Chapter 4 Multimodal Planning, Design, and Operational Considerations

4-1 Introduction

WSDOT Vision
Washington travelers have a safe, sustainable, and integrated multimodal transportation system

Washington's Transportation Plan envisions an integrated system safely connecting people and communities – fostering commerce and economic opportunity for all, operating seamlessly across boundaries, and providing travel options to achieve an environmentally and financially sustainable system. Achieving a complete transportation system requires us to provide a variety of transportation options to all users. Not only will such a system serve everyone, it will function more efficiently. The benefits are significant and wide- ranging such as a cleaner environment, a stronger economy and a more mobile and healthy population.

Multimodal Transportation Systems
A transportation network that accommodates multiple modes of travel for the movement of people and goods including, but not limited to, walking, rolling, bicycling, using public transit, and driving.

Transportation system integration requires all partners to pull from a larger, multimodal toolbox to consider solutions that can best serve the interests of communities and the traveling public. Highways and streets are a community asset where access to transit facilities and services are found; bicycle and pedestrian connections are complete; and access to major employment, education, social service and residential destinations are a priority. The roadway system needs to feel safe for all users and it should both benefit and respond to the needs of people and communities around it.

Chapter 4 of the *Traffic Manual* is intended to expand the toolbox of strategies and complement the *Design Manual*, AASHTO, NACTO, FHWA polices and guides.

4-2 Background

Washington State's population is projected to grow more than 20 percent during the next 20 years. In Spokane and Clark counties, the population is expected to grow to more than 500,000 people and Central Puget Sound is expected to add another million people in the coming decades.[1] This population growth will likely be accompanied by a number of challenges including:

- Addressing a greater backlog of public infrastructure maintenance needs
- Serving a larger number of people who are over 65 years old
- Serving an increasing percentage of the population with disabilities
- Helping a growing number of people facing health and economic inequality
- Responding to the needs of a more urbanized population and the transportation issues associated with suburbanized poverty
- Putting greater effort into the need to address climate change

The 2050's will see an increasingly diverse population, which will bring both cultural richness as well as the challenges providing a transportation system that provides for needs of road users in an equitable manner. All of these trends challenge us find the best use of the broad array of transportation services and systems, both public and private that are available to the public.

4-3 Policy

4-3.1 United States Department of Transportation

23 CFR § 652.5 states, "the safe accommodation of pedestrians and bicyclists should be given full consideration during the development of Federal-aid highway projects, and during the construction of such projects. The special needs for the elderly and the handicapped shall be considered in all Federal-aid projects that include pedestrian facilities. Where current or anticipated pedestrian and/or 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. On highways without full control of access where a bridge deck is being replaced or rehabilitated, and where bicycles are permitted to operate at each end, the bridge 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."

It is the policy of the United States, as described in 49 U.S.C. §70101 to maintain and improve the condition and performance of the National Multimodal Freight Network to ensure that the network provides a foundation for the United States to compete in the global economy.

Chapter 53 of Title 49 of the U.S. Code establishes the authority for FTA. It incorporates the Urban Mass Transportation Act originally enacted in 1964 and states that "it is in the interest of the United States, including its economic interest, to foster the development and revitalization of public transportation systems that (1) maximize the safe, secure, and efficient mobility of individuals; (2) minimize environmental impacts; and (3) minimize transportation-related fuel consumption and reliance on foreign oil."

1 Washington State Public Transportation Plan

4-3.2 WSDOT Executive Orders

Executive Order 1090.00 *Advancing Practical Solutions*: Practical Solutions uses tools, data analytics, performance measures, and stakeholder input to (1) seek lower-cost approaches and efficiencies in expanding and operating the multimodal transportation system to reduce travel demand and the need for building costly new infrastructure, identify, evaluate, analyze, and manage risk to WSDOT's strategic objectives, and identify and implement agency efficiencies. See *Design Manual* Division 11 for guidance on implementing Practical Solutions.

Executive Order 1113 *Sustainability*: This policy directs WSDOT's actions in a manner that helps Washington's economy, environment, and communities prosper now and for generations to come. To sustain prosperity, it is essential that WSDOT address current needs while preserving the ability of future generations to meet their needs. WSDOT employees are directed to take actions that sustain economic, environmental, and societal prosperity for current and future generations through a focus on energy efficiency, pollution reduction, and enhanced resilience.

WSDOT Safety Goal is Zero Fatalities and Serious Injuries by 2030

WSDOT is committed to multimodal safety as identified in Washington State's Strategic Highway Safety Plan.

The Washington Department of Transportation (WSDOT) and Washington Traffic Safety Commission (WTSC), along with dozens of partners, collaborated to create the Target Zero Strategic Highway Safety Plan (SHSP). Target Zero is a statewide, data-driven effort to reduce fatalities and serious injuries to zero by the year 2030. We will do this by developing strong leadership in organizations that directly affect highway safety, and using partnerships to develop and implement innovative, data-based solutions based on a safe systems approach. Our goal is zero deaths and serious injuries, because every life counts. For more information about the Washington Strategic Highway Safety Plan visit the Target Zero website : TargetZero.com

4-3.3 State Multimodal Transportation Plans

- WSDOT Strategic Plan
- Washington Transportation Plan
- Washington State Strategic Highway Safety Plan (Target Zero)
- WSDOT Active Transportation Plan
- ADA Transition Plan
- Statewide Human Services Transportation Plan (HTSP)
- Washington State Public Transportation Plan
- Highway Systems Plan
- Freight System Plan
- Washington State Ferries Long Range Plan
- Washington State Rail Plan
- Washington Aviation Systems Plan

4-4 Equity and Transportation

Transportation is essential for healthy, thriving communities. Safe, reliable, affordable transportation opens doors to economic and social opportunities for many people. However, not all people have the same access. Equity refers to the distribution of benefits and costs or burdens across race, economic status, disability status and other characteristics and whether that distribution is fair in the context of past and current disparities. Transportation equity focuses on transportation system effects in an effort to understand where costs and burdens are unfairly distributed. It reflects the input of an inclusive process involving the people who will be affected. This is the starting point for transportation decisions and investments that create a more just system that works for all.

Did you know?
Communities with poverty rates higher than the state average also have the highest numbers of households that lack access to a personal vehicle and are therefore more likely to rely on walking, bicycling, and transit for their transportation needs. However, studies show a long pattern of investment inequity in lower-income neighborhoods.
"Children who grow up in walkable communities fare better economically, controlling for a wide range of economic factors as well as the related characteristics of those neighborhoods." – Kids Raised in Walkable Cities Earn More Money As Adults, CityLab.
The cost of transportation and housing are inextricably linked and also play a role in traffic safety and health equity. For example, housing within walking distance of a main street or neighborhood shopping district can allow for the replacement of daily car trips with walking trips.

WSDOT has a number of tools to support analysis of existing data to use when considering equity on transportation projects. Some programs and projects will require collection of additional data. Existing data sources include:

WSDOT Application for Local Planning and Community Accessibility (ALPACA) provides demographic mapping tools for race/ethnicity, age, disability, and limited English proficiency.

United States Environmental Protection Agency EJSCREEN: For more information visit the Environmental Justice Screening and Mapping Tool. EJSCREEN is an environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining environmental and demographic indicators.

The 2020 Active Transportation Plan update included equity criteria (race, poverty, disability) in its location evaluation methodology. A GIS-based analysis of state right of way developed for the plan is available and should be consulted.

Office of Superintendent of Public Instruction (OSPI) Report Card. This webpage has information about student demographics, percent of children eligible to receive free and reduced-price meals and student population size for all public schools in Washington.

The primary guide for community engagement is the WSDOT Community Engagement Plan. The WSDOT *Environmental Manual* Chapter 458 and Social and Community Effects webpage provide guidance for engagement under NEPA and SEPA. The Washington Environmental Health Disparities Map provides an interactive tool based upon census data that combines public health and pollution measures to aid in understanding effects of transportation in the context of overall environmental health. The Washington Tracking Network maintained by the Washington State Department of Health provides census based information on variables such as household income, personal vehicle ownership, and other information relevant to equity analysis.

4-5 Multimodal Planning

Transportation facilities should provide for reasonable safe movement of people, goods, and services by multiple transportation modes, including motorized vehicles, bicycling, walking, transit, and others. WSDOT is moving towards the Safe Systems approach to roadway safety. This is a paradigm shift, a change in the way we understand transportation for all road users and identify solutions.

When evaluating the transportation system performance, the old paradigm considered motor vehicles as the main and dominant transportation mode, giving little consideration to other modes and the effects on those movements. The new paradigm is multimodal and comprehensive. Current WSDOT policies recognizes non-auto travel demands, and a wide range of economic, social and environmental effects, including vehicle ownership costs, parking costs, health effects, and the benefits of providing independent mobility for everyone regardless of mode. Speed management is a tool for the goal of reducing the incidence and severity of crashes for people using all modes.

When planning for motor vehicle and transit modes we generally think about complete systems. We want to provide travel that does not have a high probability of a crash. Such concepts apply equally well to all modes including freight, transit, and active transportation planning, though in practice we often pay more attention to isolated elements of a network like specific intersections.

In evaluating movements for all modes consider the larger areas people are likely to use. Look at where schools, grocery stores, and other services are located relative to where people live. Also consider active transportation access to intermodal connections. It is useful to take the perspective of travelers who don't own motor vehicles and can't always make use of transit, walking, or biking. The Active Transportation Plan provides methodologies for understanding network quality and connectivity and associated performance measures.

Ideally, network improvements would be considered that help increase the active transportation and/or transit mode share. Where improvements are specific to a given facility, however, it is still necessary to understand how that facility interacts with the broader network. When changes to a facility reduce utility of the broader active transportation network, consider on and off-system investments that restore network connectivity and functionality. Changes that increase roadway width, posted or operating speed, and/or motor vehicle volume increase the potential for crashes that can be serious or fatal for people using active transportation. At the planning stage, potential changes to crash exposure and mobility because of new design and future operations need to be considered. Planning actions that help remove or mitigate barriers to active transportation should be identified. Increasing mode share for active transportation and transit is considered a form a transportation demand management and can be considered to supplement or replace congestion mitigation. Mode share increases for active transportation modes occurs when road users feel reasonably safe and secure on the transportation systems.

There is not one single approach to optimizing to meet the needs of all road users on the highway system. Keys to multimodal planning include:

- Put safety first to support elimination of fatalities and serious injuries on all public roads and to reduce the severity of the crashes that may occur (e.g., everyone should to get home safely).
- Learn and understand existing and future contexts.
- Being mindful of project context beyond the immediate footprint.
- Collaborate with colleagues, subject matter experts, and stakeholders.
- Engage communities. For example: listen to priorities, discuss constraints, educate, find forums to engage, and review the Regional Transportation Plans and other relevant plans.
- Look for opportunities on all projects to improve mobility and accessibility for all modes. For example, roadway lanes can be re-purposed to add pedestrian and bicycle facilities. Safety does not need to be at the expense of increased mobility when all road users are factored in.
- Considering performance measures beyond vehicle peak hour analysis. Designing for the peak vehicle hour can lead to overbuilding facilities. Consequences of overbuilding highways can include reduced safety performance, higher maintenance costs, and increased stormwater runoff, as well as the creation of barriers to greater active transportation use that otherwise could reduce the peak load. The Exhibit 4-1 provides examples of common metrics used versus ones that are often not used.

Exhibit 4-1 Performance Metrics Examples

PERFORMANCE FACTORS CONSIDERED AND OVERLOOKED	
Usually Considered	**Often Overlooked**
Travel Time (reduced congestion)	Induced travel impacts
Project Cost	Downstream and upstream congestion
Environmental Impacts	Effects on to other modes especially active transportation
Crash History	Construction traffic delays
Property	Public health
	Effects on land use
	Statewide safety goals
	Future operations and maintenance
	Department’s strategic vision and goals

4-5.1 Community Engagement

WSDOT communications are an integral piece of our agency’s work and how we accomplish our mission to provide and support safe, reliable and cost-effective transportation options to improve livable communities and economic vitality for people and businesses. Our commitment to inclusion requires interaction and/or coordination with community and advocacy groups, chambers of commerce and downtown associations, tribes; local, state, and federal government agencies, other stakeholders, and the general public. Our agency communication philosophy includes these key points:

- Everyone is a communicator
- Engage early, often
- Be accountable, transparent
- Use all the tools
- No surprises, clearly state your intent
- A consistent brand is important

WSDOT resources to help include the *Communications Manual*, Visual Engineering Resource Group, and WSDOT Community Engagement Plan. FHWA also has published a guide called Public Involvement Techniques for Transportation Decision Making.

4-5.2 Multimodal Transportation Analysis Tools

Balancing the demands on the transportation system within a multimodal framework requires effort to identify affordable and effective solutions. WSDOT has various tools available to assist with this effort, which include but are not limited to:

Design Manual Chapter 320 - Traffic Analysis. Traffic Analysis is either "operational" or "planning" in nature. Traffic Analysis are generally examines areas such as corridors or larger geographic areas. Outcomes of Traffic Analysis include identification of multimodal needs in a corridor and effects of land use changes. These studies typically do not reach the level of providing intersection control and geometric design recommendations. Intersections are defined by Intersection Control Evaluations.

Design Manual Chapter 1300 – Intersection Control Type. Intersection Control Evaluations (ICE). ICE is a data-driven, performance-based framework used to objectively screen alternatives and identify an optimal geometric and control solution for an intersection. ICE studies can include more than one intersection or be applied on an entire corridor as needed. ICE policy is intended to be flexible, adaptable, and provide a transparent multimodal decision making process.

Design Manual Chapter 1100 – Practical Design. Practical Design is our approach to achieving the WSDOT mission. This is how we plan, design, build, operate and maintain the state's transportation system. Our goal is to identify and solve problems as quickly and inexpensively as possible. This approach uses performance-based and data-driven decision making with early community involvement to guide the development and delivery of transportation investments. Practical Solutions strategies include:

- Lowest lifecycle cost to preserve the system in a state of good repair
- Target Zero strategies for safety
- Transportation System Management and Operations (TSMO)
- Mobility management;[2] and
- Capital project investment

[2] Mobility management includes Transportation Demand Management (TDM) strategies such as programs and services that help encourage transportation alternatives, reduce reliance on the private automobile for travel, and reduce vehicle miles traveled (VMT) and greenhouse gas emissions. A good example of mobility management strategies can be found in the San Diego's Mobility Management Guidebook. WSDOT Transportation Demand Management website is another resource

Traffic Manual Chapter 12 – Multimodal Transportation Impact Analysis. If highway or intersection capacity is measured only for automobiles, then mitigation required to address "deficiencies" will only add automobile capacity in the form of vehicle travel or turn lanes, which may compromise the viability and safety of pedestrian, bicycle, and transit modes. Widening a street may not be feasible from a physical or economic standpoint, and it might not be desirable from a practical design or land use standpoint, either. Chapter 12 provides guidance to measure transportation effects across the modes.

Safety Analysis Guide - The purpose of this guide is to provide guidance to WSDOT staff regarding expectations for safety analysis. This guide defines the focus, scale, and scope of safety analyses across the different WSDOT program areas as well as safety analysis outside the typical program areas.

4-5.3 Multimodal Transportation Documentation

Every project has a unique land use and transportation context. Understanding and documenting the project's context is critical to successful application of state and WSDOT goals and defining multimodal transportation needs. Context should be viewed as both a constraint and an opportunity. WSDOT *Design Manual* Chapter 1102 provides guidance on how to define land use and transportation context and documentation requirements for the Basis of Design. The WSDOT Context and Modal Accommodation Report (CMAR) is available for determining the existing and future multimodal context.

Sources of information to assist with documentation include resources listed in Section 4-3.3 and those listed below:

- Stakeholder and/or community engagement
- Local and regional plans and/or studies
- Local land use plans
- Local design standards
- Local transit routes, plans, and/or studies
- WSDOT *Design Manual*
- WSDOT Corridor Sketches
- WSDOT planning studies
- Truck Freight Economic Corridor Maps
- Freight and Goods Transportation Map (FGTS)
- Freight Systems Plan
- Functional Classification Maps
- National Highway System Map
- WSDOT GeoPortal Map
- WSDOT Traffic GeoPortal

Definition of Context
"Context refers to the environmental, economic, and social features that influence livability and travel characteristics. Context characteristics provide insight into the activities, functions, and performance that can be influenced by the roadway design. Context also informs roadway design, including the selection of design controls, such as target speed and modal priority, and other design decisions." WSDOT *Design Manual* Chapter 1102.

How to document multimodal decisions
The multimodal assessment can be incorporated into existing studies (Traffic Impact Analysis, Intersection Control Evaluations, Basis of Design, Practical Design, Context and Modal Accommodation Report, Sustainable Safety Analysis) or other project documentation versus a standalone evaluation. Each of these forms includes multimodal questions or spaces for information you will need to consider.

- WSDOT Bicycle & Pedestrian Count Portal
- WSDOT Active Transportation Plan
- Public Transit Authority Map
- Airport Mapping Application

4-6 Active Transportation

Effective active transportation networks lead to more people walking and bicycling by creating routes that are safe, efficient, seamless, and easy to use. Years of research confirm the public health benefits of active travel modes like walking and biking. Organizations like the Centers for Disease Control and Prevention and the National Institutes of Health, among others, have long advocated for Americans to increase physical activity to reduce avoidable chronic conditions associated with inactivity. Providing well-designed and managed facilities for people walking and rolling also provides important information for drivers to understand the mix of uses present in a corridor.

Pedestrian & Bicyclist Safety
In 2015–2017, 20 percent of all traffic fatalities in our state, and 20 percent of all traffic serious injuries, were people walking or biking. These figures continued to climb in 2018. At 109 fatalities, pedestrian deaths reached their highest number in more than 30 years. Compared to 2012–2014, the 2015–2017 figures show a 41 percent increase in fatalities for people who walk and bike, and an 11 percent increase in serious injuries. ***Source:*** Washington Strategic Highway Safety Plan

4-6.1 Pedestrian Facilities

Pedestrian travel is a vital transportation mode. It is used by everyone at some point in each trip and is a critical link to everyday life for many. *Design Manual* Section 1510 outlines WSDOT polices regarding pedestrian facilities.

When evaluating pedestrian facilities in urban core, urban, suburban, and rural town/community population centers contexts consider the following:

- Local agency road standards, criteria, and guidelines
- Motor vehicle traffic volume, traffic speeds, number of travel lanes; the Level of Traffic Stress index developed for the Active Transportation Plan incorporates these elements
- Safety considerations: observed crashes, near miss data, pedestrian and bicycle volumes, safety analysis, opportunity for speed management, injury minimization policy
- Land use consideration: Presence of current or future planned destinations, context, opportunity to support latent pedestrian demand, demographics indicating higher number of disabled people and/or people reliant on active transportation/transit
- Multimodal connectivity: Transit usage, presence of transit stops, other modal connections, modal mix, roadway design, active transportation facilities connected to the particular segment in question
- Consider demographics of the population within the walk shed of the location. Give special consideration to equity, age, disabilities, car ownership, and income. These area characteristics can affect reliance on active transportation facilities and public transportation services.
- Stakeholder and community input
- Other considerations: Maintenance, other factors

A. Sidewalk Width

Sidewalk width should be sufficient to facilitate easy movement by pedestrians and may vary depending on the character of an area. At a minimum, sidewalk widths must meet the contextual needs of the pedestrian access route. Where the sidewalk is not buffered from motor vehicle traffic, the preferred total width for a curb-attached sidewalk is at least 6 feet in residential areas and at least 8 feet in commercial areas. Additional width should be provided as needed in commercial areas for frontage zones and in locations where large volumes of pedestrian traffic can be expected based on context. In locations where sidewalks are constructed so that they are immediately adjacent to roadways and building faces, the walkway should include at least 2 feet of width for shy distance from walls, railings and fixed objects while also providing the necessary width for easy travel by the expected pedestrian, including those who use wheelchairs or other mobility devices.

Curb-attached sidewalks and buffer areas should be considered on all new and reconstructed state facilities and incorporated whenever possible in population centers.

B. Sidewalk Buffer

In general, separation between pedestrian and motor vehicle traffic is desirable. The optimal width of a buffer zone varies depending on the character of an area and the traffic conditions on the adjacent roadway. Increased buffer width can reduce traffic stress for pedestrian's providing a sense of safety and comfort and reducing crash exposure. Greater separation from traffic is desirable where there are higher vehicle volumes and/or higher speeds.

Where curb-attached sidewalk is provided, at least a 3 foot buffer is required. Where an at grade pedestrian facility is separated from motor vehicle traffic by a swale or ditch a buffer zone of at least 4 feet or wider is recommended. Buffers should be maximized on higher speed, higher volume roadways. A buffer zone 7 feet wide will allow for installation of curb ramps, street lights, and signs outside the pedestrian access route. The buffer should be widened to accommodate the space occupied by any objects placed there, and still provide 2 feet clear to both the roadway and the sidewalk.

On roadways without curbs, buffer widths equal to or greater than the clear zone appropriate for the roadway are desirable.

Wider buffers also provide space to manage driveway slopes, making it easier to comply with cross slope limits that facilitate the preservation of the pedestrian access route at driveway crossings and prevent the need to drop sidewalks to grade at every driveway crossing. Buffer areas are frequently used for storage of snow removed from adjacent roadways in climates where snow accumulation is common. If the buffer area is used for snow storage, the buffer width should be scaled accordingly, bearing in mind that people who rely on pedestrian access continue to do so during the winter.

Rural Buffer

Suburban Buffer

Urban Buffer
Source: NACTO

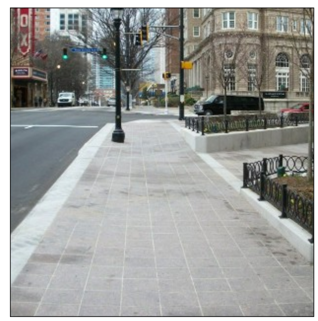
C. Multipurpose sidewalk buffers

During planning and design consider buffer areas that serve multiple purposes such as stormwater management, clear zone, bike parking, bike paths, snow storage, or hardscape buffer areas. *Design Manual* Chapter 301 discusses maintenance agreements between state and local agencies.

Urban stormwater management buffer

Surburban stormwater management buffer

Urban hardscape buffer
Source: NACTO



4-6.2 Pedestrian Crossings at Uncontrolled Locations

Uncontrolled pedestrian locations occur where a sidewalk or pedestrian path intersects a roadway where no traffic control exists such as a stop sign or traffic signal. This locations can be at intersections or midblock locations.

The focus of this section is crossings without intersection control such as a traffic signals or stop signs. Many of the design considerations for uncontrolled crossings can be incorporated into locations with controls as well; controls may need to be increased based on traffic volumes and speed.

Between 2015-2017, over half (54%) of all pedestrian and bicyclist fatalities and serious injuries occurred while the person was crossing the roadway. By focusing on pedestrian crossing needs and understanding crossing patterns agencies can take advantage of a significant statewide safety need and improve quality of life and transportation access for pedestrians of all ages and abilities. Bicyclists in crosswalks are defined in state law as pedestrians; their transportation needs are also addressed through crossing improvements.

A. Federal Law

The *Manual on Uniform Traffic Control Devices for Streets and Highways*, or MUTCD defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public travel. The MUTCD is published by the Federal Highway Administration (FHWA) under 23 Code of Federal Regulations (CFR), Part 655, Subpart F.

B. State Law

Legal crosswalks exist at all intersections, whether marked or not, per RCW 46.04.160. Marked crossings at other locations are called mid-block crossings and can occur at schools, commercial areas, parks, transit stops, or other areas where pedestrians need to cross the roadway. See *Design Manual* Chapter 1510 for additional discussion on marked and unmarked crossings.

C. Agency Application

Designated crosswalks provide guidance for pedestrians and in conjunction with other measures help alert road users to a pedestrian crossing across a roadway. There are many factors to consider when deciding whether a marked pedestrian crossing is recommended at a specific location and what type of treatment is appropriate. Because every situation is unique, it is impossible to prescribe a "one size fits all" evaluation process that would work in every situation. The study process and criteria here are presented as guidance. Consult the WSDOT Action Plan for Implementing Pedestrian Crossings Countermeasures at Uncontrolled Locations for additional discussion. The final decision to install pedestrian crossing infrastructure is subject to review and approval of the Region Traffic Engineer.

D. Studies

WSDOT requires an engineering study to determine whether a crosswalk should be provided and the treatment needed. Implementation of a marked crosswalk at an uncontrolled location shall require approval from the Region Traffic Engineer or designee in accordance with *Design Manual* Chapter 1510.

WSDOT uses engineering studies to determine where Pedestrian Signals or Pedestrian Hybrid Beacons may be used on State Highways.

Engineering studies are recommended for updating existing marked uncontrolled crossings.

An engineering study by WSDOT is not required for systems installed by local jurisdictions. Local agencies will need to comply with all applicable DOT permit approval processes.

E. Study Components

The engineering study should include:

- Location description and physical data
- Establish location context and modal priorities. See *Design Manual* Chapter 1102 and 1103 respectively.
- Review state, regional, and local plans
- Establish crossing need and patterns
- Identification of crossing treatments or countermeasures
- Stakeholder and community outreach
- Recommended action

F. Location Description and Physical Data

The following items are not an exhaustive list but can be used as guide to begin a study.

- Traffic volume, traffic speeds, number of travel lanes, destinations, transit or public transportation usage, and roadway classification. Also consider the Level of Traffic Stress index developed for the Active Transportation Plan, which incorporates as most of these elements.
- Roadway geometrics and visibility
- Traffic control and lighting
- Pedestrian/bicyclist safety data including crash severity and frequency
- Pedestrian/bicyclist volumes (noting that volumes may be low due to the lack of appropriate facilities, not lack of need or demand)
- Known pedestrian/bicyclist crossing activity in dark or night time conditions
- Proximity to adjacent enhanced crossings
- Proximity to transit stops, other intermodal connections such as ferry landings and rail stations, trails/shared-use paths, or other pedestrian/bicyclist generators (employment centers, schools, parks, restaurants, bars, businesses, health services, etc.)
- Land use context and future land use changes, growth, or development patterns
- Demographics of the population within the walk shed of the location
- Pedestrian/bicyclist delay or suitability of gaps
- Consistency with local agency plans that include the location as a part of their pedestrian/bicycle network

G. Establish crossing need

After data collection is complete the next step is assessing the pedestrian/bicyclist need at the location, as well as the suitability of the location based on roadway, traffic, and adjacent land use characteristics. Pedestrian crossing needs may exists if any of the following are indicated:

- Pedestrian/bicyclist crash and near miss history
- Crash types and contributing factors
- Known pedestrian/bicyclist crossing activity especially in dark or night time conditions
- Proximity to adjacent enhanced crossings
- Proximity to transit stops, trails/shared-use paths, or other pedestrian/bicyclist generators (employment centers, schools, parks, restaurants, bars, businesses, health services, etc.)
- Land use context and future land use changes, growth, or development patterns
- Demographics of the population within the walk shed of the location. Give special consideration in communities where there are higher numbers of people over 65, people with disabilities, and areas of lower income.
- Pedestrian/bicyclist delay or suitability of gaps
- Walking desire lines or biking patterns
- Consistency with state or local agency plans that include the location as a part of their pedestrian/bicycle network

H. Safety Data Discussion

Pedestrian crash data are the most commonly used statistic for evaluating safety. However, the frequency and accuracy of pedestrian and bicyclist crash data are generally low and research has found that crashes are underreported. Therefore using crash data as the sole method by which crossings are evaluated is not usually practical. Surrogates for crash data include roadway speeds, number of lanes, vehicle volumes, population density, and population demographics such as age and ethnicity. The Level of Traffic Stress developed for the Active Transportation Plan can serve as a proxy in the absence of crash data.[3] FHWA guidance on determination and use of pedestrian risk factors can be found in the following FHWA documents:

- Systemic Pedestrian Safety Analysis
- Synthesis of Methods for Estimating Pedestrian and Bicyclist Exposure to Risk at Area wide Levels and on Specific Transportation Facilities

[3] Contact Active Transportation Division to obtain this information

I. Collaboration with Stakeholders

Collaboration is a priority so improvements are consistent with state and local plans, goals, and overall network connectivity. Contact local agencies and communities affected by the project to help understand local context early to help aid in evaluating the project site.

J. Determine pedestrian crossing needs or countermeasures

This step of the engineering study is to evaluate the crossing based on the roadway and traffic characteristics. These characteristics relate to the FHWA guidance found in Exhibit 4-2 and 4-3. Characteristics to consider include: Traffic volumes, posted speed, number of lanes (total and number that would need to be crossed consecutively without an intermediate pedestrian refuge), presence of median, motorist and pedestrian sight distance, proximity to nearby enhanced crossings, ADA compliance of existing features, illumination, and presence of on-street parking.

K. Identify Countermeasures Options - FHWA Pedestrian Crossing Treatment Guide[4]

Once the need for a pedestrian crossing is established and the location is identified, the next step is to select the crossing treatment. This section presents countermeasures FHWA suggests to consider for various roadway conditions. Exhibit 4-2 is a baseline guide for evaluating countermeasure options for roadway conditions such as vehicle volumes, speeds, and roadway configuration. Each matrix cell indicates possibilities that may be appropriate for designated pedestrian crossings. In all cases, the countermeasures, when implemented, should follow MUTCD and other relevant AASHTO, FHWA and state policies. Follow department policy and guidance if conflicts arise with use of this table. See Section 4-6.3 for supplemental RRFB guidance.

Changes made for speed management to minimize serious-injury and fatal collisions by reducing posted and operation speeds will change crossing conditions and control measures.

[4] Exhibit 4-2 was adapted from FHWA Guide for Improving Pedestrian Safety at Uncontrolled Locations, 2017.

Exhibit 4-2 Application of pedestrian crash countermeasures by roadway feature

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

Given the set of conditions in a cell,

Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.

● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.

○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

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

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

*Refer to Chapter 4, 'Using Table 1 and Table 2 to Select Countermeasures,' for more information about using multiple countermeasures

**It should be noted that the PHB and RRFB are not both installed at the same crossing location.

This table was developed using information from: Zegeer, C.V., J.R. Stewart, H.H. Huang, P.A. Lagerwey, J. Feaganes, and B.J. Campbell. (2005). Safety effects of marked versus unmarked crosswalks at uncontrolled locations: Final report and recommended guidelines. FHWA, No. FHWA-HRT-04-100, Washington, D.C.; FHWA. Manual on Uniform Traffic Control Devices, 2009 Edition. (revised 2012). Chapter 4F, Pedestrian Hybrid Beacons. FHWA, Washington, D.C.; FHWA. Crash Modification Factors (CMF) Clearinghouse. http://www.cmfclearinghouse.org/; FHWA. Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE). http://www.pedbikesafe.org/PEDSAFE/; Zegeer, C., R. Srinivasan, B. Lan, D. Carter, S. Smith, C. Sundstrom, N.J. Thirsk, J. Zegeer, C. Lyon, E. Ferguson, and R. Van Houten. (2017). NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. Transportation Research Board, Washington, D.C.; Thomas, Thirsk, and Zegeer. (2016). NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways. Transportation Research Board, Washington, D.C.; and personal interviews with selected pedestrian safety practitioners

L. Addressing crossing characteristics

Exhibit 4-3 shows the specific crossing characteristics that each countermeasure may address. For example, the addition of Pedestrian Hybrid Beacons has been consistently shown to improve motorist yielding by 90 percent or greater, when compared with no traffic control or warning type devices. This table is from FHWA Guide for Improving Pedestrian Safety at Uncontrolled Locations, 2017 and WSDOT's Action Plan for Implementing Pedestrian Crossings Countermeasures at Uncontrolled Locations.

Exhibit 4-3 Safety issues addressed per countermeasure

Pedestrian Crash Countermeasure for Uncontrolled Crossings	Crossing Characteristic Addressed				
	Conflicts at crossing locations	Excessive vehicle speed	Pedestrian conspicuity & visibility	Driver not yielding to pedestrians in crosswalks	Separation from traffic
Crosswalk visibility enhancement	🚶	🚶	🚶	🚶	🚶
High-visibility crosswalk markings*	🚶		🚶	🚶	
Parking restriction on crosswalk approach*	🚶		🚶	🚶	
Improved nighttime lighting*	🚶		🚶		
Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line*	🚶		🚶	🚶	🚶
In-Street Pedestrian Crossing sign*	🚶	🚶	🚶	🚶	
Curb extension*	🚶	🚶	🚶		🚶
Raised crosswalk	🚶	🚶	🚶	🚶	
Pedestrian refuge island	🚶	🚶	🚶		🚶
Pedestrian Hybrid Beacon	🚶	🚶	🚶	🚶	
Road Diet	🚶	🚶	🚶		🚶
Rectangular Rapid-Flashing Beacon	🚶		🚶	🚶	🚶

*These countermeasures make up the STEP countermeasure "crosswalk visibility enhancements".
Multiple countermeasures may be implemented at a location a part of crosswalk visibility enhancements.

M. Using Multiple Countermeasures

Exhibit 4-2 provides baseline countermeasure considerations for various roadway conditions. Not all of the countermeasures listed in the matrix cell should necessarily be installed at a crossing. WSDOT staff should also review crossing characteristics discussed in Exhibit 4-3, the surrounding land development context, pedestrian travel patterns, and countermeasure effectiveness when considering what countermeasure(s) are best suited for the crossing. Apply practical solutions approach to determining appropriate treatments within the context of the project or program.

N. Multi-lane and high volume roads

At multi-lane roadway crossings where vehicle daily traffic volumes are in excess of 10,000 vehicles, a marked crosswalk alone is typically not sufficient.[5] Under such conditions, more crossing improvements are also needed to reduce pedestrian crash potential. Examples of more substantial treatments include a refuge islands, a pedestrian signal, and RRFB (rectangular rapid flashing beacon). Refer to the symbols used in Exhibit 4-1 for when a marked crosswalk should be paired with one or more of the other countermeasures described. Advance stop lines and "Stop Here for Pedestrian" signs shall be used in advance of all crosswalks with more than two or more through lanes in one direction. See MUTCD 3B.16 for guidance and IS-23 for additional Pedestrian Crossing Details.

O. Sight Distance

See *Design Manual* Chapter 1320 for establishing site lines at roundabouts and Chapter 1510 for establishing sight lines at other crossings.

P. Existing Crossings

Improving existing crossings that are not part of a new construction and alternations can be challenging for many reasons such as the natural or built environment, funding, and resource availability. The goal is to reduce the potential for, and the severity of crashes while also using the Department's limited resources strategically. For example, Exhibit 4-2 does not suggest considering Rectangular Rapid Flashing Beacons (RRFB) for three lane (1 lane in each direction with a two-way left-turn lane) roadways without medians, traffic volumes over 15,000 ADT, and speeds in excess of 35 mph. If the crosswalk will remain in place a RRFB does improve conspicuity so it still may be a practical solution until such time the roadway is reconstructed or additional funding is secured.

Q. Increasing conspicuity of crossing

To further increase visibility of pedestrian crossings, consider integrating multiple countermeasures or enhancing existing ones. Examples include:

- Doubling up signs (left and right) or adding retro-reflective strips to sign posts can enhance existing measures.
- RRFB are often installed in conjunction with advance stop markings and signs.
- Road diets or pavement reallocation present opportunities for adding pedestrian refuge islands and curb extensions at key crossing locations. Consider roadway geometry and the MUTCD when integrating multiple countermeasures.

5 Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations, FHWA, 2005

4-6.3 Pedestrian and Bicycle Beacons on State Highways

A. Rectangular Rapid Flash Beacons

At some uncontrolled crossings, particularly those with four or more lanes, and posted speeds above 25 mph it can be difficult to achieve compliance with laws that require drivers to yield to pedestrians. One type of device proven to be successful in improving driver yielding compliance at crossings is the rectangular rapid flash beacon (RRFB). RRFBs are a pedestrian crossing sign combined with an intense and rapid flashing beacon that is only activated when a pedestrian is starts it. Unlike pedestrian signals or hybrid beacons, these devices provide immediate service to pedestrians meaning there is little or no wait times. Studies indicate that pedestrians can become impatient when experiencing delays.[6]

RRFBs are considerably less expensive to install than mast-arm mounted pedestrian signals and are considered a practical crosswalk improvement solution. They can also be installed with solar-power panels to eliminate the need for a power source. RRFBs should be consistent with the WSDOT standard plan sheet library for Rectangular Rapid Flashing Beacon (RRFB) Details & Pedestrian Crossing Details (IS-22 & IS-23). They are usually implemented at high-volume pedestrian crossings, but may also be considered for school crossings, priority bicycle route crossings or locations where bike facilities/trails cross roads at mid-block locations. RRFBs must be in accordance with FHWA's Interim Approval (IA-21), issued on March 20, 2018. WSDOT has already resubmitted, and received approval from FHWA, to use the RRFB.

Exhibit 4-4 below describes the conditions under which RRFBs, alternate beacons, and advance beacons should be used. Installation on roadways with a posted speed greater than 40 mph requires a crossing study with approval from the Region Traffic Engineer. At any location type marked as "Optional" or "Not required", RRFB's or other pedestrian beacons may be installed by the local jurisdiction, but the local jurisdiction is responsible for all costs and materials for installation, maintenance, and repairs. A crossing study by WSDOT is not required for systems installed by the local jurisdiction.

Exhibit 4-4 Use of RRFB's on State Highways

Roadway Type	Posted Speed Limit (MPH)	RRFB/Alternate Beacon at Crossing [1]	Advance Beacons [2]
All roadway lane configurations	≥40	Required	Optional
	35	Optional	Optional
	≤30	Not Required	Not Required
Roundabouts	Any Speed	Contact HQ Traffic Office	
Regional Trail Crossing	Any Speed	Contact HQ Traffic Office	

Notes:

1. ADT should be considered as part of the decision.
2. Advance beacons are required when driver sight distance is not met for the crossing.

[6] 2016 *Highway Capacity Manual*, Chapter 19

B. Pedestrian & Bicycle Beacon Placement

The locations of the primary and advance beacons varies with the configuration of the roadway. Beacons shall be placed as shown in the IS-23 details (available on the IS-22 web page at www.wsdot.wa.gov/Design/Standards/PlanSheet/IS-22.htm.

Where Advance Circular Beacons are installed due to crosswalk sight distance, they shall operate continuously. All other advance beacons shall be pedestrian activated with the beacons at the crossing.

If advance circular beacons are used, then use a minimum 8-inch displays for roadways with a posted speed limit of 35 MPH or less and 12-inch displays for roadways with a posted speed limit of 40 MPH or higher. Exhibit 4-5 provides guidance on where to place beacons based upon roadway lane configuration.

Exhibit 4-5 Beacon Placement on State Highways

Roadway Configuration			Required Placement			
Traffic Direction	**Number of Lanes in One Direction**	**Median Present [1]**	**Right Shoulder**	**Left Shoulder**	**Median [1]**	**Overhead**
One-way	Two	N/A	X	X		
	Three	N/A	X	X		X
Two-way	One	N/A	X	X		
	Two	Yes	X		X	
		No	X			X
	Three or More	Yes	X		X	X
		No	X			X
Roundabout Approach	Two	N/A	X	[2]	X[2]	
	Three	N/A	X	[2]	X[2]	X

Notes:

1. Median includes open medians, median islands, pedestrian refuge islands, and roundabout approach splitter islands.
2. For one-way roundabouts approaches, the left side beacon shall be installed on the left shoulder, since no splitter island is present.

4-6.4 Roadway Bicycle Facilities

WSDOT is the steward of a multimodal transportation system and this system includes facilities for bicyclists and users of mobility assistive devices and encourages bicycle use on and interconnecting with its facilities. Bicycle facilities or improvements for bicycle transportation are included in WSDOT's project development and highway programming processes.[7] When choosing the bicycle facility keep in mind that lower stress facilities attract more users, in particular the "interested but concerned" potential users because bicycle facilities decrease exposure to moving motor vehicle traffic.

Designing for current, confident riders does less to support mode shift than designing for people of all ages and abilities.

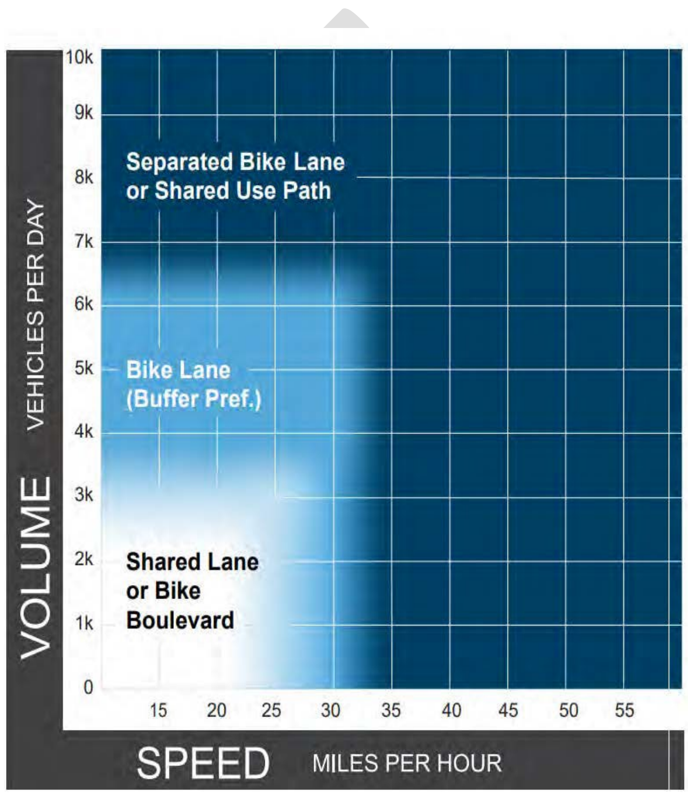
7 WSDOT *Design Manual* Section 1520.01

A. Urban Context

Generally, the higher the speed and volume of a road, the more protected or separated the recommended bikeway will be. Shared lanes or bicycle boulevards are recommended for the lowest speeds and volumes; bike lanes for low speeds and low to moderate volumes; and separated bike lanes or shared use paths for moderate to high speeds and high volumes.[8]

Use the Exhibit 4-6 from the FHWA 2019 Bikeway Selection Guide to help determine the type of bike facility to include on projects in the urban core, urban, suburban, and rural town/community center context. *Design Manual* Chapter 1515 discusses shared use path design. The NACTO Urban Bikeway Design Guide provides additional information. For discussion of intersection designs, consult the NACTO bikeway intersection supplement and research-based contextual guidance.

Exhibit 4-6 Preferred bikeway type for urban core, urban, suburban, and rural town context



Notes:

1. The chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed, or use treatments to bring operating speed down.
2. Advisory bike lanes may be an option where traffic volume is <3K ADT.
3. The Bikeway Selection Guide includes a discussion of alternatives if the preferred bikeway type is not feasible.

[8] FHWA 2019 Bikeway Selection Guide

B. Rural Context

The bicyclist type often assumed to be present on roadways in rural areas is the recreational bicyclist, who often fits the highly confident or somewhat confident user category. Based upon context and demographics, however, rural bicyclists may be riding out of necessity and should not be assumed to be highly skilled or confident. Paved shoulders, and shared use paths are appropriate bikeway types on rural roadways. Shared lanes are a last resort under conditions of extremely low traffic volume and are undesirable for high-speed roadways. Shoulder width is an important consideration to accommodate these bicyclists based on traffic volumes and posted speeds in the rural context.[9] See *Design Manual* Chapter 1520 for more information on accommodating riders in rural areas. The Level of Traffic Stress analysis in the Active Transportation Plan (2020 Update) includes analysis specific to low-volume, high-speed rural roads and should be consulted for additional information.

State highways can act as both a barrier and an opportunity for walking and bicycling especially in rural communities and transitions between rural and urban areas. Look for opportunities to increase active transportation connections and access from communities to activity centers such as schools, parks, or scenic areas. This could include adding shoulders to highways or providing a separated shared-use path, especially along rural roads with higher speeds. This is especially true for locations that attract larger volumes of bicyclists due to scenic views or for routes that serve as key bicycle connections between destinations or between segments of a regional trail.[10] Below is an example on State Route 903 where a separated multiuse path connects a school complex with the City of Cle Elum.

[9] FHWA 2019 Bikeway Selection Guide
[10] FHWA 2019 Bikeway Selection Guide

C. Shoulder Rumble Strips

Rumble strips are milled grooves or rows of raised pavement markers placed perpendicular to the direction of travel, or a continuous sinusoidal pattern milled longitudinal to the direction of travel, intended to alert inattentive drivers to a potential lane departure. The sinusoidal pattern can be used when a low noise design is desired. Rumble strips including those placed on the shoulder are considered a proven safety countermeasure by FHWA and can reduce fatal and injury crashes on two-lane rural highways by 36 percent.[11] Although rumble strips are a proven roadway safety feature they can affect other users of the roadway, particularly bicyclists. WSDOT serves all roadway users, therefore designs should consider safety purpose and assume the potential presence of active transportation users regardless of the level of usage. Additional information to determine level of bicycle usage include:

- Local transportation maps. These maps may be generated at the regional level in a Metropolitan Planning Organization or Regional Transportation Planning Organization such as bike map for Thurston Regional Planning Council in Thurston County, WA.
- WSDOT Bicycle and Pedestrian Count Portal
- Active Transportation Division's State Bicycle and Pedestrian Coordinator is a good resource for information on how a particular segment fits into the statewide active transportation network.
- Local bicycle groups. Note: When meeting with local bicycle groups include discussion of project needs, safety data, and why rumble strips are being considered. Be open to discuss how to balance all competing and complementary uses of the transportation systems. Also, it is helpful to become familiar with what national advocacy groups are recommending to their membership. Once such National advocacy organization is Adventure Cycling Association has a website regarding rumble strips and recognizes WSDOT practices for being bicycle friendly.
- Design accommodations for bicyclists should consider within the context, volumes, and adjacent land use:
  - The design, spacing and placement of rumble strips on roads with signif-icant bicycle traffic and if appropriate how other safety strategies such as wide edge lines, improved curve signing, or speed management if appro-priate for context and land use might work to address the crash potential for all users.
- Adjusting rumble strip dimensions[12]
- Reduce width. For example consider 5 to 6 inch wide rumble strips instead of 12 and 16 inches. If used check for any documentation requirements in the *Design Manual*.
- Reduce depth. For example consider ⅜ inch grooves instead of ½"

[11] FHWA, Rumble Strips and Rumble Strips Website
[12] NCHRP Report 641 Guidance for Design and Application of Shoulder and Centerline Rumble Strips

- Place rumble strips on edge line. The practice allows the placing the edge line pavement markings over the rumble strip. This improves nighttime marking visibility, particularly in wet conditions, by better positioning the marking optics on the back side of each rumble. This practice can also increase the longevity of the markings, particularly within the rumble, due to reduced wear from tires and added protection from plowing activity.
- Re-purpose roadway pavement surface if shoulder widening is not possible. Consider narrowing lane width to increase shoulder width to be at least 4' of usable shoulder or 5' along barrier.
- Providing gaps in periodic cycles to allow opportunities to move across the pattern without riding on the grooves. See Standard Plan M-60.20 for examples of different gap patterns. For highways that allow cyclists this should be considered customary practice.
- Providing gaps before and through intersections, manholes, and other objects within the roadway.
- Discontinue next to barriers and on downhill side of grades.

Other considerations include effects to future pavement preservation and most specifically bituminous surface treatments. Although it is preferred by the biking community to place rumble strips on the white edge line the rumble strip may be filled in by future bituminous surface treatment. To plan for countermeasures longevity consult with pavement management plans. If the roadway is to be resurfaced in the near future consider the following:

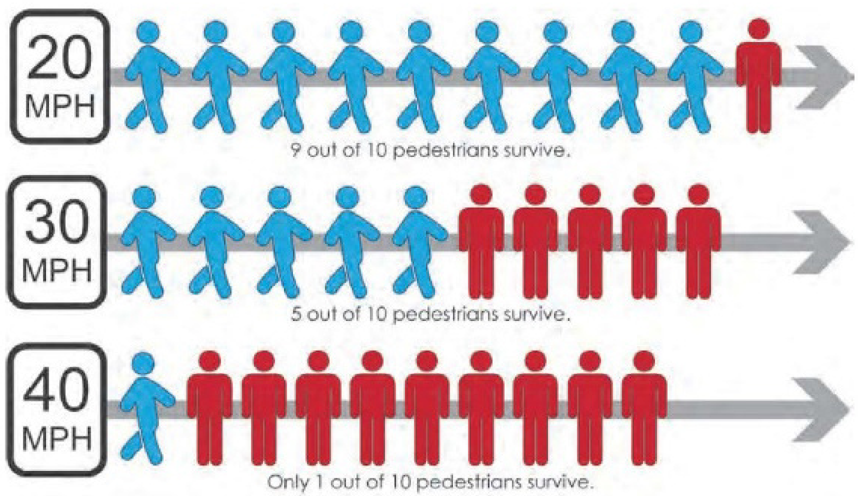
- Incorporate into future resurfacing project; or
- Delay the rumble strip installation until after roadway is resurfaced.

Consult the Standard Plans (rumble strips) or Plan Sheet Library (rumble stripes) for patterns and construction details. Also, see *Design Manual* Chapter 1600 for further information and design guidance. NCHRP Report 641 Guidance for Design and Application of Shoulder and Centerline Rumble Strips is a good reference.

4-6.5 Active Transportation Design Considerations

1. **Design to reduce speeds –** Speed affects severity of pedestrian crashes. As vehicle speeds increase pedestrians and bicyclists who are struck by a driver are more likely to die or serious injury. Also see the Washington State Strategic Highway Safety Plan, Target Zero, Pedestrian & Bicycle section speed management strategies for consideration. Exhibit 4-7 illustrates the effect of speed on pedestrian survivability.

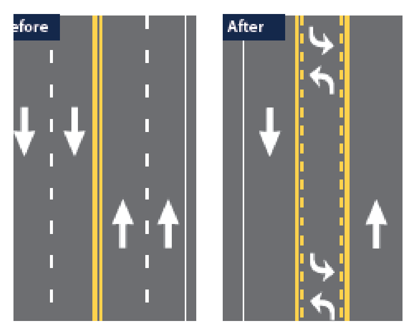
Exhibit 4-7 Effect of operating speeds on survivability odds of impact



Roundabouts

Reduce Curve Radii and provide bulb outs

Right Sized Roads and Intersections
Source: FHWA



2. **Improve crossings –** The most common action that a pedestrian takes before a fatal or serious injury crash is crossing the road. Improve crossings by increasing sight lines, crossing conspicuity, or providing design features that address identified conflicts, exposure to crashes and ADA issues.

Parking Restrictions
Source: Peter Lagerwey

Pedestrian Traffic Signal
Source: Fehr & Peers

Pedestrian Refuge Islands

Rapid Flashing Beacon

Edge line medians
Source: Transpo Group

Lighting
Source: PedSafe

3. **Reduce conflicts –** Reducing conflicts for both drivers and active transportation users reduces exposure to crashes. Intersections that reduce or simplify conflict areas such as roundabouts or protected intersections should be considered first when traffic control changes are considered.

Roundabout

Leading Pedestrian Interval

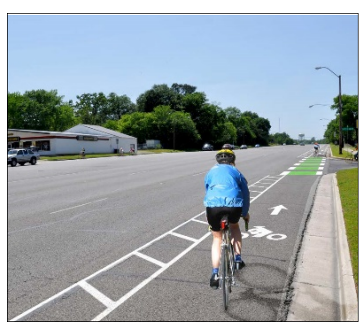
Protected Intersection
Source: NATCO

4. **Network Connectivity –** A fundamental concept of transportation is network connectivity: connecting people to where they want to go. Motorists can rely on having access to a complete network. However, this is not the case for pedestrians and bicyclists. Lack of connected infrastructure creates conflict zones with drivers, and higher potential for crashes. Disconnected street networks, highway or railroad barriers, high-crash or uncomfortable intersections, and difficult midblock crossings must be addressed to improve network connectivity and reduce crash exposure. Appropriate treatments along roadways vary widely based on context. Often times the first place to examine system gaps and opportunities are local plans and maps.

5. **Separate active transportation users from drivers –** Exposure to moving motor vehicle traffic can be stressful for people walking and riding bicycles which affects both the appeal of active transportation options and actual trip safety. Comfort and exposure to crashes are closely related. Higher comfort facilities lower crash exposure by locating higher speed heavier vehicles further from lower speed and lighter active transportation. Improved connectivity and comfort for active transportation users benefits all roadway users by providing visibility and predictability, leading to better perception and reaction within the roadway environment.

Multi-Use Path
Source: FHWA

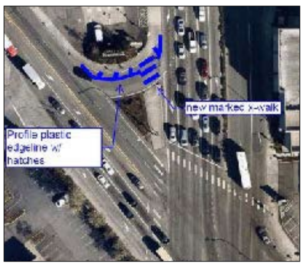
Bike Lane Buffer
Source: FHWA



Pedestrian Buffer
Source: FHWA

6. **Low cost countermeasures –** These projects offer opportunities to improve conditions for other roadway users using low cost measures especially in urban and rural town contexts where budget constraints would otherwise prevent installation of an improvement. Considerations could include updating older pedestrian crossing signs, replacing/enlarging school zone beacons, adding painted bulb-outs at intersections, and/or narrowing wide lanes to allow wider shoulders or bike lane buffers. There also may be opportunities to partner with other organization efforts such as signal replacement program, etc. that may allow for more cost effective solutions that benefit more roadway users and WSDOT programs. Examples of some low cost countermeasures are below.

Painted buffers



Painted bulb-outs

Low Cost Roundbouts

Bike Lane Buffers
Source: FHWA

Leading Pedesrian Interval

Multidiciplinary Scoping Meeting

Pavement Re-allocation
Source: Fehr & Peers

Add Pedestrian Crossing Signs

7. **Work Zones –** Public entities are responsible for maintaining pedestrian facilities under Title II of the ADA, including maintenance of their accessibility features, construction and maintenance activities often temporarily disrupt these facilities. When this occurs, provide access and mobility for pedestrians through and/or around work zones. Address this in the temporary traffic control plans if the project occurs in a location accessible to pedestrians. The designer is required to determine pedestrian needs in the proposed work zone during the public input process and through field visits. Also consider accessibility for adaptive bicycles and tricycles, which may be larger and have a different turning radius; users may not be able to dismount to get through a work zone. For more information see the following:
   - *Design Manual* Chapter 1510
   - *Traffic Manual* Chapter 5
   - WSDOT work zone website

Positive Protection
Source: Rideshark

Modular Ramps
Source: Road & Bridges

Audible Devices
Source: Empco-Lite

4-6.6 Countermeasure Descriptions

A. Advance Stop Line and Stop Here for Pedestrians Sign

A multiple threat crash results when a driver in one lane stops to let a pedestrian cross, blocking the sight lines of a driver in the other lane of a multi-lane approach, who then advances through the crosswalk and hits the crossing pedestrian. Advanced stop lines is one way to mitigate this concern.

If advance stop lines and 'Stop Here for Pedestrians' R1-5b/R1-5c signs are used in advance of a crosswalk, they should be placed together and 20 to 50 feet before the nearest crosswalk line; motor vehicle parking should be prohibited in the area between the stop line and the crosswalk. The MUTCD requires R1-5 signs when stop lines are used in advance of a crosswalk with an uncontrolled multi-lane approach. WSDOT has a Standard Plan M 24.60-04 that provides a typical detail for a stop line. Also see IS-23 for additional Pedestrian Crossing Details.

Advance stop lines and "Stop Here for Pedestrian" signs shall be used in advance of all midblock crosswalks with more than two or more through lanes in one direction.

B. Bicycle Treatments

Green Bicycle Boxes. A green bicycle box is helpful for routes that are also used as freight routes in order for drivers to better see bicyclists by situating them ahead of drivers at intersections.

Green Bicycle Lane Extensions
Source: AASHTO

Bicycle signals can be used to improve truck and bicycle safety at intersections by separating the turning and allowing for increased conflict point management. Allowing for independent or early movement of bikes, given their much smaller size increases visibility and allows for necessary maneuvers such as lane changing to occur without higher speed vehicles at intersections.

Protected bike lanes. Protected bike lanes are defined by their separation from the sidewalk and the roadway. Protected bike lanes that are part of a freight network, can provide higher visibility and predictability, information for all travelers. If a protected bike lane cannot be accommodated, a buffered bike lane with vertical separators is recommended.

See *Design Manual* Chapter 1520 for further information and guidance.

C. Curb Extensions

Curb Extension
Source: PedSafe

Known also as curb bulbs and bulbouts, curb extensions extend the curb face to the edge of the nearest driving lane. The curb extension takes the place of a parking lane or shoulder at an intersection or midblock location. They are most commonly applied at intersections where they are intended to reduce the exposure to pedestrian by reducing crossing distance, slowing right-turning vehicles, increasing the line of site between motorists and pedestrians; and providing more space for landscaping or stormwater management, among other features. Curb extensions are also seen in mid-block situations to slow vehicle speeds and reduce crossing distances at mid-block crossings. Curb extensions can affect bicyclist mobility; that design needs to take this into consideration. The description for alternative to pedestrian refuge islands in this section provides an example on how to accommodate bicycles. Also see *Design Manual* Chapter 1510 for additional guidance.

D. Enhancements at Marked Crosswalks

Pedestrian visibility and driver compliance can be increased at locations with marked crosswalks with high visibility pavement markings, advanced stop bars and with warning signs, in-street pedestrian crossing signs, illumination, curb extensions, and/or tighter curb radii.

E. High-Visibility Crosswalk Markings

High-visibility crosswalk markings make it easier for drivers to see the crosswalk, not just the pedestrian. When a decision has been made to use crosswalk markings, see Standard Plan M-15.10 for the typical longitudinal pattern known as a ladder bar crosswalk markings. This style of crossing marking is considered high-visibility.

F. In-street Pedestrian Crossing Sign

In-street signs are placed in the middle of the road at a crossing and are often used in conjunction with refuge islands. These signs may be appropriate on two-lane or three-lane roads with speed limits of 30 mph or less. MUTCD Section 2B.12 In-Street and Overhead Pedestrian Crossing Signs contains additional information about these signs. WSDOT does not have a policy for when and where to install in-street pedestrian crossing signs at uncontrolled locations. For additional information regarding the benefits of in-street pedestrian signs along with many other crossing enhancements see Oregon Department of Transportation Report 778, Safety Effectiveness of Pedestrian Crossing Enhancements.

In-street sign
Source: AASHTO

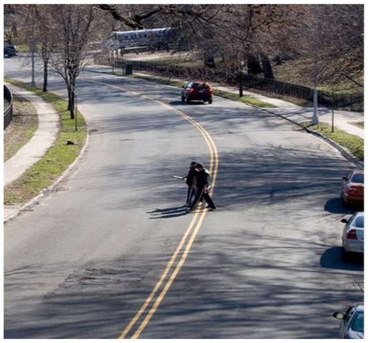
G. Illumination

In Washington state, the highest number of crashes between motorists and pedestrians tends to occur during November through February, when there is more hours of darkness and less visibility because of weather. The *Design Manual* Chapter 1510 notes that illumination of pedestrian crossings and other walkways is an important design consideration because lighting increases the likelihood of a pedestrian's being seen at night as well as a personal sense of security. Illumination provided solely for vehicular traffic is not always effective in lighting parallel walkways for pedestrians. For additional information regarding lighting and illumination see *Design Manual* Chapter 1510 and PedSafe Lighting and Illumination website.

H. Pedestrian Refuge Islands

A pedestrian refuge island is typically constructed in the middle of a street at an intersection or midblock locations. It provides a place for pedestrians to stand and wait for a gap in traffic or for drivers to stop. Whereas medians can vary in width, and composition, the minimum width of an island or median to be considered a pedestrian refuge is six feet.

Pedestrian Reguge Island (before/after)
Source: NACTO



Pedestrian refuge islands are considered a proven safety strategy by FHWA with an expected 56 percent reduction in pedestrian crashes. Washington State Strategic Highway Safety Plan, Target Zero, recommends refuge islands at pedestrian crossings to reduce crash potential.[13]

This countermeasure is highly desirable for midblock pedestrian crossings on roads with four or more lanes. Some key points are that pedestrian refuge islands minimize the exposed crossing distance; reduce the conflict area; allows pedestrians time to decide to cross one direction at a time; and minimize the effects on vehicular traffic. See *Design Manual* Chapter 1510 for accessibility Criteria for Raised Medians and Traffic Islands. Also see MUTCD Sections 3B.10—Approach Markings for Obstructions, 3B.18— Crosswalk Markings, and 3B.23—Curb Markings that provide information regarding use of signs and markings when raised medians or traffic islands are installed. See Standard Plan F-45.10 for dimensions and examples of median cut-through.

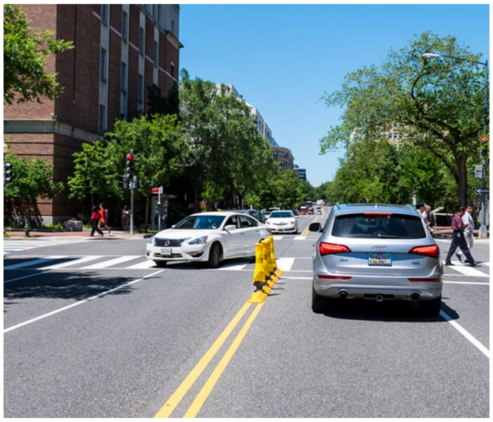
I. Pedestrian Refuge Islands (Alternatives)

A median is the portion of the roadway separating the traveled lane portions of opposing directions, or turn lanes. Medians may be depressed, raised, or flush with the road surface. Medians less than six feet and not raised do not qualify as a pedestrian refuge. However, they still provide benefits by narrowing the roadway, providing additional and more visible delineation, and contributing to speed management could be considered a low cost modification.

Edge line pedestrian medians can be considered at midblock locations or intersections where turn lanes need to remain. They can also be used in combination with pedestrian refuge islands to shorten the pedestrian crossing distance. These islands differ from medians and pedestrian refuge islands in that they align with the edge of the travel lane and have a bike lane behind them.

[13] Washington State Strategic Highway Safety Plan, 2019

Low Cost Median
Source: IIHS



Edge line Median
Source: Transpo Group

J. Pedestrian Signals including Pedestrian Hybrid Beacons (PHBs) and Half Signals

In some locations drivers may need to come to a complete stop to allow pedestrians to cross a roadway. A pedestrian traffic signal or PHB may be the preferred countermeasure.

These are candidate treatments for crosswalks across roads with three or more lanes that generally have traffic volumes above 9,000 vehicles. Refer to Exhibit 4-2 for other conditions where Pedestrian Signals and PHBs should be considered and MUTCD Sections 4C.05 Pedestrian Volume warrants and 4F-pedestrian hybrid beacons for their application. Currently the FHWA does not recommend half signals (see Sections 4C.05 and 4C.06 of MUTCD) nor placing PHB's at intersections (see Section 4F.02 of MUTCD). Pedestrian signals and PHB's can be used at roundabout intersection crossings and one- way approaches to intersections such as freeway exit ramps.

Currently, WSDOT prefers the use of pedestrian signals or rectangular rapid flashing beacons (RRFB) over PHB's due to maintenance and compatibility with existing systems. If a pedestrian traffic signal or PHB is being considered also examine the feasibility of a raised crosswalk or roundabout at the study location or adjacent intersection. Roundabouts slow driving speeds, provide refuge areas for pedestrians. For more information regarding roundabouts with pedestrians and bicyclists see FHWA Roundabouts with Pedestrians & Bicycles Brochure and WSDOT *Design Manual* Chapter 1320.

K. Rapid Flash Beacon (RRFB)

RRFB's are active (user-actuated) or passive (automated detection) amber LEDs that use an irregular flash pattern at mid-block or uncontrolled crossing locations. They significantly increase driver yielding behavior. See Section 4-6.3 for additional guidance on use of RRFB on State Highways.

L. Road Reallocation for All Modes (Also called Road Diets)

A road reconfiguration, also called a road diet, is a technique in transportation planning whereby the number of motor vehicle travel lanes and/or effective width of the road is reduced in order to achieve systemic improvements. FHWA considers road diets a proven safety strategy to reduce severe crashes. See Section 4-9 for more detailed discussion of roadway relocation.

M. Roundabouts

A roundabout is a type of circular intersection, but is quite unlike a neighborhood traffic circle or large rotary. Roundabouts have been proven safer and more efficient than other types of circular intersections. FHWA identified roundabouts as a Proven Safety Countermeasure because of their ability to substantially reduce the types of crashes that result in injury or loss of life. Roundabouts are designed to improve safety for all users, including pedestrians and bicycles. They also provide significant operational benefits compared to conventional intersections. Benefits of roundabouts to walkers and bikers include:

Less conflict: Roundabouts have fewer conflict points. A single lane roundabout has 50% fewer pedestrian-vehicle conflict points than a comparable stop or signal controlled intersection. Conflicts between bicycles and vehicles are reduced as well.

Shorter, setback crossings: Pedestrians cross a shorter distance of only one direction of traffic at a time since the entering and exiting flows are separated. Drivers focus on pedestrians apart from entering, circulating and exiting maneuvers.

Lower Speeds: Traffic speed any road or intersection is important for everyone, and especially non-motorized users. Lower speeds is associated with better yielding rates, reduced vehicle stopping distance, and lower risk of serious injury or fatality. Also the speed through a roundabout is more consistent with comfortable bicycle riding speeds.

Also see Section 4-8.6 and *Design Manual* Chapter 1310.

N. Raised Crosswalks

Raised crosswalks function as an extension of a sidewalk and allow a pedestrian to cross the street without moving down to street level. The elevated crossing draws attention to the crosswalk. Drivers slow down to cross the raised pedestrian crosswalk. It offers particular benefits for pedestrians using mobility assistance devices such as wheelchairs or walkers; consider land use, transit access and destinations that indicate potential for larger numbers of these users.

Raised Crosswalk
Interstate 35 off-ramp in Austin, Texas
Source: Google

FHWA suggests a raised crosswalk is typically a candidate treatment on two-lane or three-lane roads with speed limits of 30 mph or less and traffic volumes below 9,000. FHWA also suggested raised crossings are generally avoided on truck routes, emergency routes, and arterial streets. NACTO on the other hand suggests speed tables may be used on collector streets and/or transit and emergency response routes with vehicle operating speeds between 25 mph and 45 mph. Coordinate with emergency services and transit agencies when considering raised crossings.

See MUTCD Section 3B.25—Speed Hump Markings for additional information about markings that can be used alongside raised crosswalks.

O. Tighter Curb Radii

Tighter curb radius
Source: PedSafe

Tighter curb radii can increase sight lines between driver and pedestrian, shorten the crossing distance time to reduce exposure, bring crosswalks closer to the intersection, shortening crossing distances, and reduce speeds of right-turning drivers. The appropriate radius should be determined for each corner on a case by case based on the design vehicle for each right turn movement. Some key points are that each leg of an intersection may have a different design vehicle; that WSDOT policy provides flexibility when choosing the intersection design vehicle. The purpose for this policy is to balance user needs and avoid the unnecessary expense of oversizing intersections. Considerations include frequency of the design vehicle and effects on other design users, specifically pedestrian crossing distance and times, and bicycle turning and through movements. Consider providing more protected intersection treatments for pedestrians and bicyclists to mitigate turning conflicts. See *Design Manual* Chapter 1310 and Section 4-8 of this chapter for discussing about accommodating design vehicles and compound curves for right turn lanes.

Compound right turn curves provides a path that accommodates larger design vehicles and provides a tighter curb radii.

4-6.7 Active Transportation Resources

1. WSDOT Active Transportation Plan (2020 Update)
2. *Design Manual* Chapter 1103 Practical Design
3. *Design Manual* Division Chapter 15 Pedestrian & Bicycle Facilities
4. WSDOT Action Plan for Implementing Pedestrian Crossing Countermeasures at uncontrolled locations
5. Washington State Strategic Highway Safety Plan (Target Zero)
6. FHWA Office of Safety website
7. National Association of City Transportation Officials (NACTO).
8. NCHRP Research Report 926, Guidance to Improve Pedestrian and Bicyclist Safety at Intersections, 2020.
9. PEDSAFE Pedestrian Safety Guide and Countermeasure Selection System
10. PEDSAFE Bicycle Safety Guide and Countermeasure Selection System
11. FHWA's Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts, 2016
12. FHWA Guide for Scalable Risk Assessment Method for Pedestrians and Bicyclists
13. FHWA Bikeway Selection Guide
14. FHWA Resource Guide for Separating Bicyclists from Traffic
15. FHWA Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes
16. FHWA Small Town and Rural Multimodal Networks
17. FHWA's Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
18. FHWA's Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts, 2016.
19. FHWA's Small Town and Rural Multimodal Networks (2016)
20. FHWA Accessible Shared Streets: Notable Practices and Considerations for Accommodating Pedestrians with Vision Disabilities
21. ITE Design Guidelines for Accommodating Pedestrians & Bicyclists at Interchanges, 2016.
22. ITE, Implementing Context Sensitive Design Handbook, 2017.

4-7 Public Transportation

The need for public transportation in Washington continues to grow in many different ways. Washington is a diverse state with various public transportation markets such as urban and rural, commuter and off-peak, regional and local; and services, such as fixed-route, on-demand, bike/pedestrian facilities, telework, demand management tools and more. The figure below provides examples of different types of public transportation.

Public Transportation Definition
Public Transportation includes a broad array of transportation services and systems, public and private, that are accessible and available to the public and do not involve a single person in a motorized vehicle.

Washington's economy benefits demonstrably from public transportation's contribution to access, mobility and capacity of the transportation system. Delays on state highways, which are only a portion of the transportation system, cost Washington citizens and businesses over $800 million in 2014.[14]14 By increasing the person-carrying capacity of our roadways, public transportation supports the speed and reliability of freight movement critical to our statewide economy, and reduces crash potential by lowering the amount of vehicles on the roadway.

Primary Goal of Public Transportation
Baseline needs of transit capital projects on urban WSDOT right-of-way can relate to travel time and reliability of service. It may also be to provide access to key destinations, such as schools, hospitals, recreational destinations, or places of business.

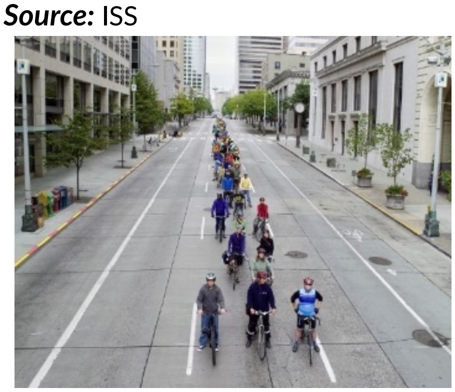
Public transportation also benefits the financial well-being of individuals in Washington State. For example, a person who lives in Seattle can save up to $11,000 a year by simply switching from driving to riding the bus.[15] Transit is also important to support growth; space is currency as the transportation system strains from traffic demands. Transit will increase in importance as communities, transit agencies, local agencies, and WSDOT examine ways to maximize the efficiency of the existing transportation system. Exhibit 4-8 illustrates the space needed for different transportation modes.

Exhibit 4-8 Illustration of 200 people using different transportation modes and illustrates the space usage by different transportation modes

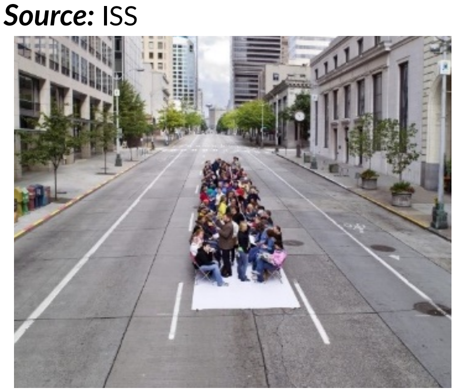
200 people in 177 cars
Source: ISS

200 people in 3 Buses
Source: ISS

200 people on bikes
Source: ISS



200 People on one light rail train
Source: ISS



14 The 2015 Corridor Capacity Report
15 Washington State Public Transportation Plan

A robust public transportation network can also support the development of compact, walkable, bikeable communities with lower infrastructure demands and can create hubs of activity that support local economies.

4-7.1 Traffic Operations Role in Public Transportation

WSDOT plays an important role in transit service as state routes affects the quality and safety of transit services. Transit routes often span many jurisdictions and one of our roles is to facilitate project development and coordinate with stakeholders.

Leading through Collaboration
All transportation partners in Washington state work together to provide a system of diverse and integrated public transportation options. People throughout the state use these options to make transportation choices that enable their families, communities, economy and environment to thrive. Public transportation also ensures the reliability, travel time, and sustainability of the integrated transportation system, including WSDOT owned right of way and facilities.

WSDOT plays an important role to help integrate station connections with the surrounding transportation network such as highways, local roads, communities, and park and ride lots. A complete trip from origin to destination typically involves one or more connections at either end. These connections are an important aspect of transit, and can make the difference between efficient and inefficient service. This is often referred to as first-mile and last-mile access. Improvements to transit access could include looking for off-system solutions such as sidewalk connections into neighborhoods, commercial areas, public facilities, regional trails, or other strategies developed in coordination with project stakeholders. Off-system solutions are supported by Practical Design. See *Design Manual* Chapter 1100.

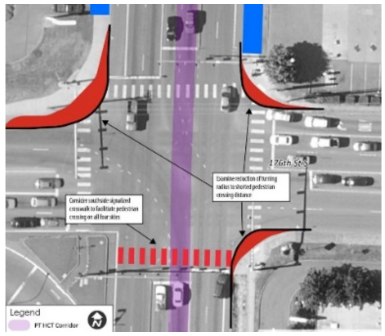
WSDOT also reviews those facilities directly supporting transit stops and stations such as sidewalks, pathways, and lighting around transit stops and stations. Adding appropriate improvements to projects supports local and regional transit services. Contact transit agencies as part of the project scoping and look for cooperative partnerships to improve transit services.

Section 4-7.2 provides examples of ways to improve public transportation on WSDOT, local agency, or developer projects.

4-7.2 Public Transportation Design Considerations

Extend biking and walking routes
Source: WSP

Improved Intersections
Source: WSP



Storm drainage
Source: Metro

Pedestrian Lighting
Source: Riverside Transit Agency

Fix old Infrastructure
Source: National Complete Streets Coalition

Placemaking
Source: National Complete Streets Coalition

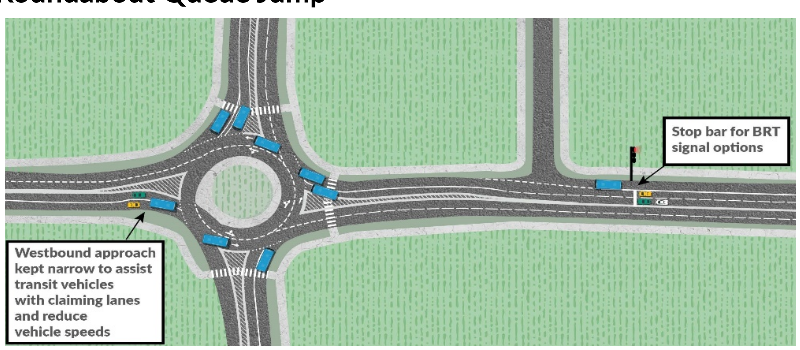
Bike Storage
Source: King County Metro

Enhanced crossings
Source: FHWA

Complete transit stops
Source: National Complete Streets Coalition

Traffic Signal Queue Jump

Roundabout Queue Jump



4-7.3 Bus Travel Time and Reliability and Bus Rapid Transit Considerations

Transit agencies in Washington are implementing Bus Rapid Transit (BRT) and other bus speed and reliability treatments on WSDOT roads. Treatments such as transit signal priority (TSP), Business Access and Transit (BAT) lanes, and bus queue jumps are part of creating effective bus service, which increases the person-carrying capacity of WSDOT facilities in a cost-effective manner meeting WSDOT's strategic vision.

What is Bus Rapid Transit?
BRT can best be described as a combination of facility, systems, and vehicle investments that convert conventional bus services into fixed-facility transit service, greatly increasing their efficiency and effectiveness to the end user.

1. **Partnership**

   Consider public transportation agencies as partners working toward common goals. While mindful of core issues such as safety and ongoing operating costs, work with transit agencies to support the WSDOT overall mission and vision. BRT projects differ from private development projects in that the former generate vehicle trips while the later reduce vehicle trips.

2. **Issue Resolution**

   Identify process to navigate issues as they arise to minimize effects on scope, schedule, and budget. This would be a multi-agency process and should include all involved WSDOT offices, which may include one or more WSDOT regions, HQ Traffic, and the Regional Transit Coordination Division (in central Puget Sound).

3. **Practical Solutions**

   Follow the intent of *Design Manual* Practical Solutions Section 1100 in defining the project purpose and context. Work with the transit agency to define baseline needs and measures, such as transit travel time, transit reliability, transit priority, pedestrian access to stations, connectivity between transit routes, and safety. Contextual needs should include examination of existing general purpose vehicle travel, impacts to active transportation travel/safety, existing/planned land use.

What are baseline needs for transit projects?
• Reducing transit travel time • Increasing transit reliability • Improving transit connections • Improving transit priority • Improving pedestrian and bicycle access to stations • Enhancing system identity • Increasing travel comfort • Enhancing safety & security

4. **Performance Measures.**

   Identify key performance measures that will guide the collaborative selection of alternatives. *Design Manual* Chapter 1101 provides guidance on defining baseline needs, performance metrics, and contextual needs. When considering performance metrics consider transportation measures beyond vehicle based capacity analysis. Also see Section 4-5.

5. **Traffic and Intersection Control Analysis Coordination and Quality Control**

Traffic analysis and intersection control evaluations including BRT systems include complicated traffic interactions. Amplified coordination should be conducted between the department, transit agency, consultant team(s), and other affected agencies. Coordination is necessary to communicate expectations, reduce misunderstandings, and promote efficiency and quality control. This helps reduce unexpected issues, delays, and extra costs.

Example QA/QC process
The Protocol for Vissim simulation can be adapted to for corridor and intersection evaluations and Region traffic offices should require that the transit agency's consultant to prepare a plan prior to beginning a traffic study or intersection control evaluation.

6. **Design Considerations**

- Many of the active transportation design considerations mentioned in Section 4-11.4 and 4-12.2 of this section apply to Bus Rapid Transit (BRT).
- BRT systems may run in a dedicated pathway separate from the general purpose lanes of traffic. As such, they are expected to run independent of other traffic. At intersections, however, the BRT system must interact with general traffic.
- BRT vehicles may need priority or pre-emption at signalized intersections.
- Roundabouts have shown efficiencies, serious and fatal injury crash reductions, and travel time improvements when applied as corridor improvements. This may allow for narrower cross sections between intersections that can be re-allocated for other modes. Roundabouts may be signalized or metered to allow for transit priority. Concerns expressed by transit agencies include roundabouts do not provide bus priority, create long walking distances, or cost more than preferred traffic signal improvements. Contact HQ Traffic Operations for design and operations modeling assistance.
- Pedestrian and bicycle crossings are an important aspect of BRT designs, especially for connecting to other BRT routes, light rail, or other public transportation or bike share systems. Additional crossings may be necessary at median stops. The Traffic Impact Analysis and ICE should include pedestrian and bicycle access design to BRT stops. Contact HQ Traffic Operations for design assistance. Bike lanes running on the same roadways also require consideration to reduce conflicts with buses and transit users.
- BRT vehicles dimensions vary and their turning radii can affect intersection design and interaction with general traffic. For example, an articulated bus typically has a tighter turning radius than the 40 foot coaches. It is important for the designer to check with local transit agency to get information to use in modeling swept paths. AutoTURN default inputs may not always represent coach turning movements.
- BRT projects at the core are people moving projects. Look for opportunities to increase the number, and improve the safety and convenience, of active transportation facilities on and adjacent to BRT routes including first and last mile connections.

7. **Operations and Maintenance**

- Identify infrastructure elements and agency maintenance responsibilities. Responsibilities should be included in an inter-governmental agreement.

4-7.4 Public Transportation References

1. Statewide Human Services Transportation Plan (HSTP)
2. Washington State Public Transportation Plan
3. Transportation Demand Management Strategic Plan
4. Statewide Public Transportation Directory
5. Transit Street Design Guide, NACTO
6. Pedestrian Safety Guide for Transit Agencies, FHWA
7. Manual on Pedestrian and Bicycle Connections to Transit, FTA
8. TCRP Report 183, A Guidebook on Transit-Sup portative Roadway Strategies, TRB
9. TCRP Synthesis 117, Better On-Street Bus Stops, TRB
10. TCRP Report 207, Fast-Tracked: A Tactical Transit Study, TRB

4-8 Freight Transportation

Freight Economics
On a per capita basis, Washington is the second-most trade-dependent state in the nation, behind Michigan, with total imports and exports valued at $126.8 billion. - 2017 Washington State Freight System Plan

Every day, people stop by a store to pick up what they need. Virtually every business and household depend on freight delivery for shipping and receiving goods – in many cases multiple times a day. The growth of ecommerce has increased the simplicity of purchasing products and masks the details of a complicated system that permits and sustains such activity. Freight transportation and goods movement involves a complex and dynamic network of logistics and supply chains. Freight logistics relies on the multimodal transportation system in Washington. As a result this multimodal system is vital to the economy of the state and country in many ways. It underpins the national and state economies, supports national defense, directly sustains hundreds of thousands of jobs, and delivers the daily necessities of life to residents.

As the population grows freight traffic or distribution of products will grow to and adapt as the ways to order and deliver goods and services changes. Freight traffic in Washington State is expected to grow by about 30 percent by 2035.

How WSDOT designs highways could have an effects on freight mobility? This section will cover two concepts: 1) background on the freight network in Washington State and; 2) Examples of design considerations when dealing with freight as part of the multimodal network.

4-8.1 *Freight Transportation System*

The following is an introduction to the various freight networks in Washington State. These networks will help define modal priorities and context for the project. See *Design Manual* Chapter 1102 for context determination guidance.

A. National Multimodal Freight Network (interim)

In 2016, USDOT established the interim National Multimodal Freight Network (NMFN).[16] This network, when finalized, is intended to inform freight transportation planning and funding processes. NFMN maps for Washington State are available from the USDOT.

B. National Highway System

The National Highway System (NHS) is considered the backbone of the nation's economy, as well as being critical to its defense and mobility networks. The NHS is an important component of the eligibility criteria for the Nationally Significant Freight and Highway Projects Program for highway or bridge projects. A total of 4,556 centerline miles are designated as NHS routes in Washington, including 3,577 miles of state highways and 979 miles of local roads. Subsets of the NHS include:

- Intermodal Connectors. These highways provide access between major intermodal facilities and the other four subsystems making up the National Highway System. There are 87 designated NHS intermodal connectors in Washington, some of which are freight-related. Port intermodal connectors are the most common type of freight intermodal connector representing 45 percent of all NHS intermodal connectors in the state.
- Strategic Highway Network. The Strategic Highway Network (STRAHNET) is a designated national network that is important to national strategic defense and used for emergency mobilization and peacetime movement of military vehicles. This 63,000-mile network provides defense access, continuity, and emergency capabilities for defense purposes. This network is a component of the NHS.

C. National Highway Freight Network

In 2015, USDOT established the National Highway Freight Network (NHFN) in consultation with WSDOT and other partners to strategically direct federal resources and policies toward improved performance of highway portions of the U.S. freight transportation system. Components of the NHFN include:

- Primary Highway Freight Systems (PHFS) is a network of highways identified as the most critical highway portions of the U.S. freight transportation system determined by measurable and objective national data. The network consists of 41,518 centerlines miles, including 37,436 centerline miles of Interstate and 4,082 centerline miles of non-Interstate roads.

[16] U.S. Department of Transportation. Interim National Multimodal Freight Network. www.transportation.gov/administrations/office-policy/interim-national-multimodal-freight-network

- Non-Primary Highway Freight Systems (non-PHFS). These highways consist of the remaining portion of Interstate roads not included in the PHFS. These routes provide important continuity and access to freight transportation facilities. These portions amount to an estimated 9,843 centerline miles of Interstate, nationwide, and will fluctuate with additions and deletions to the Interstate Highway System.
- Critical Rural Freight Corridors (CRFC). These are public roads not in an urbanized area which provide access and connection to the PHFS and the Interstate with other important ports, public transportation facilities, or other intermodal freight facilities. Nationwide, there are 4,412 centerline miles designated as CRFCs.
- Critical Urban Freight Corridors (CUFC). These are public roads in urbanized areas which provide access and connection to the PHFS and the Interstate with other ports, public transportation facilities, or other intermodal transportation facilities. Nationwide, there are 2,213 centerline miles designated as CUFCs.

D. Freight and Goods Transportation System

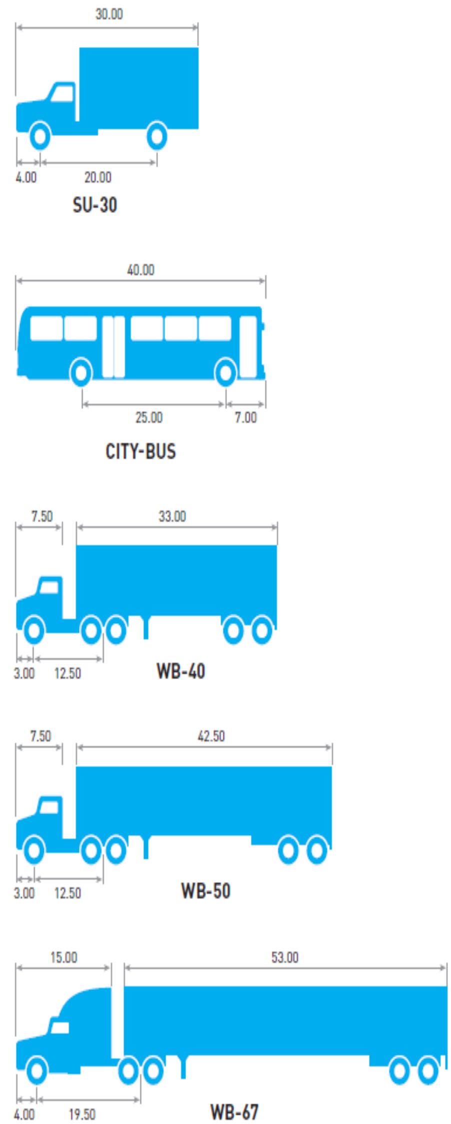
The Freight and Goods Transportation System (FGTS) is a Washington-specific designation system, separate from the national designation. FGTS truck corridors classifies all highways, county roads, and city streets by reported annual gross truck tonnage, ranging from T-1, with the highest tonnage, to T-5, with the least tonnage. Corridor classification and maps can be found at the WSDOT FGTS website.

E. Truck Freight Economic Corridors

The designations were built on the FGTS classification by considering resiliency and first-mile and last-mile connectivity. A truck freight economic corridor designation helps inform how freight connectors are being used by industry, and inform future planning efforts to identify the needs and opportunities for improving those connectors. The Truck Freight Economic Corridors include the following components:

- High volume truck corridors: T-1 and T-2 freight corridors (as defined in the FGTS) carrying at least 4 million tons of gross truck tonnage per year.
- Alternate freight routes: routes that serve as alternatives to primary cross-state freight routes during severe weather or other disruptions to increase freight system resiliency.
- First-mile or last-mile connector routes: routes that connect freight intensive land uses to high volume and alternate routes. These routes provide important freight linkage to strategic national defense facilities, significant intermodal facilities, warehouse districts, industrial land and distribution centers, and agricultural processing centers.

4-8.2 Types of Trucks



Trucks and buses come in a variety of sizes. These sizes and overall dimensions are dictated by the type of transit route or goods, materials, being transported. Trucks typically range from 8.5- to 10.0-feet wide, and with permits can be even wider.

The American Association of State Highway and Transportation Officials (AASHTO) has classified the most common sized trucks on United States roadways based either on the overall length of the vehicle (buses and single unit trucks) or vehicle wheel base (tractor-trailers). The classifications include but are not limited to:

- SU-30: 30.0-foot, single unit vehicles typical of most local delivery vehicles.
- WB-40 and WB-50: small tractor trailers with wheelbases in the 40.0-foot and 50.0-foot range.
- WB-67: 67-foot wheelbase long haul trucks, sometimes called the interstate design vehicle that has an overall length on the order of 74.0-feet.

Transit agencies operate a wide variety of city buses. For purposes of determining the swept path contact transit agencies affected by the project to city bus dimensions and turning specifications.

Other vehicles include various emergency vehicles, and public works maintenance trucks.

The figure on this page shows the typical dimensions of the most commonly used AASHTO design vehicles. Additional information on these and other design vehicles can be found in the AASHTO Policy on Geometric Design of Highways and Streets.

4-8.3 Design for” versus “Accommodate”

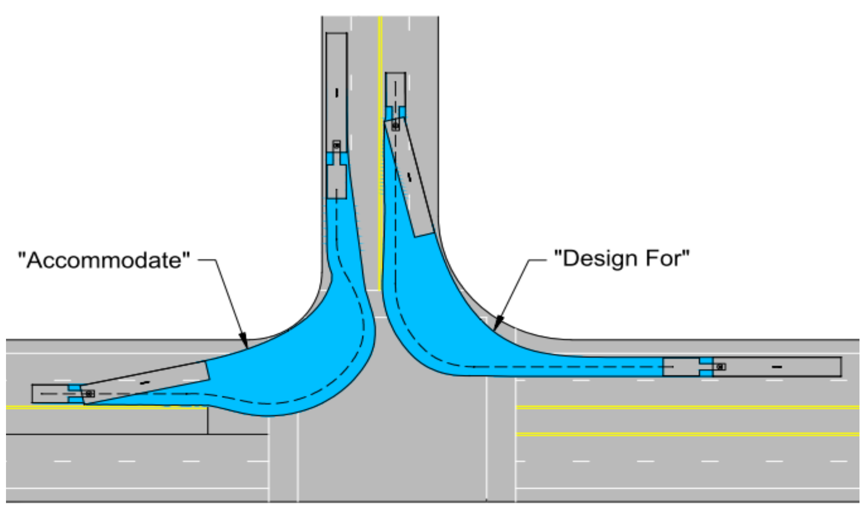
Selection of design vehicles is discussed in *Design Manual* 1103 and 1310. In selecting the appropriate design vehicle, many factors such as the number and type of trucks, functional classification of the highway, transit use, pedestrians and bicyclist shall be considered. See *Design Manual* Chapter 1102 for guidance on defining project context.

The concept of design vehicle involves providing a path for the vehicle that is free of encroachments upon other lanes, and facilities such as sidewalks. The Design Vehicle is the largest typical vehicle that will commonly use the street. It is acceptable for the design vehicle to use all of the first lane, and part of the second lane of the receiving street. In multilane roundabouts, it is considered “designing” for large trucks for them to take both lanes to navigate the roundabout.

Providing a design that accommodates a vehicle means that some level of encroachment upon other lanes is inevitable for the vehicle to make a particular movement. The accommodated vehicle is the largest vehicle that will rarely use the street. It is expected to use mountable elements, and may enter the lane adjacent to its lane of origin. The decision to design or accommodate will be based upon the context of the highway/ intersection under consideration. A balanced design approach takes into consideration more than just the amount of room required by the design vehicle. For example:

- What is the intended operating speed of the facility?
- What is the context? Designing for the largest but rare vehicle may result in an overdesigned intersection that is not compatible with other modes.
- How does the design affect pedestrians and bicyclists? For example, large turning radii at intersections increase the speed of drivers making the turns, and the time it takes to cross the road for pedestrians. So, designing for a large design vehicle will increase speeds and travel distances for all users, thereby increasing crash potential for all road users without proper consideration of the potential effects.

Designing for vs. Accomodating
Source: City of Seattle



4-8.4 *Oversize-Overweight and other unique vehicles*

Planning for freight does not end with selecting a standard design vehicle. Other types of freight traffic may be affected by a highway or intersection project. For example if the highway is near a port then accommodating very long loads such as wind turbine blades may be necessary. Identifying vehicle types includes reviewing the surrounding land use, transit plans, community input. Contact the Rail, Freight, and Ports Division and Commercial Vehicle Services to obtain information on how a unique freight could possible effect the project site.

Truck with Wind Turbine
Source: Washington Public Ports Association

4-8.5 *Emerging freight delivery modes*

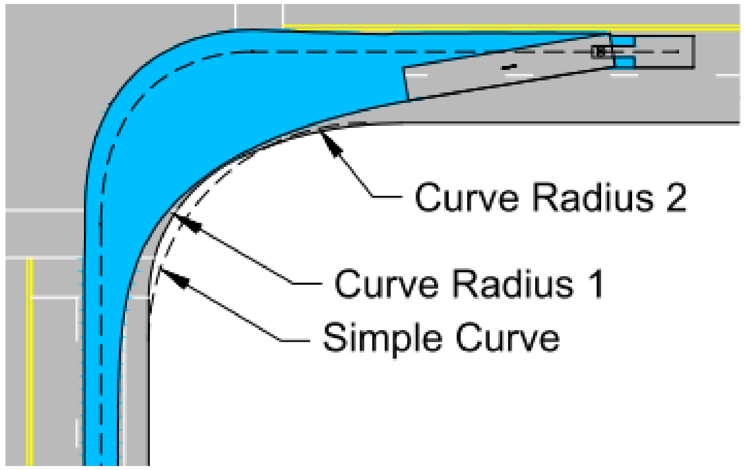
Bicycle delivery in urban areas represents another freight delivery mode that may be a factor. Cargo bicycles and tricycles are wider than a traditional two-wheeled bicycle. In some locations a freight corridor may provide the only feasible connection for the active transportation network.

4-8.6 *Design Considerations*

A. Multi-centered Corners (Compound Curves)

When trucks turn, particularly tractor-trailers, they sweep a path that can best be simulated by a series of curves. A simplified approach shown by the figure to the right would use two or three compound curves to best match the pathway of the truck. By using this approach, the full swept path of the design vehicle can be designed for and larger vehicles checked for accommodation, if appropriate, while still minimizing the amount of roadway surface. Minimizing roadway surface also manages crossing distances, signal pole arm lengths, maintenance, improves distance vehicles travel through the intersection, and reduces project cost. These designs also allow for a tighter radius corner, which will help promote speed reduction for drivers of smaller vehicles making the turn. This figure illustrates this. Also see Section 4-6.6 and *Design Manual* Chapter 1310.

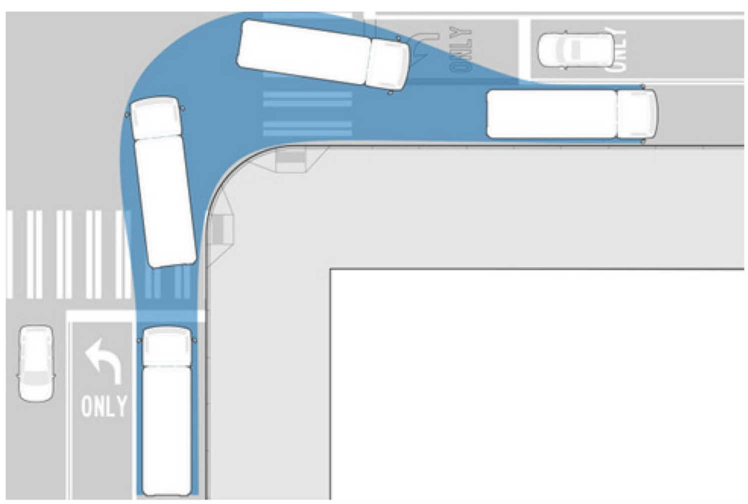
Compound Curve
Source: City of Seattle



B. Setback for Stop Bar Placement

Signalized intersections can be striped to improve the overall geometry for turning trucks without compromising traffic engineering requirements. Stop bar location on both the street a truck is turning from, as well as the cross street approach the truck driver is turning into, can have a dramatic effect on the accommodation of truck driver turning movements. Moving back the STOP bar can also assist pedestrian crossing movements and allow for a relatively small curb radii.

Mountable Curbs



C. Mountable Curbs

Mountable curbs can provide a means for a large truck to more easily navigate while making a turn. These types of curbs are mostly useful for at driveways, intersections, medians, or splitter islands. Use at intersection corners; however, should only be considered on a limited basis and must be carefully designed to minimize trucks from overrunning pedestrian areas. Mountable curbs are also used at roundabouts. Standard Plans Section F has several mountable curb options including Standard Plan F-10.18 that is specific to roundabouts.

Mountable Curbs

D. Left Turn Medians

Left turning vehicles are generally more controlled than right turning vehicles due to a greater number of vehicle-to-vehicle conflicts. Goods movement and livability concerns focus heavily on median nose treatments. Medians can provide pedestrian refuge, especially for large intersections. Full curb medians are most effective for pedestrian safety, but reduce the turning area for large vehicles. They also can be easily damaged if a truck's rear wheels run over them. Mountable and painted treatments are sometimes used, but can introduce conflicts between pedestrians and trucks. Truncating the median nose prior to the crosswalk is another option, but will not provide pedestrian refuge.

E. Bicycle Treatments

Bike boxes, bicycle signals, and protected bike lanes can be helpful for routes that are also used as freight routes. See Section 4-6.6 for further information.

Green Bicycle Boxes – A green bicycle box is helpful for routes that are also used as freight routes in order for drivers to better see bicyclists by situating them ahead of drivers at intersections.

F. Roundabouts

User perspectives regarding roundabouts are generally very context-sensitive. For pedestrians and bicyclists, roundabouts can be particularly effective in creating a more comfortable operating environment for all roadway users. Motorists benefit from roundabouts where delays and crash severities are substantially reduced and safety improved compared to stop-control or signal-control. Even if there are peak times when motorists are delayed at a roundabout, the peak hour delay needs to be considered with respect to the overall daily delay benefit. Truck drivers can similarly benefit from reduced delays, particularly where the cost of coming to, and accelerating from, a full stop can be eliminated; but care in design is necessary to all for a roundabout design that accommodates large vehicles.

Roundabouts can require more right-of-way than typical intersections at the immediate junction, but less right-of-way upstream due to the ability to reduce turn lane lengths or eliminate turn-lanes. Specific considerations regarding roundabouts are in *Design Manual* Chapter 1320 Roundabouts.

Interchange Ramp Terminal

Outside Truck Apron
Source: Google

Multi-use path and Supersize truck bypass
Source: Google

G. Work Zones

Effective temporary traffic control strategies allow all road users to successfully maneuver through or around work areas while still permitting needed work to be completed efficiently and economically. Chapter 5 provides a detailed work zone discussion. The following are examples of work zone traffic management techniques that address commercial vehicles:

Road Narrowing and Restricting Vehicle Clearance
If a construction or maintenance project is narrowing the roadway or restricting the vertical clearance, WSDOT Commercial Vehicle Services needs to be contacted in advance.

Work Zone Queue Warning System. At 65 MPH, it may take fully loaded semi-tractor and trailers at least 7 seconds and 500 feet to stop per the Work Zone Safety Consortium. It is critical for drivers of large truck to anticipate queued traffic and get slowed down in advance. Queue warning systems have reduced associated collisions up to 45 percent per the FHWA supported Work Zone Safety Consortium report. Examples of queue warning systems include Truck Mounted PCMS and Smart Work Zone Systems.

Portable Transverse Rumble Strips. Portable transverse rumble strips serve to increase driver alertness by providing both an audible warning and physical vibration as the vehicle's tires cross over them.

See the Work zone policy and guidance website for additional information and examples.

Rumble Strips
Source: PSS Inovations

Truck Mounted PCMS
Source: Trafcon

4-9 Road Reallocation (aka Road Diets)

Benefits of Roadway reallocation
Four to three lane roadway conversions have documented crash reductions from 19 to 47 percent according to FHWA

Wide street crossings can be major impediments to pedestrian access, connectivity, and increase crash potential; therefore, an effective countermeasure for pedestrians is a “road diet.” A roadway reallocation known as a road diet offers several high-value improvements at a low cost when applied to traditional undivided highways. The primary benefits include reduced crossing distance, space for separated travel, mobility, and access for road users and a “complete streets” environment to accommodate a variety of transportation modes. FHWA considers road diets a proven safety countermeasure due to proven effectiveness in reducing fatalities and serious injuries.

What about traffic volume?
FHWA advises roads with traffic volumes of 20,000 or less are good candidates for road reallocations. However, City of Seattle has successfully implemented projects on roads greater than 20,000 vehicles per day. Reports on City of Seattle’s road diets are available on their reports & studies website. The key is to understand the purpose and need for intervention, understand community priorities, and communicate tradeoffs such as increased side street delays. Often communities are willing to trade some additional peak hour congestion for safer more livable roads.

Lane diets involve reducing the width of the travel lanes and road diets involve removing one or more lanes of traffic and, in some cases, reducing the width of the travel lanes. The excess space is converted into space for pedestrians or cyclists, such as wider sidewalks, curb extensions, medians, pedestrian refuge areas, or bicycle facilities. In rural and suburban areas lane diets or narrowing can reduce intersection crash potential by reducing traffic speeds and improving conspicuity of intersections.[17]

Road diet benefits include a crash reduction of 19 to 47 percent of all crashes, all severities according to FHWA’s Road Diets/Roadway Reconfiguration webpage. Road diets also result in reduced vehicle speed differential, improved mobility and access for all road users, and integration of the roadway into surrounding uses that results in an enhanced quality of life. A key feature of a road diet is that it allows reclaimed space to be allocated for other uses, such as turn lanes, bus lanes, pedestrian refuge islands, bike lanes, sidewalks, bus shelters, parking, or landscaping. Other road diet benefits include:

- Reduced rear-end and left-turn crashes due to the dedicated left-turn lanes
- Reduced right-angle crashes as side street motorists cross three versus four travel lanes
- Fewer lanes for pedestrians to cross
- Opportunity to install pedestrian refuge islands, bicycle lanes, on-street parking, and/or transit stops
- Traffic calming and more consistent speeds
- A more community-focused, “Complete Streets” environment that better accommodates the needs of all road users

17 FHWA Report HRT-08-063

A road diet can be a low-cost safety solution when planned in conjunction with a simple pavement resurfacing project, and the reconfiguration can be accomplished at no additional cost. An example is provided Section 4-9.C where a roadway was simply re-striped after a chip seal application.

Road diets or lane diets are not appropriate for all roadways. Careful analysis to help determine the feasibility needs to be done up front utilizing traffic count data, existing and future traffic volumes, type of road, and the need and purpose of the project to determine whether the street or road is suitable for a road or lane diet.

FHWA's Road Diets/Roadway Reconfiguration webpage states a number of strategies may be considered to reconfigure the street to reduce vehicle and pedestrian crashes, while simultaneously increasing vehicle flow and reducing vehicle speeds.

Road Diet Plus
The Road Diet Plus is borne from the convergence of the standard road diet, the safety advantages of the modern roundabout, and the throughput advantages of the modern roundabout in a corridor. La Jolla Blvd in San Diego is an example of a Road Diet Plus. Priorities for this 23,000+ ADT corridor were livability, economic development, and traffic calming. Results included higher retail sales, lower noise, reduced traffic speeds, 90 percent drop in crashes, and spurred new development.
Source: January 10, 2018 article from Public Square.
A similar concept can be applied to state highway interchanges to reduce the need to widen structures and to provide the opportunity to reallocate space for other purposes.

A. Design Considerations

When converting a four-lane road into a two-lane road with a two-way left turn lane, medians or pedestrian refuge areas may be placed at intersections or mid-block pedestrian crossing locations.

The practitioner should determine the types of vehicles that primarily use the street before reducing the lane widths.

A best management practice may be considered for utilizing mountable curbs on narrower lanes to accommodate larger vehicles.

B. Roadway Reallocation References

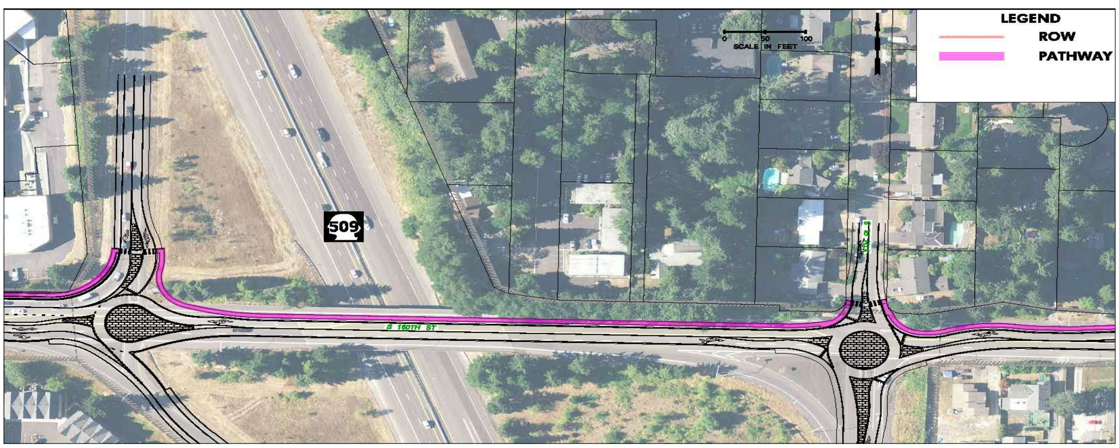
1. AASHTO, A Policy on Geometric Design of Highways and Streets
2. FHWA, Road Diets/Roadway Reconfiguration Guide
3. NACTO, Urban Street Design Guide

C. Roadway Reallocation Examples

Roadway Resurfacing Road Diet Before
Capital Mall Blvd, Olympia WA

Roadway Resurfacing Road Diet After
Capital Mall Blvd, Olympia WA

Highway Road Diet Plus
Concept SR 509 at 160th Ave



Road Diet Plus (Before)
La Jolla Blvd, San Diego CA
Source: Dan Burden and San Diego Union Tribune

Road Diet Plus (After)
La Jolla Blvd, San Diego CA
Source: Dan Burden and San Diego Union Tribune

Before
SR 4, Cathlamet WA

After
SR 4, Cathlamet WA

Before
SR 500, Camas WA

After
SR 500, Camas WA

Intersection Lane Narrowing (Diet)
Yelm Hwy SE, Lacey WA