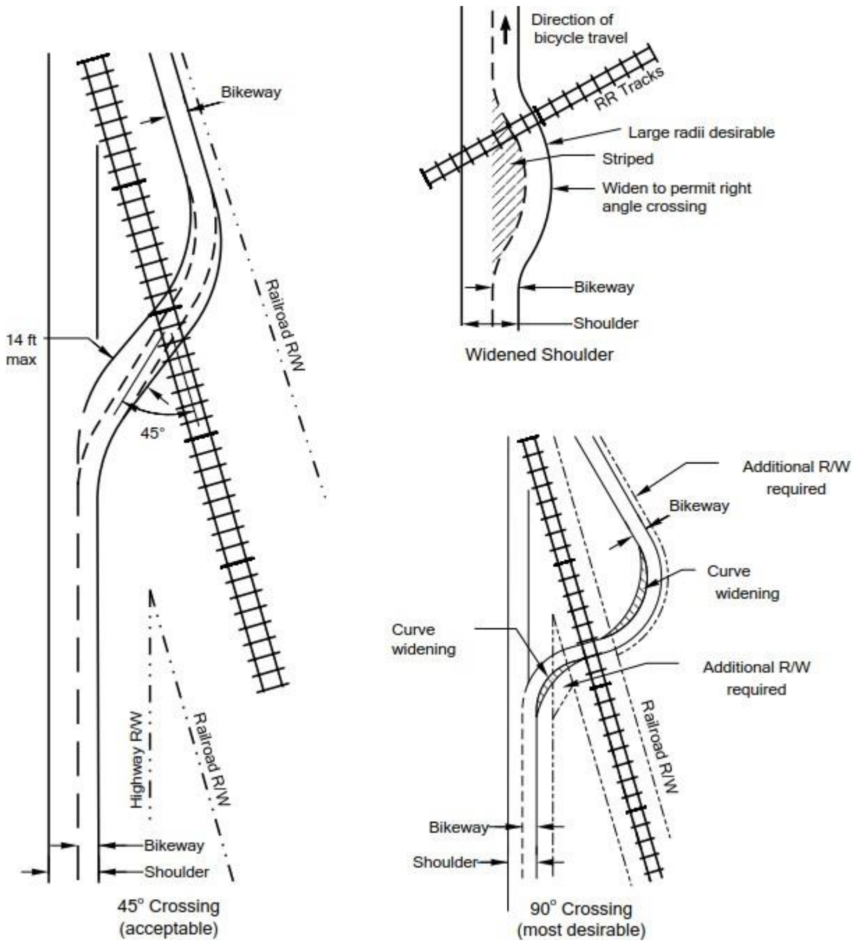
4.6.8 Railroad Crossings

Where railroad or light rail tracks cross a bicycle or pedestrian facility, special consideration is needed to provide a comfortable, easily navigable path for bicyclists and pedestrians across the tracks. TDOT Standard Drawings (MM-PM-1) provides additional details.

Key design elements at railroad crossings include:

- **Crossing Angle**: It is most desirable for bicyclists to cross railroad tracks perpendicularly to reduce the risk of bicyclists losing their balance or catching their wheels on the track, as shown in Figure 4-31. Where a skew is unavoidable, widen the shoulder or bicycle lane to permit bicyclists to cross at right angles. Similarly, pedestrian crossings should be perpendicular to the crossing when practical.
- **Crossing Surface**: Crossing surfaces may be constructed of timber, rubberized materials, or concrete. Consider materials that will allow the smoothest ride and not be slippery when wet. Concrete materials generally make the smoothest and most durable crossing surfaces. Minimize the flange opening between the rail and roadway surface to reduce the possibility of a bicycle wheel catching.
- **Width**: Maintain the width of the bicycle and pedestrian facilities through the crossing if possible.
- **Traffic Control:** Part 8 of the *MUTCD* provides information on traffic control for railroad and light rail transit grade crossings, including provisions for pedestrians and bicyclists. *(22)*

Figure 4-31 Bicycle/Railroad Crossings



Source: TDOT

4.6.9 Bridges

Bridge projects should refer to the *IIJA Bridge Requirements—Accommodations for Pedestrians and Bicycles* for direction and requirements on integrating pedestrians and bicycles into the project. This requirement states that safe accommodation of pedestrians and bicyclists shall be provided as part of a new bridge, or a bridge deck replacement and rehabilitation if the project:

- Includes Federal financial participation,
- Is located on a highway on which pedestrians and bicyclist are permitted, and
- Safe accommodation of pedestrians and bicyclists can be provided at reasonable cost. *(28)*

Bridge projects can be used to make critical new connections in pedestrian and bicycle networks. In some locations, a truly cohesive network may only exist with bridge connections for non-motorized users. In others, a new bridge may provide a more direct route than the ones currently available.

For bridges that already exist, improving both the safety and comfort of non-motorized users may require that the bridge be retrofitted with more appropriate, separated facilities. Where a bridge is over a roadway, the bridge should be designed to support pedestrian and bicycle facilities on the roadway below so the bridge does not create a barrier.

4.7 TRANSIT DESIGN

Transit serves a vital transportation function by allowing freedom of movement and access to employment, schools, community and recreational facilities, medical care, and shopping centers for a wider range of people than the private motor vehicle. Transit directly benefits people who choose this form of travel and those who are unable to use other modes. Transit also benefits users of other modes by helping reduce congestion on roadway networks, reducing parking demand, making more efficient use of road space, and being safer than private motor vehicles. People unable to drive a motor vehicle—notably the young, the old, and people with temporary or permanent disabilities—may rely heavily on public transit.

This section provides principles of transit design, focusing on transit needs and design considerations based on design year context. It notes specific design elements that may be affected by transit.

4.7.1 General Principles

Transit design requires consideration of all roadway users given the interaction between transit vehicles, passengers, and other modes. Key considerations include accessibility, transit stops and stations, transit priority measures, and crossings.

ACCESSIBILITY

A vital part of the success of a transit system depends on the availability of convenient and accessible pedestrian facilities. Accordingly, transit user access along and across roadways served by transit (and on roadways that lead to transit corridors) shall provide continuous ADA-accessible pedestrian and bicycle facilities. TDOT is responsible for state routes and local agencies are responsible for other routes. Users also commonly access transit by personal car and taxi, as well as other modes of transit. Accessible transit user facilities are typically provided:

- Within a 0.75-mile pedestrian and bicycle catchment area of an existing fixed-route transit facility (i.e., stop, station, or park-and-ride lot). A catchment area is defined by a radial distance from a transit facility per Federal Transit Administration (FTA) Guidelines, including crossing and intersecting streets. *(29)*
- Between transit stops/stations and local destinations.

In addition, transit stops should be accessible for all users and follow the requirements in PROWAG. Specific considerations include:

- **Boarding Areas:** The boarding areas should provide accessible ingress and egress for passengers at all transit vehicle doors, including an accessible landing pad that accommodates assistive lifts and wheelchairs. The slope and grade should meet TDOT ADA requirements.
- **Route:** A route accessible by people with disabilities must link the boarding and alighting area to the throughway zone of the sidewalk and to transit shelters if present. The presence of a shelter should be accounted for when determining the appropriate width of the furnishing zone, and it should not interfere with the flow of travel within the throughway zone. Refer to Chapter 6 of the *PSG* for additional information on sidewalk design and zones.
- **Clear Space:** Adequate clear space should be provided so that transit stop amenities are navigable and accessible to all passengers.

TRANSIT STOPS AND STATIONS

Transit stops and stations provide a location for passengers to wait and a designated area for transit vehicles to stop to pick up and drop off passengers. The quality and comfort of transit stops depends on the surrounding environment and amenities provided. Wide sidewalks, ample crossing opportunities, and buffers from vehicle traffic can all make a transit stop safer and more comfortable, as shown in Figure 4-32. Bollards, knee walls, and/or fencing may be used to separate the vehicle travel lane from the transit stop and pedestrian walkways. In addition, transit stop amenities should be provided whenever possible, and may be based on the surrounding land uses, design year context, service frequency, service type, transit agency standards, and expected users. Amenities include signs, benches, waste receptacles, shelters, LED lighting, bicycle parking, landscaping, public art, maps and timetables, and real-time arrival information. The *Transit Design Guidelines* for WeGo Public Transit, which serves the Nashville metropolitan area, has detailed guidance on transit stop and station amenities.

It notes that “visibility in and around transit stops improves the customer’s ability to maintain awareness of their surroundings” and supports public safety. Visibility can be improved by using transparent materials for shelters and fencing.

Proper maintenance of transit stops and stations is also important to transit riders’ comfort and sense of security. This may include:

- Removing graffiti, repairing damaged fixtures, keeping amenities clean and in good working order.
- Managing landscape to maintain sight lines, keep access ways clear, and not inhibit lighting or visibility.
- Replacing broken light bulbs or fixtures.

Transit stops and stations should also be coordinated with other facilities that provide first- and last-mile connectivity for users to and from their final destinations. This could include connectivity to sidewalks, crosswalks, adjacent land uses, bicycle facilities, parking areas, or bike share areas.

Figure 4-32 Bus Stop in Knoxville, TN (Suburban Context)

Setting transit stops farther back from the roadway provides a more comfortable waiting area for transit riders. A transit shelter provides a place to sit, shade, and protection from the rain.

Source: TDOT

Transit agencies typically identify and maintain transit stops. Transit agencies should ensure the stops provide clear sight lines between users and do not block sight distance for pedestrians crossing the roadway or motorists entering the roadway from nearby driveways. LED lighting and raised crossings can improve the visibility of pedestrians, as well as carefully considering the placement of landscaping and signage. The bus boarding and alighting pad, the walkway to the shelter, and the area within the shelter must meet the requirements for ADA and TDOT Standards. TDOT project teams should coordinate with transit agencies to identify new or updated stop locations, especially if passenger amenities and shelters are to be constructed within state right-of-way. Coordination can be supported by the TDOT ADA Office, the TDOT Office of Community Transportation (OCT), and TDOT Office of Multimodal Planning. The goal of this coordination and collaboration is to improve the transit system and meet the needs of transit users and motorists while also improving pedestrian safety and connectivity. This collaborative development and planning of transit facilities is important for TDOT and public transit agencies to meet their requirements to encourage multimodal transport and provide ADA-accessible transit stops and stations.

CROSSINGS

Safe, comfortable, and convenient crossings should be provided for transit passengers. If a transit stop is more than 250 feet from a marked crossing, provision of a crosswalk immediately adjacent to the transit stop should be considered. In some environments, such as Urban and Urban Core contexts with dense land uses and high transit ridership, 250 feet may be too far of a distance for a marked crossing and a shorter distance considered. Enhancements may be appropriate at the crosswalk, such as:

- Raised crossings to allow pedestrians to cross at grade with the sidewalk and to provide a speed table to slow vehicle traffic.
- Stamped patterns to add aesthetic value.
- Pedestrian refuges and/or curb extensions to shorten the crossing distance and provide greater pedestrian visibility.
- Traffic control, such as an RRFB, PHB, or signal.

Section 4.6 has additional guidance on crossing enhancements. Traffic calming measures may also be used in advance of crossings to reduce vehicle travel speeds and alert drivers to the crossing. Project teams should coordinate with the local transit agency in Stage 0 of the project to verify transit stops and plans based on other projects.

4.7.2 Elements of Design

A variety of design elements should be considered in the design of a roadway that serves transit vehicles and passengers. Basic design elements are described below, and additional information is provided in the TDOT *Roadway Design Guidelines* and in Chapter 6 of the *PSG*.

- **Buffer Zone Width:** Where transit stops are provided, additional width may be needed in the buffer zone to provide for transit shelters, signage, benches, waste receptacles, or other amenities. In addition, a wider pedestrian facility may be desirable to accommodate higher volumes of pedestrians and waiting passengers.
- **Travel Lane Width:** A wider travel lane may be needed where transit vehicles are anticipated, given the typical width of buses. Chapter 6 of the *PSG* provides additional guidance on lane widths for various contexts and facility types.
- **Shoulder Width:** On roadways without curbs and sidewalks, the potential use of the shoulder by transit vehicles and/or users should be considered.
- **Separation/Buffer:** Additional separation between the pedestrian facility and vehicles may be desirable on routes used by transit vehicles to improve the comfort of waiting passengers.
- **Bicycle Facility:** Potential interactions between transit vehicles, passengers, and bicyclists may influence the preferred bicycle facility type, as well as design of the bicycle facility at transit stops. Section 4.7.3 provides additional guidance on transit stop placement and bicyclists.

- **Curb Extensions/Bus Bulbs:** Bus bulbs are curb extensions that primarily serve as a bus stop. They are used primarily on roadways with on-street parking or shoulders. Besides reducing pedestrian crossing distances, curb extensions can reduce the impact on parking compared to typical bus zones, mitigate traffic conflicts with autos for buses merging back into the traffic stream, make crossing pedestrians more visible to drivers, and create additional space for passenger queuing and amenities on the sidewalk, such as a shelter and/or a bench.
- **Intersections:** The design of intersections can enhance transit operations through signal timing strategies like queue jumps, transit signal progression, transit signal priority, and shorter cycle lengths. Intersections may include dedicated transit lanes. Turning radii should consider the needs of transit vehicles.

4.7.3 Transit Stop Placement

The placement of transit stops considers the safety, needs and convenience of transit providers, passengers, bicyclists, and motor vehicles. The preferred location is often context sensitive, and must account for a variety of site conditions, including intersection control, block length, destinations, on-street parking, pedestrian and bicycle activity and facilities, and accessibility.

Transit stops can be located on the far or near side of intersections or midblock. Transit stops can also occur in the travel lane or via pull-outs. Key considerations for each type of transit stop location are described further in the sections below.

Figure 4-33 Near-Side and Far-Side In-Lane Bus Stops in Nashville, TN (Suburban Context)

Bus stops may be provided near side or far side at traffic signals, with the preferred location based on site-specific variables and user needs. In some cases, bus stops may be across the street from each other, and therefore on the near side in one direction and far side in the other direction.

Source: WeGo Transit

FAR-SIDE, NEAR-SIDE, OR MIDBLOCK TRANSIT STOPS

Generally, the preferred location for transit stops is at intersections to provide convenient crossing opportunities for passengers and connectivity to intersecting routes. Guidance from the Institute of Transportation Engineers' (ITE) *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* concerning preferred stop location based on various roadway characteristics includes:

- "Consider a near-side stop on two-lane streets where vehicles cannot pass a stopped bus.
- Consider a far-side stop on streets with multiple lanes where vehicular traffic may pass uncontrolled around the bus.
- On streets where vehicular traffic is controlled by a signal, the bus stop may be located either on the near side or on the far side, but the far side is preferable.
- Where it is not desirable to stop the bus in a lane and a bus turnout is needed, a far side or midblock stop is generally preferred.
- When locating a bus stop in the vicinity of a driveway, consider issues related to sight distance, blocking access to development, and potential conflicts between automobiles and buses." *(30)*

Additional considerations are noted in Table 4-5.

Table 4-5: Advantages and Disadvantages of Far-side, Near-Side, and Mid-block Bus Stops

	Advantages	Disadvantages
Far-Side Stops	• Right turns can be accommodated with less conflict. • Stopped transit vehicles do not obstruct sight distance for vehicles entering or crossing from a side street. • Supports the use of a variety of active transit signal priority treatments. • Encourages passengers to cross behind the transit vehicle. • Minimum interference at locations where traffic is heavier on the approach side of the intersection. • If a turnout is used just past a signalized intersection, transit vehicles may be able to more easily reenter the traffic stream. • Transit vehicles at the stop do not obscure traffic control devices or pedestrian movements at the intersection. • Transit drivers have finished obeying the traffic control devices before focusing on the transit stop and boarding passengers.	• If signal priority is not used, the transit vehicle may stop at the red light and again at the far-side stop, interfering with traffic and efficient transit operations. • Could result in traffic queued into the intersection when a transit vehicle is at the stop and blocking the receiving travel lane. • May increase rear-end crashes if drivers do not anticipate the transit vehicle stopping after the intersection.

	Advantages	Disadvantages
Near-Side Stops	• Minimizes interference with vehicular traffic when traffic is heavy on the far side of the intersection. • Less interference is caused where the cross street is one way from right to left. • Passengers generally exit the transit vehicle close to the crosswalk. • Allows passengers to board and exit the transit vehicle when it is stopped for a red light. • There is less interference with traffic turning onto the transit route street from a side street.	• Can cause conflicts with right-turning traffic. • Transit vehicles may obscure sight distance to stop signs, traffic signals, or other control devices, as well as to pedestrians crossing in front of the transit vehicle. • May encourage pedestrians to cross in front of the transit vehicle at the intersection. • Where the transit stop is too short to accommodate transit vehicles arriving at the same time, the overflow may obstruct the travel lane. • If a queue bypass or transit lane is not used at a signalized intersection, then vehicles waiting at a red signal may block transit vehicles from accessing the transit stop, which will require the transit vehicle to wait through multiple signal cycles to enter and then depart the transit stop. • Transit drivers may have to concentrate on the traffic control devices at the same time as focusing on the transit stop and boarding passengers.
Midblock Stops	• Minimizes sight distance interference for vehicles and pedestrians. • May result in passenger waiting areas experiencing less pedestrian congestion. • Stops can be located adjacent to major passenger generators and attractors. • May enable more flexibility for transit stop and crosswalk locations to be immediately adjacent if there are space constraints at the nearby intersection.	• Increases walking distance for passengers crossing at intersections and may result in passengers crossing mid-block. • Transit vehicles may have difficulty reentering the flow of traffic. • May interrupt traffic flow.

Note: Content largely drawn from ITE Designing Walkable Urban Thoroughfares: A Context Sensitive Approach (31), NACTO Transit Street Design Guide (32), and WeGo Public Transit Design Guidelines (30).

IN-LANE OR PULL-OUT STOPS

Transit vehicles can stop in the lane or turnouts can be provided to enable the transit vehicle to pull out of the vehicle lane. A turnout is a recessed curb area located adjacent to the traffic lane. Turnouts are not preferred due to the delay created when the transit vehicles must reenter traffic. They should typically not be located on the near side of signalized intersections because that makes it difficult for transit vehicles to reenter the traffic stream (queued vehicles may block the turnout on the red cycle and moving traffic may prevent the transit vehicle from reentering the travel lane during the green cycle). Turnouts may be appropriate where vehicle speeds and volumes are higher, there is a high frequency of transit vehicles and high volume of passenger boardings, and/or transit vehicles need an area for dwelling time.

Advantages and disadvantages of in-lane versus pull-out stops are noted in Table 4-6. Standard Drawing MM-BS-1 provides design details for transit vehicle pull-outs.

Table 4-6: Advantages and Disadvantages of In-Lane and Pull-Out Stops

	Advantages	Disadvantages
In-Lane Stops	• Allows transit vehicle to stop without having to exit or reenter the travel lane, reducing delay. • Provides more reliable service times, especially on roadways with high vehicle volumes and/or long cycle lengths. • Reduces wear on transit vehicles by avoiding the need to change lanes while braking. • Transit stop length can be shorter as there is no need for entry and exit tapers. • May increase transit vehicle's ability to pull up close to curb if the vehicle does not have to deviate laterally to call at the stop.	• Requires traffic to stop behind the transit vehicle or change lanes (if available), increasing delay.
Pull-Out Stops	• Allows traffic, including bicycles, to proceed around the bus, reducing delay for other traffic. • Maximizes vehicular capacity of high-volume vehicle mobility priority streets. • Clearly defines the bus stop. • Passenger loading and unloading can be conducted in a more relaxed manner. • Reduces potential for rear-end crashes.	• Makes it more difficult for buses to reenter traffic, increasing bus delay and average travel time for buses. • May reduce accessibility due to difficulty of buses pulling parallel to the curb. • Transit vehicle may need to cross bicycle lane. • Greater crash risk for buses pulling back into traffic than buses stopped in traffic lane. • Uses additional space and might require right-of-way acquisition.

Note: Content largely drawn from NACTO Transit Street Design Guide (32) and WeGo Public Transit Design Guidelines. (30)

INTERACTION WITH BICYCLE FACILITIES

Where roadways include transit and bicycle facilities, the interaction between transit stops and bicyclists requires careful consideration. There are several possible configurations for these interactions, shown in Table 4-7.

Table 4-7: Transit Vehicles and Bicycle Facilities

	Advantages	Disadvantages
Pull-Out Transit Stop: Transit vehicle pulls across bicycle facility to access stop	• Reduces delay to bicyclists compared to curbside transit stops	• Disturbance to transit operations • Potential conflicts between transit vehicle and bicyclist, as well as transit vehicle and motor vehicle traffic
Curbside Transit Stop with Bicycle Lane: Transit vehicle pulls into bicycle facility to access stop or stops in travel lane adjacent to stop	• Minimal disturbance to transit operations	• Requires bicyclists to stop behind the transit vehicle and wait, or pass the transit vehicle using the vehicle travel lane • Potential conflicts between transit vehicle and bicyclist • If transit vehicle does not fully pull up to the curb, requires passengers to step off curb and cross bicycle lane to board the transit vehicle
Curbside Transit Stop with Raised or Shared Bicycle Lane: Bicycle lane is raised to the height of the sidewalk and either delineated from the sidewalk or marked as shared space.	• Minimal disturbance to transit operations • Removes conflict between transit vehicle and bicyclist	• Requires bicyclists to yield to pedestrians boarding or alighting the transit vehicle • Potential conflicts between pedestrians and bicyclists • Potential impacts to drainage
Transit Boarding Island: Bicycle lane is routed behind the transit stop, creating a boarding island.	• Minimal disturbance to transit operations • Removes conflict between transit vehicle and bicyclist • Clearly delineates modal zones • Improves pedestrian visibility	• Requires more right-of-way • Requires bicyclists to yield to pedestrians crossing the bicycle lane to access the boarding island • Potential impacts to drainage • Diverts bike lane laterally

Source: Based on content provided in the WeGo Public Transit Design Guidelines (30)

These options are illustrated in TDOT's Standard Drawing MM-BS-1.

4.7.4 Bus Rapid Transit

Bus rapid transit (BRT) is "a high-quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms and enhanced stations… Because BRT contains features similar to a light rail or subway system, it is often considered more reliable, convenient and faster than regular bus services," according to the Federal Transit Administration" *(33)*. BRT often runs in a dedicated lane or space from vehicle traffic and is designed to have priority over some other road users, compared to a typical bus system. To achieve faster travel times and more convenience, a wide range of special design features must be considered. A comprehensive and authoritative example of the wide range of specialist design considerations is contained in The BRT Standard from the Institute for Transportation & Development Policy *(34)*. Features include:

- BRT vehicles should have priority over other vehicles, requiring consideration of left or right turn bans, driveway elimination or consolidation, and enforcement of the BRT lanes both midblock and at intersections.
- BRT vehicles interact with general traffic at intersections, potentially requiring specialized signal timing, queue jump lanes, and/or transit signal priority.
- BRT vehicles may be larger or have specific turning radii, impacting intersection and roadway design.
- Additional pedestrian crossing locations may be needed to facilitate access to BRT stops.
- BRT stops may be located in a median, requiring space for passengers to wait and board.
- BRT stops may require level boarding, ticket vending machines, and high-quality passenger amenities, all of which can affect the length and width of the stops.

Other types of transit lanes, such as shoulder-running lanes or applications on high-occupancy vehicle lanes, may be integrated into projects to provide additional transit connectivity and accessibility in constrained locations.

Figure 4-34 BRT Corridor in Nashville, TN (Suburban Context)

Transit stops along a BRT line may include amenities like real-time arrival information, bike lockers, benches, and shelters. The volume of transit riders may support enhanced pedestrian crossings, such as pedestrian signals.

Source: Google

4.7.5 Light Rail Transit and Streetcars

Many of the design considerations for general transit vehicles or BRT apply to light rail transit (LRT) and streetcars. However, because LRT and streetcars run on fixed rails, they introduce additional design considerations, including:

- LRT vehicles and streetcars require flatter vertical grades than buses and may require cross slope to be at or near zero. This may introduce drainage challenges.
- Vehicles, including bicyclists, may avoid traveling in lanes with tracks.
- LRT vehicles and streetcars may require wider horizontal curves due to their turning radii and side friction on rails.

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Tennessee Department of Transportation

Project Scoping Guide

Chapter 5 – Intersection Planning and Design

September 2024

TN TDOT Department of Transportation

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Chapter 5

Intersection Planning and Design

Intersections allow motorists to access one roadway from another, facilitating mobility throughout the transportation system, but they are inherently prone to conflict. Pedestrians and bicyclists may also need to navigate intersections, adding more conflict points as they travel through the transportation system. The operational efficiency, capacity, safety, and cost of the transportation system depend largely on intersection design, especially in urban areas.

Chapter 5 provides principles and guidance for intersection planning and design as it relates to context. It includes an overview of intersection control types and the TDOT Intersection & Interchange Evaluation (IIE) process outlined in the *Highway System Access Manual (HSAM),* Volume 2. The chapter also includes context considerations related to intersections and an overview of the TDOT *20-Flag Intersection Evaluation Guide* for project teams incorporating this approach to evaluate the safety of roadway users at an intersection.

This guidance supports Stage 0 of the Project Delivery Network (PDN) by providing background on intersection control types and design considerations that can support decisions in Stage 1 and beyond.

5.1 INTERSECTION CONTROL TYPES

As this chapter is reviewed and used, it is important to note that the project team should develop a project scope that includes the whole intersection. When approaching the intersection influence area, the cross section and other features may change, and continuity is important. Because of these changes it is important for the project team to identify these changes in context. The project team should also use design requirements in the *Traffic Design Manual (TDM)* for signing and pavement markings and the *Roadway Design Guidelines (RDG)* for most other considerations.

TDOT uses various intersection control types based on context and projected traffic volumes on intersecting roadways, with examples shown in Table 5-1.

Project teams should consider these in addition to other alternative forms as part of the design process. Section 5.2 provides guidance on analyzing and selecting the appropriate intersection control through TDOT's Intersection and Interchange Evaluation (IIE) process. For all intersection types, appropriate pedestrian and bicycle facilities should be integrated, particularly at intersections in Urban and Urban Core contexts. Chapter 4 of the *PSG* provides additional information on pedestrians and bicyclists.

Table 5-1: Typical Intersection Control Types

Intersection Control Type	Definition
Yield	A yield-controlled intersection requires vehicles to slow down and give way to all other traffic going through the intersection. If no other traffic is present at the intersection, a driver may slow down but not stop before entering the intersection.
Two-Way Stop-Control (TWSC)	At TWSC intersections, the stop-controlled approaches are on the minor street and the free-flowing approaches are on the major street. Drivers must find gaps in the major street traffic to make a turning or through movement.
All-Way Stop-Control (AWSC)	AWSC intersections require every vehicle to stop at the intersection before making a turning or through movement. If other vehicles are present at the intersection, a motorist may proceed only after determining that there are no other vehicles in the intersection and that it is their turn.
Roundabout	A roundabout is a generally circular intersection form that uses yield-controlled approaches on all its legs. Drivers must slow down prior to entering the roundabout and give way to vehicles that are in the roundabout. Additional information on roundabout design is provided in NCHRP Research Report 1043: *Guide for Roundabouts (1)* and the TDOT *Roundabout Design Reference Guide* (*2*).
Traffic signal	Traffic signals are electrically-operated traffic control devices that indicate to roadway users when they may advance through the intersection. Traffic signals allow the shared use of road space by separating conflicting movements.

5.2 INTERSECTION AND INTERCHANGE EVALUATION (IIE)

TDOT's *HSAM,* Volume 2 was developed to help project teams select the most appropriate intersection or interchange designs as part of the TDOT intersection and interchange evaluation (IIE) process. The *HSAM* provides guidance for evaluating intersections and interchanges, including scoping, the Capacity Analysis for Planning of Junctions (CAP-X) workflow, Safety Performance for Intersection Control Evaluation (SPICE), and life cycle cost analysis. *HSAM* also discusses alternative intersections, such as median U-turns and restricted-crossing U-turn intersections. *(3)*

IIE provides the framework, steps, and tools for assessing trade-offs between different intersection forms and control types. It offers project teams decision support as they select the combination of intersection form and control that best meets the intended outcomes and goals of an agency, such as TDOT.

IIE considers a wide range of factors, including safety for all roadway users; pedestrian, bicyclist, and transit operations; vehicle operations; environmental and utility impacts; right-of-way needs; design, construction, operations, and maintenance costs; equity; and community and stakeholder input. By evaluating these factors, IIE helps project teams determine how a specific intersection concept may work in a given location and context. *(2)*

As described in NCHRP Research Report 1087: *Guide for Intersection Control Evaluation*, project teams can use the IIE process for:

- "**Consistency in Approach:** Each intersection is evaluated using a common and reproducible process.
- **Transparency in Decision-Making:** Evaluations are conducted and documented in a way that clearly shows how and why decisions have been reached.
- **Variety of Intersection Control Types and Forms Considered:** Alternative intersection forms are explicitly considered as part of the range of potential options.
- **Inclusion of All Modes and Types of Evaluation Factors:** Assuring that pedestrians, bicyclists, and transit passengers are considered alongside motorized vehicle occupants, as well as considering performance measures that range beyond traffic operations to include safety, cost, equity, and others." *(4)*

Through the IIE process, an initially large pool of intersection options, including alternative intersection types, is systematically filtered to select an alternative that optimizes project-specific, community, and agency objectives. Documenting this process facilitates more transparent and defensible decision-making that encompasses all intersection control types.

APPLICATIONS

IIE is typically applied when modifying or creating a new intersection, which may be triggered by one of the following types of projects:

- Safety-focused project (general or for a specific mode)
- Congestion mitigation project (for one or multiple modes)
- Corridor project
- Access change to an adjacent parcel or land development project
- Community improvement, streetscape, or pedestrian- or bicycle-focused project
- Pavement widening/rehabilitation or bridge project *(4)*

Applying IIE at PDN Stage 0 can reduce the risk that the selected intersection type will be found infeasible or inappropriate at later project stages. While the evaluation may add effort to the early project stages, it can minimize costs and potential delays by establishing an appropriate intersection option to move forward in the design.

IIE can be applied to intersections on the state highway system as well as local agency projects and where signal warrants are met but other alternative intersection forms may also be appropriate. The IIE generally applies to at-grade intersections, including ramp terminals at interchanges. In most cases, IIE does not apply to small-scale improvement projects, such as pavement maintenance projects or signal retiming. In addition, IIE is not needed for corridor studies that include low-volume intersections that are anticipated to be TWSC unless crash patterns exist.

Many projects, including those funded through grant opportunities and being completed through the Congestion Mitigation and Air Quality (CMAQ) Improvement Program, may need additional or modified analyses, as further discussed in the *HSAM*. For further information on how to conduct the evaluation, including specific approaches and tools, project teams should review the *HSAM,* Volume 2.

5.3 INTERSECTION DESIGN PRINCIPLES

The primary design objectives for intersections are to:

- Minimize the potential for and the severity of conflicts among motor vehicles, bicyclists, and pedestrians.
- Provide for the convenience, ease, and comfort of all users.
- Supply adequate capacity.
- Minimize potential systemwide impacts, especially when constructing a new intersection.

This section offers fundamental principles of intersection design. Additional information can be found in the TDOT *Roadway Design Guidelines*, *Standard Drawings* and the *HSAM*. For fundamental principles and design criteria for intersections, consult the American Association of State Highway Transportation Officials' (AASHTO) *A Policy on Geometric Design of Highways and Streets (Green Book)*. *(5)*

5.3.1 Intersection Alignment

Intersection alignment is a key design principle that applies to horizontal curves, intersection angle, and tangent approach.

HORIZONTAL CURVES

An intersection should preferably be located on tangent sections of the intersecting roadways. When a minor road intersects a major road where the major road is on a horizontal curve, the intersection's geometric design becomes more complicated, particularly for sight distance, turning movements, channelization, and cross slopes (or superelevation in a rural context).

INTERSECTION ANGLE

Roadways should intersect at, or as close to, 90 degrees as practical. Skewed intersections are undesirable for several reasons:

- Vehicular turning movements become more restricted for the acute angle and too fast for the wider angle;
- Accommodating turns by large trucks may require additional pavement and channelization;
- The exposure time for vehicles, bicyclists, and pedestrians crossing the main traffic flow is increased; and
- The driver's line of sight for one of the sight triangles becomes restricted.

Intersections with a skew may require geometric improvements, such as realignment, auxiliary lanes, and greater corner sight distance. Setback lines, special corner rounding, or other techniques may also be used to assure desirable results related to traffic movements, visibility, and safety.

TANGENT APPROACH

To improve intersection safety, new intersections should have tangent approaches when possible. This positions a vehicle appropriately for optimum sight distance. Tangent sections also align approaching vehicles with traffic signal heads so motorists can make informed decisions as they navigate signalized intersections. For the requirements of tangent approaches, refer to the *HSAM*.

5.3.2 Lanes at Intersections

Continuous through lanes at intersections allow continuity along a corridor. For example, when a motorist uses a corridor as a through route, the lanes should be consistent, and motorists should not need to change lanes where lanes are added and removed. However, it may not always be possible to provide continuous through lanes due to site constraints. If traffic operational analysis supports dropping a lane at an intersection, signage and/or pavement markings should be included to inform motorists of the change. Design requirements for lane reductions can be found in the *RDG*.

Lane widths should be consistent within a context. Lane width criteria based on facility type and context classification is provided in Chapter 6 of the *PSG*.

TURN LANE GUIDELINES

The need for left- or right-turn lanes should be based on a traffic operational analysis and/or as dictated by other TDOT documentation and guidance. The following general rules apply:

- Queue storage estimates should be based on a traffic operational analysis.
- Left- or right-turn lanes should be designed per TDOT's *HSAM* and *RDG*.
- Adding a separate turn lane may reduce vehicle delay and crash risk but will increase the crossing distance and therefore travel time and exposure for pedestrians and bicyclists. When determining if a turn lane should be added, consideration of pedestrians and bicyclists should be given.

When considering a right-turn lane on a through roadway, give specific attention to visibility on the side street. Decelerating vehicles in the turn lane can create a moving sight obstruction. The stop line for the side street should be placed so motorists on the side street can see the through vehicles on the mainline without the obstruction of the right-turning vehicles along the mainline.

Channelizing islands (painted or raised) can be used to control proper placement of stopped and decelerating turning vehicles. Guidance for right-turn channelization related to pedestrian crossings can be found in NCHRP Report 834: *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities. (6)*

When establishing turn lanes, the project team needs to consider access to and from private properties on the legs of the intersection. Along major roads, accesses should not be located along the length of the turn lanes. Traffic activity at access points along the minor roadway may induce queue spillback onto the major road.

When there is a lane shift, skip-line extensions should be included to guide users into the appropriate lane through the intersection. Refer to the *Traffic Design Manual* for more information on pavement markings.

TURN LANE LENGTHS

The length of a right-turn or left-turn lane at an intersection should allow drivers of turning vehicles to decelerate safely. For facilities in Rural Town, Urban, or Urban Core contexts, a turn lane long enough to completely accommodate the appropriate deceleration may be impractical. In these cases, the turn lane may be designed to provide only sufficient distance for storage. For facilities in Rural and Suburban contexts, the primary consideration is deceleration distance. Project teams should consider the following elements to determine the appropriate turn lane length:

- **Taper.** A straight-line taper is typically used at the entrance of the turn lane. The taper rate is determined by the design speed. Short, straight-line tapers should not be used on curbed streets because the natural vehicle path may result in motorists hitting the leading end of the taper.

- **Deceleration.** The deceleration distance is the distance a vehicle needs to decelerate from the design speed of the traveling roadway to the back of the anticipated queue (e.g., storage) at the intersection.
- **Storage.** The storage length for turn lanes should be sufficient to store the number of vehicles likely to accumulate during the design hour.

For design requirements and criteria for taper, deceleration, and storage lane lengths, refer to the *HSAM*.

5.3.3 Design Vehicles

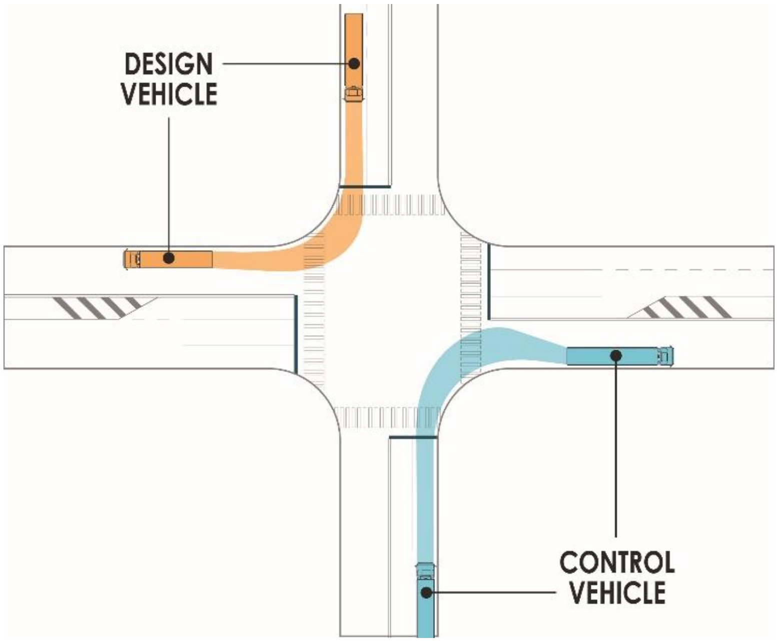
Identifying an appropriate design vehicle and control vehicle for an intersection is key to establishing geometric intersection design elements, such as turning radii. Project teams should identify and evaluate the design vehicle and control vehicle early in the intersection planning and design process. Definitions and information for both vehicles are provided below.

- **Design Vehicle:** Frequently uses a facility and should be designed without encroaching into adjacent and opposing traffic lanes (e.g., turning lane to lane).
- **Control Vehicle:** Infrequently uses a facility, but encroachment into opposing traffic lanes, multiple-point turns, or minor encroachment on the roadside is acceptable (e.g., using available pavement). The control vehicle may include buses, trucks, emergency vehicles, agricultural, and other types of vehicles that will navigate the intersection.

Selection of appropriate design and control vehicles should consider designation of TDOT’s State Industrial Access (SIA) Program and Industrial Highways. Project teams should document the design and control vehicle and demonstrate that the designs can integrate appropriate vehicles. For large vehicles, this could be demonstrated using turning templates.

Functional classification, safety, and roadway users all play a role in determining the acceptability of lane encroachment by control vehicles. For example, on a local road, full lane encroachment by a control vehicle may be acceptable if sight distance is adequate. However, on a major arterial, such encroachment may not be permitted. In Urban and Urban Core contexts, where intersections are likely to be more constrained, additional project team coordination and assessment may be required to verify the control vehicle can be integrated into the design. Figure 5-1 illustrates the paths of design and control vehicles.

Figure 5-1 Design and Control Vehicle Paths



TURNING RADII

At intersections, turning radii are the space a majority of vehicles need to navigate without encroaching on adjacent lanes or objects. Typically, the intersection turning radii are determined by evaluating the design vehicle. The turning radii play a crucial role in intersection design because they affect vehicle maneuverability, pedestrian and bicyclist safety, and intersection capacity. An intersection's turning radii vary based on the design vehicle and its turning speed.

The minimum intersection turning radii for new roads are shown in the *HSAM*. Larger curb radii may be required along designated truck routes based on an assessment of design vehicles. Smaller curb radii may be allowable based on the land use context. Additional requirements for curb radii are described below.

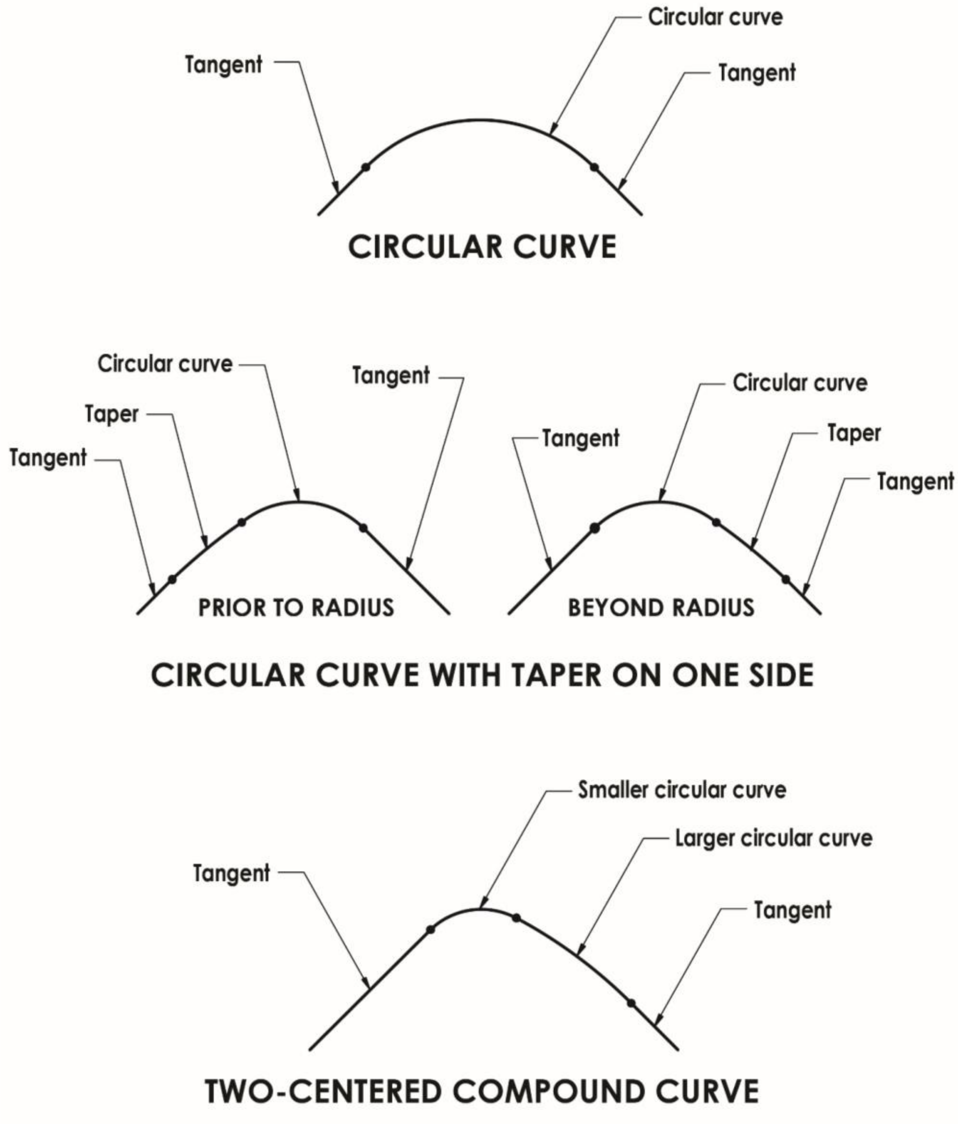
- Verify that corner radii allow emergency response vehicles space to maneuver (refer to local fire codes).
- Curb radii should be based on an assessment of design and control vehicle considerations as well as pedestrian and design speed considerations. They should use the smallest radius based on the design vehicle.

To accommodate right-turning vehicles at an intersection, project teams may select one of the following edge-of-pavement or curb lines, as shown in Figure 5-2:

- Circular radius
- Compound curve (two- or three-centered)
- Circular radius with entering and/or exiting taper(s)

Typically, the turning radii at intersections are circular curve radii. The project team should check the intersection with the design vehicle turning template to ensure the design is adequate and consider crossing distance for pedestrians and bicyclists. While the circular curve is the easiest to design and construct and is therefore the most common, the project team should consider the benefits of the compound radii configuration or a circular radius with tapers.

Figure 5-2 Types of Edge of Pavement or Curb Lines



5.3.4 Intersection Profile

This section outlines design guidance for intersection approach gradient, cross slope transitions, vertical alignment, and intersection sight distance.

To allow for the best overall intersection profile design, the major road horizontal and vertical alignments and cross section control the optimum intersection center point and elevations. The design should aim for this desired control point to develop the intersection design (e.g., flatter approach grades, better sight lines, decreased right-of-way needs, and shorter approach connections).

Context and existing conditions should be considered at the start of a project to verify the design will meet the function of an existing approach without undue adverse effects. Special considerations are needed for all approaches that extend beyond the existing right-of-way to verify that they do not adversely impact land use or encroach on neighboring properties. If design guidelines cannot be met due to physical constraints (e.g., right-of-way limitations, existing structures, or environmental considerations), the project team should document this in the PDN deliverables and potentially as part of a Design Exception/Deviation/Waiver. Additional information on the Design Exception/Deviation/Waiver process is primarily available in the *RDG* and *HSAM*.

GRADE

Roadway grades approaching an intersection should provide the appropriate drainage and align with driver expectancy and comfort depending on whether the roadway is stop-controlled or is free-flowing through the intersection. The grade of a major roadway that flows freely through an intersection may be designed with a straight grade through the intersection. Typically, drainage from a roadway with a lower classification (e.g., collector) should not flow onto a higher-classification roadway (e.g., arterial).

A roadway approach leading into an unsignalized intersection, particularly in a Rural context (e.g., public approaches, private and farm field approaches), is known as a landing area. The landing area is typically created to store stopped vehicles and position the motorist to have appropriate sight distance. The intersection should ideally be slightly higher than the approaching roadway to provide proper drainage and reduce the possibility of a vehicle sliding into the intersection during icy conditions. It is most desirable for the landing area to slope upward toward the intersection. In some cases, this may not be feasible due to topographical constraints and the landing area may slope downward toward the intersection. In these cases and typically in urban-related contexts, minimums identified in the *Public Right of Way Accessibility Guidelines (PROWAG)* should be followed.

If a minor road intersects at a superelevated area of the major road (typically in Rural context), the landing should be designed to avoid a substantial grade break where the landing meets the intersection. This can be accomplished by providing a vertical curve at the end of the intersection approach or by introducing small angle breaks within the landing. For landing areas with a pedestrian crossing, the grade should not exceed maximums identified in the *PROWAG*.

For more design requirements and criteria, refer to the *HSAM*.

CROSS SLOPE TRANSITIONS

One or both of the roadways approaching the intersection may need to be transitioned (or warped) to match or coordinate the cross slope and grade at the intersection. The project team should consider the following:

- **Stop-Controlled and Yield-Controlled Intersections:** When the minor road is stop-controlled or yield-controlled, the profile grade line and cross slope of the major road will normally be maintained through an intersection and the cross slope of the stop-controlled or yield-controlled leg will be transitioned to match the major road profile grade. The project team may need to consider roadway alignments through the intersection if there is potential for a future signal at the intersection.
- **Signalized Intersection:** At signalized intersections or potential future signalized intersections, the cross slope of the minor road will typically be transitioned to meet the longitudinal grade (profile) of the major road. If both intersecting roads have approximately equal importance, the design team may want to consider transitioning both roadways to form a plane section through the intersection. Where compromises are necessary between the two major roadways, smoother riding characteristics should be provided for the roadway with the higher design speeds and/or traffic volumes.
- **Transition Distance:** The transition distance from the normal crown of the minor roadway to match the longitudinal grade of the major roadway should be determined on a site-by-site basis.

5.3.5 Intersection Crossing Elements

Chapter 4 has design guidance for intersection crossing elements. These include:

- Curb ramps
- Crossing island/pedestrian refuge
- Curb extensions/bulb-outs
- Raised crossings

5.4 INTERSECTION CONTEXT CONSIDERATIONS

Intersection designs vary by context. Each intersection design should be customized to the site-specific conditions within its context, including user needs and site conditions. Chapter 4 provides additional guidance for users by context and Table 5-2 and Table 5-3 provide examples of how the context of an intersection influences design elements. The tables are not intended to be exhaustive nor applicable to all project locations. For additional details regarding intersection design and context, see NCHRP Web-Only Document 320: *Aligning Geometric Design with Roadway Contexts. (7)*

Table 5-2: At-Grade Intersection Design Considerations—Design Controls and Geometry

Design Element	Examples of Context Considerations
Design Controls	• Intersections in Rural Town, Urban, and Urban Core contexts (and to some extent in Suburban contexts) should be as tight as possible to minimize the exposure of pedestrians and bicyclists. • In Rural Town, Suburban, Urban, and Urban Core contexts, intersection planning and design should consider the most recent Americans with Disabilities Act (ADA) guidelines and PROWAG (cross slopes at intersection crossings). • Larger design vehicles are expected in Rural and to some extent in Suburban contexts. • In Suburban, Urban and Urban Core contexts, intersections should be designed for smaller vehicles while assessing how to accommodate the anticipated smaller number of larger vehicles. This may include allowing for encroachment into adjacent lanes. • Approaching design speeds will vary based on context. • At intersections, the intent is to minimize the speed differential between various roadway users, especially in turning movements in Rural Town, Suburban, Urban, and Urban Core contexts. • For locations with traffic signals, it is important to locate new poles so that clear sight distances and clear zones are maintained.
Geometry	• In Suburban, Urban, Urban Core, and Rural Town contexts, design should encourage small intersection corner radii to minimize exposure for vulnerable roadway users making crossings. • In urban-related contexts, tapers and radii should encourage slower speeds. • In Urban and Urban Core contexts, design should include curb extensions to shorten crossing distances, especially when on-street parking is provided along the segments. • Higher speeds, typically in Rural and Suburban contexts, will require increased intersection sight distance. • Sight distance dimensions may be shorter in Urban and Urban Core contexts due to lower speeds. • In Urban and Urban Core, minimize turn lanes as feasible to provide shorter crossing widths. • In Rural Town, Suburban, Urban, and Urban Core, consider flush or raised medians as a pedestrian crossing refuge.

Table adapted from NCHRP Web-Only Document 320, Aligning Geometric Design with Roadway Context. (6)

Table 5-3: At-Grade Intersection Design Considerations—Pedestrian and Bicycle Facilities

Design Element	Examples of Context Considerations
Pedestrian Facilities	• In all contexts, make the crossing distance as short as possible along the natural walking path. This may lead to some out-of-direction patterns, especially at alternative intersection forms. Appropriate wayfinding guidance should be provided for pedestrians. • In all contexts, intersections should be accessible to pedestrians of all ages and abilities, and ramps should be provided when pedestrian facilities exist. Designs should not preclude ramp construction later. • Consider including pedestrian-scale lighting in all contexts, when possible. • In Urban and Urban Core, consider wider sidewalks to serve higher pedestrian volumes and activities. In addition, consider pedestrian timing strategies, including leading pedestrian intervals or exclusive pedestrian phasing in these contexts. • Refer to Chapter 4 of the *PSG* for more information on context considerations for pedestrians.
Bicycle Facilities	• Bicyclists should experience the same quality of service at the intersection as they experience along the approaching segments in all contexts. • In all contexts, bicyclists are exposed going through intersections, especially when turning vehicles cross their travel paths. • Bicyclists' movements typically follow the vehicle or the pedestrian patterns in various contexts. • When bicyclists have separated approaching facilities, intersections may include dedicated and protected movements in all contexts. • Consider bicyclist and/or pedestrian leading intervals and other traffic control devices in all contexts, but specifically in Suburban, Urban, and Urban Core contexts. • Refer to Chapter 4 of PSG for more information on context considerations for bicyclists.

Table adapted from NCHRP Web-Only Document 320, Aligning Geometric Design with Roadway Context. (6)

5.5 PEDESTRIAN AND BICYCLE SAFETY EVALUATION – THE *20-FLAG INTERSECTION EVALUATION GUIDE*

NCHRP Research Report 948: *Guide for Pedestrian and Bicyclist Safety at Alternative and other Intersections and Interchanges* includes 20 design flags as a proxy for quantitative performance measures, streamlining pedestrian and bicyclist safety evaluations so they can be scored alongside other criteria during the alternatives assessment stage and throughout the design process (Stage 0 and Stage 1 of the PDN). This methodology is intended to efficiently inform facility selection and design decisions during the project development phases to improve pedestrian and bicyclist safety outcomes.

The TDOT *20-Flag Intersection Evaluation Guide* provides guidance for conducting a pedestrian and bicyclist safety evaluation using the "20 Flags Methodology" outlined in NCHRP 948. The TDOT *20-Flag Intersection Evaluation Guide* provides an overview of each of the 20 design flags and how to evaluate them at intersections. *(8)*

5.5.1 Design Flags

The methodology includes two types of flags, yellow and red, that reflect the level of exposure and risk of injury. Red flags represent a more severe injury risk than yellow flags due to factors such as vehicle speeds and volumes for adjacent or conflicting movements. The flags are prioritized by their degree of impact on pedestrian and bicyclist safety into nine primary flags and 11 secondary flags.

The methodology includes three flags that apply just to pedestrians and seven flags relevant to on-street bicyclists. The remaining 10 apply to both roadway user types, though distinct by travel path and movement through the intersection. Pedestrian design flags are evaluated for each of the four pedestrian crossing movements at an intersection, resulting in a total of 52 pedestrian flags to evaluate at a four-legged intersection. Bicyclist design flags are evaluated for each of the 12 bicyclist turning movements (left, through, and right on each approach), resulting in a total of 204 bicyclist design flags to evaluate at a four-legged intersection.

5.5.2 Beneficial Applications

Project teams can apply the TDOT *20-Flag Intersection Evaluation Guide* to compare design alternatives for pedestrian and bicyclist safety as part of PDN Stage 0 or Stage 1 and the IIE procedure. The early evaluation steps are streamlined, particularly for the first stage of the IIE, when many alternatives are under consideration and designs lack the detail necessary for some of the flags, as documented in the *20-Flag Intersection Evaluation Guide*. Otherwise, the flags are designed to capture the level of detail available and provide actionable findings to influence design decisions and trade-offs at each step of the design process.

5.6 REFERENCES

1. Transportation Research Board (TRB). National Cooperative Highway Research Program (NCHRP) Research Report 1043: *Guide for Roundabouts*. Washington, D.C., 2023.
2. Tennessee Department of Transportation (TDOT). *Roundabout Design Reference Guide*. Nashville, TN, 2024.
3. TDOT. *Highway System Access Manual (HSAM)*. Nashville, TN, 2021.
4. TRB. NCHRP Research Report 1087: *Guide for Intersection Control Evaluation*. Washington, D.C., 2023.
5. American Association of State Highway and Transportation Officials (AASHTO). *A Policy on Geometric Design of Highways and Streets* (*Green Book)*, Seventh Edition. Washington D.C., 2018.
6. TRB. NCHRP Report 834: *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities*. Washington D.C., 2017.
7. TRB. NCHRP Web-Only Document 320: *Aligning Geometric Design with Roadway Context*. Washington, D.C., 2022.
8. TRB. NCHRP Research Report 948: *Guide for Pedestrian and Bicyclists Safety at Alternative and other Intersections and Interchanges*. Washington, D.C., 2022.

Tennessee Department of Transportation

Project Scoping Guide

Chapter 6 – Context Design Guidance and Criteria

September 2024

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Chapter 6

Context Design Guidance and Criteria

The TDOT *Project Scoping Guide (PSG)* creates a framework for TDOT to implement context-based design. The design values in Chapter 6 help TDOT project teams create designs that support the surrounding land use context and serve the needs of the expected and desired roadway users.

This chapter starts by providing an overview of target speed and how it influences design and posted speeds. Target speed ranges are given for each context along with speed management treatments to achieve the target speed. Once the target speed is selected, this chapter provides design values needed to determine the cross section for the roadway project.

The criteria selection process described in this chapter builds on the performance-based design approach in Chapter 2. Criteria selection is often an iterative process as new goals and challenges arise throughout a project. This chapter provides guidance on how to initially select design values based on a project's goals and intended outcomes and how to evaluate trade-offs. Project teams document their design decisions, especially if they change from the initial Project-Specific Design Criteria Document, at each stage of the project within the specific PDN deliverables.

This chapter primarily supports Stage 1 of the PDN. Using the context recommended in Stage 0, the guidance in this chapter informs the target speed and cross section criteria documented in the Project-Specific Design Criteria Document as part of Stage 1. The outcomes support design in Stages 2 and 3.

6.1 TARGET SPEED

Instead of designing to accommodate current and sometimes undesirably high operating speeds, the concept of target speed is to identify a desired operating speed and develop design strategies and elements that reinforce the desired operating speed. This section outlines target speed ranges for each context and provides guidance on how to achieve the desired target speed.

6.1.1 Relationship between Design, Posted, Operating, and Target Speed

Vehicle speed concepts can be classified into four types:

- **Design Speed**: The selected speed used to determine design criteria such as horizontal and vertical alignment, lane width, shoulder width, grade, and stopping sight distance.
- **Posted Speed**: The maximum speed at which a vehicle may legally travel on a particular stretch of road.
- **Operating Speed**: The speed at which drivers are observed operating their vehicles during free-flow conditions.
- **Target Speed**: The highest speed at which vehicles should operate on a thoroughfare in a specific context.

The target speed can be achieved by aligning roadway design and speed limit with a roadway's intended purpose while implementing speed management countermeasures to reduce operating speeds as needed. There is no requirement to have a higher design speed than the intended posted speed. When the target speed, design speed, and posted speed are not aligned, driver expectation about the intended operating speed can be inconsistent.

6.1.2 Target Speed by Context

The selected target speed should be consistent with the level of roadway user activity generated by adjacent land uses, to provide both mobility for motor vehicles and a desirable environment for pedestrians, bicyclists, and public transit users. Chapter 3, Section 3.1.3 provides modal integration information for each context that can support target speed decisions.

In 2022, TDOT led a research study, *Addressing Traffic Safety to Reduce Pedestrian Injuries and Fatalities in Tennessee.* From 2009 to 2019, pedestrian fatalities on Tennessee roadways increased by 117 percent—more than doubling. Eighty percent of fatal pedestrian crashes statewide during this period occurred on roadways with posted speeds of 35 mph or greater. *(1)*

A key recommendation from the study was to reduce speed on urban arterials. The study acknowledged that simply changing the posted speed is not enough to change behavior. Project teams need to identify a target speed and reduce the design speed, thus changing the roadway's design to encourage slower speeds.

Table 6-1 provides target speed ranges for each context and facility type. The target speed ranges align with the Safe System Approach to safer speeds. The speed ranges promote safer speeds for all users by aligning context-appropriate speeds with design criteria to enforce the desired operating speeds.

The target speed ranges are a starting point and should be modified based on site-specific considerations. If the target speed is not practical for a specific project, provide justification for using a different speed. When considering objectives that may conflict with a lower target speed (like construction cost or vehicle mobility), consider the context, community values, and safety for vulnerable users to evaluate trade-offs.

Table 6-1: Target and Design Speeds (mph)

Context	Local	Collector	Arterial
Rural	20–45	20–55	≥40
Rural Town	20–25	20–35	25–35
Suburban	20–30	25–35	30–45[1]
Urban	20–30	25–35	25–40
Urban Core	20–25	20–25	25–30

1 In commercial areas where walking, biking, and transit are more common, start at the low end of the target speed range.

6.1.3 Process to Select Target Speed and Design Speed

The project team should identify the target speed early in the project to inform and influence the selection and establishment of the design speed and design criteria. The target speed should be selected with input from the range of project disciplines, including both planning and engineering. Coordinating and collaborating with the wide range of disciplines early in the project can help verify that the established target speed and the elements identified to achieve the target speed carry through scoping, design, and implementation.

Figure 6-1 shows the process to identify target speeds during Stage 0 (Planning), at the same time the design year context is determined. Many characteristics identified in Chapter 3 to define and identify the design year context can also help project teams determine target speed. Each TDOT project team may adapt and adjust the process as needed to meet its unique needs while maintaining the key element of identifying and documenting target speed early in the process, before scope development. The target speed should be finalized by Stage 2.

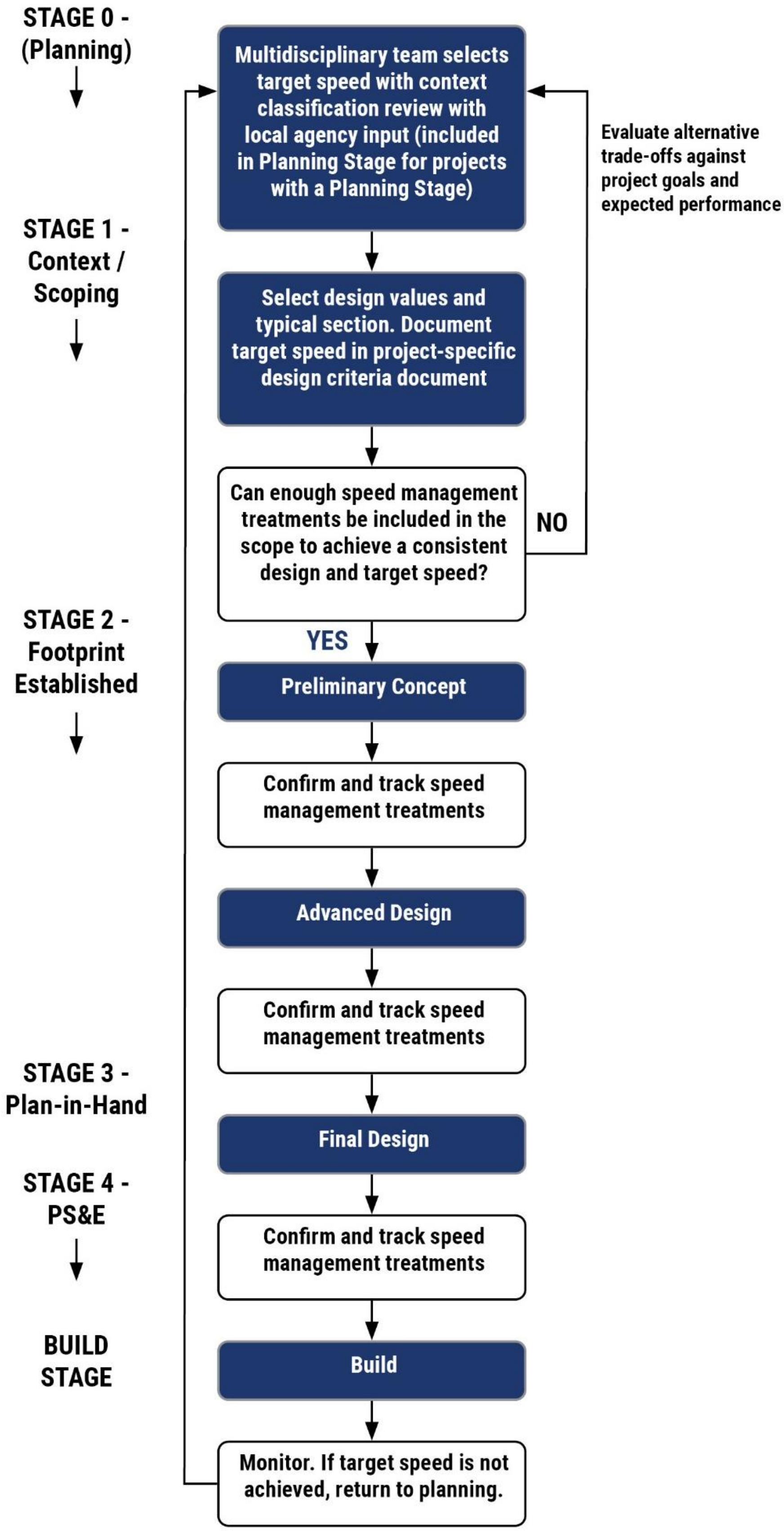
In incorporated areas, local agencies are responsible for determining posted speeds. City engineers should be involved in target speed conversations during Stage 0 to incorporate local input related to desired speeds. Coordination with local agencies early in the process can help align target, design, and posted speed. If a need arises in a later stage of the PDN to update the target speed, local agency staff should be involved in the discussions.

> The design speed should be as close to the target speed as possible based on a project's scope and topography.
>
> Selecting geometric elements that encourage drivers to travel at a speed appropriate for the intended purpose of the roadway helps create a "self-enforcing" roadway. A self-enforcing roadway encourages drivers to select operating speeds consistent with the posted speed limit.

For new alignment and new construction projects in Rural Town, Suburban, Urban, and Urban Core contexts, the target speed should be used as the design speed. If the target speed for these projects is outside the range of the values in Table 6-1, a design deviation is required. For projects on existing roadways, the design speed should be as close to the target speed as possible within the project's scope. In Rural contexts, the target speed and design speed may be different based on the topography—approaching curves, for example.

Revising the design speed and posted speed to better serve the roadway users and align with the context may take time and may require interim stages to evolve over the course of several projects.

Figure 6-1 Target Speed Selection Process



6.1.4 Aligning Posted Speed with Target Speed

On existing roadways, target speed is intended to be used as the posted speed limit; however, according to the *Manual on Uniform Traffic Control Devices (MUTCD)*, posted speeds should be established based on statutory limits unless an engineering study has been performed in accordance with established traffic engineering practices *(2)*. As documented in its *Guidance on Setting Speed Limits*, TDOT currently requires an engineering study to deviate from the statutory speed limit on an existing highway *(3)*. TDOT also allows regulatory speed limits to be set at or above the average speed based on a speed survey.

When target speed is lower than the current operating speed, consider the following options:

- Select a regulatory speed limit as close as possible to the target speed.
- Select design elements to achieve the target speed (see Section 6.1.5).
- Monitor speeds following the implementation of speed management projects and consider stronger speed controls if speeds have not decreased as intended.
- As operating speeds decrease in response to design changes, adjust the posted speed.
- Continue to monitor the national research and evolving guidance on setting speeds.

TDOT Regional Traffic Operations should monitor speeds before and after implementing speed management strategies to confirm that the posted speed is appropriate for the achieved operating speed. This review and monitoring will help TDOT project teams and decision-makers better understand what combinations of treatments are most effective in each context.

6.1.5 Speed Management to Achieve a Desired Target Speed

When the target speed is below the current design or operating speed, speed management treatments should be used to help achieve the selected target speed. Table 6-2 includes a list of treatments appropriate for each context. A single project may not immediately reduce the operating speed to the desired target speed. A series of projects may be needed to achieve the target speed. In addition, a single strategy or treatment may not be sufficient to achieve the desired speed reduction. Often achieving the desired target speed requires combining treatments and strategies.

Table 6-2: Speed Management Treatments by Context

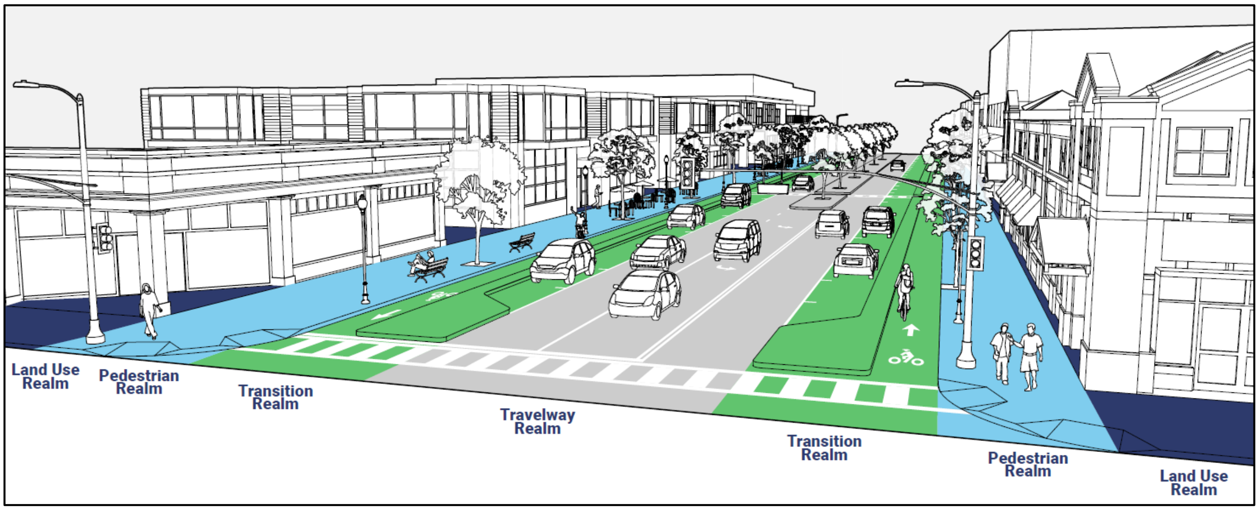
Context	Treatments
Rural	Speed feedback signs, transverse pavement markings, lane narrowing
Rural Town	Roundabouts, lane narrowing, speed feedback signs, on-street parking,[1] street trees,[2] median islands, curb extensions, chicanes, speed tables, road diets
Suburban	Roundabouts, transverse pavement markings, lane narrowing, speed feedback signs, road diets, median islands
Urban	Roundabouts, lane narrowing, speed feedback signs, on-street parking,[1] street trees,[2] median islands, curb extensions, chicanes, textured surface, coordinated signal timing, road diets
Urban Core	Roundabouts, lane narrowing, speed feedback signs, on-street parking,[1] street trees,[2] median islands, curb extensions, chicanes, textured surface, coordinated signal timing, speed tables, road diets

1 If on-street parking is not well utilized, the additional pavement width may increase operating speeds.
2 When used along roadways, street trees may not reduce speeds to a point where it is appropriate to have a vertical element adjacent to the roadway.

6.2 CROSS SECTION REALMS

TDOT roadway cross sections are organized into four realms—land use, pedestrian, transition, and travelway, as shown in Figure 6-2. Table 6-3 introduces the cross-section realms and describes their function and design characteristics. The elements and dimensions of these realms vary depending on context, anticipated users, and desired project outcomes.

Figure 6-2 Cross Section Realms



Note: Some design elements are not absolute to a specific realm. For example, on-street bicycle lanes are part of the transition realm and sidewalk-level bicycle lanes are part of the pedestrian realm.

Table 6-3: Summary of Cross Section Realms

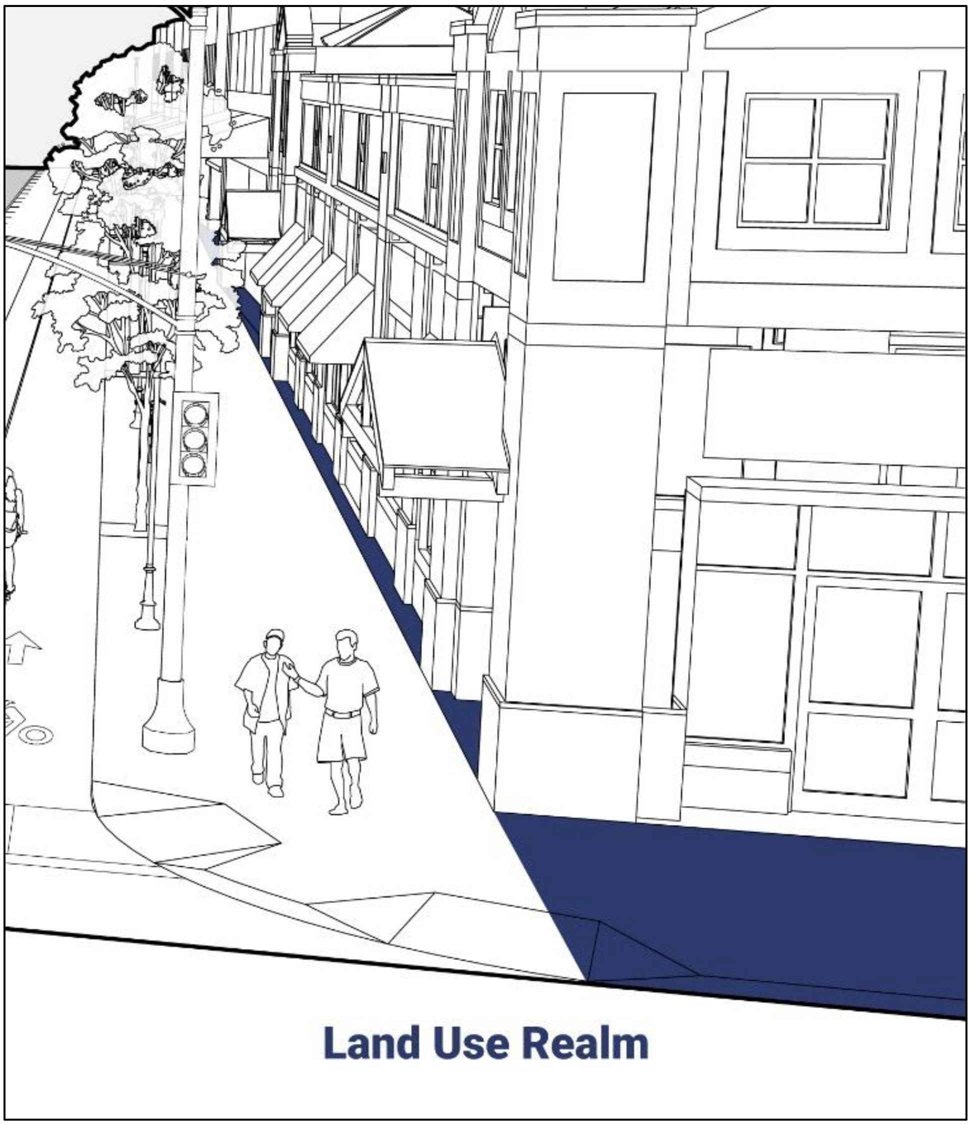
Realm	Location	Function
Land Use Realm	Immediately adjacent to the roadway right-of-way	• Typically privately owned, the land use realm contributes to the context of the place. • This realm may include pedestrian space, amenities such as bicycle parking and café seating, utilities, landscape, on-site parking, and other uses on private property. • Awnings or building appurtenances, signs and other activities that require use of the public right-of-way or overhang into the pedestrian realm must be permitted by TDOT or the local agency (if the sidewalk is locally maintained).
Pedestrian Realm	Between the curb and the edge of right-of-way; includes space for pedestrians and the buffer zone	• Commonly referred to as the sidewalk and divided into three zones: frontage, pedestrian, and buffer. • Serves pedestrian mobility and access to land uses. • In some cases, such as where shared-use paths are present, the pedestrian realm may serve bicycle mobility. • Buffer zones may include landscape material, street furniture, utilities, and road signs.
Transition Realm	Immediately adjacent to the curb or sidewalk edge (e.g., parking, loading, transit stops); may also include non-pedestrian areas behind the curb (e.g., curb-separated bicycle lanes)	• Serves bicycle movement through conventional, buffered, and separated bicycle lanes • Curbside may service multiple functions in the same block or vary by time of day. • Curb extensions and bicycle buffers can provide additional space for landscaping.
Travelway Realm	Center of the right-of-way used for movement, typically including travel lanes, median (including median separated bicycle or bus lanes), and/or turn lanes	• Primarily serves various types of vehicle movement (including motor vehicles, buses, light rail vehicles, streetcars, bicycles, motorcycles, and freight). • Vehicular access can be managed through turn lanes, medians, and other treatments. • Medians can function as a place for landscape or green stormwater treatments, and as a pedestrian refuge.

The following sections give additional detail on each realm, including key considerations for primary design elements typically found within each of the realms. These considerations can guide project team decisions about how to apply, evaluate, and design the cross-sectional elements. Guidance for project-specific design criteria is provided in Section 6.3.

6.2.1 Land Use Realm

The land use realm, shown in Figure 6-3, is a key defining feature of the context. TDOT does not typically own or control the adjacent land use directly. Typically, it is private property regulated by the local agency. TDOT project teams should work in parallel with local agencies to verify that the roadway design supports the desired context and project outcomes. Table 6-4 summarizes the design considerations within the land use realm.

Figure 6-3 Land Use Realm



Note: Presence or absence of design elements within a realm may vary.

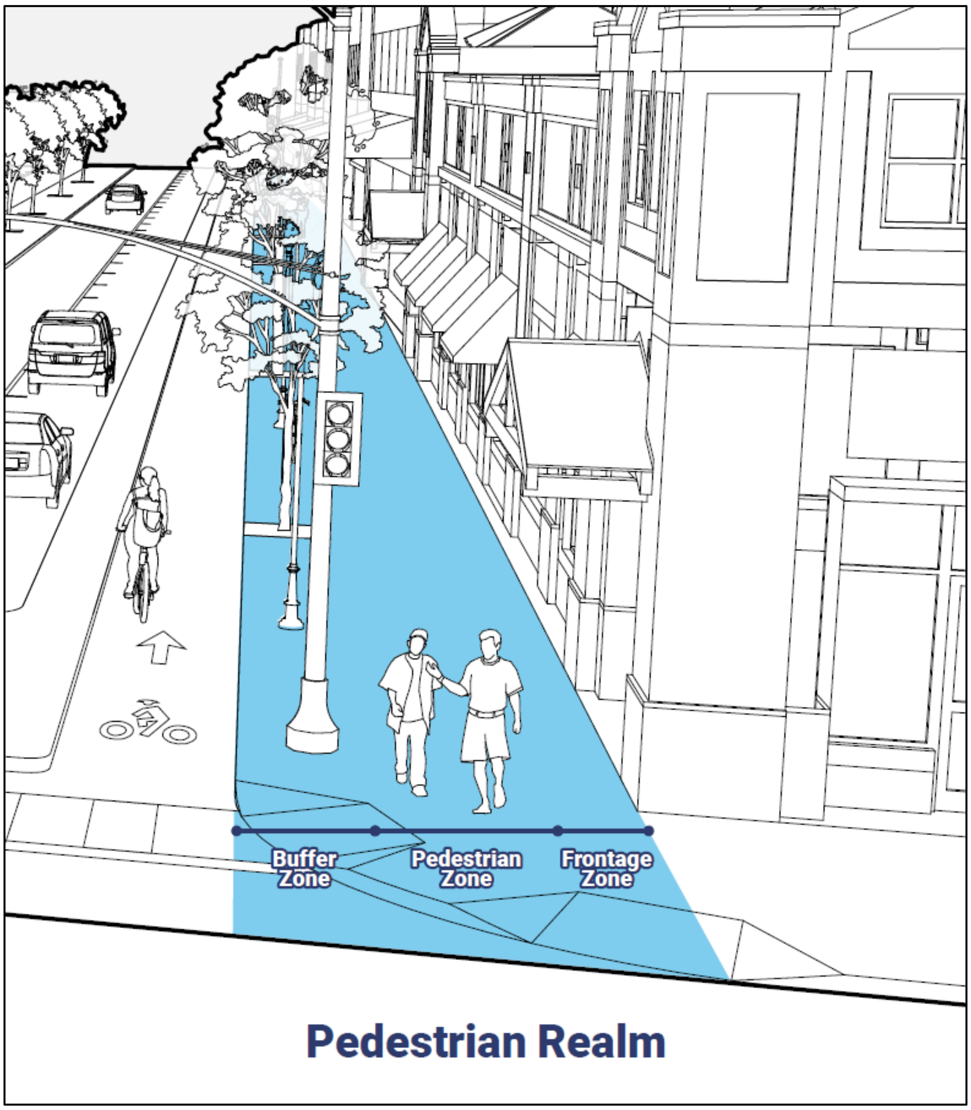
Table 6-4: Design Element Considerations within the Land Use Realm

Design Element	Land Use Realm Considerations
Access to commercial development/storefront	• In Urban Core contexts and some Rural Towns, buildings often have zero setbacks. Business entrances are at the back of the sidewalk, so people walking have direct access to businesses. Parking may be on the street, behind businesses, or in off-site parking garages. The proximity of the buildings to the roadway can support speed management as a form of enclosure. To create adequate space for building frontage in addition to pedestrian movement, wider sidewalks may be necessary. • In other contexts, buildings may have a larger setback. On-site parking may be in front, to the side, or behind property buildings. In these situations, evaluate and consider the likely pedestrian path between land uses and to/from transit stops to determine where there is a demand for roadway crossings.
Elements supportive of the pedestrian realm	• In Rural Town, Urban, and Urban Core contexts, the land use realm can offer space that supports the pedestrian realm, potentially reducing demands on the roadway right-of-way. Consider whether there is potential to work with the local agency and property owners to include any of the following: – Additional sidewalk width – Pedestrian plazas/parks – Landscape adjacent to the sidewalk – Bicycle parking – Pedestrian-scale lighting – Stormwater facilities (green streets) • Awnings or building appurtenances, signs, and other activities that require use of the public right-of-way must be permitted by TDOT or the local agency (if sidewalk is locally maintained).
Elements supportive of other roadway functions	• The land use realm can also provide space to support other functions. – Consider whether it would be appropriate to rely on the adjacent land use for parking. – In some cases, an easement can allow for utilities to be located on adjacent land use.

6.2.2 Pedestrian Realm

The pedestrian realm is typically called the sidewalk. It includes space for pedestrians to travel safely and comfortably, and often a buffer area from the adjacent land use realm and moving traffic. It is broken into three zones shown in Figure 6-4: frontage, pedestrian, and buffer. Table 6-5 summarizes the design considerations within the pedestrian realm. Understanding the different considerations can help prioritize design decisions within the pedestrian realm and help balance trade-offs when the cross section is constrained.

Figure 6-4 Pedestrian Realm



Note: Presence or absence of design elements within a zone may vary.

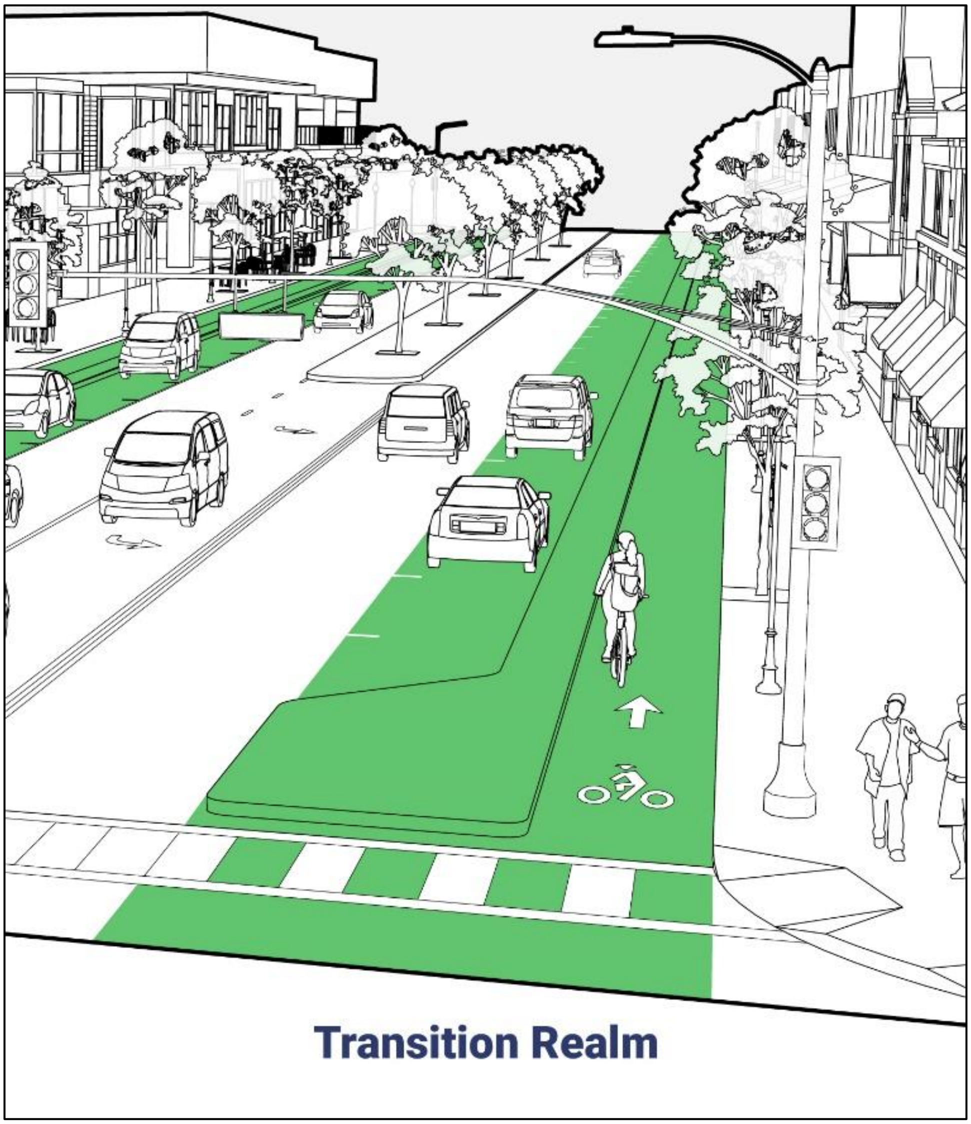
Table 6-5: Design Element Considerations within the Pedestrian Realm

Design Element	Pedestrian Realm Considerations
Frontage Zone	• The frontage zone is located between the pedestrian zone and the right-of-way. • Where buildings are built up to the sidewalk, frontage zones allow space for doors to swing open without impinging on the pedestrian zone. • Depending on the available space, uses in this zone may overlap with the buffer zone, including sandwich boards (if the sidewalk is locally maintained), bicycle racks, and benches.
Pedestrian Zone	• A pedestrian-accessible route is provided in the pedestrian zone. This space should be unobstructed by landscape, street furniture, signs, utilities, and other elements in the pedestrian realm. • The space needed for pedestrian travel varies by context and the amount of pedestrian activity anticipated. In areas with high pedestrian volumes, the pedestrian zone may need to be wider to provide a comfortable walking environment and meet the community's transportation goals. • Designers should consider the social nature of walking and allow space in the pedestrian zone for more than one person to walk side by side. There should also be space for people to pass each other, including people using mobility devices. • Pedestrian scale lighting is encouraged along the pedestrian zone and at intersections with agreements for local agency maintenance.
Buffer Zone	• Sometimes referred to as a furnishing zone. • A buffer should be provided between people walking and motor vehicle movements. A buffer can be part of both the pedestrian realm and the transition realm (e.g., on-street parking, bicycle facilities). • The buffer zone may include: – Utilities – Lighting – Signs – Street trees, planters, and other landscaping – Low-impact design treatments (e.g., rain gardens) – Bicycle parking – Café seating – Art, benches, and street furnishings – Transit stop amenities • If the sidewalk is curb-tight, provide a generous sidewalk width so pedestrian do not need to walk immediately adjacent to traffic.

6.2.3 Transition Realm

The transition realm, shown in Figure 6-5, includes the area between the travel lane and the pedestrian realm (e.g., parking, loading, transit stops). It may also include non-pedestrian areas behind the curb (e.g., separated bicycle lanes). Table 6-6 summarizes the primary design considerations within the transition realm.

Figure 6-5 Transition Realm



Note: Presence or absence of design elements within a realm may vary.

Table 6-6: Design Element Considerations within the Transition Realm

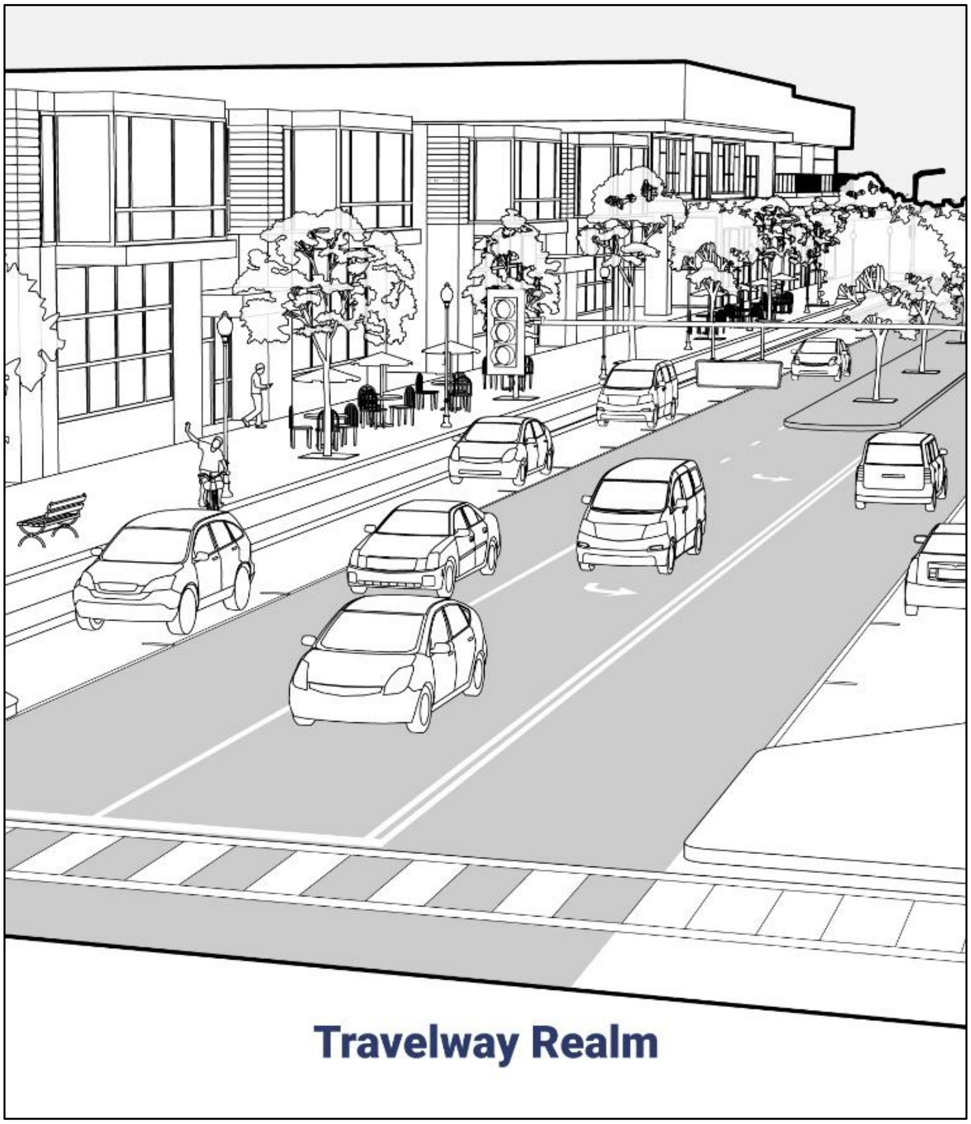
Design Element	Transition Realm Considerations
Edge Zone	• The edge zone is the transition between the pedestrian realm and the roadway. • Curbs are often present in Rural Town, Suburban, Urban, and Urban Core contexts. • Curbside uses may include parking, transit stops, loading/unloading zones, and pickup/drop-off zones. Curb uses may serve multiple functions in the same block or vary by time of day. • At intersections and driveways, the edge zone includes Americans with Disabilities Act (ADA) compliant ramps.
Right Side Shoulder	• There may be a need for roadside recoverable area or shy distance based on the context, target speed, and/or likelihood of run-off-the-road crashes. • Shoulders can limit stormwater encroachment into travel lanes. • In Rural Town, Suburban, Urban, and Urban Core contexts, the right-side shoulder is often eliminated or replaced with a dedicated bicycle facility.
Bicycle Facility Width and Separation	• When speeds and volumes are higher and/or there is a high percentage of trucks, the project team should consider additional separation, such as extra buffer width or physical separation. • Minimum bicycle lane widths should not be used adjacent to minimum travel lane widths. • In constrained areas, buffer widths can be minimized by providing higher vertical barriers. • If on-street parking is present, consider placing the parking between the bicycle facility and travel lanes, with a buffer between the bicycle lane and parking for door swings. • Additional guidance on bicycle facility selection is provided in Chapter 4.
Bicycle Buffer Zone	• Bicycle facility separation can create space for landscape and stormwater treatments. • If the buffer serves as a transit boarding platform, provide an accessible path from the pedestrian realm. In some cases, the bicycle facility can be raised to sidewalk elevation to create a level surface. • If on-street parking is present, the bicycle lane could replace parking approaching the intersection to provide space for curb extensions or a refuge island could be placed in the parking aisle. • Features such as mailboxes that need to be accessible from the travel lane, typically located in the sidewalk buffer, may be located in the bicycle buffer zone.

Design Element	Transition Realm Considerations
On-Street Parking	• Consider the need for on-street parking relative to available off-street or side street parking. • On-street parking is allowed on roadways with posted speeds of 35 mph or less. • Ensure ADA-accessible space is available. • In constrained areas, evaluate the need for on-street parking against the need for bicycle facilities, freight loading, and pickup/drop-off zones.
Maintenance	• When determining appropriate elements for the transition realm, consider maintenance access. • Special equipment may be required to sweep and plow separated bicycle lanes. • Vertical elements such as tubular markers used for delineation require maintenance.
Stormwater	• Stormwater and landscape considerations may be relevant and can impact the overall roadway cross section. • Additional guidance on stormwater treatments and drainage design is provided in the *TDOT Drainage Manual*.

6.2.4 Travelway Realm

The purpose of the travelway realm, shown in Figure 6-6, is the movement of people and goods. For long trips and heavy loads, this is done using motor vehicles. Bicycles are vehicles when in the travelwa,y and pedestrians cross the travelway via crosswalks and bridges. The travelway realm includes travel lanes, medians, and turn lanes. Understanding the user priorities and desired outcomes for a project can help prioritize design element trade-offs within the travelway realm. Table 6-7 summarizes design considerations for the travelway realm.

Figure 6-6 Travelway Realm



Note: Presence or absence of design elements within a realm may vary.

Table 6-7: Design Elements within the Travelway Realm

Design Element	Travelway Realm Considerations
Travel Lanes	• Lane width can influence driver behavior, such as speeding. Outside of the Rural context, select a narrower lane width to encourage slower driver speeds. • Consider narrowing the travel lane width when adjacent to shy distance or a buffered bicycle lane. • Minimum-width travel lanes should not be adjacent to minimum-width bicycle lanes. • On roadways with transit, the outside lane may need to be wider to reduce conflicts with bus mirrors. • The number and width of through lanes impact the amount of available space for other users. In some cases, it is appropriate to accept higher levels of congestion to allow space for other activities.
Turn Lanes	• Evaluate the need for turn lanes relative to trade-offs for bicyclists and pedestrians, such as longer crossing distances. • If turn lanes are present at signalized intersections, consider signal timing strategies such as protected phasing to reduce conflicts with pedestrians and bicyclists. • Consider how bicyclists are addressed at right-turn lanes. If the bicycle facility is separated, consider a protected corner island. If the bicycle facility is not separated, consider transitioning bicyclists onto the sidewalk or to the left of the right-turn lane (this is known as a pocket bicycle lane). • Incorporate pedestrian refuge islands where possible.
Left Side Shy Distance	• Left-side shy distance is common on limited-access highways and other high-speed roadways. • Zero-foot shy may be acceptable when considering trade-offs and design considerations in relation to the context. In contexts with lower speeds, consider minimizing “shy” distance (e.g., median or curb).
Median	• The type of median depends on the roadway’s vehicle speed and volume, adjacent land uses, frequency of access, and desire for pedestrian refuge or landscape. • Consider striped medians in low-speed environments with frequent access points. • Consider raised medians in higher-speed environments or where access to adjacent land uses needs to be managed. • If two-way left-turn lanes are used, incorporate regular median islands to create a refuge for pedestrians and bicyclists and limit motorists’ ability to use the turn lane as a passing lane. • Depressed medians are more common in Rural contexts and should allow a reasonable vehicle recovery area. • Median landscape can help create a “boulevard” effect. • Medians may include space for bicycle or transit lanes.
Transit Lanes	• If the roadway is part of the frequent transit network, consider exclusive transit lanes. This may include dedicated space for bus transit or light rail. • Transit lanes may be located in the center of the roadway or on the outside of the roadway travel lanes.

6.3 CROSS SECTION DESIGN CRITERIA

A facility's context is the starting point for identifying geometric design elements. It guides initial geometric design considerations that support alternatives development and refinement. User type and volume, desired quality of service for expected users, facility type, terrain features, and environmental considerations also influence which criteria are appropriate. Project alternatives can be optimized based on how well they address overall project needs and then compared with each other to inform decision-making, considering the value of the relative investments.

Select criteria and document them in the Project-Specific Design Criteria Document during Stage 1 of the PDN. This will also inform the Project Notebook. Section 6.4 provides guidance on selecting the appropriate design values to meet the goals and desired outcomes of a project when the preferred design elements cannot fit within the existing footprint.

6.3.1 Design Controls

Roadway designs are based on established project design controls that influence various elements such as roadway width, side slopes, horizontal and vertical alignment, drainage considerations, and intersecting roads.

Identifying applicable design controls supports:

- Safety
- Desired quality of service for various users
- Land use integration
- Design consistency

Table 6-8 provides context considerations for different design controls. The information provided is not meant to be comprehensive. Each design element should be evaluated with additional design guidance from TDOT's Roadway Design Guidelines. The considerations are intended to give project teams a starting point as they begin thinking about how to design roadways in various contexts based on the users' anticipated expectations and needs.

Table 6-8: Segment Design Control Considerations

Design Control	Context Considerations
Design Speed	• Design speeds influence dimensional values for various horizontal, vertical, and cross section design features. • Higher speeds are expected in Rural contexts. Lower speeds are expected in Rural Town, Suburban, Urban, and Urban Core contexts. • *"Addressing Traffic Safety to Reduce Pedestrian Injuries and Fatalities in Tennessee"* recommends cities reduce design speeds to 35 mph or lower on roadways that include pedestrian destinations. *(1)* • Ideally, the design speed, target speed, and posted speed are all the same to create a self-enforcing roadway. • For new construction projects, the target speed should be used as the design speed. • For existing roadways, the design speed selection should step toward the target speed. A series of projects may be needed to achieve the desired target speed.
Design/Control Vehicle	• The design vehicle affects horizontal and vertical alignments, lane widths, turning radii, and vehicle storage lengths. • Larger design vehicles (e.g., WB-67 or oversize/overweight) are expected in Rural and Rural Town contexts. • Smaller design vehicles (e.g., WB-40, transit vehicles, or school bus) are expected in Urban and Urban Core contexts. • Suburban contexts may have a mix of design vehicle types. • In Urban Core, Urban, and Suburban contexts, the use of control vehicles can help accommodate larger vehicles through encroachment into opposing lanes or mountable curbs. This helps minimize turning radii, reducing pedestrian crossing distances and encouraging slower turning speeds.
Traffic Volumes	• Traffic volumes influence the number of travel and turn lanes, turn lane storage, and signal timing. Increasing the capacity on a roadway can have an induced demand effect, further increasing traffic volumes. • Higher vehicular volumes are typically present along higher-order facility types, such as freeways, arterials, and some collectors. • More congestion is expected in Urban and Urban Core contexts than Rural and Rural Town contexts.
Non-Motorized User Needs	• Higher pedestrian volumes are anticipated in Rural Town, Urban, and Urban Core contexts, and moderate pedestrian volumes are anticipated in a Suburban context. • Higher bicyclist volumes are expected in Urban and Urban Core contexts, with moderate use in Rural Town and Rural contexts. A Suburban context may have a mix of recreational and utilitarian bicyclist users. • Suburban commercial corridors provide some of the greatest challenges to balancing user needs. *"Addressing Traffic Safety to Reduce Pedestrian Injuries and Fatalities in Tennessee"* found a higher level of pedestrian crashes on commercial and auto-centered suburban arterials than in suburban residential areas.

Design Control	Context Considerations
Vehicle Access Points and Density	• Contexts are defined by the adjacent zoning and associated land use development codes. The need for access is typically driven by the adjacent land uses. This extends beyond fronting uses to developments with direct access to the state roadway from a parking area. • There are usually more frequent and closely spaced accesses in Rural Town, Urban, and Urban Core contexts. • As redevelopment occurs in Rural Town, Urban, and Urban Core contexts, an effort should be made to restore previous roadway connections that may have been broken from past developments. • In a Suburban context, access points are often fewer and more widely spaced. Access management strategies may prohibit some turning movements for safety or operational reasons. Where vehicle access is limited, there may still be a need for a pedestrian crossing. For example, when transit is present, every transit rider accessing a transit stop must cross the roadway for the return trip.
Terrain	• A range of terrains may be found in all contexts. • The maximum grade, design speed and expected design vehicles affect geometric design choices. • Refer to Chapter 5 for guidance when one or both of the roadways approaching an intersection needs to be transitioned to match or coordinate the cross slope and grade at the intersection.

6.3.2 Project-Specific Design Criteria for Each Context

A holistic evaluation of the cross section that considers the individual design elements together, rather than separately, can help verify that the overall roadway cross section aligns with desired project outcomes and balances the needs of each user. Table 6-9 through Table 6-13 include specific criteria for design elements in each realm for each of the five context classifications. This includes design criteria for the range of facility types: local roads, collectors, and arterials. Freeway and interchange design criteria are covered in the TDOT *Roadway Design Guidelines (RDG)*.

The criteria will inform the overall footprint for the roadway design. Where all desired elements cannot fit within the right-of-way, design decisions within the respective context should consider the trade-offs for safety, design, operations, and maintenance using the guidance in Section 6.4. The selected design criteria are documented in the Project-Specific Design Criteria Document in Stage 1 of the PDN.

Avoid Stacking Minimum Criteria

Table 6-9 through Table 6-13 provide a range of dimensions for many design elements. Project teams should avoid stacking elements with minimum dimensions, such as placing a minimum travel lane width adjacent to a minimum median width without shy distance or a 4′ bicycle lane with the narrower 2′ buffer.

RURAL CONTEXT

Table 6-9 shows recommended design criteria for the Rural context. Figure 6-7 illustrates cross section design options using the criteria in the table. These are not inclusive of every combination that may occur within the Rural context but represent a range that project teams can use to visualize how to design a Rural roadway serving a variety of users.

Table 6-9: Design Criteria by Facility Type—Rural Context

Design Element	Local	Collector	Arterial
Travelway Realm[1]			
Number of Lanes	2	Primarily 2	Primarily 2-4
Travel Lane Width[2]	9′–11′	10′–12′	11′–12′
Right-Turn Lane Width	9′–11′	10′–12′	11′–12′
Left-Turn Lane Width	9′–11′	10′–12′	11′–12′
Two-Way Left-Turn Lane Width	10′–14′	10′–14′	11′–14′
Left Side Shoulder on Divided Roadways (paved)	2′–6′	4′–8′	4′–10′
Right Side Shoulder (paved)	2′–6′	4′–8′	4′–10′
Shy Distance	0′–1′	0′–1′	0′–2′
Median[3]	Flush: 0′–2′	Raised: 4′–30′ Flush: 0′–2′ Depressed: 16′-36′	Raised: 4′–42′ Flush: 0′–2′ Depressed: 36′-66′

Design Element	Local	Collector	Arterial
Transition Realm			
Bicycle Facility Type and Width[4,5,6]	Shared-use path • Width: ≥10′ • Buffer: 0′-3′ Shoulder[7] • Width: 5′-6′ • Buffer: N/A Shared lane markings if target speed is 25 mph or less and two-lane roadway	Shared-use path • Width: ≥10′ • Buffer: 0′-5′ Shoulder[7] • Width: 5′-8′ • Buffer: N/A Shared lane markings if target speed is 25 mph or less and two-lane roadway	Shared-use path • Width: ≥10′ • Buffer: 4′-16′ Shoulder[7] • Width: 5′-10′ • Buffer: N/A
Buffer and Separation	Striping: 2′-3′ Vegetation: ≥3′	Striping: 2′-3′ Vegetation: ≥4′	Striping: 2′-3′ Vegetation: ≥5′
On-Street Parking	Limited and typically informal	Not anticipated	Not anticipated
Curb/Gutter	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′
Pedestrian Realm			
Frontage Zone	N/A	N/A	N/A
Pedestrian Facility Type	Sidewalks or shared-use paths	Sidewalks or shared-use paths	Sidewalks or shared-use paths
Pedestrian Zone Width	≥5′, where provided	≥5′, where provided	≥5′, where provided
Buffer Zone	0′-3′	0′-5′	4′-16′
Target Pedestrian Crossing Spacing Range	600′+, varies based on adjacent land uses	600′+, varies based on adjacent land uses	600′+, varies based on adjacent land uses
Shared-Use Path	≥10′ if provided	≥10′ if provided	≥10′ if provided

[1] Striping for the purpose automated vehicles will not add width to the overall cross section but will be part of the lane width shown.

[2] Projects that are part of the State Industrial Access (SIA) Program may use 12′ travel lanes.

[3] Median width is the perpendicular distance measured between the inside edges of the traveled way for traffic lanes flowing in opposite directions. For divided roadways, inside shoulder width is included as part of the overall median width.

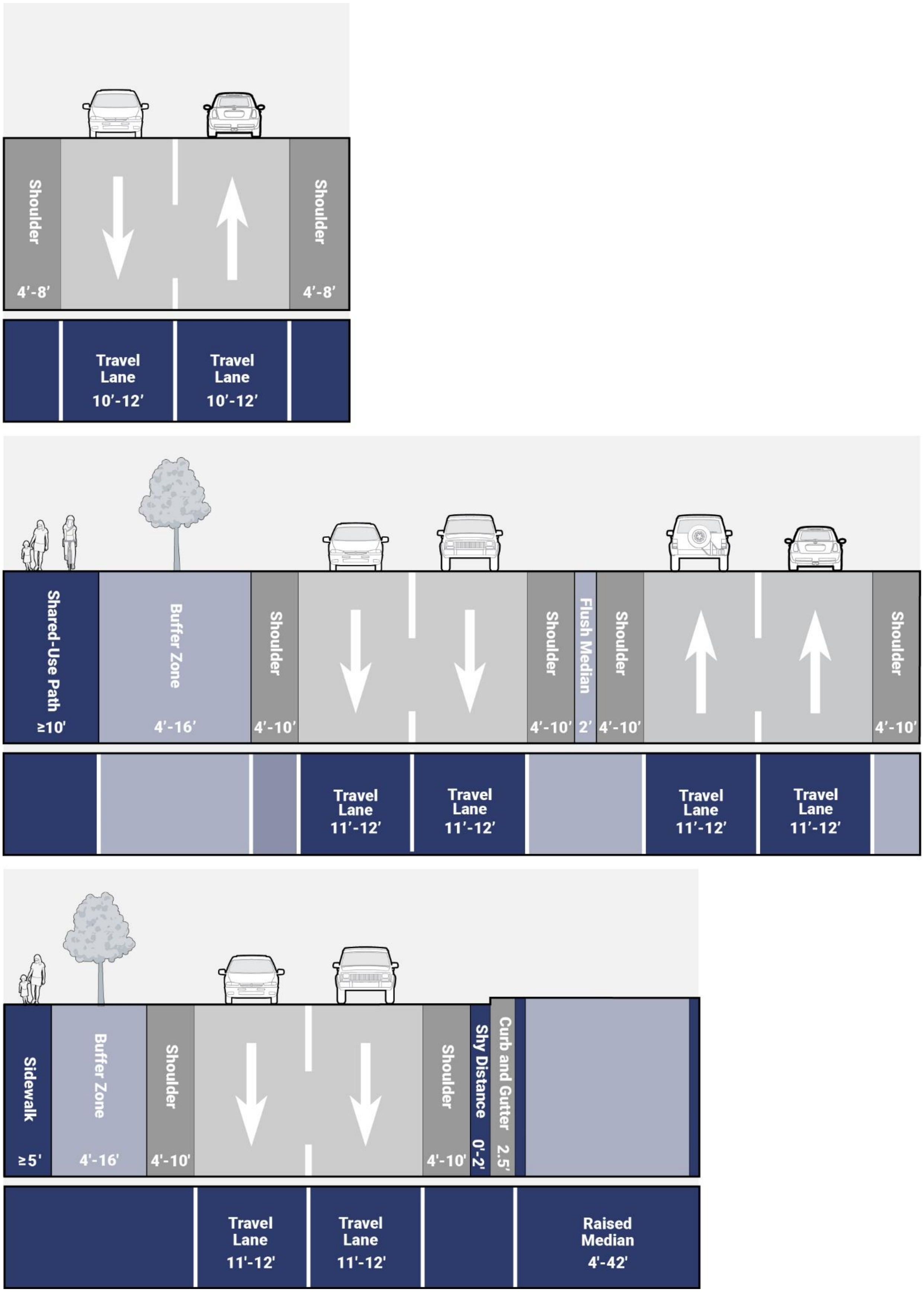
[4] Bicycle facility selection is based on Chapter 4, Section 4.4.4.

[5] Along roadways with curb and gutter, the width of the bicycle facility should not include the gutter. If there are no curb and gutter and there are vertical elements adjacent to the bicycle lane (e.g., signs, landscape) additional shy distance between the bicycle lane and vertical elements may be needed.

[6] Where the total width of an on-street bicycle lane including the striped buffer exceeds 6′, the bicycle lane should be 4′ with the remaining space striped as the buffer to prevent vehicle traffic from using the lane.

[7]A shoulder is not considered a bicycle facility but can help accommodate bicycle travel.

Figure 6-7 Rural Cross Section Examples



RURAL TOWN CONTEXT

Table 6-10 shows recommended design criteria for the Rural Town context. Figure 6-8 illustrates cross section design options, using the criteria in the table. These are not inclusive of every combination that may occur within the Rural Town context but represent a range that project teams can use to visualize how to design a Rural Town roadway serving a variety of users.

Table 6-10: Design Criteria by Facility Type—Rural Town Context

Design Element	Local	Collector	Arterial
Travelway Realm[1]			
Number of Lanes	2	Primarily 2	Primarily 2-4
Travel Lane Width[2]	9′–10′	10′–11′	10′–12′
Right-Turn Lane Width	9′–10′	10′–11′	10′–12′
Left-Turn Lane Width	9′–10′	10′–11′	11′–12′
Two-Way Left-Turn Lane Width	10′–11′	10′–11′	11′–12′
Left Side Shoulder on Divided Roadways (paved)	N/A	N/A	N/A
Right Side Shoulder (paved)	0′-4′	0′–6′	0′–6′
Shy Distance	0′–1′	0′–1′	0′–2′
Median[3]	Flush: 0′–2′	Raised: 6′-16′	Raised: 6′-16′

Design Element	Local	Collector	Arterial
Transition Realm			
Bicycle Facility Type and Width[4,5,6]	Conventional bicycle lane: • Width 4′-5′ • Buffer: N/A Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Shared lane markings if target speed is 25 mph or less and two-lane roadway	Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including parking, raised island, flexible delineator posts, planters, concrete barrier, guardrail, and vegetation Shared lane markings if target speed is 25 mph or less and two-lane roadway	Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including parking, raised island, flexible delineator posts, planters, concrete barrier, guardrail, and vegetation
Parallel On-Street Parking[7]	Limited and typically informal	7′-8′, where provided	7′-8′, where provided
Curb/Gutter	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′
Pedestrian Realm			
Frontage Zone	1′-2′	1′-2′	1′-2′
Pedestrian Facility Type	Shoulder or sidewalk	Sidewalk on both sides	Sidewalks on both sides
Pedestrian Zone Width[8]	≥6′, where provided	≥6′	≥8′
Buffer Zone	0′-6′	2′-6′, where provided	2′-8′
Target Pedestrian Crossing Spacing Range	250-550 (1-2 blocks)	250-550 (1-2 blocks)	250-550 (1-2 blocks)
Shared-Use Path	N/A	N/A	N/A

[1] Striping for the purpose automated vehicles will not add width to the overall cross section but will be part of the lane width shown.

[2] Projects that are part of the State Industrial Access (SIA) Program may use 12′ travel lanes.

[3] Median width is the perpendicular distance measured between the inside edges of the traveled way for traffic lanes flowing in opposite directions. For divided roadways, inside shoulder width is included as part of the overall median width.

[4] Bicycle facility selection is based on Chapter 4, Section 4.4.4.

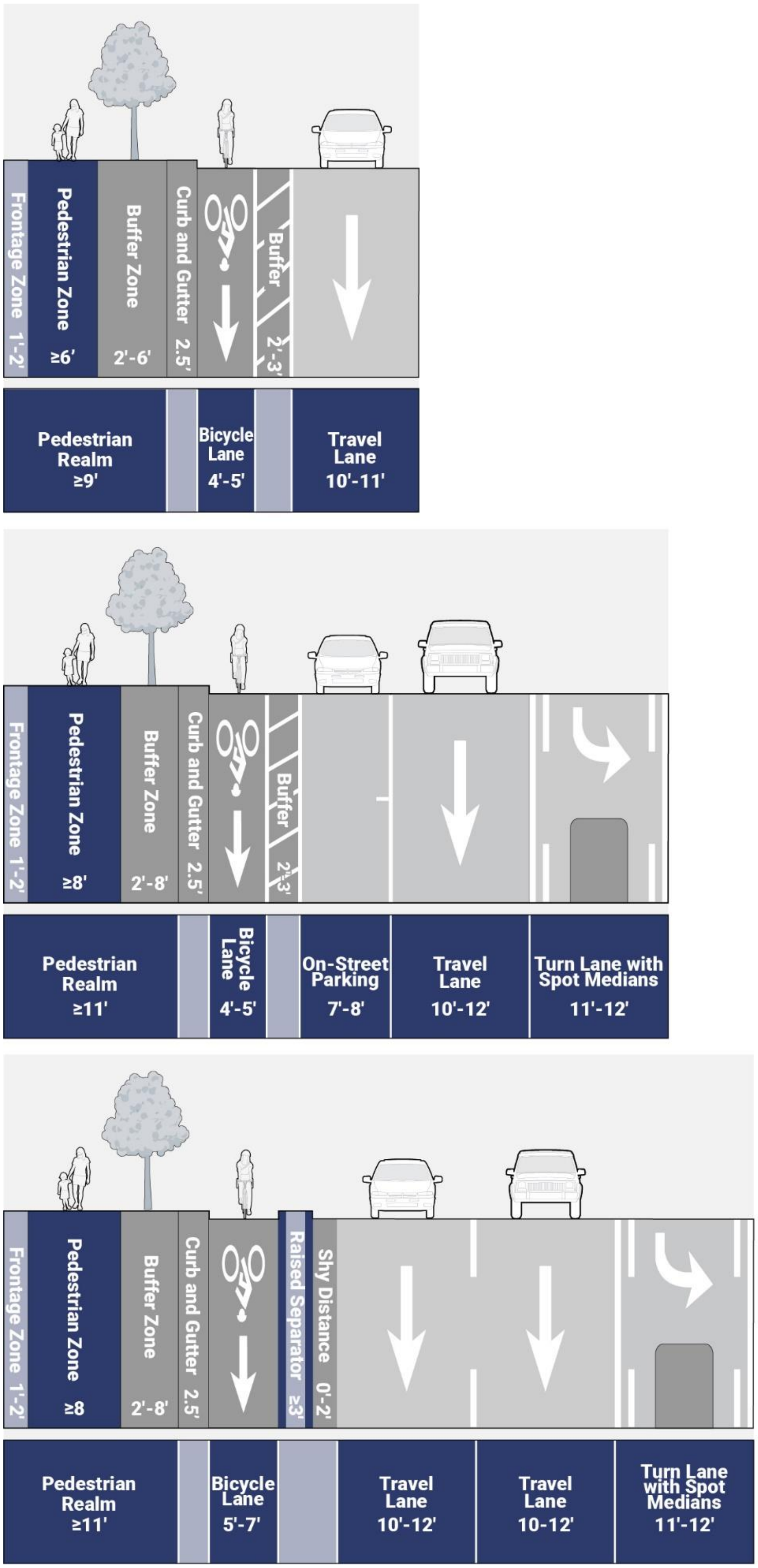
[5] Along roadways with curb and gutter, the width of the bicycle facility should not include the gutter. If there are no curb and gutter and there are vertical elements adjacent to the bicycle lane (e.g., signs, landscape) additional shy distance between the bicycle lane and vertical elements may be needed.

[6] Where the total width of an on-street bicycle lane including the striped buffer exceeds 6′, the bicycle lane should be 4′ with the remaining space striped as the buffer to prevent vehicle traffic from using the lane.

[7] Local agencies may coordinate with TDOT if angle parking is desired.

[8] Pedestrian zone width may be reduced to 5′ in constrained locations.

Figure 6-8 Example Rural Town Typical Sections



SUBURBAN CONTEXT

Table 6-11 provides recommended design criteria for the Suburban context. Figure 6-9 illustrates cross section design options, using the criteria in the table. These are not inclusive of every combination that may occur within the Suburban context but represent a range that project teams can use to visualize how to design a Suburban roadway serving a variety of users.

Table 6-11: Design Criteria by Facility Type— Suburban Context

Design Element	Local	Collector	Arterial
Travelway Realm[1]			
Number of Lanes	2	Primarily 2-4	Primarily 2-4[2]
Travel Lane Width[3]	9′–11′, 11' if transit	10′–12′, 11'-12′ if transit	10′–12′, 11'-12′ if transit
Right-Turn Lane Width	9′–11′	10′–12′	10′–12′
Left-Turn Lane Width	9′–10′	10′–11′	11′–12′
Two-Way Left-Turn Lane Width	10′–11′	10′–12′	11′–14′
Left Side Shoulder on Divided Roadways (paved)	N/A	N/A	0-2′
Right Side Shoulder (paved)	2′-4′	4′–6′	Curbed: 4-6' Flush: 10-12'
Shy Distance	0′–1′	0′–1′	0′–2′
Median[4]	Flush: 0′–2′	Raised: 6′-22′	Raised: 6′-22′

Design Element	Local	Collector	Arterial
Transition Realm			
Bicycle Facility Type and Width[5,6,7]	Conventional bicycle lane: • Width 4′-5′ • Buffer: N/A Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Shared lane markings if target speed is 25 mph or less and two-lane roadway	Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including raised island, flexible delineator posts, concrete barrier, guardrail, and vegetation	Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including raised island, flexible delineator posts, concrete barrier, guardrail, and vegetation Shared-use path • Width: ≥10′ • Buffer: 2′-16′
Parallel On-Street Parking[8]	Limited and typically informal	7'-8', where provided	7'-8', where provided
Curb/Gutter	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′
Pedestrian Realm			
Frontage Zone	0′-2′	0′-2′	0′-2′
Pedestrian Facility Type	Sidewalk	Sidewalk on both sides with option for shared-use path on one side	Sidewalk on both sides with option for shared-use path on one or both sides
Pedestrian Zone Width[9]	≥6′, where provided	≥6′	≥8′
Buffer Zone	0'-6'	2'-8'	2′-16′
Target Pedestrian Crossing Spacing Range	600+/-, Varies based on adjacent land uses	600+/-, Varies based on adjacent land uses	600+/-, Varies based on adjacent land uses
Shared-Use Path	Not anticipated	≥10′ if provided	≥10′ if provided

[1] Striping for the purpose automated vehicles will not add width to the overall cross section but will be part of the lane width shown.

[2] On existing 6-lane arterials, refer to the TDOT Highway System Access Manual for safety treatments including median considerations.

[3] Projects that are part of the State Industrial Access (SIA) Program may use 12′ travel lanes.

[4] Median width is the perpendicular distance measured between the inside edges of traveled way for traffic lanes flowing in opposite directions. For divided roadways, inside shoulder width is included as part of the overall median width.

[5] Bicycle facility selection is based on Chapter 4, Section 4.4.4.

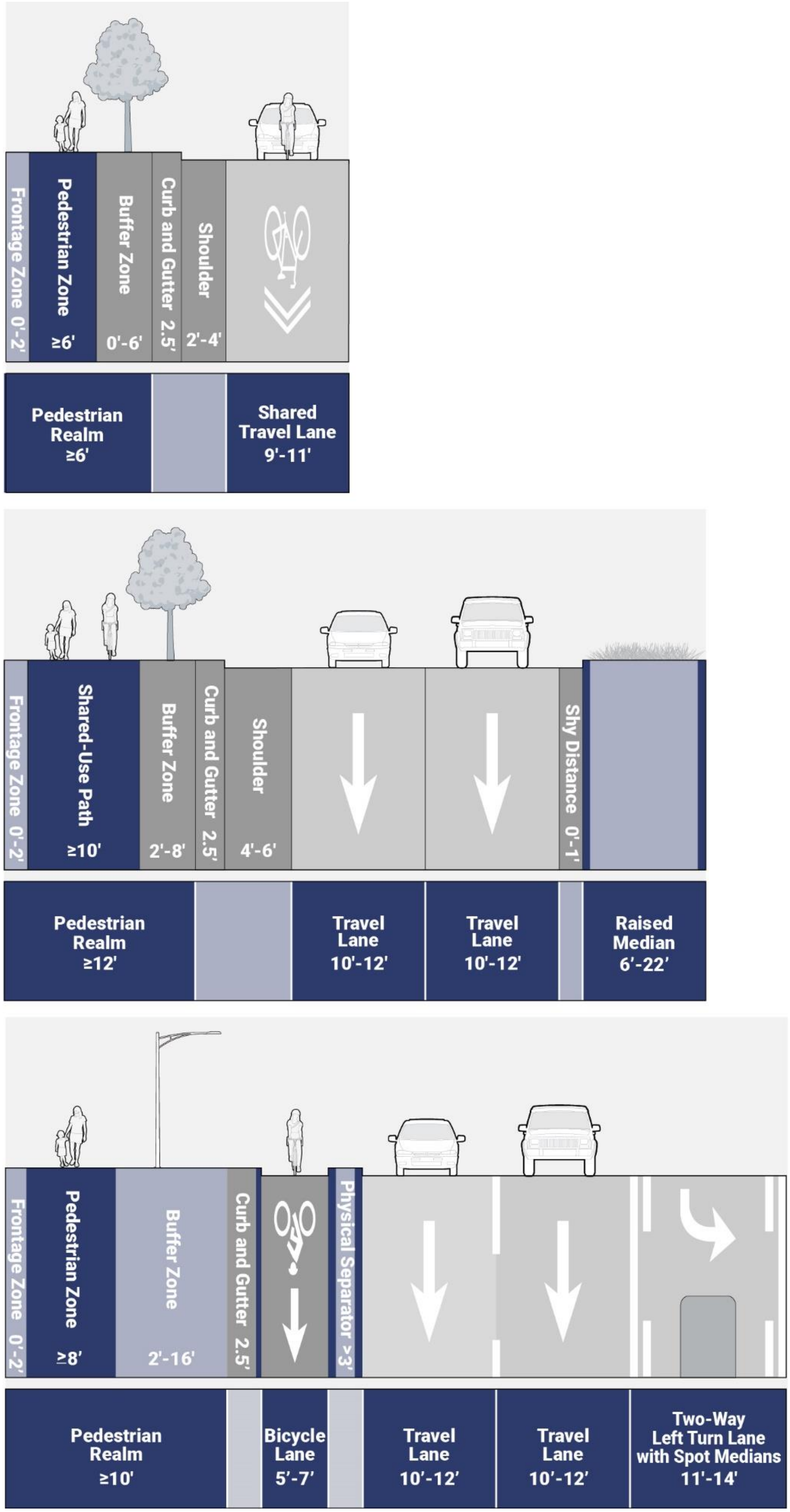
[6] Along roadways with curb and gutter, the width of the bicycle facility should not include the gutter. If there are no curb and gutter and there are vertical elements adjacent to the bicycle lane (e.g., signs, landscape) additional shy distance between the bicycle lane and vertical elements may be needed.

[7] Where the total width of an on-street bicycle lane including the striped buffer exceeds 6′, the bicycle lane should be 4′ with the remaining space striped as the buffer to prevent vehicle traffic from using the lane.

[8] Local agencies may coordinate with TDOT if angle parking is desired.

[9] Pedestrian zone width may be reduced to 5′ in constrained locations.

Figure 6-9 Example Suburban Typical Sections



URBAN CONTEXT

Table 6-12 gives recommended design criteria for the Urban context. Figure 6-10 illustrates cross section design options using the criteria in the table. These are not inclusive of every combination that may occur within the Urban context but represent a range that project teams can use to visualize how to design an Urban roadway serving a variety of users.

Table 6-12: Design Criteria by Facility Type—Urban Context

Design Element	Local	Collector	Arterial
Travelway Realm[1]			
Number of Lanes	2	Primarily 2	Primarily 2-4
Travel Lane Width[2]	9'-10', 11' if transit	9′–11′, 11' if transit	10′–12′, 11'-12′ if transit
Right-Turn Lane Width	9'-10', 11' if transit	9′–11′	10′–12′
Left-Turn Lane Width	9'-10', 11' if transit	9′–11′	11′–12′
Two-Way Left-Turn Lane Width	10′–11′	10′–12′	11′–12′
Left Side Shoulder on Divided Roadways (paved)	N/A	N/A	N/A
Right Side Shoulder	N/A	N/A	N/A
Shy Distance	0′–1′	0′–1′	0′–1′
Median[3]	0′–8′	0′-12′	0′-14′

Design Element	Local	Collector	Arterial
Transition Realm			
Bicycle Facility Type and Width[4,5,6]	Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Shared lane markings if target speed is 25 mph or less and two-lane roadway	Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including parking, raised island, flexible delineator posts, rigid bollards, parking stops, planters, and landscape Shared lane markings if target speed is 25 mph or less and two-lane roadway	Buffered bicycle lane: • Width 4′-6′ • Buffer: 2-3′ striping Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including parking, raised island, flexible delineator posts, rigid bollards, parking stops, planters, and landscape
Parallel On-Street Parking[7]	Limited and typically informal	7'-8', where provided	7'-8', where provided
Curb/Gutter	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′
Pedestrian Realm			
Frontage Zone	2′	2′	2′
Pedestrian Facility Type	Sidewalk on both sides	Sidewalk on both sides	Sidewalk on both sides
Pedestrian Zone Width	≥8′	≥10′	≥12′
Buffer Zone	0'-6'	2'-6'	2′-8′
Target Pedestrian Crossing Spacing Range	250-550 (1-2 blocks)	250-550 (1-2 blocks)	250-550 (1-2 blocks)
Shared-Use Path	N/A	N/A	N/A

[1] *Striping for the purpose automated vehicles will not add width to the overall cross section but will be part of the lane width shown.*

[2] *Projects that are part of the State Industrial Access (SIA) Program may use 12′ travel lanes.*

[3] *Median width is the perpendicular distance measured between the inside edges of traveled way for traffic lanes flowing in opposite directions. For divided roadways, inside shoulder width is included as part of the overall median width.*

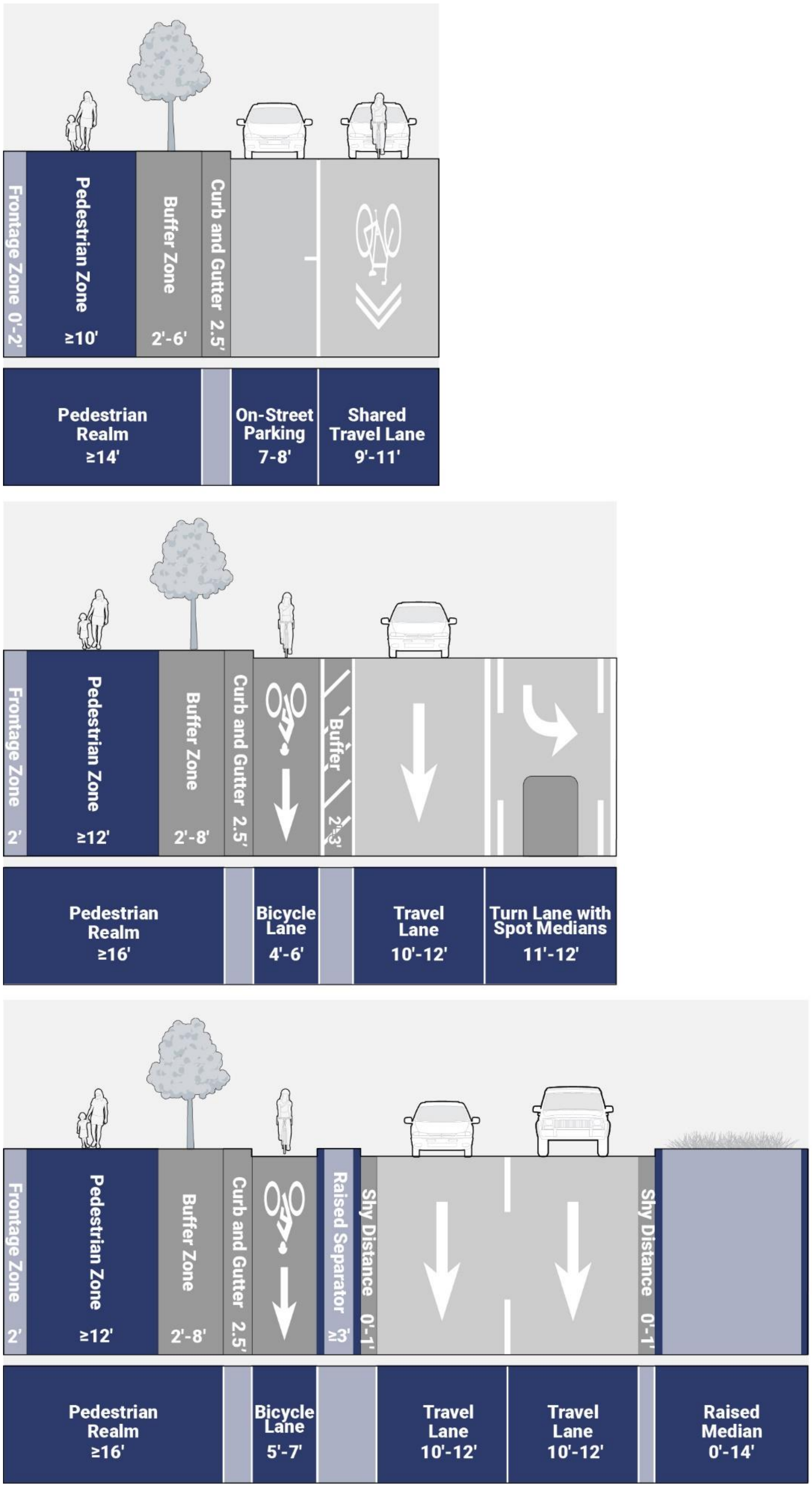
[4] *Bicycle facility selection is based on Chapter 4, Section 4.4.4.*

[5] *Along roadways with curb and gutter, the width of the bicycle facility should not include the gutter. If there are no curb and gutter and there are vertical elements adjacent to the bicycle lane (e.g., signs, landscape) additional shy distance between the bicycle lane and vertical elements may be needed.*

[6] *Where the total width of an on-street bicycle lane including the striped buffer exceeds 6′, the bicycle lane should be 4′ with the remaining space striped as the buffer to prevent vehicle traffic from using the lane.*

[7] *Local agencies may coordinate with TDOT if angle parking is desired.*

Figure 6-10 Example Urban Typical Sections



URBAN CORE CONTEXT

Table 6-13 shows recommended design criteria for the Urban Core context. Figure 6-11 illustrates cross section design options using the criteria in the table. These are not inclusive of every combination that may occur within the Urban Core context but represent a range that project teams can use to visualize how to design an Urban Core roadway serving a variety of users.

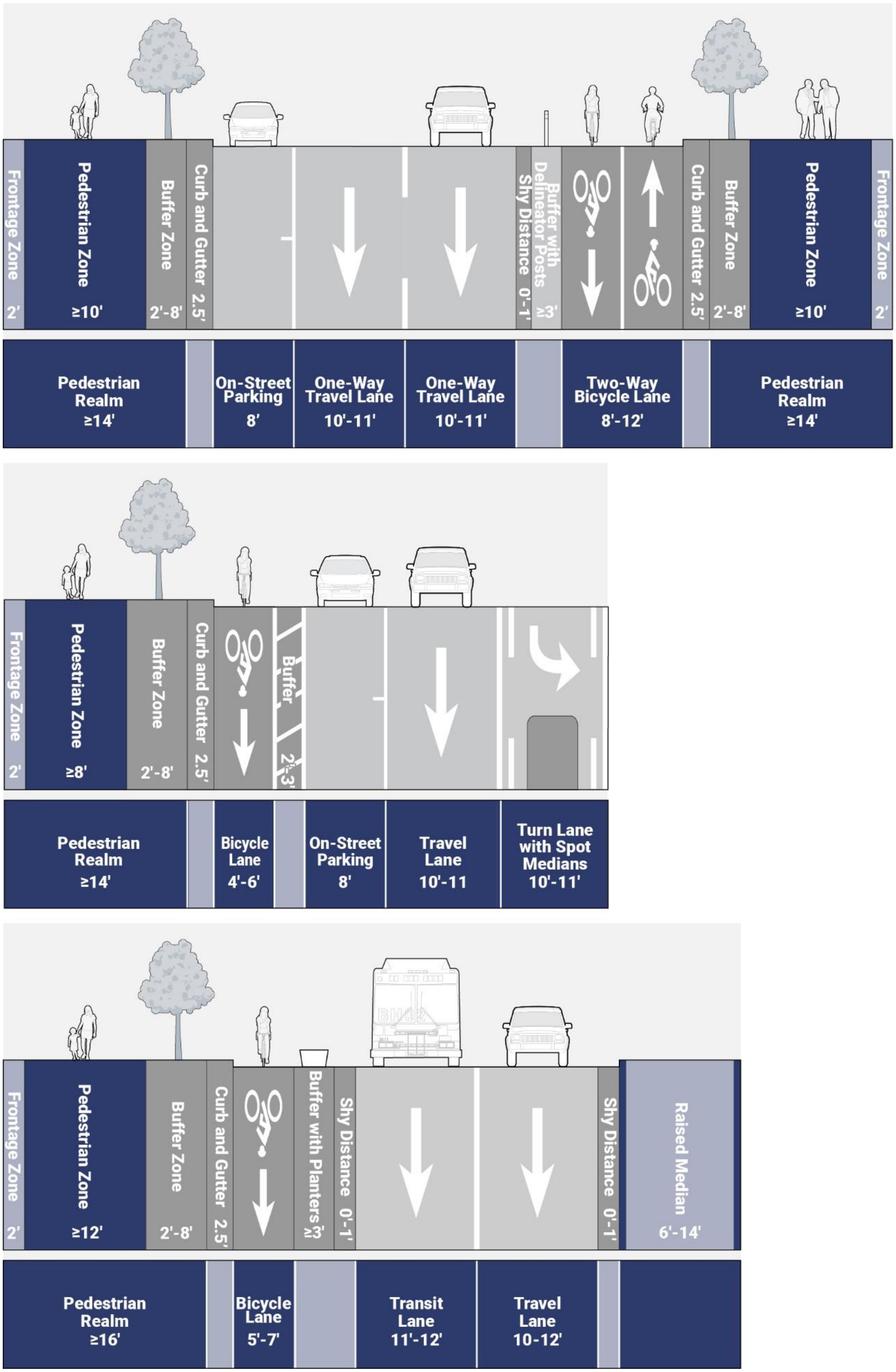
Table 6-13: Design Criteria by Facility Type—Urban Core Context

Design Element	Local	Collector	Arterial
Travelway Realm[1]			
Number of Lanes	2	Primarily 2-4	Primarily 2-4
Travel Lane Width[2]	9'-10', 11' if transit	10′–11′, 11' if transit	10′–12′, 11' if transit
Right-Turn Lane Width	9'-10', 11' if transit	9′–11′	10′–12′
Left-Turn Lane Width	9'-10', 11' if transit	9′–11′	11′–12′
Two-Way Left-Turn Lane Width	10′–11′	10′–11′	11′–12′
Left Side Shoulder on Divided Roadways (paved)	N/A	N/A	N/A
Right Side Shoulder	N/A	N/A	N/A
Shy Distance	0′–1′	0′–1′	0′–1′
Median[3]	0′–8′	0′-12′	0′-14′

Design Element	Local	Collector	Arterial
Transition Realm			
Bicycle Facility Type and Width[4,5,6]	Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Shared lane markings if target speed is 25 mph or less and two-lane roadway	Buffered bicycle lane: • Width 4′-5′ • Buffer: 2-3′ striping Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including parking, raised island, flexible delineator posts, rigid bollards, parking stops, planters, and landscape Shared lane markings if target speed is 25 mph or less and two-lane roadway	Buffered bicycle lane: • Width 4′-6′ • Buffer: 2-3′ striping Separated bicycle lane: • Width: 5′-7′ if one-way or 8′-12′ if two-way • Buffer: ≥3′ physical separation including parking, raised island, flexible delineator posts, rigid bollards, parking stops, planters, and landscape Shared lane markings if target speed is 25 mph or less and two-lane roadway
Parallel On-Street Parking[7]	Limited and typically informal	8', where provided	8', where provided
Curb/Gutter	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′	Curb: 0.5′ Gutter: 2.0′
Pedestrian Realm			
Frontage Zone	2′	2′	2′
Pedestrian Facility Type	Sidewalk on both sides	Sidewalk on both sides	Sidewalk on both sides
Pedestrian Zone Width	≥8′	≥10′	≥12′
Buffer Zone	0'-6'	2'-8'	2′-8′
Target Pedestrian Crossing Spacing Range	250-550 (1-2 blocks)	250-550 (1-2 blocks)	250-550 (1-2 blocks)
Shared-Use Path	N/A	N/A	N/A

[1] Striping for the purpose automated vehicles will not add width to the overall cross section but will be part of the lane width shown.
[2] Projects that are part of the State Industrial Access (SIA) Program may use 12′ travel lanes.
[3] Median width is the perpendicular distance measured between the inside edges of traveled way for traffic lanes flowing in opposite directions. For divided roadways, inside shoulder width is included as part of the overall median width.
[4] Bicycle facility selection is based on Chapter 4, Section 4.4.4.
[5] Along roadways with curb and gutter, the width of the bicycle facility should not include the gutter. If there are no curb and gutter and there are vertical elements adjacent to the bicycle lane (e.g., signs, landscape) additional shy distance between the bicycle lane and vertical elements may be needed.
[6] Where the total width of an on-street bicycle lane including the striped buffer exceeds 6′, the bicycle lane should be 4′ with the remaining space striped as the buffer to prevent vehicle traffic from using the lane.
[7] Local agencies may coordinate with TDOT if angle parking is desired.

Figure 6-11 Example Urban Core Typical Sections



6.3.3 Horizontal and Vertical Design Considerations

A fundamental principle of geometric design is creating roadway configurations where design speed and associated design features for vertical and horizontal alignment are coordinated. In some contexts, attaining a horizontal or vertical curve length for a given design speed may not be possible due to various constraints. The limits of the curve length or radius of one alignment portion could influence the corresponding curve length or radius of another portion.

Table 6-14 and Table 6-15 provide context considerations for horizontal and vertical design elements. The information in these tables is not meant to be comprehensive, and each design element should be evaluated with additional design guidance from the TDOT *RDG*. The considerations are intended to provide a starting point for project teams as they begin thinking about how to design roadways in various contexts.

Table 6-14: Horizontal Design Element Considerations

Design Element	Context Considerations
Minimum Radius	• Horizontal alignment is influenced by the speed for the context. • Flatter curvature with shorter tangents is preferable to sharp curves connected by long tangents; i.e., avoid using minimum horizontal curve lengths. • Curves with a larger radius are commonly found in Rural contexts.
Spiral Curve	• Spiral curves are typically discouraged except in Rural contexts and on freeways.
Superelevation	• Superelevation beyond normal and reverse crown is typically used only in a Rural context and is discouraged in other contexts. • Older roadways in formerly undeveloped areas may have superelevation that is inconsistent with the current or design year context.
Minimum Horizontal Clearances	• Horizontal clearances are influenced by the design speed for the context but should consider the pedestrian crossings and needs of each user. Higher-speed roadways may require a wider clearance to attain desired sight lines. Areas with larger design vehicles may also require wider clearances and lane widths to integrate heavy vehicle tracking or oversize/overweight (OSOW) vehicles.

Table 6-15: Vertical Design Element Considerations

Design Element	Context Considerations
Length of Vertical Curve (Sag or Crest)	• Speed for the context will influence the vertical alignment. • Flatter sag and/or crest curves are commonly found in Rural contexts. Shorter sag or crest curves may be found in areas of steep and highly-variable terrain. • The lengths of sag and/or crest curves in Urban and Urban Core contexts may be shorter but are typically adjusted based on intersection and/or driveway locations. • Vertical curve design may sometimes be dictated by roadway drainage needs.
Maximum Grades	• Steep grades may be found in Rural context. • Steep grades in some contexts may result in special design considerations to support emergency response vehicles or address pedestrian connectivity.
Minimum Vertical Clearances	• Design principles apply for all contexts except for lower order facilities (such as local roads) where trucks may be prohibited.

6.3.4 Sight Distance Design Considerations

Sight distance plays a critical role in providing road users adequate time to react to potential hazards and make safe decisions while navigating the road.

Table 6-16 describes design elements related to sight distance and provide context considerations that may impact design decisions.

Table 6-16: Sight Distance Considerations

Design Element	Context Considerations
Stopping Sight Distance (SSD)	• Based on design speed and assumptions for driver reaction time, the braking ability of most vehicles under wet pavement conditions, and the friction provided by most pavement surfaces. • Influenced by both vertical and horizontal alignment. • Higher speeds typically in Rural contexts will require increased sight distance; less sight distance will be needed in Urban and Urban Core contexts due to lower speeds
Passing Sight Distance (PSD)	• Passing sight distances only apply to two-lane highways and generally to low-volume roadways in a Rural context. • Minimum passing sight distance is sufficient only for the passing of a single isolated vehicle. • Passing sight distances coincide with the vertical alignment that is determined by the speed associated with the various contexts.
Intersection Sight Distance (ISD)	• Dimensions are affected by the operating speed and clear sight lines from the stopped vehicle. • Landscape, signs, and appurtenances should be positioned and maintained to avoid blocking needed sight lines. • Providing adequate sight distance can influence intersection design outside the TDOT footprint including obstacles on private property.

6.4 SELECTING AND DOCUMENTING DESIGN VALUES

As discussed in Chapter 3, the context informs the types of users and the intensity of uses within each context. For almost every project, user needs can be addressed in multiple ways. The alternatives developed to respond to these needs should explore a variety of methods and means for meeting them.

Chapter 2 outlines a performance-based approach to TDOT's PDN that supports decision-making from planning, concept development, evaluation and selection, and design. It gives guidance on establishing goals and performance measures related directly to a project's documented purpose. The design criteria provided in this chapter build off the guidance in Chapter 2 and create an opportunity to more directly incorporate performance-based design into TDOT's design process.

6.4.1 Design Value Selection

When selecting design values from the ranges provided in Section 6.3, project teams should align the design values with the project's goals and intended outcomes. For example, if a project goal is to provide a low-stress route for bicyclists, the criteria selected may maximize bicycle lane width and separation while minimizing travel lane width. Along a primary transit route, the criteria selected may include a wider transit lane and more space in the pedestrian realm for transit amenities. Figure 6-12 is a decision-making framework that shows how this approach may become iterative at specific stages of the project. Project goals and desired outcomes should be revisited at each stage to verify that the planning, scoping, alternatives development, and designs align with the original intent of the project and serve the needs of the users.

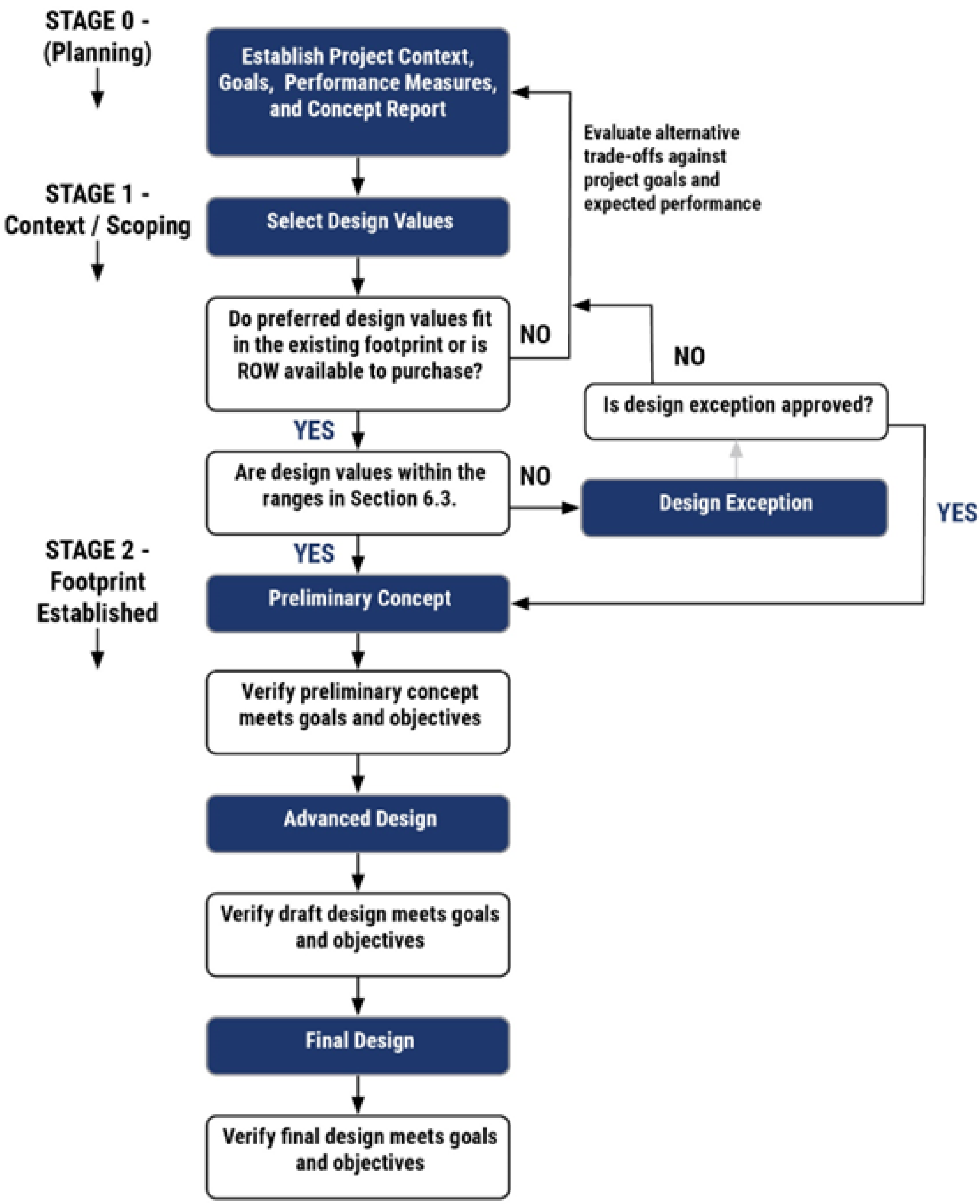
During PDN Stage 0 (Planning), the project team identifies a range of alternatives to meet the needs of the identified users consistent with the design year context. Between Stage 0 and Stage 1, the project team evaluates the design alternatives against the project's performance measures previously identified (see Chapter 2).

In many cases, there may not be one clear-cut alternative that equally serves users at the same level. Limitations like right-of-way, environmental features, and cost may require difficult choices about how to serve different users along a roadway. In these cases, the design team may have to further evaluate trade-offs and consider the availability of alternative facilities, context, modal priorities, and the relationship between safety, mobility, and convenience. As part of the evaluation and selection process, the alternatives may be refined or combined. The alternatives evaluation is documented in the Concept Report in Stage 0 of the PDN and the preferred alternative documented in the Project-Specific Design Criteria Document in Stage 1 of the PDN.

> The design values have a high degree of flexibility to meet the needs of the users in each context. Still, there may be times when the criteria cannot be reasonably met within the project footprint. If the selected alternative includes design values outside the ranges provided in Section 6.3, Design Exceptions/Deviations/ Waivers are requested during Stage 2 (see Chapter 2, Section 2.7 and the TDOT *RDG* for more information on the Design Exception/Deviation/Waiver processes).

The selected alternative is reviewed against the project goals and intended outcomes again when the preliminary design and final design are developed for consistency with the initial purpose of the project. Additional constraints may become apparent throughout the design phase and may require project elements to be revisited and refined. If changes are made to the preliminary concept, advanced design, or final design that are not aligned with the project context and intended outcomes, the project team should revisit the context and goals and adjust the design as needed. This iterative process confirms that if changes are made throughout the design process, the design is still consistent with the project purpose. Document changes clearly and provide justification for all decisions.

Figure 6-12 Performance-Based Approach to Design Value Selection



CONSTRAINED LOCATIONS

Roadways, especially in Urban and Urban Core contexts, are often constrained by available right-of-way, adjacent development, utilities, or natural features. In some cases, the preferred design criteria are not feasible and the project team needs to evaluate trade-offs, such as reducing the desired bicycle separation or buffer. The intent of performance-based design is to provide flexibility and options, with the project goals and intended outcomes driving decision-making. The list below presents potential considerations where constraints limit a roadway's cross section.

- Is there an opportunity to narrow travel lanes?
    - If existing travel lanes are wider than 10', consider options for narrowing lanes.
    - On streets with more than two through lanes, select 10' lanes for the inner lanes.
    - On low-speed streets in Urban or Urban Core contexts, 11' lanes are sufficient to serve transit and freight vehicles. Even 10' lanes adjacent to a buffer zone can serve transit and heavy vehicles.
- Is there an opportunity to reduce or remove shy distance?
    - On low-speed streets in many Urban or Urban Core contexts, shy distance can be minimized or removed.
- Is there an opportunity to narrow or remove the two-way left-turn lane?
    - On low-speed streets in many Urban or Urban Core contexts, 10' is sufficient width for a two-way left-turn lane. Turn lanes may not be needed as higher levels of vehicle congestion are expected.
- Is there an opportunity to reduce the number of motor vehicle travel lanes?
    - Depending on motor vehicle volumes, a cross-section reallocation (e.g., from four lanes to three lanes) may provide sufficient capacity and can improve safety.
    - In some contexts, comfortable bicyclist and pedestrian travel and/or other priorities may be more important than vehicular capacity.
- Is there an opportunity to remove on-street parking?
    - In some contexts, comfortable bicyclist and pedestrian travel and/or other priorities may be more important than on-street vehicle parking.
    - Converting existing angle parking to parallel parking can create more space for other design elements while preserving some on-street parking.

- Is there an opportunity to relocate drainage or utilities?
  - If there is an open drainage system, consider a closed drainage system with curb and gutter.
  - Align utilities that are currently offset. For example, if streetlights are close to the roadway and utility poles are at the back of right-of-way, consolidate in the buffer zone to create a larger pedestrian zone.
  - Evaluate underground utilities.

6.4.2 Design Value Documentation

Figure 6-12 includes milestones where documenting planning and design decisions is important. If design decisions, project team discussions, and alternative evaluations have led to any changes in the performance measures or project goals, this information and the project team decisions should be clearly documented. Chapter 2 includes additional information on documenting design decisions at each PDN stage. As noted throughout this chapter, the primary documentation for the selected cross section criteria is part of the Project Specific Design Criteria Document in Stage 1. Additional documentation is part of the Project Commitment Document in Stage 1 and 2. Refer to the PDN for additional details about deliverables and documentation requirements at each stage.

6.5 REFERENCES

1. The University of Tennessee and Vanderbilt University. TDOT Research Study: *Addressing Traffic Safety to Reduce Pedestrian Injuries and Fatalities in Tennessee*. Knoxville, TN, 2022.
2. Federal Highway Administration. *Manual on Uniform Traffic Control Devices (MUTCD)*, 11th Edition. Washington, D.C., 2023.
3. Tennessee Department of Transportation. "Traffic Operations Memorandum No. 1801, Guidance on Setting Speed Limits." Nashville, TN, May 15, 2018. https://www.tn.gov/content/dam/tn/tdot/traffic-engineering/TOM%201801.pdf (as of October 16, 2019).

Tennessee Department of Transportation

Project Scoping Guide

Chapter 7 – Case Studies

September 2024

TN TDOT Department of Transportation

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Chapter 7

Case Studies

Chapter 7 discusses how performance-based design can be incorporated into the design process and provides two case studies for applying this to real projects. The examples demonstrate how context influences design decisions and show how to use performance measures to evaluate and select alternatives.

The case studies follow the steps below, which outline specific processes, decision-making, outcomes, and connections to the stages established in TDOT's Project Delivery Network (PDN).

- STEP 1: Establish project goals and performance measures *(PDN Stage 0)*
- STEP 2: Concept development *(PDN Stage 0)*
- STEP 3: Evaluation and selection *(PDN Stage 1)*
- STEP 4: Design phase *(PDN Stage 2)*

Chapter 2 of the *PSG* has additional guidance and details on the steps of the performance-based design process.

7.1 CASE STUDY #1: TRANSITION FROM RURAL TO SUBURBAN CONTEXT

PROJECT BACKGROUND

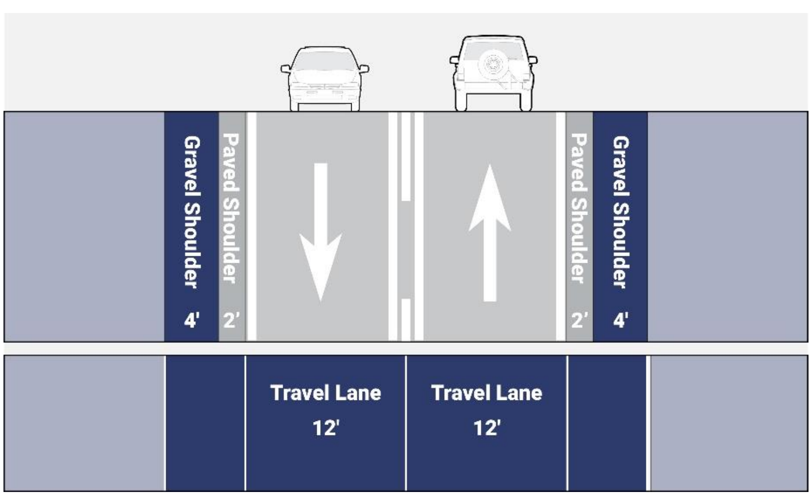
- The existing roadway has two lanes and is a high-speed arterial located in an area that is currently rural with low-density residential development.
- The roadway winds through a forested area with natural features, including a water crossing and several large mature trees near the roadway, as shown in Figure 7-1.
- The roadway connects an established metropolitan area and growing suburban development.
- The area is transitioning from a sparsely developed rural community to suburban development as growth from the metropolitan core expands.
- TDOT is evaluating potential improvements on the roadway to address a recent increase in crashes and to better serve all roadway users and ongoing development.
- Residents on the corridor are concerned about maintaining the character and aesthetic of the roadway.
- The project was identified through a statewide safety initiative and will be funded through the state.

Figure 7-1 Aerial View of Roadway

ROADWAY AND SURROUNDING LAND USE CHARACTERISTICS

- **Cross Section**: Two undivided 12′ vehicle travel lanes, 2′ paved shoulders, 4′ gravel shoulders, and roadside ditches, shown in Figure 7-2, for a total paved width of 28′. The existing TDOT right-of-way (ROW) is 60′.
- **Density**: Low but increasing with ongoing and planned development.
- **Users**: Through traffic between the metropolitan area and outlying rural communities, moderate truck traffic, recreational bicyclists, occasional pedestrians.
- **Land Use**: Mix of low-density residential and newer, denser neighborhoods and commercial clusters.
- **Parking**: No on-street parking.
- **Speed**: Posted speed is 45 mph, observed 85th percentile speed is 48 mph

Figure 7-2 Existing Cross Section



7.1.2 STEP 1: Establish Project Goals and Performance Measures *(PDN Stage 0)*

Step 1 occurs within Stage 0 of the TDOT PDN and is documented in the Concept Report. This includes identifying the overarching project outcomes driving the need for the project. Clearly articulating the design year context and goals early in the project is important so they can serve as a basis for evaluating alternatives and confirming that the selected alternative is aligned with the project purpose and intended outcomes.

Project goals are intended to be brief statements that capture the vision for the corridor and surrounding areas. They can be visionary but should be easily understood and measurable.

Performance measures are project specific and provide quantitative and/or qualitative means of assessing the project goals and intended outcomes.

GOALS

The project team conducted community outreach to gather input on the existing conditions of the roadway and surrounding area. This included safety issues for pedestrians and bicyclists as the area changes and the desire to maintain important aspects of existing environmental features. In addition, the community recognized the expected growth for the area as the nearby metropolitan areas expand and the various types and volumes of roadway users increase.

Based on the project background and community input, the goals for this project include:

1. Provide increased safety and access for pedestrians and bicyclists along the corridor.
2. Enhance long-term viability for the local community.
3. Accommodate future traffic anticipated on the corridor.
4. Preserve existing natural features.
5. Optimize project performance within available project funding.

The project background notes that the area is currently rural with low-density residential development. However, the roadway connects to an established metropolitan area and growing suburban development. Due to the expected expansion of the metropolitan area and transition from rural to suburban development, a Suburban context was selected for this project. Based on the context and project team discussions, a target speed of 35 mph was selected.

Chapter 3 of the *PSG* provides background and guidance on identifying design year context. Chapter 6 of the *PSG* provides information on target speed ranges based on context and functional classification.

PERFORMANCE MEASURES

The project's performance measures are shown in Table 7-1. These are based on the project goals and desired outcomes for the area.

Table 7-1: Project Performance Measures Based on Goals

Project Goal	Performance Measures	
1. Provide increased safety and access for pedestrians and bicyclists along the corridor.	**Safety**	Expected reduction in operating speeds
		Anticipated reduction in crashes
		Pedestrian assessment (e.g., facility type, level of separation)
		Bicyclist assessment (e.g., facility type, level of separation)
2. Enhance long-term viability for the local community.	**Livability**	Community feedback on how the design alternatives maintain the character of the roadway
	Modal Integration	Consistency with modal integration (See Chapter 3) for Suburban context
3. Accommodate future traffic anticipated on the corridor.	**Operations**	Design year volume-to-capacity (v/c) ratio
		Expected change in travel time reliability (review of available existing data and estimated microsimulation data)
4. Preserve existing natural features.	**Environmental and ROW Impacts**	Property impacts due to right-of-way acquisition
		Level of impact to environmental features
5. Optimize project performance within available project funding.	**Feasibility**	Expected project cost
		Anticipated construction feasibility

Chapter 2 of the *PSG* has additional guidance and examples to help project teams identify performance measures that align with project goals.

7.1.3 STEP 2: Concept Development *(PDN Stage 0)*

Step 2 focuses on developing alternative concepts. The alternatives are intended to represent a range of options and may be refined through the evaluation process. **Project alternative concepts are initially identified in the Final Concept Report in Stage 0 and further refined in Stage 1 as part of the Draft Project Commitment Documentation.**

The project seeks to address existing conditions on the corridor, including:

- Increasing crash severity and frequency, especially run-off-the-road crashes and turning crashes at higher-volume intersections.
- High speeds, especially on the far end of the corridor closer to the rural communities.
- Lack of access for bicyclists and pedestrians, with recreational riders using the narrow shoulder or sharing the travel lane.
- Limited sight distance at curves along the roadway.
- High projected traffic volumes and desire to minimize delays for through vehicles on the corridor.

Alternatives were developed based on existing TDOT design guidance and collaboration with community members and include the following:

- **Alternative 1:** Vehicle-oriented five-lane Suburban cross section including four 12′ travel lanes, 14′ two-way left-turn lane, 2.5′ curb/gutter, 2′ cobblestone buffer, as well as 5′ sidewalk on one side and a 10′ shared-use path on the other side (total width 86′).
- **Alternative 2:** Multimodal five-lane Suburban cross section including four 10′ travel lanes, 12′ two-way left-turn lane, 2.5′ curb/gutter, 5′ landscape buffer, 6′ separated bicycle lanes, and 8′ sidewalks (total width 95′).
- **Alternative 3:** Multimodal three-lane Suburban cross section including two 10′ travel lanes, 12′ two-way left-turn lane, 6′ bicycle lanes with 3′ buffer including raised separators, 2.5′ curb/gutter, 5′ landscape buffer, and 8′ sidewalks (total width 81′).

The alternatives are illustrated in Figure 7-3 through Figure 7-5.

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Figure 7-3 Alternative 1—Vehicle-Oriented Five-Lane Suburban Cross Section

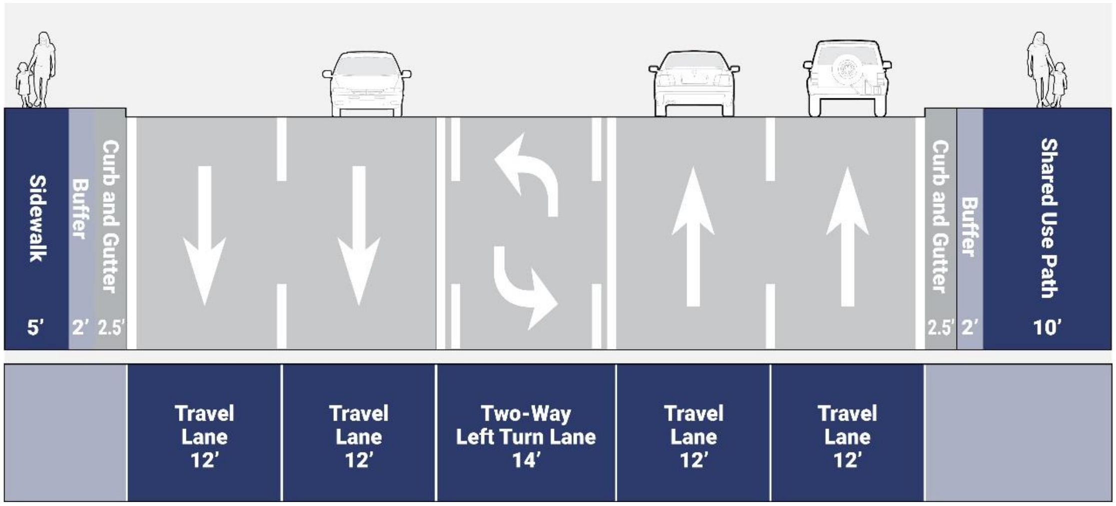


Figure 7-4 Alternative 2—Multimodal Five-Lane Suburban Cross Section

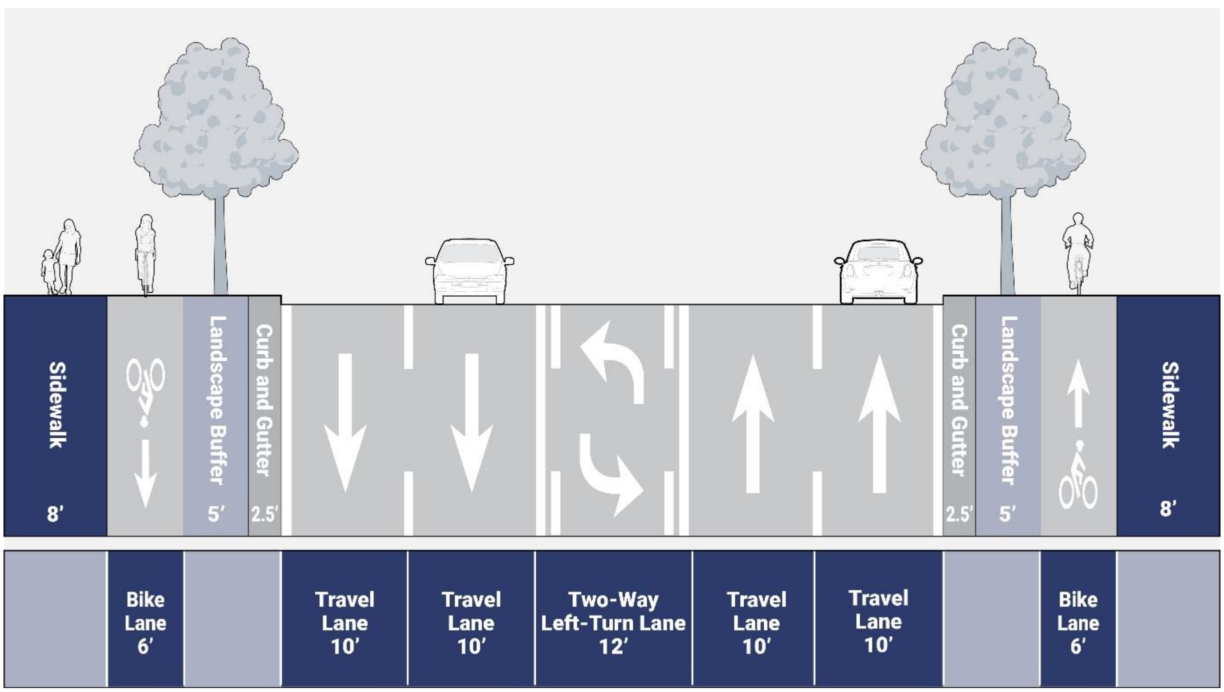
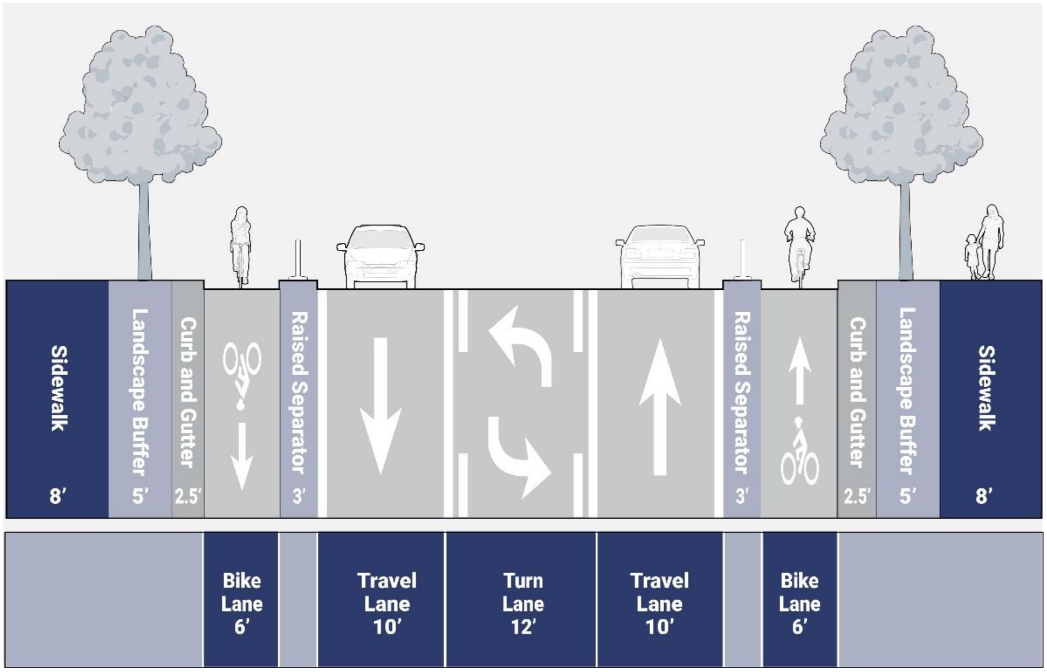


Figure 7-5 Alternative 3—Multimodal Three-Lane Suburban Cross Section



7.1.4 STEP 3: Evaluation and Selection *(PDN Stage 1)*

Step 3 alternative evaluation and selection occurs in Stage 1 and the selected alternative is documented in the Stage 1 Scope of Work Document. The Final Project Commitment Document developed in Stage 2 includes the final alternative that will move forward.

The alternatives are evaluated against the performance measures previously identified in Step 1, Table 7-1.

Developing a clear and simple approach for evaluating, categorizing, or scoring alternatives can allow project teams to verify that the project goals and performance measures are adequately integrated and assessed so they can select the most appropriate and viable alternative.

IMPROVEMENT RATING PARAMETERS

The project team set parameters for the improvement ratings for each performance measure to evaluate the alternatives. The parameters are categorized with a rating of "low," "medium," or "high" to compare and evaluate the three alternatives.

Table 7-2 through Table 7-7 list the parameters for the improvement ratings for each performance measure outlined in Table 7-1.

Table 7-2: Safety Improvement Rating Summary

Performance Measure	SAFETY Improvement Rating		
	Low	Medium	High
Expected reduction in operating speeds	Project includes **0-1 treatments** with documented effectiveness at speed **reduction**	Project includes **2 treatments** with documented effectiveness at speed **reduction**	Project **includes 3 or more treatments** with documented effectiveness at speed **reduction**
Anticipated change in crashes	Project is **not** anticipated to reduce crashes	Project has a **moderate** value crash reduction factor	Project has a **high** value crash reduction factor
Pedestrian assessment	Project provides a facility of minimum width	Project provides a wider facility with horizontal separation	Project provides a wider facility with horizontal and vertical separation
Bicyclist assessment	Project provides a facility of minimum width	Project provides a wider facility with horizontal separation	Project provides a wider facility with horizontal and vertical separation

Table 7-3: Livability Improvement Rating Summary

Performance Measure	LIVABILITY Improvement Rating		
	Low	Medium	High
Community feedback on how the design alternatives maintain the character of the roadway	Mostly negative feedback	Neutral or mixed feedback	Mostly positive feedback

Table 7-4: Modal Integration Improvement Rating Summary

Performance Measure	MODAL INTEGRATION Improvement Rating		
	Low	Medium	High
Consistency with modal integration considerations for Suburban context[1]	Modal integration is NOT consistent with expectations	Modal integration addresses some expectations	Modal integration is consistent with expectations

[1]*Modal integration expectations are described in Chapter 3, Table 3-3 of the PSG.*

Table 7-5: Operations Improvement Rating Summary

Performance Measure	OPERATIONS Improvement Rating		
	Low	Medium	High
Design year v/c ratio	>0.90	0.75 to 0.90	<0.75
Expected change in travel time reliability (review of available existing data and estimated microsimulation data)	Inconsistent travel time	Maintains travel time expectations	Improves travel time consistency

Table 7-6: Environmental and ROW Impacts Performance Measure Improvement Rating Summary

Performance Measure	ENVIRONMENTAL AND ROW IMPACTS Improvement Rating		
	Low	Medium	High
Property impacts due to right-of-way acquisition	Right-of-way acquisition impacts the function and/or structures on adjacent properties	Right-of-way acquisition required but no impacts to function and/or structures	No right-of-way acquisition
Level of impact to environmental features	Significant environmental impacts that require extensive mitigation	Minimal environmental impacts that can be mitigated	No environmental impacts

Table 7-7: Feasibility Improvement Rating Summary

Performance Measure	FEASIBILITY Improvement Rating		
	Low	**Medium**	**High**
Expected project cost	Project costs exceed available funding	Project costs align with available funding	Project costs are below available funding
Anticipated construction feasibility	Project poses significant construction challenges	Project poses moderate construction challenges	Project poses no construction challenges

EVALUATION RESULTS

Each alternative was evaluated based on the performance measures and improvement rating parameters. Some of the performance measures require analysis and preliminary estimating, while others are more qualitative and based on project team judgment and community input. Table 7-8 through Table 7-13 show the rating and justification for each alternative evaluation for this case study. In most cases, this evaluation is part of PDN Stage 1 and the documentation for decision-making is integrated into the Concept Report, Scope or Work Document and Project Commitment Document.

Table 7-8: Summary of Safety Evaluation

Performance Measure	SAFETY Improvement Rating		
	Alternative 1	**Alternative 2**	**Alternative 3**
Expected reduction in operating speeds	**Low** Project includes 0-1 treatments with documented effectiveness at speed reduction: • Curbs, sidewalks, and bicycle lanes	**High** Project includes 3 or more treatments with documented effectiveness at speed reduction: • Curbs, sidewalks, and separated bicycle lanes • Narrower travel lanes (from 12’ to 10’) • Landscaped buffer	**High** Project includes 3 or more treatments with documented effectiveness at speed reduction: • Curbs, sidewalks, and bicycle lanes • Narrower travel lanes (from 12’ to 10’) • Narrower pavement width and cross section • Landscaped buffer

Performance Measure	SAFETY Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Anticipated change in crashes	**Medium** Project provides a moderate value crash reduction factor: • Two-way left-turn lane[1]: 33% reduction turning crashes • Lighting[1]: 20% reduction for nighttime crashes • Bicycle lane[1]: 36% reduction in all bicycle crashes • Sidewalk[2]: expected reduction in pedestrian crashes	**High** Project provides a high value crash reduction factor: • Two-way left-turn lane[1]: 33% reduction turning crashes • Lighting[1]: 20% reduction for nighttime crashes • Horizontal and vertical separated bicycle lane: ≥36% reduction in all bicycle crashes • Sidewalk[2]: expected reduction in pedestrian crashes	**High** Project provides a high-value crash reduction factor: • Two-way left-turn lane[1]: 33% reduction turning crashes • Lighting[1]: 20% reduction for nighttime crashes[1] • Buffered bicycle lane: ≥36% reduction in all bicycle crashes • Sidewalk[2]: expected reduction in pedestrian crashes The reduced number of travel lanes allows opportunities for traffic calming and smaller intersections with shorter crossing distances, expected to provide a crash reduction benefit.
Pedestrian assessment	**Low** Project provides a minimum sidewalk width (5′)	**High** Project provides a wider sidewalk (8′) with vertical separation (landscape buffer)	**High** Project provides a wider sidewalk (8′) with vertical separation (landscape buffer)
Bicyclist assessment	**Medium** Project provides a minimum shared-use path on one side (10′)	**High** Project provides a bicycle lane (6′) with vertical separation (landscape buffer)	**High** Project provides a wider bicycle lane (6′) with vertical separation

[1]Federal Highway Administration (FHWA) Desktop Reference for Crash Reduction Factors (1)
[2]A crash reduction factor for sidewalks is not available, but providing a designated space for pedestrians separated by a curb is expected to reduce crashes involving pedestrians.

Table 7-9: Summary of Livability Evaluation

Performance Measure	LIVABILITY Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Community feedback on how the design alternatives maintain the character of the roadway	**Low** Wide cross section with limited aesthetics Minimum pedestrian and bicycle facilities adjacent to roadway	**Medium** Wide cross section but pedestrian and bicycle facilities have a landscape buffer that reduces impervious pavement	**High** Narrower cross section with fewer travel lanes and improved pedestrian and bicycle facilities with buffers

Table 7-10: Summary of Modal Integration Evaluation

Performance Measure	MODAL INTEGRATION Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Consistency with modal considerations for Suburban context	**Low** Vehicle-oriented priority with minimum pedestrian and bicycle facilities	**Medium** Mixed vehicle and pedestrian/bicycle priorities	**High** Pedestrian and bicycle priority

Table 7-11: Summary of Operations Evaluation

Performance Measure	OPERATIONS Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Design year volume-to-capacity ratio	**High** No capacity constraints	**High** No capacity constraints	**Low** Potential capacity impacts at intersections
Expected change in travel time reliability	**High** Free flow conditions expected during most of the day	**High** Free flow conditions expected during most of the day	**Low** Anticipated congestion during peak hours

Table 7-12: Summary of Environmental and ROW Impacts Evaluation

Performance Measure	ENVIRONMENTAL AND ROW IMPACTS Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Property impacts due to right-of-way acquisition	**Medium** Requires 13′ of right-of-way on each side of the roadway that will impact adjacent properties but no structures	**Low** Requires 17.5′ of right-of-way on each side of the roadway that will impact two adjacent structures on private property	**Medium** Requires 10.5′ of right-of-way on each side of the roadway that will impact adjacent properties but no structures
Level of impact to environmental features	**Low** Wider cross section impacts water crossing and adjacent trees	**Medium** Wider cross section impacts water crossings but buffers may potentially integrate existing trees	**High** Buffers can potentially integrate existing mature trees, and cross section can be reduced over water crossing to minimize impacts

Table 7-13: Summary of Feasibility Evaluation

Performance Measure	FEASIBILITY Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Expected project cost	**Medium** Higher project costs expected due to wider cross section and more impervious pavement Overall project cost expected to meet the budget	**Low** Highest construction and right-of-way costs compared to other alternatives Overall costs expected to exceed the budget	**High** Lower project costs expected due to least amount of impervious pavement Overall costs expected to be under budget
Anticipated construction feasibility	**Medium** Staged construction may be easier due to wider cross section	**Medium** Staged construction may be easier due to wider cross section	**Low** Staged construction may be more difficult due to narrower cross section

Table 7-14 summarizes the results for each alternative performance measure. This summary can be used to communicate the results in project team meetings and public meetings to illustrate the assessment and overall outcomes.

Table 7-14: Summary of Performance Measure Evaluation

Performance Measure		Improvement Ratings		
		Alt 1	Alt 2	Alt 3
Safety	Expected reduction in operating speeds	L	H	H
	Anticipated change in crashes	M	H	H
	Pedestrian assessment	L	H	H
	Bicycle assessment	M	H	H
Livability	Community feedback on how the design alternatives maintain the character of the roadway	L	M	H
Modal Integration	Consistency with modal considerations for Suburban context	L	M	H
Operations	Design year v/c ratio	H	H	L
	Expected change in travel time reliability	H	H	L
Environmental and ROW Impacts	Property impacts due to right-of-way acquisition	M	L	M
	Level of impact to environmental features	L	M	H
Feasibility	Expected project cost	M	L	H
	Anticipated construction feasibility	M	M	L

L = Low, M=Medium, H=High

The project team reviewed the evaluation summary, considering the original project goals and potential trade-offs between the alternatives to select the preferred alternative to move forward to the Step 4 Design Phase.

Based on the evaluation summary in Table 7-14, the project team identified the following considerations and trade-offs:

- Alternative 2 had the highest overall ratings (high and medium) compared to the other alternatives.
- Alternative 1 was eliminated due to low ratings for many of the performance measures and project goals.
- While Alternative 3 may not have rated as high as Alternative 2, the community input indicated a preference for Alternative 3.
- The primary reasons for Alternative 3's low ratings were potential vehicle capacity constraints and construction feasibility. This could lead to project team discussions on prioritizing the goals and further assessing the trade-offs between vehicle mobility and pedestrian and bicyclist comfort and safety.
- There may be opportunities to combine features from Alternative 2 and Alternative 3 to improve overall performance and align with project goals.

KEY TAKEAWAYS

In many cases, the preferred alternative might not be clear cut and limitations like ROW, environmental features, and cost may require difficult choices about how to serve different roadway users along a corridor. In these cases, the project team may have to further evaluate trade-offs and consider the availability of alternative facilities, context, modal priorities, and the relationship between safety, mobility, and convenience.

As part of the evaluation and selection process, the alternatives may be refined or combined. For example, Alternative 3 could be pursued but the travel lanes increased to 11′ to serve the moderate freight volumes expected on the corridor. An additional travel lane may be added in advance of intersections to provide adequate capacity, with a cross section that is primarily three lanes between intersections. The cross section may be reduced in areas with environmental features the community seeks to preserve (e.g., over a water crossing or near mature trees) by removing the center turn lane or reducing the buffer between the vehicle lane and pedestrian and/or bicycle facilities. However, the design should maintain continuity for pedestrians and bicyclists and not reduce the sidewalk or bicycle lane below the minimum widths provided in TDOT's design guidance and criteria.

Project teams should review the selected alternative against the project goals and intended outcomes again when the preliminary design and final design are developed to verify it is still consistent with the initial purpose of the project.

7.1.5 STEP 4: Design Phase *(PDN Stage 2)*

Step 4 covers the Design Phase and includes Stages 2 through 4 of the TDOT PDN. The design elements and criteria are documented in the Project-Specific Design Criteria and Scope of Work Document in Stage 1 and inform the Draft Project Commitment Document in Stage 1. The Final Project Commitment Document in Stage 2 includes the final project design criteria that will be carried through the design phase.

Additional constraints may become apparent throughout the design phase that require project elements to be revisited and refined. If changes are made to the preliminary concept, advanced design, or final design that are not aligned with the project context and intended outcomes, the project team should revisit the context and goals and adjust the design as needed. This iterative process ensures that if changes are made throughout the design process, the design is still consistent with the project purpose. The team should clearly document changes and provide justification for decisions.

For example, in this project, the team selected Alternative 3 in Stage 1 of TDOT's process and developed horizontal alignments with the proposed cross section centered in the existing ROW. During the ROW Strategy Meeting in Stage 2 of the project, the environmental lead identified wetlands adjacent to the corridor within the footprint of the proposed cross section. The project team brainstormed opportunities during the ROW Strategy Meeting and developed a plan to avoid impacts to the wetlands by removing the center two-way left-turn lane for a 200′ section of roadway and reducing the bicycle lanes to 5′ with a 1′ buffer. The team compared this preliminary design to the project context and goals and determined it was consistent with the project's intended outcomes. Appropriate access to adjacent properties was achievable without the center two-way left-turn lane via a planned roundabout just south of the wetlands and the buffered bicycle lane dimensions were above TDOT's minimum widths for a Suburban arterial.

As the project progresses through the Design Phase, it may not be necessary to formally document that each step of the design, including various design submittals, is reviewed alongside the goals and outcomes. However, if anything is inconsistent with the original project goals and outcomes and the design is revised, the project team must prepare the necessary documentation to justify the change and record it in the project file.

7.2 CASE STUDY #2: URBAN TRANSIT CORRIDOR

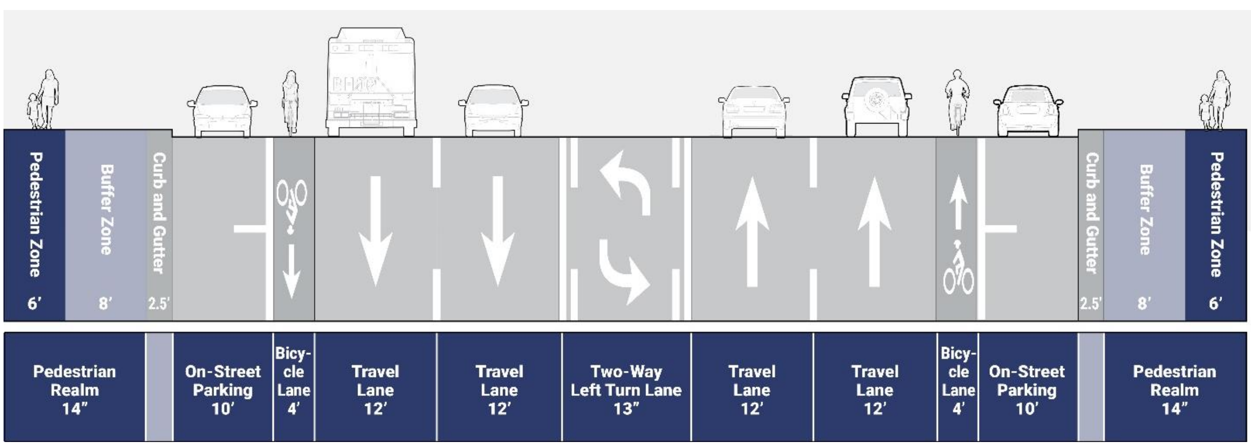
PROJECT BACKGROUND

- The existing north/south roadway has five lanes and is an arterial located on the edge of a dense metropolitan area. While previously more Suburban in character, density on the corridor is increasing, with new development and a demand for more multi-family housing.
- There is commercial development adjacent to the roadway and residential development to the east and west. There are frequent driveways and a mix of signalized and stop-controlled intersections.
- The roadway is part of the National Highway System and is a parallels the interstate.
- The local agency has identified the roadway as a high-crash corridor for pedestrians and bicyclists. There are limited facilities or crossing opportunities for pedestrians or bicyclists along the corridor, and a lack of other options in the area.
- The corridor currently supports frequent bus service, with a vision for enhanced transit service in the future to attract and support more transit-oriented development.
- The community is interested in seeing higher densities and new projects along the corridor. While businesses have closed over the last several decades after vehicle traffic moved to the interstate, the corridor is starting to see more activity. Several sites along the corridor are being considered for high-rise multi-family housing, and a large national company is considering moving their headquarters to a site nearby.
- The project was identified through a review of crash data and use of TDOT's Multimodal Prioritization Tool (MPT). The MPT identified the corridor as a high priority for improvement based on a review of infrastructure, safety, equity, and pedestrian demand.
- The state will collaborate with the local agencies on the project, including the local transit agency.

ROADWAY AND SURROUNDING LAND USE CHARACTERISTICS

- **Cross Section**: Four 12′ vehicle travel lanes with a center 13′ two-way left-turn lane (TWLTL), 4′ bicycle lanes, 10′ on-street parking, 2.5′ of curb/gutter, 6′ sidewalks with 8′ landscape buffers, shown in Figure 7-6, for a total paved width of 122′. The existing TDOT ROW is 130′.
- **Density**: Medium to high, with some older single-story commercial buildings.
- **Users**: Local traffic between commercial development and surrounding residential development; regional through traffic using the corridor as an alternative to the interstate; low truck traffic to serve commercial uses on the corridor; frequent bus service; local pedestrians and bicyclists visiting businesses along the corridor, accessing transit, or using the corridor due to a lack of other routes in the area.
- **Land Use**: Primarily medium- and high-density commercial development adjacent to the corridor, with low- and medium-density residential uses just to the east and west.
- **Parking**: On-street parking.
- **Speed**: Posted speed is 40 mph; observed 85th percentile speed is 44 mph.

Figure 7-6 Existing Cross Section



7.2.2 STEP 1: Establish Project Goals and Performance Measures *(PDN Stage 0)*

GOALS

The project team reviewed the results of the MPT, collaborated with local agencies, held community workshops, and conducted site visits and road safety audits to understand the existing conditions on the roadway and vision for the future. The MPT revealed a pattern of high-severity pedestrian crashes, especially associated with pedestrians crossing the roadway. The MPT and community reflected a desire for a more comfortable pedestrian and bicyclist experience on the corridor, given the commercial uses, transit stops, and lack of alternative options in the area. The local transit agency noted a desire for more frequent transit service in the future, with the potential for Bus Rapid Transit. In addition, community members expressed a desire to support redevelopment and investment in the corridor, including higher-density and community-focused uses. Developers considering sites on the corridor for high-rise multi-family development and a company considering building their headquarters near the corridor would like to see a more vibrant environment and options for residents and employees without vehicles.

The project team identified the following goals for the project:

1. Enhance connectivity, access and safety for pedestrians and bicyclists along and across the corridor, including safe crossing opportunities.
2. Improve transit access and mobility.
3. Accommodate regional traffic moving along the corridor.
4. Leverage local and state public investment to spur economic development.
5. Preserve and enhance existing residential neighborhoods and create a vibrant corridor that is a destination for the area.

The guidance in Chapter 3 of the *PSG* was used to identify the context for the project, considering the design year of 2040 and envisioned future of the corridor. As shown in Table 7-15, the corridor is best described by the Urban context. Based on the context and project team discussions, a target speed of 35 mph was selected.

Table 7-15: Corridor Characteristics

Characteristic	Design Year Vision for Corridor	Corresponding Context Classification[1]
Land Use	Primarily commercial along the corridor, with some high-rise residential structures; potential for headquarters and large company campus	Urban
Density of Structures	Medium to high, with potential for some single-story commercial buildings to remain	Suburban/Urban
Building Setback	On-street parking and sidewalks with mixed setbacks	Urban
Block Size	Medium blocks	Suburban/Urban
Access Control	Currently high level of vehicle access and low bicycle and pedestrian access, desire for more access control for vehicles to improve safety	Urban
Parking Location	On-street parking, potential for structured parking	Urban
Pedestrian Activity	High level of activity given transit stops and commercial uses	Urban
Bicyclist Activity	Some bicycle activity currently and more expected in the future	Urban
Transit	Currently frequent bus service, with enhanced transit service desired for the future	Urban
Utilities	Underground utilities	Urban
Landscaping	Currently grass landscape buffer between sidewalk and travelway, with desire for more vibrant landscaping and trees	Urban

[1]*Based on Table 3-1 in Chapter 3*

PERFORMANCE MEASURES

The project's performance measures are shown in Table 7-16. These are based on the project goals and desired outcomes for the area.

Table 7-16: Project Performance Measures Based on Goals

<table>
<tr><th>Project Goal</th><th colspan="2">Performance Measures</th></tr>
<tr><td rowspan="8">1. Enhance connectivity, access and safety for pedestrians and bicyclists along and across the corridor, including safe crossing opportunities.</td><td rowspan="5">Safety</td><td>Anticipated reduction in crashes</td></tr>
<tr><td>Pedestrian assessment (e.g., facility type, level of separation)</td></tr>
<tr><td>Bicyclist assessment (e.g., facility type, level of separation)</td></tr>
<tr><td>Design flag assessment (pedestrian)</td></tr>
<tr><td>Design flag assessment (bicyclist)</td></tr>
<tr><td rowspan="3">Pedestrian/Bicyclist Modal Integration</td><td>Pedestrian level of traffic stress (LTS)</td></tr>
<tr><td>Bicycle LTS</td></tr>
<tr><td>Average distance between marked crossings</td></tr>
<tr><td rowspan="5">2. Improve transit access and mobility.</td><td rowspan="3">Transit Mobility</td><td>Presence of transit priority treatments</td></tr>
<tr><td>Expected delay from transit stops</td></tr>
<tr><td>Expected change in transit travel time reliability</td></tr>
<tr><td rowspan="2">Transit Modal Integration</td><td>Proximity of marked street crossings to transit stop locations</td></tr>
<tr><td>Sidewalk effective width</td></tr>
<tr><td rowspan="2">3. Accommodate regional traffic moving along the corridor.</td><td rowspan="2">Vehicle Mobility/ Traffic Operations</td><td>Design year v/c ratio</td></tr>
<tr><td>Expected change in vehicle travel time reliability</td></tr>
<tr><td rowspan="3">4. Leverage local and state public investment to spur economic development.</td><td rowspan="2">Economic Revitalization</td><td>Feedback from local business owners</td></tr>
<tr><td>Market analysis of expected development</td></tr>
<tr><td>Financial Investment</td><td>Life cycle cost</td></tr>
<tr><td rowspan="3">5. Preserve and enhance existing residential neighborhoods and create a vibrant corridor that is an area destination.</td><td rowspan="3">Livability</td><td>Mode share</td></tr>
<tr><td>Presence of placemaking elements (trees, art, benches, vegetation, micromobility hubs, etc.)</td></tr>
<tr><td>Feedback from local community members</td></tr>
</table>

7.2.3 STEP 2: Concept Development (*PDN Stage 0*)

Alternatives were developed based on the initial project purpose of reducing the severity and frequency of pedestrian and bicyclist crashes, while also providing for enhanced transit service. The design guidance in Chapters 4 and 6 of the *PSG* were used along with community feedback through alternatives development workshops to generate alternatives. Key design guidance from the *PSG* includes:

- The recommended bicycle facility type for an arterial in a Urban context is a buffered bicycle lane or separated bicycle lane. A wider, striped or physical buffer is preferrable given the anticipated vehicle volumes and speeds.
- The recommended pedestrian facility type for an arterial in a Urban context is sidewalks on both sides of the roadway. A wider pedestrian zone and buffer is recommended given the frequency of transit stops on the corridor and desire for amenities to support adjacent commercial development and storefronts.
- Arterials in an Urban context typically include two to four vehicle travel lanes.

Key input from the community and local agencies includes:

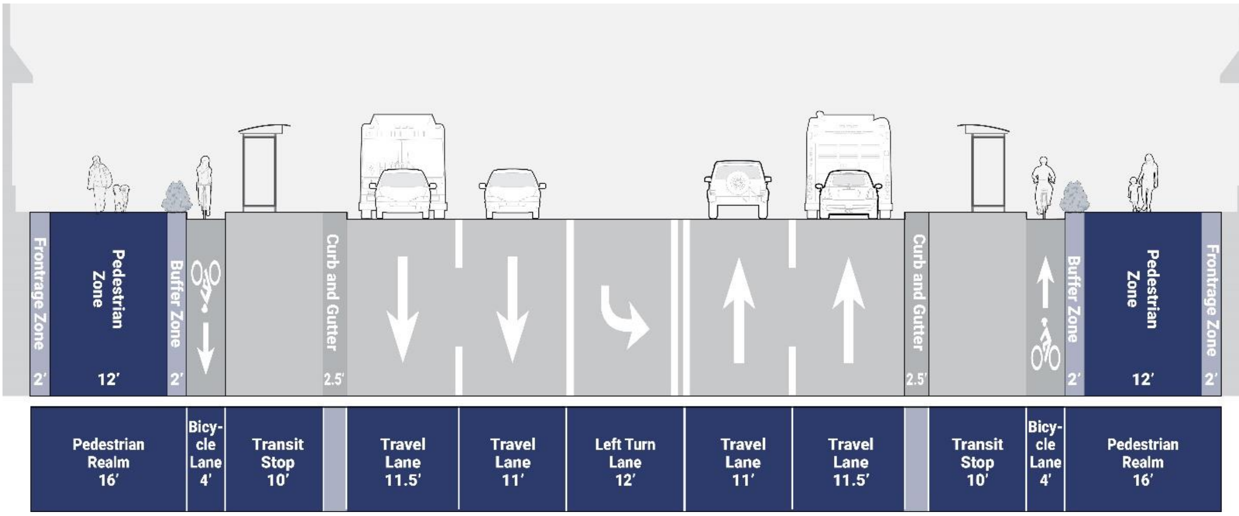
- The local transit agency has expressed a desire for designated transit lanes. They expect center-running transit lanes will provide more efficient service given the frequency of accesses and right turns along the corridor, which could lead to slow downs for buses running in the outside travel lanes. The transit agency prefers transit boarding islands (floating bus stops) with the bicycle lane routed behind the transit stop to limit interactions between transit vehicles and bicyclists.
- Business owners along the corridor are interested in increasing their visibility and providing a more aesthetically pleasing environment on the corridor, with amenities like landscaping, art, benches, and café seating.
- Community members have indicated a desire for continuous pedestrian and bicycle facilities, and expressed discomfort with current pedestrian crossings, a lack of yielding behavior from vehicles, and narrow bicycle lanes immediately next to high-speed vehicle traffic.
- Business owners and community members are concerned about reducing the number of vehicle lanes on the corridor, and potential for congestion and queueing at traffic signals.
- On-street parking is highly used due to a lack of off-street parking or structured parking. Business owners are concerned about where their customers will park if on-street parking is removed, and nearby residents are concerned about parking spilling into their neighborhoods.

Three primary alternatives were developed that maintain the existing 122′ cross-section. The alternatives are described below and illustrated in Figure 7-7 through Figure 7-9.

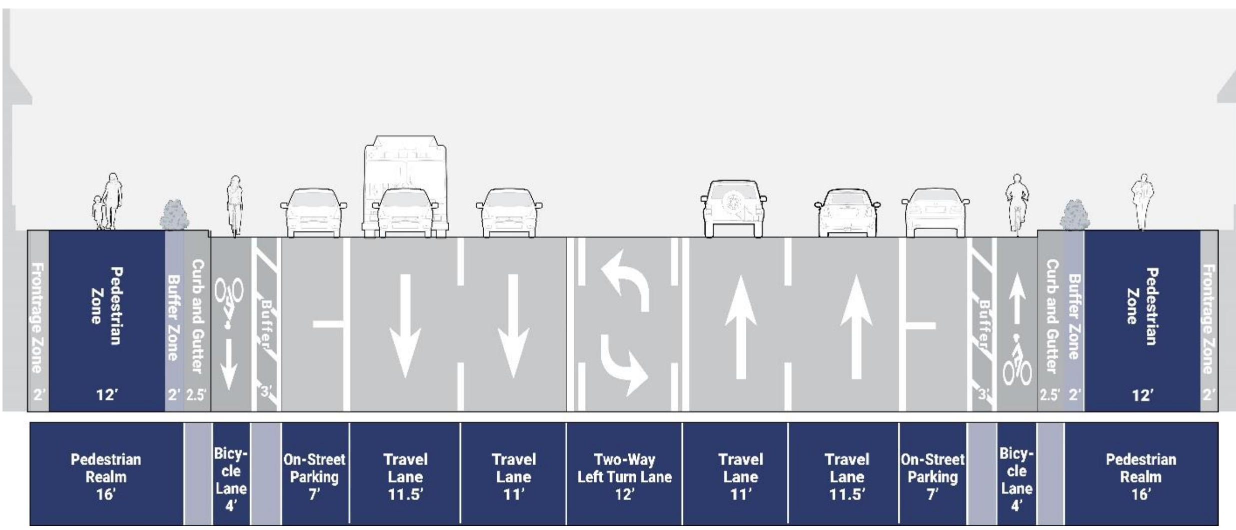
- **Alternative 1: In-Lane Transit and On-Street Parking Cross Section.** This alternative maintains five vehicle travel lanes and on-street parking, with buses sharing the lane with vehicles. In-lane floating bus stops are provided on the near or far side of intersections with transit riders crossing the bicycle lane to access the stop. The bicycle lane is moved outside of the parking lane with a 3′ striped buffer between the bicycle lane and parked vehicles to keep bicyclists out of the door zone. The pedestrian realm is widened from 14′ to 16′, with varied options for dividing the space between the frontage, sidewalk, and buffer zones.
- **Alternative 2: Exclusive Curb-Running Transit and Additional Bicycle and Pedestrian Space Cross Section**. This alternative reallocates one vehicle lane in each direction for exclusive transit lanes, which can also serve as right-turn lanes and provide business access. Floating bus stops are provided on the near or far side of intersections with transit riders crossing the bicycle lane to access the stop. The bicycle lane is widened to 7′ and separated from the transit lane by a raised separator. The pedestrian realm is widened to 21′ between intersections, with space for amenities like café seating, landscaping, bikeshare stations, public art, etc.
- **Alternative 3: Exclusive Center-Running Transit on On-Street Parking Cross Section**. This alternative provides center-running transit lanes with a raised median. Floating bus stops are provided on the far side of intersections, with transit riders using the intersection crosswalks to access the stops. Midblock stops with enhanced crossings may also be provided to serve key destinations located between intersections. Specialized signal timing is used at intersections to facilitate interactions between buses and other vehicles, with buses receiving priority treatment. A single vehicle lane is provided in each direction, with exclusive left-turn lanes at intersections. On-street parking is provided midblock. The bicycle lane is widened to 5′ and moved outside of the parking lane with a 3′ striped buffer between the bicycle lane and parked vehicles. At intersections, the bicycle lane is separated from vehicle traffic by a three-foot buffer. The pedestrian realm is widened from 14′ to 16′, with varied options for dividing the space between the frontage, sidewalk, and buffer zone.

Figure 7-7 Alternative 1—In-Lane Transit and On-Street Parking Cross Section

a. Intersection



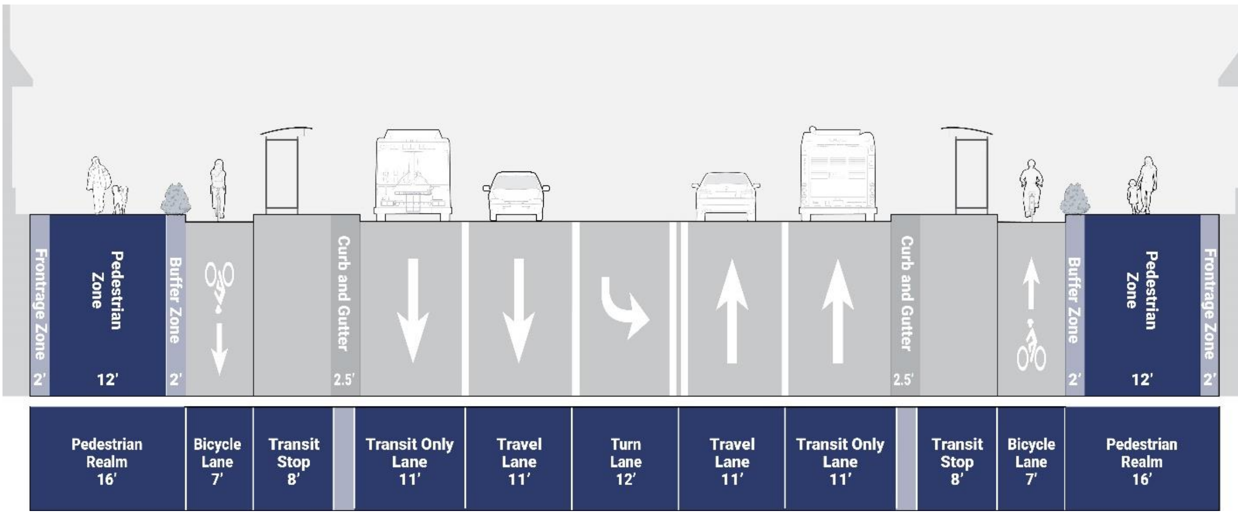
b. Midblock



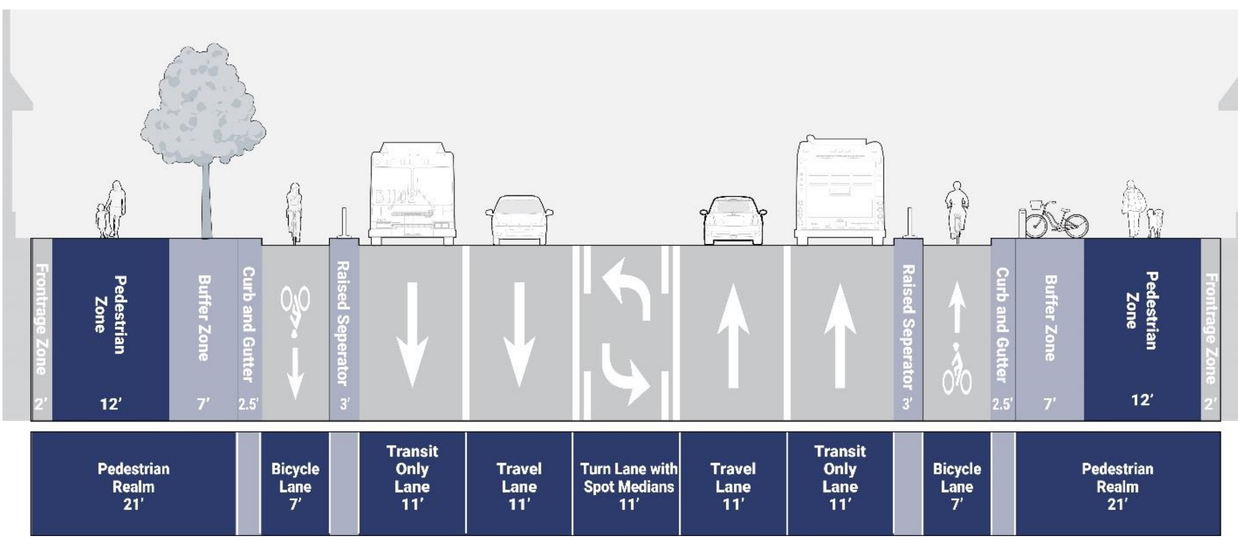
Note: Where there are intersections without transit stops, space shown as a transit stop may be used for right-turn lanes, curb extensions, and/or additional pedestrian space.

Figure 7-8 Alternative 2—Exclusive Curb-Running Transit and Additional Pedestrian Space Cross Section

a. Intersection



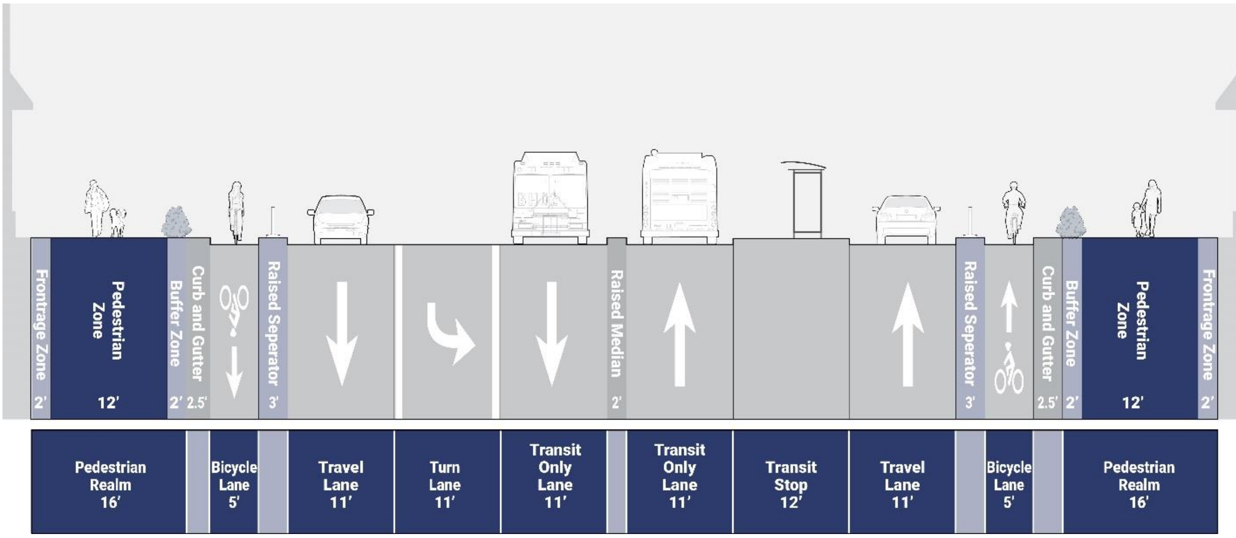
b. Midblock



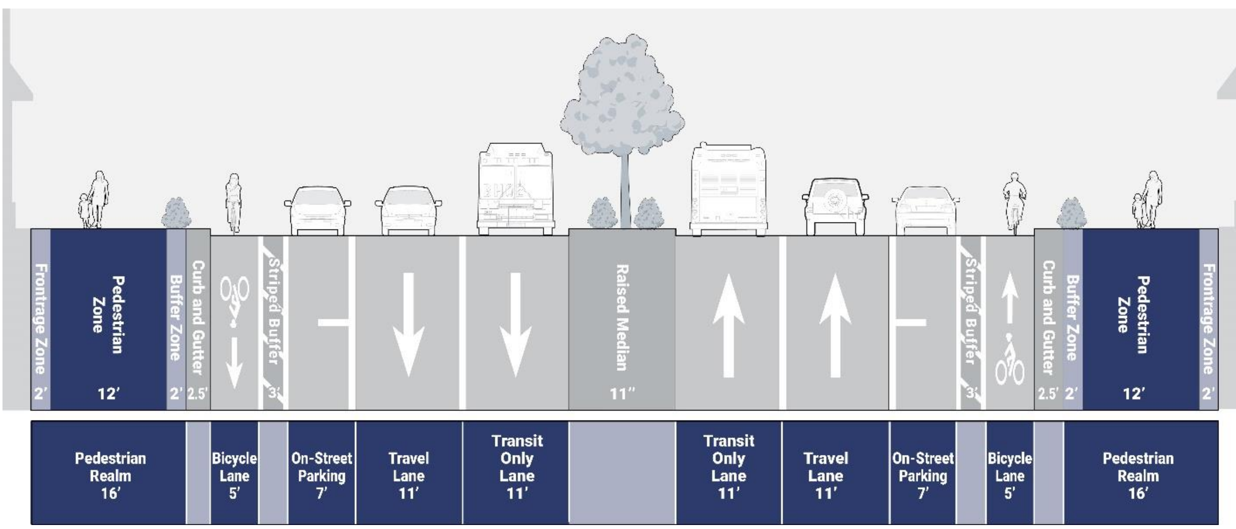
Note: Where there are intersections without transit stops, space shown as a transit stop may be used for right-turn lanes, curb extensions, and/or additional pedestrian space.

Figure 7-9 Alternative 3—Exclusive Center-Running Transit on On-Street Parking Cross Section

a. Intersection



b. Midblock



Note: Transit stops located on the far side of the intersection, so there is one transit stop on either side of the intersection. Where there are intersections without transit stops, the wider median may be maintained through the intersection.

In addition to the change in cross section, all alternatives include the following corridor improvements:

- Addition of midblock crossings where marked crosswalks are more than 550′ apart, based on the recommended spacing for pedestrian crossings on Urban arterials. Based on the corridor cross section, speeds, and volumes, enhanced crossings with curb extensions, crossing islands, and rectangular rapid flashing beacons or pedestrian hybrid beacons are proposed.
- Transit stop improvements, including addition of shelters, benches, waste receptacles, and bicycle parking.

- Revamping of the pedestrian realm, including wider sidewalks and addition of new landscaping and street trees in the buffer zone.
- Addition of pedestrian scale lighting, especially at midblock crossing locations.

Table 7-17 summarizes key considerations for each of the three alternatives.

Table 7-17: Key Considerations by Alternative

Consideration	Alt 1—In-Lane Transit	Alt 2—Exclusive Curb-Running Transit	Alt 3—Exclusive Center-Running Transit
Transit	• Transit vehicles share vehicle lane • In-lane floating transit stops at intersections	• Exclusive curb-running transit lanes • Floating transit stops at intersections • Transit signal priority at key intersections	• Exclusive center-running transit lanes • Floating transit stops at intersections • Transit signal priority at most intersections
Pedestrian	• Minium dimensions for context	• Expanded pedestrian space midblock	• Minium dimensions for context
Bicycle	• Minimum-width bicycle lane • Separated from vehicles by parking lane • Transit riders cross bicycle lane at stops	• Separated from vehicles by 3′ (could be landscaping or curb) and transit lane • Transit riders cross bicycle lane at stops • Intersection bicycle protection through addition of corner islands	• Separated from vehicles by parking lane • Intersection bicycle protection through addition of corner islands
Vehicle	• 5 vehicle lanes • Passenger and freight vehicles interact with transit vehicles and are required to stop (or change lanes) when transit vehicle stopped	• 3 vehicle lanes	• 2 vehicle lanes • Left turns allowed only at intersections
Other	• On-street parking	• No on-street parking • Transit lane could be used for right turns and vehicles accessing businesses	• On-street parking • Special signal timing required to control interactions between transit vehicles and other modes

7.2.4 STEP 3: Evaluation and Selection *(PDN Stage 1)*

IMPROVEMENT RATING PARAMETERS

The project team set parameters for the improvement ratings for each performance measure to evaluate the alternatives. The parameters are categorized with a rating of "low," "medium," or "high" to compare and evaluate the three alternatives.

Table 7-18 through Table 7-25 list the parameters for the improvement ratings for each performance measure outlined in Table 7-16.

Table 7-18: Safety Improvement Rating Summary

	SAFETY Improvement Rating		
Performance Measure	**Low**	**Medium**	**High**
Anticipated reduction in crashes	Project is not anticipated to reduce crashes	Project has a moderate value crash reduction factor	Project has a high value crash reduction factor
Pedestrian assessment	Project provides a pedestrian realm of minimum width	Project provides a pedestrian realm of minimum width with separation	Project provides a wider facility with separation
Bicyclist assessment	Project provides a facility of minimum width	Project provides a wider facility with horizontal separation	Project provides a wider facility with horizontal and vertical separation
Design flag assessment (pedestrian)	Average percentage of red and yellow design flags is over 50 percent	Average percentage of red and yellow design flags is between 15 and 49 percent	Average percentage of red and yellow design flags is less than 15 percent
Design flag assessment (bicycle)	Average percentage of red and yellow design flags is over 50 percent	Average percentage of red and yellow design flags is between 15 and 49 percent	Average percentage of red and yellow design flags is less than 15 percent

Table 7-19: Pedestrian and Bicycle Modal Integration Improvement Rating Summary

	PEDESTRIAN AND BICYCLE MODAL INTEGRATION Improvement Rating		
Performance Measure	**Low**	**Medium**	**High**
Pedestrian LTS	LTS 3 or 4	LTS 2	LTS 1
Bicycle LTS	LTS 3 or 4	LTS 2	LTS 1
Average distance between marked crossings	Distance between crossings is significantly more than target spacing	Distance between crossings is more than target spacing	Distance between crossings meets or is less than target spacing

Table 7-20: Transit Mobility Improvement Rating Summary

Performance Measure	TRANSIT MOBILITY Improvement Rating		
	Low	Medium	High
Presence of transit priority treatments	Project provides no treatments	Project provides low to moderate priority treatments	Project provides high level of priority treatments
Expected delay from transit stops	Significant delay expected from transit stops	Moderate delay expected from transit stops	Minimal delay expected from transit stops
Expected change in transit travel time reliability	Inconsistent travel time	Maintains travel time expectations	Improves travel time consistency

Table 7-21: Transit Modal Integration Improvement Rating Summary

Performance Measure	TRANSIT MODAL INTEGRATION Improvement Rating		
	Low	Medium	High
Proximity of marked street crossings to transit stop locations	Average distance to marked street crossing is >0.5 miles	Average distance to marked street crossing is 0.25-0.5 miles	Average distance to marked street crossing is ≤0.25 miles
Sidewalk effective width	≤6′	6′-10′	≥10′

Table 7-22: Vehicle Mobility/Traffic Operations Improvement Rating Summary

Performance Measure	VEHICLE MOBILITY/TRAFFIC OPERATIONS Improvement Rating		
	Low	Medium	High
Design year v/c ratio	>0.90	0.75 to 0.90	<0.75
Expected change in vehicle travel time reliability	Inconsistent travel time	Maintains travel time expectations	Improves travel time consistency

Table 7-23: Economic Revitalization Improvement Rating Summary

Performance Measure	ECONOMIC REVITALIZATION Improvement Rating		
	Low	Medium	High
Feedback from local business owners	Mostly negative feedback	Neutral or mixed feedback	Mostly positive feedback
Market analysis of expected development	Little to no development expected due to project	Moderate level of development expected due to project	High level of development expected due to project

Table 7-24: Financial Investment Improvement Rating Summary

Performance Measure	FINANCIAL INVESTMENT Improvement Rating		
	Low	Medium	High
Life cycle cost	Alternative with highest life cycle cost	Alternative with middle life cycle cost	Alternative with lowest life cycle cost

Table 7-25: Livability Improvement Rating Summary

Performance Measure	LIVABILITY Improvement Rating		
	Low	Medium	High
Expected mode share	Expected decrease in transit, pedestrian, and bicycle mode share	No change in expected mode share	Expected increase in transit, pedestrian, and bicycle mode share
Presence of placemaking elements (trees, art, benches, vegetation, micromobility hubs, etc.)	Little to no space designated for placemaking elements	Moderate amount of space designated for placemaking elements	High amount of space designated for placemaking elements
Feedback from local community members	Mostly negative feedback	Neutral or mixed feedback	Mostly positive feedback

EVALUATION RESULTS

Each alternative was evaluated based on the performance measures and improvement rating parameters. Some of the performance measures require analysis and preliminary estimating, while others are more qualitative and based on project team judgment and community input. Table 7-26 through Table 7-33 show the rating and justification for each alternative evaluation for this case study. In most cases, this evaluation is part of PDN Stage 1 and the documentation for decision-making is integrated into the Concept Report, Scope or Work Document and Project Commitment Document.

Table 7-26: Summary of Safety Evaluation

Performance Measure	SAFETY Improvement Rating		
	Alternative 1	**Alternative 2**	**Alternative 3**
Anticipated reduction in crashes	**Medium** Project provides a moderate value crash reduction factor: • Lighting[1]: 20% reduction for nighttime crashes[1] • Separated bicycle lane[2]: expected reduction bicycle crashes • Enhanced midblock crossings[3]: 47% reduction for pedestrian crashes	**High** Project provides a high value crash reduction factor: • Remove on-street parking: 42% reduction in crashes • Lighting[1]: 20% reduction for nighttime crashes[1] • Separated bicycle lane[2]: expected reduction bicycle crashes • Enhanced midblock crossings[3]: 47% reduction for pedestrian crashes	**High** Project provides a high-value crash reduction factor: • Raised median[1]: 25% reduction in crashes • Lighting[1]: 20% reduction for nighttime crashes[1] • Separated bicycle lane[2]: expected reduction bicycle crashes • Enhanced midblock crossings[3]: 47% reduction for pedestrian crashes
Pedestrian assessment	**Medium** Project provides a minimum-width pedestrian realm (16′) including vertical separation	**High** Project provides a wider pedestrian realm between intersections (21′) including vertical separation	**Medium** Project provides a minimum-width pedestrian realm (16′) including vertical separation
Bicyclist assessment	**Medium** Project provides a minimum bicycle lane (4′) with vertical separation (on-street parking) Drivers accessing parked cars cross bicycle lane Bicyclists yield to transit riders at bus stops	**High** Project provides a wider bicycle lane (7′) with vertical separation (landscaping/curb and transit lane) Bicyclists yield to transit riders at bus stops	**Medium** Project provides a near minimum bicycle lane (5′) with vertical separation (on-street parking) Drivers accessing parked cars cross bicycle lane
Design flag assessment (pedestrian)	**Medium** Average percentage of red and yellow design flags is over between 15 and 49 percent	**Medium** Average percentage of red and yellow design flags is between 15 and 49 percent	**Medium** Average percentage of red and yellow design flags is between 15 and 49 percent
Design flag assessment (bicycle)	**Medium** Average percentage of red and yellow design flags is over between 15 and 49 percent	**Medium** Average percentage of red and yellow design flags is between 15 and 49 percent	**Medium** Average percentage of red and yellow design flags is between 15 and 49 percent

[1]*FHWA Desktop Reference for Crash Reduction Factors (1)*
[2]*A crash reduction factor is not available, but providing separation between bicyclists and vehicles is expected to reduce crashes involving bicyclists*
[3]*NCHRP Research Report 841 (2)*

Table 7-27: Summary of Pedestrian and Bicycle Modal Integration Evaluation

Performance Measure	PEDESTRIAN AND BICYCLE MODAL INTEGRATION Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Pedestrian LTS	**Medium** Pedestrian LTS 2	**High** Pedestrian LTS 1	**Medium** Pedestrian LTS 2
Bicycle LTS	**Low** Bicycle LTS 3	**Medium** Bicycle LTS 2	**Medium** Bicycle LTS 2
Average distance between marked crossings	**High** Distance between crossings meets or is less than target spacing	**High** Distance between crossings meets or is less than target spacing	**High** Distance between crossings meets or is less than target spacing

Table 7-28: Summary of Transit Mobility Evaluation

Performance Measure	TRANSIT MOBILITY Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Presence of transit priority treatments	**Low** Project includes no priority treatments	**Medium** Project includes transit signal priority at key signalized intersections	**High** Signal timing used to prioritize and facilitate bus movements through all intersections
Expected delay from transit stops	**Medium** Bus stops in lane without having to merge in and out of traffic, potential for moderate delay due to interactions with vehicles	**High** Bus stops in exclusive bus lane without having to merge in and out of traffic	**High** Bus stops in exclusive bus lane without having to merge in and out of traffic
Expected change in transit travel time reliability	**Low** Buses share travel lane with vehicles, and thus are highly influenced by vehicle traffic and delays, resulting in inconsistent travel times	**Medium** Buses use transit lane, but share transit lane with right-turning vehicles and vehicles accessing businesses, resulting in some travel time inconsistency	**High** Buses exclusively use transit lane and signal timing strategies support more consistent travel times

Table 7-29: Summary of Transit Modal Integration Evaluation

Performance Measure	TRANSIT MODAL INTEGRATION Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Proximity of marked street crossings to transit stop locations	**High** Average distance to marked street crossing is ≤0.25 miles	**High** Average distance to marked street crossing is ≤0.25 miles	**High** Average distance to marked street crossing is ≤0.25 miles
Sidewalk effective width	**High** Sidewalk effective width ≥10′	**High** Sidewalk effective width ≥10′	**High** Sidewalk effective width ≥10′

Table 7-30: Summary of Vehicle Mobility//Traffic Operations Evaluation

Performance Measure	VEHICLE MOBILITY/TRAFFIC OPERATIONS Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Design year v/c ratio	**High** No capacity constraints	**Medium** Potential for moderate capacity impacts at intersections during peak hour with reduced through lanes	**Low** Potential for significant capacity impacts at intersections with reduced through and turn lanes and transit priority at intersections
Expected change in vehicle travel time reliability	**High** Free flow conditions expected during most of the day	**Medium** Free flow conditions expected during most of the day, with slight congestion during peak hours	**Low** Anticipated congestion during peak hours

Table 7-31: Summary of Economic Revitalization Evaluation

Performance Measure	ECONOMIC REVITALIZATION Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Feedback from local business owners	**Medium** Support for additional trees and higher quality landscaping along the corridor	**Medium** Concerns about removal of on-street parking and vehicle lanes Support for wider pedestrian realm with opportunities for café seating, art, public space, additional trees, and higher quality landscaping Support for higher quality transit service to support transit-oriented development	**High** Concerns about removal of vehicle lanes Support for additional trees and higher quality landscaping along the corridor Support for higher quality transit service to support transit-oriented development
Market analysis of expected development	**Medium** Improved multimodal environment to encourage higher-density development	**High** Inviting multimodal environment expected to encourage higher-density, transit-oriented development	**High** Inviting multimodal environment expected to encourage higher-density, transit-oriented development

Table 7-32: Summary of Financial Investment Evaluation

Performance Measure	FINANCIAL INVESTMENT Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Life cycle cost	**Medium** Alternative with middle life cycle cost analysis	**High** Alternative with lowest life cycle cost due to similar construction and maintenance costs as Alternative 1 but enhanced safety performance	**Low** Alternative with highest life cycle cost due to required changes for center-running transit

Table 7-33: Summary of Livability Evaluation

Performance Measure	LIVABILITY Improvement Rating		
	Alternative 1	Alternative 2	Alternative 3
Expected mode share	**Medium** Moderate increase in transit, pedestrian, and bicycle mode share expected	**High** Significant increase in transit, pedestrian, and bicycle mode share expected	**High** Significant increase in transit, pedestrian, and bicycle mode share expected
Presence of placemaking elements (trees, art, benches, vegetation, micromobility hubs, etc.)	**Medium** Moderate amount of space designated for placemaking elements	**High** High amount of space designated for placemaking elements	**Medium** Moderate amount of space designated for placemaking elements
Feedback from local community members	**Low** Concerns about width of paved area and lack of space for enhanced aesthetics	**Medium** Support for additional pedestrian space and amenities Concerns about parking spilling over into neighborhood	**Medium** Support for enhanced transit service Concerns about lack of vehicle access with median

Table 7-34 summarizes the results for each alternative performance measure. This summary can be used to communicate the results in project team meetings and public meetings to illustrate the assessment and overall outcomes.

Table 7-34: Summary of Performance Measure Evaluation

Performance Measure		Improvement Ratings Alt 1	Alt 2	Alt 3
Safety	Anticipated change in crashes	M	H	H
	Pedestrian assessment	M	H	M
	Bicyclist assessment	M	H	M
	Design flag assessment (pedestrian)	M	M	M
	Design flag assessment (bicyclist)	M	M	M
Pedestrian/ Bicyclist Modal Integration	Pedestrian LTS	M	H	M
	Bicycle LTS	L	M	M
	Average distance between marked crossings	H	H	H
Transit Mobility	Presence of transit priority treatments	L	M	H
	Expected delay from transit stops	M	H	H
	Expected change in transit travel time reliability	L	M	H
Transit Modal Integration	Proximity of marked street crossings to transit stop locations	H	H	H
	Sidewalk effective width	H	H	H
Vehicle Mobility/ Traffic Operations	Design year v/c ratio	H	M	L
	Expected change in vehicle travel time reliability	H	M	L
Economic Revitalization	Feedback from local business owners	M	M	H
	Market analysis of expected development	M	H	H
Financial Investment	Life cycle cost	M	H	L
Livability	Expected mode share	M	H	H
	Presence of placemaking elements (trees, art, benches, vegetation, micromobility hubs, etc.)	M	H	M
	Feedback from local community members	L	M	M

L = Low, M=Medium, H=High

The project team reviewed the evaluation summary, considering the original project goals and potential trade-offs between the alternatives to select the preferred alternative to move forward to the Step 4 Design Phase.

Based on the evaluation summary in Table 7-34, the project team identified the following considerations and trade-offs:

- Alternative 2 had the highest overall ratings (high and medium) compared to the other alternatives.
- While feedback from the local business owners and the community was largely favorable for Alternative 2, a common concern is the removal of on-street parking and potential impacts on customers and surrounding neighborhoods. In addition, some community members are concerned about reducing vehicle capacity on the corridor and the potential for congestion.
- There may be opportunities to retain on-street parking on some portions of the corridor with Alternative 2 by reducing the buffer zone in the pedestrian realm.

KEY TAKEAWAYS

Additional analysis may be needed to select a preferred alternative and further assess concerns from the community. For example, in this case study, additional operational analyses could be conducted to better understand impacts to vehicle capacity with the reduction in travel lanes, as well as potential for parking to spill over into the neighborhood. Based on the results, the concept could be modified to add right-turn lanes at key intersections, preserve on-street parking on blocks with higher demand, and/or identify opportunities for additional off-street parking. If changes are made, project teams should review the selected alternative against the project goals and intended outcomes again when the preliminary design and final design are developed to verify it is still consistent with the initial purpose of the project.

7.2.5 STEP 4: Design Phase *(PDN Stage 2)*

Additional constraints may become apparent throughout the design phase that require project elements to be revisited and refined. If changes are made to the preliminary concept, advanced design, or final design that are not aligned with the project context and intended outcomes, the project team should revisit the context and goals and adjust the design as needed. This iterative process ensures that if changes are made throughout the design process, the design is still consistent with the project purpose. The team should clearly document changes and provide justification for decisions.

As the project progresses through the Design Phase, it may not be necessary to formally document that each step of the design, including various design submittals, is reviewed alongside the goals and outcomes. However, if anything is inconsistent with the original project goals and outcomes and the design is revised, the project team must prepare the necessary documentation to justify the change and record it in the project file.

7.3 REFERENCES

1. Federal Highway Administration (FHWA). *Desktop Reference for Crash Reduction Factors*. Washington, D.C., 2008.
2. Transportation Research Board. National Cooperative Highway Research Program (NCHRP) Research Report 841: *Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments*. Washington, D.C., 2017.

TENNESSEE DEPARTMENT OF TRANSPORTATION

Project Scoping Guide

APPENDICES

September 2024

TN TDOT Department of Transportation

Contents

Appendix A

Glossary and Acronyms

This appendix provides a glossary of common key terms used throughout the *Project Scoping Guide (PSG)*, as well as a list of acronyms.

GLOSSARY OF KEY TERMS

- **Acceptable:** Design criteria that do not meet desirable values but are considered reasonable and safe for design purposes.
- **Accessible Pedestrian Signal (APS):** A device that communicates information about pedestrian signal timing in a non-visual format such as audible tones and/or speech messages and vibrating surfaces" *(1)*.
- **Active Transportation Considerations & Recommendations (PDN Stage 0)**: A deliverable of Stage 0: Planning of the PDN. It informs the Concept Report and ensures the project complies with TDOT's Multimodal Access Policy, incorporates recommended multimodal elements, and is coordinated with related existing or planned multimodal projects.
- **Alignment:** Geometric arrangement of a roadway (curvature, etc.).
- **All-Way Stop-Control (AWSC):** AWSC intersections require every vehicle to stop at the intersection before making a turning or through movement. If other vehicles are present at the intersection, a motorist may proceed only after determining that there are no other vehicles in the intersection and that it is their turn.
- **Americans with Disabilities Act (ADA):** A "Federal civil rights law that prohibits discrimination against people with disabilities. Under this law, people with disabilities are entitled to all of the rights, privileges, advantages, and opportunities that others have when participating in civic activities" (https://www.ada.gov/resources/title-ii-primer/). Wherever pedestrian facilities are intended to be a part of a transportation system, federal regulations (28 CFR Part 35) require that those pedestrian facilities meet or exceed ADA guidelines *(2)*.
- **Approach:** All lanes of traffic moving toward an intersection or midblock location from one direction.
- **Arterial:** A major thoroughfare that supports higher-capacity transportation through urban and suburban areas. Arterials are designated as primary routes for regional or intercity travel.

- **Average Daily Traffic (ADT):** The average number of vehicles passing a certain point each day on a highway, road, or street.
- **Bicycle Lane:** A conventional bicycle lane is designated exclusive space for bicyclists immediately adjacent to vehicle traffic.
- **Buffer:** Separation between roadway users or facilities. Buffer space typically increases the comfort and safety of roadway users and is especially recommended where there are high speed differentials between users. A variety of features can be present in the buffer space, including pavement markings, landscaping, transit stops, mailboxes, utilities, bicycle parking, lighting, street furnishings, etc.
- **Buffered Bicycle Lane:** A conventional bicycle lane paired with a designated buffer space (created by pavement markings) that separates the bicycle lane from the adjacent motor vehicle travel lane or parking lane.
- **Bus Bulb:** A curb extension that primarily serves as a bus stop. Bus bulbs are primarily used on roadways with on-street parking or shoulders and extend the width of the paring lane or shoulder. Bus bulbs enable buses to stop without leaving the travel lane.
- **Bus Rapid Transit (BRT):** A "high-quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms and enhanced stations… Because BRT contains features similar to a light rail or subway system, it is often considered more reliable, convenient and faster than regular bus services" *(3)*.
- **Capacity Analysis for Planning of Junctions (CAP-X):** A tool developed by the Federal Highway Administration (FHWA) to provide practitioners with a means of evaluating the anticipated operational performance of both conventional and innovative intersection and interchange control options. The CAP-X tool is now maintained by the Crash Modification Factors Clearinghouse (CMF), which is funded by FHWA and maintained by the University of North Carolina Highway Safety Research Center. The CAP-X tool uses a critical lane volume analysis to determine the volume to capacity (v/c) ratio for a variety of intersection control strategies and provides an assessment of the pedestrian and bicycle accommodations for the selected intersection types.
- **Clear Zone:** Roadside border area starting at the edge of the traveled way that is available for safe use by errant vehicles. Establishing a minimum width clear zone implies that rigid objects and certain other hazards with clearances less than the minimum width should be removed and relocated outside the minimum clear zone or remodeled to make breakaway, shielded, or safely traversable.
- **Collector:** A street that collects traffic from local streets and directs it towards arterials. Collectors are usually located within residential or commercial areas and are designated as secondary routes for intracity travel.

- **Concept Report (PDN Stage 0)**: A deliverable of PDN Stage 0: Planning, the Concept Report develops an initial project vision, conceptual layout, and cross section, including pedestrian facilities (type, with, buffer).
- **Conflict Point:** Locations where roadway user travel paths intersect. Conflict points can be categorized into crossing, merging, or diverging. In general, merging and diverging conflict points—where users are moving in the same direction—are associated with less severe crash types than crossing conflict points, where users move in opposite directions. Safety research suggests that intersection crash rates are related to the number of conflicts at an intersection. Conflict points also occur at accesses and midblock crossings.
- **Connected and Automated vehicles (CAVs):** Vehicles able to communicate with each other and roadside infrastructure to make driving decisions automatically. CAVs are currently under development and have the potential to change how vehicles interact with each other, the roadway, and other users.
- **Construction Projects on Existing Roads:** Projects "that keep the existing roadway alignment (except for minor changes) and do not change the basic roadway type. Such projects are classified for design purposes by the primary reason the project is being undertaken or the specific need being addressed. The typical project needs addressed by road and street improvement projects on existing roads include: repair infrastructure condition, reduce current or anticipated traffic operational congestion, reduce current or anticipated crash patterns" *(4)*.
- **Context Classifications:** Five TDOT contexts (Rural, Rural Town, Suburban, Urban, and Urban Core) that broadly identify the various built environments along TDOT roadways based on existing or future land use characteristics, development patterns, and roadway connectivity. The term context and context classification are used interchangeably throughout the *PSG*.
- **Control vehicle:** The control vehicle selected for an intersection influences geometric design elements. The control vehicle infrequently uses a facility, but encroachment into opposing traffic lanes, multiple-point turns, or minor encroachment on the roadside is acceptable (e.g., using available pavement). The control vehicle may include buses, trucks, emergency vehicles and other types of vehicles that will navigate the intersection.
- **Criteria:** A term that is typically applied to design values, usually with no suggestion as to the criticality of the design value.
- **Crossing Island/Pedestrian Refuge:** An island in the median to provide a protected area for pedestrians or bicyclists to stop while crossing the roadway. Crossing islands enable pedestrians and bicyclists to make two-stage crossings, meaning they can cross only one direction of vehicle travel at a time.
- **Cross Section Realm**: TDOT organizes cross sections into four realms: land use, pedestrian, transition, and travelway.

- **Crosswalk:** As defined in the *Public Right-of-Way Accessibility Guidelines (PROWAG)*, a crosswalk is "that part of a roadway that is located at an intersection included within the connections of the lateral lines of the pedestrian circulation paths 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 pedestrian circulation path on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the pedestrian circulation path at right angles to the center line; or at any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by pavement marking lines on the surface. Crosswalks at intersections may be marked or unmarked" *(5)*.
- **Curb Extension/Bulb Out:** An extension of the curb used at an intersection or midblock crossing to shorten the crossing distance for pedestrians while narrowing the vehicle path. They are typically used on roadways with curbs and on-street parking or shoulders. In general, curb extensions should extend the width of the shoulder or parking lane, with the curb face approximately one foot from the edge line of the through travel lane.
- **Curb Ramp:** Curb ramps are used to transition pedestrians or bicyclists between different grades and are typically required at crossings, except where the crossing is raised to be even with the sidewalk or pedestrian facility. Perpendicular design curb ramps are required. Parallel, blended transition, and lowered-corner curb ramps are appropriate for areas with right-of-way constraints and must be approved through the Design Exception/Deviation/Waiver process.
- **Curb:** A vertical or sloping member along the edge of a pavement or shoulder forming part of a gutter, strengthening or protecting the edge, and clearly defining the edge of vehicle operators.
- **Design Exception**: Requested approval for exceptions relating to the controlling design criteria listed in TDOT's *Roadway Design Guidelines* and as defined by FHWA. There are 10 controlling criteria for roadways with a design speed of 50 mph or greater (design speed, lane width, shoulder width, horizontal curve radius, superelevation rate, maximum grade, stopping sight distance, cross slope, vertical clearance, and design loading structural capacity) and two controlling criteria for roadways with a design speed of less than 50 mph (design speed and design loading structural capacity) *(6)*.

- **Design Flags:** NCHRP Research Report 948: *Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges* includes 20 design flags as a proxy for quantitative performance measures, streamlining pedestrian and bicyclist safety evaluations so they can be scored alongside other criteria during the alternatives assessment stage and throughout the design process. This methodology is intended to efficiently inform facility selection and design decisions during the project development phases to improve pedestrian and bicyclist safety outcomes. Chapter 5 of the *PSG* provides additional guidance on applying this to TDOT projects using the TDOT *20-Flag Intersection Evaluation Guide*.
- **Design Speed**: The selected speed used to determine design criteria such as horizontal and vertical alignment, lane width, shoulder width, grade, and stopping sight distance.
- **Design Vehicle:** The design vehicle selected for an intersection influences geometric design elements. The design vehicle is the largest vehicle that frequently uses a facility and should be designed without encroaching into adjacent and opposing traffic lanes (e.g., turning lane to lane).
- **Design Waiver:** Requested approval for variances from the TDOT Standard Drawings.
- **Desirable, Preferred:** An indication that the project team should make every reasonable effort to meet the criteria and that they should only use a less desirable or less preferred design after due consideration of the desirable or preferred design.
- **Detectable Warning Surface:** Truncated domes used to alert pedestrians with vision impairments that they are approaching a roadway crossing, conflict, or change in grade.
- **Freight Route:** The network of highways that have been identified as critical in supporting the movement of freight across the state.
- **Functional Classification (Facility Type):** process by which streets and highways are grouped into classes, or systems, according to the character of service they are intended to provide. The *PSG* focuses on local, collector, and arterial roadways.
- **Goals:** A brief list of succinct points that speak to the community's priorities and vision as they relate to transportation and the associated land use goals of the study area. The goals should consider the range of existing and anticipated social, economic, and environmental conditions while also reflecting the roadway designation.
- **Grade:** The rate of change of the vertical alignment, typically described as a percentage. The maximum vertical grade for a roadway is based on the design speed and terrain type. If the maximum grade is exceeded, a Design Exception is required.
- **Grade-Separated Crossing:** A bridge (overcrossing) or a tunnel (undercrossing) designed to carry pedestrians, bicyclists, and other non-motorized users over or under a roadway or other barrier to travel, such as a waterway or railroad crossing.

- **Guidance:** A statement of recommended but not mandatory practice in typical situations, with deviations allowed if engineering judgment or an engineering study indicates they are appropriate. The verb "should" is typically used. The verbs "shall" and "may" are not used in guidance statements. Guidance statements are sometimes modified by options.
- **Horizontal Clearance:** "the lateral offset distance from the edge of the traveled way, shoulder or other designated point to a vertical roadside element" *(7)*. Horizontal clearances are influenced by the design speed for the context but should consider the pedestrian crossings and needs of each user. Higher-speed roadways may require a wider clearance to attain desired sight lines. Areas with larger design vehicles may also require wider clearances and lane widths to integrate heavy vehicle tracking or oversize/overweight (OSOW) vehicles.
- **Intersection and Interchange Evaluation (IIE) process:** An IEE process provides the framework, steps, and tools for assessing trade-offs between different intersection forms and control types. It offers project teams decision support as they select the combination of intersection form and control that best meets the intended outcomes and goals of an agency,
- **Intersection Sight Distance (ISD):** ISD provides a driver approaching an intersection an unobstructed view of potentially conflicting road users, enabling them to complete their intended maneuver at the intersection. According to the American Association of State Highway Transportation Officials' (AASHTO) *A Policy on Geometric Design of Highways and Streets (Green Book)*, "Specified areas along intersection approach legs and across their included corners should be clear of obstructions that might block a driver's view of potentially conflicting vehicles. These specified areas are known as clear sight triangles. The dimensions of the legs of the sight triangles depend on the design speeds of the intersecting roadways and the type of traffic control used at the intersection" *(4)*.
- **Intersection:** The area of the roadway created when two or more roadways join together at any angle.
- **Land Use Realm:** The area immediately adjacent to the right of way. It may include pedestrian space, amenities such as bicycle parking and café seating, utilities, landscape, on-site parking, and other uses on private property.
- **Level of Service (LOS):** a range of operating conditions defined for each type of facility and related to the amounts of traffic that can be accommodated at each level.
- **Level of Traffic Stress (LTS):** A tool for quantifying the level of comfort a pedestrian or bicyclist feels when using a facility, using a rating from LTS 1 (little to no stress) to LTS 4 (high stress).

- **Life Cycle Cost Analysis:** All costs—agency and user—incurred during the design life of a project. Life-cycle cost analysis provides transportation officials with a total cost of transportation options instead of focusing solely on initial construction and engineering cost. In TDOT's Intersection and Interchange Evaluation (IIE) process, life cycle cost analysis is recommended but optional.
- **Light Rail Transit:** A form of "rapid transit that operates electric-powered single cars or short trains on fixed rails. Light refers to lighter passenger capacity, not the physical weight of the vehicles" *(8)*.
- **Local:** A low-volume road that provides access to individual properties, such as homes, businesses, and institutions.
- **May, Could, Can, Suggest, Consider:** A permissive condition. The project team is allowed to apply individual judgment and discretion to the criteria when presented in this context.
- **Median:** A continuous divisional island which separates opposing traffic and may be used to separate left-turning traffic from through traffic in the same direction as well. Medians may be designated by pavement markings, curbs, guideposts, pavement edge or other devices.
- **Micromobility Users**: "Any small, low-speed, human- or electric-powered transportation device, including bicycles, scooters, electric-assist bicycles (e-bikes), electric scooters (e-scooters), and other small, lightweight, wheeled conveyances" *(9)*. For TDOT facilities, scooters are considered the same type of user as a bicyclist for planning and design considerations.
- **Minimum, Maximum, Lower, Upper (Limits):** Representative of generally accepted limits within the design community but not necessarily suggesting that these limits are inflexible.
- **Modal Integration**: Consideration of a variety of users for a roadway facility, based on design year context, desired goals and outcomes, and other factors. Where there are constraints, trade-offs may need to be evaluated considering modal integration and priorities.
- **Multimodal:** The different types of roadway users traveling through the transportation system and considered collectively..
- **National Highway System:** The network of highways within the United States, including within Tennessee, that support the national economy, defense, and mobility, including the Interstate Highway System and other roads that serve airports, seaports, railroad terminals, military bases, etc.

- **New Construction Project:** Projects "that construct roads on new alignment where no existing roadway is present… New construction projects can often use traditional design criteria because there are often fewer constraints in construction on a new alignment than in projects on existing roads." *(4)*.
- **Operating Speed**: The speed at which drivers are observed operating their vehicles during free-flow conditions.
- **Option:** A statement of practice that is a permissive condition and carries no requirement or recommendation. Option statements sometimes contain allowable modifications to a standard or guidance statement. The verb "may" is typically used. The verbs "shall" and "should" are not used in option statements.
- **Passing Sight Distance (PSD):** The minimum length of roadway a driver needs to be able to see to execute a passing maneuver of a single isolated vehicle. Passing sight distances only applies to two-lane highways and generally to low-volume roadways in a Rural context.
- **Pedestrian Hybrid Beacon (PHB)**: "A special type of beacon that is intentionally placed in a dark mode (no indications displayed) between periods of operation and, when operated, displays both steady and flashing traffic control signal indications… [a] Pedestrian Hybrid Beacon [is] used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk" *(1)*.
- **Pedestrian Realm:** The area between the curb and the edge of right-of-way that includes space for pedestrians and the buffer zone.
- **Performance Measures:** Metrics that evaluate an alternative's ability to respond to the specific needs of the facility's users. Performance measures should relate directly to the project's documented goals.
- **Performance-Based Design Approach:** A decision-making approach for guiding and documenting planning and design decisions that emphasizes the outcomes from decisions as the primary measure for design effectiveness and project success.
- **Plans, Specifications, and Estimates** (PS&E)**:** Usually refers to the time when the plans, specifications, and estimates on a project have been completed and referred to FHWA for approval. When the PS&E have been approved, the project goes to bidding.
- **Policy:** Indicates TDOT practice, which TDOT generally expects the project team to follow, unless otherwise justified. TDOT policies are adopted through a formal process with the Policy Committee.
- **Posted Speed**: The maximum speed at which a vehicle may legally travel on a particular stretch of road.
- **Project Delivery Network (PDN) Stage:** A major step of the project development process that concludes with a milestone.

- **Project Delivery Network (PDN):** A scalable guide for those involved with the delivery and management of projects. The PDN was developed to provide consistency and transparency throughout the project delivery process, enabling project teams to improve reliability and efficiency. The PDN outlines the stages, activities, tasks, deliverables, and (links to) references to accomplish these ends.
- **Project-Specific Design Criteria Document (PDN Stage 1)**: A deliverable of PDN Stage 1: Context/Scoping, the Project-Specific Design Criteria Document establishes criteria including design speed, lane and shoulder widths, sight distance, design vehicle, and potential Design Exceptions/Deviations/Waivers.
- **Public Right-of-Way Accessibility Guidelines (PROWAG):** Minimum guidelines for the public right-of-way by the U.S. Department of Justice and the U.S. Department of Transportation.
- **Raised Crossing:** An elevated crossing that brings the level of the roadway even with the sidewalk, shared-use path, or other pedestrian/bicycle facility, providing a level pedestrian and/or bicyclist path. The crossing acts as a speed table, requiring vehicles to slow and improving safety for pedestrians and/or bicyclists crossing the roadway.
- **Reconstruction Projects:** Projects "that utilize an existing roadway alignment (or make only minor changes to an existing alignment), but involve a change in the basic roadway type. Changes in the basic roadway type include widening a road to provide additional through lanes or adding a raised or depressed median where none currently exists, and where these changes cannot be accomplished within the existing roadway width (including shoulders)" *(4)*.
- **Rectangular Rapid Flashing Beacon (RRFB)**: "[A] pedestrian-activated and/or bicycle-activated device comprising two horizontally arranged, rapidly flashed, rectangular-shaped yellow indications that is used to provide supplemental emphasis for a pedestrian, school, or trail crossing warning sign at a marked crosswalk across an uncontrolled approach" *(1)*.
- **Right-of-Way (ROW):** A general term denoting publicly-owned land, property or interest therein, usually in a strip acquired or devoted to transportation purposes. The entire width between the exterior right-of-way lines including the paved surface, shoulders, ditches, and other drainage facilities in the border area between the ditches or curbs and right-of-way line.
- **Roadway User:** Pedestrian, bicyclist, micromobility user, motorcyclist, motorist, transit user, freight handler, or other individual traveling on, crossing, or accessing a roadway.

- **Roundabout:** A roundabout is a generally circular intersection form that uses yield-controlled approaches on all its legs. Drivers must slow down prior to entering the roundabout and give way to vehicles that are in the roundabout. Additional information on roundabout design is provided in NCHRP Research Report 1043: *Guide for Roundabouts* and TDOT's *Roundabout Design Reference Guide*.
- **Rural Town:** Areas with low density but diverse land uses with commercial main street character, potential for on-street parking and sidewalks, and small setbacks.
- **Rural:** Areas with the lowest density, few houses, or structures (widely dispersed or no residential, commercial, or industrial uses), and usually large setbacks.
- **Safe System Approach (SSA):** Holistic approach to road systems and safety that seeks to eliminate serious injury and fatal crashes. It is based on six principles: "deaths and serious injuries are unacceptable, humans make mistakes, humans are vulnerable, responsibility is shared, safety is proactive, and redundancy is crucial" *(10)*.
- **Safety Performance for Intersection Control Evaluation (SPICE):** The SPICE tool was developed to assist practitioners with conducting intersection safety analysis during the scoping and screening stages of project development. This tool allows practitioners preparing Intersection and Interchange Evaluations (IIE) to consider predictive safety performance. The SPICE tool utilizes Safety Performance Functions (SPFs) and crash modification factors (CMFs).
- **Separated Bicycle Lane (Cycle Track):** A facility for bicyclists that is located within or directly adjacent to the roadway and is physically separated from motor vehicle traffic by a curb, median, on-street parking, or other vertical element.
- **Shall, Require, Will, Must:** A mandatory condition. The project team is obligated to adhere to the criteria and applications presented in this context or to perform the evaluation indicated. A deviation from the criteria may be granted through the Design Exception/Deviation/Waiver process.
- **Shared Lane:** A travel lane that provides space for both bicyclists and motor vehicles. Because experience for bicyclists is highly impacted by vehicle volume and speed, shared roadways are generally only appropriate where speeds are 25 miles per hour or less and traffic volumes are lower.
- **Shared Street (Woonerf):** A street used by pedestrians, vehicles, and bicyclists without designated separate space for different users. Typically, shared streets are used where vehicle speeds and volumes are very low or when there are severe constraints that limit the ability to provide separate spaces for different users.
- **Shared-Use Path:** A combined pedestrian and bicycle facility located within an independent right-of-way or the street right-of-way and physically separated from motor vehicle traffic by an open space or barrier. Most shared-use paths are designated for two-way travel and are designed for both daily commuting and recreation.

- **Should, Recommend:** An advisory condition. The project team is strongly encouraged to follow the criteria and guidance presented in this context unless there is reasonable justification not to do so. The decision made by the project team should be documented.
- **Shy Distance:** The space between a pedestrian, bicycle or vehicle facility and a vertical element, like a curb or building.
- **Sidewalk:** Dedicated space for pedestrians along a roadway. Sidewalks are typically provided on both sides of a roadway and ideally separated from vehicle traffic by a buffer or positive protective device where a buffer is not feasible. Sidewalk width is based on the design year context and anticipated pedestrian volumes and users.
- **Standard Drawings:** Detailed drawings for work or methods of construction that are selectively included in a project book.
- **Standard:** A statement of minimum required practice. An exception from the standard may be granted through the Design Exception/Waiver/Deviation process (discussed in Chapter 2) and requires approval.
- **State Highway System:** The network of TDOT-maintained roadways that supplements the National Highway System to provide statewide coverage.
- **State Industrial Access (SIA) Program:** The SIA Program seeks to "provide access to industrial areas and to facilitate the development of expansion and industry within the State of Tennessee" by designating Industrial Highways based on eligibility criteria and an application process *(11)*.
- **Stopping Sight Distance (SSD):** The distance that a motorist needs to be able to stop before colliding with something in the road, such as another vehicle, pedestrian, debris, etc. SSD is based on design speed and assumptions for driver reaction time, the braking ability of most vehicles under wet pavement conditions, and the friction provided by most pavement surfaces.
- **Suburban:** Areas with medium density, mixed land uses within and among structures (including mixed-use town centers, commercial corridors, and residential areas), and varied setbacks.
- **Superelevation:** Roadway banking on the approach to and through a horizontal curve that makes it more comfortable for motorists to navigate the curve.
- **Support:** An informational statement that does not convey any degree of mandate, recommendation, authorization, prohibition, or enforceable condition. The verbs "shall," "should," and "may" are not used in support statements.
- **Target Speed**: The highest speed at which vehicles should operate on a thoroughfare in a specific context. TDOT uses target speed to identify a desired operating speed and develop design strategies and elements that reinforce the desired operating speed.

- **Tort Liability:** Torty liability and risk refer to the potential for a court to find a transportation agency responsible for personal injuries or property damage caused by negligent street design or failure to fulfill a duty to maintain transportation facilities in a reasonably safe manner.
- **Traffic Control Device (TCD):** Any sign, signal, marking, or device placed, operated or erected for the purpose of guiding, directing, warning or regulating traffic.
- **Traffic Signal:** Traffic signals are electrically-operated traffic control devices that indicate to roadway users when they may advance through an intersection. Traffic signals allow the shared use of road space by separating conflicting movements.
- **Transition Realm:** The area immediately adjacent to the curb or sidewalk edge (e.g., parking, loading, transit stops) that may also include non-pedestrian areas behind the curb (e.g., curb-separated bicycle lanes).
- **Travelway Realm:** The center of the right-of-way used for movement, typically including travel lanes, median (including median separated bicycle or bus lanes), and/or turn lanes.
- **Turning Radii:** At intersections, turning radii are the space a majority of vehicles need to navigate without encroaching on adjacent lanes or objects.
- **Two-Way Stop-Control (TWSC):** At TWSC intersections, the stop-controlled approaches are on the minor street and the free-flowing approaches are on the major street. Drivers must find gaps in the major street traffic to make a turning or through movement.
- **Typical:** Indicates a design practice that is most often used in application. However, this practice does not necessarily represent the desirable treatment at a given site.
- **Unmarked Crosswalk:** A legal pedestrian route across a roadway not marked with signage or pavement markings. Pedestrians have the same right-of-way at unmarked crosswalks as they do at marked crosswalks.
- **Urban Core:** Areas with highest density, mixed land uses within and among predominately high-rise structures, and small setbacks.
- **Urban:** Areas with high density, mixed land uses and prominent destinations, potential for some on-street parking and sidewalks, and mixed setbacks.
- **Vertical Clearance:** The distance between the roadway surface and an overhead obstruction, such as a sign or bridge.
- **Volume to Capacity (v/c) Ratio**: A measure of roadway congestion, calculated by dividing the number of vehicles passing through a section of highway during the peak hour by the capacity of the section.
- **Yield**: A yield-controlled intersection requires vehicles to slow down and give way to all other traffic going through the intersection. If no other traffic is present at the intersection, a driver may slow down but not stop before entering the intersection.

LIST OF ACRONYMS

Acronym	Definition
AASHTO	American Association of State Highway Transportation Officials
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
APS	Accessible Pedestrian Signal
AWSC	All-Way Stop-Control
BRT	Bus Rapid Transit
CAV	Connected and Automated Vehicle
CAP-X	Capacity Analysis for Planning of Junctions
CFR	Code of Federal Regulations
CMAQ	Congestion Mitigation and Air Quality
CMF	Crash Modification Factor
EPA	Environmental Protection Agency
ETSA	Environmental Technical Study Area
FAST Act	Fixing America's Surface Transportation (FAST) Act
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HSAM	Highway System Access Manual
ICE	Intersection Control Evaluation
IIE	Intersection and Interchange Evaluation
IIJA	Infrastructure Investment and Jobs Act
ITE	Institute of Transportation Engineers
LOS	Level of Service
LRT	Light Rail Transit
LTS	Level of Traffic Stress
MMLOS	Multimodal Level of Service
mph	Miles Per Hour

Acronym	Definition
MPT	Multimodal Prioritization Tool
MUT	Median U-Turn intersection
MUTCD	*Manual on Uniform Traffic Control Devices*
NACTO	National Association of City Transportation Officials
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
OCT	Office of Community Transportation
OSOW	Oversize/Overweight
PCD	Project Commitment Document
PDN	Project Delivery Network
PFR	Pedestrian Fatality Rate
PHB	Pedestrian Hybrid Beacon
PLTS	Pedestrian Level of Traffic Stress
PROWAG	Public Right-of-Way Accessibility Guidelines
PS&E	Plans, Specifications, and Estimates
PSG	Project Scoping Guide
RDG	Roadway Design Guidelines
ROW	Right-of-Way
RRFB	Rectangular Rapid Flashing Beacon
SIA	State Industrial Access
SPICE	Safety Performance for Intersection Control Evaluation
SSA	Safe System Approach
TCA	Tennessee Code Annotated
TDOT	Tennessee Department of Transportation
TWSC	Two-Way Stop Control
USDOT	United States Department of Transportation
v/c	Volume-to-Capacity Ratio
VMT	Vehicle Miles Traveled

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Appendix B

Policies

This appendix provides additional information on national policies and legislation that influence TDOT's planning and design practice, including:

- Fixing America's Surface Transportation (FAST) Act Design Flexibility and Multimodal Guidance
- Infrastructure Investment and Jobs Act (IIJA)
- U.S. Department of Transportation (USDOT) Policy Statement on Bicycle and Pedestrian Accommodation
- Federal Highway Administration (FHWA) Design Flexibly Guidance
- FHWA Bicycle and Pedestrian Facility Design Flexibility
- FHWA Strategic Agenda for Pedestrian and Bicycle Transportation
- FHWA Safe System Approach

FAST ACT DESIGN FLEXIBILITY AND MULTIMODAL GUIDANCE

The Fixing America's Surface Transportation Act (FAST Act) is the bill that authorized and governed United States federal surface transportation spending between fiscal years 2016 and 2020. The FAST Act authorized funding for highway, highway and motor vehicle safety, public transportation, motor carrier safety, hazardous materials safety, rail, and research, technology, and statistics programs. *(1)*

The FAST Act made several changes to design standards to increase flexibility and provide for greater accommodation of all highway users and their safety. It required the United States Department of Transportation to encourage states and Metropolitan Planning Organizations (MPOs) to adopt design standards for federal surface transportation projects that provide for adequate accommodation of all users of the surface transportation network, including motorized and non-motorized users in all stages of project planning, development, and operation.

The FAST Act listed two resources that must be considered in developing design criteria. These resources are:

- American Association of State Highway and Transportation Officials (AASHTO) *Highway Safety Manual*
- National Association of City Transportation Officials (NACTO) *Urban Street Design Guide*

The *Highway Safety Manual (HSM)* contains concepts, guidelines, and computational procedures for predicting the safety performance of various highway facilities. This allows the inclusion of predictive safety analysis as a determinant in the alternatives analysis. The NACTO *Urban Street Design Guide* promotes the concept of streets as spaces for people as well as arteries for traffic. It typically places more emphasis on non-motorized transportation.

TDOT publishes its roadway design standards and guidelines online at: https://www.tn.gov/tdot/roadway-design/design-standards.html. These standards are based on many sources but lean heavily on AASHTO's *A Policy on Geometric Design of Highways and Streets (Green Book)*. Under the FAST Act, a locality may use a different roadway design publication than the state (with state approval), if the roadway is owned by the locality, the roadway is not on the Interstate System, the locality is the direct recipient of federal funds for the project, the publication is recognized by FHWA and adopted by the locality, and the design complies with all other applicable federal laws. To date, no locality in Tennessee has petitioned TDOT for the ability to use different standards, nor has TDOT developed an allowance process.

More information on the FAST Act is available on FHWA's website.

INFRASTRUCTURE INVESTMENT AND JOBS ACT (IIJA)

The IIJA provides investment in infrastructure and includes funding for bridges through the Bridge Formula Program (BFP).

The BFP funding established in the IIJA is "subject to requirements for accommodations for bicycles and pedestrians pursuant to 23 U.S.C. 217(e). Under this provision, all projects with Federal financial participation (including under BFP) that replace or rehabilitate a highway bridge deck are required to provide safe accommodation of pedestrians or bicyclists, as applicable, on the bridge, when both of the following conditions are met: (1) the bridge is located on a highway on which pedestrians or bicyclists are allowed to operate at each end of the bridge, and (2) FHWA determines that safe accommodation can be provided at reasonable cost." *(2)*

To determine whether safe accommodation can be provided at reasonable cost, FHWA relies on its bicycle and pedestrian travel accommodation policy. FHWA assumes accommodation can be provided at a reasonable cost absent evidence that the cost of such accommodation would exceed 20 percent of the cost of the larger project.

- Concept of minimum vs. desired
- Multimodal land use context considerations
- Summary of Findings from UT Research: *Addressing Traffic Safety to Reduce Pedestrian Injuries and Fatalities in Tennessee*

USDOT POLICY STATEMENT ON BICYCLE AND PEDESTRIAN ACCOMMODATION

The USDOT policy is to incorporate walking and bicycling facilities into transportation projects. The USDOT policy statement indicates that:

> "The DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects. Every transportation agency, including DOT, has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and bicycling into their transportation systems. Because of the numerous individual and community benefits that walking and bicycling provide—including health, safety, environmental, transportation, and quality of life—transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes." *(3)*

FHWA DESIGN FLEXIBILITY GUIDANCE

Historically, 13 controlling design criteria had been identified by FHWA as having substantial importance to the operational and safety performance of highways on the National Highway System (NHS). On October 7, 2015, FHWA published a notice in the Federal Register soliciting comments on proposed changes to the 1985 policy establishing 13 controlling criteria for design *(4)*. The October notice clarified when design exceptions are required and the documentation that is expected to support such requests. After considering the comments received, FHWA published a final notice in the Federal Register on May 5, 2016.

The revised change to controlling criteria policy reduced the number of controlling criteria from 13 to 10 for Interstate highways, other freeways, and on other roadways on the NHS with design speeds greater than or equal to 50 miles per hour (mph). The three criteria eliminated were bridge width, vertical alignment, and lateral offset to obstruction. On non-NHS roadways and NHS roadways with a design speed less than or equal to 45 mph, the controlling criteria were reduced from 13 to 2. Only design loading structural capacity and design speed apply to these routes. The controlling criteria are listed in Table B-1.

Table B-1: Controlling Criteria Requiring FHWA Design Exception

NHS Route and Speed ≥ 50 mph	Non-NHS or NHS and Speed ≤ 45 mph
Design Speed Lane Width Shoulder Width Horizontal Curve Radius Superelevation Rate Stopping Sight Distance Maximum Grade Cross Slope Vertical Clearance Design Loading Structural Capacity	Design Speed Design Loading Structural Capacity

The policy also clarified when design exceptions are needed and the documentation that is expected to support such requests. These changes provide considerable design flexibility, especially on low-speed routes.

FHWA requires a written design exception if design criteria on the NHS are not met for any of the controlling criteria. Exceptions may be approved on a project-by-project basis for designs that do not conform to the minimum or limiting criteria. Design exceptions, subject to approval by FHWA, are required for projects on the NHS only when the controlling criteria described above are not met. FHWA expects documentation of design exceptions to include all of the following:

- Specific design criteria that will not be met
- Existing roadway characteristics
- Alternatives considered
- Comparison of the safety and operational performance of the roadway and other impacts such as right-of-way, community, environmental, cost, and usability by all modes of transportation
- Proposed mitigation measures
- Compatibility with adjacent sections of roadway

The level of analysis should be commensurate with the complexity of the project.

Design speed and design loading structural capacity are fundamental criteria in the design of a project. Exceptions to these criteria should be extremely rare and FHWA expects the documentation to provide the following additional information:

- Design speed exceptions:
  - Length of section with reduced design speed compared to overall length of project
  - Measures used in transitions to adjacent sections with higher or lower design or operating speeds
- Design loading structural capacity exceptions:
  - Verification of safe load-carrying capacity (load rating) for all state unrestricted legal loads or routine permit loads, and in the case of bridges and tunnels on the Interstate, all federal legal loads

The approval of deviations from applicable design criteria are to be handled as follows:

- **NHS roadway and controlling criteria not met**: Design exceptions are required and FHWA is the approving authority.
- **NHS roadway and non-controlling criteria not met**: TDOT is the approving authority for design exceptions/waivers/deviations in accordance with state laws, regulations, directives, and safety standards.
- **Non-NHS roadway and state design criteria not met on federal-aid projects**: TDOT is the approving authority for design deviations in accordance with state laws, regulations, directives, and safety standards.

FHWA BICYCLE AND PEDESTRIAN FACILITY DESIGN FLEXIBILITY

On August 20, 2013, FHWA issued a memorandum that expresses FHWA's support for taking a flexible approach to bicycle and pedestrian facility design. The memorandum notes that the AASHTO bicycle and pedestrian design guides are the primary national resources for planning, designing, and operating bicycle and pedestrian facilities.

Under section 11129 of the Bipartisan Infrastructure Bill (BIL), also known as the IIJA, and under section 1404(b) of the FAST Act, the following publications are recognized as alternate roadway design guides *(5)*:

- Global Designing Cities Initiative (GDCI) *Global Street Design Guide*, 2016 and the *Designing Streets for Kids* supplement, 2020
- Institute of Transportation Engineers (ITE) *Designing Urban Walkable Thoroughfares: A Context Sensitive Approach*, 2010 and the supplemental *Implementing Context Sensitive Design Handbook*, 2017
- NACTO *Urban Street Design Guide*, 2023

FHWA notes that "The following external publications may be useful references for entities wishing to follow a complete streets design model as they plan, develop, and operate equitable streets and networks that prioritize safety, comfort, and connectivity to destinations for all people who use the street network. These guides focus on a particular mode, and while they are not comprehensive roadway design guides, they can be used in conjunction with other roadway design guides to inform multimodal solutions." *(5)*

- AASHTO, *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, 2021
- ASHTO, *Guide for the Development of Bicycle Facilities*, 2012
- NACTO, *Urban Bikeway Design Guide*, 2014
- NACTO, *Don't Give Up at the Intersection*, 2019
- NACTO, *Designing for All Ages & Abilities*, 2014
- AASHTO, *Guide for Geometric Design of Transit Facilities on Highways and Streets*, 2014
- NACTO, *Transit Street Design Guide*, 2016

FHWA STRATEGIC AGENDA FOR PEDESTRIAN AND BICYCLE TRANSPORTATION

The *Strategic Agenda for Pedestrian and Bicycle Transportation* is a framework to guide FHWA's pedestrian and bicycle initiatives and investments during the five-year period from federal fiscal year (FY) 2016-17 to FY 2020-21. *(6)*

Developed with input from a broad range of technical experts, transportation agency staff, and stakeholders from across the nation, the agenda articulates goals and supporting actions to promote safer, accessible, comfortable, and connected bicycle and pedestrian networks; advance ladders of opportunity and community connections; provide equitable access for everyone to jobs, schools, and essential services; and to expand transportation options and choices for all.

FHWA is committed to making all travel modes, including walking and bicycling, safer, accessible, comfortable, and convenient for everyone. Investing in these modes yields multiple benefits to the nation:

- Improved safety for travelers of all ages and abilities
- Improved mobility for all people and businesses
- Improved access to jobs and essential services for all
- Increased resilience for all communities

FHWA SAFE SYSTEM APPROACH

The Safe System approach seeks to eliminate fatal and serious injury crashes by taking a holistic, proactive approach to addressing safety.

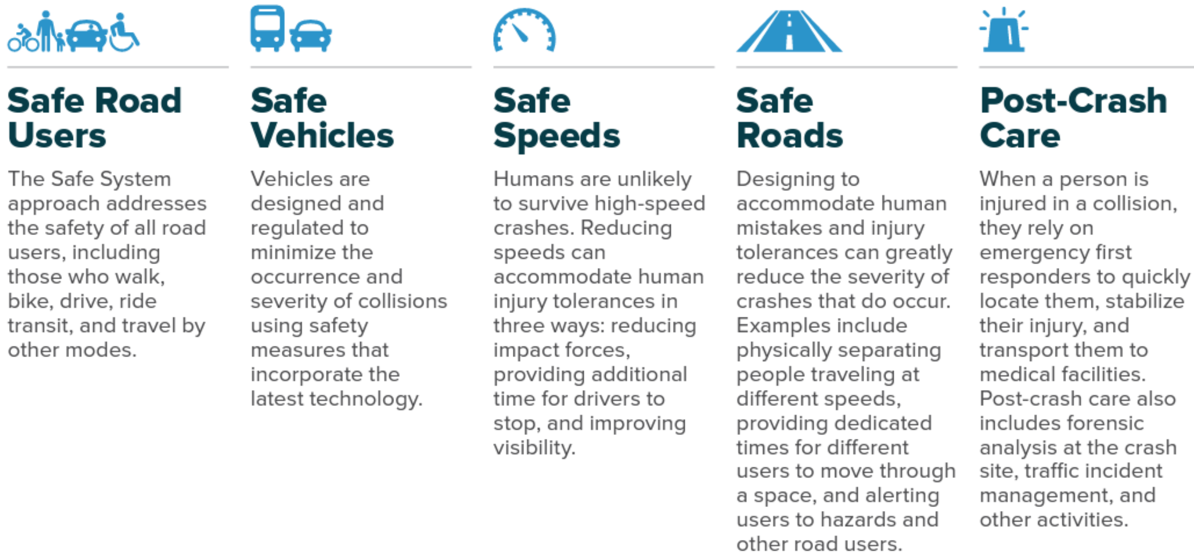
> "Reaching zero deaths requires the implementation of a Safe System approach, which was founded on the principles that humans make mistakes and that human bodies have limited ability to tolerate crash impacts. In a Safe System, those mistakes should never lead to death. Applying the Safe System approach involves anticipating human mistakes by designing and managing road infrastructure to keep the risk of a mistake low; and when a mistake leads to a crash, the impact on the human body doesn't result in a fatality or serious injury. Road design and management should encourage safe speeds and manipulate appropriate crash angles to reduce injury severity." *(7)*

The six principles that form the basis of a Safe System approach include:

1. **Deaths and serious injuries are unacceptable** and eliminating fatal and serious-injury crashes is the priority.
2. **Humans make mistakes**, so the transportation system should be designed to accommodate mistakes and avoid death and serious injuries when mistakes do occur.
3. **Humans are vulnerable**, and the transportation system should be designed to avoid crash forces that will result in death or serious injury.
4. **Responsibility is shared**, and all stakeholders should work together towards a Safe System.
5. **Safety is proactive**, requiring risks to be identified and mitigated as opposed to reacting to crashes after they occur.
6. **Redundancy is crucial**, and all parts of the transportation system need to be strengthened to protect people when one part fails.

The Safe System approach includes five elements, illustrated in Figure B-1.

Figure B-1 Five Elements of a Safe System Approach



Source: FHWA, Safe System Approach flyer (7)

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Appendix C

Key Resources

This appendix provides additional information on key resources for evaluating pedestrian and bicycle facilities, including:

- TDOT Multimodal Prioritization Tool
- National Cooperative Highway Research Program (NCHRP) Research Report 926: *Guidance to Improve Pedestrian and Bicyclist Safety at Intersections*
- NCHRP Research Report 948: *Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges*
- NCHRP Research Report 834: *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook*
- American Association of State Highway and Transportation Officials (AASHTO), *Highway Safety Manual* (*HSM*)
- Federal Highway Administration (FHWA), Crash Modification Factor (CMF) Clearinghouse
- FHWA, *Improving Intersections for Pedestrians and Bicyclists Informational Guide*
- FHWA, *Pedestrian and Bicyclist Intersection Safety Indices User Guide*
- FHWA, *Safe System Approach for Speed Management*
- FHWA, *Integrating Speed Management within Roadway Departure, Intersections, and Pedestrian and Bicyclist Safety Focus Areas*
- National Association of City Transportation Officials (NACTO), *Urban Bikeway Design Guide*
- NACTO, *Urban Street Design Guide*

TDOT MULTIMODAL PRIORITIZATION TOOL

The Multimodal Prioritization Tool (MPT) was developed by the TDOT Data Visualization Office in 2021. It can be used to prioritize roadway segments and identify areas that could benefit the most from multimodal projects. This analysis may be used as a component in other types of analyses and project prioritizations. The indices assigned to roadway segments in the final deliverable should not be used as the final word in determining which segments receive projects and which ones do not. Rather, the tool should be utilized as a guide to where resources for finer analysis may be deployed.

The MPT tool considers the following criteria:

- Infrastructure (level of pedestrian ease, safety and comfort, including roadway features like traffic volume, speed limit, number of lanes, intersection control type, presence of sidewalks or bicycle lanes)
- Safety (crash frequency, severity, and user)
- Equity (Environmental Justice Index)
- Pedestrian demand (population and employment density, active commuters, points of interest, land use, access to transit)

TDOT's Multimodal Planning Office updates the tool annually with new data and is investigating other data sources to improve confidence in and understanding of existing pedestrian travel behavior and demand. Over time, the tool could be used to evaluate changes in safety on roadway segments.

NCHRP RESEARCH REPORT 926: *GUIDANCE TO IMPROVE PEDESTRIAN AND BICYCLIST SAFETY AT INTERSECTIONS*

NCHRP Research Report 926 "provides a succinct process for selecting intersection designs and operational treatments that provide safety benefits for pedestrians and bicyclists, and the most appropriate situation for their application. The report draws from and builds on the strengths of key countermeasures and safety resources, tying these together in a systematic process for transportation practitioners to use to improve bicycle and pedestrian safety at intersections" *(1)*.

The process outlined in the Guide for selecting countermeasures is shown in Figure C-1.

Figure C-1 General Assessment and Approach to Countermeasure Selection

Source: NCHRP Research Report 926, Figure B (2)

The Guide discusses a systemic approach to making safety improvements, which involves "identifying intersection types and characteristics that have a higher risk of crashes in the future" as opposed to reacting to "hot spot" locations *(1)*. It includes a toolbox of countermeasures, including a CMF, applicable crash types, applicable contexts, complimentary countermeasures, considerations, systemic safety potential, estimated cost, potential effects on travel modes, and alternative treatments.

NCHRP RESEARCH REPORT 948: *GUIDE FOR PEDESTRIAN AND BICYCLIST SAFETY AT ALTERNATIVE AND OTHER INTERSECTIONS AND INTERCHANGES*

NCHRP Research Report 948 provides an overview of designing for pedestrian and bicycle comfort and safety at intersections. The information identifies current practices, considers future trends, outlines methods to evaluate intersection effectiveness and analyze safety and operational features, and details effective design techniques for alternative intersections and interchanges. The analysis methodology is still appropriate to apply at conventional intersections. This methodology is introduced as a design flag assessment method, often referred to as the "20 Flags Method." These flags highlight design characteristics that impact safety and quality of service for people walking and biking regardless of the intersection type *(2)*. Chapter 5 of the *PSG* provides additional guidance on applying this to TDOT projects using the TDOT *20-Flag Intersection Evaluation Guide*.

NCHRP RESEARCH REPORT 834: *CROSSING SOLUTIONS AT ROUNDABOUTS AND CHANNELIZED TURN LANES FOR PEDESTRIANS WITH VISION DISABILITIES: A GUIDEBOOK*

NCHRP Research Report 834 "presents a guidebook for the application of crossing solutions at roundabouts and channelized turn lanes to assist pedestrians with vision disabilities. The guidebook provides an accessibility assessment framework and a methodology for evaluating treatment alternatives for a proposed crossing. Guidance is provided based on the feasible range of geometric and traffic operational conditions under which similar treatments have been demonstrated to enhance accessibility" *(3)*. Appendix B of the Report includes an overview of crossing treatments, including a "description of its functionality and purpose, an estimate of installation cost, field test results for application to roundabouts and/or CTLs, limitations of the treatments, and links to additional resources and information" *(3)*. Treatments covered include pedestrian hybrid beacons (PHBs), rectangular rapid-flashing beacons (RRFBs), raised pedestrian crossings, sound strips, and flashing beacons.

AASHTO, *HIGHWAY SAFETY MANUAL*

The *Highway Safety Manual (HSM)* is published by AASHTO and "is the premier guidance document for incorporating quantitative safety analysis in the highway transportation project planning and development processes" *(4)*. The *HSM* provides methods for quantifying and predicting crash frequency and severity, using national safety performance functions and CMFs.

The *HSM* is intended to assist agencies in their effort to integrate safety into their decision-making processes.

Unfortunately, the *HSM* currently has limited data concerning low-speed urban streets and the safety of non-motorized users in general. Therefore, in many cases engineering judgment must be applied to assess crash risk for pedestrians and bicyclists.

FHWA, CRASH MODIFICATION FACTOR CLEARINGHOUSE

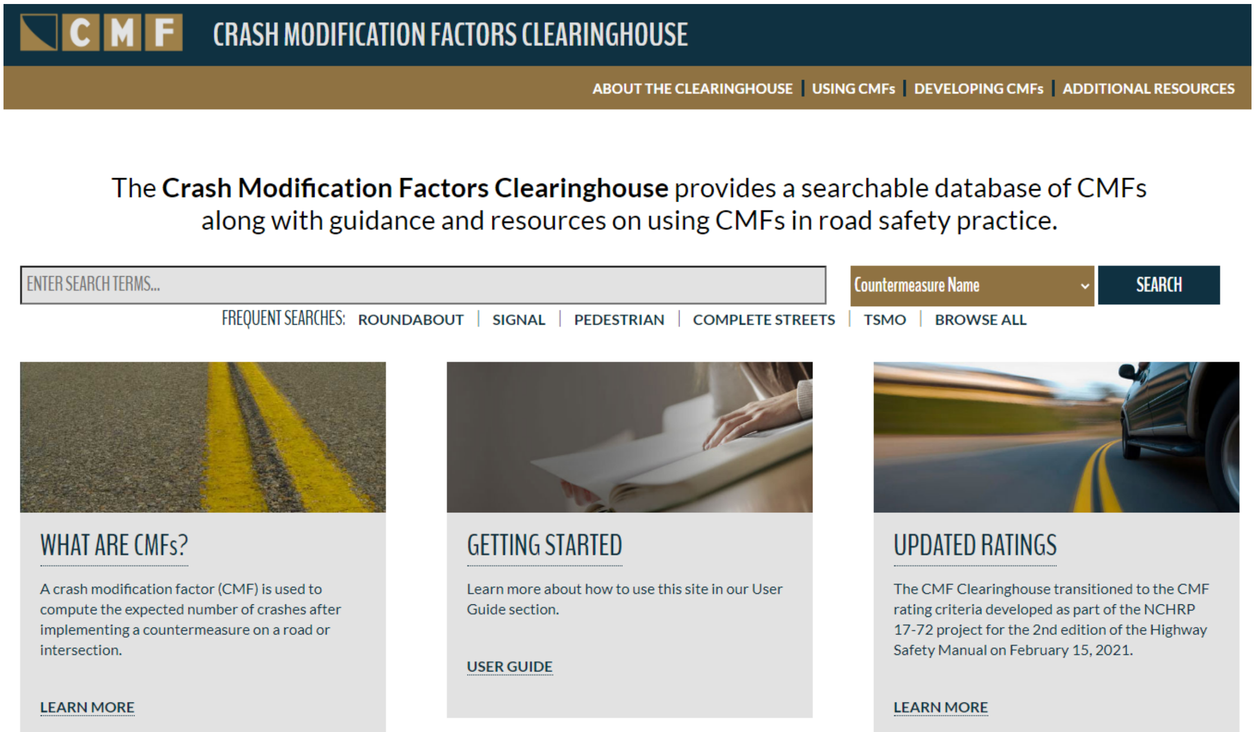
The Crash Modification Factor (CMF) Clearinghouse is a searchable online database of CMFs. It is funded by FHWA and maintained by the University of North Carolina Highway Safety Research Center (UNC HSRC).

> "A Crash Modification Factor (CMF) is a multiplicative factor that indicates the proportion of crashes that would be expected after implementing a countermeasure. Examples of countermeasures include installing a traffic signal, increasing the width of edgelines, and installing a median barrier. CMFs with a value less than 1.0 indicate an expected decrease in crashes. CMFs greater than 1.0 indicate an expected increase in crashes." *(5)*

The clearinghouse is available online at www.CMFClearinghouse.org and shown in Figure C-2. The website also includes information on how to properly apply CMFs.

The CMF Clearinghouse uses a rating system for CMFs based on the quality of the study that produced the CMF, considering factors like the study design, sample size, statistical methodology, and statistical significance. While the *HSM* provides only the highest-rated CMFs, the CMF Clearinghouse is a comprehensive listing of available CMFs that is regularly updated.

Figure C-2 CMF Clearinghouse Search Options

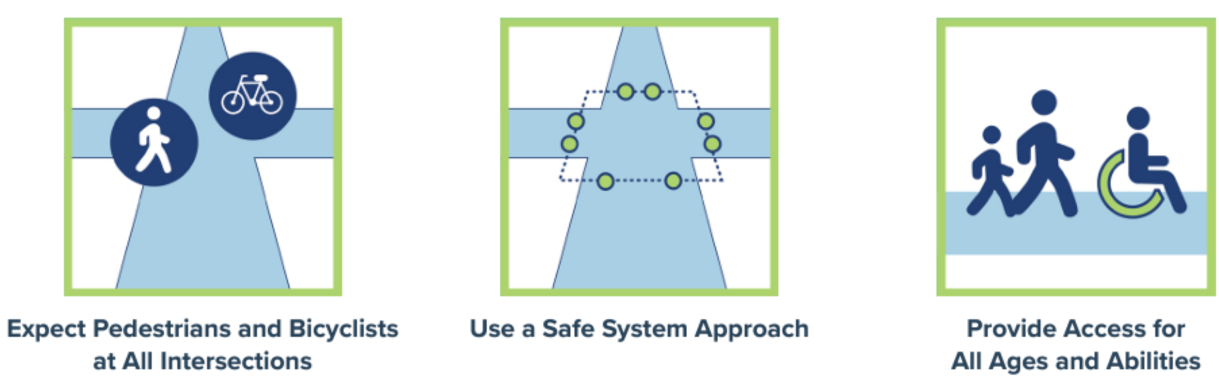


Source: CMF Clearinghouse (5)

FHWA, *IMPROVING INTERSECTIONS FOR PEDESTRIANS AND BICYCLISTS INFORMATIONAL GUIDE*

FHWA's *Improving Intersections for Pedestrians and Bicyclists Informational Guide* is intended to "inform the state of the practice concerning intersection planning and design to implement solutions that help achieve the goal for zero fatalities and serious injuries while improving mobility for bicyclists and pedestrians" *(6)*. Part 1 of the guide describes three key principles for including pedestrians and bicyclists at intersections, shown in Figure C-3.

Figure C-3 Key Principles for Planning and Designing Intersections for Pedestrians and Bicyclists



Source: Improving Intersections for Pedestrians and Bicyclists Informational Guide (6)

Part 2 provides design elements to consider and example design concepts for a range of intersection forms and "illustrates options and design flexibility for incorporating a variety of pedestrian and bicycling facility types" *(6)*. It includes assessment techniques to evaluate safety, access and comfort for pedestrians and bicyclists for a range of conditions. Techniques include a Design Flag Assessment, *Highway Capacity Manual* delay data collection, and Safe System for Intersections (SSI) method as described in *A Safe System-Based Framework and Analytical Methodology for Assessing Intersections*.

FHWA, PEDESTRIAN AND BICYCLIST INTERSECTION SAFETY INDICES

FHWA developed Pedestrian and Bicycle Intersection Safety Indices (Ped ISI and Bike ISI) to "enable users to identify intersection crossings and intersection approach legs that should be the greatest priority for undergoing pedestrian and bicycle safety improvements" *(7)*. The indices are based on data collected at 68 intersection crosswalks and reflect "expert safety ratings and behavioral data" *(7)*. The User Guide for applying the indices includes example applications and recommends the FHWA tools PEDSAFE and BIKESAFE for selecting countermeasures once locations have been prioritized for evaluation and improvement.

FHWA, *SAFE SYSTEM APPROACH FOR SPEED MANAGEMENT*

The FHWA report *Safe System Approach for Speed Management* discusses the impacts of speed on traffic safety presents a five-stage framework for speed management, based on a Safe System approach. The five stages are "establishing a vision and building consensus for speed management, collecting, and analyzing speed and safety data, prioritizing locations for speed management proactively, selecting speed management countermeasures, and conducting ongoing monitoring, evaluation, and adjustment" *(8)*.

Key themes highlighted in the report include:

- "Strategic plans, like Vision Zero, help build public will for speed management practices, and agencies can align those practices with Safe System approach-based traffic safety goals.
- Speed and safety data are helpful both to guide the speed management program and to build public support for the program.
- As much as practicable, agencies should align speed limits and target speeds to prioritize injury minimization. This alignment often requires changing the roadway environment to slow driver speeds" *(8)*.

The report case studies and examples throughout the report and appendix "demonstrating how agencies have been able to overcome institutional barriers and rally behind Safe System approach principles to enact speed management programs with proven, measurable reductions in operating speeds and crashes." *(8)*

FHWA, *INTEGRATING SPEED MANAGEMENT WITHIN ROADWAY DEPARTURE, INTERSECTIONS, AND PEDESTRIAN AND BICYCLIST SAFETY FOCUS AREAS*

FHWA has identified roadway departure, intersection, and pedestrian and bicycle crashes as focus areas for safety improvements, as these three focus areas encompass almost 90 percent of traffic fatalities, based on data from 2018 through 2020 *(9)*. In addition, speeding contributes to nearly one-third of all roadway fatalities *(10)*. Given this, FHWA developed the report *Integrating Speed Management within Roadway Departure, Intersections, and Pedestrian and Bicyclist Safety Focus Areas* to assist agencies with "integrating speed management into their policies, practices, and safety plans" *(10)*. The report discusses the state of the practice around speed management and presents program level strategies for integrating speed management. It specifically discusses how to integrate speed management within the three focus areas of roadway departure, intersection, and pedestrian and bicycle crashes.

NACTO, *URBAN BIKEWAY DESIGN GUIDE*

The NACTO *Urban Bikeway Design Guide* is intended to "provide cities with state-of-the-practice solutions that can help create complete streets that are safe and enjoyable for bicyclists" *(11)*. It is recognized by FHWA as a "useful reference" that "provides guidance for cities seeking to improve bicycle transportation in places where competing demands for the use of the right-of-way present unique challenges" *(12)*. It provides guidance on bike lanes, cycle tracks, bicycle boulevards, bicycle signals, intersection treatments, bikeway signing and marking, and designing for all ages and abilities.

NACTO, *URBAN STREET DESIGN GUIDE*

The NACTO *Urban Street Design Guide* is recognized by FHWA as an alternate roadway design guide that can "help transportation agencies plan, develop, and operate equitable streets and networks that prioritize safety, comfort, and connectivity to destinations for all people who use the street network" *(12)*. The Guide provides sections on streets, interim design strategies, intersection design elements, street design elements, intersections, and design controls. It recognizes the "unprecedented demands" on urban streets, which "must be safe, sustainable, resilient, multimodal, and economically beneficial, all while accommodating traffic" *(13)*.

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Appendix D

Traffic Control for Pedestrians and Bicyclists

This appendix provides general information on traffic control devices for pedestrians and bicyclists, as well as specific information on the following:

- Bicycle signals
- Green-colored pavement
- Bicycle boxes

TRAFFIC CONTROL FOR PEDESTRIANS

As described in the *Manual for Uniform Traffic Control Devices (MUTCD)*, "the purpose of traffic control devices, as well as the principles for their use, is to promote highway safety and efficiency by providing for the orderly movement of all road users on streets, highways, bikeways, and private roads open to public travel" *(1)*. Traffic control can provide warning or guidance to pedestrians on expected behaviors, or to other users who may interact with pedestrians. For example, pavement markings and signage may be used on a shared-use path to indicate how pedestrians and bicyclists are intended to interact or a pedestrian signal may be provided at a traffic signal to indicate to pedestrians when to cross the roadway.

Tennessee has adopted the national *MUTCD* as the standard for traffic control. Additional guidance on the use of traffic control related to pedestrian facilities is provided in the TDOT *Traffic Design Manual* and the *Roadway Design Guidelines*, including:

- Pedestrian Beacons/Signals: RDG 3-409 and 3-410
- Illumination: RDG 3-416
- Barriers and Railings: RDG 3-412

TRAFFIC CONTROL FOR BICYCLISTS

Tennessee has adopted the national *MUTCD* as its standard for traffic control. Part 9 of the *MUTCD* covers traffic control for bicycle facilities and includes general information as well as chapters on signs, markings, and signals. It covers both bicycle facilities on roadways and shared-use paths. Traffic control related to bicycles can serve to inform both bicyclists and motor vehicles of expectations and intended behaviors.

Additional guidance is available in the TDOT *Traffic Design Manual*, Chapter 3 of the *Roadway Design Guidelines*, and the Standard Drawings. TDOT Standard Drawings T-M-11 through T-M-14 and MM-PM-1 through MM-PM-5 should be referenced for additional guidance concerning signing and pavement markings for bicycle lanes.

BICYCLE SIGNALS

Agencies across the United States are showing increased interest in bicycle signal faces, which resulted in FHWA issuing a memorandum in 2013 providing interim approval for optional bicycle signal faces *(2)*. The 11th Edition of the *MUTCD* added a chapter on bicycle signals (Chapter 4H), which includes information on their application, design, and operation. It notes the following situations where a bicycle signal face may be used to separate control of bicyclist movements:

- Provide a protected bicycle phase or leading or lagging bicycle interval.
- Continue the bicycle lane on the right-hand side of an exclusive turn lane that would otherwise be in non-compliance with the *MUTCD*.
- Augment the design of a segregated counter-flow bicycle facility.
- Facilitate unusual or unexpected arrangements of bicycle movement through complex intersections, conflict areas, or signal control. *(1)*

GREEN-COLORED PAVEMENT

FHWA issued an Interim Approval (IA-14) in 2011 for the optional use of colored pavement in designated bicycle lanes and in extensions of designated bicycle lanes through intersections and other traffic conflict areas *(3)*. The 11th Edition of the *MUTCD* added a section on green-colored pavement for bicycle facilities (Section 3H.06) that includes information on its use. It notes that "Green-colored pavement is used to enhance the conspicuity of locations where bicyclists are expected to operate, and areas where bicyclists and other traffic might have potentially conflicting, weaving, or crossing movements. Green-colored pavement is also used to enhance the conspicuity of word, symbol, and/or arrow pavement markings when these markings are used in certain bicycle facilities" *(1)*.

BICYCLE BOXES

The FHWA issued an Interim Approval (IA-18) in 2016 for the optional use of intersection bicycle boxes *(4)*. The 11th Edition of the *MUTCD* added a section on bicycle boxes (Section 9E.12) that includes information on the application and design of bicycle boxes, with several examples *(1)*. Bicycle boxes are designated areas on the approach to a signalized intersection, between an advance stop line and the intersection stop line, intended to provide bicyclists a space in which to wait in front of stopped motor vehicles during the red signal phase so that they are more visible to motorists at the start of the green signal phase. Positioning bicyclists in the center of the appropriate lane allows them to turn from a location where they are more visible to surrounding traffic, can increase the visibility of stopped bicycle traffic at an intersection, can reduce conflicts between bicyclists and turning motor vehicles, can help mitigate intersection right-turn conflicts, and can help group bicyclists together to clear intersections more quickly. Bicycle boxes have also been found to prevent bicyclists and motor vehicle encroachment into the pedestrian crossing, reducing conflicts with pedestrians at intersections.

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