2015

FREIGHT ROADWAY DESIGN CONSIDERATIONS

DISTRICT 7

Centennial FDOT 1915★2015

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION
FLP
Office of Freight, Logistics and Passenger Operations

this page intentionally left blank

2015

FREIGHT ROADWAY DESIGN CONSIDERATIONS

Prepared for the **FLORIDA DEPARTMENT OF TRANSPORTATION** by:

RENAISSANCE PLANNING

This December 2014 draft Freight Roadway Design Considerations document is produced by the FDOT District 7 Office of Intermodal Systems Development, based in part upon the recommendations in the Tampa Bay Regional Strategic Freight Plan. The document was produced by Renaissance Planning Group with the participation and valuable insights provided by many key agency and consultant staff as noted below:

FDOT DISTRICT 7 PROJECT MANAGEMENT

Brian Hunter, project manager
George Boyle
Danny Lamb

RENAISSANCE PLANNING GROUP TEAM

Dan Hardy, project manager
Jessica Dimmick
Vlad Gavrilovic
Frank Kalpakis
Katherine Wood
Brian Bollas (Parsons Brinkerhof)
Cherie Royal (Parsons Brinkerhof)
Bob O'Donnell (AECOM)

FDOT DISTRICT 7 TECHNICAL ADVISORY GROUP

Kirk Bogen – District PD&E Engineer
Ron Chin – District Traffic Operations Engineer
Frank Chupka – District Consultant Project Management Engineer
Susan Finnimore – District SIS Coordinator
Rochelle Garrett – District Traffic Design Engineer
Peter Hsu – District Safety Engineer
Peter Maass – General Planning Consultant
Amy Neidringhaus – District Interstate Program Engineer
Stephanie Pierce – PD&E Project Manager
Allan Urbonas – District Roadway Design Engineer
David Winkle – Transportation Planning Analyst
Menna Yassin – Systems Planning Analyst

DISTRICT 7

Centennial FDOT 1915 ★ 2015

2015

FREIGHT ROADWAY DESIGN CONSIDERATIONS

TABLE OF CONTENTS

TABLE OF CONTENTS, continued

this page intentionally left blank

EXECUTIVE SUMMARY

The Tampa Bay Regional Strategic Freight Plan envisions the development of these Freight Roadway Design Considerations (FRDC) to help implementing agencies apply context-sensitive solutions regarding effective and efficient goods movement throughout the region. The document was developed through a collaborative process involving FDOT staff and other regional stakeholders, including the Goods Movement Advisory Committee. This Executive Summary outlines the intent, audience, and contents for the Considerations and the expected process and schedule for developing them.

WHAT DOES THE FRDC ACCOMPLISH?

The Freight Roadway Design Considerations are intended to:

- identify principles and strategies for the thoughtful integration of freight mobility needs into the roadway planning and design process on designated non-limited-access freight facilities,
- facilitate the incorporation and documentation of goods movement considerations into each step of the roadway implementation process, and
- supplement the FDOT PD&E Manual and the Plans Preparation Manual by describing how the judgments planners and engineers make during application of the Manuals can best reflect a deliberative approach to truck operations.

The primary objective of the FRDC is to ensure that both freight movement considerations and community livability objectives are balanced by promoting and selecting design strategies that most effectively accommodate truck movements in conjunction with the needs of other roadway users and community constituents.

WHAT DOES THE FRDC CONTAIN?

The Freight Roadway Design Considerations includes the following sections:

1. Applicability and the relationship to other Central Office and District manuals and guides.
2. Defining context from both freight facility function and community livability perspectives.
3. Design strategies and how to weigh trade-offs to select optimal choices within the bounds of design standards and other applicable guidelines and practices.
4. Design elements and their interrelationships as most pertinent to heavy vehicles.
5. Special cases like campus settings/edges, arterial system interchanges, and one-way streets.
6. References to best practices and emerging practices nationwide.

The document is graphically oriented, featuring decision flowcharts and design strategy diagrams that convey both planimetric and operational treatments.

WHO WILL USE THE FRDC?

The primary audience members for the document are Florida Department of Transportation District 7 planners and engineers. The Considerations are intended for a broader audience, including state, regional, and local agency planners and engineers, elected and appointed decision makers, and other stakeholders interested in the topic. The development of this Considerations document is proceeding in tandem with similar conversations in other FDOT Districts and among Central Office.

HOW DO I FIND OUT MORE?

Additional information on the Tampa Bay Regional Strategic Freight Plan and the context for the Freight Roadway Design Considerations is available at the following website: *www.tampabayfreight.com*

this page intentionally left blank

CHAPTER 1: PURPOSE and APPLICABILITY

PURPOSE

The Freight Roadway Design Considerations (FRDC) document is a resource for transportation planners and design engineers for considering and implementing truck-friendly design solutions in a variety of planning and design activities. The document identifies considerations for selecting appropriate design strategies relative to the function of the Regional Freight Network, the multimodal aspects of certain corridors, and the various land use contexts throughout the Tampa Bay Region. The document supplements the FDOT Plans Preparation Manual and supports and expands upon modal planning and design concepts in other FDOT manuals applicable statewide.

This chapter describes the purpose of this document and how it is intended to aid both roadway designers and others involved in the planning and operations of goods movement and land planning and management. This chapter also describes the relationship between this document and other FDOT practices and policies. The last section of this chapter describes the organization of the rest of the document.

Why a FREIGHT ROADWAY DESIGN CONSIDERATIONS document?

As the Tampa Bay Region continues to develop, goods movement plays an increasingly important role in the regional economy. At the same time, economic growth and environmental resource concerns are increasing the desire for compact, walkable communities. These twin objectives of goods movement and livability often present conflicting messages to roadway planners and designers.

What does the FREIGHT ROADWAY DESIGN CONSIDERATIONS document do?

This document provides ideas and suggestions to help roadway designers and planners select designs that balance goods movement and livability, within the parameters established by FDOT manuals and policies.

This document expands upon concepts presented in the Tampa Bay Regional Strategic Freight Plan and is one of the implementation actions recommended in the Plan.

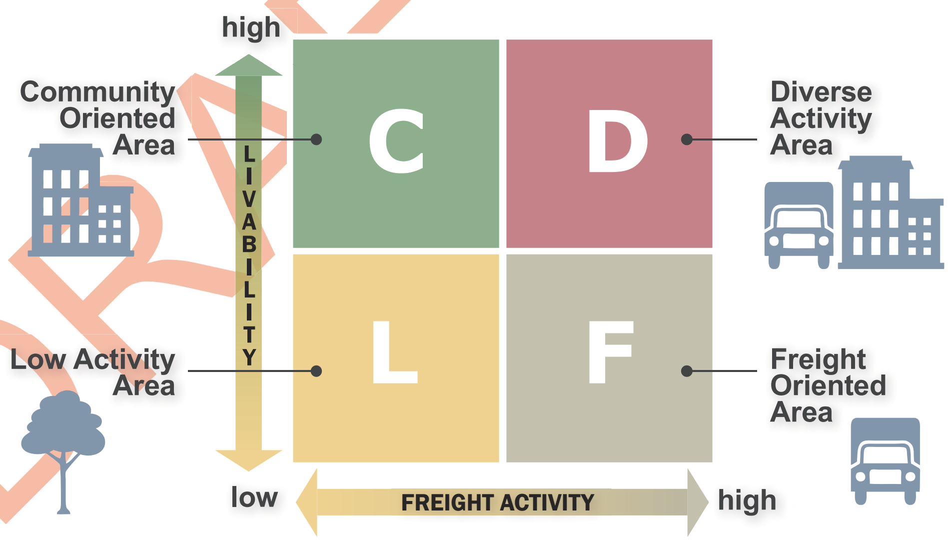
IDENTIFYING CONTEXT-SENSITIVE DESIGN APPROACHES & STRATEGIES

THE FREIGHT ACTIVITY & LAND USE COMPATIBILITY ANALYSIS

Context-sensitive goods movement strategies are developed with a recognition that the balance between truck traffic and other roadway users depends on the purpose and intensity of the goods movement and the nature and intensity of the local land use patterns. The land use patterns affect travel demand by all modes, including freight. The freight roadway function and level of goods movement demand affect the relative economic value of facilitating truck movement relative to the needs of other travelers and adjacent property owners, renters, and visitors.

The Tampa Bay Regional Strategic Freight Plan includes the results of a "Freight Activity and Land Use Compatibility Analysis" (FALUCA) that identified four general area types characterized by the land uses and activities that exist or are anticipated in areas throughout the region. The FALUCA process identified areas with higher densities or residential and employment centers that are characterized with a certain emphasis on livability and other areas that are characterized by higher levels of freight activity, such as industrial or distribution centers.

Comparing these designations revealed areas where livability or freight activity is emphasized exclusively as well as areas where both livability and freight activity are important. The Freight Plan organized this analysis into four basic context areas summarized to the left and described in greater detail in Chapter 2.

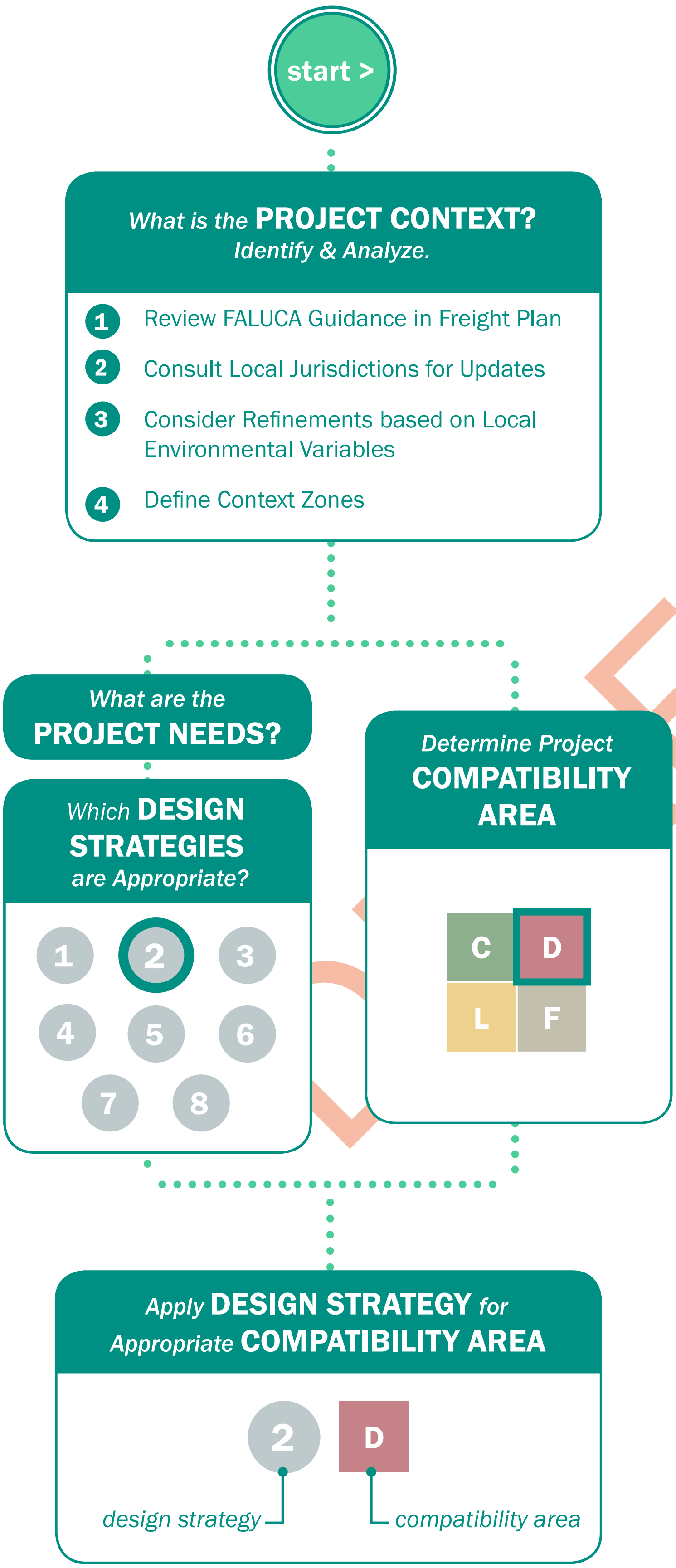


The definition of a project context area leads to the identification of appropriate design approaches, or perhaps more accurately design intent, that reflect the balance of goods movement and livability interests for that context. The identification of design intent is also included in Chapter 2. Once the design approach/intent is understood, the roadway designer has insight to select among a number of design strategies.

Chapter 3 presents eight design strategies, ranging from typical section considerations to signalized intersection phasing and timing, for which treatments vary considerably by context area. The information in Chapter 3 is structured to assist the roadway designer in selecting appropriate strategies that balance the needs for access, mobility, and safety of the different roadway users, including travelers using each mode as well as the adjacent residents and businesses. The designer may need to develop multiple design strategies for any given project; Chapter 3 helps match the appropriate design strategy and treatment to the project context.

- **LOW ACTIVITY AREAS** are characterized by land uses that would generally be compatible with freight mobility, but actual freight activity (truck traffic) in these areas is low. Therefore, these areas are not targeted for freight improvement strategies.
- **COMMUNITY ORIENTED AREAS** have low freight traffic and are characterized by medium- to high-density residential, office, and mixed uses that engender pedestrian, bicycle, and automotive traffic. Designing transportation facilities for these user groups generally impedes freight mobility, incorporating elements like fewer and narrower travel lanes, tight turn radii at intersections, and low travel speeds. Freight mobility strategies in these areas should be focused to a limited number of corridors that provide good freight accessibility to the area and limit impacts to other travel modes and the community character.
- **FREIGHT ORIENTED AREAS** have high levels of truck traffic and land uses that are supported by goods movement, such as industrial, commercial, and agricultural designations. These are areas where roads should generally be designed to facilitate truck movements, including design elements like wide travel lanes and wide turn radii at intersections. Implementing freight mobility improvements in these areas would likely have few, if any, negative sociocultural impacts. Indeed, such improvements would generally bolster the productivity of the industrial and commercial uses along the corridor.
- **DIVERSE ACTIVITY AREAS** have elements of both community oriented and freight oriented areas. Freight activity is high in these areas, either in terms of truck traffic or industrial and commercial land uses (or both), but there are also fairly dense residential and/or office uses. In such areas, freight mobility improvements would warrant special consideration to accommodate trucks, emphasizing the primary role of the freight facility and catering to the needs of other users of the facility, including motorists, bicyclists, and pedestrians.

THE FRDC DECISION PROCESS



This document helps a roadway designer understand project context and select corresponding design strategies

The FRDC Decision Process helps a roadway designer select and apply appropriate design strategies to match project context as indicated in the FALUCA process. The accompanying flowchart demonstrates the process graphically.

The consideration of project context has four basic steps that are expanded upon in Chapter 2:

1. The definition of FALUCA quadrant (community oriented, low activity, freight oriented, or diverse) begins with the guidance in the Freight Plan
2. Consultation with local jurisdictions is needed to determine whether changes have been made to land uses or zoning since the Freight Plan was developed in 2012
3. A series of local environmental variables should be considered to refine the FALUCA designation considering nuances that are below the radar of the Freight Plan guidance, and
4. The project may be segmented into different context areas depending upon its size and the magnitude of contextual changes within the study area

The selection of context-sensitive design strategies matches project needs and context-appropriate design solutions as expanded upon in Chapter 3:

> The definition of project purpose considers the scope and schedule of the project; a design strategy that is appropriate for a full roadway reconstruction may not be applicable for a resurfacing project

> The selection of a design strategy follows from land use context. In the flowchart example, there may be six different design strategies that could be applied to meet the project purpose and need. A designer working with Design Strategy 2 in a Diverse Activity Area will select a design solution that blends Design Strategy 2 with the context of the Diverse Activity Area.

Facilitating Goods Movement and Livability Integration Throughout A Project Life-Cycle

Goods movement and livability objectives should ideally be considered throughout a project life-cycle. The accompanying graphic, adapted from the Federal Highway Administration (FHWA) Guide to Transportation Decision Making, shows the stages of planning, implementation, and operation for federally funded projects. As goods movement and livability objectives work their way through the decision Making process, each decision has a ripple effect "downstream" on subsequent planning, implementation and operational elements. Regular feedback "upstream" helps to refine future plans and processes. This document focuses primarily on the Project Development stage in the process, where FDOT roadway designers are referencing the Project Development and Environment (PD&E) Manual and the Plans Preparation Manual (PPM) to develop roadway designs.

The Project Development process is informed by "downstream" guidance from documents such as the Tampa Bay Regional Strategic Freight Plan and the FDOT Strategic Intermodal System Strategic Plan. The feedback upstream occurs through both periodic planning and policy updates as well as site-specific or project-specific decisions. Periodic feedback processes include the updates to the Strategic Freight Plan. The decision to transfer portions of the state highway system to local jurisdictions, such as the case recently with US 301 in Zephyrhills and SR 582 in Tarpon Springs, are examples of project-specific feedback that will be incorporated in subsequent "upstream" decision Making processes, both from an administrative perspective relating to those particular projects, but more importantly from a systemic process associated with potential changes in other locations.

One of the most prevalent concerns affecting the relationship between project planners and project engineers nationwide is that the staff working on a particular element do not understand the decisions made upstream in the decision Making process. This document is intended to help demonstrate how considerations made at any step in the process guide subsequent decisions and to facilitate communications of general concepts, approaches, and concepts among staff working on different project stages. The FDOT PD&E process also emphasizes the use of Methodology Memorandums to document the objectives at each stage in the process and how those objectives are intended to be carried forward in subsequent stages. This document endorses the Methodology Memorandum concept, particularly regarding decisions affecting goods movement and livability.

FOCUS OF FRDC WITHIN PROJECT LIFE-CYCLE

This document focuses on decisions made during Project Development, but the concepts both influence, and are influenced by, considerations throughout a project life-cycle.

INTENDED AUDIENCE

The FRDC is written primarily to support design decisions of the FDOT District 7 roadway designer, but the materials are intended to serve as a resource for a wider audience, including other District 7 departments and offices as well as partner agencies at the statewide, regional, and local levels. The concepts may also be useful explanatory or reference materials for communicating with elected officials and interested members of the public.

ANTICIPATED USES OF THE FRDC BY DISTRICT 7 STAFF

This document is intended to serve several purposes for District 7 staff.

FDOT DISTRICT 7 DEPARTMENTS AND OFFICES

This document is developed to complement and help implement the District's Strategic Freight Plan for the Tampa Bay Region. The document is designed with the FDOT District 7 roadway design engineer as the primary target audience, but recognizes that many other planners, engineers, and administrators in District 7 may benefit from the document.

The accompanying chart shows how different functional groups within District 7 might find best value in this document, listed generally in order of their roles in project life-cycle management:

- Systems planning staff may find the document useful as a general resource, particularly in considering periodic updates of Strategic Intermodal System needs and priorities.
- Staff conducting PD&E and Design projects may find the document serves several purposes:
    - as a general resource in considering land use context and design concepts associated with goods movement and livability;
    - as a coordinating document, particularly for examining and documenting planning and design responses to satisfying project purpose and need, as projects transition from planning to design and then into implementation and operation; and
    - as a direct resource for selecting design strategies.
- Other implementation of activities such as right-of-way, traffic engineering and operations, and maintenance may find the document helpful in exploring pros and cons of alternative design strategies to ensure that the decisions made in planning and design are clearly understood and documented.

PARTNER AGENCIES

The FRDC may be of value to other groups with FDOT and its partner agencies beyond the District 7 staff who are most integrally involved in project development. The concepts in this document may assist these groups with freight planning and implementation, including:

> FDOT staff involved in developing statewide plans, corridor and district-wide plans, and operational improvements, may find the document serves:

- as a general resource for system-wide freight planning efforts;
- as a tool for coordinating planning, project development, and implementation concepts and priorities; and
- as a means for integrating goods movement concepts most particularly at a subarea level, where planning and implementation efforts are more detailed than practical statewide or region wide, but still with a geographic context broader than associated with most roadway design projects with narrowly defined study limits.

> Metropolitan and regional agencies may also find the document useful as a general resource in integrating goods movement more fully into their planning efforts and relationships with FDOT. In particular, agencies responsible for transit planning may find that the commonality in operating characteristics between some larger transit vehicles and trucks makes the document particularly relevant in coordination on alternatives analyses where different treatments are considered in a corridor or where parallel corridors may be able to serve a layered network function with deliberative designation of modal emphasis for each roadway segment.

> Because land use is so integral to the FRDC process, local agencies responsible for planning and zoning may benefit from using the materials in this document to help establish comprehensive plans, small area plans, and land development codes that are reinforced by the functional plans for the roadways that serve their communities.

POTENTIAL USES OF THE FRDC BY PARTNER AGENCIES

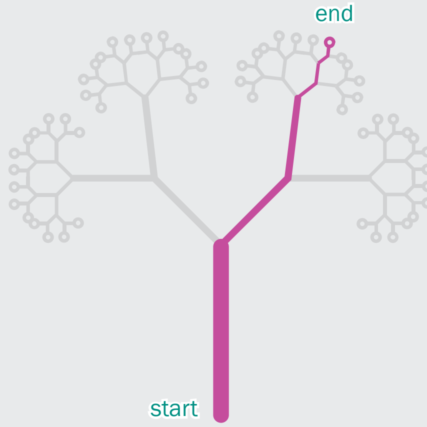
This document is intended to facilitate interagency coordination.

RELATIONSHIP TO OTHER FDOT MANUALS AND GUIDANCE

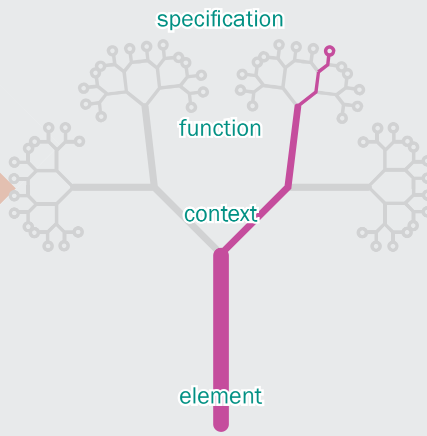
This document serves as a companion to existing FDOT Manuals and design guidance. It does not supersede materials in any other FDOT document. Rather, it organizes and presents the many considerations that a designer must address in synthesizing goods movement and livability, and demonstrates the types of approaches and strategies that are most likely to lead toward a design considered appropriate by most decision makers and constituents.

The accompanying dendritic "cauliflower diagrams" demonstrate how most design manuals are organized; primarily as a reference text. These documents serve their purposes well; they are used primarily by the designer to search out the appropriate design criteria or specifications for a given element. However, these reference documents, by necessity, tend to present each element comprehensively, but without much context beyond roadway functional classification and design speed. With most reference guides, the roadway designer is presented with a wide range of minimums, maximums, and other specifications for individual design elements. What those guides often do not include, however, is contextual guidance on how the design elements can be combined into specific design strategies and how those strategies, in turn, will affect the quality of service for different roadway users.

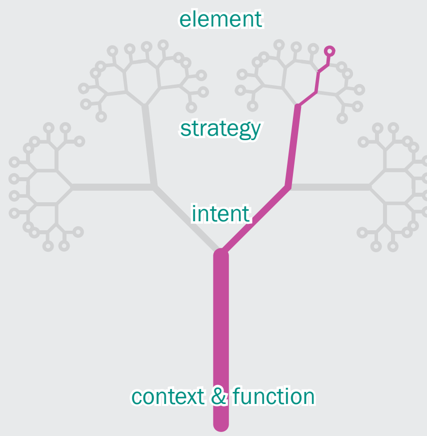
In contrast, the FRDC is intended to **spark ideas about how multiple design elements can be aggregated into design strategies that balance goods movement and livability objectives**. By necessity, this document also has a dendritic "cauliflower diagram" organizational schema. Rather than organized by design elements, however, it is organized by design strategy (in Chapter 3), with those strategies informed by land use and goods movement context and a series of resulting design approaches (in Chapter 2). In essence, the standard design manuals and guides are excellent resources for answering the question: "What". This guide seeks to help the designer understand the underlying "Why".



Nearly all roadway design references lead the designer through a series of alternative choices from a starting point to one of many potential ending points.



Most design references are organized for quick reference regarding particular design elements, based on the context (usually urban versus rural) and roadway function (usually functional class).



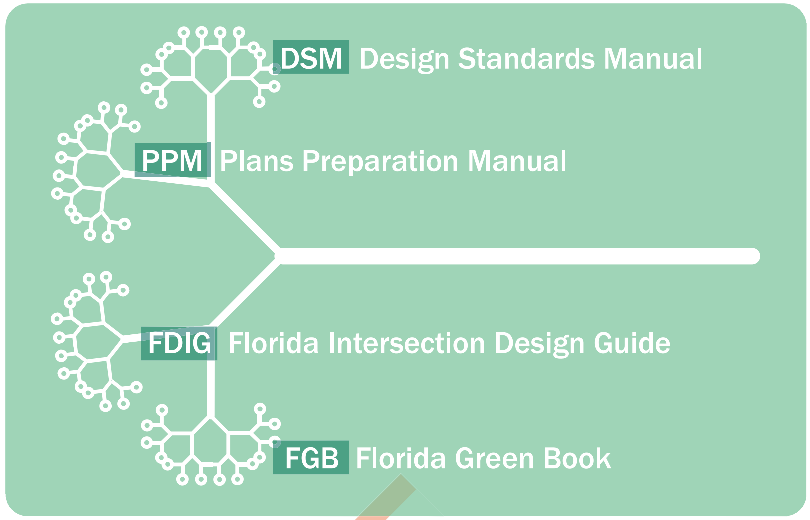
This document provides guidance on balancing land use context and goods movement function, leading to a series of design approaches and design strategies, resulting in considerations regarding design elements.

The remainder of the document consists of five chapters and appendices.

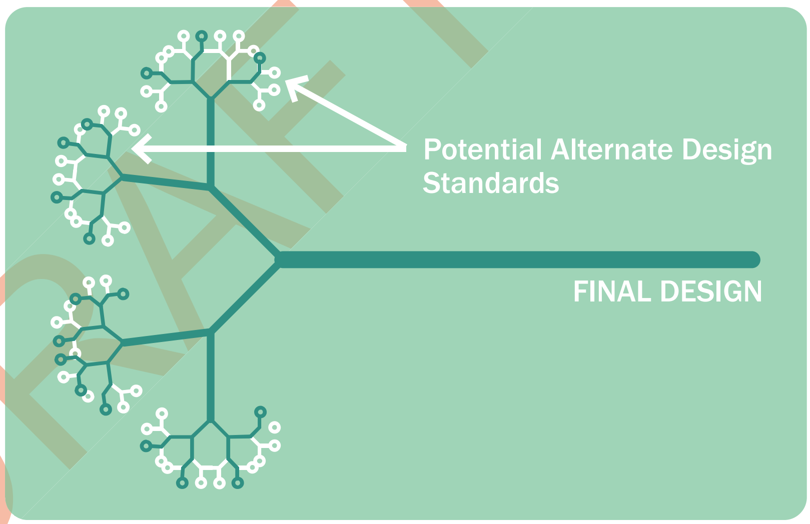
- **CHAPTER 2** describes how a roadway designer can define a project context in terms of both planned roadway function and adjacent land use. The chapter also identifies several **DESIGN APPROACHES** which tend to follow logically from the project context and set the stage with over arching guidance for emphasizing certain modal or functional priorities within the ranges established by the PD&E and PPM Manuals.
- **CHAPTER 3** presents a series of **DESIGN STRATEGIES** that a roadway designer might select in addressing several common goods movement related design challenges. Each Design Strategy is presented using a series of prototypical designs appropriate for different project contexts and a description of associated design elements and nuances.
- **CHAPTER 4** summarizes other goods-movement considerations for particular **DESIGN ELEMENTS** that hold true regardless of project context, design approach, or design strategy.
- **CHAPTER 5** describes how the design approaches and strategies might be tailored to fit special cases such as campus environments, one-way street networks, and railroad at-grade crossings.
- **CHAPTER 6** summarizes best practices and references both nationwide and locally.
- **APPENDIX A** provides "FALUCA" context maps at a more fine-grained scale than shown in Chapter 2.
- **APPENDIX B** contains a glossary of common terms used in the document with a focus on terms that may have different colloquial meanings or uses across different agencies nationwide.
- **APPENDIX C** contains a nationwide literature review conducted on best practices and knowledge gaps.

ORGANIZATION OF DOCUMENT

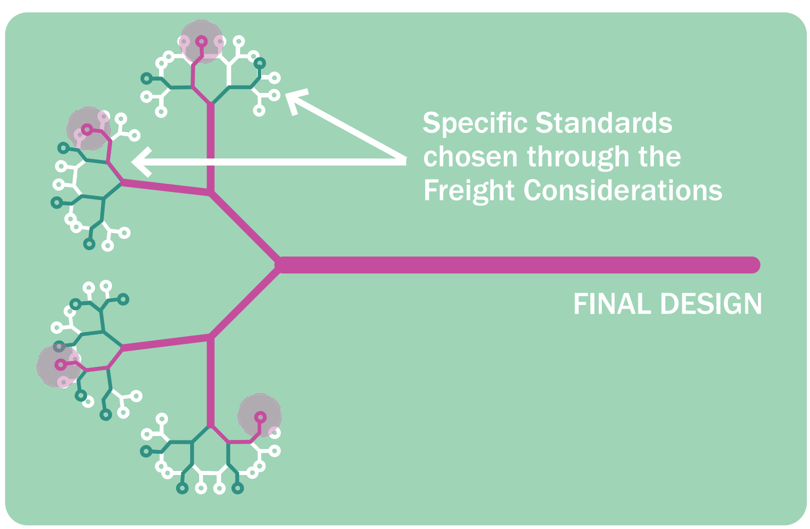
HOW THE FREIGHT ROADWAY DESIGN CONSIDERATIONS COULD BE USED WITH EXISTING DESIGN MANUALS



Roadway Design is determined by the application of several sets of Design Standards and Manuals.



In many cases, there are multiple Design Standards that would be equally acceptable depending on the objectives of the project.



The Freight Roadway Design Considerations help designers choose among multiple Design Standards that would be optimal for goods movement based on the project context.

CHAPTER 2: CONTEXT

Project context is the primary element in identifying appropriate strategies that provide an appropriate balance between the need to provide high quality of service for goods movement operations and the need to develop livable communities that promote multimodal access including walking, bicycling, and transit in addition to private motor vehicle use. This chapter provides guidance on determining project context with a particular emphasis on balancing goods movement and livability.

This chapter contains two primary sets of materials:

> A section on "Identifying the Context" describes the process and resources used to identify an appropriate project context area.

> Five different approaches to project design strategies demonstrate how the identification of a project context area helps to define the intent of design strategies in each of the context areas for:

- Design vehicle application
- Truck turning encroachment
- Modal emphasis
- Target speed
- Fine Tuning Access and Mobility

IDENTIFYING THE CONTEXT

The identification of roadway project context includes consideration of existing and planned land use and goods movement functionality, local environmental resources, and other project scoping elements; all of which help to guide the Design Approach/ Intent considerations described in the second part of Chapter 2 and the selection of Design Strategies described in Chapter 3. The following paragraphs provide:

> A description of the "FALUCA" system for integrating livability and goods movement contexts

> Guidance for defining the land use context (or contexts) for a given project

> Examples of FALUCA context types

The FALUCA Placetype Construct

The Freight Roadway Design Considerations applies a placetype context introduced in Chapter 8 of the Tampa Bay Regional Strategic Freight Plan. This context considers the juxtaposition between goods movement on the highway network and the amount and types of land uses served by each roadway. The Freight Plan conducted a "Freight Activity and Land Use Compatibility Analysis", or FALUCA, introduced in its most basic form, a two-by-two matrix shown in Chapter 1. As the materials in this chapter will demonstrate, the two-by-two matrix that results in the four quadrants of Community Oriented, Diverse, Low Activity, and Freight Oriented Areas is a simplifying organizing schema.

The particular set of improvement strategies appropriate for a given freight roadway facility depends not only on its freight transport function but also on the existing and planned land uses and activities within the corridor. The Tampa Bay Regional Strategic Freight Plan study area covers a sizeable region that includes eight counties and more than 50 municipalities. Each jurisdiction has its own plans for growth and development documented in comprehensive plans and detailed in other documents like neighborhood or special area plans. These plans express the long-term livability visions for these communities. Investment strategies developed to improve freight travel conditions within freight corridors should also consider and support the existing land uses and long-term growth vision for the area. To understand the geography of freight activity and livability planning initiatives throughout the region, a freight and land use compatibility analysis was performed that utilizes local land use and special planning area data and truck traffic statistics.

Get More Info on the
FALUCA SYSTEM

The FALUCA placetype context is introduced in Chapter 8 of the Tampa Bay Regional Strategic Freight Plan:

www.tampabayfreight.com/wp-content/uploads/Chapter8.pdf

The details of the FALUCA approach, including procedures for land use and transportation network assumptions and analytics are included in the Freight Plan Appendix C:

www.tampabayfreight.com/wp-content/uploads/AppendixC.pdf

Identifying FALUCA Placetypes

As presented in Chapter 1, the consideration of project context has four basic steps:

> Review the FALUCA guidance from the Freight Plan

> Consult local jurisdictions for updates to planning and zoning documents

> Consider refinements based on local environmental variables, and

> Define context zones

Step 1. Review FALUCA Guidance in Freight Plan

As introduced in Chapter 1, the Tampa Bay Regional Strategic Freight Plan includes an assessment of land use patterns for the region that reflect both the type and extent of land use and the amount of freight activity. The Freight Plan compatibility analysis provides a general sense of the land use character in the vicinity of each of the identified freight mobility needs. The analysis guides the development of strategies and freight-friendly roadway design given the constraints and opportunities presented by the local context of a specific facility. The compatibility analysis utilizes regional and local land use planning data and regional truck traffic data to identify areas where potential conflicts exist between freight activity and community livability. The general kinds of data used in the analysis include the following:

> Future land use

> Planned rapid transit station areas (quarter-mile buffers around station locations)

> Community redevelopment areas

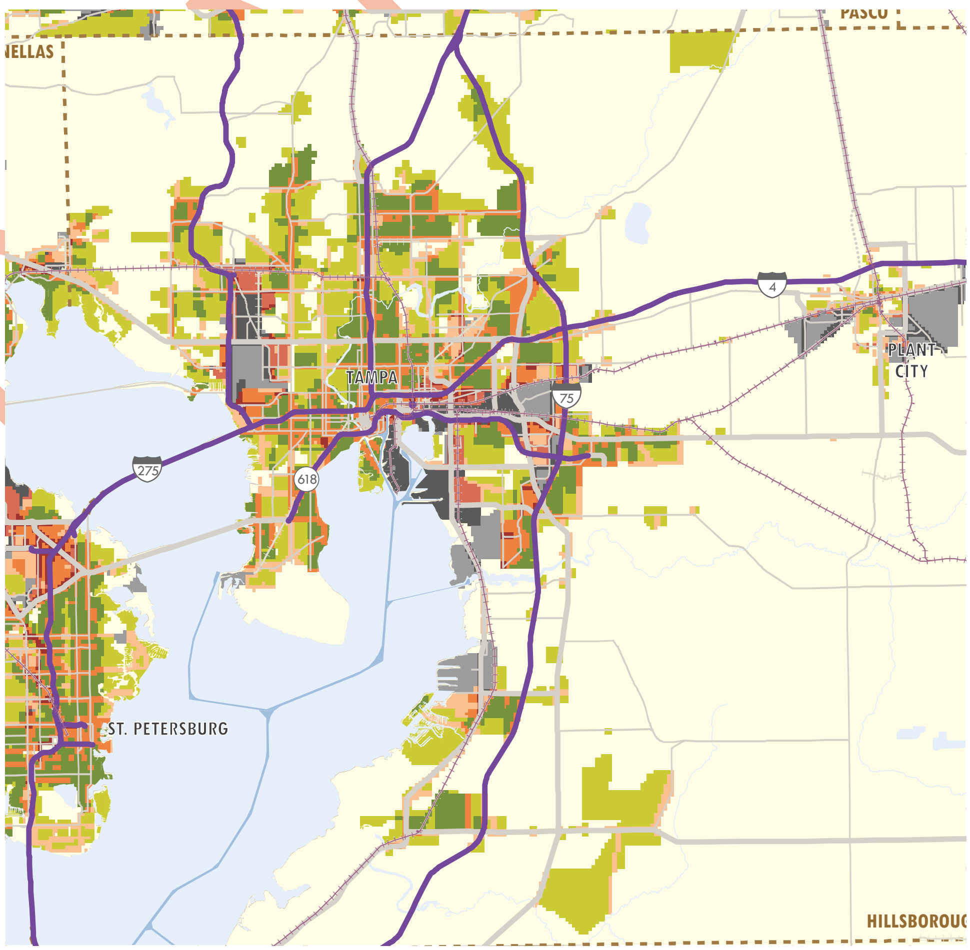
> Local activity centers defined in MPO LRTPs

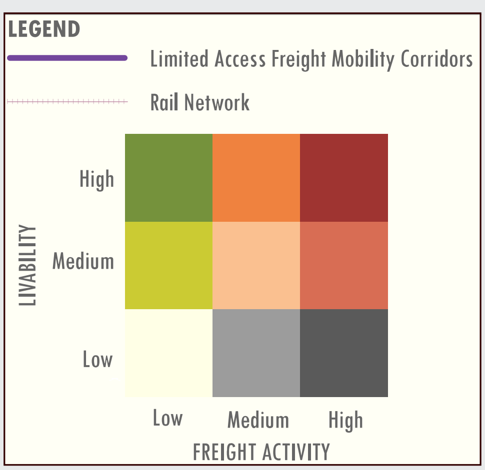
> Regional activity centers defined in regional LRTPs

> Intensity of freight activity centers

> Projected future truck traffic

Future conditions are the key to identifying appropriate placetypes. Context-sensitive solutions focus not on what the place is currently, but rather what the place is intended to be. The design of transportation projects can play a valuable role in the evolution of place where change is part of an adopted plan.

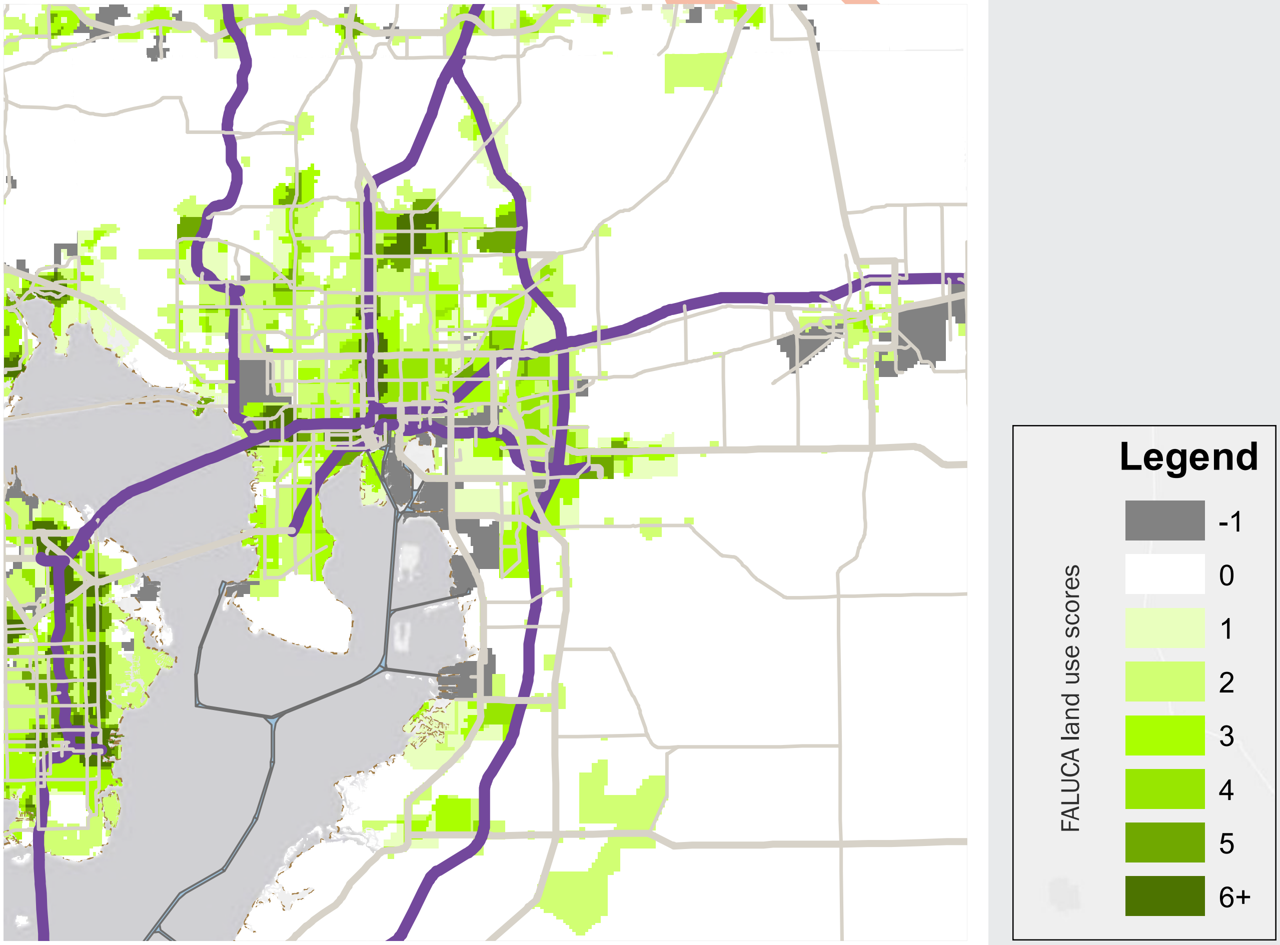




Map 8-1 in the Freight Plan identifies nine different types of context areas based on low, medium, and high levels of both livability and freight activity. This map focuses on the Hillsborough County portion of District 7.

To understand the land use context in the Freight Plan, it is useful to examine both the livability element and the freight activity element separately. The FALUCA land use scoring system assigned a series of point values for different types of planned land activity throughout the region which varied according to the land use planning processes for each jurisdiction. Additional detail is provided in the Freight Plan Appendix C, and is summarized graphically using a shade of grays and greens, wherein gray is the most industrial land use (a score of negative 1 points) and dark green is the most livable land use (with at least 6 points). Points awarded including the following considerations:

- Existing or future transit station areas designated in plans were awarded three points
- Other livable future land uses, including medium-to-high density residential, office, and mixed-use, were awarded two points
- Industrial future land uses were awarded a “negative one” point
- Regional Freight Activity Centers also were awarded a “negative one” point
- Community Redevelopment Areas were awarded one point
- Activity centers were awarded one or two points (higher points awarded to primary regional centers)
- Regional anchors were awarded one or two points (higher points awarded to high tier anchors).

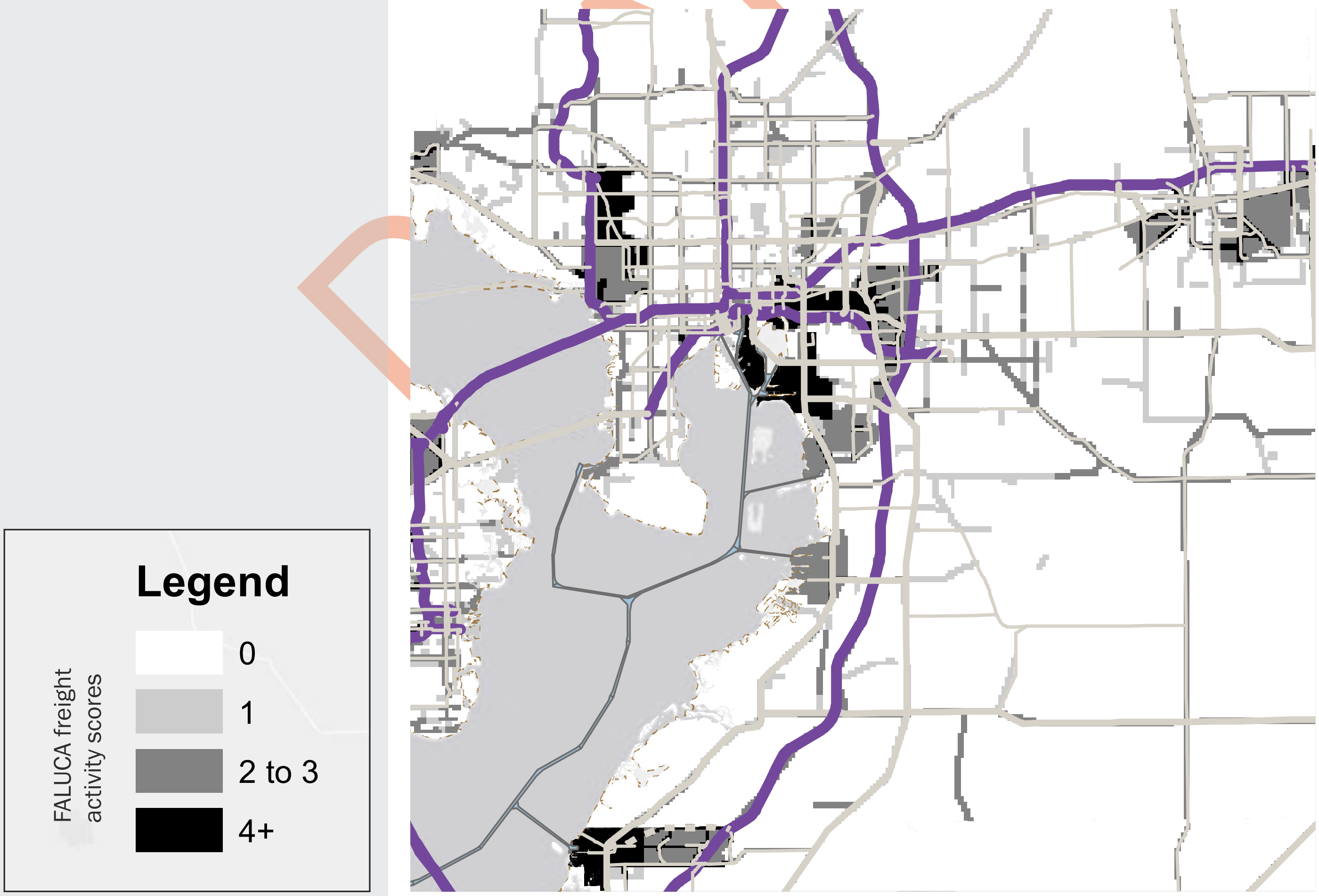


The land use component of the FALUCA matrix indicates the contrast between highly livable and industrial land uses in jurisdictional land use plans.

The FALUCA land use component map indicates in gray the freight oriented land uses such as the Port of Tampa, Tampa International Airport, and areas around Plant City. Conversely, areas with the highest livability scores are shown in green, including downtown Tampa and St. Petersburg, the University of South Florida campus vicinity, and Brandon.

From a goods movement perspective, the scoring system is summarized graphically in the FALUCA freight activity component map using a series of grays, with the darkest areas including both industrial land uses and goods movement corridors with the highest percentage of truck travel. Points were awarded for existing and planned land uses as follows:

- Industrial areas were awarded one point
- Freight Activity Centers were awarded two or three points based on the level of goods movement intensity
- Roadways region wide were awarded zero to three points based on the percentage of forecast 2035 truck traffic.



The freight activity component of the FALUCA matrix indicates both industrial land uses and the key goods movement corridors that connect them.

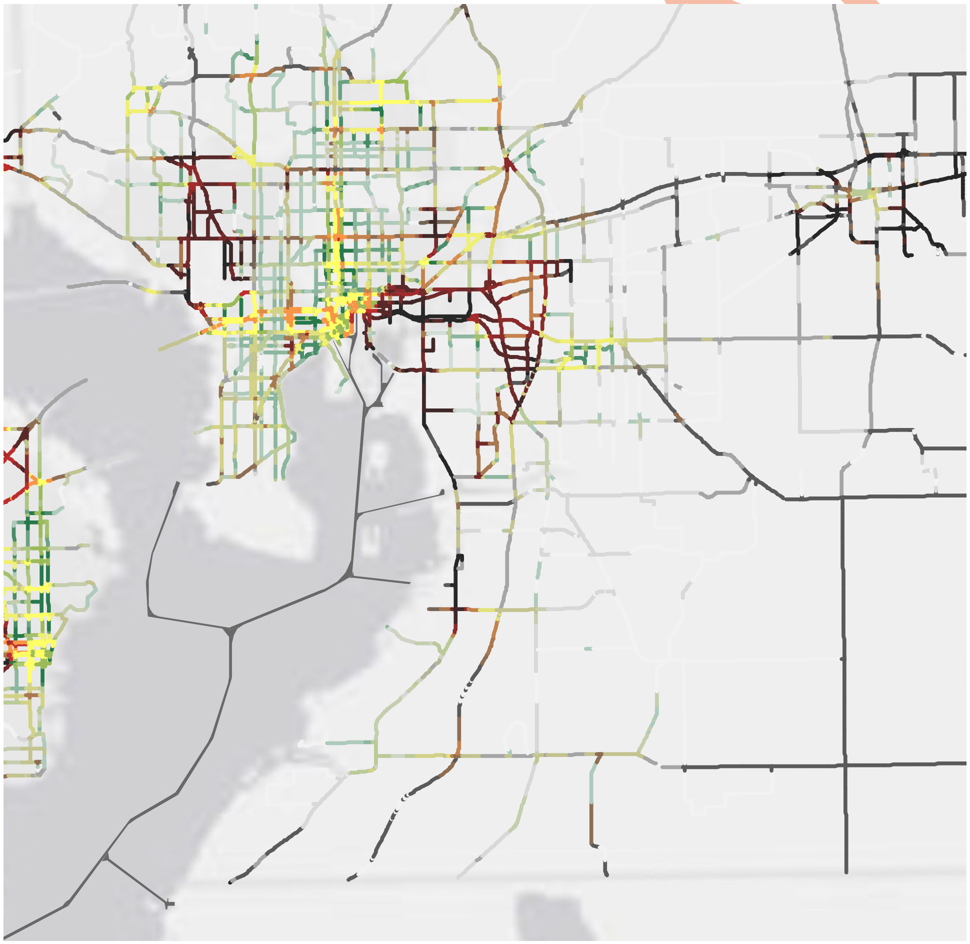
Identifying the component livability and freight activity elements of the FALUCA matrix facilitates the recombination of this information in a more detailed continuum that focuses just on the conditions immediately adjacent to the roadway network and provides a clearer graphical demonstration about how conditions may change as a roadway traverse different context areas.

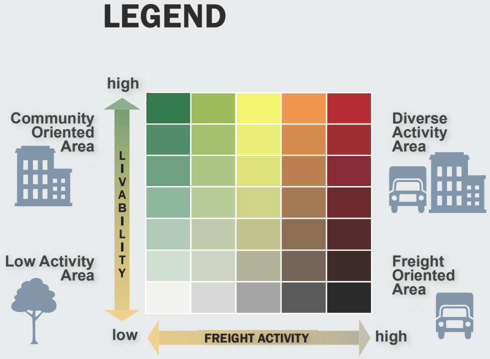
In this FALUCA roadway-based map, the livability and goods movement axes color schemes are adjusted from those used in the prior three maps:

- The goods movement continuum shifts from green (for the lowest amount of goods movement activity) to red (for the highest amount of goods movement activity)
- The livability continuum shifts from gray scale (for the lowest amount of livability) to fully colorized (for the highest amount of livability)
- The scores for each roadway segment reflect a blending of adjacent land uses. While an abrupt shift from highly livable to highly freight-oriented is rare, this graphic approach provides a smoother assessment of placetypes, balancing adjacent land uses on both sides of a study roadway segment.

Focusing on the arterial road network itself (eliminating the land areas that are not close to the state highway system and removing the limited access highways, which this document does not address) helps the pattern of goods movement and livability emerge more clearly.

A district-wide presentation of the four maps presented in this section are included in Appendix A.





The FALUCA roadway-based map places the definition of roadway context directly on the arterial network itself and demonstrates the concept of a continuum of placetypes.

Step 2. Consult Local Jurisdictions For Updates

The FALUCA maps described in Step 1 provide a starting point for setting land use context throughout the Tampa Bay Region. As with any static map published from GIS-based analysis, advantages include precision and consistency. Limitations include the currency of the data and the ability to assess nuances that might not always be apparent from, or sufficiently reflected within, the GIS metadata. Steps 2 through 4 of the process help address these limitations.

Step 2 involves consulting the local jurisdiction and regional planning and zoning authorities to determine the currency of the map data. This can be accomplished as part of the normal local jurisdiction coordination process. Elements to consider include:

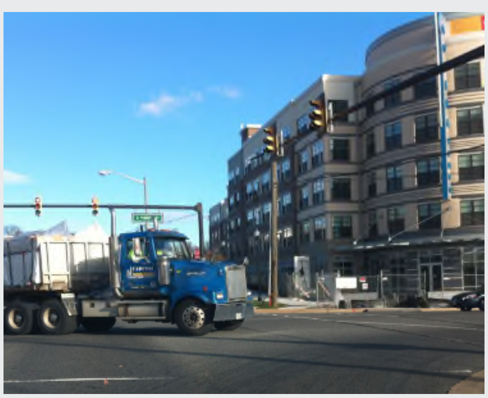
- Significant recent changes to a comprehensive plan or other significant development approval that would materially change the type or extent of planned land use in the study corridor, particularly regarding designations of new or revised planned transit stations and Community Redevelopment Areas. Many local jurisdictions make several such changes on an annual basis.
- Significant recent changes to the planned transportation network, notably relating to the degree to which goods movement patterns would be affected. Such changes might range from major investments such as the Interstate 4 - Selmon Connector or consideration of state/local ownership and truck route designations such as for US 301 in Zephyrhills.
- Specific context-setting elements that are not incorporated in the GIS analysis. This is a judgment call for the project team to make on a case-by-case basis, as each jurisdiction has its own set of land use planning rules and regulations. The FALUCA process has already established a process for providing a complementary set of ratings for different planning and zoning regulations throughout the region, but the project team should use their discretion to determine whether any adjustments should be made in this regard from a systemic perspective. More guidance on context-sensitivity from a local, resource-specific, perspective is discussed in Step 3.

Step 3. Consider Refinements Based on Local Environmental Variables

A roadway project context is influenced by many local environmental variables that are usually highly correlated and reflect not only the current GIS and planning paradigm described in the FALUCA process but also reflect the cumulative effect of an area's history and the past land use and transportation decisions made over the course of decades.

Parcel Size and Orientation

Many decisions affecting project design depend upon the layout of adjacent and nearby development parcels. Older, more established communities often have smaller parcels along state highways; these were generally places that developed prior to the widespread use of auto travel and its associated characteristics including formal roadway functional classifications and access management policies and the economic feasibility of large-scale activity centers such as shopping malls. While small-lot subdivisions have continued to be developed, most are now buffered from the arterial highway network and served by secondary streets.



Over time, many freight-oriented areas evolve into diverse activity areas.

Community oriented areas are often typified by a wide swath of smaller parcels both abutting and proximate to state highways. Freight activity areas often have larger parcels housing industrial uses. Diverse activity areas may have a mix of parcel sizes and layouts (for instance, a suburban crossroads may have a cluster of older retail uses at the corners surrounded by newer, larger subdivisions). Low activity areas tend to have large, undeveloped parcels. In fact, the presence of subdivided but vacant properties is often a clue that what may appear on the ground to be a low activity area is actually in the process of evolving into a diverse activity area.

Parcel sizes often influence project decisions, particularly in the realm of value engineering. Smaller parcels abutting the roadway rely on access to the roadway regardless of its designated functional classification, increasing the complexity of access management strategies. Smaller parcels tend to have narrower building setbacks, so any design strategies involving right-of-way acquisition are more likely to entail significant coordination regarding drainage, utilities, and access and increase the likelihood of a full property displacement. Right-of-way acquisition is also complicated by the fact that smaller parcels usually, by definition, entail a greater number of real estate negotiations. Finally, communities with small parcels along a state highway right-of-way are often those where right-of-way acquisition is most costly, due to real market value or to the community values (particularly as associated with historic or institutional uses).

Prevailing Right-of-Way

The width of the roadway right-of-way, independent of the functional classification, often provides a useful context for understanding, or influencing, land use context. Transportation and utility corridors that run parallel to a roadway segment and significantly increase the width of the total transportation right of way are indicators of a broader mobility function usually found in low-activity areas or freight-oriented areas. The increased width results in decreased walkability due simply to the larger distance between doorways on either side of the roadway. In most cases, the parallel mobility functions also increase the distance between available roadway crossing points, further decreasing walkability. Parallel transportation corridors encompass a variety of modes and purposes.

- Multiple parallel roadways, such as frontage or service roads, are typically part of an access management scheme designed to foster a mobility function for the main or central roadway. Frontage roads are often found in diverse activity areas in addition to low activity or freight-oriented areas where adjacent retail uses have a high person-trip generation rate (but also a high auto-driver mode split).
- Rail lines are often indicative of a freight-oriented area both by virtue of their purpose serving intermodal goods movement, as well as by the tendency for noise-compatible land uses to be predominantly industrial in nature. Parallel rail and roadway lines are also fairly common in low-activity areas.
- Utility corridors, including high-voltage power lines and natural gas transmission lines also typically have regulatory access restrictions and market-based suitability that leads to predominantly freight-oriented uses.

Conversely, community-oriented areas often have constrained rights-of-way for a variety of reasons:

- Urban and commercial centers that were established in the first half of the twentieth century were generally platted with rights-of-way less than 100' in width. Older communities typically have a more robust street grid supporting the main street.
- Subsequent development with a corresponding increase in property values, and the presence of a grid network to distribute traffic, are substantial enough to have inhibited further widening of the right of way. In community-oriented areas, historic institutional and community resources, ranging from parks and schools to churches and cemeteries, also contribute to the development of a defined places in which access appears to be a higher priority than mobility, regardless of the designated roadway functional classification.
- A relatively narrow right-of-way has a reinforcing effect on the real estate market for both pedestrian-scaled commercial and residential property development.

Number of Travel Lanes

The number of through travel lanes on a roadway can have an effect on land use context. The recognition of the relationship between roadway width and livability is well documented in reports such as the ITE/CNU Designing Walkable Urban Thoroughfares: A Context Sensitive Approach which suggests a maximum number of through travel lanes for different design contexts. For the purposes of the FRDC document, it is appropriate to apply the same approach but with reverse causality; if a six-lane roadway will be needed to accommodate multimodal mobility needs, then the context area is far less likely to be a thriving community oriented area and much more likely to thrive as a diverse activity area.

Other Local Environmental Variables

Several other local environmental variables are implicitly incorporated into the FALUCA process but may still warrant consideration and refinement by a roadway project team:

- Proximity to freight generators affects roadway context. For instance, the need for the I-4 Selmon Connector to help improve both efficient goods movement and livability in Ybor City is affected more by Ybor City's location near the Port of Tampa. The FALUCA process incorporates this element to a fair degree by considering truck traffic percentage, which generally decreases as the distance to a freight generator increases.
- Roadway network form or topology affects context. For instance, the importance of goods movement for the network of arterial connections at each end of the Courtney Campbell Causeway and Gandy Bridge crossings of Old Tampa Bay is increased due to the limited number of crossing points. The same effect occurs to a lesser extent for other water features and transportation facilities such as railroad tracks. Again, the FALUCA process incorporates this element through truck traffic percentage, which generally increases at places like bridge crossings where longer distance goods movement trips are more valuable than shorter local auto trips.

Even in Low Activity Areas effective guidance can minimize conflicts between goods movement and community interests.

Step 4. Define Context Zones

The final step in the process is to consider the variability of context areas within a roadway project study area and determine logical boundaries for them. This depends on the size of the project; an improvement made to a single intersection should have a single unifying approach to its design strategies and design elements, whereas a ten-mile long corridor may indeed traverse many different contexts. The three maps described in Step 1 provide an initial glance at the perspectives that may logically be considered:

- The FALUCA land use component map identifies context area boundaries based in large part on local plan designations for desired growth patterns such as Community Redevelopment Areas that are often suitable transition points.
- The FALUCA freight activity component map indicates context areas based primarily on the location of freight generators and the percentage of truck traffic on the roadways connecting them, this perspective is useful for overall context but in most cases it is not sufficiently accurate or precise for defining logical boundaries between context zones
- The FALUCA roadway-based map identifies a broader continuum between placetypes that helps demonstrate the degree of change that may be expected along longer roadway design projects.
- The following rules of thumb can help define context zones and boundaries:
    - Context areas should be at least a half-mile in length, a guideline reflected in and informed by the following more qualitative considerations.
    - Utilize local planning and zoning designation boundaries to the extent possible; these designations will be guiding the private sector context which the roadway should be serving
    - Avoid piecemeal context zones; for instance, all four quadrants of an intersection should ideally have the same context (even if the design strategies or elements for them are different) as the users of the intersection will need to relate to the intersection as a whole. Similarly, both side of a roadway should ideally be in the same context zone.
    - Consider the distances needed to transition from one context zone to another, as well as transitions in project design (such as from a two-lane segment to a four-lane segment where both are in the same project area).

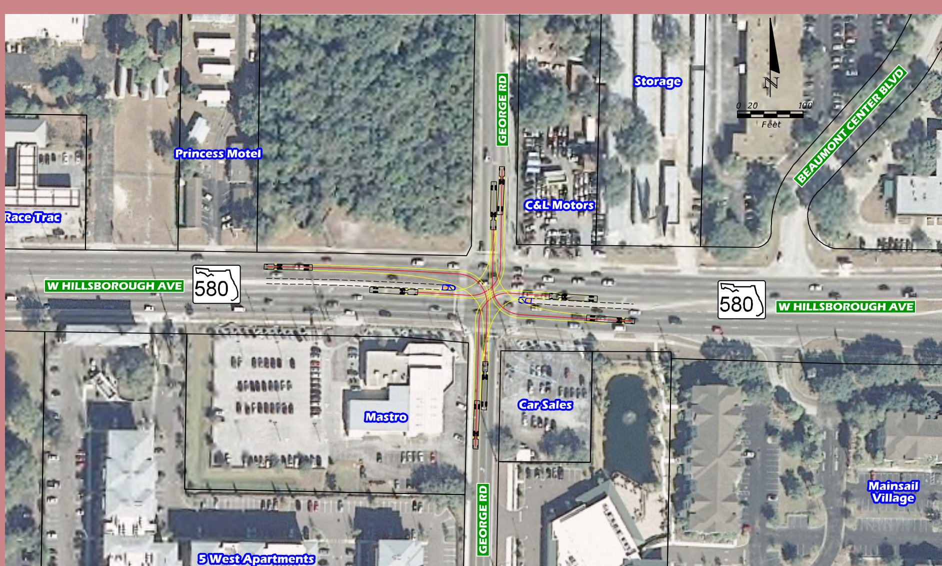
Examples of Context Areas

The following pages provide some examples of the four FALUCA quadrants, using contemporary freight-oriented projects as an example.

COMMUNITY ORIENTED AREA

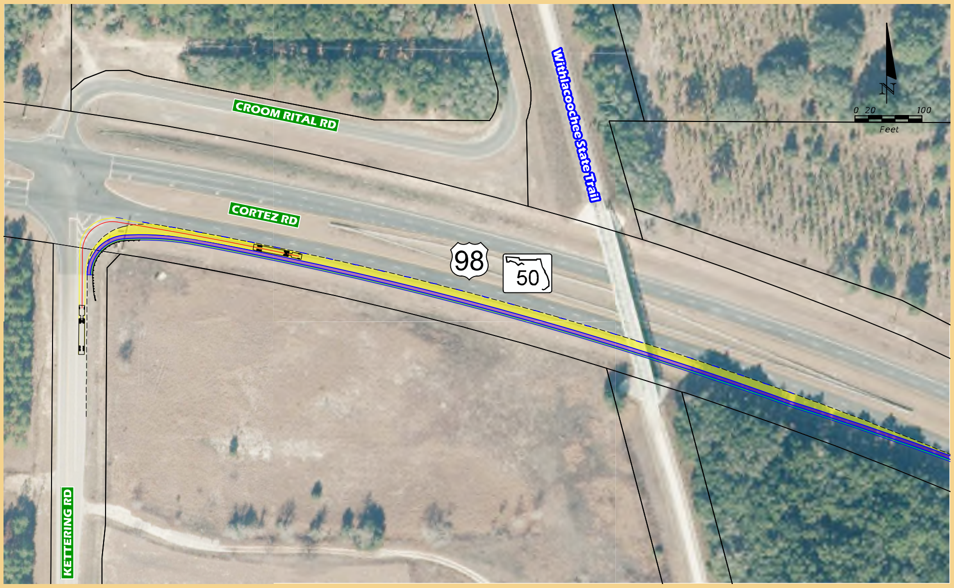
Community oriented areas include state highways serving relatively densely populated residential, commercial, or mixed-use districts where the level of bicycling and pedestrian activity can be expected to be fairly high and the extent of truck traffic is relatively low. This section of Drew Street (SR 590) east of downtown Clearwater provides an example of many elements typical of a community-oriented area, including a fairly narrow right-of-way, narrow parcels that require access from the state highway, and a closely spaced grid street network that helps disperse localized traffic. The vacant properties a block south along Grove Street demonstrate how the property development patterns can influence a community context area even in a case where the land is currently vacant.

DIVERSE ACTIVITY AREA



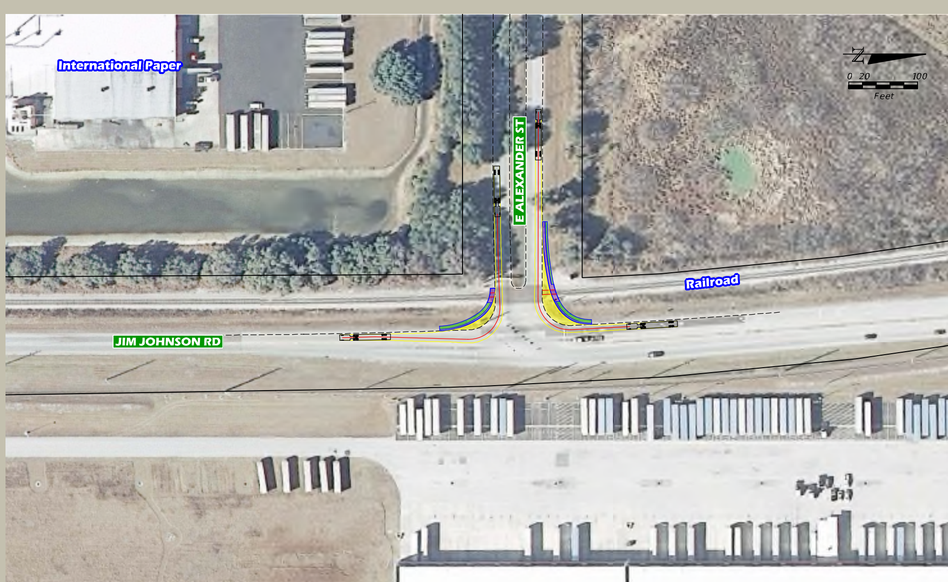
Diverse activity areas have both high levels of localized activity generating a wide variety of person trips as well as a high amount of truck traffic. West Hillsborough Avenue (SR 580) near Tampa International Airport has residential and commercial land uses sufficiently mixed to have some interparcel pedestrian connections. Parcel sizes are fairly large but irregular orientation creates access management challenges. Few buildings actually have front doors on the arterial network, yet the roadway right-of-way is generally constrained by adjacent development with little opportunity for expansion.

LOW ACTIVITY AREA



Low activity areas are characterized by land uses that generate low amounts of trip generation by any mode, including freight, and that have relatively low levels of through truck traffic. The section of Cortez Boulevard (US 98/SR 50) near Ridge Manor has adjacent land uses with low levels of activity that, taken in isolation, would be suggestive of a low activity area. However, this section of US 98/SR 50 provides both access to a local distribution center on Kettering Road and a regional connection between Brooksville and Orlando. The levels of truck traffic are therefore sufficient that the area is actually considered freight-oriented in the FALUCA GIS process.

FREIGHT ORIENTED AREA



Freight oriented areas have high levels of truck traffic and land uses that are supported by goods movement, such as industrial and commercial designations. This section of Jim Johnson Road in Plant City is an example of a freight activity center street in which the land uses are fully industrial with an evident focus on goods movement distribution. Parcels are large and access to the roadway network is both controlled by parcel size and layout as well as by the adjacent railroad tracks.

Considering Project Scoping Objectives

The primary definition of context in the FALUCA approach is a blending of planned land use and transportation system functions, described in the previous pages. It is also important to consider the project phase, project type, and project purpose in transitioning from the identification of a context area to the application of Design Approach/Intent presented in the following sections and the selection of Design Strategies described in Chapter 3.

These Freight Roadway Design Considerations are directed primarily towards roadway design efforts, but, as described in Chapter 1, may be applicable to agencies and departments responsible for the full range of project life cycle elements, from policy and planning to management and operations. The implementation of a new arterial roadway connection provides a different opportunity for exploring design strategies than does a Resurfacing, Restoration, and Rehabilitation (3R) project.

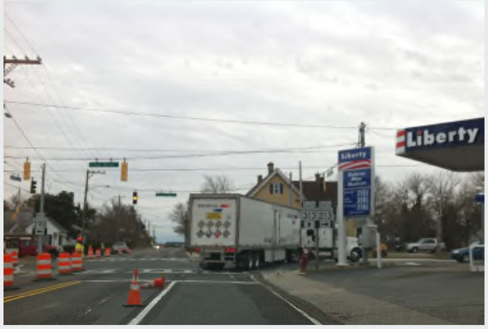
The selection of appropriate design strategies depends in part on the extent to the purpose and need for the roadway design project. These considerations include:

- What is the project horizon year and expected shelf life? Nearly all roadway design projects consider future conditions to some degree. The idea of context-sensitive design is to develop a roadway that not only respects current conditions, but more importantly helps to achieve the desired future context, a concept particularly important in urbanizing areas. The evolution of both the public realm (within the right-of-way) and the private realm (beyond the right-of-way) should occur in a coordinated process. Consider a roadway segment in a context that currently appears freight oriented, but is actually considered a diverse area due to planned development or redevelopment over time. In such a case, the low activity context designation may be appropriate for a 3R project with a life-cycle that is fairly near term. However, a roadway reconstruction project (say, widening from two to four lanes) should be considering the land use and goods movement context over a much longer time frame.
- What is the project purpose and need, and how is it related to livability and goods movement? Projects that proceed through the PD&E process benefit from a formal definition of the project purpose and need. The same level of information is valuable for all roadway design projects, whether emanating from a NEPA environmental document or simply a statement of objectives in a Methodology Memorandum or similar document.
- What is the project scope? To some extent, project scoping decisions such as the project time frame and allocated budget provide context for the level of change that the project is expected to engender. The project design team should not allow these constraints to influence a truly inappropriate design solution, but on the other hand neither should the perfect be the enemy of the good.

A key to applying this project scope perspective on influencing project context is good documentation. The Methodology Memorandum approach described in the PD&E Manual is a useful approach for deliberately addressing goods movement and livability decisions made during the project scoping regardless of whether required by policy. In other words, the intent of the state's formal approaches to Efficient Transportation Decision Making are just as effective for smaller projects when considered in the "lower case" objective of efficient transportation decision making.

Moving from Context to Intent and Approach

The project context informs many elements of design intent regarding the balance between goods movement and livability. This design intent, in turn, helps define appropriate design approaches. The remaining pages of Chapter 2 introduce the five types of design approaches that appropriately serve the design intent for each of the four FALUCA context areas.



The consideration of goods movement is important at all life-cycle stages, from planning to operations.

DESIGN APPROACH/INTENT

DESIGN VEHICLE

The selection of a Design Vehicle is controlled by FDOT rules and regulations that reflect the largest vehicle that should be assumed to use the roadway. In urban areas with a strong emphasis on creating livable places, the Design Vehicle must be accommodated on all designated freight routes, but a smaller vehicle turning template may be more appropriate for turning movements at intersections where the cross-street will not be expected to have significant levels of truck traffic. Assuming a WB-67 design vehicle for all movements at all intersections results in designs that reduce comfort and convenience for pedestrians. Since WB-67 turning movements are rare, such designs include more pavement and longer pedestrian crossing distances than are necessary for most turning maneuvers. Such designs also result in higher speeds for turning vehicles of all sizes. The increased pavement dimensions can also increase the capital cost of an improvement, particularly where urban development densities contribute to high property values, and therefore right-of-way costs.

The consideration of a smaller vehicle for turning movements between designated freight roadways and lower-classified urban streets can help balance both goods movement for the freight roadway with livability for other intersection users. This approach, recommended by group such as the National Association of City Transportation Officials (NACTO), the Institute of Transportation Engineers (ITE), and the Congress for the New Urbanism (CNU), introduces the concept of both a Design Vehicle and a Control Vehicle. In this approach, the FDOT Design Vehicle is termed a "Control Vehicle" for the purposes of turning movements; it is expected to make a turn only rarely. A smaller vehicle, more expected to make frequent turns to lower-class side streets, is designated the "Design Vehicle".

The intersection turning movement considers both the Design Vehicle (DV) and the Control Vehicle (CV):

> The Design Vehicle is one that must be accommodated without encroachment into opposing traffic lanes (see: Type D Encroachment).

> The Control Vehicle is one that is infrequent but must be accommodated by allowing:

- Encroachment into opposing lanes if no raised median is present (Type D Encroachment)
- Minor encroachment into the street side area (see Mountable Curbs) if no critical infrastructure such as traffic signal poles are present.

CONTEXT CONSIDERATIONS

The primary contextual considerations for selecting a Design Vehicle are the degree of livability and the expected frequency of turning truck traffic at intersections . The tables below describe a range of intersections that may be found between four types of freight roadways designated in the Tampa Bay Strategic Regional Freight Plan, listed below in descending order of priority:

> Signalized ramp terminals leading to limited access facilities

> Freight Mobility Corridors

> Other Freight Distribution Routes, and

> Freight Activity Center (FAC) Streets

Each of these freight roadway facility types intersects other streets of either equal or lower priority from a goods-movement perspective. The selection of appropriate design vehicle for turning movements at each of these types of streets depends on three elements:

> The overall context of the area as community-oriented, diverse, freight-oriented, or low activity.

> The relative importance of goods movement on the designated freight roadway forming the through route at the intersection, and

> The importance of goods movement on the intersecting cross-street, to and from which design vehicle turning templates will be applied.

DESIGN/CONTROL VEHICLE

Five types of Design Vehicle/Control Vehicle pairings are described in the following tables:

Intersections where turning movements for freight should be provided the highest quality of service.

Where lower classification freight roadway types (other freight distribution routes and FAC streets) intersect in community oriented and diverse areas, a WB-62 Design Vehicle may be appropriate.

Where freight roadway facilities intersect non-freight roadways in community oriented and diverse areas, a WB-40 Design Vehicle may be appropriate in concert with a WB-62 Control Vehicle. This same pairing is appropriate where freight roadway types intersect local roads and streets in low-intensity and freight-oriented areas.

Where freight roadway facilities intersect local roads and streets in community-oriented and diverse areas, a single unit (SU) truck may be appropriate in concert with a WB-40 Design Vehicle.

In limited cases where Freight Activity Centers are located a block or two from a higher type freight roadway facility, a designated Freight Activity Streets may occasionally intersect lower classification collector or local streets for which no large vehicle turning movements should be expected.

The following tables present suggested design vehicle and control vehicle considerations for turning movements at each of these intersections. Each table applies to two context types, and the matrix within each table describes the four types of freight roadway facilities in columnar format, with individual rows for each of the intersecting street types of an equal or lower classification.

COMMUNITY ORIENTED

What: Turning movements at intersections with lower classification cross-streets have significantly lower Control Vehicle and Design Vehicle requirements

Why: Tractor-trailer movements for lower classified cross-streets are fairly rare occurrences

DIVERSE ACTIVITY

What: Turning movements at intersections with lower classification cross-streets have significantly lower Control Vehicle and Design Vehicle requirements

Why: Tractor-trailer movements for lower classified cross-streets are fairly rare occurrences

CROSS STREET FACILITY TYPE	DESIGNATED FREIGHT ROADWAY FACILITY TYPE			
	Limited Access Facility Ramps	Freight Mobility Corridors	Other Freight Distribution Routes	FAC Streets
Limited Access Facility Ramps	DV = WB-67			
Freight Mobility Corridors	DV = WB-67	DV = WB-67		
Other Freight Distribution Routes	DV = WB-67	DV = WB-67	DV = WB-62	
FAC Streets	DV = WB-67	DV = WB-67	DV = WB-62	DV = WB-62
Other Major Arterials	DV = WB-40 CV = WB-62	DV = WB-40 CV = WB-62	DV = WB-40 CV = WB-62	DV = WB-40
Other Minor Arterials and Collectors	DV = WB-40 CV = WB-62	DV = WB-40 CV = WB-62	DV = WB-40 CV = WB-62	DV = WB-40
Local Roads and Streets	DV = SU CV = WB-40	DV = SU CV = WB-40	DV = SU CV = WB-40	DV = WB-40

LOW ACTIVITY

What: Turning movements at intersections with lower classification cross-streets have somewhat lower Control Vehicle and Design Vehicle requirements

Why: Even in low-intensity areas and freight-oriented areas, the extent of paving required for local street intersections can be reduced to minimize right-of-way and construction costs.

FREIGHT ORIENTED

What: Turning movements at intersections with lower classification cross-streets have somewhat lower Control Vehicle and Design Vehicle requirements

Why: Even in low-intensity areas and freight-oriented areas, the extent of paving required for local street intersections can be reduced to minimize right-of-way and construction costs.

CROSS STREET FACILITY TYPE	DESIGNATED FREIGHT ROADWAY FACILITY TYPE			
	Limited Access Facility Ramps	Freight Mobility Corridors	Other Freight Distribution Routes	FAC Streets
Limited Access Facility Ramps	DV = WB-67			
Freight Mobility Corridors	DV = WB-67	DV = WB-67		
Other Freight Distribution Routes	DV = WB-67	DV = WB-67	DV = WB-67	
FAC Streets	DV = WB-67	DV = WB-67	DV = WB-67	DV = WB-67
Other Major Arterials	DV = WB-67	DV = WB-67	DV = WB-67	DV = WB-67
Other Minor Arterials and Collectors	DV = WB-67	DV = WB-67	DV = WB-67	DV = WB-67
Local Roads and Streets	DV = WB-40 CV = WB-62	DV = WB-40 CV = WB-62	DV = WB-40 CV = WB-62	DV = WB-40 CV = WB-62

DESIGN AND CONTROL VEHICLE NUANCES

- Larger Design and/or Control Vehicles may be appropriate at intersections with lower classification side streets or private driveways if there is a significant existing or proposed use along that side street that will generate at least occasional (>10 per day) truck turning movements for larger vehicles than identified in the tables in this chapter
- When considering dual left turn or right turn lanes, the design vehicle should generally be considered as turning simultaneously with a passenger car in community-oriented and diverse context areas.
- When considering U-turns, the control vehicle may be used as the design vehicle in low-intensity and freight-oriented areas, where a sparser roadway network increases the likelihood of U-turns at median breaks with lower classification side streets.

Double trailers are generally limited to the Turnpike and its access routes.

In Community-Oriented areas, delivery vans may appropriately serve as the design vehicle.

Type A encroachment may be acceptable on a regular basis in Community-Oriented and Diverse areas.

DESIGN APPROACH/INTENT

TRUCK TURNING ENCROACHMENT

Encroachment of any motor vehicle into a path identified through signing, marking, or signal control as the right-of-way for another vehicle is an operational concern that has safety implications. In many goods movement operations, particularly regarding access and circulation at goods movement origins and destinations, some encroachment is expected.

The level of acceptable encroachment depends upon :

- The type of encroachment; a truck utilizing an adjacent lane of traffic moving in the opposing direction creates less operational concern than a truck utilizing an adjacent lane of traffic moving in the same direction, and
- The frequency of encroachment; an encroachment of any type that occurs once a day is less of a concern than the same type of encroachment occurring on an hourly basis.

CONTEXT CONSIDERATIONS

The table below indicates the generally acceptable level of encroachment for each type of encroachment within the four context areas.

COMMUNITY ORIENTED

What:
Regular Encroachment: Type **A** *&* **B** *(no consideration required for design or control vehicles)*
Occasional Encroachment: Type **C** *&* **D**

Why: Providing pedestrian access, mobility, convenience, and comfort is the highest priority

DIVERSE ACTIVITY

What:
Regular Encroachment: Type **A** *&* **B** *(no consideration required for design or control vehicles)*
Occasional Encroachment: Type **C**
Infrequent Encroachment: Type **D**

Why: Providing pedestrian access, mobility,convenience, and comfort is a high priority. Truck quality of service and safety considerations warrant only infrequent occurrences of Type D encroachment

LOW ACTIVITY

What:
Occasional Encroachment: Type **A**, **B**, *&* **C**
Infrequent Encroachment: Type **D**

Why: Providing truck quality of service generally higher priority than addressing pedestrian comfort for locations with regular truck turning movements

FREIGHT ORIENTED

What:
Infrequent Encroachment: Type **A** *&* **B**
No Encroachment: Type **C** *&* **D**

Why: Providing truck quality of service of highest priority without encroachment into opposing lanes or concurrent-flow lanes on upstream leg of intersection turning movement due to likelihood of multiple concurrent truck maneuvers

FREQUENCY OF ENCROACHMENT

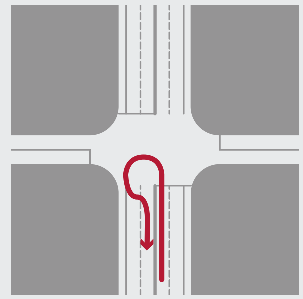
Regular: Up to 30 occurrences per hour

Occasional: Up to 10 occurrences per day

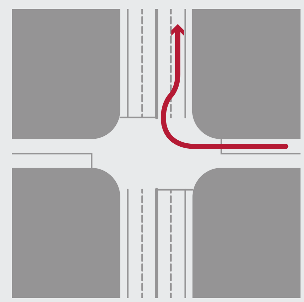
Infrequent: Average of less than 1 occurrence per day

TYPES OF ENCROACHMENT

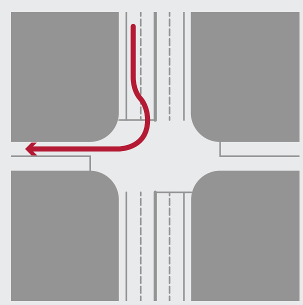
A. Encroachment into bicycle lanes or diamond (transit/HOV) lanes



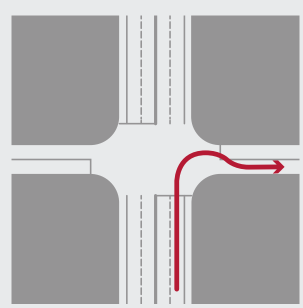
B. Encroachment into multiple receiving lanes on destination leg



C. Encroachment from multiple sending lanes from departure leg



D. Encroachment into opposing traffic when lanes are clear



ENCROACHMENT NUANCES

> Related design elements that may facilitate truck turning movements to reduce encroachment

- Pulling back the stop bar location on receiving leg can reduce frequency/severity of Type D encroachment for right turns. The encroachment would still occur if truck right turns occur while receiving leg traffic has the right-of-way.
- Where on-street parking or bicycle lanes are present on either sending or receiving legs, the effective turn radius for trucks can be increased, limiting encroachment to Type A encroachment
- Mountable curbs may be considered with caution. Allowing trailer rear wheels to track across a mountable curb can reduce the extent of pavement required in an intersection and shorten pedestrian crossing distances. Mountable curbs must also ensure that street furniture is not present within the turning template area. However, the use of mountable curbs also may create a false sense of security for the pedestrian and should only be used when truck turning movements across the curbs are expected to be less than 10 trips per day.

A type D encroachment into oncoming traffic lanes should occur no more than on an occasional basis, and never in freight-activity areas.

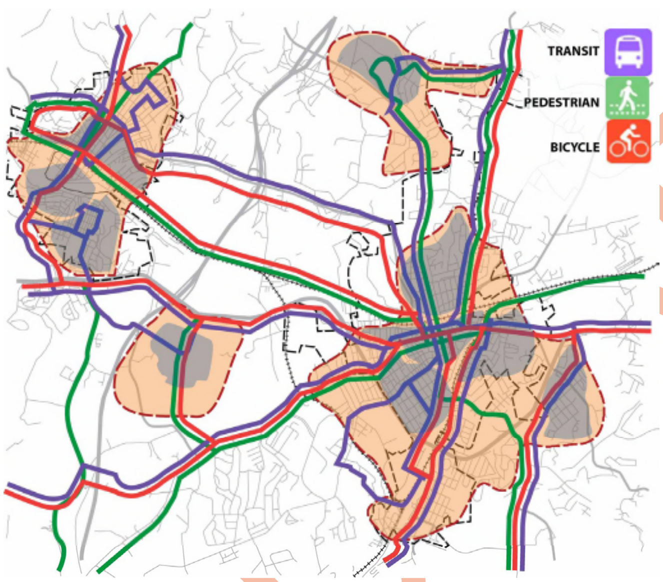
> A last resort may include consideration of multiple-point turns of the turning vehicle, but only where truck turning movements are expected to be less than a daily occurrence

DESIGN APPROACH/INTENT

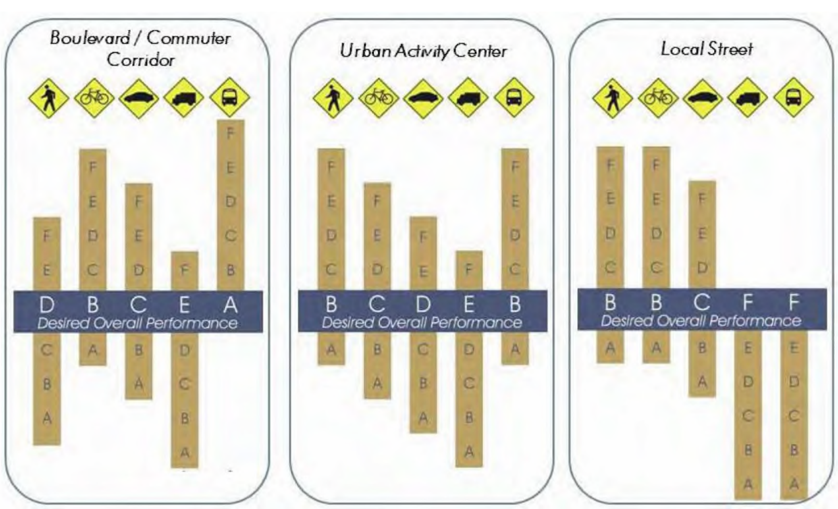
MODAL EMPHASIS

The FDOT plans and procedures are generally designed to promote both complete streets and context-sensitive solutions. These concepts are complementary approaches that are designed to ensure that all roadway users, including travelers across all modes as well as adjacent property owners, are appropriately accommodated in the design. A key tenet of the complete streets approach is to design the roadway to accommodate all users and a key tenet of the context sensitive solutions approach is to ensure that particular needs associated with the local community are met.

Defining a modal emphasis is one way that planners and engineers can synthesize the complete streets and context-sensitive solutions concepts. While all complete streets should be designed to accommodate all users, not all streets need to provide the same quality of service to all users. The evaluation of trade-offs in quality of service across user groups is an element of nearly all roadway planning and design projects. Often these trade-offs are associated with the allocation of scarce right-of-way to different modes of travel; a motor vehicle travel lane may be narrowed to increase bicycle lane or sidewalk width, or vice-versa. Even in cases where sufficient right-of-way is available to provide a high quality of service for all modes along a roadway segment, the resulting design may be undesirably wide for users crossing the roadway.



The designation of a functional network plan for bicycles, pedestrians, and transit vehicles can help planners and designers understand appropriate modal emphases for given roadway segments. Source: Virginia Department of Rail and Public Transportation, 2013



The identification of context-sensitive quality-of-service objectives for each mode of travel is one way to consider modal emphasis. Source: Institute of Transportation Engineers, 2014

If the modal emphasis is not always on pedestrians, HOW DOES THE DESIGN ACCOMMODATE PEDESTRIANS?

There are very good reasons for the current focus on designing for safe, efficient, and comfortable pedestrian facilities as part of a complete streets program. All FDOT roadways, beyond those controlled-access facilities along which pedestrians are prohibited by law, need to ensure that pedestrians are safely accommodated. However, depending upon the roadway context, the quality of service for pedestrians may not be the paramount concern for a given project.

The Institute of Transportation Engineers' Recommended Practice on Planning Urban Roadway Systems demonstrates how modal emphasis and quality of service interests can be integrated. In an Urban Activity Center or along a local street, pedestrian quality of service is paramount – a LOS B is desirable. In a commuter corridor, however, where the focus is more on mobility than on access, the pedestrian quality of service is less important – a LOS D is acceptable (lower than the LOS C quality for goods movement). This does not mean that pedestrians will not be safely accommodated on the commuter corridor, just that their quality of service is not emphasized.

Through trucks are prohibited on many local streets in community oriented areas. Incorporation of appropriate goods movement strategies in diverse activity and freight oriented areas reduces the pressure on "cut through" traffic.

CONTEXT CONSIDERATIONS

COMMUNITY ORIENTED

*What: A modal emphasis on **PEDESTRIANS**, **BICYCLISTS**, or **TRANSIT**, depending upon local plan designations*

Why: In areas with relatively high levels of land use activity and relatively low levels of goods movement, facilitating non-motorized travel typically improves facility safety.

DIVERSE ACTIVITY

*What: A modal emphasis on **LARGER VEHICLES**, such as transit buses and trucks may be appropriate*

Why: In areas with both high levels of livability and goods movement, the arterial roadway network is likely to have a relatively high proportion of transit vehicles and trucks, larger vehicles with somewhat similar operating characteristics.

LOW ACTIVITY

*What: A modal emphasis on **AUTOMOBILES** may be appropriate*

Why: In areas with low levels of livability and goods movement, the auto will be the primary form of transportation.

FREIGHT ORIENTED

*What: A modal emphasis on **TRUCKS** may be appropriate*

Why: Where land use activity is lowest and goods movement needs are highest, a greater value should be placed on facilitating quality of service for trucks.

MODAL EMPHASIS NUANCES

> Modal emphasis is most effective in a network paradigm. Transit, bicycle, pedestrian, and goods movement plans at state or local levels should be considered first in defining a modal emphasis for a project or facility. The guidance for the context areas presented here are suggestions in the event that modal emphasis is not designated or suggested by an adopted plan or policy.

> It is possible for a roadway design to reflect more than one modal emphasis. For instance, a commuter corridor may facilitate both goods movement and off-road bicycle travel if the facility is a key port access roadway that contains a regional trail.

> The selection of a particular modal emphasis does not in any way suggest that other modes should not be fully and safely accommodated in the roadway design. All arterial and collector roadways need to be designed to accommodate all modes; the subtlety of modal emphasis is the degree to which the design promotes a higher quality of service to one mode or another.

DESIGN APPROACH/INTENT

TARGET SPEED

The same types of characteristics that define land use context and goods movement function also influence an appropriate speed of travel along a roadway. Motor vehicle speeds can generally be classified according to four types:

- **DESIGN SPEED** is the selected speed used to determine various geometric elements of the roadway.
- **OPERATING SPEED** is the speed at which drivers are observed traveling during free-flow conditions
- **SPEED LIMIT** is the maximum speed allowed by law determined either through posted speed limits or by policy in the event that a **POSTED SPEED** is absent.
- **TARGET SPEED** is the speed at which vehicles should operate in a specific context, consistent with the level of multimodal activity generated by adjacent land uses, to provide mobility for all motor vehicles and a safe environment for pedestrians and bicyclists. The target speed is influenced by both elements of roadway design that are governed by design speed, as well as the form and function of the adjacent uses beyond the right-of-way.

FDOT rules and regulations describe the assignment of a roadway's Design Speed and Speed Limit. In general, it is desirable for all four types of vehicle speed measurements to be identical. In many cases, however, the Operating Speed is higher than the Design Speed and the Design Speed may be higher than the Speed Limit. The former (Operating Speed exceeds Design Speed) typically occurs where few natural or built environmental variables (horizontal or vertical curves, side friction from driveways or intersections) exist, so that the roadway is comfortable for travel not only at the Design Speed, but at significantly greater speeds than the Design Speed. The latter (Design Speed exceeds Speed Limit) typically occurs where other policy variables (such as school zones) have reduced the Speed Limit below the Design Speed.

The concept of Target Speed is to identify a desired Operating Speed and develop design strategies and elements that help reinforce Operating Speeds that are consistent with the posted or proposed Speed Limit (which may also be the Design Speed). For projects early in the development process, the consideration of Target Speed can influence the selection and establishment of the Design Speed.

CONTEXT CONSIDERATIONS

COMMUNITY ORIENTED

*What: Target Speed / Design Speed at **LOWER** end of range*

Why: Expected higher levels of multimodal encounters due to land use activity, pedestrian crash severity reduction at slower speeds

DIVERSE ACTIVITY

*What: Target Speed / Design Speed at **LOWER** end of range*

Why: Expected higher levels of multimodal encounters due to land use activity, improved maneuverability of trucks at slower speeds in multimodal environment

LOW ACTIVITY

*What: Target Speed / Design Speed at **HIGHER** end of range*

Why: Economic value of goods movement, low pedestrian / bicycle volumes, lack of adjacent land use activity to suggest slower speed environment

FREIGHT ORIENTED

*What: Target Speed / Design Speed at **HIGHER** end of range*

Why: Economic value of goods movement

DESIGN SPEED *will influence:*

- Horizontal curvature
- Vertical curvature
- Cross-slopes and superelevation
- Horizontal clearances
- Sight distances
- Typical section elements including lane and median widths, curb and gutter, roadside slopes

TARGET SPEED *may influence:*

- Access management
- Bicycle Level of Service
- Advisory speed plates
- Traffic control at junctions, including selection of roundabouts as a traffic control device and signal network synchronization
- Roadside element placement (beyond clear zone, in both public and private realms)
- Gateway landscape treatments

Posted speeds may vary from design speed for a variety of reasons. Target speed concepts help communicate appropriate motorist speed.

TARGET SPEED NUANCES

- Changes in expected land use patterns over time are particularly important in considering both an appropriate target speed. In particular, a target speed may appropriately be lower than the current operating, design, and posted speeds when planned development activity is significantly more dense than current, or includes pedestrian generators such as associated with civic uses such as libraries and parks or institutional uses such as schools and hospitals.
- In Low Activity Areas, this document suggests a target speed at the higher end of the range, but paired with a leaning toward Access rather than Mobility (see Access/Mobility Design Approach). Consideration should be given towards lower Target / Design Speeds if the focus on Access incorporates a cluster of access points in an otherwise Low Activity area, which may be reinforced through Design Elements influenced by Target Speed.
- Posted speed may be influenced by a variety of rules and regulations which may create counterintuitive changes from one roadway segment to another. The concept of Target Speed can be used within a corridor to provide design element cues to the motorist to accompany a change in posted speed. These design element cues may include warning signs and markings or typical section elements such as lane width or number of travel lanes, although in many cases a posted speed change can be effectively communicated by roadside elements like gateway treatments developed through design elements such as wayfinding treatments and landscaping.

DESIGN APPROACH/INTENT

FINE TUNING ACCESS AND MOBILITY

The FDOT roadway functional classification schema establishes a balance between the function of each state highway in providing an access function (delivering people and goods to adjacent properties) and providing a mobility function (conveying people and goods past adjacent properties). Most state highways are classified as arterial roads whose primary function is mobility, but still must provide some level of access. The FDOT design manuals and guidance often contain minimum and maximum criteria for design elements. The context for livability and goods movement can help a designer select appropriate design strategies and elements that are consistent with a given roadway functional classification and design standards, but lean towards either a access orientation or a mobility orientation where such flexibility is allowed.

CONTEXT CONSIDERATIONS

COMMUNITY ORIENTED

What: Lean toward ***ACCESS ORIENTED*** *design strategies, such as selecting minimum lengths for driveway spacing, median break spacing, and intersection spacing.*

Why: In areas with relatively high levels of land use activity and relatively low levels of goods movement, access to abutting properties by all modes will be frequent. The goods movement environment should anticipate local access, loading, and circulation activities with a relatively high level of cross-modal interaction, helping to establish an expectation of such interaction for and by all users.

DIVERSE ACTIVITY

What: Reflect ***LOCAL CONTEXT*** *at the block or driveway level in considering the balance between access and mobility.*

Why: In areas with both high levels of livability and goods movement, all modes of travel require a combination of access and mobility. A high volume or percentage of truck traffic may indicate both local delivery needs and longer distance travel.

LOW ACTIVITY

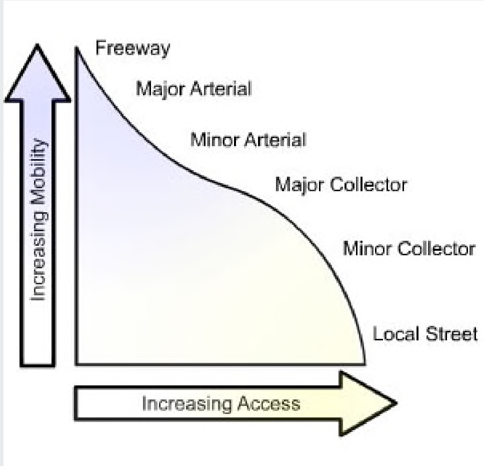
What: Lean toward ***ACCESS ORIENTED*** *design strategies and elements, such as selecting minimum lengths for driveway spacing, median break spacing, and intersection spacing.*

Why: In general, designing for higher levels of mobility increases the total cost of constructing and operating transportation infrastructure when state, local, and private sector concerns are considered in tandem. In areas with relatively low levels of activity for either people or goods movement, a focus on access therefore increases design affordability.

FREIGHT ORIENTED

What: Lean toward ***MOBILITY ORIENTED*** *design strategies and elements, such as selecting intersection spacing, median break spacing, and driveway spacing lengths that are greater than minimum standards.*

Why: Where land use activity is lowest and goods movement needs are highest, a greater value should be placed on facilitating uninterrupted goods movement flow, with a greater control of access.



ACCESS AND MOBILITY NUANCES

- The consideration of access point spacing is independent of the consideration of access point design. While it is desirable to limit access points in a freight oriented area to promote mobility in the interest of the goods movement economy, the operational characteristics of truck turning movements tends to support larger driveway access and median openings, as discussed in more detail in Chapter 3 design strategies.
- The consideration of value engineering should incorporate both public and private sector implementation and operating costs. While minimizing curb cuts along a state roadway generally increases safety by minimizing and formalizing access points, it may increase the cost of both providing and maintaining access to all parcels as well as increase vehicle miles of travel.

CHAPTER 3: DESIGN STRATEGIES

This chapter presents eight Design Strategies that address common concerns relating to integrating goods movement and livability according to the context-sensitive approaches and strategies discussed in Chapter 2. These Design Strategies are generally organized in a continuum ranging from fairly broad planning perspectives such as typical sections and intersection approach elements, to more operational considerations such as traffic control devices and signal phasing:

1. **Typical Section Configurations**
2. **Intersection Approach Configurations**
3. **Right Turn Treatments**
4. **Median Nose Treatments**
5. **Pavement Bulb-Outs and U-Turns**
6. **Access Management and Truck Parking**
7. **Traffic Control Devices**
8. **Signal Phasing**

Each of the Design Strategies presents contextual information organized into a template of four topical areas describing the "what", "for whom", "why", and "where" for that strategy. These topical areas walk the reviewer through alternative design strategies that might be appropriate for each of the four context zones (community oriented, freight oriented, low activity, and diverse activity) identified in Chapter 2 with explanations of the general approach and nuances the roadway planner or designer should consider in selecting an appropriate strategy. Each of these topics is briefly described below.

PROTOTYPES

The section on Prototypes summarizes, at a high level, the "what" and "why" behind different types of strategies appropriate for different context areas. The prototype is designed to reflect the logical outcome of the Design Strategies described in Chapter 2, and provide an "at a glance" reference point for the more nuanced materials in the other three topical areas. The prototype reflects what might be both commonly found and appropriate for each of the four context areas. At the same time, however, the prototype should be viewed solely as a concept for consideration, and not a mandate. A prototype for one context area may be appropriate for a particular roadway segment or junction in another context area to provide the most context-sensitive solution based on the nuances described in that topical area.

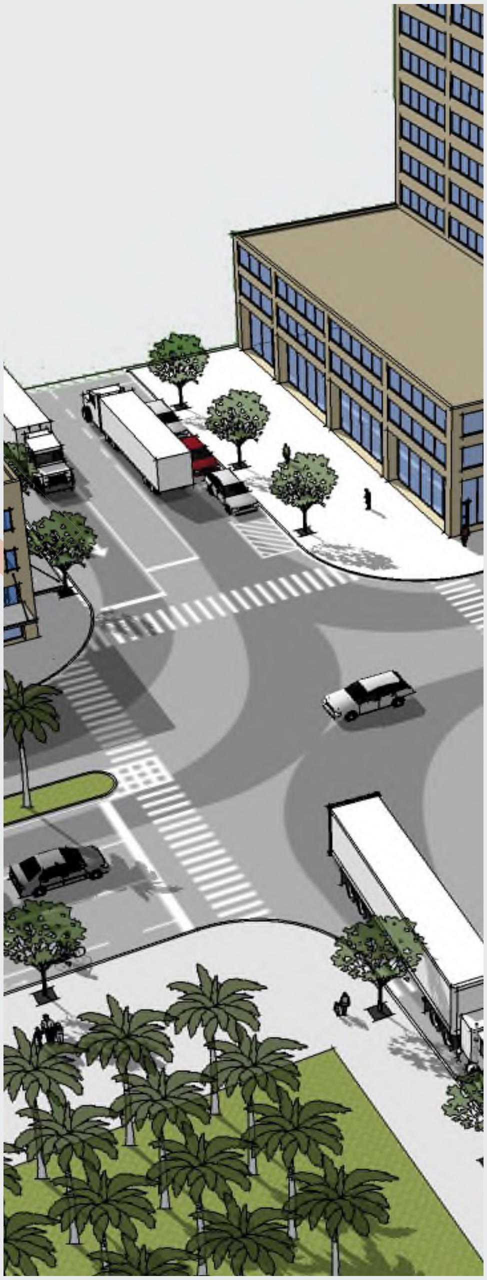
USER PERSPECTIVES

A key tenet of designing complete streets is to design for all users, recognizing the implicit trade-offs that often need to be made in addressing the quality of service provided to different constituents. Each of the design strategy prototypes tends to provide a higher quality of service or comfort for one or more of these constituent user groups, while having either mixed or negative effects on quality of service or comfort for other user groups.

The User Perspectives section provides a summary table of how the prototype design strategy within each context area is likely to be viewed by six different user groups.

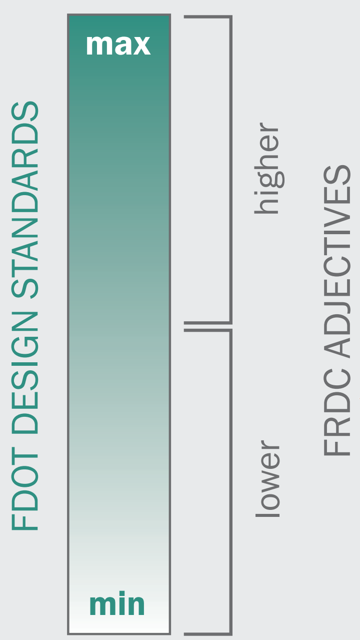
All user groups implicitly seek safe and effective mobility as a given, with differentiating characteristics associated within each group as follows:

- Truck drivers, who are generally seeking predictable travel paths that respect their relatively limited maneuverability and value of preserving momentum, whether on a long-haul or in the last mile towards pickup and delivery.
- Auto drivers, who are generally seeking convenience of flexibility, given the greater number of variable and discretionary movements (both in terms of interim destinations – do we want McDonalds or Subway today – and in the available travel paths to reach them.



DESCRIBING ADJECTIVES

Throughout Chapter 3, adjectives such as “wider”, “shorter”, or “higher speed” are used in a comparative fashion to describe the relationship between design strategies in different context areas. For instance, lane widths in freight oriented areas should generally be wider than lane widths in community oriented areas. These adjectives are used to describe choices that designers face while operating within the minimum and maximum bounds of applicable FDOT design standards, manuals, and practices. Occasionally, a designer finds a rationale for exceeding an established maximum or minimum, and the considerations for such exceptions or waivers are discussed in Chapter 5.



- Bus transit drivers, who share truck driver concerns about predictability associated with limited maneuverability and seek to provide good customer service to their riders.
- Pedestrians, who are generally seeking direct and comfortable travel paths. Pedestrians are travelers with the slowest speeds but (for most) the greatest amount of maneuverability. Pedestrians also have the lowest level of pre-qualifications, and therefore have the greatest skill set diversity. Pedestrians also have more vulnerability than any other group of travelers due to both the skill set variability and physical fragility.
- Bicyclists, who are generally seeking a continual rebalancing between being integrated within the vehicular flow and being separated/protected from that same flow. In these charts, the bicyclist perspective reflects the bicyclist who prefers to ride on-road, even if that bicyclist will utilize shared use paths where more convenient.
- Adjacent property owners, who are the one important user constituency who are rarely travelers themselves, but either experience benefits (in the case of most commercial properties) or adverse effects (in the case of most residential properties) from the presence of the adjacent traveler stream

NUANCES

While the Prototype and User Perspective sections attempt to simplify the concepts as applied to each of the four context areas, the Nuances section identifies the design considerations that prove the many exceptions to the rules. Additional design strategy treatments pertinent to goods movement, such as roundabout superelevation or signing for truck prohibitions, are outlined in this section. The interaction among different design elements, such as downstream merging and weaving associated with channelized right turn treatments, are discussed. This section also contains the greatest level of references to other documents such as the PD&E Manual and the Plans Preparation Manual as well as other studies such as NCHRP or NCFRP reports.

DIVERSE AREA CONSIDERATIONS

The diverse areas are those that have both relatively high needs for goods movement and for livability considerations, and therefore where the conflicts between goods movement and livability are most pronounced and challenging. In diverse areas, most design strategies will need to make (whether explicitly or implicitly) a choice as to which objectives takes precedence for a given strategy. One way of thinking about this is that the precedence is not a binary decision to move into the community oriented context area or the freight oriented context area, but rather reflects a “leaning” towards community or freight orientation. This section describes the conditions which might influence whether to lean towards community or lean towards freight, and the design strategy characteristics that might result.


542146
NY
661453

DESIGN STRATEGY 1

TYPICAL SECTION CONFIGURATIONS

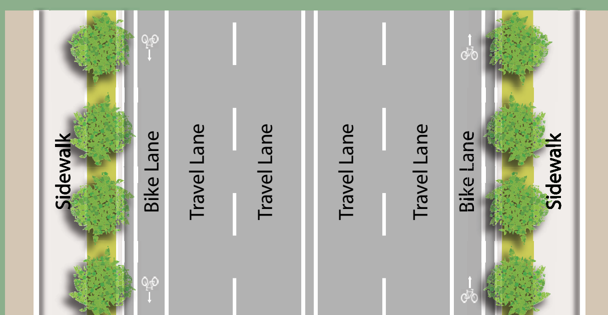
The design of a typical roadway cross-section involves distributing available right-of-way width to various elements within the right-of-way, including motor vehicle travel lanes, bicycle facilities, medians, on-street parking, and curbside elements including sidewalks and buffers. Designers must consider the needs of all road users to selecting the best combination of elements that provides safe paths for all modes and best fulfills the road's purpose within the broader transportation system.

PROTOTYPES

COMMUNITY ORIENTED

WHAT: **Narrow travel lanes without a median, with wider bicycle lanes and wide sidewalks with wide landscaped buffer with shade trees**

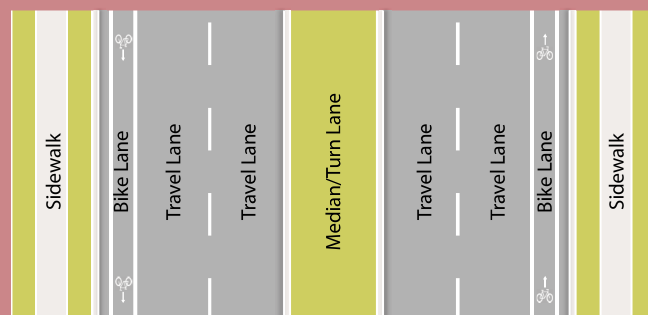
WHY: *Pedestrian and bicycle mobility and safety are paramount. Slow design speeds and high levels of roadside access typically require four lanes of travel without a median, a feature that also minimizes pedestrian crossing distances. Bicycle lanes provide added asphalt width as an extra measure of safety for larger vehicles.*



DIVERSE ACTIVITY

WHAT: **Moderately wide travel lanes with a grassy median, narrower bicycle lanes, and narrower sidewalks with narrower grassy buffers**

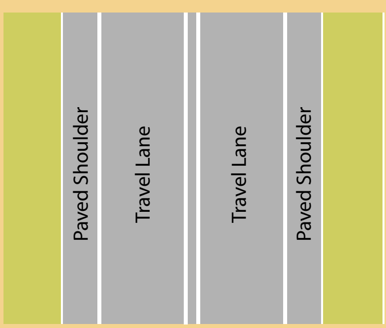
WHY: *Frequent presence of trucks requires wider lanes to accommodate truck passing. Pedestrian and bicyclist mobility and safety are emphasized with designated pathways. Medians provide left turn lanes at intersections, decreasing delays for through vehicles.*



LOW ACTIVITY

WHAT: **Wide two-lane road without a median, with a paved shoulder**

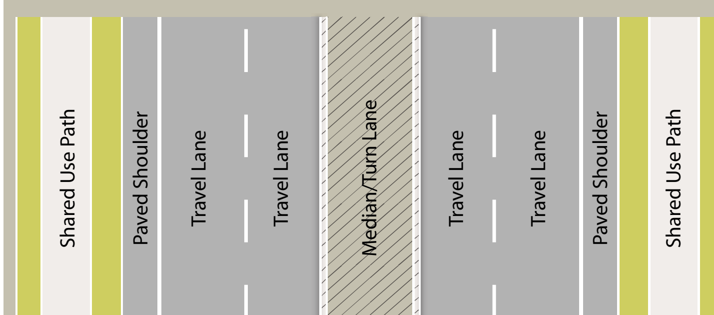
WHY: *Minimal pavement width minimizes construction and maintenance costs. Paved shoulder serves as an adequate facility for infrequent pedestrian use. Wide lane and paved shoulder provides adequate width for infrequent bicycle use.*



FREIGHT ORIENTED

WHAT: **Moderately wide inside travel lanes and wide outside travel lanes with flush painted median, paved shoulders, and shared use paths.**

WHY: *Moderate inside lane width discourages high vehicle speeds. Wider outside lane with paved shoulder accommodates infrequent conflicts between on-street bicyclists and trucks, and provides added room for truck maneuvers. Painted median allows space for frequent left turns. Shared use path accommodates pedestrians if outside of the one-mile urban buffer boundary.*



NOTE: *The prototype typical sections assume curb and gutter drainage for community oriented and diverse activity areas, and shoulder and ditch drainage for low activity and freight oriented areas. The prototypes assume low activity areas are outside the one-mile buffer from an urban area boundary where shoulders can satisfy pedestrian accommodation.*

USER PERSPECTIVES

	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	L LOW ACTIVITY	F FREIGHT ORIENTED
	Narrow travel lanes without a median, with wider bicycle lanes and wide sidewalks with wide landscaped buffer with shade trees	Moderately wide travel lanes with a grassy median, narrower bicycle lanes, and narrower sidewalks with narrower grassy buffers	Wide two-lane road without a median, with a paved shoulder	Moderately wide inside travel lanes and wide outside travel lanes with flush painted median, paved shoulders, and shared use paths
TRUCK DRIVERS	Narrower lanes give truck drivers less space for driver correction, although bicycle lanes provide additional pavement and slower speeds decrease the space needed for driver corrections.	Moderately wide lanes provide more room for truck driver correction, and makes passing other trucks easier. Bicycle lanes increase the effective curb radius at intersections. Median presence complicates access to driveways on other side of the road.	Wide lane with paved shoulder provides adequate room for driver correction.	Wide lanes and paved shoulders facilitate more room for driver correction. Shared use path provides dedicated space for bicyclists and pedestrians, minimizing conflicts between on-road bicyclists and vehicles.
AUTO DRIVERS	Narrower lanes and lack of median discourage high speeds. Four lanes allow drivers to pass slower or turning vehicles.	Median minimizes access points and reduces conflicts with turning vehicles both at intersections and along segments.	Two lane configuration provides only limited opportunities to pass slower vehicles.	Flush painted median allows more direct access to driveways and increases conflict points. Wider lanes encourage higher speeds. Shared use path lessens frequency of conflicts between on-road cyclists and motorized vehicles.
BUS TRANSIT DRIVERS	Narrower lanes provide less room for driver correction. Buses must cross over bicycle lanes at bus stops. Wider buffer provides more space for transit stop amenities.	Wider lanes provide more room for maneuvering larger vehicles. Buses must cross over bicycle lanes at bus stops.	Wider lanes provide more room for driver correction. Buses do not cross over bicycle lane at bus stops. Bus stops are infrequent in this context area.	Wider lanes provide more room for driver correction. Buses do not cross over bicycle lane at bus stops. Bus stops are infrequent in this context area.
PEDESTRIANS	Wide sidewalks allow plenty of room for joggers to pass slower pedestrians and those with strollers or wheelchairs. Wide buffer provides distance from moving vehicles and space for shade trees.	Sidewalks and buffers for utility poles and signage provide adequate and clear paths for pedestrian mobility. Narrower sidewalk makes passing other pedestrians more difficult.	Paved shoulder provides minimal protection from vehicular traffic.	Shared use path provides safe path for pedestrians. Wide lanes and flush median encourage high speeds, and high volumes of trucks make pedestrian environment feel less safe.
BICYCLISTS	Wider bicycle lanes provide more space for on-road cycling. Left turns require merging into mixed traffic.	Dedicated bicycle lanes provide adequate space for on-road cycling. Left turns require merging into mixed traffic.	Paved shoulder provides minimal protection from vehicular traffic.	Shared use path provides separate facility for cyclists. Paved shoulder and wide outside lane provide space for cyclists who prefer to ride on the street. Drivers might assume all cyclists will use shared-use path.
ADJACENT PROPERTY OWNERS	Landscaped buffer enhances street aesthetic. Wider sidewalks provide more room for street-side activities (sidewalk cafes, sidewalk sales, etc.).	No notable effects for adjacent property owners.	No notable effects for adjacent property owners.	Shared use path may require additional right-of-way.

KEY: Effect On User Group

+ positive +/− mixed − negative ☐ neither positive or negative

A Note about Individual Roadways and Their Role in the Broader Transportation System

The design of an individual road's cross-section is a process that occurs within a much broader web of transportation decision-making processes. While this Freight Roadway Design Considerations document provides information to guide roadway design decisions, it is important to note that people and goods move through the transportation system as a network, and that each individual transportation facility (for example, each road within a region's roadway network) serves different purposes, each filling its own role within the system. This variation in purpose is the concept behind functional classification of roadways, which was previously discussed in Chapter 2 and represents a spectrum between providing mobility (consistent travel conditions to move through the system) and accessibility (the ability to access a final destination from the transportation network).

Transportation professionals typically apply the concept of functional classification to vehicular travel, to understand the access and mobility needs of cars and trucks and develop a network-based approach to understanding the transportation system. Designers have different criteria for different functional classifications, such as access spacing, design speed, number of lanes, lane width, and many others. However, functional classification in this context does not fully incorporate the needs of all system users. First, the transportation needs of people and goods differ greatly and should not be assumed to be the same. Second, non-vehicular modes of travel have different mobility and access needs, and these needs vary even within the same functional class.

The design of a typical section for an individual road should not be developed in isolation. Some roads are more important for freight mobility, others are more important for freight access, and others are less important for freight movement overall. Designers must consider the function of the roadway and its context within the network when deciding what facilities are most appropriate strategies to serve the transportation needs of the roadway in question.

NUANCES FOR TYPICAL SECTION CONFIGURATIONS

> The most critical element for designing typical sections to accommodate heavy volumes of large trucks is **lane width**. A typical passenger car is only seven feet wide. Single unit trucks are typically eight feet wide, and tractor trailers can reach 8.5 feet in width. While there is only a slight difference in vehicle width between even large trucks and passenger vehicles, other characteristics including field-of-vision limitations, slower acceleration and deceleration rates, and a higher center of gravity make it crucial to provide more space for these vehicles in a typical section. Lane widths should provide adequate room for driver correction, and are designed in accordance with design/target speed. Lane widths determine the closeness to other road users in adjacent vehicular lanes and bicycle lanes, and to the curb. Traditionally, designers prefer to select wider lane widths to increase the amount of space between two road uses traveling adjacent to each other. While this often increases the comfort and perceived safety for road users, it also encourages higher travel speeds. Faster speeds negate the benefits of additional width for driver correction, and crashes that occur at faster speeds result in more injuries and fatalities than crashes at low speeds. NCFRP Report 24 references several studies that conclude roads with narrower lanes and dedicated bicycle facilities and sidewalks are safer than roads with wider lanes because they effectively communicate the appropriate travel speeds. Drivers are more alert to surrounding activity, including bicyclists and pedestrians. NCFRP Report 24 notes that current research has not shown that these safety benefits extend to freight vehicles, "but there is little reason to expect otherwise." In other words, narrower lanes that discourage high vehicle speeds may be safer for accommodating interactions between large vehicles and non-motorized modes, even though the narrower lanes put the two users in closer proximity to each other.

Although there is only a slight difference in width between trucks and other passenger vehicles, trucks have other operating characteristics due to greater height, length, and center of gravity that affect visibility and maneuverability.

	TRAVEL LANE WIDTH	BICYCLE FACILITY	MEDIAN	PEDESTRIAN FACILITY
COMMUNITY ORIENTED	Narrow	Wider bicycle lane	None	Wider sidewalks with wider grassy buffer and shade trees
DIVERSE ACTIVITY	Medium	Narrower bicycle lane	Wide grassy median	Narrower sidewalks with narrower grassy buffer
LOW ACTIVITY	Wide	Wide paved shoulder	None	Paved shoulder
FREIGHT ORIENTED	Medium inside, wide outside	Wide paved shoulder	Wide painted median	Shared use path with moderately wide buffer

> Roads in community-oriented areas may be considered for **Transportation Design for Livable Communities** (TDLC) designation as outlined in Chapter 21 of the FDOT PPM. The TDLC designation increases flexibility in the selection of several typical section elements, including lane widths, bicycle lane widths, and on-street parking configurations.

NUANCES FOR TYPICAL SECTION CONFIGURATIONS

> Lane widths for TDLC road segments may be reduced to 10 feet but truck and transit vehicle volumes must be considered due to their difficulty maneuvering within narrow lanes.

> **Adequate paths for bicyclists and pedestrians** are dependent on urban area definitions in addition to freight and land use context. Per PPM Table 8.1.1.:

- Minimum required facilities for bicyclists are bicycle lanes, wide curb lanes, or paved shoulders depending on the location of the facility (within or beyond the one-mile buffer of the urban area boundary), type of edge of pavement treatment (curb and gutter or shoulder), and type of project (new construction, resurfacing, or operational improvements).
- Minimum required facilities for pedestrians are either sidewalks or shared use paths within the one-mile urban area boundary buffer, and paved shoulders beyond the buffer.

> **Sidewalks** in community oriented areas should be wider than the five-foot minimum required by the Americans with Disabilities Act (ADA). Pedestrians are more frequent in community oriented areas, and extra width makes it easier for pedestrians to pass one another and creates a more comfortable walking environment.

> The **buffer** between the edge of curb and sidewalk in community oriented areas should be wide enough to include **shade trees** to keep the pedestrian environment as cool as possible on hot sunny days. Designers should consult with landscape architects to select tree species and planting plans to maximize the benefits of foliage, minimize water needs, and avoid root system impacts on sidewalks.

> If demand warrants, **shared use paths** are recommended for freight oriented areas as an optimal facility for pedestrians and bicyclists. Although bicyclist and pedestrian use will likely be infrequent in these areas, heavy truck traffic will be frequent, and the safest option for pedestrians and bicyclists will be to provide a shared use path set back from the road to avoid conflicts. In areas outside of the one-mile urban area buffer, a paved shoulder and wide outside curb lane will suffice as adequate pedestrian and bicycle facilities. Roads within the one-mile urban area buffer with curb and gutter can provide sidewalks and bike lanes as an alternative to the shared use path.

> **Buffered bicycle lanes** may be considered in diverse activity areas if adequate right-of-way exists. The buffer provides added comfort for bicyclists, especially on roads with heavy traffic volumes, high speed limits, and frequent truck or bus volumes.

> The FDOT PPM requires bicycle lanes on all new construction and reconstruction projects within the one-mile urban area buffer and for all roadways with curb and gutter beyond the one-mile urban area buffer. However, many bicyclists will not feel comfortable riding in on-street bicycle lanes on roads with more than four lanes of traffic. The gridded street network of many of Florida's cities provides ample opportunity for parallel bicycle facilities on lower speed lower volume streets. Bicycle facilities should not be designed in isolation. A **network approach to bicycle planning** is necessary to provide connected networks of paths that ensures bicyclists can travel safely and seamlessly from door to door.

- **Bicycle boulevards** are a series of contiguous low speed and low volume street segments that function as through streets for bicyclists while discouraging auto through traffic. Bicycle boulevards use elements including:
  - traffic diverters that allow bicyclists to proceed through an intersection but prohibit autos from going through
  - mini-roundabouts that allow bicyclists to maintain speeds while slowing auto traffic
- Some communities have a severed grid street network to discourage auto traffic cutting through neighborhoods. This structure is a prime opportunity for creating bicycle boulevards, and should be considered in the planning of bicycle facilities.

Pedestrians travel at different speeds. Wider sidewalks allow pedestrians to more easily pass each other.

Source: www.pedbikeimages.org

Shade trees keep sidewalks cooler on sweltering sunny days, like this sidewalk on Manatee Avenue in Bradenton, FL. Shade trees should be planted alongside sidewalks, especially in community oriented areas.

Source: Anna Maria Island Living (http://amipost.com/sports/robinson-preserve-bike-rides)

TYPICAL SECTION CONFIGURATIONS (CONTINUED)

NUANCES FOR TYPICAL SECTION CONFIGURATIONS

- In community-oriented areas and some diverse activity areas, designers should consider the applicability of different facilities for bicyclists beyond the standard bicycle facilities required by the FDOT PPM (see PPM Volume 1 Section 8.4 Bicycle Facilities). The AASHTO Guide for the Development of Bicycle Facilities (4th Edition, 2012) provides numerous **alternate and complementary bicycle features** that may be appropriate in diverse activity areas and that should be considered in community-oriented areas, including contra-flow bicycle lanes on one-way streets, and bicycle boulevards.
- **On-street parking** is an option on lower speed and lower volume roads in community oriented areas to increase on-street access to adjacent properties and create a buffer between the motorized vehicle lanes and pedestrians. On-street parking is not recommended in other context areas because frequent parking maneuvers add more disruptions to the flow of traffic, which is particularly problematic for trucks with slower acceleration and deceleration rates.
- The prototypes show four travel lanes for community oriented, freight oriented, and diverse activity areas. Many state roads have six lanes, and the same relationships between travel lanes and other typical section elements applies in those cases. However, additional travel lanes increase the pedestrian crossing distance at intersections, which is particularly problematic in community oriented and diverse activity areas.
- **Medians** provide separation between opposing directions of travel and can provide space for left turn and U-turn maneuvers. Medians also increase the pedestrian crossing distance at intersections and can encourage high speeds. Designers should seek to minimize medians in community oriented areas wherever possible.
- Many communities are interested in "road diets" to transfer right-of-way width from vehicular travel lanes to bicycle lanes or to the curbside realm. **Lane elimination** (taking away an entire travel lane) and lane reduction (narrowing the width of existing lanes) should be based on a network-based study to determine whether other facilities in the network can safely accommodate demand for additional vehicular trips. Refer to the FDOT Statewide Lane Elimination Guidance for additional considerations: *www2.dot.state.fl.us/planning/transtat/LEGuidance2.pdf*

In certain cases, changes to the typical section that convert through-travel-lane space to other types of space can improve the quality of service for goods movement by establishing new zones for activities such as left turn movements and transit stops outside of the through traffic lane, as shown in these before/after images of Nebraska Avenue (SR 45) in Tampa.

DIVERSE AREA CONSIDERATIONS

There are essentially two different schools of thought for allocating right-of-way width on roads in diverse areas where traffic volumes are high and where bicycle and pedestrian travel is frequent:

> Safety margin: Provide as much lateral separation as possible between facilities for different road users to decrease the potential for sharing roadway space and maximize space for traveler error correction. The theory behind this school of thought is that crashes result from a lack of adequate space, therefore more space makes roads safer.

> Behavior modification: Use narrow lanes and traffic calming measures to decrease motorist comfort levels, keep all road users alert, and minimize travel speeds to give road users more time to react and interact with each other to successfully share road space. The theory behind this school of thought is that crashes result from miscommunication or lack of communication between road users. Therefore, creating an environment where road users must communicate with each other makes roads safer.

Planners and community advocates may describe the second theory as a reason for undertaking a lane elimination project. While the second theory is applicable to some roads, like downtown main streets, it cannot be applied to all roads within a region's roadway network.

The consideration of whether a diverse area should lean towards a community oriented or a freight oriented environment depends in part on the appropriateness of either safety paradigm described above. In general, the safety margin paradigm is more applicable in freight-oriented areas and the behavior modification paradigm is more applicable in community-oriented areas. The diagram to the right identifies characteristics for leaning towards a community orientation or towards a freight orientation.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR TYPICAL SECTION CONFIGURATIONS?

C COMMUNITY ORIENTED

- Fewer Vehicle Travel Lanes
- Narrow Lane Widths
- Curb and Gutter Edge Treatment
- No Median
- On-Street Parking
- Designated Bicycle Facilities

F FREIGHT ORIENTED

- More Vehicle Turn Lanes
- Wide Lane Widths
- Shoulder Edge Treatment
- Wide Medians
- No On-Street Parking
- Fewer Amenities for Pedestrians, Bicyclists, and Transit Riders

How Do I Know WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards COMMUNITY *if:*

> Community has articulated a supporting land use vision for the corridor in adopted policies or plans

> Nearby Freight Activity Centers are small and/or surrounded by community-oriented land uses

> Non-industrial and non-freight uses exist within walking distance

> Most truck traffic occurs outside of typical weekday work hours between sidewalk and building

Lean Towards FREIGHT *if:*

> Road is closer to low activity areas than community oriented areas

> Road is a regional freight mobility corridor

> Road is a freight distribution route and most truck travel occurs during typical weekday work hours

DESIGN STRATEGY 2

INTERSECTION APPROACH CONFIGURATIONS

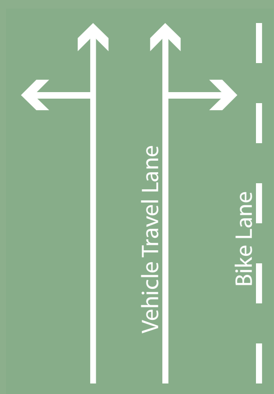
Designing for freight movement, community livability, or both is most challenging at intersections. The previous design strategy on Typical Sections focused on designing segments of roads. The remaining seven design strategies focus on designing various elements of intersections. Many of these intersection-focused design strategies are related. This Intersection Approach Configurations design strategy provides information for designers to consider when determining number of turn lanes and storage length. The design of intersection approach lanes affect how well trucks can move through the intersection and how safe an intersection is for pedestrians and bicyclists.

PROTOTYPES

COMMUNITY ORIENTED

WHAT: **Shared thru/turn lanes for both left and right turns.**

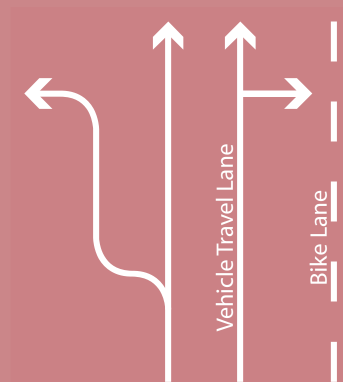
WHY: *Safety and comfort for pedestrians and bicyclists is most important. Exclusive turn lanes lengthen the pedestrian crossing distance. Vehicle mobility is a secondary priority in these areas. Truck traffic is infrequent, and truck turns can be accommodated by allowing encroachment into oncoming lanes. Bicycle lanes on the outside of the shared right/thru lane increase the effective turning radius for right turns.*



DIVERSE ACTIVITY

WHAT: **Left turns have exclusive lane with a long storage length that accommodates queues with multiple trucks. Right turns share lane with through traffic.**

WHY: *Truck volumes are frequent and can be accommodated with an exclusive left turn lane. A shared thru/right turn lane keeps the pedestrian crossing distance shorter than with an exclusive right turn lane. Bicycle lanes on the outside of the shared thru/right turn lane increase the effective turning radius.*



LOW ACTIVITY

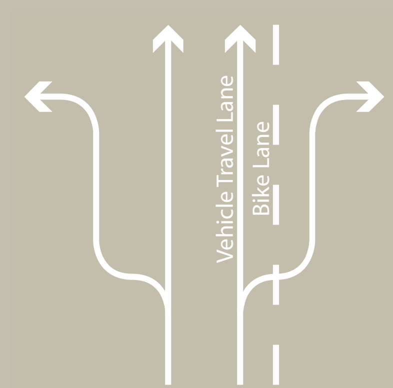
WHAT: **Exclusive left and right turn lanes with short turn lane lengths.**

WHY: *Speeds are often higher in low activity areas, and signals may be actuated with long green times for thru traffic. Exclusive turn lanes allow through traffic to pass by without delays from stopped or slowing turning vehicles. Short turn lengths accommodate expected low volumes while minimizing the amount of pavement, also minimizing construction and maintenance costs and environmental impacts from impervious surface area.*

FREIGHT ORIENTED

WHAT: **Exclusive left and right turn lanes with long turn lane lengths.**

WHY: *Frequent heavy truck volumes warrant longer storage lengths. Left turns across oncoming traffic requires larger gaps for heavy trucks with slower acceleration and deceleration rates. Exclusive turn lanes and complementary exclusive signal phasing provide dedicated physical space and green time for turns, and allow trucks and other vehicles to proceed through the intersection without delays from stopped or slowing turning vehicles.*



USER PERSPECTIVES

	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	L LOW ACTIVITY	F FREIGHT ORIENTED
	Shared thru/turn lanes for both left and right turns.	Left turns have exclusive lane with a long storage length that accommodates queues with multiple trucks. Right turns share lane with through traffic.	Exclusive left and right turn lanes with short turn lane lengths.	Exclusive left and right turn lanes with long turn lane lengths.
TRUCK DRIVERS	Drivers must yield to oncoming traffic and crossing pedestrians to make a left turn, especially difficult for trucks with slower acceleration rates. Smaller intersection area requires encroachment for all turns.	Exclusive left turn lanes with complementary signal phasing provide dedicated space and time for truck drivers to turn without yielding to oncoming traffic and pedestrians. Bicycle lanes increase effective turning radius, but right turns require minimal bicycle lane encroachment.	Exclusive turn lanes provide more room for navigating turns and decrease delays for through trucks. Short turn lane lengths do not accommodate multiple trucks at once, but the occurrence of multiple turning trucks is infrequent.	Exclusive turn lanes provide more room for navigating turns and decrease delays for through trucks. Long turn lane lengths provide adequate space for multiple trucks in the turn queue.
AUTO DRIVERS	Drivers must yield to oncoming traffic and pedestrians to make a left turn.	Exclusive left turn lanes with complementary signal phasing provide dedicated space and time for drivers to turn without yielding to oncoming traffic and pedestrians. Drivers must yield to bicyclists in bicycle lane before turning right.	Exclusive turn lanes reduce delays for through vehicles. Complementary left turn signal phases provide time for drivers to turn without yielding to oncoming traffic.	Exclusive turn lanes reduce delays for through vehicles. Longer turn lane lengths can cause confusion on when to enter right turn lane, especially with frequent driveways.
BUS TRANSIT DRIVERS	Same as truck drivers.	Same as truck drivers.	Same as truck drivers.	Long storage length for exclusive turn lanes provides more space for buses in turning queues. Long turn lane lengths can complicate near-side bus stop location and design.
PEDESTRIANS	Crossing distances are minimized. Two-phase signal minimizes pedestrian wait times.	Exclusive left turn lane increases crossing distance. Exclusive left turn signal phase increases pedestrian wait times.	Exclusive turn lanes increase pedestrian crossing distance. Exclusive right turn lanes may allow and encourage turning vehicles to turn at higher speeds.	Exclusive turn lanes increase pedestrian crossing distance. Exclusive right turn lanes may allow and encourage turning vehicles to turn at higher speeds.
BICYCLISTS	Overall approach design decreases vehicle travel speeds. Configuration requires right turning vehicles to yield to bicyclists, posing potential conflicts.	Configuration requires right turning vehicles to yield to bicyclists, posing potential conflicts.	Exclusive turn lanes encourage higher vehicle speeds through the intersection. Right turning vehicles must cross over bicycle lane in advance of the intersection, minimizing conflicts at the intersection.	Exclusive turn lanes encourage higher vehicle speeds through the intersection. Right turning vehicles must cross over bicycle lane in advance of the intersection, minimizing conflicts at the intersection.
ADJACENT PROPERTY OWNERS	No notable positive or negative effects for adjacent property owners.	No notable positive or negative effects for adjacent property owners.	No notable positive or negative effects for adjacent property owners.	No notable positive or negative effects for adjacent property owners.

KEY: Effect On User Group

positive · mixed · negative · neither positive or negative

NUANCES FOR INTERSECTION APPROACH CONFIGURATIONS

- **Exclusive left turn lanes** are beneficial for increasing vehicular throughput at high volume intersections where left turning vehicles cannot find a gap in oncoming through traffic. However, when paired with exclusive left turn signal phases, they reduce the green time for through traffic and reduce the volume of vehicles that can proceed through the intersection in each cycle. The use of exclusive/permitted turn phases (in which a left turn green arrow is used for the exclusive portion of the phase and a flashing yellow arrow or green ball governs the permissive portion of the phase) can be an efficient treatment for left turns for many vehicles. The permissive portion of the phase will be less effective for large vehicles as they need a larger gap in oncoming traffic to accommodate their slower acceleration rates and greater length. To compensate for the reduction in capacity, multiple exclusive left turn lanes may increase the number of vehicles that can proceed through the intersection. This increase in capacity is advantageous for vehicular mobility, and the added intersection width is sometimes helpful for large trucks. However, additional turn lanes increase the pedestrian crossing distance at intersections, which requires longer green times for cross-street phases. Also, increasing the overall width of the intersection approach encourages higher speeds through the intersection, and makes pedestrians feel less safe. Multiple exclusive left turn lanes are not appropriate in community oriented areas and low activity areas. They should be avoided where possible in diverse activity areas because of their adverse effects on the pedestrian environment.
- **Exclusive right turn lanes** are similarly beneficial for maintaining vehicular throughput, and have similar disadvantages for pedestrians. As described in more detail in Design Strategy 3 on Right Turn Treatments, exclusive right turn lanes are often advantageous for truck drivers when paired with a channelized island. Exclusive right turn lanes with yield control are particularly challenging for pedestrians. Drivers who travel at these intersections on a regular basis may not actively look for pedestrians if pedestrian activity is low, which poses a safety concern when a pedestrian is present. Multiple exclusive right turn lanes are particularly challenging for pedestrians unless right-turns on red are prohibited. The presence or absence of a right turn lane is a less critical design element for truck turns than the effective curb radius. Exclusive right turn lanes are most appropriate in freight oriented areas with low pedestrian activity when paired with channelized islands to allow trucks to make turns without encroachment.

Multiple exclusive right turn lanes are particularly challenging for pedestrians unless right-turns on red are prohibited.

	LEFT TURNS	RIGHT TURNS	TURN LANE LENGTH
COMMUNITY ORIENTED	Shared with thru lane	Shared with thru lane	n/a
DIVERSE ACTIVITY	Exclusive left turn lane	Shared with thru lane	Long
LOW ACTIVITY	Exclusive left turn lane	Exclusive right turn lane	Short
FREIGHT ORIENTED	Exclusive left turn lane	Exclusive right turn lane	Long

In low activity areas, some use of the shoulder may be appropriate where turns across the shoulder are infrequent, pedestrian volumes are low, and the roadway base is designed to accommodate occasional loads.

- In general, the **number of through lanes** and **number of receiving lanes** have the most significant effect on freight mobility and the pedestrian environment. More approach and receiving lanes increase pedestrian crossing distances, but allow more vehicles to pass through an intersection in each signal cycle. Intersections with two or more receiving lanes may be easier for right turning trucks because they can encroach upon the inside lane to make a turn without needing to encroach upon oncoming traffic. Increasing the overall intersection area makes turns easier for trucks to navigate, but makes intersections less comfortable and safe for pedestrians. **Medians** can provide **refuge for pedestrians**, but extend the time it takes to cross the intersection. Refer to Design Strategy 4 on Median Nose Treatments for more detail on median design and pedestrian refuge.

NUANCES FOR INTERSECTION APPROACH CONFIGURATIONS

> The prototypical intersection approach configurations are intended for signalized intersections. **Unsignalized intersection approaches** may differ in their lane configurations. Intersections whose volumes are too low to warrant a signal may need exclusive turn lanes to allow turning vehicles to wait out of the way of through vehicles. Turn lane lengths should be long enough to accommodate larger trucks. Turn lane and taper lengths on roads with high speeds and/or heavy truck volumes should be long enough to allow vehicles to fully decelerate within them. Pedestrian crossings at unsignalized intersections should be designed to safely alert drivers of the possible presence of pedestrians. Mid-block crossings may be more appropriate than crossings at 2-way stop-controlled intersections with exclusive left turn lanes on the main street approaches.

> Intersections in diverse and freight oriented areas with two approach lanes may consider providing **a wider lane width** for the **outside curb lane** to better accommodate larger trucks.

- Trucks and buses accelerate more slowly than passenger vehicles, tend to travel at slower speeds overall, with blind spots to the right of the vehicle. Truck and bus drivers often prefer to travel in the outside travel lane to prevent other vehicles from passing them on the right. However, the right side blind spot can be problematic for interactions between trucks in the outside travel lane and bicyclists riding in a bicycle lane, particularly at intersections.
- Lane widths along roadway segments are explained in greater detail in Design Strategy 1 Typical Sections.

> **Bicycle lanes** should continue through the intersection in all context types wherever possible, and must be designed in accordance with the latest MUTCD and latest AASHTO Guide for the Development of Bicycle Facilities.

- When exclusive right turn lanes exist, bicycle lanes should be placed between the right-most through lane and the exclusive right turn lane.
- Bicycle lanes for left turning bicyclists should be considered in diverse activity areas.
- Some intersections with split phasing may have an exclusive right turn lane next to a shared through/right turn lane. This configuration is not recommended in community oriented or diverse activity areas. Bicycle lanes in this configuration must end prior to the intersection.

> Bicycle lanes increase the **effective turning radius** of intersections, and the diverse activity and community oriented prototypes recommend designers place bicycle lanes adjacent to the curb. However, trucks will encroach upon the bike lane to make a right hand turn. This can pose a safety concern for bicyclists because trucks often have large blind spots on the right side. When used in this way, **complementary signage** and/or **pavement markings** such as bicycle detector pavement markings or bicycle boxes can warn right-turning vehicles to be alert for bicyclists. In diverse areas, **right turn on red prohibitions** can help reduce conflicts between pedestrians, bicyclists, and trucks.

> **Bicycle boxes** at intersections, while still an experimental concept, hold promise especially in diverse areas for encouraging bicyclists to wait in front of through vehicles to avoid conflicts with right turning trucks. Bicycle box implementation should be complimented with outreach and marketing efforts to educate both drivers and bicyclists on the correct use of the bicycle box.

> **Curb extensions** may be appropriate in community oriented areas, but these often dramatically reduce the turning radius for right turns. Curb extensions may be appropriate along select segments for a 'main street' aesthetic. Designers should avoid putting curb extensions at every intersection. Alternating intersections with and without curb extensions can provide opportunities for trucks to make turns at the intersections without curb extensions, while still encouraging pedestrians to cross at intersections with curb extensions. Curb extensions are usually most appropriate on blocks where on-street parking exists.

> **Turn lane lengths** should consider truck size, frequency, and deceleration rates. Longer turn lanes are generally most appropriate in freight oriented and diverse activity areas. However, long turn lane lengths can be confusing along streets with frequent driveway and curb cuts. Clear signage should be provided to avoid driver confusion and prevent drivers from crossing over the bike lanes too early or too late.

Turning movements by large vehicles are complicated by both a wide turning radius and blind spots.

The interaction between trucks and bicyclists is most complex at intersections.

DIVERSE AREA CONSIDERATIONS

Intersection approaches in diverse activity areas are particularly challenging because designs to enhance community livability generally call for fewer lanes and narrow pavement widths, while designs to enhance freight mobility call for the opposite.

Intersection design is usually influenced by available right-of-way. Prioritizing limited right-of-way to the most important features for the intersection's function and role within the broader system will allow the intersection to function most effectively for the surrounding context.

Designers and engineers usually design turn lanes and through lanes to achieve an optimal vehicular level of service. In diverse areas, reducing vehicular delay should be balanced with desires for a safe pedestrian environment and vibrant street aesthetics. Projects should use community engagement efforts to talk with residents and business owners about the trade-offs.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR INTERSECTION APPROACH CONFIGURATIONS?

C — COMMUNITY ORIENTED

- Smaller intersection area
- Fewer exclusive turn lanes
- Allocate excess right-of-way to bicycle facilities (wider or buffered bicycle lanes)

F — FREIGHT ORIENTED

- Larger intersection area
- More exclusive turn lanes
- Allocate excess right-of-way to outside travel lane width/ offset

How Do I Know
WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards
COMMUNITY *if:*

> No parallel bicycle facilities exist

> Corridor has frequent driveway spacing

> Community has articulated a vision for the corridor in adopted policies or plans

> Road is a lower functional classification

> Land development regulations are in place for pedestrian-oriented design for new developments

Lean Towards
FREIGHT *if:*

> Parallel bicycle facilities exist

> Road is a higher functional classification

> Planned redevelopment is not expected occur during project life-cycle.


542146
HUT
NY
661453

DESIGN STRATEGY 3

RIGHT TURN TREATMENTS

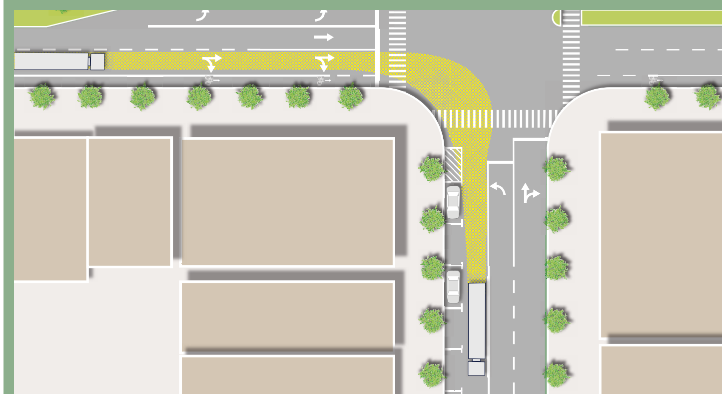
Right turn treatments are governed by the design vehicle. Smaller radii maximize sidewalk space and decrease the crosswalk distance, but often require encroachment for trucks and buses. Larger radii are easier for large vehicles to navigate, but can encourage faster speeds and may pose concerns for pedestrian safety. Channelization can provide pedestrian refuge and slow vehicle speeds, but is disorienting for pedestrians who are visually impaired.

PROTOTYPES

COMMUNITY ORIENTED

***WHAT:* Smaller radius, no channelization**

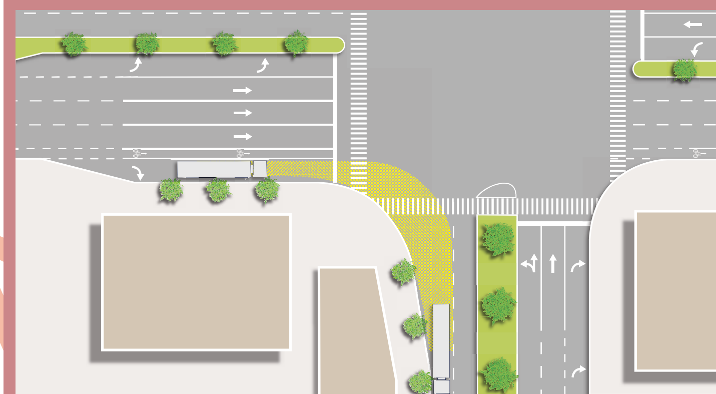
WHY: Providing pedestrian safety, access, mobility, convenience, and comfort is the highest priority. Land use context favors smaller scale infrastructure. Design vehicles are smaller in community oriented areas. Regular encroachment into bicycle lanes and multiple receiving lanes on destination leg, and occasional encroachment from multiple sending lanes from departure leg and into opposing traffic when lanes are clear is appropriate.



DIVERSE ACTIVITY

***WHAT:* Middle-range curb return radius, no channelization**

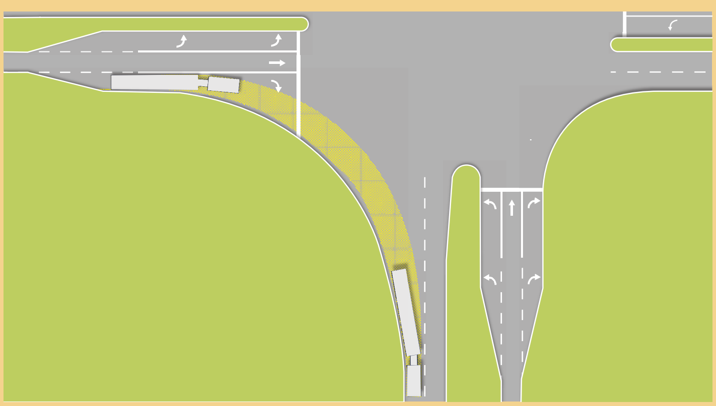
WHY: Providing pedestrian safety, access, mobility, convenience, and comfort is a high priority. Large vehicles will be using the intersection frequently, requiring a larger turning radius.



LOW ACTIVITY

***WHAT:* Large curb return radius, no channelization**

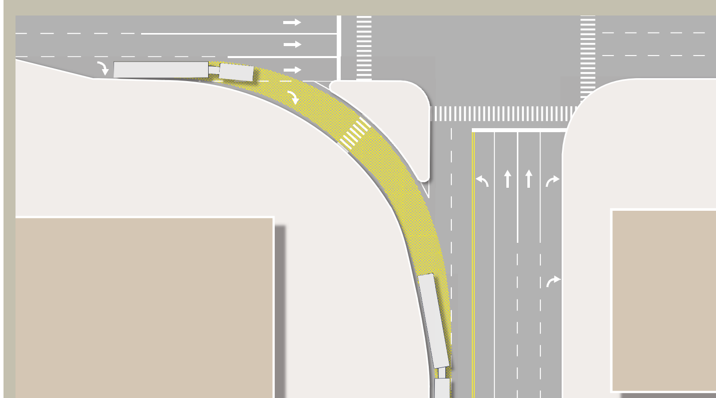
WHY: Pedestrian activity is infrequent. Safe accommodations (curb ramps and crosswalks) must be provided, but need not exceed minimum standards. Low activity areas are not areas for targeted investments; treatments in low activity areas should minimize construction and maintenance costs.



FREIGHT ORIENTED

***WHAT:* Larger curb return radius, with channelization**

WHY: Large trucks require large curb return radii. Pedestrian activity is low but occasional.



OPTIONS FOR RIGHT TURN TREATMENTS:

CURB RETURN RADIUS: Selecting appropriate radius from within wide range allowed in design standards as noted in Chapter 5

CHANNELIZATION: Option to provide a corner island

USER PERSPECTIVES

	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	L LOW ACTIVITY	F FREIGHT ORIENTED
	Smaller radius, no channelization	Middle-range curb return radius, no channelization	Larger curb return radius, no channelization	Larger curb return radius, with channelization
TRUCK DRIVERS	Requires encroachment and/or multi-point turns for large trucks. −	Easily accommodates single-unit trucks, but requires encroachment for larger trucks. +/−	Provides maximum flexibility in navigating turns. +	Can provide a larger curb return radius for easier navigation through turns, channelizing island option requires attention to back wheels. +/−
AUTO DRIVERS	Slows turning speeds. −	Easily navigable for passenger cars and SUVs. +	Encourages high turning speeds and allows passing on the right in shared through/right turn lane. +	Provides clear path for turning vehicles and allows higher turning speeds. +
BUS TRANSIT DRIVERS	May require encroachment on destination leg for turning buses. −	Minimal encroachment needed. Provides curbside space for bus stop in receiving lane. +	Easily navigable for turns, but requires transit stop to be located farther from intersection corner. +/−	Easily navigable for turns, but requires transit stop to be located farther from intersection corner. +/−
PEDESTRIANS	Shortens crossing distance and simplifies crossing maneuver. +	Moderate crossing distance. +/−	Lengthens crossing distance and encourages vehicles to make right turns on red. −	Channelized island can provide pedestrian refuge, but increased curb radius increases overall crossing distance. +/−
BICYCLISTS	Slows vehicle turning speeds, thereby increasing bicyclist safety. +	Encourages moderate vehicle turning speeds, but allows bicyclists to be flexible in lane positioning. +/−	Encourages high vehicle turning speeds and complicates bicycle lane positioning. −	Channelized island can provide better waiting space for bicyclists proceeding straight through the intersection, but complicates interaction between right-turning motorized vehicles and right-turning bicyclists.
ADJACENT PROPERTY OWNERS	Maximizes property frontage and requires minimal right-of-way. +	No notable adverse or positive effects.	Larger right of way impacts for corner properties. −	Larger right of way impacts for corner properties. −

KEY: Effect On User Group

+ positive   +/− mixed   − negative   ☐ neither positive or negative

> **CHANNELIZATION** provides opportunities for pedestrian refuge at intersections with long crossing distances. Channelization is especially useful for freight oriented and diverse activity areas where frequent large trucks require large curb return radii. Channelizing islands break up the distance a pedestrian must cross into smaller segments. However, these islands can be disorienting for pedestrians who are impaired, and islands are not recommended in community oriented areas.

> **THREE CENTERED COMPOUND CURVES** more closely approximate the turning path of a large vehicle. They require less right-of-way area and reduce the overall pedestrian crossing distance as compared to a simple curve that accommodates a certain design vehicle. This treatment may be particularly appropriate for diverse activity areas.

> **CURB EXTENSIONS** are desirable in community oriented areas because they reduce the overall pedestrian crossing distance, but can pose additional obstacles for large turning trucks because they decrease the effective turning radius.

> **BICYCLE LANES** and on street parking lanes can increase the effective turning radius for right turns without increasing the curb return radius.

> **MOUNTABLE CURBS** can accommodate large vehicles infrequently at small intersections, but are generally not recommended. They can encourage more frequent encroachment, and introduce conflicts between turning trucks and pedestrians waiting at intersection corners.

RIGHT TURN TREATMENTS (CONTINUED)

NUANCES FOR RIGHT TURN TREATMENTS

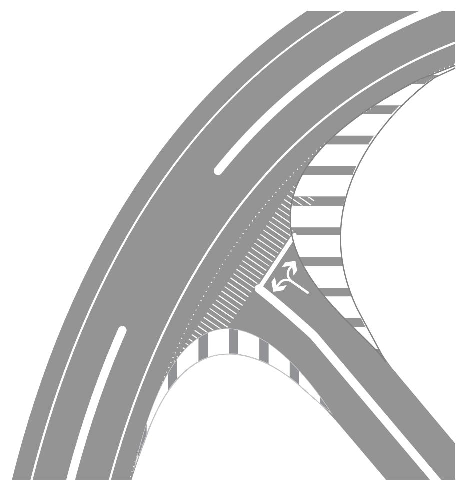
Channelization

> Channelization is recommended for skewed angle intersections, especially in diverse activity areas. A channelizing island at the approach of an acute angle intersection can provide an area of refuge for pedestrians, while still accommodating large turning radii for large trucks. For skewed angle intersections in community oriented areas (design vehicle is a passenger vehicle or small box truck), curb extensions or painted pavement may be a preferred treatment to bring the alignment of the intersection more towards 90 degrees while shortening the pedestrian crossing distance.

> Consider the traffic control device for channelized right turns. Yield control allows the most efficient vehicular flow, but creates conflicts between vehicles and pedestrians. Yield control is not recommended for community oriented and diverse activity areas, and should be used with caution in freight oriented areas. Yield control may be appropriate in low activity areas. Stop control requires vehicles to stop and increases the chance of vehicles yielding to pedestrians, and may be most appropriate in freight oriented areas and for roads with low functional classification in diverse activity and community oriented areas. Signal control is most appropriate for roads with higher functional classification in community oriented and diverse activity areas to provide a designated phase for pedestrians to cross.

> Especially for multi-lane roads, the downstream weaving experience should be a factor in the consideration of whether to channelize a right turn. Short merge lengths may be problematic for roads in freight oriented and diverse activity areas and for roads that are on the freight network in community oriented and low activity areas. The distance to the next downstream intersection and the number of lanes to cross to make a left turn should also be considered. Short distances and multiple lanes are particularly to navigate for trucks, especially with a yield controlled channelized right turn.

Channelization treatment for skewed angle intersections in diverse activity areas facilitates higher speed right turns.



Alternative treatment for skewed angle intersections replaces channelized turn with mountable curbs to reduce pedestrian crossing distance.

> Bicycle Lanes & On-Street Parking

> A bicycle lane to the right of the vehicle turning lane creates a conflict between vehicles turning right and bicyclists waiting to proceed straight through the intersection.

> Bicycle lanes should be located to the left of exclusive right turn lanes, but exclusive right turn lanes increase the pedestrian crossing distance.

> Bicycle boxes at intersections encourage bicyclists to wait in front of the vehicle queue so that right turning vehicles can see them. While not yet a common practice in the U.S., bicycle boxes can reduce conflicts between bicyclists and motorists at intersections.

DIVERSE AREA CONSIDERATIONS

Diverse activity areas need to accommodate both (a) large trucks as design vehicles, which require large swaths of pavement, and (b) pedestrian safety, where designs with minimal pavement are best. The best infrastructure designs in diverse activity areas may have unique shapes and irregular forms to accommodate both users together.

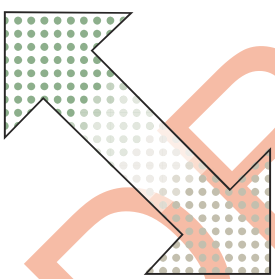
On regional freight mobility corridors and freight distribution routes, three centered compound curves are particularly recommended for diverse activity areas, as they can decrease the area of pavement needed to accommodate the wheel-path of large trucks.

However, roads that are not a part of the regional freight network should generally avoid channelized islands for pedestrian safety and comfort. Trucks are less frequent on these roads, and a suitable design may be a shared through/right turn lane with a bicycle box to encourage bicyclists to wait in front of the traffic where vehicle drivers can see them. Bicycle lanes and on street parking should be encouraged on these roads because they can both enhance the vibrancy of street life as well as increase the effective turning radius at intersections.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR RIGHT TURN TREATMENTS?

C — COMMUNITY ORIENTED

- Smaller curb return radii
- No channelization
- Curb extensions
- Bicycle boxes
- On-street parking
- Fewer vehicle travel lanes



F — FREIGHT ORIENTED

- Larger curb return radii
- Channelization
- No curb extensions
- No bicycle boxes
- No on-street parking
- More vehicle travel lanes

How Do I Know
WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards
COMMUNITY *if:*

> The approach roadway is not on the regional freight mobility network

> The cross street has more than one lane in each direction – allows for more encroachment and fewer other design interventions are needed to accommodate large trucks

> Driveways and curb cuts are frequent and/or close to the intersection

> Vehicle access is oriented to the rear with minimal setback between sidewalk and building

Lean Towards
FREIGHT *if:*

> The approach roadway is on the regional freight mobility network

> The cross street has only one lane in each direction – allows for less encroachment and more other design interventions are needed to accommodate large trucks

> Roadways (both approach and cross street) have managed access points

> Vehicle access is oriented to the front with parking lots in front of the building

DESIGN STRATEGY 4

LEFT TURN/MEDIAN NOSE TREATMENTS

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. Median nosings can provide pedestrian refuge, especially for large intersections. Full curb nosings are most effective for pedestrian safety, but reduce the turning area for large vehicles and can easily be damaged if a truck's rear wheels run over the curb. 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.

PROTOTYPES

COMMUNITY ORIENTED

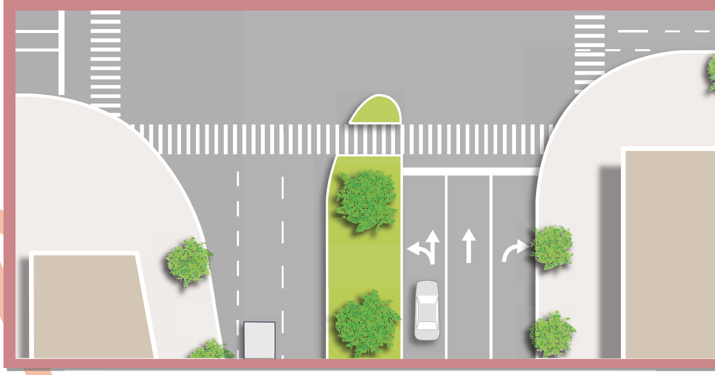
***WHAT:* Curb median nose**

WHY: *Providing pedestrian safety, access, mobility, convenience, and comfort is the highest priority*

DIVERSE ACTIVITY

***WHAT:* Curb median nose w/ nose shaped for largest design vehicle**

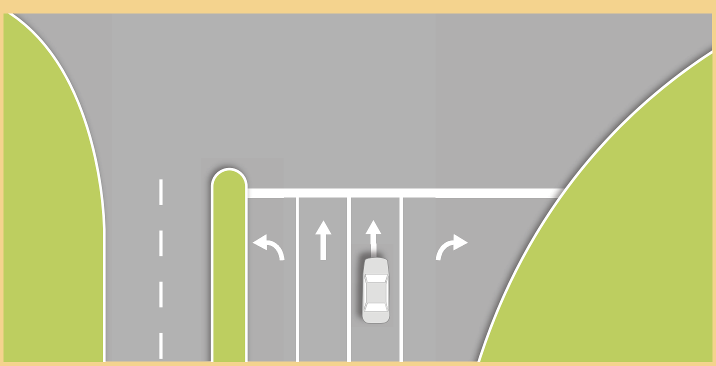
WHY: *Providing pedestrian safety, access, mobility, convenience, and comfort is a high priority, so a full pedestrian refuge must be provided. Large vehicles will be using the intersection frequently, so the median nose should be shaped to accommodate them regularly (see Design Vehicle).*



LOW ACTIVITY

***WHAT:* No median nose (median ends prior to crosswalk)**

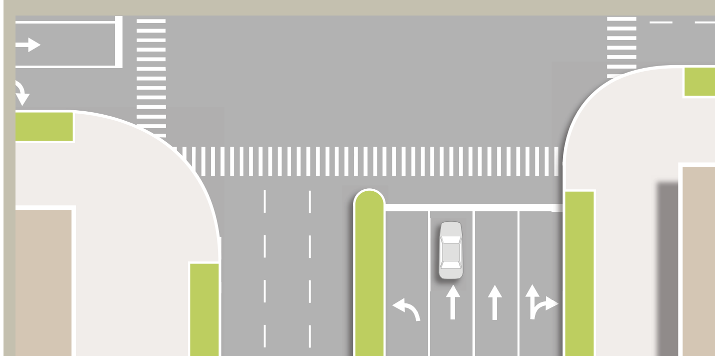
WHY: *In both freight oriented and low activity areas, pedestrian activity is infrequent. Safe accommodations must be provided, but need not exceed minimum standards. In freight oriented areas, truck quality of service is the highest priority. In low activity areas, no median nose is least expensive option for construction and maintenance.*



FREIGHT ORIENTED

***WHAT:* No median nose (median ends prior to crosswalk)**

WHY: *In both freight oriented and low activity areas, pedestrian activity is infrequent. Safe accommodations must be provided, but need not exceed minimum standards. In freight oriented areas, truck quality of service is the highest priority. In low activity areas, no median nose is least expensive option for construction and maintenance.*



USER PERSPECTIVES

	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	F/L FREIGHT ORIENTED/ LOW ACTIVITY
	Curb median nose	Curb median nose w/ nose shaped for largest design vehicle	No median nose (median ends prior to crosswalk)
TRUCK DRIVERS	Requires encroachment to facilitate turns.	Slimmer nose provides more room for rear wheels, but still may require encroachment for larger trucks.	Provides more space for rear wheels and requires least amount of encroachment.
AUTO DRIVERS	Slows travel speeds and requires careful maneuver of left turns to avoid median noses.	Provides more space for turning maneuvers; could potentially allow increased speeds.	Provides greatest amount of space and flexibility for turning maneuvers, especially for double left turn lanes.
BUS TRANSIT DRIVERS	More difficult to maneuver and may require encroachment for turning buses.	Tapered nose provides more room for rear wheels, but still may require some degree of encroachment.	Provides more space for rear wheels and requires least amount of encroachment.
PEDESTRIANS	Provides curb-protected pedestrian refuge.	May provide some space for pedestrian refuge, but asymmetrical shape may be disorienting for pedestrians who are visually impaired.	Eliminates ADA-compliant refuge and curb protection from vehicle paths. Pedestrians must cross the entire intersection in one phase.
BICYCLISTS	Can cause larger left-turning vehicles to swing wide towards the bicycle or curb lane, and may cause conflicts between left turn vehicles and left turning cyclists or right turning cyclists from opposite approach.	Facilitates lesser encroachment than full curb median nose, but may still require larger trucks to swing wide into bicycle or curb lane.	Requires the least amount of encroachment into the bicycle or curb lane, but encourages higher vehicle speeds.
ADJACENT PROPERTY OWNERS	No notable positive or negative effects for adjacent property owners.	No notable positive or negative effects for adjacent property owners.	No notable positive or negative effects for adjacent property owners.

*Applicable for divided roadways with raised medians; many roads in freight-oriented and low-activity areas are undivided or have painted medians.

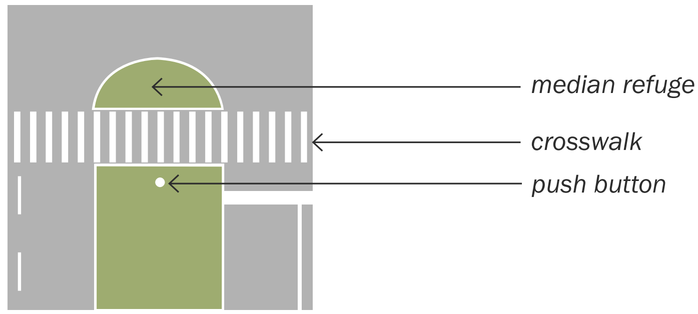
KEY: Effect On User Group

positive mixed negative neither positive or negative

NUANCES FOR LEFT TURN/MEDIAN NOSE TREATMENTS

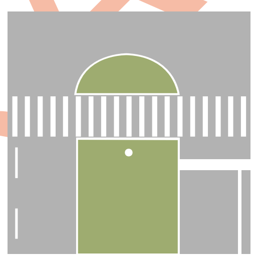
Pedestrian Refuges

- If the traffic signal has an actuated pedestrian signal, a push button should be provided in the median refuge. The push button should be located on the side of the refuge away from the intersection, in the center of the median.



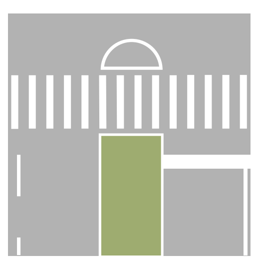
Pedestrian Signal Push Button Location

- The number of vehicle lanes, lane widths, and median width affect the pedestrian crossing distance, and should be minimized where possible in community oriented and diverse areas.
- Signal timing affects the time pedestrians have to cross. An ADA-compliant refuge may not be needed if pedestrians have enough time within the pedestrian phase to cross entirely.

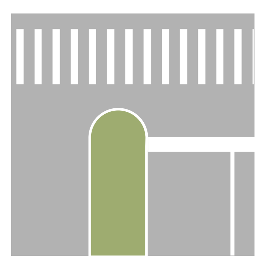


Curb Median Nose

Mountable Median Nose



Painted Median Nose (flush w/ pavement)



No Nose (median ends prior to crosswalk)

Different median nose treatments provide varying levels of guidance to pedestrians and vehicles. The full curb median nose provides the highest levels of pedestrian safety and comfort. A mountable median nose may reduce maintenance costs where truck trailer encroachment will be infrequent. The painted median nose provides turning movement guidance, but not pedestrian refuge.

- A full **PEDESTRIAN REFUGE** is most desirable in community oriented and diverse areas.
- Two **RECEIVING LANES** allow a truck to turn into the outer receiving lane with its back wheels encroaching into the inner receiving lane
- A **TAPERED MEDIAN NOSE** can accommodate a larger radius while still providing pedestrian refuge.
- **MOUNTABLE CURBS** may be used with caution. Mountable curbs can encourage truck drivers to regularly run over the median. In community oriented and diverse areas, mountable curbs are not recommended because pedestrian activity is high, and pedestrians with physical disabilities and persons who are visually impaired may frequently use the intersection.

- **FLEXIBLE BOLLARDS** may be used in special circumstances in diverse activity areas to communicate to truck drivers they should not drive over curbs, but cause minimal damage if they are run over.
- Roads without medians may accommodate larger vehicles making left turns by **PULLING BACK THE STOP BAR** to increase the effective turning radius for left turns.

DIVERSE AREA CONSIDERATIONS

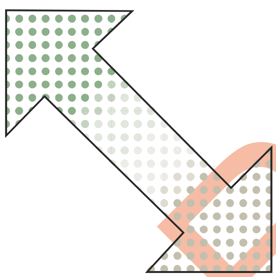
Designing a median nose treatment that both (a) provides an ADA compliant pedestrian refuge with curb protection and (b) accommodates left turns for large trucks is particularly difficult in areas where the right-of-way is limited. The best way to accommodate both large trucks and pedestrians is to design the signal timing to provide adequate time for pedestrians to cross in one phase, which can eliminate the need to provide a pedestrian refuge in the median. Designing for a slower crossing speed for pedestrians with physical disabilities should be considered.

Timing the signal for pedestrian crossings in one phase is usually simple on minor arterials, roads that are not a part of the regional freight mobility network, and other roads of lower functional classes. However, on regional freight mobility corridors and freight distribution routes (roads which usually have larger curb return radii), the signal timing may also make a shorter crossing distance desirable. Pulling back the stop bar and crosswalk of the destination leg can shorten the pedestrian crossing distance and increase the space available for vehicles to make the left turn.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR LEFT TURN/ MEDIAN NOSE TREATMENTS?

C COMMUNITY ORIENTED

- Fewer vehicle travel lanes
- Narrower vehicle travel lanes
- Shorter pedestrian crossing distances
- “Walk” pedestrian signal phase exceeds minimum crossing time
- Optional pedestrian median refuge because pedestrians can cross intersection in one phase



F FREIGHT ORIENTED

- More vehicle travel lanes
- Wider vehicle travel lanes
- Longer pedestrian crossing distances
- “Walk” pedestrian signal phase does not exceed minimum crossing time
- Pedestrian median refuge if pedestrians are not able to cross intersection in one phase

How Do I Know
WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards
COMMUNITY *if:*

> The cross-street roadway is not on the regional freight mobility network

> The area has a concentration of pedestrian-generating civic or institutional uses, such as schools, parks, or health services

> The intersection is unsignalized but has observed pedestrian activity

Lean Towards
FREIGHT *if:*

> The cross-street roadway is on the regional freight mobility network

> The intersection has skew angles that restrict median extensions or require non-perpendicular crosswalks

> Both intersecting streets are designated as freight mobility corridors

> Both intersecting streets are state routes and median is adjacent to dual left turn lane movement

> The left turning movements include high truck volumes

DESIGN STRATEGY 5

PAVEMENT BULB-OUTS AND U-TURNS

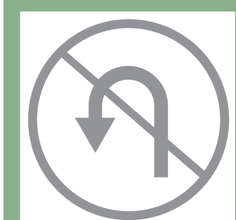
Large vehicles have wide turning radii and often require additional pavement beyond the striped vehicle lanes to complete a U-turn. These pavement bulb-outs are easier to implement on open-section roadways having slope and ditch drainage and in areas with low density land uses and wide setbacks between buildings and the right-of-way. In areas with shorter setbacks and along closed-section roads having curbs it is more difficult to accommodate pavement bulb-outs and U-turn movements may need to be considered in the context of the full street network.

PROTOTYPES

COMMUNITY ORIENTED

***WHAT:* Truck U-Turns Prohibited**

WHY: *In a pedestrian-oriented environment, buildings are closer to the street, and available right-of-way is limited. Street networks are typically connected grids, and trucks can make a series of right and left turns to access destinations on the other side of the street.*



DIVERSE ACTIVITY

***WHAT:* Intersections with Pavement Bulb-Outs Alternate with U-Turn Prohibitions**

WHY: *Goods delivery is a critical element in a diverse area. Large trucks need to be able to make U-turns without going far out of their way. Ideally, U-turns should be provided for at major intersections, considering building setbacks and available right-of-way.*

LOW ACTIVITY

***WHAT:* Gravel Bulb-Outs for U-Turns**

WHY: *Safe, low cost solutions are best in low activity areas. Gravel installation is quick, inexpensive, and adequate for low frequency use.*

FREIGHT ORIENTED

***WHAT:* Paved Bulb-Outs for U-Turns**

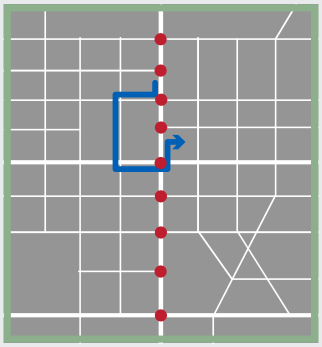
WHY: *Truck maneuverability is paramount. Buildings are typically set far back from the edge of right-of-way, and roads typically have shoulder and ditch drainage giving adequate space for pavement bulb-outs.*

USER PERSPECTIVES

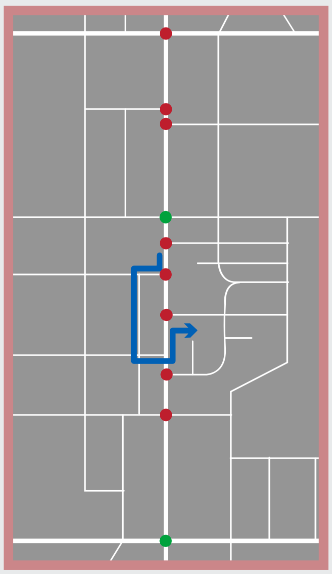
	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	L LOW ACTIVITY	F FREIGHT ORIENTED
	Truck u-turns prohibited	Intersections with pavement bulb-outs alternate with u-turn prohibitions	Gravel bulb-outs for u-turns	Paved bulb-outs for u-turns
TRUCK DRIVERS	Requires truck drivers to make a series of turns to access properties on the other side of the street. (negative)	Trucks must drive slightly further out of the way to make a U-turn, but have the opportunity to do so with minimal turning maneuvers. (mixed)	Gravel provides space but requires slower and more careful maneuvers than paved bulb-outs. (mixed)	Provides a stable surface with ample room for easy U-turns and most direct access to properties. (positive)
AUTO DRIVERS	If auto U-turns are not allowed, auto drivers will find access inconvenient. If only truck U-turns are prohibited, yield conflicts with right turning vehicles are lessened. (mixed)	Few notable impacts to auto drivers.	Right-turning vehicles from the cross street approach may mistake the gravel bulb-out as a path for right turns. (negative)	Increases the turning radius for right turns. (positive)
BUS TRANSIT DRIVERS	Transit routes rarely require U-turn maneuvers.	Transit routes rarely require U-turn maneuvers.	Gravel bulb-outs can increase the effective turning radius, but require more frequent vehicle cleaning and maintenance. (mixed)	Increases the turning radius for right turns. (positive)
PEDESTRIANS	Prohibiting truck U-turns requires less pavement which shortens pedestrian crossing distances. (positive)	Intersections where truck U-turns are permitted lengthen pedestrian crossing distances and require longer green time for left turns, increasing wait times for pedestrians. (mixed)	Gravel prohibits striped crosswalks and presents unstable surface for walking. (negative)	Increases the crossing distance and can encourage higher vehicle turning speeds. (negative)
BICYCLISTS	Truck drivers may make more right-turns and cross bicyclists paths more often. (mixed)	Truck drivers who are unfamiliar with the area may attempt to cross to the right to make a series of right turns, which can increase conflicts with bicyclists.	No notable adverse or positive effects.	Provides more space at intersections for vehicles to pass, but requires merge in quickly thereafter. (mixed)
ADJACENT PROPERTY OWNERS	Business owners may fear a lack of direct access will discourage customers from frequenting their business. (negative)	Business owners may fear the configuration is confusing for truck drivers and will discourage customers from frequenting their business. (negative)	Business owners may complain about the dirt and dust from gravel treatments. (negative)	Business owners will appreciate the direct access, but bulb-out may require right-of-way along property frontage. (mixed)

KEY: Effect On User Group

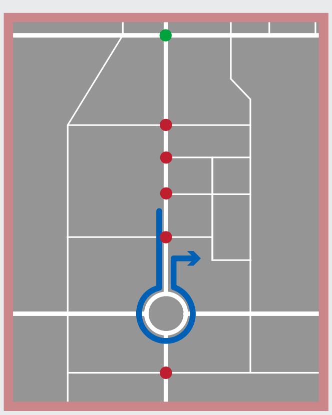
+ positive   +/– mixed   – negative   ☐ neither positive or negative



In a Community-Oriented Area, the street grid may suffice to limit nearly all U-turns from a state highway.



In a Diverse Area, the street grid may support limiting U-turns from a state highway at many intersections, as an element of sound access management.



Roundabouts can serve as a way to facilitate U-turns as well as left turns both to and from side streets and driveways.

NUANCES FOR PAVEMENT BULB-OUTS AND U-TURNS

Deciding on pavement bulb-out location:

> Roundabouts can serve as an effective intersection traffic control device that also facilitates U-turns for all motor vehicles. Superelevation considerations in roundabout design are particularly important for tractor-trailer combinations. In general, roundabout design accommodates all types of truck traffic, although considerations may be needed for design elements such mountable center island curbs. Emerging evidence suggests that load-shifting in roundabouts may present challenges for liquid cargo if design speed is exceeded.

> Even in the most freight oriented areas, pavement bulb-outs may not be necessary at every intersection or median break. The frequency of median breaks and frequency of other pavement bulb-outs are factors to consider when determining whether to provide a bulb-out for truck U-turns at a particular location.

> Areas with connected street networks and sufficient parallel roads that are designed to accommodate trucks may not need pavement bulb-outs. Truck drivers can make a series of right turns to go around the block and turn left back onto the original road as an alternative to making a U-turn. This strategy is not appropriate for accommodating large trucks in areas with narrow streets and small curb return radii.

> Turn restrictions at upstream intersections increase the vehicular demand for U-turns downstream. Innovative intersection configurations like the “superstreet” intersections facilitate both left turn and U-turn movements concurrently and may channelize enough demand to warrant a signal at the U-turn location, particularly if traffic volumes in the opposite direction are high.

> Larger trucks have much slower acceleration rates than passenger vehicles, and take longer to make a U-turn from a standstill. The sight distance of oncoming traffic should be long enough that drivers have adequate time to react to a slow-moving U-turning truck. This is particularly critical for roads with horizontal and/or vertical curvature. Designers should choose bulb-out locations with consideration for sight distance for oncoming vehicles in both directions

> Appropriate signage communicates to truck drivers where the most convenient turn-around locations are.

Designing pavement bulb-outs:

> Generally, more pavement is better for turning trucks, but not beneficial for pedestrians.

> Wider medians reduce the amount of extra pavement needed for the bulb-out design.

> Larger curb radii and/or tapered curbs provide slightly more pavement at the critical turning areas.

DIVERSE AREA CONSIDERATIONS

Intersection geometric design to accommodating truck U-turns can often be incorporated in the design of the curb return. Pedestrian frequency and the proximity of pedestrian generators should be primary factors when selecting which intersections are best suited for prohibiting truck U-turns. Intersections with greater right-of-way may be better for accommodating truck U-turns.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR PAVEMENT BULB-OUTS AND U-TURNS?

C COMMUNITY ORIENTED

- More frequent U-Turn prohibitions
- Narrower curb return radii
- Smaller intersection pavement area
- Strict boundary between pedestrian realm and vehicular realm

F FREIGHT ORIENTED

- Less frequent U-Turn prohibitions
- Wider curb return radii
- Larger intersection pavement area
- Vehicular realm can extend beyond right-of-way to accommodate larger vehicles

How Do I Know WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards COMMUNITY *if:*

- Pedestrian volumes are higher than at adjacent intersections
- Pedestrian generators are closer than at adjacent intersections
- Right-of-way is more limited
- Adjacent land uses have limited truck activity
- A transit stop is located at the intersection

Lean Towards FREIGHT *if:*

- Nearby land uses generate significant truck volumes especially during AM and PM peak hours
- Right-of-way is larger than at adjacent intersections
- Pedestrian generators are not within close proximity

DESIGN STRATEGY 6

ACCESS MANAGEMENT & TRUCK PARKING

The "last mile" is cited as the most difficult segment of a truck trip, and the "last few yards" can be the most difficult and frustrating part. Driveway access, loading/unloading zones and curbside parking regulations directly influence how easily and reliably trucks can access their destinations and ultimately deliver their goods.

The following prototypes offer arrangements for truck parking that provide space for loading and unloading and complement the function of the road and the context of the area therein.

PROTOTYPES

COMMUNITY ORIENTED

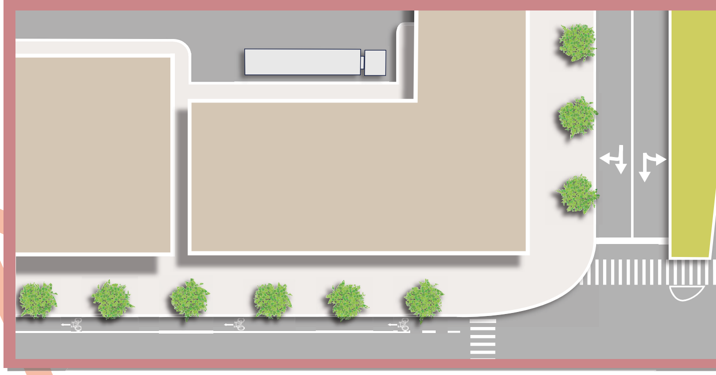
***WHAT:* Curbside truck parking at time-sensitive loading zones**

WHY: *Surface parking lots are rare, as are the volume and frequency of large trucks. Truck drivers prefer to make off-peak deliveries in denser areas to avoid traffic congestion, and time-sensitive loading zones keep curbside space available for truck parking at these times.*

DIVERSE ACTIVITY

***WHAT:* Indirect rear access from alley or other street – minimal driveways**

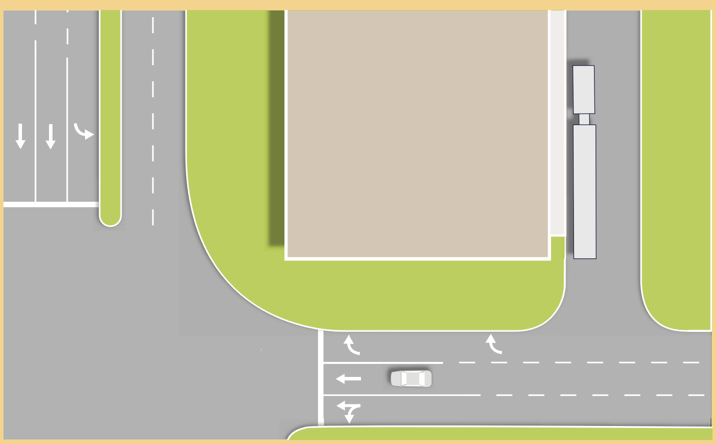
WHY: *Roadways typically have managed access points, and adequate parking space usually exists on site for deliveries. On-street parking may be prohibited.*



LOW ACTIVITY

***WHAT:* Direct front or side access with smaller aprons (lower cost, OK for slower turns)**

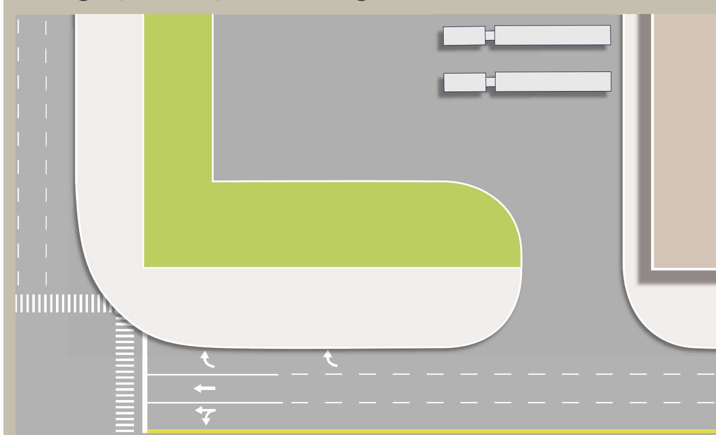
WHY: *Truck activity is relatively low, and simultaneous truck arrival is unlikely. Smaller pavement area reduces cost.*



FREIGHT ORIENTED

***WHAT:* Direct front access with wide aprons**

WHY: *Truck maneuverability is paramount. Freight activity draws many trucks, and there is a high likelihood of multiple simultaneous maneuvers. Wide expanse of pavement accommodates side-by-side loading bays and expedites turning movements.*



USER PERSPECTIVES

	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	L LOW ACTIVITY	F FREIGHT ORIENTED
	Curbside truck parking at time-sensitive loading zones*	Indirect rear access from alley or other street - minimal driveways	Direct front or side access with smaller aprons (lower cost, OK for slower turns)	Direct front access with wide aprons
TRUCK DRIVERS	Large trucks may find it difficult to parallel park within narrow curbside parking spaces, especially when other vehicles are parked next to loading/unloading spaces. This arrangement avoids alleys or driveways which may be difficult to enter or back out of.	Requires trucks to navigate through often narrow alleys or rear access roads. Truck drivers must find the alley access, which may not be easily visible.	Direct access from the main road avoids alley access. Truck drivers may have difficulty navigating smaller driveway openings. Truck drivers may need to encroach upon adjacent travel lanes or roadside to turn in and out.	Truck drivers can easily turn into driveways and directly access destinations from the main road.
AUTO DRIVERS	Trucks may stick out into adjacent travel lanes. Parking prohibitions for loading/unloading may be inconvenient for drivers who wish to park along the street.	Fewer driveways reduces conflict points.	Potential exists for truck encroachment during driveway maneuvers.	More frequent driveways with wider aprons introduce more conflict points .
BUS TRANSIT DRIVERS	Trucks may stick out into adjacent travel lanes.	Fewer driveways reduces conflict points.	Potential exists for truck encroachment during driveway maneuvers.	Potential exists for truck encroachment during driveway maneuvers.
PEDESTRIANS	Trucks may park with the wheels on the curb to avoid sticking out into travel lanes in narrow parking spaces.	Fewer driveways reduces conflict points between pedestrians walking along the road and vehicles turning into or out of local driveways.	No notable adverse or positive effects.	Paved shoulder provides minimal protection from vehicular traffic.
BICYCLISTS	Trucks may stick out into adjacent bicycle lanes or adjacent travel lanes.	Fewer driveways reduces conflict points between cyclists and vehicles turning into or out of local driveways.	More frequent driveways introduce more conflict points between vehicles turning into or out of local driveways and cyclists.	More frequent driveways introduce more conflict points between vehicles turning into or out of local driveways and cyclists.
ADJACENT PROPERTY OWNERS	Residents and business owners may wish to preserve parking for themselves or their customers. Parking prohibitions prevent residents from parking overnight or over extended periods of time.	Property owners often want direct access to properties from the main road.	Direct access is more convenient for residents and customers who access land uses by car.	Direct access is more convenient for residents and customers who access land uses by car.

NOTE:
**While curbside truck parking does not appear to be fully positive from any user perspective, this prototype is appropriate in community oriented areas to fulfill market potential and help achieve pedestrian-oriented built environment. Land values are often too high in community oriented areas to provide off-road truck parking areas. Private property may serve a higher and better use for building structures rather than for parking areas (both for trucks and vehicles).*

KEY: Effect On User Group

+ positive   +/– mixed   – negative   ☐ neither positive or negative

NUANCES FOR ACCESS MANAGEMENT & TRUCK PARKING

- Main road speeds and traffic volumes are critical factors to consider. Curbside on-street parking is not appropriate for roads with high posted speeds or traffic volumes. Frequent driveways create conflict points between vehicles entering/exiting the driveway and other road users. These conflict points are particularly problematic for pedestrians and bicyclists, as well as on roads with high traffic volumes.
- The temporal distribution of truck arrivals affects the width of the driveway apron and the necessary pavement area to provide adequate truck parking and maneuvering space. A site that generates moderate daily truck volumes that all arrive within the same hour needs more pavement than one where arrivals are staggered throughout the day.
- In urban areas, curbspace management techniques may include time-of-day designations such as off-peak period parking, wherein a curb lane can be used as a travel lane during peak commuter periods but as a loading/parking lane during other times of day.
- Building density affects the available real estate for surface parking lots. If surface parking lots are rare, wider curbside on-street parking will provide more space for truck deliveries.
- Parcel access locations should be coordinated with building door sizes. If the building's largest door is in the rear, curbside loading/unloading may suffice for small deliveries, but rear access should be preserved for large deliveries even if their occurrence is infrequent.
- Be aware of special uses especially in downtowns that have unique and/or irregular needs for large vehicles e.g. performing arts and small concert venues.
- The typical curbside parking space width in dense urban areas is not sufficient for tractor-trailer loading and unloading. Avoid narrow vehicle travel lanes adjacent to narrow curbside parking lanes. When loading space is extremely limited, truck drivers may resort to parking on the curb, reducing the width of the sidewalk, which creates obstacles for pedestrians, especially those with wheelchairs or strollers.

Truck access and circulation plans in diverse areas should seek to incorporate advance warning for truck restrictions.

In community-oriented areas, curbspace management and operations plans help to manage high frequencies of goods movement, typically by smaller delivery vehicles.

Time of day restrictions can be tailored to fine-tune curbspace management; this example in lower Manhattan demonstrates highly context-sensitive curbspace management.

DIVERSE AREA CONSIDERATIONS

In diverse activity areas, managing access for vehicles can improve the pedestrian environment while maintaining traffic flow. Access via alleys and rear access roads may be slightly less convenient for trucks than direct access, but minimizes overall conflicts. Alleys should be well-signed, and with access provided from side streets.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR ACCESS MANAGEMENT & TRUCK PARKING?

C COMMUNITY ORIENTED

- On-street parking available
- Rear vehicle access preferred
- Small and infrequent driveway openings and curb cuts

F FREIGHT ORIENTED

- On-street parking not available
- Front vehicle access preferred
- Large and frequent driveway openings and curb cuts

How Do I Know WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards COMMUNITY *if:*

> Existing or preferred future land uses will be significant pedestrian generators

> Area is located within walking distance of an existing or future premium transit stop

> Design/target speeds are 35 mph or lower

> Parallel higher capacity roads exist

> Bus transit routes serve the road

> Freight oriented uses are not located along the road (i.e. trucks use the road primarily for distribution to non-freight and non-industrial businesses or to residences)

Lean Towards FREIGHT *if:*

> Land use plans or market forces indicate freight and industrial uses will remain during the project life-cycle

> Parallel/rear access roads or alleys are not feasible because of terrain or water features

DESIGN STRATEGY 7

TRAFFIC CONTROL DEVICES

When vehicles approach an intersection, traffic control devices indicate who has the right-of-way and who must yield. Traffic control devices that moderate movements at intersections include yield signs, stop signs, and traffic signals. The different types of traffic control devices require varying amounts of communication between road users. The types of traffic control devices that are most appropriate for the situation often depend on the context of the area.

Regardless of the type of traffic control devices present, intersection safety is enhanced by improved communication among roadway users themselves, particularly through awareness of the presence and intent of other users. Such communication is generally enabled in lower speed and lower volume environments and more challenging where volumes and speed differentials are higher. The prototypes below describe the most appropriate level of traffic control for each context area. The traffic control prototypes complement the prototypes for the Intersection Approach Configurations and Signal Phasing design strategies.

PROTOTYPES

COMMUNITY ORIENTED

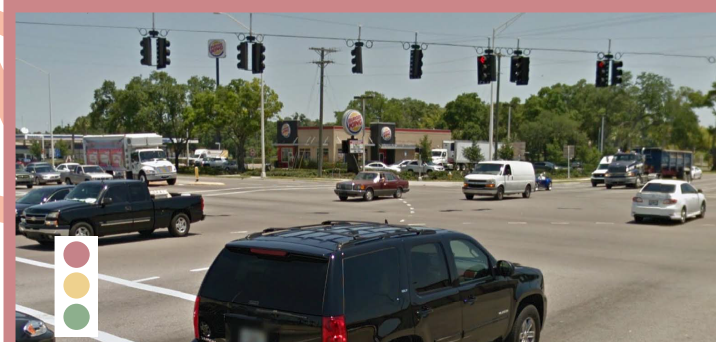
WHAT: ***Highly controlled; most sensitive to pedestrian movements.*** *Generally, signal phasing and timing at signalized intersections should favor pedestrian phases. Unsignalized intersections should feature crosswalks and other infrastructure for pedestrians as necessary*

WHY: *Managing interactions where truck volumes are lower and non-motorized volumes are higher requires priority attention to providing right-of-way to more vulnerable modes such as bicyclists and pedestrians.*

DIVERSE ACTIVITY

WHAT: Highly controlled; most sensitive to providing dedicated phases and clear right-of-way for all movements and all road users

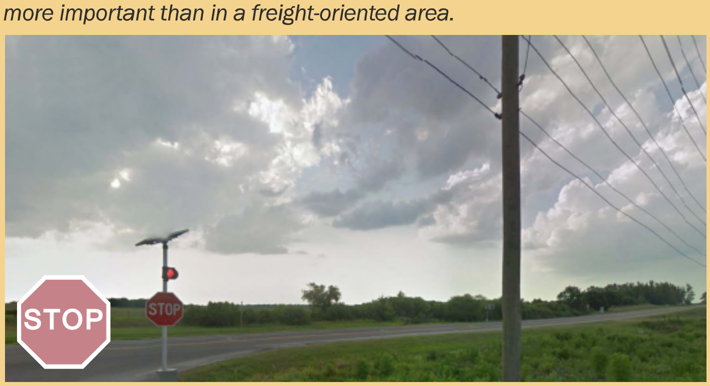
WHY: *Managing interactions among many different modes and operators of varying ages and abilities requires high levels of traffic control. Dedicated turn lanes and protected phases for turns at signalized intersections provide cross-modal clarity. Complementary regulatory or warning signage can remind road users to communicate with each other.*



LOW ACTIVITY

WHAT: Moderately controlled with stop signs for most minor road approaches. *Traffic on major roads maintains right-of-way through intersection without stopping or yielding. Side street approaches need full stop for safety.*

WHY: *Low entering/crossing volumes only warrant signal control in a few locations. High mainline travel speeds require deliberative consideration of adequate entry gaps, so side street full stop control is more important than in a freight-oriented area.*



FREIGHT ORIENTED

WHAT: ***Less fully controlled; intended to keep goods moving without requiring full stops.***

WHY: *Keeping trucks moving at slow speeds without requiring full stops reduces fuel cost, operator time, and vehicle wear and tear. In freight-oriented areas with a high proportion of commercially licensed drivers, professional courtesy facilitates yield operations.*

USER PERSPECTIVES

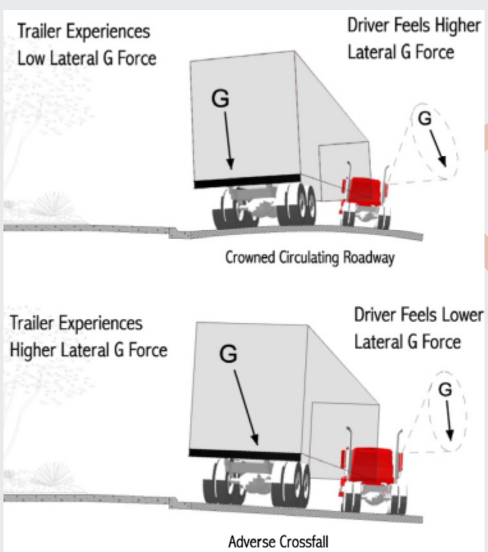
	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	L LOW ACTIVITY	F FREIGHT ORIENTED
	Highly controlled; most sensitive to pedestrian movements	Highly controlled; most sensitive to providing dedicated phases and clear right-of-way for all movements and all road users	Moderately controlled; typically with stop signs for minor road approaches	Less fully controlled; intended to keep goods moving without requiring full stops
TRUCK DRIVERS	Traffic signals typically produce longer delays for turning movements at low volume intersections. Slower vehicle acceleration and deceleration rates make it difficult for truck drivers to quickly react to pedestrians.	Traffic signals typically produce longer delays for turning movements at low volume intersections. Dedicated space and phases for turns facilitates predictable truck maneuvers.	Truck traffic on major street continues without slowing or stopping. Truck turns from minor road approaches may be difficult especially if vehicular speeds are high on major road.	Truck drivers can communicate with each other to navigate intersections with fewest delays and avoiding full stops.
AUTO DRIVERS	Traffic signals can introduce longer delays for through movements. Even minimum pedestrian crossing times for side-streets can take away green time from mainline through phases.	Provides clearest direction for interactions between different road users. Multiple phases may increase lost time at intersections, but provide safety benefits.	With low oncoming traffic, left turns from major road experience minimal delays. Driver on minor road approaches must find a gap in oncoming traffic, which may be difficult if major road has high traffic or if sight distance is poor.	Facilitated by professional drivers communicating with one another, and may be difficult for inexperienced drivers. With proper operation, yield movements minimize overall delays.
BUS TRANSIT DRIVERS	Traffic signals introduce delays and may decrease running time reliability. Traffic signals meter upstream traffic and create gaps for buses merging back into traffic after pulling off at bus stops.	Traffic signals introduce delays and may decrease running time reliability. Traffic signals meter upstream traffic and create gaps for buses merging back into traffic after pulling off at bus stops.	Traffic on major street continues without slowing or stopping. Turns from minor road approaches may be difficult especially if vehicular speeds are high on major road.	Facilitated by professional drivers communicating with one another, and may be difficult for inexperienced drivers. With proper operation, yield movements minimize overall delays.
PEDESTRIANS	Pedestrian priority in traffic control reduces wait times for pedestrians and increases comfort and convenience.	Dedicated lanes require more pavement and a larger intersection area, creating a more auto-oriented environment and decreasing pedestrian comfort. Pedestrian phase provides dedicated time for pedestrian crossing.	Looser control requires more communication between vehicles and pedestrians. Vehicles may be less likely to yield to pedestrians without stop or signal control.	Facilitated by pedestrians, drivers, and bicyclists to actively communicate with each other, which can be confusing for inexperienced users.
BICYCLISTS	Cyclists have a variety of preferences at signalized intersections. Some cyclists may choose to dismount and cross as pedestrians, but many cyclists prefer to stay in a vehicle/bike lane and move with traffic.	Cyclists have a variety of preferences at signalized intersections. Some cyclists may choose to dismount and cross as pedestrians, but many cyclists prefer to stay in a vehicle/bike lane and move with traffic.	Cyclists who prefer to travel as on-road vehicles may find it easier to navigate stop-controlled intersections. Cyclists who prefer cross roads as pedestrians at intersections will typically not have a marked pedestrian crossing to follow.	Bicyclists prefer to keep momentum and avoid full stops. Communication with motorized vehicles and pedestrians may be difficult. Communication between bicyclists and trucks can be especially challenging for both parties due to maneuverability and sight lines.
ADJACENT PROPERTY OWNERS	No notable adverse or positive effects.	No notable adverse or positive effects.	No notable adverse or positive effects.	No notable adverse or positive effects.

KEY: Effect On User Group

positive · mixed · negative · neither positive or negative

In freight activity areas, freight operators tend to value yield maneuvers to maintain momentum.

The slower acceleration rates for trucks are particularly important considerations at unsignalized intersections with significant cross-street goods movement activity.



Roundabout design should consider the experience of both the truck driver and the trailer. Tipping is a risk when the trailer G-force exceeds the force the driver feels in the cab, such as when a truck apron is combined with an adverse crossfall. The slower acceleration rates for trucks are particularly important considerations at unsignalized intersections with significant cross-street goods movement activity.

Source: Ourston Roundabout Engineering, Inc.

NUANCES FOR TRAFFIC CONTROL DEVICES

Avoiding full stops for truck drivers, especially in freight oriented areas, reduces pavement maintenance cost, overall fuel consumption, and time delays.

> Heavy loads require time and energy to change speed or direction.

> Heavy trucks are exponentially more damaging to pavement than passenger vehicles because their equivalent single axle loads (ESALs) are much higher. The more trucks need to stop and start travel, the more pavement damage they cause.

> Especially in freight oriented areas, commercially licensed drivers can maneuver through intersections using professional courtesy beyond just following the directions of traffic control devices to minimize unnecessary stops.

> Circulation and access management is important for improving maneuverability at slow speeds. See also Design Strategy 6: Access Management and Truck Parking.

It is generally better to provide only the **minimal amount of control** necessary.

> When road users can effectively communicate with each other, they generally work out effective maneuvers. However, many situations are too complex for road users to effectively communicate.

> Community oriented areas typically require less control than diverse activity areas because there are generally slower speeds that facilitate communication and a less diverse mix of road users, particularly larger trucks. Protected left turn phases may not be necessary in community oriented areas (see also Design Strategy 8: Signal Phasing).

Safety for all modes is always a high priority; the efficient movement of goods and people is secondary to ensuring their safety.

> Pedestrians and bicyclists are the most vulnerable road users. Ensuring their safety should always be paramount.

> In community oriented and diverse activity areas, traffic control devices will likely limit vehicle throughput and travel speeds to provide safe pedestrian mobility.

> In low activity areas, minor road approach turning volumes and pedestrian volumes are both low because these areas lack destinations. The function of roads in low activity areas is primarily for longer distance trips traveling through the area. Maintaining high travel speeds is more important in low activity areas than in other areas, but safety is still paramount. Traffic control devices on the major road should focus more on warning signs than on regulatory signs.

> In low activity areas, entering and crossing traffic volumes are often too low to warrant signals to interrupt mainline. Stop control (as opposed to yield control) is important to ensure drivers correctly assess gap size. This is particularly important for larger, slower vehicles entering or crossing the major road.

> Sight distance of minor road approach in two-way stop controlled intersection is important, especially where major road speeds are high.

> The location of traffic control devices needs to consider the sight lines for truck drivers as well as the effect of trucks on traffic control devices for other roadway users. In areas of high truck volumes, consideration should be given to the use of secondary or supplemental signs and signals.

Roundabouts are efficient designs for four-way yield control at low volume intersections and in community oriented or diverse activity areas with low volumes and moderate to high functional classification.

> Mountable center islands can allow large trucks to maneuver around the roundabout, however trucks with fragile cargo may prefer to avoid mountable curbs.

> Trucks carrying liquid cargo may be sensitive to superelevation on roundabouts.

> Larger roundabouts may be more appropriate for diverse activity areas. The center island provides opportunities for designing public space. Larger roundabout diameters accommodate turning radii of large trucks with less encroachment onto center island.

Yield control intersections without roundabouts may be appropriate on Freight Activity Center Streets where a large majority of traffic is trucks. Streets that are internal to freight activity centers may need little to no traffic control where all traffic is freight related, operating speeds are low, and drivers understand etiquette of professional courtesy.

NUANCES FOR TRAFFIC CONTROL DEVICES

Wayfinding signage should fit within the appropriate context. Pedestrian oriented wayfinding signs are more prevalent in community oriented areas. Larger overhead signs will be more appropriate in freight oriented areas.

Unsignalized intersections in community oriented areas should clarify pedestrian priority. Marked crosswalks may suffice for intersections where pedestrian activity is frequent and drivers anticipate the need to yield to pedestrians. Unsignalized intersections where speeds are higher and pedestrian activity is not as frequent may benefit from additional signing and marking to communicate to drivers that pedestrian movement is priority.

Traffic control devices include signing and marking for regulatory, warning, and guidance purposes well beyond those associated with intersection right-of-way. The concerns regarding traffic control devices associated with integrating goods movement with livability are most pronounced at intersections. Other notable considerations associated with goods movement include the following types of traffic control described below.

Load limits and clearances are important elements to both minimize truck incidents and reduce routine maintenance costs. The need to post weight limit signs depends both on the constraints of the roadway structure warranting the limits and the expected role of the roadway in goods delivery. Over-height detectors may be considered for cases where repeated over height incidents have occurred or may be expected due to changes in containerized operations.

Warning signs particular to freight operations (with FHWA MUTCD designations) include truck crossing signs (W11-10), truck rollover signing (W1-13), and warnings regarding adverse weather or roadway conditions, particularly low ground clearance (W5-10) and high/gusty wind areas (W8-21). These signs, which are of benefit to all roadway users by alerting them to the potential for otherwise unanticipated truck maneuvers, tend to be most effective in low activity areas where truck activity is unexpected.

Wayfinding systems will vary by context area depending on the primary audience. In community-oriented areas, wayfinding may be most effective in describing local destinations and presented at a pedestrian scale. In diverse areas, goods movement may be facilitated by guide signing identifying the most direct path to the Interstate highway system or other Strategic Intermodal System (SIS) facilities.

DIVERSE AREA CONSIDERATIONS

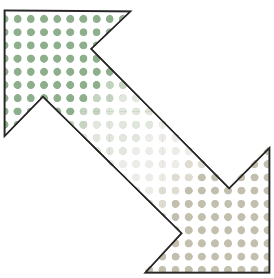
In diverse activity areas, pedestrian priority may increase vehicular delays and queue lengths, which may decrease driver patience and could potentially create unsafe situations if drivers attempt to stretch the signal phase (i.e. running yellow or red lights at high speeds to “make it” before the phase changes). Additional traffic control devices may be necessary to discourage aggressive driver behavior, such as “don’t block the box” pavement markings or “turning vehicles must yield to pedestrians in crosswalk” signs.

Interactions between pedestrians, bicyclists, autos, buses, and trucks are often most unpredictable in diverse activity areas. High levels of traffic control (i.e. traffic signals with protected phases for pedestrians and vehicular turning movements) are most appropriate in diverse activity areas.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR TRAFFIC CONTROL DEVICES?

C — COMMUNITY ORIENTED

- Smaller pedestrian scale way-finding signs
- Signalized intersections with pedestrian countdown signals
- More traffic control devices to clarify right-of-way for a wide diversity of road users



F — FREIGHT ORIENTED

- Larger overhead guide signs
- Yield or stop controlled unsignalized intersections with fewer pedestrian amenities
- Fewer traffic control devices overall to encourage communication between truck drivers

How Do I Know
WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards **COMMUNITY** *if:*

- Area attracts significant amount of tourists
- Community has adopted a vision, strategic plan, or other policies to encourage redevelopment
- Existing or future land uses do not include heavy industry
- Truck traffic occurs mainly during off peak hours
- Area is located within walking distance of an existing or future premium transit stop
- Design/target speeds are 35 mph or lower

Lean Towards **FREIGHT** *if:*

- Road is within a freight activity center
- Trucks and industrial-related vehicles compose a large majority of traffic volumes
- Truck traffic occurs mainly during peak weekday work hours

DESIGN STRATEGY 8

SIGNAL PHASING

Larger vehicles, particularly tractor trailers, have different operating characteristics than passenger cars. Notably, tractor trailers have larger turning templates and slower acceleration and deceleration rates than passenger vehicles. Where traffic signals are warranted, signal phasing assigns intersection right-of-way to different directions of travel, each with varying levels of motor vehicle and pedestrians demand. Signal phasing serves to balance both intersection safety and capacity for all users. Signal phasing and timing are determined by an assessment of operational and safety related needs as described in the Florida Intersection Design Guide. The accommodation of these needs often results in context-sensitive solutions that are summarized by the prototypical types of signal phasing described within this design strategy.

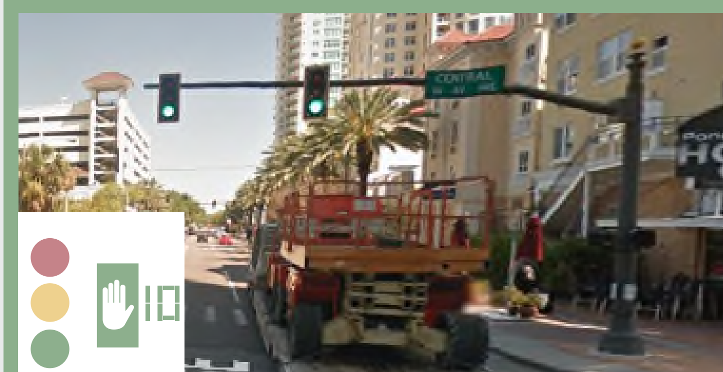
The following prototypes describe generalized signal phasing designs that are likely to be found appropriate for each context area. See also Design Strategy 2: Intersection Approach Configurations and Design Strategy 7: Traffic Control for more information on complementary intersection elements for the four context area prototypes.

PROTOTYPES

COMMUNITY ORIENTED

***WHAT:* Two-phase signals with short cycle lengths to minimize pedestrian wait times.**

WHY: *Pedestrian mobility and access is highest priority. Minimizing pedestrian wait times between signal phases enhances the overall walking environment and makes it easier to access destinations. Maximizing the walk phase for pedestrians is more important than minimizing vehicular delay.*



DIVERSE ACTIVITY

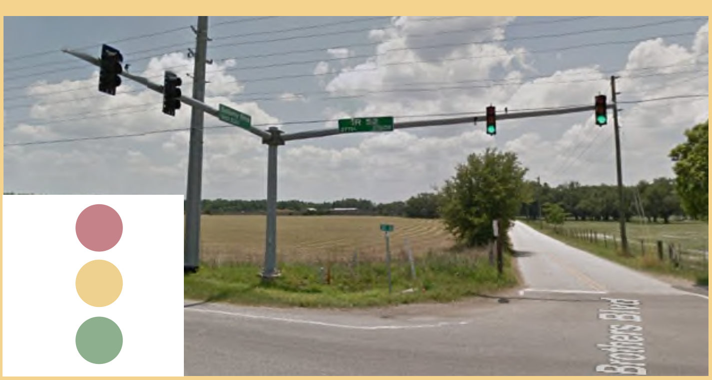
***WHAT:* Exclusive left turn signal phases for protected left turns**

WHY: *An exclusive phase for left turns accommodates frequent truck turns without yielding to heavy oncoming traffic. .*

LOW ACTIVITY

***WHAT:* Simple two-phase signal with actuated minor road approach**

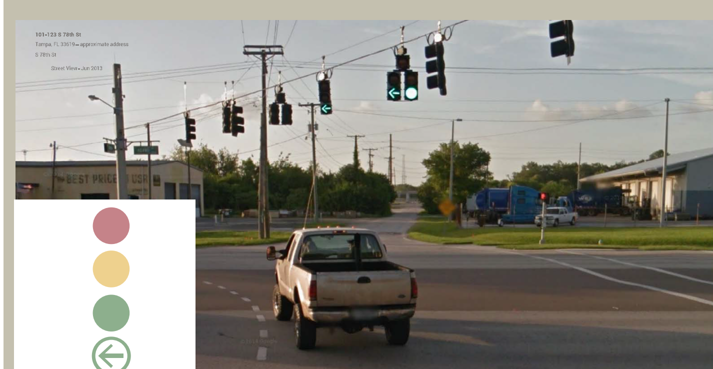
WHY: *Fewer signal phases altogether reduces delays and minimizes infrastructure costs.*



FREIGHT ORIENTED

***WHAT:* Split phasing on side street approaches serving significant truck traffic generators**

WHY: *Allowing all turns from one approach to go simultaneously can improve left turn lane utilization and decrease potential conflicts with opposing vehicles.*



USER PERSPECTIVES

	C COMMUNITY ORIENTED	D DIVERSE ACTIVITY	L LOW ACTIVITY	F FREIGHT ORIENTED
	Two-phase signals with short cycle lengths to minimize pedestrian wait times.	Exclusive left turn signal phases for protected left turns	Simple two-phase signal with actuated minor road approach	Split phasing on side street approaches serving significant truck traffic generators
TRUCK DRIVERS	Short cycle lengths increase the number of stops, particularly inefficient for trucks because of slower acceleration rates. Lack of protected turning phase makes turns on high volume streets difficult.	Protected left turn phase makes turns easier for trucks. Longer cycle lengths are better for accommodating slower acceleration rates.	Actuated minor road approach keeps traffic on major road moving. Permissive left turns onto minor road often do not require full stop because of low volume of oncoming traffic.	Allows more time for truck turns from minor road approach. Potential for shared left-through lane operations reduces need for long left turn lanes. Avoids opposing truck left turns.
AUTO DRIVERS	Short cycle lengths decrease overall vehicular wait times per cycle, but also decrease capacity of vehicular throughput per cycle and may produce queues that cannot clear in one cycle. Drivers may be able to find gaps more quickly in permitted turn phases than in phasing designs with protected only turn phases.	Protected left turn phase allows vehicles to turn left without yielding to oncoming vehicles or crossing pedestrians. Protected phase takes green time away from mainline through movement. Usually requires longer cycle lengths, which can increase wait times for other phases.	Actuated minor road approach keeps traffic on major road moving while creating timely opportunities for access from minor road.	Reduces vehicular capacity of intersection and introduces more delays.
BUS TRANSIT DRIVERS	Short cycle lengths increase the number of stops, particularly inefficient for buses because of slower acceleration rates.	Protected left turn phase allows vehicles to turn left without yielding to oncoming vehicles or crossing pedestrians. Protected phase takes green time away from mainline through movement.	Actuated minor road approach keeps traffic on major road moving. Bus drivers may have difficulty finding a gap in oncoming traffic to make left turns at high volume intersections. Bus transit is unlikely provided in low activity areas.	Reduces vehicular throughput capacity of intersection and introduces more delays.
PEDESTRIANS	Shorter cycle lengths minimize pedestrian wait times, increasing pedestrian comfort and convenience.	Pedestrians cannot cross intersection during protected turn phase, which increases wait times. Pedestrians still have time to cross during the through phase.	Usually pedestrian signals are not included in low activity areas to minimize installation and maintenance costs, which may make it challenging for pedestrians to cross safely.	Pedestrian signals may not be warranted. The pedestrian phases for parallel crossings occur at different times, which may be confusing, particularly if pedestrian signals are not installed.
BICYCLISTS	Bicyclists may encounter long queues. Navigating a left turn may be difficult for those who want to stay in the travel lane and avoid dismounting and crossing with pedestrians.	Bicyclists have slightly slower acceleration rates than motorized vehicles, and may find it difficult to accelerate fast enough in the left turn lane to proceed through the intersection within the protected left turn phase.	Bicyclists may not be able to initiate the actuated minor street approach.	No notable adverse or positive effects.
ADJACENT PROPERTY OWNERS	No notable adverse or positive effects.	No notable adverse or positive effects.	No notable adverse or positive effects.	No notable adverse or positive effects.

KEY: Effect On User Group

positive — mixed — negative — neither positive or negative

NUANCES FOR SIGNAL PHASING

Frequent stops and starts are difficult for truck drivers because of the truck's slow acceleration and deceleration rates. Trucks will use more fuel accelerating from a standstill at a traffic light than other vehicles. Trucks cannot accelerate quickly, and vehicles behind trucks will experience delays too. Trucks also cause more pavement damage when they are accelerating or decelerating than when they are moving at a constant speed.

Longer cycle phases are better for trucks because they allow the vehicle queue to clear completely and avoid trucks having to stop multiple times at the same intersection. This is particularly relevant at high volume intersections. However, long cycle phases are not optimal for pedestrians because they introduce long wait times for pedestrians to cross the road. Long cycle phases also create longer queue lengths, which require longer and possibly more turn lanes to clear queues, which also increases the pedestrian crossing distance.

Signal progression is important, as it can minimize the number of times trucks must stop on an arterial with a sequence of traffic lights. The signal progression can be designed with the slower acceleration and deceleration rates of trucks to ensure that trucks can progress through the traffic signals with the 'green wave.'

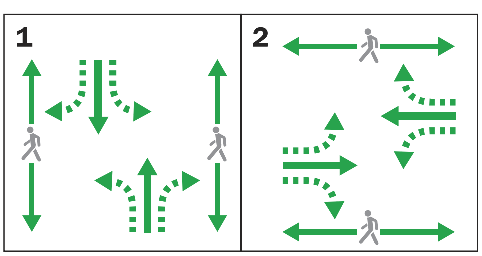
Protected turning phases have mixed effects for trucks. Turning phases take away green time from through movements. However, they are advantageous for turning trucks, who may have a harder time finding a gap in oncoming traffic than passenger vehicles because of their slower acceleration rates. Minimizing protected turning phases at consecutive intersections along an arterial can improve signal progression.

A **TWO-PHASE SIGNAL** is generally appropriate for community oriented and low activity areas. Two-phase signals require turning vehicles to yield to oncoming traffic and crossing pedestrians. In community oriented areas, the pedestrian phases should be called without pedestrian actuation. Actuated pedestrian phases are an option in low activity areas, and will minimize vehicular delays by allowing lower side street green phase durations for cycles without pedestrian actuation. The two-phase signal is generally best for pedestrians, as it minimizes overall wait times. It is also appropriate in low activity areas with minor road actuation to keep green times on the major road as long as possible.

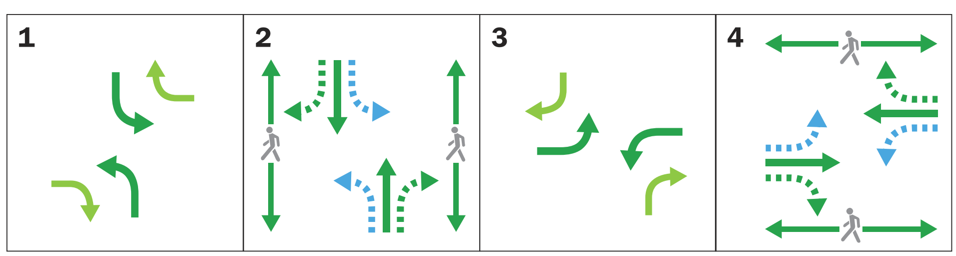
In diverse activity areas, **PROTECTED LEFT TURNING PHASES** are identified as a prototype because turning trucks may not be able to find a large enough gap in oncoming traffic and protected turning phases minimize conflicts between turning vehicles and pedestrians. Concurrent right turns from the cross street approach can be included in the protected turning phase if the intersection geometric configuration includes exclusive right turn lanes for that movement. Exclusive right turn lanes increase the crossing distance for pedestrians.

KEY

- Protected Vehicular Movements
- Yielding Vehicular Movements
- Optional Yielding Vehicular Left Turn Movements
- Optional Protected Vehicular Right Turn Movements in Areas with Exclusive Right Turn Lanes
- Protected Pedestrian Movements



Two-Phase Signal



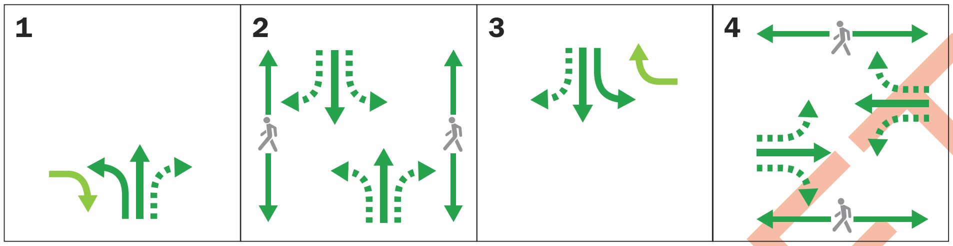
Protected Left Turning Phases

NUANCES FOR SIGNAL PHASING

LAGGING LEFT TURNS are an alternate option for diverse activity areas, and may be better suited in areas with pedestrian emphasis. If left turns are permitted during the general through phase, turning vehicles may wait beyond the stop bar, and may try to find a gap at the end of the phase, which may increase conflicts between turning vehicles and pedestrians. Lagging left turns may diffuse some of the conflict because it provides a time after the through phase for left turns to proceed.

LEAD/LAG PROTECTED LEFT TURNING PHASES may be an appropriate variation for freight oriented and diverse activity areas with high volumes of through traffic on the major road (shown as the north-south road in the signal phasing diagram to the right). The lead/lag configuration is often better for overall signal progression in a network, but can be confusing for both motorists and pedestrians.

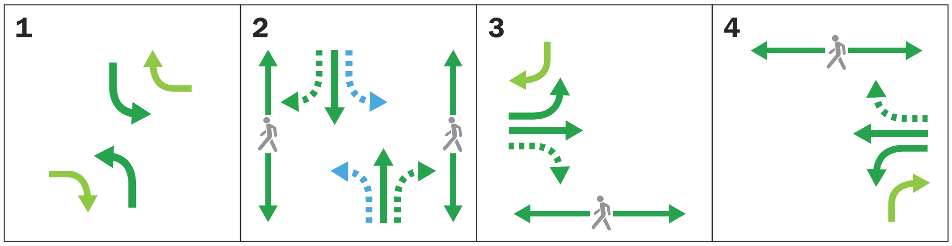
In general, **ACTUATED PHASES** may not detect smaller vehicles including bicycles and small passenger cars. The type of detection technology should be considered to detect these types of vehicles.



Lead/Lag Protected Left Turning Phases on North-South Street

SPLIT PHASING, where the two approaches of the minor road have their own signal phase, is identified as the prototype for freight oriented areas because it provides each minor street approach with unopposed green time, reducing conflict points and facilitating effective lane utilization, particularly for side streets where truck traffic gains access to the arterial street network. It can best accommodate large vehicles making left turns from the minor road approaches. This prototype is particularly relevant where truck turning templates preclude concurrent left turn operations from opposing approaches. This phasing scheme takes away more green time from the major road, which in freight oriented areas may not be as heavy with passenger vehicle traffic as other context areas.

The signal phasing diagram below shows protected left turns for the major (north-south) road in addition to split phasing on the minor (east-west) road. The protected left turn phase allows provides a dedicated phase for trucks on the major road to turn into the minor road – an important phase for heavy truck volumes. The dashed blue lines indicate that allowing left turns during the through phase is an option, depending on the individual characteristics of the intersection (sight distance, speed limit, and volume of oncoming traffic). The dashed green lines represent an option to actuate the pedestrian movements if pedestrian signals are installed.



Split Phasing on East-West Street

DIVERSE AREA CONSIDERATIONS

Diverse activity areas often have high volumes of traffic, including high truck volumes, and significant volumes of pedestrians. It is important to find a balance in the signal phasing schemes for pedestrian safety and vehicular mobility. If the signal phasing does not allow queues to clear, motorists can become impatient and may choose to turn during inadequate gaps or run red or yellow lights, which can decrease safety for pedestrians. Finding the optimal balance for each unique situation will require careful consideration of modal emphasis and intersection characteristics.

WHAT ARE THE FEATURES ACROSS THE DESIGN SPECTRUM FOR SIGNAL PHASING?

C COMMUNITY ORIENTED

- Shorter overall cycle lengths
- Fewer protected turning phases
- Pedestrian phases not actuated
- Simple phasing schemes

F FREIGHT ORIENTED

- Longer overall cycle lengths
- More protected turning phases
- Actuated pedestrian phases
- More complex phasing schemes

SIGNAL TIMING CONSIDERATIONS

When establishing signal timing parameters for side street approaches with a high proportion of truck traffic, consider the establishment of longer green extension times that reflect the slower acceleration rates of larger trucks and minimize “gap out” occurrences.

Right-turn green arrow overlap phases should not be used if the overlapping left turn has a high proportion of U-turning trucks.

How Do I Know
WHICH END OF THE SPECTRUM TO LEAN TOWARDS?

Lean Towards
COMMUNITY *if:*

- Existing or future land uses will generate significant amounts of pedestrian activity
- Community has adopted a vision or other planning document that articulates pedestrian emphasis and pedestrian oriented design
- Truck activity is limited to through movements on the major road and off-peak deliveries

Lean Towards
FREIGHT *if:*

- Adjacent land uses are industrial
- Truck and passenger vehicle volumes are consistently high throughout the weekday and weekends
- Pedestrian oriented uses are not a part of the future vision
- Turning volumes are high

CHAPTER 4: DESIGN ELEMENTS

This chapter summarizes observations about common design elements as they appear in multiple contexts as part of the Design Strategies presented in Chapter 3. This chapter serves two basic purposes:

First, to provide a summary of goods-movement related considerations for some of the more common design elements that serve multiple Design Strategies and can be differentiators across the four different context areas:

> Motorized vehicle travel lane widths
> On-road bicycle treatments
> Landscape/sign-panel buffer widths
> Stormwater management and utilities
> Horizontal and vertical clearances
> Roundabouts
> Mountable curbs

Second, to address considerations for other design elements not necessarily featured as differentiators in multiple Design Strategies but for which the literature review in Appendix C identified knowledge gaps.

> Climbing lanes
> Noise and vibration
> Landscaping and public art

MOTORIZED VEHICLE TRAVEL LANE WIDTHS

In general, all motorized vehicle operators, auto drivers, truck drivers, and bus drivers, tend to prefer wider lane widths for their own perceived safety and comfort. Wider travel lanes are generally not helpful for pedestrians or adjacent property owners because, all else being equal, the more right-of-way assigned to vehicular travel, the less remains available for signage, utilities, and front door operations for adjacent property owners (whether oriented toward pedestrian or vehicular access). Wider travel lanes also increase pedestrian crossing lengths at intersections. In general, the Design Strategies recommend selecting lane widths toward the narrower end of the allowable range in Community-Oriented Areas and toward the wider end of the allowable range in FDOT design manuals and guides. Nuances relate to the total number of through and turning travel lanes, the presence or absence of a bicycle lane or on-street parking, the level of transit activity, and the type of roadside drainage. Specific considerations regarding lane widths are discussed in the following Design Strategies:

> Design Strategy 1: Typical Section Configurations
> Design Strategy 2: Intersection Approach Configurations
> Design Strategy 4: Median Nose Treatments

ON-ROAD BICYCLE TREATMENTS

Both motorists and on-road bicyclists tend to prefer treatments that increase the separation between motor vehicles and bicyclists, particularly for multi-lane streets and highways. A 2013 University of California at Berkeley study found this applied to both stated and revealed preferences for a wide range of bicyclist experience as well as for motor vehicle drivers who were not bicyclists. However, some experienced on-road cyclists note disadvantages to fully separated bicycle paths, whether barrier-separated cycle tracks or painted lanes, primarily associated with motorist expectations for lane changing maneuvers, which are more readily accomplished in a shared environment, particularly on two-lane streets with lower traffic volumes, fewer heavy vehicles, and lower speeds. Emerging bicyclist infrastructure such as bicycle boxes at intersections can help address some of these concerns. As with motor vehicle travel lanes, space dedicated solely to on-road bicyclists may mean longer crosswalks for pedestrians and less space for other roadway or roadside elements that affect pedestrians and property owners. The accommodation of on-road cyclists with a bicycle lane is required for most

In some community-oriented and diverse activity areas, constrained rights-of-way can prompt careful consideration of motor vehicle, bicycle, and pedestrian needs in addition to design elements such as utilities and drainage. In other areas, sufficient right-of-way exists to provide generous widths for all users.

designated freight routes in Florida's urban areas. Specific considerations regarding on-road bicycle treatments are discussed in the following Design Strategies:

> Design Strategy 1: Typical Section Configurations

> Design Strategy 2: Intersection Approach Configurations

> Design Strategy 3: Right Turn Treatments

> Design Strategy 4: Median Nose Treatments

> Design Strategy 6: Access Management and Truck Parking

LANDSCAPE/SIGN PANEL BUFFER WIDTHS

Separation of roadside elements from the traveled way is generally desirable for a variety of safety purposes. Horizontal clearance requirements to elements such as signs, utilities, and other fixed objects generally establishes buffer widths in low-activity and freight-oriented areas. In community-oriented and diverse activity areas, higher right-of-way costs lead to more constrained designs with greater use of curb-and-gutter drainage and increased value of a landscape buffer for pedestrian safety and comfort. Specific considerations regarding buffer widths are discussed in the following Design Strategies:

> Design Strategy 1: Typical Section Configurations

STORMWATER MANAGEMENT AND UTILITIES

The treatment of stormwater management is often achieved through open-section swales and ponds in low activity areas and through closed-section curb and gutter treatments based largely on the trade off between adjacent levels of development. Similarly, dry utilities (both serving the transportation infrastructure and adjacent properties) are typically above ground except in the most urban settings. These design elements are vitally important to project design and cost-effectiveness. In general, there are not particular drainage or utility strategies that materially affect goods movement. Specific assumptions regarding stormwater management and utilities are included in the following Design Strategies:

> Design Strategy 1: Typical Section Configurations

> Design Strategy 5: Pavement Bulb-Outs and U-Turns

HORIZONTAL AND VERTICAL CLEARANCES

The experience of both goods movement operators and FDOT District 7 staff indicates that warning systems for overheight or overwidth trucks is an area of increasing concern. This type of concern should be incorporated into the project development and design process, but is also pertinent to routine operations and maintenance due in part to the continuing evolution of the freight industry to explore new vehicle and container types. As shippers change their fleets, conditions may change so that a particular overpass that did not initially warrant passive or active detection may later benefit from a warning system.

Similarly, operations and maintenance to trim foliage is of benefit to goods movement operators. The passage of large vehicles can and does act as a natural trimming device for smaller twigs. When larger branches shift (such as may occur after a storm) into the path of a tractor trailer, the resulting incident can be as severe to property damage and traffic delays as a collision with any ground-based fixed object. Specific considerations regarding horizontal and vertical clearances are discussed in the following Design Strategy:

> Design Strategy 7: Traffic Control Devices

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 on low-speed, low-volume roadways. Many motorists benefit from roundabouts in moderate-volume situations where delays are substantially reduced and safety improved compared to stop-control or signal-control. 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 must be taken to ensure the roundabout design accommodates large vehicles. Bus drivers can also benefit from reduced delays, although the sway caused by roundabout traversal typically has a more adverse effect on passenger comfort than does a stopping and starting maneuver. The perception of adjacent property owners is location and use-specific: roundabouts typically require more right-of-way than standard intersections at the immediate junction, but less right-of-way upstream due to the ability to reduce turn lane lengths. Specific considerations regarding roundabouts are discussed in the following Design Strategies:

> Design Strategy 1: Typical Section Configurations

> Design Strategy 5: Pavement Bulb-Outs and U-Turns

> Design Strategy 7: Traffic Control Devices

MOUNTABLE CURBS

Mountable curbs facilitate accommodation of large vehicle turns in situations where the demand for those turns is infrequent and there is value in a tighter channelizing of turns for smaller vehicles for traffic control, context-sensitivity, economic, or environmental reasons. Truck drivers benefit from mountable curbs to facilitate turning movements when the mountable curb presence is evident. Pedestrians benefit from the fact that mountable curbs generally reduce crosswalk distances, although a risk of mountable curbs is that the allocation of shared space (for pedestrians at most times and trucks occasionally) may not be evident to both user groups. Specific considerations regarding mountable curbs are discussed in the following Design Strategies:

> Design Strategy 3: Right Turn Treatments

> Design Strategy 4: Median Nose Treatments

> Design Strategy 5: Pavement Bulb-Outs and U-Turns

> Design Strategy 7: Traffic Control Devices

The following paragraphs summarize goods-movement related design elements which are not prominently featured in the Chapter 3 Design Strategies, but for which the literature review in Appendix C identified knowledge gaps.

CLIMBING LANES

Chapter 12 of the 2014 PPM includes climbing lanes as one of the types of auxiliary lanes that may be warranted on either freeway or arterial roadways. No guidance is provided on where climbing lanes would be appropriate. For District 7, climbing lanes on arterial roadways are expected to rarely be warranted, and AASHTO Green Book guidance is appropriate for defining climbing lane need, length, and taper. Generally, however, climbing lanes are not compatible with community-oriented, diverse-activity, or freight-oriented areas where truck turning volumes are likely to be frequent. Climbing lanes likely would only be expected in low-activity areas where trucks and other traffic have different speeds and encounter little or no right turning volumes.

NOISE AND VIBRATION

Addressing traffic noise is a key element of roadway design that is heavily influenced by goods movement activities. The assessment and mitigation of roadway noise impacts involves both analysis of a variety of causative transportation and land use factors and extensive stakeholder engagement. For these reasons, noise and vibration considerations are not explicitly addressed in Chapters 2 or 3 of this document. In general, however, the incorporation of any active noise abatement techniques are generally incorporated into the typical section elements described in Design Strategy 1, whether through geometric refinements, traffic management, increased buffer zones, noise insulation, or implementation of a noise barrier.

In general, the adjacent property owner is the user group whose perspective is most critical in determining an appropriate noise abatement technique, and that perspective varies largely based on the degree to which the property owner desires a high level of access to the adjacent street. Commercial properties generally favor abatement techniques that do not require a noise barrier, whereas larger residential communities without frequent direct access to the adjacent roadway through driveways or collector streets are often more likely to favor a noise barrier. Generally, noise attenuation considerations with or without a noise barrier, will generally occur in diverse activity areas where the combination of land use activity, freight activity, and levels of access management are all relatively high.

LANDSCAPING / PUBLIC ART

Chapter 9 of the 2014 PPM identifies the process for which landscaping and public art should be considered in the roadway design process. In general, the value of landscaping and public art in helping provide place identification and improving property values is greatest in community-oriented areas and diverse activity areas. As noted in the Chapter 2 Design Approach on target speeds, landscaping and art are particularly useful for gateway treatments that help communicate a lower appropriate travel speed for all motor vehicles entering a more densely developed community.

Effective landscaping can reinforce the roadway context in all types of context areas.

CHAPTER 5: SPECIAL CASES

This chapter provides guidance on considerations that apply in special cases such as the following:

- Project context, including campus settings and Transportation Design for Livable Communities (TDLC) projects.
- Unusual design considerations such as one-way streets and railroad at-grade crossings.
- Potential procedural concerns, including consideration of design variances and consideration of maintenance of traffic.

PROJECT CONTEXT

Two types of special project contexts warrant additional description; those serving any kind of campus development and those designated as TDLC projects under Chapter 21 of the Plans Preparation Manual.

CAMPUS SETTINGS

In most cases, roadway design projects have a variety of land uses on either side whose land use context directly influences their need for access and mobility. Campus settings, on the other hand, often create special transportation system demands that are not evident by the person-trip generators immediately adjacent to, or even visible from, the state highway serving the campus.

Colleges, universities, military installations, and medical centers represent a specialized form of activity center typified by a defined campus settings. They are located in downtowns and suburban activity centers alike, as well as on separate campuses in cities, suburbs, and rural locations. The high degree of variability makes each academic and medical institution an individual case for planning.

The specific characteristics of an institution, its policies, and the surrounding environment provide a basis for planning. Surveys of current characteristics are usually necessary before transportation planning can be initiated for existing institutions. For new medical and academic campuses, characteristics may be inferred from comparable projects and adjusted to reflect anticipated policies and conditions for the new campus.

A pedestrian bridge connects the University of South Florida on both sides of East Fowler Avenue but its value is neither evidenced nor driven by the immediately adjacent campus development.

Specific characteristics of campus settings that influence goods movement and livability include:

- A somewhat homogenous daytime population whose commitment to the on-campus facilities and services is more predictable than for more heterogeneous assemblies of employees and customers, and whose travel behavior is susceptible to proactive Travel Demand Management techniques that are more likely to be influenced, and perhaps even controlled, by campus management, particularly regarding employee commute options and parking management.
- A propensity for special events, whether planned, such as collegiate football games, or reactive, such as for managing changes to protocols such as homeland security requirements; typically associated with military posts but applicable on all types of campuses.
- A high level of reliance on organized pedestrian and bicyclist connectivity, certainly for on-post travel and often for trips to and from the campus
- A fairly low degree of walking-supportive land uses; in contrast to the TDM approach emphasizing walkability, many campuses have fairly dense single-purpose nodes surrounded by open spaces (often used for stormwater management, parking, or landscaping); the word campus derives from Latin for "a field" and this characteristic is often the initial image evoked by use of the word.
- A focus on boundary issues, ranging from the level of safety, security, and branding required or desired (gateways, if not actual gates) and the degree to which uses on campus relate to the uses in the adjacent community (the classic "town and gown" relationship)
- A centralized organizational approach to physical space and operational management, typically including a detailed master plan that includes specific goods movement and multimodal considerations, providing leverage for sound planning and operating principles.

Coordination with campus management on Travel Demand Management measures is important to maximize design efficiency. Regardless of the type of campus environment, the ability to influence both recurring and special event traffic to best utilize roadway, transit, and sidewalk/path infrastructure is a desire shared equally by campus owners/operators and transport agencies.

TRANSPORTATION DESIGN FOR LIVABLE COMMUNITIES PROJECTS

Chapter 21 of the Plans Preparation Manual covers the development of Transportation Design for Livable Communities (TDLC). The TDLC approach in Chapter 21 facilitates the consideration of design concepts in projects serving communities where livability needs are sufficient to promote some alternative design criteria, notably regarding design speeds and land widths, that would otherwise require waivers. This Freight Roadway Design Considerations document is intended to be applicable for all projects, including those designated as TDLC projects or for which TDLC elements are proposed or adopted. The guidance in Chapter 3 describing how adjectives like "wider" or "narrower" and "higher" or "lower" apply to all FDOT regulations also apply to those projects with TDLC elements. The TDLC process described in Chapter 21 of the Plans Preparation Manual would almost certainly be applicable only to projects in a community oriented area.

DESIGN ELEMENTS

Several types of transportation design elements affect both the land use context and the transportation system context. The following paragraphs describe how arterial interchanges, one-way streets, at-grade railroad crossings, and drawbridges affect the consideration of goods movement and livability. For many cases, the presence of one or more of these design elements is a given that informs the project context. In certain cases, the designer may have the ability to change that environment (perhaps most particularly in the consideration of the application or removal of one-way streets).

ARTERIAL INTERCHANGES

This Design Considerations document is intended to apply to the arterial, or surface, street system where goods movement concerns need to be integrated with quality of life considerations for adjacent property owners, and does not cover limited access freeways or tollways. A separate context zone is often created, however, where limited access facilities intersect the arterial system, or where the arterial system itself includes a grade-separated interchange.

The adjacent context to a freeway interchange is often typified by land uses that gain value from ready access to the freeway, including auto-oriented or auto-serving retail uses such as malls and big box stores, and industrial uses where truck access to the freeway system is facilitated. Often the perceived access to the freeway (typified by advertising) is not as direct as the actual access due to access management constraints; the freeway interchange is, from a topological perspective, only a single point and due to access controls on the freeway, ramps, and adjacent surface streets a dendritic, or branching, series of frontage or backage roads may be needed to serve the land uses visible from the freeway.

The context of the adjacent cross street is influenced substantially by both the traffic control (merging maneuvers, signals, stop-control, and roundabouts) at the ramp terminal and at the adjacent surface street intersections. These areas may all be considered the functional area of the interchange, and their design influences the transition between the freeway and arterial environments. For example, the surface street environment needs to accommodate all modes of travel, including non-motorized modes likely prohibited by law from the freeway. Conversely, the surface street environment needs to provide sufficient capacity and mobility to avoid queues backing up onto the freeway.

Considerations for arterial interchange termini include the following:

> Defining an appropriate change in target speed from the limited access facility to the arterial facility.

> Determining what paths trucks are likely to make through the interchange, depending upon the location of nearby freight activity generators.

> Considering the effect of surface street operations on freeway operations

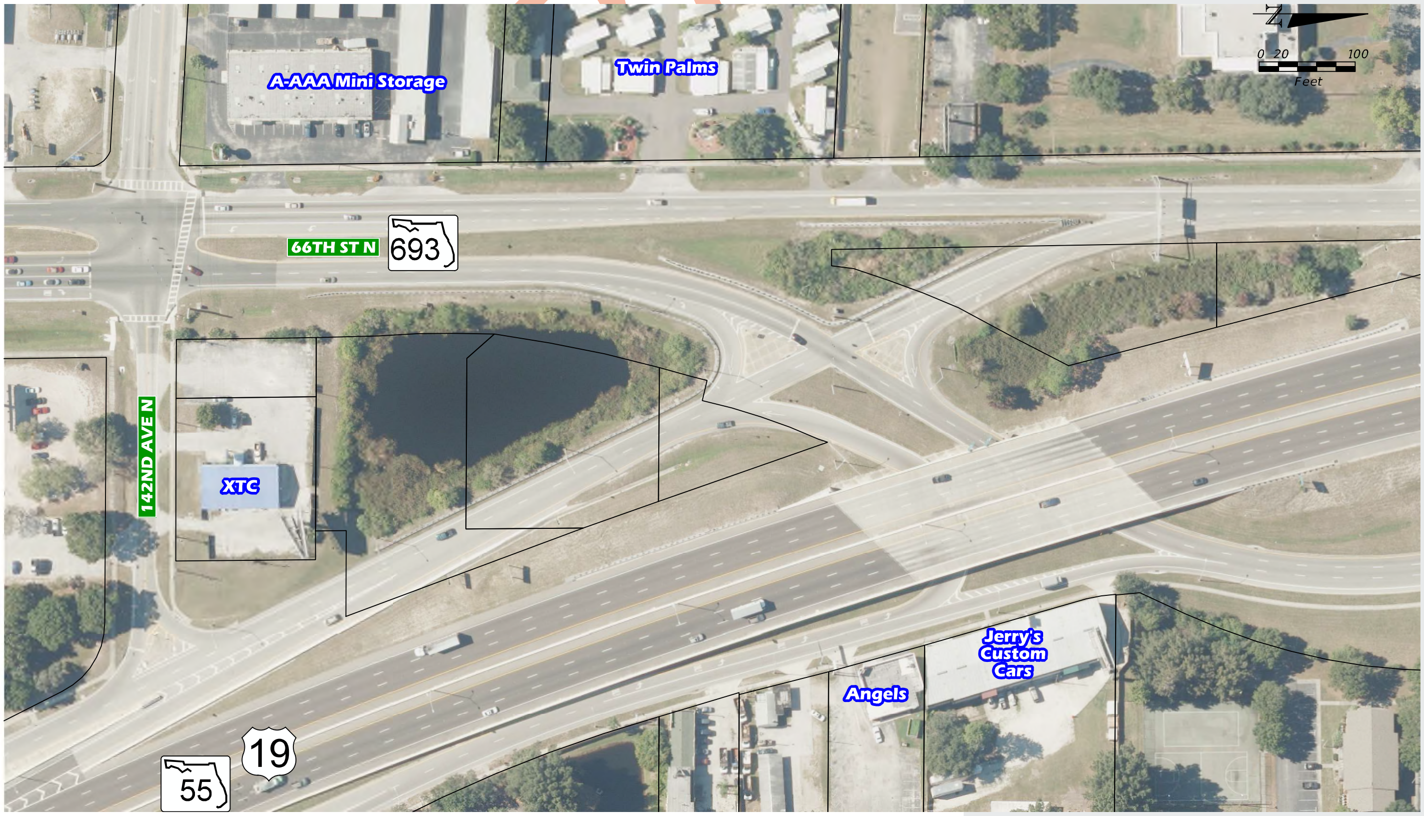
> Ensuring safe pedestrian and bicyclist movement through the interchange

For example, the junction of US 19/SR 55 and SR 693 (66th Street N) in Pinellas County reflects a diverse activity area with a wide variety of features that make the definition of context area challenging:

> US 19 (which runs from the southeast at lower left to the north at right) is a controlled access facility that is not intended to be covered by these Design Considerations, however it has a continuous pair of one-way arterial frontage roadways that are covered by these design considerations.

> SR 693 (which approaches US 19 from the south at left) is a four-lane divided arterial roadway

> 142nd Avenue (which runs east-west from top to bottom at left) is a two-lane to five-lane collector street.



Arterial interchange treatments often serve as a boundary between context areas

The land use context in the vicinity of the interchange is diverse, consisting primarily of residential and low-intensity commercial uses at the top portion of the graphic (west of SR 693) and retail/industrial uses at bottom left (in the vicinity of the US 19 frontage road intersections.

Direct access to and from the controlled access highway (US 19) is achieved by slip ramps from the frontage road to the freeway mainline (only one of those ramps, the on-ramp to southbound US 19 at lower left) is close enough to the SR 693 junction to be visible in the graphic. The design of this interchange places the frontage road in a relatively high speed environment. The northbound frontage road is fully yield controlled throughout the diagram, with the only slower movements being relatively infrequent turning movements to and from the businesses at the bottom of the graphic. In contrast, the southbound frontage road has a much greater need for attention to an appropriate transition. First, the slip ramp from southbound US 19 to SR 693 (not shown to the right of the graphic) introduces a weaving maneuver between ramp traffic destined for SR 693 and mainline frontage road traffic. Second, both branches at the frontage road/SR 693 diverge are followed relatively closely by signalized intersections. The oblique angle junction of the two one-way frontage road streets is a low-activity area; no adjacent activating land uses are present and pedestrian facilities are absent. The right-angle junction of SR 693 and 142nd Street, however, is more of a diverse area, with pedestrian facilities and more frequent nearby driveways.

If the land use were to change to be of significantly higher intensity, opportunities to better communicate the transition from high speed environment to diverse area environment might include:

> Increased advance warning signing regarding speed limit change and pedestrian activity

> Gateway landscaping treatments in the diverge/gore area

> Potentially, even signalization of the slip ramp with a two-phase signal for ramp and frontage road, although only with ensurance of appropriate stopping sight distance and queue storage (which could be accomplished in part by southward relocation of the slip ramp merge area, increasing storage length and reducing the now-obsolete weaving distance).

ONE-WAY STREETS

Urban roadway networks are predominantly composed of two-way streets that carry traffic in both directions. One way streets are employed in many downtown areas nationwide as a tool for improving the efficiency of traffic movement. As described in the ITE Recommended Practice Planning Urban Roadway Systems, one-way streets may serve several different roadway network configurations:

> An individual one-way street may serve a key connection in an otherwise two-way street grid due to right-of-way or other operational constraints

> A one-way couplet may be formed by two parallel streets, whether adjacent (such as US 41 on Jefferson and Broad Streets in Brooksville) or separated (such as US 301 in Zephyrhills, which is being transferred to 6th and 7th Streets on either side of two-way Gall Boulevard)

> An urban network consisting of two one-way couplets (as illustrated in the "Urban Network" concept by Peter Calthorpe), or

> A full downtown grid of one-way streets (as found in the Tampa Central Business District)

During peak congestion periods, one-way streets can improve both mobility and safety for all modes, including bicyclists and pedestrians, by removing the conflicts associated with left turns across opposing traffic. During off-peak periods, however, the same one-way street characteristics tend to increase vehicular traffic speeds, decreasing safety and comfort for non-motorized travelers. One-way streets also tend to increase vehicle-miles of travel due to the circuitous movements needed to access individual properties; complicate wayfinding, particularly for transit system users; and are not favored by many retailers who prefer the increased visibility and access a two-way street frontage provides. For these reasons, one-way streets are a complex, and often controversial, approach to transportation system management.

Goods movement considerations in central business districts often include access and circulation within a grid of one-way streets.

Many design considerations for one-way streets have similar elements as for two way streets, but with different orientations. For instance, the considerations applicable to right turn treatments in a two-way street grid also apply to left turn treatments in a full one-way street grid. Goods movement considerations are particularly important where one-way couplets transition to two way streets and a U-turn function needs to be addressed, either with sufficient U-turning radii or through an alternate maneuver of designated left turns or right turns in the adjacent street network.

RAILROAD AT-GRADE CROSSINGS

Railroad at-grade crossings create special access and safety considerations for all travelers, as well as specific requirements for goods movement, depending upon the type of cargo being carried.

Section 316.159 of Florida statutes requires all trucks carrying explosive substances or flammable liquids as part of a cargo to fully stop at all railroad crossings, and then proceed without changing gears as they cross the tracks. The same rule applies to passenger transport vehicles as well. Other commercial vehicles need not stop, but must slow to check that the tracks are clear.

A key consideration on most Florida state highways relates to the ability of storage for the design vehicle to ensure that when a tractor trailer crosses the tracks the vehicle can clear the tracks completely. Under low traffic conditions, defining a downstream clear zone is primarily a design consideration. Under higher traffic conditions where queueing downstream can affect storage length, the consideration is operational as well. In higher traffic area, traffic management of the area around an at-grade crossing can be accomplished with upstream and downstream traffic control devices at adjacent intersections that help ensure adequate downstream clearance for truck storage.

In cases where active transportation management is not practical, a safety buffer can be created by ensuring that there is sufficient clear zone downstream of an at-grade crossing to allow a vehicle to clear the tracks by using a shoulder, siding, or other escape route in an emergency.

A secondary concern for goods movement at railroad at-grade crossings may occur along low-volume local roadways where the at-grade crossing has low ground clearance. Signing along a state highway can use the W10-5 MUTCD sign as an advance warning of low ground clearance along an intersecting local roadway to provide route guidance for local commercial vehicles.

DRAWBRIDGES

Similar to railroad at-grade crossings, drawbridges are intermodal junctions where right-of-way is assigned to the non-highway mode on an infrequent basis, but for often minutes at a time, with total physical separation of the roadway on either side of the waterway. Commercial vehicles do not have the same legal requirements to stop or slow for a drawbridge as for a railroad crossing, but the need to preserve the ability to fully exit the drawbridge without being blocked by a downstream design element or traffic queue is the same, and the same operational solutions (traffic signal control) and design solutions (escape routes) apply.

PROCEDURAL CONSIDERATIONS

The design process, summarized in Chapter 1 and described in greater detail in the FDOT PD&E and PPM Manuals, consists of a rigorous set of checks and balances. Three procedural considerations described below are particularly germane to the consideration of goods movement.

METHODOLOGY MEMORANDA

The documentation of project purpose and need, alternatives evaluation, design selection, and management and operations is a valuable element of defining consistency as projects move forward through the life cycle. The FDOT PD&E Manual espouses the concept of Methodology Memoranda to document key decisions at each stage in the project life cycle that will provide guidance, and set stakeholder expectations, for subsequent stages in the process. Travel demand forecasting and Quality/Level of Service reports are fairly common methodology memoranda on PD&E projects (although the use of the formal methodology memorandum terminology is less common). The evaluation and integration of livability and goods movement considerations throughout

At-grade railroad crossings present design concerns for all travelers, with special operational concerns for goods movement.

The low ground clearance warning can be used to notify trucks departing a state highway of a nearby local road constraint.

the process should be documented at each stage to memorialize the justifications for decisions made at that stage to enlighten the discussion should any concepts warrant review and revision in subsequent stages.

In the case of the PD&E study process, project documentation should include specific reference to the challenges of goods movement in the project study area, relying on a purpose and need statement, and identifying existing and forecast conditions relevant to goods movement forecasts, land use context, and operator concerns. References such as the Comprehensive Freight Improvement Database (CFID) can be helpful in this regard. For the PPM process, the documentation should include the land use context for the study area and the rationale for decisions made that resulted in a deliberative balance between goods movement and livability.

DESIGN VARIANCES

An overarching element of this design considerations document is to complement existing FDOT standards and practices. As indicated in Chapter 2, guidance to consider comparative design concepts such as wider or narrower lanes, higher or lower target speeds, and larger or smaller curb radii are directed towards the general ranges already established within the existing design manuals and guides, not to encourage designs beyond those ranges. Nevertheless, the most appropriate balance between goods movement and livability interests may occasionally entail the application of a design exception or variance.

Chapter 23 of the Plans Preparation Manual describes the procedures for applying for design exceptions or variances. When such variance applications involve tradeoffs between goods movement and livability interests, the conflict and proposed solution should both be documented to show how the exception or waiver helps provide an appropriate balance.

MAINTENANCE OF TRAFFIC

The consideration of goods movement should be an integral part of any roadway construction process, both for access to local businesses as well as for trucks traveling through the construction zone.

Detailed construction phasing that addresses access to individual properties is typically not developed during the roadway design process, but consideration should be given to high-volume goods movement travel patterns during construction. In certain cases with high truck generation rates in the study area, the consideration of access management during the planning and design process may help inform the selection of an appropriate outcome.

Encroachment during maintenance of traffic can be managed by a variety of active or passive control devices.

CHAPTER 6: REFERENCES

This chapter summarizes some of the key reference documents and best-practice case studies that are either directly cited in the prior chapters or that otherwise materially informed the considerations. There are three types of reference documents / best practices:

> Policies or guides directly informing design considerations

> Examples of best or promising practices

> Other references and bibliography sources

Additional details on many of these references are provided in the project literature review completed as Appendix C.

POLICIES / PRACTICES INFORMING DESIGN CONSIDERATIONS

Several of the concepts presented in the previous chapters are directly informed by concepts addressed in recent policies or practices prepared by other jurisdictions or research/advocacy groups. For each citation below, the adapted concept is briefly described, including changes incorporated into the considerations document.

Charlotte, NC Urban Street Design Guide

The concept of user perspectives presented in Chapter 3 for each Design Strategy is guided by similar matrices used by the City of Charlotte, NC in developing their Urban Street Design Guide (USDG). This approach is useful for quickly conveying what types of treatments are likely to be viewed as positive or negative by different user groups, including not only travelers in the right-of-way but also recognizing the adjacent property owners as users of the street also. The FRDC user perspectives matrices adds the category of truck drivers and includes brief prose descriptions of the pros and cons.

Institute of Transportation Engineers Planning Urban Roadway Systems

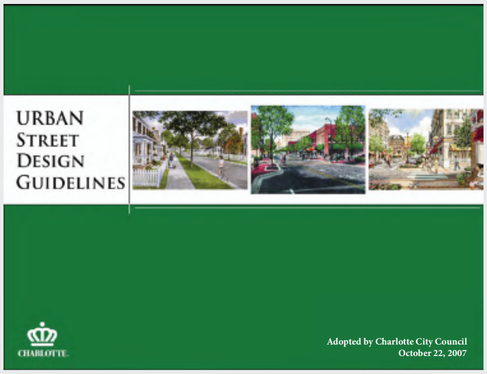
The concept of context-sensitive quality of service described in Chapter 2, with trucks comprising a separate mode from autos, is developed from the ITE Recommended Practice on Planning Urban Roadway Systems. This approach, linked to the concept of modal emphasis, recognizes that there are certain context zones and functional classifications where different roadway users should have a high quality of service, even at the expense of the quality of service for other modes sharing the roadway. This concept does not sacrifice the safety of all users, but speaks rather to the comfort of each user group. The FRDC design approach applies this concept to each of the four context areas.

Virginia Department of Transportation / Fairfax County Department of Transportation Transportation Design Standards for Tysons Corner Center

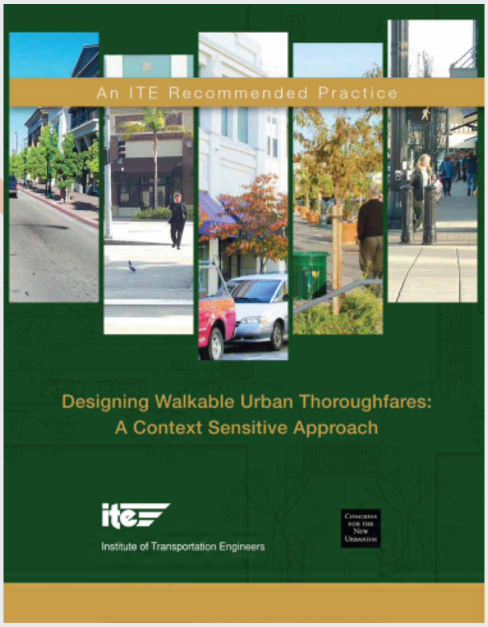
The assessment of appropriate design vehicle and control vehicle designations for intersections between roadways of different functional classifications in Chapter 2 was influenced by the guidance in this landmark collaboration between VDOT and FCDOT in a joint effort to help develop one of the nation's premier auto-oriented edge cities into a walkable urban center.

Institute of Transportation Engineers / Congress for the New Urbanism Designing Walkable Urban Thoroughfares – A Context-Sensitive Approach

The concept of target speed described in Chapter 2 is based on the descriptions of target speed in the joint ITE/CNU document on context-sensitive walkable urban thoroughfares. This approach recognizes that the ambient travel speed of motor vehicles can greatly affect both pedestrian and bicyclist comfort and safety, that in many jurisdictions design speed is not always well correlated with posted speed, and that in some cases a comfortable operating speed may be well in excess of the design speed where topographic and environmental constraints do not significantly influence roadway design elements, a characteristic of many roads in District 7.



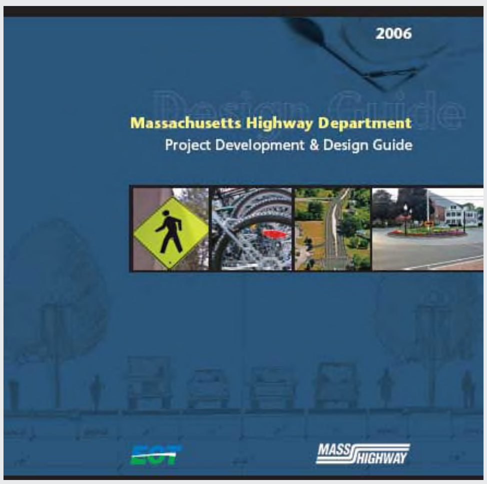
Charlotte, NC Urban Street Design Guide



Institute of Transportation Engineers / Congress for the New Urbanism Designing Walkable Urban Thoroughfares – A Context-Sensitive Approach

Massachusetts DOT Project Development and Design Guide

The concept of the acceptability of encroachment described in Chapter 2 is based on the Massachusetts DOT design guide, which recognizes that it is not always either feasible or desirable to design for infrequent large truck maneuvers without some level of encroachment, and that the type of encroachment and roadway functional classification are important variables in making that judgment. The FRDC concept of encroachment replaces functional classification with an estimate of encroachment frequency and adjusts the types of encroachment to recognize that bicycle lanes or other diamond-lane restricted lanes are an additional type of encroachment not addressed in the MassDOT guide but frequently encountered in District 7.



Massachusetts DOT Project Development and Design Guide

City of Portland, Designing for Truck Movements and Other Large Vehicles in Portland

Two years after adopting its Freight Master Plan, the City of Portland developed this landmark resource in roadway design for freight movement that recognizes the various contexts of roads within a diverse city and the variety of roles each street plays for all travel modes. These Guidelines incorporate safety, mobility, and access considerations. It is a resource for engineers, architects, designers, and planners that lists design consideration and suggests best practices illustrated by several examples. This document provided useful guidance for ways to link format and content that help make the subject matter accessible to roadway designers, other transportation professionals, and interested community stakeholders alike.

Virginia Multimodal System Design Guidelines

Virginia Multimodal System Design Guidelines

The concept of modal emphasis described in Chapter 2 is influenced by the Virginia Department of Rail and Public Transportation's Multimodal System Design Guidelines. This concept recognizes that complete streets need to accommodate all users of all ages and abilities, but that not every street needs to provide the same level of accommodation to all users. Rather, modal emphasis should be based on the development of a multimodal system plan that uses a layered network concept to identify streets where the highest quality of service might appropriately be targeted towards one or two modes. The FRDC simplifies the concept to some extent to suggest appropriate modal emphases for freight roadways in each of the four context areas, with the recognition that a specific modal facility recommendation in a planned transportation network should supersede the general context area modal emphasis.

LOCAL EXAMPLES OF BEST OR PROMISING PRACTICES

Transportation planning initiatives are more frequently bringing together transportation and community health professionals in the interest of defining best practices serving both fields. The field of health and human services employs a structured definition of a variety of practice types:

An effective practice is the general term used to refer to best, promising, and innovative practices as a whole. This term may also refer to a practice that has yet to be classified as best, promising, or innovative through a validation process;

A best practice would be defined as a method or technique that has been proven to help organizations reach high levels of efficiency or effectiveness and produce successful outcomes. In the health and human services industry, best practices are evidence-based and proven effective through objective and comprehensive research and evaluation;

A promising practice describes a method or technique that has been shown to work effectively and produce successful outcomes. Promising practices are supported, to some degree, by subjective data (e.g., interviews and anecdotal reports from the individuals implementing the practice) and objective data (e.g., feedback from subject matter experts and the results of external audits). However, promising practices have not been validated through the same rigorous research and evaluation as best practices; and

LOCAL EXAMPLES OF BEST OR PROMISING PRACTICES (CONTINUED)

Finally, an innovative practice is a method, technique, or activity that has worked within one organization and shows promise during its early stages for becoming a promising or best practice with long-term, sustainable impact. In the health services industry, innovative practices must have some objective basis for claiming effectiveness and must have the potential for replication among other organizations.

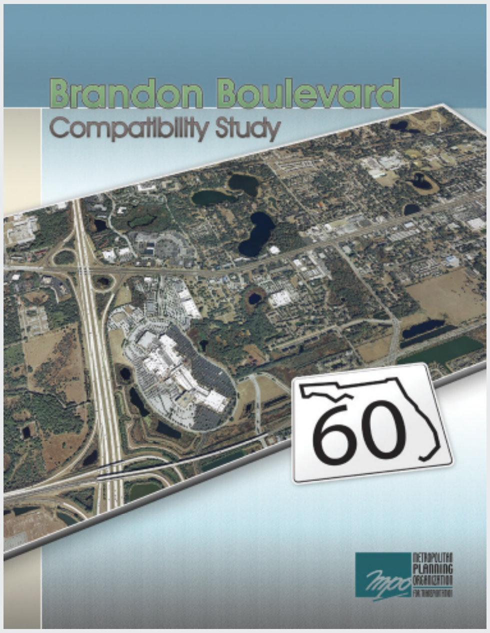
The transportation engineering / planning profession is in the process of learning about ways to better balance goods movement and livability through a wide range of innovative and promising practices. This process is continually evolving and can benefit from recognition of the state-of-the-practice without the rigorous trials established in the health and human services field. The following paragraphs provide some examples of promising and innovative practices within District 7.

PLANNING AND POLICY

As indicated in Chapters 1 and 2, the development of an appropriate balance between goods movement and livability requires continuing attention from policy and planning through to management and operations. Recent promising practices to integrate goods movement and livability include:

Brandon Boulevard (SR 60) Compatibility Study

This study identifies different suburban and urban components of the study area through the community of Brandon, reflecting context as defined by both historic development patterns, available rights-of-way, and the 2004 SR 60 Zoning Overlay District Land Development Code. Specific issues considered in the study helped set context-sensitive approaches, including overall travel demand, roadway configuration, varying speed limits, crash hot spots, congested intersections, freight mobility needs, pedestrian and bicycle connectivity, adjacent street connectivity, and community input.



Brandon Boulevard (SR 60) Compatibility Study

Zephyrhills US 301/SR 41 (Gall Blvd)

The balancing of livability and goods movement for Gall Boulevard, the main commercial arterial serving downtown Zephyrhills, is being addressed through a swap of state and local roadway ownership. Existing SR 41 will be relocated from Gall Boulevard to the parallel one-way couplet of 6th Street and 7th Street, local roadways already serving an arterial-like function as an alternative to Gall Boulevard. Conversely, Gall Boulevard will be transferred to local ownership, allowing roadway design criteria to focus more heavily on serving the adjacent businesses.

DESIGN AND CONSTRUCTION

Recent advancements to both provide an improved quality of service for both heavy vehicles and address community compatibility concerns include the following:

I-4 / Selmon Expressway Connector:

This one-mile long, limited access toll connector provides direct access between I-4, the Selmon Expressway, with a truck-only connector to the Port of Tampa Bay via 22nd Street south of the Selmon Expressway. This connector improves safety and capacity for goods movement to Tampa Bay and provides trucks an alternative to the one-way couplet of 21st and 22nd Streets through historic Ybor City.

I-4 / Selmon Expressway Connector

MANAGEMENT AND OPERATIONS

System management and operations includes both initiatives to improve today's conditions as well as providing feedback upstream in the project life-cycle to inform the next round of policy, planning, design, and construction opportunities:

Comprehensive Freight Improvement Database (CFID):

This database contains a wealth of information, based on both quantitative data and stakeholder input, on conditions affecting goods movement on the Greater Tampa Bay regional roadway network. The database is designed to facilitate access for planners, engineers, and other freight stakeholders to an inventory of roadway and other transportation infrastructure conditions. The CFID serves as an entry point for goods movement operators to provide commentary on problem locations as well as a clearinghouse for the identification and implementation of solutions to address those problems.

BIBLIOGRAPHY

American Association of State Highway and Transportation Officials. *A Policy on Geometric Design of Highways and Streets, Sixth Edition. Washington,* D.C., 2011.

American Society of Civil Engineers. Integrated Truck and Highway Design (Policy Statement 276). 2012. Retrieved from: http://www.asce.org/Content.aspx?id=8591.

Bassok, A., et. al. *NCFRP Report 24: Smart Growth and Urban Goods Movement.* Transportation Research Board of the National Academies, Washington D.C., 2013.

Christensen Associates, et. al. *NCFRP Report 16: Preserving and Protecting Freight Infrastructure and Routes.* Transportation Research Board of the National Academies, Washington D.C., 2012.

City of Portland (Oregon). Office of Transportation. *Designing for Truck Movements and Other Large Vehicles in Portland.* Portland, Oregon, 2008. Retrieved from: http://www.portlandoregon.gov/transportation/article/357099.

City of Seattle (Washington). Department of Transportation. *Right-of-Way Improvements Manual.* Seattle, Washington, 2012. Retrieved from http://www.seattle.gov/transportation/rowmanual/manual/.

Florida Department of Transportation. Environmental Management Office. *Project Development and Environmental Manual.* Tallahassee, Florida, 2013. Retrieved from http://www.dot.state.fl.us/emo/pubs/pdeman/pdeman1.shtm.

Florida Department of Transportation. Office of Design. Project Management Section. *Project Management Handbook.* Tallahassee, Florida, 2013. Retrieved from http://www.dot.state.fl.us/projectmanagementoffice/PMHandbook.

Florida Department of Transportation. Office of Roadway Design. F*lorida Intersection Design Guide 2013.* Tallahassee, Florida, 2013.

Florida Department of Transportation. Roadway Design Office. *Plans Preparation Manual.* Tallahassee, Florida, 2013. Retrieved from: http://www.dot.state.fl.us/rddesign/PPMManual/PPM.shtm.

Giuliano, G., et. al. *NCFRP Report 23: Synthesis of Freight Research in Urban Transportation Planning.* Transportation Research Board of the National Academies, Washington D.C., 2013.

Harwood, D.W., et. al. *NCHRP Report 505: Review of Truck Characteristics as Factors in Roadway Design.* Transportation Research Board of the National Academies, Washington D.C., 2003.

Institute of Transportation Engineers, and Congress for the New Urbanism. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach.* Washington D.C., 2010.

Iowa State University, Institute for Transportation. *Statewide Urban Design and Specifications.* Ames, Iowa, 2013.

Los Angeles County. *Model Design Manual for Living Streets*. 2011.

Massachusetts Department of Transportation, Highway Division. *Project Development and Design Guide.* 2006.

Middleton, D. *Truck Accommodation Design Guidance: Designer Workshop*. Texas Transportation Institute, College Station, Texas, 2003.

National Association of City Transportation Officials. *Urban Street Design Guide,* Overview. New York, New York, 2012.

New Jersey Department of Transportation, and Pennsylvania Department of Transportation. *Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities*. Trenton, New Jersey, 2008.

Pivo, G., et. al. "Learning from Truckers: Truck Drivers' Views on the Planning and Design of Urban and Suburban Centers." *Journal of Architectural and Planning Research.* Spring 2002: 12-29.

Resource Systems Group, Inc. *SHRP 2 C16: The Effect of Smart Growth Policies on Travel Demand*, 2nd Interim Report. 2011.

Strauss-Wieder, A. *NCHRP Synthesis 320: Integrating Freight Facilities and Operations with Community Goals.* Transportation Research Board of the National Academies, Washington D.C., 2003.

Texas Department of Transportation. *Roadway Design Manual.* Austin, Texas, 2010.

U.S. Department of Transportation. Federal Highway Administration. Office of Freight Management and Operations. *FHWA Freight and Land Use Handbook.* Washington, D.C., 2012.

Virginia Department of Transportation. *Multimodal System Design Guidelines*. 2013

Virginia Department of Transportation in partnership with Fairfax County Department of Transportation. *Transportation Design Standards for Tysons Corner Urban Center.* 2011.

Wisconsin Department of Transportation. *Facilities Development Manual*. 2013.