9.1.1 Roundabout Design Criteria

Each roundabout should be designed to meet field conditions. Figure 9.7-B provides general design guidance for roundabouts. For the latest design guidance on roundabouts, review the information provided in NCHRP Report 672, *Roundabouts: An Informational Guide – Second Edition* and guidance found on the FHWA's roundabout website. The traffic designer will determine if a single or multilane roundabout is required.

Design Element	Single-Lane Roundabout	Multilane Roundabout
Desirable maximum entry design speed	20 to 25 mph	25 to 30 mph
Maximum number of entering lanes per approach	1	2+
Typical inscribed circle diameter	105 to 150 ft	150 to 300 ft
Central island treatment	Raised (may have traversable apron)	Raised (may have traversable apron)

* *Operational analysis needed to verify upper limit for specific applications or for roundabouts with more than two lanes or four legs.*

GENERAL ROUNDABOUT CRITERIA
Figure 9.7-A

The following are several design issues that should be addressed in the design of the roundabout:

1. Volumes. In general, roundabout traffic analysis will not be required if the total entering volume for a four-leg roundabout is less than 10,000 vehicles per day for single lane roundabouts and 20,000 vehicles per day for two-lane roundabouts. For three-leg roundabouts, use 75% of above volumes. Volumes above these amounts do not automatically warrant increasing the size of the roundabout.

   A traffic analysis will be required for any proposed roundabout; particularly if:

   - number of entry lanes is not the same for all legs;
   - volumes on the legs aren't balanced;
   - there is a high percentage of left-turn movements (over 30 percent);
   - there is a high volume of pedestrians; or
   - there are other geometric considerations that warrant additional analysis (e.g., nearby driveways or intersections).

If a traffic analysis is required, assume the roundabout and each approach leg of the roundabout to operate at no more than 85 percent of capacity (0.85 maximum degree of saturation). Figure 9.7-C provides volume guidance for single and multilane roundabouts.

Volume Range (Sum of Entering and Conflicting Volumes)	Number of Lanes Required
0 to 1000 veh/h	• Single-lane entry likely to be sufficient
1000 to 1300 veh/h	• Two-lane entry may be needed • Single-lane may be sufficient based upon more detailed analysis
1300 to 1800 veh/h	• Two-lane entry likely to be sufficient
Above 1800 veh/h	• More than two entering lanes may be required • A more detailed traffic analysis should be conducted to verify lane numbers and arrangements

VOLUME GUIDELINES FOR DETERMINING ROUNDABOUT LANES
Figure 9.7-B

2. Inscribed Circle Diameter. The inscribed circle diameter is the distance across the circle inscribed by the outer curb (or edge) of the circulatory roadway. It is the sum of the central island diameter and twice the circulatory roadway width. The inscribed circle diameter is determined by a number of design objectives, including accommodation of the design vehicle and providing speed control.

   At single-lane roundabouts, the size of the inscribed circle is largely dependent upon the turning requirements of the design vehicle. The inscribed circle diameter typically needs to be at least 105 feet to accommodate a WB-62 design vehicle. Smaller roundabouts can be used for some local street or collector street intersections, where the design vehicle is an S-BUS-40. For locations that must accommodate a WB-67 design vehicle, a larger inscribed circle diameter will be required, typically in the range of 130 feet to 150 feet. In situations with more than four legs, larger inscribed circle diameters may be appropriate. Truck aprons are typically needed to keep the inscribed circle diameter reasonable while accommodating the larger design vehicles.

   At multilane roundabouts, the size of the roundabout is usually determined by balancing the need to achieve deflection with providing adequate alignment of the natural vehicle paths. Generally, the inscribed circle diameter of a multilane roundabout ranges from 150 feet to 250 feet. For two-lane roundabouts, a common starting point is 160 feet to 180 feet. Roundabouts with three- and four-lane entries may require larger diameters of 180 feet to 330 feet to achieve adequate speed control and alignment. Truck aprons are typically needed to keep the inscribed circle diameter reasonable while accommodating the larger design vehicles.

3. Speeds. The operating speed of a roundabout is widely recognized as one of its most important attributes in terms of safety performance; therefore, the designer should give

careful attention to the design speed of a roundabout. Maximum entering design speeds of 20 to 25 miles per hour are recommended for single-lane roundabouts and 25 to 30 miles per hour for multilane roundabouts. These speeds are influenced by a variety of factors, including the geometry of the roundabout and the operating speeds of the approaching roadways. When developing fastest path speeds, the maximum speed differential shall be 15 mph.

4. Lane Balance and Continuity. As discussed in Item 1 "Volumes," the designer should conduct an operational analysis to determine the required number of entry lanes serving each approach to the roundabout. For multilane roundabouts, ensure the design provides the appropriate number of lanes within the circulatory roadway and on each exit.

   The allowed movements assigned to each entering lane affect the overall design. Basic pavement marking layouts are integral to the preliminary design process to ensure that lane continuity is provided. In some cases, the geometry within the roundabout may be dictated by the number of lanes required. Lane assignments should be clearly identified on all preliminary designs in an effort to retain the lane configuration information through the various design iterations.

   In some cases, a roundabout designed to accommodate design year traffic volumes can result in substantially more entering, exiting and circulating lanes than needed in the earlier years of operation. To maximize the potential safety during those early years of operation, the designer may wish to consider a phased design solution that initially uses fewer entering and circulating lanes.

5. Lane Widths. The required width of the circulatory roadway is determined from the number of entering lanes and the turning requirements of the design vehicle. The circulating width should be at least as wide as the maximum entry width and up to 120 percent of the maximum entry width. Typical circulatory roadway widths range from 14 feet to 18 feet for single-lane roundabouts. The designer should avoid making the circulatory roadway width too wide within a single-lane roundabout because drivers may think that two vehicles are allowed to circulate side-by-side.

   At single-lane roundabouts, the circulatory roadway width should be comfortable for passenger car vehicles and should be wide enough to accommodate a design vehicle up to an S-BUS-40 at a small roundabout. A truck apron will often need to be provided within the central island to accommodate larger design vehicles (including the WB-62), but maintain a relatively narrow circulatory roadway to adequately constrain vehicle speeds. Usually, the left-turn movement is the critical path for determining circulatory roadway width. A minimum clearance of 1 foot and preferably 2 feet should be provided between the outside edge of the vehicle's tire track and the curb line.

   If the entering traffic for multilane roundabouts is predominantly passenger cars and buses (P and S-BUS-40) and where semi-tractor traffic is infrequent (less than/equal to 10 percent), it may be appropriate to design the width for two P vehicles or a P and S-BUS-40 side by side. If the semi-tractor trailer traffic is frequent, it may be necessary to provide sufficient width for the simultaneous passage of a WB-62 in combination with a P or S-BUS-40 vehicle.

Multilane circulatory roadway lane widths typically range from 14 feet to 16 feet. Use of these values results in a total circulating width of 28 feet to 32 feet for a two-lane circulatory roadway and 42 feet to 48 feet total width for a three-lane circulatory roadway.

6. Alignment of Approaches. The alignment of the approach legs plays an important role in the design of a roundabout. The alignment affects the amount of deflection (speed control) that is achieved, ability to accommodate the design vehicle and visibility angles to adjacent legs. The optimal alignment is generally governed by the size and position of the roundabout relative to its approaches. Figure 9.7-D provides the advantages and tradeoffs for each alignment approach.

The alignment does not have to pass through the center of the roundabout; however, it has a primary effect on the entry/exit design. The optional alignment allows for an entry design that provides adequate deflection and speed control while also providing appropriate view angles to drivers and balancing property impacts/costs.

A roundabout may be designed so that the centerline of each leg passes through the center of the inscribed circle. This location typically allows the geometry of a single-lane roundabout to be adequately designed such that vehicles will maintain slow speeds through both the entries and the exits. The radial alignment also makes the central island more conspicuous to approaching drivers and minimizes roadway modification required upstream of the intersection.

A roundabout may also be designed to offset the centerline of the approach to the left. This alignment will typically increase the deflection achieved at the entry to improve speed control. However, the designer should recognize the inherent tradeoff of a larger radius exit that may provide less speed control for the downstream pedestrian crossing. Especially in urban environments, it is important to have drivers maintain sufficiently low vehicular speeds at the pedestrian crossing to reduce the risk for pedestrians.

		Advantages	**Trade-Offs**
	Alternative 1: Offset Alignment to the Left of Center	• Allows for increased deflection • Beneficial for accommodating large trucks with small inscribed circle diameter — allows for larger entry radius while maintaining deflection and speed control • May reduce impacts to right side of roadway	• Increased exit radius or tangential exit reduces control of exit speeds and acceleration through crosswalk area • May create greater impacts to the left side of the roadway
	Alternative 2: Alignment Through Center of Roundabout	• Reduces amount of alignment changes along the approach roadway to keep impacts more localized to intersection • Allows for some exit curvature to encourage drivers to maintain slower	• Increased exit radius reduces control of exit speeds/ acceleration through crosswalk area • May require a slightly larger inscribed circle diameter (compared to offset-left design) to

		speeds through the exit	provide the same level of speed control
	Alternative 3: Alignment to Right of Center	• Can be used for large inscribed circle diameter roundabouts where speed control objectives can still be met • Although not commonly used, this strategy may be appropriate in some instances (provided that speed objectives are met) to minimize impacts, improve view angles, etc.	• Often more difficult to achieve speed control objectives, particularly at small diameter roundabouts • Increases the amount of exit curvature that must be negotiated

ENTRY ALIGNMENT
Figure 9.7-C

Approach alignments that are offset to the right of the roundabout's center point typically do not achieve satisfactory results, primarily due to a lack of deflection and lack of speed control that result from this alignment. An offset-right alignment brings the approach in at a more tangential angle and reduces the opportunity to provide sufficient entry curvature. Vehicles will usually be able to enter the roundabout too fast, resulting in more loss-of-control crashes and higher crash rates between entering and circulating vehicles. However, an offset-right alignment alone should not be considered a fatal flaw in a design if speed requirements and other design considerations can be met.

7. Traffic Control. Vehicles entering the roundabout must yield to the traffic within the circle. A YIELD sign is required at the entry along with the appropriate pavement markings. Proper regulatory control, advance warning and directional guidance are required to avoid driver expectancy related problems. Signs should be located where they have the maximum visibility for road users, but a minimal likelihood of even momentarily obscuring pedestrians and bicyclists. Review the roundabout signing and pavement makings criteria in NCHRP Report 672, *Roundabouts: An Informational Guide – Second Edition* and the *MUTCD.* Contact traffic designer for guidance.

8. Splitter Islands. Splitter Islands are designed to separate entering and exiting traffic. A properly designed splitter island also deflects traffic and positions vehicles into a correct alignment to enter the circulatory roadway. This deflection is critical to slowing vehicles before they enter the circulatory roadway. Splitter islands also can be used for pedestrian refuges. Splitter Islands shall be 100 feet in length for approach design speeds of less than 45 mph and 200 feet for design speeds 45 mph or greater.

9. Central Island. The central island of a roundabout is the raised, mainly non-traversable area surrounded by the circulatory roadway. It may also include a traversable truck apron. The island is typically landscaped for aesthetic reasons and to enhance driver recognition of the roundabout upon approach. A circular central island is preferred because the constant-radius circulatory roadway helps promote constant speeds around the central island. The landscaping of the inner central island shall consist of Pink Muhly

with mulch and the outer central island shall be Weeping Love Grass. The location of the inner and outer transition is based on sight distance.

10. Curb. When installing a roundabout, including those on an open rural highway, provide concrete curbs at the on the outer edge of the roundabout and on the approaches. The curb should extend out on each leg (entrance and exit) to 100 feet for approach design speeds of less than 45 mph and 200 feet for design speeds 45 mph or greater.

11. Pedestrians. In urban areas, the designer should anticipate the needs of pedestrians. Pedestrians should not be allowed to enter the central island, but should be directed around the outside of the roundabouts. Locate the crossings on the approaches to the roundabout and set the crossings back from the yield line a minimum of 20 feet. Whenever a raised splitter island is provided, there should also be an at-grade pedestrian refuge. In this case, the crosswalk facilitates two separate moves — curb-to-island and island-to-curb. The exit crossing will typically require more vigilance from the pedestrian and motorist than the entry crossing. It is recommended that all crosswalks be marked.

    Provide special attention to assist pedestrian users who are visually impaired or blind. For example, these users typically attempt to maintain their approach alignment to continue across a street in the crosswalk, because the crosswalk is often a direct extension of the sidewalk. A roundabout requires deviation from that alignment, and attention needs to be given to providing appropriate informational cues to pedestrians regarding the location of the sidewalk and the crosswalk. For example, appropriate landscaping is one method of providing some information. Another is to align the crosswalk ramps perpendicular to the pedestrian's line of travel through the pedestrian refuge.

    Special consideration should also be given concerning pedestrian access at multilane roundabouts. Coordinate with the traffic designer on the use of pedestrian signals, crossing restrictions, and redirection to adjacent facilities or crossings.

12. Entry Design. The entry is bounded by a curb consisting of one or more curves leading into the circulatory roadway. It should not be confused with the entry path curve, defined by the fastest vehicular travel path through the entry geometry. At single-lane roundabouts, a single entry curb radius is typically adequate; for approaches on higher speed roadways, the use of compound curves may improve guidance by lengthening the entry arc.

    The entry curb radius is an important factor in determining the operation of a roundabout because it affects both capacity and safety. The entry curb radius, in conjunction with the entry width, the circulatory roadway width, and the central island geometry, controls the amount of deflection imposed on a vehicle's entry path. Excessively large entry curb radii have a higher potential to produce faster entry speeds than desired. Entry widths should match the circulatory roadway width.

    If the distance face of curb of the corner radii to the outside of the circulatory roadway is greater than four feet an outside truck apron is required to avoid the appearance of an additional lane.

13. Exit Design. The exit curb radii are usually larger than the entry curb radii in order to minimize the likelihood of congestion and crashes at the exits. This, however, is balanced by the need to maintain slow speeds through the pedestrian crossing on exit. The exit design is also influenced by the design environment (urban versus rural), pedestrian demand, the design vehicle, and physical constraints.

14. Bicyclists. A bicycle path that is separate and distinct from the circulatory roadway is preferred (e.g., a shared bicycle-pedestrian path of sufficient width and appropriately marked to accommodate both types of users around the perimeter of the roundabout).

15. Trucks. Roundabouts should always be designed for the largest vehicle that can be reasonably anticipated (the design vehicle). For single-lane roundabouts, this may require the use of a mountable truck apron around the perimeter of the central island to provide the additional width needed for the off-tracking of the trailer wheels. At multi-lane roundabouts, large vehicles may track across the whole width of the circulatory roadway to negotiate the roundabout. Truck aprons shall be concrete and "Brick Red" in color and shall not be stamped. The truck apron concrete pavement design shall be submitted for approval by the contractor.

16. Illumination. Lighting of roundabouts serves two main purposes:

    - it provides visibility from a distance for users approaching the roundabout; and
    - it provides visibility of the key conflict areas to improve users' perception of the layout and visibility of other users within the roundabout.

    Illumination shall be evaluated for all roundabouts, including those in rural environments. If the department determines lighting is not warranted, additional delineation for the entry islands and splitter islands should be provided so that they can be correctly perceived by day and night.

    In areas where only the roundabout is illuminated (no lighting is provided on the approach roadways), the scope of illumination needs to be carefully considered. Any raised channelization or curbing should be illuminated. A gradual illumination transition zone should be provided beyond the final trajectory changes at each exit. Review the illumination criteria in NCHRP Report 672, *Roundabouts: An Informational Guide – Second Edition* and contact the traffic designer for guidance.

17. Transit. Transit considerations at a roundabout are similar to those at a conventional intersection. If the roundabout has been designed using the appropriate design vehicle, a bus should have no physical difficulty negotiating the intersection. To minimize passenger discomfort, if the roundabout is on a bus route, it is preferable that scheduled buses are not required to use a truck apron if present. Locate bus stops to minimize the probability of vehicle queues spilling back into the circulatory roadway. This typically means that bus stops located on the far side of the intersection need to have pullouts or be further downstream than the splitter island.

18. Rail Crossings. Rail crossings through or near a roundabout may involve many of the same design challenges as at other intersections and should be avoided if better alternatives exist. In retrofit, the rail track may be designed to pass through the central island, or across one of the legs. Queues spilling back from a rail blockage into the

roundabout can fill the circulatory roadway and temporarily prevent movement on any approach.

19. Signing. All signing placed in the splitter island and central island shall be breakaway.