1 - Plan Preparation Considerations

The overall concept of roundabout plan preparation is similar to other intersection types. The designer should provide the following plan information when designing roundabouts.

1.1 - Alignment Plans

The designer can place an alignment at many locations through out the roundabout, and should make the alignment location consistent with other areas of the plan. When locating an alignment near a roundabout the designer should consider the following locations:

- Along the flange line of the splitter islands and central island curb and gutter
- Through the center of the splitter islands and central island.
- Dual alignments along each flange line of the curb and gutter at the splitter island and central island.
- One main alignment as noted above with supplemental layout alignments around the splitter islands and outside curb lines.

1.2 - Profile Information

The designer can place a profile at many locations through the roundabout. As discussed in FDM 11-26-30, the designer should consider that it is generally desirable from a drive-ability and safety perspective to design and construct the circular component of the roundabout in one plane (planar). Therefore the designer should consider placing a profile around the circulatory roadway or ICD to accomplish the planar design. Once the circulatory roadway profile is established the approach and exit leg profiles can be adjusted or best fit to the circulatory roadway profile. This will usually cause some deviation from the main roadway profile near the roundabout. The designer should try to minimize the distance of the adjusted or best-fit profile from the circulatory roadway to the main roadway.

1.3 - Typical Sections

At a minimum, roundabout plans should include typical sections at the following:

- Approach and exit to the roundabout
- Within the splitter island
- Within the central island

1.4 - Plan Details

At a minimum, roundabout plans should include the following plan details:

- Layout details for any alignments utilized for the roundabout
- Layout details for any cross walks and bike ramps if utilized
- Elevation or joint details
- Storm sewer plans
- Landscaping and erosion control plans
- Permanent signing plans
- Lighting plans
- Pavement marking plans

1.5 - Cross Sections

The plans should include a sufficient number of cross sections through the roundabout to allow for accurate construction of the roundabout.

1.6 - Example Plan Sheets

Several example plan sheets of the above information have been provided as an aide to the designer when completing roundabout plans. The plan sheets provided are examples and should only be used as guidance.

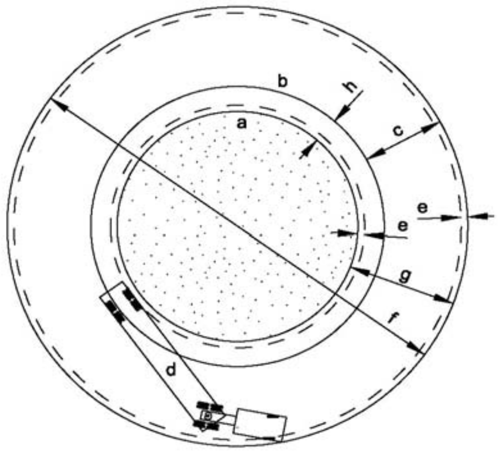
Designers are not required to follow these examples. FDM 11-26-50, pdf1 is a .pdf of the various plan sheets. The PDF attached has bookmarks for the various plan sheets as noted above to assist you in viewing the sheets.

- Example 1: Project Overview
    - Example 2: Typical Section
    - Example 3: Pavement Elevation (Concrete)
    - Example 4: Pavement Elevation (Asphalt)
    - Example 5: Erosion Control
    - Example 6: Storm Sewer
    - Example 7: Landscaping
    - Example 8: Permanent Signing
    - Example 9: Permanent Signing (Interchange)
    - Example 10: Lighting
    - Example 11: Pavement Marking
    - Example 12: Construction Staging
    - Example 13: Construction Details (1 of 2)
    - Example 14: Construction Details (2 of 2)
    - Example 15: Plan and Profile
    - Example 16: Cross Section

2 - Truck Apron Sizing

Figure 1 can be used as a guide to truck apron sizing but is not a substitute for AutoTurn.

Typical Circulatory Turning Widths for Normal Roundabouts



Legend

- a Raised vertical curb face at central island.
- b Low profile mountable curb at apron.
- c Remaining circulatory roadway width is 1.0 - 1.2 times the maximum entry width.
- d Design vehicle.
- e 2 feet clearance from wheels based on desirable 'c' values.
- f Inscribed circle diameter (ICD).
- g Width between curbs (face to face).
- h To obtain a circulatory roadway width for single lane roundabouts that allows a bus not to need the truck apron, determine 'g' for a truck then subtract 'g' for the bus to obtain the truck apron width (h).

Circulatory Turning Widths (g) for Normal Roundabouts (feet)				
Inscribed Circle Diameter (ft)	Design Vehicles (d)			
	CITY - BUS	Wb-50 Truck	Wb-65 Truck	Wb-67 Truck
100	20.0	32.5	N/A	N/A
110	19.0	30.0	N/A	N/A
120	18.5	27.5	39.0	42.0
130	18.0	26.0	36.0	38.0
140	17.5	24.5	33.5	35.5
150	17.0	23.5	31.5	33.0
160	17.0	23.0	30.0	31.5
170	16.5	22.0	28.5	30.0
180	16.5	21.5	27.5	28.5
190	16.0	21.0	26.5	27.5
200	16.0	20.5	25.5	26.5
210	16.0	20.0	24.5	26.0

The values provided in this figure are for general guidance. They are not intended to be strict standards that ensure good design.

Figure 1. Truck Apron Sizing

3 - Creating Roundabout Fastest Paths (Spline Curves)

Spline curves can be created in both Microstation and AutoCAD. In AutoCAD, they are called polylines and in Microstation they are called B-spline curves. The following steps are for creating a B-spline curve in Microstation version 8.

Step 1: Copy Curb Offsets

Create the curb offsets as shown in FDM 11-26-30, Figure 2 using the move/copy parallel function.

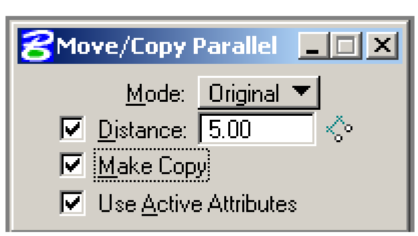


Figure 2. Move/Copy Parallel

A. 5' from left side face of curb (or 3' from painted C/L or flange line of curb & gutter) on each approach.

B. 5' from face of curb on driver's right side at each entry and exit.

C. 5' from central island face of curb. Face of curb for the Type R and T is 6-inches from the back of curb.

D. Not less than 165' from roundabout Inscribed Circle Diameter (ICD). Typically this distance may be 165' but could be more depending on how a driver would approach the yield line at high speed. *"To determine the speed of a roundabout, the fastest path allowed by the geometry is drawn. This is the smoothest, flattest path possible for a single vehicle, in the absence of other traffic and ignoring all lane markings, traversing through the entry, around the central island and out the exit" (R1).*

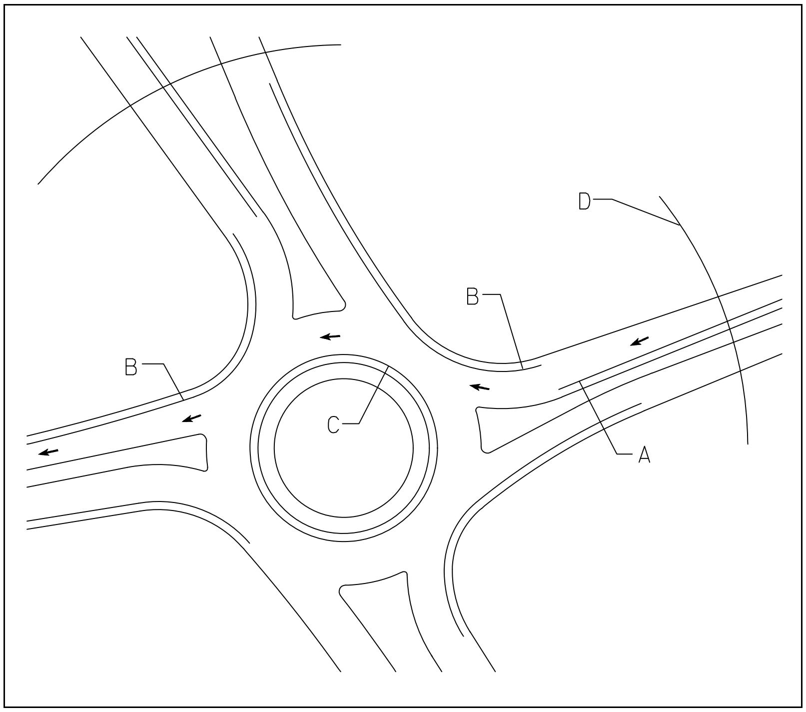


Figure 3. Offsets for Fastest Path

Step 2: Draw Spline Curve

There are a couple different ways to set up spline functions as shown below:

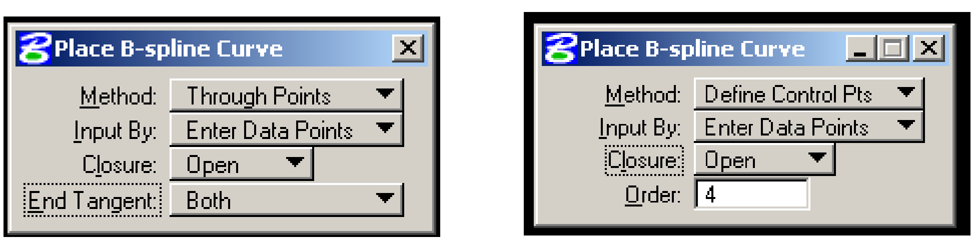


Figure 4. Place B-spline Curve

Draw the spline curve for the through movement as shown below, using "near" snaps for all points picked:

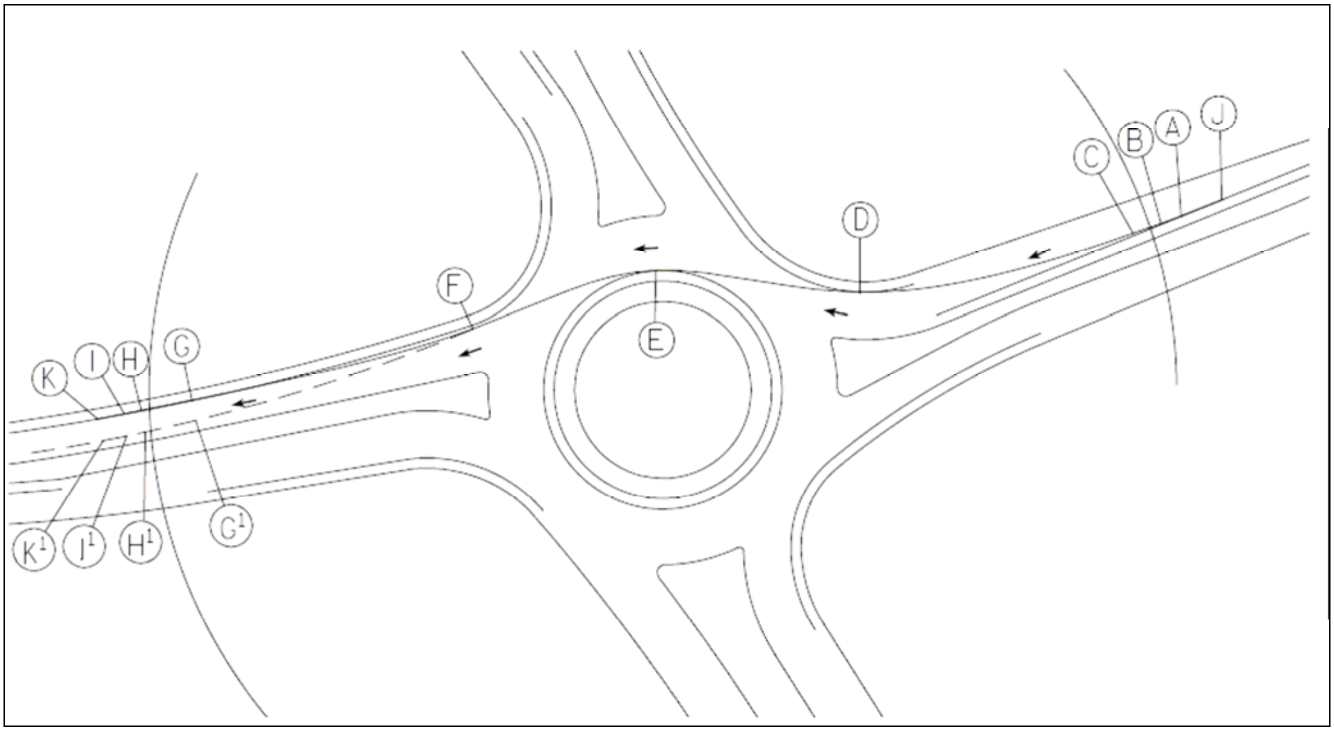


Figure 5. Spline Curve through movement

Clicking sequence:

1. Choose points A through C on the first 5' curb offset from splitter island (tentative snap, then left click to accept). Choose 3 points that are approximately 5 feet apart that will approximate the path of an approaching vehicle. It is advisable to choose two points outside of the 165' line and one inside the 165' line.
2. Choose point D on the 5' curb offset from entry curve (tentative snap, then left click to accept).
3. Choose point E on the 5' curb offset from central island (tentative snap, then left click to accept).
4. Choose point F on the 5' curb offset from exit curve (tentative snap, then left click to accept).
5. Choose points G through I, or G^1 through I^1,on the 5' offset from the right side exit curb (tentative snap, then left click to accept). There may be times when it is appropriate to check the left side instead of the right side. The side is dependant on the anticipated driving path of the vehicle and the roadway alignment. Choose 3 points that are approximately 5 feet apart that will approximate the path of an exiting vehicle. Two points should be outside the 165' line and one point inside of the 165' line.
6. Right click to end the spline curve. MicroStation will then "jump" back to the start of the curve.
7. Snap to a point just upstream from the start of the spline at point J (tentative snap, then left click to accept). This forces the beginning of the spline to be tangent to the splitter island curb.
8. Microstation will then "jump" to the end of the curve.
9. Snap to a point just downstream from the end of the spline at point K (tentative snap, then left click to accept). This forces the end of the spline to be tangent to the splitter island curb.

Step 3: Modify Spline Curve

Check the spline created in Step 2 above to see if it violates the 5' curb offsets. This can be done two different ways. One with the "Measure Distance" tool using the "Minimum Between" function. Measure the distance between the face of curb and the spline curve at points A through I shown above.

Figure 6. Measure Distance

The second is to zoom into the areas of points A through I and visually inspect whether the spline curve violates the curb offsets.

In most cases, the spline may slightly violate the 5’ curb offset. Use engineering judgment to determine if the spline will need to be modified. As shown, the spline should be modified.

Modify the spline:

If the spline is between the curb offset and the curb or outside of the curb offset, it will need to be modified.

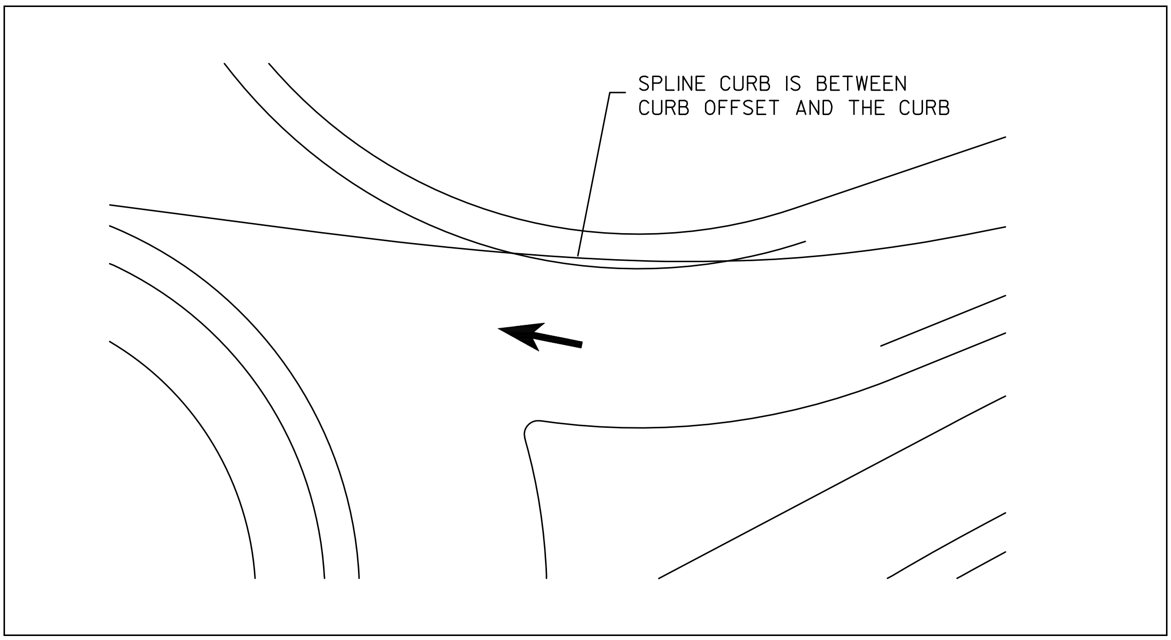


Figure 7. Spline curve between curb offset and the curb

Using the tool ‘Modify Element’ shown below grab the spline curve and pull it to a desired location on top of the curb offset. This may need to be done a few times before the spline is on top of all the curb offsets.

Figure 8. Modify Element

Evaluate the spline as a whole to see if it “looks” like it is the path that a vehicle would use. Oftentimes, the beginning or end of the spline may need to be pulled further away from the roundabout itself.

Step 4: Measure R-values

1. Once an acceptable spline is created, fit arcs to the spline to measure the R-values using the “Place Arc” tool with the “Edge” method.

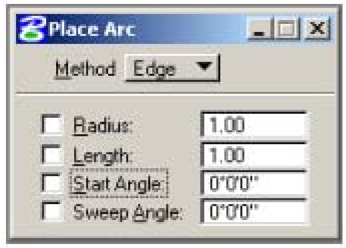


Figure 9. Place Arc

2. Using "Near" snaps, fit an arc onto the spline at a point that appears to be the tightest portion of the spline. This should occur prior to the yield line and not more than 165' from the yield line.
3. Check the length of the arc. Per FDM 11-26-30, Figure 2 if the arc is not 65 to 80 feet long, recreate it to try to get an arc that is 65 to 80 feet long.
4. Measure the radius of the arc.
5. Repeat to find R-values for R-1, R-2, and R-3.
6. To find R-4, simply measure the radius of the 5' curb offset from the central island.
7. To find R-5, create a spline that is tangential to the three curb offsets that define the R5 path (the 5' splitter island offset on the entry, the 5' offset on the inside of the right turn, and the 5' splitter island offset on the exit). Check that the arc does not cross any curb offsets, especially when the geometry of the right turn movement is created with multiple arcs. Below is a diagram of a typical R5 spline.

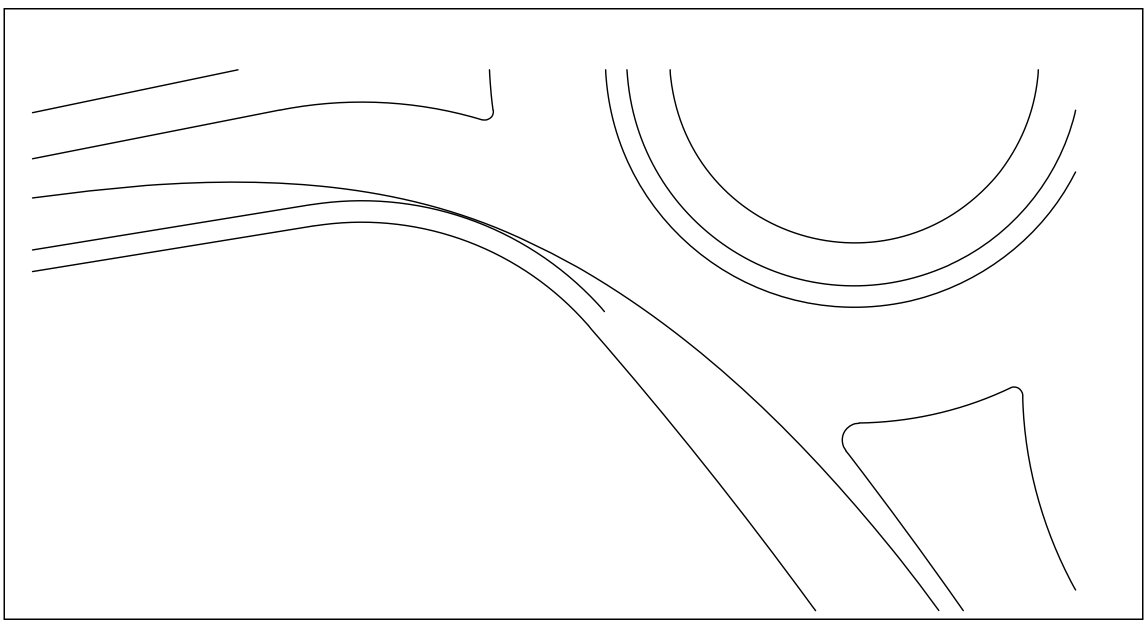


Figure 10. Example R5 Spline

4 - Guide for Using AutoTURN Version 5.1 in Microstation Version 8

This is a guide for the basics of driving a truck or automobile through a roundabout using AutoTURN Version 5.1 in microstation. Please refer to the AutoTURN user's manual for further information on other options.

Below is a step-by-step demonstration of driving a truck through a roundabout

- Once AutoTURN has been loaded, the toolbar below should appear on the screen. A few operational devices have been labeled in the graphic below.

Figure 11. AutoTURN Toolbar

- Select device labeled 1, the AutoTURN: Simulation Properties box should show up. Select Envelopes from the select category box and the screen should be similar to the one below.

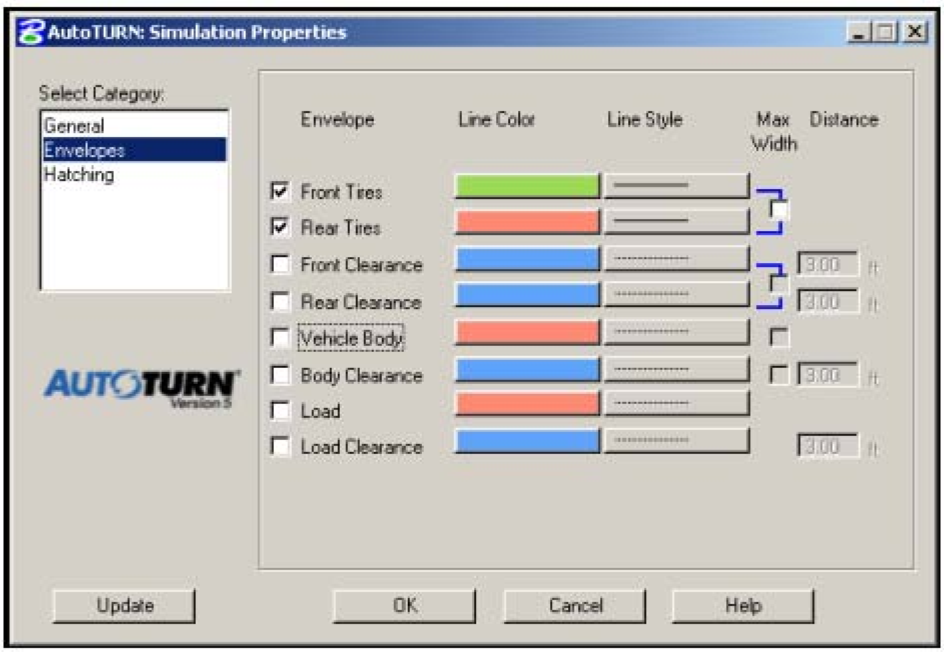


Figure 12. AutoTURN Simulation Properties

- Once in this screen, toggle on the boxes for front tires and rear tires. This will give an accurate envelope for the outside paths of the tires. Other envelopes can be toggled on/off as needed.
- Select device labeled 2
    - Use this device to choose the correct group and correct design vehicle
    - Below is an example of the WB-65 design vehicle. Note the difference in size from the WisDOT WB-65 design vehicle. AASHTO requires 43.50 ft from king pin to rear axel, WisDOT only requires 43.00 ft. Leave as 43.50 ft to be slightly conservative.

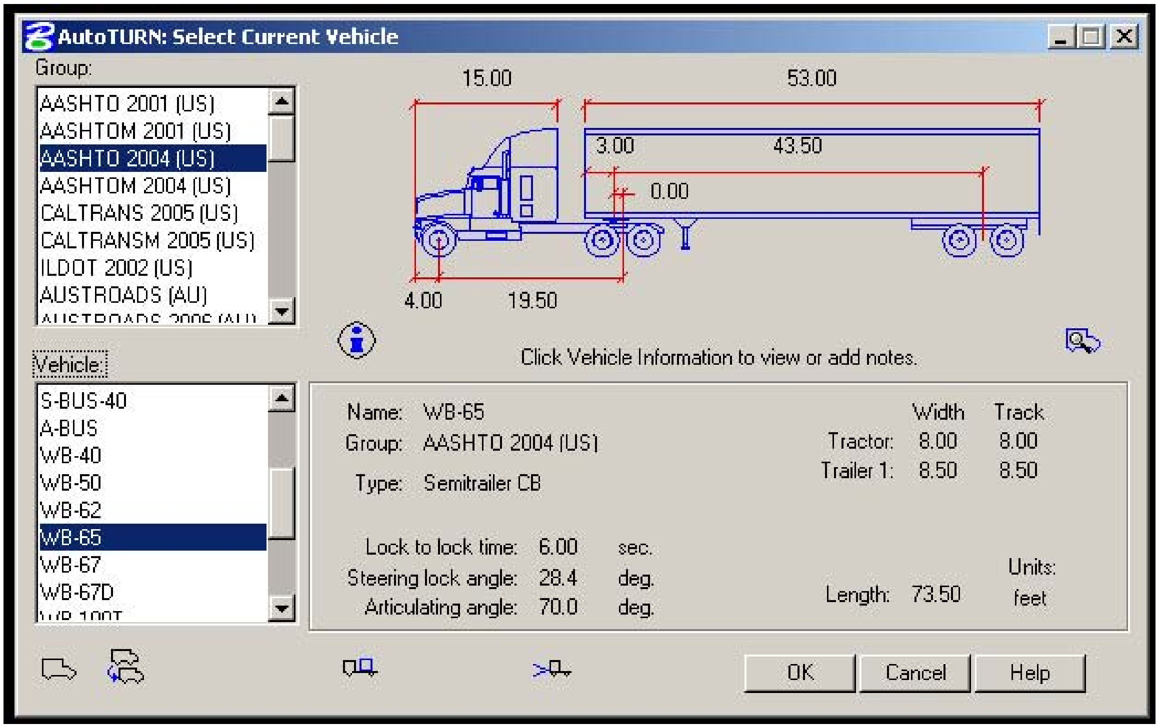


Figure 13. AutoTURN Select Current Vehicle

- Once the correct vehicle is highlighted, select device labeled 3.
    - A top-view of the design vehicle should show up on the microstation display. That view should look similar to the graphic below.

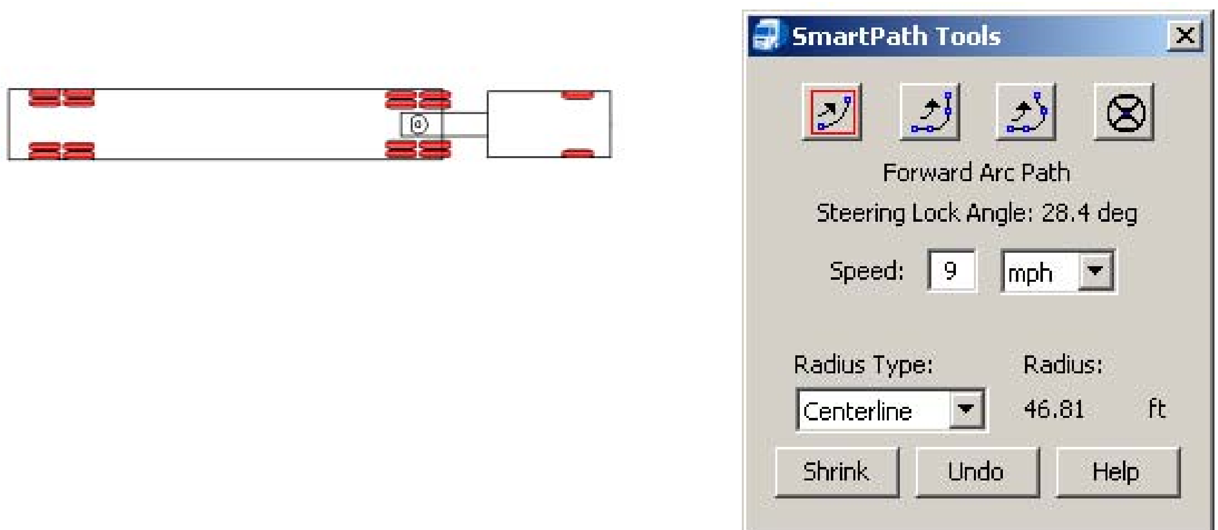


Figure 14. Selected Design Vehicle

- With the design vehicle loaded, select the correct placement for the start of the arc path. The starting point should be prior to the roundabout entrance at a proper angle a truck would be driving if it were approaching a roundabout.
- The box to the right will pop up, use this box to input a reasonable speed (6mph minimum and 9mph desirable) for a driving truck. There may be rare situations where the speed will be below the minimum. AutoTURN sets the steering lock angle.
- Begin to the steer the vehicle through the entrance making sure the truck tires do not go onto the gutter pan at any point.
- Continue to steer the vehicle through the circular roadway of the roundabout avoiding the gutter pans.

The truck apron should only be used by the rear trailer tires for through and left turn movements. The vehicles front tires should not use the truck apron for any movement.

- Continue steering the vehicle until it exits the circular roadway at the correct exit.
- A completed right turn movement is shown in the two graphics below.

Multilane roundabouts can be designed in two different ways to accommodate large trucks. One way to design a multilane roundabout is to assume a truck will use two lanes to enter, circulate and exit the roundabout, as shown be below.

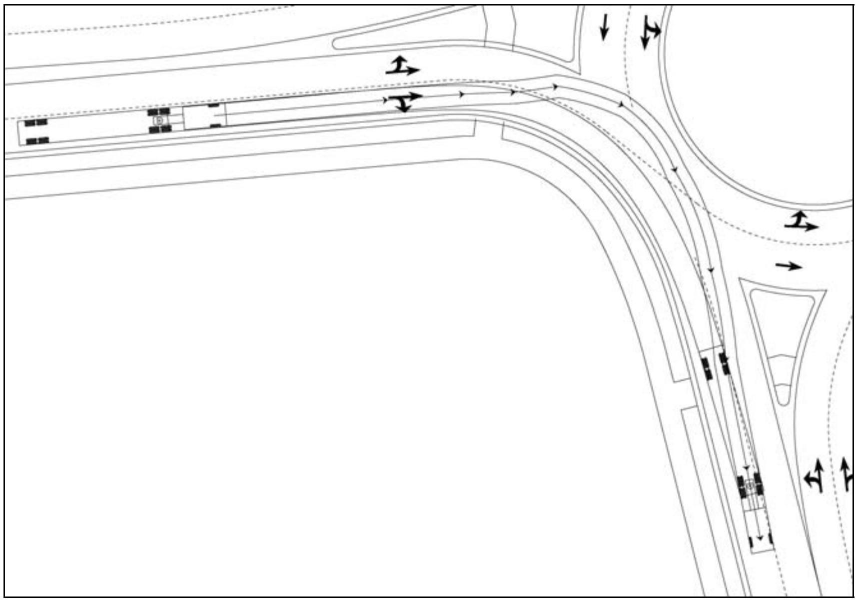


Figure 15. AutoTURN Right turn Movement

Alternatively, a roundabout can be designed so that trucks can remain in one lane as they traverse the intersection. This approach is less commonly used since overall geometry must be larger, possibly resulting in increased ROW needs, higher cost, and a potential for increases in certain types of crashes. An example of this design is shown below. This example utilizes a truck hatching area to allow the truck to make the right turn without encroaching on the adjacent left lane.

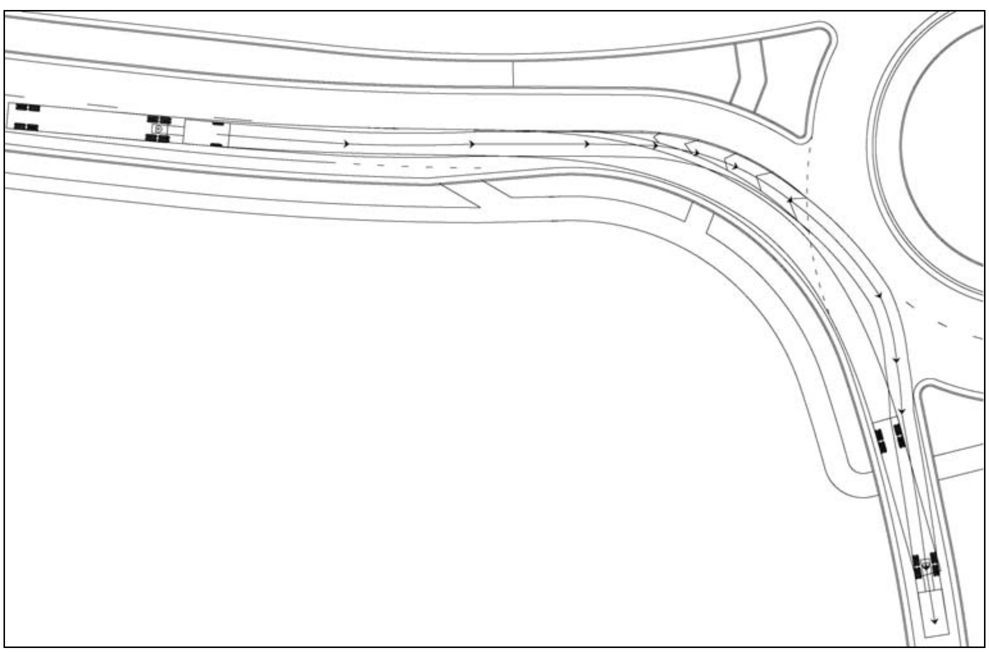


Figure 16. AutoTURN Right turn Movement w/truck hatching

AutoTURN is also a tool utilized for evaluating the size of a truck apron needed at roundabouts. As shown below, when a left turn movement is utilized in AutoTURN the rear wheel path of the truck movement provides guidance for determining the central island truck apron width.

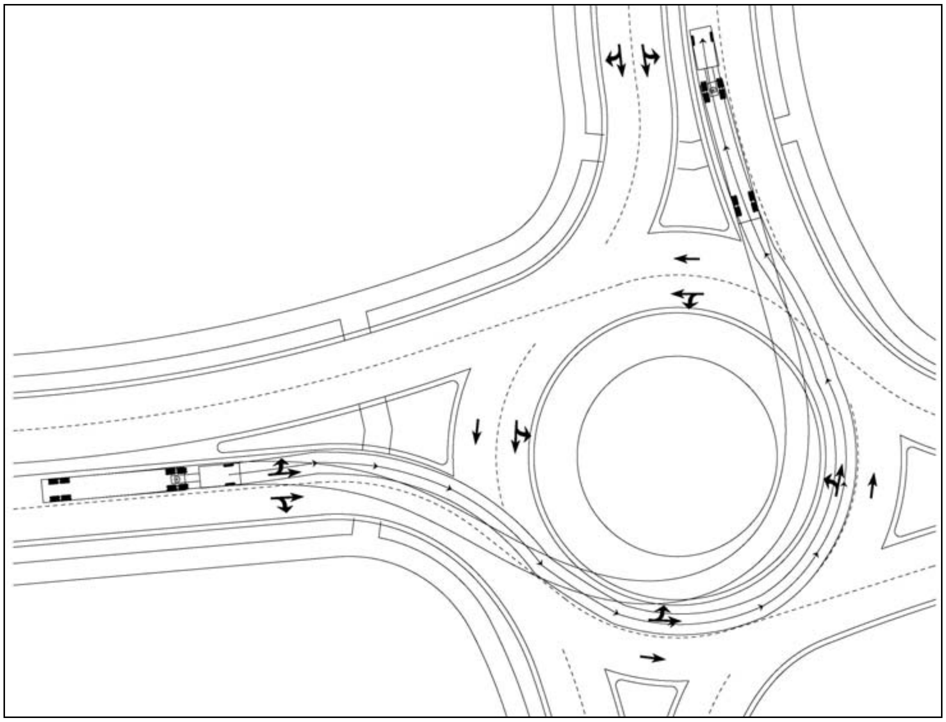


Figure 17. AutoTURN Left turn Movement

5 - RODEL, Stop Delay Verses Total Delay

Please note that most versions of RODEL software (which is used for WisDOT's roundabout evaluations) report roundabout delay as "stop" delay. Stop delay includes only the time when a vehicle is actually stopped while waiting to enter an intersection. This is the way that the Highway Capacity Manual (HCM) reported delay for signalized intersections in the 1985 edition.

Most software that is used today to evaluate intersections controlled by traffic signals reports delays in the form of "control" delay. This is the way the Highway Capacity Manual (HCM) reports delay for signalized intersections in the current 2000 edition.

Control delay is a portion of the total delay including initial deceleration delay, queue move-up time, stopped delay and final acceleration delay. Total delay then includes both control delay and "geometric" delay which is the time that is lost as a vehicle maneuvers through the intersection.

In rare cases where total delay is used/reported for an intersection with a traffic signal or stop control, total delay for a roundabout at the same intersection can be calculated to provide a reasonable estimate by adding the approximate geometric delays found in Table 1 to the control delay reported from RODEL (all versions of RODEL except version 1.9.2 report control delay – version 1.9.2 reports total delay which includes geometric delay, so the geometric delays in Table 1 should not be added to the delay reported from version 1.9.2.).

At roundabouts, the size of the Inscribed Circle Diameter (ICD) has little effect on geometric delay. The approach speed is more important, because the extra distance required to travel around a larger ICD is essentially offset by the faster circulating speed. When comparing traffic operations of a roundabout concept against other intersection types, the main criteria considered should be average seconds of control delay rather than level of service (LOS). LOS can be provided for informational purposes if desired. Control delay should be used when conducting cost/benefit analysis.

Table 1. Geometric Delay For Roundabouts

Road Approach Speed (MPH)	Average Geometric Delay per Vehicle (add to RODEL delay to get total delay)
30	9 seconds
40	12 seconds
50	14 seconds
60	16 seconds

When evaluating a roundabout with other intersections nearby, it is extremely important to assess the interaction of the intersections. Chapter 8 of the FHWA Roundabout Guide provides additional information on this topic. This assessment should take into consideration queue lengths, lane utilization, the distance between the intersections,

6 - Lane Balance

Lane balance and utilization is tested at multilane roundabouts for both peak hours after the geometry has initially been identified. By default, the current version of RODEL assumes equal utilization of all entry lanes at a multilane roundabout. In some situations, incorrect lane assignments (i.e., right, through, left) will affect lane utilization enough to result in significant unbalanced lane use, long delays, and long queues. Therefore, once roundabout geometry is identified at multilane roundabouts, it is important to analyze lane usage by manipulating the "capacity factor" function in RODEL. This will result in identification of proper lane assignments and should be reflected in the concept design. Users need to toggle from the "flow factor" to the "capacity factor" by using the F4 key to test lane balance and identify lane assignments. Once the capacity factor has been enabled, this value should be changed from the default 1.00 to 0.50 (two-lane entry) or 0.33 (three-lane entry) for the leg to be analyzed. This allows the capacity of one lane to be tested with the peak hour traffic volume for a specific turning movement (i.e., right, through, left). The movement to be analyzed must be isolated by zeroing out the other two movements. If the predicted queues and delays for the movement are acceptable using one lane, then the designer can either assign the lane only for that movement (e.g., "left only", "right only", etc.) or as a combined use which includes that movement (e.g., "left/through", etc.). More than one lane may be needed for the movement (e.g., double left, etc.), if queues and delays are not acceptable. This process can be repeated for each movement and each leg to determine lane assignments for the intersection. Based on these results, the designer can adjust geometry and pavement markings.

7 - Maximum Queue

The "maximum queue" reported by RODEL is the largest total number of vehicles queued on an approach (in all lanes added together) at the end of any one "time slice" during the results period (users should see the RODEL user's manual for more details on maximum queue, times slices, and results period). The maximum queue is calculated using the 50 percent confidence level. Assuming balanced lane use is achieved, the maximum queue in any one lane would theoretically be equal to the maximum queue divided by the number of lanes. Because the maximum queue is defined as the longest queue at the end of the time slices, it is influenced by the number and length of the time slices which are defined by the user. If the default values are changed to include more/shorter time slices, the maximum queue will usually increase because the default 15-minute time slices can mask some of the variation within each time slice. In situations where queue length is a key issue, detailed queue analysis using times slices of one to five minutes is advisable (queue evolution can be viewed in version 1.9.4 of RODEL using the "F6" key). It should also be noted that the maximum queue is quite different from the 95 percent random queue. The 95 percent random queue is determined by the random variation around the average queue and can be considerably longer than the maximum queue. While it may be longer than the maximum queue, the 95 percent queue only occurs five percent of the time, meaning that it takes place a few days per year, usually for only a few minutes during the peak hour.

The maximum queue is one important piece of information, but the longest queue which is actually observed during a peak hour can be considerably longer than the maximum queue predicted by RODEL. This is due to random variation and the use of 15-minute time slices as noted above. In order to minimize the potential for queuing problems, designers should assume that the worst actual observed queue during any peak hour could reach up to two times as long as the maximum queue predicted by RODEL. This is especially important when a roundabout is being designed close to an adjacent intersection or where a queue on a freeway off ramp could potentially back onto the freeway mainline. In some unusual circumstances (e.g., special event traffic, holiday weekend traffic, detoured traffic from another route, etc.), the longest observed queue could be longer than two times the maximum queue.