Oregon Department of Transportation

JANUARY 2020

BLUEPRINT FOR URBAN DESIGN

Volume 2 of 2
APPENDICES

ODOT's Approach for Design in Oregon Communities

Preface

Volume 2: Appendices of the Oregon Department of Transportation (ODOT) Blueprint for Urban Design contains supplemental information associated with the chapter content. Refer to **Volume 1: Blueprint for Urban Design** for the primary urban design guidance presented in each chapter.

The Blueprint for Urban Design was developed by the ODOT Planning Section, Statewide Project Delivery Brand, and Active Transportation staff with a collaborative approach which included multiple disciplines and region staff. This document was developed with support from the Federal Highway Administration (FHWA) Oregon Division and the transportation engineering consulting firm, Kittelson & Associates, Inc.

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Appendix A

List of Key Terms

January 2020

APPENDIX A

LIST OF KEY TERMINOLOGY

Descriptions for key terms used throughout the Blueprint for Urban Design are shown below.

Practitioners – Planners, engineers and designers within ODOT, local agencies, and consultant teams.

Project Flow – ODOT's transportation system project lifecycle. The four-stage process includes Program Development, Project Development, Construction Management, and Maintenance/Operations.

Roadway – Facility in an Urban Context.

Roadway User (also referred to as User) – Bicyclist, pedestrian, motorist, transit user, person using a different travel mode, or freight handler traveling on, crossing or accessing a roadway.

Urban – An area falling within one of the six ODOT Urban Contexts.

Urban Contexts – Six ODOT urban land use contexts that broadly identify the various built environments along ODOT roadways, based on existing or future land use characteristics, development patterns, and roadway connectivity of an area.

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Appendix B

Existing ODOT Resources

January 2020

APPENDIX B

EXISTING ODOT RESOURCES AND TOOLS

Fundamental ODOT resources and tools for design, safety, and operations associated with the urban environment are described in **Table B-1** through **Table B-3.** Other recently published research, such as *NCHRP Report 880: Design Guide for Low-Speed Multimodal Roadways (NCHRP Report 880),* also provide useful resources for considering design trade-offs in an urban environment.

Table B-1 provides the existing resources and tools for evaluating safety on ODOT projects. The table includes resources such as policies, methods, and tools for safety performance measurement.

Table B-1: Overview of Available ODOT Safety Resources

Resources	Description
Analysis Procedures Manual (APM)	• **Chapter 4: Safety** o Provides guidance on safety analysis procedures for specific transportation planning and project development applications. o Examples of guidance include: ▪ Intersection crash rate calculation (Section 4.1.1). ▪ Intersection crash rate summary to compare rates with statewide averages (Exhibit 4-1). Crash rates associated with urban land use is provided. ▪ Critical crash rate method and discussion typically associated with transportation system plans and corridor plans (Section 4.3.4). ▪ What data to report (Section 4.2.6). ▪ Predictive methods and tools are discussed in Section 4.4. • **Chapter 14: Multimodal Analysis** o Provides a range of different multimodal analysis types and modal considerations. o Section 14.3.4 provides qualitative assessment of roadway conditions that provide for a decreased chance of crashes, such as illumination, longer intersection/driveway spacing, lower speed, etc.
Transportation Safety Action Plan	• The Transportation Safety Action Plan outlines long-term goals, policies and strategies and near-term actions to improve safety on Oregon's transportation system. • Outlines ODOT emphasis areas and provides information on how ODOT plans to address those areas. o Helps identify consistencies between local agency and statewide safety priorities to support project collaboration.
All Roads Transportation Safety Program	• The All Roads Transportation Safety (ARTS) Program is a collaboration with local jurisdictions to address safety needs on all public roads through a data driven process. • Example information in this resource includes: o Crash Reduction Factor List for any Oregon safety project to help practitioners identify crash modification factors (or unit cost, if appropriate). o Benefit/Cost Analysis Form to provide guidance on calculations, such as comprehensive economic value per crash, etc. o Information on the statewide systemic safety plans and SPIS.
HSM Calibration Factors	• Oregon State University and Portland State University completed a research study to develop calibration factors for Oregon to better apply the predictive methods found in the Highway Safety Manual (HSM).
ODOT Crash Data System	• A resource for obtaining crash data.
Crash Decoder Tool	• A resource for summarizing and reviewing crash data.
Critical Rate Calculator	• Performs crash rate analysis and identifies priority intersections or segments for further safety analysis. See Chapter 4 of the APM for more information.
Excess Proportion of Specific Crash Types Calculator	• Performs statistical analysis to calculate a probability of specific crash types exceeding a threshold proportion. See Chapter 4 of the APM for more information.

Table B-2 provides existing resources and tools for designing ODOT projects. Evaluating the tradeoffs within a constrained roadway environment and balancing the needs of each user can be particularly challenging in an urban area. The ODOT Highway Design Manual is the primary resource for detailed design guidance and discusses the flexibility in urban highway design in relation to land use and community-based decision processes.

Table B-2: Overview of Available ODOT Design Resources

Resources	Description
Highway Design Manual	• **Chapter 1: Design Standard Policies and Processes** o Introduces various land use areas and provides an overview of practical design. o Outlines the design standard policies and project delivery process. • **Chapter 2: Design Controls and Criteria** o Includes discussion on project context and guidance for design controls such as design vehicle, design speed, and others. o Provides guidance for urban areas, such as appropriate design speed for transition areas between rural and urban. • **Chapter 3: Elements of Design** o Provides guidance for design elements such as sight distance, and horizontal and vertical alignment. • **Chapter 4: Cross Section Elements** o Provides design guidance for cross sectional elements such as curb, sidewalks, medians, clearances and others. • **Chapter 6: Urban Highway Design (Non-Freeway)** o Provides design guidance for urban, non-freeway design, references ODOT's policy on Practical Design and provides appropriate flexibility in urban highway design in relation to land use, context sensitive design and community-based decision processes. • **Chapter 8: Intersections** o Provides design standards, guidelines and processes for designing road approaches, and unsignalized and signalized intersections. • **Chapter 12: Public Transportation and Guidelines** o Provides guidance to designers for integrating public transportation design practices into projects. • **Chapter 13: Pedestrian and Bicycle** o Provides guidance for pedestrians and bicycles on state highways and provides guidance on how to utilize additional information found in Appendix L: Bicycle and Pedestrian Design Guide. • **Chapter 14: Design Exception Process** o Describes the process for design exceptions. o Details the design elements and features that require design exceptions. o Outlines information needed to justify approvals of design exceptions. • **Appendix D: Practical Design Strategy:** Describes a systematic approach to deliver the broadest benefit to the transportation system, within existing resources, by establishing appropriate project scopes, to deliver specific results. • **Appendix E: Designated Bikeways:** Provides information and maps of designated bikeways in Oregon. • **Appendix L: Bicycle and Pedestrian Design Guide:** Provides design guidance, standards, and considerations for designing bicycle and pedestrian facilities on state highways.
Analysis Procedures Manual	• **Chapter 14: Multimodal Analysis** o Section 14.3: Qualitative Multimodal Assessment provides consideration for design elements associated with various modes, such as pedestrians (Section 14.3.1), bicycles (Section 14.3.2), and transit (Section 14.3.3).

Table B-3 provides existing resources and tools for evaluating operations for ODOT projects. While in the past the primary focus was motor-vehicle operations, there are now resources and tools to guide practitioners in multimodal analysis and evaluating the needs for each user from an operational perspective.

Table B-3: Overview of Available ODOT Operations Resources

Resources	Description

Analysis Procedures Manual	• **Chapter 10: Analyzing Alternatives**
	  o Provides guidance on facility-level alternative transportation analysis for corridor plans, refinement plans, and project development
	• **Chapter 11: Segment and Facility Analysis**
	  o Provides analysis methods for evaluating the operations of the uninterrupted-flow portions of multilane and two-lane highways
	• **Chapter 12: Unsignalized Intersection Analysis**
	  o Provides analysis procedures and methods for evaluating the operations of unsignalized intersections
	• **Chapter 13: Signalized Intersection Analysis**
	  o Provides analysis procedures and methods for evaluating the operations of signalized intersections
	• **Chapter 14: Multimodal Analysis**
	  o Section 14.4: Bicycle Level of Traffic Stress (LTS) provides a methodology for measuring the effects of traffic-based stress on bicycle riders.
	  o Section 14.5: Pedestrian Level of Traffic Stress (LTS) provides a methodology to understand the level of pressure or strain experienced by pedestrians and other sidewalk users.
	  o Section 14.6: Multimodal Level of Service (MMLOS) provides design considerations for pedestrian and bicycle facilities, as well as a methodology for analyzing how well a roadway serves various users. This includes:
	    ▪ Pedestrian and Bicycle LOS Criteria (Section 14.6.2, Exhibit 14-25)
	    ▪ Pedestrian LOS (Section 14.6.3)
	    ▪ Bicycle LOS (Section 14.6.4)
	  o Section 14.7: Transit LOS provides guidance for estimating the LOS of transit and includes operational and design considerations for transit.
	• **Chapter 18: Operations Analysis**
	  o Provides an overview of transportation system management and operations (TSMO) program elements, methods, strategies, and analysis tools
	• **Supplemental Materials**
	  o Provides additional resources and references papers for specific operational analysis topics

Oregon Highway Plan	• **Policy 1F**
	  o Establishes mobility targets (as defined by motor vehicle volume-to-capacity ratios) for state facilities that vary by region, facility classification, and whether the roadway is located within an urban growth boundary
	  o Allows for development of alternative mobility targets in areas where it is "infeasible or impractical to meet mobility targets"
	  o Allows for the use of alternative mobility targets to "balance overall transportation efficiency with multiple objectives of the areas being addressed"

Table B-3: Overview of Available ODOT Operations Resources (continued)

Resources	Description
Traffic Manual	• Focuses on ODOT traffic engineering policies and practices. The manual also clarifies roles and responsibilities, as well as provides information that may be required when considering traffic control changes.
Volume Development Tools	• A resource that provides spreadsheet tools associated with obtaining and evaluating traffic volumes for operational analysis, including: o TruckSum tool process ODOT-counted 12-hour or greater counts. (APM Chapter 11) o Count Processors tool to process count data output from the ODOT Traffic Count Management program for input into Visum or ArcGIS. (APM Appendix 17A)
Signalized Intersection Tools	• A resource that provides tools associated with conducting signalized intersection analysis, including: o Saturation Flow Rate Calculator o Signal Progression Calculator o Synchro/Sim Traffic Templates
Unsignalized Intersection Tools	• A resource that provides tools associated with conducting unsignalized intersection analysis, including: o Preliminary Traffic Signal Warrant Analysis Form o Two-Way Stop-Control Intersection Calculator (APM Chapter 11)
Multimodal Analysis Tools	• A resource that provides tools associated with conducting multimodal analysis, including: o Separated/Buffered Bikeways Calculator (APM Chapter 14) o Simplified MMLOS Calculator (APM Chapter 14) o Shared Path Calculator (APM Chapter 14) o Pedestrian and Bicycle Signalized Intersection MMLOS Calculator (APM Chapter 14)
Segment Analysis Tools	• A resource that provides tools associated with conducting segment analysis, including: o Queue and Delay Cost Worksheet (APM Chapter 10) o FREEVAL_OR (APM Chapter 11 and Appendix 11E) o ODOT Software Capacity Calculator (APM Chapter 11)

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Appendix C

ODOT Urban Design Initiative Topical Memorandums

January 2020

APPENDIX C

BLUEPRINT FOR URBAN DESIGN TOPICAL MEMORANDUMS

As part of the ODOT Urban Design Initiative, the project team developed three detailed topical memorandums for specific urban planning and design topics. Recommendations from each topical memorandum are included in Chapter 3 of the Blueprint for Urban Design. Appendix C contains the full topical memorandums for each topic:

- Bicycle Facility Selection
- Pedestrian Crossings
- Target Speed

OREGON DEPARTMENT OF TRANSPORTATION

URBAN DESIGN INITIATIVE

>>> Topical Memorandum: Bicycle Facility Selection Process

KITTELSON & ASSOCIATES

August 2019

PREFACE

The Bicycle Facility Selection Topical Memorandum was prepared as part of the Oregon Department of Transportation (ODOT) Urban Design Initiative. This memorandum recommends updates to guidance for identifying, planning, designing, and implementing appropriate bicycle facilities on ODOT-owned facilities in urban areas. Information from this memorandum has been integrated into the ODOT Blueprint for Urban Design and is included in full as an appendix to the Blueprint for Urban Design.

ODOT Planning and Technical Services Engineering and Active Transportation staff developed the Bicycle Facility Selection Topical Memorandum using a collaborative approach including multiple disciplines and region staff. The Federal Highway Administration (FHWA) Oregon Division and the transportation engineering consulting firm Kittelson & Associates, Inc. supported the development of this document. The following people contributed to the development of this document:

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EXECUTIVE SUMMARY

This topical memorandum recommends updates to guidance for identifying, planning, designing, and implementing appropriate bicycle facilities on ODOT-owned facilities in urban areas. It provides a framework to support appropriate bicycle facility selection and implementation.

The recommended approach is similar to what is outlined in FHWA's Bikeway Selection Guide. There are three parts: policy, planning and bikeway selection. Bikeway Selection Policy is already established in the Oregon Bicycle and Pedestrian Plan. Bikeway Selection Planning includes efforts to identify and designate connected bicycle networks of "low-stress" bicycle facilities at the transportation system plan level. These networks represent the community's vision for how to provide comfortable and safe access to key destinations for people riding bicycles. Planning efforts should identify ODOT highway contexts as well as the role of the ODOT highway in the bikeway network. The Bikeway Selection framework uses traffic characteristics to identify the bikeway tier and uses key planning level information to refine the bicycle facility. The process shown in **Figure 1** (and supported by

Table 1, **Table 2**, and **Figure 2**) summarizes the process for selecting appropriate bicycle facilities on state-owned urban streets in different contexts.

In many cases, implementation of bicycle facilities on ODOT streets in urban areas is completed through a retrofit project, in which additional space for bicycle facilities require weighing trade-offs compared to other uses for the space. This memorandum provides initial considerations for considering trade-offs on ODOT facilities, based on national and international best practices and other available guidance documents.

Figure 1. Bicycle Facility Selection Process

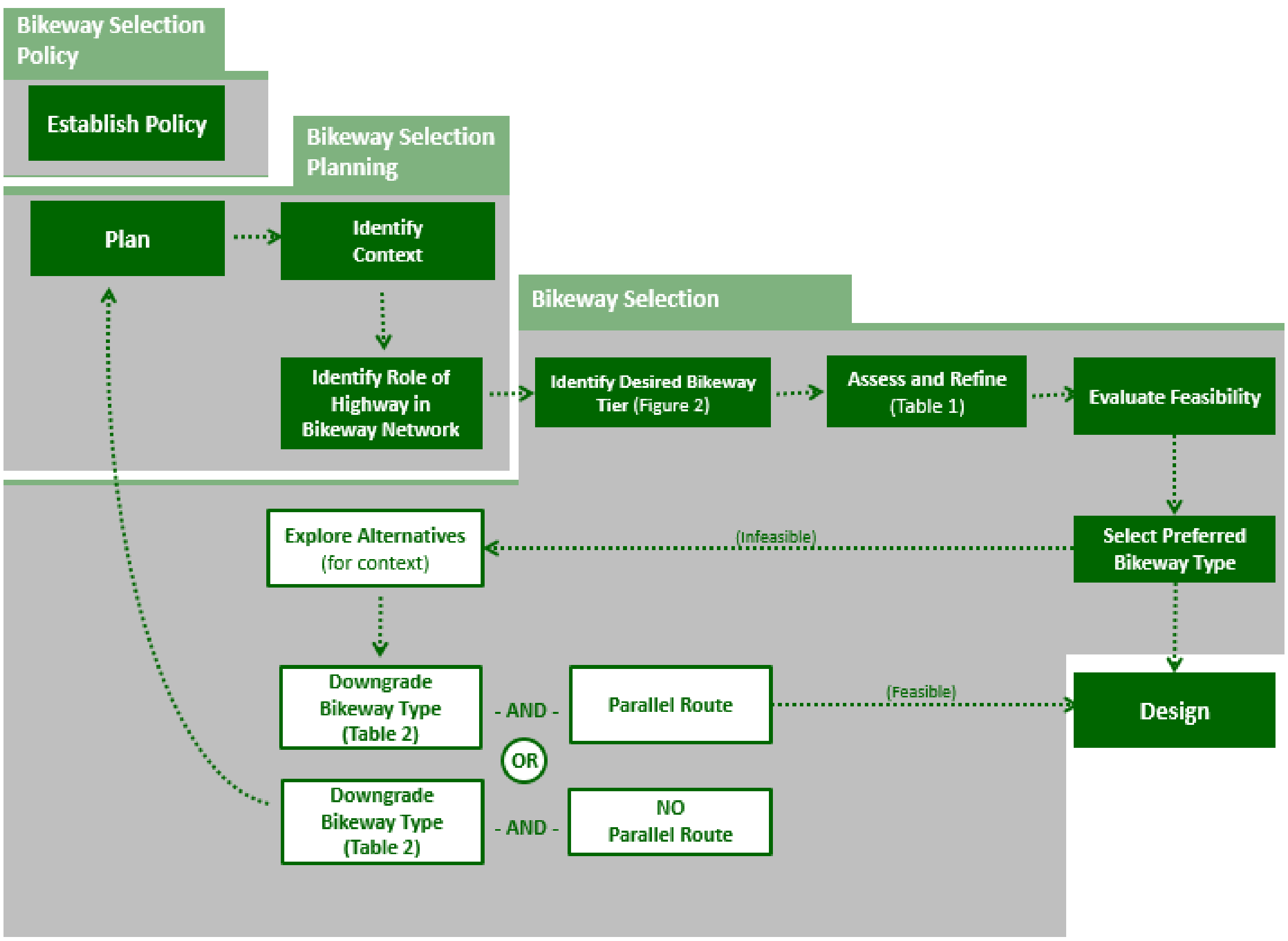
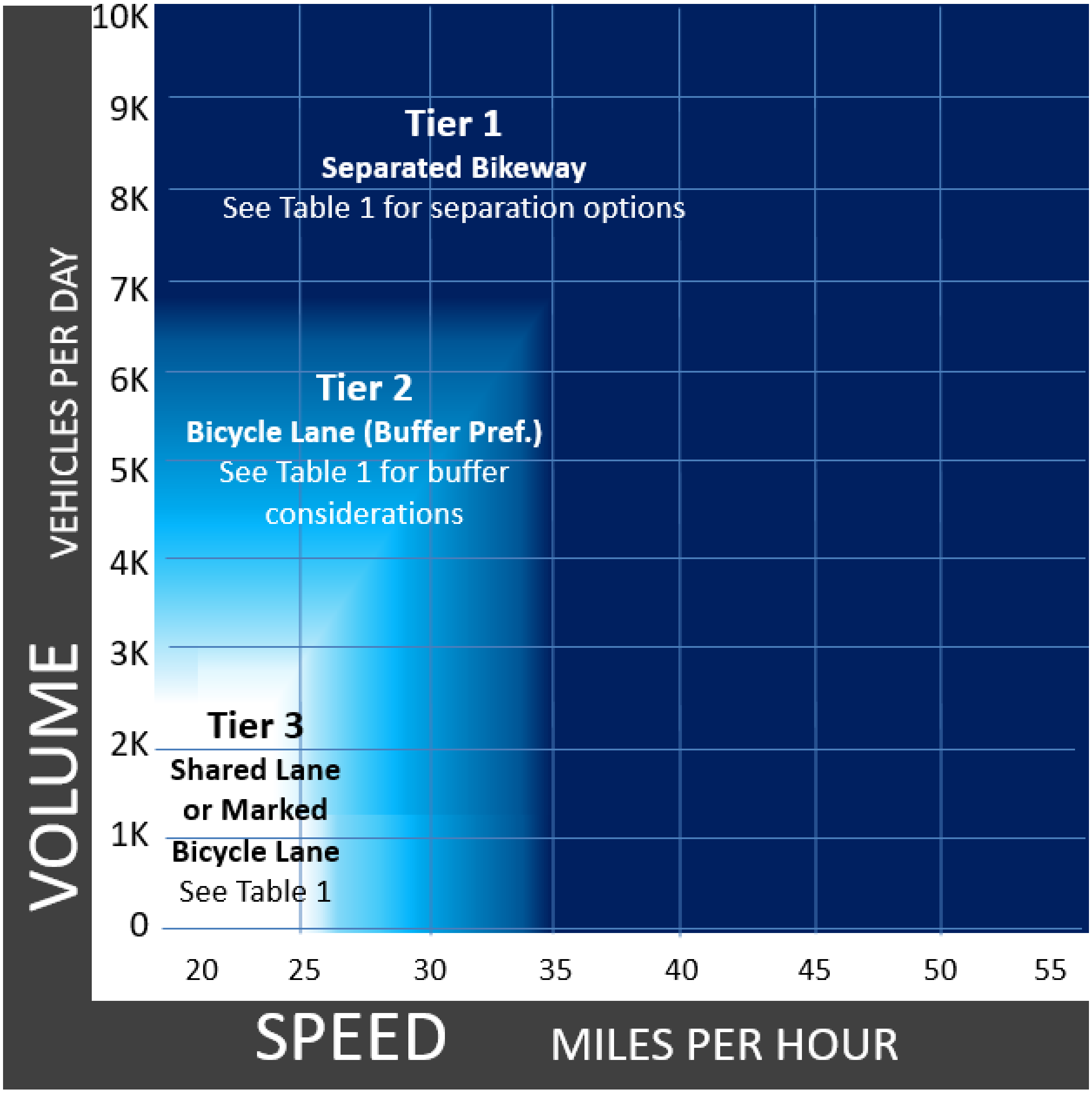


Figure 2. Bicycle Facility Tier Identification Matrix[1]



[1] On urban interstates, freeways, and expressways, bicycle traffic should be accommodated on parallel streets or shared use paths.

Table 1. Preferred Bicycle Facility Design for ODOT Highways in Urban Areas

Urban Context	Tier 1 – Separated Bikeway [1] Delineation options in the bicycle/street buffer zone	Tier 2 Bicycle Facility[2]	Tier 3 Bicycle Facility[3]
Traditional Downtown/ CBD	parking, raised island, flexible delineator posts, rigid bollards, parking stops, planters, bioswale	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Urban Mix	parking, raised island, flexible delineator posts, parking stops, planters, bioswale	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Commercial Corridor	raised island, flexible delineator posts, concrete barrier, guardrail, bioswale, ditch	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Residential Corridor	raised island, flexible delineator posts, concrete barrier, guardrail, bioswale, ditch	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Suburban Fringe	raised island, flexible delineator posts, concrete barrier, guardrail, bioswale, ditch	Bike lane or wide shoulder. Evaluate Buffer	Evaluate Bicycle Lane vs Shared Lane
Rural Community	parking, raised island, flexible delineator posts, planters, concrete barrier, guardrail, bioswale, ditch	Bicycle lane or wide shoulder. Evaluate Buffer	Evaluate Bicycle Lane vs Shared Lane

[1] Separated Bikeways may include shared use paths, sidewalk level separated bike lanes, or buffered bike lanes with vertical delineation in the buffer zone. See ODOT Bicycle and Pedestrian Design Guide for more information on various separated bikeway designs.

[2] Considerations whether to provide additional buffer width for a bicycle lane are given on page 24 of the FHWA Bikeway Selection Guide. See Tables 11-16 for bicycle/street buffer widths.

[3] Evaluate by considering factors that influence the appropriateness of a shared travel lane condition, which are discussed on pages 1-4 to 1-5 in the ODOT Bicycle and Pedestrian Design Guide. Note that Shared lanes should only be used where operating speeds are 25 mph or lower.

Table 2.* Alternative Bike Facility Design for ODOT Highways in Urban Areas – with Identified Lower Stress Parallel Routes

Urban Context	Alternative Bicycle Facility	Width	Other potential facility types	Design Concurrence Documentation Needed?
Traditional Downtown/CBD	Shared Lane (25 mph)	--	6' Bike Lane 5' Bike Lane (with no on-street parking)	If the proposed facility does not align with the "bicycle facility" and "width" AND does not match the other potential facility types, design concurrence documentation is necessary.
Urban Mix	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	
Commercial Corridor	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	
Residential Corridor	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	
Suburban Fringe**	Shoulder	6'	4'-5' Shoulder 5'-6' Bike Lane	
Rural Community	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	

*Note: **Table 1** is to be used as the "standard" bicycle facility design. **Table 2** is to be used to identify alternative bicycle facility design options where the preferred bicycle facility design is infeasible. If **Table 2** is used, projects should still consider a design that does not preclude the preferred bicycle facility or future vision for a planned bike route. If the preferred bicycle facility design cannot be provided on the ODOT highway, improvements should be considered to provide a low-stress parallel route. See "Parallel Routes" for more information.

** The "suburban fringe" context is typically adjacent to rural areas at the edge of urban development, but often is in the process of developing. For projects in the "suburban fringe" context zone, practitioners should consider likely future development and consider applying designs for "residential corridor," "commercial corridor," or "urban mix" contexts if this type of development is likely to occur.

Parallel Routes

In Oregon all public urban roadways should have appropriate walkways and bikeways provided, regardless of whether or not they are a "designated" route. Per ORS 366.514, walkways and bikeways must be provided whenever a roadway is "constructed, reconstructed, or relocated." Extra effort should be given to provide the preferred facility type (Table 1) on ODOT facilities that are part of state, regional, local bike routes, scenic bikeways, US Bicycle Routes, or other designated bikeways. On highways that are not part of a planned bicycle route, accommodations for bicycle traffic should still be provided with "interested but concerned" rider in mind, unless a low-stress parallel route has been identified by the local jurisdiction or an adopted network plan. When parallel routes are selected, they should be as direct as possible and well signed for bicycle wayfinding. To be viable, parallel routes should provide equivalent access to destinations along the highway, provide facilities and crossings for "interested but concerned" users, and should increase average trip lengths by less than 0.27 miles or 1.5 minutes for short trips.

Urban Interstates, Freeways, Expressways

Wide shoulders on urban limited access highways serve many purposes; as recovery zone for vehicle roadway departures, breakdown zones for vehicles during mechanical incidents or after collisions, emergency and maintenance vehicle access, and potential bus on shoulder operations. Shoulders should be available for pedestrians to access the nearest exit during mechanical incidents or after collisions, but it is not preferred to accommodate bicycle or pedestrian travel on shoulders on urban limited access facilities. Instead, pedestrian and bicycle travel should be accommodated on a parallel multi-use path, separated bikeway, or parallel streets. Limited access highway shoulders should only be used as a primary pedestrian and bicycle accommodation in low volume rural areas and/or where physical constraints and sparse surrounding network make a parallel route infeasible.

1. DEFINE THE PROBLEM

Guidance for identifying, planning, designing, and implementing appropriate bicycle facilities on ODOT-owned facilities in urban areas is not up-to-date. There is not a framework, when the appropriate bicycle facility is determined, to make sure that such a facility is implemented in projects.

IN THIS MEMO >>

- ODOT's bicycle facility selection policies and guidance
- Review of other guidance and agency approaches
- Future considerations for urban bicycle facility selection

1.1 Expanded Problem Statement

In 1971, legislators in the State of Oregon recognized that "it's almost impossible to go anywhere except in your car" and therefore sought to make roads friendly for people to use bicycles for transportation. This was completed by implementing a statute (ORS 366.514) that requires the Oregon Department of Transportation (ODOT) to construct bicycling (and walking) facilities whenever a road is reconstructed and to dedicate a portion of the state highway fund exclusively for improving the state's bicycling (and walking) network. Since the statute does not directly address the quality of bicycling infrastructure, and provides exclusions for cost proportionality, the types of bicycling improvements that have been constructed on most highways serve only the most confident bicycle riders.

Research over recent decades has shown that a large portion of the population who might consider bicycling – people who are "interested but concerned" – do not feel comfortable riding in standard bike lanes in most conditions. These individuals need facilities that provide a higher level of comfort to consider traveling by bicycle instead of by car. In order serve these people and justify constructing higher quality bicycle facilities, ODOT has provided bicycle facility selection guidance, as documented in their *Bicycle and Pedestrian Design Guide* (Appendix L to *Highway Design Manual* [HDM]). This guidance helps identify the appropriateness between three categories of bicycling accommodation based on various site characteristics. However, it does not provide specific guidance on facility type, nor does it require that the preferred facility be selected. Finally, the current guidance does not have a decision-making framework that is initiated during the planning phase, which would allow facility selection discussions to take place earlier. This would provide an opportunity for full consideration of design trade-offs earlier in the project decision-making flow.

This topical memorandum will draw on recent sources to expand ODOT's current guidance about bicycle facility selection. When the appropriate bikeway facility is in the category of separated bikeways, this memorandum will introduce a method to evaluate opportunities and consider trade-offs and barriers to implementation.

2. OVERVIEW OF POLICY, REGULATORY, AND DESIGN GUIDANCE CONTEXT

Currently, there are no policies, design requirements, or mandatory processes that explicitly specify the selection of one type of bicycle facility over another. However, there are many policies, design guidance criteria, and processes regarding the inclusion of bicycle facilities on highways and/or that guide the decision-making regarding how bikeway facilities could be selected. The following sections provide an overview of the current framework that influences how ODOT's decisions are governed and its correlation in selecting the prevalent bicycle facility types. Key findings from this review include:

- Implementation of ORS 366.514 is limited to rare occurrences where a roadway is built or upgraded, does not require a certain quality of facility, and allows for many exclusions.
- Bikeways that have been constructed on most highways serve only the most confident bicycle riders.
- Key agencies, including USDOT, FHWA, and ODOT, endorsed flexibility, innovation, and going beyond minimum requirements in selecting bicycle facilities.
- The existing Highway Design Manual poses some confusion as to required standards and bicycle facilities options.
- The Bicycle and Pedestrian Design Guide differentiates between shared and separated facilities based on site characteristics. However, it does not provide guidance or a decision-making framework on the appropriate separated facility, nor does it require the preferred facility be selected.

  The planning stage is where bicycle facility type decisions should be made in order to garner community buy-in and to provide direction to project teams.

2.1 ODOT Policies Related to Bicycle Facility Selection

Sources of policy come from state and federal law with their implementing policies, and from planning documents. Below is an outline of these policies:

- Oregon Statute ORS 366.514
- Federal Rules and Policy
  - Federal Regulation 23 CFR Part 652
  - USDOT Policy Statements and Memoranda
  - The *Manual on Uniform Traffic Control Devices* (MUTCD)
- Transportation Planning Policies
  - Transportation Planning Rule (OAR 660, Division 12)
  - Oregon Highway Plan (OHP)
  - Oregon Bicycle and Pedestrian Plan
  - Oregon Transportation Safety Action Plan (TSAP)

Oregon Statute ORS 366.514

The nation's first 'complete streets' law was passed in Oregon in 1971. It came about because legislators recognized that "it's almost impossible to go anywhere except in your car" [1] and therefore sought to make roads friendly for people to use bicycles for transportation by implementing a statute that requires construction of bicycling (and walking) facilities and dedicates a portion of the state highway fund exclusively for improving the state's bicycling (and walking) network. In the following paragraphs, selected text from the Statute is quoted with explanations. Also, the 1995 Oregon Bicycle and Pedestrian Plan contained Appendix C which elaborated on the purpose and implementation of ORS 366.514 and provided ODOT's interpretation of its use.

The statute refers to improvements for bicycling using the term 'bicycle trail.' "*As used in this section, "bicycle trail" means a publicly owned and maintained lane or way designated and signed for use as a bicycle route.*" Based on the terminology, it may have been understood or assumed at the time the legislation was passed that people are more likely to ride bicycles when a separated facility is provided. The generic term 'bikeway' is more commonly used to refer to all facilities where a bicycle can ride. Thus, quotations using the term 'trail' may be substituted with 'bikeway.'

The mandate to construct bikeways is phrased in the ORS: *"Out of the funds received…from the State Highway Fund reasonable amounts shall be expended as necessary to provide … bicycle trails… as part of the project… wherever a highway, road or street is being constructed, reconstructed or relocated. Funds received… may also be expended to maintain … trails and to provide … trails along other highways, roads and streets."* This statute has limited application to ODOT projects because 'Construct, reconstruct or relocate' refers only to projects where a roadway is built or upgraded. The 1995 Bike & Ped Plan, Appendix C says: *"Walkways and bikeways don't necessarily have to be provided on projects where the scope of work is signal or signing improvements, landscaping and other incidental work. Preservation overlays are also excluded if the only intent of the project is to preserve the riding surface in usable condition, without any widening or realignment."* Projects in which the entire depth of the roadway bed is replaced are few and rare today. Thus, whenever a road is not fully reconstructed, but a lesser scale alteration to the roadway is made nonetheless, there is not a requirement to upgrade the quality of bikeway.

(2) …trails are not required to be established under subsection (1) of this section:

- *a. Where the establishment of such … trails would be contrary to public safety;*
- *b. If the cost of establishing such … trails would be excessively disproportionate to the need or probable use; or*
- *c. Where sparsity of population, other available ways or other factors indicate an absence of any need for such … trails.*

Where the statute mandates a project to include bikeway facilities, it does not address the quality of bicycling infrastructure, and provides exclusions for safety, cost proportionality and expected usage. The 1995 Oregon Bicycle & Pedestrian Plan, Appendix C: ODOT Interpretation of ORS 366.514 has explanations for each of the exceptions. The following are excerpts that may pertain to bikeway selection: *"…cost is excessively disproportionate to need or probable use: this exemption applies if it can be shown that there is insufficient need or probable use to justify the cost. Probable use must extend to cover the anticipated life of the project, which can be twenty years or longer for roadway projects, fifty years or longer for bridge projects. It is not sufficient to claim that there is little or no current pedestrian or bicycle use. This is often due to the lack of appropriate facilities…"* This exception can affect the type of bicycling improvement that is included in a project if the more appropriate facility is more expensive. Another excerpt: *"… other available ways ... indicate an absence of any need: For this exemption to apply, it must be shown that the "other available ways" serve bicyclists and pedestrians as well as or better than would a facility provided on the road, street or highway in question. The "other available ways" must provide equal or greater access and mobility than the road, street or highway in question. An example sufficient to indicate other available ways would be providing sidewalks and bike lanes on a parallel or adjacent street rather than along a freeway. An example not sufficient would be choosing not to provide bike lanes and sidewalks on an arterial street and encouraging use of local side streets that do not include bicycle and pedestrian facilities nor offer the equivalent direct route or access as the arterial street."* This exception has also been used in the past to justify improvements on other streets to avoid riding on the highway. Another excerpt: *"…other factors ... indicate an absence of any need: This exemption allows consideration of other factors that are particular to a project. A common example is the acceptability of cyclists sharing the roadway with automobiles on low volume, low traffic local streets. Again, the absence of any need must be found."* This exception indicates that accommodating bicyclists in mixed traffic conditions is adequate under some conditions. As a result, bikeways that have been constructed on most highways serve only the most confident bicycle riders, while the majority of people who are interested in cycling for transportation would require a different level of accommodation to consider traveling by bicycle, instead of by car, for the short trips they might ride.

The statute identifies the minimum amount of funding required for bicycling (and pedestrian) expenditures and requires ODOT to prescribe the standards for bikeway construction. *"The amount expended… shall never…be less than one percent of the total amount of the funds received from the highway fund…"* ODOT ensures compliance with the statutory obligation to spend a minimum of 1% of the State Highway Fund on bikeway (and walkway) facilities through the ODOT Bicycle and Pedestrian Program that funds projects specifically targeting improvements to the state's bikeway (and walkway) network. Since the ODOT Bicycle and Pedestrian Program has some authority in project selection for projects funded in its own program, there is some ability to also influence bikeway facility selection.

The statute also says: *"…The department* ***shall recommend construction standards for … bicycle trails****. … The department shall… provide a uniform system of signing … bicycle trails which shall apply to … trails under the jurisdiction of the department ...The department…may restrict the use of… bicycle trails…"* Based on this ORS, ODOT is the authority to provide the guidance on what bikeway facility is appropriate. ODOT guidance about construction (design) standards are documented in the Oregon Bicycle and Pedestrian Design Guide, which is Appendix L of the *Highway Design Manual*.

Federal Rules and Policy

Federal law regarding the administration of federal aid for highways is established in 23 CFR, subchapter G, part 652.5. Included in this regulation is the following policy statement: *"The safe accommodation of…bicyclists should be given full consideration during the development of Federal-aid highway projects, and during the construction of such projects…Where current or anticipated…bicycle traffic presents a potential conflict with motor vehicle traffic, every effort shall be made to minimize the detrimental effects on all highway users who share the facility…where a bridge deck is being replaced… shall be reconstructed so that bicycles can be safely accommodated when it can be done at a reasonable cost. Consultation with local groups of organized bicyclists is to be encouraged in the development of bicycle projects."*

In 2010, the United States Department of Transportation issued a policy statement declaring support for going beyond minimum requirements to provide improved pedestrian and bicycle facilities. Their 2010 policy statement said that *"every transportation agency… has the responsibility to improve conditions and opportunities for…bicycling and to integrate…bicycling into their transportation systems. Because of the numerous individual and community benefits that…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."* This memorandum encouraged road authorities to go beyond accommodation to improving the conditions for people walking and riding bicycles.

The FHWA issued a related memorandum in 2013 suggesting that current design references should be supplemented with various innovative guides and resources *"…to help fulfill the aims… to go beyond the minimum requirements, and proactively provide convenient, safe, and context-sensitive facilities that foster increased use by bicyclists…of all ages and abilities."* This memorandum affirmed support for design flexibility through the utilization of innovative designs that build upon the flexibility provided by current design standards in order to achieve improved conditions for bicycling.

In 2015, ODOT responded with a letter of support that encourages engineers, planners and designers to reference the growing library of resources that help fulfill ODOT's mission *"…to provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians…"* and *"…to be at the forefront of the integration of sustainable intermodal transportation…to help form sustainable solutions to today's ever-increasing intermodal transportation challenges…"* The design resources referenced in ODOT's letter are intended to endorse selection of appropriate bikeway facilities.

The Manual on Uniform Traffic Control Devices

Federal law 23 CFR 655 Subpart F requires that all traffic control devices on public highways be in substantial conformance with the national standard established by the *Manual on Uniform Traffic Control Devices* (MUTCD). Oregon Administrative Rule OAR 734-020-0005 establishes an Oregon Supplement to the MUTCD that contains approved deviations from the federal manual in order to be in conformance with Oregon laws or other approved reasoning. Other deviations from MUTCD standards are permitted when following FHWA experimentation procedures or interim approvals. Some bikeway facility types are not likely to function effectively unless accompanied with traffic control measures.

Transportation Planning Policies

Transportation Planning Rule

In Oregon, transportation planning is governed by Oregon Administrative Rule 660, Division 12. This is also known as the Transportation Planning Rule (TPR). Excerpts from the TPR are listed below with some commentary:

Part 660-012-0000 identifies the role of bicycle facilities in the planning process: *"(1) …The purpose of this division is to direct transportation planning in coordination with land use planning to… (b) Encourage and support the availability of a variety of transportation choices for moving people that balance vehicular use with other transportation modes, including…bicycling…in order to avoid principal reliance upon any one mode of transportation…(c) Provide for safe and convenient...bicycle access and circulation."* Thus, transportation planning efforts should be cognizant of the land use around it and examine how transportation networks enable people to realistically use the bicycling network if they choose to avoid relying on automobile travel. This analysis could include the selection of appropriate bicycle facilities within those networks in order to accomplish that goal.

Part 660-012-0020 talks about Transportation System Plans (TSP): *"(2) A TSP shall include the following elements…(d) A bicycle…plan for a network of bicycle…routes throughout the planning area. The network and list of facility improvements shall be consistent with the requirements of ORS 366.514…(3)…shall contain…(c) A description of the location of planned facilities, services and major improvements, establishing the general corridor within which the facilities, services or improvements may be sited. This shall include a map showing the general location of proposed transportation improvements, a description of facility parameters such as minimum and maximum road right of way width and the number and size of lanes, and any other additional description that is appropriate."* This section suggests that an understanding of the appropriate bicycle facility would be known during the development of a TSP in order for the TSP to include a description of the parameters and a range of dimensions. However, if a completed TSP did not go into detail to evaluate each bicycle facility in the network, the lack of a specified appropriate bikeway type could be a barrier to implementing that bikeway in a project, particularly if the appropriate bikeway dimensions would require acquisition of right-of-way.

Part 660-012-0045 talks specifically about governments implementing TSPs and provides direction about adopting regulations for bicycle travel that include the types of facilities and where they are required. *"(3)(b) On-site facilities shall be provided which accommodate safe and convenient…bicycle access from within new subdivisions, multi-family developments, planned developments, shopping centers, and commercial districts to adjacent residential areas and transit stops, and to neighborhood activity centers within one-half mile of the development…(B) Bikeways shall be required along arterials and major collectors. Sidewalks shall be required along arterials, collectors and most local streets in urban areas, except that sidewalks are not required along controlled access roadways, such as freeways;…(c) Where off-site road improvements are otherwise required as a condition of development approval, they shall include facilities accommodating convenient pedestrian and bicycle travel, including bicycle ways along arterials and major collectors; (d) For purposes of subsection (b) "safe and convenient" means bicycle and pedestrian routes, facilities and improvements which: (A) Are reasonably free from hazards, particularly types or levels of automobile traffic which would interfere with or discourage pedestrian or cycle travel for short trips; (B) Provide a reasonably direct route of travel between destinations such as between a transit stop and a store; and (C) Meet travel needs of cyclists and pedestrians considering destination and length of trip; and considering that the optimum trip length of pedestrians is generally 1/4 to 1/2 mile."* This section presumes that the appropriate bikeway uniformly corresponds with the street types (arterial, collector, local) and that the bikeway network should proceed along the same street network with motor vehicles. In describing bicycling facilities as 'safe and convenient', the rule suggests that bikeways are intended to be separated from motor vehicle travel. Another assumption in this section is that trip lengths are only ½-mile, which considers both pedestrian and bicycle modes, but underrepresents trip lengths that bicyclists travel.

Oregon Highway Plan

The provision of bicycle facilities is addressed in a statewide perspective in statewide planning documents, including the Oregon Highway Plan and the Oregon Bicycle and Pedestrian Plan.

The Oregon Highway Plan has two actions related to bicycle facilities: Action 1B.10 *"Continue to develop and implement design guidelines for highways that describe a range of automobile, pedestrian, bicycle or transit travel alternatives"* and Action 2F.3 *"In identifying solutions to traffic safety problems, consider solutions including, but not limited to: Constructing appropriate bicycle and pedestrian facilities including safe and convenient crossings."*

Oregon Bicycle & Pedestrian Plan

The Oregon Bicycle and Pedestrian Plan has nine goals, a number of policies within those goals, and a number of planning strategies identified for achieving each of those policies. Those policies and strategies that pertain to bicycle facility selection are noted below with commentary.

Within Goal 1 (safety), Policy 1.1, Strategy 1.1A says: *"Continue to update the ODOT Design Guidelines and Highway Design Manual to identify appropriate…bicycle design features (e.g. type of separation, buffers, or crossing designs) suitable for different contexts, including consideration of: vehicle speed, roadway characteristics and constraints, planned land uses, users and uses, areas of … cyclist priority, and latent demand."* Strategy 1.1J says: *"Track and implement national guidance on emerging technologies that improve…bicycle safety."* It is a stated policy to develop design guidelines for a wide range of appropriate bicycle facilities.

Within Goal 2 (connectivity), three of the policies relate to bike facility selection. Policy 2.1, Strategy 2.1B says: *"When local planning processes have, in consultation with ODOT, identified a local parallel bike route, and a bikeway on the state highway is determined to be contrary to public safety, is disproportionate in cost to the project cost or need, or is not needed as shown by relevant factors and therefore justified to be exempt from ORS 366.514 based on one of those statutory exemptions, ODOT will work with the jurisdictions to support the development of the parallel route and assure reasonable access to destinations along the state highway. ODOT and the local jurisdiction may enter into an agreement in which ODOT helps to fund, in negotiation and partnership with the local jurisdiction, construction of the bikeway in the vicinity of the state highway project that serves as an alternative or parallel route to the highway project."* Another policy mentions that the bicycle facility itself can help steer prioritization of projects, which could relate to the adequacy of a bicycle facility. Policy 2.2 says: *"Inventory and define …biking networks to aid in project prioritization."* Another example of a policy that touches on bicycle facility selection mentions the facility to be used for the promotion of tourism. Policy 2.5 says: *"Support off roadway…bikeways that help to connect communities, provide alternatives to motorized travel, or promote and support…biking tourism."*

Within Goal 3 (mobility and efficiency), Policy 3.3, Strategy 3.3A says: *"Research best practices and integrate into design guidelines innovative design treatments that both safely accommodate bicyclists and pedestrians and maintain appropriate freight carrying capacity. Promote opportunities for separation that does not constrain the mobility/accessibility of either mode."* Consideration of freight carrying capacity is necessary when considering the selection of bicycle facilities.

Within Goal 8 (strategic investment), Policy 8.2, Strategy 8.2A gives priorities for identifying investments in bicycle projects. Among the priorities, it says: *"Elaborate the system through increased network connectivity, such as … more costly user comfort features."* Strategy 8.2B says: "*Be opportunistic in acquiring right-of-way for future potential…bicycle facilities…"* Part of the policy is to strategically improve the statewide bicycle network by addressing those locations where the existing bikeway type underserves the need or is not sufficiently comfortable for potential users to choose to ride under existing conditions. Elaborating the system would be to improve the bikeway type to something appropriate for its context. In many cases, the appropriate facility requires right-of-way and/or extra cost.

In order to achieve the goals stated within the Oregon Bicycle and Pedestrian Plan, an Implementation Work Plan is in place that contains near-term actions in order to put the policies into action. Three key initiatives are identified, the first of which endorses the functionality of bikeway facilities. Initiative 1 is "Defining the network" which is summarized: *"Establish design and function expectations. Provide clarity on appropriate infrastructure, design, and treatments given unique contexts. Identify needs."* The way that a bikeway facility functions is a description of the selection of the bikeway facility type.

Oregon Transportation Safety Action Plan

The Oregon Transportation Safety Action Plan (TSAP) is a statewide strategic highway safety plan that provides a framework to accomplish a vision to eliminate fatalities and serious injuries by 2035. To achieve that vision, it has six goals and a number of policies and strategies within those goals. A couple of these policies can relate to the selection of bikeway facilities.

Within Goal 2 (infrastructure), Policy 2.3 says: *"Plan, design, construct, operate, and maintain the transportation system to achieve healthy and livable communities and eliminate fatalities and serious injuries for all modes."* Strategy 2.3.4 says: *"Educate transportation planning and design professionals on how to incorporate safer context-sensitive designs into community projects."* Since different bicycle facilities may be appropriate in different contexts, this strategy and policy direct the consideration of context-sensitivity in bikeway selection.

Within Goal 3 (Livable Communities), Policy 3.4 says: *"Invest in transportation system enhancements that improve safety and perceptions of security for people while traveling in Oregon."* Strategy 3.4.1 says: *"Enhance perceptions of bicycling, walking, and transit safety and security by identifying and implementing appropriate facility design, lighting, and other changes to the built environment to improve personal security for pedestrians, bicyclists, and transit riders."* Thus, the selection of bikeways influences users' perception of safety, and facilities that promote the perception of safety should be selected.

Transportation System Plan Guidelines

ODOT recently updated its guidelines for TSPs. An interactive website is available to help guide TSPs toward needs determination, including a specific application for bicycles. The application has descriptions for actions that Shall, Should and Could be included. Below are the guidelines with emphasis added in bold, underlined text:

Shall: At a minimum, the assessment of the bicycle infrastructure Shall include:

- Identification of the local, regional, and state **standards for adequacy**
- **Evaluation of deficiencies** in the bicycle network, including gaps/missing bike lanes, narrow bike lanes, poor surface conditions, roadway hazards, etc.

Should: In addition to the items listed above, the assessment of the bicycle infrastructure Should include the following elements when locally appropriate and when funding allows:

- Analysis of bicycle connectivity along key study corridors using one of two methodologies:
    - Conduct a Qualitative Multimodal Assessment of the bicycle network (see ODOT's Analysis and Procedures Manual for technical guidance)
    - Conduct a bicycle level-of-traffic stress analysis of the bicycle network (see ODOT's Analysis and Procedures Manual for technical guidance)
- Evaluation of gaps in bicycle access to destinations including transit stops, schools, shopping, medical, civic, recreational uses, and trails
- Analysis of bicycle crash data and risk-based safety issues (see ODOT's Bicycle Safety Implementation Plan for additional information)
- Evaluation of high bicycle fatality and serious injury crash locations

Could: Although not typically required or critical to the development of most TSPs, the assessment of the bicycle infrastructure Could include the following elements when locally appropriate and when funding allows:

- Evaluation of **bicycle design standards** (e.g. Central Business District, residential standards, etc.)

The TSP Guidelines also have an application for Developing Solutions. The guidance also details Shall, Should, and Could, and includes many specific bicycle solutions.

2.2 Current Design Guidance for Bicycle Facilities

This section summarizes ODOT's existing design guidance for bicycle facility selection. Areas are highlighted where the current guidance may result in differing interpretations for bicycle facility selection and/or gaps in bicycle facility selection guidance. A "gap" may indicate the need for direction about a "design user" and at what point should a parallel facility be developed. Sources of guidance come from the following:

- *Highway Design Manual* (HDM) Chapters 2, 6, & 13
- HDM Appendix L – Bicycle and Pedestrian Design Guide, Chapters 1 & 2

Oregon Highway Design Manual

Chapter 2 of the HDM discusses design controls. While design vehicles are discussed in this chapter, design users of bicycle facilities are not. Section 2.3 discusses accommodation of bicyclists as well as mentions the range of bicyclists in age and ability. The discussion mentions requirements in ORS 366.514 and the ADA, and then links ODOT's agency mission statement to "improve livability and economic prosperity" to the goal of higher quality bicycle facilities. It says (emphasis added):
"Bicycle tourism is a significant industry in Oregon that also impacts Oregon's livability and

economic prosperity. Comprehensive bicycle facility design, rather than basic accommodation should be considered ***along designated bicycle routes****."* Section 2.3.2 goes on to say (emphasis added): *"Bicycle accommodation is required on all highways, except those described in OAR 734-020-0045. Bike accommodation should be continuous on both sides of the roadway…. Bicycles are vehicles and should be accommodated as roadway users where possible. The path for bicyclists should be direct, logical and close to the path of motor vehicle traffic, making bicyclist movements visible and predictable to motorists. Safe on-street bicycle accommodation includes bicycle-safe drainage grates and adjusting manhole covers to street grade. Designs* ***may also*** *accommodate bicyclists of lesser abilities. Only in rare cases should bicyclists be required to proceed through intersections as pedestrians. Oregon law (ORS 814.420) requires bicyclists to use a bike path or bike lane, rather than the roadway travel lanes, if a bike path or bike lane is provided."* The language in this section notes a preference that bicyclists should always be accommodated as a vehicle, while additional accommodations that may benefit all ages and abilities are an option. It clarifies that it is not appropriate for bicycles to be accommodated as pedestrians by saying that such accommodation should be rare. In practice, some efforts to provide for bicyclists of lesser ability result in accommodation that is mixed with pedestrians and may have operational disadvantages not tolerated by people who are capable of traveling as a vehicle. Thus, this statement recognizes that bikeway facilities should be separated both from pedestrians and from vehicles, which relates to the selection of bikeway facilities.

Chapters 6 and 13 of the HDM indicate the required accommodation for bicycles. Chapter 6 is organized by facility type and includes all modes. **Table 3** compares all segment types in Chapter 6 with HDM sections that address bikeway design:

Table 3. Segment Type Information Comparison

Segment Type	Section in HDM	Guidance
Urban Expressway	6.2.1.3	5 paragraphs
Special Transportation Area (STA)	6.2.2.3	3 paragraphs
Urban Business Area (UBA)	6.2.3.3	3 paragraphs
Commercial Center (CC)	6.2.4	1 paragraph
Special Overlay – Freight Route	6.2.5	Not specified
Special Overlay – Lifeline Route		Not specified
Special Overlay – Scenic Byway		Not specified
Non-designated Urban Highway	6.3	Not specified
Urban Fringe	6.3.1.3	3 paragraphs
Developed Areas	6.3.2	Not specified
Traditional Downtown	6.3.3.3	3 paragraphs

The organization of information in Chapter 6, if read altogether, should provide adequate information about bikeway design, but since some of the context types do not specify the bikeway accommodation, there could be potential confusion as to which standard is required. Chapter 13 provides the same information as Chapter 6; however, it discusses bicycle accommodation from the perspective of bikeway design rather than the whole urban context, and contexts are mentioned only in a comparison table. Section 13.1.2 says (emphasis added): *"The greatest need for bicycling facilities is on urban highways…Table 13-1 compares the required minimum 4-R shoulder width with a **list of possible bicycle facility types** for each type of highway segment designation. The proper bicycle facility is context dependent. Factors for consideration are given in the Urban/Suburban Recommended Separation Matrix in Appendix L, pages 1-2 to 1-5."* The table format indicates that there are multiple options for which bike facility type can be used. It should be noted that separated bike lanes were called 'cycle tracks' in the 2012 HDM. However, the table format could seem to limit the types of bicycle facilities, where a particular option is not listed. The footnote of the table refers to the Bicycle & Pedestrian Design Guidance if considering accommodation only on parallel routes. Section 13.1.2.3 indicates where only accommodating bikes on parallel streets would be appropriate.

Additionally, Section 13.1.1.2 says *"Rural (or urban) highways designated as Scenic Bikeways, National Bike Routes **or other recognized bikeways** should have greater attention to bicycle accommodation. Rumble strips are usually omitted along sections of highway that are designated bikeways but may be included where their impact on cyclists is sufficiently mitigated. Shoulder width is a significant consideration. See Traffic Manual, section 6.27. Ongoing maintenance to keep shoulders clear should be a priority on these routes. Construction activity on shoulders of designated bikeways should make provisions to accommodate cyclists during construction or consider signed detours that may be different from motor vehicle detour routes. A list of milepoints, corresponding to currently designated bikeways can be found in Appendix E."* Based on this discussion, the way to indicate the need to design for all ages and abilities is to recognize or designate the route as a bikeway. Where a route is identified as a bikeway, accommodation should be greater than the simplest form. Thus, high quality bikeways could be the required facility wherever a bikeway is recognized.

Oregon Bicycle & Pedestrian Design Guide

Appendix L to HDM (The Bicycle and Pedestrian Design Guide) provides bicycle facility selection guidance. The format of this guidance is to answer the question: what level of separation is needed in urban/suburban settings? A nomograph is provided to compare speed and traffic volume with an output that helps identify the appropriateness between three categories of bicycling accommodation. Following the nomograph are a table and discussion that include various site characteristics to help make the decision between the appropriateness of shared lane versus the need to provide a bike lane. If separation is needed, the current guidance does not refine that decision-making among the options, does not have a decision-making framework to support project needs, and does not require that the preferred facility be selected. A specific note is made about cycle tracks (protected bike lanes) on pages 1-2 that notes its status as an emerging design not yet in wide use. This statement could discourage some practitioners from implementing that design.

The design matrix is not a requirement for providing bicycle facilities. If ODOT required bicycle facilities to match the guidance in this section, as ODOT requires for ADA, then more robust facilities could be designed and constructed. If required bike facilities are not appropriate at certain locations, then a design exception/documentation can be submitted.

The bulk of Chapter 1 in Appendix L discusses each bikeway type individually and provides design information that helps determine the appropriateness for its use. Beginning on pages 1-27, there is discussion of 'innovative designs' followed by 'practices to be avoided' on pages 1-31. Some protected bikeway designs are in conflict with some of the practices to be avoided. There is discussion about the appropriateness of using parallel routes as an alternative to bike lanes on pages 1-15.

Chapter 2 of Appendix L is entirely focused on strategies to provide conventional bike lanes when reconfiguring existing roadway space (road diet). Other bikeway facility types are not mentioned in this chapter, making the assumption that bike lanes are the preferred facility for a road diet project.

2.3 Current Process for Selecting Bicycle Facilities

Currently, ODOT's process to identify the appropriate bicycle facility to be included in upcoming projects varies. This section is divided to discuss the project cycles:

- Planning Studies
- STIP Projects
- Maintenance Projects
- Local Agency Projects
    - Enforcing code for the cross section
- Developer Projects
    - Enforcing code for the cross section

Transportation Plans

The planning process leads into project development in a manner similar to developing a shopping list. A plan is typically meant to identify the needs and priorities of a transportation network over a long period of time. It is intended to identify potential projects, but not design them. Typically, part of any planning study includes a focus on bicycle facilities, which may or may not be a major focus of the overall plan. Every planning study has a public involvement process. The bikeway portion of the plan is often presented during the public meetings, which gives opportunity for community support for the facility type as presented. Some planning studies go into great detail refining the specifics of bikeway facilities, while others do not. A study may contain cross section alternatives along a corridor, or a high-level study may only identify routes where a bicycle facility is missing and needed. Some plans merely indicate a bike lane is needed. Some indicate descriptions, such as 'enhanced bikeway' to indicate something more than bike lanes without designating the specific design. Others lay out a proposed cross section that may include dimensions. A transportation plan that does not go into as much detail about bicycle facility selection could result in assumed community support for a lesser quality bicycle facility than what might be recommended.

Current planning projects that follow modern statement of work requirements (whether it is a TSP or refinement-type study) typically will have a multimodal analysis performed either using Level of Traffic Stress (LTS) or a multimodal LOS to determine deficiencies (e.g., missing sections, uncomfortable sections). Methodologies exist for the full range of modern bike facilities from mixed traffic to separated paths and bikeways. Deficiencies are addressed in the alternative development phase with a number of proposed alternatives/projects/options analyzed with the same performance measure (i.e. LTS) to determine the best facility choice. These alternatives would be later evaluated against a set of criteria and funding requirements. The successful projects would be placed in the preferred list and given appropriate short/medium/long-term priorities.

Older projects would not have as much in the plan other than a gap analysis, and TSPs often provide a typical cross section. In translating the plan to a project, it would be up to the project team to figure out the best solution for a particular roadway, guided by the roadway functional class, existing roadway standards, etc. Since plans are intended to and expected to represent the transportation needs over a long time period (e.g., 20 years), a jurisdiction with a plan that lacks a focus on bicycle facility types could be a barrier to implementing enhanced bikeway facilities in that jurisdiction due to not having been spelled out on a needs list. Likewise, a plan that did focus on bikeway facility types could be a barrier to implementing the appropriate bikeway type if the plan specified a basic bikeway facility type (because that was all that was known at the time of the study) and since then, might have been deemed less adequate than the current thinking. Not many of the TSPs throughout the state include projects that call for physically separated bicycle facilities aside from shared-use paths. Another barrier is that 'bolder' bicycle projects are sometimes not adopted in local TSPs.

One of the perceived barriers to implementing a desired cross section that supports an appropriate bikeway facility is that the cross section would not meet ODOT design standards and would require approval through a design exception. However, ODOT provided the flexibility through the design exception process so that the exception can be approved in the planning phase, allowing for agreement on dimensions. Currently, requests for design exceptions during planning are seldom, likely because planning consultants are not aware that design exceptions are possible and because the process is not clearly spelled out in ODOT guidance documents.

Planning documents have been used as a resource in Project Development. The Tech Center has discouraged the specific callout of bicycle facility dimensions, and ODOT has maintained that at the planning phase they are only trying to identify needs. Sometimes this results in a lack of direction in the project scoping phase for how to reconcile planning documents with minimum ODOT standards. The planning stage is where bicycle facility type decisions should be made in order to garner community buy-in and to provide direction to project teams. The process lacks a more detailed investigation and involvement of a multi-disciplinary team to determine what is feasible and what may not be viable. Planning documents need more guidance around what information within plans would assist future implementation. For example, if a plan calls for a protected bicycle facility, it should be included in a future project. If it is not in the plan, then often it may be perceived as just something the "bike guy" wants added to the project.

STIP Projects

The Statewide Transportation Improvement Program (STIP) is a blueprint for how all state and federal transportation funds are used in a four-year period. The cycle to allocate funding into projects is initiated every three years, re-visiting one of the years finalized in the previous STIP. The process for project selection is different between funding categories. The categories for funding are also subject to change whenever federal transportation funding changes. There are currently five categories: Fix-It, Enhance, Safety, Non-highway, and Local Government. Although much of the funding in the STIP is supplied by federal funding programs that have their own rules on how the money can be spent, Oregon's STIP funding categories have their own rules that may further limit what can be included in a project.

The ability to include bold bikeway facilities depends on whether there is a focus on bike/ped improvements in the project and how it is applied in the business case.

For any of the funding scenarios, reviewing local long-range planning documents and the role of the documents in determining the planned function and in assessing the adequacy of bicycle facilities on state highways may or may not be done. The following is a list of practices that help with decision-making in the project planning/development stage that are available, but not currently required. Each item on the list below may or may not be refined for implementation.

- Review of prior ODOT and local planning/data evaluation efforts
- Reference to Active Transportation Needs Inventories
- Application of methodologies in the Analysis Procedures Manual (APM) (Level of Traffic Stress [LTS] and Multimodal Level of Service [MMLOS])
- Application of *Highway Design Manual* Guidance (as noted in Section 2.2)

Typical outcomes of these approaches in urban areas (what bicycle facility types have been selected/implemented in recent urban 4R projects) result in conventional bike lanes, even after protected bike lanes were recommended. A recent example is a project on US26 in Portland (Outer Powell), where protected bike lanes were recommended. However, due to numerous conflicts and difficulties in implementation, protected bike lanes were not deemed possible, so a thorough Outer Powell bicycle facility analysis was conducted that resulted in some protected bikeway improvements, but much smaller in scale than was envisioned.

Fix-It

The Fix-It category is intended only to preserve and repair the transportation system. Within the Fix-It category, there are several programs, and each has a corresponding ODOT work unit that selects the projects. The criteria for project selection for each program are based on statewide policies or legislative goals that are linked to how ODOT's performance is measured (e.g., number of miles of pavement in a condition of fair or better). Thus, projects funded by one of the Fix-It programs can only use that Fix-It money to address the primary objective of the project. Other needs can only be added to a project if using another funding source.

The ODOT *Highway Design Manual* defines the scope of work for a paving project based on categories that list the number of 'R' words defining a level of pavement improvement: Reconstruction, Resurfacing, Restoration, and Rehabilitation. ODOT categories include 4R, 3R, and 1R. (Currently, 2R is not an approved program in Oregon). While ODOT Pavements unit will recommend work to repair highways with poor pavement ratings, project scoping teams must also assess other needs along a project corridor. There is a table in the HDM with like-to / have-to features. When scoping, features are evaluated to determine what else needs to be part of the scope. Depending on that assessment, a project intended to have been 1R has to be 3R, or a 3R project may have to be 4R. The quality of bikeway facilities is not an evaluation metric that would change the project type. However, if the project becomes 4R, the bikeway is in the scope of work. (See 'Enhance' below.) While 1R and 3R projects do not include bikeway improvements, Sidewalk Improvement Program (SWIP) funds or safety funds can be added to 1R or 3R projects to take advantage of contract efficiency and include bikeway improvements with that project. SWIP is described in 'Non-Highway' below. Opportunities to add bikeway improvements are often missed. It requires more attention to the planning phase.

Enhance

Within the Enhance category, the Area Commissions on Transportation (ACTs) recommend the projects and local transportation plans are a key influencer on which projects the ACT will select. This involves a review of local long-range planning documents and identifying the role of these documents in determining the planned function and assessing the adequacy of bicycle facilities on State Highways. Among projects where the focus is not bicycling, there are many levels of design. Few projects are in the category of New or Major Reconstruction (4R) Projects. Many of these projects were preceded by decision-making settled at the Planning Phase or NEPA phase, since most of these are large projects likely to have environmental impacts. Additionally, almost all 4R projects in the last 20 years have come from earmarks by legislature that may also influence the project scope. The bicycle facility should be decided long before a specific project is going to construction. Long range planning documents are mentioned above, but design decisions made in the planning process could memorialize the scope of the eventual improvement. By the time the project is designed, project teams are looking at the details, not determining what facility type is appropriate. If the facility is not the same as presumed during the planning phase, the project would need to launch a whole new planning process, which was done in the Outer Powell example above. Some enhance projects have a direct focus on bikeway improvements. These are described below with 'Non-Highway.'

Safety

Within the Safety category, projects are selected on a basis of cost-benefit, meaning additions that improve access for bicycles would be less-competitive unless they have a significant measurable safety benefit. Thus, bicycle improvements are not added to Safety projects unless funding comes from another source. The Pedestrian and Bicycle Safety Implementation Plan was developed to guide the selection of projects to address bicycle crashes and identify bikeway improvements that qualify as safety countermeasures.

Safety projects use a process that identifies corridors with the most potential for reducing frequency and severity of bicycle crashes based on risk factors and crashes. Review of planning documents and a site-specific assessment of the roadway are used to determine the most appropriate bikeway facility designs, and an analysis of costs and potential reduction in crashes is used to prioritize investments.

The Pedestrian and Bicycle Risk Scoring Tool may be used too.

Non-Highway

The Non-Highway category of the STIP is named inappropriately. It includes projects that focus specifically on making improvements for bicycles (and pedestrians) even though most of these improvements are actually on the Highway. Among these are projects that are administered through competitive grant programs. The following is a list of some of these competitive programs, though many of them no longer exist or change for each STIP cycle, while different ones exist in different STIP cycles. Some examples include: Safe Routes to Schools, Transportation Enhancements/Transportation Alternatives, Bike & Ped Grants, Connect Oregon, Federal Flex Funds, and so forth.

A portion of the funding is state highway funds, which has restrictions on the use of the funds that must be used in highway public right-of-way. Federal funds can be used outside of the ROW for trail projects.

ODOT sets the criteria for these competitive programs and thus has influence on the bikeway selection, but the ACTs often select the projects themselves.

There is also a portion of State Bicycle & Pedestrian funding for the ODOT Bicycle and Pedestrian Program that has SWIP and QuickFix money. SWIP money is managed by the ODOT Regions and is primarily intended to leverage Fix-It or Maintenance projects that would not otherwise upgrade bicycle facilities. Bicycle/Pedestrian QuickFix projects are also intended to be used as opportunity permits. They tend to be used for ODOT Maintenance districts to make small low-cost improvements but could also be enhancements to the pedestrian or bicycle network. There is also a Safety QuickFix program that operates similarly for Safety improvements.

Local Government

Portions of highway funding are allocated to counties and cities. Their funding can be leveraged with federal funds or can be used by itself. When local governments leverage their funds with federal funds, ODOT is involved, unless that local government is fully certified to manage federal funds. Thus, ODOT manages these projects whether or not they are on ODOT's highway system and has influence on the development of appropriate bikeway facilities on those local streets when federal funds are used. Likewise, if a local government uses its own funds to do a project on the state highway system, ODOT has the authority to influence the bikeway facility type (among other influences) for that project. Usually, this is done similarly to the process for private developer permit projects described below.

Maintenance

Highway funding comes to Oregon from state and from federal sources. State funds are used to match federal funds in order to qualify for the various types of federal programs, as described above with STIP projects. Also, 1% of the state highway funds is allocated to the Bicycle and Pedestrian Program for projects, described in the 'Non-Highway' section above. The balance of state highway funds is used for maintenance. Outside of the STIP process, ODOT conducts a variety of smaller scale work on highway that includes paving, traffic signal operations, and so forth. Paving projects trigger the obligation to include curb ramps, but do not include bikeway improvements. ODOT has a policy to preserve the condition of a bikeway's shoulder when paving so that the seam is not in the middle of the bike lane or shoulder.

Private Funding (Developer Projects)

Many improvements on the state highway system come from private sources as a condition for a development on or along the state highway. Private properties are required to obtain a permit to perform work, and ODOT has conditions that may be imposed on a development to obtain that permit. However, according to adjudicated Supreme Court land-use cases Nollan versus California Coastal Commission (1987) and Dolan versus City of Tigard (1994) (commonly referred to as Nollan and Dolan), governments may only require developers to pay for work through a permit that is directly related to and roughly proportional with the impact of that development. Thus, ODOT cannot require a developer to pay for necessary bikeway improvements that otherwise might be included when a highway is redeveloped if the development itself is too small to warrant the associated cost. Also, since ODOT is a third party in a development scenario, ODOT does not have authority to require sidewalk or bicycle improvements as a condition of a permit unless the local government has in its land use code that such improvements are required. The local government, rather than ODOT, must specify that requirement as a condition.

2.4 Barriers to Implementing Bicycle Facilities

Barriers to implementing the desired bicycle facility type have been noted in the Sections 2.1, 2.2 and 2.3. A summary of these barriers is repeated in **Table 4**. These are reasons that bicycle facilities may not be selected and implemented in alignment with the Urban/Suburban Recommended Separation Matrix on pages 1-3 of Appendix L (and/or in alignment with upcoming AASHTO bicycle facility design guidance).

Table 4. Summary of Barriers to Implementing Desired Bicycle Facility Types

Section	Topic	Barrier
2.1.1	366.514	• Refers only to projects where a roadway is built or upgraded • Such projects are few and rare. • There is not a requirement to upgrade the quality of bikeway. • Exclusions exist for safety, cost proportionality and expected usage.
2.2	HDM	• Seems to note a preference that bicyclists should always be accommodated in a vehicular-cycling manner • Could be potential confusion as to which standard is required • Table format could seem to limit the types of bicycle facilities, where a particular option is not listed.
2.2	BPDG	• It labels status of cycle tracks as an emerging design not yet in wide use. • Some protected bikeway designs are in conflict with some of the section: practices to be avoided. • Assumes that bike lanes are the preferred facility for a road diet • Design matrix is not a requirement for providing bicycle facilities.
2.3.1	Adopted Plans	• A low-detail planning study could result in assumed community support for lesser quality bicycle facility or could be a barrier to implementing a bikeway if it would require acquisition of right-of-way. • Not spelled out on a needs list • 'Bolder' bicycle projects are rarely included in TSP project list. • Currently, requests for design exceptions during planning are rare. • Lacking a bicycle functional class system and related performance standards makes it difficult to show a need and to choose appropriate facility types, as opposed to just filling a gap where no facility exists. • Process lacks a more detailed investigation involving a multi-disciplinary team to determine what is feasible and what may not be viable.
2.3.2	Projects	• 'It's just something the "bike guy" wants added to the project.' • Decision-making for large projects settled years ago at planning phase. • Project teams ambivalent to go through the work of following the required process for traffic control that may support bikeway (e.g., experimental). • Opportunities to add bikeway improvements are often missed. It requires more attention to the planning phase.

The following is a list of miscellaneous barriers.

- Trade-offs with other design priorities in constrained urban environments (e.g., shy distance, clear zone, lane widths)
- ORS 366.215 ("Hole in the Air")
- Lack of detailed ODOT design guidance for some facility types
- Any design guidance that conflicts
- Lane width
- Funding
- Long-term maintenance/operations concerns
- Right-of-way, limitations, costs, and time constraints
- Street parking (safety and space allocation)
- Transit conflicts (safety)
- Access management/ driveways (safety)
- Speed differential between bicycle and posted speed (safety)
- Intersections and operations (safety)
- Interchanges/ramps (safety)
- Bridge and overpass cross section constraints (safety)
- Lack of continuity, connections
- New, innovative ideas; untested treatments and products
- Roundabouts

3. NATIONAL GUIDANCE AND CASE STUDIES

Bicycle facility guidance in the United States has evolved significantly over the past decades, coming more into alignment with guidance from high-bicycle use international examples. A recent paper[1] documents the evolution of bicycle facility guidance in the US over the last 50 years, noting the changes in AASHTO's published guidance and the strong influence of the vehicular cycling movement in the 1980s. This vehicular cycling perspective influenced the direction of guidance away from separated bicycle facilities and towards designing primarily for high-speed bicycling, integrated with vehicle traffic. These facilities were designed to serve confident, skilled bicyclists.

In the 1990s, research began to recognize the varying needs of different user types, classifying riders as A (advanced), B (basic), or C (child). Further research evaluated the safety of bike lanes and other types of infrastructure. The National Association of City Transportation Officials (NACTO) first published a different design approach at the national level in 2012, including a higher level of separation for bicycle facilities.

NACTO's most current guidance includes an approach to serve bicyclists of all ages and abilities, recommending physically protected bicycle facilities on any streets with vehicle volumes over 6,000 ADT or target speeds higher than 25 mph. The upcoming 2019 edition of AASHTO's *Guide for the Development of Bicycle Facilities* provides context-based guidance to design facilities that appeal to four types of bicyclists[2]:

- **Strong and Fearless**: People willing to bicycle regardless of the roadway conditions.
- **Enthused and Confident**: People willing to bicycle in mixed traffic, but appreciate bicycle lanes and boulevards.
- **Interested but Concerned**: People willing to bicycle in low-speed, low-volume settings and paths separated from vehicles.
- **No Way, No How**: People unwilling to bicycle even if high-quality bicycle infrastructure is in place.

Increasingly, local jurisdictions in the US are also adopting guidance for installing more separated bicycle facilities and are exploring ways to implement these facilities, considering ways to make trade-offs with other roadway design elements.

This section (Section 3) presents highlights from these key US guidance documents and case studies, as well as some international sources. International examples include locations that have relatively

[1] A Historical Perspective on the AASHTO Guide for the Development of Bicycle Facilities 2 and the Impact of the Vehicular Cycling Movement

[2] Roger Geller, Bicycle Coordinator Portland Office of Transportation, four types of bicyclists:

high bicycle ridership and safety. To best inform ODOT's direction, the review focused on four key topics:

- What context-related attributes are considered in determining the appropriate bicycle facility?
- How is the concept of "design user" applied, if at all?
- At what point are bicycle facility-type decisions made? (i.e. policy-level decision, planning decision [TSP, area, corridor], project-level decision?)
- How are trade-offs evaluated? What is the process for selecting and implementing "Plan B" or "Plan C" bicycle facilities, when the ideal facility results in untenable trade-offs?

Across guidance documents and case studies reviewed, the following themes include:

- Not all bicyclists are comfortable on the same type of facilities. Design users can be described in various ways.
- Serving bicyclists of all ages and abilities means designing infrastructure that allows them to feel safe.
- Some best practices and examples include low-stress (high separation) facilities as the "standard" (through a policy statement or within design guidance).
- In other cases, high separation applies to higher classification or designated bicycle routes, making a connected network of low-stress routes, but not to all streets.
- Design flexibility and narrower cross-sectional elements should be allowed in "constrained" areas.
- The most common attributes for determining bicycle facilities are motor vehicle speeds and volumes.

3.1 Relevant Guidance Documents

This section provides an overview of national and international guidance and research on the selection and design of various bicycle facilities.

FHWA Bikeway Selection Guide

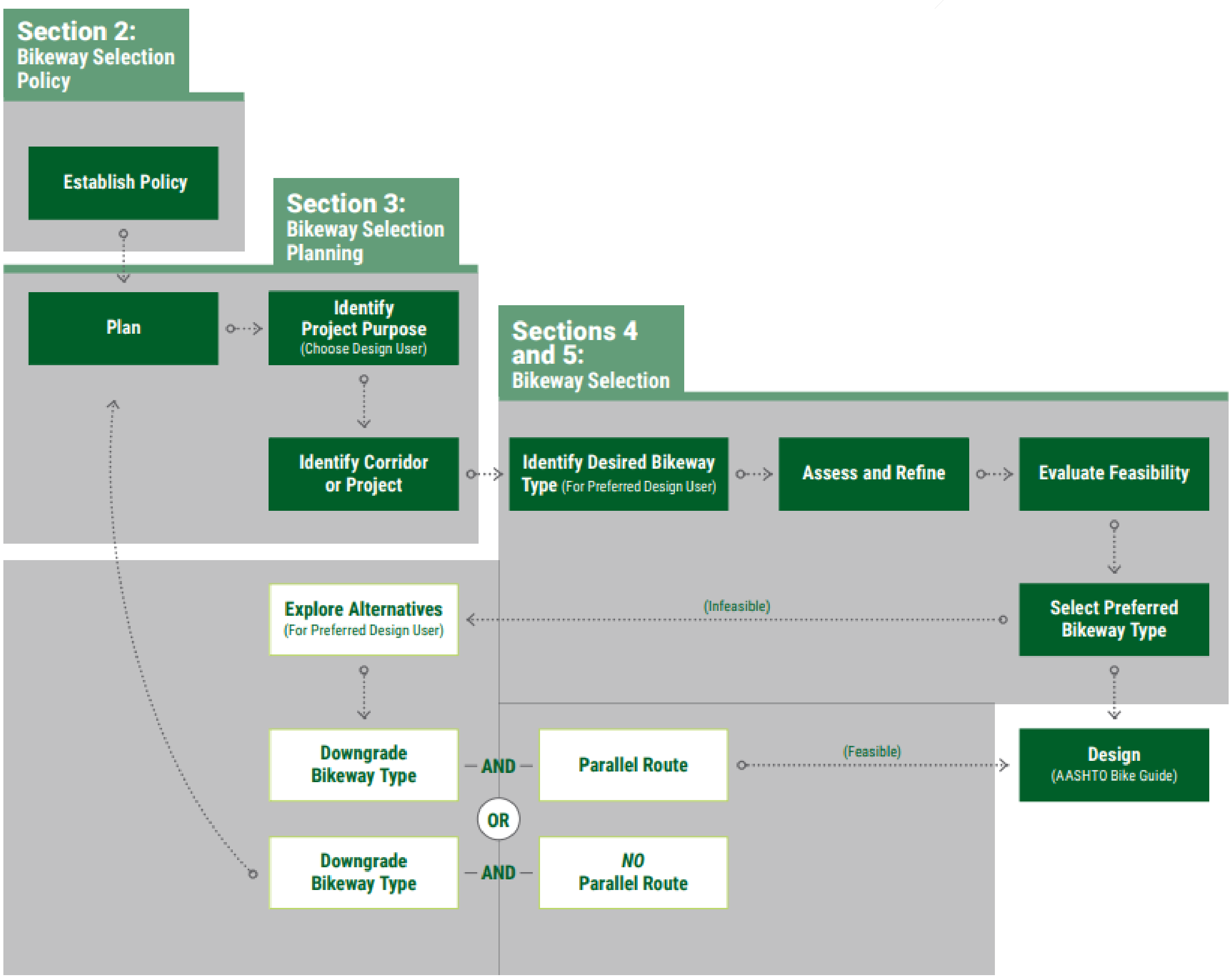
In February 2019, FHWA released the *Bikeway Selection Guide*, building on FHWA's support for design flexibility to enable the development of safe, connected, and comfortable bicycle networks for people of all ages and abilities. The *Bikeway Selection Guide* provides a process outline that agencies can follow in selecting and designing bikeways, shown in **Figure 3**. The Guide provides information on setting policy related to bicycle facilities, developing a vision for the bicycle network, and then determining what types of designs should be implemented to fulfill the policies and vision. This guidance also includes a speed/volume bicycle facility selection matrix for the "interested but concerned bicyclist" shown in **Figure 4**.

The Guide also provides agencies with information about how to assess feasibility of implementation, including options for reallocating roadway space. These opportunities include:

- Narrowing travel lanes
- Removing travel lanes
- One-way streets with excess capacity
- Reorganizing street space
- Changes to on-street parking

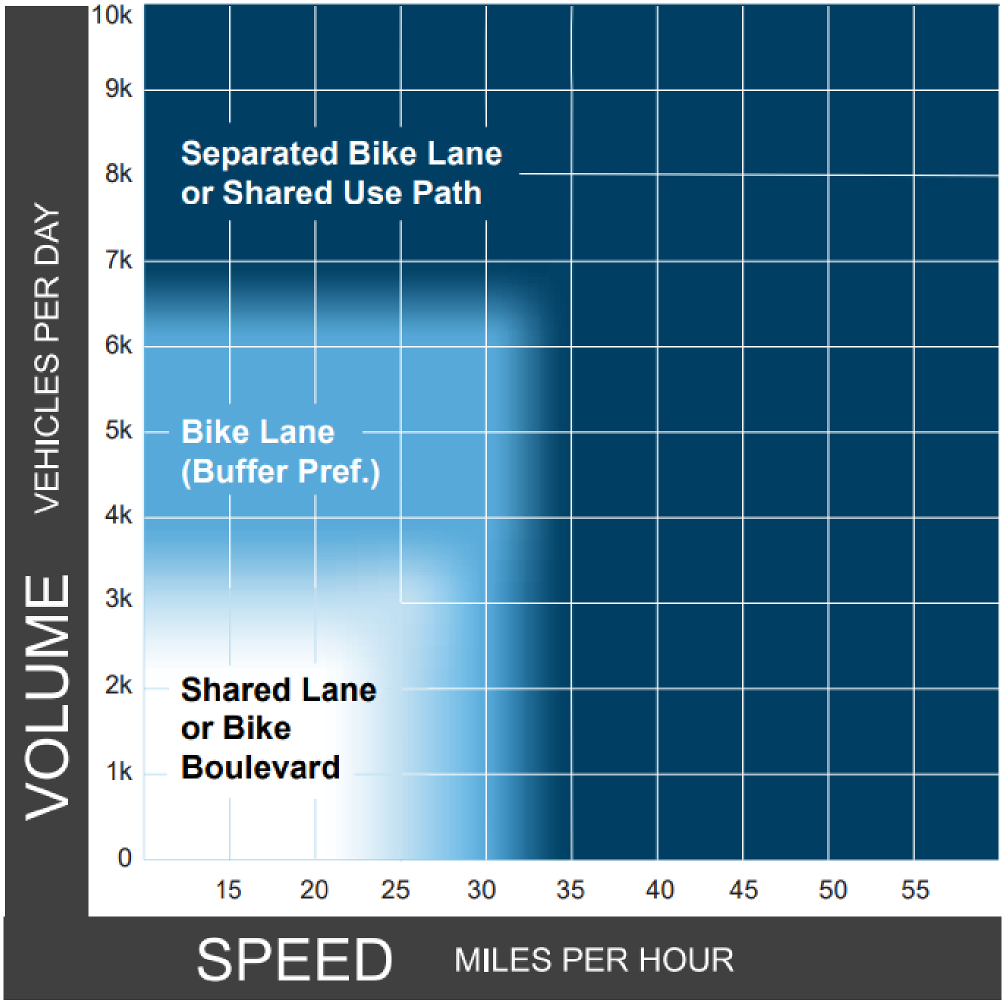
The Guide also recommends that, when parallel routes are selected, they be as direct as possible. To be viable, these routes need to increase trip length less than 30 percent.

Figure 3. FHWA Bikeway Selection Process and Guide Outline



Source: FHWA Bikeway Selection Guide

Figure 4. Preferred Bikeway Type of Urban, Urban Core, Suburban, and Rural Town Contexts



Notes

1 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.

2 Advisory bike lanes may be an option where traffic volume is <3K ADT.

3 See page 32 for a discussion of alternatives if the preferred bikeway type is not feasible.

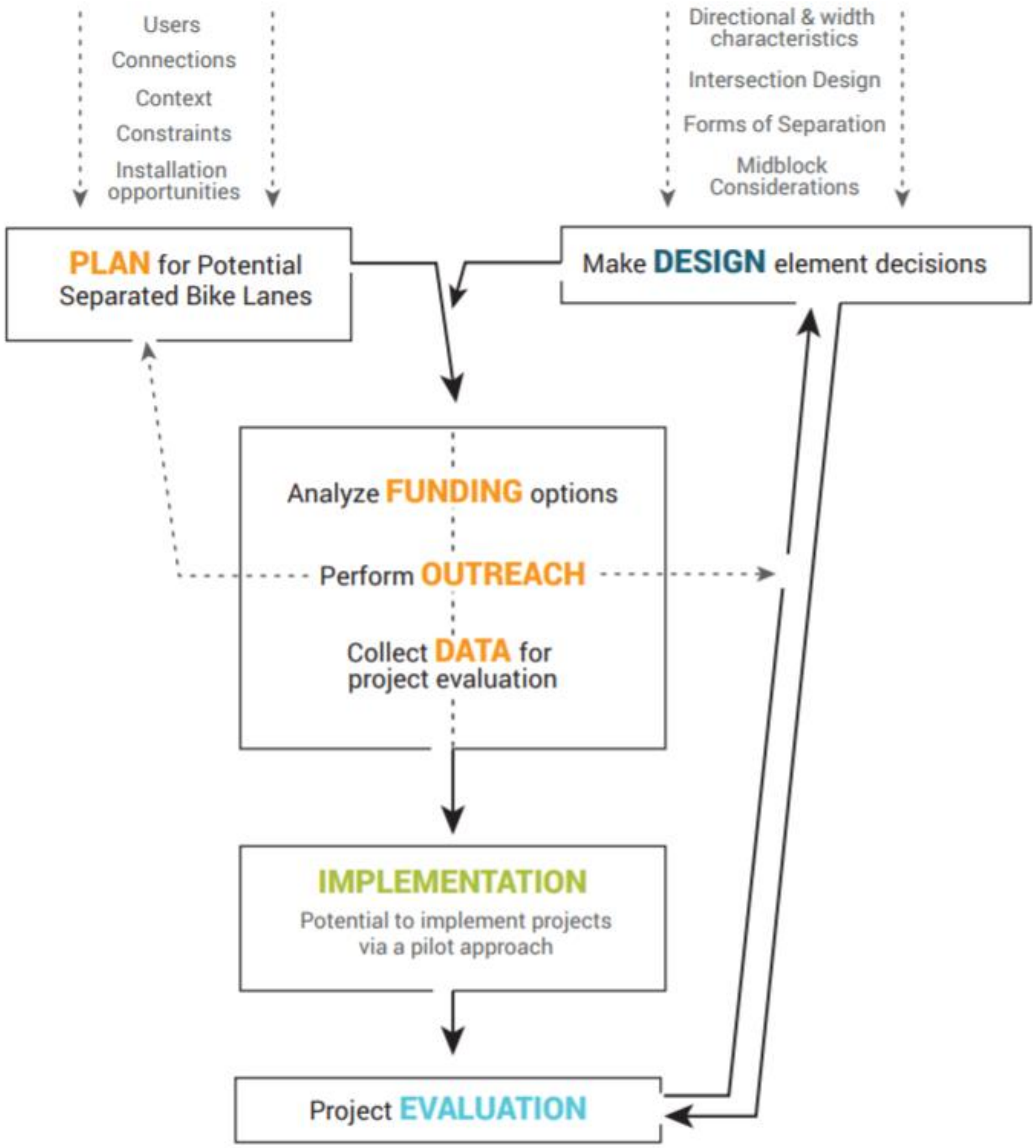
Source: FHWA Bikeway Selection Guide

FHWA Separated Bike Lane Planning and Design Guide

FHWA's *Separated Bike Lane Planning and Design Guide* offers a flexible approach to design to help agencies strategically implement separated facilities where they are most needed. Guidance is provided on separation type, intersection treatments, and other design elements to promote safety and manage traveler expectations. The Guide encourages agencies to plan for separated facilities on corridors that already attract cyclists to naturally increase cycling opportunities.

The Guide provides an example decision-making framework, where practitioners first identify context, constraints, and intended users. As shown in **Figure 5**, the process is an iterative one where planning and design decisions are revisited as additional information is gathered through public outreach and data analysis and funding opportunities change.

Figure 5. FHWA Separated Bike Lane Planning and Design Guide Process Diagram



Source: FHWA *Separated Bike Lane Planning and Design Guide*, Figure 7

NACTO Urban Bikeway Design Guide and Designing for All Ages and Abilities

NACTO's *Urban Bikeway Design Guide* was created to offer guidance on low-stress bicycle facility selection and design in urban contexts. NACTO recently released a supplemental publication, *Designing for All Ages and Abilities*, which provides criteria for selecting and implementing bicycle facilities that serve all ages and abilities. As shown in **Figure 6**, the Guide recommends bicycle facilities based on common sources of bicycling stress, such as vehicular speeds and volumes, number of lanes, and other operational uses. This guidance is meant to be applied at the system level to help cities grow bicycling as a safe, equitable mode for the majority of people, including: children, seniors, women, people of color, bike share users, low-income riders, people with disabilities, people moving cargo, and confident cyclists.

In some cases, agencies will not be able to meet the recommended bicycle facility. NACTO suggests that if the recommended facility cannot be provided, lesser accommodation should require additional justification. A lesser accommodation may still substantively reduce traffic stress. Jurisdictions should not use an inability to meet the criteria as reason to avoid implementing a bikeway and should not prohibit the construction of facilities that do not meet the criteria.

Figure 6. NACTO's Contextual Guidance for Selecting All Ages & Abilities Bikeways

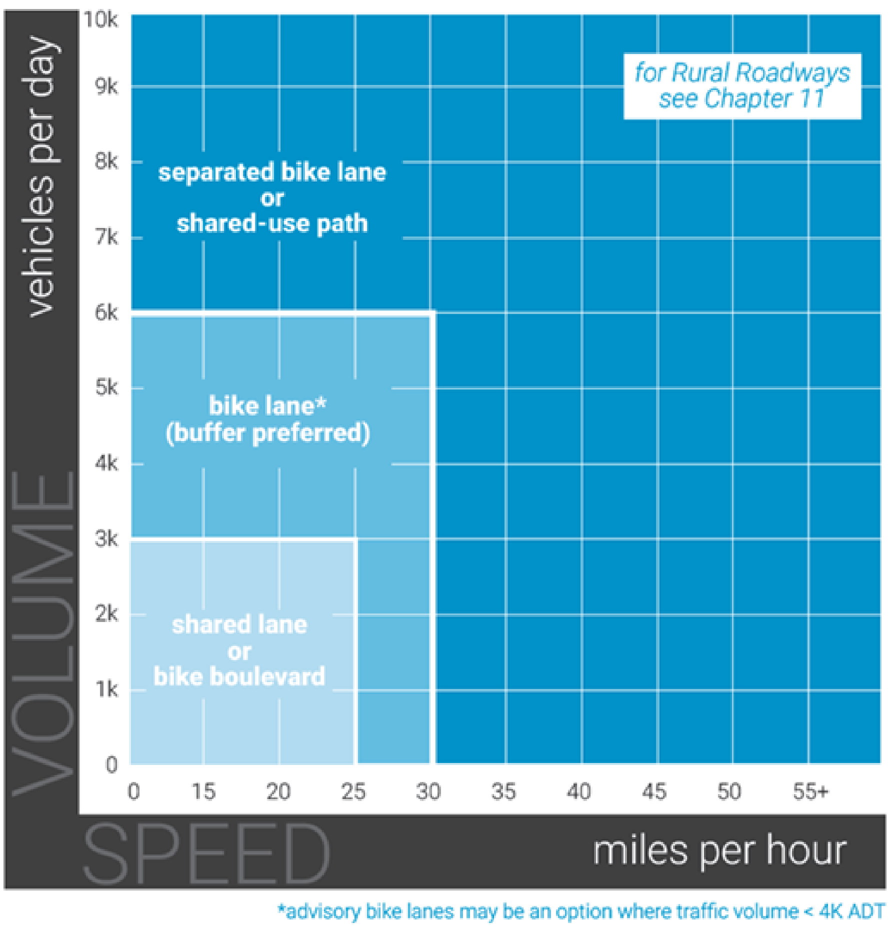
Roadway Context				All Ages & Abilities Bicycle Facility
Target Motor Vehicle Speed[*]	**Target Motor Vehicle Volume (ADT)**	**Motor Vehicle Lanes**	**Key Operational Considerations**	
Any		*Any*	*Any of the following:* high curbside activity, frequent buses, motor vehicle congestion, or turning conflicts[‡]	**Protected Bicycle Lane**
< 10 mph	Less relevant	No centerline, or single lane one-way	Pedestrians share the roadway	**Shared Street**
≤ 20 mph	≤ 1,000 – 2,000		< 50 motor vehicles per hour in the peak direction at peak hour	**Bicycle Boulevard**
≤ 25 mph	≤ 500 – 1,500			
	≤ 1,500 – 3,000	Single lane each direction, or single lane one-way	Low curbside activity, or low congestion pressure	**Conventional or Buffered Bicycle Lane, or Protected Bicycle Lane**
	≤ 3,000 – 6,000			**Buffered or Protected Bicycle Lane**
	Greater than 6,000			**Protected Bicycle Lane**
	Any	Multiple lanes per direction		
Greater than 26 mph[†]	≤ 6,000	Single lane each direction	Low curbside activity, or low congestion pressure	**Protected Bicycle Lane, or Reduce Speed**
		Multiple lanes per direction		**Protected Bicycle Lane, or Reduce to Single Lane & Reduce Speed**
	Greater than 6,000	*Any*	*Any*	**Protected Bicycle Lane**
High-speed limited access roadways, natural corridors, or geographic edge conditions with limited conflicts		*Any*	High pedestrian volume	**Bike Path with Separate Walkway or Protected Bicycle Lane**
			Low pedestrian volume	**Shared-Use Path or Protected Bicycle Lane**

Source: NACTO *Designing for All Ages and Abilities*, pg. 4

AASHTO Update to Guidance for the Development of Bicycle Facilities, Chapter 4

The 2019 update to AASHTO's *Guidance for the Development of Bicycle Facilities* will include a bicycle facility selection chart similar to ODOT's existing Urban/Suburban Recommended Separation Matrix[3]. **Figure 7** shows an interim version of AASHTO's selection guidance for urban and suburban roadways. This selection chart is still under review by AASHTO and may change; however, the project team shared this version to indicate the general direction. Much like ODOT's existing separation matrix, the AASHTO guide will use speed and vehicular volume to determine the appropriate bicycle facility. The AASHTO matrix will likely offer more refined thresholds than ODOT's current matrix and differentiate buffered bike lanes from separated facilities, effectively prioritizing vertical separation over horizontal separation alone.

Figure 7. AASHTO Bicycle Facility Selection Chart for Urban and Suburban Roadways



Source: Interim Presentation on the forthcoming 2019 AASHTO *Guide for the Development of Bicycle Facilities*

3 Oregon Bicycle and Pedestrian Design Guide, pg 42

NCHRP Report 880: Design Guide for Low-Speed Multimodal Roadways

The *Design Guide for Low-Speed Multimodal Roadways* recognizes that the level of bicycle use on the road, or roadside, is directly related to the activities generated by the adjacent land uses. When selecting a bicycle facility, practitioners should consider existing and future land use context, roadway classification, vehicle speeds, user volumes, available right-of-way width, cross section (curb, shoulder or no shoulder), modal network plans, and community plans. Ideally, the multimodal design of the street will support interactions between the roadway, roadside, and existing and planned multimodal activity generated by adjacent land uses and local modal networks.

In low speed settings, vehicles and bicyclists can safely co-exist in the roadway. As vehicular volume and speed increase, bicycle facilities become a more critical part of the design process. This Guide recommends beginning the design process with an evaluation of the project's purpose and need. The project goals and desired outcomes should address how the new or redesigned facility should address the needs of the identified users and use a range of performance measures to evaluate scenarios. The Guide provides recommended bike lane widths depending on the priority level of bicycle users on the roadway, presented in **Figure 8**.

When the width of the right-of-way in urban areas is limited, facilities can be prioritized into the following categories:

- **Optimal Conditions**: Space in right-of-way for all desired roadway elements
- **Predominant Conditions**: Space in right-of-way for all the higher priority elements
- **Functional Minimum**: Constrained sections with space for most higher priority elements
- **Absolute Minimum**: Constrained sections with space only the highest-priority elements without acquiring roadway or changing the roadway function

Where a separated facility cannot be provided, and bicyclists are expected to use a shoulder, the shoulder should be at least 4 feet wide and continuous along the length of the roadway. If a curb or other roadside barrier is present, the shoulder should be at least 5 feet wide to accommodate a "shy" distance. Where there is space, providing a buffered bike lane can provide more shy distance between motorized vehicles and bicyclists and allows bicyclists to pass other bicyclists without encroaching into the vehicle travel lane.

Figure 8. Recommended Separated Bike Lane Widths by Multimodal Priority Level

Multimodal User Priority Level *	Separated Bike Lane Zone	Width **
LOW Multimodal Priority	Vertical Buffer Area	1.5 to 3 ft. (0.45 – 0.9 m)
	One-Way Clear Travel Area	5 ft. (1.5 m)
	Two-Way Clear Travel Area	10 ft. (2.4–3.0 m) ***
MODERATE Multimodal Priority	Vertical Buffer Area	3–4 ft. (0.9–1.2 m)
	One-Way Clear Travel Area	7 ft. (2.1 m)
	Two-Way Clear Travel Area	10 ft. (3.0 m)
HIGH Multimodal Priority	Vertical Buffer Area	3.0–6.5 ft. (0.9–2.0 m)
	One-Way Clear Travel Area	10 ft. (3.0 m)
	Two-Way Clear Travel Area	12 ft. (3.6 m)

*Design and operating speeds should be commensurate with multimodal priority. Moderate and high multimodal priority designs should typically have design speeds of 35 mph and lower.
**Total clear width between the curb face and vertical element should be at least the fleet maintenance vehicle width. Clear widths narrower than 7 ft. (2.1) may require specialized equipment. (FHWA 2015e)
***In constrained conditions, an 8 ft. (2.4 m) minimum width may be appropriate.

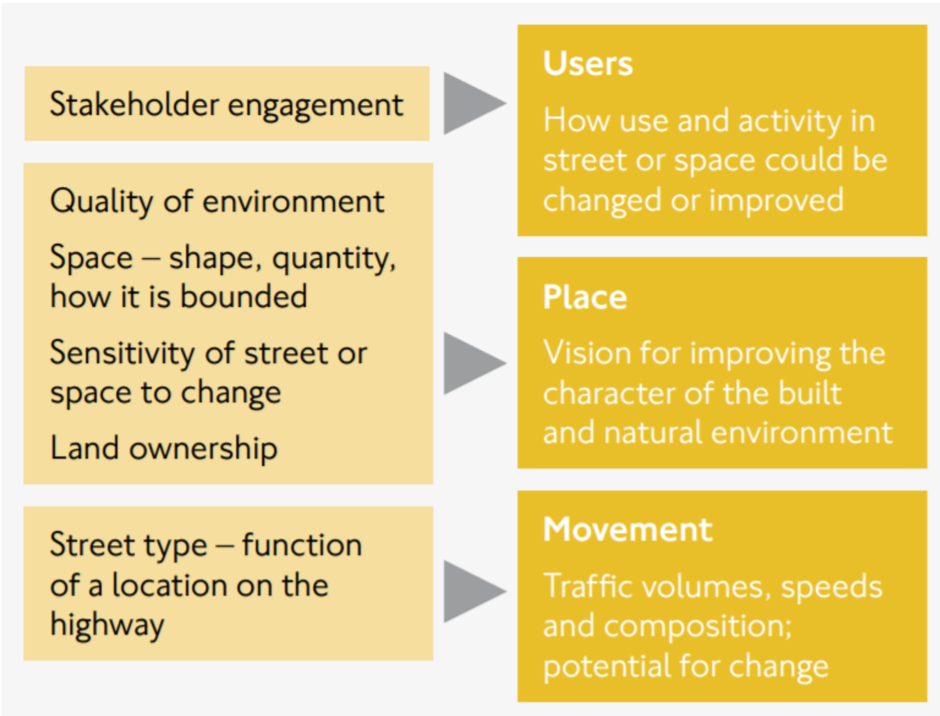
Source: Adapted from information in AASHTO (2014b), FHWA (n.d.a) and FHWA (2015d)

Source: NCHRP Report 880: *Design Guide for Low-Speed Multimodal Roadways*, Exhibit 4-17

London Cycling Design Standards

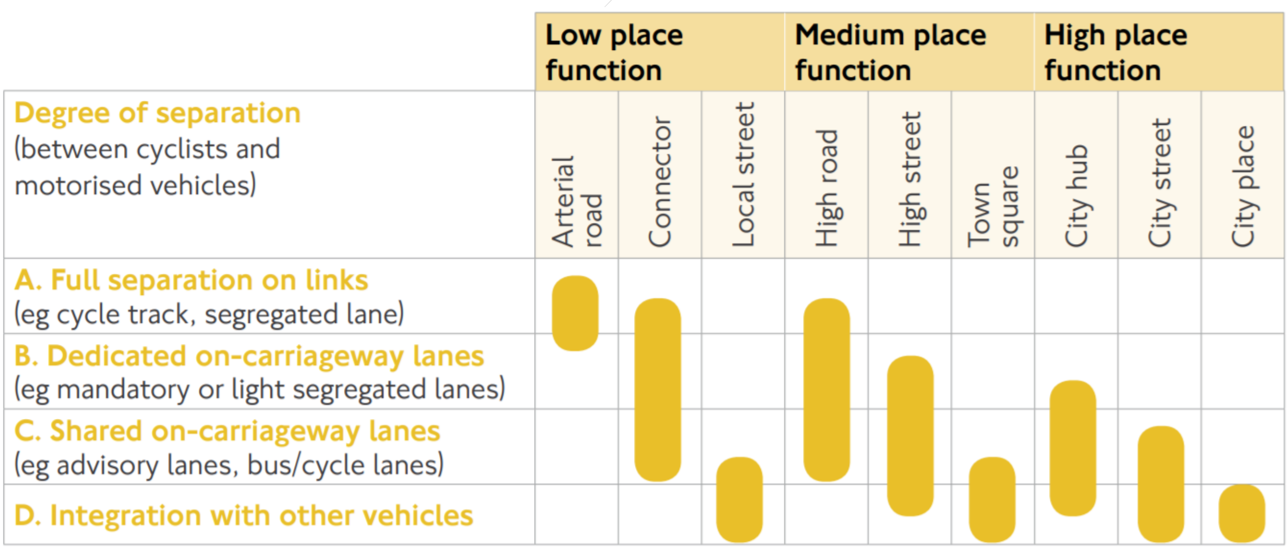
The *London Cycle Design Standards* (LCDS) provides insight into the types of attributes to consider in determining an appropriate bicycle facility. **Figure 9** shows the three main criteria considered – users, place, and movement – and the considerations for each. **Figure 10** provides an example of how practitioners in London combine place and movement to identify an appropriate facility for the user, in this case bicyclists. The LCDS further specifies that when speeds are higher than 30 mph or peak hour volume is greater 1,000 vehicles, a higher degree of separation is required. Low degrees of separation work best when speeds are below 20 mph and peak hour volumes is less than 200 vehicles.

Figure 9. Selecting an Appropriate Degree of Separation for Cycle on Links



Source: *London Cycle Design Standards*, Chapter 4, Figure 4.5

Figure 10. Recommended On-Carriageway Cycle Facility Provision by Street Type



Source: *London Cycle Design Standards*, Chapter 4, Figure 4.6

Figure 11 shows how the various facility types appear in different place and movement contexts. When deciding what facility-type to implement, practitioners start with network planning, using "mesh density" analysis, measuring the distance bicyclists would have to travel to get to a similar quality route. From there, they evaluate "area porosity," how many places exists for bicyclists to enter, pass through and leave an area. In the final step of the analysis, they conduct cycling level-of-service (CLoS) analyses. Then, based on the network, the facility is selected. When a facility does not meet the minimum CLoS standard on critical factors, a reassessment is triggered.

When evaluating trade-offs, practitioners refer to the following guiding principles:

- Cycling is now mass transport and must be treated as such;
- Facilities must be designed for larger numbers of users;
- Cycles must be treated as vehicles, not as pedestrians;
- Cyclists need space separated from volume motor traffic;
- Where full segregation is not possible, semi-segregation may be the answer;
- Separation can also be achieved by using lower-traffic streets; and
- Where integration with other road users is necessary, differences of speed, volume and vehicle type should be minimized.

The LCDS encourage practitioners not to shy away capital projects and changes to road space that can influence modal choice. They also recommend all practitioners ride existing facilities to understand why they do or do not work.

Figure 11. Cycling Infrastructure that may Typically Feature in each Street Type

Source: *London Cycle Design Standards*, Chapter 1, Figure 1.3

The LCDS also provides guidance on the design user, including non-standard bicyclists (see **Figure 12.** Indicative Dimensions of Typical 'Non-Standard' Cycles). The intent in London is to provide for all types of cyclists, and it is important to consider those who do not fit the stereotypes.

Figure 12. Indicative Dimensions of Typical 'Non-Standard' Cycles

Source: *London Cycle Design Standards*, Chapter 3, Figure 3.4

Dutch CROW Design Manual for Bicycle Traffic

The *Dutch Design Manual for Bicycle Traffic* (CROW Manual) provides empirical data and guidance to help practitioners implement effective bicycle facilities. The Manual was updated in 2016 to include guidance on bicycle highways, bicycle paths, and roundabouts for bicyclists. When determining an appropriate facility, the Manual considers roadway function, vehicle speed and volume, and role in the "cycle network" (based on bicycle volume), as shown in **Figure** . In the CROW Manual, "cycle lane" is similar to "bicycle lane" in the US context; "cycle path" is similar to a "separated bicycle lane." A "bicycle street" refers to a shared street, where bicyclists have the right-of-way over vehicle travel, and vehicle speeds are very low (10-15 mph).

Figure 13. Selection Plan for Cycle Facilities in the Case of Road Sections in Built-Up Areas

Road Category	Speed limit motorized traffic (km/h)		Volume of motorize traffic (PCU/24-hour period)	Cycle Network Categories		
				Basic Structure ($I_{bicycle}$ < 750/ 24-hour period)	Main Cycle Network ($I_{bicycle}$ 500-2,500/ 24-hour period)	Bicycle Highway ($I_{bicycle}$ > 2,000/ 24-hour period)
Residential Road	Walking Pace or 30		<2,500	Mixed Traffic	Mixed Traffic or Bicycle Street	Bicycle Street (with right-of-way)
			2,000-5,000		Mixed Traffic or Cycle Lane	Cycle Path or Cycle Lane (with right-of-way)
			>4,000	Cycle Lane or Cycle Path		
Distributor Road	50	2x1 lane	Not relevant	Cycle Lane or Cycle Path	Cycle Path	
		2x2 traffic lanes		Cycle Path		
	70			Cycle/Moped Path		

Source: Dutch CROW *Design Manual for Bicycle Traffic*, Chapter 5, Table 5-2

Collection of Cycle Concepts (Cycling Embassy of Denmark)

In the *Collection of Cycle Concepts*, Denmark uses bicycle network, vehicle speeds and volumes, and land use context to determine an appropriate bicycle facility. They categorize users into three types when planning the bicycle network:

- Daily cycling – Focus on providing travel from point A to point B that is convenient, quick, safe, and a pleasant experience.
- Sunday (leisure) cycling – Focusing on providing a convenient link between the city's infrastructure and the activity destinations.
- Cycling toddler – Focus on providing safe, traffic-calmed streets near their homes.

The default facility is typically a cycle track. Cycle tracks widths are becoming a more important issue on Danish streets with growing bicycle traffic and increasing number of three-wheeled cargo bikes. The Collection offers the following guidance on cycle track width:

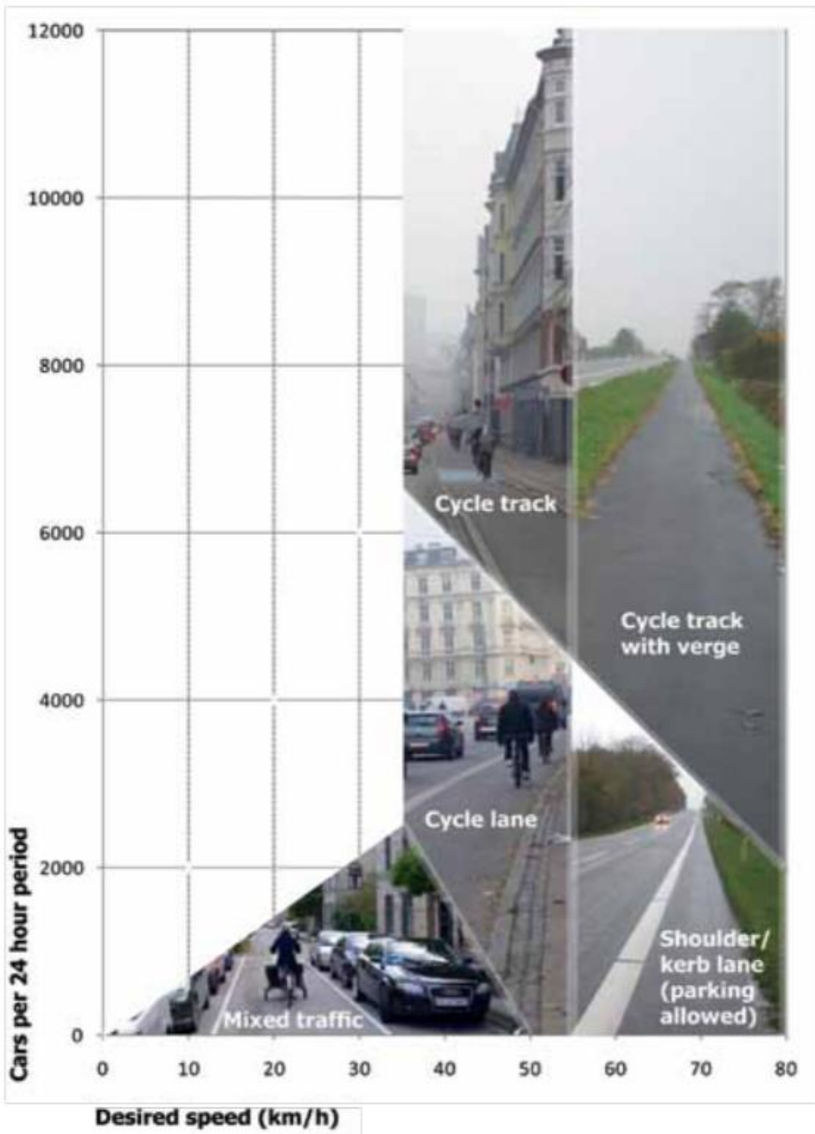
- Two-Way Cycle Track – Minimum width of 2.5 m (8.2 feet); consider 3.0-3.5 m (9.8-11.5 feet) with high cyclist volume
- One-Way Cycle Track – Minimum width of 1.7 m (5.6 feet); road standard guideline of 2.2 m (7.2 feet); consider 2.5-3.0 m (8.2-9.8 feet) with high cyclist volume

The larger widths allow cargo bikes to pass each other.

The Collection recognizes there will be times when all desired elements will not fit in the street. In some cases, street elements can be removed (e.g., parking on one side only). In other cases, it may work to use the minimum cycle track widths. When the minimum width cannot be provided, the Collection recommends exploring other options to avoid a situation where the cycle track is too narrow to function. In these cases, enhanced cycle lanes are considered. Where possible, these lanes are supplemented with traffic islands and short sections of cycle track where possible (e.g., at transit stops). **Figure** shows the vehicle volume and speed ranges where cycle lanes can be an appropriate alternative to cycle tracks.

In addition to user types, jurisdictions in Denmark have used bicycle counts, location of schools, location of transit hubs, crash data, ease of implementation, and availability of funding to prioritize bicycle investments.

Figure 14. Cycling Solutions in Relation to Motor Traffic Volume and Speed



Source: *Collection of Cycle Concepts*, page 53

3.2 Case Studies

This section presents case studies of bicycle facility selection processes used at various state and local agencies. The case study examples contain more specific guidance on how to address situations in which an all ages and abilities bicycle facility may not be desirable or feasible.

Washington State DOT Design Manual

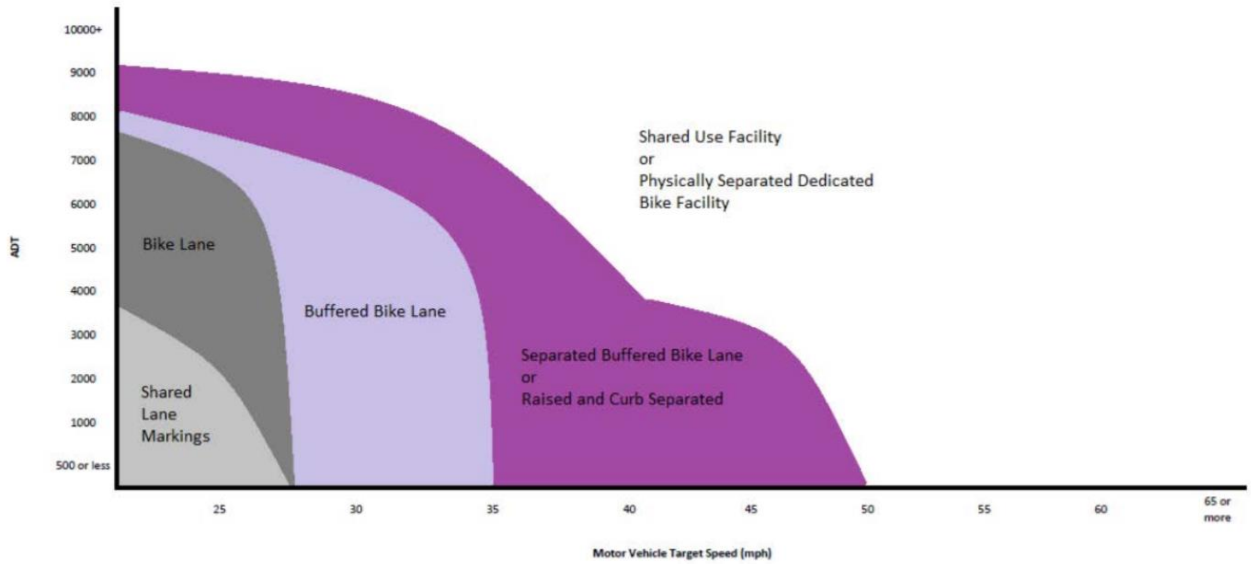
The Washington State Department of Transportation (WSDOT) *Design Manual* adopted the following six types of bicycle facilities and provides same typical sections for each:

- Shared-Use Paths
- Raised and Curb-Separated
- Separated Buffered Bike Lanes
- Buffered Bike Lanes
- Conventional Bike Lanes
- Shared Lane Markings

WSDOT considers the local, state, and regional bike routes when selecting a bicycle facility. If the state highway is the bike route, intersects with an existing route, or if bicycle users are an identified modal priority, bicycle facility needs should be accounted for within the design. If the state highway is not a bike route, projects should still consider a design that does not preclude the future vision for a planned bike route, depending on the context and design year. The only instance during planning or design when performance effects on existing or planned bike facilities may not be considered is in locations being designed for the existing context, and the location prohibits bicycle use.

Bicycle facility selection uses the "Interested, but Concerned" as a starting point, as shown in **Figure .** In cases where right-of-way is very constrained or where bicycles are not considered the modal priority, the Manual suggests using **Figure** , intended for "Confident" bicyclists for facility selection, with the understanding this facility selection may result in less mode shift.

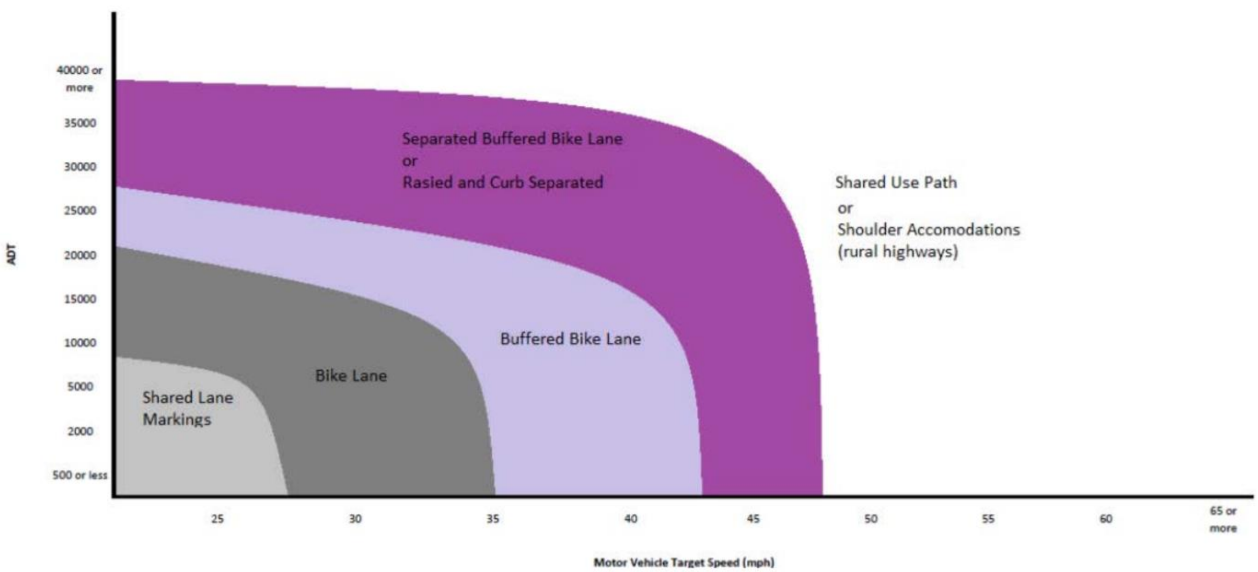
Figure 15. Bicycle Facility Selection Chart – Interested, but Concerned Cyclists



Note: Adapted from *Montgomery County Bicycle Planning Guidance*, Montgomery County Department of Transportation, 2014.

Source: Washington State DOT *Highway Design Manual*, Chapter 1520, Exhibit 1520-6a

Figure 16. Bicycle Facility Selection Chart – Confident Cyclists

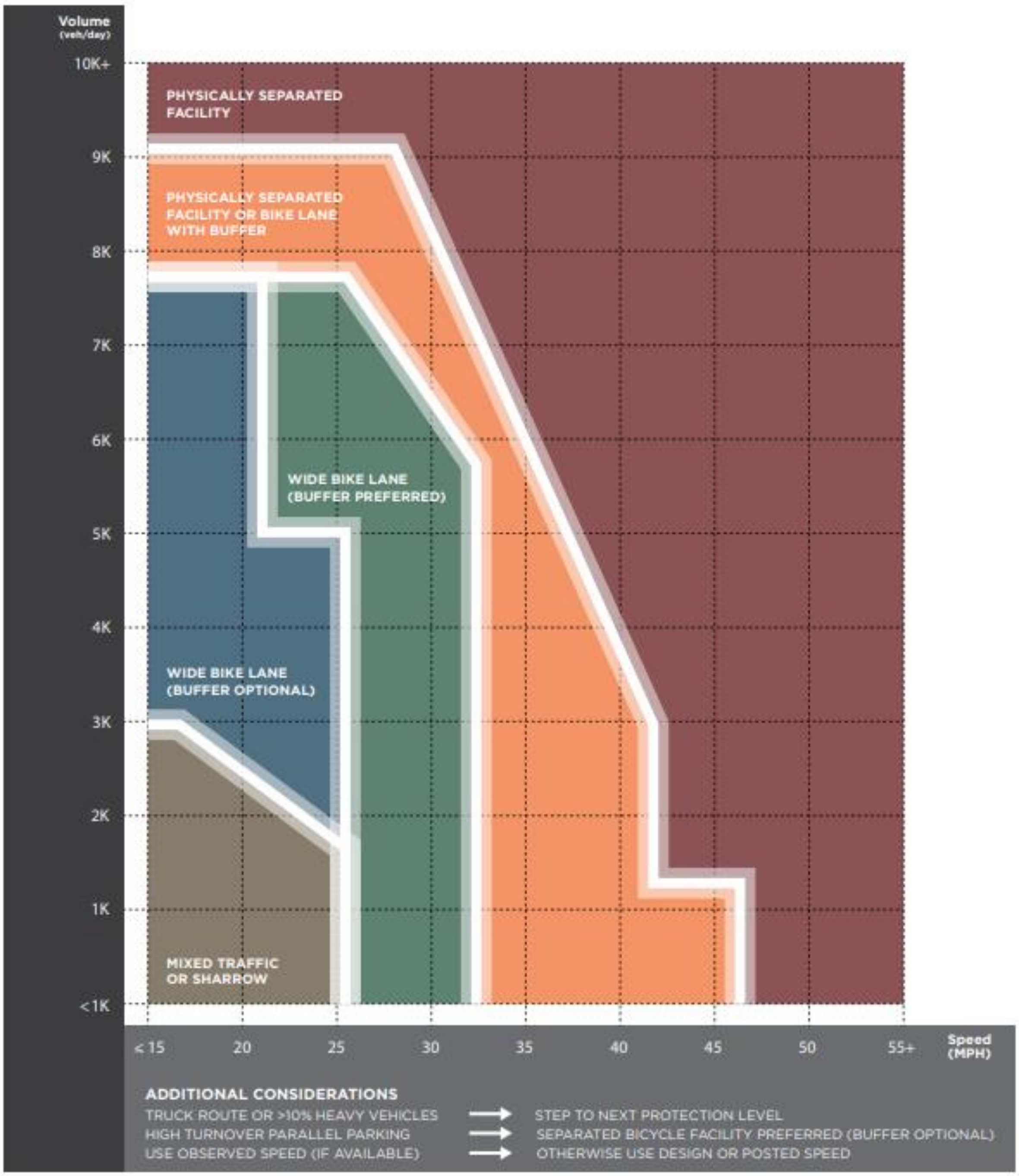


Source: Washington State DOT *Highway Design Manual*, Chapter 1520, Exhibit 1520-6b

Montgomery County (Maryland) Bicycle Planning Guidance

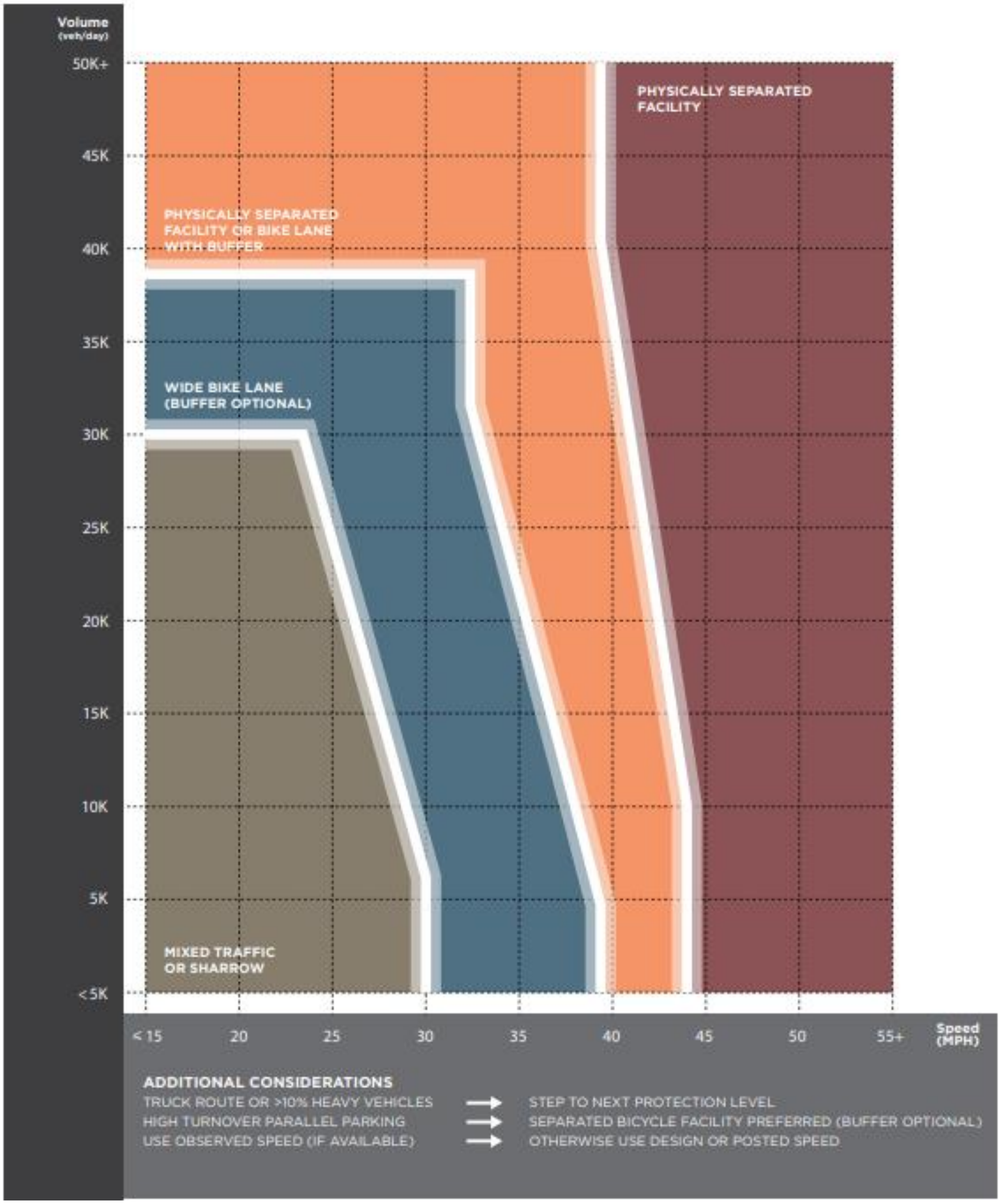
Montgomery County aligned their bicycle guidance with the four types of bicyclist. The starting point for facility selection is a facility for the “Interested but Concerned” bicyclist, shown in **Figure** . If that type of facility is not feasible, they downgrade the user group (e.g., Confident bicyclists, see **Figure**) and identify a parallel route for the “Interested but Concerned.” This iterative process is shown in **Figure** . These trade-offs are discussed and decided in the planning phase, before the project moves into design.

Figure 17. Pre-Selection for Interested but Concerned



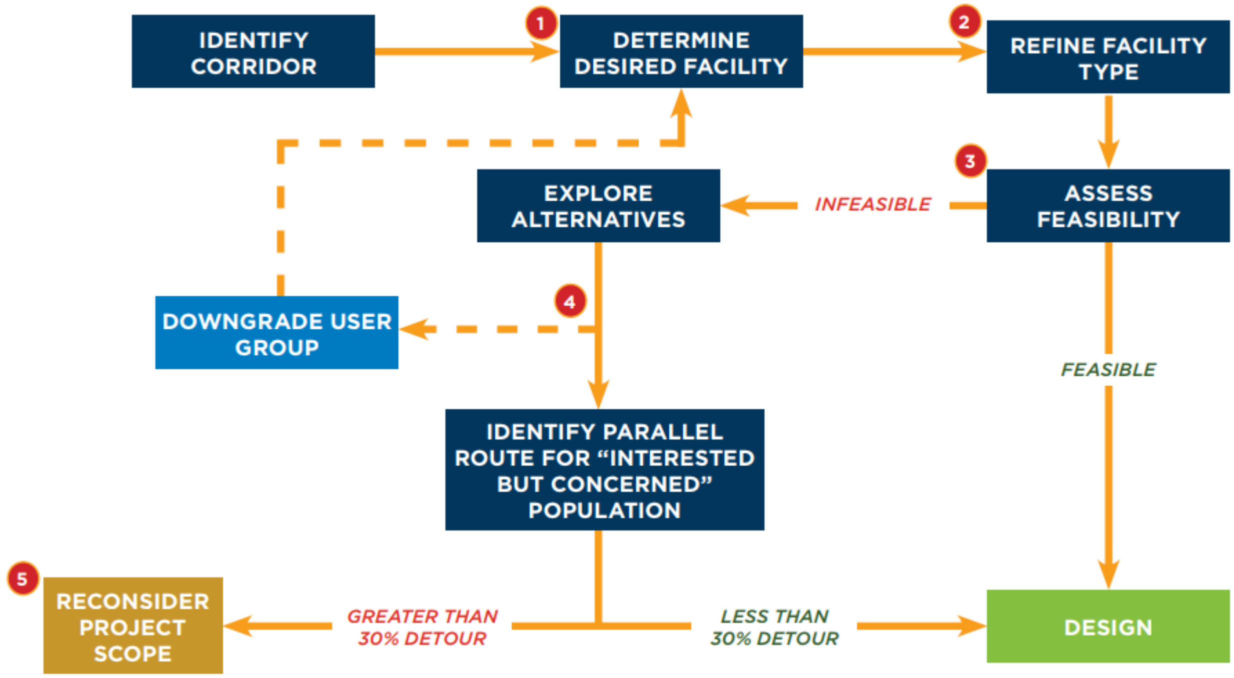
Source: Montgomery County (Maryland) *Bicycle Planning Guidance*, Figure 5

Figure 18. Pre-Selection for Confident Concerned



Source: Montgomery County (Maryland) *Bicycle Planning Guidance*, Figure 6

Figure 19. Montgomery County Decision-Making Process

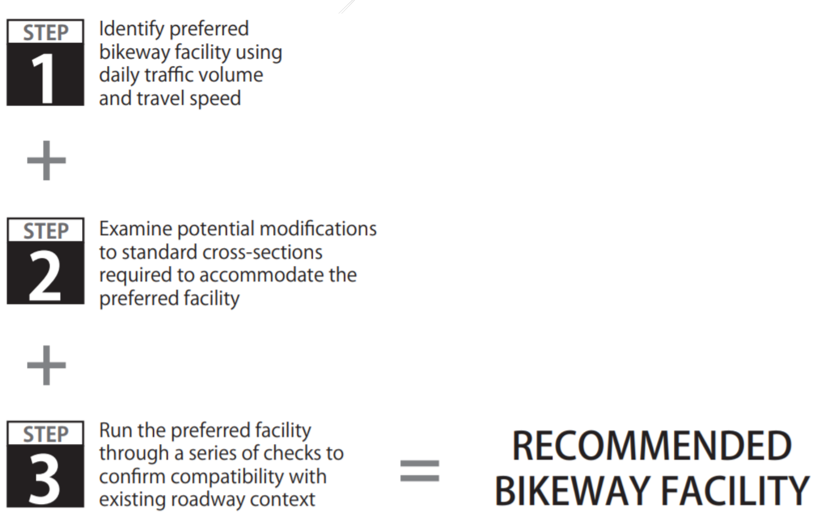


Source: Montgomery County (Maryland) *Bicycle Planning Guidance*, Figure 4

Washington County (Oregon) Bicycle Facility Design Toolkit

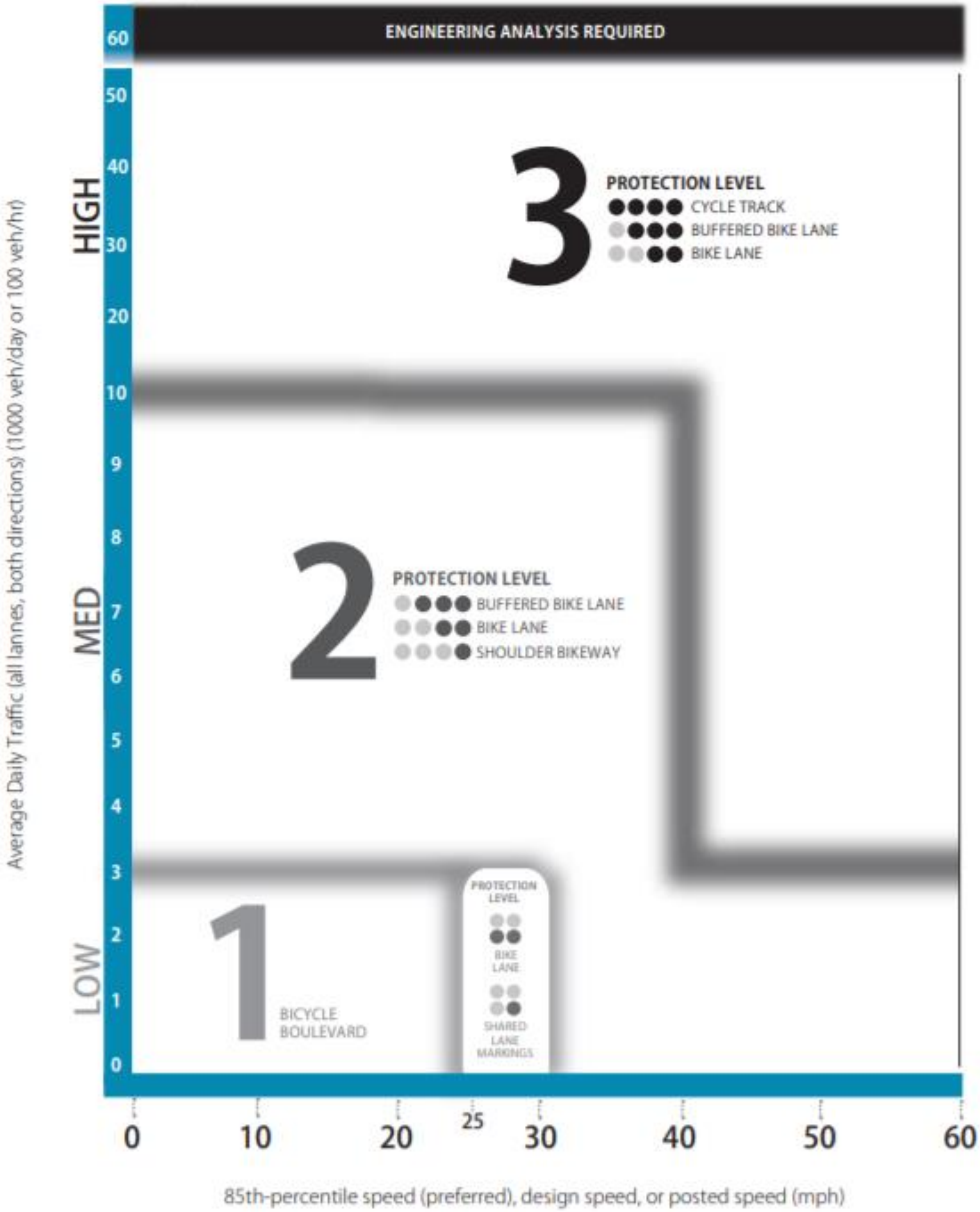
Washington County, Oregon identifies three types of bicycle design user: advanced, basic, and concerned. The County uses a three-step process to determine the recommended bicycle facility, shown in **Figure 20**. They start with a preferred facility based on traffic volume and speed (see **Figure**). Then, they review the feasibility of adding the preferred facility to the existing cross section, and finally, confirm the compatibility of the preferred facility with the roadway context.

Figure 20. Washington County Facility Selection Process



Source: Washington County Bicycle Facility Design Toolkit, page 9

Figure 21. Washington County Facility Considerations



Source: Washington County Bicycle Facility Design Toolkit, page 11

Austin Street Design Guide

The City of Austin considers land use context, vehicle speed and volume, number of travel lanes, and level of transit service to select an appropriate bicycle facility (see **Figure**). The recommended widths for facilities urban contexts are provided in **Figure** .

As shown in **Figure 244,** land use context is the first consideration in the decision-making process, followed by the street function. If the preferred bicycle facility does not fit within the existing ROW, they consider the following:

- Acquire ROW;
- Apply compact design;
- Prioritize elements; or
- Privatize elements.

Figure 22. Austin Multimodal Design Summary

Context	Level	Typical ADT Range (vpd)[1]	Number of Lanes[1]	Target Speed (mph)[1]	Bus Frequency	Bike Facility*	Pedestrian Facilities		Transit Facility*	Parking Facility***
						Type[2]	Sidewalks	Safe Crossing Density***	Type[3]	Type[3]
All (Except Alternatives)	1	< 2,000	2	20	Very Low	Quiet Street	Sidewalk and Buffer	Every Block	None	Parallel
Urban	2	2,000 - 5,000	2	25	Low	Conventional, Buffered, or Raised Bicycle Lane		1/8 Mile	Boarding islands/bulbs	Parallel
		5,000 - 10,000	2	25	Medium	Buffered or Raised Bicycle Lane			Peak-only dedicated lanes	Parallel
	3	10,000 - 20,000	3	35	High	Raised Bicycle Lane			Dedicated to Peak-only lanes	Parallel
		15,000 - 40,000	4 (Divided)	35	Very High	Raised Bicycle Lane			Dedicated Transit Lanes	
	4	35,000 - 45,000	4 (Divided)	40	High	Raised Bicycle Lane		1/4 Mile	Dedicated or Peak-only lanes	Access Lanes
		40,000 +	6 (Divided)	40	Very High	Raised Bicycle Lane			Dedicated Transit Lanes	
Suburban	2	2,000 - 5,000	2	25	Very Low	Conventional, Buffered, or Raised Bicycle Lane		1/4 Mile	None	Parallel
		5,000 - 10,000	2	30	Low	Buffered or Raised Bicycle Lane			Boarding islands/bulbs	Parallel
	3	10,000 - 20,000	3	35	Medium	Raised Bicycle Lane			Peak-Only dedicated lanes	Curb Extensions
		20,000 - 40,000	4 (Divided)	40	High	Raised Bicycle Lane			Dedicated or Peak-Only lanes	None
	4	35,000 - 45,000	4 (Divided)	40	Medium	Raised Bicycle Lane OR Shared Use Path	Sidewalk OR Shared Use Paths and Buffer Zone	1/2 Mile	Peak-Only dedicated lanes	None
		40,000 +	6 (Divided)	45	High	Raised Bicycle Lane OR Shared Use Path			Dedicated or Peak-only lanes	None
Industrial	2	< 20,000	3	25	N/A	Buffered Bicycle Lane	Sidewalk and Buffer Zone	1/2 Mile	None	Parallel
	3	10,000 - 30,000	5	30	N/A	Raised Bicycle Lane			None	None
Alternative	1	< 3,000	2	25	N/A	Wide Outside Lane	Sidewalk and Buffer Zone	1/2 Mile	None	Shared Space
	2	3,000 - 10,000	2	35-40	N/A	8' Shoulder OR Share Use Path	Sidewalk OR Shared Use Paths and Buffer Zone		None	None
	3	8,000 - 20,000	3	45-55	N/A	8' Shoulder OR Shared Use Path			None	None
	4	20,000 +	5	50-65	N/A	(8+)' Wide Shoulder OR Shared Use Path			None	None

*** Denotes preferred facility if ROW allows. Alternatives can be found in the Design Matrix.**
****Denotes that these will not be included except by ROW/easement dedication for expanded pavement width of additional 8' per side of parking.**
*****For Crossing Facilities, reference TCRP Report 112/NCHRP Report 562 "Improving Pedestrian Safety at Unsignalized Crossings".**

Source: *Austin Street Design Guide*, page 24

Figure 23. Austin Urban Context - Design Matrix

	Level 2		Level 3		Level 4	
	Desired Range		Desired Range		Desired Range	
ROW	**74'-92'**		**92'-132'**		**120'-146'**	
Additional ROW/ Easement Dedication for Parking (by Owner Request)	**Parking Desired (Included in pavement)**		**0'-16'**		**n/a**	
Pedestrian Zone						
Subsection Width	**8'-15'**		**10'-16'**		**13'-18'**	
Toolbox:	RECOMMENDED	CONSTRAINED	RECOMMENDED	CONSTRAINED	RECOMMENDED	CONSTRAINED
Sidewalk	6'	5'	7'	6'	7'	6'
Tree & Furniture Zone	8'	3'	8'	4'	10'	7'
Shared Use Path (instead of sidewalks)[1]	n/a	n/a	n/a	n/a	n/a	n/a
1' Setback[2]	1'	0'	1'	0'	1'	0'
Bicycle and Street Edge Zone						
Subsection Width (Excludes Parking)	**8'-11'**		**8'-12'**		**10'-18'**	
Toolbox:	RECOMMENDED	CONSTRAINED	RECOMMENDED	CONSTRAINED	RECOMMENDED	CONSTRAINED
Bicycle Facility						
Protected Bike Lanes (One of Two-Sided) ***Preferred***	7' Clear 4' Buffer	7' Clear 3' Buffer	8' Clear 4' Buffer	7' Clear 3' Buffer	8' Clear 4' Buffer	7' Clear 3' Buffer
On-Street Separated Bike Lanes ***Alternative***	n/a	6' Clear 2' Separation	n/a	6' Clear 2' Separation	n/a	n/a
Other Facilities						
Parallel Parking†	8'	7'	9.5'	7'	n/a	n/a
Access Lanes	n/a	n/a	n/a	n/a	18' (10' refuge)	16' (8' refuge)
Motor Vehicle and Transit Zone						
Subsection Width[3]	**24'-40' (Includes Parking)**		**34'-60'**		**55'-82'**	
Travel Lanes (# of Lanes)	**2-3**[6]		**3 - 4 (Divided)**		**4 - 6 (Divided)**	
Transit Only Lanes	**n/a**	**n/a**	**12.5'**	**12'**	**12.5'**	**12'**
	RECOMMENDED	CONSTRAINED	RECOMMENDED	CONSTRAINED	RECOMMENDED	CONSTRAINED
Outside Travel Lane Width[4]	13'	12'	12.5'	12'	12.5'	12'
Interior Travel Lanes Width[5]	n/a	n/a	11'	10'	11'	10'
Center Turn Lane Width	10'	10'	11'	10'	n/a	n/a
Median Width	11'	n/a	14'	10'	14'	11'

NOTES:
All dimensions from FOC and center of stripe (including center of double yellow set)
†Parking to be dedicated by developer as an extra 8' of pavement.
[1] Shared use path not desirable in urban context.
[2] The setback in an urban environment may be an extension of the development sidewalk.
[3] On-Street Bike Lane as opposed to Raised Bike Lanes may require more pavement.
[4] Defined as against physical obstruction. Outside Travel Lanes can be reduced if next to bike lane.
[5] Defined as adjacent to stripe only.
[6] Left turn pockets required at intersection of Level 2, 3, and 4 streets.

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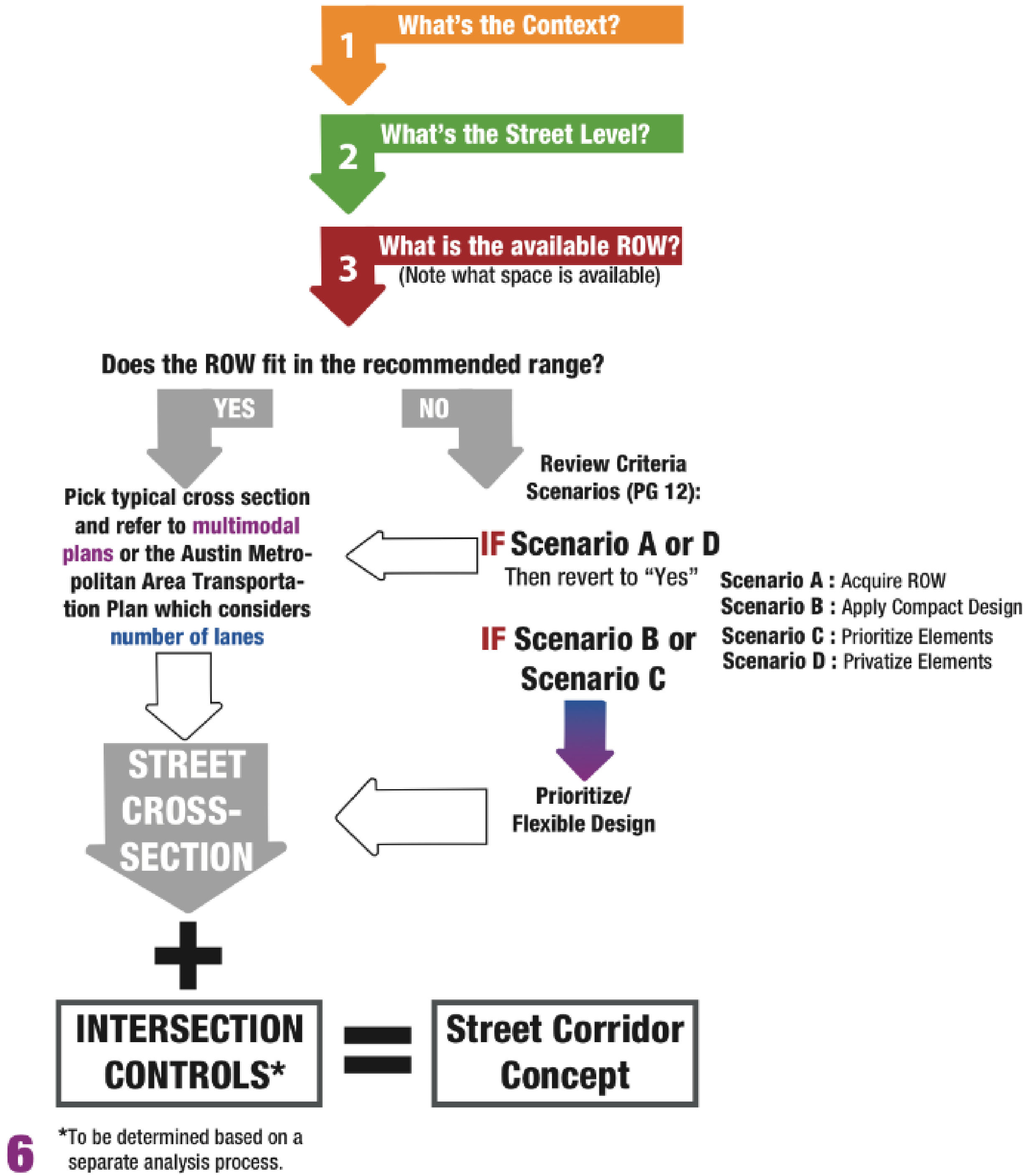
Source: Austin Street Design Guide

Figure 244. Austin Street Design Decision Process



Source: *Austin Street Design Guide*, page 24

Portland Protected Bicycle Lane Planning and Design Guide

The *Portland Protected Bicycle Lane Planning and Design Guide* provides practitioners tools to implement a protected bikeway network. The preferred facility in the City is a sidewalk-level protected bicycle lane; however, the Guide focuses on retrofit designs because the opportunities for significant roadway reconstruction in the City are limited. Protected bicycle lane retrofit designs are grouped in six categories:

- Parking-protected
- Parking-protected with delineators
- Delineator-protected
- Traffic separator-protected
- Planter-protected
- Concrete island-protected

The Guide uses NACTO’s guidance for determining when a protected bike is appropriate (refer to **Figure 6.** NACTO's Contextual Guidance for Selecting All Ages & Abilities Bikeways) and states that protected bicycle lanes are appropriate on most streets where separate facilities for bicycling are called for.

Ontario Traffic Manual Book 18: Cycling Facilities

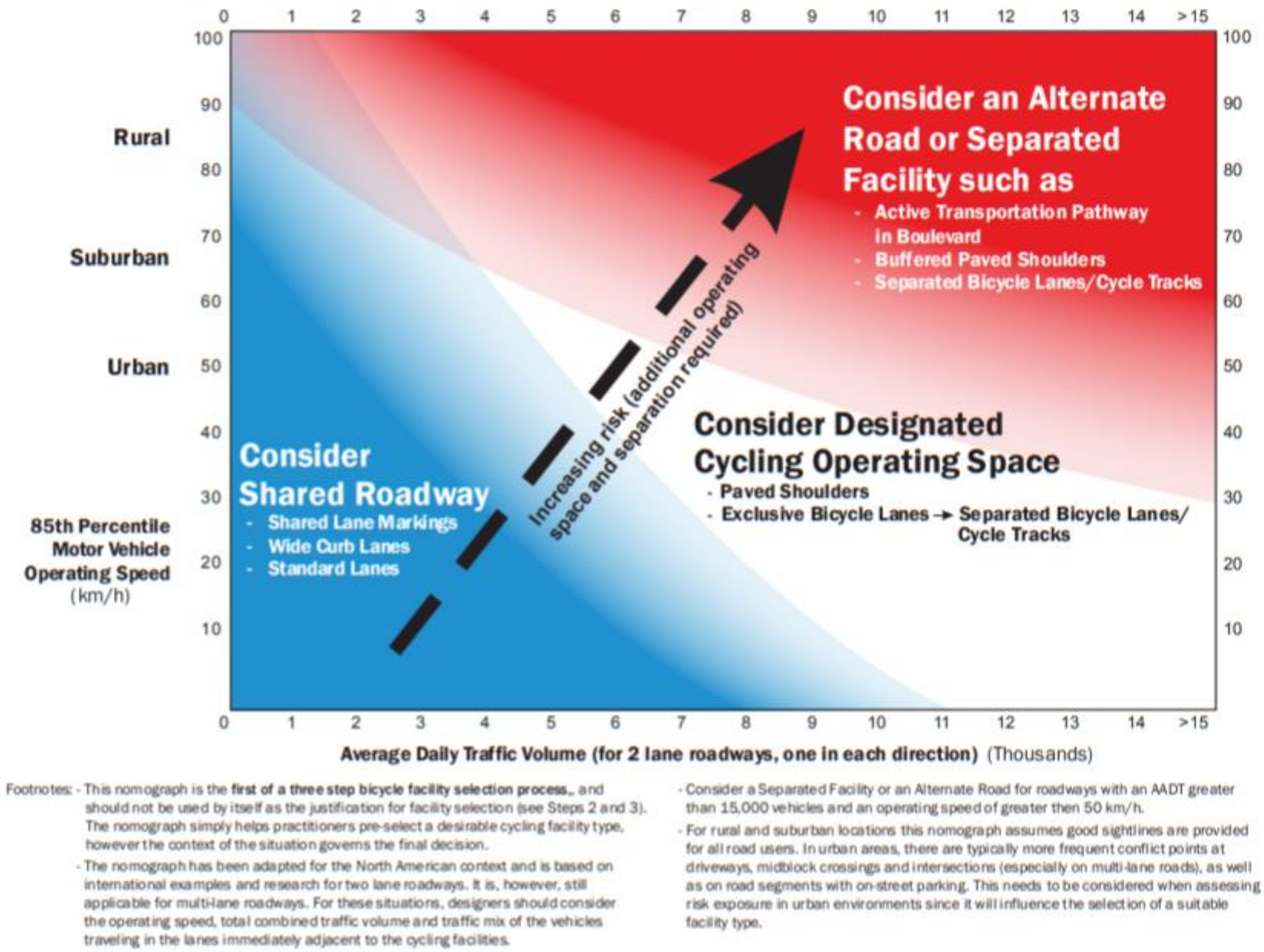
The *Ontario Traffic Manual* includes primary and secondary criteria for bicycle facility selection:

- **Primary Criteria:** 85th percentile speeds, motor vehicle volumes, function of the roadway, vehicle mix, collision history, and available space
- **Secondary Criteria**: Costs, anticipated users in terms of skill and trip purpose, level of bicycle use, function of route within bicycle facility network, type of roadway improvement project, on-street parking, and frequency of intersections

The decision to provide a separated versus non-separated bicycle facility is not a simple “yes” or “no” decision. Practitioners use **Figure** as a starting point. If the motor vehicle operating speed and the average daily traffic volume of a route fall in the red area, alternate parallel corridors more conducive to cycling should be examined where possible. Practitioners should consider the implications in terms of cyclist access to popular destinations, network connectivity, and the spacing of parallel routes. The types of bicycle facilities that might be suitable include a buffered paved shoulder on a rural road, a separated bicycle lane or raised cycle track on an urban road, or a path in a roadway boulevard.

The design criteria and associated thresholds used to select one bicycle facility type over another need to be flexible to accommodate site specific characteristics. The final decision requires professional judgement. The experience and judgement of a qualified practitioner should ultimately influence the bicycle facility type, as well as the added design features or enhancements that are selected.

Figure 25: Ontario Desirable Cycle Facility Pre-Selection Nomograph



Source: *Ontario Traffic Manual*, Book 18: Cycling Facilities, Figure 3-3

Massachusetts DOT Separated Bike Lane Planning & Design Guide

The Massachusetts DOT (MassDOT) *Separated Bike Lane Planning & Design Guide* considers vehicle volume and speed when selecting appropriate bicycle facilities. The Guide notes that separated bike lanes are better than standard bikes lanes in nearly all cases and does not recommend using standard bike lanes. MassDOT suggests separated bike lanes may not be necessary when roadways are 25 mph or less with 6,000 ADT or less.

MassDOT focuses on low-stress network planning and determines bicycle facilities during the planning phase of projects. If separated bike lanes are deemed the appropriate facility given the context, but not feasible based on available space and/or funding, the highest quality feasible alternative should be provided on the corridor (e.g., a shared use path, buffered bike lanes, or standard bike lanes). In these circumstances, consideration should also be given to identifying a parallel route to accommodate the "Interested but Concerned" users.

Minnesota DOT Bikeway Facility Design Manual

Minnesota DOT (Mn/DOT) Bikeway Facility Design Manual uses FHWA's "advanced bicyclist," "basic bicyclist," and "children" user groups. The Manual recognizes that no one road design suits every bicyclist, and there may need to be more than one option on a corridor to serve all bicyclists.

When selecting a facility, Mn/DOT considers the bicyclists' abilities, corridor conditions, existing and future land use, topography, population growth, roadway characteristics, and the cost of facility construction and maintenance. As early as possible in the planning, scoping, and project development process, Mn/DOT project managers evaluate the existing facilities and how they fit with the bikeway network plan.

3.3 Separated Bicycle Lanes

Separated bicycle lanes, also referred to as protected bicycle lanes or cycle tracks, are an increasingly recommended practice in a variety of urban settings. While design details vary, these facilities are characterized by a dedicated space for bicyclists separated from vehicle traffic by some type of vertical element in the buffer space between the bicycle lane and the motor vehicle travel lane. Many separated bicycle facilities have been implemented in the United States and other parts of the world, and various studies and guidance documents have examined their effects. These various studies have provided information on a number of different aspects of separated bicycle lanes. Overall conclusions from these studies include:

- Separated bicycle lanes attract higher numbers of bicyclists than other on-street facilities;
- Crash rates for bicyclists typically go down, even while the number of crashes varies by location and design details; and
- Some studies reviewed overall crashes for all modes before and after implementation of separated bicycle lanes and found decreases in all crashes.

The following sources include literature reviews summarizing studies related to safety and other aspects of separated bicycle lanes:

- FHWA's BIKESAFE *Bicycle Safety Guide and Countermeasure Selection System*: Separated Bike Lanes and summary of studies looking at safety effects
- FHWA's *Separated Bicycle Lane Planning and Design Guide*: Appendix A: Literature Review and Appendix C: Crash Analysis Report

Other studies released after those summaries include the following (this is not a comprehensive list):

- Safer Cycling Through Improved Infrastructure compared fatality and serious injury rates across countries with different levels of infrastructure. It also reviews bicyclist crash history trends in 10 US cities that have significantly increased bicycle infrastructure and finds that all cities have reduced serious and fatal bicyclist crash rates.

- Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S. This widely cited study evaluated separated bicycle lanes in the US in terms of their use, perception, benefits, and impacts. It used counts, video observations, and surveys.

Based on these findings, numerous agencies have incorporated separated bicycle lanes into their design guidance. FHWA's *Bikeway Facility Selection Guide* includes a summary of the potential conflicts and safety implications with a variety of bikeway types, shown in **Figure** and **Figure** .

Figure 26: Intersection Performance Characteristics by Bikeway Type

	Shared Lanes	Boulevards	Shoulders	Bike Lanes	One-Way Separated Bike Lanes with Mixing Zones	Separated Bike Lanes and Sidepaths with Protected Intersections
Functionality (Comfort) - Roads can be categorized by their function						
Lowest at higher vehicle speeds and volumes	✓	✓	✓	✓		
Highest at lower vehicle speeds and volumes	✓	✓	✓	✓		
Moderate to High due to separation from traffic and constrained entry point					✓	
High due to separation from traffic and constrained conflict point						✓
Homogeneity - Roads with vehicles of balanced speeds, directions, and masses are the safest						
Intersection approach exposure to potential motorist conflict is high	✓	✓	✓			
Turning conflict exposure correlates with vehicle speeds and volumes	✓		✓	✓	✓	✓
Turning conflict exposure generally lower due to lower vehicle speeds and volumes		✓				
Constrained entry point reduces approach exposure if visibility is good					✓	
Constrained conflict point eliminates approach exposure, and constrains conflicts to a single point						✓
Predictability (Right-of-Way) - Roads should be intuitive						
No ability to imply right-of-way priority to bicyclists	✓		✓			
Right-of-way priority can be clarified by providing a bikeway on the approach or restricting through-vehicle access		✓				
Right-of-way priority is clarified to require motorists to yield				✓	✓	✓
Conflicts may occur anywhere within the facility	✓	✓	✓	✓		
Conflict point is constrained to one location increasing predictability					✓	✓

Source: FHWA *Bikeway Facility Selection Guide*

Figure 27: Intersection Performance Characteristics by Bikeway Type (continued)

	Shared Lanes	Boulevards	Shoulders	Bike Lanes	One-Way Separated Bike Lanes with Mixing Zones	Separated Bike Lanes and Sidepaths with Protected Intersections
Forgiveness (Safety) - Infrastructure can be designed to accommodate human error						
Relies upon perfect user (driver and bicyclist) behavior to avoid crashes	✓	✓	✓	✓		
Minimal: bicyclists operating in shared space with vehicles	✓					
Moderate: application of traffic calming treatments and lower operating speeds can improve safety		✓				
Moderate: bicyclists operate in separated space from vehicles, however vehicles can encroach into the facility at any location			✓	✓		
Moderate: bicyclists operate in separated space from vehicles except for defined entry point, followed by shared operating space					✓	
High: bicyclists operate in separated space from vehicles except for defined conflict point which can be designed to reduce motorist speed, but contraflow movement from two-way operation can increase risk						✓
Awareness (Visibility) - Awareness improves safety for all users						
Visibility may be restricted by parking necessitating parking restrictions					✓	✓
Visibility is typically unrestricted	✓	✓	✓	✓		
Requires high level of motorists scanning to identify bicyclists approaching from behind or operating beside them	✓	✓	✓	✓		
Requires moderate level of motorists scanning to identify bicyclists approaching or within the conflict point					✓	✓
Key Crash Types Associated with Bikeway Type						
Right and left hooks	✓	✓	✓	✓	✓	✓
Sideswipes	✓	✓	✓	✓		
Overtaking	✓	✓	✓	✓		
Hit from behind	✓	✓	✓	✓		
Merging	✓	✓	✓	✓	✓	
Failure to yield at conflict point	✓	✓	✓	✓	✓	✓

Source: FHWA *Bikeway Facility Selection Guide*

3.4 Information Gaps

The guidance and examples reviewed do not include clear documentation of exactly what practitioners should do in constrained situations where there are trade-offs, nor do they clearly define which trade-offs are "acceptable" vs. "not acceptable." Instead, the guidance discusses some of the options practitioners can consider and, in some cases, provides direction on how to consider and make decisions. Ultimately, most guidance tries to clarify the range of options and relies on practitioners to evaluate each situation and strive to meet the policies and intent of the agency and the community.

4. CONSIDERATIONS FOR THE BLUEPRINT FOR URBAN DESIGN

Section 2 of this document presented an overview of ODOT's policy, regulatory, and design guidance related to the selection and implementation of bicycle facilities. Section 3 summarized a variety of current best practices and examples within the United States and internationally. This section (Section 4) describes areas of alignment between ODOT and other best practices, as well as areas of opportunity (Section 4.1). It describes a potential approach to clarifying ODOT's design guidance for bicycle facilities in urban areas, aligning with the emerging multimodal decision-making framework from the Blueprint for Urban Design (Section 4.2).

4.1 Best Practices: Highlights and Alignment with ODOT

A number of key themes emerged from the best practices review, drawing on both national and international sources, and recalling the focus questions guiding the review in Section 3[4]. ODOT's current policy guidance aligns with many of these themes, but there are opportunities for better alignment within the planning and design guidance.

Overall Themes from Best Practices Review

Across guidance documents and case studies reviewed, the following themes included:

- **Not all bicyclists are comfortable on the same type of facilities. Design users can be described in various ways.** Much of the national guidance and examples described bicyclists at various confidence/skill levels. The guidance resources recognized that confident bicyclists are expected to be comfortable bicycling in a wider range of environments and varying stress levels compared to bicyclists with less confidence or skill. In international examples, design users were classified by purpose (recreation, commute, or children learning) or by differing physical styles (hand-cycle, cargo-bike, bike with trailer). Much of the guidance and examples have started to use the term "All Ages and Abilities" to generally describe the people they aspire to serve.
- **Serving bicyclists of all ages and abilities means designing infrastructure that allows them to feel safe.** The most recent guidance and examples agree that creating low stress facilities, through separation from high motor vehicle volumes and speeds, is important for achieving a feeling of safety.
- **Some best practices and examples include low-stress (high separation) facilities as the "standard" (through a policy statement or within design guidance).** NACTO encourages this approach on all urban streets, and the City of Portland has a directive to consider separated (protected) bicycle lanes whenever any separation is warranted. Denmark uses a cycle track

[4] What context-related attributes are considered in determining the appropriate bicycle facility? How is the concept of "design user" applied, if at all? At what point are bicycle facility-type decisions made? (i.e., policy-level decision, planning decision, [TSP, area, corridor] project-level decision?) How are trade-offs evaluated? What is the process for selecting and implementing "Plan B" or "Plan C" bicycle facilities, when the ideal facility results in untenable trade-offs?

as the default facility, and the City of Austin's street design guidance sets a protected bicycle lane as the "preferred" facility on streets classified higher than Level 1 (local).

- **In other cases, high separation applies to higher classification or designated bicycle routes, making a connected network of low-stress routes, but not to all streets**. In general, these higher classification routes, "designated" for regular bicycle use, should serve bicyclists of varying ages and abilities – not just the most confident riders. Other streets that are not part of the critical network may include more basic (or higher stress) bicycle facilities. These designated routes should make up a connected network of low-stress routes, often developed through a planning process. This network can provide a safe and comfortable experience for most bicyclists. Defining and implementing these networks is important and should consider access to destinations, connections to transit, a desire for recreation, and the need for places where children can bicycle.
- **Design flexibility and narrower cross-sectional elements should be allowed in "constrained" areas.** Flexibility allows for more buffering, and as a result, implementation of lower stress bicycle facilities. The recently released NCHRP Report 880: *Design Guide for Low-Speed Multimodal Roadways* recommends using narrower vehicle travel lane widths in some urban contexts.
- **The most common attributes for determining bicycle facilities are motor vehicle speeds and volumes**. Various examples determine appropriate level of separation and design details (i.e. width, buffer) based on: land uses, bicycle networks, vehicle speeds, travel lanes, volumes, speed differentials, and other geometric or usage characteristics.

Areas of Alignment and Opportunity within ODOT

ODOT and the State of Oregon's existing policies, plans, planning guidance, design guidance, and practices (thoroughly described in Section 2) align with many of the themes identified in the best practices review. In some cases, updates to ODOT's planning and design guidance is needed to better align with existing ODOT policies and national best practices.

As noted in Section 2, the State's original "bike bill" used the term "trail" to describe bikeways – indicating an understanding that separation from motor vehicle traffic creates safe and comfortable bikeways. The Transportation Planning Rule also suggests that bikeways need to be free from hazards, including exposure to high motor vehicle volumes and speeds. Other language within ODOT's *Highway Design Manual* suggests using designs beyond the most basic, particularly on "designated" routes. This aligns with federal guidance from 2010, which encourages agencies to go beyond the minimum in designing for pedestrians and bicyclists.

Further, the Oregon Bicycle and Pedestrian Plan (OBPP) uses encompassing language in its vision statement – "people of all ages, incomes, and abilities" – providing direction to design for all users, not just those confident bicycling with vehicle traffic. The goals and policies in the OBPP provide direction to ODOT to work on developing designs and updating design guidance that will achieve this vision and create safe and comfortable bicycling networks for all.

Also, as noted in Section 2, ODOT's design guidance does not currently require designs that create a low-stress bicycle facility. The review in Section 2 notes various parts of the *Highway Design Manual* (HDM) that pertain to bicycle facilities in urban areas (Chapter 2, Chapter 6, Chapter 13, and Appendix L). These chapters and appendix, written at different times and with differing core topics, are not always in alignment.

As noted above, both Chapters 2 and Chapter 13 of the HDM contain language indicating that designing bicycle facilities beyond the minimum should be considered on some routes. Chapter 2 says, "Comprehensive bicycle facility design, rather than basic accommodation should be considered along **designated bicycle routes**," while Chapter 13 says, "…highways designated as Scenic Bikeways, National Bike Routes or **other recognized bikeways** should have greater attention to bicycle accommodation."

Appendix L of the HDM, focused on bicycle facility design, was written in 2011 (prior to the publication of NACTO's guidance) and was ground-breaking at the time for its separation matrix. It included a number of innovative bicycle facilities – some for which few examples were available (such as cycle tracks and raised bike lanes). The separation matrix provided guidance to ODOT practitioners on selecting the appropriate facility for the roadway context (vehicle speeds and volumes). However, this guidance is not fully reflected in other parts of the HDM, nor is it required that practitioners consult the matrix. ***As the HDM is updated, ODOT should verify that the various chapters provide practitioners with consistent guidance, recognizing that commonly referenced tables should seek to reflect the guidance described within other parts of the Manual.***

ODOT's recent policy guidance in the OBPP aligns with the direction towards creating low-stress networks. The OBPP focuses on creating a safe and comfortable experience for all ages and abilities of bicyclists that allows them to access daily needs and transit. It suggests that routes parallel to ODOT facilities may be acceptable for serving less confident bicyclists in some cases, if the bicycle facility on the ODOT highway is not considered low-stress. This practical approach aligns with national guidance and other jurisdictions working towards improving their bicycle networks. ***Critical to achieving these low-stress, complete bicycle networks is a network planning process that results in agreement on which streets will ultimately include low-stress bicycle facilities.***

ODOT allows some design flexibility, which is a key factor for selecting and implementing low-stress bicycle facilities. However, much of this flexibility is only permitted through a design exception/documentation process, and this is rarely done at the planning stage when preliminary facility selection should occur. Moreover, most system planning efforts do not develop concepts to the level of detail needed for a design exception/documentation. ***ODOT's design guidance can be updated to facilitate use of this flexibility and further embrace the range of options included within AASHTO's design guidance, as well as other sources endorsed by ODOT in 2015 (as noted above in Section 2) and other recently published research.***

4.2 Aligning Policy, Planning, Design and Implementation of Bicycle Facilities: Recommended Approach

The information from this topical memorandum (and this approach) is included in the Blueprint for Urban Design.

ODOT has clear *policy* guidance related to the topic of bicycle facility selection, outlined in the vision, goals, and policies of the OBPP. However, ODOT must consider changes to its planning and design guidance to more effectively implement the direction of the OBPP.

Planning Approach

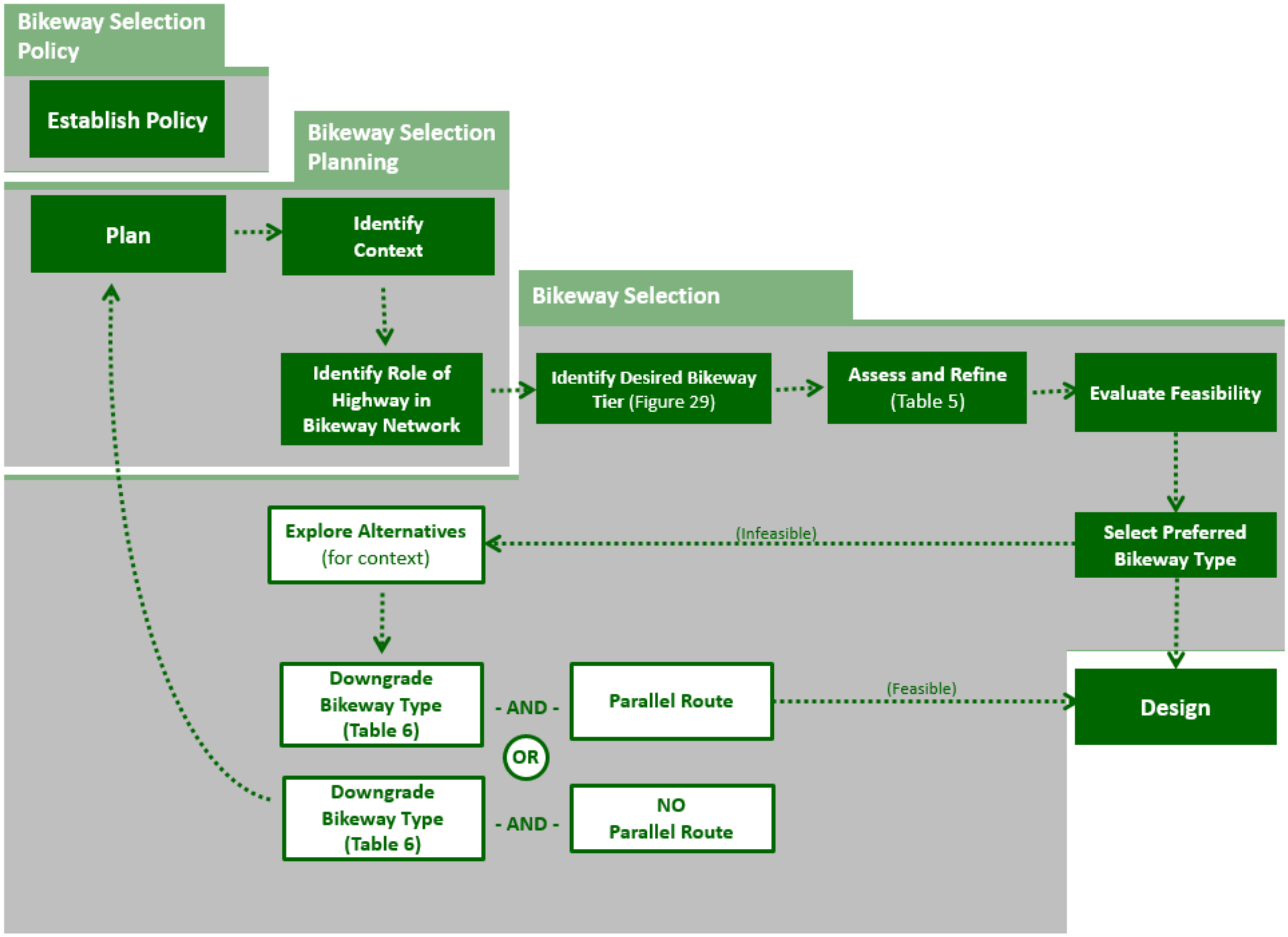
Within planning, there currently is not a consistent process and method of documentation among ODOT planning and local jurisdiction efforts to provide guidance on the envisioned bicycle networks or facilities. The proposed approach is described below. Key steps for each project are shown in a flowchart in **Figure 28** (repeated from Executive Summary Figure 1):

- For transportation system planning:
    - Consider updating the TSP planning guidelines to guide local jurisdictions in developing a plan for envisioned connected "low-stress" bicycle networks, and best practices for doing so. These plans should determine whether or not ODOT facilities are part of the envisioned low-stress network.
    - Consider setting a state "standard for adequacy" on the low-stress networks of Level of Traffic Stress (LTS) 2. "LTS" is a metric included in the APM that can help local jurisdictions in these planning efforts. "Low Stress" is typically considered LTS 1 or 2. The "standard for adequacy" on state routes not on the low stress network would be "basic bicycle facilities" (not based on an LTS standard). The APM could be updated further to reflect this guidance.
    - If ODOT highways are part of the low-stress network in an adopted local jurisdiction plan, these routes are then "recognized" or "designated" (terms used within the HDM as the types of routes that warrant treatment beyond the minimum). This results in the application of the guidance in **Table 5** (repeated from Executive Summary Table 1).
    - If ODOT highways are excluded from the low-stress network (with low-stress bicycle travel provided on other facilities), guidance from **Table 6** (repeated from Executive Summary Table 2) would apply.
    - If there is an urban ODOT route and the existing transportation system plan does not specify or consider it, apply the guidance from **Table 5**.
    - **The system plan should then make a "preliminary bicycle facility selection" based on Figure 29 and Table 5 or Table 6 if applicable** and pending the results of an engineering and feasibility review. The preliminary bicycle facility selection typically will not include design details but will specify the facility type. The TSP should also

determine the width required to implement the preliminary bicycle facility selection in order to ensure adequate right-of-way dedication as development occurs.

- For corridor planning:
    - Incorporate a bicycling site visit for ODOT and local agency practitioners and decision-makers into the scope of the corridor planning effort. This visit will allow the practitioners to experience the existing conditions and level of traffic stress for bicyclists, and to consider potential appropriate solutions.
    - Determine whether the route has been identified in a system plan as being part of an envisioned low-stress network.
    - If it has, or if it is not specified in a system plan, develop a concept design for bicycle facility based on **Figure 29** and **Table 5**. Develop design documentation if it does not align with updated guidance from **Table 5**.
    - If the system plan identified a parallel route to serve as part of the low-stress network, develop a concept design for bicycle facility based on guidance from **Table 6**. Develop design concurrence documentation if the concept design does not align with the downgraded bikeway options in **Table 6.**
    - **The corridor plan should result in a "bicycle facility design concept" based on Table 5 and Table 6 (if applicable)** and pending the results of an engineering and feasibility review. The bicycle facility design concept typically will include direction on some key design aspects, such as type of separation/buffer and treatment at intersections and access points.
- For both system planning and corridor planning, develop a system of documenting and maintaining decisions and direction from planning work. This documentation could be a GIS-based system on ODOT's highway network, using highway numbers and mile points. The Active Transportation Needs Inventories in Regions 1, 4, and 5 includes summaries of plans with needs or projects identified for ODOT highways. This information can be compiled into an asset in ODOT's GIS system and updated as local jurisdictions or ODOT updates planning documents.

Figure 28. Bicycle Facility Selection Process



Project Scoping and Design Approach

Development of the business case, followed by project scoping, typically determines the general scope and overall budget of a project. It can be challenging for design teams to select and design a different bicycle facility than what is outlined in scoping because funds are allocated based on the scoped project. Therefore, the stages of planning, developing the business case, project scoping, and design, should be aligned with the same bicycle facility selection guidance.

- Business case and project scoping
  - Review corridor or system plan to determine if a preliminary bicycle facility type selection has been made.
  - If no selection has been made, refer to guidance in **Table 5** for bicycle facility selection. Note the need for a design documentation if the selected facility does not align with guidance from **Table 5** and **Figure 28**.
- Design
  - Design based on guidance in **Figure 29/ Table 5** (for facility selection) and the AASHTO *Guide for the Development of Bicycle Facilities* for further design details.

(Other design guidance endorsed by ODOT can also be used.) ODOT manuals should be updated to reflect this guidance.

- Design based on **Table 6** if the ODOT highway is identified in a plan as NOT being part of the low-stress network. When **Table 6** standards apply, projects should still, when possible, consider a design that does not preclude a future vision for a planned bike route, depending on the context and design year.
- In constrained environments and/or constrained budgets, design decisions should consider the modal consideration figure (Figure 4) from Chapter 2 of the Bridging Document, in determining how to make trade-offs (see additional guidance in following section).
- Design concurrence documentation can be used to implement designs that do not align with guidance in **Table 5**.
  - Note: If this occurs, ODOT and local jurisdiction will need to determine if the ODOT facility should remain the envisioned low-stress route (to be implemented with a future project) or should select a parallel low-stress facility.

Considering Trade-offs in Constrained Locations

Urban areas are often constrained, creating the need to consider trade-offs in design. ODOT is in the process of developing further guidance on the level of flexibility provided for specific design elements. As this guidance is created, it will provide designers with a range of options for implementing a bicycle facility. Potential considerations include:

- Is there an opportunity to narrow travel lanes?
  - If existing travel lanes are greater than 10 feet, consider options for narrowing lanes.
  - On streets with more than two through lanes, select 10-foot lanes for the inner lanes.
  - On low-speed urban streets, 11-foot lanes are sufficient to serve transit and freight vehicles. Even 10-foot 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 contexts, shy distance can be minimized or removed.
- Is there an opportunity to narrow or remove the center turn lane?
  - On low-speed streets in many urban contexts, 10 feet is sufficient width for a two-way left turn lane.
- Is there an opportunity to reduce the number of motor vehicle travel lanes?
  - Depending on motor vehicle volumes, a lane reallocation (e.g., from 4 lanes to 3 lanes) may provide sufficient capacity and can improve safety.
  - In some contexts, comfortable bicycle 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 bicycle travel and/or other priorities may be more important than on-street vehicle parking.

Depending on the existing street configuration, these options can often create sufficient space to add a buffer (with potential vertical element) between the bicycle lane and the motor vehicle travel lane, or in some cases, add a new bicycle facility to a street. Through the development of the Blueprint for Urban Design and subsequent refinements to ODOT design guidance, the agency will provide further guidance on the menu of options available for street retrofits in urban contexts.

Figure 29 includes a graphic for selecting the preferred bikeway type, based on the FHWA *Bikeway Selection Guide*, and is supplemented by the guidance provided in **Table 5**. The chart assumes operating speeds are similar to posted speeds. However, if they differ, the Guide recommends using operating speeds. The FHWA Guide provides additional information on advisory bike lanes and alternatives to preferred bikeway types.

Figure 29. Bicycle Facility Tier Identification Matrix[1]

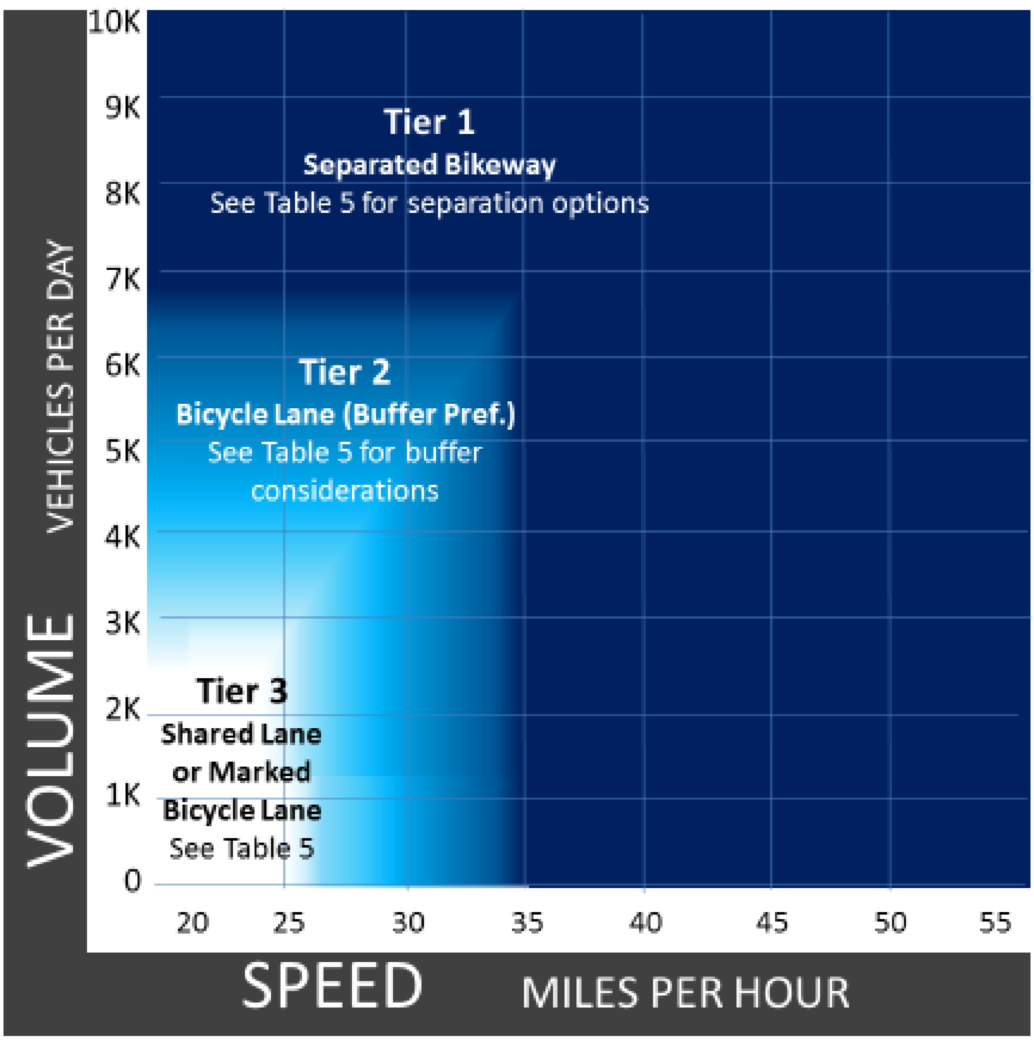


Table 5: Preferred Bicycle Facility Design for ODOT Highways in Urban Areas

Urban Context	Tier 1 – Separated Bikeway [1] Delineation options in the bicycle/street buffer zone	Tier 2 Bicycle Facility[2]	Tier 3 Bicycle Facility[3]
Traditional Downtown/ CBD	parking, raised island, flexible delineator posts, rigid bollards, parking stops, planters, bioswale	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Urban Mix	parking, raised island, flexible delineator posts, parking stops, planters, bioswale	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Commercial Corridor	raised island, flexible delineator posts, concrete barrier, guardrail, bioswale, ditch	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Residential Corridor	raised island, flexible delineator posts, concrete barrier, guardrail, bioswale, ditch	Evaluate Bicycle Lane Buffer	Evaluate Bicycle Lane vs Shared Lane
Suburban Fringe	raised island, flexible delineator posts, concrete barrier, guardrail, bioswale, ditch	Bike lane or wide shoulder. Evaluate Buffer	Evaluate Bicycle Lane vs Shared Lane
Rural Community	parking, raised island, flexible delineator posts, planters, concrete barrier, guardrail, bioswale, ditch	Bicycle lane or wide shoulder. Evaluate Buffer	Evaluate Bicycle Lane vs Shared Lane

[1] Separated Bikeways may include shared use paths, sidewalk level separated bike lanes, or buffered bike lanes with vertical delineation in the buffer zone. See ODOT Bicycle and Pedestrian Design Guide for more information on various separated bikeway designs.

[2] Considerations on whether to provide additional buffer width for a bicycle lane are given on page 24 of the FHWA Bikeway Selection Guide. See Tables 11-16 for bicycle/street buffer widths.

[3] Evaluate by considering factors that influence the appropriateness of a shared travel lane condition, which are discussed on pages 1-4 to 1-5 in the ODOT Bicycle and Pedestrian Design Guide. Note that Shared lanes should only be used where operating speeds are 25 mph or lower.

Table 6:* Alternative Bike Facility Design for ODOT Highways in Urban Areas with Identified Lower Stress Parallel Routes

Urban Context	Bicycle Facility	Width	Other potential facility types**	Design Concurrence Documentation Needed?
Traditional Downtown/CBD	Shared Lane (25 mph)	--	6' Bike Lane 5' Bike Lane (with no on-street parking)	If the proposed facility does not align with the "bicycle facility" and "width" AND does not match the other potential facility types, further documentation of design decision-making (design concurrence documentation) is necessary.
Urban Mix	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	
Commercial Corridor	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	
Residential Corridor	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	
Suburban Fringe**	Shoulder	6'	4'-5' Shoulder 5'-6' Bike Lane	
Rural Community	Bike Lane	6'	Shared Lane (25 mph) 5' Bike Lane (curb adjacent)	

*Note: **Table 5** is to be used as the "standard" for bicycle facility design. This table (**Table 6**) is to be used on ODOT highways to identify alternative bicycle facility design options where the preferred bicycle facility design is infeasible. If **Table 6** is used, projects should still consider a design that does not preclude the preferred bicycle facility or future vision for a planned bike route. If the preferred bicycle facility design cannot be provided on the ODOT highway, improvements should be considered to provide a low-stress parallel route

** The "suburban fringe" context is typically adjacent to rural areas at the edge of urban development, but often is in the process of developing. For projects in the "suburban fringe" context zone, practitioners should consider likely future development and consider applying designs for "residential corridor," "commercial corridor," or "urban mix" contexts if this type of development is likely to occur.

Parallel Routes

In Oregon all public urban roadways should have appropriate walkways and bikeways provided, regardless of whether or not they are a "designated" route. Per ORS 366.514, walkways and bikeways must be provided whenever a roadway is "constructed, reconstructed, or relocated". Extra effort should be given to provide the preferred facility type (**Table 1**) on ODOT facilities that are part of state, regional, local bike routes, scenic bikeways, US Bicycle Routes, or other designated bikeways. On highways that are not part of a planned bicycle route, accommodations for bicycle traffic should still be provided with "interested but concerned" riders in mind, unless a low-stress parallel route has been identified by the local jurisdiction or an adopted network plan. When parallel routes are selected, they should be as direct as possible and well signed for bicycle wayfinding. To be viable, parallel routes should provide equivalent access to destinations along the highway, provide facilities and crossings for "interested but concerned" users, and should increase average trip lengths by less than 0.27 miles or 1.5 minutes for short trips.

Urban Interstates, Freeways, Expressways

Wide shoulders on urban limited access highways serve many purposes; as recovery zone for vehicle roadway departures, breakdown zones for vehicles during mechanical incidents or after collisions, emergency and maintenance vehicle access, and potential bus on shoulder operations. Shoulders should be available for pedestrians to access the nearest exit during mechanical incidents or after collisions, but it is not preferred to accommodate bicycle or pedestrian travel on shoulders on urban limited access facilities. Instead, pedestrian and bicycle travel should be accommodated on a parallel multi-use path, separated bikeway, or parallel streets. Limited access highway shoulders should only be used as a primary pedestrian and bicycle accommodation in low volume rural areas and/or where physical constraints and sparse surrounding network make a parallel route infeasible.

Bicycle Facility Design Challenges

Although agencies have been installing and designing separated bicycle facilities throughout the United States over the past 5 to 10 years, they are still considered a relatively new facility type in many US contexts. As agencies gain experience with effective selection and implementation approaches, design guidance continues to be updated. An update to the AASHTO *Guide for Development of Bicycle Facilities* is anticipated in 2019 and will include guidance on some of these approaches and more challenging aspects of design.

To facilitate broad adoption of best practices, ODOT can consider further updating its design guidance specific to bicycle facility design. ODOT should continue to monitor the latest guidance and draw on it to address the following identified design challenges:

- Intersections (protected intersections, roundabouts, bicycle signals)
- Interaction with on-street parking, loading, and unloading
- Interaction with transit stops and/or lanes
- Ensuring Americans with Disability Act (ADA) compliance
- Integration with stormwater treatments
- Driveway access

5. PARKING LOT

This section documents elements of this topic that are out of the scope of this topical memorandum but will need to be addressed through future efforts.

a. Bicycle-specific intersection design treatments
b. Selection and design of parallel routes, when required
c. As ODOT develops separated bicycle facility designs, the agency will also need to develop an approach to maintaining these facilities. Depending on the design, separated bicycle facilities may require use of a specialized, narrow street sweeper.
d. What is the best way to "phase in" and transition bicycle facility upgrades along a corridor when projects are "spot" improvements (e.g., redevelopment, intersection improvements) rather than corridor modernization projects?
e. Design is ever-evolving – this is the current state of practice but necessary for ODOT to engage in the AASHTO and TRB to stay current and share best practices, including which types of designs result in the best safety performance.
f. Having a lack of a bicycle functional class system and related performance standards makes it difficult to show a need and choose appropriate facility types, as opposed to just filling a gap where no facility exists.

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OREGON DEPARTMENT OF TRANSPORTATION

URBAN DESIGN INITIATIVE

>>> Topical Memorandum:
Pedestrian Crossing Spacing

KITTELSON & ASSOCIATES

August 2019

PREFACE

The Pedestrian Crossing Spacing Topical Memorandum is a part of the Oregon Department of Transportation (ODOT) Urban Design Initiative. The purpose of this memorandum is to addresses how to determine frequency (spacing) of pedestrian crossings on ODOT highways. Information from this memorandum has been integrated into the ODOT Blueprint for Urban Design and is included in full as an appendix to the Blueprint for Urban Design.

ODOT Planning and Technical Services Engineering and Active Transportation staff developed the Pedestrian Crossing Spacing Topical Memorandum using a collaborative approach, including multiple disciplines and region staff. Federal Highway Administration (FHWA) Oregon Division and the transportation engineering consulting firm Kittelson & Associates, Inc. provided support to develop this document. The following people contributed to the development of this document:

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CONTENTS

EXECUTIVE SUMMARY

This topical memorandum addresses how to determine frequency (spacing) of pedestrian crossings on Oregon Department of Transportation (ODOT) highways. ODOT has some policy guidance related to the topic of pedestrian crossing spacing; however, ODOT can consider providing additional guidance to more specifically outline a target frequency of crossings in urban contexts.

The target spacing of crossings for each urban context is provided in **Table 1**. A range, rather than a single target, is provided for flexibility to adjust based on roadway network characteristics (e.g., frequency and spacing of intersections), pedestrian destinations (e.g., transit stops), and cluster of land uses. For example, within a mixed-use area, development may not be distributed uniformly or practitioners may consider the lower end of the range where the land uses are most intense.

Table 1. Target Crossing Spacing

Urban Context	Target Spacing Range (feet)
Traditional Downtown/CBD	250-550
Urban Mix	250-550
Commercial Corridor	500-1,000
Residential Arterial	500-1,000
Suburban Fringe*	750-1,500
Rural Community	250-750

* The “fringe” context is typically adjacent to rural areas at the edge of urban development, but often is in the process of developing. For projects in the “fringe” context zone, practitioners should consider likely future development and consider applying designs for “residential arterial,” “commercial corridor,” or “urban mix” contexts if this type of development is likely to occur.

The targets in Table 1 are a starting point. Practitioners should evaluate the density of land uses and pedestrian generators and their locations to determine if a lesser or greater spacing is needed. When considered as part of a larger project, such as a corridor project, ODOT should strive to meet the spacing targets. If the target crossing spacing cannot be met on a project, the project team should document why. Similarly, if a crossing is proposed for removal and would lead to a spacing distance beyond the target range for the context, justification should be provided.

1. DEFINE THE PROBLEM

This topical memorandum will address how to determine frequency (spacing) and location of pedestrian crossings[1] across ODOT facilities.

1.1 Expanded Problem Statement

State highways in urban areas often present barriers for pedestrians and bicyclists seeking to cross them. Increasing the opportunities to cross ODOT's urban facilities can improve access and network connectivity for these modes. ODOT is committed to working with communities to provide connected pedestrian networks, including across state highways.

IN THIS MEMO >>

- ODOT's existing crossings guidance and processes
- Review of other guidance and agency approaches
- Future considerations for crossings of ODOT highways in urban areas

ENHANCED CROSSING >>

Crosswalks with devices and design treatments that enhance the ability of pedestrians to cross the street and the visibility of the crossing location and pedestrians waiting to cross. Treatments may include pavement markings, signage, beacons, and signalization, among others.

Existing guidance could be improved to give clear direction on when and where to provide crossings. Guidance should be based on an overall desired permeability or pedestrian/bicycle network connectivity, rather than existing pedestrian volumes. The Bicycle and Pedestrian Design Guide in the Highway Design Manual does suggest crossings should be provided no more than every ¼ mile on developed, urban state highways; however, this is not currently a requirement and may not be sufficient in all urban contexts.

The agency lacks clear and consistent written guidance on how pedestrian crossing needs along an urban corridor should be identified and prioritized during the planning process and through project delivery and maintenance. ODOT staff and agency partners would like both planning level and scoping guidance on frequency (spacing) and locations for crossings in urban contexts.

The ODOT Traffic Manual includes guidance and resources for determining crossing treatments once the decision is made to provide a crossing at a particular location. Therefore, this memorandum will not address design treatments.

[1] While crossings can be designed for and used by both pedestrians and bicyclists, this memorandum will focus on selecting locations and target spacing of crossings for use by pedestrians. Bicyclists may have different needs due to bicycle networks more frequently aligning with local street networks. The considerations developed in this memorandum may also apply to bicyclists, and bicyclists can also benefit from pedestrian crossings. When the needs of pedestrians and bicyclists differ, the solution should be developed based on the local context and characteristics.

2. OVERVIEW OF POLICY, REGULATORY, AND DESIGN GUIDANCE CONTEXT

2.1 ODOT Policies Related to Crossings

There are a number of laws and administrative rules that govern ODOT policies, guidelines, and procedures related to crossings. These laws and rules:

- Define what a crosswalk is (ORS 801.220);
- Define who has authority to establish or close crosswalks (ORS 810.080);
- Govern the traffic control devices used at crosswalks (ORS 810.200) and define authorities and procedures within ODOT related to those traffic control devices (OAR 734-020);
- Establish the responsibilities of road users at crosswalks (ORS Chapters 811 and 814);
- Set rules and procedures within ODOT related to access management (OAR 734-051);
- Set procedures within ODOT related to road widths for movement of freight (ORS 366.215 and OAR 731-012);
- Mandate development and maintenance of a comprehensive transportation policy and long-range plan for a safe, multimodal transportation system (ORS 184.617);
- Ensure pedestrians with disabilities have an equal opportunity to use the transportation system in an accessible and safe manner (Title II, 42 USC § 12132; 28 CFR Part 35);
- Require a minimum amount of funding dedicated to pedestrian facilities, including crossings (ORS 366.514);
- Allow district school boards to fund pedestrian facility improvements to enhance safe access to and from a school (ORS 332.405); and
- Require transportation system plans (TSPs) include a bicycle and pedestrian plan for a network of bicycle and pedestrian routes throughout a planning area (OAR 660-012-0020[2d]).

[NOTE: ODOT is currently working with Department of Justice (DOJ) to clarify nuances in ORS 801.220, primarily related to what happens when a crosswalk is marked across one leg of an intersection but not the other. This is part of a planned ODOT policy on identifying where crosswalks are located – mostly related to unmarked crosswalks – to help designers locate ADA ramps in the bounds of a crosswalk.]

Within this legal and administrative framework, ODOT is committed to providing a safe and reliable multimodal transportation system that connects people and helps Oregon's communities and economy thrive. Specifically by 2040, the Oregon Bicycle and Pedestrian Plan envisions that people of all ages, incomes, and abilities can access destinations in urban and rural areas on comfortable, safe, well-connected walking routes. The Oregon Bicycle and Pedestrian Plan establishes many policies to fulfill this mission and vision. Some of these policies related to pedestrian crossings include:

- Provide safe and well-designed streets and highways for pedestrian and bicycle users (Policy 1.1);
- Add pedestrian and bicycle infrastructure and street crossings to connect system gaps, understanding the unique needs of urban, suburban, and rural communities (Policy 2.3);
- Improve access to multimodal connections for bicyclists and pedestrians through planning, design, prioritization, and coordination (Policy 2.4);
- Bring about a pedestrian and bicycle network that achieves ease of movement, especially considering the people using these modes are vulnerable users of the system (Policy 3.1);
- Integrate pedestrian and bicycle mobility considerations in planning, design, construction, and maintenance (Policy 3.2);
- Balance pedestrian and bicycle needs and freight mobility needs through planning and design guidance and coordination (Policy 3.3);
- Understand the disparities, barriers, and needs affecting the availability and use of walking and biking options for all Oregonians (Policy 5.2);
- Promote walking to help achieve public health goals to improve air quality, and provide opportunities for physical activity to help reduce risk of chronic diseases and other health issues (Policy 6.1);
- Promote walking and biking to help achieve local, regional, state, and federal environmental goals to reduce vehicle miles traveled, reduce greenhouse gas emissions, and improve air and water quality (Policy 7.1); and
- Invest strategically in the overall pedestrian and bicycle system by preserving existing infrastructure, addressing high need locations, and supporting programmatic investments (Policy 8.2).

The Transportation Safety Action Plan is another plan that establishes policies to fulfill this mission and vision. Some of these policies related to pedestrian crossings include:

- Continually improve and implement design and analysis techniques for safety-related decision-making in transportation planning, programming, design, construction, operations and maintenance for all modes (Policy 2.2);
- Plan, design, construct, operate, and maintain the transportation system to achieve healthy and livable communities and to eliminate fatalities and serious injuries for all modes (Policy 2.3);
- Invest in transportation system enhancements that improve safety and perceptions of security for people while traveling in Oregon (Policy 3.4); and
- Allocate infrastructure safety funds strategically, considering all modes, to maximize total safety benefits (Policy 6.1).

The Transportation Safety Action Plan also includes pedestrian-related action items to reduce fatal and serious injuries. One of those action items is to provide safe facilities and crossings in areas where pedestrians are present or access is needed, prioritizing transit corridors, school areas, multilane streets and highways, and other high-risk areas and facilities (Action 6.8.2).

The ODOT Traffic Manual establishes overall policies and guidelines related to traffic engineering at ODOT, including where to establish marked crosswalks and other enhancements at crosswalks. The most significant Traffic Manual policy related to crossings is the requirement for an engineering study and engineering approval to mark a crosswalk and install other crosswalk enhancements (Section 6.6.2.11). This is intended to ensure the marked crosswalk is placed where needed and with the appropriate level of safety treatments for the context of the crossing.

The Traffic Manual also establishes policies and guidelines for pedestrian-activated warning lights and in-street pedestrian crossing signs to further enhance crosswalks (Rectangular Rapid Flashing Beacons [RRFB], Pedestrian Hybrid Beacons [PHB], standard Warning Beacons, in-roadway lights); criteria for closing or removing crosswalks is also included.

2.2 Current Design Guidance for Implementing Crossings

In 2015, ODOT leadership issued a memorandum encouraging ODOT engineers, planners, and designers to use national and Oregon references to incorporate pedestrian improvements and urban design elements into the agency's projects to help meet ODOT's mission, vision, and policies[2].

ODOT guidance for selecting locations for crossings includes:

- Transportation System Plan (TSP) Guidelines
- Highway Design Manual (HDM)
- Traffic Manual
- Guide to School Area Safety

The TSP Guidelines help guide TSP development to be consistent with other TSPs and the Oregon Transportation Plan and its modal topic plans. When developing or updating a TSP, the Guidelines:

- Require an inventory and assessment of existing pedestrian infrastructure, including enhanced pedestrian crossings;
- Require addressing gaps or inadequacies in the pedestrian network;
- Require a narrative that can discuss pedestrian crossing spacing or location guidelines; and
- Recommend consideration of enhanced pedestrian crossings.

The Guidelines do not discuss what an appropriate crossing frequency is.

The Highway Design Manual, in particular Chapters 6 and 13, the Access Management Standards (Appendix C), and the Bicycle and Pedestrian Design Guide (Appendix L), contains guidance on the following:

- Human factors (e.g., people will take the shortest route to their destination)

[2] https://nacto.org/wp-content/uploads/2015/10/Oregon-DOT-USDG-Endorsement-092515.pdf

- Crossing frequency on developed, urban state highways (should be no further than every ¼ mile)
- Crossing location relative to other signalized crossings (e.g., crossing improvements no closer than 300 feet from nearest signalized crosswalk). It acknowledges planning documents might identify potential crossing locations.
- Access management spacing standards in urban areas
- How signal spacing, access management, location of transit stops, and surrounding land use affect pedestrian demand and where crossings should be located
- Locating crosswalks midblock or at an intersection
- Various types of crossing treatments
- Context and facility type related to crossings (e.g., crossings not appropriate on urban expressways, frequent crossings in STAs and UBAs)
- Median island and curb extension design guidance

The Traffic Manual contains guidance, criteria, and procedures for marking and enhancing crosswalks with traffic control devices primarily based on minimizing risks to pedestrians. It sets minimum distances between mid-block and intersection enhanced crosswalks (300') and minimum distances between different types of traffic control devices (e.g., a minimum distance of 250' between an RRFB enhanced crossing and another crosswalk, traffic signal, or stop sign). However, recommended maximum spacing between crossings is not discussed in the Traffic Manual. The Traffic Manual's guidance, criteria, and procedures are discussed further in the next section.

ODOT's A Guide to School Area Safety provides a reference on school zones and safe travel to and from school. It does not establish policy or standards for ODOT or other road authorities in Oregon. Guidance related to crossings includes:

- What is typically included in an engineering study to determine where a designated school crossing is needed;
- Discussion of how to treat crosswalks once a school crossing is located; and
- Where to locate a school zone and school speed zone relative to designated school crossings.

The considerations listed in the Guide for the engineering study are largely consistent with other ODOT practices with the addition of school-specific considerations such as drop-off and pick-up operations, Safe Routes to School Plan, and input by the school district, traffic safety committees, and other community representatives.

The ODOT Bicycle and Pedestrian Plan includes a cost estimate to complete identified improvements to pedestrian and bicycle facilities in 25 years. Specifically, for crosswalks, this cost estimate was calculated based on the assumption that a crossing would be needed at least every ¼ mile inside urban boundaries, consistent with the Bicycle and Pedestrian Design Guide.

2.3 Current Process for Determining Crossing Needs

Identifying the need for a crossing can begin in system planning, corridor planning, Safe Routes to School Action Plans, engineering studies, project development, community/city/county request, or maintenance request. The variety of starting points reflects the many different ways in which Oregon's transportation system is used and managed. It also means each starting point identifies crossing locations differently.

Regardless of how the location is identified, if the crosswalk will be marked and/or enhanced with other pedestrian-activated traffic control devices (e.g., beacons, RRFBs, PHBs, signal), State Traffic-Roadway Engineer approval is required under OAR 734-020-0410. To obtain approval, the Region Traffic Office investigates the location through an engineering study (unless it is at an intersection where crosswalks are put in as a standard such as a signal or roundabout). The study and approval process are conducted to ensure the crossing is placed where it is needed and with the appropriate level of safety treatments for the context of the crossing.

If reducing the crossing distance is desired on an identified freight route (e.g.: by installing curb extensions or median islands), freight needs must be considered (ORS 366.215 and OAR 731-012). The ORS includes a flow chart[3] to determine if an exception can be granted by the Oregon Transportation Commission to provide curb extensions or median islands for safety considerations when they would reduce the vehicle carrying capacity of the freight route.

2.4 Barriers to Implementing Crossings

Prioritizing Funding

Sometimes, a location is not desirable for a crossing, even if pedestrian demand is high, and the location cannot be made objectively safe with the available treatments and available funding. For example, locations where motor vehicle speeds are high (above 45 mph), where there is not enough sight distance, or where unusual or unexpected motor vehicle conflicts occur might be places where the only way to objectively make a crossing safe is prohibitively expensive.

Crossings along a corridor usually need to be prioritized because there is not enough funding to provide treatments at every crossing identified with a need. The corridor may get fewer treatments; the treatments may be cheaper or less effective; or a combination of both.

[3] https://www.oregon.gov/ODOT/MCT/Documents/ORS366Guidance.pdf

Barriers in Engineering Studies

ODOT's policy to complete an engineering study to determine crossing needs is intended to ensure crossings are placed where needed and with the appropriate level of safety treatments for the context of the crossing.

According to the *Manual on Uniform Traffic Control Devices* (MUTCD), a basic goal for all traffic control devices should be to fulfill a need. Pedestrian volumes are currently used in the engineering study as a primary way to show a need for a crossing. Pedestrian counts ideally capture pedestrian use during a peak travel period. The peak period for pedestrian demand may not align with the traditional peak period for motor vehicle traffic, making it difficult to effectively schedule counts that show a real need. Sometimes, recent pedestrian counts are available, but often not, and if funding or resources are not available to do a count, this can be a barrier to determining crossing needs. Counting pedestrian volumes along a corridor where demands are dispersed can be especially challenging and time-consuming to collect and tabulate.

Using pedestrian volumes to show a need also does not necessarily measure the level of demand for pedestrians to cross a highway. Adding or modifying a crossing changes pedestrian patterns, but this will not be reflected in a change in pedestrian volumes until after the crossing or modifications are built. This positions ODOT to react to how people use the current roadway environment instead of examining where pedestrians need and want to cross.

The cost of conducting an engineering study for crossings on a corridor or city-wide scale can also be a barrier. Funding for studies is often not considered in scoping, and Region investigations staff have limited time and budget to effectively study needs on this scale if locations for crossings have not been previously identified in a plan. When the study is considered in scoping, the funding sources are inconsistent, meaning staff has to be creative to complete each study.

Barriers to Refuge Islands

Motor vehicle mobility, especially freight mobility, is another real and perceived barrier to implementing crossing treatments. An important safety enhancement, especially on multilane approaches, is reducing the crossing distance. This is typically done with a median refuge island and/or curb extension. However, this safety tool is subject to laws and rules governing reductions in "vehicle-carrying capacity of an identified freight route" (ORS 366.215 and OAR 731-012). If a proposed median refuge island and/or curb extension reduces the vehicle-carrying capacity of an identified freight route, there can be an exception made for safety considerations, but this involves a complicated process that results in a decision by the Oregon Transportation Commission. Even if an exception is not needed, freight needs still must be considered on these routes by going through the freight engagement process. This process can be a significant barrier to a project, especially if the treatments are not part of a STIP project.

Proximity to driveways and accesses can be another barrier to installing some safety treatments. For example, a median refuge island might not be installed if a left-turn lane or two-way left-turn lane is needed for access to and from a driveway or side street. ODOT has the ability to restrict turning movements to and from an existing private approach to provide a staged pedestrian crossing (OAR 734-051-1065). This can lead to sensitive discussions with the property owner, local jurisdiction, freight industry, and other stakeholders where pedestrian safety is weighed against other community or individual goals.

Institutional Barriers

There may be perceived barriers related to federal policies and funding for crossing treatments. To counter these perceptions, USDOT issued a policy statement in 2010 that encourages and recommends transportation agencies to go beyond minimum design standards and requirements to create safe, attractive, sustainable, accessible, and convenient walking networks. In support of this policy statement, Federal Highway Administration (FHWA) also issued guidance in 2013 in support of using resources from American Association of State Highway and Transportation Officials (AASHTO), National Association of City Transportation Official (NACTO), and Institute of Transportation Engineers (ITE) to develop walking networks, particularly in urban areas.

Other institutional barriers can include:

- Safety concerns because of how past studies interpreted results when comparing safety at marked and unmarked crosswalks.
- Safety concerns related to driver human factors (e.g., distraction related to sign clutter if closely spaced crosswalks are all enhanced with signing and markings and speeds are not sufficiently low).
- Long-term maintenance responsibilities. ODOT has historically required local agencies to maintain, or pay ODOT to maintain, enhanced crosswalk treatments. This is typically documented in an Intergovernmental Agreement (IGA).
- Finally, ODOT's policy of requiring approvals for marked crosswalks and other crosswalk enhancements (per OAR 734-020-0410) can be seen as a barrier. While this process often improves the final design, it also adds time to the design process before crosswalk treatments can be installed.

3. NATIONAL GUIDANCE AND CASE STUDIES

The practice of where to install crossings differs considerably from one jurisdiction to another across the United States. A review of existing literature indicates that little guidance exists related to the frequency of pedestrian crossings in various contexts. Engineers have been left to use their own engineering judgment (sometimes influenced by political and/or public pressure) in reaching decisions and to prepare the necessary documentation of their recommendations.

This section provides relevant guidance and examples from a variety of sources with the goal of determining best practices for crossing spacing in urban environments. Across guidance documents and case studies reviewed, the following themes emerged:

- Pedestrian volume is still widely used to locate crossings, but agencies recognize the limitations of this approach and are starting to use other factors.
- Increased pedestrian travel time and delay are tied to likelihood of a pedestrian making a risky crossing behavior, especially among young children.
- Some restrictions to implementing standard crossing spacing exist.
- There are limited examples of documented spacing standards or guidelines.

3.1 Relevant Guidance Documents

There is currently a lack of federal guidance on the specific questions of crossing spacing. This section summarizes the guidance that does exist and related topics, such as:

- Information on typical trip length and accepted "out-of-direction travel;"
- Acceptable levels of delay for pedestrians at intersections; and
- Locating crossings in proximity to specific land uses and transit stops.

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities

The 2004 AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* lists considerations when designing pedestrian crossings (page 81). These include:

- "Assume that pedestrians want and need safe access to all destinations that are accessible to motorists."
- "Typical pedestrian generators and destinations include residential neighborhoods, schools, parks, shopping areas, and employment centers. All transit stops require that pedestrians be able to cross the street."
- "Pedestrians must be able to cross streets and highways at regular intervals. Unlike motor vehicles, pedestrians cannot be expected to go a quarter mile or more out of their way to take advantage of a controlled intersection."

ITE Designing Walkable Urban Thoroughfares: A Context Sensitive Approach

ITE provides guidance on crossing spacing in different contexts in its 2010 publication *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*. It describes a walkable thoroughfare as having "protected pedestrian crossing frequency (pedestrian signals or high-visibility markings at unsignalized crossings)" every 200-600 feet. It also describes vehicle-oriented thoroughfares as having these pedestrian crossings as needed to accommodate pedestrian needs. Other related recommendations include:

- "Pedestrian facilities should be spaced so block lengths in less dense areas (suburban or general urban) do not exceed 600 feet (preferably 200 to 400 feet) and relatively direct routes are available. In the densest urban areas (urban centers and urban cores), block lengths should not exceed 400 feet (preferably 200 to 300 feet) to support higher densities and pedestrian activity" (p. 32).
- "Consider providing a marked midblock crossing when protected intersection crossings are spaced greater than 400 feet or so that crosswalks are located no greater than 200 to 300 feet apart in high pedestrian volume locations" (p. 153).

Manual on Uniform Traffic Control Devices

The 2009 *Manual on Uniform Traffic Control Devices* (MUTCD) includes a Pedestrian Volume warrant for a traffic signal, intended for use in cases where the traffic volume on a major street is so heavy that pedestrians experience excessive crossing delay. The warrant is based on pedestrian and vehicle volume thresholds. The warrant also includes a standard that it shall not be applied at locations where the distance to the nearest traffic control signal or STOP sign controlling the street that pedestrians desire to cross is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of motor vehicle traffic. The requirement to be no closer than 300 feet from another signal is limited to the pedestrian volume and school crossing warrants. Traffic signals can be installed within 300 feet of each other if the intersection meets the vehicular volume or crash experience warrants.

NACTO Urban Street Design Guide

The National Association of City Transportation Official's (NACTO) *Urban Street Design Guide* discusses considerations for applying crosswalk markings in different traffic conditions. The Guide recommends considering land uses, present and future demand, pedestrian compliance, speed, safety, and crash history when judging the application of a crosswalk. The Guide notes that volumes alone are not enough to determine whether or not a particular crossing treatment should be used. It suggests the MUTCD Pedestrian Volume Warrant (MUTCD 4C.05) should be considered alongside land use, future demand, and factors of the built environment. Referring to the common condition that pedestrian crossings should be no closer than 300 feet from the nearest traffic signal or stop-controlled crossing opportunity, the Guide suggests in some cases crossings may be appropriate within 300-feet of each other, and the minimum spacing threshold should be evaluated based on the street network and anticipated crossing demand.

When describing pedestrian crossing spacing, NACTO suggests that there is no absolute rule, and that spacing should consider block length, street width, building entrances, and traffic signal spacing. They claim 120-200 feet has been shown to be sufficient. The Guide states that, in general, if it takes a person more than three minutes to walk to a crosswalk, wait to cross the street, and then resume their journey, they may decide to cross along a more direct, but potentially less safe or unprotected, route. NACTO does not cite specific research for this guidance.

Lastly, NACTO suggests agencies place midblock crosswalks where there is a significant pedestrian desire line. Frequent applications include midblock transit stops, parks, plazas, building entrances, and midblock passageways.

FHWA DRT-04-100 Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations, 2005

FHWA's 2005 *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations*, was a landmark study that has shaped the current approach agencies are taking for crosswalk placement and treatment.

The Report calls out the following conditions where marked pedestrian crosswalks may be useful to delineate preferred pedestrian paths across roadways:

- At locations with stop signs or traffic signals to direct pedestrians to those crossing locations and to prevent vehicular traffic from blocking the pedestrian path when stopping for a stop sign or red light.
- At unsignalized street crossing locations in designated school zones. Use of adult crossing guards, school signs and markings, and/or traffic signals with pedestrian signals (when warranted) should be considered in conjunction with the marked crosswalk, as needed.
- At unsignalized locations where engineering judgment dictates that the number of motor vehicle lanes, pedestrian exposure, average daily traffic (ADT), posted speed limit, and geometry of the location would make the use of specially designated crosswalks desirable for traffic/pedestrian safety and mobility.

The Report claims marked crosswalks alone (e.g., without traffic-calming treatments, traffic signals and pedestrian signals when warranted, or other substantial crossing improvement) are insufficient under the following conditions:

- Where the speed limit exceeds 40 MPH;
- On a roadway with four or more lanes without a raised median or crossing island with ADT 12,000 or greater; or
- On a roadway with four or more lanes with a raised median or crossing island with ADT 15,000 or greater.

In the Report, FHWA suggests priority for marked crossings should be given to locations where pedestrian volume exceeds 20 per peak hour or 15 or more elderly pedestrians and/or children per peak hour.

TCRP Report 112/NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Intersections, 2006

The TCRP/NCHRP Report on *Improving Pedestrian Safety at Unsignalized Intersections* found a pedestrian's choice of whether to cross at an intersection is affected by the distance to the intersection. Researchers conducted an on-street pedestrian survey at five uncontrolled locations. The data collection sites were urban areas of Austin, TX, Tucson, AZ, and Fort Lauderdale, FL with two to six travel lanes. Researches would ask, "If this crossing was not here, would you walk to the next intersection?" and point to the next intersection. At three of the sites, where the next signalized intersection was 550, 950, or 1,000 feet away, only about 25 percent of the respondents would walk to the next intersection. For the site with a signalized intersection about 200 feet from the crossing, about 50 percent of those interviewed would walk to that crossing. The remaining site where this question was asked did not follow similar findings. Over 65 percent of the respondents indicated that they would walk 600 feet to cross at a signalized crossing. The increased compliance rate was influenced by a higher number of lanes (six), higher traffic volume, and higher speed compared to the other sites.

The Report also cites the U.S. DOT's 1995 Nationwide Personal Transportation Survey, which found that most pedestrian trips (73 percent) are 0.5 mile (2,640 feet) or less. The authors assumed pedestrians might not be willing to increase their trip length by more than 10 percent (264 feet) in order to walk to a different crossing location.

Engineers interviewed during the research project expressed concern about the 2003 MUTCD pedestrian warrant, specifically that the pedestrian volumes are too high to meet. Those that expressed this concern, unanimously agreed the required pedestrian volumes were too high to adequately address many pedestrian crossing issues in their jurisdiction. To address their pedestrian issues, many engineers either installed crossing treatments with fewer application restrictions, modified the existing MUTCD pedestrian warrant, or used a supplementary engineering analysis to justify a traffic signal installation. The 2009 edition of the MUTCD added flexibility to reduce the volume thresholds as much as 50 percent if the 15th-percentile crossing speed of pedestrians is less than 3.5 feet per second.

The Report was also reviewed for possible parallels between accepted pedestrian delay at unsignalized intersections and accepted out-of-direction travel. Shown in **Table 2**, the Report summarized the likelihood of a pedestrian to accept a short gap in traffic at an unsignalized intersection, related to the HCM thresholds for pedestrian level of service. The Report noted that young children, in particular, desire to limit crossing time and can be impulsive and unpredictable.

Table 2: HCM LOS criteria for pedestrians at unsignalized

Level of Service	Average Delay/Pedestrian (s)	Likelihood of Risk-Taking Behavior*
A	< 5	Low
B	≥ 5 – 10	
C	> 10 – 20	Moderate
D	> 20 – 30	
E	> 30 – 45	High
F	> 45	Very High

* Likelihood of acceptance of short gaps.

Source: TCRP Report 112/NCHRP Report 562: *Improving Pedestrian Safety at Unsignalized Intersections*, Table 8

AASHTO Green Book - A Policy on Geometric Design of Highways and Streets, 7th Edition

The American Association of State Highway and Transportation Officials (AASHTO) Green Book was reviewed to understand potential relationships between pedestrian trip lengths and crossing frequency. The Green Book claims the typical pedestrian will not walk over one mile to work or over 0.5 mile to catch a bus, and about 80 percent of the distances traveled by the pedestrian will be less than 0.5 mile. The typical pedestrian is a shopper about 50 percent of the time that he or she is a pedestrian and a commuter about 11 percent of the time. The Green Book goes on to say that pedestrians tend to walk in a path representing the shortest distance between two points. Therefore, crossings in addition to those at corners and signalized intersections may be appropriate at particular locations.

3.2 Case Studies

This section presents case studies of the process used by various agencies to add pedestrian crossings and considerations for crossing spacing and steps taken by agencies to establish such processes.

Portland's PedPDX Crossing Guidance

With the PedPDX Crossing Guidance, Portland became the first city in the United States to establish crosswalk spacing standards[4]. The mission of PedPDX is to make walking a safe, accessible, and attractive experience for everyone in Portland by putting pedestrians at the forefront of City policy, investments, and design. The desired crossing frequencies were established to identify crossing gaps in Portland's pedestrian network. They are intended to identify gaps where further engineering analysis is required.

[4] The City of Missoula, City of Atlanta, Hillsborough Metropolitan Planning Organization, and potentially others are in the process of developing their own crossing spacing standards. If the standards are published before this document is final, they may be included.

The following standards are based on the City's typical 200-foot block network (265-feet center intersection to center intersection) and may vary based on roadway context:

- **Inside Pedestrian Districts:** For streets within designated Pedestrian Districts, the desired crossing frequency is 530 feet. On a street with Portland's standard 200-foot block faces, this results in a marked and/or enhanced pedestrian crossing at a minimum of every other block. Marked pedestrian crossings may be provided at greater frequency, particularly in Pedestrian Districts located in the Center City, where traffic signals are provided at every block. Where blocks are longer than 530 feet, the Guidance recommends mid-block crossings be provided. Demonstrating existing crossing demand is not required to justify new marked crossings.
- **Outside Pedestrian Districts:** On streets outside of and between Pedestrian Districts, the desired crossing spacing is 800 feet. On a street with Portland's standard 200-foot block faces (265-feet center intersection to center intersection), this results in a marked and/or enhanced pedestrian crossing at a minimum of every three blocks (compared with every two blocks in Pedestrian Districts and Main Streets). To ensure that new marked crossings on streets with lower pedestrian volumes do not result in driver disregard of crosswalks, a minimum of 20 pedestrian/bicycle crossings per peak hour are required to provide new marked/enhanced crossings on streets outside of Pedestrian Districts or where there is not a transit stop.
- **Transit stops:** Within the City of Portland, the Guidance states that a marked and/or enhanced crossing will be provided within 100 feet of all transit stops, regardless of street classification. Marked crossing requirements at transit stops may be implemented by providing new marked pedestrian crossings at existing transit stops, and/or by strategically relocating or consolidating transit stops so they are located at existing marked crossings.

The Guidance defines every intersection as a legal crosswalk where motorists are required to yield to pedestrians.

Metro's Regional Transportation Functional Plan

Metro's Regional Transportation Functional Plan (RTFP) provides guidance on street spacing to support walking, bicycling, and access to transit. Metro recommends a network of major arterial streets at one-mile spacing and minor arterial streets or collector streets at half-mile spacing. If proposed residential or mixed-use development of five or more acres involves construction of a new street, Metro suggests the city or county should require full street connections with spacing of no more than 530 feet between connections, where feasible. Where full street connections are not possible, Metro recommends bicycle and pedestrian accessways be placed no more than 330 feet apart. The RTFP also states city and county TSPs shall include a transit plan that includes provision for safe, direct, and logical pedestrian crossings at all transit stops, where practical.

Washington DOT Pedestrian Design Guidance

In their Pedestrian Design Guidance, the Washington Department of Transportation provides the following guidance on where midblock crossings are most valuable:

- High pedestrian crossing volume present with long block spacing
- Evidence of pedestrian-vehicular midblock conflicts (site observations, law enforcement reporting, and city traffic engineers)
- Proposed crossing with a realistic opportunity to channel multiple pedestrian crossings to a single location
- Sight lines that enable sufficient eye contact between motorists and pedestrians
- Community commitment for a successful outcome
- Ability to mitigate risks associated with the location using proven countermeasures such as, but not limited to, refuge islands, rectangular rapid flashing beacons, and/or pedestrian hybrid beacons
- Modal interchange points where high volumes crossing pedestrians occur (e.g., transit stop to apartment complex)

In the *Pedestrian Facilities Guidebook*, Washington DOT limits mid-block crosswalks (unless they are stop-controlled) less than 300 feet from a traffic signal or bus stop where motorists are not expecting pedestrians to cross and within 600 feet of another crossing point, except in central business districts or other locations where there is a well-defined need.

Austin Pedestrian Safety Action Plan

The City of Austin listed the following action item in its Pedestrian Safety Action Plan: "Establish a Pedestrian Crossing Improvement Program to install large numbers of high-impact, cost-effective pedestrian safety treatments throughout Austin."

The Plan explored the characteristics of streets where pedestrian crashes occur and found that streets with long distances between controlled crossing opportunities see more severe crashes. If the distance to the nearest traffic control device is too far out of their path of travel, pedestrians may be more likely to cross the street in risky locations. The Austin crash data shows the further away the pedestrian path of travel is from a traffic control device (either a traffic signal or pedestrian hybrid beacon), the more severe the crash.

The Plan included the development of a Pedestrian Safety Priority Network tool to identify and prioritize locations where countermeasures might have the biggest impact in improving pedestrian safety and creating a more walkable city[5]. Inputs include:

- **Crash Score**: Based on historical pedestrian crash data, with a higher weight given to serious injury and fatal crashes.
- **Demand Score**: Potential for walking demand based on proximity to transit, businesses, or other attractors, with a special focus on prioritizing traditionally underserved communities.

[5] This is consistent with ODOT's Transportation Safety Action Plan which includes an action to add pedestrian crossings as a way to reduce fatal and serious injury crashes. See Section 2.1 for additional information on ODOT's plan.

- **Risk Characteristic Score**: Physical characteristics that are shown to contribute to severe injury and fatal crashes, including high vehicular speeds, wide street widths, long distances between signalized crossings or street lighting, and lack of sidewalks.

FHWA Guidebook for Measuring Multimodal Network Connectivity: Caltrans Case Study

FHWA's *Guidebook for Measuring Multimodal Network Connectivity* recommends measures to evaluate network density (how well the street grid provides options for travel between locations for people who walk and bike) and route directness (variation in trip distance between the route a bicyclist or pedestrian will actually travel versus the shortest available path). The Guidebook includes a specific example in Caltrans District 4. Caltrans assesses network permeability along state highways to understand the barrier that major highways may create. Permeability was assessed considering both the entire roadway network and a low-stress network (determined by level of traffic of stress) to determine the level of out-of-direction travel required to cross the highway via low-stress crossings. Routes were evaluated on a low connectivity to high connectivity scale based on existing crossing locations.

The Guidebook also mentions that some communities have minimum street spacing standards that could serve as a basis for assessing the density of the bicycle and pedestrian network, but it does not provide specific examples.

3.3 Information Gaps

The guidance and examples reviewed provide minimal documentation of how frequently pedestrian crossings should be spaced in urban contexts. The City of Portland and ITE were the only agency and organization to have documented standards or guidelines. Instead, the relevant guidance discusses the factors that should be considered when determining if a crossing is appropriate (e.g., land use, pedestrian demand, proximity to signals).

3.4 Comparable Guidance

Given the lack of existing guidance, this section summarizes alternative considerations that may be relevant in creating pedestrian spacing goals.

Roadway Spacing for Other Modes

Access management and new development guidelines typically include standards for spacing between roadway connections. These roadway spacing standards could be used to inform the maximum desired frequency of pedestrian connections. The approach used by Metro is summarized in Section 3.2. Additional examples include:

- The Oregon Highway Plan includes the following access management spacing standards in Appendix C:

Posted Speed (mph)*	Spacing (ft) AADT less than 5,000 (more than 5,000)		
	Regional & Highways District Highways	Statewide Highways	
	Rural and Urban Areas	Urban Areas	Unincorporated Communities in Rural Areas
≥55	650	1,320 (1,320)	1,320
50	425	1,100 (1,100)	1,100
40-45	360	360 (800)	750
30-35	250	250 (500)	425
≤25	150	150 (350)	350

- Massachusetts Department of Transportation (MassDOT) recommends intersection spacing of around 200 feet in urban areas.
- FDOT's Access Management policy includes standards for street connections and full and directional median openings. Street connections can occur every 125 to 1,320 feet depending on roadway speed and access class.
- American Planning Association has a Time Saver Standard discussing block size. The Standard suggests principal arterials should be located every three to four miles in urban areas, minor arterials should be spaced at around one-mile intervals from other arterials, and other collector streets should be spaced roughly one-half mile from arterials. Local streets complete the network with a block spacing appropriate to the land use – typically 300 to 500 feet.

- Montgomery County, Maryland uses the following table for new intersection spacing in their subdivision regulations:

Road Classification	Locale	Distance Between Intersections (feet)
Tertiary Residential	All	150
Secondary Residential	Urban	200
	Suburban	200
	Rural	200
Primary and Principal Secondary	Urban	300
	Suburban	400
	Rural	400
Business District and Industrial	Urban	300
	Suburban	400
	Rural	400
Country Road		400
Country Arterial		800
Minor Arterial	Urban	300
	Suburban	500
	Rural	800
Arterial	Urban	300
	Suburban	600
	Rural	800
Major Highway	Urban	300
	Suburban	800
	Rural	1,000
Controlled Major Highway	Urban	300
	Suburban	1,000
	Rural	1,000
Parkway	Urban	300
	Suburban	600
	Rural	800

Transit Stop Spacing

Best practice for local transit stop spacing could be used as a guide for the distance pedestrians are willing to travel out-of-direction to get to where they are going. NACTO's *Transit Street Design Guide* recommends stops at every 800 feet for local service. In his Human Transit blog, Jarret Walker observes that in Australia and Europe, local transit stops are typically spaced every ¼-mile, while some transit agencies in the United States stop every 300 feet. Walker's rule of thumb in transit planning is that riders will walk up to ¼-mile for local transit service.

Motorist Delay

Another potential approach is to compare industry-approved delay thresholds for motorists to create guidance for the amount of time (and therefore distance) a pedestrian can be expected to travel to safely cross the street. For example, the Highway Capacity Manual (HCM) LOS F threshold for vehicle delay at signals is 80 seconds. At a 3.5 feet/second walk speed, a pedestrian could walk 280 feet in the same amount of time. If 280 feet was the total out-of-direction travel we would accept for pedestrians, that would be a crossing every 140 feet, accounting for a pedestrian trying to get somewhere directly across the street. The distance traveled does not account for delay experienced by the pedestrian while waiting at an intersection to cross the street. The intent of the example is to illustrate that if we assume equal "maximum acceptable" delay for the various users (e.g., motorist and pedestrian), then crossings in theory should be provided more often.

Out of Direction Travel

In Section 3.1, the TCRP/NCHRP Report 562 includes survey data on how far pedestrians are willing to walk to a nearby crossing. The report also cited a 1995 Nationwide Personal Transportation Survey in which the authors claimed that pedestrians would not be willing to increase their trip length by more than 10 percent in order to walk to a different crossing location.

Portland State University conducted research for the Oregon Transportation Research and Education Consortium (OTREC) on how far bicyclists are willing to travel out-of-direction in *Understanding and Measuring Bicycling Behavior*. The focus of the project was on travel time and route choice. Researchers found that for half of the trips, bicyclists rode 0.27 miles farther than the shortest path. At an average speed of 10.8 mph, this would be about 1.5 extra minutes. Looking only at the trips 10 miles or shorter, the median difference between the observed route and the shortest path was 0.24 miles, or 1.3 extra minutes.

ODOT could conduct additional research to understand typical pedestrian trip lengths along ODOT highways and select an out-of-direction threshold that would be acceptable in different urban contexts. This information could be used to create guidance on the proximity of pedestrian crossings to pedestrian attractors and generators.

4. CONSIDERATIONS FOR THE BLUEPRINT FOR URBAN DESIGN

Section 2 of this document presented an overview of ODOT's policy and regulatory guidance related to the placement of pedestrian crossings. Section 3 summarized a variety of current best practices related to placement of pedestrian crossings; however, there are limited examples of pedestrian crossing spacing guidelines within the United States and internationally. Considering the lack of documented guidance, Section 3 also summarized alternate types of guidance ODOT could consider in creating spacing goals. This section (Section 4) describes areas of alignment between ODOT and other best practices, as well as areas of opportunity (Section 4.1). It describes a potential approach to establish crossing spacing goals in urban areas, aligning with the emerging multimodal decision-making framework from the Blueprint for Urban Design (Section 4.2 in this memorandum).

4.1 Best Practices: Highlights and Alignment with ODOT

A number of key themes emerged from the best practices review, drawing on both national sources and local examples. ODOT's current policy guidance aligns with many of these themes, but there are opportunities for better alignment within the planning guidance. This section summarizes the key findings from the guidance and case studies reviewed in Section 3, focusing specifically on findings most relevant to ODOT (based on Section 2).

Overall Themes from Best Practice Review

Across guidance documents and case studies reviewed, the following themes emerged:

- **Pedestrian volume is still widely used to locate crossings, but agencies recognize the limitations of this approach and are starting to use other factors.** The MUTCD uses pedestrian volumes as one of two factors in the pedestrian signal warrant. FHWA suggests priority for marked crossings should be given to locations where pedestrian volume exceeds about 20 per peak hour or 15 or more elderly pedestrians and/or children per peak hour. NACTO suggests volumes alone are not enough to determine whether a crossing treatment should be used. It suggests the MUTCD warrant be considered alongside land use, future demand, and factors of the built environment. NACTO recommends placing midblock crosswalk where there is expected pedestrian demand, included near transit stops, parks, plazas, and building entrances. Many agencies are placing crosswalks at school crossing locations and reviewing crash data and pedestrian-vehicle conflicts.
- **Increased pedestrian travel time and delay are tied to likelihood of a pedestrian making a risky crossing behavior, especially among young children.** However, there is limited and inconclusive research on thresholds for out-of-direction travel in various contexts. Most sources reviewed acknowledged that pedestrians will choose the shortest path between their start and end point. NACTO suggests if it takes a person more than three minutes to walk to a crosswalk, wait to cross the street, and then resume their journey, they may decide to cross along a more direct, but less safe or unprotected, route. If you consider a 30-second

delay at the intersection (LOS E), the remaining 2.5 minutes would allow for 525 feet of total out-of-direction travel, assuming a walk speed of 3.5 ft/s. A TCRP/NCRHP Report conducted an on-street survey and generally found beyond 500 feet, pedestrian willingness to walk to a crossing drop to about 25%. The Report tied likelihood of risky crossing behavior to the HCM pedestrian delay thresholds of unsignalized, claiming that above 30 seconds (LOS E), likelihood of risk-taking behavior is high.

- **Some restrictions to implementing standard crossing spacing exist.** The MUTCD restricts pedestrian signals within 300 feet of a traffic signal or STOP sign controlling the street that pedestrians desire to cross. This requirement is limited to the pedestrian volume and school crossing warrants. Traffic signals can be installed within 300 feet of each other if they meet one of the other signal warrants. State DOTs, including WSDOT, refer to this MUTCD guidance in their own guidance documents. NACTO has suggested the 300-foot spacing requirement may be too far in some cases and should be evaluated based on the street network and foreseen crossing demand. However, FHWA, through the MUTCD, has regulatory authority on use of signals. Any proposed treatment not meeting current MUTCD guidance can potentially still be implemented through MUTCD request to experiment process.
- **There are limited examples of documented spacing standards or guidelines.** NACTO claims 120 to 200 feet has been shown to be sufficient, but they do not offer research or specific examples to support the claim. ITE gives recommendations for crossing spacing in different urban contexts. Portland is the first city to establish spacing standards. The City's standards vary by roadway context. The City of Missoula, City of Atlanta, and the Hillsborough (Florida) Metropolitan Planning Organization are in the process of developing their own crossing spacing standards. Other local agencies may also be doing so.

Areas of Alignment and Opportunity within ODOT

ODOT and the State of Oregon's existing policies, plans, and practices (described in Section 2) align with many of the themes identified in the best practices review.

The establishment of crossing spacing targets supports the Transportation System Plan (TSP) Guidelines, which requires TSPs to have a narrative discussing pedestrian crossing spacing or location guidelines. The Guidelines use the term "enhanced pedestrian crossings," requiring their considerations in TSPs.

Chapter 13 of the Highway Design Manual starts to establish a crossing frequency, requiring crossings on developed, urban state highways be no further than every ¼-mile (1,320 ft). The Oregon Bicycle and Pedestrian Plan also cites the ¼-mile spacing threshold when providing a cost estimate to complete identified pedestrian crosswalk improvements. Like other state manuals reviewed, the Highway Design Manual recommends crossings be no closer than 300 feet from the nearest signalized crosswalk.

The Oregon Bicycle and Pedestrian Plan includes a policy to add pedestrian infrastructure that connects system gaps to fill the needs of urban, suburban, and rural communities. This policy suggests a commitment to improving pedestrian network connectivity and an understanding that pedestrian infrastructure needs vary by land use context. The policy goes on to suggest that multimodal connectivity be considered throughout the project delivery process in planning, design, prioritization, and coordination. Lastly, the policy encourages an understanding of the barriers and needs affecting the availability and use of walking options for all Oregonians. A lack of crossings is such a barrier.

ODOT's Transportation Safety Action Plan includes an action item to provide crossings in areas where pedestrians are present or where access is needed, prioritizing transit corridors, school areas, multi-lane streets and highways, and other high-risk areas and facilities. The Bicycle and Pedestrian Design Guide (Appendix L in the Highway Design Manual) includes guidance on how the location of transit stops and surrounding land use affects pedestrian demand and where crossings should be located. These references further support a land use-based approach to identifying and prioritizing crossings.

In some cases, updates to guidance are needed to align with ODOT policies and national best practices, including:

- **ODOT should coordinate with the school board when implementing crossing treatments near schools to potentially leverage this source of funding.** As noted in Section 2, Oregon Revised Statute (ORS) 332.405 allows district school boards to fund pedestrian facility improvements to enhance safe access to and from a school. This authorization supports the best practice guidance to locate pedestrian crossings in front of schools and along safe routes to school.
- **If ODOT opts to provide crossings at regularly spaced intervals, the minimum review needed for an engineering study should be revisited and clearly defined.** The ODOT Traffic Manual requires an engineering study and an engineer's approval to mark a crosswalk and install other crosswalk treatments. Currently, local jurisdictions may be instructed by ODOT technical staff to avoid showing specific crossing locations in planning documents until they have completed an engineering study (which allows for more detailed evaluation of a potential crossing). This is typically beyond the scope of most planning efforts. Some local jurisdiction plans may specify crossing "needs" without designating a specific location. As a result, when funding is available for crossing improvements, ODOT does not have a list of identified/prioritized local needs. An engineer should continue to review recommended crossings to confirm the appropriate level of safety treatments for the context of the crossing are being used, but the engineering study should not become too high a burden.

4.2 Aligning Policy, Planning, and Implementation of Pedestrian Crossings: A Potential Approach

The information from this topical memorandum (and this approach) is included in the Blueprint for Urban Design.

Proposed Spacing Target Ranges

ODOT has some guidance related to the topic of pedestrian crossing spacing; however, ODOT can consider providing additional guidance to more specifically outline the target frequency of crossings in urban contexts.

Table 3 provides target spacing ranges of crossings in each urban context. A range, rather than a single value, is provided for flexibility to adjust based on roadway network characteristics (e.g., frequency and spacing of intersections), pedestrian destinations (e.g., transit stops), and cluster of land uses. For example, within a mixed-use area, development may not be distributed uniformly, or practitioners may consider the lower end of the range where the land uses are most intense.

Table 3. Target Crossing Spacing

Urban Context	Target Spacing Range (feet)
Traditional Downtown/CBD	250-550
Urban Mix	250-550
Commercial Corridor	500-1,000
Residential Arterial	500-1,000
Suburban Fringe*	750-1,500
Rural Community	250-750

* The "suburban fringe" context is typically adjacent to rural areas at the edge of urban development, but often is in the process of developing. For projects in the "suburban fringe" context zone, practitioners should consider likely future development and consider applying designs for "residential arterial," "commercial corridor," or "urban mix" contexts if this type of development is likely to occur.

The spacing targets are based on existing Oregon documentation including the City of Portland's PedPDX Crossing Guidance and Chapter 13 of the ODOT Highway Design Manual, and recommendations from ITE. While the ranges presented in **Table 3** are documented in City and State guidance documents, there is limited research to support the specific values. ODOT may consider conducting additional research to understand:

- How far pedestrians are willing to travel out of direction in various contexts (including roadway characteristics) and for different purposes;
- What conditions lead to risky crossing decisions (e.g., level of delay or distance to crossing); and
- What types of land uses are most likely to generate pedestrian demand.

The targets in **Table 3** are a starting point. Practitioners should evaluate the density and type of land uses and pedestrian generators and their locations to determine if a lesser or greater spacing is needed. When considered as part of a larger project, such as a corridor project, ODOT should strive to meet the spacing targets. If the target crossing spacing cannot be met on a project, the project team should document why. Similarly, if a crossing is proposed for removal and would lead to a spacing distance beyond the target maximum, justification should be provided. However, if a crossing is being proposed as a standalone project or as part of a maintenance process, a justification should not be required if the resulting spacing is still outside the target spacing.

Identifying Crossing Locations

Additional analysis will be required to identify appropriate crossing locations within the target spacing. ODOT's current policy is to complete an engineering study for all proposed marked crossings. Pedestrian volumes are currently used in the engineering study as a primary way to show a need for a crossing. However, using pedestrian volumes to show a need does not necessarily measure the level of demand for pedestrians to cross a highway. Where pedestrian counts are not available or do not sufficiently show demand, demand can be assumed based on the presence of pedestrian generating land uses (e.g., transit stops, schools). The cost of conducting an engineering study for crossings on a corridor or city-wide scale can also be a barrier. The minimum level of review needed for an engineering study should be revisited and clearly defined.

At the project level, ODOT should document likely origins and destinations of pedestrian trips in the study area and show how they would be served by a crossing. If a proposed crossing is not located along the expected pedestrian trip path, the project team should document their assumptions about out-of-direction travel and show that pedestrians can be reasonably expected to use another crossing. Locations may need to be prioritized based upon funding or other factors. The prioritization of crossing treatments by location and against other project elements should be determined on a project-by-project basis, considering the project's desired outcomes and input from the community. Additional information on setting project goals and desired outcomes can be found in Chapter 4 of the Blueprint for Urban Design.

At the statewide level, ODOT could conduct a crossings inventory across the state to compare existing crossing spacing against the targets in **Table 3**. ODOT could use this statewide inventory to identify and prioritize areas that may need additional crossings based on their context.

5. PARKING LOT

This section documents elements of this topic that are out of the scope of this topical memorandum but will need to be addressed through future efforts.

a. Unmarked crossings
b. Crossings of limited access highways will not be addressed.
c. Bicycle specific crossings are also not the focus, though we do acknowledge that the two modes often have overlapping needs. In the future, ODOT will need to determine how needs for bicycle and pedestrian crossings in proximate, but not the same, locations should be adjudicated.
d. Identification of appropriate pedestrian/bicycle crossing treatments - NCRHP Report 562 provides guidance, but it may not be consistently applied within ODOT. Clarified guidance may be needed.
e. Pedestrian crossings at multilane roundabouts – design guidance is needed to determine appropriate treatments:
    - NCHRP Report 674: *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities*
    - NCHRP Report 834: *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook*
f. Process for determining when to close or remove a marked crossing – this process may be impacted by the outcomes of this memorandum but will not be directly addressed within it.
g. Potential guidance on the maximum thresholds at which ODOT would consider installing an at-grade crossing (versus requiring grade separation)
    - Vehicle speeds, volumes, crossing distance, roadway characteristics, operational factors, and others
h. Guidance on how the specific context will set the bounds for what type of documentation (or engineering study) is needed, with the intention to streamline the process and create a more consistent approach.
    - When, why, how and how much detail should go into the study?
    - Potential form/worksheet to document decision-making and analysis
    - Who pays for the study and completes the work?
i. Discussion of the "design user" and designing for an array of user types, including children, seniors, people with vision/hearing/mobility disabilities, bicyclist
j. Policy and plan driven prioritization of crossings when not able to implement the number of crossings recommended because of funding or other constraints
k. Components of a pedestrian crossing engineering study and cost estimate

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OREGON DEPARTMENT OF TRANSPORTATION

URBAN DESIGN INITIATIVE

>>> Topical Memorandum: Target Speed

KITTELSON & ASSOCIATES

August 2019

PREFACE

The Target Speed Topical Spacing Memorandum is a part of the Oregon Department of Transportation (ODOT) Urban Design Initiative. This memorandum describes the relationship between target speed, design speed, posted speed, and the actual operating speed of a roadway and provides a recommendation for target speed in each ODOT Urban Context. Information from this memorandum has been integrated into the ODOT Blueprint for Urban Design and is included in full as an appendix to the Blueprint for Urban Design.

ODOT Planning and Technical Services Engineering and Active Transportation staff developed the Target Speed Topical Memorandum using a collaborative approach, including multiple disciplines and region staff. Federal Highway Administration (FHWA) Oregon Division and the transportation engineering consulting firm Kittelson & Associates, Inc. provided support to develop this document. The following ODOT staff contributed to the development of this document:

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CONTENTS

EXECUTIVE SUMMARY

This memorandum considers speed for highways within urban areas from various perspectives, including consideration of a target speed and speed management strategies. The memorandum describes the relationship between target speed, design speed, posted speed, and the actual operating speed of a roadway.

The Oregon Department of Transportation (ODOT) has clear policy guidance related to posted speed selection. However, ODOT may consider changes to its guidance to more effectively achieve desired operating, or target speed. **Table 1** provides a recommendation for target speed in each Urban Context.

In practice, the target speed and design speed should be the same, and a roadway should encourage an actual operating speed at the 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 1** includes a list of treatments that would be appropriate in each Urban Context.

The target speed is intended to be used as the posted speed limit; however, per 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. ODOT typically uses the 85^{th} percentile operating speed to set the posted speed. When the target speed is lower than the current operating speed, ODOT may consider:

- Selecting a design speed as close as possible to the target speed. Select design elements to achieve the target speed and set the posted speed as close to target speed as possible within current Oregon Administrative Rules (OAR). As operating speeds decrease in response to design, adjust posted speed to reflect the current OAR guidance.
- Adjusting OARs to reflect the Federal Highway Administration's (FHWA) guidance on using 50th percentile speeds in urban areas rather than 85th percentile speeds.
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ODOT should continue to monitor national research and guidance on setting speeds and work with Oregon cities and counties to consider context, road classification and other factors as appropriate, for establishing posted speeds to improve safety for all users of the system.

Table 1. Recommended ODOT Target Speed and Design Treatments for Urban Areas

Urban Context	Target Speed (MPH)	Design Treatments
Traditional Downtown/CBD	20-25	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
Urban Mix	25-30	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
Commercial Corridor	30-35	Roundabout, lane narrowing, speed feedback signs, landscaped median Islands, coordinated signal timing, road diets
Residential Arterial	30-35	Roundabout, lane narrowing, speed feedback signs, landscaped median Islands, coordinated signal timing, road diets
Suburban Fringe*	35-40	Roundabouts, transverse pavement markings, lane narrowing, speed feedback signs, road diets
Rural Community	25-35	Roundabouts, lane narrowing, speed feedback signs, on-street parking[1], street trees[2], median islands, curb extensions, chicanes, speed tables, road diets

* The "fringe" context is typically adjacent to rural areas at the edge of urban development, but often is in the process of developing. For projects in the "fringe" context zone, practitioners should consider likely future development and consider applying designs for "residential arterial," "commercial corridor," or "urban mix" contexts if this type of development is likely to occur.

[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 in a specific urban context to a point where it is appropriate to have a vertical element adjacent to the roadway.

1. DEFINE THE PROBLEM

> **IN THIS MEMO >>**
> - ODOT's design speed selection
> - Review of other guidance and approaches
> - Future considerations for setting target speed

Vehicle speed is among the greatest factors in serious injury and fatal crashes for vulnerable users.[1] Communities and agencies have a desire to reduce fatal and serious injury crashes and encourage walking and bicycling by reducing vehicle operating speeds. This memorandum will consider speed for highways within urban areas from various perspectives:

- Considering a target speed (desired operating speed) and strategies to achieve it in actual operating speeds;
- Selecting the highway design speed; and
- Setting the posted speed.

1.1 Expanded Problem Statement

Discussions about changing vehicle speeds can be categorized in five ways: target speed, operating speed, 85th percentile speed, design speed, and posted speed.

- **Posted speed** is the legally enforceable speed drivers must follow;
- **Operating speed** is a distribution of measured speed data;
- **85th percentile speed** is the observed speed that 85 percent of vehicles do not exceed;
- **Design speed** is the number used for engineering calculations that affects the geometric design of a road; and
- **Target speed** is the speed set as a goal for speed reduction (what the operating speed is supposed to be).

At the present time, there is no mechanism in ODOT's processes to use target speeds. While the focus of this memorandum is target speed, all four speed types are affected.

In Oregon, posted speed limits are set based on a number of factors, including the results of a speed study. They cannot be arbitrarily lowered to the target speed. To change posted speed, drivers must first slow down (i.e. operating speeds must be lowered), then the posted speed limit can be modified to reflect the change in operating speeds. This method of setting posted speed is based on primarily on driver behavior and expectation. Research has shown the risk of pedestrian

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[1] https://safety.fhwa.dot.gov/geometric/pubs/mitigationstrategies/chapter3/3_designspeed.cfm

crashes increase with increasing vehicle speed.2 To achieve target speeds that are safe for various modes, speed reduction strategies are needed.

The design speed influences some speed management strategies, such as channelization and lane width. Currently, the design speed is selected by the Region Roadway Manager in cooperation with Technical Services Roadway Staff and is typically set at or above the posted speed, per ODOT Highway Design Manual (HDM) Section 2.5.2. ODOT does not consider design exceptions that would allow setting a design speed lower than the posted speed or 85th percentile travel speed. Design speed and posted speed influence each other. One cannot change without the other. The Roadway Manager may select a design speed lower than the posted speed if the project includes elements than are expected to lower the operating speed. The design speed would be set at the expected posted speed at the conclusion of the project.

Currently, the ODOT HDM accommodates lower posted speeds (25 and 30 mph) for Special Transportation Areas (STAs) and Urban Business Areas (UBAs); however, there are limited road segments along state facilities that fall within these designations and that have posted speeds of 25 and 30 mph.

One other challenge in creating a roadway environment that encourages drivers to travel at speeds that reinforce safety and comfort for all users is disagreement within the engineering community as to the extent that specific roadway design elements can influence operating speeds and how those design elements may influence safety. Some design elements that may reduce operating speeds (e.g., narrower lanes, fixed objects adjacent to the roadway) may introduce other safety issues, depending on the context. Guidance for selecting the use of these elements and the actual related reduction in operating speed is limited.

In the built urban environment with existing buildings and other right-of-way constraints, the roadway geometry has already been established. Horizontal and vertical alignments, including superelevation, are set and difficult, as well as expensive, to modify. Effective, realistic and practical strategies need to be investigated. It is necessary to identify potential options that can aid designers in slowing drivers to an appropriate operating speed for the urban context of the roadway and surrounding community through which they are traveling.

[2] Killing Speed and Saving Lives, UK Dept. of Transportation, London, England. See also Limpert, Rudolph. Motor Vehicle Accident Reconstruction and Cause Analysis. Fourth Edition. Charlottesville, VA. The Michie Company, 1994, p. 663.

2. OVERVIEW OF POLICY, REGULATORY, AND DESIGN GUIDANCE CONTEXT

2.1 ODOT Policies Related to Speeds

This subsection summarizes the existing policy direction related to speed.

Oregon Statute ORS 810.180

This is the legal and regulatory framework for setting speeds in various contexts. Oregon Revised Statutes (ORS) provide the basis for setting speeds in Oregon. Statutory speeds set the default speeds, such as 20 mph in a business district[3], 25 mph on a local road in a residential district, or 55 mph on rural roads (see ORS 811.105 and 811.111 for more details on statutory speeds).

To designate a different speed than in statute, a traffic engineering investigation is required. If that investigation indicates that a different speed is safe and reasonable, a speed zone order may be issued, and a lower speed posted. ORS 810.180 sets out the statutory requirements for designating speeds in different areas. The Oregon Administrative Rules (OAR Chapter 734 Division 20) outline the requirements of an engineering study and the data to be analyzed.

Oregon Transportation Plan

The Oregon Transportation Plan refers to speed in Goal 2 (Management of the System). Policy 2.1 (Capacity and Operational Efficiency) states that Oregon will "manage the transportation system to improve its capacity and operational efficiency for the long-term benefit of people and goods movement." To that end, Strategy 2.1.3 identified speed management as one of several tools to "extend efficiency, safety, and capacity of transportation systems." Other strategies in Policy 2.1 refer to access management and managing mode share across the system.

Oregon Bicycle and Pedestrian Plan

The Oregon Bicycle and Pedestrian Plan[4] refers to setting speeds only in the context of Goal 1 (Safety), which seeks to "eliminate pedestrian and bicycle fatalities and serious injuries and improve the overall sense of safety for those who bike or walk." Policy 1.1 establishes that state and local agencies will provide "safe and well-designed streets and highways for pedestrian and bicycle

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[3] "Business district" refers to a territory contiguous to a highway when 50 percent or more of the frontage thereon for a distance of 600 feet or more on one side, or 300 feet or more on both sides, is occupied by buildings used for business. [1983 c.338 §26].

[4] Strategy 1.2B also directs agencies to educate motorists on the risks of speeding (among other elements) to bicyclists and pedestrians, but this is not a design or speed-setting strategy and may be out of scope for the initiative.

users." To implement Policy 1.1, Strategy 1.1A directs ODOT to update the ODOT Design Guidelines and Highway Design Manual for "pedestrian and bicycle design features" that reflect different contexts, including "vehicle speed, roadway characteristics and constraints, planned land uses, users and uses, areas of pedestrian and cyclist priority, and latent demand."

Strategy 1.1B directs ODOT and other agencies to use "the latest statewide guidance when selecting roadway cross sections, determining speed and type of separation, buffers needed, or other design features." Agencies are to consider the following in order to facilitate a safe and multimodal transportation system:

- Vehicle speeds
- Volumes
- Facility type
- Adjacent land use attractors
- Safety and comfort of all users

Strategy 1.1H directs agencies to use design features to influence speed where speed is a known contributor to pedestrian and bicycle crashes. For example, agencies can consider:

- Intersection geometrics
- Lane and roadway width
- On-street parking
- Street trees
- Sidewalks
- Planting strips
- Frequency of pedestrian crossings
- Other elements that create visual friction

Lastly, Strategy 1.1I directs agencies to "study barriers and opportunities for the setting of posted speed limits," including safety implications of posted speeds and how they are set and developing related guidance. Strategy 1.1I seems to be exactly what the Urban Design Initiative is acting upon.

Oregon Highway Plan

The Oregon Highway Plan (OHP) provides the most content and guidance related to speed, which can be divided in two parts: (1) guidance on what facility speed should be, and (2) how to respond to speed in access management and other design decisions. This section focuses on the former, but references for the latter are provided in footnotes.[5]

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[5] See Highway Plan Actions 1F.1 (Mobility Targets), 3B.3 (Nontraversable Medians), 1A.1 (State Highway Classifications), 1F.10 (Mobility Targets), and 3A.1-3A.4 (Classification and Spacing Standards).

Goal 1 (System Definition) focuses on "maintaining and improving the safe and efficient movement of people and goods," with related policies and strategies that guide speed setting. Policy 1A (State Highway Classification System) directs ODOT to develop and apply a state highway classification system, with speeds generally outlined for each class:

- **Interstate Highways (NHS):** High-speed (45 mph and above), continuous flow operation
- **Statewide Highways (NHS):** High-speed, continuous flow operation. In urban areas, interruptions to flow should be minimal. In Special Transportation Areas (STAs), local access may be a priority
- **Regional Highways**: Moderate- (30 to 45 mph) to high-speed operations in urban areas. Local access is a priority in STAs. Mobility is balanced with local access in Urban Business Areas (UBAs).
- **District Highways**: Low-speed (under 30 mph) operation in urban areas for traffic flow and for pedestrian and bicycle improvements. Local access is a priority in STAs. Mobility is balanced with local access in UBAs.
- **Local Interest Roads:** Low to moderate speed or traffic flow and for pedestrian and bicycle improvements. Local access is a priority in STAs.

Action 1A.2 further classifies Expressways as a subset of statewide, regional, and district highways**.** In Expressways in urban areas, speeds are moderate to high, there are no pedestrian facilities, and bikeways "may be separated from the roadway."

Action 1B.3 designates highway segments identified in local transportation system plans, downtown plans, facility plans, or other adopted plans supported by both a local agency and ODOT. The intent of each segment designation is to manage the state highway in a manner consistent with its existing and planned land use context. These designations may impact the posted speed set for that segment of the highway system.

- **Special Transportation Areas (STAs) (Category 1):** Segments located on Statewide, Regional or District Highways that are not on Interstate Highways, Expressways or designated OHP Freight Routes.
- **Special Transportation Areas (STAs) (Category 2):** Segments that are located on Statewide Highways that are also designated OHP Freight Routes; these require a management plan.
- **Urban Business Areas (UBAs):** Designated on Statewide, Regional or District Highways that are not Interstate Highways or Expressways, and that have posted speeds greater than 35 miles per hour. Although not necessarily stated, the plan reads as though UBA designation is meant to reduce speed to 35 mph or less.
- **Commercial Centers (CCs) (Category 1):** Segments located on Statewide, Regional or District Highways that are not on Interstate Highways, designated OHP Freight Routes or Expressways.
- **Commercial Centers (CCs) (Category 2):** Segments that may be located on designated OHP Freight Routes or Expressways; these require a management plan.

- **Non-Designated Urban Highways**: The default designation for all state highways within urban growth boundaries with speeds greater than 35 mph, except Interstate Highways unless otherwise designated as an Expressway, STA, UBA or CC.

Policy 1H (Bypasses) provides direction on establishing bypass facilities around downtowns, urban or metropolitan areas, or an existing highway. While the policy language suggests bypasses are meant to go around urban areas, it is not clear that they do so in all cases. Action 1H.2 directs ODOT to design bypasses for "moderate to high speeds at freeway or Expressway standards."

Lastly, Goal 2 (System Management) focuses on managing the state highway system as a single integrated asset in cooperation with federal and local agencies. Policy 2F (Traffic Safety) seeks to improve safety of all highway users through engineering and other solutions. Specifically, Action 2F.3 identifies:

- Engineering improvements such as geometrics, signing, lighting, striping, signals, improving sight distance, and assessing conditions to establish appropriate speed
- Constructing appropriate bicycle and pedestrian facilities including safe and convenient crossings

Oregon Transportation Safety Action Plan

The Transportation Safety Action Plan (TSAP) provides long-term goals, policies, and strategies and near-term actions to eliminate deaths and serious injuries on Oregon's transportation system. Goal 2 (Infrastructure) directs ODOT to "develop and improve infrastructure to eliminate deaths and serious injuries." Specifically, Strategy 2.3.2 directs ODOT to "plan, design and construct or retrofit facilities for desired operating speed"[6]. Further, Strategy 2.4.1 directs ODOT to work with state and local agencies to implement best practices in setting design speeds and speed limits.

The TSAP provides additional actions for intersections and infrastructure to "implement design treatments to achieve appropriate speeds and manage sight distance consistent with context, users, and community goals" (Action 6.5.1).

In addition to statewide policy plans, designers should also refer to applicable facility plans. Facility plans (including Interchange Area Management Plans [IAMPs], Corridor, Refinement, Access Management, Scenic Byways, Intersection, and Safety Corridor plans) provide additional guidance for specific transportation facilities that can influence speed setting.

[6] "Desired Operating Speed" is referred to as "Target Speed" elsewhere in the document.

2.2 Current Design Guidance on Speeds

Design Speed is a concept used to establish a starting point for determining roadway design parameters. It is most effective when designing new roadways on new alignments and in rural locations. It is less effective as a concept when dealing with existing roadways within the built environment and within urban locations because alignments are already established and modifying them is difficult and expensive.

ODOT has been working to tie roadway design to adjacent land use in urban locations since the inception of context sensitive design ideas in the 1990s. In conjunction with ODOT's context sensitive design goals implemented in 1996, the 1999 Oregon Highway Plan (OHP) outlined specific urban highway segment designations in conjunction with land use types. The 2003 ODOT Highway Design Manual (HDM) created specific design criteria in relation to the OHP urban highway segment designations to differentiate urban roadway design from rural roadway design. For lack of a better model, criteria such as lane width, sidewalk width/separation, and width of on-street parking are still based on design speed. However, when selecting the design speed for urban locations, more aspects of a location are considered in the final determination rather than just the roadway or segment designation itself; these include: adjacent land use, pedestrian access and movements, bicycle access and movements, freight needs, and community values. In 2010, ODOT instituted a Practical Design Policy to further establish appropriate design decisions for projects in relation to their contexts. This fits with current research outlined in the recently published National Cooperative Highway Research Program (NCHRP) Report 855: *An Expanded Functional Classification System for Highways and Streets*. This research presents roadway design based on Rural, Rural Town, Suburban, Urban, and Urban Core contexts (TRB 2018). For the time being, design speed is still being used as the starting point for project design elements.

Design speed is defined as a selected speed used to determine the various geometric design features of the roadway. Design speed directly affects only a portion of design elements in an urban cross-section. Design elements directly associated with design speed include:

- Horizontal Curvature
- Vertical Curvature
- Superelevation (when needed)
- Roadway Grade
- Stopping Sight Distance and Intersection Sight Distance
- Channelization – Deceleration Taper Rates/Lengths (S), Transition Lengths (T)
- Clear Zone

Design elements not directly related to design speed include:

- Lane Width
- Median Width
- Sidewalk Width

- Bridge Widths
- Pavement Cross-Slope
- Design Life; V/C Ratio
- Parking Lane Widths
- Shoulder Width (generally) - Shoulder widths on urban roadways are generally not a parameter of design speed. They are mostly determined by roadway classification or segment designation.

There has been a desire to establish a more comprehensive approach to guidance for design speed in urban contexts. The 2003 and the 2012 editions of the ODOT HDM differentiated application of design speed between rural high-speed roadways and lower speed urban locations. In most cases for ODOT urban roadway projects, the posted speed is being considered as an appropriate design speed by ODOT roadway designers.

Highway Design Manual – Chapter 2, Design Controls and Criteria

The selected design speed should be consistent with the speeds that drivers are likely to expect on a given highway. When selecting an appropriate design speed, not only is the roadway section in question considered, but so are the adjacent roadway segments to the proposed project. Within the project, the chosen design speed should be applied consistently throughout the corridor, keeping in mind the speed a driver is likely to expect. *In a rural environment, setting a consistent driver expectation for a travel speed perspective is important. A project should account for speeds approaching and leaving the project segment.*

The proper use of design speed creates consistent roadways and expectations for the users of the facility. For all projects on state highways, the design speed is selected by the Region Roadway Manager in cooperation with Technical Services Roadway Staff. Setting an appropriate design speed is important. A design speed set too high can encourage faster than desirable speeds. A design speed set low without design elements to reinforce driver operating speed (e.g., medians, on-street parking) may not be successful in producing lower speed traffic. The selected design speed should be consistent and reasonable with speeds that drivers are likely to expect on a given roadway within a given contextual environment.

In urban areas, the design speed should generally be equal to or, in some cases, based on criteria specific to a location, higher than the posted speed of the particular section of roadway. The design speed selected will take the roadway context into consideration (e.g., roadway classification, OHP segment designation, land use, pedestrian needs, safety, and community livability). Design speeds are generally selected in increments of 5 mph. Care must be taken to not confuse design speed with operating speed, posted speed, or 85th percentile speed.

The selection of the appropriate design speed for a particular section must also consider transition areas from rural to urban environments. Providing a smooth and clear transition from high rural speed conditions to urban environments is critical in controlling drivers' perceptions of the areas they are entering. These transitions alert users of the changing environment and control vehicular speeds as they enter various urban environments. The most common and effective transitions are those that establish a different roadway environment and visual effect to alert drivers to the change to an urban area. A common technique for transition areas is visual narrowing of the roadway with raised islands, buffer strips, and landscaping. Adding vertical elements and on-street parking where appropriate at the roadside can also be effective in transition zones.

Highway Design Manual – Chapter 6, Urban Highway Design (Non-Freeway)

With a few exceptions, the majority of the urban state highway system is composed of arterial roadways. Arterials carry high traffic volumes, serve multiple modes, and function as the conduit for longer internal and external trips within an urban area while providing access to transit stops and destinations along the highway. They also provide connectivity for travel between city centers. Arterials often traverse a variety of contexts including traditional downtowns, central business districts, regional commercial centers, and other developed areas. Due to existing land use and development patterns, arterials often are adjacent to areas of intense auto-oriented development. Different land use patterns and designations can substantially affect the design of a particular arterial highway. Considerations, such as pedestrian, transit and bicycle access and movement, freight routes, through traffic capacity and adjacent land use and community needs, must all be considered when designing urban arterials.

Chapter 6 includes urban design criteria in terms of functional classification and the Oregon Highway Plan (OHP) segment designations. These include Urban Expressways, Urban Arterials, Special Transportation Areas (STAs), Urban Business Areas (UBAs), Commercial Centers (CC), and Non-Designated Urban Highways, which include Urban Fringe/Suburban, Developed, and Traditional Downtown/CBD classifications. In addition to this list, Chapter 6 includes information for OHP Special Overlays designated as Freight Routes, Lifeline Routes, and Scenic Byways. These classifications and segment designations are evaluated as part of the final decision and selection of an appropriate design speed for a project.

For 4R (Modernization) Projects, design speed ranges are as follow:

- Expressways: 45-70 mph
- STAs and Traditional Downtown/CBD: 25-30 mph
- UBAs: 30-45 mph
- Urban Fringe/Suburban: 35-55 mph

For Urban 1R and 3R projects, unless there are specific needs, the design speed is generally considered to be the posted speed.

2.3 Current ODOT Processes Related to Speeds

This subsection summarizes the various processes within ODOT related to speeds, including the following scenarios (and any others that ODOT typically faces).

Selecting Design Speeds

In urban locations, ODOT determines an appropriate design speed through a process of collaboration between the Region Roadway Manager and Technical Services staff taking into account roadway classification, OHP segment designation, land use, pedestrian needs, safety, and community livability. There are a few exceptions when specific needs dictate a different answer, but in most cases, urban design speed is determined to be the posted speed. Because most projects in urban locations are working within the existing built environment with existing alignments, design speeds below posted speeds are not considered.

For transition areas from rural high speed to urban low speed, ODOT uses a step-down process (e.g., 55 mph to 45 mph to 35 mph).

Process and Criteria to Request a Posted Speed Limit Change

As required by statute, the process is established in Oregon Administrative Rule (OAR). Requests to perform a speed zone investigation typically come from the public or the Road Authority (the jurisdiction responsible for the roadway). Requests may occur because of concerns over safety or because the roadway may have significantly changed since the current speed was posted. Requests for an investigation on a city street or county road must come from the City or County Road Authority; the public is encouraged to make their requests directly to the appropriate Road Authority. Requests for an investigation on a state highway within the city limits must come from the City.

The OARs outline the requirements of an engineering study and the data to be collected such as:

- Number and type of vehicles
- Number of pedestrians and cyclists
- Crash history
- Speed checks
- Lane and shoulder widths
- Signals and stop signs
- Number of intersections and other accesses
- Roadside development
- Parking and bicycle lanes

Typically, ODOT will collect and analyze the data, but if requested, the Road Authority can perform the engineering study following the process in OAR. ODOT or local agency staff prepare a report and make a recommendation based on an evaluation of the data.

All the factors above are considered when making a recommendation for an appropriate posted speed. The speed data and crash history play an integral part in determining a recommended speed. The speeds are heavily influenced by the existing conditions, including roadway geometry and the roadside culture and development.

ODOT's current approach for setting speed depends on the 85th percentile speed as the key factor in determining the recommended speed. The basis for using 85th percentile speeds was originally safety, since research had shown that traveling at or near 85th percentile speed was the lowest risk of crash for drivers. Newer research indicates that drivers are primarily at higher risk when driving faster than the 85th percentile. Thus, the 85th percentile speeds seem to separate the acceptable behavior from the unsafe behavior.

The 85th percentile is attractive for other reasons. It reflects the collective driving judgment of what is safe and reasonable given the traffic and roadway conditions found to exist. It requires less enforcement to achieve compliance. It also gives agencies an objective measurable statistic, a place to start. The measured speed data also take into account the conditions the drivers find on the roadway. When drivers encounter a higher number of driveways or more development, they typically will choose lower speeds.

In urban areas, where lower speeds are desired, speeds are generally posted 4 to 7 mph slower than the 85th percentile as a result of the process. The OARs allow some flexibility on decisions on posting speeds. On state highways in rural areas, the speed must be within 5 mph of the 85th percentile, except under certain conditions. On local agency roadways and state highways within city limits, the State Traffic-Roadway Engineer has the authority to vary as much as 10 mph from the 85th percentile. If the Road Authority agrees with the recommendation, the speed zone is established, and a speed zone order is issued. If not, the Road Authority can appeal to the Speed Zone Review Panel who receives testimony and makes a final decision.

A criticism of the 85th percentile speed is that many drivers are not a good judge of safe speed. They may choose a speed that personally feels comfortable and safe, but they may not take into account the safety of other users or other unknown or unanticipated hazards. This is somewhat complicated by the fact that cars have become more efficient, powerful, safer and quieter and the driver may be less aware of their speed because of fewer audible and tactile cues. The speed zone process allows for taking this into consideration and to make appropriate adjustments to the recommendation. However, lowering posted speeds alone is not an effective means of lowering operating speeds. To be effective, lower speed limits must be combined with other strategies, such as effective enforcement and road design or road culture changes that trigger drivers to drive slower. Posted speeds set much below the 85th percentile may not provide the public and users a valid indication of the appropriate operating speed and may not be accepted as appropriate by drivers.

Special Cases

An alternative method was developed and approved for setting speeds on non-arterial roadways in the City of Portland. The process, authorized by ORS 810.180, is a modified process, requiring much of the same data but in an abbreviated report format. This process is a pilot process and will be evaluated for effectiveness when crash data is available.

There are special clauses in statute that allow any city to designate non-arterial streets in a residential district as 20 mph (5 mph under the statutory 25 mph) with certain conditions. Further, the City of Portland was granted (HB2682 in 2017) the authority to designate non-arterial residential streets at 20 mph.

ODOT can delegate authority for designating speeds on low volume and unpaved roads to cities and counties, given that cities and counties agree to follow a process established in rule. The statutory authority can apply to posted speed 25 mph and below and 55 mph and above.

2.4 Existing Barriers to Targeting Lower Speeds

In most urban locations, roadways are already established within the built environment. As a result, a de facto design speed is established based on the existing horizontal and vertical curvatures and other related elements and conditions. Additionally, if a roadway is straight, alignment has no relation to controlling operating speed, and so, the concept of design speed is ineffective. Other design elements or cues are required to indicate drivers need to reduce their speed.

The traditional approach of setting design speeds above posted speeds in urban areas is one from which ODOT has been moving away and was meant to add a “safety” factor for motorists, particularly on rural, high-speed highways. Traditionally, speeds have been set based on driver behavior and expectation without considering the vulnerable user. When determining speeds in urban contexts, the ability of drivers to perceive non-motorized users around them and react to their movements should be considered (e.g., faster speeds require greater distances to react). Speed affects vulnerable roads users, puts them at risk, and creates a challenge in designing multimodal facilities. The question then becomes, what design elements or combinations of elements actually create a positive behavior to slow a driver and produce a self-regulating speed outcome?

3. NATIONAL GUIDANCE AND CASE STUDIES

Traditionally, state DOTs have maintained a relatively high standard for speed on state highways, with design speeds of 45 mph and above; however, there has been an industry shift to accommodate lower speeds in urban environments to improve safety and reduce injury severity for people walking, bicycling, and accessing transit. Recent national guidance supports reduced speeds in urban areas. AASHTO’s *A Policy on Geometric Design of Highways and Streets*, 7th Edition, commonly referred to as the Green Book, states that in urban, mixed use, and mixed mode areas, lower speeds are desirable, and this should affect the selection of a design speed. Increasingly, state agencies and local jurisdictions in the United States have adopted design guidance to support lower design speeds in urban areas. References to the use of target speed to set design speeds and desired operating speeds are starting to be included in design manuals. However, specific research of what treatments achieve a desired operating speed is relatively limited. This section presents highlights from these key United States guidance documents and case studies on opportunities to explore different ways to address speed.

3.1 Relevant Guidance Documents

This section provides an overview of national and international guidance and research on different ways to address speed in urban areas.

AASHTO A Policy on Geometric Design of Highways and Streets, 7th Edition, 2018

AASHTO's *A Policy on Geometric Design of Highways and Streets,* 7th Edition, also referred to as the Green Book, recommends that topography, anticipated operating speed, adjacent land use, and functional classification be considered when selecting design speed. The Green Book acknowledges that designating a design speed does not address posted speed limits.

The Green Book states that in urban, mixed use, and mixed mode areas, lower speeds are desirable, and this should affect the selection of a design speed. For these streets, a target speed which represents the highest speed at which vehicles should operate on a thoroughfare given the context, multimodal activity, and vehicular mobility should be selected. The target speed is intended to be used as the posted speed limit, though in some jurisdictions, the speed limit is established based on measured speeds. In these cases, it is important to design (horizontal, vertical and cross section) the thoroughfare to encourage an actual operating speed at the target speed.

The Green Book recommends urban arterial streets should be designed and operated to permit running speeds from 20 to 45 mph. Speeds in the lower portion of this range are applicable to local and collector streets through residential areas and to arterial streets through more crowded business area. Speeds in the higher portion of the range apply to principal arterials in outlying suburban areas. For arterial streets through crowded business areas, coordinated signal control through successive intersections is generally needed to permit attainment of even the lower speeds.

The revised design process described in the Green Book, 7th Edition considers the following types of projects: new construction, reconstruction, and construction on existing roads. The design guidance notes that urban projects are most likely to be confronted with constraints that may influence design decisions. Therefore, a flexible, performance-based approach to design is appropriate for all project types to adapt the design to fit the roadway context and meet multimodal needs.

AASHTO Roadside Design Guide, 4th Edition, 2011

The *Roadside Design Guide* does not provide specific guidance related to speed. However, Table 10.5 in the Guide provides design strategies to protect pedestrians in motor vehicle crashes (e.g., reducing severity of motor vehicle-pedestrian crashes at roadside location through reducing roadway design speed, operating speed, or both in high pedestrian volume locations). Further, it highlights that curbs have limited re-directional capabilities and that these only occur at operating speeds approximately 25 mph and lower.

ITE Designing Walkable Urban Thoroughfares: A Context Sensitive Approach, 2010

ITE's *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* provides guidance for design controls, street side design, throughway design, and intersection design for a variety of context zones and thoroughfare types. The urban thoroughfares addressed in the report include boulevard (divided arterial), avenue (urban arterial or collector thoroughfare), and street (primarily serving adjacent property). While the primary role of 'streets' is to serve adjacent property, they can be classified as arterial or collector. For each of these urban thoroughfares, the target speed ranges from 25 to 35 mph. **Table 2** provides additional information on the role and characteristics of each urban thoroughfare. Each thoroughfare has a recommended cross section which reinforces the target speed through design aspects such as signal timing progression, lane widths, curb extensions and medians, on street parking, elimination of superelevation, pavement materials, and elimination of high-speed channelized right turns.

Table 2. Thoroughfare Type Descriptions

Thoroughfare Type	Functional Definition
Boulevard	Walkable, low-speed (35 mph or less) divided arterial thoroughfare in urban environments designed to carry both through and local traffic, pedestrians and bicyclists. Boulevards may be long corridors, typically four lanes but sometimes wider, serve longer trips, and provide pedestrian access to land. Boulevards may be high-ridership transit corridors. Boulevards are primary goods movement and emergency response routes and use vehicular and pedestrian access management techniques. Curb parking is encouraged on boulevards.
	Multiway boulevards are a variation of the boulevard characterized by a central roadway for through traffic and parallel access lanes accessing abutting property, parking and pedestrian and bicycle facilities. Parallel access lanes are separated from the through lanes by curbed islands with landscaping; these islands may provide transit stops and pedestrian facilities. Multiway boulevards often require significant right of way.
Avenue	Walkable, low-to-medium speed (25 to 35 mph) urban arterial or collector thoroughfare, generally shorter in length than boulevards, serving access to abutting land. Avenues serve as primary pedestrian and bicycle routes and may serve local transit routes. Avenues do not exceed 4 lanes, and access to land is a primary function. Goods movement is typically limited to local routes and deliveries. Some avenues feature a raised landscaped median. Avenues may serve commercial or mixed-use sectors and usually provide curb parking.
Street	Walkable, low speed (25 mph) thoroughfare in urban areas primarily serving abutting property. A street is designed to (1) connect residential neighborhoods with each other, (2) connect neighborhoods with commercial and other districts and (3) connect local streets to arterials. Streets may serve as the main street of commercial or mixed-use sectors and emphasize curb parking. Goods movement is restricted to local deliveries only.

Source: ITE's *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, Table 4.2

ITE Traffic Engineering Handbook, 7th Edition, 2016

Chapter 14 of the *Traffic Engineering Handbook* discusses traffic calming in detail. It presents a typical process for establishing traffic calming needs and potential solutions; discusses volume-control and speed-control measures; and includes case studies from across the country and emerging trends. The solutions discussed are generally not applicable to arterials.

ITE Urban Street Geometric Design Handbook, 2008

The *Urban Street Geometric Design Handbook* addresses operational and safety aspects associated with geometric design of roadways in urban areas. This includes the need for all users, considering pedestrian, bicycle, and transit needs, as well as a need for performance measures for each. This Handbook claims the "target vehicle operating speeds for walkable streets in urban areas should be 35 MPH or less," and the design speed and target speed should be equivalent. Some design factors presented which can contribute to speed reduction in urban areas include: reducing excessive lane widths, minimal to no horizontal offset between the travel lanes and median curbs, elimination of superelevation, elimination of shoulders in most urban applications, on-street parking, smaller curb radii, elimination of high speed channelized right turns, spacing of signalized intersections, traffic signal coordination, paving materials with texture, proper use of warning and advisory signs to transition speeds. The Handbook also discusses the effects of trees on safety. It notes that trees and landscaping are the most common fixed-object obstacles involved in fatal crashes; however, recent research has established that, in some situations, the presence of trees near the roadway has a positive influence on roadway safety, associated with a reduction in vehicle speed.

ITE/FHWA Traffic Calming State of the Practice, 1999

ITE and FHWA's *Traffic Calming State of the Practice* focuses primarily on local roads. There are some treatments discussed that could be applied on arterials. The report provides guidance on speed tables, for example. The report claims a speed table that is 3 to 4 inches high and 22 feet long in the direction of travel, with 6-foot ramps at the ends and a 10-foot field on top, has an 85th percentile speed of 25 to 30 mph. These tables have been used in Florida, Georgia, Texas, and Maryland.

- Other treatments discussed include textured pavement, roundabouts, chicanes, curb extensions, raised crosswalks, and raised intersections. The report summarized before and after studies for some treatments, summarized in **Table 3**.

Table 3. Speed Impacts Downstream of Traffic Calming Measures

Treatment	Sample Size	85th Percentile Speed (mph)	
		Average After Calming	Average Change After Calming
22-foot tables	58	30.1	-6.6
Longer tables	10	31.6	-3.2
Raised intersections	3	34.3	-0.3
Narrowing (curb extensions)	7	32.3	-2.6

Source: Adapted from ITE/FHWA Traffic Calming State of the Practice, Table 5.1

FHWA Memorandum: Relationship between Design Speed and Posted Speed, October 7, 2015

FHWA released the Relationship between Design Speed and Posted Speed memorandum to clarify their position on the relationship between design speed and posted speed. Posted speed is an operation decision for which the owner/operator of the facility is responsible. There is no regulation establishing a direct link between anticipated operating and posted speeds with the design speed. As per the MUTCD, posted speeds should be established based on statutory limits unless an engineering study has been performed in accordance with established traffic engineering practices. In a rural setting, the FHWA Design Consistency Module of the Interactive Highway Safety Design Model (IHSDM) can be used to estimate the 85th percentile speeds on a given alignment, allowing the designer to look for deviations between design and likely operating speeds and make adjustments to improve the safety and operation of the facility. In urban areas, the design of the street should generally limit the maximum speed at which drivers can comfortably operate to balance the needs of all users. The inferred design speed is the maximum speed for which all design-speed-related criteria are met at a particular location. If the posted speed is established greater than the inferred design speed, the FHWA recommends that a safety analysis be performed to determine the need for appropriate warning or informational signs such as advisory speeds on curves or other mitigation measures prior to posting the speed limit.

FHWA Self-Enforcing Roadways: A Guidance Report, 2018

FHWA's *Self-Enforcing Roadways: A Guidance Report* focuses primarily on two-lane rural highways; however, several concepts discussed in the report can be applied to urban arterials. The Report describes an approach to self-enforcing speed by setting speed limits that are reasonable, rational, and consistent with the features of the roadway. FHWA released a tool that determines rational speed limits in developed areas based on the following factors:

- 85th-percentile speed
- 50th-percentile speed
- Section length in miles
- AADT
- Adverse alignment
- Statutory speed limit
- One-way street
- Divided/undivided
- Number of through lanes
- Area type (e.g., residential-subdivision, residential-collector, commercial, large complexes)
- Total number of driveways and unsignalized access points
- Total number of signals
- On-street parking and usage
- Pedestrian/bicycle activity

The model, called USLIMITS2, uses an expert system with a fact-based set of decision-making rules to determine an appropriate speed limit for all roadway users. For roadway segments that experience high pedestrian and bicyclist activities, USLIMITS2 recommends speed limits close to 50th percentile instead of 85th percentile speed. This method provides an alternative to setting speed that does not rely solely on the 85th percentile speed that could satisfy the MUTCD requirement for an engineering study to determine posted speed.

FHWA Speed Management Toolkit

The FHWA *Speed Management Toolkit* provides references for various speed management resources. This resource also provides suggestions for crash and speed-reducing countermeasures, along with crash modification factors (CMFs). These countermeasures are identified by area type, location, and road type. Examples of countermeasures for urban arterials include road diets, roundabouts, enhanced curve delineation, variable speed limits, changing signal phasing, and automated speed enforcement.

FHWA Speed Concepts Informational Guide, 2009

The FHWA *Speed Concepts Informational Guide* discusses design speed, inferred design speed, target speed, posted speed, and operating speed. The design speed is the value used for design element calculations. Inferred design speed is the maximum speed possible for a specific element based on the design speed criteria. The design speed and inferred design speed can be different if a value other than the criterion-limiting value is used in the calculation of elements. The target speed is the preferred operating speed. The posted speed is the legally enforceable speed, and the operating speed is a distribution of measured speed data. Design elements should maintain a relatively constant speed over a corridor. Isolated speed restrictive elements may violate a driver's expectation.

FHWA Engineering Countermeasures for Reducing Speeds: A Desktop Reference of Potential Effectiveness in Reducing Speed, 2014

FHWA's *Engineering Countermeasures for Reducing Speeds: A Desktop Reference of Potential Effectiveness in Reducing Speed* provides a chart of studies conducted on countermeasures used for speed management[7]. While most countermeasures decrease speeds, some also report an increase of speeds. Examples of countermeasures applicable for urban arterials and collectors include chicanes, center island, road diet, landscaped median, speed activated speed limit sign, speed feedback sign, and access control. These countermeasures were all shown to reduce speeds in various before/after studies.

[7] https://safety.fhwa.dot.gov/speedmgt/ref_mats/eng_count/2014/reducing_speed.cfm

FHWA Traffic Calming on Main Roads through Rural Communities, 2009

The FHWA report *Traffic Calming on Main Roads through Rural Communities* is an evaluation of the effects on speed of low-cost traffic calming treatments on rural highways which become the main roads of small rural communities. Speed management is of particular concern on these roadways, as they typically provide a dual role: (1) outside the town, the roadway provides high-speed travel over long distances; and (2) within the built-up area, the same roadway accommodates local access, pedestrians of all ages, on-street parking, and bicyclists. As part of this study, seven (7) low-cost traffic-calming treatments were implemented and evaluated in five (5) Iowa communities. Speed limits ranged from 55-60 mph outside the community and 25-35 mph inside the community. **Table 4** shows the traffic-calming treatments evaluated.

Table 4. Summary of Impacts and Costs of Rural Traffic Calming Treatments

Treatment	Change in 85th percentile speed (MPH)	Cost	Maintenance	Application
Transverse pavement markings	-2 to 0	$	Regular painting	Community entrance
Transverse pavement markings with speed feedback signs	-7 to -3	$$$	Regular painting	Community entrance
Lane narrowing using painted center island and edge marking	-3 to +4	$	Regular painting	Entrance or within community
Converging chevrons and "25 MPH" pavement markings	-4 to 0	$	Regular painting	Community entrance
Lane narrowing using shoulder markings and "25 MPH" pavement legend	-2 to 4	$	Regular painting	Entrance or within community
Speed table	-5 to -4	$$	Regular painting	Within community
Lane narrowing with center island using tubular markers	-3 to 0	$$$	Tube replacement when struck	Within community
Speed feedback sign (3-months after only)	-7	$$$	Troubleshooting electronics	Entrance or within community
"SLOW" pavement legend	-2 to 3	$	Regular painting	Entrance or within community
"35 MPH" pavement legend with red background	-9 to 0	$	Background faded quickly; accelerated repainting cycle	Entrance or within community

Source: FHWA *Traffic Calming on Main Roads Through Rural Communities*, Table 10

The most effective treatments were the speed feedback signs, speed table, median island using tubular markers, and speed limit markings with red background. The converging chevrons and transverse pavement markings were somewhat effective with speed reductions generally less than 3 mph. Lane narrowing using pavement markings to create a center island, lane narrowing using shoulder markings in combination with on-pavement speed limit markings, and on-pavement "SLOW" markings were either ineffective or were only marginally effective. The chevron markings, transverse markings, and red background for pavement legend evaluated in this study are not standard devices and require experimental approval in accordance with Section 1A.10 of the MUTCD.

FHWA Traffic Calming E-Primer – Module 3, 2017

The Traffic Calming E-Primer from FHWA provides an introduction to traffic calming measures, a toolbox of traffic calming measures, and effects of traffic calming on various road users. The toolbox of traffic calming measures presented in Module 3 provides sample design plans, photographs of built examples, and various measures of effectiveness relating to multimodal safety.

Table 5 summarizes the toolbox measures along with the likelihood of acceptability for various road types. Countermeasures shown as having the highest level of appropriateness for thoroughfares and major streets include roundabouts, on-street parking, and road diets.

Table 5. Likelihood of Acceptability of Traffic Calming Measure

Traffic Calming Measure	Segment or Intersection	Functional Classification			Street Function	
		Thoroughfare or Major Street	Collector or Residential Collector	Local or Local Residential	Emergency Access	Transit Route
Horizontal Deflection						
Lateral Shift	Segment	3	5	5	5	5
Chicane	Segment	1	5	5	3	3
Realigned Intersection	Intersection	1	5	5	5	5
Traffic Circle	Intersection	1	3	5	3	3
Small Modern & Mini-Roundabout	Intersection	3	3	5	5	5
Roundabout	Intersection	5	3	1	5	5
Vertical Deflection						
Speed Hump	Segment	1	5	5	1	3
Speed Cushion	Segment	1	5	5	5	5
Speed Table	Segment	3	5	5	1	3
Offset Speed Table	Segment	3	5	5	5	3
Raised Crosswalk	Both	3	5	5	1	3
Raised Intersection	Intersection	3	5	5	3	3
Street Width Reduction						
Corner Extension	Intersection	5	5	5	5	5
Choker	Segment	5	5	5	5	5
Median Island	Both	5	5	5	5	5
On-Street Parking	Segment	5	5	5	5	5
Road Diet	Both	5	5	3	5	5
Routing Restriction						
Diagonal Diverter	Intersection	1	3	3	1	3
Full Closure	Both	1	3	3	1	1
Half Closure	Intersection	1	5	5	3	3
Median Barrier	Intersection	3	5	5	1	3
Forced Turn Island	Intersection	3	5	5	3	3

Legend:
5 – traffic calming measure may be appropriate
3 – caution; traffic calming measure could be inappropriate
1 – traffic calming measure is likely inappropriate
Note: Refer to individual traffic calming measure section for a complete description of the appropriate application of each measure.
Source: Traffic Calming E-Primer, Module 3, Table 3.1

The primer also provides design considerations. For instance, for median islands the following guidance was provided:

- A median island can be designed in conjunction with an at-grade crosswalk or a vertical traffic calming feature (e.g., speed hump, speed table, raised crosswalk) to increase the likelihood of lower vehicle speeds.
- If a median island is at least 6 feet wide, a pedestrian refuge area can be included in the design.
- On-street parking should not be permitted along the curbing of a median island that is used for traffic calming. If the parking spaces are unoccupied, the potential roadway width reduction caused by the island (and its traffic calming effect) is absent.
- A median island should not be placed in front of or in close proximity to a driveway, unless access control is desired.
- A median island should include MUTCD compliant signs in order to alert motorists of the presence of the median island. Signs can be supplemented by landscaping.

NHTSA Speed Management Program Plan, 2014

The National Highway Traffic Safety Administration's (NHTSA) Speed Management Program Plan states that the Department of Transportation (DOT) will work with States to expand the implementation of proven countermeasures and test innovative strategies for reducing speed related crashes. These countermeasures and strategies include the application of appropriate engineering practices, effective messaging and data-driven enforcement activity, and encouraging the coordination of the disciplines associated with engineering, enforcement, education, and communication. The Plan does not provide specific information on countermeasures or how to implement them on urban arterials.

NTSB Reducing Speeding-Related Crashes Involving Passenger Cars, 2017

In this safety study, the National Transportation Safety Board (NTSB) examines causes of and trends in speeding-related passenger vehicle crashes and countermeasures to prevent these crashes. These countermeasures include engineering, enforcement, and education. In particular, speed limit reduction, data-driven speed enforcement, automated speed enforcement, intelligent speed adaptation, and traffic safety campaigns are discussed.

NACTO Urban Street Design Guide, 2013

The *Urban Street Design Guide* from the National Association of City Transportation Officials (NACTO) features various design guidelines for urban walkable streets and intersections. The Guide claims reduction in traffic speeds can be achieved by changing the configuration of a roadway or changing how people psychologically perceive and respond to a street. The following tools can help enforce target speeds:

- **Median:** Medians create a pinch point for traffic in the center of the roadway and can reduce pedestrian crossing distances.
- **Pinch point:** Pinch points, where the road narrows from the outside toward the centerline, restrict motorists from operating at high speeds on local streets and significantly expand the sidewalk realm for pedestrians.
- **Chicane:** Chicanes slow drivers by alternating parking or curb extensions along the corridor.
- **Lane shifts:** Lane shifts horizontally deflect a vehicle and may be designed with striping, curb extensions, or parking.
- **Speed hump:** Speed humps vertically deflect vehicles and may be combined with a midblock crosswalk.
- **Roundabouts:** Roundabouts reduce traffic speeds at intersections by requiring motorists to move with caution through conflict points.
- **Signal progression:** Signal progression is timed to a street's target speed.
- **Building lines:** A dense built environment with no significant setbacks constrains sightlines, making drivers more alert and aware of their surroundings.
- **Street trees:** Trees narrow a driver's visual field.
- **On-street parking:** Parking narrows the street and creates friction for moving vehicles.

Austroads Towards Safe System Infrastructure: A Compendium of Current Knowledge, 2018

Towards Safe System Infrastructure: A Compendium of Current Knowledge by Austroads Publications Online states that "planning, road design and traffic management needs to also consider how to reduce the severity of crashes when they occur." In some cases, crashes are found to be due to user error, when it is actually the road system that invites certain errors to be made. Road design should be forgiving to predictable errors: "There is a need to acknowledge that the current road system is inherently unsafe and that road users are frequently placed in circumstances where errors are to be expected" (Austroads 2012b). One of the main tenets of a forgiving road network is speed management. Traveling speed is a primary determinant of injury outcome, vehicle controllability, and crash likelihood. Small changes in speed can have large benefits, so any reductions are better than none.

NCHRP Report 737: Design Guidance for High-Speed to Low-Speed Transitions Zones for Rural Highways

NCHRP Report 737 includes guidance for high- to low-speed transitions zones on rural highways, particularly as they approach small town. The researchers developed a process for analyzing the transition zone, selecting appropriate techniques to address issues in the zone, and evaluating the effectiveness of the techniques after implementation. The techniques discussed include: raised center islands, roundabouts, roadway narrowing, road diet, transverse pavement markings, speed-activated feedback sign, rumble strips, colored pavement, welcome signs, and landscaping. Researchers found that roundabouts and transverse pavement markings increased the rate of speed limit compliance in the transition zone. The findings suggest additional measures are needed to maintain a speed reduction downstream of the transition zone through the community.

NCHRP Report 880: Guidelines for Designing Low and Intermediate Speed Roadway that Serves All Users

Functional classification and design speed are the primary factors in determining highway design controls and criteria. NCHRP Report 880 suggests a target speed should be established as the highest operating speed at which vehicles should ideally operate on a roadway in a specific context. This target speed should consider the level of multimodal activity, adjacent land uses, and mobility. The target speed should become the posted speed. Target speeds typically range from 25 to 35 mph for roadways that are considered bikeable and walkable by today's practices.

Selecting a target speed that is artificially low without design factors to encourage travel at the slower speed will simply result in operating speeds higher than desired and will be difficult to enforce. Factors that can contribute to a lower operating speed include narrower travel lanes, curb extensions and medians to narrow the traveled way, on-street parking and other side friction, minimal horizontal offset between the lane and the median curbs, roundabouts, and other speed management techniques. Other factors claimed to impact speed include a tree canopy, proximity of multistory buildings, edge line striping, and parking lanes. In urban areas, intersection operations have a greater impact on travel time and capacity than speed.

Ongoing NCHRP Projects

- NCHRP Project 17-58: Safety Prediction for Urban and Suburban Arterials
- NCHRP Project 17-76: Guidance for the Setting of Speed Limits

3.2 Case Studies

This section presents case studies of state and local agency speed management practice.

Massachusetts Highway Department Project Development and Design Guide

The Project Development and Design Guide from the Massachusetts Highway Department (MassHighway) provides a matrix of design speeds by area and roadway type, see **Table 6.**

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Table 6. Design Speed Ranges (MPH)

	Roadway Type					
Area Type	Arterials			Collectors		Local
	Freeway	Major*	Minor	Major	Minor	Roads
Rural Natural	50 to 75	40 to 60*	35 to 60	30 to 60	30 to 55	20 to 45
Rural Developed	50 to 75	40 to 60*	35 to 60	30 to 60	30 to 55	20 to 45
Rural Village	N/A	30 to 45	30 to 40	25 to 40	25 to 35	20 to 35
Suburban Low Intensity Development	50 to 75	30 to 60*	30 to 55	30 to 55	30 to 55	20 to 45
Suburban High Intensity	50 to 75	30 to 50*	30 to 50	25 to 50	25 to 40	20 to 40
Suburban Town Center	N/A	25 to 40	25 to 40	25 to 40	25 to 35	20 to 35
Urban	50 to 75	25 to 50	25 to 40	25 to 40	25 to 35	20 to 35

N/A Not Applicable
* A higher design speed may be appropriate for arterials with full access control
Source: Massachusetts Highway Department Project Development and Design Guide, Exhibit 3-7 (Adapted from A Policy on Geometric Design of Highways and Streets, AASHTO, 2004 – Chapter 3 Elements of Design)

MassHighway defines target speed as the desired operating speed along a roadway. When determining target speed, they consider the following:

- The context of the roadway including area type, roadway type, and access control;
- The volume, mix, and safety of facility users; and
- The anticipated driver characteristics and familiarity with the route.

The Guide suggests design speeds selected for traffic calming elements should be consistent with the target speed of the corridor. Selection of a reasonable design speed for traffic calming elements, selection of type of elements, and the spacing of these elements can help achieve the desired uniform reduction in operating speed along the roadway.

The goal of traffic calming can be to reduce the number of vehicles exceeding the posted speed, to reduce the operating speed of all vehicles to the target speed, and/or to support the reduction of the posted speed limit. If a proposed design speed is lower than the existing operating speed, the burden is on the individual designer of a traffic-calming feature to document a reasonable expectation that the proposed measures will reduce the operating speed. Once traffic calming has been implemented, performance monitoring is recommended to evaluate if operating speeds have indeed been reduced.

The traffic calming elements applicability to various roadway types is provided in **Table 7**.

Table 7. Traffic Calming and Traffic Management Applicability by Roadway Type

	Arterials	Major Collectors	Minor Collectors	Local Roads
Street Narrowing				
Narrow Lanes		∆	■	■
Raised Curbs	■	■	■	■
Street Furniture	■	■	■	■
Street Trees	■	■	■	■
Street Lighting	■	■	■	■
Spot Narrowing	∆	■	■	■
Medians and Crossing Islands	■	■	■	■
Curb Extensions	■	■	■	■
Road Diets	∆	∆	■	■
Building Siting	■	■	■	■
Horizontal Deflection				
Chicanes			■	■
Crossing Islands/Short Medians	■	■	■	■
Mid-Block Traffic Circles			∆	■
Roundabouts	■	■	■	■
Lane Offsets		∆	∆	■
Profile Alterations				
Speed Humps		∆	∆	■
Raised Crosswalks		∆	■	■
Raised Intersections		∆	■	■
Textured Pavement	■	■	■	■
Traffic Management	∆	∆	∆	∆

■ Often used for new design or retrofit programs in traffic calming settings
∆ May be suitable

Source: Massachusetts Highway Department Project Development and Design Guide, Exhibit 16-2

WSDOT Highway Design Manual

In the Washington State Department of Transportation (WSDOT) Highway Design Manual, the design speed is determined with a target speed approach. The objective of this approach is to establish the design speed at the desired operating speed. If excessive speed was identified as a performance need and/or if a target speed was selected that is lower than the existing posted speed, WSDOT considers speed management options to help achieve the selected target speed. Speed management options are categorized into geometric, roadside, and pavement treatments. Examples of speed management techniques include chicanes, pinch points, roundabouts, landscaping, raised vegetated medians, rumble strips, and gateways.

The design manual has three classifications of target speed based on development form and roadway network features: low speed, intermediate speed, and high speed. Low speeds are 35 mph or below and applicable for roadways with pedestrian and bicycle mode priority. Intermediate speeds are between 40 and 45 mph and ideal for speed transitions between high and low speed areas. High speeds are 50 mph and above and applicable for motor vehicle-oriented roadways. These target speed classifications drive the decision of which speed management techniques to use.

FDOT Speed Zoning Manual

The Florida Department of Transportation (FDOT) Speed Zoning Manual defines target speed as the speed at which vehicles should operate in a specific land use context, in accordance with the FDOT land use context classification system. The target speed should also be consistent with the level of multimodal activity generated by adjacent land uses, to provide mobility for motor vehicles and a safe environment for pedestrians and bicycles. The target speed is influenced by both elements of roadway design that are governed by design speed, as well as the form and function of the adjacent uses beyond the right-of-way. When determining the speed limit, consideration should be given to the land use context and speed range provided in the FDOT Design Manual.

FDOT Design Manual

In the FDOT Design Manual, design speed is recommended to be selected early in the design process and should be context appropriate. Safety, mobility, and efficiency are considered when selecting a design speed. For new construction or reconstruction, design speed should be selected based on the land use context classification and roadway facility type, shown in **Table 8**. For resurfacing, rehabilitation, or restoration projects, the design speed is the original design of the highway if within the allowable range. When the posted speed is greater than the original design of the highway, the design speed should be equal to the posted speed for any new elements or modification to existing elements.

Table 8. FDOT Design Speed for Arterials and Collectors

Context Classification	Allowable Range (MPH)
C1 – Natural	55-70
C2 – Rural	55-70
C2T – Rural Town	25-45
C3 – Suburban	35-55
C4 – Urban General	30-45
C5 – Urban Center	25-35
C6 – Urban Core	25-30

Source: FDOT Design Manual, Chapter 201, Table 201.4.1

The Speed Management chapter in the FDOT Design Manual covers various tools for speed management on state roadways. Three main approaches to speed management presented are

Enclosure, Engagement, and Deflection. When selecting different speed management strategies, land use context classification, desired operating speed, community vision, multimodal needs (including emergency vehicles), and access management should be considered. Typically, strategies are most effective when several are used together. Techniques presented in the design manual include roundabouts, on-street parking, trees, short blocks, median islands, road diet, chicanes, textured surfaces, and more. **Table 9** summarizes which strategies are appropriate in each land use context.

Table 9. Strategies to Achieve Desired Operating Speed

Context Classification	Design Speed (MPH)	Strategies
C2T – Rural Town	40-45	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, RRFBs and PHBs
	35	Techniques for 40-45 MPH, plus On-street Parking, Street Trees, Short Blocks, Median Islands at Crossings, Road Diet, Bulbouts, Terminated Vista
	30	Techniques for 35-45 MPH, plus Chicanes, Median Islands in curved sections, Textured Surface
	≤ 25	Techniques for 30-45 MPH, plus Vertical Deflection
C3 – Suburban	50-55	Project-specific; see FDM 202.4.
	40-45	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, RRFB and PHB
	35	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, Median Islands in crossings, Road Diet, RRFB and Hawk, Terminated Vista
C4 – Urban General	40-45	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, RRFB and PHB
	35	Techniques for 40-45MPH plus On-Street Parking, Street Trees, Short Blocks, Median Islands at Crossings, Bulbouts, Terminated Vista
	30	Techniques for 35-45 MPH plus Chicanes, Median Islands in Curve Sections, Textured Surface
C5 – Urban Center	35	Roundabout, On-street Parking, Street Trees, Short Blocks, Speed Feedback Signs, Median Islands in Crossings, Road Diet, Bulbouts, RRFB and HAWK, Terminated Vista
	30	Techniques for 35 MPH plus Chicanes, Median Island in Curve Sections, Textured Surface
	25	Techniques for 30-35 MPH plus Vertical Deflection
C6 – Urban Core	30	Roundabout, On-Street Parking, Horizontal Deflection, Street Trees, Median Islands in Curve Sections, Road Diet, Bulbouts, Terminated Vista, Textured Surface
	25	Techniques for 30 MPH plus vertical deflection

Source: FDOT Design Manual, Chapter 202, Table 202.3.1

Caltrans Main Street, California

The California Department of Transportation (Caltrans) *Main Street, California* report states that if a community wants slower speeds along a main street, the first strategy is to implement physical traffic calming features. Following this, a speed study can be conducted to determine if the speed limit may be lowered. The report states: "Research shows that motorists tend to drive at the speed at which they feel comfortable, based on the design of the road and current roadway conditions, even when their driving speed is incongruent with the posted speed limit. A posted speed limit that drivers perceive as arbitrarily low given the actual roadway conditions does not reliably induce slower driving speeds." This report gives guidance on the number of lanes, lane widths, raised median and refuge islands, pedestrian crossings, curb extensions, roundabouts, signals and beacons, parking, bicycle and pedestrian facilities, pavement treatment, and landscaping which provide speed management.

Arizona DOT Complete Transportation Guidebook

In the Arizona Department of Transportation Complete Transportation Guidebook, safety is listed as one of the benefits of complete transportation: "Designing streets with speed limits in accordance with the human-scale context, reducing roadway widths, or narrowing travel lanes to minimize pedestrian crossing distance can result in fewer and less severe crashes." Speed management techniques, such as signalized pedestrian crossings, raised medians, and pedestrian crossing islands, are listed. The benefits of these techniques include responding to the needs of the community, facilitating mobility for all users, and improving safety. Lane widths, traffic circles, pedestrian refuge islands, curb extensions, and curb radii are also listed as traffic calming measures. Activity center type is listed as a factor in determining design elements.

New York Vision Zero Plan

New York City's Vision Zero Plan has multiple initiatives, including outreach, enforcement, legislation, and street design. Within the street design initiative, the city DOT is adding safety engineering improvements at intersections and along arterials. Some intersection improvements include pedestrian islands, pedestrian head start, expanded pedestrian space, and improved crosswalks. For arterials, "slow zones" have been created with reduced speed limits combined with adjusted signal timing, enforcement, and distinctive signs.

3.3 INFORMATION GAPS

The guidance and examples reviewed do not include clear documentation of exactly how practitioners should determine the recommended target speed on a project. They also do not clearly define what treatments or group of treatments are necessary to achieve a lower operating speed on an existing arterial roadway. Instead, the guidance discusses treatments individually with guidance on where they would be appropriate. The guidance relies on practitioners to evaluate what level of change is required to bring about a desired change in operating speed.

4. CONSIDERATIONS FOR THE BLUEPRINT FOR URBAN DESIGN

Section 2 of this document presented an overview of ODOT's policy, regulatory, and design guidance related to target, design, and posted speeds. Section 3 summarized a variety of current practices and examples within the United States. This section (Section 4) describes areas of alignment between ODOT and other best practices, as well as areas of opportunity (Section 4.1). It describes a potential approach to clarifying ODOT's design guidance for speed management in urban areas (Section 4.2), aligning with the emerging multimodal decision-making framework from the Blueprint for Urban Design.

4.1 Best Practices: Highlights and Alignment with ODOT

A number of key themes emerged from the practices review, drawing on both national and state sources. ODOT's current policy guidance aligns with many of these themes, but there are opportunities for better alignment within the planning and design guidance.

Overall Themes from Best Practices Review

Across guidance documents and case studies reviewed, the following themes emerged:

- Given land use context, multimodal activity, and vehicular mobility, target speed can be defined as the speed at which vehicles should operate on a roadway. In practice, the target speed and design speed should be the same, and a roadway encourages an actual operating speed at the target speed. The target speed is intended to be used as the posted speed limit; however, FHWA clarified there is no regulation establishing a direct link between anticipated operating and posted speeds with the design speed. Per the MUTCD, posted speeds should be established based on statutory limits unless an engineering study has been performed in accordance with established traffic engineering practices. Most agencies are currently using the 85th percentile operating speed to set the posted speed; however, this is not an MUTCD requirement. The MUTCD requires an engineering study be performed, and the 85th percentile speed is just one approach. For example, for segments that experience high pedestrian and bicycle activities, USLIMITS recommends speed limits close to the 50th percentile instead of 85th percentile speed.
- Federal and state guidance have established design speed and desired operating speeds in urban contexts**.** The majority of sources reviewed, including ITE, NCHRP, MassHighway, WSDOT, and FDOT, recommend speeds of 35 mph or less in urban contexts. Speeds between 40 and 55 mph are recommended in high to low speed transition zones. The Green Book recommends design and operating speeds as low as 20 mph on some urban arterials.
- Target speed should consider the level of multimodal activity, adjacent land uses, and mobility. 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. Treatments can include operational, geometric, roadside, and pavement treatments. Selecting a target speed that is artificially low without design factors to encourage travel at

the slower speed will result in operating speeds higher than desired and will be difficult to enforce.

- Speed management treatments commonly permitted on arterials include:
  - **Signal Timing:** For arterial streets through urban business contexts, coordinated signal progression can be timed to a street's target speed.
  - **Roundabouts:** Roundabouts reduce traffic speeds at intersections through horizontal deflection and by requiring motorists to move with caution through conflict points.
  - **Medians:** Pinch points for traffic in the center of the roadway can reduce pedestrian crossing distances.
  - **Curb Extensions:** Pinch points, typically at intersections, where the road narrows from the outside, restrict motorists from high speed turns and reduces the crossing distance for pedestrian.
  - **On-Street Parking:** Parking narrows the street and creates friction for moving vehicles.
  - **Road Diets:** Road diets reduce the street width through lane reduction or repurposing (e.g., addition of cycle track), creating a sense of friction.
  - **Speed Feedback Signs:** Providing drivers with feedback about their speed in relationship to the posted speed limit can be an effective method for reducing speeds at a desired location.
- Speed management is particularly important on highways that transition from high to low speed to serve as main streets through towns. Research has found roundabouts and transverse pavement markings increased the rate of speed limit compliance in the transition zone. The findings suggest additional measures are needed to maintain a speed reduction downstream of the transition zone through the community. Additional treatments shown to be effective in reducing speed through towns include speed feedback signs, speed table, median island using tubular markers, speed limit markings with red background, and gateway signs.

Areas of Alignment and Opportunity within ODOT

The Oregon Bicycle and Pedestrian Plan includes a goal to "eliminate pedestrian and bicycle fatalities and serious injuries and improve the overall sense of safety for those who bike or walk." Strategy 1.1I directs agencies to "study barriers and opportunities for the setting of posted speed limits," including safety implications of posted speeds and how they are set and developing related guidance. This helps establish the need for the overall Urban Design Initiative and use of target speed.

The Oregon Transportation Safety Action Plan directs ODOT to plan, design, and construct or retrofit facilities for desired operating speed. Additionally, the Plan provides actions to implement design treatments that achieve appropriate speeds and manage sight distance consistent with context, users, and community goals. This is consistent with the intent and definition of target speed presented earlier in Section 4.1.

Several of the speed management treatments included in the best practice guidance are already mentioned in Oregon policies and guidance. The OHP includes an action to identify engineering improvements such as geometrics, signing, lighting, striping, and signals to establish appropriate speed. A strategy of the Oregon Bicycle and Pedestrian Plan directs agencies to use design features to influence speed and lists several specific treatments including: roadway width, on-street parking, and street trees. Additionally, with regards to speed transition areas, the HDM states the most effective transitions are (1) those that establish a different roadway culture and (2) visually narrowing of the roadway using raised islands, buffer strips medians, and landscaping. The HDM begins to address the role of land use in roadway design by creating specific design criteria in relation to the OHP urban highway segment designations to differentiate urban roadway design from rural roadway design. These criteria are currently based on design speed.

ODOT's current practice for selecting design speed in urban areas is to use the current posted speed. Because most projects in urban locations are working within the existing built environment with existing alignments, design speeds below posted speeds are not considered. Best practice indicates that agencies are selecting a target speed that is appropriate for the roadway context and selecting design elements that can be implemented on existing roadways to reduce speed.

For projects on ODOT highways, the design speed is selected by the Region Roadway Manager in cooperation with Technical Services Roadway Staff. This existing process is very similar to the process that other state agencies are using to set target speed. ODOT does not have a process for setting or considering the target speed (or desired operating speed). *It is recommended that ODOT incorporates a step to help designers select a desired operating speed that aligns with the community, agency, and project goals and then select appropriate design elements and treatments to achieve the target speed. Choosing a target speed for a roadway segment should draw on the Urban Context, anticipated multimodal activity, and project goals/desired outcomes as described in Chapter 2 in the Blueprint for Urban Design. In addition,* ***ODOT should involve the multidisciplinary project team described in Chapter 4 of the Blueprint for Urban Design in target speed setting decisions.***

There is an area of opportunity within the OHP policies and strategies related to speed setting. The policies outline objectives for each state highway classification. The objective of Statewide Highways and Regional Highways is to provide high-speed, continuous flow operation. *The Blueprint for Urban Design encourages additional flexibility be added to the Statewide and Regional Highway classifications to allow for lower speeds in Urban Contexts and to further support safe movement of bicyclists and pedestrians. Currently, District Highways have different objectives in urban and rural areas; the same could be done for Statewide and Regional Highways.*

There is existing precedent in Oregon statute to set lower posted speeds in certain land use contexts. ORS 810.180 sets the default speeds as 20 mph in a business district and 25 mph in a residential district. These speeds are limited to certain types of roads defined in statute. To designate a different speed than in statute, a traffic engineering investigation is required. If that investigation indicates that a different speed is safe and reasonable, a speed zone order may be issued, and a lower speed may be posted.

ODOT depends on the 85th percentile speed as a key factor in determining the posted speed. Typically, the 85th percentile speed is adjusted based on the conditions found in the speed study. Adjustments are typically made when crash frequency is high and for developed areas with a higher potential for pedestrians and bicycles. The speed requested by the Road Authority is also taken into account. In urban areas, where lower speeds are desired, speeds are generally posted 4 to 7 mph slower than the 85th percentile as a result of the process. The OARs allow some flexibility on decisions on posting speeds. On local agency roadways and state highways within city limits, the State Traffic-Roadway Engineer has the authority to vary as much as 10 mph from the 85th percentile.

4.2 Aligning Policy, Planning, Design and Implementation of Bicycle Facilities: A Potential Approach

The information from this topical memorandum (and this approach) is included in the Blueprint for Urban Design. ODOT has clear *policy* guidance related to the topic of posted speed selection. However, ODOT can consider changes to its guidance to more effectively achieve desired operating, or target, speed. This section outlines potential guidance for consideration, with the goal of consistently applying principles in selecting design speed and responding to desires for lower operating speeds in urban areas.

Target Speed Selection

Table 10 provides a recommendation for target speed in each Urban Context, based on the best practice research summarized in Section 3. The recommended target speed should be used as the starting point. If the target speed is not practical for a specific project, justification should be provided. The Urban Context, community values, and safety for vulnerable users should be considered when reviewing trade-offs associated with a different target speed, such as construction cost or vehicle mobility objectives. The multidisciplinary project team introduced in the Blueprint for Urban Design should make the final decision in the target speed determination.

For resurfacing, rehabilitation, or restoration projects, ODOT should look for opportunities to implement speed reduction strategies that move the operating speed closer to the recommended target speed. **Table 3** and **Table 4** provide speed reduction results for several treatments. Practitioners should understand that these treatments in isolation may not result in significantly reducing operating speed, but emerging trends indicate that a combination in treatments based on the context is starting to show promising outcomes in lower operating speeds. Project teams should also become familiar with Chapter 2 of the Blueprint for Urban Design which provides more details associated with the six urban context categories, modal considerations, and other roadway designations and/or characteristics (e.g., freight) that may influence what is appropriate.

Table 10. Recommended ODOT Target Speed and Design Treatments

Urban Context	Target Speed (MPH)	Design Treatments
Traditional Downtown/CBD	20-25	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
Urban Mix	25-30	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
Commercial Corridor	30-35	Roundabout, lane narrowing, speed feedback signs, median Islands, coordinated signal timing, road diets
Residential Arterial	30-35	Roundabout, lane narrowing, speed feedback signs, median Islands, coordinated signal timing, road diets
Suburban Fringe*	35-40	Roundabouts, transverse pavement markings, lane narrowing, speed feedback signs, road diets
Rural Community	25-35	Roundabouts, lane narrowing, speed feedback signs, on-street parking[1], street trees[2], median islands, curb extensions, chicanes, speed tables, road diets

* The "fringe" context is typically adjacent to rural areas at the edge of urban development, but often is in the process of developing. For projects in the "fringe" context zone, practitioners should consider likely future development and consider applying designs for "residential arterial," "commercial corridor," or "urban mix" contexts if this type of development is likely to occur.

[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 in a specific urban context to a point where it is appropriate to have a vertical element adjacent to the roadway.

Achieving a Desired Target Speed

In practice, the target speed and design speed should be the same, and a roadway should encourage an actual operating speed at the target speed. Additional flexibility should be added to the HDM for use of lower design speeds in Urban Contexts that are not designated an STA or UBA.

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 10** includes a list of treatments that would be appropriate in each Urban Context. These treatments are currently being used on state-maintained arterials in other parts of the country. The majority of the treatments listed are not currently based on design speed in the HDM and could be used to help achieve lower operating speeds in the near-term.

Until additional research is conducted on the combined effects of each speed management treatment, speed management will be an iterative process. A single project may not reduce the speed immediately to the desired target speed.

Relationship of Target Speed to Posted Speed

The target speed is intended to be used as the posted speed limit; however, per the MUTCD, posted speeds should be established based on statutory limits unless an engineering study has been performed in accordance with established traffic engineering practices. ODOT typically uses the 85th percentile operating speed to set the posted speed within the limits of the OARs.

When the target speed is lower than the current operating speed, ODOT should consider the following near-term and long-term paths to obtain acceptance of a lower posted speed based on the speed reduction potential of the design treatments being implemented.

Near-Term – using current OARs:

1. Select target speed based on land use context (**Table 8**).
2. Select a design speed as close as possible to the target speed. The design speed should not be higher than the "inferred design speed" of the current roadway design (if there is an existing road). Designs developed to address safety but meeting a higher design speed than the inferred design speed may not reflect the desired intended outcome of the project.
3. Select design elements to achieve the target speed (shown in **Table 8**).
4. Set the posted speed as close to target speed as possible within current OARs.
5. Monitor speeds following the project. Consider stronger speed controls if speeds have not decreased as intended.
6. As operating speeds decrease in response to design, adjust posted speed to reflect the current OAR guidance – up to 10mph below 85th percentile.

Long-Term – considering updates to the OARs:

1. Evaluate the results of the City of Portland alternative method and consider advocating to apply it across the state if results show a net positive outcome.
2. Adjust OARs to reflect FHWA guidance on using 50th percentile speeds in urban areas rather than 85th percentile speeds.
3. Continue to monitor national research and guidance on setting speeds and work with Oregon cities and counties to consider context, road classification and other factors as appropriate, for establishing posted speeds to improve safety for all users of the system.

ODOT should monitor speeds before and after implementation to confirm the posted speed is appropriate given the achieved operating speed. This review and monitoring will aid ODOT in future decision-making as practitioners better understand what combinations of treatments are most effective in each context.

5. PARKING LOT

This section documents elements of this topic that are out of the scope of this technical memorandum and will be addressed through future efforts.

a. Design criteria for design speeds in urban areas. Updated tables could be a desired outcome from this process but will not be addressed in this memorandum.
b. Discussion of context-sensitive applications of design treatments to address road maintenance such as snow removal, street sweeping, freight mobility and ADA compliance.
c. Posted speed limit setting processes. This memorandum will not address legal or regulatory processes for setting posted speed limits.
d. Considerations to potentially expand STA and UBA designations that allow selecting a lower design speed or to amend the text of OHP Policy 1B to allow selection of lower design speeds in designated STAs and UBAs.
e. Consider impacts on sight distance, stopping sight distance (SSD), intersection sight distance (ISD), and decision sight distance (DSD).
f. Guidance on specific safety impacts. For instance, narrower lanes may result in more sideswipe crashes (which tend to be less severe) while reducing the severity of all crashes and reducing bike/ped crashes.
g. Policy guidance on considering tradeoffs between various functions of the roadway edge – e.g., a bicycle facility/shoulder where vulnerable users operate versus an unimpeded recovery space for motor vehicles.
h. Considerations for local agency role in identifying urban land use context areas, associated road segments, and desired speeds.
i. Safety implications of posted speeds
j. Focus on incremental approach to speed reduction.
k. ODOT should prioritize certain speed reduction strategies in specific contexts for HDM update.

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ODOT's Approach for Design in Oregon Communities

Appendix D

Example Project Goals

January 2020

APPENDIX D

EXAMPLE PROJECT GOALS

Project A - The intersection of a four-lane state arterial and two-lane local street has been identified as a problem intersection for multi-modal traffic by the City. The state arterial is programmed for routine maintenance. The City wants to explore possibilities of improving safety and pedestrian access at this intersection. Project goals:

- Provide increased safety and access to pedestrians and bicyclists crossing the intersection
- Leverage the public investment (resurfacing along state arterial) to help encourage private redevelopment

Project B - A two-mile state arterial located about 10 miles from the city's downtown has been identified as a potential redevelopment corridor by the City. ODOT wants to improve multimodal mobility and access along this five-lane roadway and has partnered with the City to develop a multimodal corridor plan. Project goals:

- Enhance connectivity and access for walking and bicycling to connect activity areas along the corridor, including safe crossing opportunities
- Improve transit access and mobility
- Accommodate regional traffic moving along the corridor
- Leverage local and state public investment to spur economic development
- Preserve and enhance existing residential neighborhoods surrounding the study area

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Appendix E

Example Performance Measures

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APPENDIX E

EXAMPLE PERFORMANCE MEASURES

Examples of project-level performance measures by mode:

Vehicular	Freight	Bicycle	Pedestrian	Transit
• Volume-to-capacity ratio • Travel-time reliability • Peak and off-peak travel time • Estimated potential reduction in crashes using crash reduction factors • Length of vehicle queues • Average or 85th percentile travel speed	• Volume-to-capacity ratio • Travel-time reliability • Peak and off-peak travel time • Ability to serve freight origins and destinations • Availability of loading zones • Average and 85th percentile travel speed	• Bicycle Level of Traffic Stress • Multimodal level of service (simplified or full calculation) • 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 • Forecast volumes of bicyclist (various methods available)	• Pedestrian Level of Traffic Stress • Multimodal level of service (simplified or full calculation) • Sidewalk coverage and connectivity • Sidewalk width • Average distance between marked crossings • Percent of ADA-compliant pedestrian crossings • Average pedestrian delay at intersections • Presence of pedestrian refuge islands • Degree of street trees and shade • Level of pedestrian-scale street lighting • Estimated potential reduction in crashes using crash reduction factors	• Number/percent of ADA-compliant transit stops • Number of residents/jobs within ¼ mile of stop locations (or ½ 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

Examples of tying performance measures to project goals and desired outcomes (based on *NCHRP Report 785* example):

Project Goals	Desired Outcomes	**Performance Measures**
• Economic revitalization of the study corridor • Enhanced long-term livability for local community • Create a more complete urban street environment • Maximize use of the existing right-of-way	• Improved road-user experience, including safety • Improved access for pedestrians, bicyclists, and transit riders • Enhanced economic activity on the street	• MMLOS (quality of service for all modes) • Predicted crashes and management of conflict points • Type and presence of multimodal facilities and transit service • Average travel time • Reliability (consistency in travel times)