NORTH CAROLINA
Department of Transportation

Roundabouts Lunch and Learn

Research Standards and Innovation Team

October 17, 2024

Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina

Overview of Today's Presentation:

- NCHRP Report 1043 Breakdown
- High level roundabout decision making
- Safety and Performance checks
- Characteristics of roundabout types
- Horizontal/Vertical design overview
- Examples of NC Roundabouts

Main Roundabout Design Resource: NCHRP 1043: Guide for Roundabouts

A New Go-To Guide for the Planning and Design of Roundabouts

NCHRP Research Report 1043: Guide for Roundabouts supersedes NCHRP Report 672 and presents a performance-based approach to the design of roundabouts. It includes guidance for all roundabouts, including multilane, mini-roundabouts and compact roundabouts. The Guide provides enhanced information on bicycle facilities, pedestrian crossings, traffic control devices, illumination, retrofitting existing roundabouts, and many other aspects of roundabout planning, design, and implementation. It is available to be downloaded here on TRB's website.

Roadway Design Manual — Nov 2023 Revisions

Design Manual Revisions

The following general revisions have been made throughout the Roadway Design Manual:

Section	Summary of General Revision(s)
Cover, title page, footers	Updated revision date to Nov 2023
4.1, 4.14.1	Changed multi-use to shared-use
All	Updated Roadway Standard Drawings and Standard Specifications links
All	Updated Roadway Standard Drawings references to 2024 Standards. Also removed sheet numbers
8.2.4, 8.10, 9.2.2.3	Updated roundabout guidance links from NCHRP Report 672 to NCHRP Report 1043

Guide for Roundabouts (2023)

DETAILS

426 pages | 8.5 x 11 | PDF

ISBN 978-0-309-69840-5 | DOI 10.17226/27069

CONTRIBUTORS

Kittelson & Associates, Inc., Sunrise Transportation Strategies, LLC, Texas A&M Transportation Institute, Kimley-Horn and Associates, Inc., and Accessible Design for the Blind, LLC; National Cooperative Highway Research Program; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

SUGGESTED CITATION

National Academies of Sciences, Engineering, and Medicine. 2023. *Guide for Roundabouts*. Washington, DC: The National Academies Press. https://doi.org/10.17226/27069.

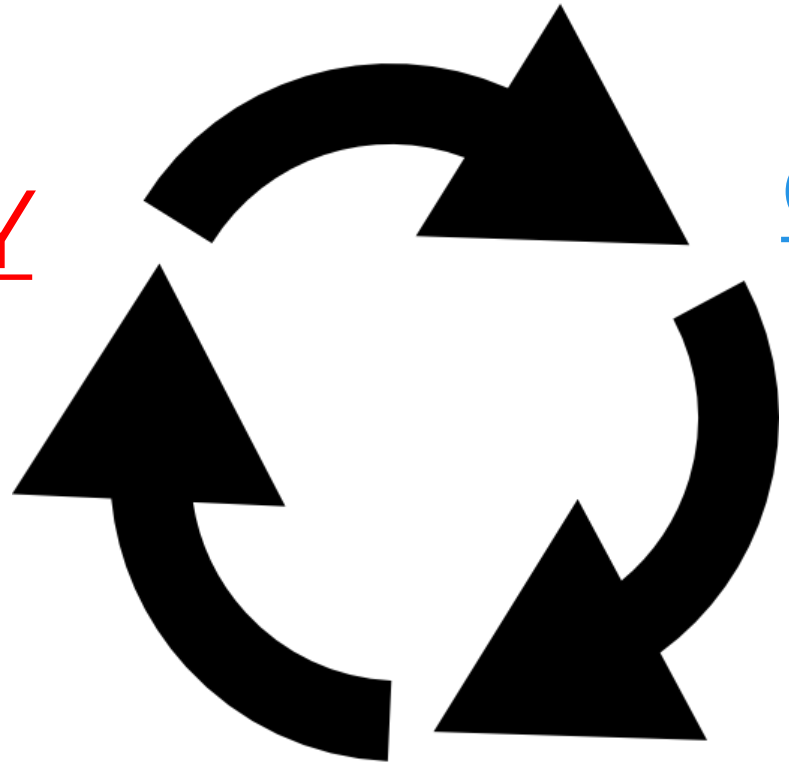
NCHRP 1043: Guide for Roundabouts Breakdown

PROJECT DEVELOPMENT PROCESS

	Part I: Introduction to Roundabouts	**Chapter 1: Introduction** **Chapter 2: Roundabout Characteristics and Applications**
Planning	*Part II: Planning and Stakeholder Considerations*	Chapter 3: A Performance-Based Planning and Design Approach Chapter 4: User Considerations Chapter 5: Stakeholder Considerations Chapter 6: Intersection Control Evaluation
Identify and Evaluate Alternatives	*Part III: Roundabout Evaluation and Conceptual Design*	Chapter 7: Safety Performance Analysis Chapter 8: Operational Performance Analysis Chapter 9: Geometric Design Process and Performance Checks
Preliminary Design	*Part IV: Horizontal, Vertical, and Cross-Section Design*	Chapter 10: Horizontal Alignment and Design Chapter 11: Vertical Alignment and Cross-Section Design
Final Design	*Part V: Final Design and Implementation*	Chapter 12: Traffic Control Devices and Applications Chapter 13: Curb and Pavement Details Chapter 14: Illumination, Landscaping, and Artwork Chapter 15: Construction and Maintenance
Construction, Operations, and Maintenance		
Supplemental Appendix		Appendix: Design Performance Check Techniques

Balancing Roundabout Priorities

SAFETY



OPERATIONS

COST

Contextual Design Considerations

Land Use Influence Project Type Project Context

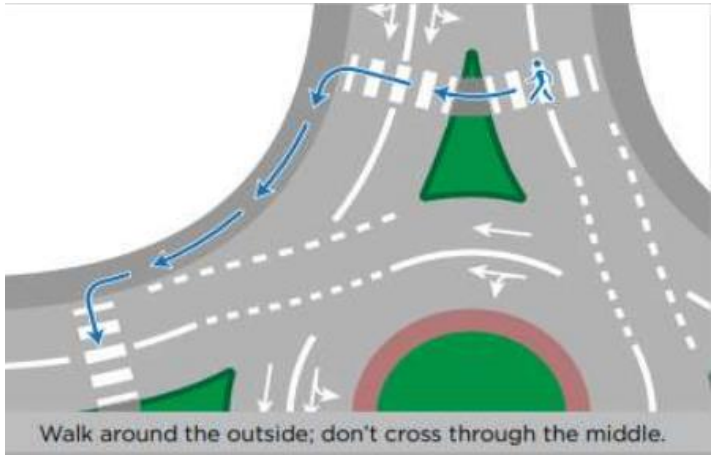
Rural Roundabout

Urban Roundabout

User Considerations

- Users of a roundabout:
  - Pedestrians
  - Bicyclists and Micromobility users
  - Passenger Cars and Motorcycles
  - Large Vehicles/Trucks
  - Emergency Vehicles

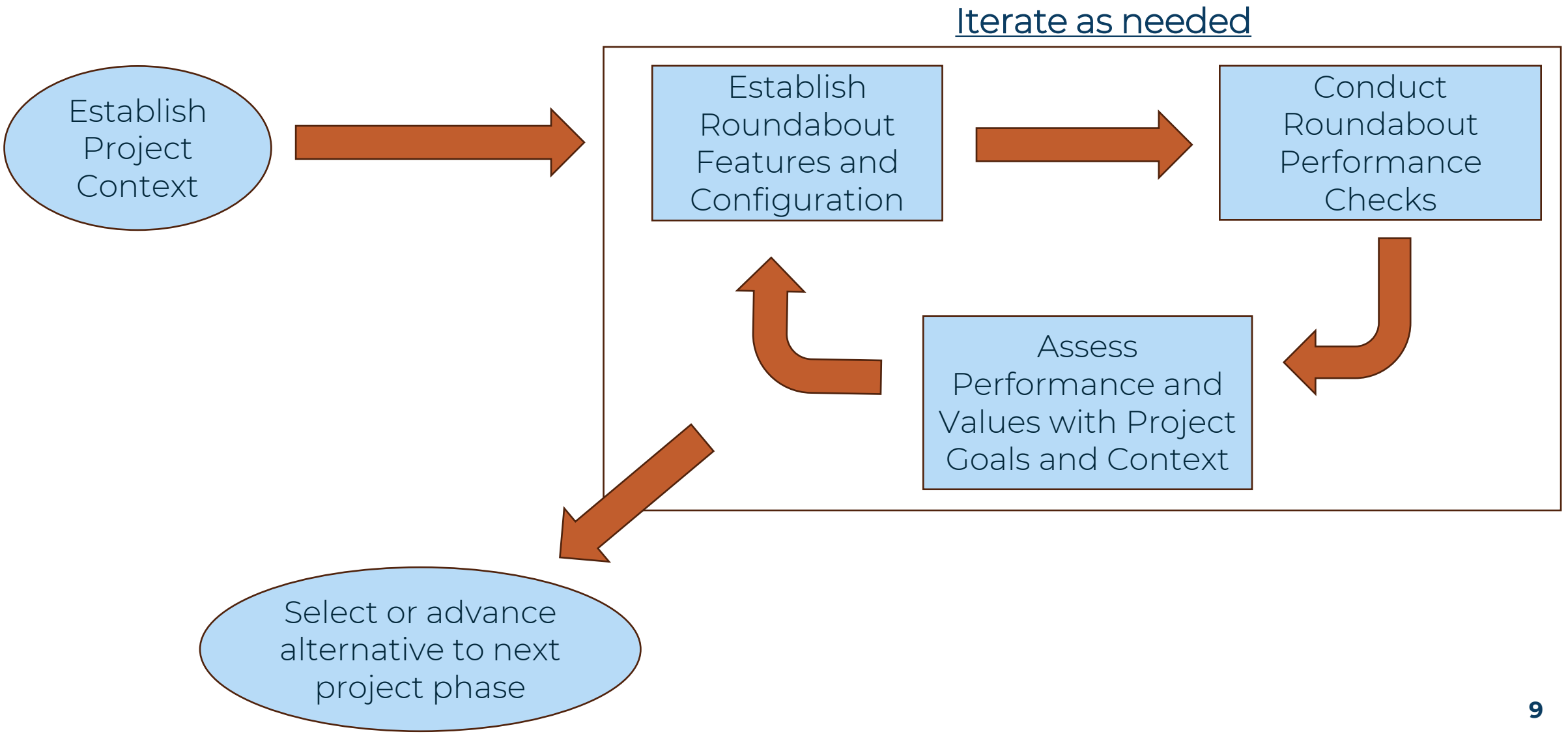
- Pedestrians and Bicyclists are the most vulnerable modes



General Roundabout Design Goals

- Providing adequate vehicle capacity and lanes
- Maintaining speed control and consistency
- Accommodating the design-vehicle
- Integrating all modes expected
- Natural driving paths
- Maintaining proper sightlines
- Holding to driver expectations

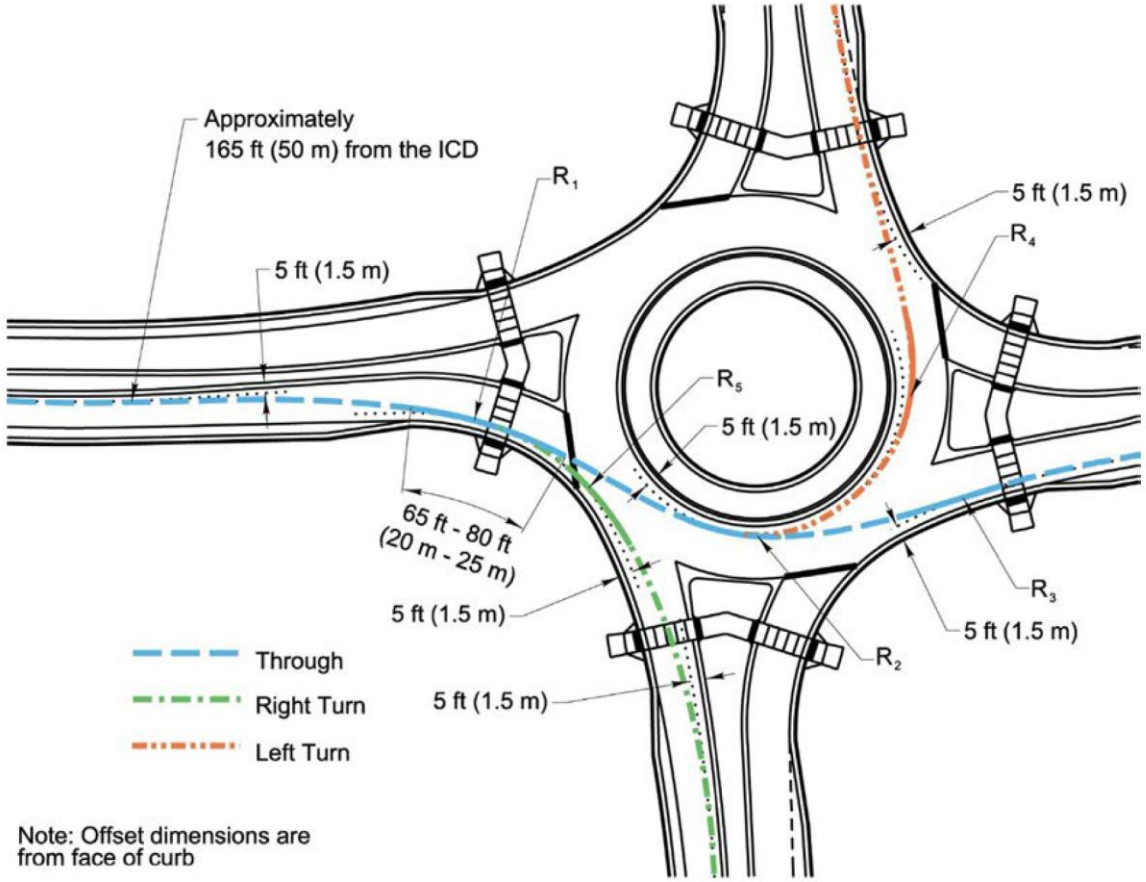
Iterative Roundabout Design Process



Performance Checks

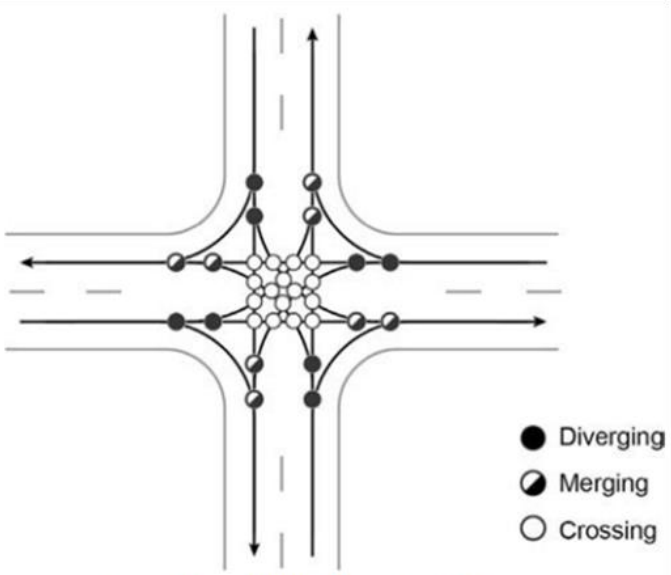
- Geometric Speed Considerations
  - Entry angle
  - Curvature and Radius
  - Deflection Angle
  - Lane Widths
- Design Vehicles
  - Accommodating Different Modes
  - Lane and Apron Design
- Sight Distance
  - Stopping Sight Distance (SSD)
  - Intersection Sight Distance (ISD)
  - Decision Sight Distance
- Vehicle Path Alignment
  - Entry and Exit Path Design
  - Conflict Point Management

Exhibit 9.7. Fastest paths at a single-lane roundabout.



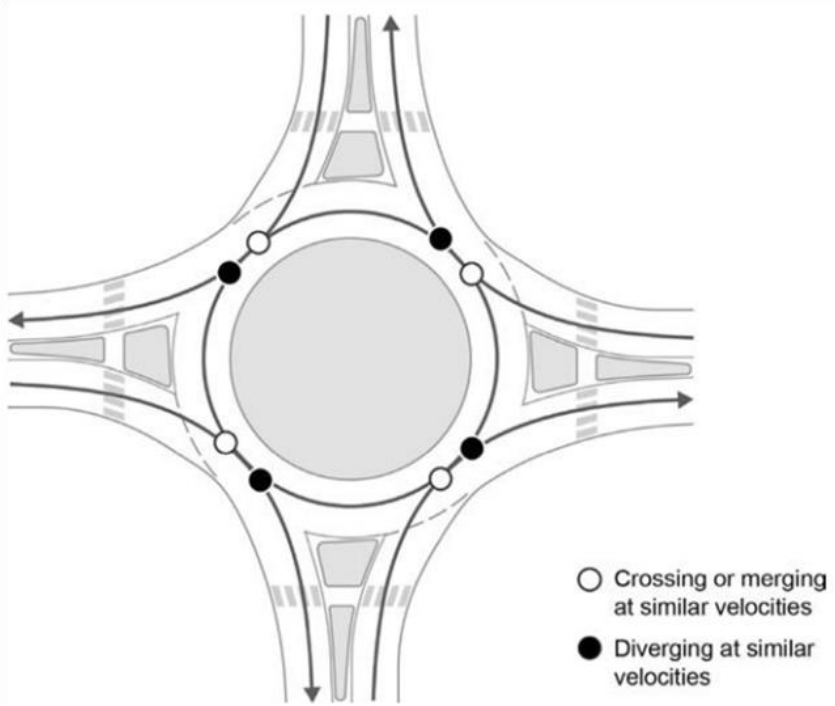
SOURCE: Adapted from Georgia Department of Transportation (*3*).

Safety Performance Analysis – 1 Lane vs 2 Lane Roundabouts



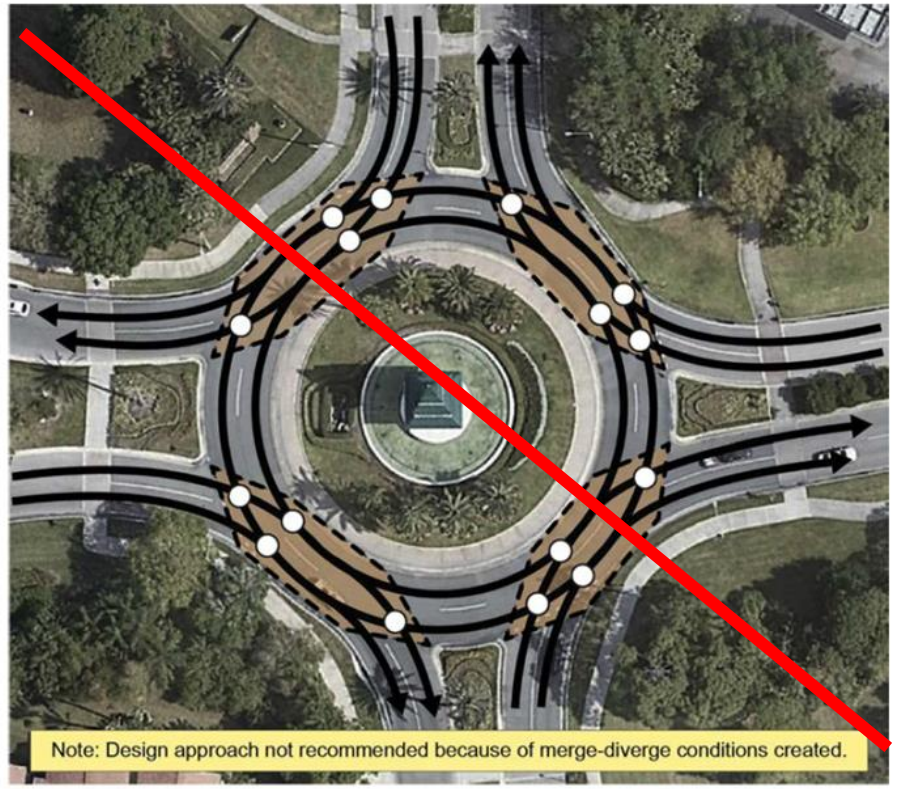
SOURCE: Adapted from *NCHRP Report 672* (5).

32 Conflict Points



SOURCE: Adapted from *NCHRP Report 672* (5).

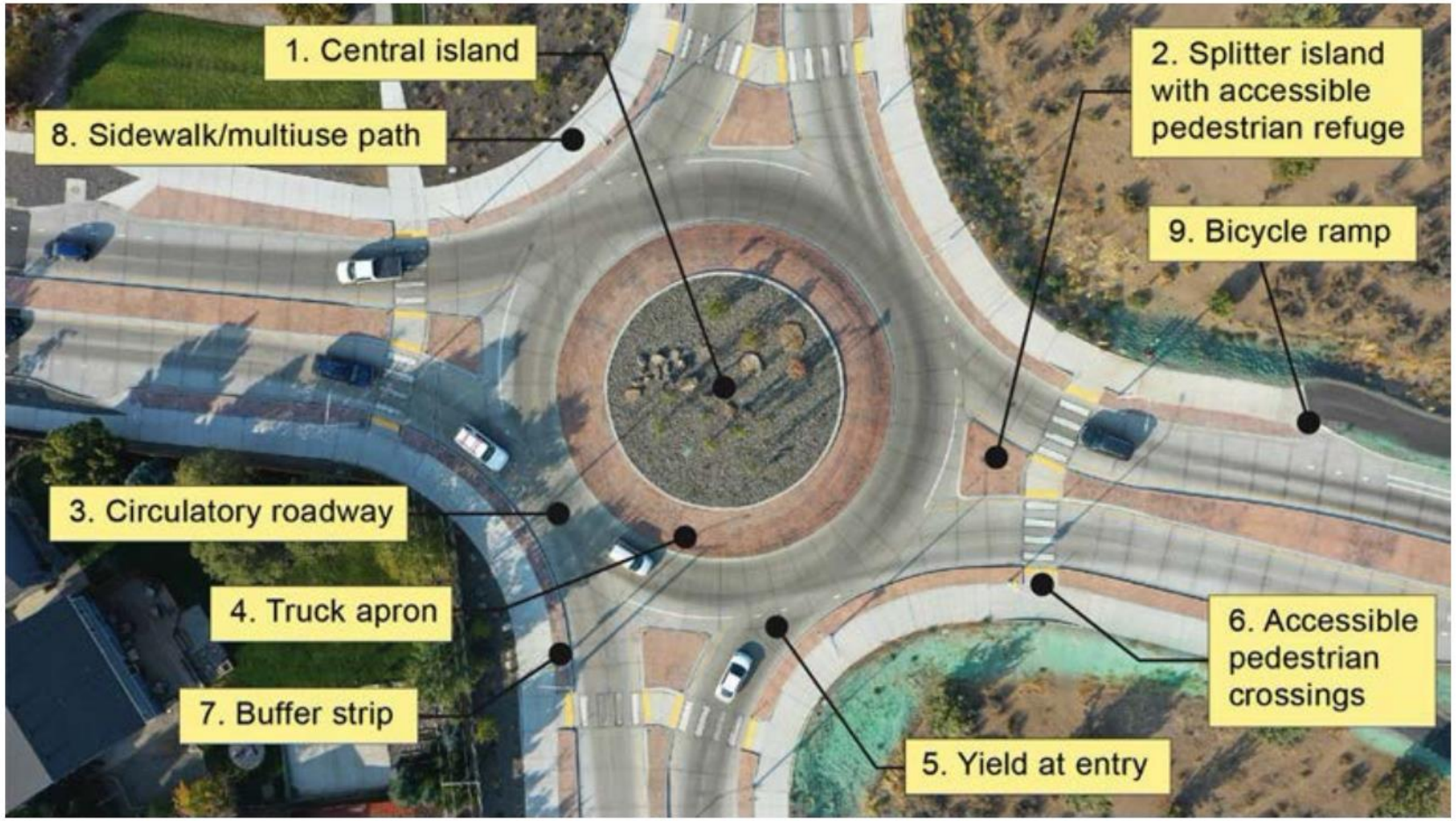
8 Conflict Points



Crossing or Merging Conflict Area

SOURCE: Google Earth.

Features of A Roundabout



SOURCE: Kittelson & Associates, Inc.

Comparing Roundabout Features

Exhibit 2.9. Comparison of common roundabout features across types of roundabouts.

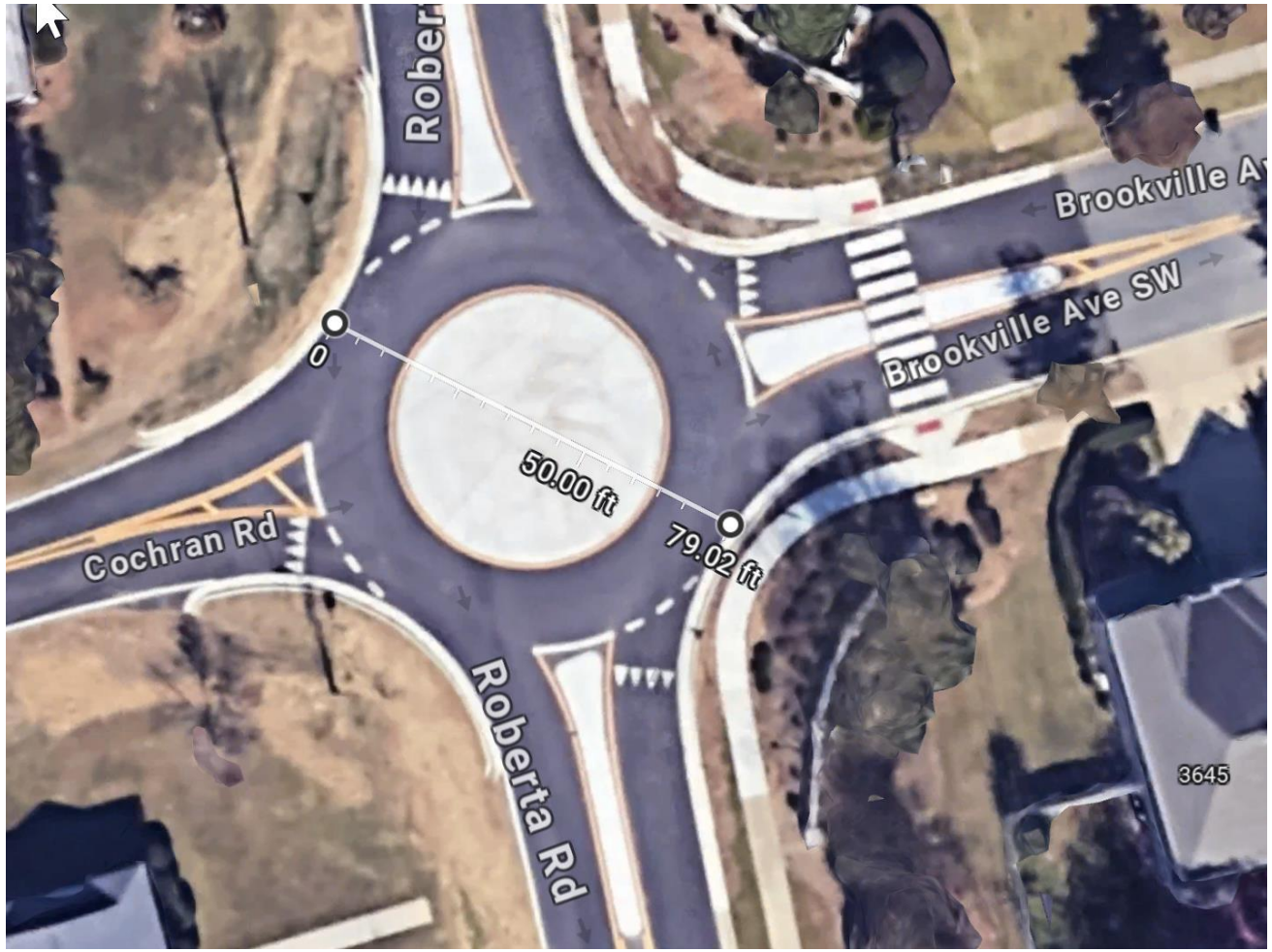
Roundabout Feature	Mini-Roundabout	Compact Roundabout	Single-lane Roundabout	Multilane Roundabout
Central island	Traversable	May be traversable	Non-traversable, but typically includes truck apron	Non-traversable, but typically includes truck apron
Splitter islands	May be traversable with one-stage pedestrian crossing	May be traversable with one-stage pedestrian crossing	Non-traversable with one-stage or two-stage pedestrian crossing, depending on dimensions of pedestrian refuge	Non-traversable with two-stage pedestrian crossing
Common ICD range	45 ft to 90 ft (14 m to 27 m)	65 ft to 120 ft (20 m to 37 m)	90 ft to 180 ft (27 m to 55 m)	150 ft to 200 ft (46 m to 61 m)
Maximum number of circulating lanes conflicting with each entry	1	1	1	2+

NOTE: ICD values are not to be used as design constraints or targets. See Chapter 10 for further discussion.

Single-Lane Typical Characteristics

- Single entry, exit and circulatory lane
- Non-traversable central and splitter islands
- Truck aprons
- Inscribed Circle Diameter 90’-180’

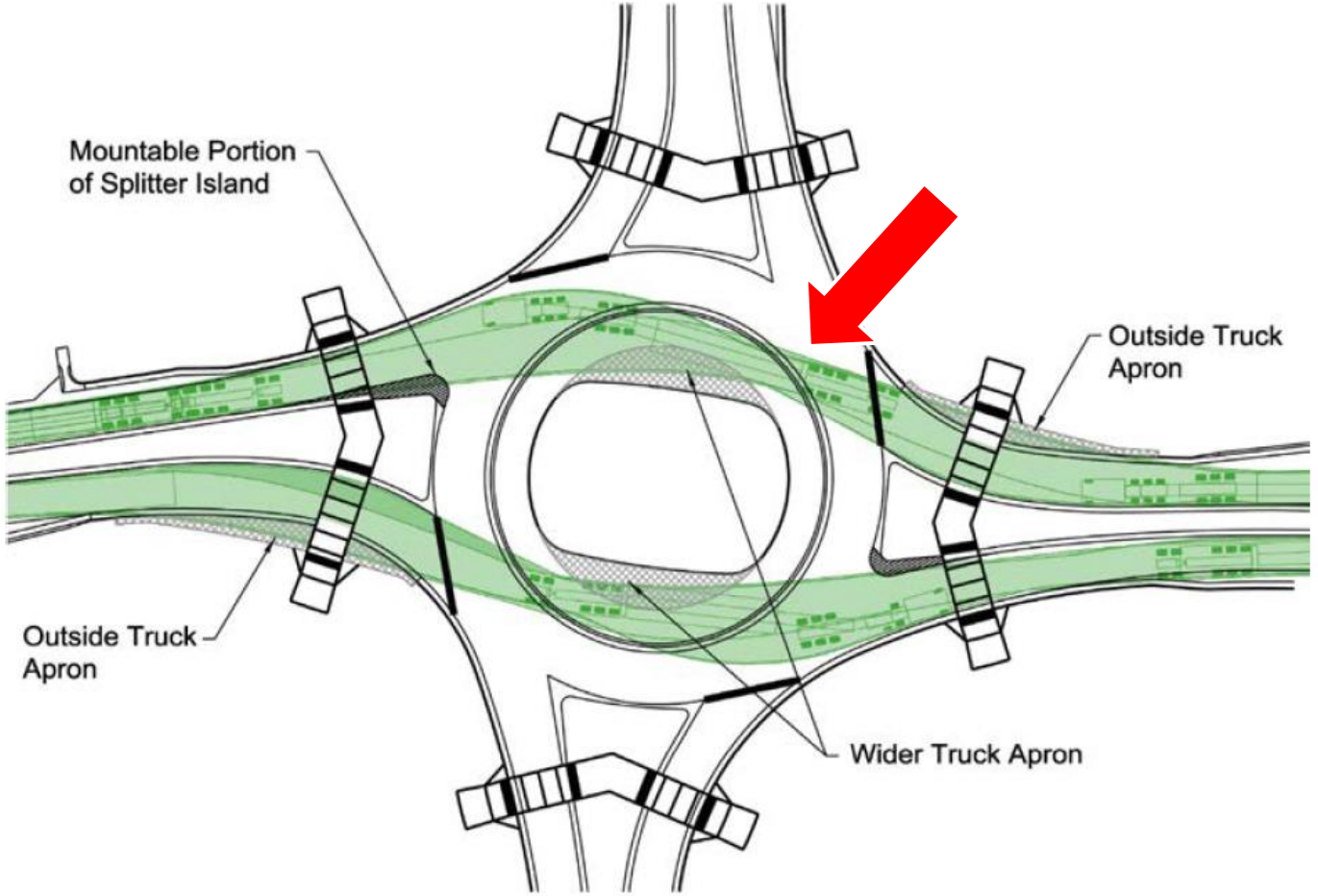
Compact/Mini Typical Characteristics



- Traversable Central island accommodates large vehicles/trucks
- Lower cost, less ROW
- Urban locations with low speeds
- Variable splitter islands

Painted, Traversable, or Non-Raised Center Island (for a Compact or Mini Roundabout)

Modified Center Island



SOURCE: Adapted from Georgia Department of Transportation (*3*).

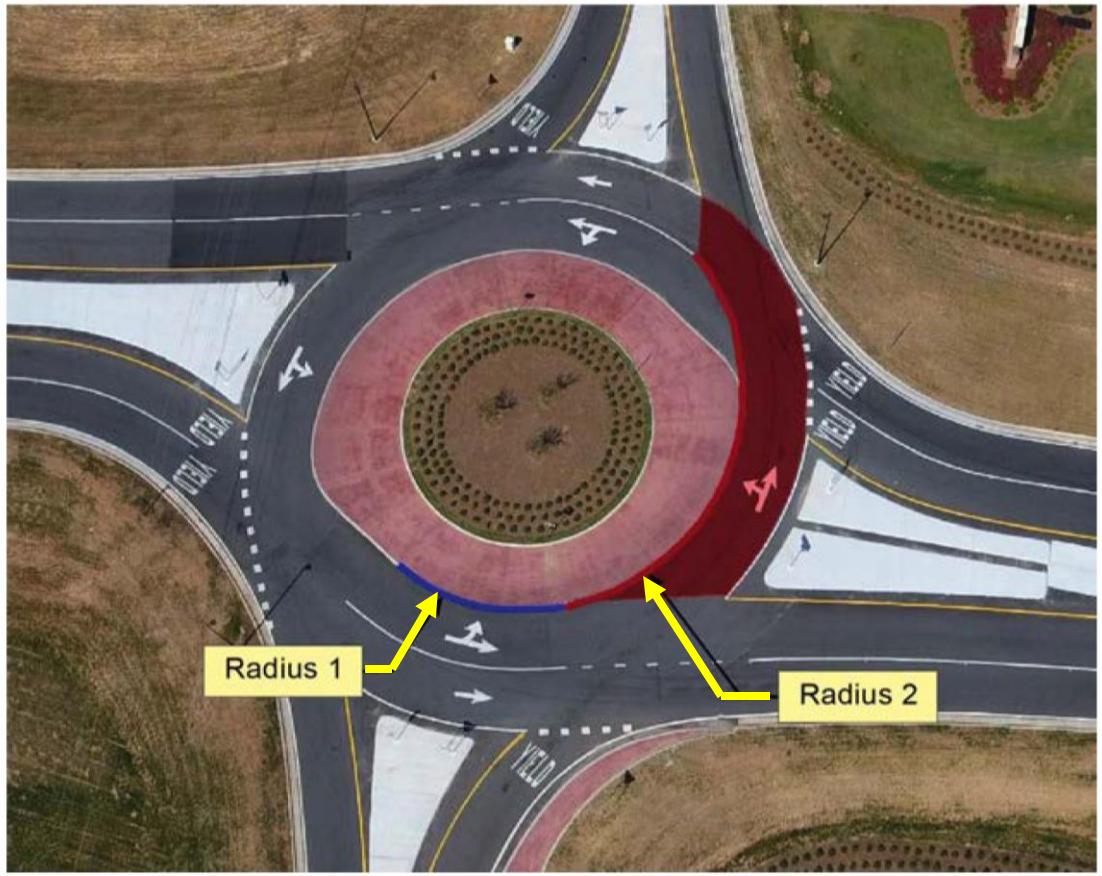
Interchange Roundabouts

Multilane Typical Characteristics

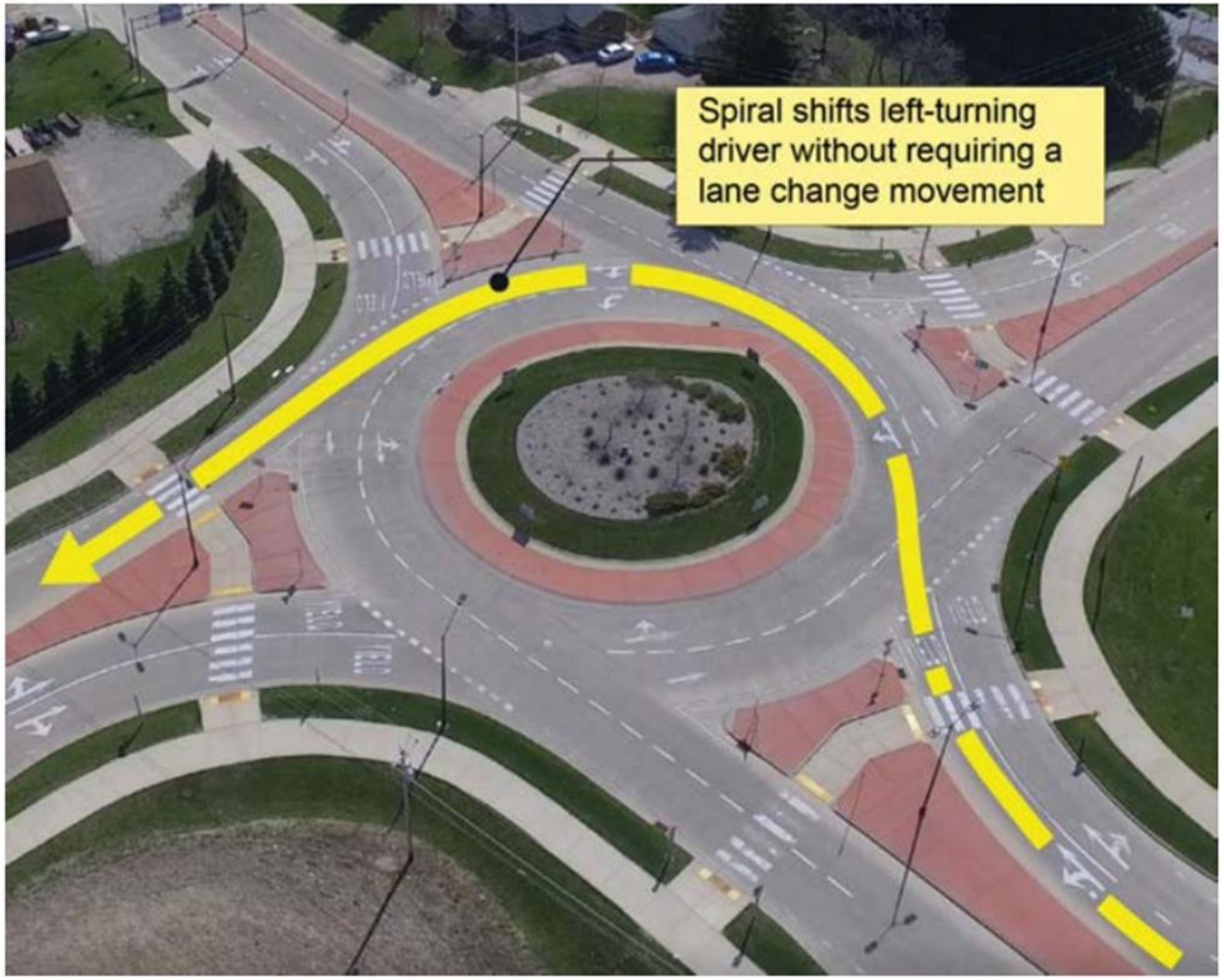
- Multilane approaches
  or
  Single entries may flare to multiple lanes
- Higher speeds
- Larger Inscribed Circle Diameters and wider entries/exits
- Increased pedestrian exposure

Spiraling in Multilane Roundabouts

- Multilane with spiral geometry
- Spirals reduce lane changes



SOURCE: Georgia Department of Transportation.



SOURCE: Wisconsin Department of Transportation.

Turbo Roundabouts

Image source: Arcadis

- Form of 2X1 Roundabout
- Perpendicular (hence, shorter) and divided approach
- Traffic separation potentially using:
  - Flush lane dividers
  - Solid Pavement markings
  - Raised lane dividers
- Advanced signing and pavement markings are needed for drivers to choose their entry lane according to their intended exit direction

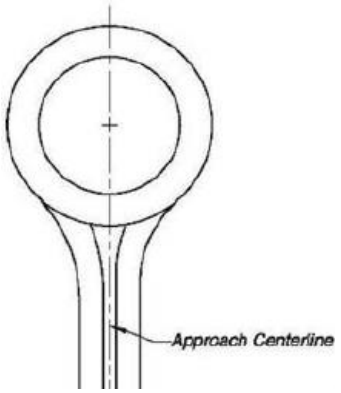
LOCATION: University Boulevard/Merrill Road, Jacksonville, Florida.
SOURCE: Federal Highway Administration.

Horizontal Alignment and Design

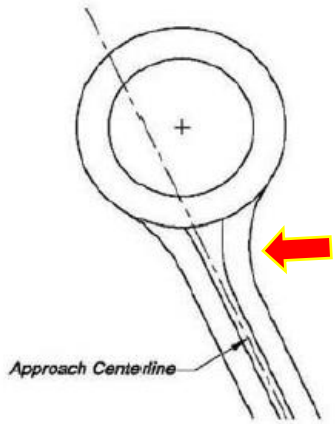
Horizontal Design Features & Performance Influences:

- Roundabout size and shape
  - Lane configuration
  - Design vehicle
  - Approach alignment
- Roundabout location
- Roundabout approach and entry
- Facilities for pedestrians and bicyclists

Approach Alignment:



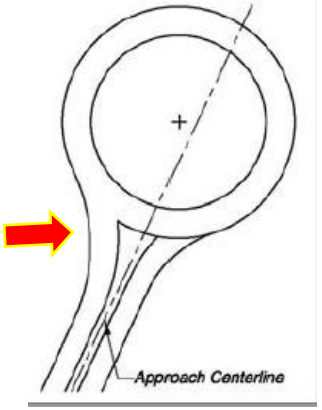
Center



Speed control at Entry

Left

Speed control at Exit



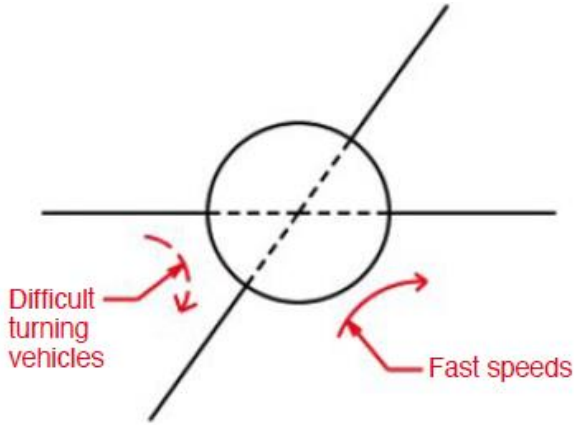
Right

Horizontal Alignment and Design

Horizontal Design Features & Performance Influences:

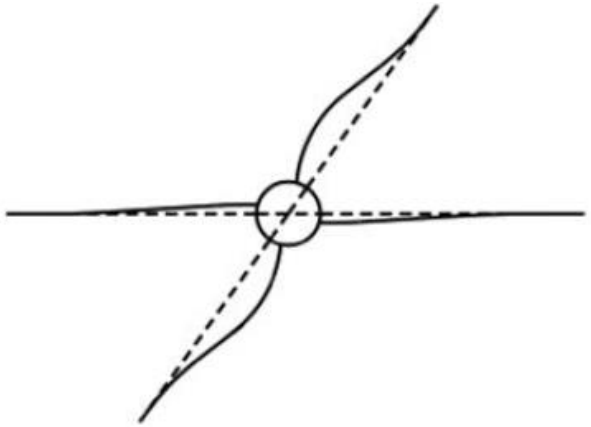
- Roundabout size and shape
  - Lane configuration
  - Design vehicle
  - Approach alignment
- Roundabout location
- Roundabout approach and entry
- Facilities for pedestrians and bicyclists

Roundabout Approach and Entry:



Fast right turns and difficult-to-turn design vehicle

Scenario 1



Realign approaches

Solution 1

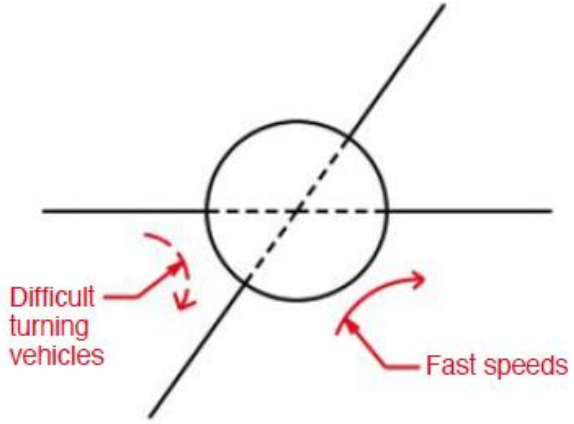
SOURCE: Adapted from Georgia Department of Transportation

Horizontal Alignment and Design

Horizontal Design Features & Performance Influences:

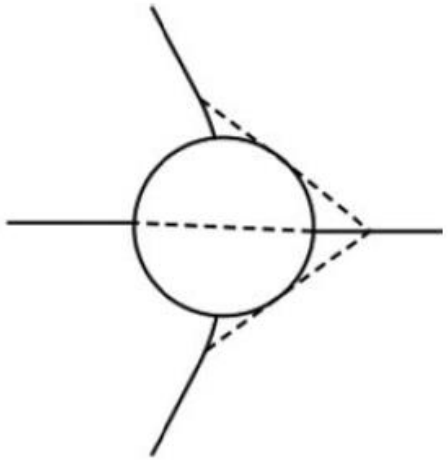
- Roundabout size and shape
  - Lane configuration
  - Design vehicle
  - Approach alignment
- Roundabout location
- Roundabout approach and entry
- Facilities for pedestrians and bicyclists

Roundabout Approach and Entry:



Fast right turns and difficult-to-turn design vehicle

Scenario 1



"Square up" intersection

Solution 2

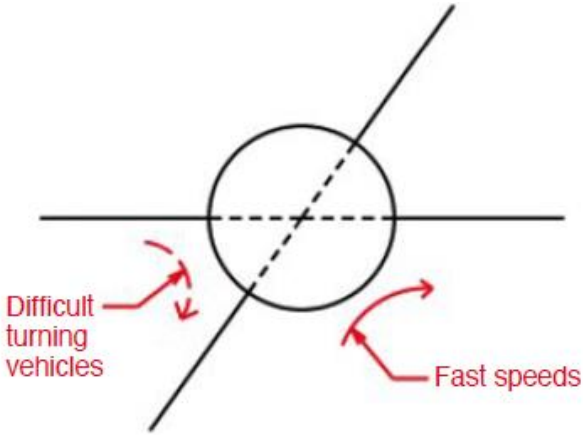
SOURCE: Adapted from Georgia Department of Transportation (3).

Horizontal Alignment and Design

Horizontal Design Features & Performance Influences:

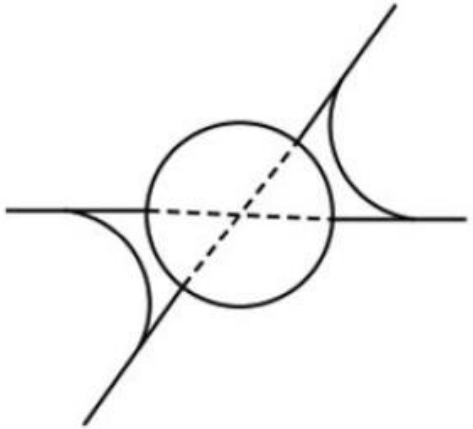
- Roundabout size and shape
  - Lane configuration
  - Design vehicle
  - Approach alignment
- Roundabout location
- Roundabout approach and entry
- Facilities for pedestrians and bicyclists

Roundabout Approach and Entry:



Fast right turns and difficult-to-turn design vehicle

Scenario 1



Add right-turn bypasses

Solution 3

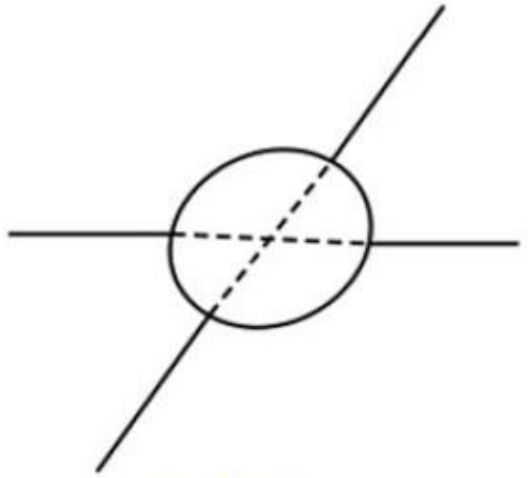
SOURCE: Adapted from Georgia Department of Transportation (3).

Horizontal Alignment and Design

Horizontal Design Features & Performance Influences:

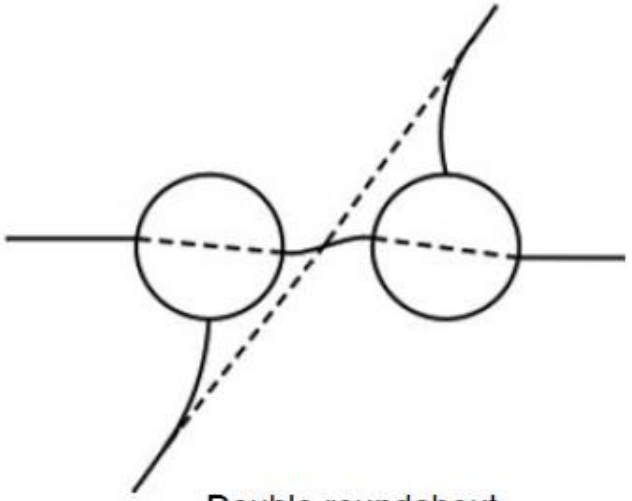
- Roundabout size and shape
  - Lane configuration
  - Design vehicle
  - Approach alignment
- Roundabout location
- Roundabout approach and entry
- Facilities for pedestrians and bicyclists

Roundabout Approach and Entry:



Elliptical ICD

Scenario 2



Double roundabout

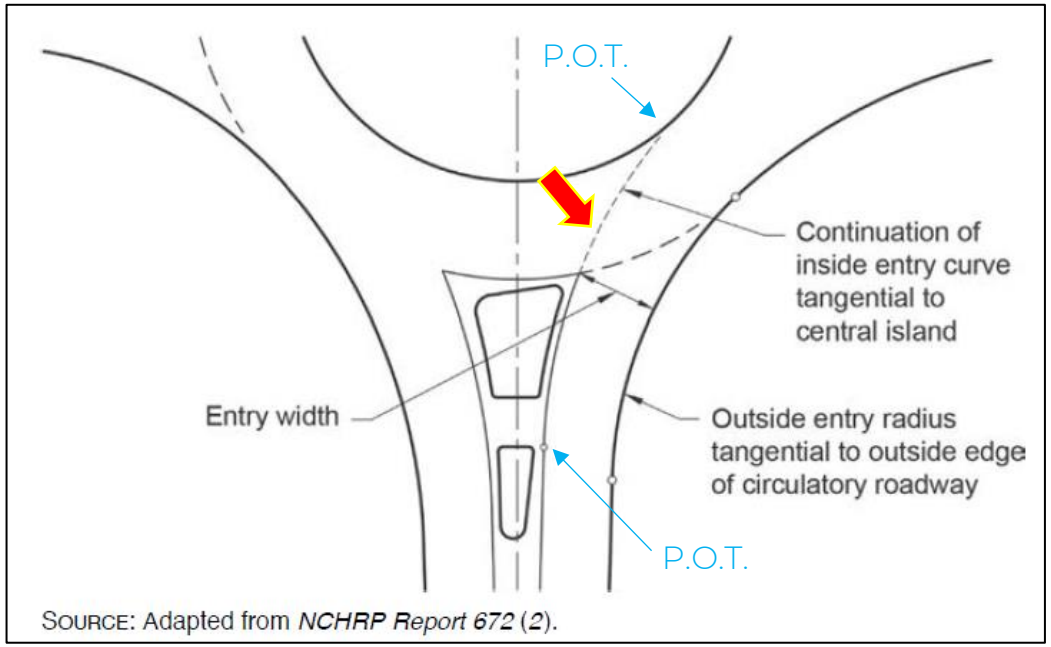
Solution

SOURCE: Adapted from Georgia Department of Transportation (3).

Horizontal Alignment and Design

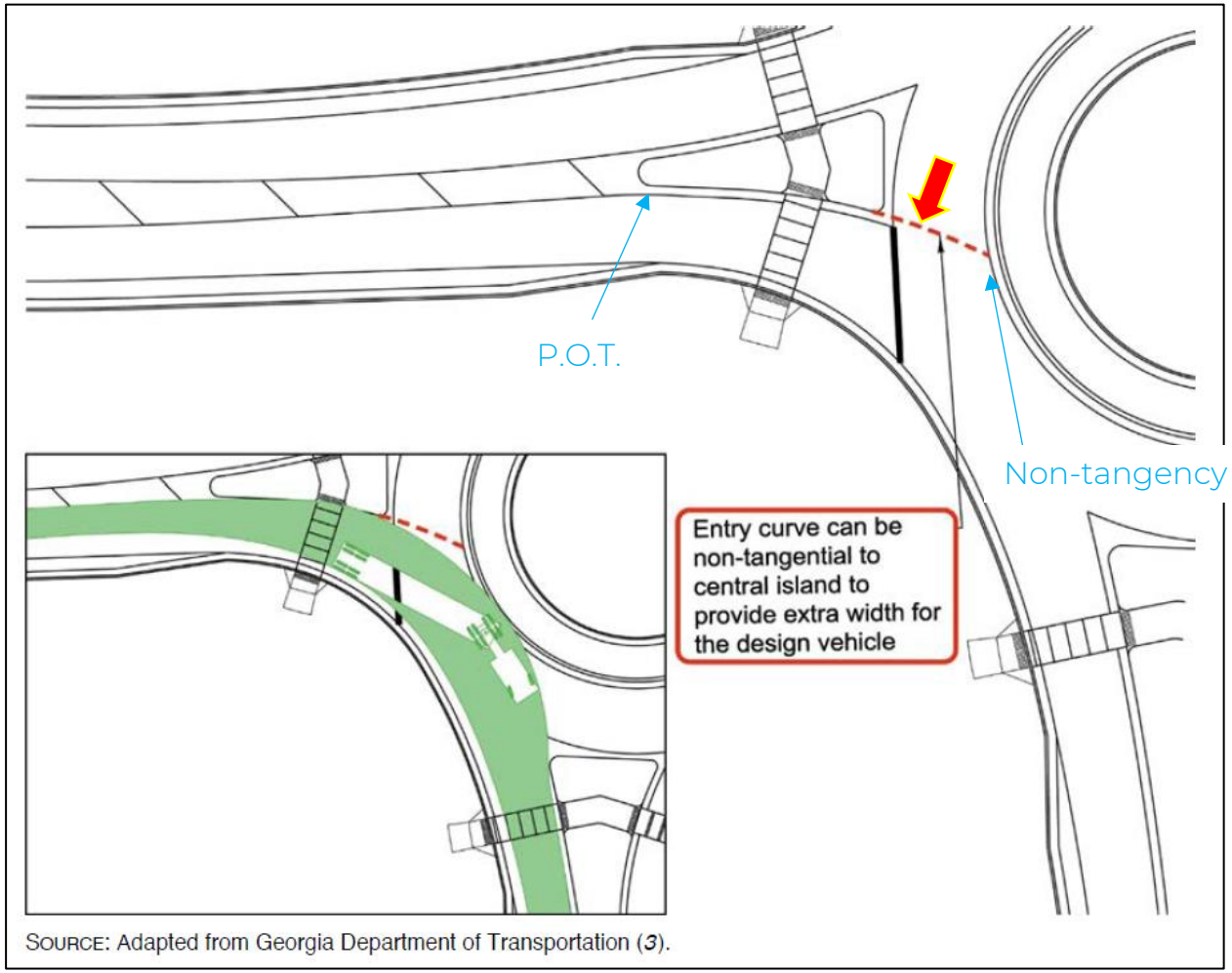
Curve Manipulation for extra width :

Entry



SOURCE: Adapted from *NCHRP Report 672* (*2*).

Before



SOURCE: Adapted from Georgia Department of Transportation (*3*).

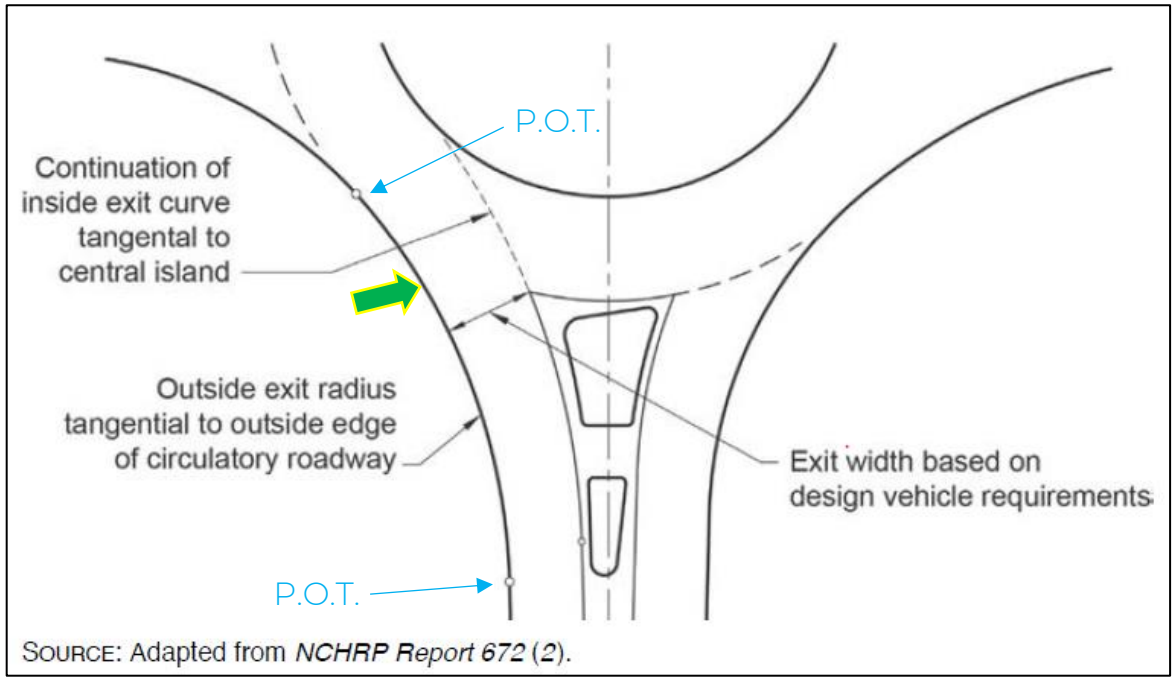
After

P.O.T. - Point of Tangency

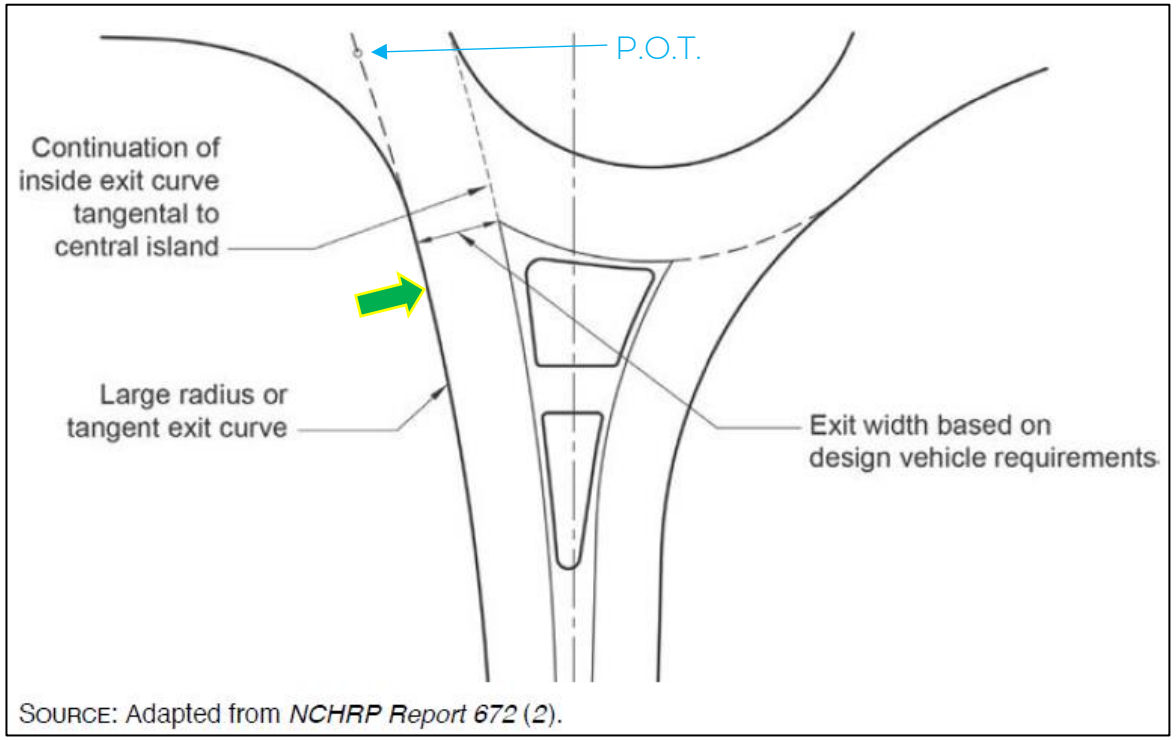
Horizontal Alignment and Design

Curve Manipulation for extra width :

Exits



Before



After

P.O.T. - Point of Tangency

Horizontal Alignment and Design

Circulatory Roadway Width Recommendations (NCHRP Report 1043):

- Lane width for Single-lane RA <= 20'

Single-lane circulatory roadway widths greater than 20 ft (6.1 m) may lead drivers to assume two vehicles are allowed to circulate side by side.

- Design vehicle at minimum - Bus

The circulatory roadway width needs to be wide enough to accommodate a design vehicle up to a bus without using a truck apron. A truck apron will often need to be provided within the central island to accommodate larger design vehicles

- Minimum clearance from vehicle path – 1' / 2' (preferred)

In accordance with AASHTO policy, a minimum clearance of 1 ft (0.3 m) (preferably 2 ft [0.6 m]) is provided between the outside edge of the vehicle's tire track and the curb line to allow for variations in driver performance and truck dimensions.

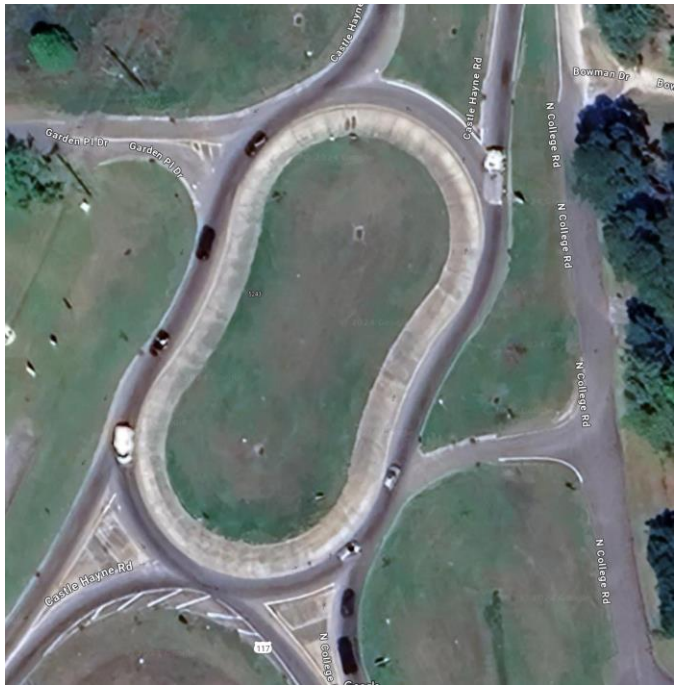
Horizontal Alignment and Design

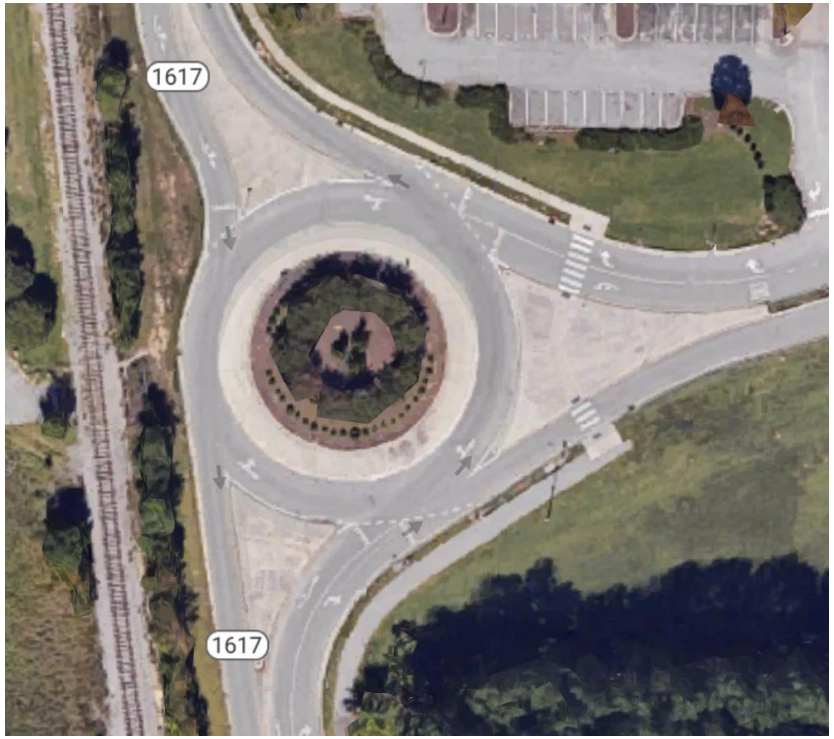
Yielding Bypass Lane

- Increases radius for sharp right-turns
- Lowers circulating traffic volume
- Provides better "Destination Angle"

Horizontal Alignment and Design

Modifying Roundabout Shape to Optimize Performance





Vertical Alignment and Cross Section Design

Vertical Alignment Development & Performance Checks:

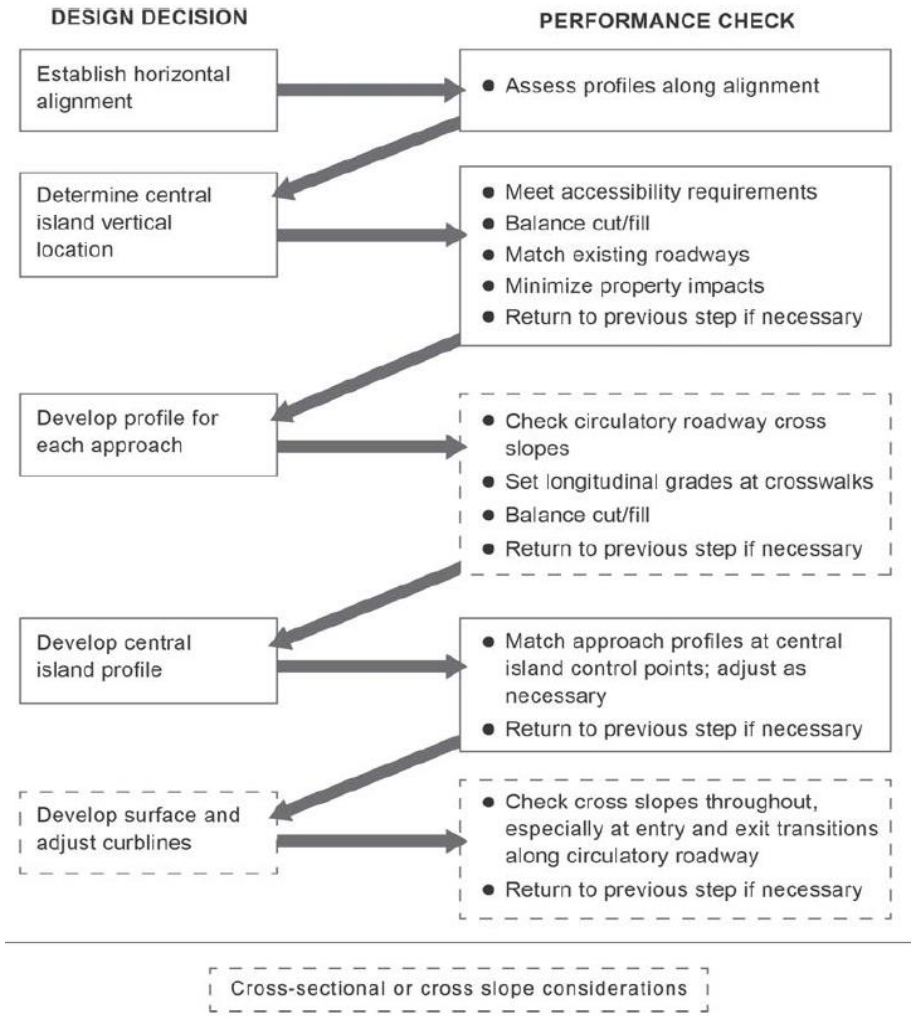
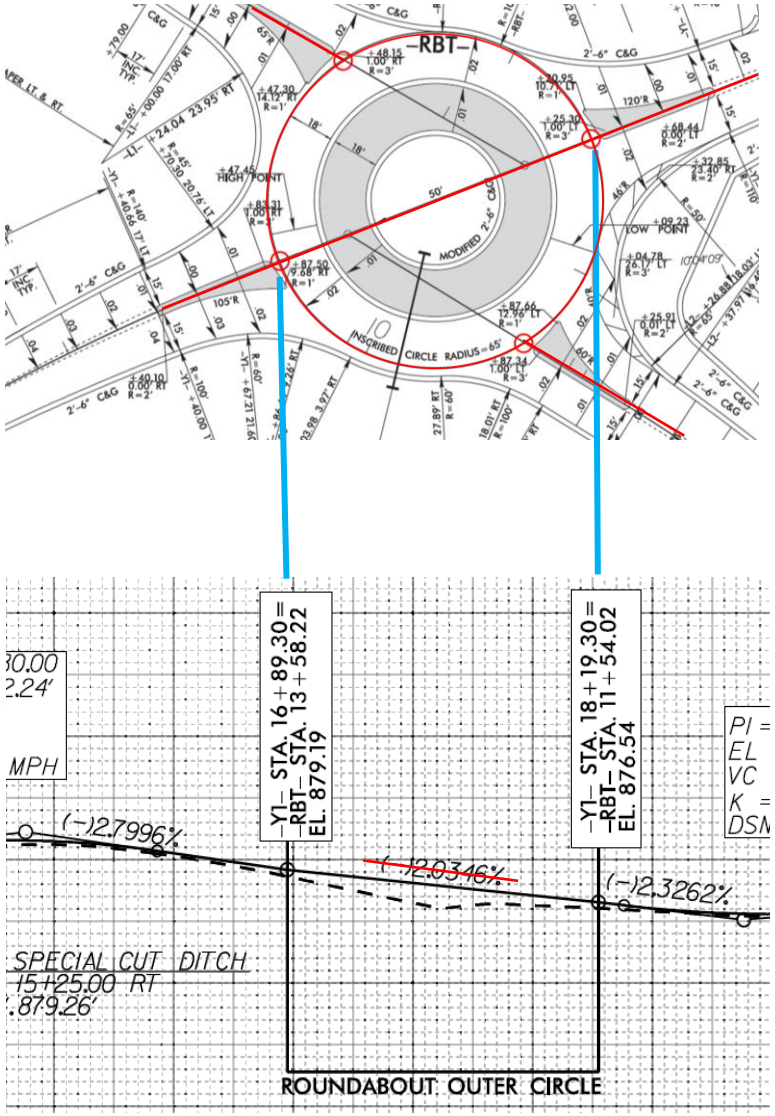


Exhibit 11.1 - NCHRP Report 1043

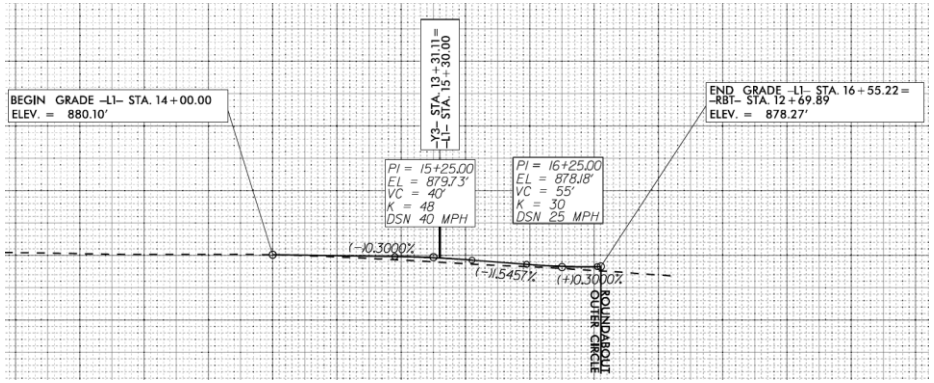
Vertical Alignment & Plan/Profile



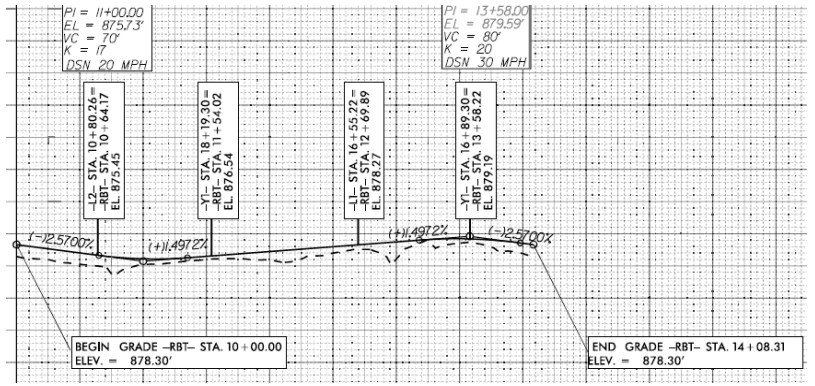
Mainline Profile

Profile Development Process:

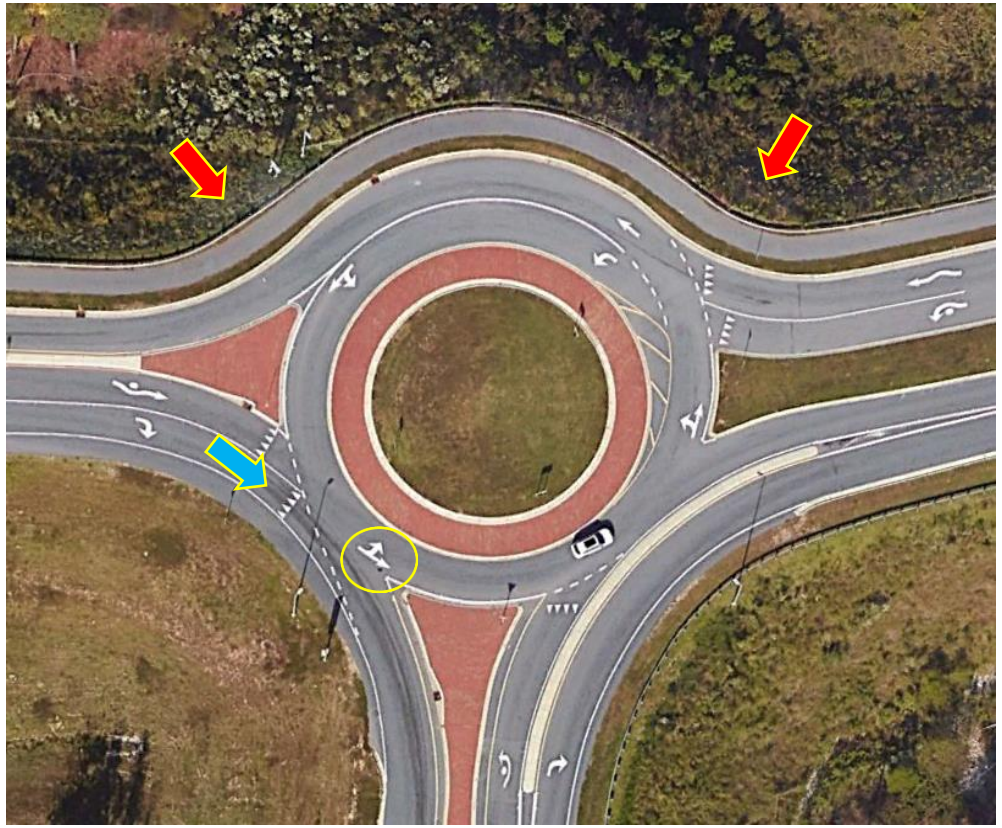
1. Establish horizontal alignment
2. Assess existing ground profile
3. Determine central island vertical elevation
4. Develop the profile of each roundabout leg
5. Develop the central island profile
6. Develop design surface

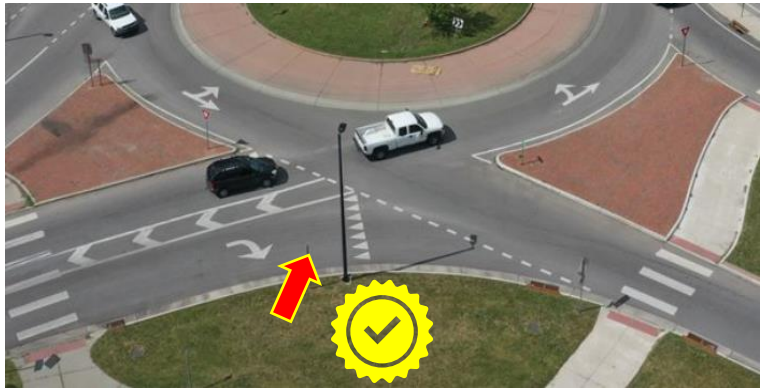


Minor leg Profile



Central Island Profile

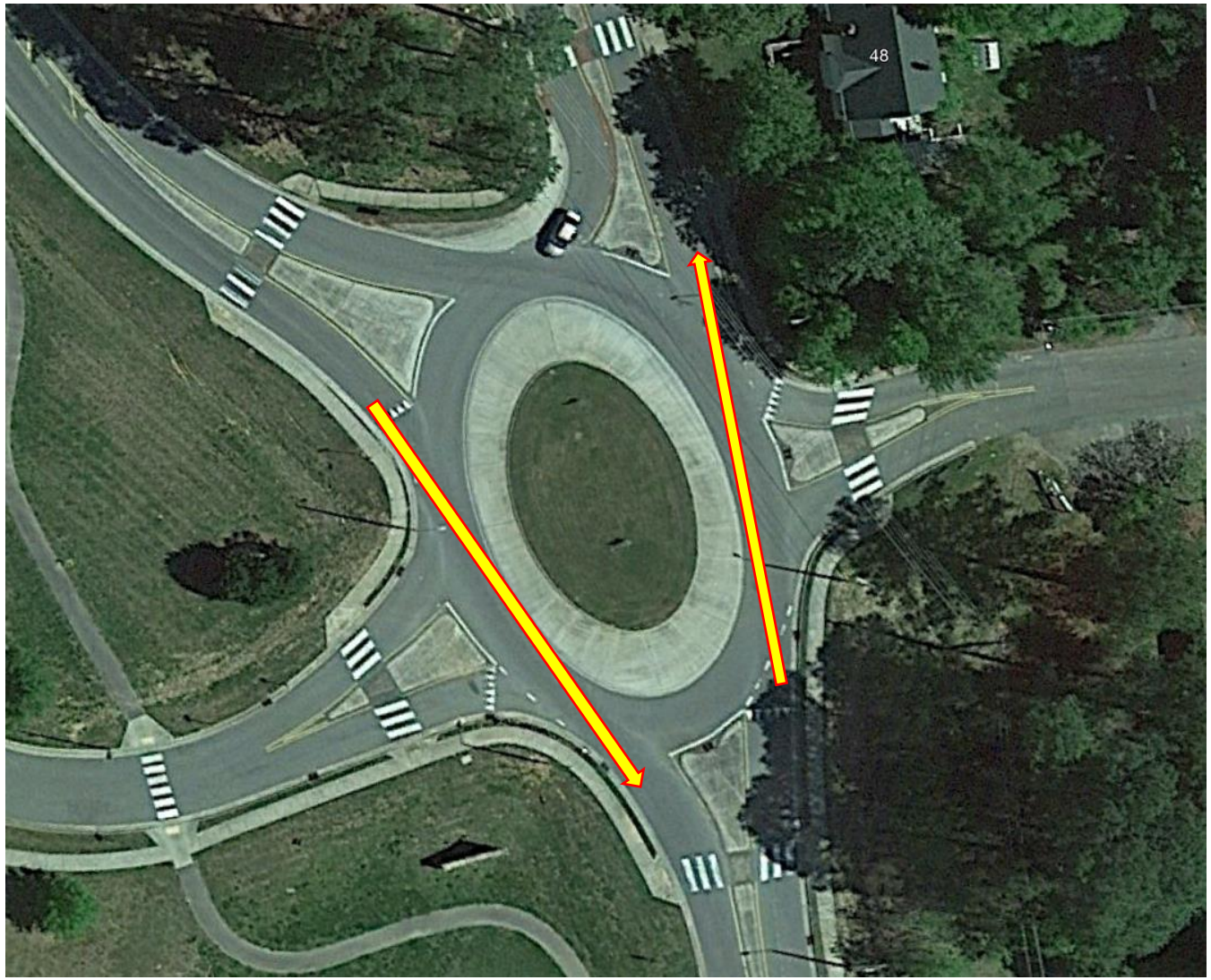




Elements of Roundabouts

- Tight Entry & Exit radii (Red arrows).
- Straight + Left turn arrow may cause confusion to the driver. Move the marking at the center of the lane (Yellow circles).
- Better orient the Destination Angle (Blue arrow).

Elements of Roundabouts



Evaluating Performance:

- Fastest Path through lanes allowed

Potential Adjustments:

- Modify central island to circular and/or increase diameter

Elements of Roundabouts

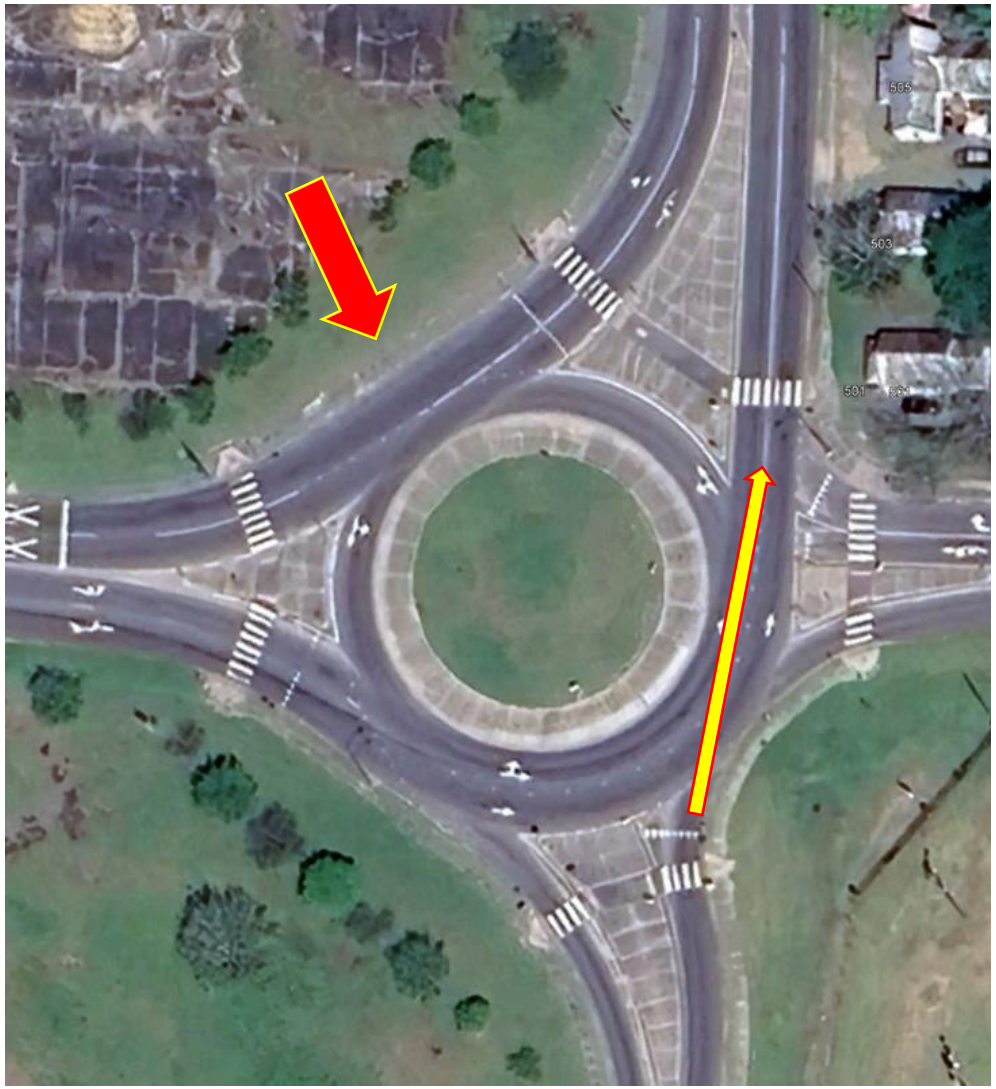
Evaluating Performance:

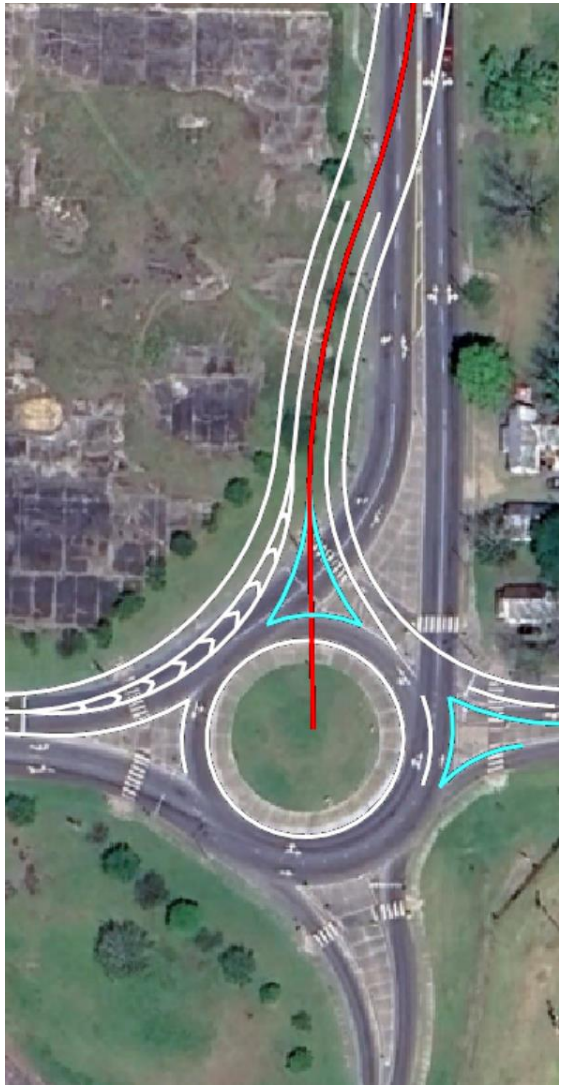
- High speed entry and exit

Potential Adjustments:

- Increase the central island radius to increase curvature, thereby, reducing speed
- Adjust approach centerlines towards left and right to increase curvature at the entry and exit respectively

Elements of Roundabouts





Evaluating Performance:

- SB to WB: High speed right-turn
- NB to NB: Fastest Path high-speed issue

Potential Adjustment:

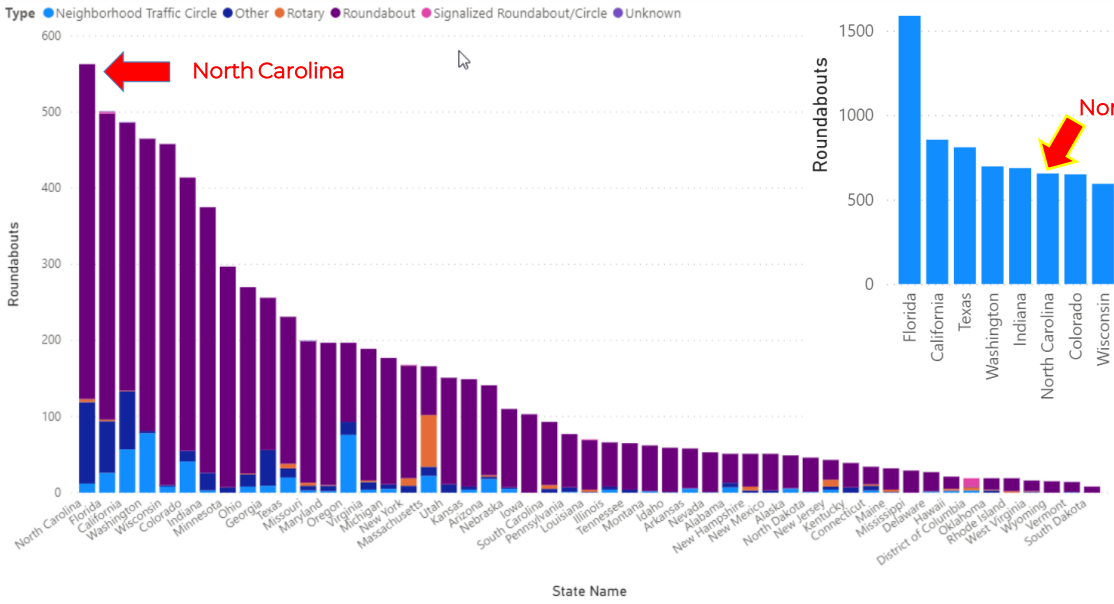
Realign the SB approach as shown to -

- Enhance speed control through SB to WB
- Smoothen right turn for WB to NB traffic
- No straight-line path for NB approach to NB exit

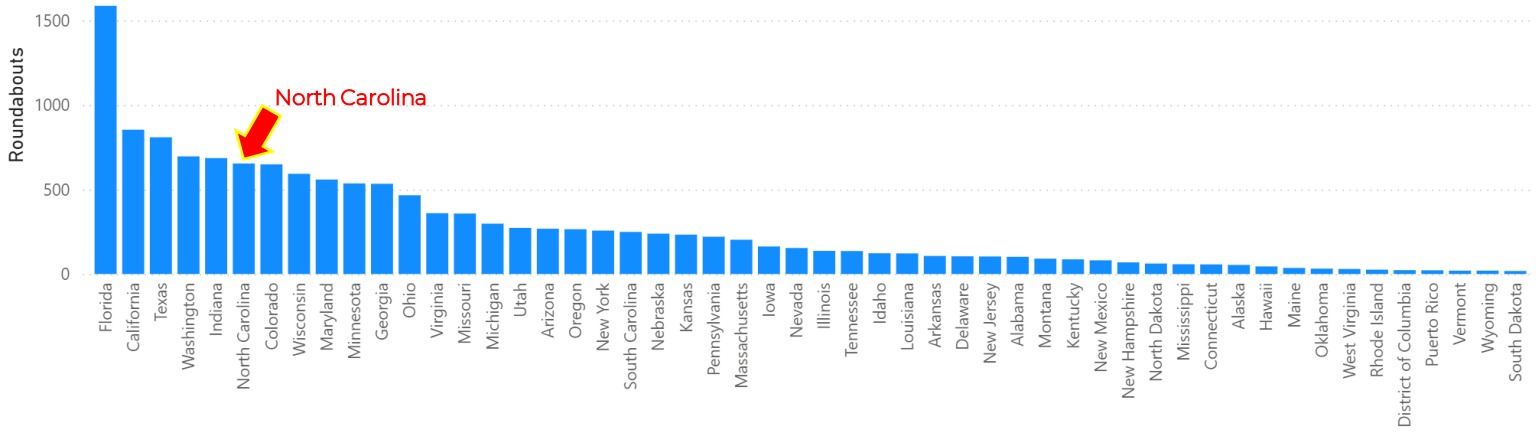
Roundabouts in NC

- Roundabout installations are increasing, but there are still roundabout deserts.
- NCDOT wants to get drivers familiar and comfortable with navigation.
- NC typically uses single-lane (1x1) or roundabouts with two lanes (2x1) for the major approaches and single lane for minor approaches.

2020



2024



As of April 30, 2020

http://roundabout.kittelson.com/Home/PBIReports

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