FDM 11-25-1 General

February 25, 2011

1.1 Selection of Intersection Criteria

An intersection may be designed to either rural or urban design criteria depending on its location and the type of development existing or planned in the area. Design intersections located to serve a present or future residential or commercial area to urban standards with specific consideration of the current or eventual need for traffic signals, roundabouts, cross walks, pedestrian signals, expected traffic volumes and size of vehicles expected. Consult with the region planning staff to determine the type of development planned in the area of the intersection.

Specific factors and features to consider are:

- Current and expected traffic volume on the crossroad. Traffic signals may be warranted in outlying or rural areas to satisfy Warrant 2, "Interruption of Continuous Traffic" as defined in Part IV of the MUTCD, when the two-way traffic volume on the crossroad reaches approximately 1500 AADT. A current AADT of 1000 or more can be an indicator that there may be a potential need for signals within about 10 years where the traffic volume on the main highway also meets the warranting criteria.
- The length of the crossroad available for traffic generating development including potential extensions.
- The function of the through highway. If it serves to connect urban areas, there is the potential for strip development to occur along the highway or adjacent frontage roads. Traffic from this development will feed into the crossroad.
- The safety of the intersection is one of the most important considerations. In general terms, any intersection, urban or rural, that meets the criteria for a four-way stop condition or a traffic signal, also qualifies for evaluation as a modern roundabout. For more information on roundabouts see Section 26 of this chapter.
- Commercial or industrial zoned areas may attract truck terminals or other truck generators.
- Oversized overweight (OSOW) Freight Network statewide.

1.1.1 Truck Routes and OSOW Routes

There are 3 categories of truck routes on the STH:

1. “Designated Long Truck Routes” (no overall length limitation; MAX 53' trailer w/ 43' king pin to rear axle; MAX 28’-6” trailers on double bottoms).
2. “75' Restricted Truck Routes” (75-ft overall length limitation; MAX 53' trailer, 43' king pin to rear axle; no double bottoms).
3. “65' Restricted Truck Routes” (65-ft overall length limitation; MAX 48' trailer, no double bottoms).

See SS 348 and Administrative Code Trans 276 for requirements and definitions for these routes. Trans 276 has a listing of “Designated Long Truck Routes” and for a listing of 65’ Restricted Truck Route (Note: there are non-STH routes on this list as well). If a STH is not listed as either a “Designated Long Truck Route” or a “65' Restricted Truck Route” then it is a “75' Restricted Truck Route”. The “Wisconsin truck operators map” includes these identified routes and is available at http://www.dot.wisconsin.gov/travel/maps/truck-routes.htm.

All Federally Designated Truck Routes in Wisconsin are Wisconsin “Designated Long Truck Routes” as listed in 23 CFR 658, Appendix A, but not all Wisconsin “Designated Long Truck Routes” are Federally Designated Truck Routes. The design requirements for Federally Designated Truck Routes differ somewhat from other Wisconsin “Designated Long Truck Routes” (see FDM 11-15-1, FDM 11-20-1).

OSOW vehicles are those vehicles that exceed the maximum requirements for a route. These vehicles require a permit[1]. The OSOW Freight Network map is available from the Regional Freight Operations Unit. This information is in draft condition and may experience updates and changes in the near term. Therefore this document should not be shared with others unless they are working on projects that include the OSOW Freight

[1] SS 348.25(1) states “No person shall operate a vehicle on or transport an article over a highway without first obtaining a permit therefore as provided in s. 348.26 or 348.27 if such vehicle or article exceeds the maximum limitations on size, weight or projection of load imposed by this chapter.”

Network. The required permits fall into two general categories: (1) single-trip; and (2) multiple-trip.

WisDOT has established a statewide OSOW Freight Network for the use of permit OSOW vehicles, based on routes that these vehicles have used in the past, and on projected requirements. The statewide OSOW Freight Network is a subset of “Designated Long Truck Routes”, i.e., all OSOW routes are on “Designated Long Truck Routes”, with exception of a few roadways that may be an origination point, such as a manufacturing plant, or a re-occurring destination point.

1.1.2 Single-Trip permit OSOW vehicles

Single-trip permit OSOW vehicles are very large loads that exceed legal length, height, weight and/or width. The permits are on a load specific and route-specific basis. These vehicles generally have an overall length greater than 110 feet, and typically are required to incorporate rear steering maneuverability. Escorts are typically required.

Identify the specific movements of OSOW vehicles to accommodate. There may be special design considerations to accommodate the largest OSOW vehicles. The frequency of specific movements of the OSOW loads is critical when considering the type of special design that may be used. Some examples of special designs may be to allow an OSOW to go over curbs, or travel counter directional on a right-turn bypass lane, or provide a gated bypass lane just for the OSOW vehicles to use. To aid in this design, refer to the OSOW vehicle inventory on Attachment 1.3 that shows vehicles of various configurations that can be used with truck turning software to check if the OSOW vehicles will be able to negotiate the intersection. There are 5 representative Single-trip permit OSOW vehicles shown on the WisDOT vehicle inventory:

1. 80’ Mobile Home
2. Wind Tower Upper-Mid Section, 79.5’ L x 11.5’ W
3. Wind Tower Section, 78’ L x 14.7’ W
4. 55 Meter Wind Blade
5. 165’ Beam

Check through and turning maneuvers at each intersection where the OSOW routes intersect or where these loads are known to travel. This may include county or local roads to the OSOW origin such as the manufacturing plant. This will generally include freeway interchange off-on ramp terminals at the crossroad for a through movement, or may include a turning movement where it is known that the OSOW loads will turn. It is estimated that if these 5 vehicles are accommodated by the intersection then other OSOW vehicles will be accommodated as well. There may be special design considerations to accommodate the largest OSOW vehicles. The frequency of these OSOW loads is critical when considering the type of special design that may be used. Some examples of special designs may be to allow an OSOW to go over curbs, or travel counter directional on a right-turn bypass lane, or provide a gated bypass lane just for the OSOW vehicles to use. Coordinate the OSOW Freight Network intersection maneuverability check with the Regional freight operations unit.

1.1.3 Multiple-Trip permit OSOW vehicles

Multiple-trip OSOW vehicles exceed the legal semi truck criteria to use the highway system. The permits are not load specific or route specific, but the vehicles are typically limited to designated long truck routes. These vehicles generally have an overall length less than 110 feet and therefore are not required to incorporate rear steering maneuverability. Escorts are typically not required. The multi-trip permit account for about 15,000 to 17,000 permits (300,000 to 400,000 loads) annually. There are 2 representative Multiple-trip permit vehicles shown on the WisDOT vehicle inventory, see Attachment1.3.

1. Combine
2. WisDOT WB-67 - Long

It is important to check the through movement and turning maneuvers at each intersection where truck routes intersect or where the multi-trip permitted loads are anticipated to travel. Intersections where truck routes cross or where the multi-trip permitted loads are known to travel should be checked using the 103.5 foot semi (WB-67 Long) and the combine shown in the vehicle inventory. A link to the OSOW vehicle inventory is provided above. The designer should check to see if the WB-67 Long check vehicle will fit through the intersection or make turns at the intersection without tires going over the curbs or having to remove signals, light poles or sign posts. Lane encroachment and full use of roundabout truck aprons for the check vehicle is acceptable. Coordinate the intersection maneuverability check with the Regional freight operations unit.

1.2 General Intersection Features

1.2.1 Physical and Functional Areas of an Intersection

Figure 1.1 shows the Physical and Functional Areas of an intersection.

The Physical Area of an Intersection is basically the pavement area where the intersecting roads coincide. The outer boundaries of the area are defined by the points of curvature of the intersection radii [ref: page 561, GDHS 2001].

The Functional Area of an Intersection includes the physical area, but also extends upstream and downstream, along all of the intersection roadways, from the physical area. It includes any auxiliary lanes and their associated channelization. It is composed of three elements:

- d1 = distance traveled during perception–reaction time;
- d2 = distance traveled while driver maneuvers laterally and decelerates to a stop;
- d3 = storage length, determined on a site-by-site basis (typically storage is provided for a minimum of two vehicles).

Figure 1.2 graphically defines these dimensions.

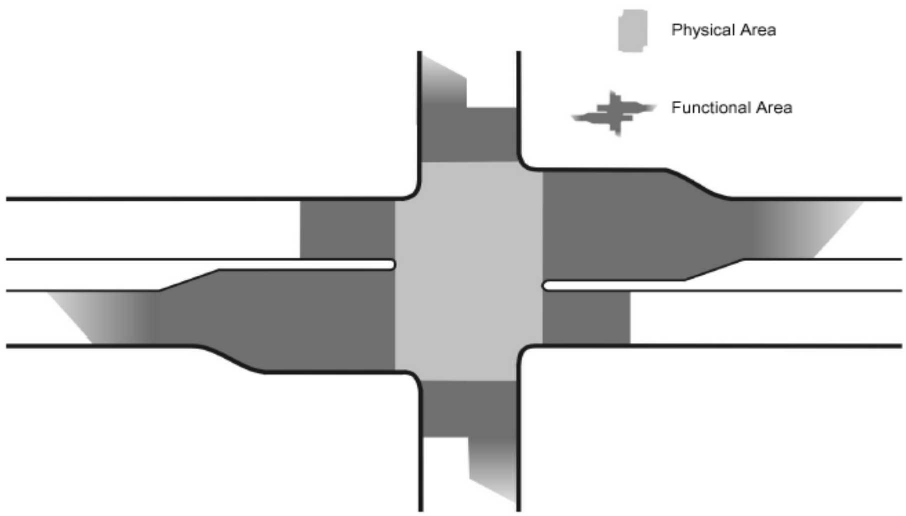

Figure 1.1 Physical and Functional Areas of an Intersection [1]

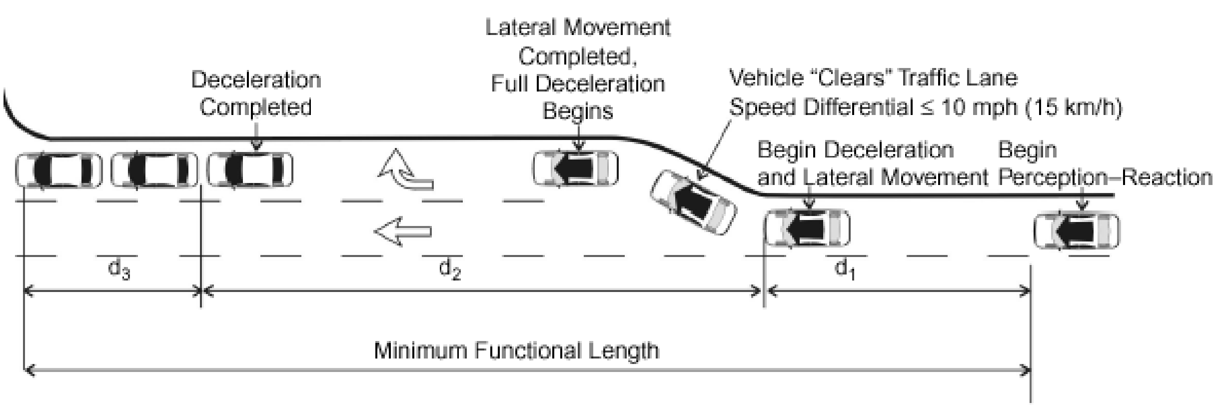

Figure 1.2 Elements of Upstream Functional Intersection Area [2]

Table 1.1 shows the d1 and d2 distances. Determine the limits of functional intersection area for both left turning and right turning vehicles. The downstream limit of the functional area is the greater of stopping sight distance or the upstream limit for the next downstream intersection or driveway. On the OSOW Freight Network, the storage distance (d3) may need to be adjusted to accommodate one OSOW vehicle, depending on load frequency. Increased storage distance would not be required at intersections with non-priority routes.

***Table 1.1* Distance Traveled During Driver's Perception–Reaction (d1) and Desirable Maneuver Distances (d2) [3]**

	Distance Traveled During Driver's Perception–Reaction **(d1)**		Desirable Maneuver Distances **(d2)**
Design speed (mph)	Rural (ft) (PRT = 2.5 sec)	Uurban/Suburban (ft) (PRT = 1.5 sec)	Distance [A,B,C] (ft)
20	75	45	70
30	110	65	160
40	145	90	275
50	185	110	425
60	220	135	605
70	255	155	820

[A] Assumes a turning vehicle has "cleared the through lane" when it has moved laterally about 9 ft so that a following through vehicle can pass without encroaching upon the adjacent traffic lane.

[B] The speed differential between the turning vehicle and following through vehicles is 10 mph when the turning vehicle "clears the through traffic lane."

[C] 5.8 ft/s^2 deceleration while moving from the through lane into the turn lane; 6.5 ft/s^2 average deceleration after completing lateral shift into the turn lane.

1.2.2 Corner Clearance

Corner clearance represents the distance that is provided between an intersection and the nearest driveway. Figure 1.3 defines the four types of corner clearance. Table 1.2 shows corner clearance distances for STHs.

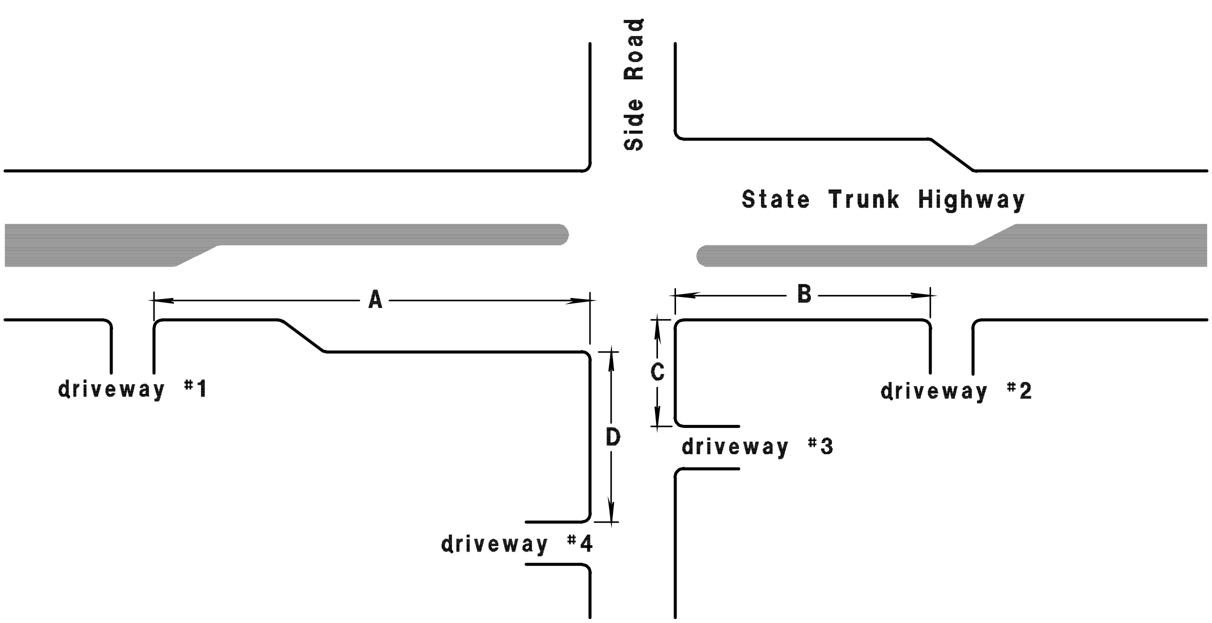

***Figure 1.3* Intersection Corner Clearances [4]**

Inadequate corner clearances can result in traffic operation, safety, and capacity problems. These problems can be caused by blocked driveway ingress and egress, conflicting and confusing turns at intersections, insufficient weaving distances, and backups from a downstream driveway into an intersection.

If possible, locate driveways outside the corner clearance distance. Also, if possible, locate driveways on the side road instead of the mainline. If it is necessary to locate a driveway within the corner clearance area then try to locate it as far as possible from the intersection. Also, try to limit the volume of traffic that uses the driveway; and to restrict the movements to right-in / right-out.

Table 1.2 Corner Clearance Distances

Corner Clearance Description	Urban	Rural
A - Upstream on the STH	Functional length of the intersection (see Table 1.1)	Desirable The greater of the functional length of the intersection (see Table 1.1) or the distance for private intersections from FDM 11-5 Attachment 5.1 Minimum The distance for private intersections from FDM 11-5 Attachment 5.1
B - Downstream on STH	The greater of Stopping Sight Distance, or the functional length of the intersection for the driveway	Desirable The greater of Stopping Sight Distance, or the distance for private intersections from FDM 11-5 Attachment 5.1, or the functional length of intersection for the driveway Minimum The distance for private intersections from FDM 11-5 Attachment 5.1
C - Approach side on the side road	Vehicles on a crossroad approach will produce a queue of vehicles that can potentially block a driveway entrance. Obtain sufficient access control and/or work with the local jurisdiction to provide a corner clearance that is greater than the largest expected queue. This will reduce the probability of a back-up into the intersection by vehicles making a left turn into the driveway. See pages 155-158 of the TRB Access Management Manual for additional guidance. If the side road is a STH, use a corner clearance equal to corner clearance "A." Consider using a corner clearance equal to corner clearance "A" for major non-STH side roads such as arterials.	
D - Departure side on the side road	Drivers of vehicles making a left or a right turn onto a crossroad from a STH need some time to fully complete the maneuver before being faced with vehicles at a downstream driveway. The left turn from the STH is the more complex maneuver because the driver is making it without positive guidance and must adjust speed, path, and direction change. Obtain sufficient access control and/or work with the local jurisdiction to provide adequate corner clearance. See pages 155-158 of the TRB Access Management Manual for additional guidance. If the side road is a STH, use a corner clearance equal to corner clearance "B." Consider using a corner clearance equal to corner clearance "B" for major non-STH side roads such as arterials.	

1.3 Traffic Controls

Traffic control signal design and location are to follow the guidelines in the MUTCD, the Traffic Signal Design Manual and consultation with region traffic section staff.

1.4 Intersection Grades

Avoid grades in excess of 3% within the intersection area and on the portion of approaches where vehicles are required to stop. Desirably, grades will be flatter than the maximum values allowed. On the OSOW Freight Network, check the roadway profile to avoid abrupt grade transitions that may affect vehicles with low ground clearance. OSOW vehicles often have very low ground clearance and can hang on roadway crown or the roll-over between a superelevated section and a side road profile at intersections.

1.5 Angle of Intersection [6, 7, 8, 9]

It is preferable for intersecting streets to meet at an angle as close to 90°as possible. On the OSOW Freight Network, it is preferable for roadways to intersect at an angle as close to 90° as possible, thus reducing the impact of those vehicles with a large turning radius. Use the following guidelines:

1.5.1 New Intersection on New Construction, Reconstruction, and 3R Projects

Intersection on tangent or on outside of curve:

- Desirable: between 75° and 105°
- Minimum: 70°
- Maximum: 110°

Intersection on inside of curve: (use Table 1.3)

Table 1.3 Intersection on Inside of Curve

Road	Radius (ft)	Desirable angle	Minimum angle	Maximum angle
	>6000	between 75° and 105°	70°	110°
High Speed and Transitional	4000-6000	between 80° and 100°	75°	105°
	<4000	between 85° and 95°	80°	100°
Low Speed	>3000	between 75° and 105°	70°	110°
	2000-3000	between 80° and 100°	75°	105°
Low Speed	<2000	between 85° and 95°	80°	100°

1.5.2 Existing Intersection on New Construction and Reconstruction Projects

Intersection on tangent or on outside of curve

Improve the intersection angle using the guidelines for NEW intersections:

- If the existing angle is <minimum or >maximum angle for NEW intersections and the angle is contributing to intersection crashes, or
- If the existing angle is <65°or >115°.

Intersection on inside of curve

Improve the intersection angle using the guidelines for NEW intersections:

- If the existing angle is <minimum or >maximum angle for NEW intersections and the angle is contributing to intersection crashes, or
- If the existing angle is less than the minimum angle for new construction by 5° or more, or
- If the existing angle is greater than the maximum angle for new construction by 5° or more.

1.5.3 Existing Intersection on 3R Projects

Intersection on tangent or on outside of curve

Improve the intersection angle using the guidelines for NEW intersections:

- If the existing angle is <minimum or >maximum angle for NEW intersections and the angle is contributing to intersection crashes, or
- If the existing angle is <60°or >120°.

Intersection on inside of curve

Improve the intersection angle using the guidelines for NEW intersections:

- If the existing angle is <minimum or >maximum angle for NEW intersections and the angle is contributing to intersection crashes, or
- If the existing angle is less than the minimum angle for new construction by 10° or more, or
- If the existing angle is greater than the maximum angle for new construction by 10° or more.

1.6 Intersection Sight Distance

For information about intersection sight distance, refer to FDM 11-10-5.

1.7 Rural Intersections

The latest editions of SDD 9A1 a & b illustrate six types of rural at-grade intersection: A1, A2, B1, B2, C and D. This SDD applies to two-lane undivided and multilane divided rural highways. The intersection type will indicate the length of a turn lane and shall apply to both the left turning and the right turning traffic entering the same side road leg. The lengths of the turn lanes in the Type A1 and the A2 intersections are for deceleration only. If additional storage is needed to accommodate queuing Design Hour Traffic, or there is a high volume of truck turning movements, then provide a longer turn lane based on needed storage. Attachment 1.1 lists the criteria for using each type of intersection. FDM 11-25 Attachment 5.4 shows the median opening and non-slotted turn lanes on rural expressways.

1.8 Tee Intersection Bypass Lane

A Tee intersection bypass lane (also known as a “SHOULDER BYPASS AT THREE-WAY (T) INTERSECTION” and as “LEFT TURN BYPASS LANE”) allows a through vehicle to bypass a left-turning vehicle that is stopped in the traffic lane. A detail is shown on SDD 9A1a.

Exclusive left turn lanes are the most effective and safe way to separate the left-turning from the through traffic streams [5]. Warrants for left turn lanes are shown in FDM 11-25 Table 5.1. If a left turn lane is warranted and practical, then build it. A Tee intersection bypass lane is a quick and inexpensive way to make intersections (that would otherwise have no left-turn treatment) more efficient for traffic operation.

Provide a Tee intersection bypass lane at Type A Tee intersections if a left-turn lane is not warranted, or if the construction of a warranted left-turn lane is not practical (due to R/W, terrain, etc.) Provide a Tee intersection bypass lane at other intersections if the construction of a warranted left-turn lane is not practical (due to R/W, terrain, etc.), leaving no left-turn treatment as the only other alternative. Consider a Tee intersection bypass lane at other intersections where a left-turn lane is not warranted.

Do not provide a bypass lane at a four-legged intersection.

1.9 Intersections on Curves

Intersections on curves of any facility are problematic and are discouraged for the following reasons:

- Drivers have more difficulty judging the speed of vehicles approaching on a curve than on a tangent.
- Superelevation complicates the intersection geometry.
- More right-of-way may be required to ensure adequate intersection sight distance (ISD), particularly on the inside of curves where the line of sight for intersection sight distance may be a considerable distance outside the roadway.
- Intersections on the inside of a curve require drivers on the side road to turn their heads more to see approaching traffic. This can be difficult for some drivers, including older drivers.

If an intersection must be on a curve, then try to use a flatter radius curve and to make the intersection as close to radial as possible. For example, on high speed roads, using a curve that requires a superelevation of 3% or less will make it easier to match into the side road profile and to transition the cross slope on auxiliary lanes. It will also keep the ISD line of sight closer to the roadway. A radial intersection in combination with a flat radius will reduce the amount drivers have to turn their heads to see approaching traffic.

Intersections on curves of high-speed (posted speed greater than 55 mph) expressways require additional design considerations. Crash history shows that there is no difference in whether the side road intersection approaches the expressway from the outside or the inside of the curve. Providing more than the minimum intersection sight distance at these intersections appears to have no impact on the number or severity of crashes. If there appears to be no alternative to designing an intersection on a curve then provide a wide median. If a wide median for intersections on curves is not possible then it is important to restrict intersection movement by closing the median or at least not allowing side road traffic to turn left onto the expressway.

1.10 Median Openings and Left Turn Lanes

Provide a wide median where possible when the divided highway intersects a side road on a curve or at any location to accommodate long trucks or combinations of farm machinery. The median should be at least 100 feet wide, up to approximately 150 feet wide to accommodate long trucks like the WB-65 or combinations of farm machinery that produce a long train of connected equipment. Median roadways wider/longer than 150 feet can cause problems as well. When wide medians are provided it is also necessary to consider appropriate signing to prevent Wrong Way entry onto the expressway facility.

On median roadways wider than 60 feet provide double yellow pavement marking to separate the opposing traffic and provide stop bars and STOP signs at each end of the median roadway.

A median width of between 30 feet and 100 feet is fine for cars or short trucks for at grade intersections. However, this width is not desirable when the intersection must accommodate long trucks or combinations of connected farm equipment. When the median is 30 feet to 60 feet wide consider providing slotted left turn lanes. Slotted left turns will provide a couple of advantages like increased sight distance in the direction of approaching traffic and allows the turning vehicles to pass each other to the left of each other. If it is anticipated that a divided highway may be signalized in the foreseeable future it is better to provide a median width of 30 feet at the intersection.

Do not allow a median break for a driveway or alley within the limits of an exclusive left turn lane or its approach taper.

For additional median opening and left turn lane information see FDM 11-25-5.

1.11 Urban Intersections

At-grade urban intersections are made up of a variety of types that cannot be grouped by a class of highway. Factors that influence intersection design are peak-hour traffic volumes, type and size of turning vehicles, traffic control, turning roadways, auxiliary lanes, number of lanes, divided or undivided cross section, pedestrian traffic, and right of way limitations. The proximity of commercial and industrial sites may require special designs.

When possible, prohibit parking near the intersection on routes identified on the Long Truck Operators Map and the OSOW Freight Network to avoid conflicts with turning traffic. Large vehicles require greater turning radii and wider sweeping paths to negotiate corners. Review whether parking, or roadside utilities, or street furniture will impede long truck and OSOW movements. This is of particular concern at the intersection of multiple state trunk highways in established urban environments. Certain OSOW loads (such as a bridge girder) will encroach beyond the face of curb even when the transport axles stay within the street. Refer to FDM 11-20-1 for additional Parking Lane and Border guidance.

1.12 Taper Design

Tapers commonly used around at-grade intersections can be classified as follows.

- Shifting taper
- Merge taper
- Turn bay taper
- Shoulder taper [2]

See Attachment 1.2 for descriptions of these features as well as guidance for designing them. Much of the guidance in Attachment 1.2 comes from the 2000 MUTCD, Section 3B-09 and GDHS 2001, Pages 719-720.

The table in Attachment 1.2 shows both the desirable and minimum length of tangent section that is to precede a merging taper on the downstream side of an intersection. This comes from Table 2C-4 on page 21 of the Wisconsin Supplement to the MUTCD (available on both the dotnet and the extranet). The desirable distance provides enough room for placing two signs (W9-1R and W4-2R) upstream from the merge point. The minimum distance provides enough room for placing only one sign (W4-2R).

The minimum tangent length is shown in the right column of the table and represents the distance between the W4-2R sign and the start of the merge taper. This distance varies according to the posted speed of the road.

WisDOT's standard practice is to provide for two signs in advance of a merge condition. The first sign is the W9-1R and it is placed either on the signal pole on the downstream side of the intersection or on a separate post just beyond a non-signalized intersection. The second sign (W4-2R) is located 200 ft downstream from the first sign. For example, at a posted speed of 55 mph, the W4-2R sign is placed 750 ft ahead of the start of the merge taper. By adding the 200 ft back to the first sign, the total desirable tangent length prior to merge is 950 feet. This is shown in the center column of the table in Attachment 1.2. At 45 mph the W4-2R sign would be placed the minimum distance of 550 ft ahead of the start of the merge taper and the W9-1R sign would be place 750 ft (550 + 200) ahead of the start of the merge taper.

Stopping sight distance is another factor to be considered. If stopping sight distance is not per AASHTO 2001, Exhibit 3-1, then a longer tangent distance may be needed.

1.13 References

[1] TRB Access Management Manual, Figure 8-12, p 132 [3]

[2] Shoulder tapers would be used where there is some construction or other temporary obstacle on the shoulder.

[2] TRB Access Management Manual, Figure 8-13, p 132

[3] TRB Access Management Manual, Table 8-3, p 133 and Table 10-2, p 172

[4] TRB Access Management Manual, Figure 9-10, p 157

[5] MNDOT Road Design Manual, Section 5-4.01.04, p 5-4(2), June 2000

[6] Gattis, JL and Low, ST. "Intersection Angle Geometry and the Driver's Field of View." Transportation Research Board Record 1612-Highway and Facility Design / Highway Geometric Design Issues. (1998) pp10-16

[7] United States. Department of Transportation Federal Highway Administration. Highway Design Handbook for Older Drivers and Pedestrians (FHWA-RD-01-103). 2001.

[8] United States. Department of Transportation Federal Highway Administration. Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians (FHWA-RD-01-051). May, 2001.

[9] United States. Department of Transportation Federal Highway Administration. Older Driver Highway Design Handbook - ch. I Intersections (At-Grade) (FHWA-RD-97-135)

LIST OF ATTACHMENTS

FDM 11-25-3 Intersection Control Evaluation — *February 25, 2011*

3.1 Intersection Control Evaluation

It is important to evaluate an intersection to determine the appropriate intersection control. Typical intersection analysis will include criteria such as crash data, crash diagrams, user delay or level of service for all current and design year traffic movements, appropriate design vehicle (WB-65[4] on the STH system), right-of-way impacts and other safety improvements for pedestrians and bicyclists.

If the intersection is on the OSOW Freight Network, OSOW vehicles shall be taken into consideration to determine the appropriate intersection control type The OSOW Freight Network map is available from the Regional Freight Operations Unit. This information is in draft condition and may experience updates and changes in the near term. Therefore this document should not be shared with others unless they are working on projects that include the OSOW Freight Network. Determine the frequency of OSOW vehicles using the intersection. It may be appropriate to consider unique designs when considering how to accommodate OSOW vehicles such as; allowing the OSOW vehicles to drive over curbs, drive counter–directional for short distances, removal of signs, wrong-way travel on a right-turn bypass lanes, or special designs that only allow the OSOW vehicles to use (controlled by gates) to accommodate OSOW vehicles.

All roadways that intersect with a State Trunk Highway shall have some type of control. There are 3 types of intersection control to consider for at grade intersections. The 3 types are:

1. Stop Control - The intersection may have two-way stop control, or four-way stop control. The two-way stop control is most common and requires traffic to stop at the minor road connection to a major highway. The four-way stop is used when warrants or safety concerns are identified and believed to improve the safety of the intersection.
2. Signal Control - This is an intersection control alternative to consider when certain traffic warrants are met (MUTCD, Section 4C).
3. Roundabout Control - This requires a yield condition at entry and is warranted by vehicular volumes that meet the four-way stop or traffic signal warrants. There may be situations where it is appropriate to evaluate a roundabout where an intersection may have unique safety or geometry concerns or may be stop controlled. For example an interchange ramp terminal or other intersection within the 20 year design life of the project traffic volumes increase to the point where traffic signals are anticipated within 10 years from date of construction (see Table 3.3, Anticipated Traffic Signal). It may be desirable to

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[3] TRB references are reproduced with permission of the Transportation Research Board, From Access Management Manual, Transportation Research Board, National Research Council, Washington, D.C., 2003
[4] A WB-65 uses a 43 ft distance between the centerline of the king pin to the centerline of the rear duals. This is the maximum allowed by state statute.

construct the roundabout with the initial project or to preserve right-of-way for the roundabout in the future. Another situation is where a current two-way stop controlled intersection has safety concerns a roundabout may be appropriate.

There is guidance on how many crashes may be reduced by implementing certain improvements. For information on Crash Reduction Factors refer to the “Desktop Reference For Crash Reduction Factors”, September 2007, Publication Number FHWA-SA-07-015.

http://www.transportation.org/sites/scohts/docs/Crash Reduction Factors Desktop Reference 12-19-07.pdf

If an intersection warrants a signal or a four-way stop within the design life of the proposed project, the modern roundabout shall be evaluated as an equal alternative. Where there is an existing four-way stop or signal and there are operational problems with the current control, then the roundabout shall be considered as a viable alternative. As stated above the roundabout may be a viable alternative for a two-way stop control in certain circumstances. In either case, roundabouts are a potential intersection control strategy until such time that the evaluation indicates that the roundabout alternative is not appropriate. If the intersection is located on the OSOW Freight Network, it shall be analyzed for the adverse affect that a roundabout, traffic signal or other intersection control may have on the passage of OSOW vehicles.

3.2 Early Evaluation Process

This section describes a process to evaluate intersections to help determine the appropriate intersection control. The evaluation process begins in the Region SPO-Planning unit and is referred to as Program Level Scoping phase. At this phase an intersection is evaluated by reviewing the 10 factors described in Table 3.1.

Review Figure 3.1 to become familiar with the WisDOT Life Cycle process. Figure 3.1 provides an overview of the terminology that is used to describe a project from initiation through Life Cycle 40. The Life Cycle numbers are milestones. The time between the Life Cycle numbers are the phases of the process. This figure also identifies who at WisDOT is in responsible charge of the process.

Life Cycle	LC 00 Unprogrammed	LC 10 Authorized	LC 11 Program Level Scoping	LC 12 PMP Approved		LC 15 DSR	LC 20 PS&E	LC 40 Award
Project Initiation Process	Needs Identification	CDR	Program Level Scoping	PMP Approval	---	---	---	---
PMP Development Phase	---	---	Program Level Scoping	PMP Approval	Preliminary Plan Review	DSR	PS&E	Design Project Closeout
Project Review Meeting								
Time Required	---	3-6 months *	3-12 months	3-18 months	3-12 months	5-18 months	7-30 months	3-6 months
Responsible Section	Programming	Programming	Programming	PDS	PDS	PDS	PDS	PDS

Figure 3.1. Life Cycle Project Overview

Project evaluations are conducted internally by the WisDOT Region Project Initiation Process (http://dotnet/tpms/docs/pippres.ppt) Scoping Team. PIP teams will typically consist of the following members: PDS Representative*, Pavement Engineer*, Traffic / Safety Engineer*, Roadway Maintenance Engineer*, Bridge Maintenance Engineer*, Planning Engineer* and other functional areas as needed (* indicates required team members). If the proposed intersection improvement is located on the OSOW Freight Network, the Regional Freight Operations engineer should be included. The SPO-Planning level effort is typically less rigorous, less data driven, and less accurate than the higher level of effort completed by the Project Development Section (post-life cycle 11).

The objective of Program Level Scoping is the completion of the project scoping and feasibility well enough to identify deficiencies, potential environmental and right-of-way impacts, safety concerns, structure needs, lighting and landscaping needs, major bid item cost estimate, summary schedule, begin State-municipal agreements, order mapping if needed and prepare a preliminary budget anticipated to be within 80% of the final budget. The PIP team, working together in a collaborative effort shall decide the viable intersection control alternatives that are taken to the post-Life cycle 11 project team. If a cost estimate for one intersection control alternative is considerably higher than the other, then the higher cost alternative is used to determine the project budget. Both alternatives are taken forward to the post-Life cycle 11 project team. Typically, the PIP team will identify viable alternatives but usually will not have conducted an in-depth evaluation of the 10 factors. The factors are explained in Table 3.1 and Table 3.2, to help determine the selected alternative.

A WisDOT Region may decide during the Program Level Scoping phase to submit a portion of a project to a consulting firm for the preliminary evaluation. This may include at-grade intersections, preliminary environmental impacts, structures, or other deficiencies identified by the PIP team. But this does not change the overall process to determine deficiencies, impacts, viable alternatives, or preliminary costs.

The Project Management Plan (PMP) approval phase is when SPO-Planning and Project Development agree to the final project scope. Once the Program Level Scoping work, cost estimate, etc. is complete, the PDS Unit becomes the lead, this is known as the post-Life cycle 11 phase. This is also when the Project Management Plan (http://dotnet/tpms/index.htm) is developed and maintained by the PDS Unit. The project development section will determine whether an improvement project will be completed in-house (by WisDOT employees) or made available to a consulting firm.

The following projects that are designed and constructed with federal or state funding must comply with the Intersection Control Evaluation process.

1. Improvement Projects (3R, 4R) – the scoping and feasibility evaluation occurs at the Program Level Scoping phase (SPO-Planning leads the process, Pre-Life Cycle 11). A more detailed evaluation occurs during the post-Life Cycle 11 phase (PDS leads the process) as addressed in FDM 11-26-5.

2. Majors - the evaluation would take place in time to incorporate the findings into the environmental document.

3. Highway Safety Improvement Program (HSIP) - the evaluation is in the agreement with WisDOT per the Division of Transportation Investment Management's Program Management Manual, Section 04-01-10, that signal and roundabout alternatives will be evaluated as equals. HSIP funds are made available as a result of an identified safety problem/concern, therefore the preferred intersection control alternative is a roundabout, unless it can be demonstrated that another intersection control will function more safely and efficiently.

4. Traffic Impact Analysis (TIA) - the evaluation is part of the documentation prepared for the project alternatives.

5. Safe Routes To School (SRTS) - the analysis is part of an intersection alternative evaluation.

6. Congestion Mitigation and Air Quality (CMAQ) – Contact, John Duffe by email at john.duffe@dot.state.wi.us or by phone at (608) 264-8723

7. Local projects - the analysis is part of an intersection alternative evaluation.

The intersection control evaluation process is the same for projects identified by WisDOT, counties, municipalities, or local units of government that are interested in receiving federal or state funds on any of the projects identified above.

There are three conditions that should be identified early during the Program Level Scoping. The impact of any of these conditions may be so great that with proper justification may allow the scoping team to dismiss the roundabout as a viable intersection control alternative. The three conditions are:

1. The intersection in question is part of a larger coordinated signal system (more than two) that is interconnected to form a progressive signal system.

2. The right-of-way impact of the properly sized and located roundabout has far greater adverse real estate impacts than the other intersection control alternatives. This requires an evaluation of each intersection control alternative.

3. The proposed improvement to the intersection is rather minor and requires no right-of way to complete. An example of this situation may be extending a left turn bay, or adding a left turn bay where a median already exists, or upgrading (not adding) signal heads and/or controller box to improve operational efficiency.

The intersection must have stopping sight distance for any type of intersection control. However, this is typically achievable through intersection geometric improvements.

An Intersection Control Evaluation shall be completed during Program Level Scoping by the PIP team and during Project Development by the PDS team. See the following definitions.

1. Intersection Control Evaluation, Program Level Scoping. This phase is a planning level of effort that may not have detailed project information and is intended to include enough information to determine what types of intersection control are viable alternatives. See Table 3.1 for a listing of issues that need

to be addressed at the Program Level Scoping (pre-Life Cycle 11) in a spreadsheet of 10 factors.

2. Intersection Control Evaluation, Project Development. This phase (see Table 3.2) is quantitative and involves a greater level of effort to document the strength and weakness of each intersection alternative. The list of 10 factors is the same for the Program Level Scoping (pre-Life cycle 11) as for the more rigorous project development phase conducted during (post-Life cycle 11). Table 3.3 has a worksheet of factors called the Intersection Control Evaluation. Since there are 2 levels of evaluation effort each spreadsheet needs to identify the level of effort that is provided in the spreadsheet, thus select the option for your spreadsheet. Select the alternative control that is addressed in that column. This document will become part of the project file.

For those outside of the WisDOT system that are planning to request federal or state funding the evaluation process is the same. In other words the local governmental agency shall first look at the intersection to determine the extent of the problem. Use the Intersection Control Evaluation, Program Level Scoping, 10 factors, to determine if one of the 3 conditions above exist that may drop one alternative from further consideration.

After the Program Level Scoping is completed and it's discovered that more that than one alternative is viable then all the alternatives are taken to the Project Development phase. At the Project Development phase a more rigorous evaluation is required. See Table 3.2 to complete a more rigorous evaluation of the intersection.

The following steps describe the process used to complete an Intersection Control Evaluation. The intent of the Program Level Scoping evaluation is to compare alternatives and document the recommendation.

Step 1

Identify the intersection location.

Step 2

Check the box for each intersection. Select "Anticipating traffic signal" when it appears that traffic signal warrants will be met within 10 years from the construction year. Rather than installing the infrastructure needed for a future traffic signal (i.e. pull boxes and conduit), the Project Team should also consider a modern roundabout. It may be desirable to install the roundabout with the initial construction.

Step 3

Complete the 10 factors for each alternative. Table 3.1 describes the Program Level Scoping evaluation. Table 3.2 describes the Project Development evaluation. Complete Table 3.3 for both the Program Level Scoping evaluation and the Project Development evaluation. Continue to update Table 3.3 as more information becomes available.

Step 4

Generally, take the roundabout alternative beyond Scoping and Feasibility (Life Cycle 11) for further evaluation. Special consideration should be given to OSOW vehicles if the intersection is located on the OSOW Freight Network.

Submit Table 3.3 documenting the Intersection Control Evaluation through the Regional Traffic Engineering Supervisor to the Bureau of Traffic Operations State Traffic Engineer of Design for review. Submit at Life Cycle 11 and again during the Project Development phase when the intersection control recommendation is determined and Table 3.3 is complete. If a new traffic signal is recommended and the intersection is located on a state trunk highway or connecting highway, a signal warrant analysis must be completed and submitted as described in FDM 3-10-15 and the Traffic Signal Design Manual Chapter 2.

Table 3.1 Intersection Control Evaluation – Program Level Scoping (Pre-Life Cycle 11)

Factor	**Description**	**Responsibility**
Safety	Review crash diagrams, crash type and other relevant crash data to assess existing conditions. Explain what percent of crashes and the type of crashes that each alternative would eliminate. Provide an overview of access concerns near the intersection and the side road traffic impacts.	Traffic Safety Engineer
Operational Analysis	Provide a traffic distribution overview. Identify intersections that require a higher level of control such as signal, four way stop, or roundabout. Explain if an existing signalized intersection needs minor geometric improvements. Consider implications for coordinated signal system operations, truck and OSOW vehicle routes, and need to accommodate high volumes of diverted traffic through the intersection during incidents on freeways. For roundabout analysis and to estimate circle size use the Traffic Flow Worksheet, FDM 11-26 Figure 20.5 and the Typical Geometric Parameters in Table 3.4. If the scoping team (PIP) is unfamiliar with roundabout sizing use the following general guidance; for <20,000 vehicles entering the intersection use single lane, 130-ft ICD; for 20,000 to 45,000 use double lane, 160-ft ICD; for 45,000 to 65,000 use triple lane, 220-ft ICD. Sketch circle placement in most desirable intersection location to cause the least impacts. Use caution with results based only on vehicles entering the intersection thresholds. More experienced Program Level Scoping teams may analyze the roundabout and estimate circle size by using the Traffic Flow Worksheet, FDM 11-26 Figure 20.5. If the intersection is located on the OSOW Freight Network, consideration must be given to ensure that OSOW vehicles will be able to negotiate their paths at the roundabout or traffic signal. Special features, such as mountable curbs, wider lanes, larger roundabout ICD, among others, may be needed and feasibility must be assessed. Document potential conflicts for OSOW vehicles. Prepare conceptual sketches of alternatives for the signal and the roundabout alternative when appropriate.	Traffic & Operations
Construction Cost	Prepare cost estimate based on past typical project costs for each alternative, Identify the cost of high-cost utility impacts. Assume the highest cost alternative and carry to Post-Life Cycle 11. Indicate the anticipated construction year. Include major considerations for OSOW vehicles such as bypass roadways.	SPO – Planning and PIP Team
Right-of-way	Prepare a best estimate based on rough anticipated R/W acreage needs and real estate cost for each alternative. Include major considerations for OSOW vehicles on the Freight Network.	SPO – Planning, PIP Team, and Real Estate

Practical Feasibility	Consider the 3 conditions identified previously that may eliminate a roundabout from further consideration, if so desired. For HSIP projects involving intersections with a history of safety problems, roundabouts should receive primary consideration. Use FDM 11-26 Table 15.1 for values associated with the cost of a crash, by type. Over the design life of a project the socio-economic benefit as a result of reducing injury type crashes could have a large monetary benefit to society. It may be justifiable to select a higher cost intersection control alternative when the number of reduced crashes are taken into consideration. If the intersection is on an alternate route consider the capacity and safety implications, including consideration of large truck and OSOW vehicle routing. State concerns about major adverse impacts on businesses, parking availability; real estate, environment, utilities, for each alternative.	PIP Team
Operation and Maintenance Costs	Prepare a preliminary project agreement to address funding. Also prepare a maintenance agreement to address the responsibility for traffic control devices, lighting & landscaping.	SPO – Planning, Maintenance, and Traffic & Operations
Environmental	Identify significant environmental impacts for each alternative.	PIP Team, and Env. Coordinator
Pedestrian and Bicycles	Identify nearby pedestrian generators, bike routes, and ADA impacts.	SPO - Planning, Bicycle & Pedestrian Coordinator, and Traffic & Operations
OSOW Vehicles	Indentify nearby OSOW generators.	PDS in collaboration with Traffic & Operations
Recommendation	After consideration by the PIP Team, each viable alternative is carried forward to Post Life Cycle 11. Discuss the recommended alternative when applicable. Submit Table 3.3 through the Regional Traffic Engineering Supervisor to the Bureau of Traffic Operations State Traffic Engineer of Design for review. If a new traffic signal is recommended and the intersection is located on a state trunk highway or connecting highway, complete the signal warrant analysis as described in the Traffic Signal Design Manual Chapter 2 and attach the warrant analysis worksheets to Table 3.3.	PIP Team

Table 3.2 Intersection Control Evaluation – Project Development (Post-Life Cycle 11)

Factor	Description	Responsibility
Safety	Review crash diagrams, crash type and other relevant crash data to assess existing conditions. Explain what percent of crashes, and type of crashes, that will be reduced by this alternative and the effects on the most common type of crash. State the anticipated crash severity reduction. Provide an overview of access near the intersection and side road traffic impacts. Describe any unique feature or issue that may make one type of intersection control less safe than the alternative traffic control.	Traffic Safety Engineer, PDS has a role with access impacts

Operational Analysis	List any traffic warrants for a signal or 4-way stop that will be met within 10 years of the initial construction (anticipating signal warrant)? State what traffic control warrant(s) have been met to justify a signal or 4-way stop. Quantify the LOS with a letter for each movement, leg and intersection average, for whatever the analysis software provides. Show delay in seconds, queue length in number of vehicles or feet whatever the software provides. Describe how the queue length may impact adjacent driveways and other access points. Describe the distribution of traffic by approach and movement. State the fluctuation of traffic by time of day or by time of year. On routes parallel to a freeway consider the capacity of the intersection to accommodate 5% to 20% diverted traffic due to incidents on freeways. If the intersection is on a freeway alternate route and if the freeway is an OSOW primary or secondary route, OSOW vehicles must be included in the traffic diversion analysis. Document if a railroad crossing is within 500 feet of the intersection and state if any mitigation measures or devices have been considered when a railroad is nearby. Is this intersection within a well-coordinated progressive signalized system? Estimate intersection size and prepare a drawing of the intersection alternatives. Consider implications of truck and OSOW vehicle routes through intersection. Include in the consideration, evaluation of particular intersection movements that may be impacted or prevented due to the proposed improvements.	PDS in collaboration with the Traffic & Operations
Construction Cost	State the estimated hard dollar construction cost for each alternative. Include all appropriate utilities cost associated with each alternative. Indicate the anticipated construction year.	PDS
Right-of-way	List type of land use and amount of R/W acreage impacted (i.e. # of relocations, access restrictions, type of land use). State the anticipated R/W and real estate cost associated with the intersection improvement.	PDS and Real Estate
Practical Feasibility	List concerns that this alternative may present. List signal system consideration. Consider history of safety problems. What are the operational consequences if this intersection is within a major alternate route? Identify major impacts on businesses, parking availability, real estate, environmental and utilities. Use FDM 11-26 Table 15.1 for values associated with the cost of a crash, by type. Over the design life of a project the socio-economic benefit as a result of reducing injury type crashes could have a large monetary benefit to society. It may be justifiable to select a higher cost intersection control alternative when the number of reduced crashes are taken into consideration. For HSIP projects involving intersections with history of safety problems, roundabouts should receive primary consideration. Frequency of use as an alternate route, and effect on each alternative. Identify major impacts on businesses, parking availability, real estate, environment, utilities, etc. If the intersection is located on the OSOW Freight Network or if the intersection is part of a freeway alternate route and if the freeway is on the OSOW Freight Network, list the additional operational impacts associated with truck and OSOW vehicle routes through the intersection. Consider the frequency of load and include all particular intersection movements that may be impacted or prevented due to the proposed improvements.	PDS with input from other sections
Operation and Maintenance Costs	Discuss cost implications and maintenance commitment of signal lighting, overhead street lighting, landscaping maintenance at the intersection for each alternative. Are there any additional signing and marking considerations? A paved central island is not an option. Determine if the intersection is located along the OSOW Freight Network and whether there is a need for additional paved areas, removable signing, or gated connections needed to accommodate OSOW vehicles.	PDS with input from the Traffic & Operations and Maintenance

Environment	Describe the type (historical, archeological, wetlands, or hazardous material) and amount of environmental acreage affected by each alternative. List the advantages / disadvantages for each traffic control alternative.	PDS and the Env. Coordinator
Pedestrian and Bicycles	Describe the need for accommodating facilities for pedestrians & bicyclists. State whether schools or bike routes are nearby. State whether sidewalks are proposed, within, or near the project area. List the advantages / disadvantages for each traffic control alternative.	PDS, Bicycle & Pedestrian Coordinator with input from Traffic & Operations
OSOW Vehicles	Identify nearby OSOW generators.	PDS in collaboration with Traffic & operations
Recommendation	Discuss each alternative and make PDS recommendation before the environmental documentation completion. Submit Table 3.3 through the Regional Traffic Engineering Supervisor to the Bureau of Traffic Operations State Traffic Engineer of Design for review. If the recommendation is a new traffic signal and the intersection is located on a state trunk highway or connecting highway, complete the signal warrant analysis as described in the Traffic Signal Design Manual Chapter 2 and attach the warrant analysis worksheets to Table 3.3 if not completed previously.	PDS and Team

Table 3.3 Intersection Control Evaluation Worksheet

Project ID ___________________ Intersection Location				
Factor	**ALTERNATIVE CONTROL** ☐ TRAFFIC SIGNAL, ☐ ANTICIPATING TRAFFIC SIGNAL ☐ ROUNDABOUT ☐ 4-WAY STOP ☐ 2-WAY STOP ☐ EXISTING CONTROL		**ALTERNATIVE CONTROL** ☐ TRAFFIC SIGNAL, ☐ ANTICIPATING TRAFFIC SIGNAL ☐ ROUNDABOUT ☐ 4-WAY STOP ☐ 2-WAY STOP ☐ EXISTING CONTROL	
Safety				
Operational Analysis				
Construction Cost				
Right-of-Way				
Practical Feasibility				
Operation & Maintenance Cost				
Environmental				
Pedestrian and Bicycles				
OSOW Vehicles				
Recommendation				
Responsibility	PIP Team	PDS Team	PIP Team	PDS Team

The intent of Table 3.3 is to show the input from the PIP team adjacent to the input from the PDS team. Over time the PDS team will update or add information to the table. See FDM 11-25-3, doc1 for a 11" x 17" spreadsheet.

The Project Development phase has three stages where the various levels of project progress are identified. Stages 1, 2 and 3 are described in FDM 11-26-5. These stages require participation from a qualified designer.

3.3 Roundabout as viable alternative

When the Intersection Control Evaluation determines that a roundabout is a viable alternative the general and initial guidance provided in Table 3.4 will help to begin the roundabout design. See FDM 11-26-30 for the 10 steps in developing a roundabout design. Determining the size and space requirements of a roundabout is an iterative process. However, it is appropriate to begin with certain typical initial values for the six geometric parameters provided in Table 3.4. Note that the typical initial values for circulating roadway and exit radius are for general information and are not required in the RODEL analysis. The typical initial values are just the first step in the roundabout development process. These typical initial values are most likely not the final values used in the project. If the intersection is located on the OSOW Freight Network, the size of the roundabout may need to be increased or other accommodations for through and turning movements may need to be considered without compromising the safety and vehicle speeds at the roundabout.

Table 3.4 Typical Initial Geometric Parameters A for Both Urban & Rural Roundabouts C

Geometric Parameter	Single-Lane Entry	Dual-Lane Entry	Triple-Lane Entry
Half width (V)[B]	Travel lane width approaching the roundabout prior to any flared section, typically 12 feet per lane. Do not include bike lanes.		
Entry width (E)[B]	18-22 ft (5.5-6.7 m)	24-28 ft (7.3-8.5 m)	34-40 ft (10.4-12.2 m)
Effective Flare Length (L')[B]	15-330 ft **(5-100 m)**		
Inscribed diameter (DIA)	130 ft **(40 m)**	160 ft **(50 m)**	220 ft **(67 m)**
Entry Radius (RAD)	65 ft **(20 m)**	65 ft **(20 m)**	65 ft **(20 m)**
Entry angle (phi)	30 Degrees		
Circulating roadway width	Typically 1.0 to 1.2 times the width of the widest entry into the roundabout.		
Exit radius	Typical range is 200-1000 feet. Exit curves should be larger than entry curves and typically have R3 speeds higher than the R2 speed.		

[A] At this time RODEL works only with metric values.

[B] High influence on capacity.

[C] The values provided in this table are for general design guidance and are not intended to be strict standards that ensure good design.

FDM 11-25-5 Left-Turn Lanes

February 25, 2011

5.1 Warranting Criteria

A left-turn lane at intersections where left turns are frequent is always desirable from a safety and capacity standpoint. The primary factors to consider when determining the need for an exclusive left-turn lane are the left-turn traffic volume, opposing traffic volume, accident history and experience. A capacity analysis is generally used to determine turn lane requirements at signalized urban intersections. Additional factors to consider include median width, available right of way, construction and right of way costs and the design classes of the intersecting roadways.

As a general policy, provide exclusive left-turn lanes on all expressway at-grade intersections with public streets or highways.

Exclusive left-turn lanes are provided in order to enhance the safety and to facilitate the movement of through traffic. Generally, consider providing an exclusive left-turn lane if the construction year AADT on the main road exceeds 7,000 and the side road AADT exceeds 1,000. For more specific guidance use Table 5.1 below or refer to [4]. Left turn lanes for OSOW movements on OSOW routes should be provided independent of the AADT guidance, depending on frequency of load.

Table 5.1 Operational Warrants for Left-Turn Lanes at Intersections on Two-Lane Highways.

Opposing Traffic	**Advancing volume to warrant a left-turn lane (veh/hr)**			
Opposing Volume (veh/hr)	with 5 percent left turns	with 10 percent left turns	with 20 percent left turns	with 30 percent left turns
		60-mph Operating Speed		
800	230	170	125	115
600	290	210	160	140
400	365	270	200	175
200	450	330	250	215

5.2 Design Criteria

5.2.1 Widths

The width of a left-turn lane is desirably the same as the width of the through lane. Curb adjacent to the left-turn lane is offset to at least the width of the gutter. Provide a turn-lane width of 12 ft on rural and suburban arterial highways.

Narrower turn lanes are often necessary on urban arterials because of restricted right-of-way and median widths. The minimum and desirable widths for left-turn lanes are shown below.

Table 5.2 Median and Lane Widths for Left-Turn Usage (Minimum Widths)

	Highly Developed Area	**Outlying Area**	**Desirable Width**
Left-turn lane Width (to gutter flange line)	10 ft	10 ft	11-12 ft
Minimum f/c-f/c Width *	The greater of 4 feet or fixed object width (e.g., sign or signal head) + 2 feet on each side.	The greater of 8 feet or fixed object width (e.g., sign or signal head) + 2feet on each side.	The greater of 14 feet or fixed object width (e.g., sign or signal head) + 2 feet on each side.
Total Median Width between opposing traffic lanes where cross traffic storage is **NOT** required.	f/c – f/c* width + gutter width on each side + left-turn lane width.		
Total Median Width between opposing traffic lanes where cross traffic storage **IS** required.	**Low Speed Urban Roadways** **Desirable**: the greater of f/c – f/c* width + gutter width on each side + left-turn lane width, or 30 feet. **Minimum**: the greater of f/c – f/c* width + gutter width on each side + left-turn lane width, or 24 feet. **Transitional and High Speed Urban Roadways** the greater of f/c – f/c* width + gutter width on each side + left-turn lane width, or 30 feet.		

* f/c-f/c width is the face of curb to face of curb distance between the curb adjacent to the left-turn lane and the curb adjacent to the opposing traffic lane.

See FDM 11-20-1 under "Medians" for further guidance on median widths.

5.2.2 Median End Treatment

For a median width of 10 ft or more, the bullet nose is superior to the semicircular end and is the preferred design. A bullet nose is designed to closely fit the path of a turning vehicle and results in less intersection pavement and a shorter median opening than the semicircular shape. The bullet nose is formed by two symmetrical portions of control radius arcs (see R3 - R6 in Attachment 5.1 – 5.3) These arcs need to be large enough to accommodate the turning path of the design vehicle. For rural expressways, a control radius of 80 ft and median opening width of 45 ft at a right angle intersection will accommodate the WB-62 design vehicle. See Attachment 5.4 for an illustration of this design. Attachment 5.1 provides left-turn control radii and median opening guidance for urban arterials. Intersection designs, including the location and shape of the median nose and median opening, are developed by using design vehicle turning templates and an appropriate control radius (refer to Attachment 5.2 and Attachment 5.3). A 60-ft turning radius is usually appropriate for right-angle urban intersections. On the OSOW Freight Network, use the vehicle inventory of OSOW check vehicles, FDM 11-25 Attachment 1.3, that may require alternative intersection geometrics The OSOW Freight Network map is available from the Regional Freight Operations Unit. This information is in draft condition and may experience updates and changes in the near term. Therefore this document should not be shared with others unless they are working on projects that include the OSOW Freight Network. Alternative nose configurations may be warranted that allow passage of OSOW vehicles while providing direction to turning vehicles.

For pedestrian accommodation or protection in the median, line up the face of the median nose with the center of the cross street sidewalk extended.

5.2.3 Length

The length of a median left-turn lane must be adequate for storage or speed change of left-turning vehicles and the entering taper.

Attachment 5.1 and Attachment 5.2 provide guidance on the length and design of turn lanes for urban highways and streets. Coordinate with the region traffic engineer's staff in determining the required storage length at signalized intersections. Consider using traffic control devices with left-turn indicators when the number of left-turning vehicles exceeds 100 per hour. For additional information see pp 717-726 of the 2001 GDHS and the Highway Capacity Manual. [1]

Attachment 5.4 illustrates a left-turn lane on a typical rural expressway and includes a table which relates the length of a left-turn lane to the type of rural at-grade intersection into which the traffic is turning.

5.3 Special Designs

5.3.1 Slotted Left-Turn Lanes

A problem with left-turn lanes is the inability of drivers in opposing left-turn bays to see past each other to detect oncoming traffic. Although it is desirable to provide a positive offset, as shown in Figure 5.1, this may not be possible at all locations. It is suggested that the turning lane be kept as far to the left as practical on wider medians, thus creating a slotted or channelized left-turn lane.

The desirable and minimum widths of a left-turn lane and of a median separating left-turning traffic from opposing traffic are based on Table 5.2 above.

The total width of a left-turn island is defined as the distance between the right edge of the turn lane and the median edge of the travel lane.

If the f/c – f/c width of a left-turn island would be less than 4 feet, then install a flush left-turn island of contrasting pavement or color to delineate the turning lane from the through lane. Otherwise, install a raised left-turn island and make the lateral offset between the curb face of the left-turn island and the adjacent through lane equal to the offset from the curb face of the median to the same adjacent through lane. See Figure 5.1.

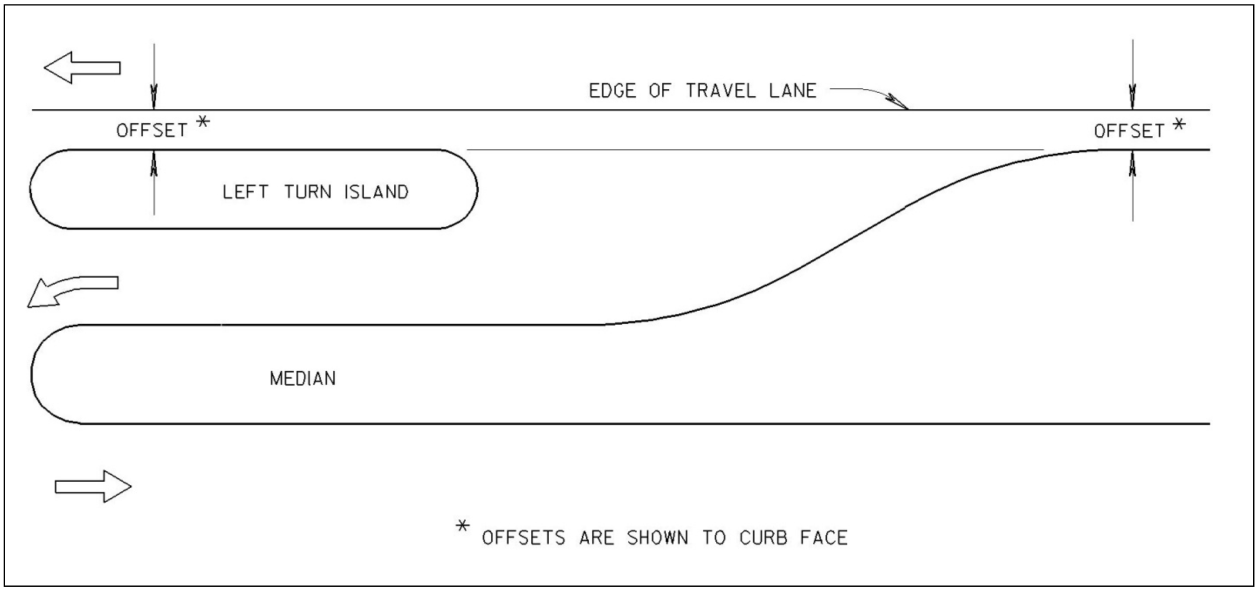


Figure 5.1. Left-Turn Island / Median Offsets

The width of the channelized lane is desirably 14 feet (f/c-f/c). However, if the intersection is on the OSOW Freight Network, this width may need to be increased to accommodate OSOW vehicle turning movements.

An offset and slotted left-turn design is illustrated on Attachment 5.3. For additional guidance see pp 727-728 of the 2001 GDHS.

5.3.2 Two-way Left-Turn Lane (TWLTL)

Consider installing a two-way left-turn lane (TWLTL) in existing commercial or residential areas where the existing roadway is undivided (flush median) and where there is a combination of traffic congestion and numerous left-turn maneuvers, coupled with rear-end accidents. Two-way left-turn lanes consist of a traffic lane in the median area, 14-16 feet in clear width, delineated by pavement marking strips. Marking and signing in accordance with the Manual on Uniform Traffic Control Devices shall be used to identify the lane and regulate its proper use. Additional delineation may be achieved by either using a different type of pavement material with contrasting color or texture, or a mountable raised median.

Two-way left-turn lanes work well for speeds up to 50 mph when there are numerous access points without high turning volume concentration and traffic volumes vary from 8,000 to 15,000 AADT for a 3 lane TWLTL. Use a raised median at intersections and driveways with a high concentration of left turning vehicles. Use an appropriate alternate median treatment for higher traffic volumes or for speeds greater than 50 mph. This median lane treatment is intended for use by vehicles traveling in either direction for deceleration and refuge while making a midblock left-turn maneuver. Use of two-way left-turn lanes for passing maneuvers is strictly prohibited and must be signed appropriately. The lane serves as a separation for opposing lanes of travel, an acceleration lane for vehicles turning left to enter the street from midblock driveways, and can be utilized as a detour route for maintenance work in adjacent lanes. It also allows easier and safer emergency vehicle movement, particularly during peak-hour periods.

See SDD 15C10, "Raised Pavement Markers" and MUTCD Figure 3-5 for typical details of marking for two-way left-turn channelization. Two-way left-turn lanes are also discussed in the 2001 GDHS on pp 478-482.

5.4 References

[1] Highway Capacity Manual, 2000, Transportation Research Board

[2] NCHRP Report 279, Intersection Channelization Design Guide, 1985.

[3] NCHRP Report 282, Multi-lane Design Alternatives For Improving Suburban Highways, 1986.

[4] “Low Cost Methods for Improving Traffic Operations on Two-Lane Roads,” D. W. Harwood and C. J. Hoban, January 1987

[5] NCHRP 395, Capacity and Operational Effects of Midblock Left-Turn Lanes.

LIST OF ATTACHMENTS

FDM 11-25-10 Right-Turn Lanes *February 25, 2011*

10.1 Introduction

These guidelines apply to right-turn lanes at intersections without channelizing islands. See FDM 11-25-15 for guidance about channelized right-turn lanes.

The selection of a right turn radius requires consideration of design speed, types of turning vehicles, type of intersection by location (rural, urban or suburban), pedestrian needs and whether the through highway is divided or undivided.

10.2 Intersections in Rural and Developing Areas

Refer to FDM 11-25-1 for guidance about right turn radii for intersections located in rural and developing areas.

10.2.1 Storage Length

The right turn lane lengths in the standard rural intersection designs (discussed in FDM 11-25-1) are for deceleration of turning vehicles. Where cross road traffic volumes are high additional length may be needed to accommodate vehicle storage. Storage requirements should also be evaluated where signals are added to the intersection. However, existing intersection Types A, B1 or B2 will typically provide adequate vehicle storage especially where right turns on red are permitted.

The length of turn lane required for vehicle storage should be determined in cooperation with the region traffic engineer's staff based on a length of 25 feet per vehicle stored. If the intersection is on the OSOW Freight Network, depending on frequency of load, it may be appropriate to consider additional length for OSOW vehicles.

10.3 Intersections in Urban Areas

10.3.1 Undivided Roadways

Downtown streets are typically undivided and often operate as one-way roadways. A minimum corner radius of 10 feet may be adequate for these streets especially where there is pedestrian activity and little truck traffic. Progressively larger corner radii are required depending on the functional classification of the intersecting street; at least 15 feet for locals, 20 feet for collectors and 25 feet for arterials. Large trucks can be accommodated with these radii if encroachment into the opposing traffic lane can be allowed and parking can be held back from the corner by at least two spaces.

Where there is a significant number of trucks turning and encroachment into the opposing lanes cannot be allowed, the corner should be designed using an appropriate turning template or three centered compound curves. See GDHS [1] Table IX-4, "Minimum Designs for Turning Roadways." Pedestrian accommodation and signal locations should be included in the design where appropriate.

10.3.2 Divided Roadways

Where truck volumes are not significant, the right turn radius can be as small as 10 feet in downtown streets and 25 feet at intersections with arterial streets. Intersections which must handle large numbers of turning trucks, should be designed for a WB-62 design vehicle. This design vehicle requires a minimum corner radius of 30 feet to turn onto a four lane divided highway where the semitrailer can encroach into the median lane. Truck drivers will use the median lane when necessary which is allowed under state law for large trucks. A larger radius should be provided where possible. However, a radius greater than 45 feet should not be used because it can cause substantial problems with the location of stop signs, traffic signals, pedestrian push buttons, and crosswalk locations. A large radius also causes crosswalks to be extra long which results in more pedestrian exposure and visibility problems.

The corner radius can be shorter where the intersection is on a street where parking is permitted. However, future growth in traffic volumes may demand that the parking lane be converted to a traffic lane. If this is foreseeable, a large radius should be provided.

For additional guidance, see GDHS [2] discussion about "Intersection Curves."

10.3.3 Lane Width

The width of a non-channelized right turn lane should generally be the same as the width of the through lane. For guidance on the use of narrower lanes, see "Median Widths for Left-Turn Usage" table in FDM 11-25-5. The desirable width for channelized right turn lanes is discussed in FDM 11-25-15.

10.4 References

[1] 1990 GDHS, page 734 and 1994 GDHS, page 691

[2] 1990 GDHS, pages 689-716 and 1994 GDHS, pages 647-672

FDM 11-25-15 Turning Roadways (Channelized Right) — *February 25, 2011*

15.1 Criteria

At intersections with a considerable number of turning movements, especially by trucks, and where it is desirable to maintain a turning speed for passenger vehicles of roughly 15 mph (25 km/h) or greater, a separate turning roadway or channelized right-turning lane should be provided between intersection legs. Give consideration to OSOW vehicles if the intersection is located on the OSOW Freight Network. Verify that OSOW vehicles are not prohibited from turning at the intersection where needed.

The term "turning roadways" also applies to ramps and ramp terminals, particularly at the crossroad. Refer to FDM 11-30 Attachment 1.4, 5, and 6 for geometrics at ramp terminals.

15.2 Speed And Curvature

The speed maintained on turning roadways is governed by the radius of curve and superelevation. See FDM 11-10-5. Compound curves should be used to avoid vehicle encroachment onto the shoulders. Three-centered compound curves for vehicles of different design classification are shown in Exhibit 9-20, pages 588-595, GDHS 2001.

15.3 Design Guides

The width of turning roadways should accommodate the design class of vehicle that is anticipated. For turning lanes that are longer than 50 feet, provisions should be made to pass a stalled vehicle in the turning lane. The design width of pavement for turning roadways is shown in Exhibit 3-55, page 224, GDHS 2001 with 15 feet as a minimum plus the gutter width.

The taper on the approach to the turn is dependent upon design speed, but 20:1 is typical with 10:1 as a practical minimum for most urban streets. This taper should also be used on the receiving leg of the turning roadway.

If curb and gutter is used, the island that results by providing a turning roadway should be offset an additional 2 feet [4 feet to face of curb] from the through lane. For speeds in excess of 40 mph, the island should be offset 8 to 10 feet.

FDM 11-25-20 Median Openings — *December 30, 1993*

20.1 Introduction

Median openings, whether they are located at major intersections or serve traffic generators between intersections, all tend to interrupt through traffic flow. On arterial streets it is highly desirable to have free flow of traffic without interruptions. Other than at intersections the designer should attempt to provide optimum access points and median openings. Values for spacing of median openings, nose radii, and lengths of openings are shown in FDM 11-25 Attachment 5.1and FDM 11-25 Attachment 5.2.

20.2 U-Turns

For driver convenience median openings for U-turns should be provided in advance of signalized intersections and every 1,000 feet thereafter (maximum), except where other controls govern the spacing. The widths of medians required to accommodate U-turns are shown in Figure IX-67, page 825, GDHS.

20.3 Length Of Opening

The length of a median opening should be determined by the control radii for left-turn movements of vehicles turning into a driveway or making a U-turn. A 40-foot length should be used as a minimum length. The nose of the median end may be either circular or bullet shaped. The bullet nose is preferred in most instances where the median is wide enough to provide it. The radius used to form the end of the bullet nose should be between one foot and five feet but desirably should be as near to 3 feet as possible. See Table IX-16, 17, and 18, pages 804 to 807, GDHS for length of median opening.

For additional information on median openings, refer to pages 799-817 of GDHS.

FDM 11-25-25 Channelization *February 25, 2011*

25.1 General

Traffic can be channelized by using various combinations of islands, pavement markings, rumble strips, contrasting pavement, traffic signals, etc. The design guides for providing left- and right-turn lanes (FDM 11-25-5 and FDM 11-25-10) are also methods of channelizing traffic.

25.2 Islands

This discussion assumes that islands are raised by using curb and gutter. The use of islands for directing traffic should be held to a practical minimum, as they in themselves can present problems, especially for winter maintenance activities. Islands when used should not be too small, preferably 100 square feet as a minimum. The approach end of the island should provide sufficient warning to identify the island's existence. This can be accomplished by using a raised delineator (non-rigid) or a rumble strip. To prevent damage to snowplows or errant vehicles, a mountable curb should be constructed on the approach nose.

When possible, median islands should be offset 8 feet from the travel lane and transitioned to a normal curb offset, usually 2 feet.

The transition length is dependent on the design speed.

Minimize channelization islands, raised islands and other raised features that may inhibit turning movements of OSOW vehicles on the OSOW Freight Network.

25.3 Pavement Markings

Painted islands should not be offset from the through lane except where the lane width is insufficient. For additional discussion refer to pages 718-719 of GDHS.

FDM 11-25-30 Curb Ramps *October 5, 2011*

This portion of the FDM has been transferred to FDM 11-46-10.

FDM 11-25-35 Auxiliary Lanes *February 28, 2001*

35.1 Auxiliary Lanes

An auxiliary lane is defined as the portion of roadway adjoining the traveled way such as turning lanes, storage for turning, weaving, or the added lane between two interchange ramp areas, and other purposes supplementary to through-traffic movement.

Truck climbing lanes and passing lanes are not considered auxiliary lanes. For more information on truck climbing lanes and passing lanes see FDM 11-15-10.

35.2 Acceleration Lanes

For design details of acceleration lanes refer to FDM 11-30-1. Acceleration lanes may also be used at non-signalized intersections with turning roadways, particularly for right-turning vehicles entering an arterial. In some cases a length of the parking lane may become the acceleration lane. For details relating to a tapered or a parallel type of acceleration lane, refer to pages 797-799, GDHS.

35.3 Bus Stops

Bus transit is an integral part of the operation of many urban streets and highways. The existing operating policies and the future transit needs of communities should be given design consideration where applicable, particularly where bus movements caused by bus stops will affect intersection capacity.

Other transit facilities that should be considered for buses are bus passenger shelters, park-and-ride lots, and turnouts (separate loading lane). The decision to include bus turnouts should be based on the volume and turning movements of both the bus traffic and through traffic, the distance between bus stops, and right-of-way limitations. The design features for turnouts should be based on the size and turning radius of the bus. Generally, turning radii should be such that buses can remain in the outer lane during the full turn. A more complete discussion of bus considerations can be obtained from pages 405-415, GDHS.

FDM 11-25-40 Railroad Crossings

April 26, 2007

FDM 17-60-5 establishes railroad grade crossing design criteria. FDM 17-40-5 explains factors to consider when evaluating the potential need for a grade separation structure. All signing, marking, signals, and gate installations shall conform to the Manual on Uniform Traffic Control Devices, FHWA, 2000 and the Wisconsin Supplement. Additional information can be found on pages 735-743, GDHS (2001.)

Sight distance triangles should be provided for vehicles approaching a crossing, but a separate sight distance triangle must be provided for vehicles such as buses and trucks, which are required to stop. Stopped vehicles need additional sight distance to proceed safely across a railroad crossing. An additional lane should be considered for stopped vehicles, particularly on multi-lane highways.

FDM 11-25-45 Frontage Roads

September 3, 2004

A service road is a public or private street or road that runs generally parallel to but is separated from the major roadway by a physical barrier. Its primary function is to provide access to the abutting properties. Service roads are also referred to commonly as frontage or backage roads.

A frontage road is a service road between the right-of-way of the major roadway and the front building setback line. It provides access to properties while separating them from the principal roadway. Frontage roads will “front” on the major roadway.

A backage road is a service road that is separated from the major roadway by intervening land uses. The arterial abuts the rear lot line and buildings face the backage road. Buildings on backage roads face away from the major roadway.

Freeway/expressway interchange areas that have frontage road access to the crossroad outside the ramps are addressed in FDM 11-5-5.

Service roads provide the following benefits:

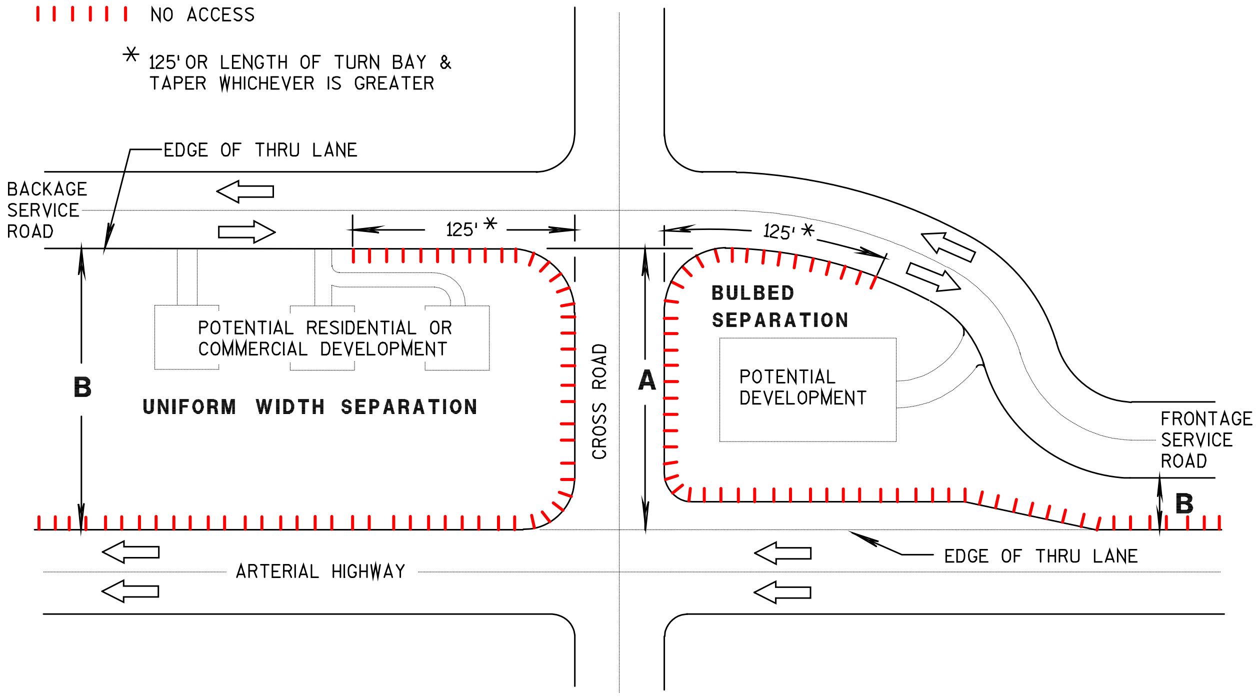
- Effectively control access to the through lanes on the arterial street,
- Provide access to adjoining property,
- Separate local traffic from through traffic, and
- Permit circulation of local traffic adjacent to the arterial.

From an operational and safety standpoint, one-way service roads on each side of an arterial may be preferred to two-way service roads.

Maximize the separation distance between the service road/crossroad intersection and the arterial/crossroad intersection to ensure sufficient storage for traffic on the crossroad between the service road and the arterial. At some time the arterial/crossroad intersection may be signalized or include a roundabout. Provide adequate storage for queued vehicles.

The absolute minimum separation distance (Dimension A in Figure 45.1) is 150 feet in a tightly constrained urban environment with low crossroad traffic volumes. This is the shortest length for placing signs and other traffic control devices. Greater distances are needed to provide adequate vehicle storage and to separate operation of the two intersections. Spacing of at least 300-feet, preferably more, in urban areas enables turning movements to be made from the arterial lanes onto the service road without seriously disrupting arterial traffic. High crossroad traffic volumes with high service road volumes will typically justify a greater separation distance. This may be achieved by taking the service road around an existing or proposed development as shown in the “bulbed separation” area, in effect developing a backage road for that portion of the otherwise frontage road. A greater separation than those shown in Figure 45.1 may be needed if signalization is required. The recommended separation distance between signals is about 1,300 feet, unless the signals are coordinated like the close spacing between interchange ramps. The separation between properly designed roundabouts may be 300 feet or less in tight situations.

Away from the arterial intersection consider the distance separating the service road travel lanes from the arterial travel lanes, distance “B” on the bulbed separation” side of Figure 45.1. Headlight glare, driver confusion about the location of an approaching vehicle and errant vehicles are safety concerns that suggest keeping that distance as wide as practical. In tight built-up urban areas this distance may be as low as 45 feet. In situations that present a safety concern, glare fence or other protective shielding may be required between the service road and the arterial.



Min. Distance A[1] (stop control)		
Crossroad Design year AADT	Distance (ft)	
	Urban	Rural
< 100	150	300
100 – 1,000	300	300
> 1,000	600	600

Distance B[2]			
Urban		Rural	
Des.	Min.	Des.	Min.
85 ft	45 ft	115 ft	85 ft

1. References. NCHRP 420, pages 121 – 127; 2001 GDHS, pages 729-732.
2. Greater distances may be warranted where noise barriers, berms or landscaping are located along the arterial. Distance ‘B’ for a backage road does not necessarily equal Distance ‘A’ along the crossroad.

Figure 45.1. Frontage Road Offset Guidelines