



## Facilities Development Manual

ORIGINATOR Director, Bureau of Highway Development		PROCEDURE 11-26-5
CHAPTER 11	Design	
SECTION 26	Roundabouts	
SUBJECT 5	Scoping & Feasibility	

### **Scoping**

Roundabouts may be considered for a wide range of intersection types including but not limited to freeway interchange ramp terminals, state route intersections, and state route/local route intersections. Roundabouts generally process high volume left turns more efficiently than all-way stop control or traffic signals, and will process a wide range of side road volumes. Roundabouts can improve safety by simplifying conflicts, reducing vehicle speeds, and providing a clearer indication of the driver's right of way compared to other forms of intersection control. The required intersection sight distance is approximately half what is required for a signalized intersection.

Coordinate early in the scoping stage with the District Planning and Traffic sections to determine whether a roundabout should further be considered as an alternate once an initial analysis is completed.

Critical to the acceptance of the roundabout intersection concept is overcoming the internal skepticism of its advantages and value over alternate intersection types. At a minimum, compare the capacity, delay and crash analysis for the roundabout and other alternatives to determine the relative advantages and disadvantages of each.

Meet with local officials and adjoining property owners early in the process to address potential political or economic impacts.

There are typically three phases to a roundabout project:

1. Feasibility
2. Alternatives analysis and preliminary design
3. Final design

Phases 2 and 3 will be addressed in subsequent procedures.

### **Feasibility**

The feasibility phase is conducted to estimate the general size of the roundabout (inscribed diameter, number of entry and exit lanes, and potential right-of-way conflicts). The feasibility phase is based on preliminary data and it is therefore not intended to provide detailed geometric dimensions.

Design year, design hour traffic volumes and default geometric values for the six geometric design parameters can be used to identify the general size of the roundabout

and operating characteristics. Conduct a capacity analysis to estimate the general size of the roundabout to include the inscribed diameter, entry width and number of entry lanes. There are two different methods to achieve this estimated general size. The first and preferred method is to use RODEL software for the analysis. Table 2 provides default values for six geometric features for both single-lane and multi-lane roundabouts. These default values are only a first estimate and preliminary and final design values will change.

The second method is included in the [Roundabouts: An Informational Guide](#), Appendix A. Operational Analysis Formulas are provided to assist in the preliminary determination of roundabout capacity, inscribed diameter, and number of entry lanes at each approach. The formulas provided in the FHWA Guide treat the roundabout as a series of independent “T” intersections and may provide initial results at low v/c ratios. Using these formulas does not allow for interaction between the legs of the roundabout whereas RODEL does.

Do not assume that a roundabout will not work well when the side road traffic is a low percentage of the total traffic entering the intersection. The primary Measure of Effectiveness (**MOE**) for a roundabout or other intersection treatments is delay. Queue length is a function of delay and is an important consideration as well. Other factors to consider are crash rate, severity of crashes, overall project cost and the ability to meet project objectives while minimizing negative impacts associated with the project such as business access, encroachment, etc.

### **Documentation**

Documentation is required showing the evaluation results of the intersection treatments considered, which includes the roundabout alternative. There may be many legitimate reasons why a roundabout would not be appropriate and that shall be stated in the documentation. There is an interest to maintain the STH system as a high mobility system but not at the expense of compromising safety.

### **Appropriate Applications**

Feasibility for roundabouts begins with specifying a preliminary configuration. The configuration is specified in terms of the minimum number of lanes required on each approach and thus which roundabout category is the most appropriate basis for design: urban or rural, single-lane, or multi-lane. Roundabouts are appropriate at high-speed intersections, especially those with a poor crash history. Roundabouts are a reasonable alternative at locations with poor visibility, as only short visibility left and right is needed. However, the stopping sight distance to the roundabout must be provided. There are many additional levels of detail required in the design and analysis of a high capacity, multi-lane roundabout that are beyond the scope of a planning level procedure. Therefore, this procedure focuses on the more common questions that can be answered using reasonable assumptions and approximations.

A feasibility analysis requires an approximation of some of the design parameters and operational characteristics. Some changes in these approximations should be expected as the design evolves. A more detailed methodology for performing the geometric design and operational evaluation tasks is presented in [Procedure 11-26-10](#). Also refer to the FHWA Roundabout Guide, Chapter 6.

Examples of appropriate applications of roundabouts on state facilities are given in the following sections.

### Crash Evaluation

A roundabout can provide a possible solution for high crash rates by reducing the number of conflict points where the paths of opposing vehicles intersect. For example, over half of the crashes at conventional intersections occur when a driver either

1. Misjudges the distance or speed of approaching vehicles while making a left turn, or
2. Causes a right angle collision after violating a red light or stop sign.

Such crashes would be eliminated with a roundabout, where left turns and crossing movements are prohibited. Furthermore, collisions at roundabouts would involve low speeds and low angles of impact, and therefore, are less likely to result in serious injury for all road users. Pedestrians are more safely accommodated since the vehicular speeds are slower and crossing tasks are simplified by the presence of the refuge area in the splitter islands. Crash evaluation is an important process to complete for any intersection improvement alternative. Typically the crash evaluation will include location, date, type of crash, time of day, age of driver, weather conditions, severity of crash, and other important information to assess the problem(s), patterns and potential improvement need.

### Intersection Capacity Evaluation

When considering methods to increase the capacity of an intersection, a roundabout can be an alternative to stop signs or traffic signals. With conventional types of traffic controls, only alternating streams of vehicles are permitted to proceed through the intersections at one time, causing a loss of capacity when the intersection clears between phases. In contrast, the only restriction on entering a roundabout is the availability of gaps in the circulating flow. The slow speeds within the roundabout allow drivers to safely select a gap that is relatively small. By allowing vehicles to enter simultaneously from multiple approaches using short headways, a possible advantage in capacity can be achieved with a roundabout. This advantage becomes more prominent when the volumes of left or right turning movements are relatively high.

Use the "RODEL" software at the 50% confidence level to analyze the capacity of the roundabout alternative for comparison to the other intersection treatments. Higher confidence levels are used for testing designs for robustness. "Delay" is the primary measure of effectiveness in determining the intersection level of service.

### Queue Storage Evaluation

Roundabouts can produce operational improvements in locations where the space available for queuing is limited. Roadways are often widened to create storage for vehicles waiting at red lights, but the reduced delays and continuous flows at roundabouts allow the use of fewer lanes between intersections. One possible application can be found at existing diamond interchanges, where high left turn volumes can cause signals to fail. By constructing a pair of roundabouts at the ramp intersections, capacity improvements to the interchange can be accomplished without the costly requirements of widening the structure to carry additional lanes over or under a freeway, or expressway (see [Procedure 11-30-1](#) for more information on interchanges).

### Unconventional Intersection Geometry Evaluation

Conventional forms of traffic control are often less efficient at intersections with a difficult skew angle, significant offset, odd number of approaches, or close spacing to other intersections. Roundabouts may be better suited for such intersections, because they do not require complicated signing or signal phasing. Their ability to accommodate high turning volumes make them especially effective at "Y" or "T" junctions. Roundabouts may

also be useful in eliminating a pair of closely spaced intersections by combining them to form a multi-legged roundabout. Intersection sight distance for roundabouts is about half what it is for other intersection treatments.

Another possible application is where access is controlled with raised medians. Roundabouts would facilitate left turns and U-turns to access properties on the opposite side of the highway.

### **Roundabout Categories**

Roundabouts have been categorized by size and environment. The following is a list of the basic categories explained in the [FHWA Roundabout Guide](#). There will be situations where categories are not applicable, or do not make sense given the situation. The planning process and final design methodologies for roundabouts are to be based on “principles” versus strict rules or one-size fits all standards. For example there are no categories for transitional areas and the final design will depend on the various factors mentioned above.

#### **Mini-roundabouts**

Mini-roundabouts are small roundabouts used in low-speed urban environments and will not be addressed in this manual.

#### **Urban Compact Roundabout**

Urban compact roundabouts are small roundabouts used in low-speed urban environments and will not be addressed in this manual.

#### **Urban Single-Lane Roundabout**

This type of roundabout is characterized as having a single-lane entry at all legs and one circulatory lane. The roundabout design is focused on achieving consistent entering and circulating vehicle speeds. The geometric design includes raised splitter islands, a non-mountable central island, and may include an apron surrounding the non-mountable part of the central island to accommodate long trucks. The smaller inscribed diameter roundabouts shown in Table 1 may not allow for the WB-65<sup>1</sup>. The minimum inscribed diameter to accommodate a WB-65 should be greater than 110 feet. Where long trucks are anticipated, verify that the circulating roadway width and the off tracking can accommodate a WB-65 design vehicle.

#### **Urban Multilane Roundabout**

Urban multilane roundabouts include all roundabouts in urban areas that have at least one approach leg with two or more entry lanes. They include roundabouts with entries on one or more approaches that flare from one to more lanes or the approach is a multilane facility. These require wider circulatory roadways to accommodate more than one vehicle traveling side by side. The speeds at the entry, on the circulatory roadway, and at the exit are similar to those for the urban single-lane roundabouts. Again, it is important that the vehicular speeds be consistent throughout the roundabout. The geometric design includes raised splitter islands, no truck apron, a non-mountable central island, and appropriate horizontal deflection.

Alternate paths are generally provided for bicyclists who choose to bypass the roundabout. Bicycle and pedestrian pathways must be clearly delineated with sidewalk

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<sup>1</sup> 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.

construction and landscaping to direct them to the appropriate crossing locations and alignment. In areas with high pedestrian or bicycle volumes, urban double-lane roundabouts may have special design recommendations such as those provided in [Procedure 11-26-10](#) (Preliminary Design).

### **Rural Single-Lane Roundabout**

Rural single-lane roundabouts generally have high approach speeds in the range of 45 to 55 mph. They require supplementary geometric and traffic control device treatments on approaches to encourage drivers to slow to an appropriate speed before entering the roundabout. Rural roundabouts may have larger diameters than urban roundabouts to allow slightly higher speeds at the entries, on the circulatory roadway, and at the exits. This is permissible if few pedestrians are expected at these intersections, currently and in the future. A truck apron may be required depending on the diameter of the inner circle, the width of the circulating roadway and the off-tracking of long vehicles. The smaller inscribed diameter roundabouts shown in Table 1 may not allow for the WB-65 to make a left turn or U-Turn. The minimum inscribed diameter to accommodate a WB-65 should be greater than 110-feet. Where long trucks are anticipated, verify that the circulating roadway width and off-tracking can accommodate a WB-65. Supplemental geometric design elements include raised splitter islands, a non-mountable central island, and adequate horizontal deflection.

Like their urban counterparts, rural roundabouts that may one day become part of an urbanized area, should be designed as urban roundabouts, with slower speeds and pedestrian treatments. In the interim design them with supplementary approach and entry features to achieve safe speed reduction.

### **Rural Multilane Roundabout**

Rural multilane roundabouts have speed characteristics similar to rural single-lane roundabouts with approach speeds in the range of 45 to 55 mph. They differ in having two or more entry lanes, or entries flared from one or more lanes, on one or more approaches. Consequently, many of the characteristics and design features of rural multi-lane roundabouts mirror those of their urban counterparts. The main design differences are designs with higher entry speeds and larger diameters, and recommended supplementary approach treatments. Design rural roundabouts that may one day become part of an urbanized area for slower speeds, with design details that fully accommodate pedestrians and bicyclists. In the interim design them with approach and entry features to achieve safe speed reduction.

## **Site Requirements**

When a roundabout is being considered as an intersection alternative, the following sections give a list of site requirements to study for the ability to construct a roundabout. Intersection sight distance for a roundabout is typically half what other intersection treatments require.

### **Space Requirements and Capacity Limitations**

The inscribed diameter needed for the roundabout is the most critical space requirement for installation.

The following table gives general inscribed circle diameters and daily service volumes for the different WisDOT categories of roundabouts. For more specific inscribed circle diameter default values to help begin the roundabout analysis process see the section on

“Intersection Evaluation.” Diameters will vary and may fall outside these prescribed ranges in some situations. The diameters in Table 1 are given in meters because the RODEL analysis software requires units in metric. Table 1 also provides a rough estimate of capacity for the WisDOT roundabout categories. Since the actual capacity is based on turning movements and other factors, run the RODEL design software to verify capacity prior to going forward with the roundabout alternative. Adjust the final diameter on the plans to be shown in U.S. Customary units (feet). Refer to the [FHWA Roundabout Guide](#), Exhibit 1-7, for information on additional categories.

More space is typically needed directly at the intersection. However, this may be more than offset by the space saved on approaches and exits compared with the requirements at alternatives like a signalized intersections.

**Table 1. Typical Inscribed Circle Diameters and Daily Service Volumes**

Roundabout Type	Typical Inscribed Circle Diameter <sup>1</sup>	Typical Daily Service Volume <sup>2</sup> (vpd) 4-leg roundabouts
Urban Single-Lane	100 -160 ft <b>(30 – 50 m)</b>	less than 25,000
Urban Multilane (2-lane entry)	150 - 200 ft <b>(45 – 60 m)</b>	25,000 to 55,000
Urban Multilane (3 or 4-lane entry)	180 - 330 ft <b>(55 – 100 m)</b>	55,000 to 80,000
Rural Single-Lane	115 -180 ft <b>(35 – 55 m)</b>	less than 25,000
Rural Multilane (2-lane entry)	180 - 230 ft <b>(55 – 70 m)</b>	25,000 to 55,000
Rural Multilane (3-lane entry)	180 - 330 ft <b>(55 – 100 m)</b>	55,000 to 70,000

<sup>1</sup>The diameters provided are for general guidance.

<sup>2</sup>Capacities vary substantially depending on entering traffic volumes and turning movements (circulating flow).

**Terrain**

Roundabouts typically should be constructed on relatively flat or rolling terrain with a maximum approach grade of 4%. Grades approaching 4% and steeper terrain may require greater transitions to provide an appropriate flat area or plateau for the intersection.

For purposes of this text the roundabout is broken into two main components, the ‘Circulating Roadway’ (diameter) and the ‘Approaches and Departures’ (intersection legs).

Circulating Roadway (diameter):

It is generally desirable from a drive-ability and safety perspective to design and construct the circular component of the roundabout in one plane (planner). An example of this is to imagine a circular plane (dinner plate) that is placed onto the site and swiveled about its center point to optimize the ‘fit’ with exiting topography. This will produce a ‘high point’ and a ‘low point’.

For roundabouts placed on the state trunk highway system, crown the ‘circulating roadway’ with a 2% cross slope with approximately 2/3 sloping toward the central island and 1/3 sloping outward. The crown vertical design feature provides good drivability and

smooth transitions in/out of the approaches and departures. This 'crown' also reduces the probability of truck over turning.

#### Approaches/departures (intersection legs):

The most critical vertical design area of the roundabout is the portion of roadway from the approach end of the splitter island to the circulatory roadway. This area requires special attention by the designer to ensure that the user is able to safely enter and exit the circulatory roadway. This area usually requires pavement warping or cross slope transitions to provide an appropriate superelevation rate through the entire transition area and within the circulatory roadway.

Entry grades (approximately 2 car lengths) are not to exceed 3%, with 2% being the desirable maximum. It is desirable to match the exit grades and the entry grades; however, the exit grade may be steeper but should not exceed 4%. Adjustments to the circulatory roadway cross slope may be required to meet these criteria, but should be balanced with the effects on the circulatory roadway. For a drawing of the preliminary cross section and layout refer to the [FHWA Roundabout Design Guide](#), Chapter 6.

### **Intersection Evaluation**

To evaluate the capacity and level of service of a particular intersection it is important to begin with basic traffic data:

- Existing AM and PM turning volumes
- Design year AM and PM turning volumes (Compare design year flows with the existing flows and check out any anomalies. It is critical that the design year flows do not exceed the capacity of the surrounding network.)
- Design vehicle
- Base plan with defined constraints
- Existing and design year pedestrian and bicycle volumes

Determining the size and space requirements of a roundabout is an iterative process. However, it is appropriate to begin with certain default values for the six geometric parameters described previously that are required to run the RODEL software. See Table 2. Note that the default values for items 7 and 8 are for general information and are not required in the RODEL analysis.

The circulating roadway width is typically 1.0 to 1.2 times the width of the widest entry into the roundabout. If no other initial circulating roadway width is available, use the value(s) listed. The initial exit radii are also listed. The default values are just the first step in the evaluation process. These initial default values are most likely not the final values used in the project.

**Table 2. Default Geometric Parameters<sup>A</sup> for Both Urban & Rural Roundabouts**

Geometric Parameter	Single-Lane Entry	Dual-Lane Entry	Triple-Lane Entry
1 Half width <sup>B</sup>	Travel lane width approaching the roundabout prior to any flared section.		
2 Entry width <sup>B</sup>	Face of curb to face of curb shortest distance at yield point.		
3 Effective Flare length <sup>B</sup>	15-330 ft ( <b>5-100 m</b> ) if needed.		
4 Inscribed diameter <sup>C</sup>	130 ft ( <b>40 m</b> )	160 ft ( <b>50 m</b> )	250 ft ( <b>75 m</b> )
5 Entry Radius	65 ft ( <b>20 m</b> )	80 ft ( <b>25 m</b> )	100 ft ( <b>30 m</b> )
6 Entry angle	30 Degrees		
7 Circulating roadway width	20-25 ft ( <b>6-7 m</b> ) (truck apron may be needed)	30 ft ( <b>10 m</b> ) (truck apron not needed)	45 ft ( <b>14 m</b> ) (truck apron not needed)
8 Exit radius	50-65 ft ( <b>15-20 m</b> )	65-100 ft ( <b>20-30 m</b> )	100-130 ft ( <b>30-40 m</b> )

<sup>A</sup> At this time RODEL works only with metric values.

<sup>B</sup> High influence on capacity. <sup>C</sup> Low influence on capacity.

The delay and LOS values provided by the RODEL software is based on total delay, which is similar to other highway capacity software. However, the delay thresholds used by RODEL to define LOS do not correspond to the Highway Capacity Manual thresholds. The LOS values in RODEL may be modified in the RODEL folder file called LOSDATA using MS Word or Notepad. For similar delay values, RODEL typically assigns a worse LOS. The 50 percent confidence level is the industry standard for software evaluating capacity, delay and queuing. The default confidence level for RODEL is also 50 percent, but the 85<sup>th</sup> percentile confidence level is also tested to verify the sensitivity of the design.

### **Adjacent Intersections and Highway Segments and Coordinated Signal Systems**

A comprehensive traffic analysis is needed to determine if it is appropriate to locate a roundabout within a coordinated signal network. There may be situations where an intersection within the coordinated signal system requires a very long cycle which is caused by high side road traffic or large percentage of turning movements and is dictating operations and reducing the overall efficiency for the coordinated system. Replacing this signalized intersection with a roundabout may allow for the system to be split into two systems thus improving the efficiency of both halves while improving the efficiency of the entire roadway segment.

It is generally undesirable to have a roundabout located near a signalized intersection; however, a corridor analysis may show the roundabout as a good option. Traffic queues that back up into adjacent intersections need to be analyzed further. Prohibit on-street parking approaching a roundabout within 75 feet of the yield point and maybe further depending on site-specific conditions.

### **Entry Lanes and Volume Balance**

A roundabout can typically accommodate the same volume of traffic as a signalized intersection with fewer entry lanes. Roundabouts may perform better than a signal with balanced approach flows. Roundabouts can be designed for a wide range of traffic flow conditions. There is no formula of minimum side road traffic where a roundabout will not

function properly. Generally, if an all-way stop control or a traffic signal will function properly it is reasonable to analyze the intersection to determine if a roundabout will also function properly. Run the RODEL software to determine the number of entry lanes needed and capacity.

### **Approach Alignment**

Roundabouts can accommodate a wide range of approach alignments and skews. However, they work best when the approach alignments intersect the roundabout at roughly 90 degrees. As with most intersection designs, roadway re-alignment work may be necessary to “square-up” the intersection and improve operations and performance.

### **Pedestrian and Bicyclist Accommodations**

Research conducted in Europe indicates fewer pedestrian accidents with less severity occur at roundabout intersections when compared to signalized and unsignalized intersections with comparable volumes. Design principals need to be applied that provide for slow entries and exits for pedestrian safety.

Accommodating non-motorized users is a Department priority. Therefore, give special consideration to sites where

- Pedestrian volumes are high,
- There is a presence of young, elderly, visually impaired or infirm citizens wanting to cross the road, and
- Pedestrians are experiencing particular difficulty in crossing and being delayed excessively.

Also, consider adjoining land use near the roundabout location, such as schools, playgrounds, hospitals, and residential neighborhoods. These sites may warrant additional treatments as presented below. Prior to determining whether bicycles and/or pedestrian concerns will be a factor in the design of the roundabout, the designer is strongly encouraged to contact the District or State Bicycle and Pedestrian Coordinator for their guidance.

#### Pedestrians:

In general, due to relatively low operating speeds of 15 to 20 mph, it appears that pedestrian safety is generally better with a roundabout design than with other intersection types. Below is a list of roundabout advantages and disadvantages as related to pedestrians.

**Table 1 Roundabout Advantages and Disadvantages for Pedestrians**

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>Vehicle speed is reduced as compared to other intersections.</li> </ul>	<ul style="list-style-type: none"> <li>Vehicle traffic is yield controlled so traffic does not necessarily come to a full stop. Therefore, pedestrians may be hesitant to use the cross walk at first.</li> </ul>
<ul style="list-style-type: none"> <li>Pedestrians have fewer conflict points than at other intersections.</li> <li>Pedestrians are responsible for judging their crossing opportunities. This requires more alertness and may be considered an advantage.</li> </ul>	<ul style="list-style-type: none"> <li>May be unsettling to the pedestrian, depending on age, mobility, visual impairments, and ability to judge gaps in traffic.</li> </ul>
<ul style="list-style-type: none"> <li>The splitter island gore allows pedestrians to resolve conflicts with entering and exiting vehicles separately and simplifies the task of crossing the roadway. Crossing is often accomplished with less wait than at signalized intersections.</li> </ul>	<ul style="list-style-type: none"> <li>Pedestrians at first glance may have to adjust to the operation of a roundabout. Part of this adjustment includes the crosswalk location which is behind the first stopped vehicle or approximately 25 feet from the yield point.</li> </ul>

Choosing the appropriate crossing location for pedestrians is a delicate balance between their safety and convenience, and operation of the roundabout. Pedestrians want crossing locations as close to the intersection as possible to minimize out-of-direction travel. The further the crossing is from the roundabout, the more likely that pedestrians will choose a shorter route that may put them in greater danger. Both crossing location and crossing distance are important. Minimize crossing distance to reduce exposure to pedestrian-vehicle conflicts.

In general, locate the pedestrian crossing a minimum of 25 feet upstream from the yield point [2003 MUTCD, Section 3B.24]. This helps to reduce decision-making problems for drivers and to avoid creating a queue of vehicles waiting to enter the roundabout. However, for pedestrian safety the crossing should not be located too far back from the inscribed circle such that entering vehicle speeds are insufficiently reduced or exiting vehicles are accelerating. The pedestrian crossing path is located a minimum of 25 feet prior to the yield point at single or dual lane entries. It may be appropriate to design the pedestrian crossing at two or three car lengths from the yield line at some multi-lane entries. Make the crossing perpendicular to the direction of traffic on multi-lane entrances and exits to minimize pedestrian travel and exposure time. On single-lane roundabouts it may be appropriate to provide a crosswalk straight through the splitter island.

At roundabouts with high traffic volumes, or where pedestrian volumes are high, the pedestrian crossing could be enhanced with features such as standard crosswalk pavement marking, colored concrete with patterned borders 6-inches wide if used and 6-inch white crosswalk marking next to colored concrete [2002 Wisconsin MUTCD Supplement, Section 3E.01 (dotnet)(extranet)], light bollards at entries/exits, or activated (push button or automatic detection) warning signals. In areas with very high pedestrian volumes, consider accommodating both users in the same facility with an overpass or

underpass. Consult with the District and State Traffic Engineer, to ensure that appropriate treatment is applied.

The greatest challenge lies with the continual movement of traffic, and the inability of some pedestrians to judge gaps in an oncoming travel stream. This is especially true of children, the elderly or the disabled. These types of pedestrians generally prefer larger gaps in the traffic stream, and walk at slower speeds than other pedestrians. In recognition of pedestrians with disabilities, pedestrian crossing at roundabouts should be given special consideration, to ensure that all crossings comply with Americans with Disabilities Act (ADA) mandated accessibility standards. See the [FHWA Roundabout Guide](#), Chapter 5, Section 5.3.3 Pedestrians and 2003 MUTCD, Section 3B.17.

#### Bicyclists:

The experience in other countries with bicyclists at roundabouts has been mixed with regard to safety. The Insurance Institute for Highway Safety reports that roundabouts provide a 10 percent reduction in bicycle crashes when 24 signalized intersections were converted to roundabouts in the U.S. Multi-lane entry roundabouts may be more problematic than single lane entries. However, all multi-lane high capacity roundabouts in the U.S. have experienced a good bicycle safety record.

The operation of a bicycle through a roundabout presents challenges to the bicyclist similar to that of traditional signalized intersections especially for turning movements. As with pedestrians, one of the difficulties in accommodating bicyclists is their wide range of skills and comfort levels in mixed traffic. While experienced bicyclists may have no difficulty maneuvering through a roundabout, less experienced bicyclists may have difficulty and discomfort mixing with vehicles, and are more safely accommodated as pedestrians on the adjacent shared use path. The complexity of vehicle interactions within a roundabout could leave a cyclist vulnerable, and for this reason, designated bike lane markings within the circulatory roadway shall not be used [2003 MUTCD, Section 3B.24]. Effective designs that constrain motorized vehicles to speeds more compatible with bicycle speeds, around 15 –20 mph, are much safer for bicyclists.

Design features such as proper entry curvature, and entry width help to slow traffic entering the roundabout. Providing a ramp from the roadway to a shared-use path prior to the intersection allows a bicyclist to exit the roadway and proceed around the intersection safely through the use of cross walks.

Bicyclists are often less visible and therefore more vulnerable when merging into and diverging from multilane roundabouts. Therefore, it is recommended that a wider shared-use pedestrian-bicycle path, separate from the circulatory roadway, be built where bicycle use is expected. While this will likely be more comfortable for the casual cyclist, the experienced commuter cyclist will be significantly slowed down by having to cross as a pedestrian at the cross walk and may choose to continue to traverse a multilane roundabout as a vehicle. Consider providing cyclists with an alternative route along another street or path that avoids the roundabout, which should be considered as part of overall network planning. The provision of alternative routes should not be used to justify compromising the safety of bicycle traffic through the roundabout because experienced bicyclists and those with immediately adjacent destinations will use the roadway.

Try to provide bicyclists the choice of proceeding through the roundabout as either a vehicle or as a pedestrian. In general, bicyclists are better served by being treated by roundabout designers as vehicles. However, when entering traffic volumes are projected to be too large (i.e., greater than 12,000 AADT), look at other options such as shared-use

paths which provide a physical separation from vehicles around the periphery of the roundabout.

The following guidance is intended for shared-use paths at roundabouts.

- Construct a widened sidewalk, or separate shared-use path around the outside of a roundabout to accommodate bicyclists who prefer not to travel through the roundabout.
- Do not provide a bike lane within the circulatory roadway.
- Begin and end the shared-use path approximately 35 to 65 feet upstream of the yield point to allow the bicyclist an opportunity to transition onto the path away from the circulatory roadway itself. More room may be needed when a flared entrance is provided.
- Provide a ramp or other suitable connection between this sidewalk or path and the bike lane, shoulders or road surface on the approaching and departing roadway.
- Make the shared-use path or sidewalk the same width as an attached multi-use path or, when not connected, maintain a minimum of 8 feet. A 6-foot wide path may be acceptable if pedestrian use is very low.

Review the 1999 AASHTO Guide for Development of Bicycle Facilities, page 64, and the Wisconsin Bicycle Facility Design Handbook or consult with the District or State Bicycle and Pedestrian Coordinator for more detail on the design requirements for bicycle and shared-use path design.

Grade Separation (overpasses or underpasses) for bicyclists may be considered for high-capacity roundabouts, with high bicyclist volumes. For information on permanent public trails crossing rural public roads refer to [Procedure 11-55-15](#).

### **Transit, Large Vehicle and Emergency Vehicle Considerations**

#### Transit:

Transit considerations at roundabouts are similar to those for any other intersection configuration. A properly designed roundabout will readily accommodate buses. If possible, locate bus stops downstream of the roundabout and should be far enough away to prevent traffic from backing up into the roundabout. Coordinate bus stop locations with the community. Provide bus pullouts, if possible, to get the buses out of the traffic stream.

#### Large and Oversized Vehicles:

Design roundabouts for the largest vehicles that can routinely be anticipated. On the state trunk highway system the design vehicle is a WB-65. Therefore, the longer vehicle will either have a longer tractor or will have a greater rear overhang that will have minimal, if any, impact on wheel tracking.

Smaller roundabouts are designed with a truck apron to accommodate wheel tracking of larger vehicles. On multilane roundabouts, large vehicles can use the entire width of the circulatory roadway to negotiate through the roundabout. In some cases, roundabouts have been designed with a gated roadway through the center island to accommodate oversized or emergency vehicles.

The Department produces a map showing designated truck routes in Wisconsin. It is located at <http://www.dot.wisconsin.gov/travel/maps/docs/truck-routes.pdf>. In addition, administrative rule TRANS 276 also lists those routes designated for use by trucks. In some special situations there may be other local considerations for long vehicles.

A well-designed roundabout will address load-shifting problems with larger vehicles. Problems such as inadequate entry deflection leading to high entry speeds, long tangents leading into tight curves, sharp turns at exits, excessive cross slopes, and adverse cross slopes have been the principal causes of load shifting. Right turns are also problematic for trucks as they tend to run over sidewalks and splitter islands to make the turn.

#### Emergency Vehicles:

Emergency vehicles passing through a roundabout encounter the same problem as other large vehicles and may require the use of a mountable apron. On emergency response routes, compare the delay for the relevant movements with alternative intersection types and controls.

Roundabouts provide the benefit of lower vehicle speeds which may make them safer for emergency vehicles to negotiate than signalized intersections.

The Wisconsin Motorists Handbook provides information on what to do when the driver encounters an emergency vehicle. The driver must yield the right-of-way for emergency vehicles using a siren, air horn or a red or blue flashing light. The driver in the circulatory roadway, should exit the roundabout before pulling over if possible. Emergency vehicles will typically find the safest and clearest path to get through an intersection. This may include driving the emergency vehicle, with caution and with lights and siren on, in the opposing lane(s) or however the operator sees as the most desirable alternative path.

#### **Social, Environmental, and Economic Considerations**

Public acceptance of roundabouts can be one of the biggest challenges facing a jurisdiction that is planning to install its first roundabout. Without the benefit of explanation or first-hand experience, the public is likely to incorrectly associate roundabouts with older, nonconforming traffic circles that they have either experienced or heard about. Equally likely, without adequate information the public (and agencies alike) will often have a natural resistance to changes in their driving behavior and driving environment.

Public receptivity can be improved by informing the public about the safety and operational benefits of roundabouts.

Impacts on historic and cultural resources need to be considered especially when a roundabout is proposed for an existing urban area. Public participation and coordination with the State Historic Preservation Office is necessary.

Impacts on visual resources can be a serious issue as well. However, the roundabout offers an excellent opportunity for enhancing the visual environment since the interior of the circle can be landscaped to become an attractive local feature. Also the potential adverse visual impact of signal poles is avoided with a roundabout solution. Public support can be encouraged if the local community can see the alternate as a visual enhancement. With regards to noise, energy consumption and air pollution, the modern roundabout offers distinct advantages over other intersection types. Vehicles can create significant air and noise pollution while idling and accelerating through an intersection. On the other hand, vehicles are generally kept moving at lower speeds through a roundabout resulting in less fuel consumption and less air and noise pollution.

#### **Access Management**

Management of access to arterial roads is vital to creating a safe and efficient transportation system for motorists, bicyclists, and pedestrians. Access guidance is provided through the district access coordinator, the Facilities Development Manual

(FDM), [Chapter 7](#) and the WisDOT Traffic Impact Analysis (TIA) Guidelines. Some benefits include:

- Increased capacity along arterial roads,
- Reduction of traffic congestion and delay,
- Improved safety,
- More efficient use of land, and
- Savings on infrastructure investments.

The operational characteristics of roundabouts may offer advantages when compared to existing conventional approaches to access management. For example connecting two roundabout intersections with a raised median precluding lefts in/out of side street or business access to protect main-line capacity is much less detrimental as U-Turns are not problematic at the roundabout. This provides the desired capacity protection and safety along the mainline with much less impacts to business accessibility.

Major commercial driveways may be permitted along the circulating roadway. However, installation of a signal or roundabout strictly for access to private development is discouraged. They may be designed at a public road access point as an intersecting leg of a roundabout. Moreover the roundabouts may reduce the need for additional through-lanes thus narrowing the overall footprint of the roadway system.

Minor commercial and residential driveways are not recommended along the circulating roadway unless designed as a leg of the roundabout. Some situations may dictate the need for a driveway and must be analyzed on a case-by-case basis. Driveways may be located along entrances and exits, but need to be set back to not interfere with pedestrian movements in the crosswalks, and to minimize the number of conflict points with vehicles approaching or exiting the roundabout

The preliminary planning phase for any intersection including roundabouts should include a comprehensive access management plan for the site. Consider the possible need to realign/relocate existing driveways, and include their associated costs in the project's preliminary estimate. Account for pedestrian accessibility and safety during all stages in the development of a comprehensive access management plan.

## **System Considerations**

Roundabouts have been considered as isolated intersections throughout this section. However, roundabouts may need to fit into a network of intersections with the traffic control functions of a roundabout supporting the function of nearby intersections and vice versa.

Because the design of each roundabout generally follows the principles of isolated roundabout design, this guidance is at a conceptual and operational level and generally complements the planning of isolated roundabouts addressed in the rest of this procedure. In many cases, site-specific issues will determine the appropriate roundabout design elements.

### **Roundabouts in an Arterial Network**

In order to understand how roundabouts operate within a roadway system, it is important to understand their fundamental arrival and departure characteristics and how they may interact with other intersections and highway features.

Planned Network, Access Management:

Rather than thinking of roundabouts as an isolated intersection or replacement for signalization, identify likely network improvements early in the planning process. This is consistent with encouraging public and other stakeholder interaction to prepare or update local comprehensive or corridor plans with circulation elements. Project planning and design are likely to be more successful when they are part of a larger local planning process. Then, land-use and transportation relationships can be identified and future decisions related to both.

Roundabouts may be integral elements in village, town, and city circulation plans with multiple objectives of improving circulation, safety, pedestrian and bicycle mobility, and access management. Roundabouts rely on the slowing of vehicles to process traffic efficiently and safely which results in a secondary feature of “calming” traffic. It can be expected that local studies and plans will be a source of requests for roundabout studies, projects, and coordination on state arterials. A potential use of arterial roundabouts is to function as gateways or entries to denser development, such as villages or towns, to indicate to drivers the need to reduce speed for upcoming conflicts including turning movements and pedestrian crossings.

Retrofit of suburban commercial strip development to accomplish access management objectives of minimizing conflicts can be a particularly good application for roundabouts. Raised medians are often designed for state arterials to minimize left turn conflicts; and roundabouts accommodate U-turns, where U-turn at signals in Wisconsin is illegal. Left-turn exits from driveways onto an arterial that may currently experience long delays and require two-stage left-turn movements could be replaced with a simpler right turn, followed by a U-turn at the next roundabout. Again, a package of improvements with driveway consolidation, reverse frontage, and interconnected parking lots, should be planned and designed with close local collaboration. Also, a roundabout can provide easy access to corner properties from all directions.

Platoon Arrivals on Approaches:

Vehicles exiting a signalized intersection tend to be grouped into platoons. Platoons, however, tend to disperse as they move down-stream. Roundabout performance is affected by its proximity to signalized intersections and the resulting distribution of entering traffic. If a signalized intersection is very close to the roundabout, it causes vehicles to arrive at the roundabout in closely spaced platoons. The volume of the arriving platoon and the capacity of the roundabout will dictate the ability of the roundabout to process the platoon. Analyze these situations carefully to achieve a proper design for the situation. Discuss proposed roundabout locations with the District traffic section staff.

Roundabout Departure Pattern:

Traffic leaving a roundabout tends to be more random than for other types of intersection control. Down stream gaps are shorter but more frequent as compared to a signal. The slower approach and departing speeds along with the gaps allow for ingress/egress from nearby driveways or side streets. The slowing effects are diminished as vehicles proceed further down stream. However the gaps created at the roundabout are carried downstream and vehicles tend to disperse again providing opportunities for side street traffic to enter the main line roadway.

Sometimes traffic on a side street can find it difficult to enter a main street at an un-signalized intersection. This happens when traffic platoons from signalized intersections on

either side of it arrive at the side street intersection at or about the same time. If a roundabout replaced one of these signalized intersections, then its traffic platoons would be dispersed and it would be easier for traffic on the side street to enter the main street.

If a roundabout is used in a network of coordinated signalized intersections, then it may be difficult to maintain the closely packed platoons required. If a tightly packed platoon approached a roundabout, it could proceed through the roundabout as long as there was no circulating traffic or traffic upstream from the left. Only one circulating vehicle would result in the platoon breaking down. Hence, this hybrid use of roundabouts in a coordinated signalized network needs to be evaluated carefully.

Another circumstance in which a roundabout may be advantageous is as an alternative to signal control at a critical signalized intersection within a coordinated network. Such intersections are the bottlenecks and usually determine the required cycle length, or are placed at a signal system boundary to operate in isolated actuated mode to minimize their effect on the rest of the surrounding system. If a roundabout can be designed to operate within its capacity, it may allow a lowering of the system cycle length with resultant benefits to delays and queues at other intersections.

### **Closely Spaced Roundabouts**

It is sometimes desirable to consider the operation of two or more roundabouts in close proximity to each other. In these cases, the expected queue length at each roundabout becomes important. Compute the expected queues for each approach to check that sufficient queuing space is provided for vehicles between the roundabouts. If there is insufficient space, then drivers may occasionally queue into the upstream roundabout and may cause it to reduce the desired operations. However, the roundabout pair can be designed to minimize queuing between the roundabouts by limiting the capacity of the inbound approaches.

Closely spaced roundabouts may improve safety and accessibility to business or residential access or side streets by slowing the traffic on the major road. Drivers may be reluctant to accelerate to the expected speed on the arterial if they are also required to slow again for the next close roundabout. This may benefit nearby residents. Additional information including closely spaced offset T-intersections is contained in [FHWA's: \*Roundabouts: An Informational Guide, 2000.\*](#)

### **Roundabout Interchange Ramp Terminals**

Freeway ramp junctions with arterial roads are potential candidates for roundabout intersection treatment. This is especially so if the subject interchange typically has a high proportion of left-turn flows from the off-ramps and to the on-ramps during certain peak periods, combined with limited queue storage space on the bridge crossing, off-ramps, or arterial approaches. In such circumstances, roundabouts operating within their capacity are particularly amenable to solving these problems when compared with other forms of intersection control.

Traffic performance evaluation of the roundabout interchange is the same as for a single conventional roundabout. The maximum entry capacity depends on the circulatory flow and the geometry of the roundabouts. The evaluation process is included in [Procedure 11-26-10.](#)

The benefits and costs associated with this type of interchange also follow those for a single roundabout. Some potential benefits of roundabout interchanges are:

- The queue length on the off-ramps may be less than at a signalized intersection. In almost all cases, if the roundabout would operate below capacity, the performance of the on-ramp is likely to be better than if the interchange is signalized.
- The intersection site distance is much less than what it is for other intersection treatments.
- The headway between vehicles leaving the roundabout along the on-ramp is more random than when signalized intersections are used. This more random ramp traffic allows for smoother merging behavior onto the freeway and a slightly higher performance at the freeway merge area similar to ramp metering.

There are no special design parameters for roundabout interchanges. They are only constrained by the physical space available to the designer and the configuration selected. The raindrop form, which does not allow for full circulation around the center island, can be useful if grades are a design issue since they remove a potential cross-slope constraint on the missing circulatory road segments. If there are more roads intersecting with the interchange than the single cross road, then two independent circular roundabouts are likely to be the best solution.

Refer to the [FHWA Roundabout Guide](#), Chapter 6, all of Sections 6.2 and 6.3. for additional information.

### **Traffic Signals at Roundabouts**

Roundabouts typically are not planned to include metering or signalization.

### **At-Grade Rail Crossings**

Locating any intersection near an at-grade railroad crossing is generally discouraged. However, intersections are sometimes located near railroad-highway at-grade crossings. Contact the railroad and consider allowing the railroad crossing to pass through the circle center or across one of the legs. Additional information on roundabouts in the vicinity of At-Grade rail crossings is contained in [FHWA Roundabout Guide](#), Chapter 8, Section 8.2, FDM Section 17-60 and 2003 MUTCD.

## **Agency and Public Coordination**

### **Public Awareness**

The success or failure of a project can often be attributed to how well the Department included the public in its development. This can be particularly true with introducing the modern roundabout because of confusion with past circular intersections. As mentioned, there are several excellent resources to assist the designer in explaining the concept to the public.

Concept acceptance and project buy-in are best achieved when the local community has been involved from beginning of the project. Take as many opportunities as possible to explain the project. The meetings listed below are good places to start and continue to build project support.

Inform the public of advantages and disadvantages of a proposed roundabout. As with any new concept, the project team can anticipate a certain degree of skepticism about a proposed roundabout. It may be viewed as the traffic circle of the past; at best not seen as an improvement, at worst associated with poor operational characteristics. Early public education is essential to a successful project start up. Several educational tools and media are available to help designers inform the public about roundabouts, and build support for the concept. Information brochures and videos can be very helpful. There is

software available that demonstrates the characteristics of roundabout operations. At times, a local newspaper may be looking for general interest articles; this may be an opportunity to increase public awareness of roundabouts. The WisDOT roundabout web site is another source of current information and frequently asked questions regarding modern roundabouts. The site address is <http://www.dot.wisconsin.gov/safety/motorist/roaddesign/roundabout.htm>

Another important aspect of public information is to familiarize new drivers with how roundabouts operate.

### **Public Meetings**

Public meetings provide an excellent opportunity to bring the public into the design process. Depending on the receptivity of the community, a less formal meeting where information can be exchanged, explained, and discussed can be very useful in developing a project. Holding open houses and public information “exchange” meetings, and attending village and town board meetings or local service organizational meetings are all good formats for education and consensus building.

### **Information Brochures**

Informational brochures are a very useful way to educate the public about roundabouts. Not only can they explain the roundabout concept, its advantages and disadvantages, but they can also be used to compare roundabouts to older circular intersection concepts and traditional intersection types. They can also include graphics or photographic images to assist in demonstrating technical issues to non-technical audiences. Wisconsin has developed the “All About the Roundabout” brochure which is available at no charge from WisDOT Stores. Driver education is also provided in the Wisconsin Motorist’s Handbook published by WisDOT.

### **Internet**

Designers are encouraged to place project site-specific materials on the WisDOT web site. Coordination of this effort must be through the Central Office (IT) Coordinator and the Web Site Content Coordinator. ★