Technical Summary

Access Management in the Vicinity of Intersections

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

FHWA-SA-10-002

Foreword

This technical summary is designed as a reference for State and local transportation officials, Federal Highway Administration (FHWA) Division Safety Engineers, and other professionals involved in the design, selection, and implementation of access management near traditional intersections (e.g., signalized, unsignalized and stop controlled intersections). Its purpose is to provide an overview of safety considerations in the design, implementation, and management of driveways near traditional intersections in urban, suburban, and rural environments where design considerations can vary as a function of land uses, travel speeds, volumes of traffic by mode (e.g., car, pedestrian, or bicycle), and many other variables.

The technical summary does not include any discussion on roundabout intersections. More information about roundabouts is available in *Roundabouts: An Informational Guide*, published by the FHWA [1]. Section 1 of this technical summary presents an overview of access management factors that should be considered for improving safety near intersections in any setting. Section 2 presents access management considerations and treatments to improve safety near traditional intersections in suburban, urban, and rural settings. This section features a case study of an access management retrofit project in a suburban area. Section 3 points the reader to additional resources.

This publication does not supersede any publication; and is a Final version.

Disclaimer and Quality Assurance Statement

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Cover Photo by Ralph Bentley

Introduction

"Access management" refers to the design, implementation and management of entry and exit points (i.e., driveways, entrances or exits) between roadways and adjacent properties. These entry and exit points can be managed by careful planning regarding their location, the types of turning movements allowed, and if appropriate, medians that provide or prohibit access to the driveways. Developing and implementing effective access management strategies that promote or improve safety requires considering the location of driveways in the context of current and future access needs, current and future intersection operations, and mobility for pedestrians and bicyclists.

This technical summary is designed as a reference for State and local transportation officials, Federal Highway Administration (FHWA) Division Safety Engineers, and other professionals involved in the design, selection, and implementation of access management near traditional intersections (e.g., signalized, unsignalized and stop-controlled intersections). Its purpose is to provide an overview of safety considerations in the design, implementation, and management of driveways near traditional intersections in urban, suburban, and rural environments where design considerations can vary as a function of land uses, travel speeds, volumes of traffic by mode (e.g., car, pedestrian, or bicycle), and many other variables. The technical summary does not include any discussion on roundabout intersections. More information about roundabouts is available in *Roundabouts: An Informational Guide,* published by the FHWA [1].

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Section 1: General Access Management Considerations

Planning, designing, and implementing access management strategies to promote safety near intersections begins with an awareness of several considerations. These considerations are independent of the environment or setting in which the driveway is located (i.e., urban, suburban, or rural). These factors include roadway functional classification (sometimes referred to as "roadway hierarchy" [1]); the functional area of the intersection; the location and number of driveways and resulting conflict points; the use of medians; and driveway design.

By considering the following seven guidelines when developing and evaluating access management treatments, practitioners can apply access management techniques to help improve safety in the vicinity of intersections[2].

1.1 Locate Driveways on the Appropriate Roadway Functional Classification

Providing access (i.e., driveways, entrances or exits) onto roadways with the lowest traffic volumes and speeds generally improves safety near intersections. In planning, designing, and managing access, critical consideration must be given to arterial and collector streets as these streets serve both mobility and access functions. To the extent possible, it is best to manage driveways so that access is provided to and from the roadway with the lower functional classification as these roadways typically have lower traffic volumes and speeds. This helps to reduce the frequency of conflicts, which minimizes both the opportunity for crashes and the severity of those crashes, should they occur.

1.2 Limiting Driveways within the Functional Area of an Intersection Improves Safety

Figure 1 provides a schematic representation of functional and physical areas of an intersection. The physical area of an intersection is a fixed area that represents the space confined within the corners of the intersection.

The functional area of an intersection includes areas upstream and downstream of the intersection. Unlike the physical area of an intersection, the functional area of an intersection is variable. The American Association of State Highway and Transportation Officials' (AASHTO) *A Policy On Geometric Design of Highways and Streets* [2] defines the upstream functional

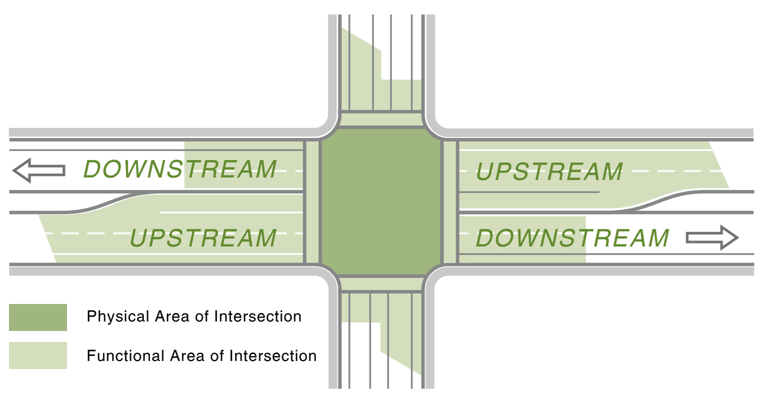

Figure 1: Functional and Physical Areas of an Intersection

1 Typical roadway functional classifications include freeway, arterial, collector, and local street—with freeways providing the highest level of mobility but the lowest level of accessibility, and local streets providing the highest level of accessibility but lowest level of mobility (assuming normal traffic).

2 These are general guidelines and may not apply to all situations. Understanding these principles can help practitioners more comprehensively evaluate options, understand tradeoffs, and make better decisions to help promote the safest possible access management treatments in the vicinity of intersections.

area of an intersection as a variable distance, influenced by: 1) distance traveled during perception-reaction time, 2) deceleration distance while the driver maneuvers to a stop, and 3) the amount of queuing at the intersection[3]. The upstream functional area is highly dependent on whether or not the traffic in the through lane is required to come to a stop at the intersection. Therefore, the functional area should be a consideration in situations where a driveway is near an intersection (due to a traffic signal or stop sign).

For example, at a stop-controlled intersection with approach speeds of 30 mph and a queue length of 125 feet (with additional assumptions for perception-reaction time and deceleration distance), the upstream functional area of the intersection is 200 feet. For a signalized intersection with identical speed and queue characteristics, the upstream functional area is 395 feet.

At that same stop-controlled intersection with a similar queue but a higher approach speed – 50 mph – the upstream functional area is 425 feet (compared to just 200 feet with 30 mph approach speeds). For a signalized intersection with identical speed and queue characteristics, the upstream functional area is 735 feet [3].

The AASHTO Policy on Geometric Design does not define the downstream functional area of the intersection as the criteria used to determine the downstream functional area can vary between jurisdictions. The *Access Management Manual* [3], published by the Transportation Research Board (TRB), notes that "stopping sight distance is one method for establishing the downstream functional distance of an intersection."

In the case of the stop-controlled intersection previously described (30 mph approach speed, 125 feet queue), the downstream functional area using the Access Management Manual's stopping sight distance calculation is 200 feet. At an approach speed of 50 mph the downstream functional area is 425 feet. When calculating downstream functional area with this method, traffic control at the intersection is not a factor.

Limiting or, where possible, eliminating driveways within the functional area of an intersection (upstream and downstream) helps reduce the number of decisions motorists must make while traveling through an intersection and improves safety in the vicinity of an intersection. A recent study evaluating crashes in the vicinity of signalized intersections in suburban areas completed by the Utah Department of Transportation [4] provides one illustration of the correlation between driveways in the functional area of intersections and increased safety risk. The study evaluated right-turn and rear-end crashes at signalized intersections in suburban areas. The study found that the existence of accesses within the upstream functional area of the intersection correlated to increased crashes and crash severity costs. The report identified an even greater increase in total crashes, crash rates, and rear-end crashes as commercial access density increased[4].

Additionally, a recent study by the Texas Transportation Institute (TTI), the "Roadway Safety Design Synthesis" [5] discusses the safety effect of driveways in rural areas. The study includes equations to calculate the Accident Modification Factor (AMF) for access control based on the number of driveways within 250 feet of a rural intersection.

1.3 Reducing the Number and Types of Conflict Points Created by a Driveway May Reduce Crashes

In general, the number and types of conflict points (i.e., the number of locations where the travel paths of two different vehicles may cross) at the intersection of a driveway and a public road influence the safety of motorists. It is desirable to minimize the number of conflict points created with existing and future driveways since more conflict points increase the risk of a crash occurring. For example, a crash due to crossing maneuvers (created by motorists turning across the roadway or making left turns) can lead to more severe crashes then merging or diverging conflicts because of the angle and speed differentials between the vehicles. As the angle and speed differentials increases, crash severity can also increase.

The number and type of conflict points at a driveway can be managed by limiting both the amount of access allowed at the driveway (e.g., full-movement, left-in/left-out, right-in/right-out, right-in only or right-out only) and

3 American Association of State Highway and Transportation Officials, A Policy On Geometric Design of Highways and Streets, 5th Edition (Washington, DC: 2004).

4 This study examined safety-related data upstream of signalized intersections within suburban areas.

the location of the driveway relative to other driveways in the area. In most cases, property owners prefer to have at least one direct, full-movement driveway from their property onto the major street (i.e., the street with higher traffic volumes) adjacent to the property. In many cases, it may occur that property owners are requesting direct, full-movement driveways to different properties on both sides of the major street. It is not always possible to align these driveways to minimize the number of conflict points, so another strategy, such as implementation of a raised median, should be considered (see Section 1.5 for information on median treatments).

Figure 2 illustrates a scenario in which it is not possible to align the full-movement driveways in a manner that would reduce conflict points. Figure 3 illustrates how construction of a raised median on the major roadway could reduce the number of conflict points in this situation. The raised median in Figure 3 limits the access to Driveways A and B to right-in/right-out movements only. Also, the number of conflicts in the vicinity of Driveways C and D in Figure 2 are reduced by relocating Driveway C to the minor road (see Figure 3). This solution limits conflict points by providing a direct, full-movement driveway (i.e., left-in/left-out/right-in/right-out) to the minor road, and by constructing a median on the major road and limiting access at Driveway D to right-in/right-out only.

Finally, in Figure 3, additional right-in/right-out only driveways are provided on the minor street (Driveways E and F) to improve the access to the properties adjacent to Driveways B and D. If possible, it is preferable to provide driveways onto the minor street instead of on the major street in order to preserve mobility on the major street. Limiting turn movements to properties adjacent to the roadway can result in circuitous travel to and from a site. For example, a motorist exiting Driveway B is limited to one direction of travel and is required to make a U-turn or use Driveway F to reach other destinations.

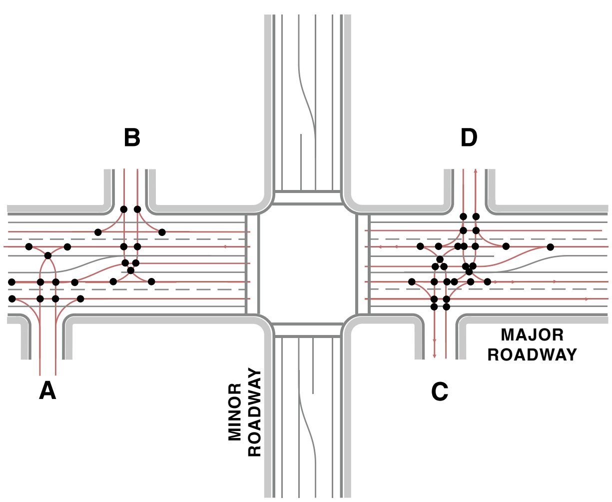

Figure 2: Typical Access Scenario at the Intersection of Two Public Roadways

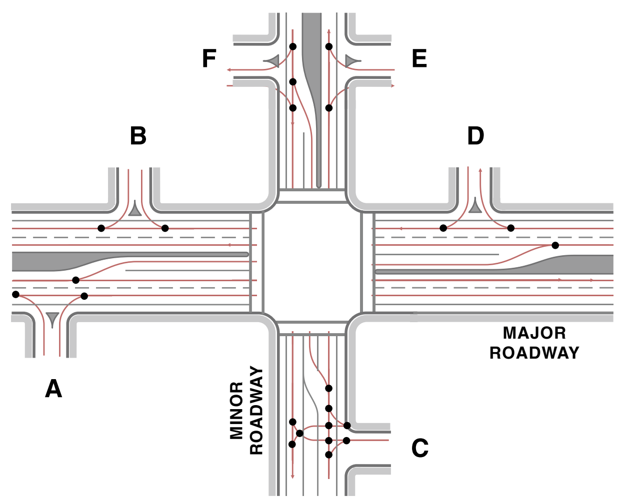

Figure 3: Desirable Access Scenario at the Intersection of Two Public Roadways

1.4 Eliminating Left-Turn Movements at Driveways is Beneficial from a Safety Perspective

Where restricting turning movements to and from a driveway is possible, it is most beneficial from a safety perspective to prohibit left-turning movements. Research suggests that approximately 72 percent of crashes at a driveway involve a left-turning vehicle [6]. As illustrated in Figure 4, approximately 34 percent of these crashes are due to an outbound vehicle turning left across through traffic. Twenty-eight percent of crashes are due to an inbound, left-turning vehicle conflicting with opposite direction through traffic, and 10 percent are due to outbound, left-turning movements incorrectly merging into the same direction through movement. This suggests that reducing or eliminating left turns to or from driveways, combined with efforts to reduce conflict points (described in Section 1.3), enhances safety. When turn movements are restricted at driveways, roadway engineers, planners, and policy makers need to consider the tradeoffs of shifting the turning movement to another location along the roadway.

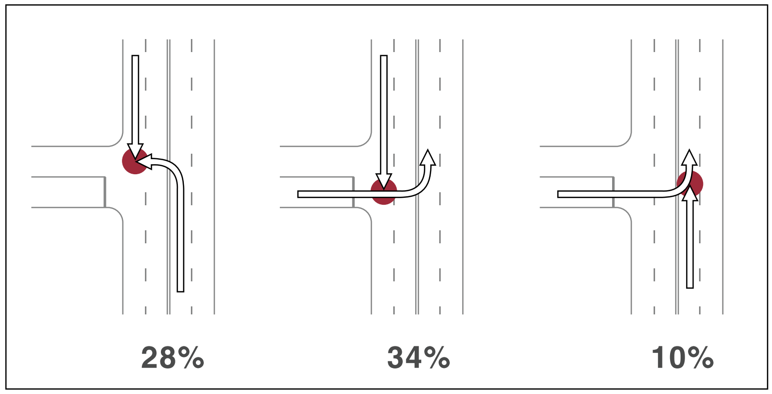

Figure 4: Crash Percentages for Turning Motorists to and from the Driveway

1.5 Median Treatments Can Impact Safety

One method to manage or limit left turns to and from driveways is with the proper use of medians. Proper use of medians has been found to improve roadway safety significantly relative to undivided roadways. National Cooperative Highway Research Program (NCHRP) *Report 420: Impacts of Access Management Techniques* [7] identifies two types of medians typically used:

- Non-traversable medians.
- Continuous two-way left-turn lanes (TWLTL).

Non-traversable medians separate opposing directions of travel, significantly reducing the potential for head-on crashes and physically eliminating or limiting where left-turns and crossing movements across the median can occur. When a non-traversable median of sufficient width is constructed, it can also provide refuge for pedestrians crossing the roadway. Non-traversable medians generally result in an overall crash reduction of approximately 35 percent as compared to undivided roadways.

TWLTLs provide for left turns in both directions of travel, except near signalized intersections where the center turn lane transitions to a conventional left-turn lane for one direction of travel. TWLTLs generally result in an overall crash reduction of approximately 33 percent as compared to undivided roadways. However, NCHRP Report 420 states that "Most studies, and the models derived from them, also suggest that safety is improved where physical medians replace TWLTLs." Factors to consider include differing roadway types, traffic volumes, travel speed, number of through lanes, and the number of left turns and crossing maneuvers.

1.6 Reducing Driveway Density Reduces Crash Rates

Research over the past decades has consistently shown that crash rates increase as driveway density increases on a roadway (i.e., number of driveways per mile). Figure 5 illustrates this trend under a variety of roadway conditions and environments across the U.S. and in Canada. Property access points should be designed, approved, and permitted within the context of the number of driveways on both sides of the street within the vicinity of the proposed access points and should not be considered in isolation. Possible strategies

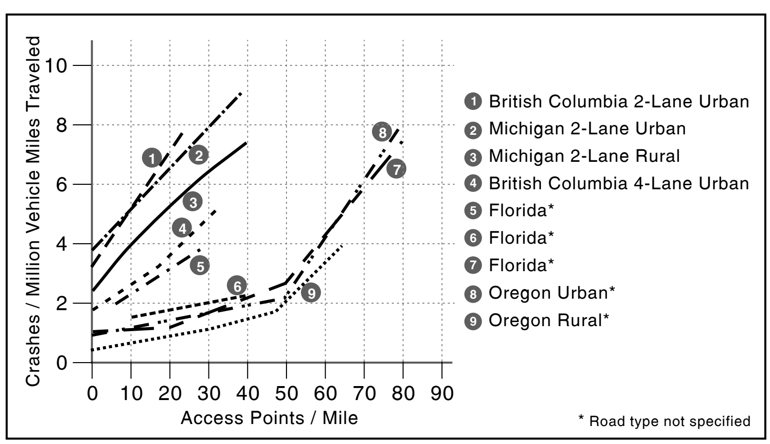

Figure 5: Effect of Access Point Density on Crash Rate

to reduce the number of driveways over time include the use of shared access to serve more than one property, the planning and development of additional roadways to provide connectivity and complementary mixed uses to minimize the need for multiple parking areas, and multiple driveways.

1.7 Properly Designed Driveways Influence Safety and Mobility at the Driveway

Driveway connections to public roads must be adequately designed to ensure safe and efficient movement of vehicles to and from the roadway, balancing safety with mobility interests. There are many elements to consider in proper driveway design, including upstream and downstream sight distance, the angle at which the driveway intersects the major road, the appropriate width of the driveway in tandem with curb radii so that vehicles can make the desired turn movement, the number of lanes (sufficient for the volume at the site), and the vertical grade and length of the driveway throat.

In general, driveways should be of sufficient length to allow motorists to completely pull off the road without interference from on-site parked vehicles, vehicle queues, or pedestrian or vehicle circulation once they enter the property adjacent to the roadway. The design of a driveway at any given location is a function of the design vehicle, travel speeds onto and off of the property, traffic volume, pedestrian and bicycle volume, and the type of traffic control (e.g., a signalized driveway should accommodate queues that may conflict with on-site turning movements). For motorists leaving a property, the vertical alignment of the driveway should be as close to level as possible where it intersects with the roadway. The driveway should be level for a sufficient distance to allow the motorist to easily stop with an unobstructed view upstream and downstream prior to entering the major roadway.

The Florida Department of Transportation (FDOT) Driveway Manual [8] provides a thorough overview of the criteria and application methods that a practitioner should consider in the design of a driveway. In addition, jurisdiction-specific design guidelines should be consulted when designing a driveway.

Photo: Ralph Bentley (used with permission)

Section 2: Special Considerations for Suburban, Urban and Rural Areas

Urban, suburban, and rural areas each present unique opportunities and challenges with respect to design, selection and implementation of access management strategies that provide the highest level of safety in the vicinity of intersections. The following sections (2.1, 2.2 and 2.3) provide an overview of some additional special considerations that apply within each of these environments. Because suburban areas offer the greatest opportunities to improve safety through access management strategies (due to development trends and traffic volumes), this discussion addresses suburban areas first, followed by a discussion of urban and rural environments.

2.1 Access Management Considerations in the Vicinity of Suburban Intersections

Suburban areas offer the greatest opportunity to positively impact safety through access management treatments for several reasons. New development and redevelopment often occurs on large parcels of land, providing planners with more flexibility and options for implementing optimal access management treatments. This can provide the opportunity for access to be considered from a systematic perspective, from the outset of a project, where stakeholders have the opportunity to plan for the appropriate number of driveways and optimum types of access (e.g., right-in/right-out only; or right-in/right-out-left-in). For example, access to developments on corner lots may be limited to a side street where traffic volumes and speeds are typically lower. Where access to a major roadway is allowed, agencies with authority over the roadways have opportunities to limit turn movements to and from the driveway with physical treatments, such as medians along the major roadway and/or median islands at locations where the driveway connects to the major roadway. Further, adjacent land uses, including residential, commercial, and industrial require significant access management planning and accommodation. Finally, while suburban areas are often lower density than urban areas, their residential and commercial centers are often connected by higher speed arterials (35 to 50 mph and occasionally up to 55 mph) than are found in urban areas, creating safety risks and opportunities through access management planning and implementation.

This section describes specific characteristics and access management challenges and opportunities associated with suburban areas and intersections, and provides a summary of potential access management treatments that can improve safety for motorists, bicyclists, and pedestrians. It also features a case study highlighting an access management retrofit project in a suburban area.

2.1.1 Characteristics of Suburban Roads and Intersections

As the distance from the urban core increases, the density of development decreases. Emphasis on residential land use grows as one moves further from the urban core. Suburban areas tend to be characterized by large-scale and residential, commercial, industrial, or retail development typically separated by larger distances than in the urban core. In developing suburban areas, parcels can be combined to accommodate larger developments, such as big box retail and strip malls. Land values often rely on spacious parking lots and convenient access to adjacent roadways.

Physical characteristics of suburban areas include medium to long block lengths that may vary from 400 feet to a half mile and signalized intersections on arterials and major collectors. Traffic characteristics of suburban areas include roadways with speeds that generally range from 35 to 50 mph (and occasionally up to 55 mph), medium to high traffic volumes (30,000 to 50,000 vehicles per day) on mainline roadways; and 5,000 to 15,000 vehicles per day on side streets and non-residential driveways. Physical characteristics include:

- Moderate to large site setbacks for structures.
- Non-traversable medians (in some cases) or continuous two-way left-turn lanes (TWLTLs) .
- Left- and right-turn lanes.
- Six or fewer traffic signals per mile.

Suburban Case Study: La Grande, Oregon

In June 1996, the Oregon Department of Transportation (ODOT) initiated a study of an unsignalized, full-access driveway (i.e., left and right turns allowed for inbound and outbound vehicles) in a suburban area. The study driveway was located on Oregon 82 (OR 82), approximately 600 feet south of Walton Road in La Grande, Oregon. La Grande has a population of approximately 12,500, and OR 82 is an undivided five-lane road. Adjacent land use development is a mix of big-box retail, commercial, and some industrial uses. The posted speed on this segment of OR 82 is 40 mph. During a 34-month period [5] between November 1994 and August 1997, ODOT crash reports show that 12 crashes occurred at this unsignalized driveway. Figure A depicts this driveway (driveway "A") and the roadway configuration during the study period, prior to implementation of any access management treatments.

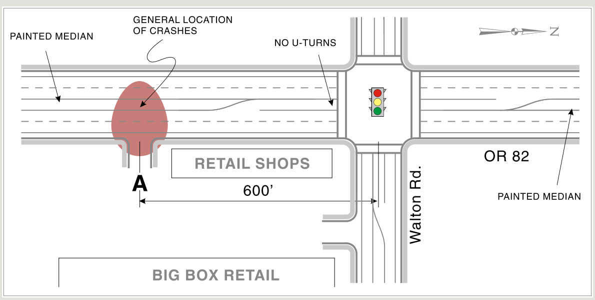

Figure A: Original Driveway and Roadway Configuration

During the study period, the average annual daily traffic volumes on OR 82 approached 17,200 in the vicinity of driveway "A." Data also showed that approximately 500 vehicles per day traveled inbound/outbound on the study driveway "A." The average crash rate was 0.66 crashes per million entering vehicles[6]. Table 1 summarizes the crashes reported during this period.

Table 1
Reported Crashes on OR 82 at
Study Driveway (November 1994 to August 1997)

Total Crashes	Crash Severity			
	Fatality	Injury	PDO	Left-turn
12	0	6	6	12

PDO = Property Damage Only

All reported crashes involved left-turning vehicles. Eleven of the crashes involved vehicles turning left from the driveway onto southbound OR 82.

All of these crashes included a collision with a vehicle moving northbound on OR 82. One of the crashes involved a motorist turning left out of driveway "A" onto southbound OR 82 and colliding with a motorist traveling northbound on OR 82, who was turning right into the driveway.

After performing a review of the roadway configuration, ODOT staff recommended the following access management improvements, depicted in Figure B:

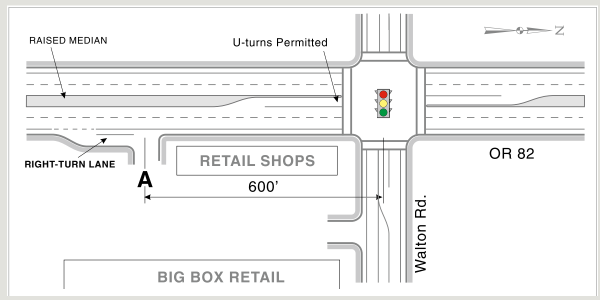

Figure B: OR 82 Roadway Configuration After Implementation of Access Management Techniques

- Restrict left turns to and from the driveway with a non-traversable median to eliminate left turns into and out of the site.
- Modify the adjacent signalized intersection to accommodate U-turns to allow motorists to access southbound OR 82, which has been eliminated at the driveway with the non-traversable median.
- Construct a northbound right-turn deceleration lane in advance of driveway "A." This treatment reduces the speed differential between motorists slowing to access the driveway and following motorists, while improving sight distance upstream from the driveway.

The proposed access management treatments were approved and funded through the State's access management fund. The State implemented the recommended improvements in August 1997.

In the ten years following implementation, only two crashes have occurred at the unsignalized driveway on OR 82 and neither involved another vehicle[7]. Given the estimated 18,900 vehicles per day on OR 82 for the 10-year period after the access management treatments were made,[8] this equates to a crash rate of approximately 0.06.

5 The 34-month study period represents the time period from when the full access driveway was approved until when ODOT completed mitigation measures.

6 Crash rate is calculated by: 1) multiplying average daily traffic by the number of years of crash data by 365 days per year, and dividing by 1,000,000 and 2) dividing the total number of crashes at the site during the study period by the million entering vehicles calculated in Step 1.

7 One crash involved a single vehicle and a fixed object, and the other involved a vehicle attempting a left turn across the raised median.

8 Based on a review of ODOT crash reports for the 10-year period from September 1, 1997, through August 31, 2007.

Traffic signal spacing in suburban areas is a function of the ability to progress two-way traffic along the mainline roadway. Signalized driveways are often not permitted in private developments but may be allowed if the spacing and timing can meet established standards to ensure adequate progression of traffic on the mainline roadway. Roadway and intersection improvement projects often are required to provide additional capacity for increasing traffic volumes.

2.1.2 Potential Access Management Treatments to Improve Safety for Motorists in Suburban Areas

The following access management techniques can help to improve motorist safety and mobility at access points implemented in the vicinity of suburban intersections:

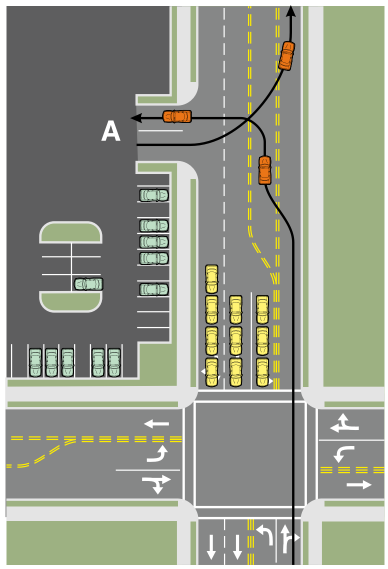

Figure 6: Driveway Location in Relation to Traffic Queues on a Major Roadway

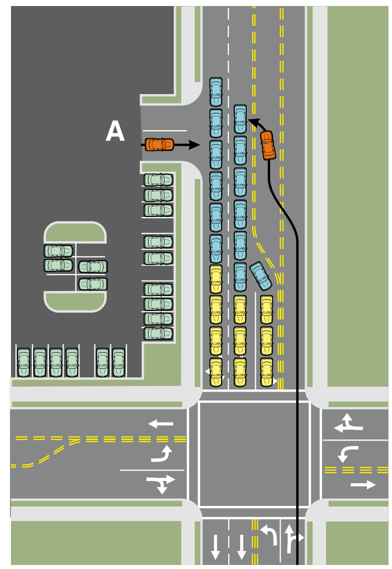

Figure 7: Driveway Location in Relation to Future Traffic Queues on a Major Roadway (Blue Vehicles Indicate Future Traffic Queues)

- Locate driveways upstream of the vehicle queue caused when the downstream traffic signal is red. Figure 6 illustrates this scenario, in which site driveway "A" is located beyond the limits of the typical queue as shown with the yellow (light) vehicles, with current traffic volumes. Without changes in capacity, existing traffic queues will grow as traffic volumes increase. If possible, therefore, as development occurs, plan and locate driveways for future estimated traffic volumes. Figure 7 demonstrates potential access issues at driveway "A" if future traffic queuing conditions, as illustrated with the blue (dark) vehicles, are not anticipated.

- Prohibit median openings to restrict driveway movements to and from the left-turn lane at a major intersection. Figure 8 illustrates the risks of allowing such a median opening. In this example, motorists turning left into the site access may conflict with the left-turning or through traffic.

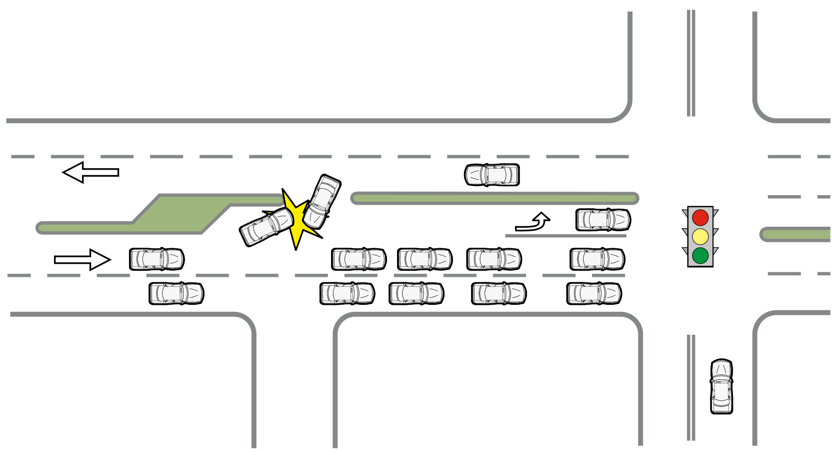

Figure 8: Avoid Median Opening Across Left-Turn Lane for Downstream Intersections (Courtesy of FDOT)

- In cases where there is a traversable median (e.g., TWLTL), aligning driveways to have a positive offset to minimize conflicts between left-turning vehicles is advantageous. Figure 9 illustrates driveway alignment with a positive offset. With a positive offset, motorists can use the two-way, left-turn lane to access either driveway with a reduced likelihood of a crash. Figure 10 demonstrates a negative offset of driveway. In Figure 10 if two motorists are using the two-way, left-turn lane at the same time, the drivers' paths would overlap (i.e., a crash may occur) as each driver tries to access the driveways.

- Where it is not possible to align driveways with a positive offset (as depicted in Figure 10), align driveways directly across the street from one another. Figure 11 illustrates this technique, which allows drivers to access either driveway without utilizing the same median area while decelerating prior to turning from the major roadway.

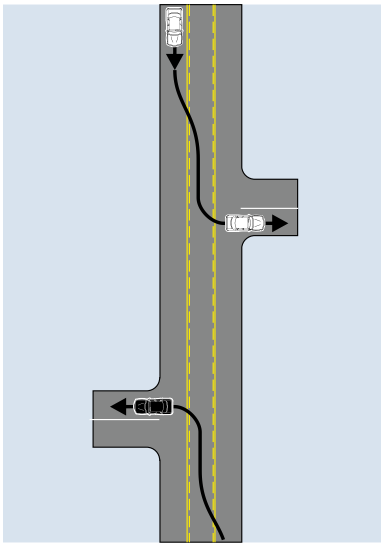

Figure 9: Locate Driveways on Opposite Sides of a Roadway to Achieve a Positive Offset

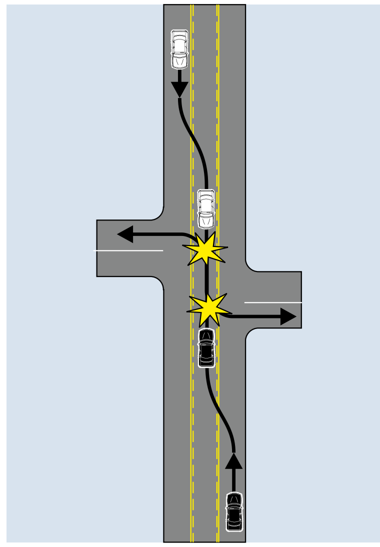

Figure 10: Avoid Locating Driveways on Opposite Sides of the Roadway that Create an Overlap for Left Turns Exiting the Major Roadway

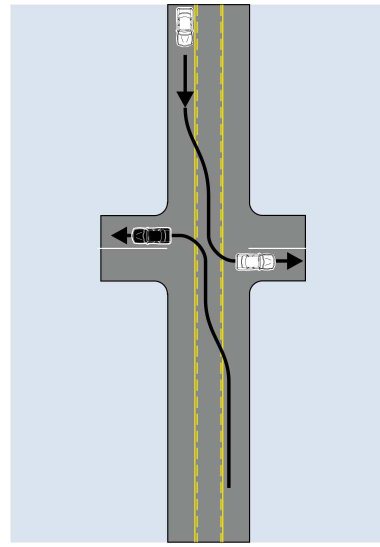

Figure 11: Align Driveways on Opposite Sides of the Roadway

2.1.3 Potential Access Management Treatments to Improve Safety for Bicyclists and Pedestrians in Suburban Areas

The following access management approaches can help to improve pedestrian and bicyclist safety as well as mobility at access points in the vicinity of urban and suburban intersections (both signalized and unsignalized):

- Provide raised medians on the major roadway to prohibit vehicles from turning left into driveways. This improves pedestrian safety by reducing the number of potential pedestrian-vehicle conflicts at a driveway.
- Construct a channelized island between the inbound and outbound movements at right-turn-only driveways to provide a pedestrian refuge across the driveway.
- Minimize the width of the driveway as much as possible in order to reduce pedestrian crossing distances (i.e., reduce exposure).
- Place sidewalks and pedestrian driveway crossings so that pedestrians are visible to the drivers, and drivers are visible to the pedestrians. Do not block pedestrian-driver sight-lines with landscaping or signage.
- Include bike lanes and signage, as appropriate, to alert bicyclists that motorists may be entering or exiting a driveway and to alert motorists that bicyclists may be crossing the driveway.

2.2 Access Management Considerations in the Vicinity of Urban Intersections

Implementing access management treatments in urban areas can be difficult to achieve because of some of the constraints in urban areas and the amount of time planning and implementation can consume for local jurisdictions. This section describes specific characteristics and design challenges associated with access management near urban intersections (Section 2.2.1), and provides a summary of potential access management treatments that can improve the safety for motorists (Section 2.2.2), bicyclists, and pedestrians (Section 2.2.3).

2.2.1 Characteristics of Urban Roads and Intersections

Urban areas (including central business districts) are typically characterized by dense, multi-modal, fully built-out transportation systems. Adjacent land uses are typically high-density office, commercial, and retail developments with minimal setbacks from the street. Parking is usually along roadways, in parking structures, and in some cases available via surface parking lots. Older businesses often rely on on-site parking;

therefore, eliminating driveways on these properties can significantly impact business operations.

Physical characteristics of urban environments include short block lengths (200 to 350 feet), two-way streets with some left-turn lanes, six or more traffic signals per mile, and minimal site setbacks. Where there are driveways to and from the streets, the driveways have small radii and width, and curbs and gutters exist in almost all areas. Intersections are controlled with a mix of signalized or unsignalized intersections while the driveways are generally unsignalized.

Traffic characteristics include low to medium driveway volumes (500 to 5,000 vehicles per day), medium to high adjacent street traffic volumes (20,000 to 50,000 vehicles per day), and coordinated, fixed signal timing. Pedestrians, bicycles, and buses often are present, and speeds generally are equal to or below 30 mph.

One-way couplets are often found within the urban area and provide access management benefits. One-way streets limit driveways to right-in/right-out only or left-in/left-out only turning maneuvers and reduce the number of crossing conflict points and the spacing required between adjacent driveways. One-way streets also reduce the need for intersection sight distance downstream of a driveway as there is no oncoming vehicular traffic. One-way streets can also be beneficial for pedestrians crossing the street as they only need to look for oncoming traffic in one direction.

Based on a speed of 30 mph, the upstream functional area of an urban signalized intersection often exceeds the length of a typical urban block. For this reason, engineers in urban areas often cannot avoid placing driveways within functional areas of intersections. Furthermore, on-street parking and other sources of friction within an intersection's functional area, including bus pull-outs and areas for truck loading/unloading, can diminish the benefits otherwise associated with placing driveways outside of the functional area of an intersection.

2.2.2 Potential Access Management Treatments to Improve Motorist Safety Near Urban Intersections

The following access management approaches can help to improve motorist safety and mobility at access points implemented in the vicinity of urban area intersections. The techniques apply whether or not the urban intersection is signalized:

- Develop a right-turn lane for inbound vehicles on the through road in advance of the site driveway by removing a section of on-street parking; this removes the turning vehicle from the flow of traffic.
- Avoid locating on-site parking bays near site driveways. This allows motorists to drive completely onto the property without having to stop for other motorists completing on-site parking maneuvers, as illustrated in Figure 12. Parking maneuvers near the site driveway can also result in delays for inbound motorists, creating queues that extend back into the major roadway. Figure 13 illustrates an unobstructed driveway, which allows motorists to exit the roadway unimpeded by other motorists maneuvering in the driveway.
- Replace gated parking entries with alternate ticketing options to decrease the driver's entrance time into the driveway and off the main roadway, thus reducing the likelihood of queues on the main roadway.
- Locate loading and bus bays on the far side of the driveway to maximize sight distance for motorists exiting a driveway.
- Place driveways on lower volume roadways (side streets or alleys) wherever possible (Figure 3).

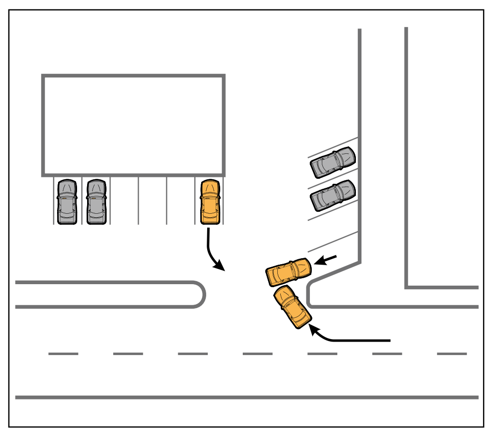

Figure 12: Parking Maneuvers Close to the Roadway Result in Delays for the Inbound Motorist

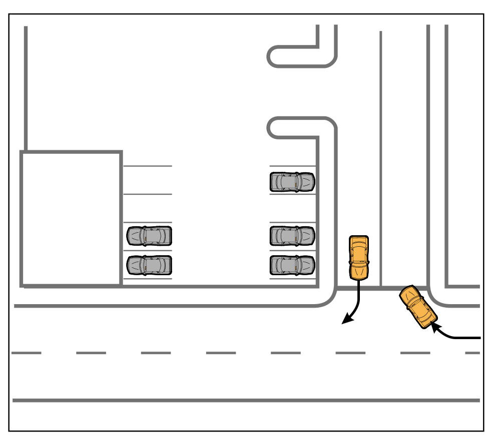

Figure 13: Unobstructed and Clearly Defined Driveways Allow Easy Access for Inbound Motorists

- Sign and stripe for right-turn, outbound movements only, wherever possible. It is not always possible to enforce this condition without geometric restrictions (i.e., raised channelization) to eliminate outbound, left-turning conflicts.
- Place driveways on one-way streets where possible. This results in right-in/right-out only or left-in/left-out only driveways and therefore fewer conflict points.
- Place driveways that serve left-turning, inbound vehicles near the center of the block to minimize interaction with upstream and downstream intersection queues, thus reducing the potential for left-turn related crashes.
- Position driveways as far upstream from intersections as possible to provide motorists leaving a property with distance along the roadway to make any necessary lane changes for traveling through the downstream intersection (e.g., maneuvering into an intersection left- or right-turn lane).

2.2.3 Potential Access Management Treatments to Improve Safety for Pedestrians and Bicyclists in Urban Areas.

In addition to the access management treatments identified in 2.1.3, the following access management approaches can help to improve pedestrian and bicyclist safety and mobility at access points in the vicinity of urban intersections. The techniques apply whether or not the urban intersection is signalized:

- Use colored pavement across driveways in combination with crosswalk markings, and audio/visual treatments for exiting vehicles with limited sight distance. Such treatments include a signal and/or flashing sign that is activated to alert pedestrians a vehicle is about to cross the sidewalk from an adjacent parking area.
- Restrict inbound vehicle speeds by designing the driveway access with appropriately designed radii.
- Smaller driveway radii of 25 to 35 feet are more sensitive to pedestrian movements [5] because motorists have to slow down to complete the turn. However, on-street parking and bike lanes can increase the effective driveway radius, so care should be taken to balance vehicle and pedestrian safety.

2.3 Access Management Considerations in the Vicinity of Rural Intersections

Rural areas, in general, have fewer access management needs in the vicinity of rural intersections than urban or suburban areas. Intersections with county roads are generally infrequent, and these roads often have fairly low traffic volumes. The majority of driveways in the vicinity of intersections serve low traffic generators such as single family homes and/or farms. Large property frontages adjacent to the roadway allow the regulating jurisdiction to locate a driveway a significant distance from the intersection. However, rural intersections can have intersecting high-speed roadways, which can create access management risks.

This section describes specific characteristics and access management challenges and opportunities associated with rural areas and intersections, and provides a summary of potential access management treatments that can improve the safety of motorists, bicyclists, and pedestrians.

2.3.1 Characteristics of Rural Roads and Intersections

Rural areas are characterized by low-density commercial development, such as gas stations and small convenience stores, industrial land and farm land, as well as, in some cases, large expanses of private or publicly-owned undeveloped property. Large property frontages along rural roadways allow jurisdictions to adequately space driveways, though topographical and environmental constraints (e.g., steep hills, wetlands, or rivers) may impact where driveways can be located.

Physical characteristics of rural roads include divided or undivided two-lane and multilane highways; paved and unpaved shoulders; and infrequent full-access, unsignalized, and on occasion, signalized intersections. Traffic characteristics include speeds of 50 mph and higher. Pedestrian and bicycle volumes are typically the lowest on rural roads as compared to urban and suburban roadways. Rural areas may be subject to development in the future. TTI has published research on rural intersections that relates driveway frequency to crash frequency. Researchers estimate that a rural signalized intersection with no driveways within 250 feet "will be associated with 13 percent fewer crashes than an intersection with three driveways (say, two driveways on one major-approach and one on the other approach)." Researchers also estimate that a rural unsignalized intersection with no driveways within 250 feet will be associated with 20 percent fewer crashes than an intersection with three driveways [9].

2.3.2 Potential Access Management Treatments to Improve Safety for Motorists in Rural Areas

The following access management approaches can help to improve motorist safety and mobility at access points implemented in the vicinity of intersections in rural areas:

- Early participation by jurisdictional staff and all stakeholders in planning processes can help assure that access requests do not become problematic for regulating jurisdictions. As development occurs in rural areas, a potential concern is development of subdivisions or partitions of large properties near rural intersections that could create a demand for additional access to the major roadway. Early communication and coordination with property owners can help to establish the location and number of driveways that can be permitted to the major roadway as part of the land subdivision process.
- Provide adequate throat depth and on-site circulation for vehicles to easily exit a major roadway. This will minimize speed differential between through vehicles and vehicles slowing to turn into a driveway.
- Pave the shoulders near driveways to provide additional entry and exit width and, hence, higher entry and exit speeds to help minimize speed differentials between through vehicles and vehicles turning onto or off of the roadway within the functional area of an intersection.
- In situations where there are higher traffic generators in the vicinity of rural intersections, frontage roads that parallel the major roadway may also be employed as a means to provide access to each of the adjacent properties. This solution can help to eliminate several access points to the major roadway as access to each development is achieved via the frontage/backage road rather than to the major roadway. In instances where the intersecting roadway has high traffic volumes, the jurisdiction may elect to implement some type of grade-separated facility rather than allow the installation of a traffic signal on a high-speed corridor.

2.3.3 Potential Treatments to Improve Safety for Pedestrians, and Bicyclists in Rural Areas

In rural areas, where there is no sidewalk, pedestrians and bicyclists benefit from roadway shoulders that are at least 4 feet wide or wider, paved and well maintained. As access and intersection modifications are considered in these environments, to the extent possible, shoulder widths should be maintained in order to provide facilities for non-auto travelers. Figure 14 depicts an example of a paved shoulder for bicycles or pedestrians on a rural road.

Photo: Kittelson & Associates, Inc. (used with permission)

Figure 14: Paved shoulder for bicycles or pedestrians

Section 3: References

The following documents were referenced in the development of this technical summary.

1. *Roundabouts: An Informational Guide,* Report FHWA-RD-00-067. FHWA, U.S. Department of Transportation, June 2000. This comprehensive guide is anticipated to be published in 2010. It will include the most recent research and findings for the design and implementation of roundabouts in the U.S.

2. *A Policy on Geometric Design of Highways and Streets, AASHTO 2004.* Commonly referred to as the "Green Book," this manual provides the transportation professional with a wide array of guidelines for the design and operation of roadways and streets.

3. *Access Management Manual,* Transportation Research Board. Washington, D.C. 2003. A comprehensive overview on access management, the *Access Management Manual* provides information on how to develop a State or local access management program. The manual also includes sections on corridor management, land development, access location and spacing criteria, medians, public involvement, right-of-way and legal concerns, driveway applications and permitting processes, and case studies.

4. G. Schultz, C. Allen, and D. Eggett. *Crashes in the Vicinity of Major Crossroads,* Brigham Young University, Department of Civil and Environmental Engineering for the Utah Department of Transportation, December 2008. The study focuses on the evaluation of crashes in the vicinity of signalized -intersections in suburban areas.

5. J. Bonneson, K. Zimmerman, and K. Fitzpatrick, *Roadway Safety Design Synthesis,* Texas Transportation Institute, November 2005. This document describes the effect of key design components on street and highway safety.

6. *Analysis of Crossing Path Crashes,* U.S. Department of Transportation. July 2001. This 76-page report examines crossing path crashes within the physical area of an intersection, including contributing factors to the crashes and a section on pedestrian and bicyclists' crashes at intersections.

7. *Report 420, Impacts of Access Management Techniques*, Transportation Research Board. Washington, D.C. 1999. This 170-page report presents access management techniques and provides methods for estimating the safety and operational effects of different techniques. The report was a precursor to the 2003 Access Management Manual.

8. *Florida Driveway Information Guide,* Florida Department of Transportation, September 2008 (http://www.dot.state.fl.us/planning/systems/sm/accman/pdfs/driveway2008.pdf). This guide provides a comprehensive overview on issues related to driveways including information on appropriate connection radii and flare, driveway width, grade and length, sight distance considerations, optimum location for a driveway, and pedestrian considerations.

9. J. Bonneson, K. Zimmerman, and K. Fitzpatrick, *Roadway Safety Design Synthesis,* Texas Department of Transportation, 2005. The synthesis includes safety information related to freeways, interchange ramps, rural highways and intersections and urban streets and intersections.

The following web sites offer two of the most comprehensive portals available for online access management information:

- FHWA Access Management Web site: http://www.ops.fhwa.dot.gov/access_mgmt/resources.htm

The web site provides links to FHWA resources and publications published on access management topics, including videos/CDs; brochures, including the *Benefits of Access Management* (2003); the publication *Safe Access is Good for Business* (2006), with accompanying CD; contact information for the National Highway Institute 3-day classroom course "Access Management, Location and Design"; and a link to the *Access Management Manual* at the TRB Bookstore. The FHWA materials and classroom course will be especially beneficial for those involved in public outreach and coordination and those desiring to learn more about the technical and legal aspects of an access management program.

- TRB Access Management Committee: http://www.accessmanagement.info/

The site includes information on all of the access management related publications that have been developed within the United States and many other countries in the past two decades. The site provides links to published research (including NCHRP reports); guides and handbooks for the practitioner; outreach materials; papers, PowerPoint and video presentations from past access management conferences; information on upcoming conferences and future research needs; and policies and programs from international, state, and local agencies.

For More Information

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Visit FHWA's intersection safety web site to download this and other technical outreach products highlighting proven intersection safety treatments from across the country:

http://safety.fhwa.dot.gov/intersection

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