PDHonline Course C711 (6 PDH)

Modern Roundabout Design

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Gregory J. Taylor, P.E.

Introduction

This course is a summary of the geometric design process for modern roundabouts. Its contents are intended to serve as guidance and not as an absolute standard or rule.

Upon course completion, you should be familiar with the general design guidelines for modern roundabouts. The course objective is to give engineers and designers an in-depth look at the principles to be considered when selecting and designing roundabouts.

For this course, Chapter 6 of the ***FHWA Roundabout Guide (NCHRP Report 672 – Roundabouts: An Informational Guide, 2nd Edition)*** will be used primarily for the fundamental design principles of modern roundabouts. This document is intended to explain some principles of good design and show the potential trade-offs that the designer may have to face in a variety of situations.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf

Further guidelines specifically for multi-lane roundabouts are provided in the latter part of Chapter 6. This type of design is significantly more challenging and many of the techniques used in one-lane entry roundabout design do not directly transfer to multi-lane design. Therefore, it is important that engineers and designers become very familiar with Chapter 6 in the ***FHWA Roundabout Guide***.

Course topics covered will include:

- FHWA General Design Process
- Principles and Objectives
  - Speed Management; Lane Arrangements; Appropriate Path Alignment; Design Vehicle; Non-motorized Design Users; Pedestrian Design Considerations; Bicycle Design Considerations; Sight Distances and Visibility
- Size, Position, and Alignment of Approaches
  - Inscribed Circle Diameter; Alignment of Approaches; Angle between Approach Legs
- Single-lane Roundabouts
  - Splitter Islands; Entry Width; Circulatory Roadway Width; Central Island; Entry Width; Exit Design; Design Vehicles
- Multilane Roundabouts
  - Entry Width; Circulatory Roadway Width; Entry Geometry and Approach Alignment; Splitter Islands; Exit Curves
- Mini-Roundabouts
- Performance Checks
  - Fastest Path; Sight Distance; Angles of Visibility
- Closely Spaced Roundabouts
- Signs
  - Regulatory; Warning; Guide
- Pavement Markings
  - Approach & Departure; Circulatory Roadway

History

Traffic circles or rotary intersections have been part of the U.S. transportation system since the early 1900's. Typical rotaries have large diameters (sometimes greater than 300 feet) which allow circulatory roadway travel speeds in excess of 30 mph. These circular intersections may have very little horizontal deflection for through traffic or require circulating traffic to yield to entering vehicles ("yield-to-the-right" rule).

Traffic circles are normally constructed at street intersections for traffic calming or aesthetic purposes. With intersection diameters between 50 to 100 feet, approaches to the traffic circle may be uncontrolled, yield-controlled, or stop-controlled without any raised channelization. Traffic signals are also used at traffic circles to control entry-circulating points as opposed to the roundabout's yield controls.

The main design concepts allowed high-speed merging and weaving of traffic with priority given to entering vehicles. In the mid-1950s, the popularity of old-style circular intersections waned in the U.S. due to high crash rates and congestion from increasing traffic volumes.

What is a Modern Roundabout?

The "modern roundabout" was a British solution to the problems associated with rotary intersections. The resulting design is a one-way, circular intersection with traffic flow around a central island. The U.K. adopted a mandatory "give-way" rule for entering traffic at all circular intersections to yield to circulating traffic. This rule greatly reduced the number and severity of vehicle crashes.

Basic Principles for Modern Roundabouts

1) **Yield control at all entry points** – All approaching traffic is required to yield to vehicles on the roundabout's circulatory roadway before entering the circle. Yield signs are used primarily as entry control. Weaving maneuvers are not considered a design or capacity factor.

2) **Traffic deflection** – Entering vehicles are directed to the right (in the U.S.) by channelization or splitter islands onto the roundabout's circulating roadway avoiding the central island. No entrance traffic is permitted to travel a straight route through the roundabout.

3) **Geometric curvature** – Entry design and the radius of the roundabout's circulating roadway can be designed to slow the speeds for entering and circulating traffic.

Exhibit 2-5

Summary of Roundabout Advantages and Disadvantages

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Advantages	Disadvantages
Non-Motorized Users	
• Pedestrians must consider only one direction of conflicting traffic at a time. • Bicyclists have options for negotiating roundabouts, depending on their skill and comfort level.	• Pedestrians with vision impairments may have trouble finding crosswalks and determining when/if vehicles have yielded at crosswalks. • Bicycle ramps at roundabouts have the potential to be confused with pedestrian ramps.
Safety	
• Reduce crash severity for all users, allow safer merges into circulating traffic, and provide more time for all users to detect and correct for their mistakes or the mistakes of others due to lower vehicle speeds. • Fewer overall conflict points and no left-turn conflicts.	• Increase in single-vehicle and fixed-object crashes compared to other intersection treatments. • Multilane roundabouts present more difficulties for individuals with blindness or low vision due to challenges in detecting gaps and determining that vehicles have yielded at crosswalks.
Operations	
• May have lower delays and queues than other forms of intersection control. • Can reduce lane requirements between intersections, including bridges between interchange ramp terminals. • Creates possibility for adjacent signals to operate with more efficient cycle lengths where the roundabout replaces a signal that is setting the controlling cycle length.	• Equal priority for all approaches can reduce the progression for high volume approaches. • Cannot provide explicit priority to specific users (e.g., trains, emergency vehicles, transit, pedestrians) unless supplemental traffic control devices are provided.

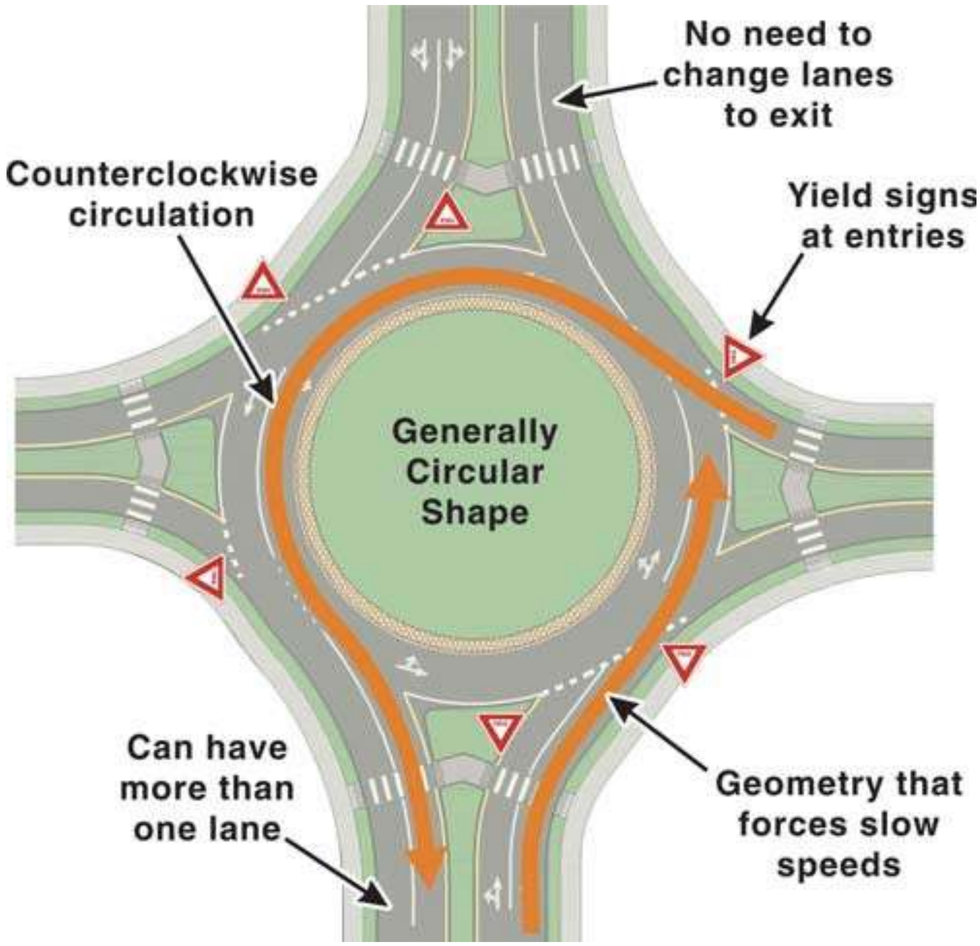
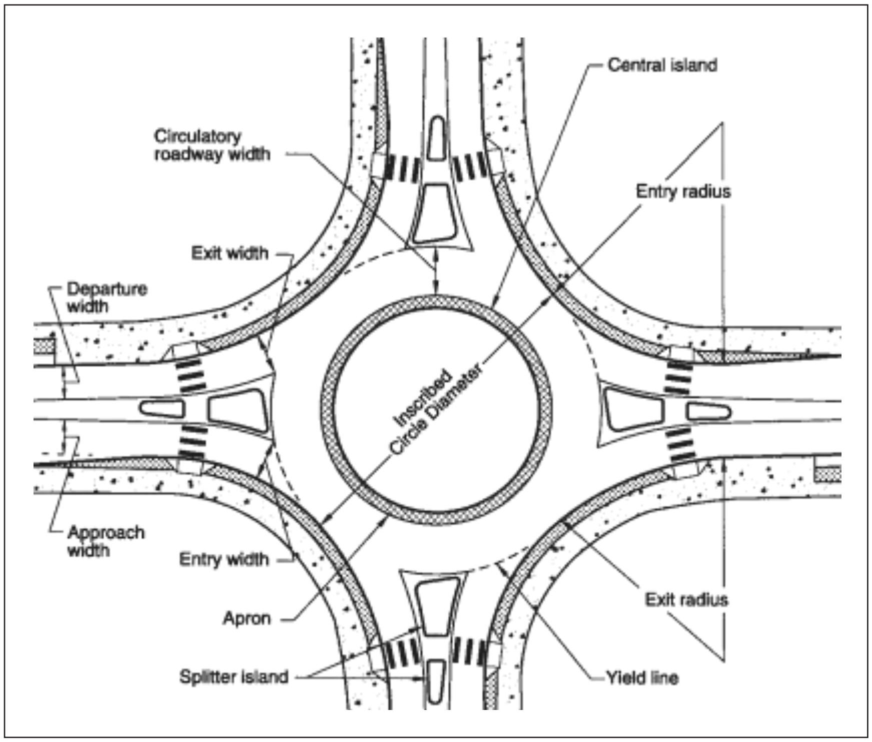


Exhibit 1-1
Key Roundabout Characteristics
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Roundabout geometric design is a combination of balancing operational and capacity performances with the safety enhancements. Roundabouts operate best when approaching vehicles enter and circulate at slow speeds. By using low-speed design elements (horizontal curvature and narrow pavement widths for slower speeds) the capacity of the roundabout may be negatively affected. Many of the geometric criteria used in design of roundabouts are also governed by the accommodation of over-sized vehicles expected to travel through the intersection.

Exhibit 6-1. Basic Geometric Elements of a Roundabout.
(FHWA. Roundabouts: An Informational Guide. 2000)



Roundabout Geometric Elements

Central Island
Raised area (not necessarily circular) in the center of the roundabout which is bordered by circulating traffic.

Splitter Island
Raised or painted approach area for delineating, deflecting and slowing traffic. It also permits non-motorist crossings.

Circulatory Roadway
Curved vehicle path for counterclockwise travel around the central island.

Apron
Optional mountable part of the central island for accommodating larger vehicle wheel tracking.

Yield Line
Pavement marking for entry point to the circulatory roadway. Entry vehicles must yield to circulating traffic before crossing the yield line onto the circulatory path.

Accessible Pedestrian Crossings
Non-motorist access that is setback from the entrance line and cut through the splitter island.

Landscape Strip
Optional areas for separating vehicle/non-motorist traffic, designating crossing locations, and providing aesthetic improvements.

Roundabout design is a creative process that is specific for each individual intersection. No standard template or "cookie-cutter" method exists for all locations. Geometric designs can range from easy (mini-roundabouts) to moderate (single lane roundabouts) to very complex (multi-lane roundabouts). How the intersection functions as a single traffic control unit is more important than the actual values of the individual design components. It is crucial that these individual geometric parts interact with each other within acceptable ranges in order to succeed.

Safety

The safety performance of roundabouts has been proven to be better than other types of at-grade intersections. The ability of its geometric design to control vehicle speed at all times helps to provide the following safety benefits:

More time for entering vehicles
Increased yielding
Less frequent and severe crashes
Reduced sight triangles
More time for all users
Safer area for novice users

Crash frequencies are directly related to the quantity of conflict points at any intersection. Exhibit 5-2 compares the number of vehicle conflict points for a typical four-leg intersection (32 conflicts) versus a single-lane roundabout (8 conflicts).

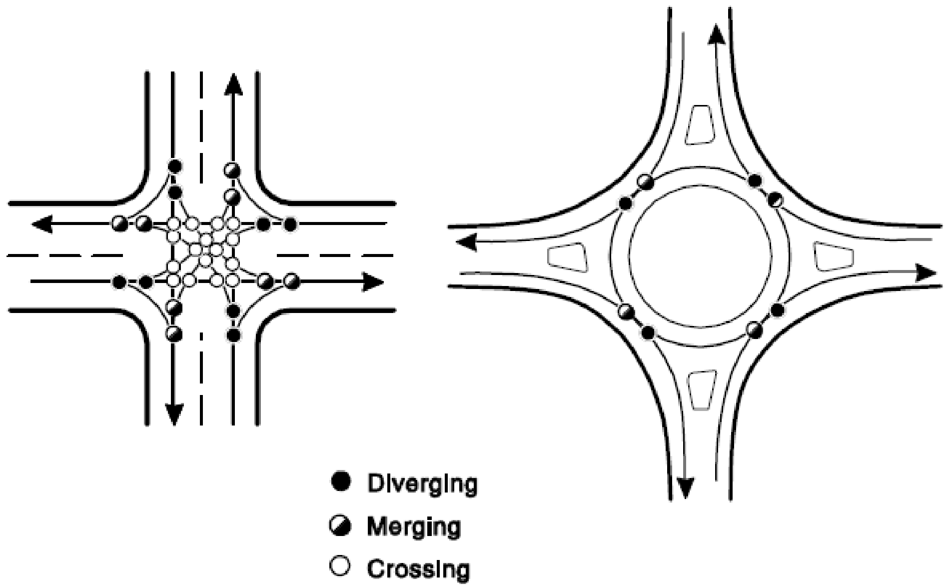


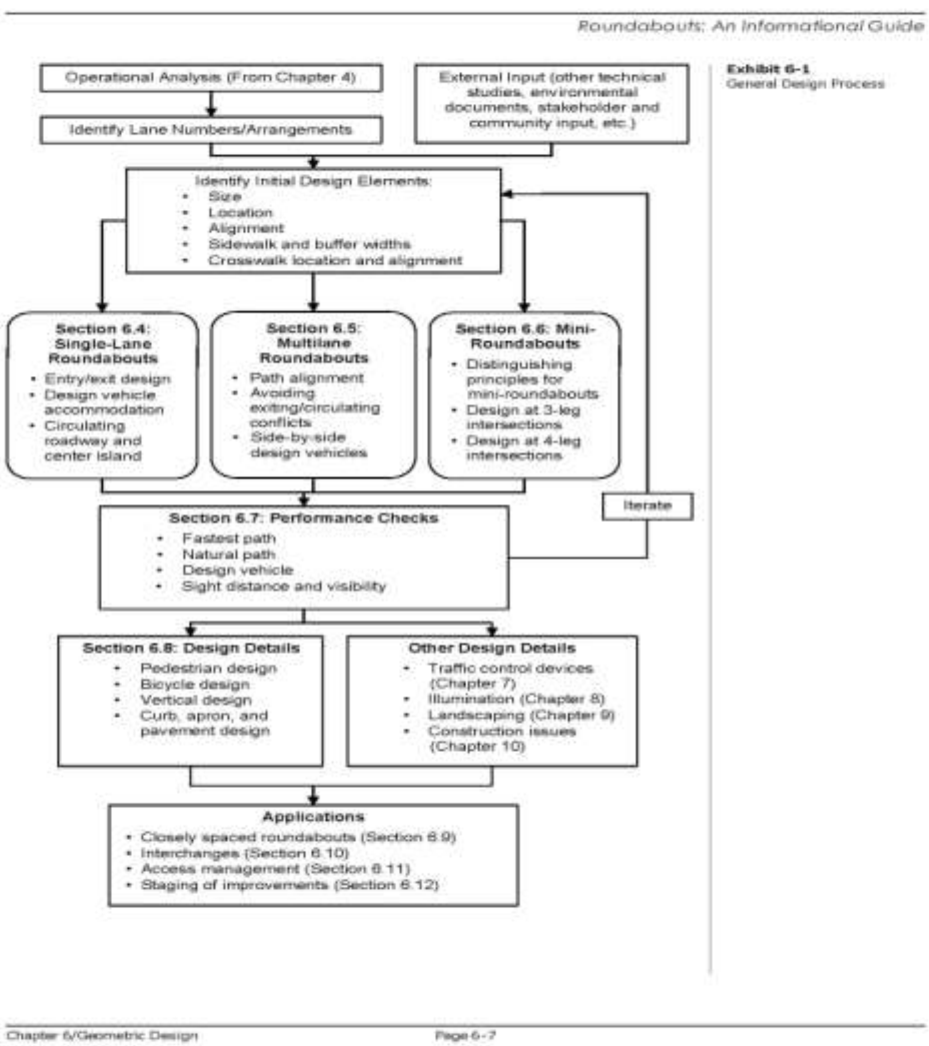
Exhibit 5-2
Vehicle Conflict Point Comparison for Intersections with Single-Lane Approaches
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Vehicle Conflict	Four-Leg	Roundabout
Diverging (conflicts from separating 2 traffic streams – right turns, exits, etc.)	8	4
Merging (conflicts caused by joining 2 traffic streams – side swipes, rear ends, etc.)	8	4
Crossing (conflicts where 2 traffic streams intersect – right angle, head-on, etc.)	16	0
TOTAL	**32**	**8**

Exhibit 5-2 shows the vast decrease in the number of vehicle conflict points by using a roundabout. Vehicle crossing conflicts are eliminated using this design. The single-lane roundabout's ability for reducing conflicts with geometric features has proven to be more effective than driver obedience at typical intersections.

FHWA General Design Process

Exhibit 6-1 of NCHRP Report 672 (Roundabouts: An Informational Guide) shows a possible outline of the roundabout design process, involving planning and design elements into an iterative process. Operational analysis data should be used to determine the required sizing and many other design considerations.



The key is to conduct an adequate number of runs to check the optimum size, location, and approach alignments to determine if any adjustments are necessary. Additional features can then be tailored to the basic design after more detailed analysis.

The use of another design method or results with atypical values do not automatically create an unacceptable roundabout design since there is no standard design template for this process.

Principles and Objectives

Speed Management

The design speed of vehicles is a critical factor for roundabout design. Speed management is often a combination of managing speeds at the roundabout plus the approaching legs. Forecasting these vehicular speeds when traveling through a proposed roundabout is fundamental for attaining good safety performance.

Maximum entering design speeds of 20 to 25 mph are recommended for single-lane roundabouts. For multi-lane roundabouts, these maximum entering design speed increase to 25 to 30 mph (based on the theoretical fastest path). Exhibit 6-4 shows the recommended design speeds for different types of roundabouts.

Exhibit 6-4. Recommended maximum entry design speeds. (FHWA. Roundabouts: An Informational Guide. 2000)

Site Category	Recommended Maximum Entry Design Speed
Mini-Roundabout	25 km/h (15 mph)
Urban Compact	25 km/h (15 mph)
Urban Single Lane	35 km/h (20 mph)
Urban Double Lane	40 km/h (25 mph)
Rural Single Lane	40 km/h (25 mph)
Rural Double Lane	50 km/h (30 mph)

Another important objective is to produce consistent speeds for all roundabout movements which along with overall speed reduction can help to minimize the crash rate between conflicting traffic. For any design, it is desirable to minimize the relative speeds between consecutive geometric elements and conflicting traffic streams.

Lane Arrangements

The entry movements assigned to each lane within a roundabout are critical to its overall design. An operational analysis can help determine the required number of entry lanes for each approach. Pavement marking may also be used in the preliminary phase to ensure lane continuity through the various design iterations.

Roundabouts are typically designed to accommodate design year traffic volumes (normally projected 20 years in the future). This design may produce more entering, exiting, and circulating lanes than needed at the start of operation. It may be necessary to use a phased design that initially uses fewer entering and circulating lanes while maximizing potential safety. In order for lane expansion at a later phase, an optimal roundabout configuration (including horizontal and vertical design) needs to be considered as early as possible in the initial design. Lanes may then be removed from the optimal roundabout design to provide the necessary initial capacity. This phased method ensures that adequate right-of-way is acquired and any revisions to the original roundabout are minimized.

Appropriate Path Alignment

The fastest speed path is a basic principle in the geometric design of roundabouts. This path is the fastest and smoothest path possible for a single vehicle to travel through the entry, around the central island, and out the exit of a roundabout. Its purpose is to restrict operating speed by deflecting the paths of entering and circulating vehicles. Typically, the through movement will be the **critical fastest path**. However, in some cases it may be a right turn movement.

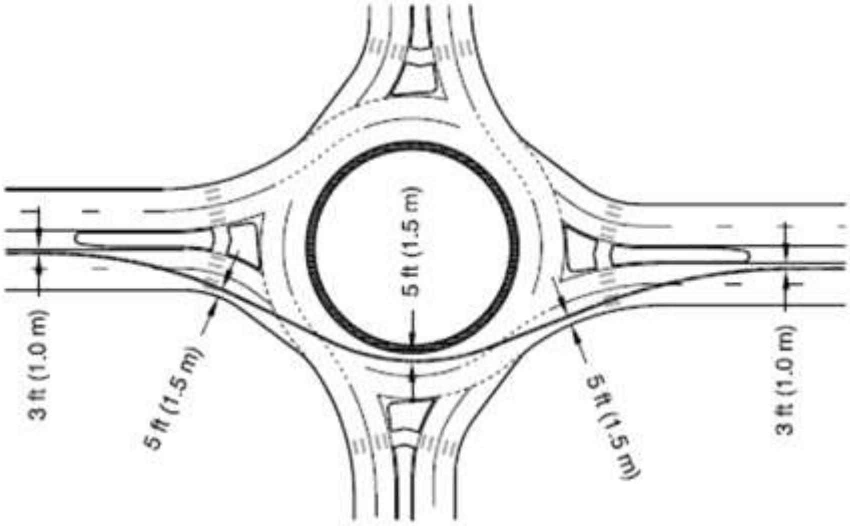


Figure 7: Fastest Vehicle Path Through a Single-Lane Roundabout (FHWA. Roundabouts: Technical Summary. 2010)

A good entry and exit design permits appropriate lane alignment throughout the roundabout. Engineers may improve the operations and safety of a roundabout design by analyzing the traffic path alignments. Approaching traffic will be channelized by lane markings to the roundabout's entry and then continue onto the circulatory roadway. Natural path interference or overlap reduces the safety and efficiency of the roundabout. Exit geometry also affects the natural travel path and possible vehicle overlap.

Design Vehicle

A primary factor in determining the design of a roundabout is the choice of the largest vehicle (design vehicle) that will use the facility. Turning path requirements will have a direct effect on many of the dimensions of the roundabout (inscribed circle diameter, approach re-alignment, etc.).

Appropriate design vehicle consideration is dependent on the following criteria:

- ❖ Roadway classification
- ❖ Input from local authorities
- ❖ Surrounding environmental characteristics

For rural areas, agricultural machinery may determine design vehicle requirements while emergency, mass transit and delivery vehicles should be considered in urban environments. Local emergency agencies need to be involved in any plans for designing a roundabout in their area.

The AASHTO Green Book recommends using the following guidelines when choosing a design vehicle:

Design Vehicle	**Location**
Passenger Car (P)	parking lots or series of parking lots
Single-unit Truck (SU)	residential streets and park roads
City Transit Bus (CITY-BUS)	highway intersections with city streets designated bus routes
Large or Conventional School Bus (S-BUS36 or 40)	highway intersections with local roads under 400 ADT
Interstate Semitrailer (WB-65 or 67)	freeway ramps with arterial crossroads or high volume traffic roadways

For most cases, the *Intermediate Semi-trailer (WB-50)* is the largest design vehicle for urban collectors/arterials. Its also considered to be the minimum design vehicle for all turning movements for roundabouts on the state highway system.

Non-motorized Design Users

Roundabouts are designed to meet the needs of all facility users. The safe and efficient accommodation of all non-motorized users (bicyclists, drivers, pedestrians, disabled or impaired persons, strollers, skaters, etc.) is as important as the considerations made for vehicles. The potential for any conflicting traffic or severe crashes is substantially reduced by forcing roundabout traffic to enter or exit only through right turns . The low speeds through roundabouts allow more user reaction time resulting in fewer crashes involving pedestrians.

Exhibit 6-7. Key Dimensions of Non-Motorized Design Users
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

User	Dimension	Affected Roundabout Features
Bicyclist		
Length	5.9 ft	Splitter island width at crosswalk
Minimum operating width	4 ft	Bike lane width on approach roadways; shared use path width
Pedestrian (walking)		
Width	1.6 ft	Sidewalk width, crosswalk width
Wheelchair user		
Minimum width	2.5 ft	Sidewalk width, crosswalk width
Operating width	3.0 ft	Sidewalk width, crosswalk width
Person pushing stroller		
Length	5.6 ft	Splitter island width at crosswalk
Skaters		
Typical operating width	6 ft	Sidewalk width

Pedestrian Design

Pedestrian needs should be addressed and controlled to maximize safety and minimize conflicts with other traffic flows. Pavement marking inside the crosswalk area is recommended to improve safety. Many cities and suburban areas have gone to the next level by adding aesthetic treatments to their crosswalk designs.

<u>Pedestrian Crosswalk Considerations</u>

Should be located at intersections
Have appropriate curb ramps for accessibility
Should be highly visible

Pedestrians are accommodated by crosswalks and sidewalks around the perimeter of the roundabout. Sidewalks (5 ft minimum, 6 ft recommended) should be set back from the edge of the circulatory roadway (2 ft minimum, 5 ft recommended) with a landscape strip. Low shrubs or grass may be planted in the strip between the sidewalks and curb. This setback discourages pedestrians from cutting across the roundabout's central island and guides visually-impaired pedestrians to the designated cross-walks. Fencing or other barriers may be necessary in heavy pedestrian traffic areas to guide users to the appropriate crossings.

The location of the pedestrian crossing is generally recommended to be a minimum setback of 20 ft (one vehicle length) from the edge of the circulatory roadway. For some designs, it may be necessary to put the crosswalk two or three car lengths back from the circle (using a 5 ft gap between car lengths for this type of queued distance). Closer pedestrian crossings may reduce roundabout capacity due to potential back-ups and longer entry waiting times. Placing crosswalks further away from the entrance of the roundabout increases walking distances and may expose pedestrians to higher vehicle speeds.

The Americans with Disabilities Act requires that all new or modified roundabouts be accessible to and usable by disabled individuals. Visually impaired pedestrians may have more difficulty crossing roundabouts since these intersections do not typically include the normal audible and tactile cues used to successfully maneuver crosswalks.

Pedestrian signals should be coordinated with traffic lights at all signalized intersections with pedestrian activity. Push buttons can be used for isolated intersections or locations where traffic warrants maximum vehicle travel time through the intersection. Fixed time traffic signals with short cycle lengths are more appropriate for urban or downtown environments.

Bicycle Design Considerations

Research has shown that bicyclists are the most vulnerable users of roundabouts with over 50 percent of bike crashes at roundabouts involving entering vehicles and circulating bicycles.

Modern roundabouts are typically designed to accommodate bicyclists of different skills and experience levels.

When designing a roundabout for bicycle safety and travel, the following general methods may be used to accommodate bicyclists:

1) **Motor Vehicle Method** - mixed flow with regular traffic

Typical bicycle (12 – 20 mph) and design vehicle entry (20 – 30 mph) speeds are similar and compatible for low-speed, single-lane roundabouts with low potential conflicts.

2) **Pedestrian Method** - shared use paths.

Bicycle safety tends to deteriorate at high-speed, multiple lane roundabouts and many cyclists may be more comfortable and safer using bike ramps connected to a sidewalk or shared use path around the outside of the roundabout. The typical sidewalk width should be a minimum of 10 ft in order to accommodate both pedestrians and bicyclists. Bicycle lanes or shoulders used on approach roadways, should end at least 100 feet before the edge of the circulatory roadway. A taper rate of 7:1 is recommended to transition the combined travel/bike lane width down to the appropriate width for the desired vehicle speeds on the approach. Bicycle ramps may be provided to allow access to the sidewalk or a shared use path at the roundabout. These ramps should only be used where the design complexity or vehicle speed is incompatible for some cyclists. AASHTO's *Guide for Development of Bicycle Facilities* provides specific details for designing shared-use paths.

Sight Distance and Visibility

Adequate visibility and sight distance for approaching vehicles is crucial for providing safe roundabout operation. For roundabouts, the two most relevant parts of sight distance are *stopping sight distance* and *intersection sight distance.*

Stopping sight distance is the distance required for a driver to see and react to an object in the roadway and then brake to a complete stop. Stopping sight distance should be provided within a roundabout and on each entry and exit leg. The required distance is based on speed data from the fastest path speed checks.

Exhibit 6-54

Computed Values for Stopping Sight Distance

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Speed (km/h)	Computed Distance* (m)	Speed (mph)	Computed Distance* (ft)
10	8.1	10	46.4
20	18.5	15	77.0
30	31.2	20	112.4
40	46.2	25	152.7
50	63.4	30	197.8
60	83.0	35	247.8
70	104.9	40	302.7
80	129.0	45	362.5
90	155.5	50	427.2
100	184.2	55	496.7

* Assumes 2.5 s perception–braking time, 3.4 m/s^2 (11.2 ft/s^2) driver deceleration

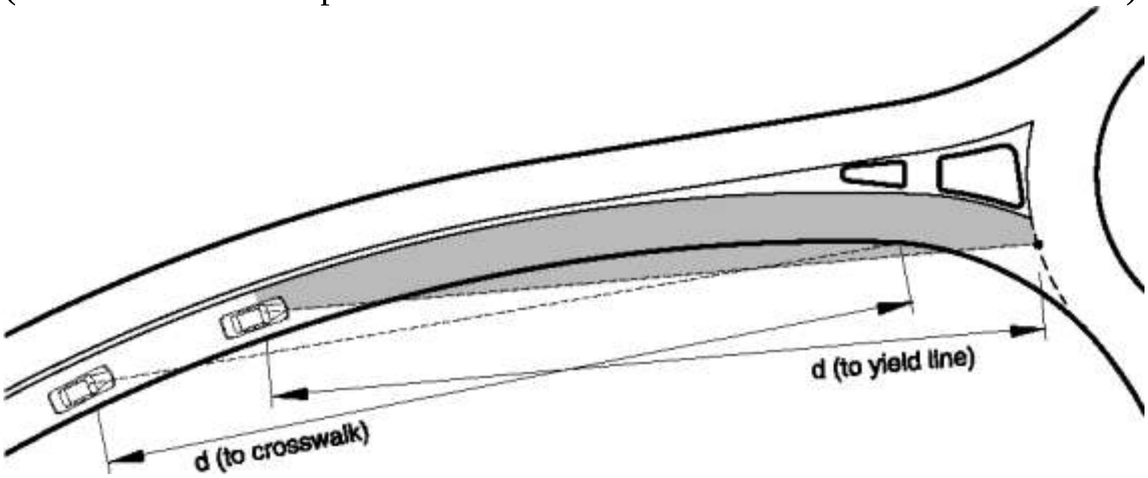
AASHTO recommends using an assumed height of **driver's eye of 3.5 ft** and an assumed **object height of 2 ft** for stopping sight distances. Three critical roundabout locations should be checked for sight distance:

approaches;
circulatory roadway;
and exit crosswalks.

Exhibit 6-55

Stopping Sight Distance on the Approach

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)



LEGEND

d Stopping sight distance related to approaching speed

Exhibit 6-30

Sight Distance on Circulatory Roadway

(FHWA. Roundabouts: An Informational Guide. 2000)

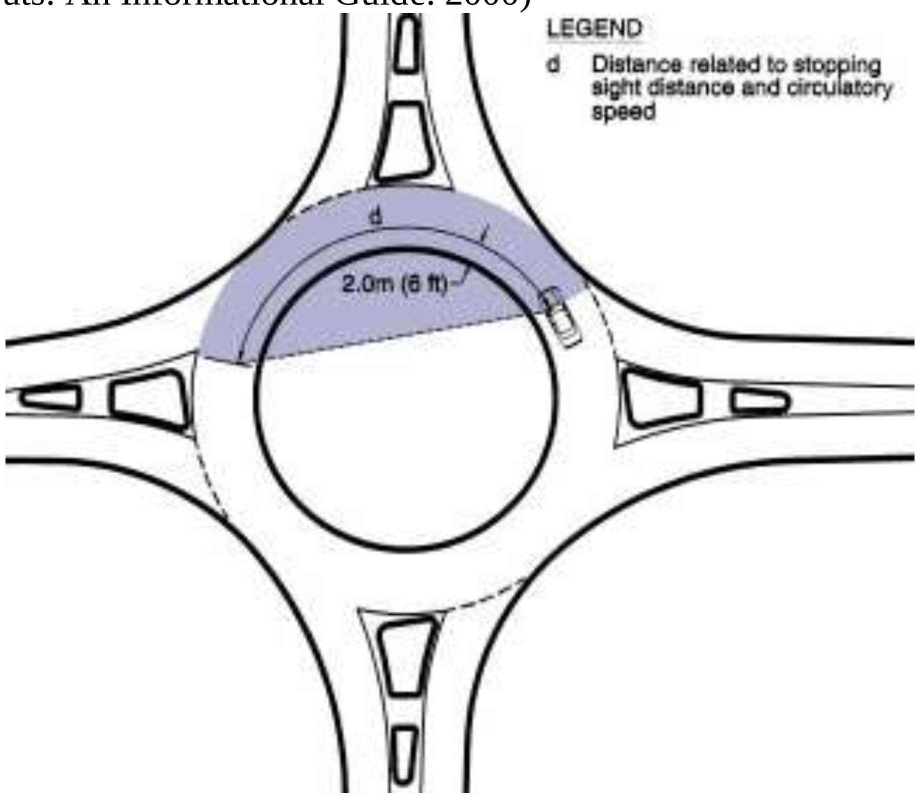
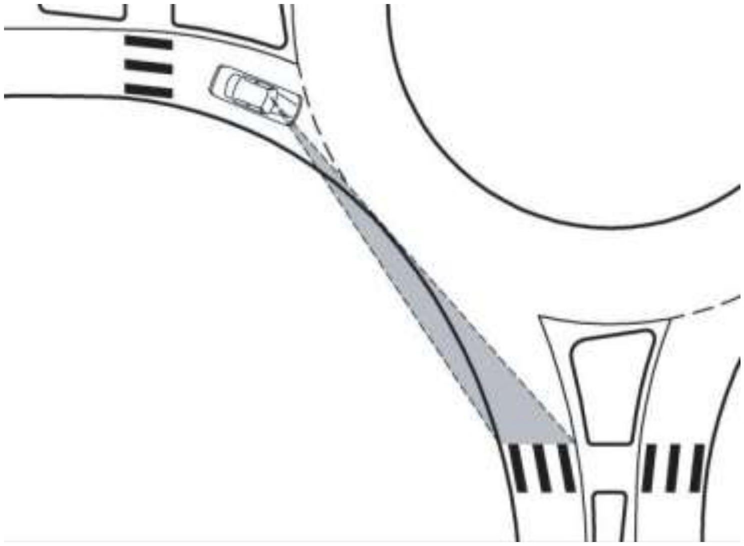


Exhibit 6-57
Sight Distance to Crosswalk on Exit
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)



Intersection sight distance is the distance required for a driver to anticipate and avoid conflicting vehicles. Adequate intersection sight distance ensures drivers can safely enter the circulatory roadway without impeding traffic flow. Entry roadways are the only roundabout locations requiring evaluation of intersection sight distance.

Sight triangles are used to measure intersection sight distance. This triangle consists of a boundary defining a distance away from the intersection on each approach and by a line connecting those two limits. The distance between the entering vehicle and the circulatory roadway is fixed while the other legs of the sight triangle are based on two conflicting approaches:

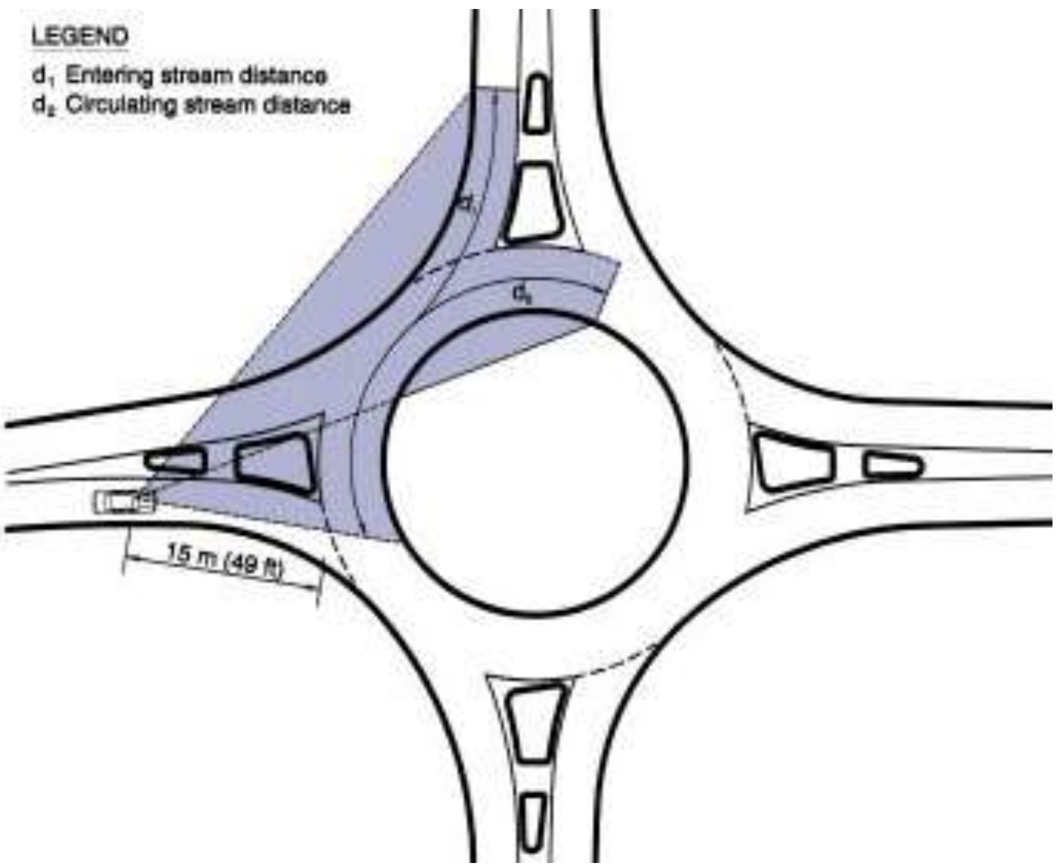
1. Entering stream of vehicles from the immediate upstream entry. The approximate speed can be calculated using the average values for the entering and circulating speeds.

2. Circulating stream of vehicles entering the roundabout prior to the immediate upstream entry. The speed can be approximated from the speed of left turning vehicles.

In both cases the distance is a function of vehicular speed and a reasonable design value of the critical headway for the drivers. These sight triangle legs should follow the curvature of the roadway, and not be measured as straight lines but as distances along the vehicle path.

In some cases, sight distance at the roundabout may be increased at the expense of the roundabout's visibility. Normally, it is desirable to allow no more than the minimum required intersection sight distance for each approach. Excessive visibility may result in higher speeds and safety reduction for the roundabout.

Exhibit 6-32
Intersection Sight Distance
(FHWA. Roundabouts: An Informational Guide. 2000)



The AASHTO “Green Book” recommends that intersection sight distance should be measured using an assumed height of **driver’s eye of 3.5 ft** and an assumed **object height of 3.5 ft.**

Angles of Visibility

The intersection angle at roundabouts is measured between the vehicular alignment at the entry and the sight line required. This angle must allow drivers to comfortably turn their heads to view oncoming traffic upstream. Current guidelines recommend using an **intersection angle of 75**° to design for older driver and pedestrian needs.

Size, Position, and Alignment of Approaches

The design of a roundabout involves optimizing the following design decisions to balance design principles and objectives:

(1) size
(2) position
and **(3) the alignment of the approach legs.**

Creating the best design will often be based upon the constraints of the project site balanced with the ability to control traffic speeds, accommodate over-sized vehicles, and meet other design criterion.

Inscribed Circle Diameter

The inscribed circle is the entire area within a roundabout between all approaches and exits. Its diameter consists of the distance across the central island (including the truck apron) bordered by the outer curb of the circulatory roadway. A number of design objectives determine the inscribed circle diameter and designers often have to experiment with varying dimensions before determining the optimal roundabout size.

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
Single-Lane Roundabout	WB-50 (WB-15)	105 to 150 ft	(40 to 55 m)
	WB-67 (WB-20)	130 to 180 ft	(32 to 46 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

For single-lane roundabouts, the inscribed circle's size depends on the design vehicle's turning requirements – circulatory roadway width, entry/exit widths, radii and angles.

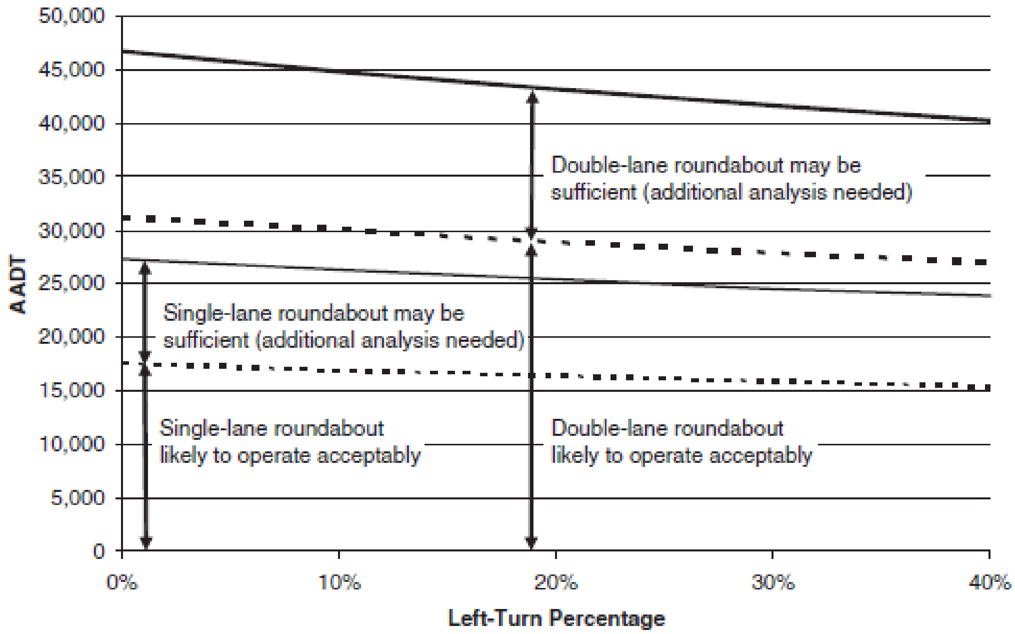
For multilane roundabouts, the size is dependent on balancing deflection with aligning natural vehicle paths.

Capacity

A roundabout's capacity and size depends on the number of lanes required to handle future traffic. Exhibit 3-12 illustrates a simple, conservative way to estimate roundabout lane requirements. It is applicable for the following conditions:

Ratio of peak-hour to daily traffic (K)	0.09 to 0.10
Acceptable volume-to-capacity ratio	0.85 to 1.00
Ratio of minor street to total entering traffic	0.33 to 0.50
Direction distribution of traffic (D)	0.52 to 0.58

Exhibit 3-12
Planning-Level Daily Intersection Volumes
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)



Roundabout entry depends on the amount of conflicting traffic (circulatory roadway vehicles) at each approach. For single-lane entrances, it is likely to be adequate where the sum of entry and conflicting traffic is less than 1000 veh/hr. For two-lane entries and circulatory roadways, it is likely sufficient for sums less than 1800 veh/hr. Exhibit 3-14 shows volume thresholds for the number of required entry lanes.

Exhibit 3-14
Volume Thresholds for Determining the Number of Entry Lanes Required (FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

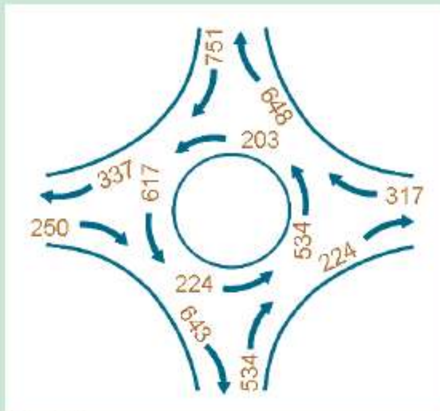
Volume Range (sum of entering and conflicting volumes)	Number of Lanes Required
0 to 1,000 veh/h	▪ Single-lane entry likely to be sufficient
1,000 to 1,300 veh/h	▪ Two-lane entry may be needed ▪ Single-lane may be sufficient based upon more detailed analysis.
1,300 to 1,800 veh/h	▪ Two-lane entry likely to be sufficient
Above 1,800 veh/h	▪ More than two entering lanes may be required ▪ A more detailed capacity evaluation should be conducted to verify lane numbers and arrangements.

Source: New York State Department of Transportation

Example: Estimating Number of Lanes Using Turning-Movement Volumes

Question

How many lanes are required to serve these design-year traffic volumes:



Calculations

Entering volume + Circulating volume = X Compare to Exhibit 3-14

250 + 617 = 867	<1,000	Single Lane OK
534 + 224 = 758	<1,000	Single Lane OK
317 + 534 = 851	<1,000	Single Lane OK
751 + 203 = 954	<1,000	Single Lane OK

Conclusions

Using the traffic data identified above and the volume ranges in Exhibit 3-14, a single-lane roundabout would be estimated to adequately handle the design-year traffic volumes for each individual approach. Therefore, a single-lane roundabout could be advanced forward for the rest of the planning-level evaluations, including estimates of the intersection footprint (right-of-way needs) and impacts.

Exhibit 3-15
Example Planning-Level Exercise for Determining Required Numbers of Lanes Using Turning-Movement Data
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

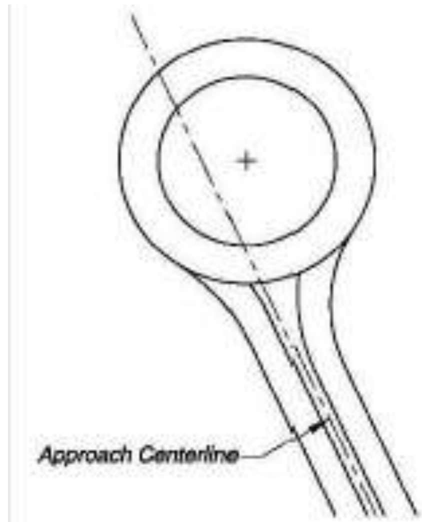
Alignment of Approaches

The entry alignment of the approaching legs to a roundabout affects the deflection and speed control achieved, accommodation for the design vehicle, sight angles to drivers, and property impacts/costs.

Although it is desirable for these alignments of the roundabout approaches to pass through the center of the inscribed circle, it is not mandatory for a successful design.

Exhibit 6-10 Entry Alignment Alternatives (NCHRP Report 672) provides 3 major alternatives for roundabout approach alignments as shown below.

Alternative 1: Offset Alignment to the Left of Center



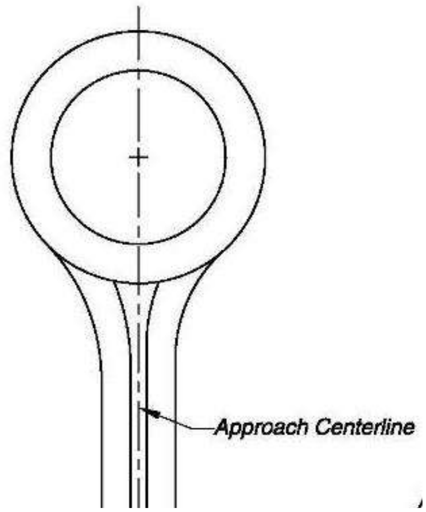
ADVANTAGES:

- 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

TRADE-OFFS

- 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



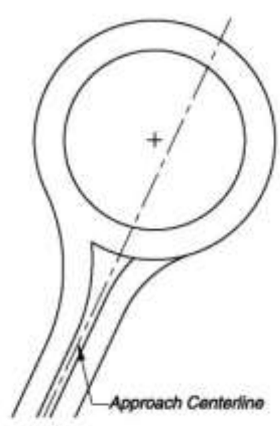
ADVANTAGES:

- 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 speeds through the exit

TRADE-OFFS

- 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 provide the same level of speed control

Alternative 3: Alignment to Right of Center



ADVANTAGES:

- Could 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.

TRADE-OFFS

- Often more difficult to achieve speed control objectives, particularly at small diameter roundabouts
- Increases the amount of exit curvature that must be negotiated

Angle between Approach Legs

It is preferable for roundabout approach legs to intersect at near perpendicular intersection angles. Two approach legs with an angle greater than 90° often results in excessive speeds for right turns. Approach angles less than 90° may result in large vehicles having difficulty navigating the roundabout. Perpendicular approaches usually produce desired slow, consistent operating speeds for roundabouts.

Single-Lane Roundabouts

Single-lane roundabout design consists of single-lane approaches at all legs and a single-lane circulatory roadway around a central island. This design permits slightly higher operation speeds for the entry, exit and the circulatory roadway. Like all roundabouts, the size of single-lane design is largely dependent on the type of design vehicle and available right-of-way.

Single-lane Geometric Design Characteristics

Larger inscribed circle diameters
Raised splitter islands
Non-traversable central island
Crosswalks
Truck apron

Exhibit 1-12 illustrates the distinguishing features of typical single-lane roundabouts.

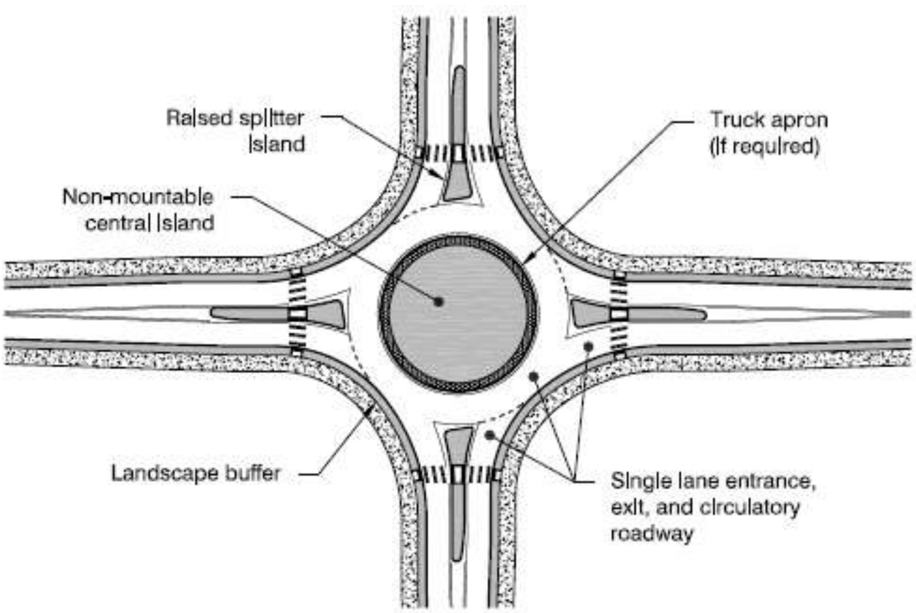


Exhibit 1-12
Features of Typical Single-Lane Roundabout
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

The size of the inscribed circle must be large enough to accommodate the design vehicle's turning requirements and maintain adequate deflection curvature for safe travel speeds. Close selection of circulatory roadway width, entry and exit widths, entry and exit radii, and entry and exit angles may allow a smaller inscribed circle diameter to be used in constrained locations. For a WB-50 (Intermediate Semitrailer Truck) design vehicle, the inscribed circle diameter needs to fall within the 105 to 150 ft range. Smaller single-lane facilities may be used for other intersections, where the design vehicle may be a bus (BUS-40) or single- unit truck (SU). For a larger WB-67 (Interstate Semitrailer Truck) design vehicle, a larger inscribed circle diameter (130 to 180 ft) is typically required. Larger inscribed circles may also be appropriate for roundabouts with more than four legs. Truck aprons are used for accommodating larger design vehicles and restricting the inscribed circle diameter to reasonable limits.

Splitter Islands

Splitter islands should be provided on all roundabouts unless visibility of the central island is obstructed. Their purpose is to provide refuge for non-motorized users, control vehicle speeds, guide traffic through the intersection, physically separate entry and exit traffic, deter wrong-way movements, and provide a location for signs.

The total length of the raised splitter island should be a minimum of 50 ft. with a desirable value of 100 ft. to provide adequate visibility and refuge. High speed approaches may require splitter island lengths of 150 ft or more. By extending the island beyond the end of the exit curve, exiting vehicles are prevented from accidentally meeting oncoming traffic. The splitter island should have a **minimum width of 6 feet** at the crosswalk to adequately meet non-motorized user needs.

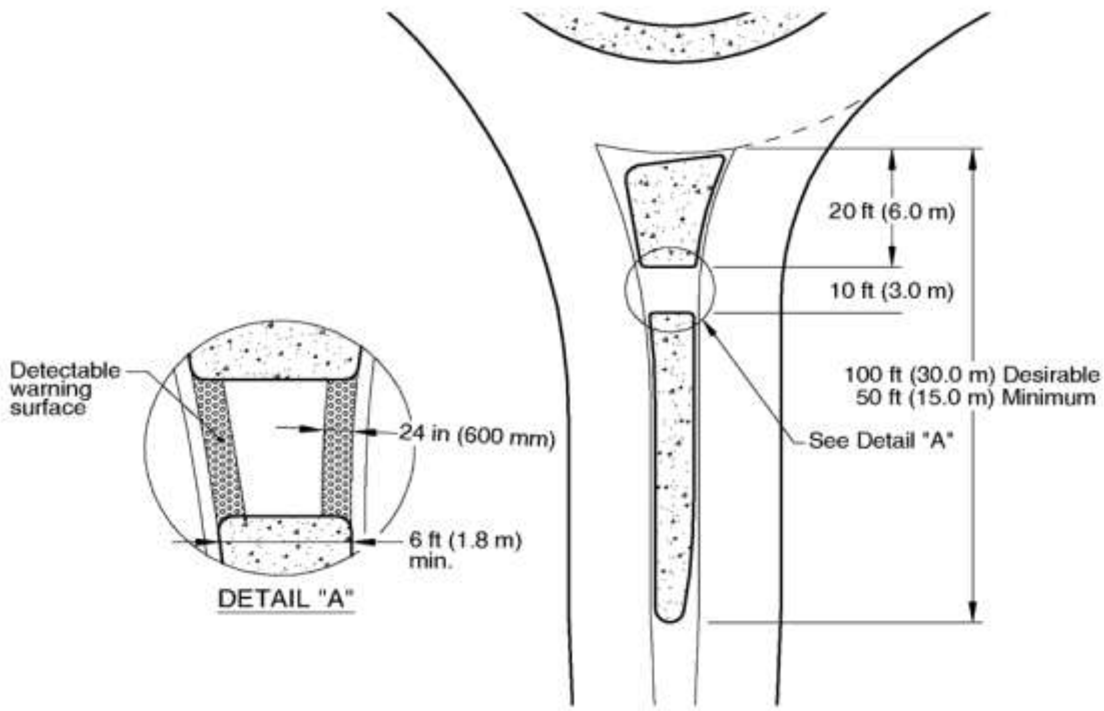


Exhibit 6-12
Minimum Splitter Island Dimensions
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Entry Width

A roundabout's entry width is designed to reduce vehicle speeds and maximize the visibility of the central island. This width is measured from outside curb face to inside curb face at the splitter island point nearest the inscribed circle. The entry width is the key capacity determinant that is dependent on the roadway width and the design vehicle. Entry capacity increases as entry width increases. The minimum circulatory roadway width should be as wide as the widest approach and should remain constant throughout the roundabout.

It is recommended to keep roundabout entry widths to a minimum in order to maximize safe and efficient operation. Optimal capacity and operational balance should also be considered in determining the width and number of approaches.

Typical entry widths range from 14 ft to 18 ft (common starting value of 15 ft) for a single-lane roundabout. Higher or lower entry widths may be acceptable for site-specific design vehicle and speed requirements. However, entry widths greater than 18 ft or those wider than the circular roadway should be avoided in order to prevent driver confusion as to the correct number of lanes. A mountable apron around the central island's perimeter may be used to provide additional width for accommodating off tracking by combination trucks.

When capacity needs can only be accommodated by increasing the entry width, design options include:

- adding a full lane upstream of the intersection and maintaining parallel lanes through the roundabout

- widening the approach lane gradually through the entry.

Circulatory Roadway Width

The circulatory roadway width is the distance between the outer edge of the inscribed diameter (curb face) and the central island curb face (not including the width of any truck apron). This width defines the roadway width for vehicle circulation around the central island.

The circulating roadway design width within the roundabout depends on the number of entry lanes and the radius of vehicle paths. The circulating width should be constant with the minimum width being at least as wide as the maximum entry width and not exceeding 1.2 times the maximum entry width.

For single lane roundabouts, the constant widths of the circulating roadway range from 16 to 20 ft. Designers should avoid making the circulatory width too wide in order to prevent drivers from interpreting the roundabout as a multilane design.

Central Island

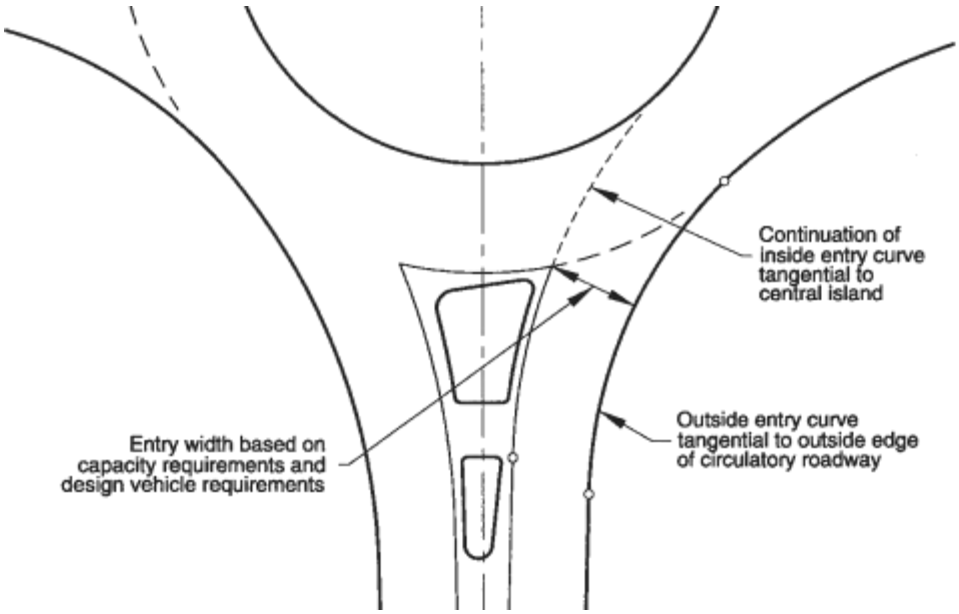
The central island is the raised, non-traversable area in the center of a roundabout that is surrounded by the circulatory roadway. This island is typically landscaped for aesthetic reasons and may include a traversable apron for large vehicles. Central islands should always be raised to enhance visibility of the roundabout upon approach. The size of the central island is dependent on the inscribed circle diameter and the circulatory roadway width.

Although the central island is typically circular, other shapes may be required for unusual site conditions. A circular island with a constant-radius roadway helps promote constant speeds around the center of the roundabout. Irregular shapes are more challenging and can result in higher speeds on the straight sections and reduced speeds on the curves. This speed differential can make it difficult for approaching traffic to judge the speed and availability of gaps - resulting in more loss-of-control crashes.

Entry Design

A roundabout entry is bordered by a curb with one or more curves connected to the circulatory roadway. The entry curb radius affects both capacity and safety by controlling the amount of deflection imposed on a vehicle's entry path. Too small (below 50 ft) entry curb radii may lead to single-vehicle crashes while too large radii may result in higher entry speeds with little effect on capacity.

Exhibit 6-14
Single-Lane Roundabout Entry Design
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)



The goal in selecting an entry curb radius is to meet appropriate speed requirements for the design vehicle. For an urban single-lane roundabout, entry radii typically range from 50 to 100 ft (common starting point: 60 to 90 ft).

For speed differential values between rural approaches and entries greater than 12 mph, it may be advantageous to add features to reduce the approaching vehicle speeds.

The angle of visibility is another important roundabout design consideration. This angle to the left should allow drivers to see oncoming traffic from the upstream entry or the circulatory roadway. Typical values for entry angles range between 20 to 40 degrees. Severe entry angles may result in poor visibility, driver strain, and merging behavior. While shallow entry angles may not produce successful lane alignment or prevent wrong-way movements.

Exit Design

The exit width is where the width of the exit meets the inscribed circle. This width is measured perpendicularly from the right curb to the intersection of the left curb and the inscribed circle. The exit radius is the curvature of the outside curb face at the exit.

For urban single-lane roundabouts, exits should be designed for a curved exit path with a design speed under 25 mph in order to maximize pedestrian safety. Exit radii should normally be a minimum of 50 ft. However, for locations with low speeds, low traffic and pedestrian activity, these radii may be as low as 33 to 39 ft. resulting in a very slow design speed that maximizes safety and comfort for pedestrians. Such low exit radii should only be used with a similar entry design for urban compact roundabouts with a maximum inscribed circle diameter of 115 ft.

In rural locations with few pedestrians, larger exit radii may be used to allow vehicles to exit quickly and accelerate back to normal speeds. Any straight paths tangential to the central island should be avoided since many existing rural locations may become urban in the future. Pedestrian activity should be considered at all exits except where conditions eliminate the chance of any future pedestrian activity.

Design Vehicle Considerations

The design vehicle is the controlling factor for most of the following roundabout considerations:

Entry width
Entry radii
Inscribed circle diameter
Circulatory roadway width

Roundabouts may be required to accommodate both over-sized and passenger vehicles. Location constraints can limit the ability to provide adequate deflection for small vehicles while accommodating large trucks or emergency vehicles. Truck aprons can be used to provide additional area around the central island for trucks and discourage overtopping by passenger vehicles.

The location of a roundabout may determine its specific design vehicle. Rural agricultural areas may need to use farm equipment. Urban cities may need large semi-trailer combinations. Recreational areas may require motor homes or buses. The design vehicle's needs should be used in the preliminary stages of the roundabout design since it helps to determine size, position, and approach alignments.

Multilane Roundabouts

Multilane roundabouts contain a minimum of one entry (two or more lanes) and require wider circulatory roadways to accommodate more than one vehicle traveling side by side. The roundabouts may have a different number of lanes or transitions on one or more legs. The number of lanes should be the minimum needed for the anticipated traffic demand. The design speeds at the entry, on the circulatory roadway, and at the exit may be slightly higher than those for single-lane roundabouts. Multilane roundabouts include raised splitter islands, truck aprons, a non-traversable central island, and appropriate entry path deflection.

The size of a multilane roundabout is typically determined by balancing two critical design objectives:

the need to achieve deflection;
and **providing sufficient natural vehicle path alignment.**

To achieve both of these objectives, a diameter larger than those used for single-lane roundabouts is required. Generally, the inscribed circle diameter of a multilane roundabout ranges from 150 to 220 ft (two-lane) and 200 to 300 ft (three-lane) for achieving adequate speed control and alignment. Truck aprons are recommended to accommodate larger design vehicles and keep the inscribed circle diameter reasonable.

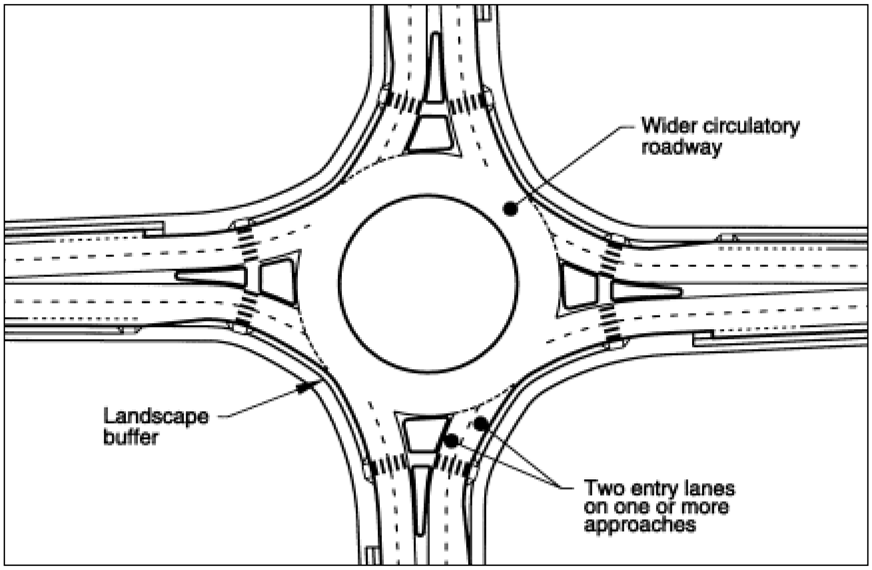


Exhibit 1-11
Typical Urban Double-Lane Roundabout
(FHWA. Roundabouts: An Informational Guide. 2000)

Entry Width

The entry width is determined by the number of lanes required and the turning needs of the design vehicle.

Typical Entry Lane Widths

Single-lane	12 to 15 ft
Two-lane	24 to 30 ft
Three-lane	36 to 45 ft.

Unless the entry can be fully utilized by traffic, any excessive entry width may not benefit capacity.

Where additional entry capacity is needed, the following designs may be used:

- Gradually widening the approach
- Adding a lane for parallel entry

Research shows that flared entries are an effective means of increasing capacity while requiring less land and having little impact on safety.

Minimal entry widths with maximum flare lengths should produce desired capacity and acceptable safety.

In multi-lane roundabouts, over-sized vehicles may travel the entire width of the circulatory roadway. Roundabouts with truck aprons or gated roadways through the central island may accommodate large trucks, emergency vehicles, or trains.

Circulatory Roadway Widths

Multilane roundabout circulatory roadway widths depend on the types of vehicles that need to be accommodated side-by-side through the roundabout. For locations where traffic is mainly passenger cars (P) and single-unit trucks (SU), the appropriate width may be either two passenger cars or a car/truck combination. For semi-trailer traffic (WB-50) greater than 10%, it may be acceptable to design for a semi-trailer/passenger vehicle combination.

Typical lane widths for multilane circulatory roadways range from 14 to 16 ft, resulting in total widths of 28 to 32 ft for two-lane and 42 to 48 ft for three-lane circulatory roadways.

Entry Geometry and Approach Alignment

For multilane roundabouts, the designer should ensure that the proposed entry design directs vehicles to stay within the appropriate lanes of the circulatory roadway and exits. Path overlap occurs when the natural vehicle paths overlap or cross one another.

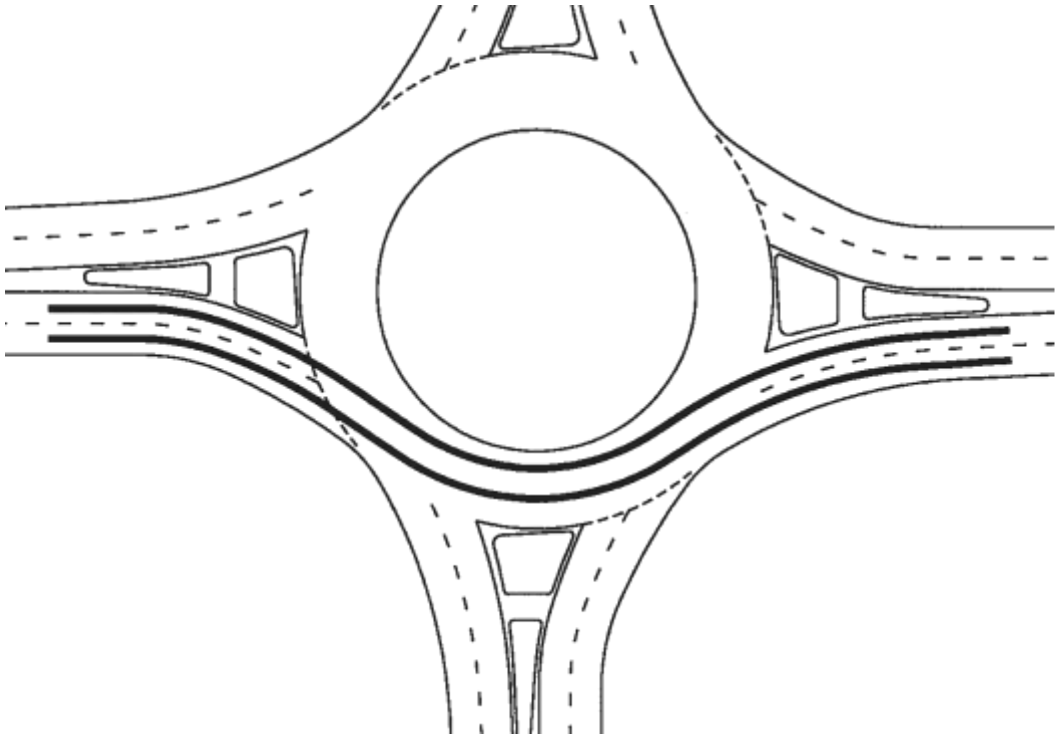


Exhibit 6-44
Sketched Natural Paths Through a Double-Lane Roundabout
(FHWA. Roundabouts: An Informational Guide. 2000)

Creating an optimal design with good path alignment within multilane roundabouts while controlling entry speeds with adequate deflection can be difficult. Designs that improve path alignment may also increase fastest path speeds. An optimal geometric design for a multilane roundabout balances the entry speed, path alignment, design vehicle, and other needs.

One possible design technique is to locate the entry curve for the projection of the inside entry lane at the entrance line connects tangentially to the central island. Exit design should also provide sufficient exit radii and alignment to allow drivers to maintain their proper lane. Other techniques involving changes to approach alignment, entry curvature, and/or inscribed circle diameter may result in creating trade-offs.

Problems can occur when a design has excessive distance between entries and exits. Large separations can cause entering vehicles to join next to circulating traffic and create conflicts at the exit point between exiting and circulating vehicles.

Possible solutions include changing lane configurations, revising inscribed circle diameters, and realigning the approaches. Realignment of the approach legs to allow the paths of entering vehicles to cross the paths of the circulating traffic (rather than merging) minimize conflict. This increases the likelihood that entering drivers will yield to both conflicting lanes.

Splitter Islands

For multilane roundabouts, the entry geometry is typically developed to control fastest-path entry speeds, avoid entry path overlap, and accommodate the design vehicle. The splitter island is designed to provide sufficient median width for non-motorist users and signage.

Exit Curves

Exit curvature design for multilane roundabouts is more complex and larger than the other types. Exit conflicts may occur if appropriate lane assignments for exiting and circulating vehicles are not provided. At locations where the exit radius is too small, vehicles on the inside of the circulatory roadway may exit in the outside exit lane.

To prevent potential problems from too much separation between entries and exits, two possible design alternatives are available:

1) Using a combination of striping/ physical modifications for compatible traffic volume
2) Realignment of approaches for entry vehicle paths to cross (and not merge with) circulatory traffic

Mini-Roundabouts

Mini-roundabouts are small intersection designs with a fully traversable central island that are commonly used in low-speed urban environments (average operating speeds of 30 mph or less). The small footprint of a mini-roundabout (inscribed circle diameter less than 90 ft) can be useful in such environments where conventional roundabout design is limited by right-of-way constraints. The small diameter is made possible by using a fully traversable central island for accommodating heavy vehicles. Passenger cars should be able to exit the mini-roundabout without running over the central island. The overall design should naturally guide entering vehicles along their intended path and minimize traversing the central island.

Mini-roundabouts are very popular for retrofit applications due to their low cost from requiring minimal additional pavement at the intersecting roads and minor widening at the corner curbs. Small, mini-roundabouts are also seen as pedestrian-friendly with short crossing distances and very low vehicle entry/exit speeds.

Limitations of mini-roundabouts are due to the reduced ability to control speeds with the traversable central island. Therefore, it is important to consider the advantages and limitations of mini-roundabouts versus the larger-diameter roundabouts and intersection designs based upon site-specific conditions.

Figure 1 (Mini-Roundabouts Technical Summary) shows the distinctive features for a typical mini-roundabout.

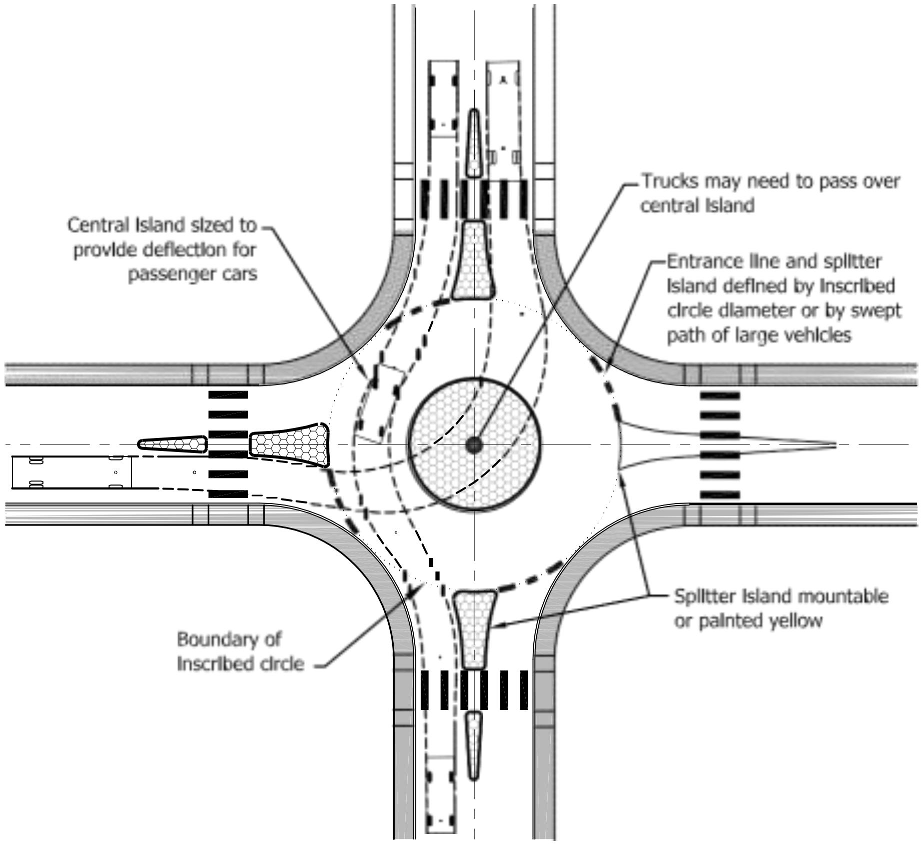


Figure 1.
Design Features of a Mini-Roundabout
(FHWA. Mini-Roundabouts Technical Summary. 2010)

General Design Criteria for Mini-Roundabouts
The geometric design of a mini-roundabout, as with other types of roundabouts, requires the balancing of competing design objectives with different emphasis areas. Substandard designs may result in speeding, improper yielding, left turn movements at the intersection, or vehicles running over the central island.

<u>Size</u>
A major benefit of using a mini-roundabout versus a larger, single-lane roundabout is minimizing the impacts to the existing intersection footprint. For a mini-roundabout, the existing intersection curb line is a typical starting point for establishing the inscribed circle diameter. Mini-roundabouts should be made as large as possible within existing conditions with a maximum inscribed circle diameter of 90 ft. Any inscribed circle diameter greater than 90 ft will be large

enough for a single-lane roundabout design which accommodates traffic navigating around a raised central island and provides physical channelization to control vehicle speeds.

Design Vehicle

As with other roundabouts, it may be desirable to accommodate buses within the circulatory roadway rather than traveling over the central island within a mini-roundabout. However, the turning radius of a bus is typically too large to navigate around the central island while staying within the circulatory roadway with very small inscribed circle diameters. Using a bus for the design vehicle instead of a passenger car may result in a geometric design with a wider circulatory roadway and smaller central island.

Central Island

The central island location should be at the center of the left-turning inner swept paths - which will be near the center of the inscribed circle. Large design vehicles should be accommodated by the footprint of the central island while passenger cars should be able to safely navigate counterclockwise through the intersection without over-tracking.

Designing the central island size and location for deflection through the roundabout will result in proper circulation and reduced speeds through the intersection.

The central island is typically a small, conspicuous and fully traversable island composed of asphalt concrete, Portland cement concrete, or other paving material, The central island should be domed or raised with a mountable curb using 5 to 6 percent cross slope, with a maximum height of 5 in. The mountable curb for a mini-roundabout should be designed in a similar way to truck aprons on other roundabouts.

Entrance Line Placement

The entrance line is defined as the edge line extension across the approach leg of a mini-roundabout, and incorrect placement can result in unsafe driver behavior. Two common designs are used for entrance line placement:

(1) Advancing the entrance line forward,

The outer path of passenger cars and the largest vehicle likely to use the intersection are identified for all turning movements. The entrance line is placed a minimum of 2 ft outside the vehicle paths.

(2) Simultaneously enlarging the central island and reducing the circulatory roadway width, with the entrance line coincident with the inscribed circle of the roundabout.

Advancing the entrance line may be used to discourage left-turns in front of the central island but it may also reduce capacity due to yields at the entry.

Splitter Islands

For mini-roundabouts, splitter islands are used to provide pedestrian refuge, to encourage deflection and proper circulation, and to align vehicles. These islands may be raised, mountable, or flush depending upon their size and whether trucks will need to mount the splitter island in order to successfully navigate the intersection.

NCHRP Report 672 (FHWA) provides the following general guidelines for the types of splitter islands under various site conditions:

• Consider a **raised (non-traversable)** island if one or more of the following conditions exists:
-- All design vehicles can navigate the roundabout without tracking over the splitter island area
-- Sufficient space is available to provide an island with a minimum area of 50 ft^2, and/or
-- Pedestrians are present at the intersection with regular frequency.

• Consider a **mountable (traversable)** island if:
-- Some design vehicles must travel over the splitter island area and truck volumes are minor, and
-- Sufficient space is available to provide an island with a minimum area of 50 ft².

• Consider a **flush (painted)** island if:
-- Vehicles are expected to travel over the splitter island area with relative frequency to navigate the intersection
-- An island with a minimum area of 50 ft² cannot be achieved, and
-- The approach has low vehicle speeds (preferably no more than 25 mph).

Figure 4 illustrates the recommended longitudinal dimensions for splitter islands at mini-roundabouts. For narrow approach widths, it may be necessary to extend the islands between the entrance line and the crosswalk. For raised islands, it is crucial for them to be highly visible to approaching motorists.

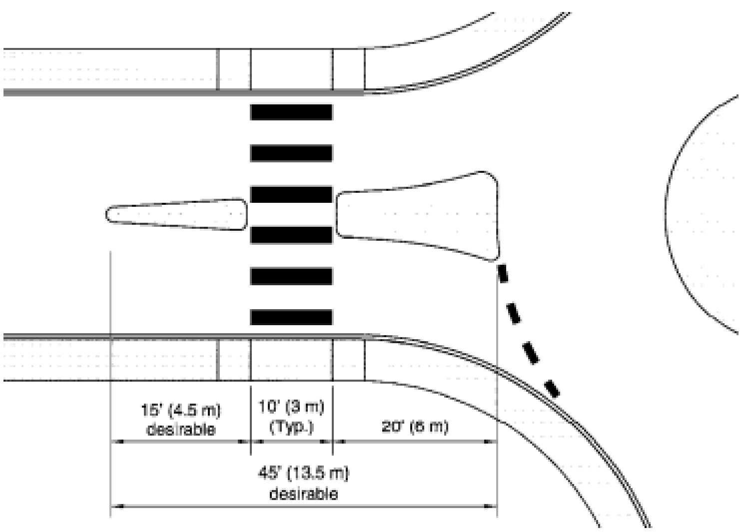


Figure 4.
Recommended Longitudinal Dimensions of a Mini-Roundabout
(FHWA. Mini-Roundabouts Technical Summary. 2010)

Performance Checks

Fastest Path

The fastest path through any roundabout is the flattest and most efficient traverse of the intersection – from entry to around the circulatory roadway and out the exit. These routes need to be determined for all approaches and traffic movements. The fastest path represents the theoretical design speed as opposed to expected traffic speeds.

Five critical path radii must be checked for each approach:

R1 - entry path radius
minimum radius on the fastest through path prior to the entry

R2 - circulating path radius
minimum radius on the fastest path around the central island.

R3 - exit path radius
minimum radius on the fastest path to exit.

R4 - left-turn path radius
minimum radius on the path of conflicting left-turns

R5 - right-turn path radius
minimum radius on the fastest path of right-turn vehicles

Please note that these vehicular path radii are not the same as the curb radii.

Exhibit 6-46
Vehicle Path Radii (FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

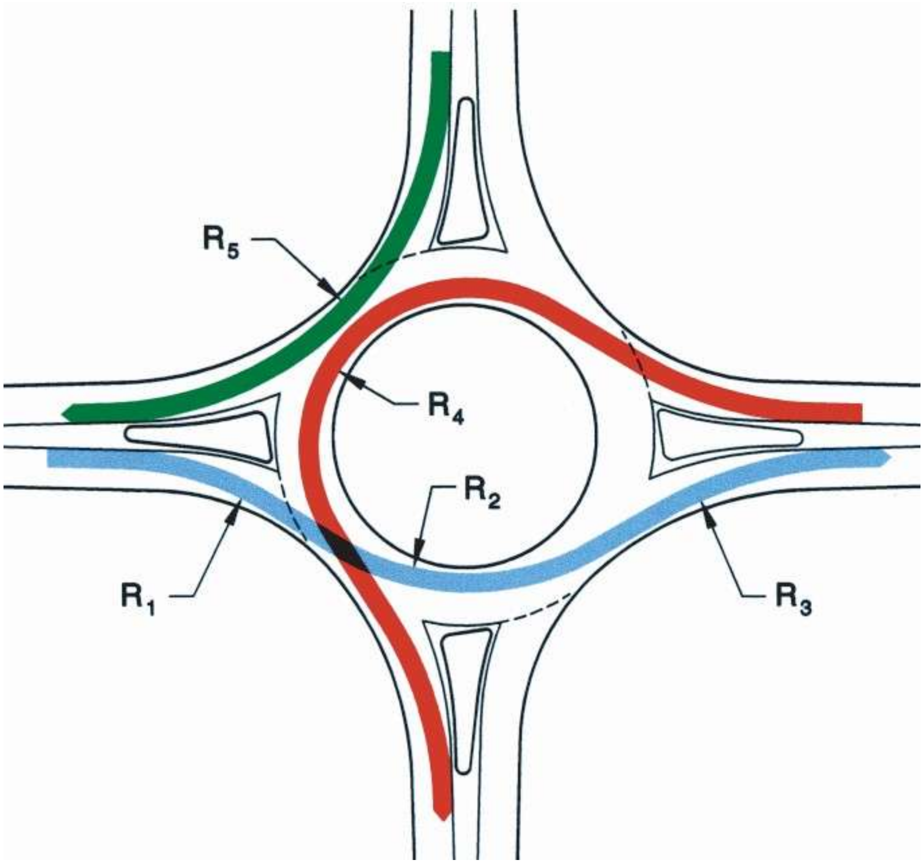


Exhibit 6-47
Recommended Maximum Entry Design Speeds
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Site Category	Recommended Maximum Theoretical Entry Design Speed
Mini-Roundabout	20 mph (30 km/h)
Single Lane	25 mph (40 km/h)
Multilane	25 to 30 mph (40 to 50 km/h)

Vehicle Path Assumptions	
Vehicle width	6 ft
Minimum lateral clearance	2 ft

Centerline of Vehicle Path	
Distance from concrete curb	5 ft
Distance from roadway centerline	5 ft
Distance from edge line	3 ft

The fastest path should begin a minimum of 165 ft before the entrance line. *R1* should be measured over a distance of 65 to 80 ft.

The maximum speed differential between conflicting traffic movements within roundabouts should be less than 10 to 15 mph which can be achieved from low absolute maximum speed for the fastest entry traffic.

Closely Spaced Roundabouts

In some cases, it may be necessary to consider the operation of multiple roundabouts in close proximity to each other. The expected queue length at each roundabout is a major design consideration. For closely spaced intersections, the engineer should compute the 95th-percentile queues for each approach in order to determine if sufficient queuing space is available for vehicles between the roundabouts. Insufficient space may result in occasional queuing at the upstream roundabout and gridlock to the entire system.

A system of closely spaced roundabouts may also produce a traffic calming effect for arterial roadways. Drivers may be hesitant to speed on connecting roadways if they know that they will be required to slow down for the upcoming roundabout.

Figure 25.
Chickamauga Dam Roundabouts
Chattanooga, TN (Google Earth)

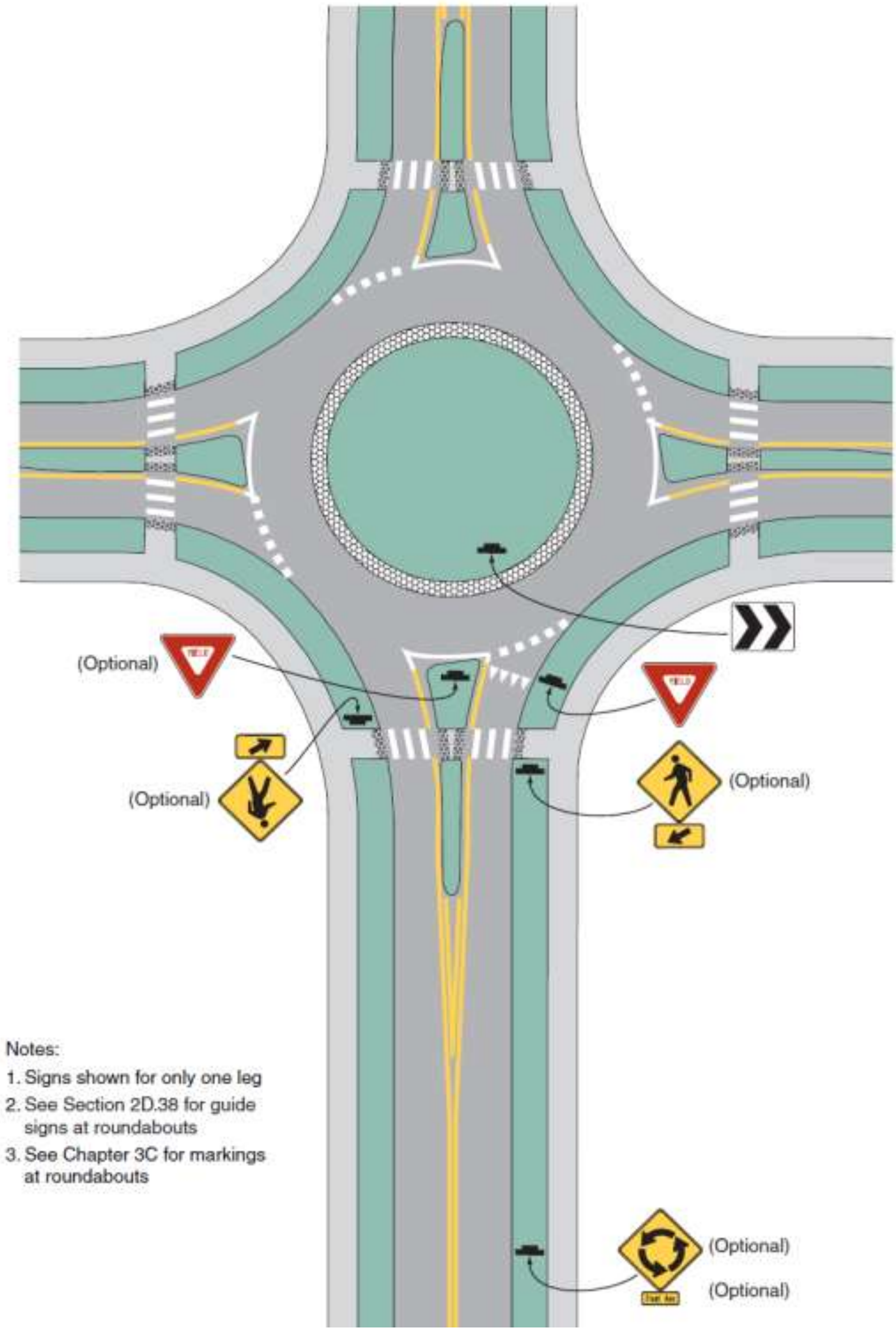
Figure 25 shows two closely spaced roundabouts at a high traffic intersection system connected to an interstate. The two roundabouts work together as a system to effectively serve the traffic demands. Serious consideration must be given to a system of roundabouts with this complexity in order to produce optimal geometric designs that have sufficient capacity for each approach leg and driver-friendly intersections without lane changes or weaving.

Signs

The *Manual on Uniform Traffic Control Devices (MUTCD)* provides excellent guidance for the design and placement of traffic control devices (signs, pavement markings, signals, etc.) for roundabouts. These devices should work together as an integrated unit to guide the user.

Figure 2B-22

Example of Regulatory and Warning Signs for a One-Lane Roundabout
(FHWA. Manual on Uniform Traffic Control Devices . 2010)



Signing for roundabouts is similar to the methods for other intersections. The signs should be located for maximum visibility with proper regulatory control, advance warning, and directional guidance while meeting driver expectations. Roundabout signage designs are dependent on its location (urban or rural) and category (mini-roundabout, single-lane, or multilane).

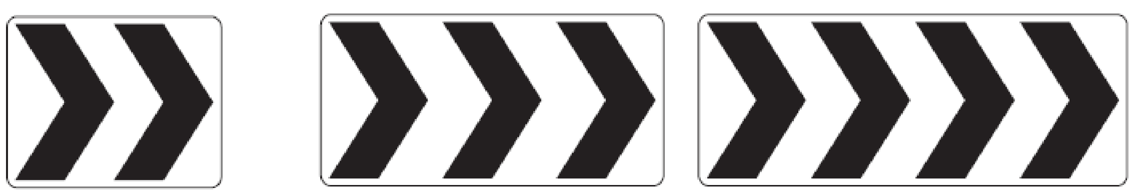
REGULATORY SIGNS

Regulatory signs for roundabouts provide directions to the user that must be obeyed.

R1-2

Yield Sign (R1-2)

Required on right-side of approaches
Additional Yield Sign recommended on left side (splitter island)



R6-4 R6-4a R6-4b

Roundabout Directional Arrow Sign (R6-4, R6-4a, R6-4b)

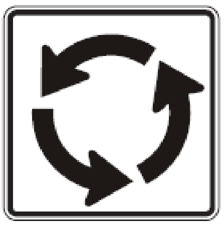
Should be placed on central island opposite of entries
Directs counterclockwise traffic
Replaces black-on-yellow chevron warning signs

R6-1R

One Way Sign (R6-1R)

May be used instead or addition to Roundabout Directional Arrow

Required in some states



R6-5P

Roundabout Circulation Plaque (R6-5P)

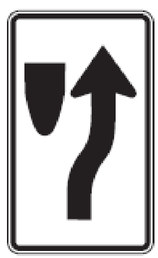
May be used below Yield signs on approaches

Defines direction of circulation

R4-7

R4-7a

R4-7b



R4-7c

Keep Right Sign (R4-7, R4-7a, R4-7b, R4-7c)

Used at nose of non-mountable splitter island

Narrow Keep Right Sign (R4-7c) or Object Marker may be used for small splitter islands

Intersection Lane-Control Sign Arrow Options

Used at multilane roundabouts to utilize left, through, and right movements

Required for approaches with double left-turn or double right-turn lanes

WARNING SIGNS

Warning signage for roundabouts is directly related to the intersection's location and approaching speeds.

W2-6

Circular Intersection Sign (W2-6)

To be installed on each roundabout approach to give advance notice

Universal and easily recognizable symbol

W11-2

Pedestrian Crossing Sign (W11-2)

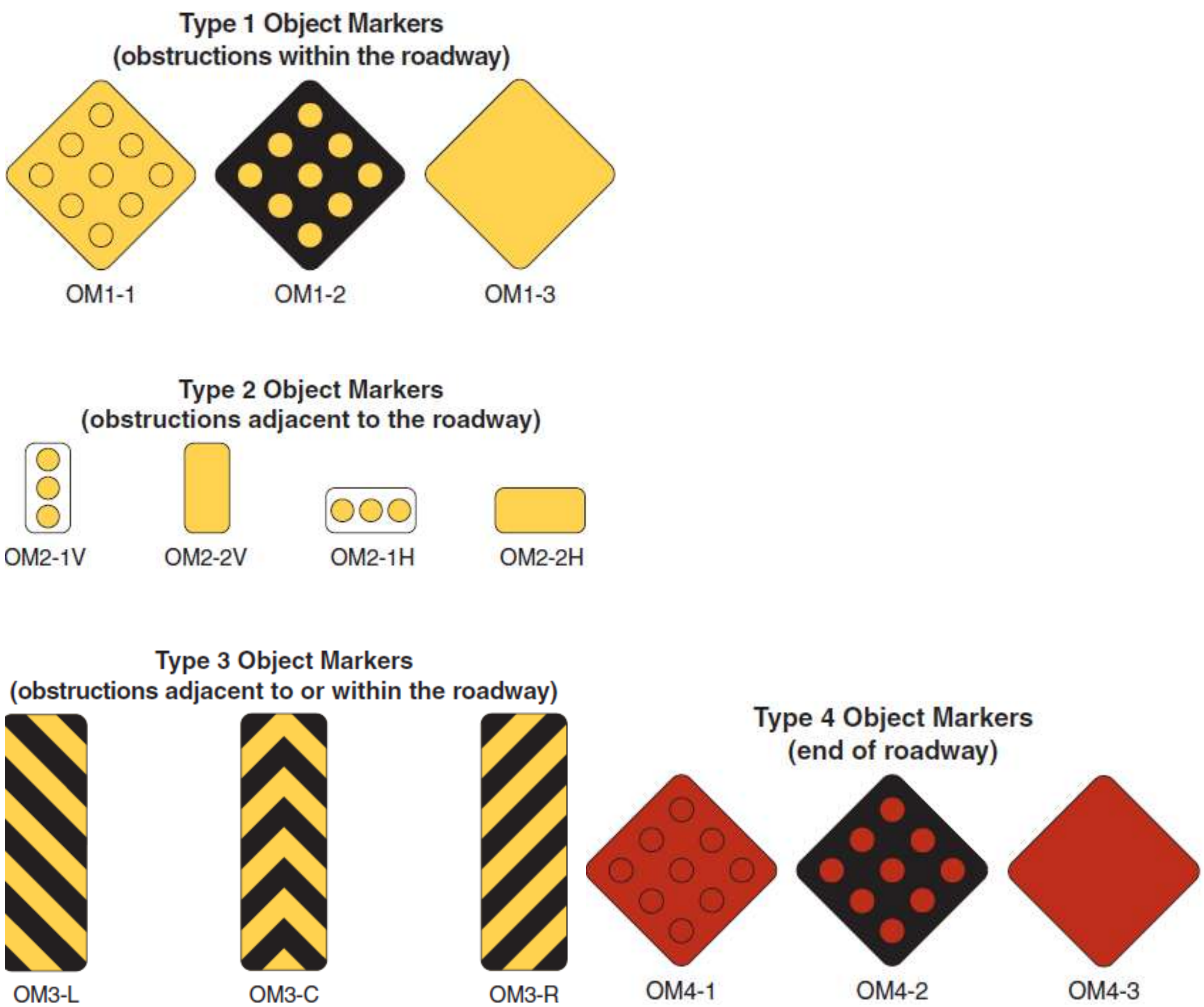
May be used for crossings at roundabout entries and exits

Can be supplemented with Diagonal Downward Pointing Arrow Plaque (W16-7P)

W3-2

Yield Ahead (W3-2)

Recommended to be used to provide advance notice on approaches for special cases



Object Markers

Used at nose of non-mountable splitter island in addition to or instead of Keep Right signs

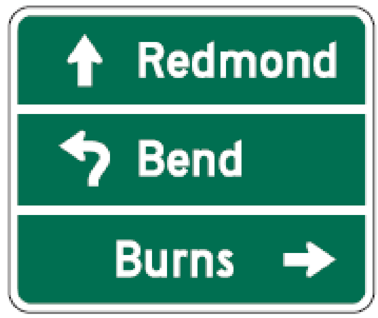
Reduces clutter and improves sign visibility

Type 3 Object Markers are more appropriate for narrow splitter islands

GUIDE SIGNS

Guide signs for roundabouts provide navigational information to motorists.

D1-2d

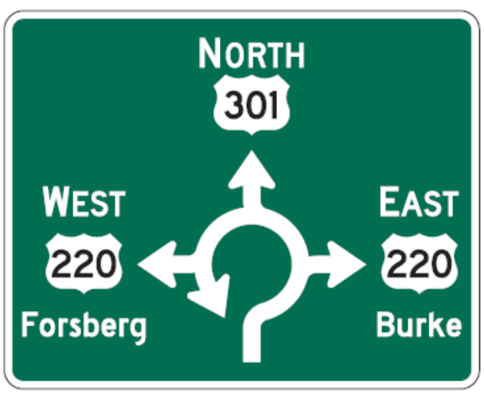


D1-3d

Text Exit Destination Signs (D1-2d, D1-3d)

May be used on approaches to show destinations for each exit

Curved arrows may be used for left-turns



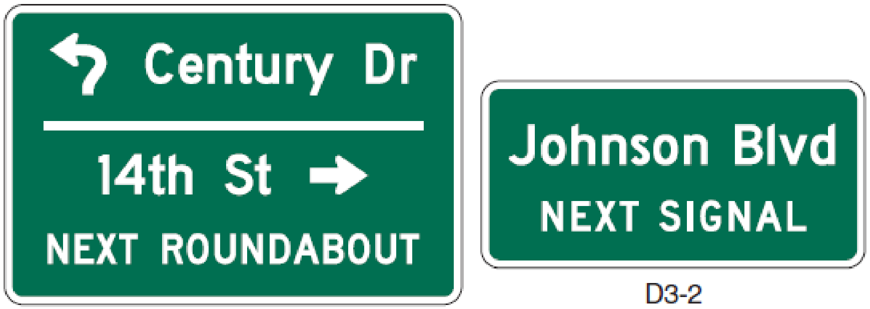
D1-5

D1-5a

Dragrammatic Exit Destination Signs (D1-5, D1-5a)

Used similar to Text Exit Destination Signs

Arrows can be used to show each leg and their angles



D3-2

Advance Street Name Signs (D3-2)

Can be used prior to roundabouts to inform users of next street intersection

Advance Street Name Plaques (W16-8 or W16-8a) may be placed with Circular Intersection Sign (W2-6) as an alternative

D1-1d

D1-1e

Exit Guide Signs (D1-1d, D1-1e)

Used to designate roundabout exit destinations

Placed either on exit's right-hand side or in splitter island

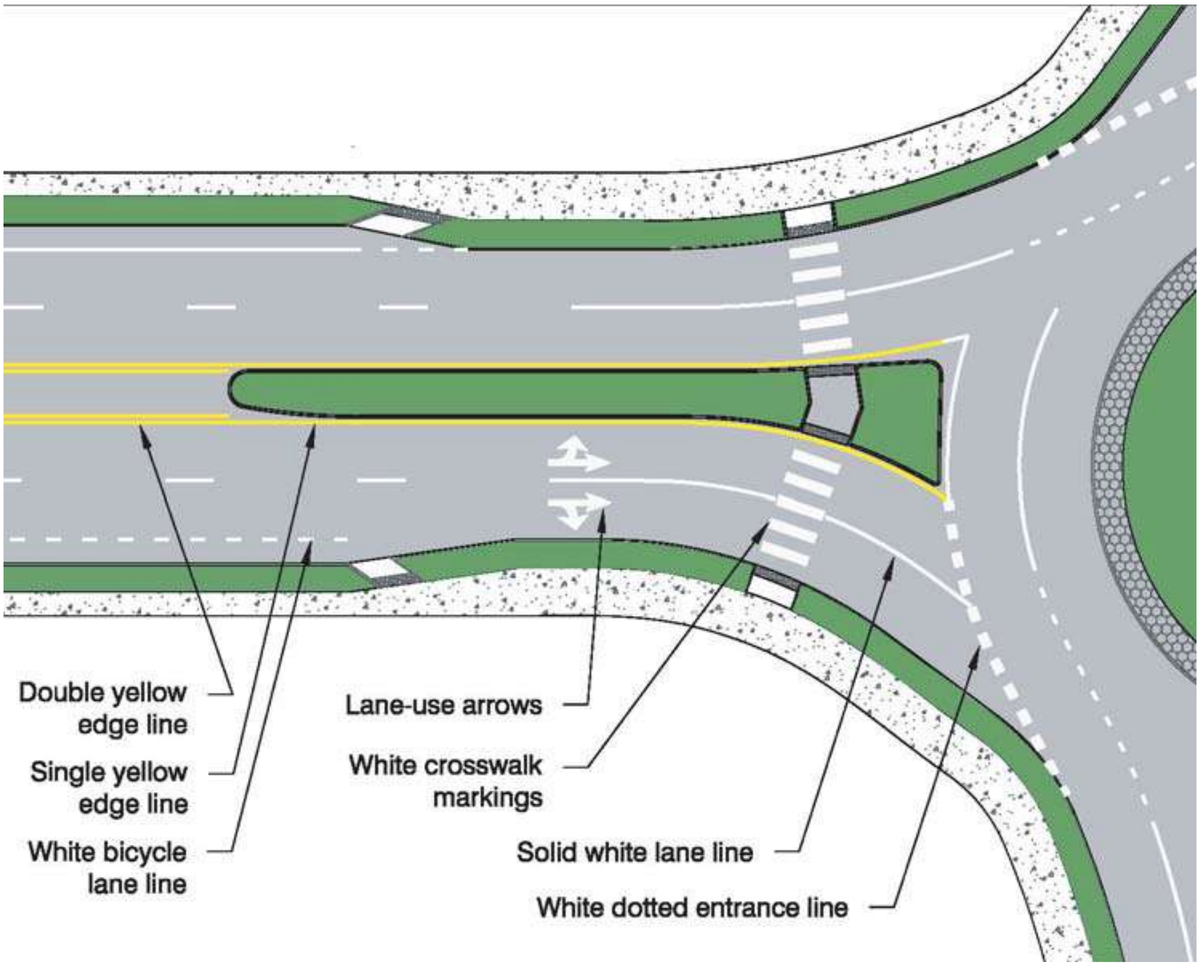
Pavement Markings

Pavement markings are used to delineate travel paths within roundabouts (entrances, exits, circulatory roadway, etc.) and provide guidance for the user.

APPROACH & DEPARTURE PAVEMENT MARKINGS

- Lane Lines
- Edge Lines
- Lane-Use Arrows
- Word and Symbol Markings
- Yield Lines
- Crosswalk Markings

Exhibit 7-1
Approach and Departure Pavement Markings
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)



Yellow edge lines should be used along splitter islands on the left edge of entries and exits, as well as the left edge of right-turn bypass roadways.

Double yellow centerline markings should be installed on undivided approaches to splitter islands. These centerline markings should split and taper to the splitter island.

White edge lines may be used on the right side of approaches and departure roadways to enhance driver awareness.

Raised pavement markers can supplement edge lines and provide additional roadway visibility.

White lane lines should be used on multilane approaches and departures to discourage lane changes in the immediate roundabout vicinity.

White channelizing lines are used on approaches and departures for right-turn bypass islands with traffic on both sides.

Bike lane lines on roundabout approaches ahould end in advance of the circulatory roadway (at beginning of taper and a minimum of 100 ft from the roadway's edge). The last 50 to 200 ft of these lines should be dotted to provide advance warning of required merging maneuvers.

Lane-use arrows are crucial at roundabouts for directing users to their appropriate lane. These markings should be installed at approaches with double left-turn or double right-turn lanes as well as at other locations to improve lane utilization. The arrows should be installed far enough in advance of the roundabout to give users adequate selection time for their path of travel. These markings may be repeated to encourage proper approach lane selection.

Left-turn arrows should be included wherever lane-use arrows are used on approaches. This pavement marking combination will encourage proper lane use by drivers.

Pavement Word and Symbol Markings

ONLY word marking

May be used with lane-use arrows in single movement lanes

Route numbers, destinations, street names, directions

May be used with lane-use arrows, lane-use signs, and guide signs (examples: NORTH, EAST, HWY 58, I-75, US 411)

Yield Ahead symbol or word marking

Can be used on approaches to supplement Yield Ahead sign

YIELD word marking

May be used at entries with Yield sign for additional yield emphasis

Dotted circulatory edge lines should be used as entrance lines across roundabout entrance lanes to emphasize the border between entry and circulating traffic.

Yield lines consist of a series of white solid triangles ("shark teeth") pointing toward approaching traffic. These markings (placed at right angles to the roadway) can be used to supplement entrance lines and enhance yielding requirements.

Crosswalk markings for pedestrians should be used at all crossing locations (entries, exits, right-turn bypasses) for roundabouts. Longitudinal crosswalk markings ("zebra" or "continental") are preferred. Their advantages include: better visibility; less user confusion; and less maintenance.

CIRCULATORY ROADWAY PAVEMENT MARKINGS

- Lane Lines
- Edge Lines
- Lane-Use Arrows

Yellow edge lines (4 to 6 in width) may be used along the circulatory road's inside edge (central island or truck apron). These markings can be used with lane lines for channelizing traffic to appropriate roadway lanes.

White edge lines (normal width) are to be installed on the circulatory roadway's outer edge.

White dotted edge line extensions (12 to 18 in width) across roundabout entries have a typical marking pattern of 2 ft lines with 2 to 3 ft gaps.

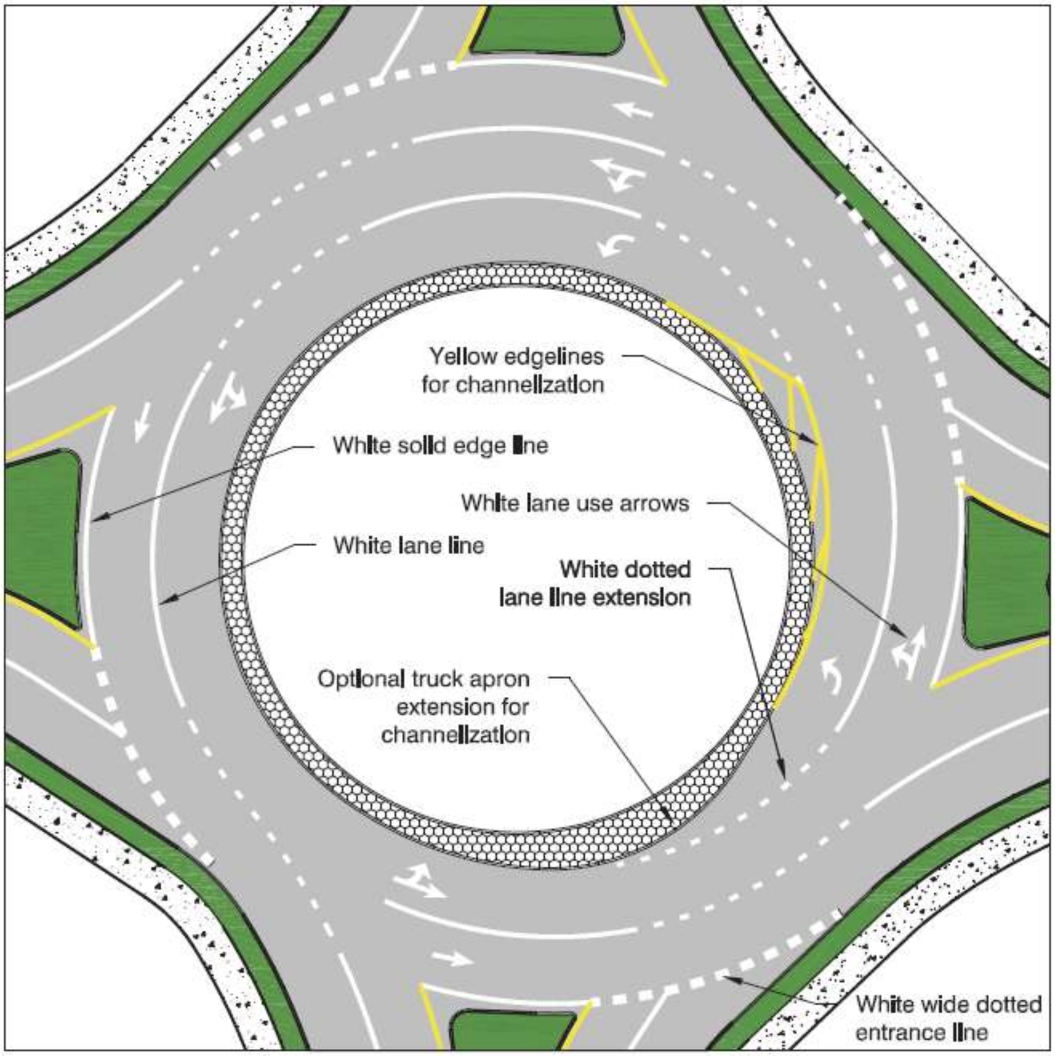


Exhibit 7-8
Circulatory Roadway Markings
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Multilane roundabouts should have ***lane lines*** (4 to 6 in width) within the circulatory roadway for channelizing traffic to their appropriate travel path. The markings on the circulatory roadway should work with approach pavement markings to guide the user.

Lane-use arrows are normally installed in front of the splitter island at the beginning of the circulatory roadway lane line. These markings provide adequate visibility and confirm the driver's lane choice within the roundabout.

CONCLUSION

The modern roundabout is a common intersection application which is becoming increasingly popular in the U.S. As with any intersection, its selection and design requires balancing competing objectives (economics, safety, environmental concerns, operation, accessibility, land usage, aesthetics, etc.). Therefore, it is crucial to provide sufficient flexibility for tailoring the roundabout's design to its particular situation.

The intention of this course was to explain some principles of good roundabout design and show potential trade-offs that may be encountered. By combining these principles with work experience and engineering judgement, the designer may produce plans that greatly benefit the traveling community.

Exhibit 7-17
Circular Intersection Sign (W2-6)
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

LIST OF FIGURES

FHWA. Roundabouts Technical Summary. 2010

Figure 7 – Fastest Vehicle Path Through a Single-Lane Roundabout

FHWA. Manual on Uniform Traffic Control Devices. 2010

Figure 2B-22 – Example of Regulatory and Warning Signs for One-Lane Roundabout

Regulatory Signs Warning Signs Guide Signs

Google Earth

Figure 25 – Chickamauga Dam Roundabouts

Minnesota Department of Transportation

Exhibit 3-24

Example of General Informational Brochure

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

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