



Access Management **GUIDEBOOK**

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION
SYSTEMS IMPLEMENTATION OFFICE

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Chapter 1: Introduction

1.1 Purpose

The [Florida Department of Transportation's \(FDOT\) Systems Management Division of the Systems Implementation Office](#) has developed this guidebook as a way for state and local transportation officials to better understand access management. Previous documents, such as the Median Handbook and Driveway Information Guide, were used to develop this guidebook, as well as new materials such as the [FDOT's Context Classification System](#) and [FDOT Design Manual \(FDM\)](#). This guidebook provides background by defining access management, how it is applied on Florida's roadways and some best practices.

1.2 Background

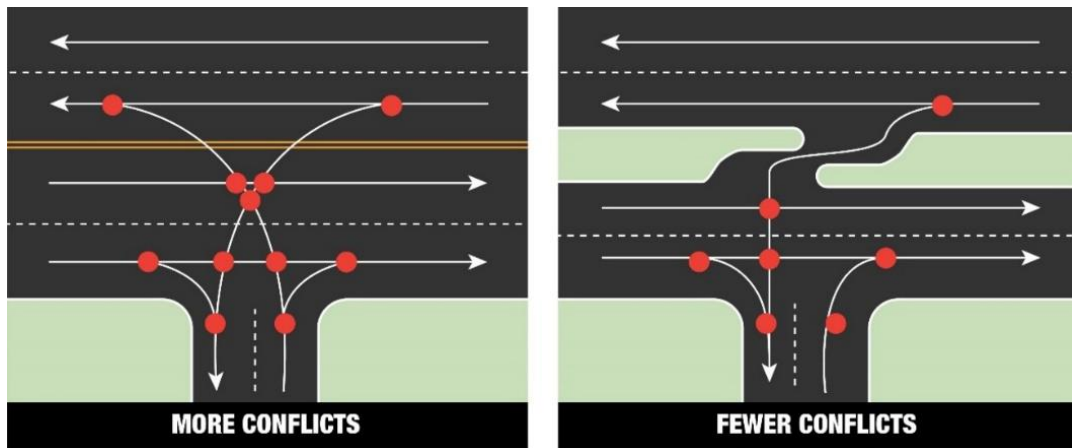
There are two main functions of roadways: to provide mobility and to provide access. Mobility is best defined as the ability for people and goods to be moved in an efficient manner while access allows people and goods the ability to enter or exit the system or property. These are competing functions that must be balanced depending on the highest need or desired result. Effectively balancing one's mobility with access is a high priority of roadway and land use planning. Highways are an example of a roadway where access has been limited to ensure greater mobility for users. A street in an urban downtown area with access to many of the adjacent properties would limit mobility for some users due to reduced speeds. As roadways change and serve increasingly more vehicles and users, balancing access and mobility is more important than ever.

1.2.1 What is Access Management?

Access management is the coordinated planning, regulation, and design of access between roadways and land development. It promotes the efficient and safe movement of people and goods by reducing conflicts on the roadway system and at its interface with other modes of travel.

Conflict points are defined as points along a roadway where travelers' paths can legally cross one another. Some examples of conflict points within a roadway are: vehicles changing lanes, a pedestrian crossing a driveway using a sidewalk, a vehicle making a right or left turn. The goal of access management is to manage conflicts between users of the transportation network. For example, access management may be applied on a roadway to increase safety by implementing a restrictive median to reduce overall conflicts (See [Figure 1](#)). In this example, the installation of a median and directional median opening restricts vehicular movements, resulting in fewer conflicts overall (shown as red dots). Access was limited by the installation of the median opening, but mobility was increased, as well as safety for users.

Figure 1 – Access Management Example

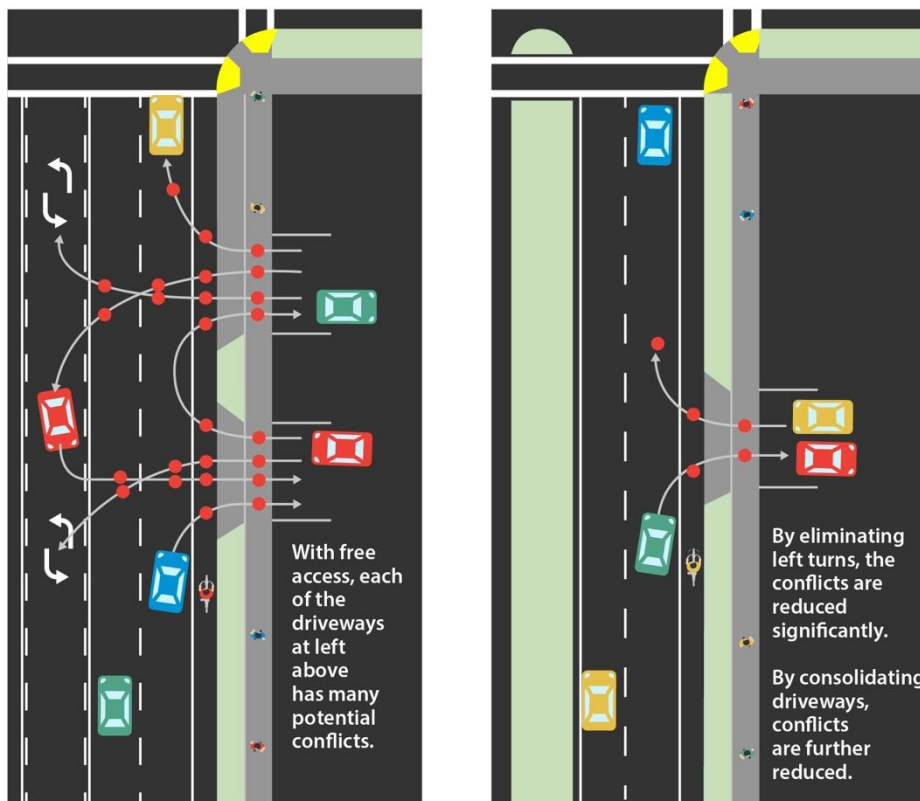


Source: FDOT

In another example, focused on non-motorized travelers, [Figure 2](#) shows how eliminating left turns and combining two driveways can significantly reduce the number of conflict points between vehicles, pedestrians and bicycles from twenty-five to five (See [Figure 2](#)). Further discussion on medians and median openings is provided in [Locating Roadway Openings](#).

Figure 2 – Conflict Points and Non-Motorized Users

Driveway conflicts contribute to unsafe sidewalks and roads.



Source: Adapted from Oregon Department of Transportation

Chapter 2: Roadway Openings

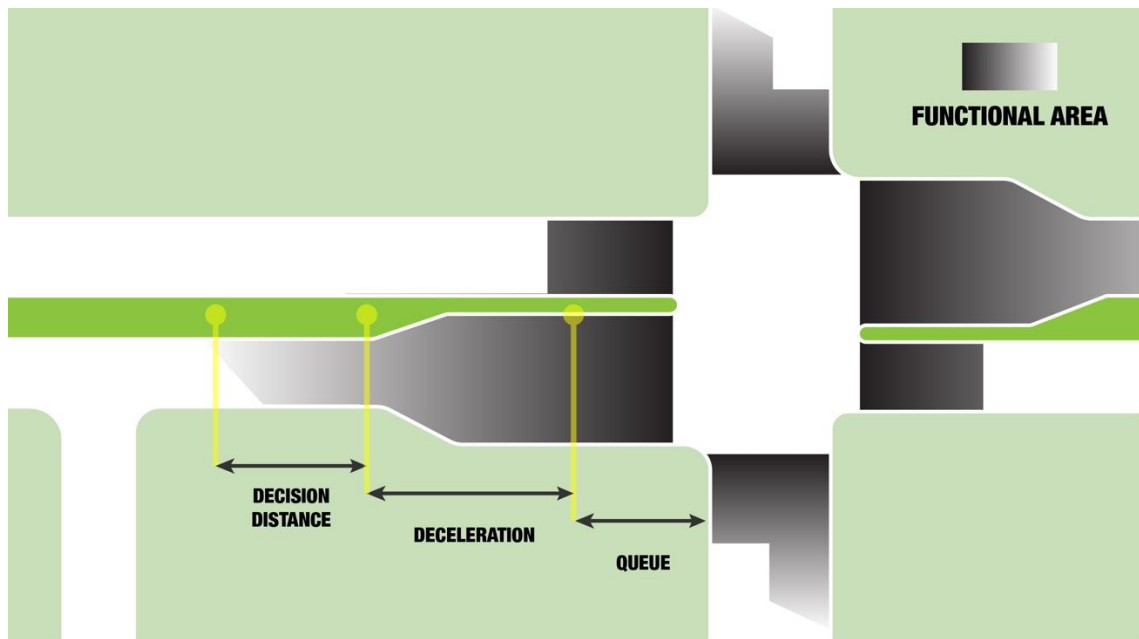
2.1 Overview

This chapter focuses on the various roadway design elements of access management and where openings in the road may occur, such as driveways and median openings. Understanding these roadway design elements and the procedures that regulate them is imperative for designing safe and efficient roadway system per FDOT policies.

To properly discuss the impacts of medians and driveways on roadway traffic, reference is made to the functional area of an intersection. The functional area can be described simply as the area beyond of two intersecting roadways where vehicle movements are affected by the intersection.

To prevent conflicts, vehicular traffic from roadway openings should not interact with the functional area of an intersection (See [Figure 3](#)).

Figure 3 – Functional Area of an Intersection



Source: FDOT

2.2 Driveways

As defined by the *American Association of State Highway and Transportation Officials (AASHTO)*, and the *FDM*;

“A driveway is an access constructed within a public R/W (Right-of-Way) connecting a public road with adjacent property.”

It is also important to note that within other FDOT manuals, handbooks and guides, driveways are at times referred to as “connection(s)” or “turnouts”.

Driveways provide a physical transition between a property and the abutting roadway and thus are one of the most common roadway design elements. They should be located and designed to minimize impacts on roadway traffic while providing safe access to and from developments. The location and design of the connection must consider characteristics of the roadway, the geographic site, context classification and the potential users. More information on these considerations will be discussed in later chapters.

2.2.1 Driveway Categories and Designs

The following sections describe how FDOT categorizes driveway design, which is influenced by roadway type such as “Urban” where shoulders are constructed with a curb and gutter design, or “Rural” where a flush shoulder design is used.

Categories

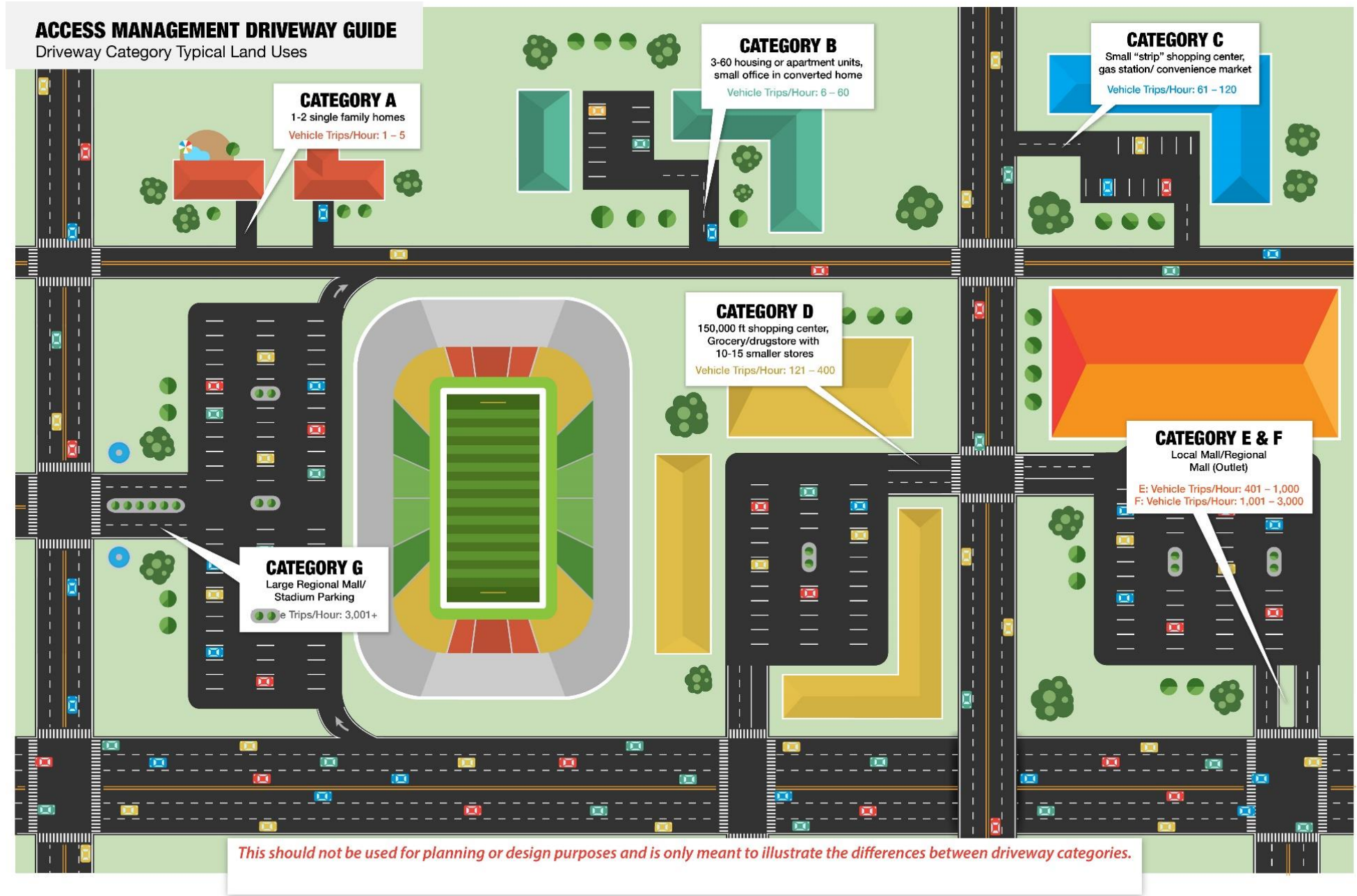
The FDOT defines driveways into seven main categories; A, B, C, D, E, F and G. These categories are based upon the number of vehicle trips per day or trips per hour that they are meant to serve (See [Table 1](#)). This ultimately leads to differences in the width and number of lanes that these driveways typically require (See [Figure 4](#)).

Table 1 – Driveway Category Criteria

Driveway Category	Vehicle Trips/Day	Vehicle Trips/Hour	Typical Land Uses
A	1 – 20	1 – 5	1 or 2 single family homes
B	21 – 600	6 – 60	3 to 60 housing or apartment units. Small office in converted home.
C	601 – 1,200	61 – 120	Small “Strip” shopping center (20-75,000 sq. ft.) Gas station/ convenience market
D	1,201 – 4,000	121 – 400	150,000 ft shopping center Grocery/drugstore with 10-15 smaller stores
E	4,001 – 10,000	401 – 1,000	Local Mall Wholesale Club
F	10,001 – 30,000	1,001 – 3,000	Regional Mall (Outlet)
G	30,001+	3,001	Large Regional Mall

Source: FDOT

Figure 4 – Driveway Categories



Source: FDOT

Category A Driveways

This category includes driveways that serve a low amount of vehicular traffic and is typically associated with land uses such as single-family home or small businesses. (See [Table 1.](#)) Typically, there are 1 – 20 vehicle trips-per-day in a driveway for this category and only the minimum requirements are necessary for designing this type.

Category B Driveways

This category includes driveways that serve a moderate amount of vehicular traffic and is typically associated with land uses such as apartment complexes and small office buildings or commercial properties. Typically, there are 21 – 600 vehicle trips-per-day in a driveway for this category. Design standards will vary for these driveways and may require larger radial returns or turn lanes depending on the site and context classification.

Category C Driveways

This category is reserved for driveways that serve a moderate to significant amount of vehicular traffic for land uses such as small strip shopping centers and convenience stores. Typically, there are 601 – 1,200 vehicle trips-per-day in a driveway for this category. An example of this would be a small to medium sized shopping center, or a strip mall. Design standards will vary for these driveways and may require larger radial returns or turn lanes depending on the site and context classification.

Category D Driveways

This category includes driveways that serve a significant amount of vehicular traffic. These types of driveways should be designed as if they are an intersecting side street and should meet all local government requirements for streets as well. Typically, there are 1,201 – 4,000 vehicle trips-per-day in a driveway for this category with land uses that are similar to a large commercial property with multiple smaller properties utilizing the same driveway. An example of this would be a larger grocery store with other retail or commercial stores next to it.

Category E Driveways

Category E driveways that serve a greater amount of vehicular traffic than Category D and are designed similarly but typically accommodate 4,001 – 10,000 vehicle trips-per-day. Land uses are similar to a large commercial property with multiple smaller properties utilizing the same driveway such as a larger grocery store with other retail or commercial stores next to it. The [FDOT Manual on Intersection Control Evaluation \(FDOT ICE Manual\)](#) must be used when designing driveways in this category.

Category F Driveways

Category F driveways that serve a greater amount of vehicular traffic than Category E and are designed similarly but typically accommodate 10,001 – 30,000 vehicle trips-per-day. The [FDOT ICE Manual](#) must be used when designing driveways in this category.

Category G Driveways

Category F driveways that serve a greater amount of vehicular traffic than Category E and are designed similarly but typically accommodate over 30,000 vehicle trips-per-day. An example land

use of this category would be a large sports stadium or a larger regional mall. The [FDOT ICE Manual](#) must be used when designing driveways in this category.

2.2.2 Driveway Design and Roadway Types

There are two types of driveways used when connecting to the [State Highway System \(SHS\)](#); the radial return design and the flared design. The type of design is based upon whether the roadway is curbed or has a flush shoulder, as well as the driveway category itself (See [Figure 5](#), [Figure 6](#), and [Figure 7](#) for examples of a curbed or flush shoulder).

Figure 5 – Flush Shoulder Roadway (Radial Return)



Source: Brandon, FL – Google Earth

Figure 6 – Curbed Roadway (Radial Return)



Source: Pompano Beach, FL - Google Earth

Figure 7 – Curbed Roadway (Flared Return)



Source: Fort Lauderdale, FL – Google Earth

Typically, on curbed roadways, a flared driveway is used when the driveway traffic volume does not exceed 600 vehicle trips/day (VPD). This is applicable for driveway categories A and B. For driveways that exceed 600 VPD, (category C and D) a radial return radius design is more appropriate (See [Table 2](#) for further details). For roadways with a flush shoulder, a radial return is the most appropriate driveway design.

Table 2 – Driveway Type Guidance

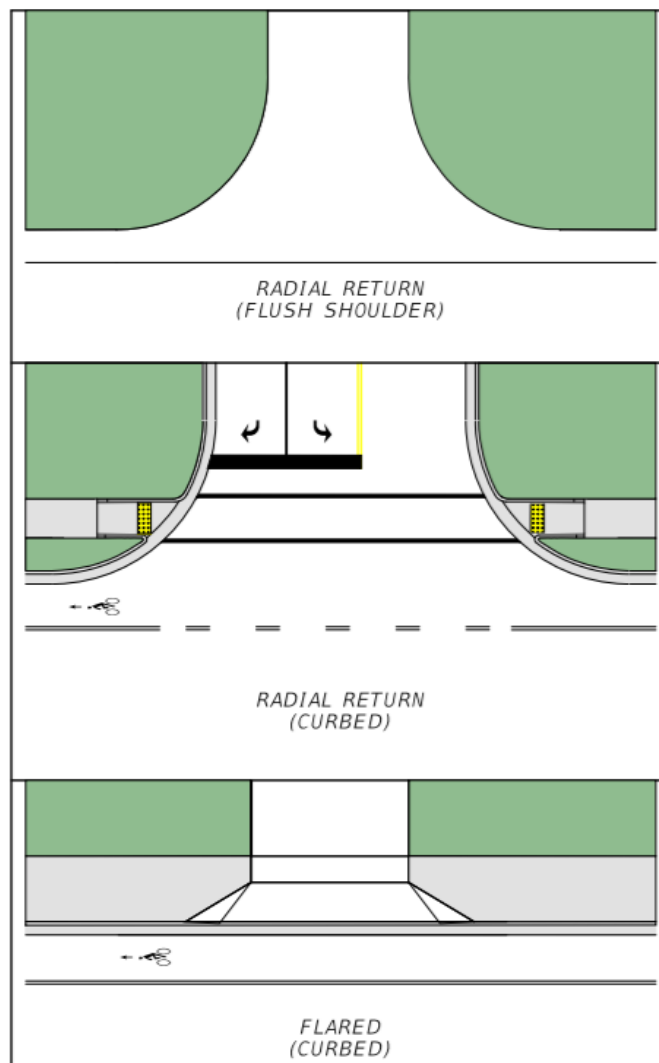
Element Description	Connection Category		
	A	B	C and D
		2-Way	2-Way
Curbed Roadways	Flared	Flared	Radius
Flush Shoulder Roadways	Radius	Radius	Radius
<p>Notes:</p> <ol style="list-style-type: none"> 1. Connection Categories A, B, C, and D are defined in FDM 214.1.1. 2. Small radii may be used in lieu of flares for curbed roadways with Category B Connections when approved by the Department. 			

Source: FDM 214 – Driveways (Table 214.2.1)

A comparison of the driveway and shoulder types can be found in the [FDM 214 – Driveways](#) (See [Figure 8](#)). These designs impact vehicles entering and exiting sites, with larger radial return type allowing for higher speeds. Other considerations for driveway design are:

- Design speed of roadway
- Driveway traffic volume
- Entry and exit movements (e.g., one-way, two-way, right-in/right-out)
- Available right-of-way (R/W)
- Design vehicle
- Non-motorized users
- Context classification

Figure 8 – Comparison of Driveway Types



Source: FDM 214 – Driveways (Figure 214.2.1)

Additional information on design specifics are discussed in [Driveway Dimensions](#) of this guidebook.

2.3 Medians and Median Openings

Restrictive medians and well-designed median openings are also a key component of access management. Raised or restrictive medians are paved or landscaped areas that separate vehicular traffic. The documented benefits of raised medians are so significant that FDOT requires a raised or restrictive median on divided roadways with a design speed of 45 mph or greater, per [FDM 210 – Arterials and Collectors](#). Medians should be installed whenever possible on multi-lane arterial roadways.

By reducing conflicts, medians allow vehicular traffic to move more freely on a roadway. Additional conflict points that exist when a roadway has no median can lead to potential safety issues (Refer back to [Figure 1](#)). Medians provide safety benefits to those traveling on the roadway, as well as non-motorized users and can improve the overall aesthetics of an area.

The design and placement of median openings is essential in managing access and minimizing conflicts.

2.3.1 Median Opening Types

There are two main types of restrictive median openings; full and directional (See [Figure 9](#) and [Figure 10](#), respectively). Both provide specific benefits but should be installed depending on the local roadway conditions.

Full Median Openings

Full median openings provide fewer restrictions for vehicles and allow for a range of vehicular movements to occur (See [Figure 9](#)).

Figure 9 – Example of a Full Median Opening



Source: Moore Haven, FL – FDOT APLUS

Vehicles can make several movements when a full median opening is installed. Vehicles from the travel lanes can enter from either direction to make left turns onto other streets or driveways or make a U-turn (depending on the local conditions). Vehicles from driveways may also enter them to complete a left turn. Full median openings are usually located at:

- Signalized intersections or those expected to be signalized
- Intersections that conform to the adopted median opening spacing interval or are separated from neighboring median openings, to avoid interfering with the deceleration, queuing or sight distance of the full opening
- Divided roadways where the traffic patterns allow left turns and crossing maneuvers from the intersecting access connection to be made with little delay
- Locations with adequate sight distance for:
 - Drivers to observe activity at the median opening and to proceed without decelerating if the median opening is unoccupied
 - A driver to complete a left turn into the roadway without interference with traffic on the roadway

Directional Median Openings

Directional median openings are designed to restrict certain traffic movements. The main characteristic of a directional median opening is that vehicular traffic from the cross streets cannot conduct left turns or cross the arterial. The only movements allowed are right turns onto the arterials (See [Figure 10](#)).

Figure 10 – Example of a Dual Directional Median Opening



Source: Clearwater, FL – FDOT APLUS

2.4 Florida Administrative Code Chapters and FDOT Guidance

There are several rules within the Florida Administrative Code Chapters which influence how driveways and median openings are designed, regulated and enforced on the Florida State Highway System. All new driveways associated with a new or expanded development must be permitted in accordance with Florida Administrative Code (F.A.C.): Rule Chapter 14-96 (State Highways System Connection Permits).

The standards for driveway and median spacing are found in F.A.C. Rule Chapter: 14-97.003 (Access Control Classification System and Access Management Standards) These standards are found in FDM 201 – Design Controls and are based on the roadway access management class (See **Table 3**).

Table 3 – Access Management Standards for Controlled Access Facilities

Roadway Access Class	FDOT Context Classification	Median Type	Connection Spacing (feet)		Median Opening Spacing (feet)		Minimum Signal Spacing (feet)***
			≤45mph Posted	>45mph Posted	Directional	Full	
2	C1 Natural, C2 Rural	Restrictive w/Service Roads	660	1320	1,320	2,640	2,640
3	C1 Natural, C2 Rural, C2T Rural Town, C3R Suburban Residential, C3C Suburban Commercial	Restrictive	440	660	1,320	2,640	2,640
4	C2T Rural Town, C4 Urban General, C5 Urban Center, C6 Urban Core	Non-Restrictive**	440	660			2,640
5		Restrictive	245	440	660	2,640/1,320*	2,640/1,320*
6		Non-Restrictive**	245	440			1,320
7		Both Median Types**	125		330	660	1,320
*Spacing 1,320 feet when roadway speed limit is 45 mph or below							
**It is recommended that additional safety/operational analysis is completed for non-restrictive medians							
***Traffic signals, proposed at intervals closer than the access management standard for the designated access class, will only be approved where the need for such signal(s) is clearly demonstrated for the safety and operation of the roadway through the signal warrant process. (F.A.C. Rule Chapter: 14-97.003) Applicants requesting or requiring the addition, removal, or modification of a traffic signal for Category E, F, and G connections, must submit an Intersection Control Evaluation Form, Form 750-010-30 (F.A.C. Rule Chapter: 14-96.003). This language is in the draft version of rule 14-96.							

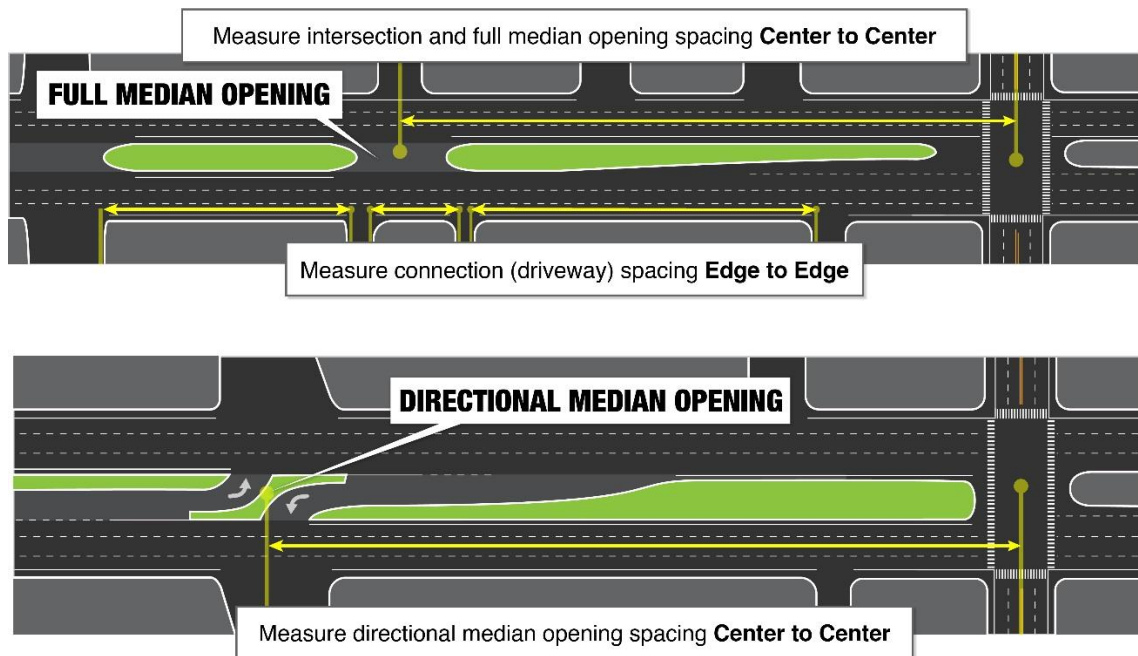
Source: Adapted from FDM 201 - Design Controls and FDOT Context Classification

It is critical to know the roadway access classification and the posted speed limit of the highway/road segment to determine what roadway features and access connection modifications are appropriate to adhere to the access management process.

The Access Management Classification can be found in the *FDOT Roadway Characteristics Inventory (RCI)* under feature 146. This information is also available within the *Access Management Classification KMZ File*, which can be downloaded from the *Systems Implementation Office website*. The file includes traffic information, the access classification and roadway speed limit. A legend for the Access Management Classification File is included [here](#)¹. In the past, the *Florida Transportation Traffic Information DVD* contained Access Management Classification as well, but this product has transitioned to the *Florida Traffic Online Application*, which is a web-based mapping application that provides traffic count site locations and historical traffic count data. It no longer supports any Access Management Classification data.

While the spacing standards from **Table 3** are important for correctly designing a roadway, it is equally important to understand how to conduct the measurements. Full median openings are measured from the center of the median opening to the center of the next full median opening (or intersection). For driveways, measure from either edge of a driveway to the nearest edge of the next driveway. Where a pair of directional median openings is used, the distance is typically measured from the center of a full median opening to the center of the pair of openings (See **Figure 11** for examples of these situations). These measurements are specified in *Rule 14-97 F.A.C.* (See also **Table 3**).

Figure 11 – Measuring Spacing Between Openings



Source: FDOT

¹https://www.fdot.gov/docs/default-source/content-docs/planning/systems/programs/sm/accman/pdfs/KMZ_File_Legend.pdf

2.4.1 FDOT Procedure Topic No.: 625-010-021

One of the impacts of these spacing standards is the concentration of more left turn and more U-turns. This requires careful planning of well-designed, well-placed median openings to avoid issues with left turns and U-turns. In response to this, FDOT created the following Procedure: [Topic Number 625-010-021 \(Median Opening and Access Management Procedure\)](#).

The *Median Openings and Access Management Procedure* provides guidance on applying the standards in *F.A.C. Rule Chapter 14-97.003* to promote consistent application of access management practices throughout FDOT. It addresses the median review process, application of the standards, public comment, and considerations for review of deviations from standards.

Adhering to the median opening spacing standards of *F.A.C. Rule Chapter 14-97* may not be achievable for various reasons. Therefore, FDOT developed a process to analyze deviation from the standards found in the Rule. The process allows project managers/permits staff a 10% deviation from the standards for full median openings and gives complete flexibility decisions involving directional median openings provided they meet minimum traffic engineering standards for storage, deceleration, sight distance, and maneuverability.

Each District has a multi-disciplinary team of Department heads, called the Access Management Review Committee (AMRC) to consider deviations from *F.A.C. Rule Chapter 14-97* standards. The team meets on a fixed schedule of publicly noticed meetings. All deviations greater than 10% for full median openings must go to the AMRC for further study and recommendation. The AMRC will review certain proposed deviations from access management and median opening spacing standards. The factors evaluated are the project's effect on:

- Traffic Safety
- Traffic Efficiency
- Functional Integrity
- Context classification of the surrounding development or use

For minor deviations, decisions can be made by a responsible engineer with a 10% deviation for "full" openings allowed. Directional openings are decided on a "case-by-case" basis.

It is important to note that even deviations of less than 10% might be problematic and create operational issues. Districts can follow a stricter decision-making policy and process.

Requests for deviation from median opening standards must be fully documented and signed by a Professional Engineer knowledgeable in traffic engineering. Section 5.4 of the Procedure also cautions that deviations should not be approved in situations that would jeopardize safety or degrade the efficiency of the system.

Considerations for Review of Deviations from Median Opening Standards

Procedure 625-010-021 provides guidance on queue storage lengths and identifies median opening designs that should be avoided.

Recommended Queue Storage Length

A critical measure for adequate median opening design is left-turn lane queue storage. Site or project specific projections of queue storage should be used at all critical intersections. Due to the variable nature of left-turn demand, actual volumes should be collected and reviewed. Designs should also include a factor of safety to account for any uncertainty in demand.

Where left turn volume is unknown and expected to be minor, adhere to the recommended minimums below:

- Urban/suburban minimum = 4 cars or 100 ft.
- Rural/small town minimum = 2 cars or 50 ft.

For more information on queue storage length, please review [Queue Storage](#) in [Locating Roadway Openings](#).

Design Prohibitions and Cautions

Section 5.6 of the Procedure illustrates why median openings that allow vehicular traffic to cross left or right turn lanes should not be approved. These illustrations are explained in greater detail in the [Median Opening Placement Principles](#) section of Chapter 3. This section illustrates the functional area of a signalized intersection and the distance traveled during perception-reaction time, plus deceleration distance and queue storage. These principles are also explained in greater detail in [Designs of Medians & Median Openings](#) section of Chapter 3.

2.4.2 Public Involvement

As mentioned earlier in this chapter, public involvement is a key aspect of the planning process. This statute, [335.199 F.S.](#), governs how FDOT works with the public regarding median changes. It states:

Whenever the Department of Transportation proposes any project on the State Highway System which will divide a state highway, erect median barriers modifying currently available vehicle turning movements, or have the effect of closing or modifying an existing access to an abutting property owner, the Department shall notify all affected property owners, municipalities, and counties at least 180 days before the design of the project is finalized. The Department's notice shall provide a written explanation regarding the need for the project and indicate that all affected parties will be given an opportunity to provide comments to the department regarding potential impacts of the change.

*For all proposed connections (permitting) that would erect or modify medians or have the effect of closing or modifying left turns to an owner of property abutting the state highway system, the **Applicant must provide the Department:***

A list of the names and mailing addresses of all property owners with neighboring connections as described in Rule 14-96.005(4)(c)5, F.A.C. If the property is leased to a residential tenant with exclusive use of the parcel or commercial tenant(s), the list will also include the name and mailing address of the tenant(s).

A single copy of the letter of notification provided to the real property owners and listed tenants describing the proposed modification. The letter must include the name and address of the person to whom comments on the change can be sent and provide at least 30 days for receipt of the comments.

Proof of delivery of the notification letter to all listed persons by mail, email, or hand delivery.

A copy of all correspondence received in response to the letter and other correspondence related to the permit provided within 10 days of receipt by the Applicant.

Per F.A.C. Rule Chapter: 14-96.003, it states that:

Connection permits authorize the initiation of construction of connections within Department right of way and the maintenance of connection(s) according to the permit provisions and adopted department standards. It is the responsibility of the applicant or permittee to obtain any other local permits or other agency approvals that may be required before the initiation of the connection construction. No person may construct, relocate, or alter a connection without first obtaining a connection permit from the Department, as provided in this rule chapter, regardless of governmental entity permits and approvals.

Public Hearing Requirements May be Met in the ETDM/PD&E Phase

335.199 F.S. requires at least one public hearing (advertised and recorded). Many times, the decision whether to construct a median is made during the Planning and/or Efficient Transportation Decision Making (ETDM)/Project Development & Environment (PD&E) phases of a project. During these phases, the FDOT works with a community with an emphasis on their participation in the decision-making process concerning the project's need and basic concepts. These phases involve local government representatives, public input, business interest input as well as other interested parties along the corridor and others outside the corridor. The ETDM/PD&E phases document these activities for major projects throughout.

As this phase progresses, stakeholder input is sought and may involve multiple mailings, meetings and workshops depending on the scope of the project. This process in most cases will satisfy the 180-day hearing requirement. Since only major studies like an EIS, EA, and major Type 2 Categorical Exclusions are required to have a formal hearing, a hearing during the final design phase shall be conducted when one hasn't been conducted during the ETDM/PD&E phase.

2.4.3 Other Public Involvement Activities

For on-going design projects, additional outreach to the community is provided through implementation of Community Awareness Plans, which include notification of property owners and occupants.

If a final design plan has been inactive (on-the-shelf) for a time long enough that there are major changes in roadside business ownership and occupancy, FDOT staff should work with the new owners and residents to inform them of the upcoming changes and allow for a dialogue before construction begins.

The Department provides property owners Access Management Notices with project plans and right (See [120.525 F.S.](#)). The Access Management Review Committees continue to meet and provide property owners the ability to voice their concerns before the Department.

Additional Public Involvement Guidance

[FDM 104 – Public Involvement](#), which addresses public involvement in design and construction projects, provides further guidance on when additional public involvement may be required.

Typically, when a project reaches the design phase, many of the project commitments and community issues have already been identified. However, there are times when design alternatives need to be reevaluated to determine their community impacts. Any commitments made in previous phases are communicated to designers, who are responsible for carrying them out. If constraints arise that require design changes which affect FDOT's ability to meet commitments, then the process would require follow-up with the affected community. In such cases, additional public involvement and community impact assessment may be necessary to address public concerns.

It lists medians or access changes as projects which may have potential community impacts which are not identified until the design phase.

In *FDM 104.2 - Community Awareness Plan*, it points out that median openings or closures are Level 3 projects which may be controversial, significantly affect traffic flow or significantly affect the accessibility to properties. The highest level of public involvement is Level 4 and is associated with widening, new interchanges, etc.

FDOT's [Project Development and Environment Manual Part 1, Chapter 11](#), provides detailed guidance on public involvement activities.

FDM and FDOT Standard Plans

While F.A.C. Rule Chapters 14-96 and 14-97 regulate the process for approving and locating driveways, FDOT Standard Plans, Index [522-003](#) and [330-001](#), and [FDM 214](#), dictate driveway type and design criteria based on multiple criteria, such as radius, width, angle, and setback. These specific dimensions are discussed in [Driveway Dimensions](#). For additional guidance, always refer to the FDM or the Standard Plans.

2.5 Safety Benefits and the HSM

The *Highway Safety Manual* (HSM), published by AASHTO, is a scientifically based guide that predicts the impacts of safety improvements on the highway system. The *HSM* conclusively demonstrates the safety benefits of access management, especially the provision of restrictive medians. It also provides a method for safety impact projections which quantify the safety impact of installing restrictive medians. In addition, it provides crash prediction methods for driveway related crashes. The *HSM Part C* (Chapters 10-12) contains the information and methodology for these computations.

2.5.1 Safety Performance Functions (SPFs)

Median Example Using SPFs

Using the information in Chapter 12 of the *HSM*, the following example demonstrates how it could be applied to predict the safety benefits of placing a raised median:

Example: Evaluate the safety benefits for converting a 5-lane section consisting of two lanes in each direction with a center two-way left-turn lane (TWLTL) into a 4-lane facility with a restrictive median. The example corridor is one (1) mile in length and has annual average daily traffic (AADT) volume of 30,000 vehicles.

Figure 12 graphs the relationship between the predicted crash frequency per mile and the AADT of different facility types. It is based on the equations in the HSM called Safety Performance Functions (SPFs). These equations are used to estimate the expected average crash frequency as a function of traffic volume and roadway characteristics (such as AADT, number of lanes, median width, intersection control, etc.).

Figure 12 – SPF Comparison of Urban 4-lane Divided and 5-lane with Center TWLTL Roadway Segments

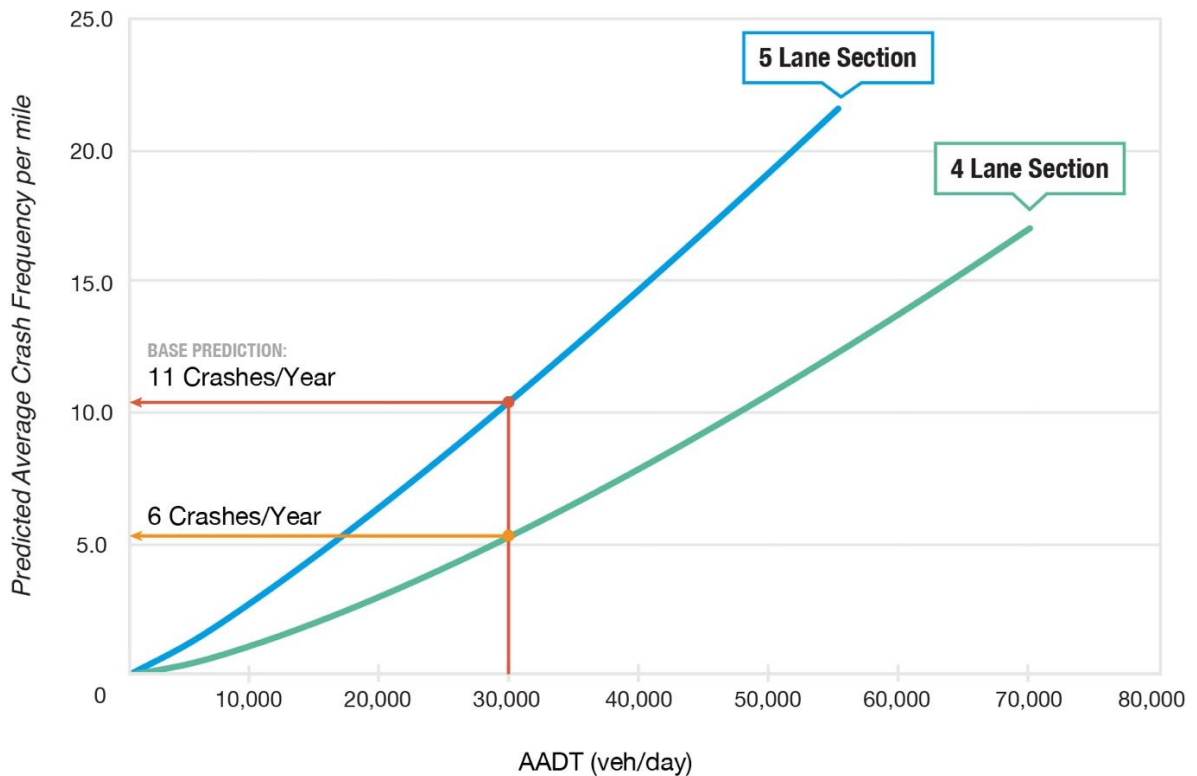


Figure 12-3. Graphical Form of the SPF for Multiple Vehicle Nondriveway collisions (from Equation 12-10 and Table 12-3)

Source: Adapted from HSM Equation 12-10 and Table 12-13

Using the above method, adding a restrictive median is expected to reduce crashes by five per year (11 - 6 = 5). Most corridor reconstruction safety project analyses are performed on a multi-year basis. Therefore, an examination of the cumulative safety benefits is used because the roadway improvement may serve the public for fifteen to twenty years.

A detailed analysis example of using the HSM for predicting crash reduction can be found in [Appendix A](#).

2.5.2 Benefit/Cost Analysis

This example illustrates how the crash prediction methods in the HSM are employed in benefit/cost analysis studies. The HSM provides methods to predict crashes only and does NOT provide cost, benefit dollar estimates as these values may vary with jurisdiction.

FDOT District 7 Office (greater Tampa area) performed a benefit/cost analysis on a resurfacing proposal. To improve the existing conditions, the District found that they would need to spend \$2,200,000 for R/W to improve to a 4-lane roadway with restrictive medians compared to a projected cost of \$600,000 for a 5-lane roadway with TWLTL.

[Table 4](#) provides the estimated crash costs associated with the two alternatives.

- The cost = R/W acquisition, construction of proposed facility etc.
- The benefits = Monetary value of crashes reduced (The HSM provides the number of crashes that are reduced by the alternative.)

Table 4 – Estimated Crash Costs for Different Facility Types

Crash Type	4-Lane Divided	5-Lane with Center TWLTL
Multi-Vehicle	\$1,492,000	\$2,856,000
Single Vehicle	\$155,000	\$235,000
Driveways	\$561,000	\$3,337,000
Total	\$2,208,000	\$6,428,000

The Benefit/Cost Ratio is found by calculating the difference between the benefits and costs of each alternative. In this example, the difference in crash costs divided by the extra R/W costs, indicates the benefit/cost ratio to be 2.64 (shown in [Table 5](#)). This shows that the expenditure of the extra funds for R/W is justified by the savings in crash costs over the 20-year period.

Table 5 – Benefit/Cost Ratio: 4-lane Divided to 5 lane Center Turn Lane

4-Lane Crash Costs	\$2,208,397	\$4,219,132
5-Lane Crash Costs	\$6,427,529	
4-Lane R/W Costs	\$2,200,000	\$1,600,000
5-Lane R/W Costs	\$600,000	
	B/C =	2.64

$$B/C = \frac{\text{Societal Benefit}}{\text{Additional Cost to Build}} = \frac{\$4,219,132}{\$1,600,000} = 2.64$$

2.5.3 Crash Modification Factors (CMF)

Another important element for predicting crashes are variables called Crash Modification Factors. CMFs represent the relative change in crash frequency after implementing a countermeasure to improve safety on a road or intersection.

The *HSM* and FHWA's CMF Clearinghouse provide numerous CMFs for practitioners to apply when analyzing access management treatments. Increasing the width of a median, installing a raised median, or installing or removing a driveway, are examples of the numerous CMFs that could affect the number of crashes along a roadway. The *CMF Clearinghouse* is updated regularly and is an excellent source to refer to when doing these calculations. Table 6 below based on *HSM* CMF's illustrates the relative difference in crash reduction that can be achieved by consolidating driveway openings on a roadway. The roadway setting is for urban and suburban arterials.

Table 6 – HSM Access Management: Effects of Driveway Density

Urban and Suburban Arterials • Focus on Driveway Density; Reducing Driveways Reduces Crashes

Treatment	Setting (Road Type)	Traffic Volume	Crash Type (Severity)	Percent Reduction in Crashes
Reduce driveways from 48 to 26-48 per mile	Urban and suburban (Arterial)	Unspecified	All types (Injury)	29%
Reduce driveways from 26-48 to 10-24 per mile				31%
Reduce driveways from 10-24 to less than 10 per mile				25%
<p><i>Note: Initial driveway density per mile based on values in this table (48, 26-48, and 10-24 per mile).</i></p>				

Source: Adapted from *HSM Chapter 13.14: Access Management - Table 13-58. Potential Crash Effects of Reducing Access Point Density; Elvik, R. and T. Vaa. Handbook of Road Safety Measures. Elsevier, Oxford, United Kingdom, 2004.*

Chapter 3: Locating Roadway Openings

3.1 Overview

This chapter focuses on the best practices for locating the roadway openings which were identified within the previous chapter. Driveways and median openings have specific geometric requirements, which are based upon the number of trips expected per hour and/or day.

3.1.1 Functional Area

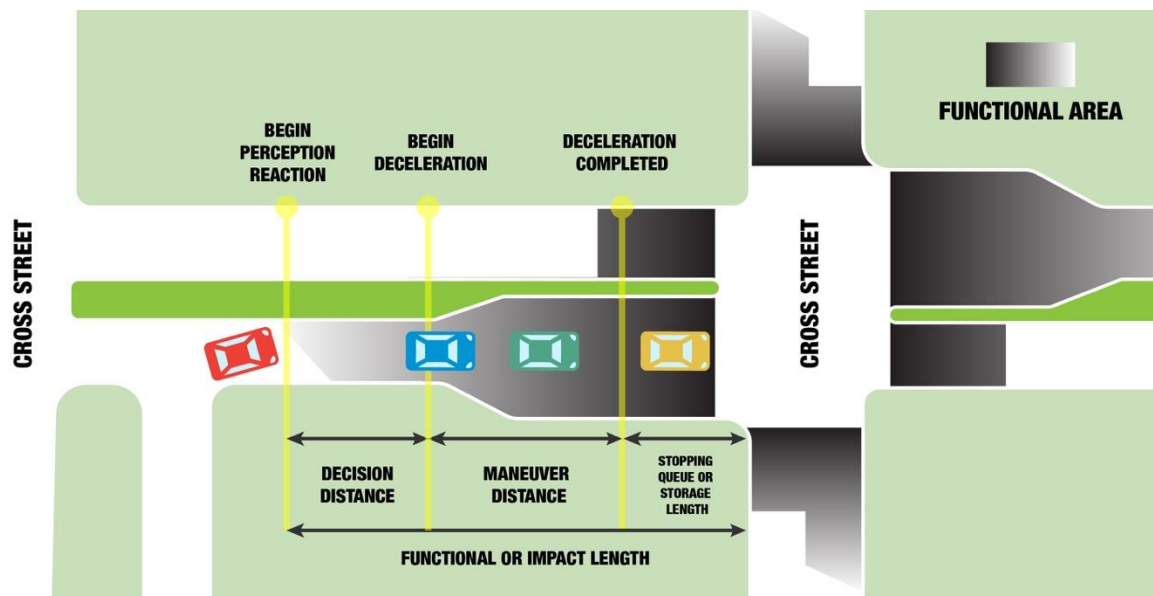
To properly discuss the impacts of medians and driveways on the transportation system, the following background information of functional area of an intersection is provided below. The functional area can be described simply as the area beyond two intersecting roadways where vehicle movements are affected by the intersection (See [Figure 13](#)). This area is further broken down into three basic elements where drivers prepare to enter the intersection.

Connection spacing standards and corner clearance standards are the tools used to protect this functional area from median openings and driveway traffic.

The intersection functional area consists of three basic elements:

- Distance traveled during decision time,
- Maneuver-deceleration distance, and
- Queue-storage distance

Figure 13 – Functional Area Diagram



Source: FDOT

3.2 Driveways

While it is important to design driveways correctly, it is also critical to locate them in areas where they will not interfere with other elements. Some examples of areas where driveways should be restricted are at signalized intersections, limited access interchange ramps, other driveways and median openings, and roundabouts. Placing a driveway too close to these elements may create an unsafe roadway environment.

For example, in [Figure 14](#) and [Figure 15](#), a building site was modified so that one of the driveways could be closed. Before the driveway was closed, there were four connections in an area which may have created conflicts with the vehicles entering and exiting the site, as well as conflicts with pedestrians on the sidewalk. After the site was re-developed (see [Figure 15](#)), the second driveway was closed, which reduced conflicts and increased the overall safety in this section of the roadway.

Figure 14 – Before Driveway Closure



Source: Miami, FL – FDOT APLUS

Figure 15 – After Driveway Closure



Source: Miami, FL – FDOT APLUS

The distance between connections (e.g., distance between a driveway and a side street or intersection) is measured from the two closest edges of the connection (or its projected edge line at the edge of travel way) as shown as “D” in [Figure 15](#) (*F.A.C. Rule Chapter: 14-97*). More information on connection spacing, and the other driveway terms are discussed in [Driveway Dimensions](#).

3.2.1 Spacing Standards

A driveway being constructed too closely to another connection could negatively impact traffic safety and flow. As discussed previously, the standards for determining the spacing requirements for driveways comes from the *F.A.C. Rule Chapter: 14-97.003*. [Table 7](#) shows these spacing standards and the distances from other connections based upon the roadway speed limit and roadway access classification.

Table 7 – Driveway Spacing Standards

Roadway Access Class	FDOT Context Classification	Connection Spacing (feet)		Minimum Signal Spacing (feet) ^{***}
		≤45mph Posted	>45mph Posted	
2	C1 Natural, C2 Rural	660	1320	2,640
3	C1 Natural, C2 Rural, C2T Rural Town, C3R Suburban Residential, C3C Suburban Commercial	440	660	2,640
4	C2T Rural Town, C4 Urban General, C5 Urban Center, C6 Urban Core	440	660	2,640
5		245	440	2,640/ 1,320*
6		245	440	1,320
7		125		1,320
*Spacing 1,320 feet when roadway speed limit is 45 mph or below				
**It is recommended that additional safety/operational analysis is completed for non-restrictive medians				
***Traffic signals, which are proposed at intervals closer than the access management standard for the designated access class, will only be approved where the need for such signal(s) is clearly demonstrated for the safety and operation of the roadway and approved through the signal warrant process. (F.A.C Rule Chapter: 14-97.003) Applicants requesting or requiring the addition, removal, or modification of a traffic signal for Category E, F, and G connections, must submit an Intersection Control Evaluation Form, Form 750-010-30 (F.A.C. Rule Chapter: 14-96.003). This language is in the draft version of rule 14-96.				

Source: Adapted from [FDM 201 - Design Controls](#) and [FDOT Context Classification](#)

3.2.2 Important Considerations

Driveways and median openings close to a major intersection create conflicts for drivers making decisions in an area that has been designed to manage large volumes of traffic. This situation can lead to poor safety and operational conditions. Proper driveway placement can help alleviate this problem. Proper driveway placement can also help the business operators, because traffic queues can become so long that traffic exiting driveways may be blocked for long periods of time. According to the AASHTO publication, [A Policy on Geometric Design of Highways and Streets](#), also known as the *AASHTO Green Book (Chapter 9, 2011)*, “Driveways should not be situated within the functional area of at-grade intersections.”

3.3 Median Openings

The location of median openings has a direct relationship to safety, operational efficiency and traffic progression along a roadway. To support safe and efficient traffic operations, full median openings should only be at locations which are thoughtfully placed along the corridor. Properly spaced median openings will facilitate signalized traffic to flow at efficient and uniform operating speeds.

3.3.1 Spacing Standards

The F.A.C. Rule Chapter: 14-97.003 regulates median opening spacing and provides recommended distances. **Table 8** shows the median types and spacing standards for each roadway access classification.

Table 8 – Median Opening Spacing Standards

Roadway Access Class	FDOT Context Classification	Median Type	Median Opening Spacing (feet)		Minimum Signal Spacing (feet)**
			Directional	Full	
2	C1 Natural, C2 Rural	Restrictive w/Service Roads	1,320	2,640	2,640
3	C1 Natural, C2 Rural, C2T Rural Town, C3R Suburban Residential, C3C Suburban Commercial	Restrictive	1,320	2,640	2,640
4	C2T Rural Town, C4 Urban General, C5 Urban Center, C6 Urban Core	Non-Restrictive**			2,640
5		Restrictive	660	2,640/1,320*	2,640/1,320*
6		Non-Restrictive**			1,320
7		Both Median Types**	330	660	1,320
*Spacing 1,320 feet when roadway speed limit is 45 mph or below					
**It is recommended that additional safety/operational analysis is completed for non-restrictive medians					
***Traffic signals, which are proposed at intervals closer than the access management standard for the designated access class, will only be approved where the need for such signal(s) is clearly demonstrated for the safety and operation of the roadway and approved through the signal warrant process. (F.A.C. Rule Chapter: 14-97.003) Applicants requesting or requiring the addition, removal, or modification of a traffic signal for Category E, F, and G connections, must submit an Intersection Control Evaluation Form, Form 750-010-30 (F.A.C. Rule Chapter: 14-96.003). This language is in the draft version of rule 14-96.					

Source: Adapted from [FDM 201 - Design Controls](#) and [FDOT Context Classification](#)

3.3.2 Important Considerations

Median Opening Placement Principles

The basic concept used in median opening location and design is avoidance of unnecessary conflicts which result in crashes.

The unsignalized median opening is essentially an intersection. Properly designed, it will have an auxiliary lane allowing the left-turning vehicles to decelerate without interfering with the through movements of the leftmost through lane. The potential of high-speed crashes is the greatest in the through lanes. Before median opening placement is determined, it is important to know what speed, maneuvering distances, and storage length the project requires.

- Follow the spacing criteria in *F.A.C. Rule Chapter: 14-97*
- Median openings should not encroach on the functional area of another median opening or intersection

Avoid Openings Within Exclusive Turn Lanes

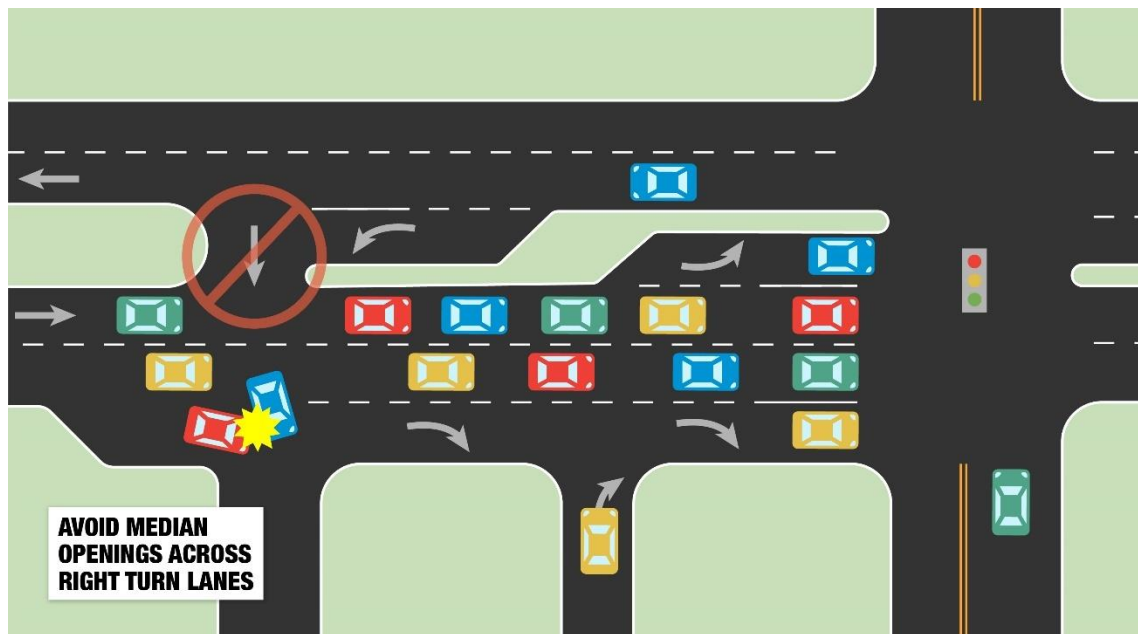
Median openings can cause significant traffic issues if they are improperly placed. For example, placing a median opening across a turn lane could introduce additional conflict points, which could result in vehicular crashes.

Exclusive right-turn lanes are most appropriate under the following conditions:

- No median openings interfere,
- The right-turn lane does not continue across intersections, and
- No closely spaced high volume driveways

In [Figure 16](#), driver 1 in the through-lane decides to allow the driver 2 to make a left-turn into the driveway, which results in a crash with driver 3 in the right-turn lane. Driver 3 in the right turn lane was unable to see driver 1 because of the queued traffic in the through lanes. In this example, while the intentions of driver 2 were good, it unfortunately led to a crash.

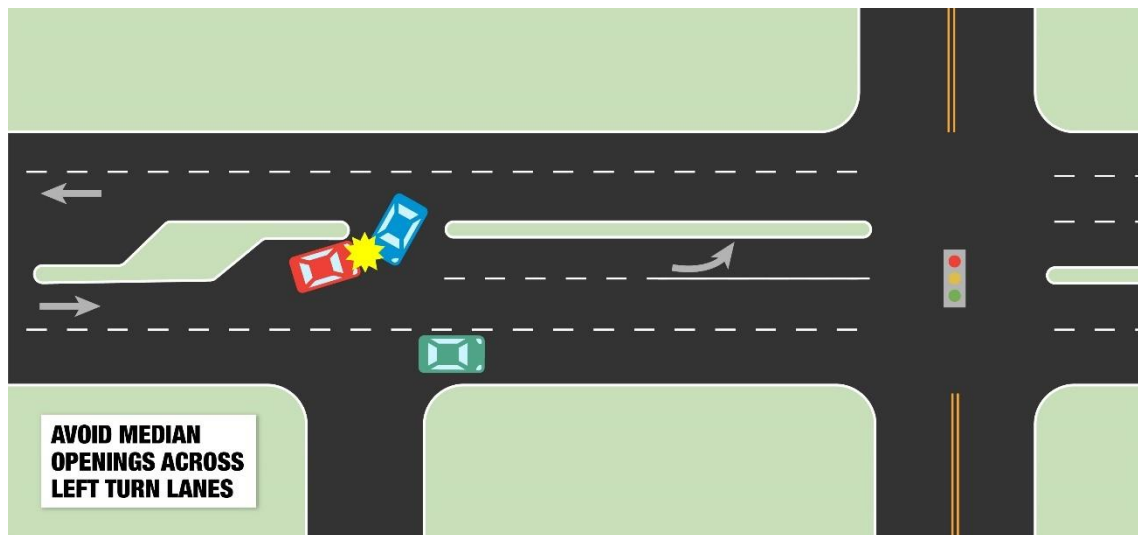
Figure 16 – Improper Median Opening



Source: FDOT

Another example of an improper median opening is one located on a left-turn lane, as shown in [Figure 17](#). The vehicle entering the left-turn lane is involved in a crash with an opposing vehicle turning left in the median opening.

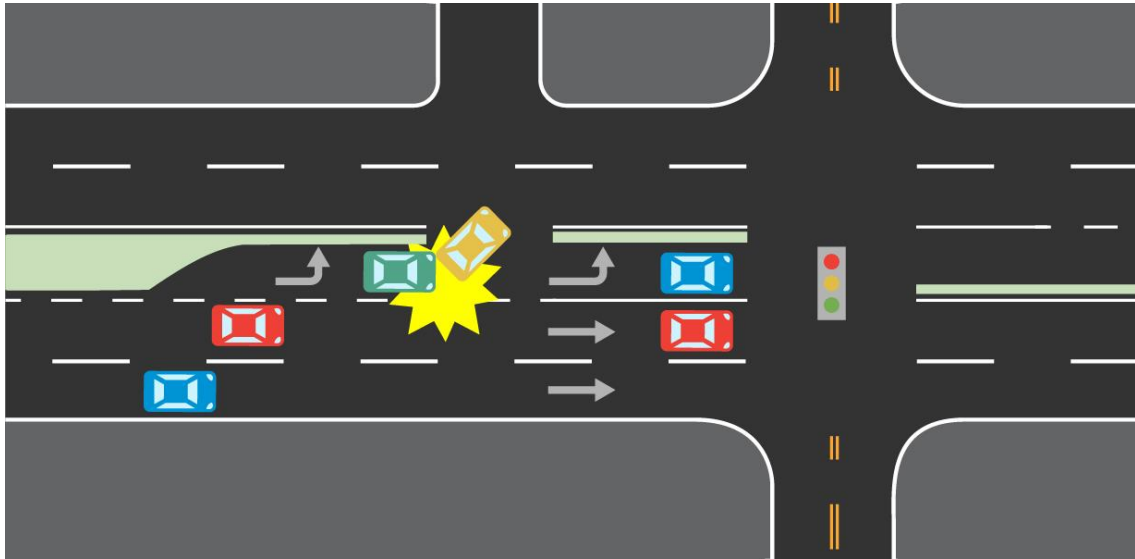
Figure 17 – Improper Median Opening



Source: FDOT

In **Figure 18**, a rear-end collision occurs with the vehicle attempting a left turn through the opening prior to the intersection. Both examples violate driver expectancy.

Figure 18 – Improper Median Opening Violates Driver Expectancy



Source: FDOT

Additional guidance on turn lanes, median openings and driveways can be found later in this chapter, as well as in **Driveway Dimensions**, **Sight Distances**, and **Turn Lanes and U-Turns**.

3.4 Designs of Medians & Median Openings

Factors such as width and median taper play a critical role when designing median openings in how they affect access management along a roadway. A critical function of many medians is to protect vehicles turning left. These design criteria are influenced by similar factors as driveways. The speed limit of the roadway, design of the roadway shoulders (flushed vs. curbed) and context classification all influence the various design criteria for medians and median openings. These criteria are discussed in the following sections.

3.4.1 Width

One of the major design criteria for medians and median openings is the width of the median. Per **FDM 210 – Arterials and Collectors**, “Median width is expressed as the dimension between the inside edges of traveled way”.

Table 9 describes the various recommended median widths based on numerous factors. For example, a curbed or flushed shoulder roadway with a design speed of 25-35 MPH in a C2T-Rural Town context classification has a minimum width specified as 15.5 feet.

Table 9 – Median Widths

Context Classification	Curbed Roadways and Flush Shoulder Roadways (feet)	High Speed Curbed Roadways (feet)	Flush Shoulder Roadways	
	Design Speed (mph)			
	25-30	40-45	50-55	60-65
C1 Natural	N/A	N/A	30	40
C2 Rural	N/A	N/A	30	40
C2T Rural Town	15.5	22	N/A	N/A
C3 Suburban	22	22	30	40
C4 Urban General	15.5	22	N/A	N/A
C5 Urban Center	15.5	N/A	N/A	N/A
C6 Urban Core	15.5	N/A	N/A	N/A

Notes:

1. On reconstruction projects where existing curb locations are fixed due to severe right of way constraints, the minimum median width may be reduced to 19.5 feet for design speeds = 45 mph, and to 15.5 feet for design speeds ≤ 40 mph.
2. A minimum 6-foot median may be used within C5 and C6 context classifications only where left turn lanes are not expected.

Source: FDM 210 – Arterials and Collectors (Table 210.3.1)

The appropriate median width should be determined by the specific function the median is designed to serve. Considerations which affect median width on roadways having at-grade intersections include the following:

- Separate opposing traffic streams
- Pedestrian refuge
- Left-turns into side streets
- Left-turns out of side streets
- Crossing vehicle movements
- U-turns
- Aesthetics and maintenance

There are situations when additional median width may be necessary. For example, if there are trees, bushes or other similar features within the median, it may need to be enlarged. Also, if there are dual or triple left lanes or a need to offset turn lanes, then the median width will need to be larger. Finally, if there is a directional median opening, then the median width should be larger.

Determining the width of a median opening is dependent on whether it is a full or directional median opening. According to the *FDM*, full median opening width is described as;

“...the same width as the intersecting road (including shoulders) which is sufficient to accommodate the swept path of left-turning vehicles.”

The minimum widths shown in **Table 9** represent a balance between mobility, safety and context classification. Median width will be discussed in further detail in **Sight Distances** and **Turn Lanes and U-Turns**.

Important Considerations

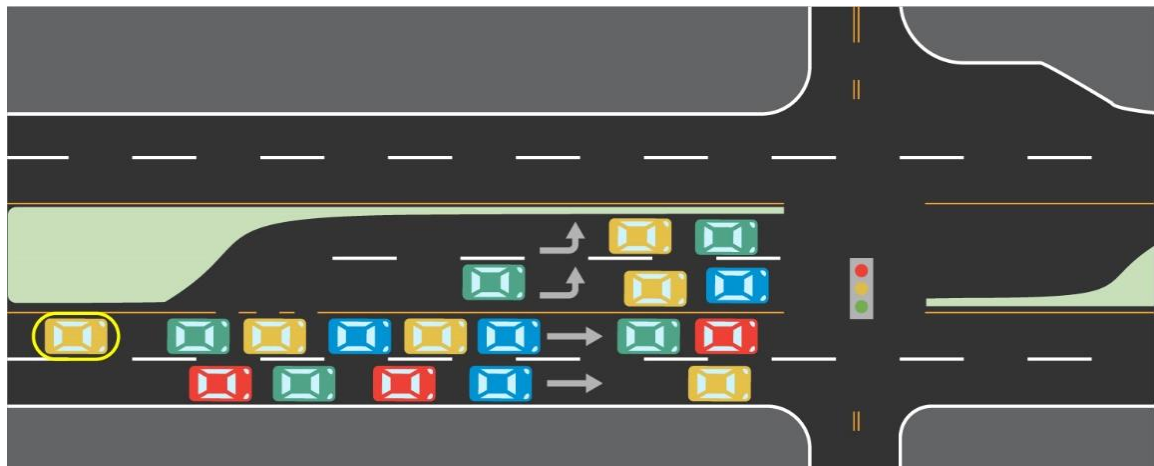
FDM 210 – Arterials and Collectors provides the following direction: Two-way left-turn lane widths (flush median) may be used on 3-lane and 5-lane typical sections with design speeds ≤ 40 mph. On new construction projects, flush medians are to include sections of raised or restrictive median to enhance vehicular, bicycle, and pedestrian safety, improve traffic efficiency, and attain the standards of the Access Management Classification of that highway system. Sections of raised or restrictive medians are recommended on RRR projects.

3.4.2 Median Opening Failures

Median opening failure can occur when critical components of the opening are not designed appropriately. This is usually due to the inadequate space for left-turn storage. This can result in excessive deceleration in the through lane, because vehicles are queued in the area of the left-turn lane needed for deceleration. Additionally, an inadequate left-turn lane length can lead to vehicle queues extending into the through lane creating a more hazardous situation.

When the queue in the through traffic lane spills past the left-turn lane, turning vehicles are trapped in the queue (See highlighted vehicle in **Figure 19**). The left-turning vehicles are not able to move into the turn bay until the queue advances and often miss the left-turn signal phase which negatively impacts intersection efficiency. Dual left turn lanes may be more prone to this problem.

Figure 19 – Through-Lane Queue Blocks Entry into the Left-Turn Bay

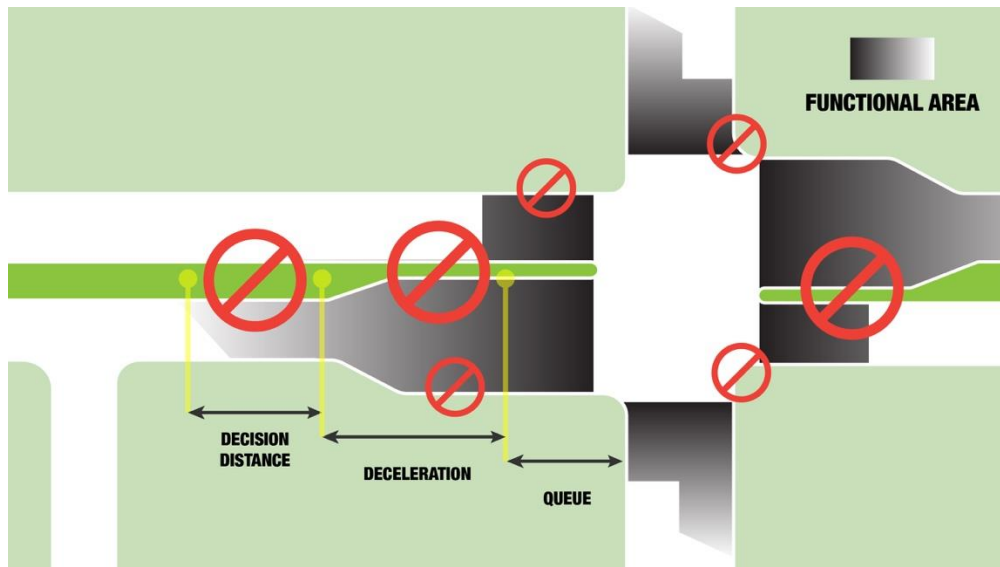


Source: FDOT

Exclusive Left-Turn Lane Length

This section will discuss exclusive left-turn lane length. To determine adequate storage lengths, the roadway designer should know the decision distance, deceleration distance and queue length as shown in [Figure 20](#). In this figure, the areas that are marked out with a “do not” symbol are places where you would not want to install a median opening or driveway as it would negatively impact the roadway safety and operation.

Figure 20 – Functional Area and Medians



Source: FDOT

Perception-Reaction-Decision Distance

The perception-reaction-decision distance required by drivers varies depending on certain factors. For motorists who frequently use the corridor, this may be as little as one second or less. However, unfamiliar drivers may not be in the proper lane to execute the desired maneuver and may require three or more seconds. Further guidance on these distances is taken from *FDOT Procedure 625-010-021* (See [Table 10](#)).

Table 10 – Guidance on Perception-Reaction-Decision Distances

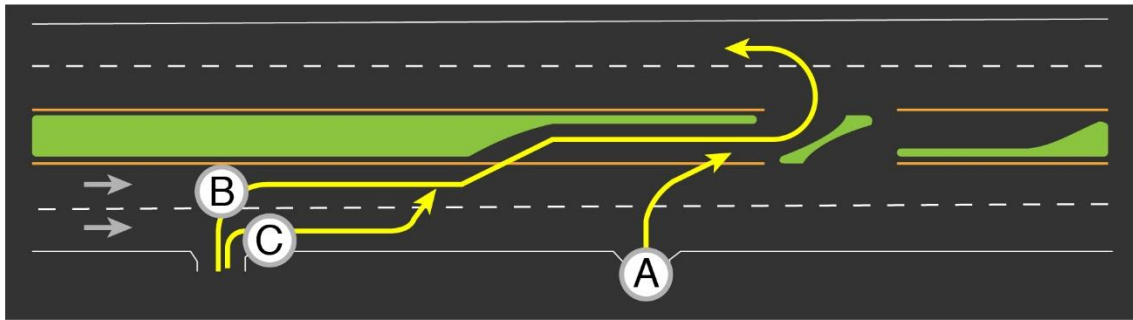
Areas	Seconds	35 MPH	45 MPH	55 MPH
Rural	2.5	130 ft.	165 ft.	200 ft.
Suburban	2	100 ft.	130 ft.	160 ft.
Urban	1.5	75 ft.	100 ft.	120 ft.

For more information on decision time: *AASHTO Green Book*.

Right-Turn Weaving Distance (Right-Turn Weave Offset)

Vehicles turning right from a downstream driveway will need distance to weave if they are turning left at the next opening. [Figure 21](#) shows the potential weaving patterns if there is a driveway in close proximity to a median opening.

Figure 21 – Weaving Patterns



Source: FDOT

A Short Separation:

Drivers select a suitable simultaneous gap in all traffic lanes and then make a direct entry into the left-turn/U-turn lane.

B Long Separation, Low-Volume approaching from the left:

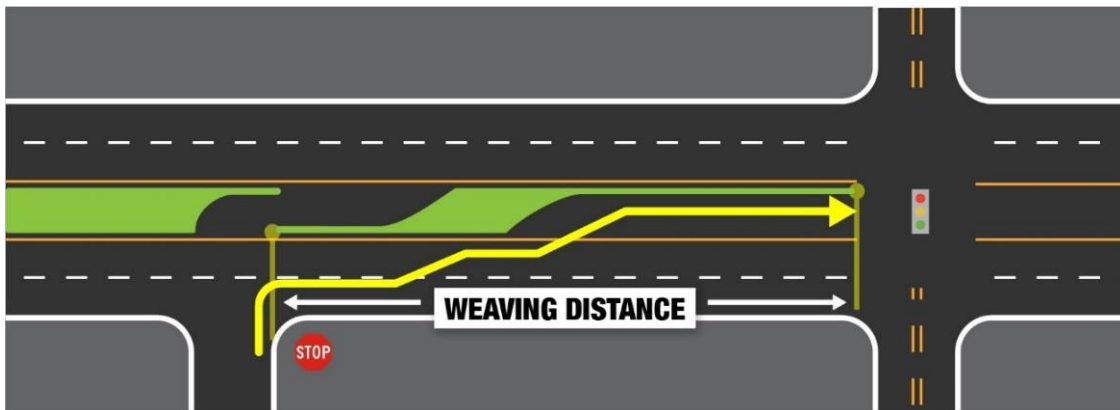
Drivers select a simultaneous gap in all traffic lanes, turn right, and make a direct entry maneuver into the left through lane.

C Long separation, high volume or low volume and high-speed traffic from the left:

Drivers wait for suitable gap, turn right, accelerate and make a lane change maneuver, then decelerate as they enter the left-turn lane.²

A study by the University of South Florida gives some guidance for the weaving distances needed. [Figure 22](#) shows the “weaving distance.”³

Figure 22 – Weaving Distance Between Driveway and U-Turn



Source: FDOT

² NCHRP 420 Impacts of Access Management Techniques - 1999

³ Determination of the Offset Distance between Driveway Exits and Downstream U-turn Locations for Vehicles making Right Turns Followed by U-turns –University of South Florida, November 2005 - Jian John Lu, Pan Liu, and Fatih Pirinccioglu

Although the study focused on the weaving made by vehicles positioning for a U-turn, the recommended distances are the same as weaving distance for left-turn and U-turns. The research highlights that the more through lanes a facility has, the longer the weaving distances are from the driveway to the median opening.

Table 11 – Guidance on Weaving Distances

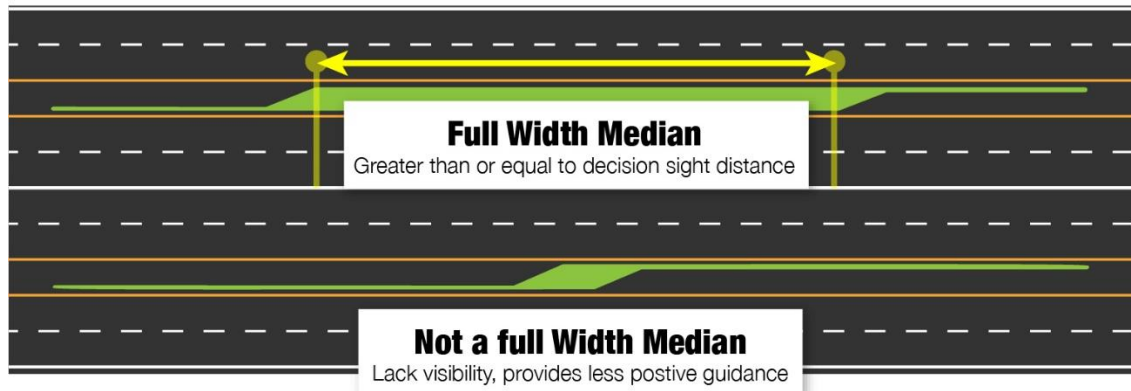
Turn Location	Number of Lanes	Weaving Distance (Ft.)
Median Opening	4	400
	6 or More	500
Signalized Intersections	4	550
	6 or More	750

Source: University of South Florida. (2005). *Determination of the Offset Distance between Driveway Exits and Downstream U-turn locations for Vehicles making Right Turns Followed by U-turns.*

Full Width Median

Where at all possible, the length of the full width median should be as long as possible so the median will be more visible to the driver. This also gives more space for traffic signs and landscaping. The full width median should be greater than or equal to the decision distance. (See *AASHTO Greenbook Chapter 3* for more information).

Figure 23 – Length of Full Width Median



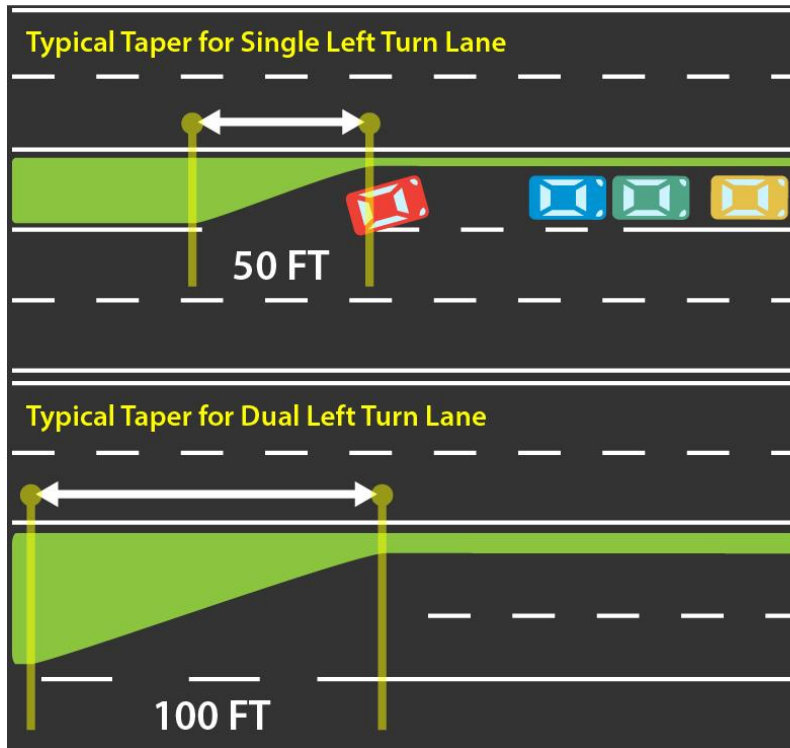
Source: FDOT

Maneuver/Deceleration Distance

The Maneuver-Deceleration Distance consists of two components; taper and deceleration. Taper is the portion of the median opening that begins the transition to the turn lane. [FDM 212 - Intersections](#) contains the standards for this feature.

Design standards for left-turn lanes are available from several sources, most of which determine their rate of taper length from the approach speed; the faster the speed, the longer the taper. The FDOT does offer standards for the design of left turn lanes. FDM 212 dictates the use of a 4:1 ratio, or 50 ft. for turn bay tapers on all multilane divided facilities regardless of speed. This may appear to be an abrupt transition area for free-flow conditions, however, most urban areas will benefit from a longer storage area for queued vehicles. It also provides a better visual cue to the driver for the turn lane. Typically, 50 ft. (or 100 ft. for dual-left-turn lane tapers). [Figure 24](#) is an example of taper distances depending on the roadway and number of lanes.

Figure 24 – Taper Distances



- More storage
- Less chance of a vehicle blocking through lane

Source: Adapted from FDM 212 – Intersections

Additional Taper Designs can be found in the *AASHTO Green Book*.

Total Deceleration

Minimum standards for the distance needed to properly slow a vehicle down and bring the vehicle to the storage portion of the median opening, or deceleration distance, is found in *FDM 212* and [FDOT Standard Plans, Index 711-001](#). This distance is measured from the beginning of the taper to the end of the queue storage portion.

The standards found in *FDM 212* however should be considered a minimum because research has shown reactions vary considerably with drivers. In many cases, more space may be needed. A table summarizing these values is provided in [Table 12](#).

The turn bay should be designed so that a turning vehicle will develop a speed differential (“through vehicle” speed minus the entry speed of the “turning vehicle”) of 10 mph or less at the point it clears the through traffic lane and enters the turn lane. The length of the turn lane should allow the vehicle to come to a comfortable stop prior to reaching the end of the expected queue in the turn lane. It is important to note that class 4 - 13 vehicles can be 40’ - 75’ long and may require additional length to meet this requirement.

Design Speed

The design speed is the speed used to make critical decisions on the roadway design features. The AASHTO Green Book defines the design speed as:

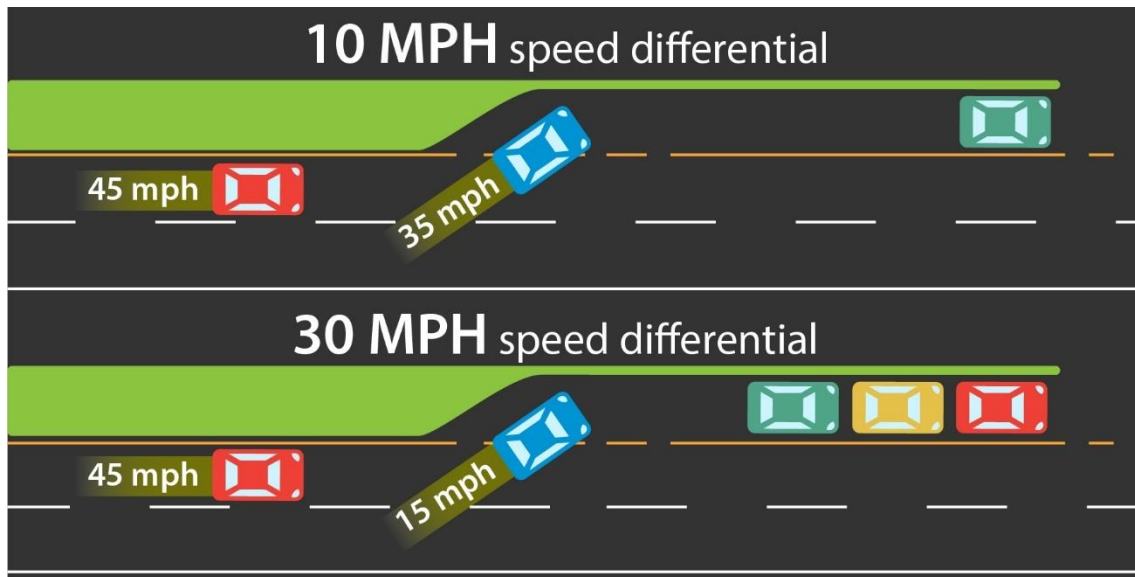
“Design speed is a selected speed used to determine the various geometric design features of the roadway... In selection of design speed, every effort should be made to attain a desired combination of safety, mobility, and efficiency within the constraints of environmental quality, economics, aesthetics, and social or political impacts.”

“Once selected, all of the pertinent features of the highway should be related to the design speed to obtain a balanced design. Above-minimum design values should be used where practical, particularly on high speed facilities.”

Entry Speed

When considering medians and median openings, the greatest use of design speed is for determining the length of right- and left-turn lanes. FDM 212 identifies that design speed and the related entry speed are the basis for determining the minimum length of the turn lane for deceleration and stopping behind the turn lane queue.

Figure 25 – Excessive Deceleration



Source: FDOT

If the turn lane is too short, or queued vehicles take up too much of the deceleration portion of the turn lane, excessive deceleration will occur in the through lane. This creates a high crash potential.

Non-Peak hour speeds are also important considerations since around 80% of the daily traffic takes place outside of the peak hours at that time, usually at higher speeds. Turning volumes are lower at those times which will make queuing requirements smaller.

Table 12 – Deceleration Distances

Design Speed (mph)	Entry Speed (mph)	Total Deceleration (ft)
35	25	145
40	30	155
45	35	185
50 Urban	40	240
50 Rural	44	290
55 Rural	48	350
60 Rural	52	405
65 Rural	55	460

Source: FDM 212 – Intersections

For more information on speed definitions:

- *FDM 201.4 Design Controls*
- *Design Speed, Operating Speed, and Posted Speed Practices, NCHRP Report 504, 2003*
- *AASHTO Green Book*

Queue Storage

Turn lanes must include adequate length for the storage of traffic waiting to perform a turn. This is also called turn lane queue length.

The queue length provided should be based on a traffic study. [FDM 232 - Signalization](#) states:

“Storage lanes for left turns can affect the capacity and safety of intersections. The storage length of a left turn lane is a critical design element. The queue of left turn vehicles in a storage lane of inadequate length may extend into the through lanes. The result is loss of capacity for the through lanes. The queue of through vehicles may also extend beyond the entrance of a short left-turn storage lane, blocking access to the storage lane. Either case results in a less efficient operation of the intersection and may cause last minute lane changes, thereby increasing the possibility of conflicts.”

In low-volume situations, [FDM 212.14](#) states:

“For low volume intersections where a traffic study is not justified, a minimum 50-foot queue length (2 vehicles) should be provided for rural context classifications. A minimum 100-foot queue length (4 vehicles) should be provided in urbanized context classifications. Locations with over 10% truck traffic should accommodate at least one car and one truck.”

For queue lengths at signalized intersections, refer to [FDM 232](#).

Median Openings Near Freeway Interchanges

Good access management practices are needed in the area surrounding freeway interchanges as these are areas where high speed traffic transitions to arterial speeds. In addition, congestion on the arterial can cause freeway exit ramp traffic to back up onto the mainline, creating a serious high-speed crash risk.

F.A.C. Rule Chapter: 14-97, the main rule on access management standards, considers interchange areas differently than other portions of a corridor. These areas may require spacing of median openings at greater distances than required by the individual access management class of the arterial.

Interchange Areas 14-97.003 1. (i) 3:

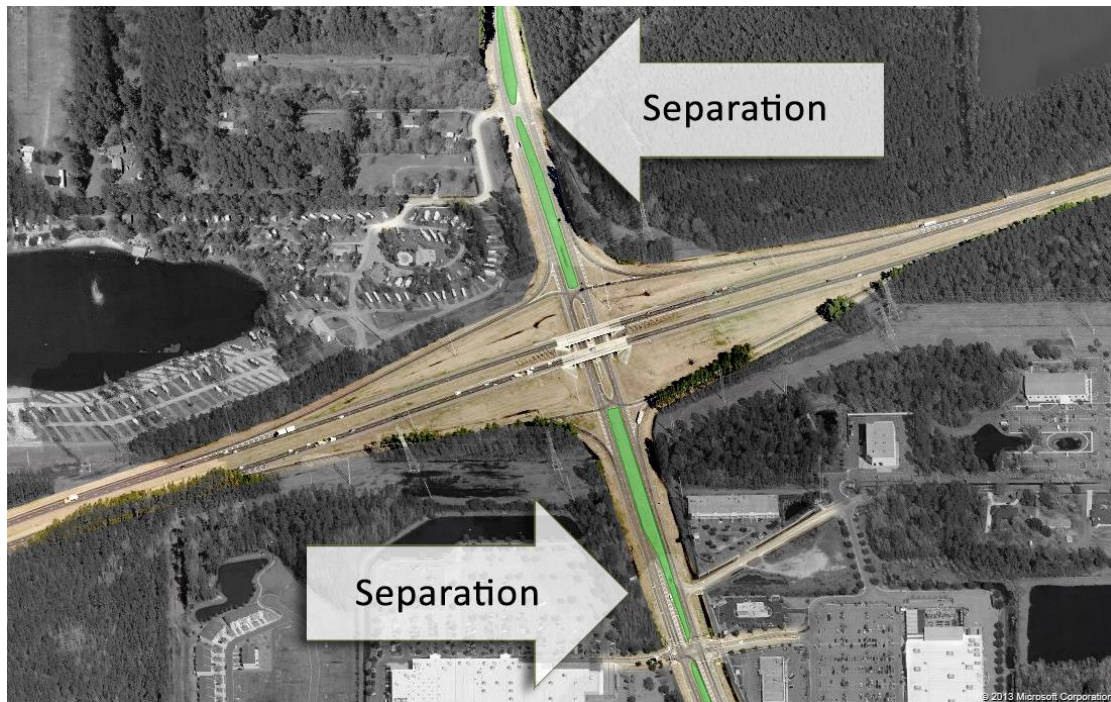
“The standard distance to the first full median opening shall be at least 2,640 ft as measured from the end of the taper of the off ramp.”

Figure 26 illustrates the greater spacing needs in the vicinity of a freeway interchange.

Interchange Areas 14-97.003 1. (i) 4:

“Greater distances between proposed connections and median openings will be required when the safety or operation of the interchange or the limited access highway would be adversely affected. Based on generally accepted professional practice, FDOT makes this determination when the engineering and traffic study projects adverse conditions.”

Figure 26 – Median Openings Near Freeway Interchanges



Source: FDOT

The standards in *F.A.C. Rule Chapter: 14-97* are difficult to achieve in many cases. Therefore, FDOT relies upon generally accepted professional practice to analyze and design the separation of median openings.

Transportation analysis techniques and operational models are added and changed frequently. Other generally accepted professional practice, including transportation simulation models and the Highway Capacity Manual, may also be used.

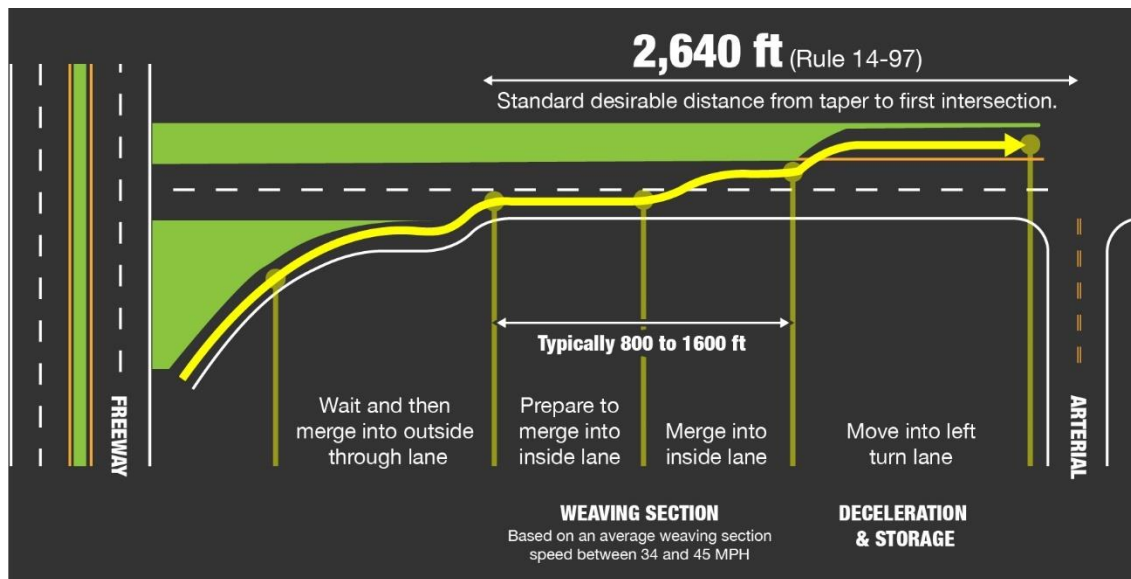
Figure 26 illustrates the rationale behind the 2640' distance between the off-ramp and the first signalized intersection.

Unsignalized On and Off-Ramps

Drivers may make erratic maneuvers in areas where there is a limited separation between the off-ramp and the median opening. Desirable conditions would permit a driver to accelerate, merge into the outside traffic lane, select an acceptable gap in order to merge into the inside lane, move laterally into the left-turn lane, and come to a stop as shown in **Figure 27**. The desired distance needed between an unsignalized freeway off-ramp and median opening at first signalized intersection is 2,640 ft.

Research^{4 5} shows that most urban situations fall within 800 ft to 1,600 ft of conflicting weaving movements within the arterial weaving section, during the peak hour. If a lower average speed such as 35 mph through that section can be achieved, the weave section may be as low as 400 ft.

Figure 27 – Distance Between Off-Ramp and First Signalized Intersection



Source: FDOT

⁴ Jack Leisch – Procedure for Analysis and Design of Weaving Sections 1985

⁵ Robert Layton - Interchange Access Management Background Paper 2 - 1996

Signalized On/Off-Ramps:

If the ramp is signalized, this weaving distance will need to be determined by a signal spacing analysis or other methods and standards.

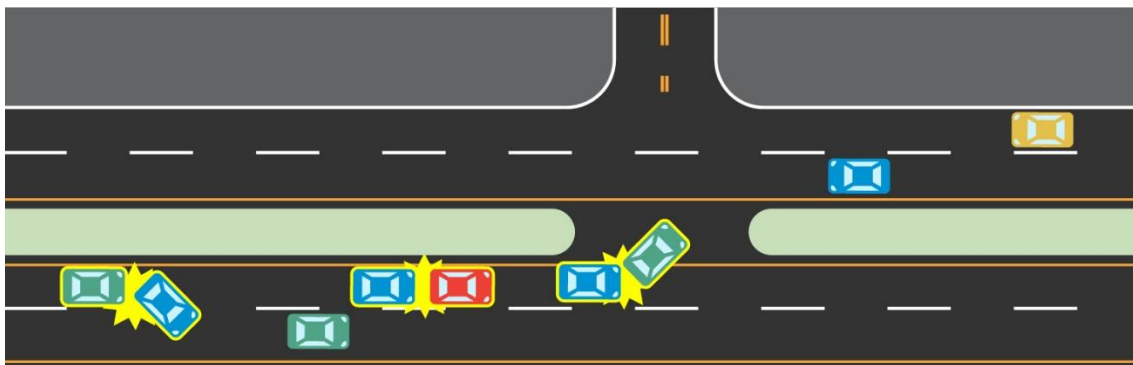
For additional information on median and roadway opening spacing in the vicinity of interchanges see the *TRB Access Management Manual 2nd Edition, NCHRP Report 420, Impacts of Access Management Techniques*. Two national research projects are underway on this topic: *NCHRP 07-23 - Access Management in the Vicinity of Interchanges* and *NCHRP 15-66 - Arterial Weaving on Conventional and Alternative Intersections*.

3.4.3 Median End Treatments

The median end design for an urban arterial should be designed for a passenger vehicle while assuring it can accommodate a larger design vehicle. Alternative median end designs include: semicircular, symmetrical bullet nose, asymmetrical bullet nose and the half-bullet nose.

The “bullet nose” median opening requires a vehicle to make a left turn from a through lane interfering with the through traffic. This will result in a situation with a high potential for rear-end crashes as shown in [Figure 28](#).

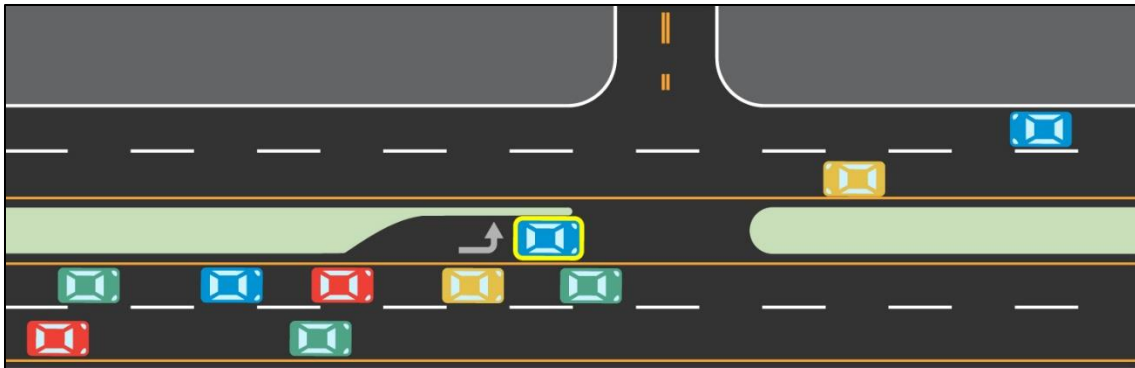
Figure 28 – Potential Crash Problems When Left Turns are Made from the Through Traffic Lane



Source: FDOT

The most common method in which left-turning vehicles can be removed from a through traffic lane is to install a left-turn lane as shown in [Figure 29](#). The lane should be of sufficient length to allow for adequate maneuvering distance plus queue storage as discussed earlier in Section 3.4.2. The total deceleration length, including the taper, should be sufficient to allow the turning vehicle to decelerate from the speed of through traffic to a stop, plus queue storage. Per the *FDOT Median Opening and Access Management Procedure*, “Existing bullet nose median openings should be replaced with an adequate left-turn lane.”

Figure 29 – Left Turn Lane to Remove Left-Turn Vehicles from the Through Traffic Lanes

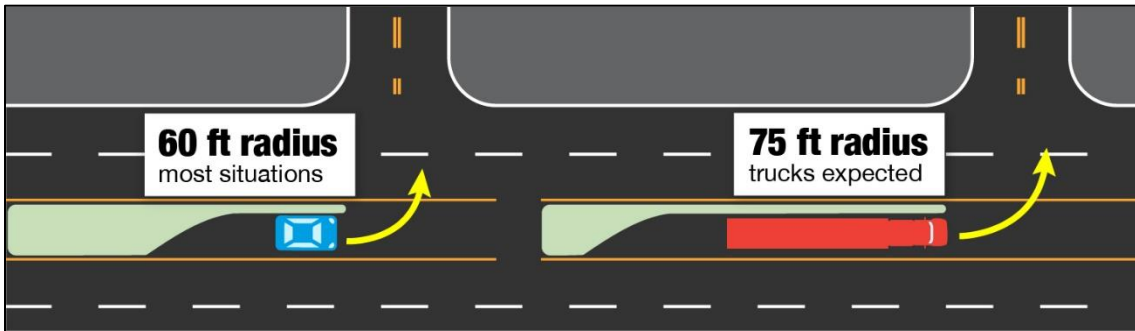


Source: FDOT

3.4.4 Median Opening Left Turn Radius

FDOT has historically used 60 ft. for most situations and 75 ft. when significant truck volumes are expected for left-turn or control radii.

Figure 30 – Typical Radius for Left-Turn Movements



Source: FDOT

The [FDM 212.9](#) provides guidance on median openings and provides control radii for minimum speed turns. The control radius refers to a radius that must be considered in establishing the location of median or traffic separator ends on divided highways and the stop bar on undivided highways. It directs the designer to provide the radius for minimum speed (10-15 mph) left turn movements when appropriate for establishing the location of median ends. [Table 13](#) provides the desired control radius by design vehicle.

Table 13 – Control Radii for Minimum Speed Turns

Design Vehicles Accommodated	Control Radius (ft)			
	50 (40 min)	60 (50 min)	75	130
Predominant	P	SU-30	SU-40, WB-40	WB-62FL
Occasional	SU-30	SU-40, WB-40	WB-62	WB-67

Source: FDM 212 – Intersections (Table 212.9.2)

For more detailed information on design vehicle control radius, see the [FDM 212.9, Median Openings](#).

3.4.5 Median Opening Length

Median opening length is governed by the:

- Turning or control radii
- Side street geometrics
- Median (traffic separator) width
- Intersection skews
- Intersection legs

An excessively wide median opening will store multiple vehicles in an unsignalized full median opening while they are waiting to complete a maneuver. Excessively wide openings result in multiple conflicts for both the turning vehicles and through traffic. The situations illustrated in [Figure 31](#) and [Figure 32](#) are common occurrences at wide full median openings on high-volume roads during peak periods. This often occurs in areas that experienced significant development and growth in traffic volumes since the median opening was originally constructed.

Figure 31 – Vehicles Stopped in Excessively Wide Median Opening



Source: CDM Smith

Figure 32 – Vehicles Stopped in Excessively Wide Median Opening



Source: FDOT

The presence of several vehicles in the median opening results in impaired sight distance, especially when one or more of the vehicles is a pickup, van or RV. Signalization should be considered only if the median opening meets the criteria of a signal warrant analysis.

Alternative solutions to the problem are:

- Reconstruct the unsignalized full opening as a more restrictive median opening
- Close the median opening
- Directionalize the median opening

The solution selected, as well as the design of the restrictive movement (if used) will depend on several factors including; the proximity to other median openings, alternative routes, traffic volumes, and the crash history of the roadway.

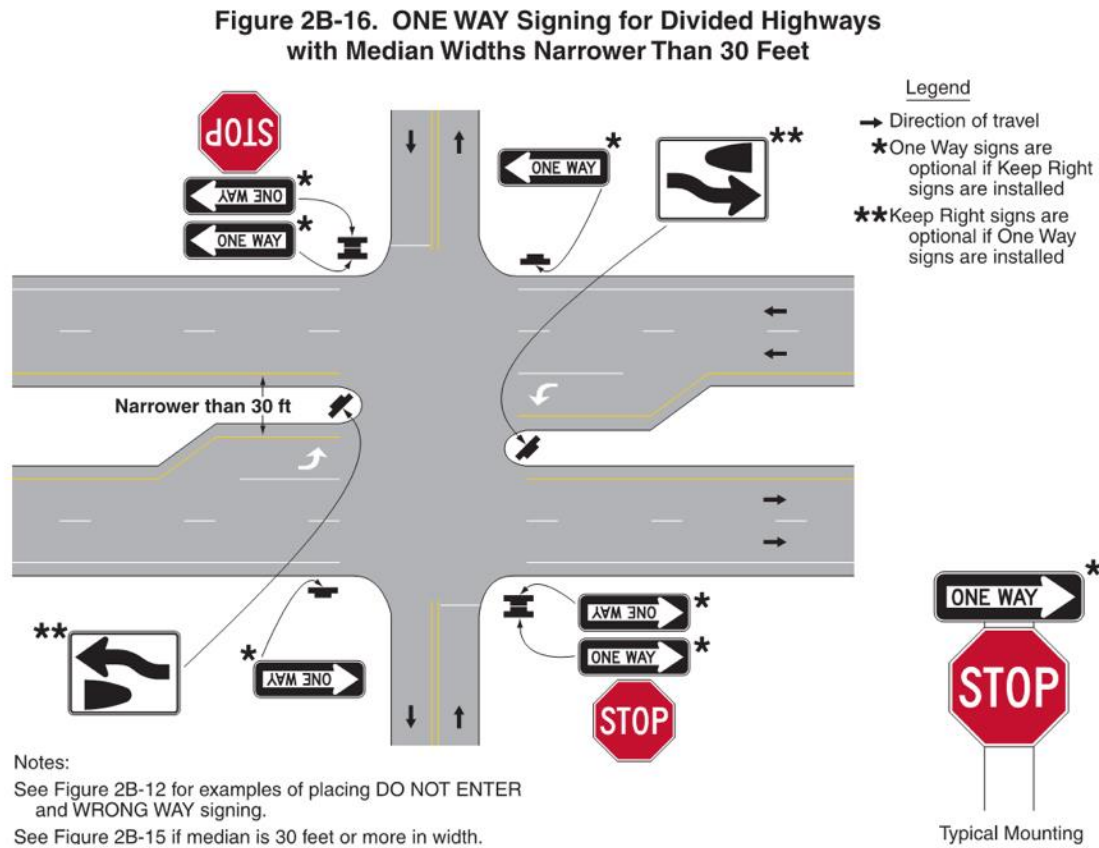
The [FDM 212.9](#), provides additional guidance below on median opening length:

“The overall length of a full median opening is typically the same width as the intersecting road (including shoulders) which is sufficient to accommodate the swept path of left turning vehicles...For un-signalized intersections, median openings should not be longer than the required length to avoid multiple vehicles attempting to stop within the opening.”

3.4.6 Pavement Markings and Signing

The [Manual on Uniform Traffic Devices \(MUTCD\)](#) contains guidance on the type and placement of signs and traffic control devices at median opening areas (See [Figure 33](#)). FDOT also provides guidance for signing and pavement markings in the [FDOT Standard Plans, Index 711-001](#).

Figure 33 – MUTCD Figure 2B-16



Source: MUTCD

3.5 Retrofit Considerations

When resurfacing or altering a segment of a roadway within the SHS, it is recommended that all medians, median openings, and driveways be assessed to determine if it is appropriate to retrofit any of the median characteristics.

3.5.1 Assessing a Median Opening

The following assessment guidance is adapted from *Guidelines for Median Opening Placement and Treatment Type* from FDOT District 5 published in 1996. This practice is still employed by District 5 and considered relevant guidance today.

For the initial assessment of the existing median opening, the design requires data collection and analysis. A 4-step process described below should provide adequate information for decision making on whether to close/alter/or maintain an existing median opening.

1. Determination of Major Cross Streets and Major Driveway Locations

2. Data Collection

- Identification of all existing signalized intersections, as well as those locations scheduled for signalization in the near future
- Elimination of intersections from consideration for signalization (based on proximity to other signalized intersections)
- 24-hour bi-directional approach counts on each leg of each intersection
- Other pertinent traffic data includes;
 - Traffic count locations for vehicle classification and volume to develop traffic characteristics
 - Planned development in the corridor
 - Locations of schools, school crossings, and school zones
 - Locations of facilities/design characteristics that serve emergency vehicles
 - Locations of land uses which have special access requirements (bus terminals, truck stops, fire stations)
 - Existing pedestrian crossings, parks, or other pedestrian generators
 - Existing and proposed bicycle facilities
 - Recent (3 years) crash data, especially individual crash reports

3. Analysis

- Preliminary signal warrant analysis using existing volumes
- Determine if (proposed) signal spacing is adequate using progression analysis
- Verify that existing signals still meet the warrants
- Intersection and arterial capacity analyses based on anticipated roadway improvements to determine overall corridor level of service (using projected design-year data)

4. Recommendations

- Provide a list of existing signalized intersections which are expected to continue to meet the warrants for signalization
- Develop a list of intersections which are candidates for future signalization that will still provide adequate spacing between signalized intersections
- Provide roadway segments where median openings are not recommended (site specific reasoning), as well as noting all existing median openings being closed or modified
- Recommendations for median opening locations and treatment type

Once the recommendation has been made to close/alter/or maintain an existing median opening, the following sections of this handbook provide guidance on how to proceed with that decision.

Closing a Median Opening

The following criteria provides guidance on a recommendation to close an existing median opening:

- Narrow median width (<14 ft or less than length of design vehicle) where left turning vehicles cannot be protected during a two-stage left turn (move to median and then proceed left when the appropriate gap becomes available for the left turn vehicle).
- A combination of high volume left- turn out movements coupled with high through and left- turn in movements, significantly reducing making the availability of available gaps
- High volume of left-out movements onto the major roadway (AADT >27,000 AADT or dictated by existing crash data)

- Disproportionate share of angled crashes involving the left-out turning movement
- Provision of an appropriate place for the displaced left-turn to make U-turns

Driveway consolidation and median opening alterations that would improve traffic conditions as a result of a plan that includes median closure(s).

Altering a Median Opening

Additional guidance on the alteration of an existing median opening based on median width:

- Narrow Median (12 – 14 ft.)
 - Replace a full median opening with a directional opening for left-turns from one direction only
- Median (>14 ft.)
 - Replace a full median opening with a directional opening for left-turns from both directions

3.5.2 Constructing a Raised Median on an Existing Roadway

On a 5-lane or 7-lane roadway with center turn lane;

- Replace the center turn lane with a raised median to restrict movements to right-in/right-out only
- Install a raised median with a directional median opening. Where the center-turn lane width is 14 ft. or more, the directional opening may be designed for left-turns from both directions on the roadway. Where the center turn lane is less than 14 ft. wide, the directional opening should be designed for left-turns from one direction only. Consideration as to the choice as to which connection will have left-turn in movements and which will not include:
 - Alternative access - The directional median opening given to the property not having alternative access, or the less extensive alternative, and
 - Traffic generation - The directional opening going to the property generating the most traffic

For more information on this topic, see [Access Connections on Opposite Sides of Roadway](#), CUTR (2008).

3.5.3 Considerations for Resurfacing, Restoration, and Rehabilitation (3R) Projects

When a 3R project is planned for a corridor, many features of the facility are analyzed. Some of the most important considerations involve access management. These may include:

- Radius improvements at side road driveways due to evidence of off-tracking
- Close abandoned driveway in urban/curb & gutter section to improve ADA accessibility/sidewalk
- Correct driveways that do not meet design standards (i.e. slopes too steep, documented dragging or damaged driveway and/or asphalt on roadway)

- Construct new transit/bus amenities (bus bays, pads for bus shelters, bus stop pads, etc.)
- Construct new turn lanes to meet projected need*
- Lengthen/revise existing turn lanes at signalized intersections due to documented operational issues
 - Any intersection could be revised as needed based on verified crash history⁶⁷

Also, while new driveways on a roadway located on the SHS must go through the full permitting process, driveways that are modified by FDOT due to roadway improvements do not need to go through the full process.

TWLTLS

FDM 210 – Arterials and Collectors provides the following direction:

“Two-way left-turn lane widths (flush median) may be used on 3-lane and 5-lane typical sections with design speeds ≤ 40 mph. On new construction projects, flush medians are to include sections of raised or restrictive median to enhance vehicular, bicycle, and pedestrian safety, improve traffic efficiency, and attain the standards of the Access Management Classification of that highway system. Sections of raised or restrictive medians are recommended on 3R projects.”

3.6 Rural Median Opening Considerations

Unsignalized intersections in rural areas can often lead to some of the most dangerous points of conflict due to generally higher speeds and reduced enforcement of proper driver behavior. Crash data in rural areas has shown a higher proportion of right-angle crashes and injury rates compared to more urbanized areas. It is in the best interest of the travelling public to limit the number of through movements across major roadways from minor roadways. The following sections provide suggestions to improve safety on rural facilities on the SHS.

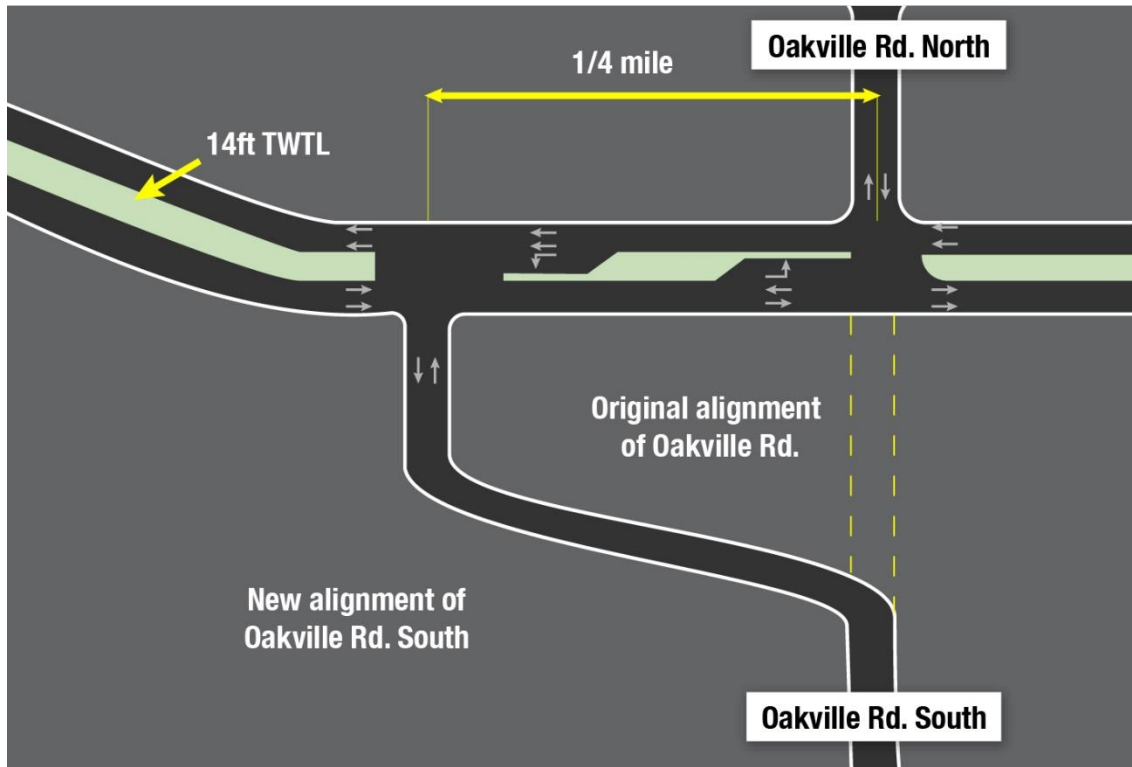
3.6.1 Re-Aligning Minor Roadway Intersections

Where an unsignalized intersection in a rural area experiences a high crash rate, due to a minor roadway crossing a major roadway, it is recommended (when sufficient right-of-way exists) that one of the access points to/from the minor roadway be re-aligned so that a 4-way intersection is modified to create two 3-way intersections, ideally spaced approximately ¼ mile part or more (See [Figure 34](#)). This technique can reduce the number of conflict points from 32 to 24 and reduce serious injury crashes. Specific guidance and case studies for this technique can be found in [NCHRP Report 650 Median Intersection Design for Rural High-Speed Divided Highways](#).

⁶ To remain in resurfacing projects at the engineer’s discretion

⁷ [FDOT Office of Design 02-12 3R Project Scoping “List of Optional Items to Review on RRR Projects” 04/05/2012](#)

Figure 34 – Realigning Roadway to Create Two 3-Way Intersections



Source: New Jersey Department of Transportation

3.7 Special Rural Highway Treatments

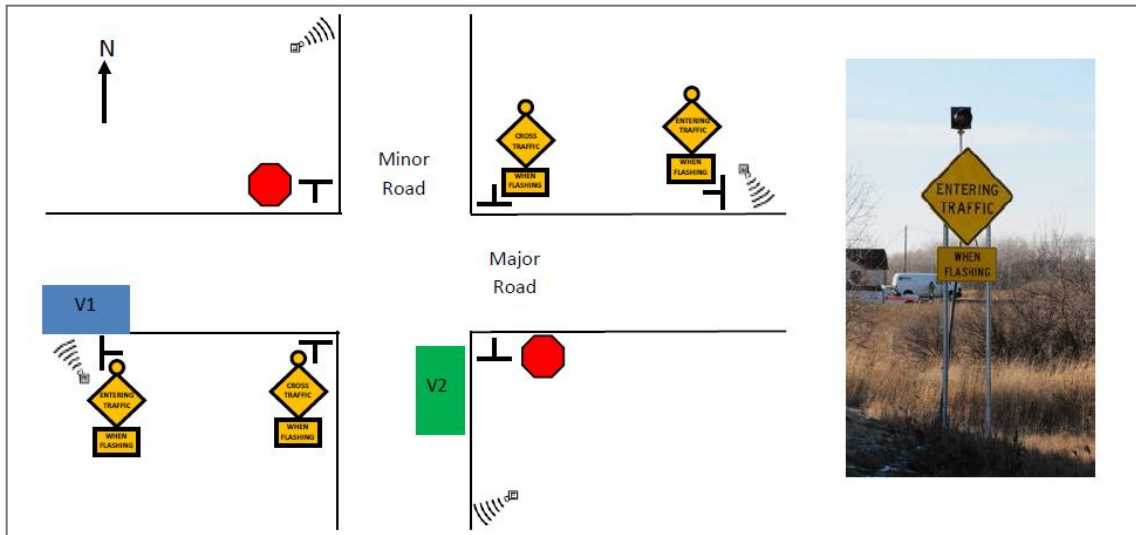
3.7.1 Advance Warning of Oncoming Vehicles on Rural Highways

Innovative treatments of problematic intersections in rural settings have proven to be beneficial in reducing the number of accidents that result in injuries and fatalities. Even though an intersection meets all FDOT guidelines and design standards, certain situations could result in higher than expected conflicts. All geometrics and hazards should be considered when attempting to improve the safety of an intersection and no one method may offer the desired results. It is recommended that FDOT staff should consider innovative treatments if all other design options have been exhausted.

3.7.2 Rural Intersection Conflict Warning System

Another innovative idea designed to alleviate traffic crashes has been developed by the Minnesota Department of Transportation (MnDOT) and employed elsewhere as well. This is illustrated in [Figure 35](#). The system warns motorists if a vehicle is approaching the intersection from either direction. As a vehicle on the minor roadway approaches the major roadway, a red flashing beacon will warn the motorist if vehicles on the major roadway are approaching the intersection. Alternately, as a vehicle on the major roadway approaches the minor roadway, a yellow flashing beacon will warn the motorist if there are vehicles approaching the intersection. This system requires loop sensors in advance of the intersection from each direction.

Figure 35 – Intersection Conflict Warning System (ICWS) Concept



Source: *Rural Intersection Conflict Warning Systems Deployment – Concept of Operations (2012)*
 Minnesota DOT

For more information on ICWS see the *FHWA Enterprise Pooled Fund Multi-state Study* webpage:
<http://enterprise.prog.org/itswarrants/icws.html> or the *USDOT Research and Development* page:
<https://highways.dot.gov/research-programs/safety/safety-rd-overview>

3.8 Context Classification

Throughout *FDM 210* there is guidance on how dimensions for medians and median openings are affected by the context classification. Low speed C5 or C6 roadways require different median treatments than high speed C2 or C3 arterials. [Table 14](#) below illustrates the interplay of context classification and median location and design. *FDM 214 - Driveways* provides guidance on how driveway design is affected by the context classification. Low speed C4 or C5 roadways require different driveway designs than high speed C2 or C3 arterials. [Table 15](#) below illustrates the interplay of context classification and driveway design.

These tables include proposed levels of “Modal Emphasis” (High, Medium, or Low) for each context classification for Car, Bicycle, Walking, Transit, and Truck modes.

A "High" emphasis means this mode should be a primary consideration when designing access management interventions. The access management tools used should optimize for this mode first while continuing to support the other modes. For example, in a C5 downtown location, pedestrians are a "High" emphasis, so pedestrian crossing times and distances should be minimized, and pedestrian crossing opportunities should be maximized. Conversely, in a C2 Rural highway condition, the pedestrian mode is a "Low" emphasis and decisions are made to favor the movement of the Car and Truck Modes, which are "High" emphasis in the C2 context classification.

A "Medium" emphasis means this mode should be expected and incorporated into the access management interventions as a matter of course. Special provisions for this mode should not be needed in normal operation.

A "Low" emphasis means that while this mode will be provided for and considered during the selection and implementation of the access management intervention, this mode may receive only the most general and basic provisions. The design and operation of the intervention will not necessarily be optimized for this mode and may entail lower speeds, longer crossing times, or similar trade-offs in favor of "High" or "Medium" priority modes.

Table 14 – Context Classifications, Medians and Median Openings, and Modal Emphasis

CLASS	CHARACTERISTICS BY MODE	RELATIVE MEDIAN MODAL EMPHASIS BY CONTEXT CLASSIFICATION					GENERAL MEDIAN CONSIDERATIONS
		CAR	BICYCLE	WALKING	TRANSIT	TRUCKS	
C1 Natural <small>Access Class 2,3</small>	Motor vehicles predominant, Occasional bicycle and pedestrian activity, occasional public transportation	High	Low	Low	Low	High	<ul style="list-style-type: none"> Install medians on all major four-lane highways. Provide turn lanes at all median openings Retrofit continuous two-way left turn lanes into restrictive medians
C2 Rural <small>Access Class 2,3</small>	Motor vehicles predominant, Occasional bicycle and pedestrian activity, occasional public transportation	High	Low	Low	Low	High	<ul style="list-style-type: none"> Install medians on all major four-lane highways. Provide turn lanes at all median openings Retrofit continuous two-way left turn lanes into restrictive medians
C2T Rural Town <small>Access Class 4,5,6</small>	Sidewalk paved from utility strip or in some cases the curb edge to face of building, shorter block sizes, higher pedestrian volumes, often on street parking	Medium	Medium	High	Low	Medium	<ul style="list-style-type: none"> Install medians on all major four-lane highways leading into the rural town. Provide turn lanes at all median openings Based on expected traffic and speed, consider 3-lane section through the rural town with enhancements to the pedestrian environment to ensure visibility of pedestrians. Minimize extra driveways Maintain sidewalks across driveway openings Improve left turn conditions to side streets, especially parking and rear delivery entrances. Assure safe, visible, and accessible midblock pedestrian crossings where warranted and signal spacing is greater than 660 feet Preserve the existing street network and intersection spacing based on existing block sizes
C3R Suburban Residential <small>Access Class 3</small>	Bicycles and pedestrians present. Bus transit transportation is usually present. Entrances into subdivisions usually local street design	High	Medium	Medium	Medium	Medium	<ul style="list-style-type: none"> Install medians on all major multi-lane highways. Provide turn lanes at all median openings Retrofit continuous two way left turn lane sections into restrictive medians Assure safe, visible, and accessible midblock pedestrian crossings where warranted and signal spacing is greater than 660 feet
C3C Suburban Commercial <small>Access Class 3</small>	May include activity centers Bicycles and pedestrians present. Bus transit usually present	High	Medium	Medium	Medium	Medium to High	<ul style="list-style-type: none"> Install medians on all major multi highways. Provide turn lanes at all median openings Retrofit continuous two way left turn lane sections into restrictive medians. Assure sufficient turning radii where large vehicles are frequent Assure safe, visible, and accessible midblock pedestrian crossings where warranted and signal spacing is greater than 660 feet
C4 General Urban <small>Access Class 4,5,6,7</small>	Mix of uses within small blocks, well-connected roadway network, some blocks may extend long distances, Road network usually connects to residential neighborhoods along the corridor or behind	Medium	Medium	High	Medium to High	Medium	<ul style="list-style-type: none"> Install medians on all major multi highways. Provide turn lanes at all median openings Retrofit continuous two way left turn lane sections into restrictive medians. Assure sufficient turning radii where large vehicles are frequent Assure safe, visible, and accessible midblock pedestrian crossings where signal spacing is greater than 660 feet Preserve the existing street network and intersection spacing based on existing block sizes
C5 Urban Center <small>Access Class 4,5,6,7</small>	Connected buildings, sidewalk paved from curb to building face, shorter blocks, high pedestrian volumes, high bicycle volumes and bike-share possible, high bus volumes, possible rail or BRT, motor vehicle traffic congested during peak hours	Medium to Low	Medium to High	High	High	Medium	<ul style="list-style-type: none"> Block sizes in these sections should be sufficiently short to not require separate midblock pedestrian crossings. Preserve the existing street network and intersection spacing based on existing block sizes
C6 Urban Core <small>Access Class 4,5,6,7</small>	Connected buildings, sidewalk paved from curb to building face, shorter blocks, high pedestrian volumes, high bicycle volumes and bike-share possible, high bus volumes, possible rail or BRT, motor vehicle traffic congested during peak hours	Medium to Low	Medium to High	High	High	Medium	<ul style="list-style-type: none"> Block sizes in these sections should be sufficiently short to not require separate midblock pedestrian crossings. Preserve the existing street network and intersection spacing based on existing block sizes

Source: FDOT

Table 15 – Context Classifications, Driveways, and Modal Emphasis

CLASS	CHARACTERISTICS BY MODE	RELATIVE DRIVEWAY MODAL EMPHASIS BY CONTEXT CLASSIFICATION					GENERAL DRIVEWAY CONSIDERATIONS
		CAR	BICYCLE	WALKING	TRANSIT	TRUCKS	
C1 Natural Access Class 2,3	Motor vehicles predominant, occasional bicycle and pedestrian activity, occasional public transportation	High	Low	Low	Low	High	<ul style="list-style-type: none"> Wide turning radius and width necessary for multi-unit tractor trailer when present. Extra width needed to accommodate single direction only
C2 Rural	Motor vehicles predominant, occasional bicycle and pedestrian activity, occasional public transportation	High	Low	Low	Low	High	<ul style="list-style-type: none"> Wide turning radius and width necessary for the design vehicle only in one direction
C2T Rural Town	Sidewalk paved from utility strip or in some cases the curb edge to face of building, shorter block sizes, higher pedestrian volumes, often on-street parking	Medium	Medium	High	Low	Medium	<ul style="list-style-type: none"> Minimize the number of driveways to create a consistent pedestrian environment. When driveways are built, the first principle is to keep the sidewalk level across the driveway space. The second is that the flare or apron not cross the sidewalk zone. Vehicular access should be through the side and back. FDOT should reinforce local network connectivity for access/ accessibility (e.g. blocks and local streets).
C3R Suburban Residential	Bicycles and pedestrians present. Bus service common. Entrances into subdivisions usually of local street design	High	Medium	Medium	Medium	Medium	<ul style="list-style-type: none"> Medium turning radii in neighborhoods with attention paid to the pedestrian environment through the use well marked crosswalks. Consider the use of small sized radii, and the use of a reinforced textured raised surface to allow off-tracking of typical multi-unit tractor trailers when present.
C3C Suburban Commercial	May also include activity centers. Bicycles and pedestrians present. Bus service common.	High	Medium	Medium	Medium	Medium to High	<ul style="list-style-type: none"> Wide turning radius and width necessary for multi-unit tractor trailers when present. Extra width may be needed to accommodate two movements exiting and entering at the same time, especially in industrial areas.
C4 General Urban	Mix of uses within small blocks. Well-connected roadway network. Some blocks may extend long distances. Road network usually connects to residential neighborhoods along the corridor or behind.	Medium	Medium	High	Medium to High	Medium	<ul style="list-style-type: none"> Small to medium-sized radii on driveways. Consider the use of small sized radii, and the use of a raised reinforced textured surface to allow off-tracking to the typical multiunit tractor trailer. FDOT should reinforce local network connectivity for access/ accessibility to support rear or side entrances and exits (e.g. blocks and local streets).
C5 Urban Center	Connected buildings, sidewalk paved from curb to building face, shorter blocks, high pedestrian volumes, high bicycle volumes and bike-share possible, high bus volumes, possible rail or BRT, motor vehicle traffic congested during peak hours	Medium to Low	Medium to High	High	High	Medium	<ul style="list-style-type: none"> Minimize the number of driveways to create a consistent pedestrian environment. When driveways are built, the first principle is to keep the sidewalk level across the driveway space. The second is that the flare or apron not cross the sidewalk zone. This establishes that the driver is now entering a pedestrian environment. Vehicular access should be through the side and back of developments. FDOT should reinforce local network connectivity for access/ accessibility to support rear or side entrances and exits (e.g. blocks and local streets).
C6 Urban Core	Connected buildings, sidewalk paved from curb to building face, shorter blocks, high pedestrian volumes, high bicycle volumes and bike-share possible, high bus volumes, possible rail or BRT, motor vehicle traffic congested during peak hr.	Medium to Low	Medium to High	High	High	Medium	<ul style="list-style-type: none"> Minimize the number of driveways to create a consistent pedestrian environment. When driveways are built, the first principle is to keep the sidewalk level across the driveway space. The second is that the flare or apron not cross the sidewalk zone. This establishes that the driver is now entering a pedestrian environment. As much as possible, large vehicle access should be through the side and back of developments. FDOT should reinforce local network connectivity for access/ accessibility (blocks, local streets)

Source: FDOT

Chapter 4: Driveway Dimensions

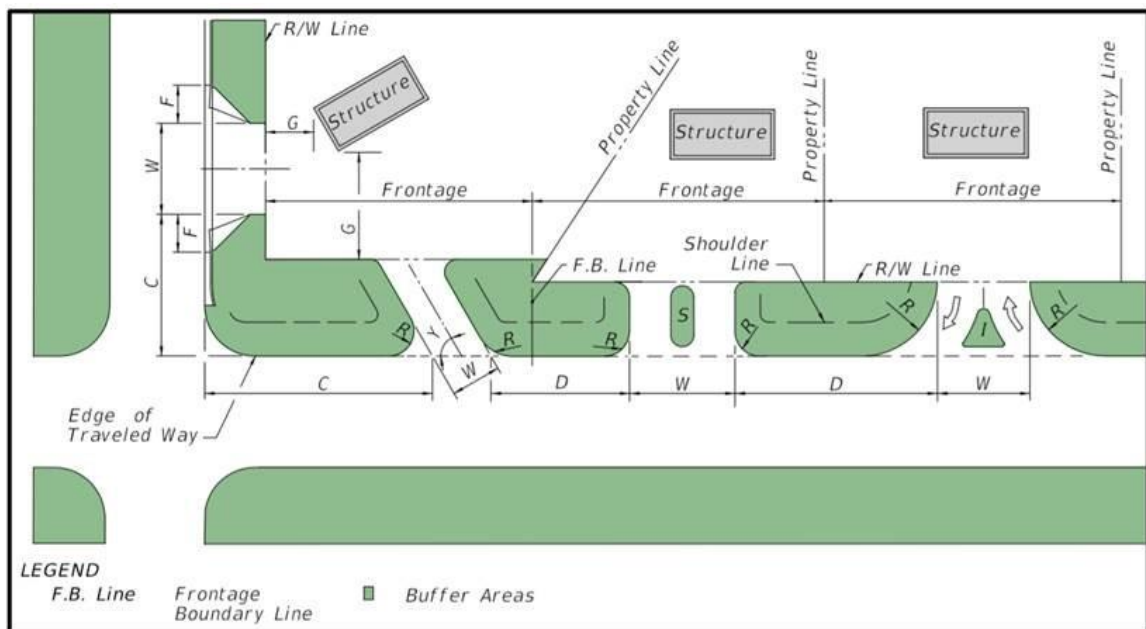
4.1 Overview

The design of driveways is influenced by numerous elements. The design speed of the roadway, the number of vehicles per day that utilize them, the roadway class and FDOT context classification all influence the various geometries of the final design. For example, a higher roadway design speed may require a driveway to have a larger radius. A significant increase in number of vehicles that enter a driveway due to new development may dictate installing a traffic separator. The following section, Driveway Geometries, will discuss the design criteria governing driveways and provide examples of how they affect operations of both the driveway and abutting roadways.

4.2 Driveway Geometries

The design elements and other requirements for driveways are discussed within [FDM 214 - Driveways](#), with construction details detailed in [Standard Plans, Index 522-003 and 330-001](#). This information enables planners and engineers to determine the best designs for driveways based on roadway conditions, the context classification and other conditions. The various design criteria of a driveway are illustrated in [Figure 36](#), which is from *FDM 214 - Driveways*. Each of these elements play an integral role in driveway design.

Figure 36 – Driveway Terminology



Source: [FDM 214 - Driveways \(Figure 214.1.1\)](#)

Taken from *FDM 214*, the text below describes the various design elements that are used to develop driveway designs:

- **Radius (R)** – The radial dimension of curved driveway entry or exit.
- **Flare (F)** – The total length of angled approach/exit at the edge of roadway for a flared driveway.
- **Driveway Connection Width (W)** – Effective width of the driveway, measured between the left edge and the right edge of driveway.
- **Driveway Connection Spacing (D)** – Spacing between driveways from the projected edge line of each driveway (see connection spacing in the FDM Tables 201.3.2 and 201.3.3).
- **Corner Clearance (C)** – Distance from an intersection, measured from the projected closest edge line of the intersecting roadway to a driveway projected edge line (see connection spacing in Tables 201.3.2 and 201.3.3).
- **Angle (Y)** – Angle of the driveway between the driveway centerline and the roadway edge of traveled way.
- **Setback (G)** – Distance from the right-of-way (R/W) line to the closest permanent structure.
- **Driveway Location** – Position of driveway in relation to other traffic features such as intersections, neighboring driveways, median openings, and interchanges.
- **Driveway Length** – Distance needed into the site to transition vehicles to the internal circulation system of the site.
- **Driveway Traffic Separators (S)** – Linear islands or raised medians used to separate traffic movements on the driveway.
- **Channelizing Islands (I)** – Used to facilitate right turns and discourage left-turn movements on the driveway.

As discussed in the previous chapters, there are seven different driveway categories (A – G). This chapter focuses on the first four (A – D). The various driveway design elements which are listed above are influenced by the driveway category, roadway type (Curbed vs. Flush shoulder) and context classification. These three areas affect the recommended dimensions (See [Table 16](#) and [Table 17](#)).

Table 16 – Driveway Dimensions (Curbed Roadways)

Element	Description	Connection Category		
		A	B	C & D
			Two-Way	Two-Way
C & D	Corner Clearance and Driveway Connection Spacing	See connection spacing in FDM Tables 201.3.2 and 201.3.3		
F	Flare (Drop Curb)	10' Min	10' Min	N/A
G	Setback	12' Min., All categories.		
R	Radial Returns (Radius)	N/A	See Note 1	25' Min 50' Std 75' Max
S	Driveway Traffic Separator or Median	N/A	4'-22' Wide	4'-22' Wide
W	Connection Width	12' Min 24' Max	24' Min 36' Max	24' Min 36' Max
Y	Angle of Driveway	60° - 90°		

Note 1: Small radii may be used in lieu of flares for curbed roadways in Connection Category B when approved by the Department.

Source: [FDM 214 - Driveways \(Table 214.3.1\)](#)

Table 17 – Driveway Dimensions (Flush Shoulder Roadways)

Element	Description	Connection Category		
		A	B Two-Way	C & D Two-Way
C & D	Corner Clearance and Driveway Connection Spacing	See connection spacing in FDM Tables 201.3.2 and 201.3.3		
F	Flare (Drop Curb)	N/A		
G	Setback	12' Min., All categories.		
R	Radial Returns (Radius)	15' Min 25' Std 50' Max	25' Min 50' Std 75' Max	25' Min 50' Std (Or 3-centered curves)
S	Driveway Traffic Separator or Median	N/A	4'-22' Wide	4'-22' Wide
W	Connection Width	12' Min 24' Max	24' Min 36' Max	24' Min 36' Max
Y	Angle of Driveway	60° - 90°		
Note 1: Small radii may be used in lieu of flares for curbed roadways in Connection Category B when approved by the Department.				

Source: *FDM 214 - Driveways (Table 214.3.1)*

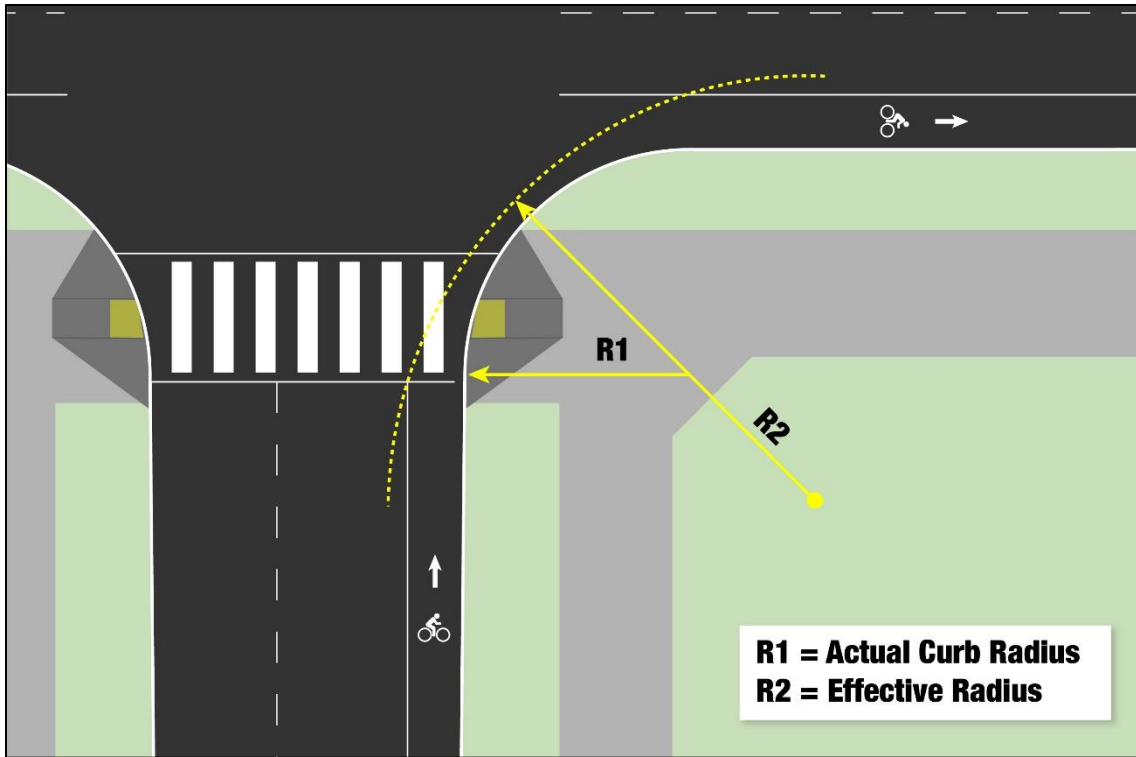
4.2.1 Radius (R)

The radius of a driveway (also called radial return) affects the turning movements of vehicles. Smaller radii, such as the 15' and 25' minimums in [Table 17](#), force drivers to slow down when turning. Larger radii, such as the 50' and 75', allow vehicles to turn more quickly but increases the crossing distance for pedestrians and bicycles. Lower turning speeds are preferable in higher context classifications and C2T, as well as other locations where speed management is desired.

Effective Radius

It is sometimes possible to accommodate both non-motorized users and large vehicles by utilizing an effective radius approach as illustrated in [Figure 37](#). This shortens pedestrian crossing distance and can reduce R/W requirements. The presence of a bike lane or parking lane creates an “effective radius” that allows a smaller curb radius to be constructed than otherwise would be required for some motor vehicles because these lanes occasionally can provide turning vehicles extra maneuvering space.

Figure 37 – Actual and Effective Curb Radius



Source: FDOT

Large Vehicular Movements

It is important to design roadways using a context sensitive design, to ensure large vehicles can be accommodated while safely providing for non-motorized users. For a driveway that serves multiple larger vehicles every hour, it is recommended that the final design provide assistance to these types of vehicles to minimize any potential operational or safety issues arising from conflicts with other users.

In context classifications C4 - C6, care should be taken to balance large vehicle needs and pedestrian needs. [Table 18](#) below provides some general guidance on driveway design to be used along with [Table 16](#) and [Table 17](#).

Table 18 – Recommended Driveway Design Criteria Based on Large Vehicle Use

Number of Trucks or Buses Per Hour	Operation to Design for:	Design Vehicle
Commercial and Office Uses		
≤ 2	Simultaneous 2-way	P-Vehicle or a Standard Passenger Vehicle*
≥ 3	Simultaneous 2-way**	Single Unit vehicle (typical FedEx or UPS Truck)
Industrial Uses		
	Simultaneous 2-way	Typical multi-unit tractor trailer
Other Uses		
Truck stop	Simultaneous 2-way***	Largest Vehicle****
Transit Center/ Bus Terminals	Simultaneous 2-way	Largest Bus
Recreational with RVs and trailers	Simultaneous 2-way	Motor Home w/ Trailer
* A standard passenger car (P vehicle) can enter while another standard passenger car (P vehicle) is waiting to exit.		
** A standard delivery Single Unit truck (SU vehicle) can enter when a standard passenger car (P vehicle) is waiting to exit.		
*** Designed so that larger vehicles can off-track through the driveway		
**** Interstate semi-trailer and turnpike double trailer will be the design vehicle in many states, especially in the vicinity of freeway interchanges.		

Source: Adapted from *Transportation and Land Development, 2002, Stover (pages 7-12)*

4.2.2 Flare (F)

As mentioned previously in **Roadway Openings** there are two main types of driveways; flared and radial return. The flare design criterion is applicable towards flared driveway designs for driveway categories A and B. A flared driveway is intended for areas where there are low vehicular volumes and low speeds for vehicles entering or exiting and where a curb and gutter exists.

Flare is described as the total distance between the beginning of the angled approach at the edge of the roadway. Per **Table 16**, the minimum requirements for driveway flare are 10'. There are some instances where a small radial return design can be used in lieu of a flared driveway on curbed roadways on category B driveways, but this must be approved by the Department. An example that shows the flare at a flared driveway can be seen in **Figure 38**.

Figure 38 – Flared Driveway Example



Source: Google Earth – Tallahassee, FL

Important Considerations

While a driveway may meet the requirements to design a flared driveway (curbed roadway and driveway category A/B), it may not be appropriate to design this driveway type depending on the circumstances. It is important to review these factors thoroughly:

- Speed of traffic on roadway
- Amount of traffic expected on the driveway (especially the chances of a vehicle in the driveway attempting to exit as another vehicle enters)
- Amount of available R/W, since the radial return may require more land
- Vehicle type (Design Vehicle) typically present

There are also certain instances when a radial return driveway is appropriate in comparison to a flared driveway. For a roadway with a flush shoulder, a radial return driveway design is most appropriate.

4.2.3 Driveway Connection Width (W)

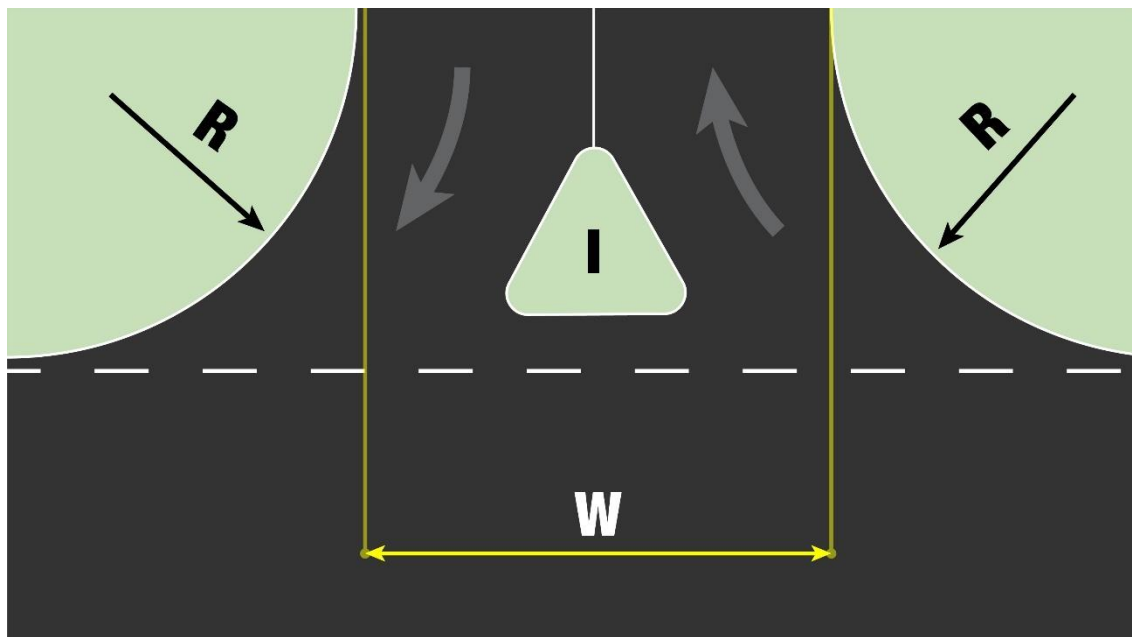
The width of the driveway is an integral part in the driveway design because it affects how quickly or easily a vehicle can enter and exit. One of the goals of good driveway design is to serve the entry and exit movements separately so the movements do not encroach on each other. This allows a vehicle to enter the driveway without encroaching on the area needed for a vehicle to exit the driveway.

A larger width also allows for vehicles to enter at a higher speed, potentially reducing roadway congestion and crashes as vehicles following the turning vehicle do not have to decelerate suddenly. A driveway with too small of a width could force vehicles to slow more than the following driver expects, thus leading to a collision. It is important to correctly design driveway width to minimize these types of collisions and situations. Context classification provides useful information about where higher-speed driveways may be appropriate. As shown in [Table 15](#), context classifications C1, C2, and C3C have a "High" or "Medium to High" modal priority for trucks and autos, so higher speed design may be more appropriate in these locations.

Alternatively, while designing driveways with large widths would decrease the burden for persons driving, it would likely increase it for pedestrians, bicyclists and other non-vehicular users. For pedestrians walking on a sidewalk crossing a driveway entrance, the width is critical because it greatly increases their exposure to traffic. More discussion on exposure for non-motorized users will be in ***Integration Considerations***. Context classification provides useful information about where higher-speed driveways may be appropriate. As shown in **Table 15**, context classifications C2T, C3C, C4, C5 and C6 have a "Medium" or "Medium to Low" modal priority for trucks and autos, so lower speed design may be more appropriate in these locations.

The width of the driveway and how it is measured is dictated by several factors. One is the angle of the driveway itself, which will be discussed later in this chapter. An example of how to appropriately determine the width of various driveways can be seen in **Figure 39**. The correct method for measuring a driveway is to begin from the left edge and end at the right edge. Traffic separators and channelizing islands should be included within this measurement as well, as can be seen in the figure below.

Figure 39 – Driveway Width



Source: *Adapted from FDM 214 - Driveways (Figure 214.1.1)*

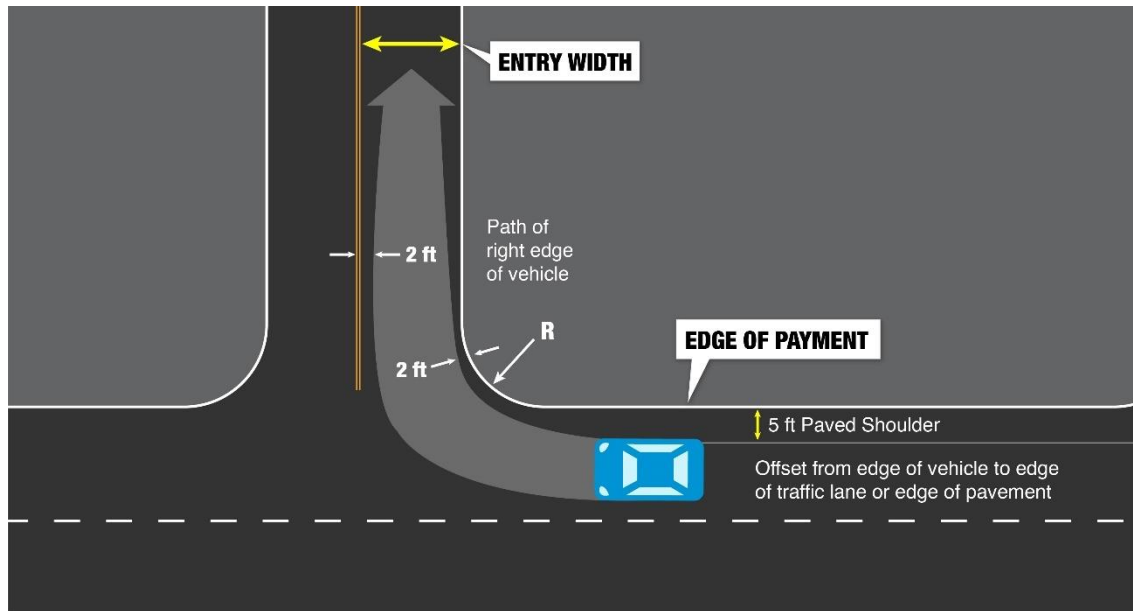
Driveway width and radius can be used in combination to create good driveway operation. Generally, a wide driveway can be used in combination with a small radius or flare to achieve similar operations. **Figure 40** shows the relationship between width and radius that provide for the entering passenger vehicle at approximately 10 mph to enter without encroaching on an outbound driveway vehicle.

For driveways with expected volumes of less than 20 per-day (a single home or duplex), it may not be necessary to design for “the no encroachment standard” with an outbound vehicle. For driveways above an expected volume of 20 per-day, the proper implementation of a radius is needed.

Excessive width of a driveway can create problems for both drivers and pedestrians. If the driveway is over 36' wide, pavement markings or channelization is generally needed to help guide the driver to the appropriate portion of the driveway. Pedestrian crosswalks are also encouraged to increase visibility to drivers entering and exiting the driveway as the width of a driveway increases.

Without the guidance of markings, drivers exiting a driveway tend to position themselves left of the driveway center. Double yellow paint lines help in guiding exiting drivers to the proper exit position. This helps ensure that the intended driveway width is available to drivers making an entry maneuver.

Figure 40 – Driveway Width and Radius



Source: FDOT

NCHRP Report 659 provides detailed guidance on the interaction of driveway width and radius. The driveway width and the curb radius can perform in concert, so to some degree one can increase as the other decreases. In other words, a wide driveway can be used together with a small radius or flare to achieve similar operations to a narrower driveway with a larger radius or flare. When only one vehicle is expected to be using the driveway at any given time, such as a residential driveway serving a two-car garage, the smaller radii are suitable with the greater widths.

Table 19 offers guidelines for driveway width and radius. These dimensions do not consider the presence of an offset between the outer edge of the traveled way and the end of the driveway, i.e., the driveway threshold.

Table 19 - Driveway Width and Curb Radius Guidelines

Category	Description of Common Applications	Driveway Width	Driveway Curb Radius (in ft.)		
			Higher speed road	Moderate speed road	Lower speed road
STANDARD DRIVEWAYS					
Very high intensity	Urban activity center, with almost constant driveway use during hours of operation.	Many justify two lanes in, two to three lanes out. Refer to street design guides.	30–50	25–40	NA
Higher Intensity	Medium-size office or retail (e.g., community shopping center) with frequent driveway use during hours of operation.	One entry lane, 12–13 ft. wide Two exit lanes, 11–13 ft. wide.	25–40	20–35	NA
Medium intensity	Smaller office or retail, with occasional driveway use during hours of operation. Seldom more than one exiting vehicle at any time.	Two lanes, 24–26 ft total width	20–35	15–30	NA
Lower intensity	Single-family or duplex residential, other types with low use, on lower speed/volume roadways. May not apply to rural residential.	May be related to the width of the garage, or driveway parking. Single lane: 9–12 ft Double: 16–20 ft	15–25	10–15	5–10
SPECIAL SITUATION DRIVEWAYS					
Central Business District	Building faces are close to the street.	Varies greatly, depending on use	NA	20–25	10–15
Farm or ranch; Field	A mix of design vehicles; some may be very low volume.	Min. 16 ft, desirable 20 ft. Affected by widths of field machinery.	30–40	20–30	NA
Industrial	Driveways are often used by large vehicles.	Minimum 26 ft	50–75	40–60	40–60
<p>NOTES:</p> <ol style="list-style-type: none"> 1. These widths do not include space for a median or a parallel bike lane or sidewalk. 2. Additional width may be needed if the driveway has a curved horizontal alignment. 3. For a flare/taper design, use the radius as the dimension of the triangular legs. 4. For industrial or other driveways frequented by heavy vehicles, consider either a simple curve with a taper or a 3-centered curve design. 5. For connection angles greatly different than 90 degrees, check the radius design with turning templates. For connection corners at which a turn is prohibited, a very small radius is appropriate 6. Driveways crossing an open ditch should have a minimum 2 ft shoulder on each side. 7. (Source: <i>Statewide Urban Design and Specifications</i>, Iowa State U., Ames, IA (October 21, 2008) p. 4.) 8. If the roadway has a usable shoulder, a somewhat smaller radius may perform acceptably. 					

Source: NCHRP Report 659 Exhibit 5-24 Driveway width and curb radius guidelines

One-Way Driveway Widths

While most driveways allow for vehicles in both directions, there are times when a one-way only direction is warranted. NCHRP 659 provides some information and guidance on these types of driveways:

Only a small fraction of driveways operate in a one-way mode. Information on which to base guidance for the design of one-way driveways is limited and, as Table 20 shows, current agencies' standards differ considerably. Structured studies of one-way driveway design elements would be helpful.

Table 20 - One-way driveway widths from selected states.

Agency	Source	Category	Width for one-way
Missouri	940.16 (5/13/09)	Driveway	20–30 ft
New Jersey	C-11 (6/20/07)	Driveway	20–23 ft
New York	608-03 (1/8/09)	Minor Commercial	12–24 ft; 16 ft normal
Utah	12.1.1601.10	Driveway	12–32 ft

Source: Adapted from NCHRP Report 659

4.2.4 Driveway Connection Spacing (D)

The distances between connections is a key component when determining the location of a driveway. Placing a driveway too close to another could potentially cause traffic congestion and operations issues between vehicles. The appropriate method for measuring the distance between driveway connections is to begin at the near edge of one driveway and the near end at the edge of another. [Figure 36](#) provides examples of how driveway connection spacing is measured.

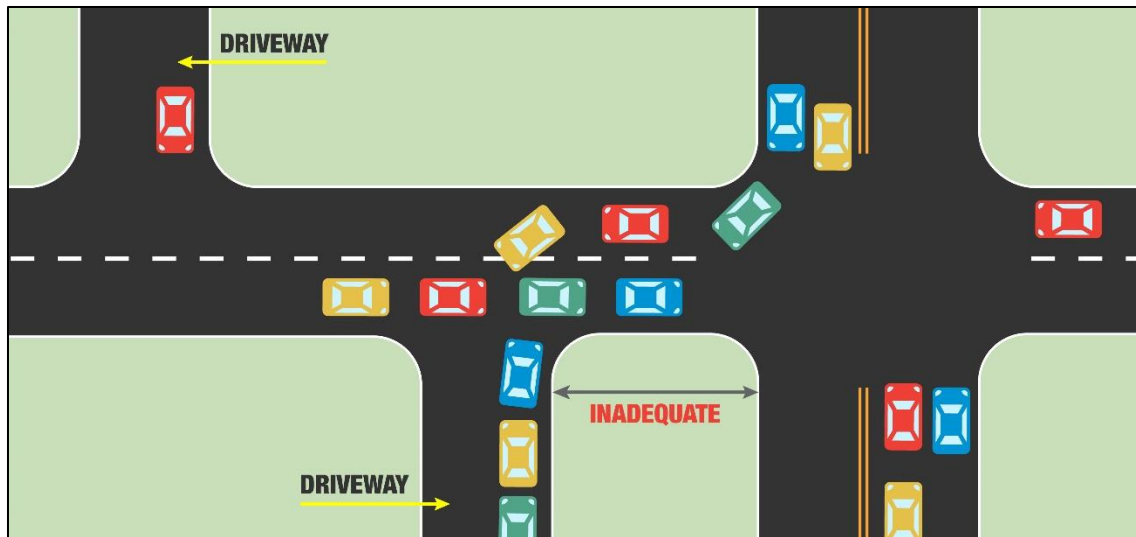
To alleviate any potential issues, there are spacing standards for driveways based on posted speeds and roadway access classification. More information on these standards can be found in [Table 7](#).

4.2.5 Corner Clearance (C)

Corner clearance design criterion is described as the distance from one connection to an intersection. Guidance governing the distance between a driveway and intersection is based on roadway access classification (1-7) and the speed limit. [Table 3](#) describes the connection spacing standards for driveways and intersections. For example, a roadway with access classification 6 has a recommended corner clearance of 440' when the speed limit is over 45 MPH and 245' when 45 MPH or lower. The appropriate way to measure corner clearance is from the beginning of the connection to the nearest edge of the intersection. [Figure 36](#) shows examples of corner clearance.

Driveways located too close to an intersection may have potential safety or operational issues, as shown in [Figure 41](#). This is because vehicles attempting to exit the driveway may need to queue for significant periods of time due to being blocked by vehicles in the roadway near the intersection. Also, congestion could occur if a vehicle attempted to cross the lane and turn into the driveway from the opposite direction. These are just two of the situations that could occur from a driveway being too close to an intersection.

Figure 41 – Corner Clearance and Driveways



Source: FDOT

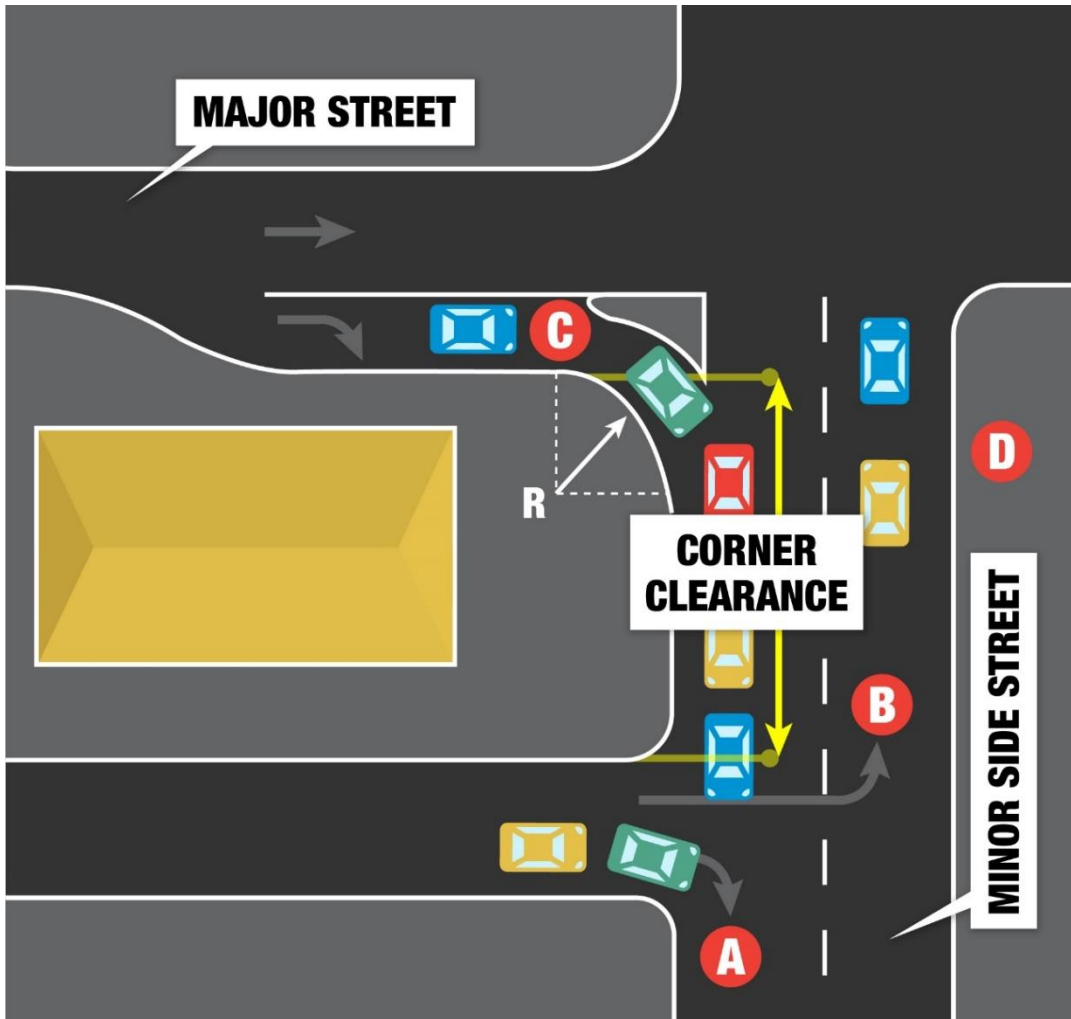
The minimum corner clearance guidance can be found within *F.A.C. Rule Chapter: 14-97.003(1)(i)*. When this cannot be met due to specific site conditions, guidance offered by the CUTR report for FDOT *Model Access Management Policies and Regulations for Florida Cities and Counties: 2nd Edition* suggests that reviewing agencies consider the following regulatory strategies:

- Require that the access connection be located as far from the intersection as possible
- Limit driveway movements to right-in/right-out only and require construction of a non-traversable median or flexible pylon as conditions of the permit, if necessary, to limit the movements
- Limit the maximum driveway volume (vehicles per hour and vehicles per day) as a condition of the permit

Important Considerations

Corner clearance is important for traffic flow upstream from an intersection, but in certain circumstances, it also is important for downstream traffic. For example, there must be enough corner clearance with a driveway that is constructed on a small side street to a major roadway. Vehicles that are exiting the major roadway may be traveling at a high speed. An example of this can be seen in [Figure 42](#) below; if the vehicle in the driveway is attempting to make a right turn (A), then vehicles coming from the main roadway (C) may be turning at a high speed and may not have enough time to stop and avoid a collision with the vehicle making a right turn from the driveway. Vehicles that are queuing (D) to exit onto the major roadway may prevent vehicles making a left turn (B). In both situations, a driveway that is too close to the major roadway could lead to safety or operational issues. Suggested guidance for minimum downstream corner clearance to side streets is provided in [Table 21](#) below.

Figure 42 – Downstream Traffic & Corner Clearance Issues



Source: FDOT

Table 21 – Downstream Corner Clearance for Side Street

Radius (Feet)	Minimum Suggested Corner Clearance (Feet)
50' - No Channelization	120'
50' - Channelization	200'
75' - Channelization	230'
100' - Channelization	275'

Source: Vergil Stover – Transportation and Land Development – ITE, 2002

4.2.6 Angle (Y)

The angle which a driveway connects to the roadway is one of the factors that influences the speed drivers will need to slow to complete their turning movement. For all driveway categories and types, the appropriate angle for driveways is from 60-degrees to 90-degrees. Typically, a driveway should be designed with a 90-degree angle as that is the angle that drivers expect. Driveways that deviate from this expectation could cause safety issues, especially on high-volume driveways. Driveways with large angles also increase the distance and exposure risk for pedestrians, bicyclists and other users that may need to cross it.

The method for measuring the driveway angle is to begin at the centerline of the driveway and end at the edge of the traveled way of the roadway (See [Figure 36](#)). It should be noted that per *FDM 214*:

“The Angle of Driveway for Connection Category A may be reduced with approval by the local Operations/Maintenance Engineer.”

4.2.7 Setback (G)

The distance from the R/W line to the nearest structure is called the “setback” distance (See [Figure 36](#)). For any driveway design or type, the minimum distance is 12’ (See [Table 16](#) or [Table 17](#)). While this is the minimum, some situations may require different setback distances depending on the context classification and local conditions.

When there is not enough “setback” distance from the structures on the site, there could be potential safety issues with the driveways on that site due to vehicles traveling too close to the structures. [Figure 14](#) and [Figure 15](#) demonstrate how a structure’s setback was changed and potentially enhanced the safety of the site and roadway. By increasing the setback, the traffic flow of the site was able to be modified and one of the driveways could be closed. This reduced the amount of connections from four to three, considerably increasing the overall safety of this portion of roadway.

4.2.8 Driveway Traffic Separators (S)

Per the FDM, this design criterion is defined as, “Linear islands or raised medians used to separate traffic movements on the driveway.” (See [Figure 36](#)). Per the driveway dimension [Table 16](#) and [Table 17](#), the width for a traffic separator within a driveway for categories B - D is 4’ to 22’ depending on the conditions; traffic separators are not required for category A driveways.

Important Considerations

While traffic separators can assist with separating entering and exiting driveway traffic flow, thus reducing potential safety issues for vehicles, they can also lead to potential safety issues for pedestrians and bicyclists. If a 6’ - 22’ traffic separator is used as a pedestrian refuge, then curb cuts and sidewalks should also be installed to accommodate wheelchairs, strollers and those with mobility impairments.

Larger vehicles, such as buses or semi-trailers, may also cause potential safety issues for bicyclists or pedestrians. These vehicles may encroach onto the traffic separator due to their large turning radius, or their mirrors or other portions of the vehicle could potentially impact the area where a pedestrian or bicyclist is located.

4.2.9 Channelizing Islands (I)

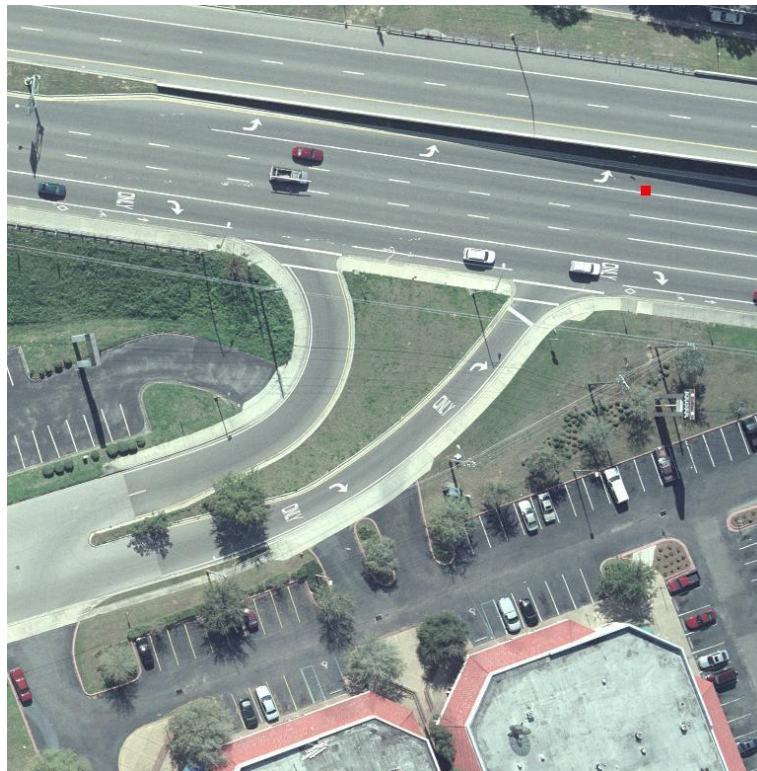
A channelizing island (divisional island) is another design criterion, similar to a traffic separator. These islands serve the same purpose in directing traffic at a driveway to ensure traffic separation and flow but are typically reserved for a significant amount of traffic. The following situations are where a channelizing island may be considered:

- A large pavement area which may confuse drivers
- Right-in/right-out driveways where movements may be unclear
- The driveway is expected to have a signal in the future
- The driveway has two or more entrance lanes

Important Considerations

The context classification of the area and the typical vehicles that use it must be considered when designing channelizing islands. For example, if there are numerous trucks which use the driveway, a larger channelizing island will likely be required. An example of this can be seen below in [Figure 43](#).

Figure 43 – Large Driveway Channelizing Island



Source: Tallahassee, FL – Google Earth

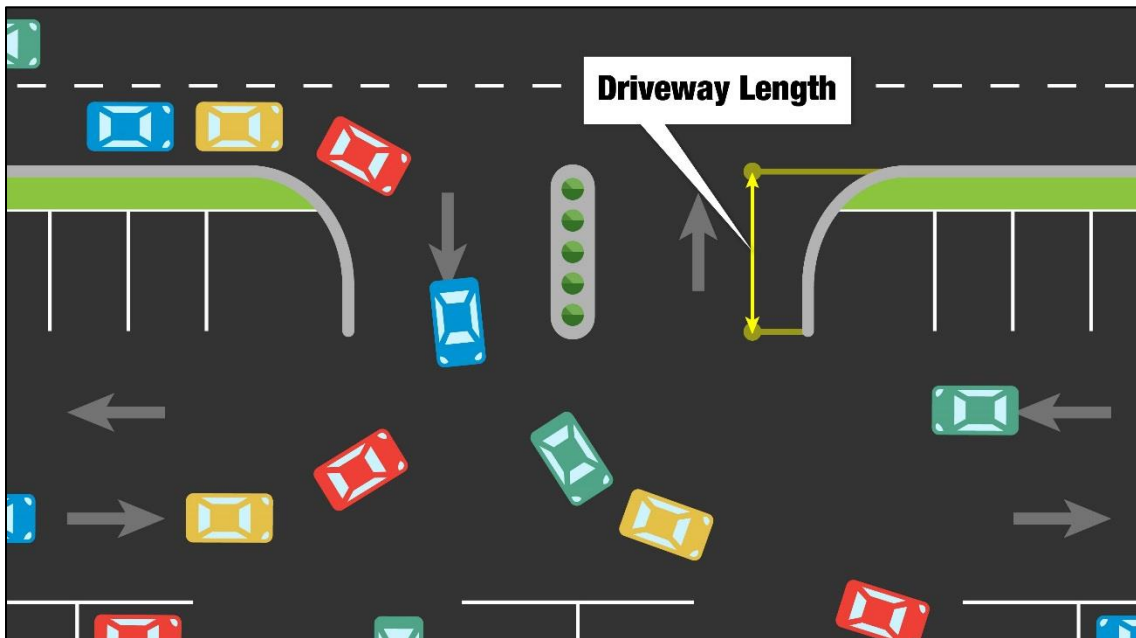
While larger islands may help with traffic, thought must be given to pedestrians and bicyclists who must cross these areas. These larger islands ultimately increase the crossing distance for non-motorized users and could decrease overall safety the overall risk. Channelizing islands that are too small may not be seen well by drivers when entering or exiting the driveway.

4.2.10 Driveway Length

Sufficient driveway length helps make the driveway operate more efficiently. As vehicles enter a site, they should be able to move quickly enough so that they don't interfere with traffic within the site nor interrupt traffic that is moving along the roadway. A driveway that is too short could delay vehicles exiting the roadway as the driveway is filled with vehicles entering. This can lead to rear end collisions. Similarly, if there are multiple conflict points near the driveway, this could cause delays for people entering the site and similar issues. An uninterrupted area (driveway length) before the first conflict point on site is an important tool to prevent these scenarios. The greater the volume using the driveway, the more the driveway should be designed like a roadway intersection.

The appropriate method for measuring a driveway's length is to begin from the edge of the traveled way to the first "conflict point". Below is an example of a driveway that is not long enough (See [Figure 44](#)). As vehicles attempt to enter the site, they are blocked by others who are attempting to exit or park. Not only is this driveway not long enough, but a traffic separator or channelizing island (as shown below) is needed to improve the operation and traffic flow of this driveway.

Figure 44 – Improper Driveway Length



Source: FDOT

Major driveways to large developments should be designed as roadway intersections and not just a simple driveway. This type of access will have multiple lanes and sufficient positive guidance to the driver.

For driveways that may be signalized, driveway length should be determined by a traffic study of expected future traffic and queues. An important measurement in determining the driveway length is the outbound queue. The estimates in [Table 22](#) can be used for unsignalized driveways or for a first estimate of driveway length.

Table 22 - Recommended Minimum Driveway Length for Major Entrances

Land Use	Driveway Length (In feet)
Any major entrance to a development with 4 or more total lanes in the driveway. (Typically, malls and “Big Box Centers”)	300 or greater, based on traffic study
Regional Shopping Centers (over 150,000 sq. ft.)	250
Community Shopping Center (100-150,000 sq. ft.) (supermarket, drugstore, etc.)	150
Small Strip Shopping Center	50
Smaller Commercial Developments (convenience store with gas pumps)	30
Note: for large developments (such as regional malls, big box centers, or regional office centers), the total recommended length is not necessary for all entrances, only the major ones.	

Source: Adapted from Vergil Stover unpublished course notes

Additional discussion on driveway length can be found in NCHRP Report 659. **Table 23** from this report presents simplified guidance on driveway length (also referred to as throat length) based on number of lanes and type of control.

Table 23 - Minimum Driveway (Throat) Length Based on the Type of Control and Number of Lanes

Type of Control	Number of Exit Lanes Present			
	1 Exit Lane	2 Exit Lanes	3 Exit Lanes	4 Exit Lanes
Stop Sign	30 to 50 ft	50 ft (2 cars)	--	--
Signal	N/A	75 ft	200 ft	300 ft
Note: N/A indicates no value given				

Sources: Transportation and Land Development, 2nd ed. (2002), p. 7-28 (5-13) and Access Management Manual (2014), p. 31-316

Important Considerations

For corridor improvements (not during the driveway permit process), the ability to design adequate driveway length may depend on existing development and available R/W. Where the land use along the corridor is dense, driveway length might be restricted at individual locations. Working with the property owner for a better design on their property will benefit the business as well as the driver. Coordination with the local government might be needed where landscaping or parking spaces are impacted.

Drive-through Queues

When determining site design, including driveway length, knowledge of the expected queue of drive-through traffic is important. These queues should be stored away from the area of the driveway used for driveway length. This is especially important in areas that are classified as the C3C – Suburban Commercial context classification. C3C areas typically have a disconnected roadway network (non-grid pattern) and thus roadways that are arterials have a higher likelihood of high vehicle speeds. Land-use types that produce a significant number of vehicle trips that also include a drive-through should be studied carefully to not impact the vehicles which are not visiting these sites.

It is also important to ensure access for non-motorized users (pedestrians, bicyclists, etc.) for sites. For example, the site that was referenced in [Figure 14](#) and [Figure 15](#) showed how sidewalk access was kept when it was redeveloped. This access is important for these users because without it, they are forced to traverse the site without any specific space dedicated to them and perhaps may need to enter the site using the driveway. This could be dangerous, especially for sites that have a high number of vehicles entering/exiting (fast-food, convenience store, etc.).

Larger site sizes for modern service stations, convenience markets and the stand-alone drugstores with drive-through prescription service have helped assure that these distances are provided for newer development.

School Driveway Queues

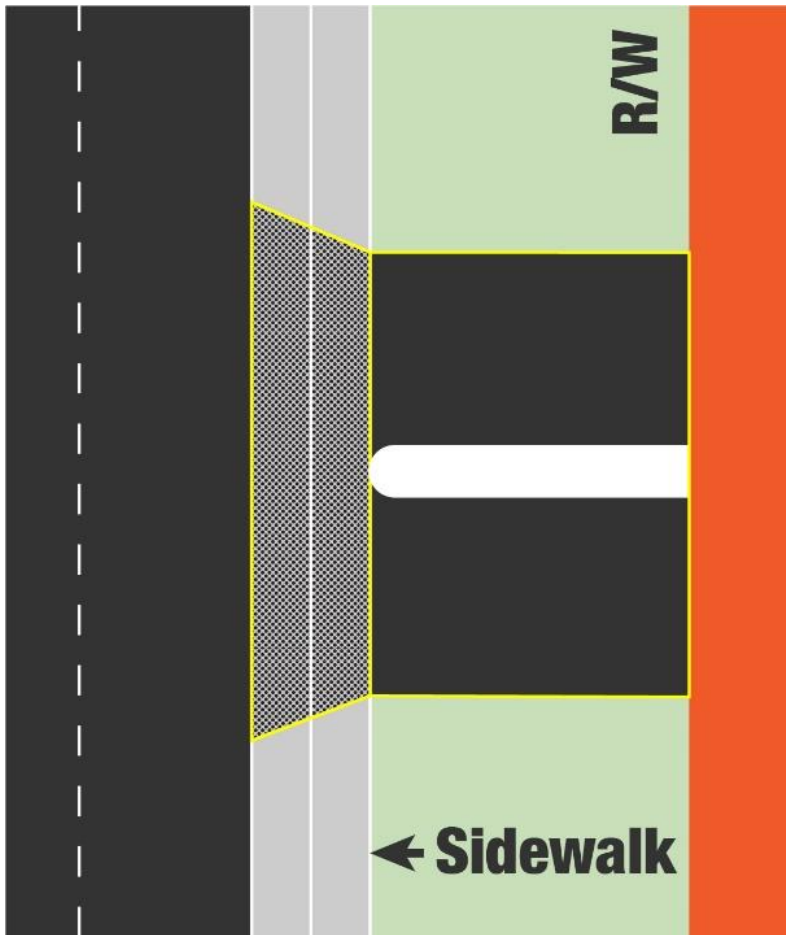
Schools served by school buses pose a challenge as well. Driveways should be designed with sufficient queue areas so that waiting vehicles don't conflict with movements on the highway system. The size of school buses together with the peaking characteristics from people picking up kids can make designing sufficient queue areas a significant challenge. A queuing study might be necessary in order to assure that back-ups on the SHS are avoided. It is recommended to include school officials in the planning process.

For any schools that are within areas that are C3R and C3C, sufficient queue lengths are especially important due to the typical volumes and vehicles speeds on these roadways. Any waiting vehicles could cause significant safety issues, as well as operational issues along the main roadway. It is also important to consider the placement of sidewalks and to ensure they do not interfere with the driveway(s) of the school.

Maintenance

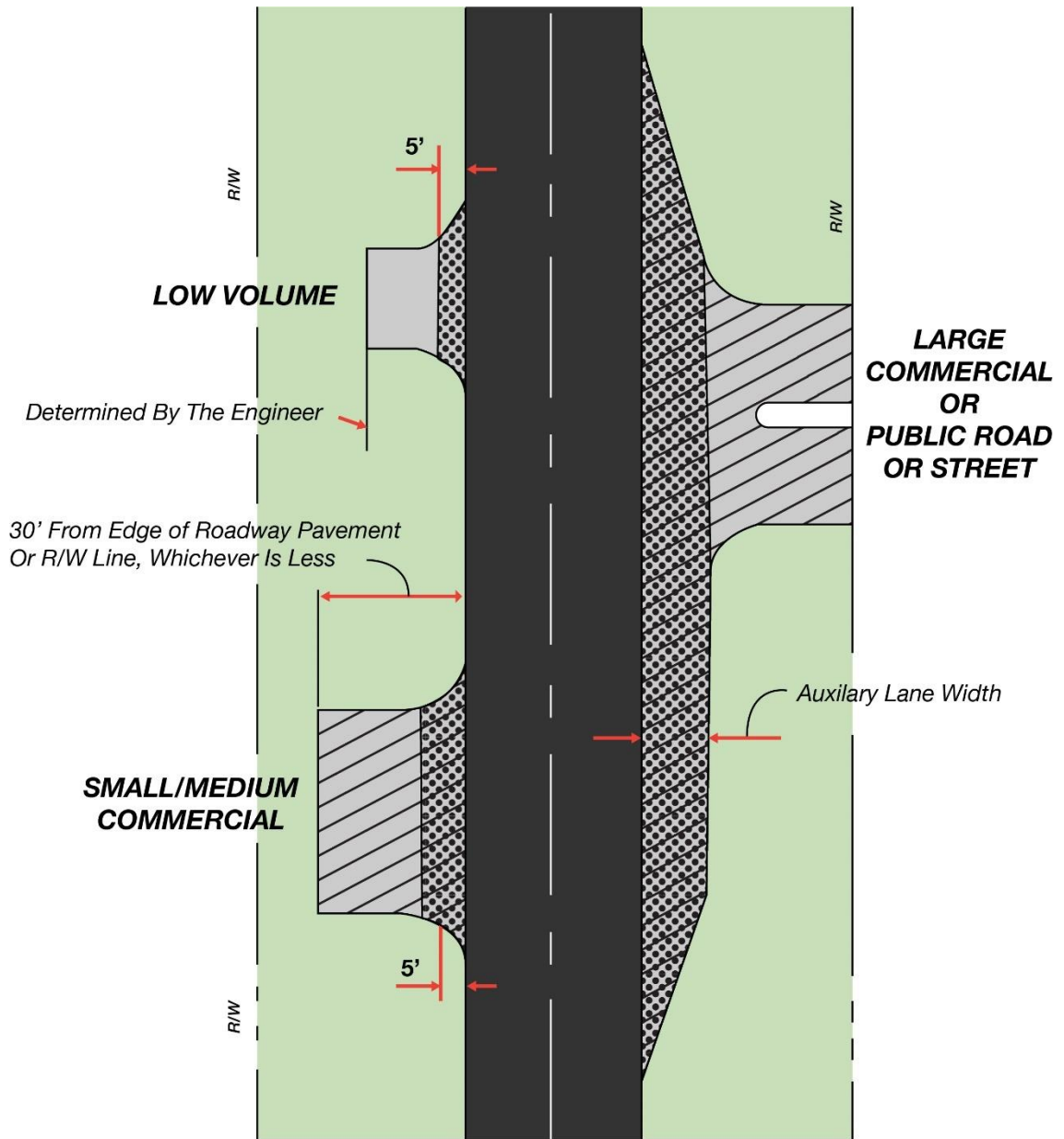
Per F.A.C. Rule Chapter: 14-96.016, it states that FDOT will be responsible for driveway maintenance from the roadway to the back of the sidewalk. For driveways on non-curbed or rural sections, FDOT maintenance will extend five feet beyond the edge of the roadway pavement (See [Figure 45](#) and [Figure 46](#)).

Figure 45 - Limits of Construction and Maintenance for Flush Shoulder "Rural" Section Connections



Source: F.A.C. Rule Chapter: 14-96.016

Figure 46 - Limits of Construction and Maintenance for Flush Shoulder "Rural" Section Connections



Legend

-  Graded or Paved
-  Required Paving
-  Limits of Department Maintenance

Source: F.A.C. Rule Chapter: 14-96.016

4.2.11 Driveway Grade

Driveway grade is important because turning vehicles must slow down to enter a driveway. The steeper the driveway, the greater the reduction in speed required to prevent hitting the bottom of the vehicle against the pavement.

Vehicles entering and leaving driveways that have abrupt changes in grade must travel at extremely low speeds. For those entering the driveway, the possibility of rear-end collision on the roadway is increased because following traffic must slow down for right-turn vehicles. Exiting vehicles and those turning left into the driveway must wait for larger gaps in traffic.

Reducing driveway grade is an important consideration along roadways that carry considerable through traffic volumes. Steep driveways might be more acceptable on local streets and reconstruction/resurfacing projects. Steeper grades are also more acceptable at locations with low driveway traffic volumes where only a few trucks are expected to use the driveway.

Grades

Requirements for the driveway grades are included in FDM 214 – Driveways and *Standard Plans, Index 522-003*. Maximum grades are 10% for commercial driveways and 28% for residential driveways and details for each application are included in *Standard Plans, Index 522-003*. FDM 214.4 provides direction and information for various applications on flared driveways. [FDM 214.4](#) provides guidance on flush shoulder driveways. An important note, it also states that in reconstruction projects, the 10% or less grade for commercial can be exceeded with the approval of the District Design Engineer where operational and safety impacts are acceptable. If regular scheduled passenger buses will be using the driveway, the maximum grade should not exceed 12% with a preferred maximum design grade of about 8%.⁸

While these may be the maximum practical grades, it is much better to use smaller grades. Research has shown that grades less than 14% for low-volume driveways and grades less than 5% for higher volume driveways are more desirable (See [Figure 47](#) for an example of a commercial driveway grade).

Consideration for the expected volume and class of traffic on driveways is important. Though the FDM uses the terms “Commercial” and “Residential”, there is great variability within these terms. The amount and type of traffic for a barbershop (commercial) is very different than a one million square foot mall (also commercial) or a 300-unit apartment complex (residential). The barbershop, of course, would not need the design standards of either the mall or the apartment complex.

⁸ Adapted from the Design Guide for Transit Facilities on Highways and Streets. AASHTO Phase I

Figure 47 – Commercial Driveway - Grade



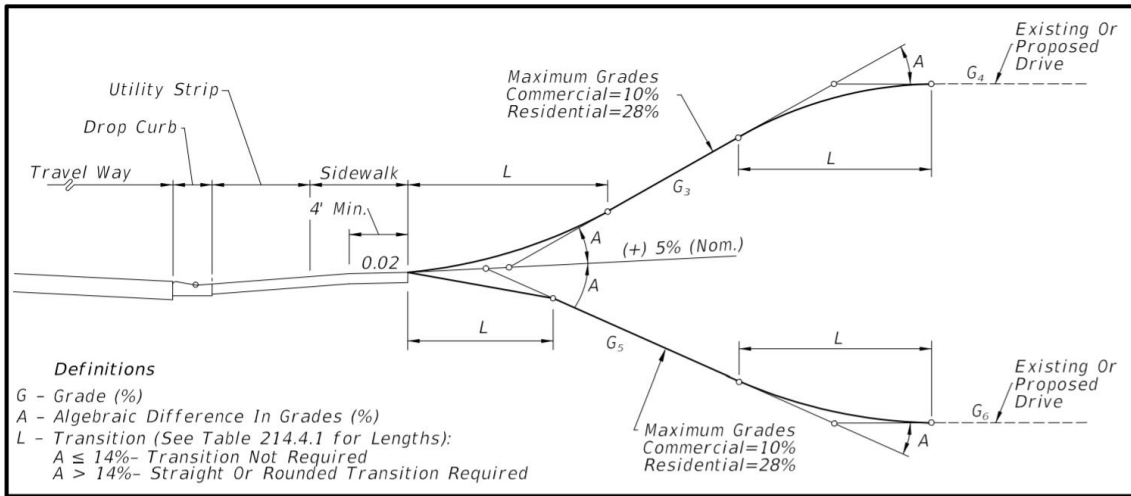
Source: CDM Smith

Important Considerations

Driveway Grade Differences

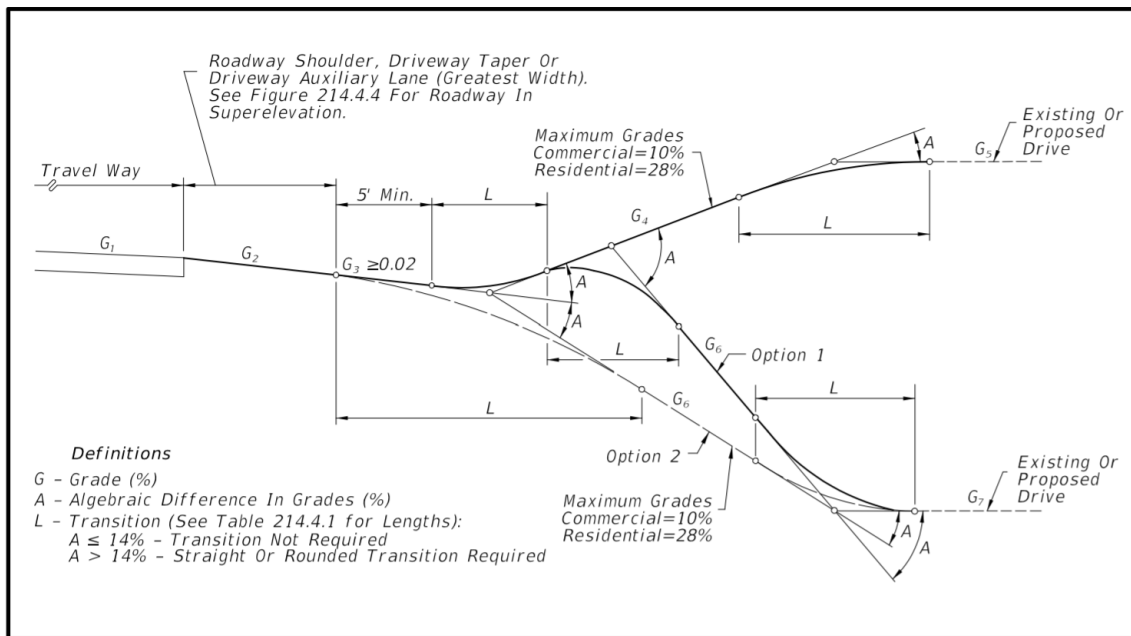
The maximum practical difference in grade is 12%. Above these grades, vehicles will routinely “bottom out” and potentially cause damage to their vehicles and/or the roadway itself. This is called “A” or “Algebraic Difference in Grade” (See [Figure 48](#) and [Figure 49](#)).

Figure 48 – Curbed Roadway Driveway Profiles



Source: FDM 214 – Driveways (Figure 214.4.2)

Figure 49 – Flush Shoulder Roadway Driveway Profiles



Source: FDM 214 – Driveways (Figure 214.4.3)

For areas and driveways with a significant number of large vehicles or trucks, special attention should be paid to the driveway grades as these vehicles will have a different profile than passenger vehicles and may encounter operational issues. Larger class vehicles (Class 9 – 10) may require lower grades than what is typical.

Super Elevation and Driveway Visibility

Another concern in driveway grade is the visibility of the driveway. A driveway that slopes downward and connects with a roadway on a horizontal curve that has super-elevation, has sight distance problems. Guidance for this concern is also found in *FDM 214* driveway profile grades adjacent to super-elevated roadways (See G2 in Figure 214.4.3) with the slopes and break-overs shown in Figure 214.4.4.

Guidance for Driveway Design in the Standard Plans and in the FDOT Design Manual (Curb Sections)

FDM 214 and *Standard Plans, Index 522-003* provides criteria and guidance for design of flared driveways for curbed roadways.

Some guidance for curbed roadway driveway design is also shown in the [FDM 113 - Right of Way](#). The manual states the following:

“On projects with sidewalks and driveway connections, the design elements can be accurately established only if proper survey data has been obtained for the designer’s use. Profile elevations along the proposed R/W line and back of sidewalk and half-sections or profiles at each driveway location should be obtained as a minimum standard practice.”

4.2.12 *Sight Distances*

Driveways must be built to provide sufficient sight distance so that drivers can safely operate their vehicles. More information on sight distances can be found in [Sight Distances](#).

4.2.13 *Driveway Location*

Determining the correct placement for driveways along a roadway is important because they affect the traffic patterns and overall flow of traffic. For more information on properly locating driveways, review [Locating Roadway Openings](#). Important design criteria that affect the driveway location are the connection spacing requirements and corner clearance.

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Chapter 5: Sight Distances

5.1 Overview

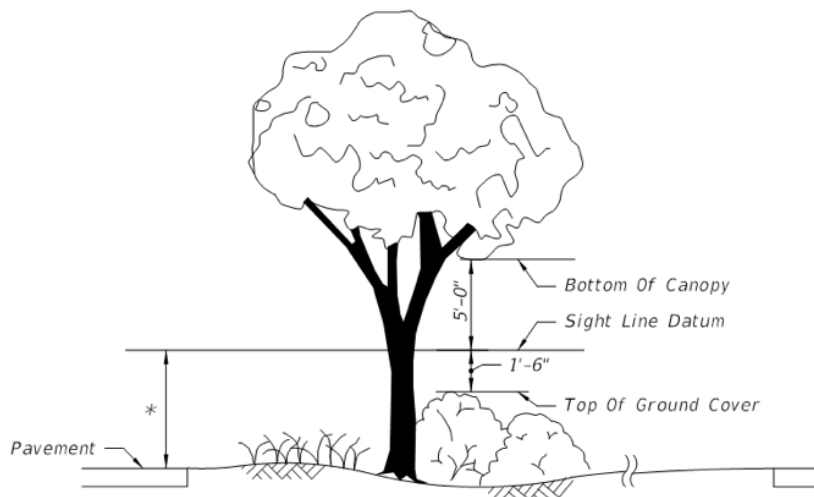
The focus of this chapter is to review the role of sight distance for unsignalized driveways and median openings. Specifically, the concepts of stopping sight distances and intersection sight distances will be discussed. Much of the current literature on sight distances stems from the *AASHTO Green Book*. It discusses sight distances in detail and is the basis for much of the standards for Florida. Passing sight distances are not discussed within this chapter as they are typically not involved in these types of roadway designs. For more information on passing distances, please refer to [FDM 210 - Arterials and Collectors](#).

5.1.1 Sight Distance Factors

There are multiple types of sight distances, each of which are affected by several factors. Some of these factors which affect the sight distances for a person driving are: height of the eye, height of the object, driver eye setback, vehicle area, time, and visibility.

The height of the eye pertains to the person who is passing or moving through the intersection, typically the driver. This measure is significant as it assumes people to be able to see above a certain height and could affect the design of the driveway or median, as well as any landscaping. *FDM 210* defines this height as 3.5 ft (3'6"). It is also referred to as the sight line datum (See [Figure 50](#)).

Figure 50 – Sight Distance Parameters



*Since observations are made in both directions, the line of sight datum between roadways is 3.5 feet above both pavements.

Source: *FDM 212 – Intersections* (Figure 212.11.2)

The object height is similar to the previous measure, with various heights being determined based on roadway environment. For stopping sight distances, the object height is determined to be 0.5 ft. (6") above the road surface. This is meant to allow drivers to see oncoming vehicles when traveling through the intersection.

Another factor that influences sight distance is the distance of a driver’s eye from the roadway itself, which is called the driver eye setback. For intersections and driveways, the minimum distance is 14.5 ft. (14’6”) from the edge of traveled roadway (See [Figure 53](#)).

Vehicle area size is used to determine whether a vehicle is considered visible or not. Landscaping or other objects along the roadway can obscure a person’s sight, reducing their overall sight distance. The Department states that if a driver can see 50% of the visual area of another vehicle, then it is considered to have 50% “shadow”, but still considered visible (See [Figure 51](#)).

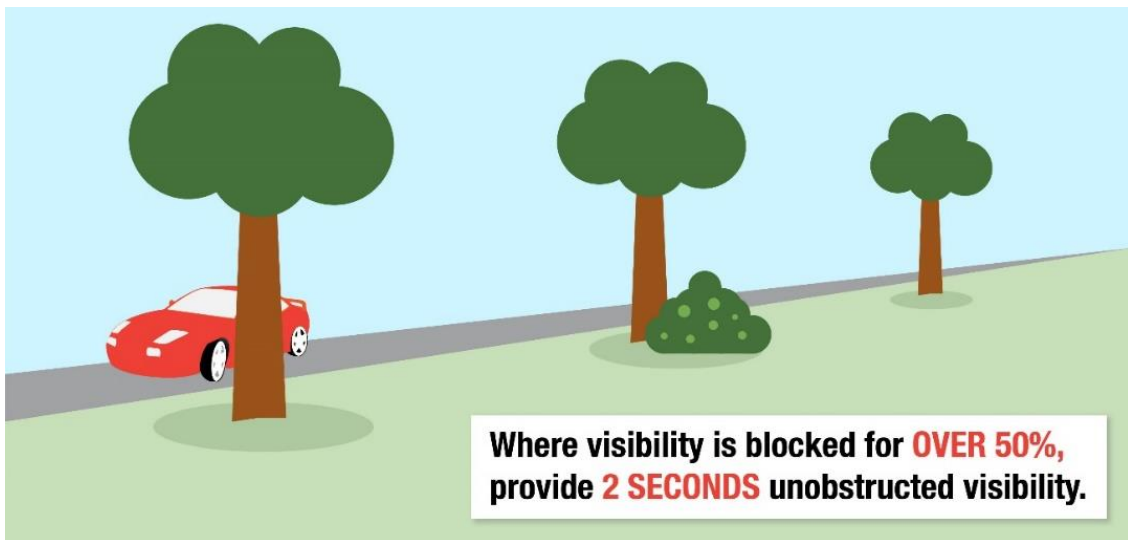
Figure 51 – Vehicle Area Size



Source: FDOT

One of the last factors that influences sight distance is amount of time that something is obstructed (See [Figure 51](#)). According to the *FDM 212.11.2*, allow for two seconds of unobstructed visibility when the area is blocked 50% (See [Figure 52](#)).

Figure 52 – Time and Visibility



Source: FDOT

5.2 Stopping Sight Distance (SSD)

Per [FDM 210](#), stopping sight distance can be defined as “...the distance needed for drivers to see an object on the roadway ahead and bring their vehicles to a safe stop before colliding with the object.” Stopping sight distance plays an important role for both driveways and median openings. The various factors that affect stopping sight distance are the grade of the roadway and design speed which in turn determine the SSD for the roadway (See [Table 24](#)). See FDM 210 for the complete Minimum Stopping Sight Distance (SSD) table.

Table 24 – Minimum Stopping Sight Distance

Grade (Percent)	Minimum Stopping Sight Distance (Feet)									
	Design Speed (MPH)									
	25	30	35	40	45	50	55	60	65	70
Downgrade/Upgrade (≤2%)	155	200	250	305	360	425	495	570	645	730

Source: Adapted from [FDM 210 - Arterials and Collectors \(Table 210.11.1\)](#)

There may be instances when the minimum stopping sight distances shown in [Table 24](#) may not be adequate. In these situations, when drivers require additional time to make decisions, larger distances may be necessary. The *AASHTO Green Book* states that:

“...greater distances may be needed where drivers must make complex or instantaneous decisions, when information is difficult to perceive, or when unexpected or unusual maneuvers are needed.”

5.3 Intersection Sight Distance (ISD)

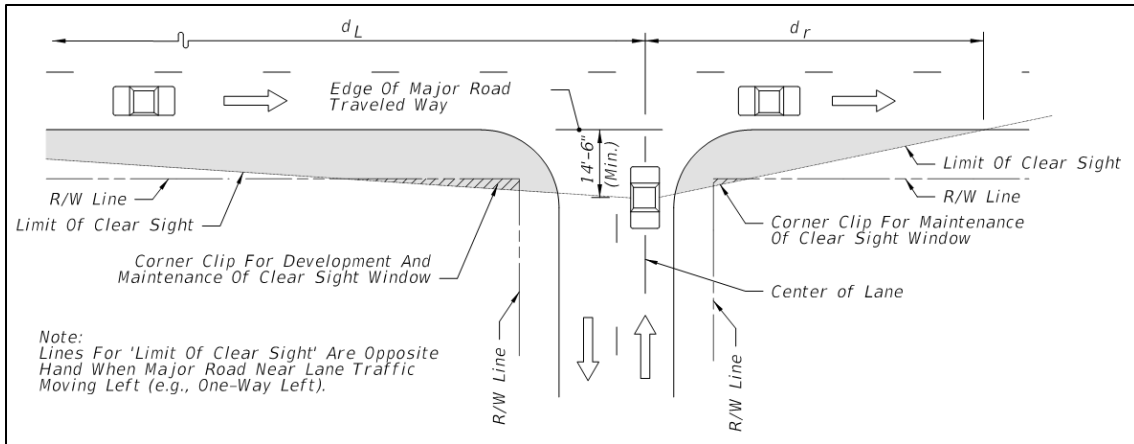
Per [FDM 212 - Intersections](#), intersection sight distance can be defined as:

“...the distance necessary for drivers to safely approach and pass through an intersection.”

Intersection sight distances are important for medians and median openings, but more importantly for driveways, since they are treated as intersections. An overview of intersection sight distance can be seen in [Figure 53](#). For vehicles at the driveway, the driver must be 14.5 ft (14'6”) away from the edge of the traveled way (driver eye-setback) and must have clear sight to their left and right, which are called clear sight triangles.⁹

⁹ Per the FDM, “The minimum driver-eye setback of 14.5 feet from the edge of the traveled way may be adjusted on any intersection leg only when justified by a documented, site-specific field study of vehicle stopping position and driver-eye position.”

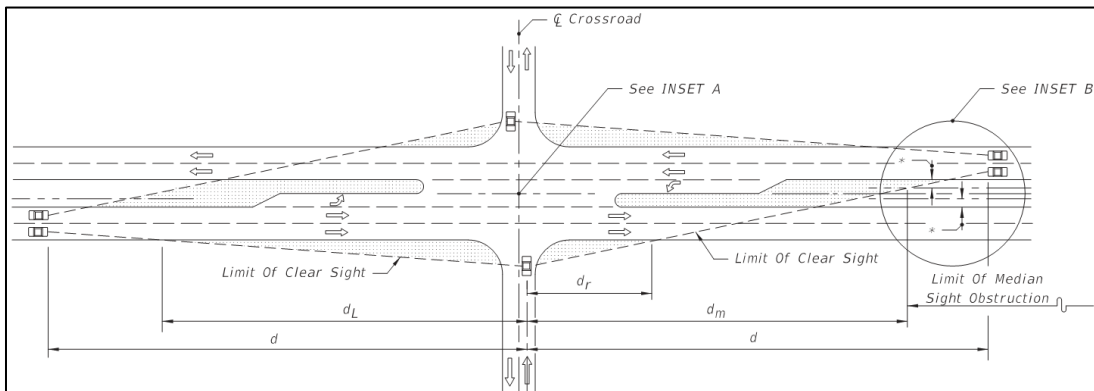
Figure 53 – Clear Sight Triangles



Source: FDM 212 - Intersections (Figure 212.11.1)

An example of intersection sight distance for a 4-lane divided roadway can be seen in [Figure 54](#), along with the corresponding sight distances in [Figure 55](#).

Figure 54 – Intersection Sight Distance (4-Lane Divided Roadway)



Source: FDM 212 - Intersections (Exhibit 212-6)

Figure 55 – Sight Distances

Design Speed (mph)	Sight Distance at Intersection (in feet) Passenger Vehicle (P) (feet)	Sight Distance at Intersection (in feet) Single Unit Vehicle (SU) Common Delivery Truck (feet)
30	395	540
35	460	630
40	525	720
45	590	810
50	655	900
55	720	990
60	785	1,080
65	850	1170

Source: *FDM 212 - Intersections (Exhibit 212-6)*

For more information on intersection sight distances for combination trucks other types of roadways, please refer to *FDM 212*.

Similar to other standards, if sufficient intersection sight distance cannot be achieved, and there are no other driveway location alternatives, stopping sight distance can be used on roadways that have a design speed of 35 mph or less. This distance will allow the through traffic driver to avoid a hazard at the driveway (See *FDM 210* and *214* for further requirements).

5.3.1 The Crossing Maneuver as a Two-Step Process

Also, if full intersection sight distance cannot be achieved on a driveway connecting to a multi-lane highway, and the median is sufficiently wide (minimum 25' for a passenger vehicle), the maneuver may be performed as two operations. The stopped vehicle must first have adequate sight distance to depart from a stopped position and cross traffic approaching from the left. The crossing vehicle may then stop in the median prior to performing the second operation. The second move requires the necessary sight distance for vehicles to depart from the median opening, to turn left into the cross road, and to accelerate without being overtaken by vehicles approaching from the right. *Exhibit 212-6 – Intersection Sight Distance: 4-Lane Divided and Exhibit 212-7 – FDM 212* show the shorter distance criteria for this movement.

5.4 Important Considerations

While sight distances play an integral role in the development of driveways and median openings, there are specific considerations that must be made. The landscaping near a driveway or along a median can affect the sight distances for drivers, and there are certain designs that are needed for left turns and U-turns for median openings and driveways. See *FDM 212.11.6* for criteria.

5.4.1 Landscaping

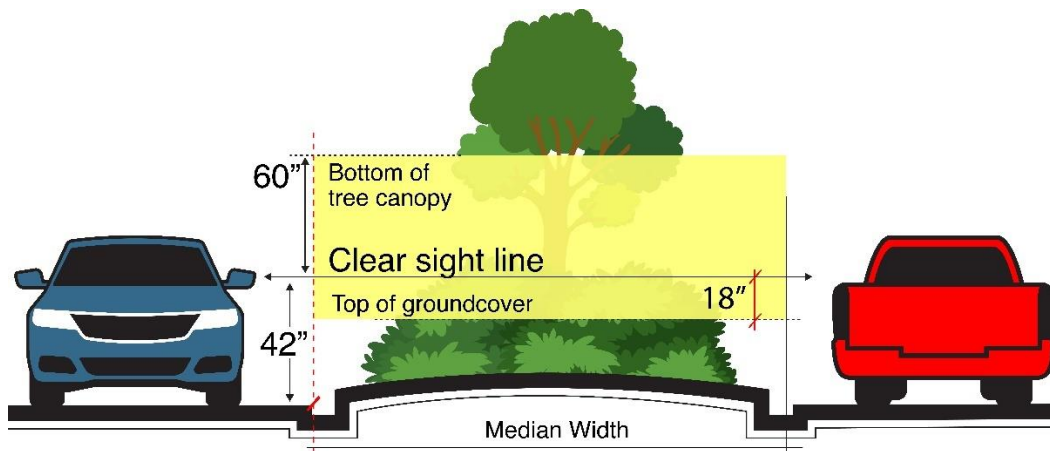
As mentioned earlier in this chapter, there are several factors that influence sight distances for drivers; eye height, object height, the vehicle area size and visibility. Another set of factors that impact the sight distance for vehicles is landscaping that surrounds or is near a median or driveway.

Driveways and medians can be treated like intersections when evaluating the correct landscaping procedures. Per [FDM 212](#), the “...clear sight window concept may provide opportunities for vegetation within the limits of intersection sight triangle.” (See [Figure 56](#)). The chapter states that this detail provides:

“...the required vertical clear sight limits with respect to the sight line datum. The horizontal limits of the window are defined by clear sight triangles. Within the limits of clear sight triangles, the tree canopy must be at least 5 feet above the sight line datum and the top of the ground cover must be at least 1.5 feet below the sight line datum. See [FDM 228.2\(2\)\(a\)](#) for additional information about plant selection and placement.”

Please consult with the Project/District Landscape Architect on proper vegetation choices to maintain clear sight triangles.

Figure 56 – Landscaping and Sight Distances



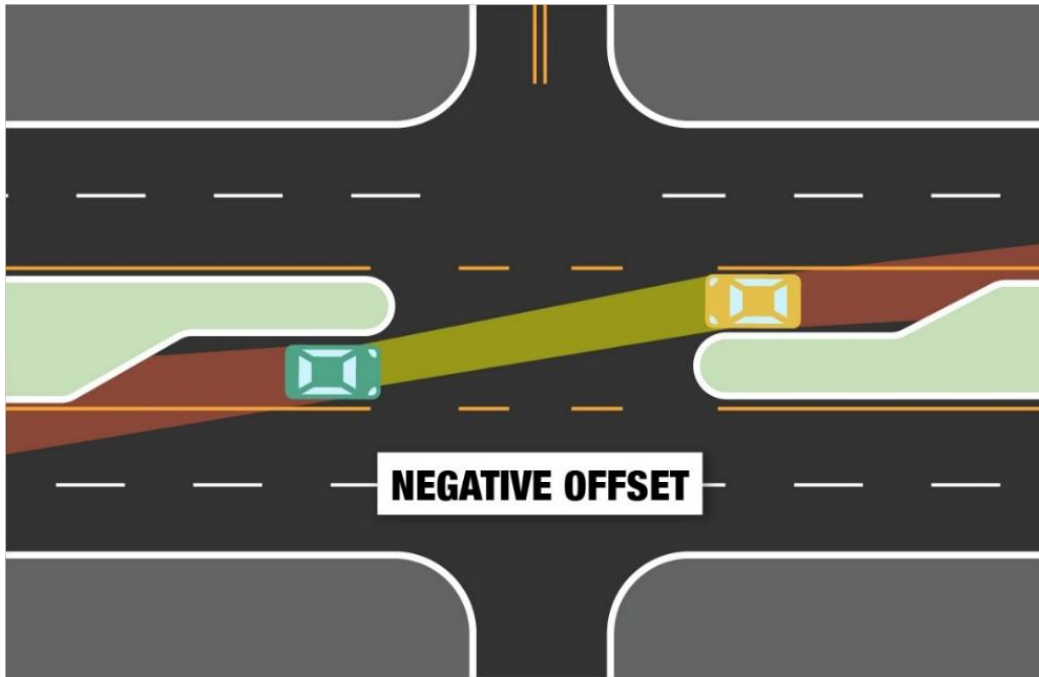
Source: FDOT

Spacing between vegetation located in medians of a roadway and or in the vicinity of driveways fall in the limits of clear sight triangles. To maintain minimum spacing and diameter requirements for vegetation, please refer to [FDM 212](#).

5.4.2 Lateral Offset for Left-Turn Lanes

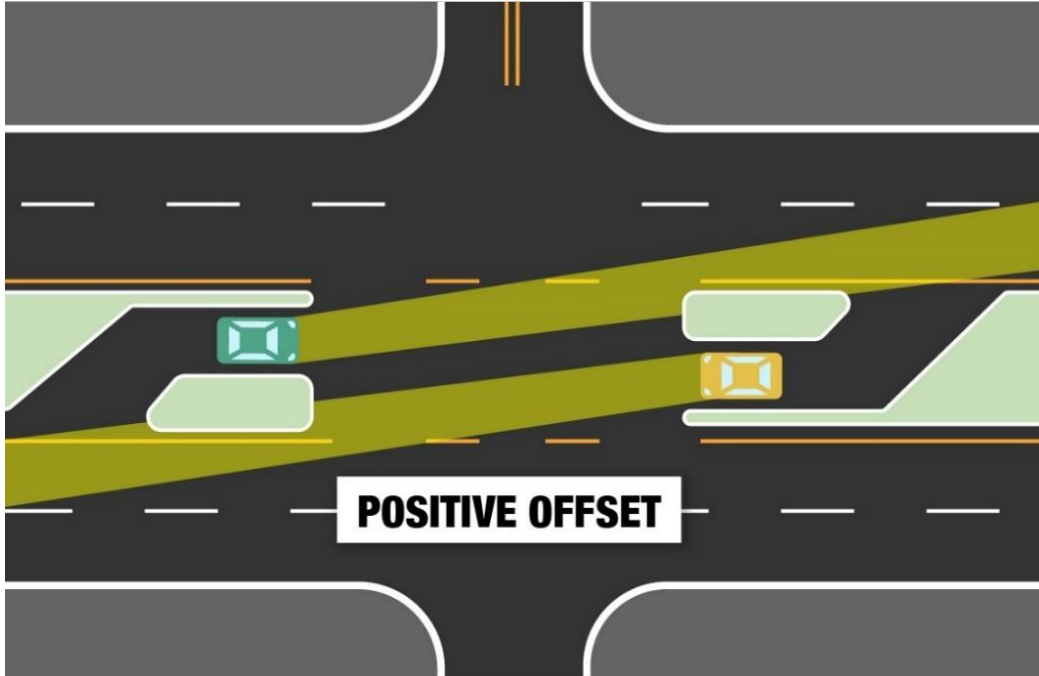
Offset is defined as the lateral distance between the left edge of a left-turn lane and the right edge of the opposing left-turn. Vehicles turning left from opposing left-turn lanes may restrict sight distance with a negative offset (See [Figure 57](#)). Creating a positive offset in the roadway design allows for improved sight distance for each vehicle (See [Figure 58](#)).

Figure 57 – Negative Offset between Opposing Left-Turn Lanes



Source: FDOT

Figure 58 – Positive Offset between Opposing Left-Turn Lanes



Source: FDOT

Desirable offsets should be positive with a recommended minimum 2-foot offset when the opposing left turn vehicle is a passenger car and a minimum 4-foot offset when it is a large vehicle. In both cases, the left-turn vehicle is assumed to be a passenger car.

In an urban setting, context classifications C4-C6 (or other areas with curbed roadways), offset left-turn lanes are recommended with median widths greater than 18 ft. A 4-foot-wide traffic separator should be used when possible to channelize the left-turn movement and provide separation from opposing traffic. It is recommended to use offset left-turn lanes at rural intersections with a high volume of vehicular turning movements.

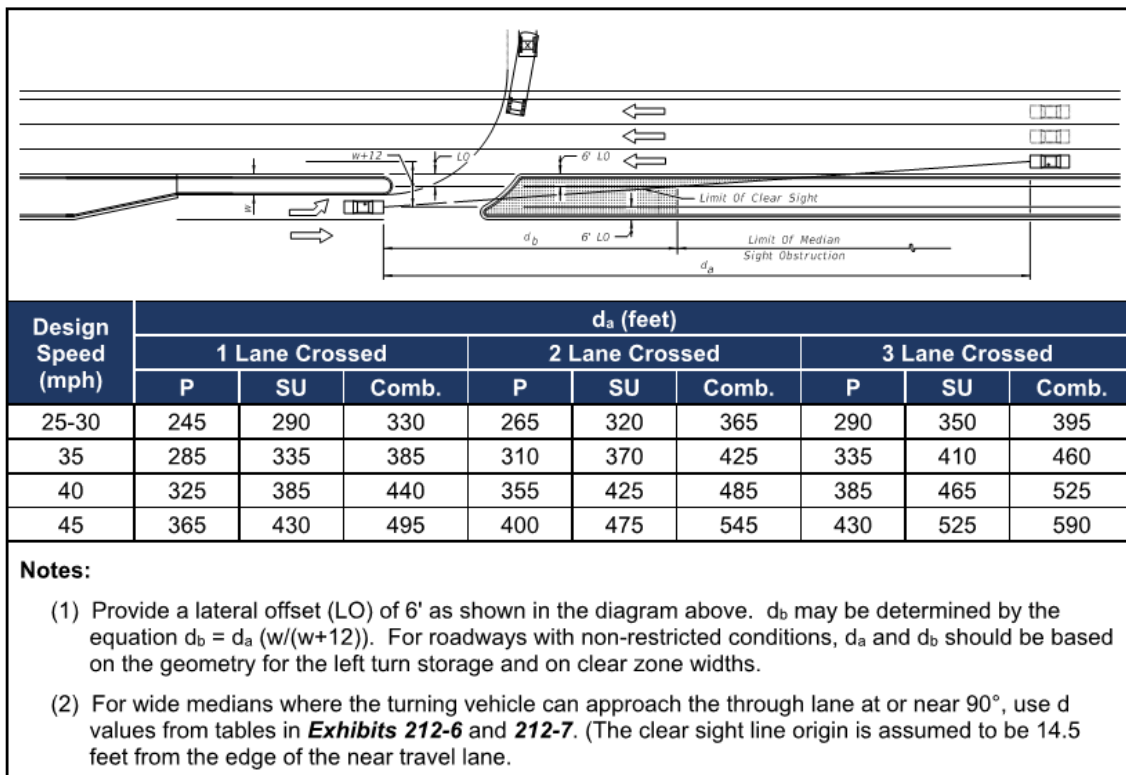
On median widths 30 ft or less, an offset left-turn lane parallel to the through lane is recommended. In addition, the area between the left-turn lane and the through lane where vehicles are moving in the same direction should be channelized with pavement markings. On medians greater than 30 ft, a tapered offset should be considered.

See [FDM 212 - Intersections](#) for more Information on Offset Design.

5.4.3 Left-Turn onto Side Street

FDM 212 provides sight distance guidance for left turns from a divided highway. [Figure 59](#) provides guidance for different design vehicles: passenger cars (P), single unit trucks (SU) and combination trucks (Comb.). Further guidance is available in the [AASHTO Green Book, Chapter 9](#).

Figure 59 – Sight Distance for Left Turn from Highway



Source: [FDM 212 – Intersections \(Table 212.11.1\)](#)

5.4.4 U-Turns

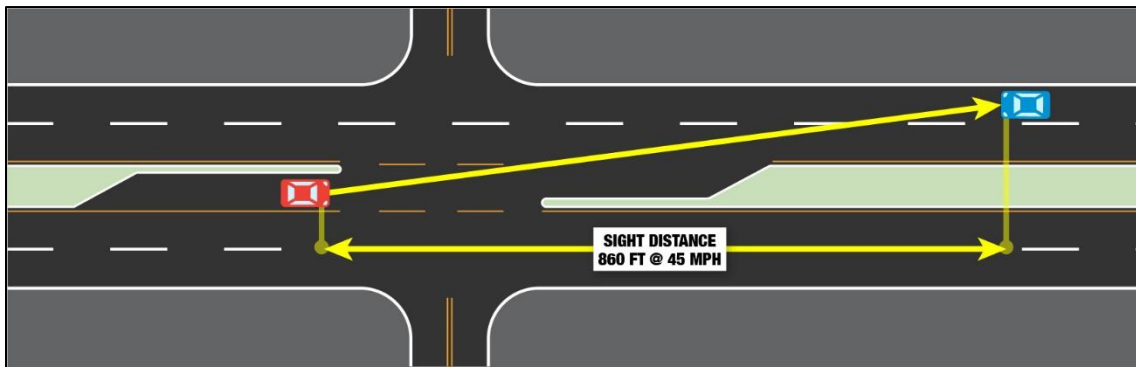
U-turns are more complicated than simple turning or crossing maneuvers. Sight distances for U-turns, shown in [Figure 60](#), were calculated for automobiles with the following assumptions:

- “P” vehicle (Passenger vehicle)
- 2.5 seconds reaction time
- Additional time required to perform the U-turn maneuver
- Begin acceleration from 0 mph only at the end of the U-turn movement (this is conservative)
- Use of speed/distance/and acceleration figures from *AASHTO Green Book*
- 50 ft clearance factor

For information on these calculations, please reference

Appendix C.

Figure 60 – U-Turn Sight Distance



Source: FDOT

In addition, sight distances are also impacted by speed, as shown in [Table 25](#). As the speed of the vehicles in the opposite lanes increases, more sight distance is required. For vehicular speeds of 45 MPH, there is a required sight distance of 860 feet for vehicles to safely complete a U-Turn at an unsignalized median opening.

Table 25 – Sight Distance for U-turn at Unsignalized Median Opening

Speed (mph)	Sight Distance (ft)
35	540
40	670
45	860
50	1,075
55	1,290
60	1,585

Source: Adapted from the course material notes of Virgil Stover

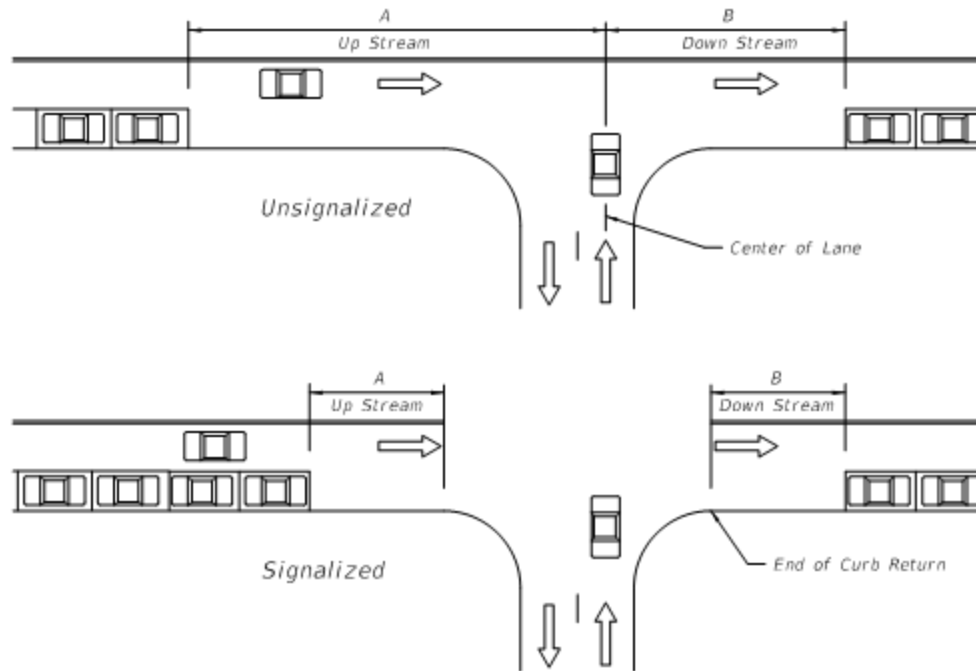
5.4.5 On-Street Parking

The location of a driveway close to on-street parking can seriously impact visibility. In [FDM 212.11.5](#), there is additional guidance on the placement of driveways in relation to on-street parking (See [Table 26](#)).

Table 26 – Parking Restrictions for Driveways and Intersections

Control Type	Posted Speed (mph)	A – Up Stream (ft)	B-Down Stream (ft)	
			2-Lane	4-Lane
	<35	90	60	45

Unsignalized	35	105	70	50
Signalized	< 35	30	30	30
	35	50	50	50



Notes:

- (1) For entrances to one-way streets, the downstream restriction (B) may be reduced to 20 feet.
- (2) Do not place parking within 20 feet of a marked crosswalk.

Source: *FDM 212 – Intersections (Table 212.11.2)*

5.4.6 Sight Distance and Construction

Barriers erected during construction work on roadways or buildings can interfere with clear sight distances for driveways or intersections. It is important to coordinate with local government overseeing this work to ensure that clear sight distances are maintained throughout the construction period.

5.4.7 Sight Distance Concerns at Driveways

When designing or reviewing site plans which include driveways, it is important to ensure that adequate sight distances are maintained so that drivers exiting the driveway have clear view of pedestrians and bicyclists utilizing sidewalks. This principle applies to travel in both directions on

the sidewalks adjacent to and entering the business. **Figure 61** shows how a brick fence column (highlighted in yellow) or a tall vehicle parked in the handicap parking space could contribute to a pedestrian or bicycle crash with a vehicle exiting the driveway.

Figure 61 – Sight Distance Concerns at Driveways



Source: Google Earth – Oakland, California

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Chapter 6: Turn Lanes and U-Turns

6.1 Overview

For driveways, medians and median openings, the placement and design of turn lanes and U-turns are critical to avoid potential traffic safety issues. For example, a median opening placed across a left-turn lane at an intersection could create conditions leading to a vehicular crash (See [Figure 16](#) or [Figure 17](#)). The locating of these roadway openings is discussed in greater detail in [Locating Roadway Openings](#). This chapter will instead focus on where to locate and design turn lanes and U-turns and how they relate to driveways, medians and median openings.

6.2 Exclusive Right-Turn Lanes

Exclusive right-turn lanes are useful where a combination of high roadway speeds, and high right-turn volumes into a driveway are expected. Congestion on the roadway may also be a good reason to use an exclusive right-turn lane. If properly built, they remove the turning vehicle from the through lanes, thereby decreasing the operational and safety impact of right turning vehicles on the through traffic.

Previous requirements in Standard Index 301 were removed and placed into [FDM 212 – Intersections](#). There is no specific guidance on warrants for right-turn lanes based on number of turns in and out of unsignalized driveways, but the guidelines in this chapter were developed to assist in the decision-making process. *FDM 212* does contain the standards needed to design right-turn lanes.

6.2.1 When to Consider Exclusive Right-Turn Lanes

Here are some additional situations when adding an exclusive right-turn lane may be required:

- Facilities having a high volume of buses, trucks or trailers (2 or 3 per hour)
- Poor internal site design of a driveway facility causing potential backups in the through lanes
- Heavier than normal peak flows on the main roadway
- Very high operating speeds (such as 55 mph or above) and in rural locations where turns are not expected by through drivers
- Highways with curves or hills where sight distance is impacted
- Gated entrances
- Crash experience, especially rear end collisions
- Intersections or driveways just after signalized intersections where acceleration or driver expectancy would make a separate right-turn lane desirable
- Severe skewed angle of intersection requiring right-turn vehicle to slow greatly

When Not to Consider Exclusive Right-Turn Lanes

- Dense or built-out corridors with limited space
- Right-turn lane that would negatively impact pedestrians or bicyclists
- Vehicular movements from driveways or median openings that cross the right-turn lane resulting in multiple threat crashes
- Context classifications C2T, C4, C5, or C6

When Exclusive Right-Turn Lanes are Beneficial

There are instances when adding an exclusive right-turn lane for unsignalized driveways are beneficial to traffic operations and safety. **Table 27** provides some guidance for this situation based on the speed limit of the roadway and how many right turns occur per hour. Locations where the Auto and Truck Modal Emphasis is "High" may be appropriate for consideration of Exclusive Right Turn Lanes.

Table 27 – Recommended Guidelines for Exclusive Right-Turn Lanes to Unsignalized Driveway¹⁰

Roadway Posted Speed Limit	Number of Right Turns Per Hour
45 mph or less	80 – 125 ¹
Over 45 mph	35 – 55 ²
<i>Note: A posted speed limit of 45 mph may be used with these thresholds if the operating speeds are known to be over 45 mph during the time of peak right turn demand.</i>	
<i>Note on traffic projections: Projecting turning volumes is, at best, a knowledgeable estimate. Keep this in mind especially if the projections of right turns are close to meeting the guidelines. In that case, consider requiring the turn lane.</i>	
¹ The lower threshold of 80 right-turn vehicles per hour would be most used for higher volume (greater than 600 vehicles per hour, per lane in one direction on the major roadway) or two-lane roads where lateral movement is restricted. The 125 right-turn vehicles per hour upper threshold would be most appropriate on lower volume roadways, multilane highways, or driveways with a large entry radius (50 feet or greater).	
² The lower threshold of 35 right-turn vehicles per hour would be most appropriately used on higher volume two-lane roadways where lateral movement is restricted. The 55 right-turn vehicles per hour upper threshold would be most appropriate on lower volume roadways, multilane highways, or driveways with large entry radius (50 feet or greater).	

Source: [NCHRP Report 420 \(Impacts of Access Management Techniques\)](#)

These recommendations are primarily based on the research done in [NCHRP Report 420, Impacts of Access Management Techniques, Chapter 4 – Unsignalized Access Spacing \(Technique 1B\)](#), and [Use of Speed Differential as a Measure to Evaluate the Need for Right-Turn Deceleration Lane at Unsignalized Intersections](#).

In the *NCHRP Report 420*, the observed high-speed roads, 30 to 40 right-turn vehicles per hour caused evasive maneuvers on 5 - 10 percent of the following through vehicles. For lower speed roadways, 80 to 110 right-turn vehicles caused 15 - 20 percent of the following through vehicles to make evasive maneuvers. The choice of acceptable percentages of through vehicles impacted is a decision based on reasonable expectations of the different roadways.

In this study, by modeling speed differentials, a better understanding of the impacts of through volume and driveway radius was discovered.

¹⁰ May not be appropriate for signalized locations where signal phasing plays an important role in determining the need for right turn lanes.

6.2.2 Exclusive Right-Turn Lane Design

For information on exclusive right-turn lane design, refer to [FDM 212 Intersections](#) and [Standard Plans, Index 711-001](#). The FDM states that “Right-turn lane tapers and lengths are identical to left turn lanes under stop control conditions. Right-turn lane tapers and lengths are site-specific for free-flow or yield conditions.” Sheet 11 of Standard Plans, Index 711-001 provides requirements for clearance distance, brake to stop distance and deceleration distance by design speed for both curbed and uncurbed roadways. **Section 3.4.2** provides discussion on the various parameters used in turn lane design such as decision distance, stopping distance etc.

6.2.3 Important Considerations

Right-Turns and Large Vehicles

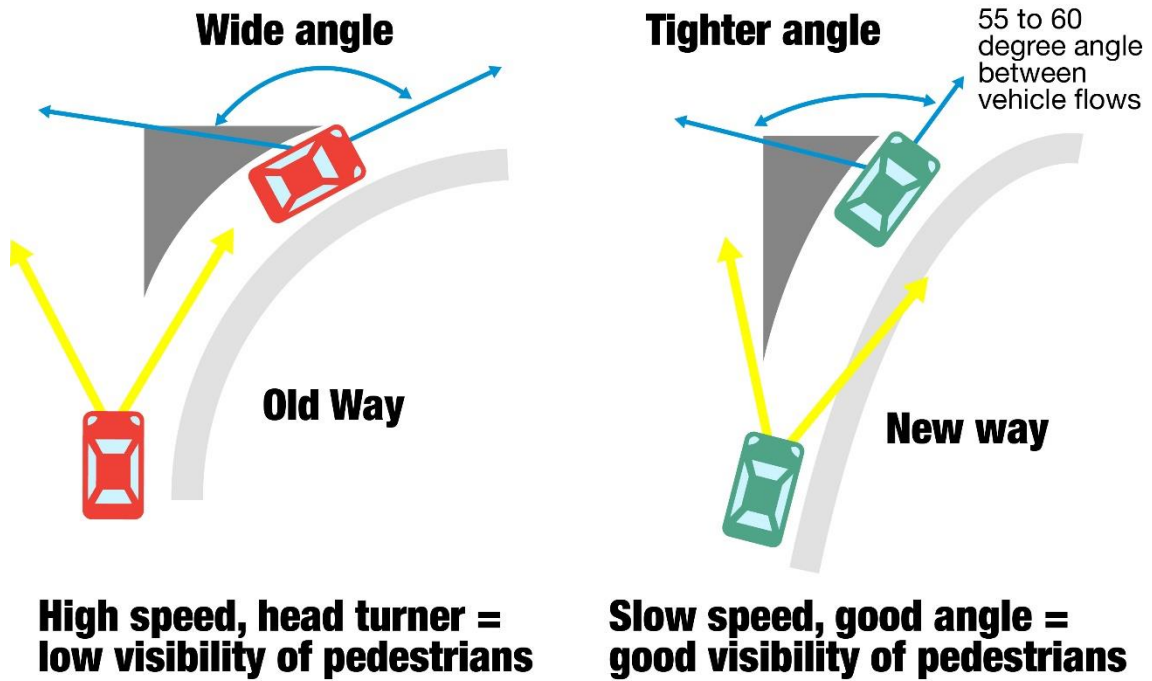
The speed and the volume of right-turns should not be the only criteria used to determine the requirement for an exclusive right-turn lane at unsignalized intersections. To minimize the rear-end collision potential of some situations, a right-turn lane may be required where large and slow-moving vehicles need to turn right such as;

- Trucking facilities (or locations that have a high volume of large vehicle traffic such as water ports, train stations, etc.)
- Recreational facilities attracting boats, trailers and other large recreation vehicles
- Transit facilities
- Schools driveways to drop-off and pick-up areas

Right-Turn Channelization

Where right turn exiting channelization is used, be careful to provide a traffic entry angle that is easy for the exiting driver to negotiate while trying to enter traffic. [Figure 62](#) illustrates how driver head turn angles between 120°-125° (Tighter Angle) are more comfortable than the 145°-150° (Wide Angle) associated with more traditional designs. The tighter angle also encourages drivers to slow down, which provides more time for a thorough scan for conflicts.

Figure 62 – Right-Turn Channelization



Source: *NCHRP No. 279 (Intersection Channelization Design Guide)* and Chapter 9 of the *AASHTO Green Book*

Proper right-turn channelization at intersections can also improve safety for bicyclists and pedestrians by improving visibility to turning motorists. The “old way” for channelized right-turn lanes with a 30-40° angle-of-entry (Wide Angle) entering the roadway decreases driver’s view of pedestrians and increases pedestrian crossing distance. The driver’s head must turn further to merge successfully and can easily miss a crossing pedestrian or bicyclist.

Research performed by Schattler and Hanson showed a 44% overall reduction in intersection crashes and a CMF of 0.56 when the angle-of-entry of channelized right turns was reduced. This resulted in a reduction of the angle drivers had to turn their heads to scan for traffic and pedestrians. This “new way” improves the line-of-sight of right turning passenger vehicles by reducing the angle-of-entry, while at the same time continuing to accommodate large semi-tractor trailer trucks to make right turns without encroachment.¹¹

This countermeasure is included in the CMF Clearinghouse as “Improve angle of channelized right turn lane.”¹²

¹¹ Schattler, K. and T. Hanson. "Safety Impacts of a Modified Right Turn Lane Design at Intersections". Presented at the 95th Annual Meeting of the Transportation Research Board, Paper No. 16-0790, Washington, D.C., (2016).

¹² <https://apps.ict.illinois.edu/projects/getfile.asp?id=4949>

6.3 Exclusive Left-Turn Lanes

While some principles for right-turn lanes apply to left-turn lanes, there are inherent differences between them.

6.3.1 When Exclusive Left-Turn Lanes are Beneficial

There are several situations when a left-turn lane should be built on the roadway. For example, if on a multilane roadway and there is a median opening that is serving a driveway, there should be a left-turn lane to allow for vehicles to move safely out the way of the through traffic. Exclusive left-turn lanes should be considered at any location serving the public, especially on curves and where speeds are in excess of 45 mph. The **AASHTO Green Book** contains guidance on this issue. However, the guidelines were developed based on delay rather than crash avoidance. Safety is the main reason behind exclusive left-turn lanes.

6.3.2 Designing Exclusive Left-Turn Lanes

Similar to right-turn lanes, information on how to design left-turn lanes can be found in [FDM 212 Intersections](#) and [Standard Plans, Index 711-001](#). Sheet 11 of *Standard Plans, Index 711-001* provides requirements for clearance distance, brake to stop distance and deceleration distance by design speed for both curbed and uncurbed medians. **Section 6.3.3** below provides further guidance on left turn lanes and driveways. **Section 3.4.2** provides discussion on the various parameters used in turn lane design, such as decision distance, stopping distance and other factors.

6.3.3 Important Considerations

Left Turns and Driveways

One area where left turns may need to be discouraged is when the driveway is located near an intersection. In these instances, a driveway may need to be channelized (See **Section 4.2.9 Channelizing Islands (I)** for more information) to restrict unsafe vehicular movements. These are also known as “Divisional Islands.”¹³

Divisional Islands can provide guidance to drivers on roadways with medians for right-in, right-out movements. However, they are not sufficient to prohibit left turns in or out. The divisional island design might also be useful on an undivided roadway where the driveway is so close to an intersection that the left-turn would be unsafe at any time. The most effective way to prohibit left turns is to install restrictive medians. Where space for a median is not available, the traffic engineer can use flexible traffic delineator posts in the main road to discourage left turns.

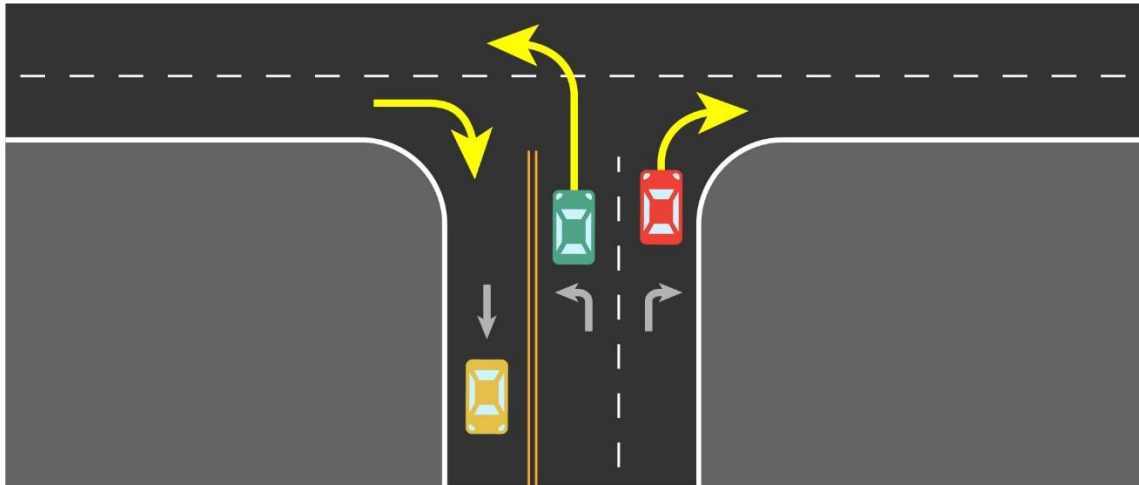
Separate Left-Turn Exit Lanes for Driveways

Separate left-turn and right-turn lanes should be considered on commercial driveways where both left-turns and right-turns are permitted to exit. Even a small number of left-turns may cause a substantial delay to right-turns out of the driveway with a single exit-lane. This driveway layout is

¹³ These are colloquially called “Pork Chops”.

needed where expected driveway volumes exceed 600 trips-per-day. They may also be beneficial as low as 300 trips-per-day, depending on the character of the exiting traffic.

Figure 63 – Three Lane Driveway¹⁴



Source: Adapted from Vergil Stover

Left Turn Lanes Serving Driveways on Multilane And 2 Lane Roadways

Multilane Roadway with A Median

Whenever a driveway is served by a median opening, a left turn lane should be available. This provides for the safest left turns into the driveway.

Two-Lane Roadway

Exclusive left turn lanes should be considered at any location serving the public, especially on curves and where speeds are 45 mph and higher.

The *AASHTO Green Book* contains guidance on left turns. However, the guidelines were developed based on delay rather than crash avoidance. Safety is the main reason behind exclusive left turn lanes.

6.4 Center Two-Way Left-Turn Lanes (TWLTL)

TWLTLs (also referred to as flush medians) allow for multiple turning vehicular movements but can cause operational and safety issues depending on the application. **Section 2.5 Safety Benefits and the HSM**, demonstrates the reduced safety of TWLTLs compared with raised medians. Per FDM 210.3, a raised or restrictive median should be provided on divided roadways that have a

¹⁴ When driveway volumes exceed 600 trips-per-day, a three-lane cross-section should be considered. Consider channelization if traffic is over 4,000 trips-per-day.

design speed of 45 mph or greater. TWLTLs (flush median) may be used on 3-lane and 5-lane typical sections with design speeds \leq 40 mph.

Design criteria for lane widths and pavement slopes are given by lane type, design speed and context classification. Minimum travel, auxiliary, and two-way left-turn lane widths are provided in FDM 210. On new construction projects, flush medians are to include sections of raised or restrictive median to enhance vehicular, bicycle, and pedestrian safety, improve traffic efficiency, and attain the standards of the Access Management Classification of that highway system. Sections of raised or restrictive medians are recommended on RRR projects.

6.5 U-Turns

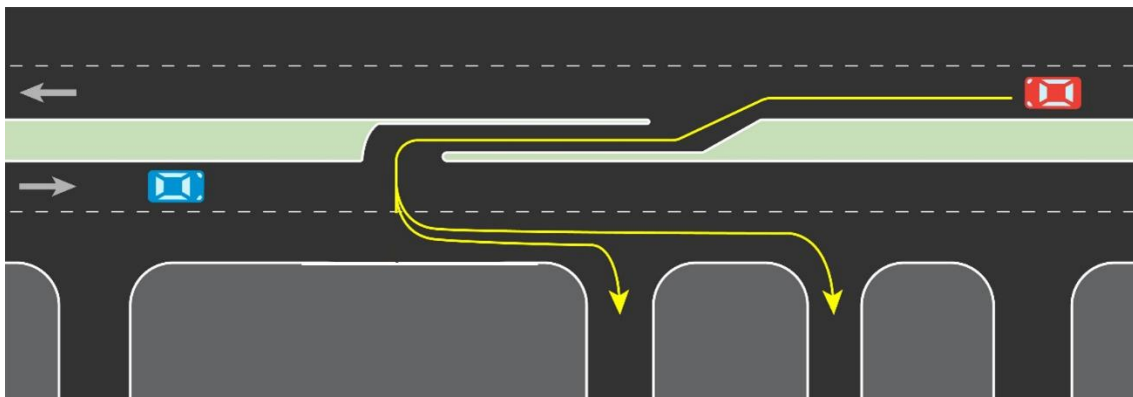
Vehicles attempting to make U-turns from a median opening onto the roadway, into a driveway, or from a left-turn lane may require specific considerations to avoid potential safety issues.

6.5.1 Important Considerations

Driveways and U-Turn Movements

Driveways should be located directly opposite, or downstream, from a median opening. Where it cannot be directly across, driveway access should be located more than 100 feet upstream from the median opening to prevent wrong-way maneuvers (See [Figure 64](#)).

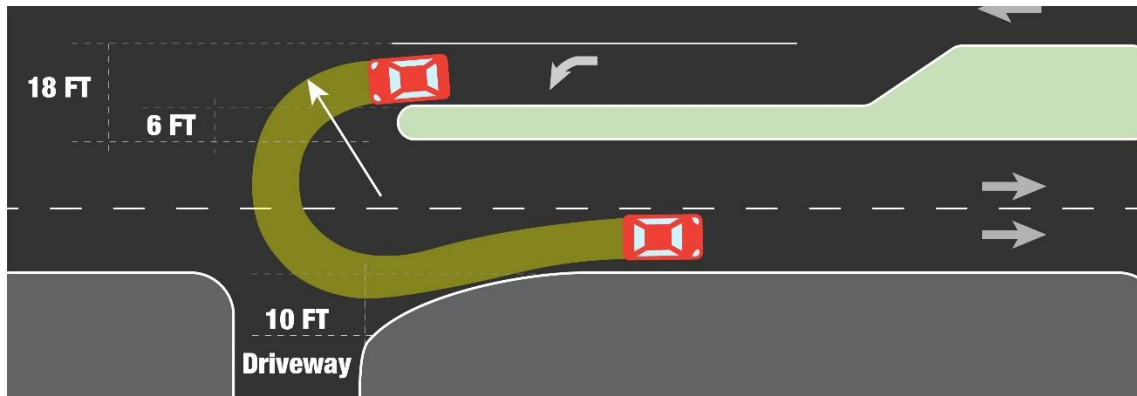
Figure 64 – Entry Maneuvers from a U-Turn



Source: FDOT

It is sometimes necessary to widen the driveway apron to allow easier U-turns at a median opening. This is typically the case on four-lane roadways with driveways across from the median opening. A design like the one shown in [Figure 65](#) can allow the ease of this movement. Paved shoulders can also provide the extra space needed to facilitate U-turns for class 4-9 vehicles with more than two axles.

Figure 65 – U-Turns and Driveways¹⁵



Source: Adapted from 2011 AASHTO Greenbook

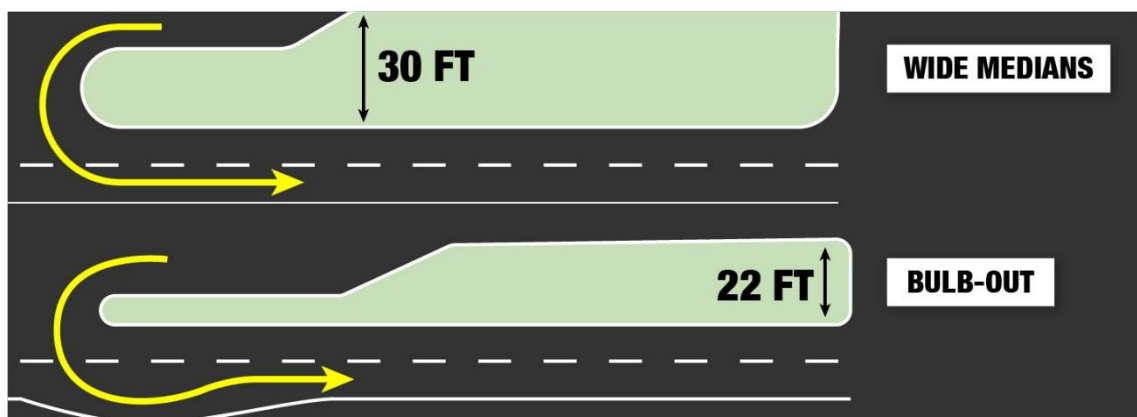
Medians, Median Openings and U-Turns

U-turns should not be permitted from the through traffic lane due to the potential for high-speed, rear-end crashes and serious impact on traffic operations. All left-turns and U-turns should be made from a left-turn/U-turn lane.

Designing Medians for U-Turns

To accommodate U-turns, either a wide median can be designed or a bulb-out can be placed onto the side of the roadway. This principle is illustrated in [Figure 66](#) which shows the typical turning width required by a large passenger car or SUV on a suburban 4-lane arterial roadway. The type of traffic, land uses and terrain surrounding the area will determine whether these designs are viable. For specific information on median widths, refer to [Table 9](#) in [Locating Roadway Openings](#) where guidance is provided based on design speed and context classification.

Figure 66 – Example U-Turn Options on a 4-Lane Arterial



Source: FDOT

¹⁵ Providing extra driveway pavement across from median openings can help U-turn movements. This would typically be done on 4-lane roads

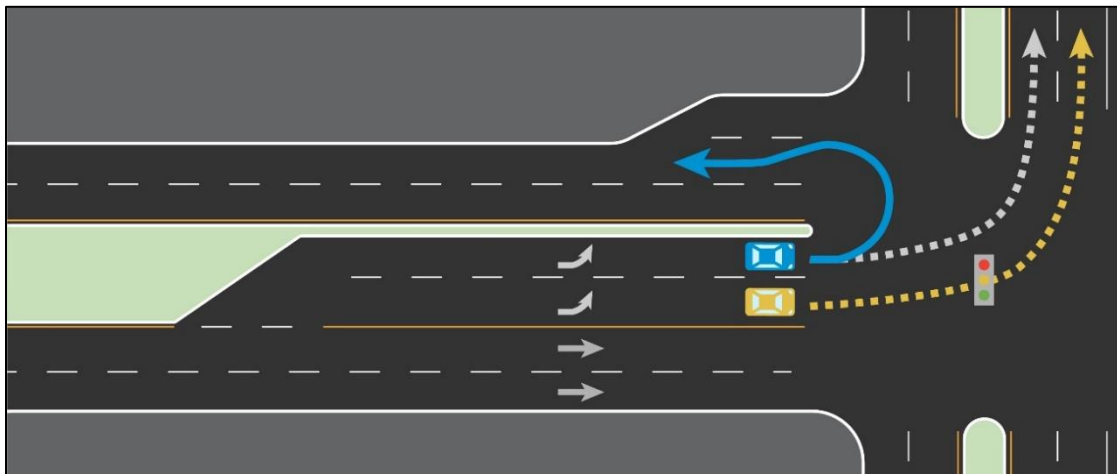
U-Turn Locations

The locating and allowing of a U-turn movement must be reviewed thoroughly to avoid causing issues with other aspects of the transportation network. This is especially important when there are multiple signalized intersections and driveways on the roadway.

For U-turn movements that are meant to be completed at a signalized intersection, there must be sufficient median width to avoid encroachment onto the sidewalks. There should also be a low combined left-turn plus U-turn volume at signalized single left-turn lanes at the intersection. The reason for this is that vehicles making U-turn movements take longer to complete in comparison to left turns. Caution should be taken when there are side streets with "right-on-red" restrictions or for signal operation that includes right-turn overlaps.

Where medians are of sufficient width to accommodate dual left-turn lanes, an option is to allow U-turns from the inside (left-most) left-turn bay as illustrated in [Figure 67](#).

Figure 67 – Dual Left-Turn Lanes and U-Turns



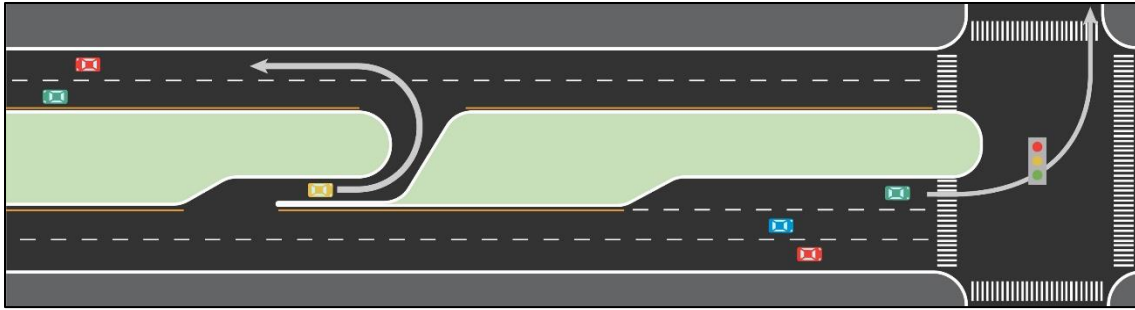
Source: FDOT

U-Turns Before or After Intersections

A U-turn in advance of a signalized intersection will result in two successive left-turn lanes as illustrated in [Figure 68](#). However, unless there is a substantial length of full median width, drivers may mistakenly enter the U-turn lane when desiring to perform a left-turn at the downstream signalized intersection. Motorists may perform abrupt re-entry maneuvers into the through traffic lane to escape the U-turn lane. Over 100 ft. of full median width between the median opening and the intersection helps to alleviate this problem. If 100 ft. is not possible, signage or other pavement markings can be used to help guide the motorist. Indications that you should consider a U-turn opening before a signalized intersection are:

- High volume of left turns currently at signalized intersection
- Numerous conflicting right turns
- A gap of oncoming vehicles would be beneficial at a separate U-turn opening
- Where there is sufficient space to separate the signalized intersection and U-turn opening

Figure 68 – U-Turn (Median U-Turn) Before a Signalized Intersection



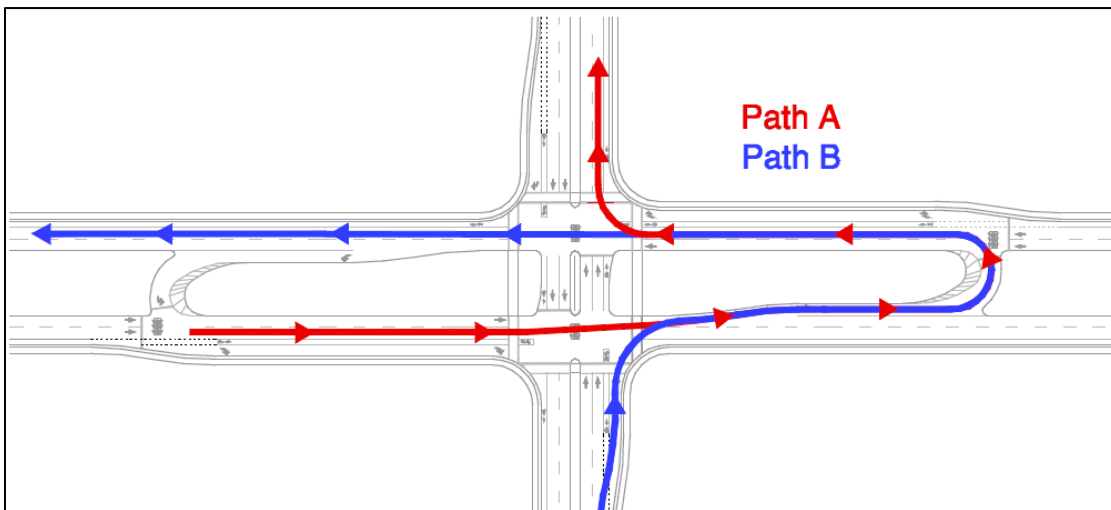
Source: *Safety and Operational Evaluation of Right Turns Followed by U-turns as an Alternative to Direct Left Turns*, University of South Florida

For U-turns that are to be made after a traffic signal (See [Figure 69](#)), it is recommended that a “Median U-Turn” is used to allow for these types of movements (previously called “Michigan U-Turns”). See the FDOT ICE Manual and the [FHWA Median U-Turn Information Guide](#) for guidance on median U-turn intersections.

The Median U-Turn (MUT) and other alternative intersection designs such as the Restricted Crossing U-Turn Intersection (RCUT) are techniques that reduce the number of signal phases at intersections which in turn can reduce delay and increase intersection efficiency for multiple modes. By providing carefully designed U-Turning paths, direct left-turns are eliminated.

As shown in Path A in [Figure 69](#), Drivers desiring to turn left from the major road onto an intersecting cross street must first travel through the at-grade, signal-controlled intersection and then execute a U-turn at the median opening downstream of the intersection. These drivers then can turn right at the cross street. As shown in Path B in the same figure, drivers on the side street desiring to turn left onto the major road must first turn right at the signal-controlled intersection and then execute a U-turn at the downstream median opening and proceed back through the signalized intersection.

Figure 69 – Median U-Turn Intersection Vehicle Paths



Source: *FHWA Median U-Turn Intersection Information Guide*

The MUT can be implemented with and without signal control at the median openings on the major road. There are many variations of the MUT which are covered in the FHWA guidance. These include U-turn crossovers before and after the intersection. Any installation of an alternative intersection should be done following the guidance in the *ICE Manual* and in conjunction with the *FDOT Roadway Design Office*.

There are similar operational issues for vehicles when the U-turn is before the signal, but the implementation of this roadway design is said to increase capacity by 20-50%. According to FHWA, while there are no absolute traffic volume requirements for the use of this design, they have traditionally been implemented on state roads with average traffic volumes of at least 10,000 vehicles per day.

Overall, it has been found that there are reduced average delays for left-turning vehicles and through-traffic with this design. They have also been found to be safer for pedestrians who are crossing the roadway and reduce vehicular safety by decreasing the amount of crashes.

Large Vehicles and U-Turns

The extremely wide median that is required for buses and trucks to make a U-turn makes it impractical to design for these vehicles except in special cases. An example of a truck U-turn can be seen in [Figure 70](#). The need for U-turns by large vehicles can generally be avoided in the following ways:

- Bus and truck delivery routes can be planned to eliminate the need for U-turns on a major roadway
- Driveways can be adjusted, and on-site circulation designed to eliminate the need for U-turns by trucks

Local governments can avoid the need for U-turns by large vehicles through their subdivision and site development ordinances. Sample land development regulations which include these features can be found in the CUTR report for FDOT: [Model Access Management Policies and Regulations for Florida Cities and Counties: 2nd Edition](#).

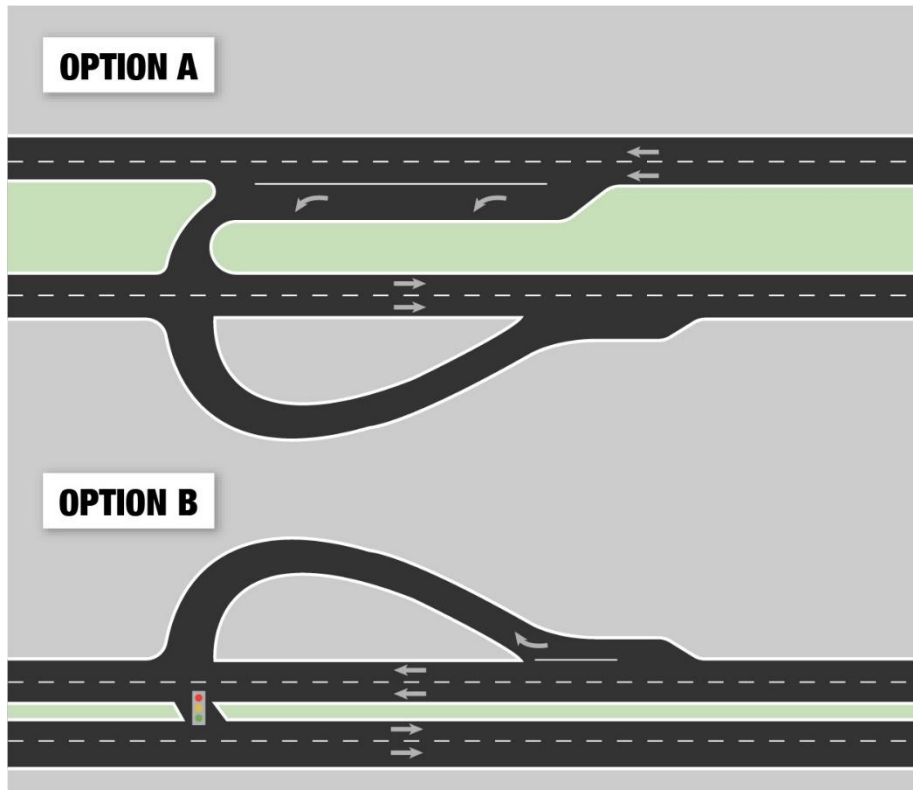
Figure 70 – Truck U-Turn in Williston, FL



Source: Google Earth – Williston, FL

There are various roadway designs though that can be used to allow trucks or other large vehicles to make U-turn movements. These alternatives are sometimes called “Jughandles” and permit the vehicle to complete the U-turn without encroaching into lanes (See [Figure 71](#)). By creating a large, sweeping design on the side of the roadway, these vehicles can more safely make U-turns.

Figure 71 – U-Turn Alternatives for Large Vehicles



Source: FDOT

Both Option A and B are useful, but there are differences in these two designs. Option A has the following desirable operational features:

- A U-turning vehicle is stored in the median parallel to the through traffic lanes
- A suitable gap is needed in the opposing traffic stream only
- After completion of the U-turn the driver can accelerate prior to merging into the through traffic lane
- Typically, commercial drivers would prefer Option A over Option B as they will only be required to travel over one direction of traffic

In most cases, Option B will need a signal. Both options require more right-of-way than most standard highway designs, but it may be more cost feasible where public land is available or in special cases. For example, a horse race track installed a “jughandle” design to more easily allow for movements of vehicles that had horse trailers (See [Figure 72](#)).

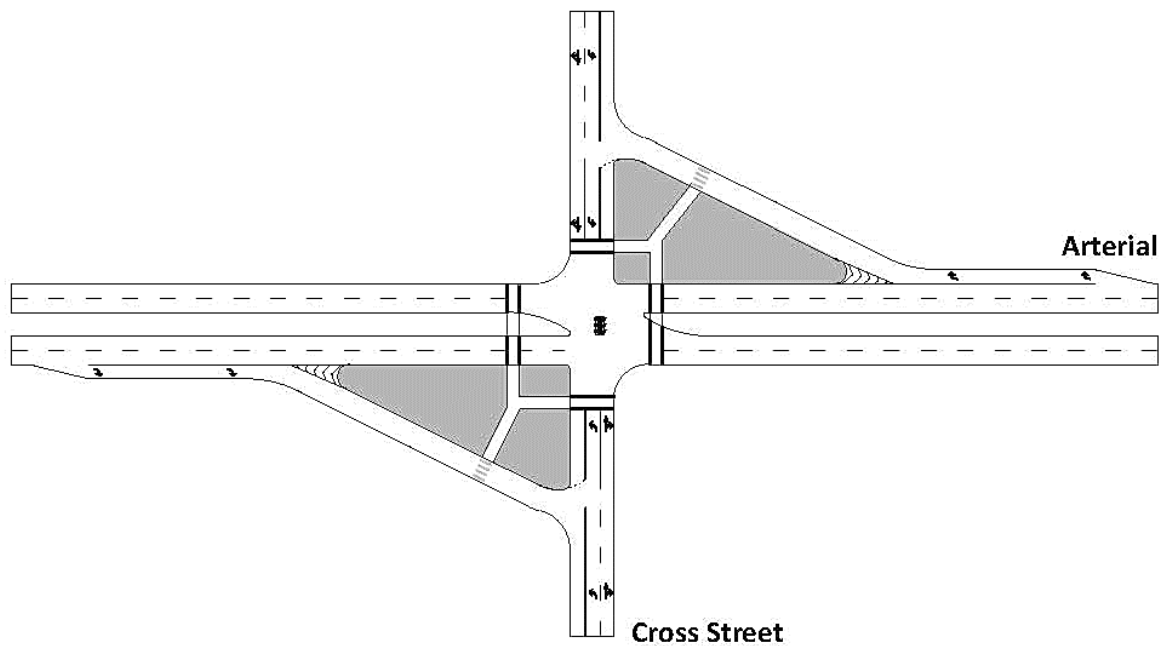
Figure 72 – U-Turn Alternative B



Source: Google Earth – Miami, FL

When this treatment is used at an intersection it is known as a New Jersey Jughandle Intersection (NJI). For a simplified view of the NJJI design, please refer to [Figure 73](#).

Figure 73 – NJJI Simplified View



Source: New Jersey Department of Transportation

For more information on “Jughandles”, please refer to the [FDOT ICE Manual, Appendix A](#) or [FHWA’s Techbrief on “Jughandle” intersections](#).

Alternative Intersections and U-Turns

Below is a list of the various alternative intersection designs:

- Median U-Turn
- Restricted Crossing U-Turn
- Roundabout
- Displaced Left-Turn
- Quadrant Roadway

For more information on them, please refer to the [FDOT Intersection Control Evaluation \(ICE\) Manual](#).

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Chapter 7: Integration Considerations

7.1 Overview

Consider all elements of the transportation network when designing medians, median openings and driveways. Unique aspects of the built environment, varying local conditions and other modes, must be incorporated into the planning and design phases of access management plans. Fully understanding the context classification of a location is a good way to structure the consideration of these elements.

This chapter focuses on tools to improve the efficiency and safety of all users. It discusses selection of intersection control evaluation techniques and when to use the [Manual on Intersection Control Evaluation](#) (ICE) process to select and document the best alternative. Roundabouts are often selected in this process and are often encouraged as an access management and intersection control strategy. This roundabout portion discusses U-Turns, median openings, methods to maximize benefits for all modal users and resources for proper design. The next section explores using non-motorized network connectivity techniques as an access management strategy. This leads into the Department's complete streets program and discusses access management considerations for freight, transit vehicles and bus stops. Finally, strategies to share driveways and connect parcels internally are discussed.

7.2 Intersection Control

Intersection control design is discussed in detail in the [FDM 212](#) and the [FDOT Traffic Engineering Manual \(TEM\)](#). To ensure that the best intersection control strategy is implemented, the FDOT Traffic Engineering and Operations Office, has developed the ICE Manual. This was published in November 2017 and provides direction to transportation professionals when building a new intersection or modifying an existing one.

7.2.1 Intersection Control Evaluation Process

With the implementation of [FDOT's Complete Streets Policy](#), increased emphasis has been placed on the safety of all road users in intersection design. The ICE process quantitatively evaluates several intersection control scenarios (alternatives) and ranks these alternatives based upon their operational and safety performance. Implementing a "performance-based" procedure such as ICE creates a transparent and consistent approach to consider intersection alternatives based on metrics such as safety, operations, cost, and social, environmental, and economic impacts.

Specific guidance on when an ICE process is required is provided below:

Applicability (1) An ICE is required when: (a) New signalization is proposed; (b) Major reconstruction of an existing signalized intersection is proposed (e.g., adding a left-turn lane for any approach; adding an intersection leg); (c) Changing a directional or bi-directional median opening to a full median opening; (d) Driveway Connection permit applications for Category E, F, and G standard connection categories (defined by average daily trips thresholds in Rule 14-96.004, F.A.C.) add, remove, or modify a traffic signal; or (e) District Design Engineer (DDE) and District Traffic Operations Engineer (DTOE) consider an ICE a good fit for the project. (2) An ICE is not required for intersection projects if any

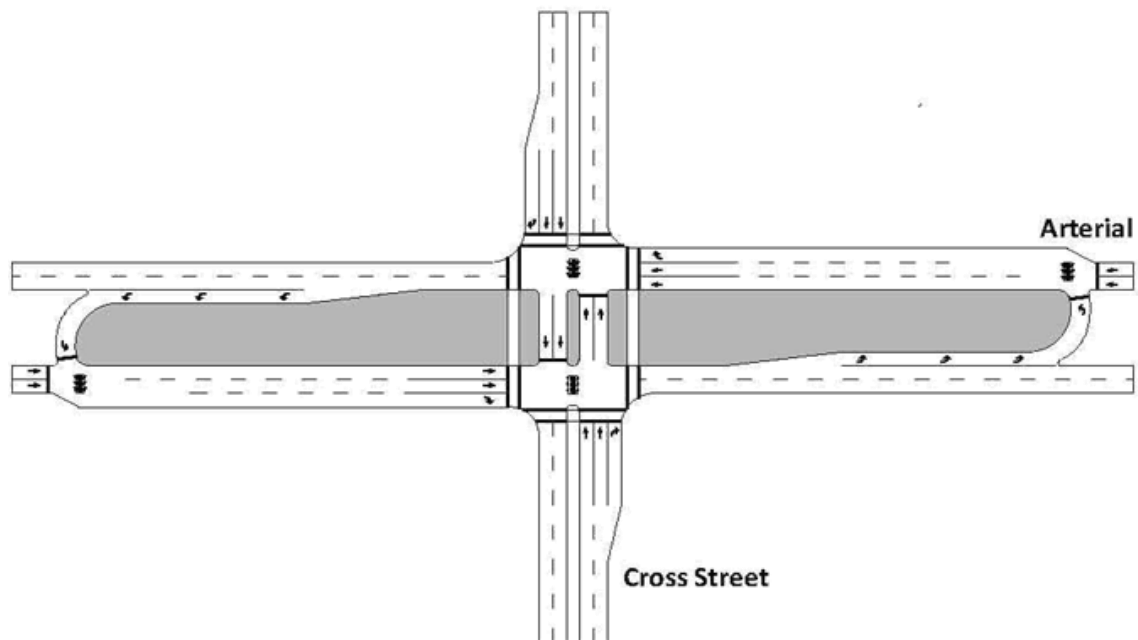
of the following apply: (a) Work involved does not include any substantive proposed changes to an intersection (e.g., a project limited to only “mill and resurface” pavement with no change to intersection geometry or control; converting a 2-way stop intersection to a 4-way stop intersection; changing a full median opening to a directional median opening). (b) Minor intersection operational improvements (such as adding right-turn lanes or changing signal phasing) or signal replacement projects where the primary purpose is to upgrade deficient equipment and installations. (3) FDOT encourages local agencies and counties to perform an ICE for projects they lead on locally maintained roadways, but ultimately it is the choice of the local jurisdiction.

Alternative Intersections

Traditionally, the most common solutions to intersection challenges involved stop-controlled, conventional signalization scenarios, or interchanges and focused on the movement of vehicles through the intersection. In recent years, several new innovative intersection designs have been introduced across the United States. These “alternative” intersection control types are enhancing safety and improving operations, along with varying degrees of other benefits.

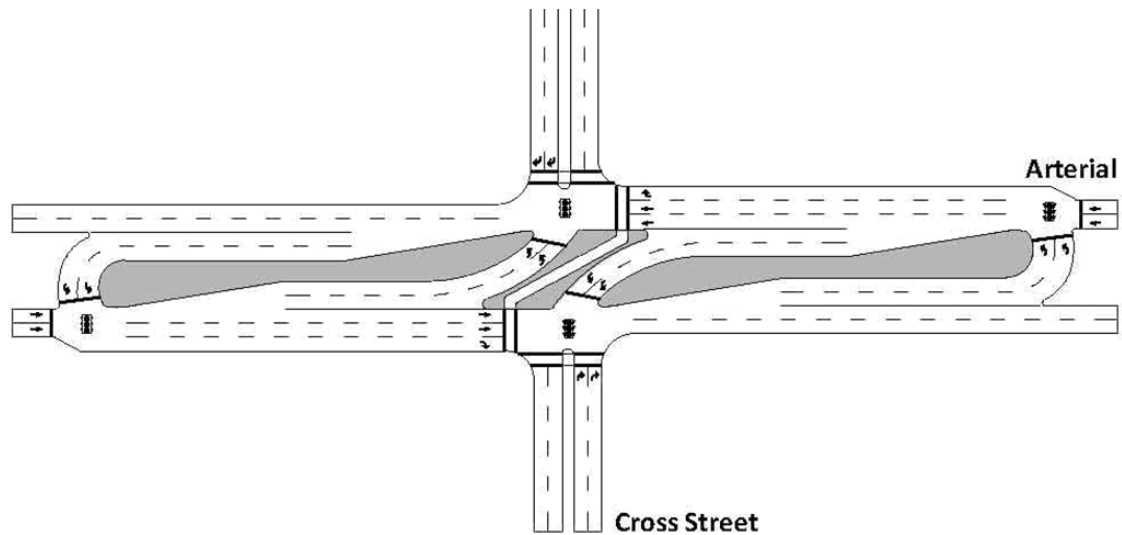
Alternative intersections (including roundabouts, cross-over-based designs, and U-turn-based designs) often consider community needs, transportation needs, and control strategies to achieve multiple objectives. The Median U-Turn and Signalized Restricted Crossing U-Turn (RCUT), are shown in [Figure 74](#) and [Figure 75](#). Roundabouts are discussed in greater detail in [Section 7.3](#).

Figure 74 – Median U-Turn



Source: FDOT ICE Manual

Figure 75 – Signalized Restricted Crossing U-Turn (RCUT), or Superstreet



Source: FDOT ICE Manual

The FHWA has published comprehensive informational guides for alternative intersections which include guidance on how to plan, design, construct, and operate them. The following link provides access to these guides: [FHWA Alternative Designs](#). Using these types of alternate intersection designs should be coordinated with the [Central Office Roadway Design](#). The method to evaluate and compare these intersection types is part of the ICE manual. In addition, forms, templates and software to assist in this process are located on the [FDOT Intersection Operations and Safety](#) webpage and in the *ICE Manual*. Appendix A of the ICE manual details all the intersection control strategies.

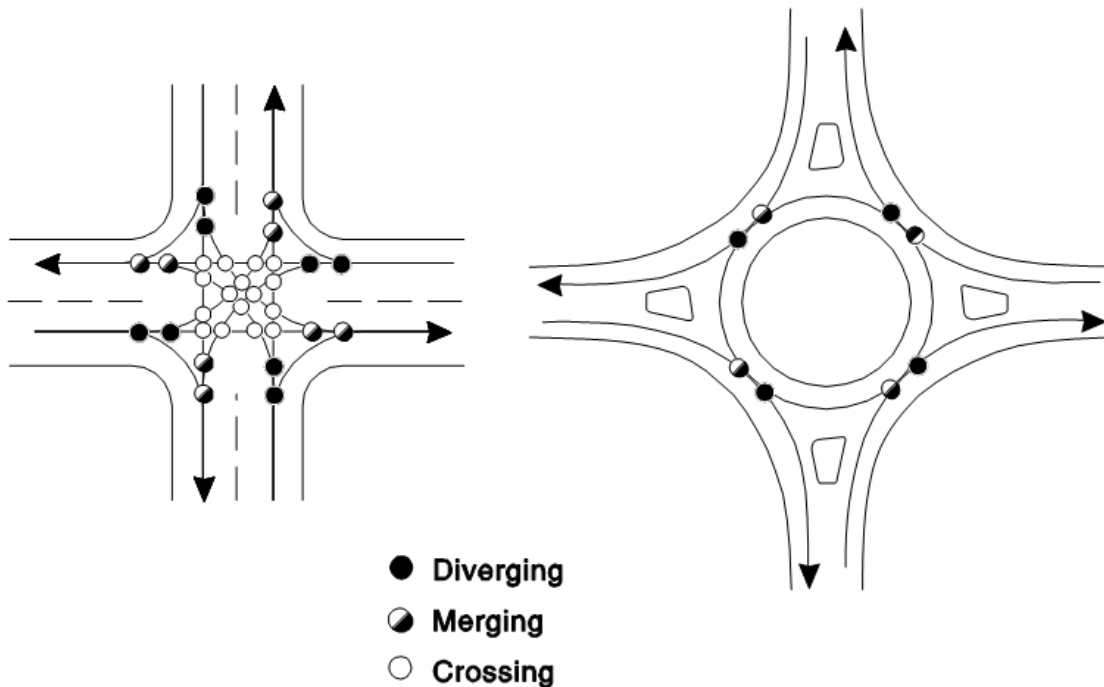
7.3 Roundabouts

Roundabouts provide significant benefits for roadway users by reducing the number of conflict points that can occur when compared to a signalized or unsignalized intersection. [Figure 76](#) demonstrates how vehicular conflict points are reduced from thirty-two to eight while eliminating crossing conflicts, which are the main cause of serious injuries and fatalities. According to the Highway Safety Manual, this has been found to increase overall safety for roadway users by reducing the amount of serious injuries and fatalities by 79% when compared to a signalized intersection.¹⁶ Although the number of conflicts increases at multilane roundabouts when compared to single-lane roundabouts, the overall severity (and often number) of conflicts is typically less than other intersection alternatives. In addition to reducing conflict points for vehicles, they are similarly reduced for non-motorized users as well¹⁷. NCHRP 672 and FDM 213 provide greater detail in non-motorized users safety benefits. Typically, these benefits are higher with single lane roundabouts.

¹⁶ <http://www.cmfclearinghouse.org/detail.cfm?facid=4184>

¹⁷ [NCHRP Report 672 - Roundabouts: An Informational Guide – Second Edition](#)

Figure 76 – Intersection vs. Roundabout Conflict Points



Source: NCHRP Report 672 (Figure 5-2)

For planning purposes, a roundabout will typically provide better operational performance than a signal in terms of stops, delay, vehicle queues, fuel consumption, safety, and pollution emissions. According to *NCHRP 672*, a roundabout that operates within its capacity will generally produce lower delays than a signalized intersection operating with the same traffic volumes and right-of-way limitations.¹⁸

A detailed methodology for section of roundabouts is provided in the ICE Manual. In addition, *NCHRP 672* provides a detailed methodology for comparing potential roundabout performance with a comparable signalized intersection. A simplified version of this is summarized in **Table 28** below. Several other benefits of roundabouts include providing simpler U-turn movement opportunities for users, as well as potentially creating a system that can move vehicular traffic more efficiently in a city when multiple roundabouts are built in a network.

Table 28 – Guidance on Roundabout Category Comparisons

Factor	Single lane	Multi-lane
Total Entering Traffic Volumes	Up to 25,000	Up to 45,000
Entry Speed	20 - 25 mph	25 - 30 mph
Typical Inscribed Circle Diameter	90 - 180 ft.	150 - 300 ft.

Source: Adapted from NCHRP 672

¹⁸ NCHRP Report 672 - Roundabouts: An Informational Guide – Second Edition

Roundabouts should be able to accommodate most large vehicles easily through them, such as; school buses, moving vans, garbage trucks, fire trucks, and other emergency vehicles should be able to utilize a roundabout with no significant operational issues. The inclusion of a truck apron around the circular island allows for larger trucks to safely make all turning movements. Appropriate pavement markings are key to guide where the steering axle and wheels are needed to minimize off-tracking.

7.3.1 Geometric Considerations

When properly designed, the geometric design of roundabouts reduces the speed of vehicles approaching, using, and exiting the roundabout. Reducing vehicle speed benefits all users.

Traffic flow through a roundabout is especially sensitive to small geometric changes. Some considerations that must be addressed for successful implementation are:

- Good deflection at the entry of a roundabout
- Truck movements
- Public acceptance/awareness

Roundabouts can handle higher volumes of traffic than equivalent signalized intersections. [Table 28](#) provides guidance for comparing single and double-lane roundabouts.

Peer review of all designs is highly recommended because many minor crashes can be avoided by a careful review of initial designs. Roundabouts are one of the [FHWA Proven Safety Countermeasures](#). The *FDOT Central Office's Roadway Design Office* will also review roundabout designs if requested.

[FDM 213 Modern Roundabouts](#) provides specific FDOT criteria on roundabout design. These criteria are supported by [NCHRP Report 672, Roundabouts: An Informational Guide](#) which covers certain aspects of roundabout design in more detail.

This section provides some general guidance on roundabouts in conjunction with access management strategies.

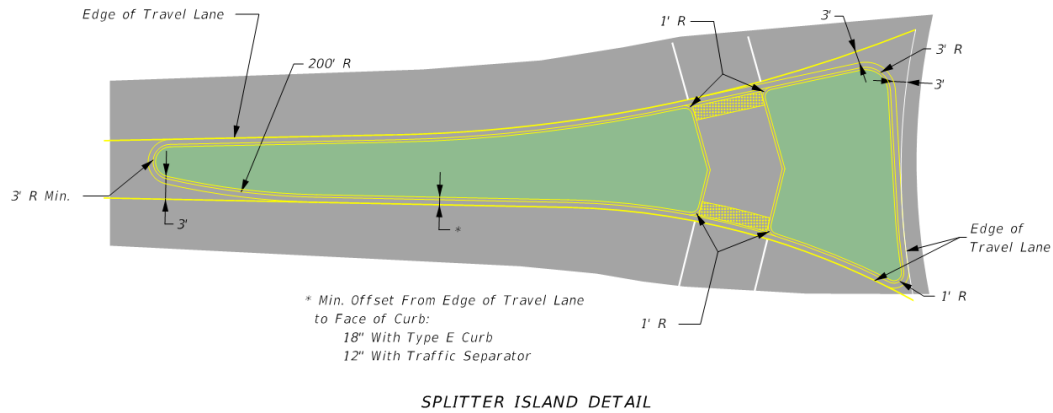
7.3.2 Important Considerations

Bicyclists may be offered two paths upon approach to the roundabout (See [Figure 77](#), [Figure 78](#), or [Figure 79](#)). An existing or planned bicycle lane on an approach roadway must end in advance of a 2-lane roundabout with "bicycle ramps" providing access to the sidewalk. Bicycle ramps are optional for single-lane roundabouts. Bicycle ramps near roundabouts may be confusing to pedestrians with visual impairments. Directional Indicators are intended to minimize confusion by redirecting pedestrians with visual impairments away from bicycle ramps and guide them to stay on the sidewalk. Directional Indicators are designed to be detectable by cane, underfoot, and visual contrast with surrounding pavement ([Refer to FDOT Roadway Design Bulletin 19-5 for more information](#)). [FDM 213](#) provides overall FDOT guidance on roundabout design

At the end of the bicycle lane, the bicyclist may either "control the lane" and navigate the roundabout as a vehicle or divert onto the sidewalk/shared-use-path and cross at pedestrian crossings. The typical motor vehicle operating speed within the roundabout is in the range of 15 to 25 mph, which is similar to that of a bicycle. No bicycle lane markings are to be placed within the circulatory roadway.

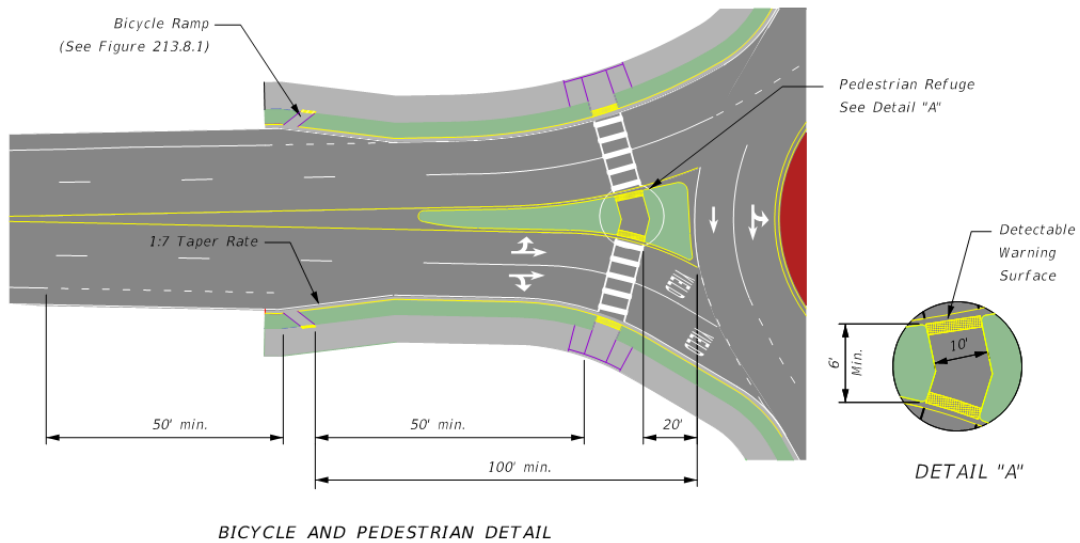
Pedestrians are accommodated by crossings around the perimeter of the roundabout. By providing space to pause on the splitter island, pedestrians can consider one direction of conflicting traffic at a time, which simplifies the task of crossing the street. The roundabout should be designed to discourage pedestrians from crossing to the central island, e.g., with landscape buffers on the corners.

Figure 77 – Roundabout Details – Splitter Island



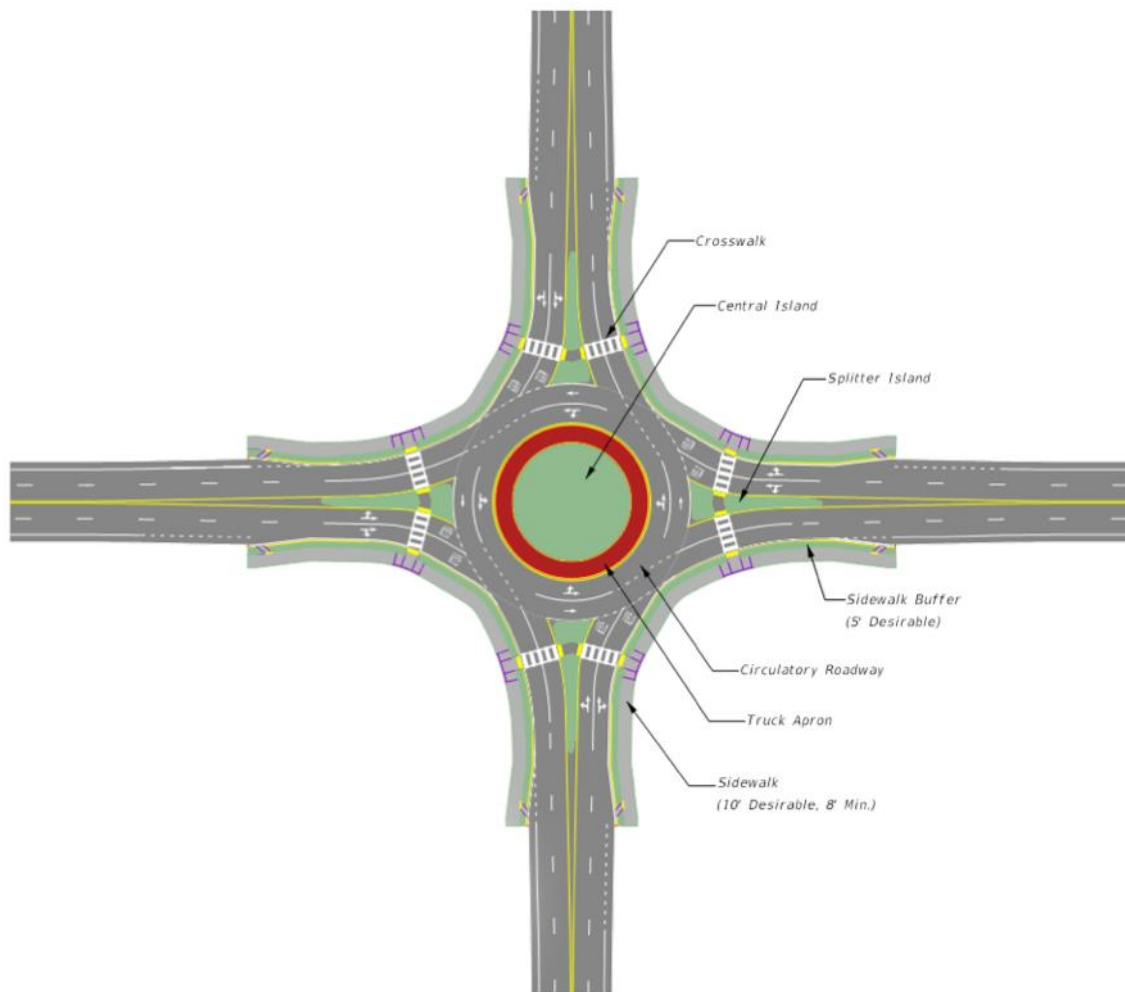
Source: FDM 213 – Modern Roundabouts (Exhibit 213-1)

Figure 78 – Roundabout Details – Non-Motorized Features



Source: FDM 213 – Modern Roundabouts (Exhibit 213-1)

Figure 79 – Roundabout Details



Source: FDM 213 – Modern Roundabouts (Exhibit 213-1)

Roundabouts should always be designed for the largest vehicle that can be reasonably anticipated (the “design vehicle”). For single-lane roundabouts, this may require the use of a mountable apron around the perimeter of the central island to provide the additional width needed for tracking the trailer wheels (See [Figure 80](#)). At double-lane roundabouts, large vehicles may track across the whole width of the circulatory roadway to negotiate the roundabout.

Transit considerations at a roundabout are similar to those at a conventional intersection. Buses should not be forced to use a truck apron to negotiate a roundabout. To minimize passenger discomfort, if the roundabout is on a bus route, it is preferable that scheduled buses are not required to use a truck apron if present. Bus stops should be located carefully to minimize the probability of vehicle queues spilling back into the circulatory roadway.

Figure 80 – Roundabout Example

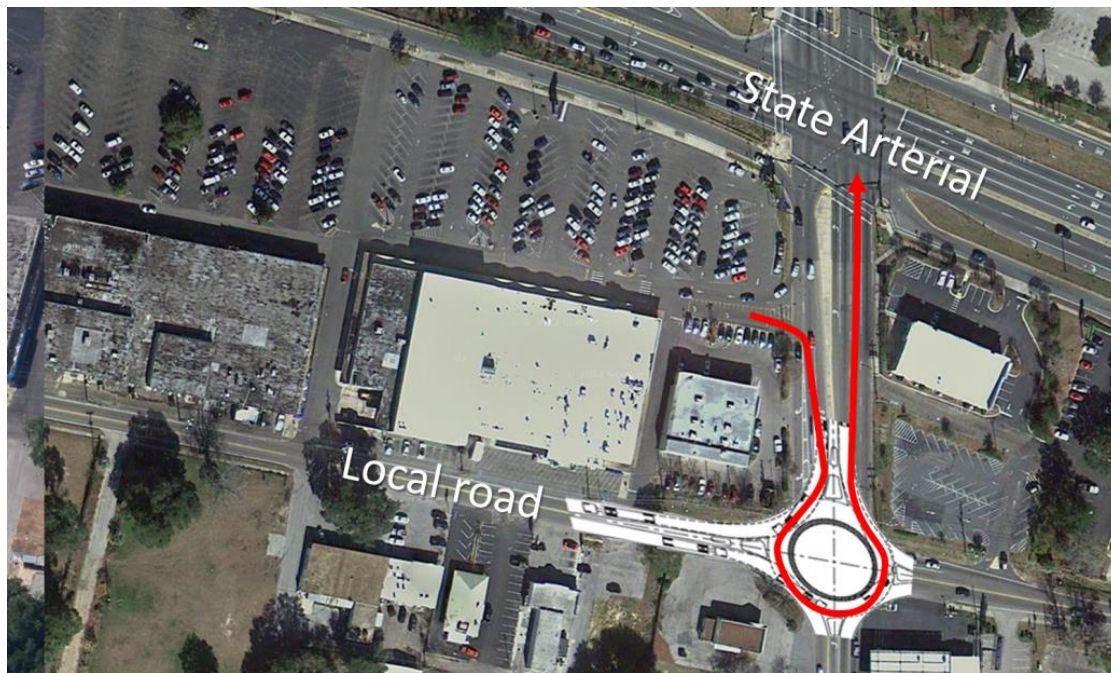


Source: Aerial Innovations – Lake Wales, FL

7.3.3 U-Turns

Roundabouts allow U-turns within the normal flow of traffic, which often are not possible at other forms of intersection. Roundabouts can also change access management patterns by changing side street and driveway access spacing needs and requirements. For example, a roundabout can facilitate access from an arterial to a shopping center, where the median opening was closed (See [Figure 81](#)).

Figure 81 – Example of Proposed Roundabout Near Arterial



Source: Google Earth

7.3.4 Median Openings

The operational characteristics of a roundabout are different than a conventional intersection. The slower speeds and traffic queues provide more flexible turning opportunities that would typically disrupt a signalized intersection.

Directional median openings could be considered after exiting a roundabout. The ease of making a U-turn reduces the need for median openings prior to roundabouts. Since speeds are lower before and after roundabouts, the design and location of median openings will depend on the specific location.

7.3.5 ICE Manual

Roundabouts are one of several alternative intersection control strategies considered by the *FDOT ICE Manual*. The *ICE Manual* replaces the former FDOT roundabout evaluation process. Appendix A of the *ICE Manual* details all the intersection control strategies.

7.4 Non-Motorized Connections

For design purposes, bicyclists are considered vehicles when traveling within the roadway. All users of the roadway benefit from improved safety and operations when conflict points are well managed as part of a comprehensive approach.

7.4.1 Median Benefits to Pedestrians

Although medians have significant benefits for vehicular operations, they are also beneficial for pedestrians. Pedestrians are permitted to travel along all non-limited access facilities. Therefore, considerations for pedestrian safety and mobility should be included in median design decisions. Pedestrians are a "High" modal priority in context classifications C6, C5, C4 and C2T.

7.4.2 Proven Safety Countermeasures

Medians and Pedestrian Refuge Islands Improve Pedestrian Midblock Crossings

Nationally, pedestrian crashes account for approximately 15 percent of all traffic fatalities annually, and over 75 percent of these occur at non-intersection locations.¹⁹ For pedestrians to safely cross a roadway, they must estimate vehicle speeds, adjust their walking speed, determine gaps in traffic, and predict vehicle paths. Installing raised medians or pedestrian crossing islands can help improve safety by simplifying these tasks and allowing pedestrians to cross one direction of traffic at a time.

Nighttime Conditions

Under nighttime conditions, the crossing task is even more complex for pedestrians. Pedestrians are watching car headlights and it is more difficult to correctly judge the speed of, and distance to, approaching motor vehicles when only headlights are visible. Valuable cues used by pedestrians to judge speed, e.g., change in the observed shape of the approaching car and relative location with respect to roadside objects, are more difficult to observe at night. Variations in motor vehicle travel speeds add to the complexity of judging adequate gaps in traffic. Raised medians and refuge islands provide a space to install improved lighting at pedestrian crossing locations. Improved lighting has been shown to reduce the nighttime pedestrian fatalities at crossings by 78 percent.²⁰

Delay Reduction

Raised medians and refuge islands also reduce the amount of delay incurred by pedestrians waiting for a gap in traffic to cross. Shorter delays translate into fewer pedestrians taking risks by crossing through "holes" in the traffic stream. On a four-lane roadway with 5,000 ADT, medians can reduce pedestrians' delay waiting for a gap by 79 percent (from 41 seconds to 9 seconds).²¹

Midblock Crossing Locations

FHWA directs that transportation agencies should consider medians or pedestrian crossing islands in curbed sections of urban and suburban multi-lane roadways, particularly in areas with a significant mix of pedestrian and vehicle traffic, high volumes of traffic (more than 12,000 vehicles-per-day) and intermediate or high travel speeds. Some example locations that may benefit from raised medians or pedestrian crossing islands include:

- Midblock areas
- Approaches to multi-lane intersections

¹⁹ National Highway Traffic Safety Administration, Traffic Safety Facts - 2015 Data - Pedestrians. Report DOT HS 812 375, (Washington, DC: 2017).

²⁰ FHWA, Desktop Reference for Crash Reduction Factors, FHWA, Washington, DC, September 2007.

²¹ NCHRP Report 616, Multimodal Level of Service Analysis for Urban Streets, TRB, Washington DC, 2008.

- Areas near transit stops or other pedestrian-focused sites

Vehicle travel speeds are typically higher at midblock locations, which contributes to the larger injury and fatality rate seen at these locations. A pedestrian's risk of fatality or serious injury is 85% when hit by vehicles traveling at 40 mph or faster while that risk drops to 5% when hit at 20 mph or less.²²

Installing such raised channelization on approaches to multi-lane intersections has been shown to be especially effective. Medians are a particularly important pedestrian safety countermeasure in areas where pedestrians access a transit stop or other clear origins/destinations across from each other. Providing raised medians or pedestrian refuge areas at marked crosswalks has demonstrated a 46 and 56 percent reduction in pedestrian crashes, respectively.²³ At unmarked crosswalk locations, medians have demonstrated a 39 percent reduction in pedestrian crashes.

Important Considerations

FHWA guidance further states that medians/refuge islands should be at least 4 ft. wide (preferably 8 ft. wide for accommodation of pedestrian comfort and safety) and of adequate length to allow the anticipated number of pedestrians to stand and wait for gaps in traffic before crossing the second half of the street.²⁴ On refuges 6 ft. or wider that serve designated pedestrian crossings, detectable warning strips complying with the requirements of the Americans with Disabilities Act must be installed.

Other important design considerations for pedestrian refuge islands:

- Include a vertical element (such as landscaping, bollard, or other) on pedestrian refuges to ensure visibility to motorists;
- Use the "z crossing" or angled crossing design for the pedestrian refuge to ensure that pedestrians are facing oncoming traffic (See [Figure 82](#));
- Include adequate lighting to ensure that crossing pedestrians are visible on the refuge and through the crosswalk (See [Table 29](#))

²² Source: "Killing Speed and Saving Lives - The Government's Strategy for Tackling the Problems of Excess Speed on our Roads." London: Department of Transport, 1987

²³ https://safety.fhwa.dot.gov/provencountermeasures/ped_medians/

²⁴ https://safety.fhwa.dot.gov/legislationandpolicy/policy/memo071008/#ped_refuge

Figure 82 – Angled Pedestrian Refuge Crossing



Source: FHWA Median Brochure

Installation Criteria

FDOT's *Traffic Engineering Manual (TEM)* Section 3.8 provides installation criteria for marked midblock crosswalks and refuge islands. It states that:

“Placement of midblock crosswalks should be based upon an identified need and not used indiscriminately. Important factors that should be considered when evaluating the need for a midblock crosswalk include:

- Proximity to significant generators
- Pedestrian demand
- Pedestrian-vehicle crash history
- Distance between crossing locations

Any marked crosswalk proposed at an uncontrolled location across the SHS must be reviewed and approved by the District Traffic Operations Engineer prior to installation. A full engineering study documenting the need for a marked crosswalk based upon the location of significant generators, demand, crashes, and distances to nearest crossing locations provides the basis for the determination. Refer to the TEM Section 3.8 for detailed criteria for each facet of this evaluation.”

Treatments

The *TEM* also provides standards for the appropriate treatments for marked midblock crossings. The determination of the appropriate treatments is generally based upon pedestrian volumes, vehicular volumes, distances to adjacent traffic signals, presence of shared use path crossings, etc. The *TEM* outlines three primary treatment options for midblock crossings beyond an appropriately signed and marked crosswalk:

1. **Traffic Signal** – A conventional full traffic signal installed at a midblock location. Consideration for traffic signal warrant and spacing criteria must be addressed as part of this option.
2. **Pedestrian Hybrid Beacon** – This treatment is also referred to as a High-Intensity Activated Crosswalk Beacon or HAWK beacon. This treatment provides for signalized, protected pedestrian crossings while minimizing disruption to vehicular traffic flow. Pedestrian hybrid beacons must meet specific warrant criteria for installation as outlined in the *TEM*. This is an option for locations where a full traffic signal is not warranted by pedestrian volumes, yet demand justifies a more intense warning treatment.
3. **Supplemental Beacons** – The *TEM* provides two (2) options for supplemental beacons: flashing yellow warning beacons and rectangular rapid flashing beacons (RRFBs). Note that the *TEM* requires that these beacons be activated by a pedestrian to increase the effectiveness of the treatment. Conventional flashing yellow warning beacons are installed as part of regulatory or warning signs and provide additional emphasis on the crossing location. FHWA considers RRFBs to be highly successful for marked crosswalks at uncontrolled approaches. RRFB's are also pedestrian actuated and quickly flash alternating warning lights in a “wig-wag” pattern.

In addition to these treatments, other enhancement tools are available to the roadway designer to further enhance midblock crossings. These enhancements include, but are not limited to, supplemental and advanced pavement markings/signage and in-street lighting. Note that all marked midblock crossings must meet the ADA Standards. The *TEM* provides guidance for the application of these supplemental enhancements.

In addition to the *TEM*, FHWA has developed the [Safe Transportation for Every Pedestrian](#) program. The [Guide for Improving Pedestrian Safety at Unsignalized Locations](#) includes two matrices for determining the appropriate countermeasure(s) to use based on roadway geometry, traffic, crossing distances etc. **Appendix A** contains the table with crash reduction and modification factors for each of the recommended countermeasures.

Lighting information for midblock crosswalks is provided in [FDM 231 - Lighting](#). A simplified version of Table 2.3.1 is provided in [Table 29](#) below. This also contains lighting levels for sidewalks and shared use paths.

Table 29 – Midblock Crossing Lighting Standards - FDM

Roadway Classification Or Project Type	Illumination Level Average Initial Foot Candle		Illumination Uniformity Ratios	
	Horizontal (H.F.C.)	Vertical (V.F.C.)	Avg./Min.	Max./Min.
Midblock Crosswalk Lighting				
Low Ambient Luminance	N/A	2.3	N/A	N/A
Medium & High Ambient Luminance		3.0		
Sidewalks and Shared Use Paths				
Facilities Separated from the Roadway	2.5	N/A	4:1 or Less	10:1 or Less

Source: FDM 231 – Lighting (Table 231.2.1)

7.4.3 Additional Pedestrian and Bicycle Considerations

Bicycle and Pedestrian Network Continuity

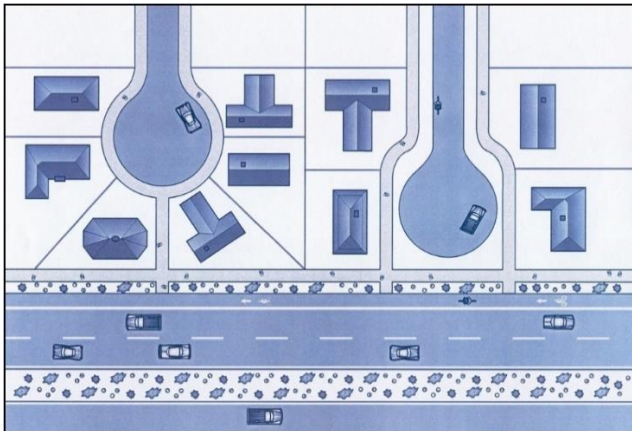
Access management can benefit all transportation modes. Crashes can be reduced by separating modal users. To encourage people to walk, bicycle or access transit safely, it is important to provide a connected sidewalk and bicycle facility network. People on foot often travel slower, make shorter trips than automobiles, and seek direct routes. It is important that their transportation networks be permeable and offer multiple options to keep trips direct. **Midblock Crossing Locations** are discussed above and are one tool to accomplish this.

In the suburban context classifications, C3R and C3C, the roadway networks typically consist of large blocks which can provide fewer opportunities for pedestrians and bicyclists to cross at signalized intersections than in urban context classifications C4 – C6. The techniques in this chapter can be helpful to overcome this hurdle. This section will discuss methods of providing connectivity to complete these networks.

Connected Cul-de-Sacs

Another way to separate non-motorized traffic from vehicular traffic is to provide direct connections through connected cul-de-sacs, which connect the end of cul-de-sacs or dead-end streets to nearby sidewalks (See **Figure 83**). A sidewalk in a cul-de-sac is connected to the nearby sidewalks to allow for people to walk or ride their bicycle. This type of neighborhood design promotes connectivity for pedestrian and bicycle modes, while prohibiting vehicles from driving through the area. These types of connections can make it possible for non-motorized users to avoid arterial roadways and access key destinations, which greatly shortens trips.

Figure 83 – Connected Cul-de-Sac



Source: [FHWA Achieving Multimodal Networks](#)

Bicycle Boulevards

Sometimes a short connection between two cul-de-sacs, a path through a park, a footbridge over a river or highway, can overcome a major barrier to connectivity and become the linchpin of a bicycle boulevard route. A bicycle boulevard also known as a neighborhood greenway, can take advantage of low-volume streets parallel to arterials to create a designated bicycle route where bicycles have priority over other modes. This can include diverting motorized traffic off the street and allowing bicycles through movement. In [Figure 84](#), signage indicates that vehicular traffic must turn and pavement markings and signage direct bicyclists to use a short cut-throughs to continue their travel. These treatments are typically applied in areas with a well-connected roadway grid. Bicycle Boulevards employ a network-based strategy of traffic calming or diverting methods to keep motorized traffic volumes and speeds low. For more information on this technique, see the North American City Transportation Officials ([NACTO](#)) [Urban Bikeway Design Guide](#).

Figure 84 – Bicycle Boulevard Example



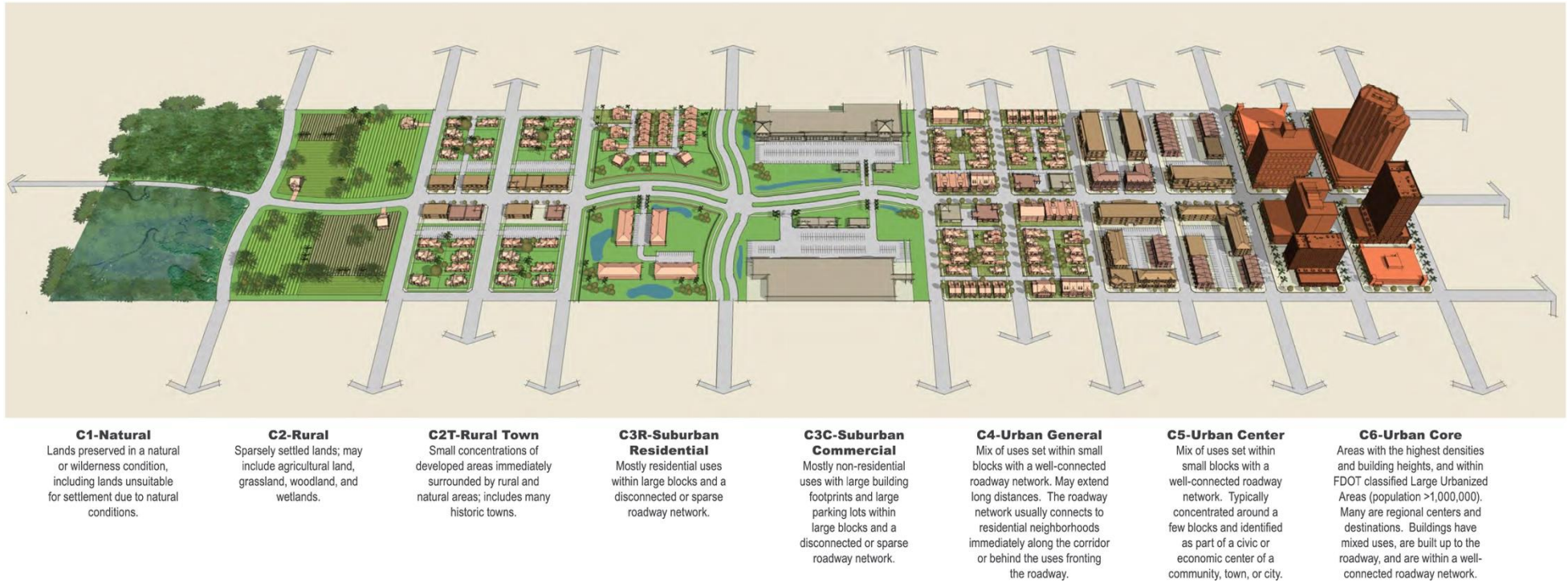
Source: CDM Smith - Tallahassee, FL

7.5 Complete Streets

The [FDOT Context Classification](#) document was published in 2017 to provide guidance on determining context classifications along state highways. In [Figure 85](#) the spectrum of context land use zones is shown. They range from C1-Natural to C6-Urban Core; these classifications are meant to provide planners and engineers with additional tools for designing roadways that function for everyone.

The context land use classifications were discussed earlier in this guidebook and have been integrated into the current access management guidance in [Table 3](#), [Table 7](#), and [Table 8](#). These context classifications offer additional guidance by providing a set of different design criteria and standards linked to the land use context. In addition, [Table 14](#) and [Table 15](#) describe the relationship of access management treatments and context classification.

Figure 85 – FDOT Context Classifications



Source: FDOT Context Classification

7.6 Large Vehicle and Freight Considerations

It is equally important to incorporate different roadway designs for non-motorized users, just as it is important to consider freight and large vehicular movements on a roadway. Just as non-motorized users have specific needs on a roadway, freight and other vehicles can require specific needs when designing a roadway. General guidance on design and control vehicles is provided in [FDM 201 - Design Controls](#). A chart showing the FHWA vehicle classification scheme is included in [Appendix B](#). Techniques, guidance, and criteria to support freight movement are included throughout this document.

7.6.1 Access Management and Freight Deliveries

Trucks need to be able to park and unload their goods in a safe and efficient fashion. The context classification and surrounding roadways can influence the types of delivery areas that are available to freight traffic. It may be appropriate to have the deliveries and truck parking be placed behind the facilities if there is a significant amount of non-motorized traffic, to minimize conflicts. Similarly, another option is to place truck parking in specific areas and/or allow for deliveries during certain periods of the day. This topic is covered in detail in the [ITE Curb Management Practitioners Guide](#). The guide provides methods to organize curb space and prioritize modal users.

Non-Motorized Users, Freight and Access Management

Another possible consideration for freight traffic would be freight/industrial areas where there are also bicycle lanes. There is value in considering the interaction of access management techniques with other modes and how they may interact with one another. For instance, it may be appropriate to either redirect trucks off these roadways or move the bike lanes to a different facility. Another option would be to utilize buffered bike lanes to separate the traffic from one another (See [Figure 86](#)). Large trucks can create hazards for bicyclists when traveling on the roadway due to the wind blast trucks create when passing or the mirrors extending into the bicyclists' space. Buffered bike lanes or separated bicycle facilities can negate or lessen these effects.

Figure 86 – Buffered Bike Lanes in Freight/Industrial Areas



Source: FDOT

Driveways and Freight

It's important to understand and consider the roadway and land use of an area, especially if special considerations need to be made for freight movements. Driveways are a piece of the roadway design which require special attention due to the typical size and profile of freight vehicles. For areas where there is a significant amount of freight vehicles entering a property, the driveway would need to be designed to be wider than normal to allow for them to turn inside safely. Alternatively, if there was a significant amount of other types of non-motorized traffic then other considerations may need to be made to account for all modes of traffic in the area.

Another example of this type of design is in [Figure 87](#), which was built in Hartford, CT. The radius of the turn was reduced for vehicles so they would enter the turn at a slower speed, while still allowing for large vehicles to enter with less operational issues. It also integrates a sidewalk into the design to still allow for pedestrians to walk safely.

Figure 87 – Truck Apron and Driveways



Source: Google Earth – Hartford, CT

Three Centered or Compound Curves for Handling Trucks Instead of Large Radii

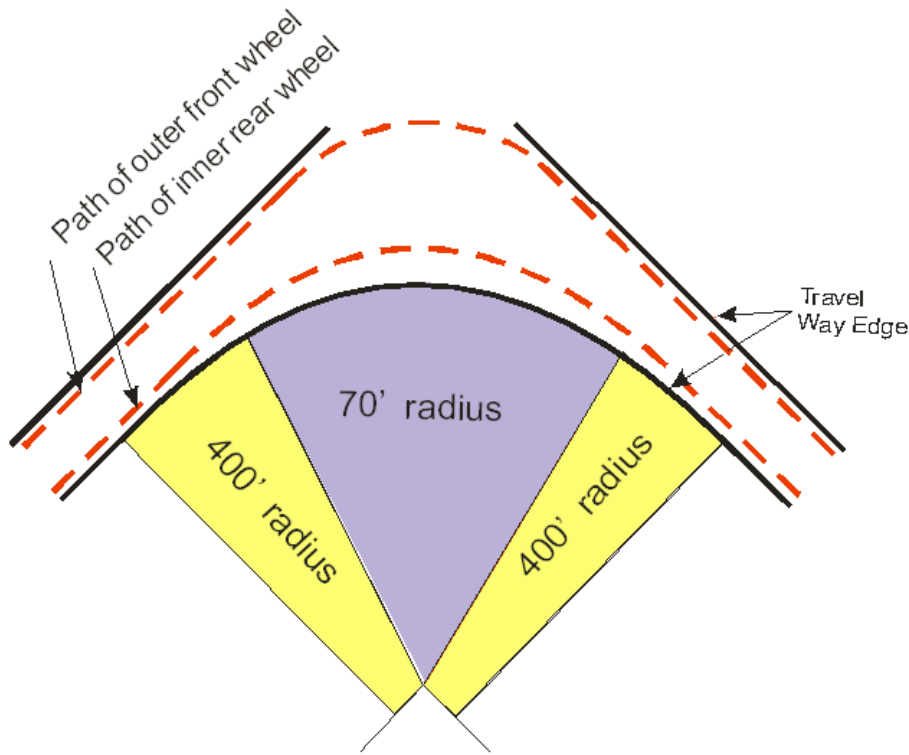
To have the best design for trucks, the use of compound curves rather than a simple radial return has many advantages (See [Table 18](#)), including the following:

- The total driveway width is reduced;
- Where the driveway is designed primarily for vehicles, the occasional truck can be better accommodated; and
- When the driveway is designed for trucks, the narrower exit lane width and geometrics of the connection provide better positive guidance to vehicular drivers

Using a compound curve rather than a simple radial return of 30 ft. will permit the driver of a passenger car to exit a driveway without encroaching on the through lanes.

The *AASHTO Green Book* also gives guidance on the use of compound curves. [Figure 88](#) is an example for the design of a WB-62 using compound curves for a 90-degree turn.

Figure 88 – Equivalent Compound Curves Geometrics for Departure Radii



WB-62 SEMITRAILER COMBINATION

Source: AASHTO Turning Template

Exclusive Right Turn Lanes for Trucks and Buses

To turn into a driveway, trucks and other large vehicles need to slow down considerably, which can cause considerable disruption for the through movement traffic. If there is a site that has large vehicles turning into it at a higher than average proportion, than this roadway design may be helpful. See **Turn Lanes and U-Turns** for more information on exclusive right-turn lanes and how to design for them.

7.7 Transit Vehicle Considerations

7.7.1 Driveways near Bus Stops and Transit Facilities

Bus stop locations can have a major impact on the operations and visibility of driveways. This is even more important in locations where buses may “layover”, since the sight distance may be blocked for a large amount of time. If a poorly positioned driveway cannot be moved, work with the local transit authority to possibly move the bus stop to avoid any potential safety issues.

Interaction Between Modes

When transit is present, improving safety by minimizing conflicts between transit, transit passengers, and other modes must be a primary consideration. The first step, in locating a driveway near a bus stop, is to consider the interaction of the bus with other vehicles and pedestrians. It is important to identify and analyze any potential hazards and vulnerabilities that could lead to a crash. For example:

- The bus operator must be able to see the vehicles entering and exiting the driveway
- The bus operator and those entering and exiting the driveway should be able to see transit patrons
- The people using the driveway should have sufficient sight distance to see oncoming buses and traffic

The landscape and facility design for entrances and exits to lots which are used by both vehicles and buses should not obstruct clear lines of sight. All landscaping should adhere to current FDOT standards along FDOT-designated highways.

The [FDOT Accessing Transit](#) document recommends that whenever possible, bus stops should be located beyond driveways to minimize conflicts (See [Figure 89](#)). Transit stops should be located a minimum of 200 feet away from any existing driveway when at all possible.

Figure 89 – Acceptable Bus Stop Placement Near Driveway



Source: [FDOT Accessing Transit 2013 \(Figure 4.2.4\)](#)

It recommends that if blocking a driveway cannot be prevented, at least one entrance and exit to a property should remain open while a bus is loading or unloading. In the worst-case circumstances where a bus stop location requires passengers to board or alight in a driveway, the slope cannot exceed ADA Standards.

Transit Stops in Medians

If an exclusive transit way is a median transit way, bus stops may be in the median itself. However, bus shelters on the median are prohibited in Florida except when maintained by bus rapid transit providers using an inside lane for passenger transport.²⁵

Sight Distances for Buses

For each driveway exit, the local street and roadway standards will determine the required sight distance for the critical design vehicle using the driveway. For driveways used primarily by transit, the transit vehicle should be held as the critical design vehicle due to its slower acceleration capabilities. Additional information on the modal interactions and driveways can be found in [Table 15 – Context Classification](#).

7.8 Shared Driveways and Internal Site Connections

Sharing driveways and providing cross parcel access has two benefits:

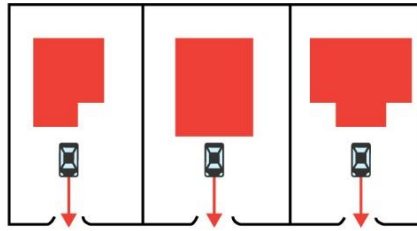
- The first minimizes the number of driveways on the arterial road
- The second is providing cross access between properties broadens the access choices for the driver

If a group of smaller developments share access, a driver needing to turn left across heavy volumes can usually find an access that is signalized, allowing safer left turns (See [Figure 90](#)). Having good cross parcel access also maximizes the number of well-designed unsignalized driveways. Drivers will have improved visibility and will be able to take advantage of sufficient gaps in traffic from a nearby signal. Joint driveways and cross access especially help small corner lots and out parcels. On small corner parcels, left turn access is a problem because left turns would conflict with the functional area of the intersection.

²⁵ Section 14-20.003 FS

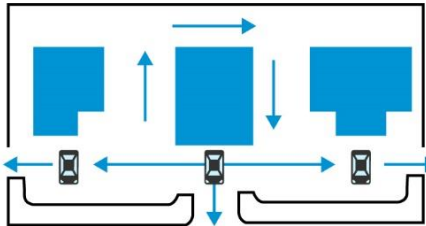
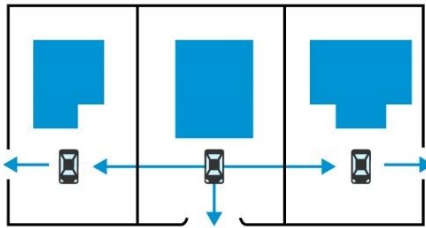
Figure 90 – Driveway Consolidation

Avoid



Promote

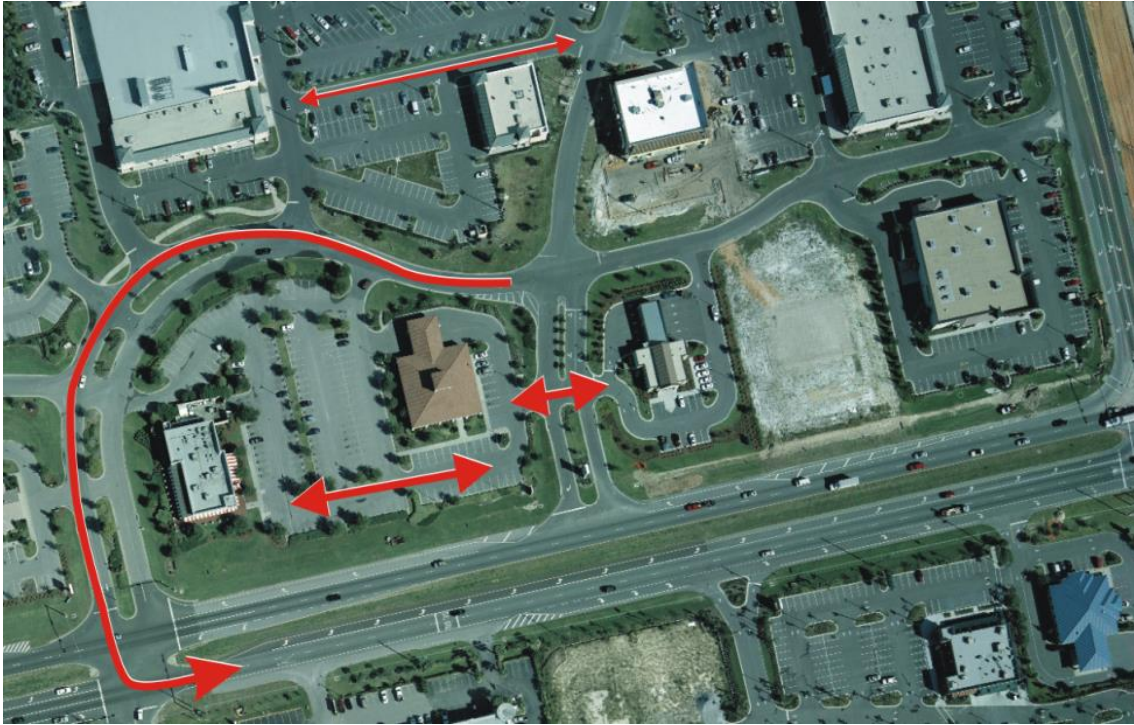
- Cross Access
- Joint Access
- Complete On-Site Circulation



Source: “*Managing Corridor Development, A Municipal Handbook*”, Center for Urban Transportation Research, University of South Florida, October 1996. Williams, Kristine M. and Marshall, Margaret A.

Interconnected developments give customers and delivery trucks more options, especially for completing safer left turns. It is easier to provide cross and joint access if it is planned at the beginning of a development process. At that time, there will be the ability to lay out access systems and allow for good separation between these access points. Many local governments have already addressed these issues in their land development regulations by providing requirements for joint and cross access with large neighboring developments and small corner out parcels. Sample land development regulations which include these features can be found in the CUTR report for FDOT “[Model Access Management Policies and Regulations for Florida Cities and Counties: 2nd Edition.](#)”

Figure 91 – Joint and Cross Access Example



Source: FDOT

There are some challenges associated with joint and cross access in retrofit situations. These situations usually deal with groups of small shallow land parcels where joint access has never been considered in the past (See [Figure 91](#)). A major problem associated with producing new joint and cross access is that cross-access points are often too close to the driveway entrances. This proximity may prevent having adequate driveway depth (See [Driveway Length](#)). In retrofit situations, consider the volume of traffic using these driveway entrances and exits and the volume of adjacent cross access traffic to determine whether the shallow driveway depth will cause an internal traffic circulation difficulty. Signing and landscaping may also help in these tighter situations on cross access in retrofit situations.

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Chapter 8: References

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Appendix A

Driveway-Related Collisions on a Roadway Segment

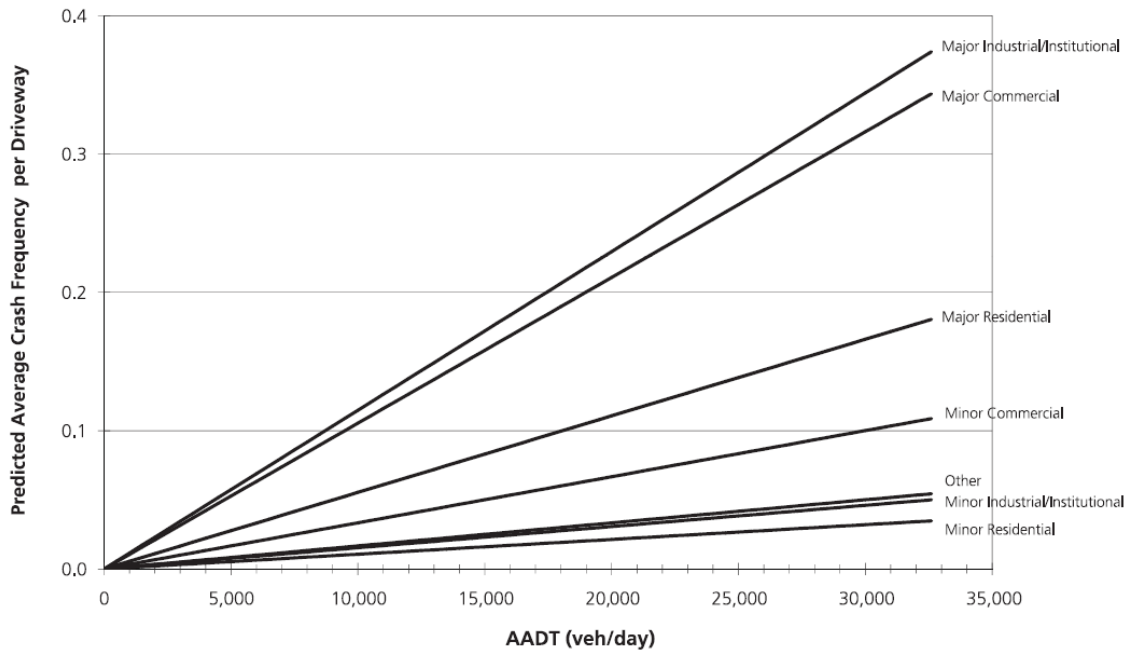
The HSM provides crash prediction methods for driveway related crashes. Seven types of driveways are considered:

- Major commercial driveways
- Minor commercial driveways
- Major industrial/institutional driveways
- Minor industrial/institutional driveways
- Major residential driveways
- Minor residential driveways
- Other driveways

For the HSM, a driveway is considered 'Major' if it serves a location with 50 or greater parking stalls. Commercial driveways access retail locations while industrial/institutional driveways serve factories, warehouses, schools, hospitals, churches, offices, public facilities, and other places of employment.

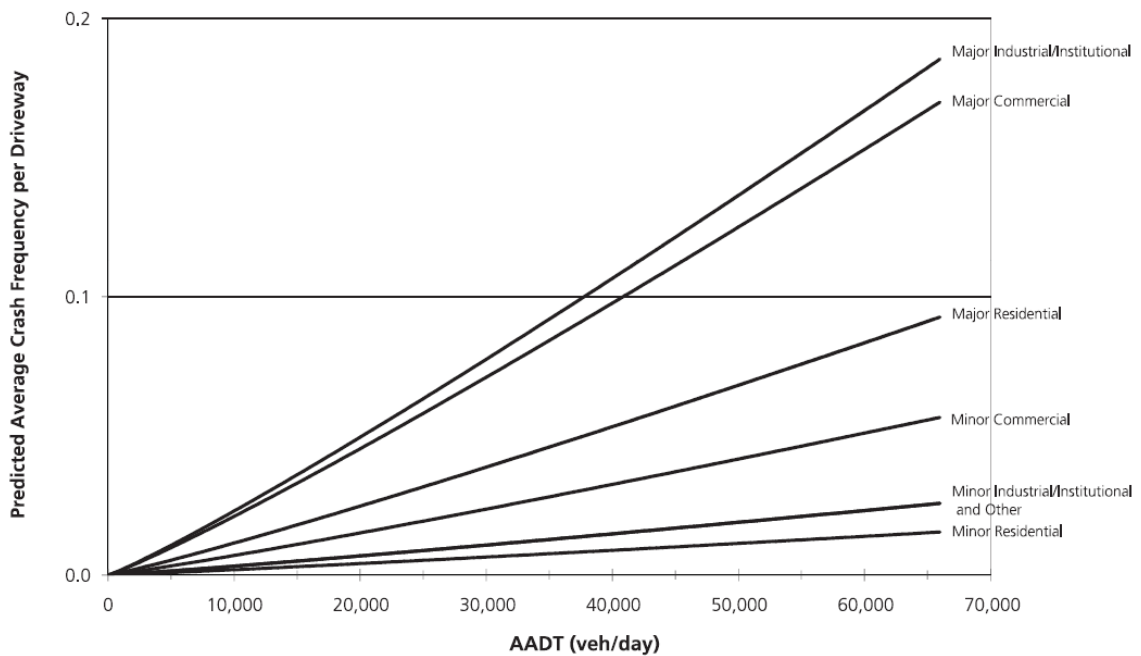
HSM prediction methods are available for the following types of roadway segments: Two-lane undivided arterials (2U), Three-lane arterials including a center two-way left-turn lane (TWLTL) (3T), Four-lane undivided arterials (4U), Four-lane divided arterials (i.e., including a raised or depressed median) (4D), Five-lane arterials including a center TWLTL (5T). For Driveway Related Collisions for each of these facility types refer to HSM Figure 12-5 through Figure 12-9. [*Figure 92*](#) and [*Figure 93*](#) below illustrate the predicted crashes by individual driveway type for 2U and 4U roadways compared to AADT.

Figure 92 – Multiple Vehicle Driveway Related Collisions on Two-Lane Undivided Arterials (2U)



Source: Fig 12-5: Multiple Vehicle Driveway Related Collisions on Two-Lane Undivided Arterials (2U)

Figure 93 – Multiple Vehicle Driveway Related Collisions on Four-Lane Undivided Arterials (4U)



Source: Fig 12-7: Multiple Vehicle Driveway Related Collisions on Four-Lane Undivided Arterials (4U)

The following example illustrates how SPF coefficients are applied to each driveway type to predict the number of crashes per year.

Example:

What is the predicted Driveway Related (multiple vehicles) crashes per year for this urban arterial?

Roadway Type = Two-lane undivided arterials

Length of segment, L (mi) = 1 mile

AADT (vehicle/day) = 17,700 (Maximum Service Volume for LOS D using FDOT Generalized Urbanized Area Tables for 2 lane undivided arterials)

Number of Driveways = 30 driveways (10 minor commercial, 2 major residential, 15 minor residential, 3 minor industrial/institutional)

Solution:

Multiple-Vehicle collisions are estimated using HSM Equation 12-16 shown below.

$$N = \sum n_j \times N_j \times \left(\frac{AADT}{15000}\right)^t$$

n_j = Number of driveways of driveway type j

The value of N_j and t is found from HSM Table 12-7 shown below.

Table 12-7. SPF Coefficients for Multiple-Vehicle Driveway Related Collisions

Driveway Type (j)	Coefficients for Specific Roadway Types				
	2U	3T	4U	4D	5T
Number of Driveway-Related Collisions per Driveway per Year (N_j)					
Major commercial	0.158	0.102	0.182	0.033	0.165
Minor commercial	0.050	0.032	0.058	0.011	0.053
Major industrial/institutional	0.172	0.110	0.198	0.036	0.181
Minor industrial/institutional	0.023	0.015	0.026	0.005	0.024
Major residential	0.083	0.053	0.096	0.018	0.087
Minor residential	0.016	0.010	0.018	0.003	0.016
Other	0.025	0.016	0.029	0.005	0.027
Regression Coefficient for AADT (t)					
All driveways	1.000	1.000	1.172	1.106	1.172
Overdispersion Parameter (k)					
All driveways	0.81	1.10	0.81	1.39	0.10
Proportion of Fatal-and-Injury Crashes (f_{inj})					
All driveways	0.323	0.243	0.342	0.284	0.269
Proportion of Property-Damage-Only Crashes					
All driveways	0.677	0.757	0.658	0.716	0.731

Given 10 minor commercial, 2 major residential, 15 minor residential, 3 minor industrial/institutional driveways we can estimate the number of crashes as below:

Driveway Type	n_j	N_j	t	$n_j \times N_j \times \left(\frac{17700}{15000}\right)^t$
Major commercial	0	0.158	1.000	0.000
Minor commercial	10	0.050	1.000	0.590
Major industrial/institutional	0	0.172	1.000	0.000
Minor industrial/institutional	3	0.023	1.000	0.081
Major residential	2	0.083	1.000	0.196
Minor residential	15	0.016	1.000	0.283
Other	0	0.025	1.000	0.000
Total				1.151

There will be 1.151 driveway related collisions per year.

Table 12-7 can be used to get a breakdown of how many of these are Fatality/Injury (FI) and Property Damage Only (PDO) crashes. In this case 32.3% is FI and remaining 67.7% are PDO.

Appendix B

In the table below, the vehicle examples refer to specific design vehicles which are mentioned in the FDM. The corresponding FHWA vehicle classification was determined to provide greater context in how they relate to the FDM.

Table 30 – FHWA Vehicle Classifications for FDM Freight Vehicles

Vehicle Example	FHWA Vehicle Classification
<p>SU-30</p>	Class 5 with only 2 axles (as shown) Class 6 with only 3 axles Class 7 with only 4 axles
<p>CITY-BUS</p>	Class 4 with 2 or 3 axles
<p>WB-40</p>	Class 9 with 5 axles (as shown) Typically, WB-40 configuration is a Class 8 with 3 or 4 axles
<p>WB-50</p>	Class 9 with 5 axles
<p>WB-67</p>	Class 9 with 5 axles

Source: FHWA and FDM

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Appendix C

U-turn Sight Distance

Assumptions:

- Passenger Car U-turn on a level road.
- Perception/Reaction time = 2.5 Secs.
- Driver will start to accelerate from zero mph to design speed after 180 degree turn. (Acceleration distance can be found in 2011 AASHTO Green Book Fig 2-24, Pg. 2-34)
- Turn radius = 15 ft (Minimum Turning Radii of Design Vehicles can be found in 2011 AASHTO Green Book, Table 2-2b, Pg. 2-7)
- Clearance distance = 50 ft

Table 31 - U-turn sight distance for various seconds of PRT and Design Speed

Speed (mph)	Sight Distance (ft)			
	2 s	2.5 s	3 s	3.5 s
35	516	541	567	593
40	641	671	700	729
45	827	860	893	926
50	1037	1074	1110	1147
55	1252	1292	1333	1373
60	1542	1586	1630	1674

Source: Dr. Vergil Stover

Sample Calculation:

- Calculate total Distance traveled:
 - Distance traveled along the circular part of U-turn = $\pi \times \text{turn radius} = 3.14 \times 15 \text{ ft} = 47.1 \text{ ft}$

According to 2011 AASHTO Green Book Fig 2-24, Pg. 2-34, going from 0 to 45 mph, the vehicle will travel 580 ft.

Length of a passenger car = 19 ft. (Design Vehicle Lengths can be found in 2011 AASHTO Green Book, Table 2-1b, Pg. 2-4)

Total Distance = $47.1 + 580 + 19 = 646.1 \text{ ft}$ (say, 645 ft)

- Calculate total time spent:

Perception/Reaction time = 2.5 Secs

Time to travel 645 ft @ rate of acceleration $3.77 \text{ ft/sec}^2 = \sqrt{645 \times 2 / 3.77} = 18.5 \text{ secs.}$

Total time = 2.5 + 18.5 = 21.0 secs

- Calculate Sight Distance:

Distance traveled by Opposing vehicle during this time = 1.47 x design speed x 21.0 ft =

1.47 x 45 x 21.0 = 1,390.1 ft. (1.47 converts mph to ft/sec)

Clearance = 50 ft

Total distance = 1,390 + 50 = 1440 ft

Sight distance = Total distance – Distance traveled by vehicle to go from 0 mph to Design Speed
= 1,440 – 580 = 860.1 ft (say 860 ft)

Other Notes: (Equation of Motion) Calculation of acceleration rate (= 3.77 ft/sec²)

Calculation of acceleration rate (= 3.77 ft/sec²)

$$v^2 = u^2 + 2as$$

$$v = 45\text{mph}, u = 0\text{mph}, s = 580\text{ft}$$

$$a = \frac{v^2}{2s} = 3.77$$

Also,

$$S = ut + \frac{1}{2}at^2$$

$$u = 0$$

$$t = \sqrt{2s/a} = \sqrt{2 \times 645 / 3.77} = 18.5.$$

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