Prepared by:
The Center for Transportation Research
The University of Texas at Austin
Kittelson & Associates, Inc.

Prepared for:
Texas Department of Transportation
July 12, 2011
WELCOME

1975 Roundabout in Saigon, Vietnam
WELCOME

- Introductions
- **Course objectives:**
  - Introduction to roundabout design and operations guidelines for the state of Texas
  - Basic ideology and principles of roundabouts
  - Informational sources for designing, evaluating, and implementing roundabouts
**PROJECT OVERVIEW**

- **Purpose:** Develop roundabout guidelines for Texas that incorporate successful practices, recent U.S. research, and Texas specific conditions.
- **Key Project Components:**
  - Synthesis
  - Methodological Development
  - Validation and Enhancement
  - Implementation and Support
  - Knowledge Transfer
PROJECT OVERVIEW

Work Plan

Task 1: Survey the State of the Practice
Task 2: Update Safety Assessment Techniques
Task 3: Update Traffic Operations Assessment Techniques
Task 4: Update Geometric Design Guidelines
Task 5: Collect Data for Calibration
Task 6: Traffic Simulation of Roundabouts
Task 7: Develop Evaluation Process for Comparing Roundabouts and Traditional Intersection Forms
Task 8: Develop Implementation Framework for Roundabout Planning and Design
Task 9: Pilot Roundabout Design and Evaluation Workshop
Task 10: Final Recommendations
PROJECT OVERVIEW

Task 1 Survey the State of the Practice

- Reviewed Existing Roundabout Guidelines (as of Jan 2010)
  - 2000 FHWA Guidance
  - Other U.S. State’s Standards and Supplementary Materials
  - Recent Research Materials
  - Input from Agencies Regarding Current Practices
- Recently Released
  - NCHRP 672
  - Highway Safety Manual 2010
PROJECT OVERVIEW

Task 2 Update Safety Assessment Techniques

• Elements discussed in safety assessment technical memorandum...
  – Recent developments in safety prediction and evaluation
  – Connection between recent safety assessment techniques and roundabouts
  – Guidance on applying approach-level and intersection-level safety prediction models
PROJECT OVERVIEW

Task 2 Update Safety Assessment Techniques

- Intersection level safety prediction models
  - Equations (available for 11 geometries) that are functions of AADT
- Approach level safety prediction models
  - Equations for entering-circulating, exiting-circulating, and the approach (functions of AADT and geometric parameters)
  - Useful to gage the relative impact of a design change, not to estimate intersection-level safety
PROJECT OVERVIEW

Task 3 Update Traffic Operations Assessment Techniques

• Provided updated...
  – Entry capacity models based on most recent U.S. research
  – Delay and queue length models based on most recent U.S. research
  – (All models will be calibrated to Texas data.)
• Considered potential software packages for roundabout traffic operations analysis
  – SIDRA, ARCADY 7 and RODEL
PROJECT OVERVIEW
Task 3 Update Traffic Operations Assessment Techniques

- Focus is to recommend methodologies to predict...
  - Roundabout Capacity
  - Delay
  - Queue Lengths

- Preliminary recommendation is SIDRA
- Final recommendations will seek a balance between accuracy, ease of use, and model complexity.
PROJECT OVERVIEW

Task 4 Update Geometric Design Guidelines

- Plays a significant role in how well a roundabout operates....
  - Speed control and consistency
  - Reducing and eliminating conflicts
  - Reducing delay for travelers
  - Serving pedestrians and bicyclists
  - Accommodating larger vehicles
PROJECT OVERVIEW
Task 5 Collect Data for Calibration

- Pilot Data Collection (completed June 2010)
  - Approximately 13 roundabouts considered
- Final Data Collection (completed Aug 2010)
  - 5 roundabouts selected based on geometric features and traffic volume
    - On Site (TAMUK):
      - Speed readings
      - Video footage
        - 1 hour per approach
        - Peak period
    - Off Site:
      - Geometric design
      - Crash statistics

Blanco Rd/Fulton Ave, San Antonio
PROJECT OVERVIEW

Task 6 Traffic Simulation of Roundabouts

• Objectives...
  – Confirm recommendations made in Tasks 2, 3, and 4; and
  – Enhance guidelines for evaluating roundabouts using intersection based software

• Completed Work:
  – Validation of VISSIM roundabout models
  – Capacity analysis using VISSIM & SIDRA
PROJECT OVERVIEW

Task 7 Develop Intersection Evaluation Process

- Spreadsheet based evaluation process.
- Purpose...
  - Develop a process for alternatives comparison.
    - Roundabout vs. Traffic Signal
    - Roundabout vs. Two-Way Stop or All-Way Stop
    - Single Lane Roundabout vs. Multilane Roundabout
  - Provide screening level guidance for identifying promising sites as well as a quantitative procedure for comparing alternatives.
PROJECT OVERVIEW

Task 8 Develop Implementation Framework

- The workbook will . .
  - Introduce the modern roundabout
  - Provide a “how-to” for using the spreadsheet (Task 7) and other available resources to evaluate candidate designs
  - Emphasize the importance of feedback and refinement
  - Present Texas-specific considerations
PROJECT OVERVIEW
Task 9 Pilot Roundabout Design and Evaluation Workshop

Task 10 Final Recommendations

• The final report and recommendations will document....
  – Research project activities;
  – Methodologies;
  – Assumptions;
  – Resources; and
  – Final Recommendations.

• Final report will be provided in printed and electronic form.
INTRODUCTION

National Guidelines and Research
INTRODUCTION

What is a roundabout?

East Continental Blvd. and South Carroll Ave. in Southlake, Texas
(Source: Google maps)
INTRODUCTION

Roundabout Characteristics

(Source: NCHRP 672)
INTRODUCTION

Design Features

(Source: NCHRP 672)
INTRODUCTION

Categories

Single Lane Roundabout, source: NCHRP 672

Miniature Roundabout
INTRODUCTION

Categories

Multilane Roundabout, source: NCHRP 672
INTRODUCTION
Circular Intersections

Signalized Traffic Circle—Hollywood, CA, source: NCHRP 672
INTRODUCTION

Circular Intersections

Rotary – Fort Worth, TX, source: NCHRP 672
INTRODUCTION
Circular Intersections

Traffic circle – Portland, OR, source: NCHRP 672
INTRODUCTION

Roundabout vs. Signalized Intersection: Safety Improvements

- Eliminates right-angle and left-turn conflicts
- Provides speed control by geometric features
INTRODUCTION

Roundabout vs. Signalized Intersection: Safety Improvements

- Safety Benefits:
  - Drivers have more time to:
  - Judge when to enter into the circulating traffic and
  - Detect and correct for their mistakes or mistakes of others

- Sight triangles are smaller so users can see one another easier
- Drivers are more likely to yield to pedestrians
- Crashes are less frequent and less severe
INTRODUCTION

Roundabout vs. Signalized Intersection: Safety Improvements

- For Single-Lane Roundabouts:
  - Drivers do not have lane use decisions to make
  - Pedestrians only cross one lane of traffic at a time
  - Roadway speeds are low enough for bicycles to travel alongside vehicles
INTRODUCTION

Roundabout vs. Signalized Intersection: Safety Improvements

- For Multi-Lane Roundabouts:
  - Drivers have to select the proper lane to use
  - Pedestrians cross more than one lane of traffic at a time, which increases the chance of conflicts with vehicles
  - Bicyclists traveling as vehicles must select the proper lane to use
INTRODUCTION

Roundabout vs. Signalized Intersection: Decision Making

- **Drivers**
  - Select appropriate lane and
  - Yield to those with right-of-way

- **Pedestrians**
  - Choose the appropriate time to cross each leg of the roundabout.

- **Bicyclists**
  - Travel as a vehicle or
  - Travel as pedestrian
INTRODUCTION

Roundabout vs. Signalized Intersection: Conflict Points

Vehicle – vehicle conflict points, source: NCHRP 672
INTRODUCTION

Roundabout vs. Signalized Intersection: Conflict Points

Pedestrian-vehicle conflict points, source: NCHRP 672
INTRODUCTION

Roundabout vs. Signalized Intersection: Spatial Requirements

Wide Nodes, Narrow Roads Concept, source: NCHRP 672
INTRODUCTION

Roundabout vs. Signalized Intersection: Pedestrian Considerations

- **Crosswalk** is located around the perimeter of the roundabout and set back from the yield line.
- **Splitter island** provides space for pedestrians to pause.
- **Landscape buffers** prevent pedestrians from crossing to the central island.

(Source: http://cae2k.com/photos-de-studio-0/roundabout-pictures.html)
# INTRODUCTION

**Roundabout vs. Signalized Intersection: Pedestrian Considerations**

<table>
<thead>
<tr>
<th>Roundabouts</th>
<th>Signalized Intersections</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ Pedestrians only have one direction of conflicting traffic.</td>
<td>❑ Pedestrians are vulnerable to unprotected right-turn and left-turn movements.</td>
</tr>
<tr>
<td>❑ Pedestrians are required to judge when to cross the intersection.</td>
<td>❑ Signal indication prompts pedestrians to cross the intersection.</td>
</tr>
<tr>
<td>❑ Speed-constrained environment results in less severe crashes.</td>
<td>❑ High-speed crashes occur when vehicles run through red light.</td>
</tr>
</tbody>
</table>
INTRODUCTION
Roundabout vs. Signalized Intersection: Operation and Maintenance Costs

Roundabouts
- Higher illumination power and maintenance costs
- Higher signing and pavement marking maintenance costs
- Additional landscape maintenance costs
- Service life of 25 years

Signalized Intersections
- Additional traffic signal power and maintenance costs
- Additional signal timing maintenance
- Service life of 10 years
INTRODUCTION

*Roundabout vs. Signalized Intersection: Safer for Emergency Vehicles*

- Drivers should not enter a roundabout when an emergency vehicle is approaching on another leg.
- Vehicles should clear out of the circulatory roadway when an emergency vehicle is traveling on it.
- Lower vehicle speeds makes it safer.
- Elimination of through vehicles unexpected running a signalized intersection and hitting the emergency vehicle
INTRODUCTION

Roundabout vs. Signalized Intersection: Comparing Performance

- Roundabouts do not have lower overall delays than TWSC intersections.
- At TWSC intersections that were converted to roundabouts, U.S. research identified average reductions of 44.2% for all crashes and 81.8% for injury crashes.
- Roundabouts reduce queues for left-turning vehicles yielding to opposing traffic.
INTRODUCTION

Roundabout vs. Signalized Intersection: Comparing Performance

- Roundabouts provide operational benefit during off-peak periods
- Roundabouts provide lower overall delays than signalized intersections.
- U.S. research identified average reductions of 47.8% for all crashes and 77.7% for injury crashes.

Average Control Delay Per Vehicle

Source: NCHRP 672
INTRODUCTION

Roundabout vs. Signalized Intersection: Information Resources

- NCHRP 672, Roundabouts: An Informational Guide – 2nd edition
  - Current national guidance document regarding roundabouts
  - Covers operations analysis, safety, geometric design, traffic design, and system considerations
INTRODUCTION

Roundabout vs. Signalized Intersection: Information Resources

- Supplemental State Roundabout Design and Implementation Guides
  - Most are based on 1st edition of FHWA Roundabout Guide
  - Some are influenced by British practices
  - Contains state-specific information related to planning considerations, design attributes, or signing and pavement markings
INTRODUCTION

Roundabout vs. Signalized Intersection: Information Resources

- Roundabout Research Findings
  - Influences the guidelines developed for analysis, design, and implementation of roundabouts
  - Contains the most recent U.S. research related to roundabout safety, operations, and geometry
Roundabout Applications

Part I
APPLICATIONS PART I
Roundabouts Near Schools

- Considerations
  - Sharp, often simultaneous peaks in pedestrians & traffic
  - Design vehicle (school bus, emergency vehicles)
  - Right-of-way
  - User education & outreach
  - If crossing guards are used, the distance between crosswalks may require two crossing guards instead of one.
APPLICATIONS PART I
Roundabouts Near Schools

• Benefits
  – Lower vehicle speeds in and around intersection
  – Improved pedestrian and vehicle safety
  – Landscaping and gateway treatment

Near Schools -
Clearwater, Florida
APPLICATIONS PART I

Roundabouts Near Schools

• Wider sidewalks/pathways near roundabout to allow for children walking side-by-side, bicycles, etc.
• Greater concentration of distracted drivers & pedestrians
• Educate & enforce pedestrians to not cross circulatory roadway
• Central island is not a “playground”
  – Be mindful of objects/landscape within circulatory roadway
• Bus and passenger drop-off circulation
  – Avoid use of roundabout as element in circulation plan, but consider it’s impacts
APPLICATIONS PART I
Roundabouts in Rural, High-Speed Locations

- Historical safety of rural roundabouts:
  - Overall reduction in accidents
  - Increase in single vehicle accidents

- Specific design guidance:
  - Maximize visibility of the central island
  - Add changes in cross section or alignment to alert drivers on approaches

High-Speed, Rural Roadway - Paola, KS

Photo: Lee Rodegerds
APPLICATIONS PART I

*Rural Roundabouts*

- Pedestrian accommodations
- Larger diameter than urban forms
- Exit is somewhat more tangential than urban forms
- Apron (if required)
APPLICATIONS PART I

Rural Roundabouts

- Design objective is to raise awareness
  - Visibility
    - Terminal vista
    - Illumination
  - Curbing
  - Splitter islands
  - Approach curves
APPLICATIONS PART I  
*Rural Roundabouts - Visibility*

- **Illumination**
  - Some roundabouts are rural today but will be developing into urban/suburban areas
  - Recommend using urban illumination levels based on expected traffic volume and pedestrian activity (design year)
  - For unlit approaches, use illuminance of approx. half the intersection value at the nose of the splitter islands to provide transition zone

- **Advance warning**
  - If necessary
APPLICATIONS PART I

*Rural Roundabouts - Curbing*

- Change in cross section alerts driver of upcoming intersection
- Creates “funneling” effects, along with extended splitter islands
APPLICATIONS PART I

Rural Roundabouts

- AASHTO Exhibit 10-73 – Deceleration lengths
  - Design speed = 65 mph
  - Target speed = 25 mph
  - Desired deceleration length = 500 - 570’
APPLICATIONS PART I

Rural Roundabouts – Approach Curves
APPLICATIONS PART I

*Rural Roundabouts – Safety Performance*

- Study by Isebrands, 2008
  - Seventeen roundabouts
  - Approach speeds of 40 to 65 mph
  - Crash Rate Reduction
    - Total – 67%
    - Injury – 89%
    - Fatal – 100%
APPLICATIONS PART I

*Rural Roundabouts – User Types*

- Pedestrians/Cyclists?
- Emergency vehicles
- Oversized design vehicle
- Snow plows
- Farm equipment
  - Combine
  - Large tractor
APPLICATIONS PART I

Rural Roundabouts - Myths

- Reduction in approach speed
- Driver expectation
- Unbalanced flows results in poor operational performance
- Can’t accommodate large design vehicle, farm equipment
APPLICATIONS PART I

Rural Roundabouts – Example: Kittitas County, WA
High-Speed Approach Treatments

Consider using:

- Longer splitter islands
- Advance approach curves

Photo: W&H Pacific, Inc.
APPLICATIONS PART I

Rural Roundabouts – Example: Verboort Road, Washington County

High-Speed Approach Treatments
APPLICATIONS PART I

Rural Roundabouts – Summary

- Roundabouts in rural locations have proven safety benefits
- Other state DOTs have successfully implemented rural roundabouts
- Rural locations have unique context to consider
- Cost effective solution to localized peak conditions
- Multiple applications on a corridor enhance the overall effectiveness
TRAFFIC ANALYSIS

- Recommended traffic analysis methods from the most comprehensive and recent research on traffic operations analysis for roundabouts in the U.S
- Information comes from NHCRP 572 - Roundabouts in the United States and NCHRP 672 – Roundabouts: An Informational Guide Second Edition
- Methods:
  - Planning level method
  - Highway Capacity Manual method
  - Deterministic software
  - Simulation
# TRAFFIC ANALYSIS

## Selection of Analysis Tool

<table>
<thead>
<tr>
<th>Application</th>
<th>Typical Outcome Desired</th>
<th>Input Data Available</th>
<th>Potential Analysis Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning-level sizing</td>
<td>Number of lanes</td>
<td>Traffic volumes</td>
<td>Section 3.3 of this guide, HCM, deterministic software</td>
</tr>
<tr>
<td>Preliminary design of roundabouts with up to two lanes</td>
<td>Detailed lane configuration</td>
<td>Traffic volumes, geometry</td>
<td>HCM, deterministic software</td>
</tr>
<tr>
<td>Preliminary design of roundabouts with three lanes and/or with short lanes/flared designs</td>
<td>Detailed lane configuration</td>
<td>Traffic volumes, geometry</td>
<td>Deterministic software</td>
</tr>
<tr>
<td>Analysis of pedestrian treatments</td>
<td>Vehicular delay, vehicular queuing pedestrian delay</td>
<td>Vehicular traffic and pedestrian volumes, crosswalk design</td>
<td>HCM, deterministic software, simulation</td>
</tr>
<tr>
<td>System analysis</td>
<td>Travel time, delays and queues between intersections</td>
<td>Traffic volumes, geometry</td>
<td>HCM, simulation</td>
</tr>
<tr>
<td>Public involvement</td>
<td>Animation of no-build conditions and proposed alternatives</td>
<td>Traffic volumes, geometry</td>
<td>Simulation</td>
</tr>
</tbody>
</table>

Source: NCHRP 672
TRAFFIC ANALYSIS

Planning-level Method

Planning-level daily intersection volumes

(Source: NCHRP 672)
TRAFFIC ANALYSIS

Planning-level Method

- **Capacity** is directly affected by the amount of vehicles on the circulatory roadway (conflicting traffic)

(Source: VISSIM)
TRAFFIC ANALYSIS

Planning-level Method

- **Capacity** is directly affected by the amount of vehicles on the circulatory roadway (conflicting traffic)

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

(Source: NCHRP 672)
TRAFFIC ANALYSIS

2010 Highway Capacity Manual Method

Capacity estimation

\[ c_{e, pce} = 1,130 e^{(-1.0 \times 10^{-3})v_{c, pce}} \]

\( c_{e, pce} = \text{lane capacity (pc/h)} \)

\( v_{c, pce} = \text{conflicting flow (pc/h)} \)

(Source: NCHRP 672)

Bend, Oregon (Source: Flickr.com)
TRAFFIC ANALYSIS

Delay and Queue Length Models

CONTROL DELAY

\[
d = \frac{3600}{c} + 900T \times \left[ \frac{v}{c} - 1 + \sqrt{\left( \frac{v}{c} - 1 \right)^2 + \left( \frac{3600}{c} \right)^2 \frac{v}{c}} \right] + 5 \times \min \left( \frac{v}{c}, 1 \right)
\]

- \(d\) = average control delay (s)
- \(c\) = entry capacity (veh/hr)
- \(T\) = time period (hrs)
- \(v\) = vehicle flow (veh/hr)
TRAFFIC ANALYSIS

Delay and Queue Length Models

GEOMETRIC DELAY

WDOT Roundabout (Source: Flickr)
TRAFFIC ANALYSIS

Delay and Queue Length Models

**QUEUE LENGTH**

\[
Q_{95} \approx 900T * \left[ \frac{v}{c} - 1 + \sqrt{\left(1 - \frac{v}{c}\right)^2 + \left(\frac{3600}{c} \frac{v}{150T}\right) \left(\frac{c}{3600}\right)} \right]
\]

- \( Q_{95} = 95^{th} \) percentile queue length in \# vehs
- \( c \) = entry capacity (veh/hr)
- \( T \) = time period (hrs)
- \( v \) = vehicle flow (veh/hr)
TRAFFIC ANALYSIS

*Delay and Queue Length Models*

- Other factors effecting performance...
  - Pedestrians
  - Exiting vehicles
  - Changes in effective priority
  - Capacity constraint
  - Origin-destination patterns
  - Geometry
TRAFFIC ANALYSIS

*Deterministic Software Method*

- Model vehicle flows as flow rates
- Sensitive to **various flow** and **geometric features** of a roundabout (i.e. number of lanes, arrangement of lanes, entry width, and inscribed circle diameter)
- The most common deterministic model used in the U.S. is based on British and Australian research and practice.
  - British research correlates capacity to geometry
  - Australian research correlates capacity to traffic flow
- NCHRP 672 discusses calibration of driver behavior, lane use, and geometry for deterministic software models.
TRAFFIC ANALYSIS

Traffic Operations Software Tools

- Most commonly used: RODEL and SIDRA
  - Based on information in NCHRP 572 and the questionnaire distributed to U.S. agencies by this research team
- Task 3 considered these as well as ARCADY
  - ARCADY7 and RODEL model capacity, delay, and queue length using empirical questions developed from British roundabout data
- Preliminary recommendation: SIDRA
TRAFFIC ANALYSIS

Traffic Operations Software Tools

- ARCADY7 and RODEL
  - Model capacity, delay, and queue length using empirical questions developed from British roundabout data.
  - Roundabout capacity is linked to roundabout geometry including precise geometric details without directly incorporating gap acceptance theory
  - Require detailed input for geometry
- ARCADY7 provides a calibration process to incorporate findings presented in NCHRP Report 572
  - Unclear if RODEL can do the same
TRAFFIC ANALYSIS

Traffic Operations Software Tools

- SIDRA
  - Also, models capacity, delay, and queue length
  - Incorporates gap acceptance theory and basic geometric features
    - attractive for modeling U.S. roundabouts because key parameters such as critical headway and follow-up headway are common between the two approaches
  - Models are consistent with NCHRP 572 findings
    - Variations in driver behavior and aggregate geometry have more influence then geometric design
TRAFFIC ANALYSIS
Traffic Operations Software Tools

- SIDRA (continued)
  - Parameters can be modified by users to reflect local driving conditions
  - Use of “environmental factor” reflects tentative nature of U.S. drivers.
  - Reasonably approximates calculations achieved with the capacity, delay and queue models recommended in NCHRP Report 572.
  - Follow-up headway and critical headway can be modified
TRAFFIC ANALYSIS

Simulation

- Models transportation networks
- Sensitive to individual vehicle behaviors (e.g., car-following behavior, lane-changing behavior, and decision-making behavior)
- The most commonly used simulation method in the U.S. is based on U.S., British, and German research and practice.
- NCHRP 672 discusses the necessary driver behavior and traffic volume calibrations that must be applied when using the simulation model.
- FHWA Traffic Analysis Toolbox
- Examples of Simulation Software: VISSIM
TRAFFIC ANALYSIS

Capacity Analysis of Texas Roundabouts Using SIDRA and VISSIM

- Validation and enhancement phase of developing Texas-specific roundabout guidelines
- Objectives:
  - Confirm roundabout design criteria based on reasonability of results.
  - Use microsimulation results to enhance current guidelines for evaluating roundabout operations.
TRAFFIC ANALYSIS

Capacity Analysis of Texas Roundabouts Using SIDRA and VISSIM

East Continental Blvd. and South Carroll Ave., Southlake, TX

Fulton Ave. and Blanco Rd., San Antonio, TX
TRAFFIC ANALYSIS

Capacity Analysis of Texas Roundabouts Using SIDRA and VISSIM

- Results from VISSIM models were validated using data collected in the field
  - Southlake (PM) and San Antonio modeled trajectory, speed, and entry decision accurately so they were concluded to be the best models overall.
- Using the calibrated models the effect exiting flow, origin-destination patterns, and mean speed have on capacity were evaluated separately
- VISSIM **entry lane capacity** results compared to SIDRA results and the 2010 HCM entry lane capacity curve.
TRAFFIC ANALYSIS

Spreadsheet Evaluation Tool

- Evaluation of possible conversion of two-way stop to a roundabout

Source: Google Maps, 2011
TRAFFIC ANALYSIS

Spreadsheet Evaluation Tool

- Step 1: Check for Roundabout Feasibility
  Is there space available for the roundabout?

  Maximum inscribed diameter
  = 50’

  Design vehicle = single unit
  truck

Source: Google Maps, 2011
TRAFFIC ANALYSIS
Spreadsheet Evaluation Tool

- **Step 1: Check for Roundabout Feasibility**
  Can it handle the traffic demand?

  AADT = 13,000 veh/day
  9% Left Turns
  3% Cross Traffic

*Source: Google Maps, 2011*
TRAFFIC ANALYSIS
Spreadsheet Evaluation Tool

- Step 2: Enter Intersection Data
  How many lanes are needed on each approach?

<table>
<thead>
<tr>
<th>Approach</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>30</td>
<td>700</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>35</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>35</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>20</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Peak Hour Factor = 0.97
2% Heavy Vehicles

Source: Google Maps, 2011
TRAFFIC ANALYSIS
Spreadsheet Evaluation Tool

- Step 2: Enter Intersection Data
  Optional data entry for crash prediction

<table>
<thead>
<tr>
<th>Approach</th>
<th>Entering AADT</th>
<th>Exiting AADT</th>
<th>Circulating AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7600</td>
<td>3600</td>
<td>13000</td>
</tr>
<tr>
<td>2</td>
<td>950</td>
<td>850</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3650</td>
<td>7650</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>800</td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*Assumed peak hour counts are 10% of daily counts

Source: Google Maps, 2011
### TRAFFIC ANALYSIS

**Spreadsheet Evaluation Tool**

- **Step 2: Inputs for Roundabout Alternative**

  Data needed to calculate performance measures

![Roundabout Diagram](image)

<table>
<thead>
<tr>
<th></th>
<th># Lanes</th>
<th>RT Bypass Lane? (Y or N)</th>
<th># Exit Lanes</th>
<th>Entry Width [ft]</th>
<th>Angle to Next Leg [deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach 1</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>90</td>
</tr>
<tr>
<td>Approach 2</td>
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<tr>
<td>Approach 5</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>90</td>
</tr>
</tbody>
</table>

**Roundabout Alternative:**
- Number of Approaches
- # Lanes in Circle
- Mini-roundabout? (Y or N)
- Inscribed Circle Diameter [ft]
- Circulatory Width [ft] - 11

*Source: Google Maps, 2011*
TRAFFIC ANALYSIS
Spreadsheet Evaluation Tool

- Step 3: Inputs for Roundabout Alternative
  Option manual entry of performance measures

Source: Google Maps, 2011
TRAFFIC ANALYSIS
Spreadsheet Evaluation Tool

- Step 4: Inputs for Non-Roundabout Alternative
  Option manual entry of non-roundabout alternative characteristics

Source: Google Maps, 2011
### TRAFFIC ANALYSIS

**Spreadsheet Evaluation Tool**

- **Step 4: Inputs for Non-Roundabout Alternative**
  - Option manual entry performance measures

<table>
<thead>
<tr>
<th>Vehicle Conflict Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Conflict Points</td>
</tr>
<tr>
<td>Intersection Total Crash Prediction [crashes/year]</td>
</tr>
<tr>
<td>Intersection Injury Crash Prediction [crashes/year]</td>
</tr>
<tr>
<td>Average Speed [mph]</td>
</tr>
<tr>
<td>Volume-to-capacity ratio</td>
</tr>
<tr>
<td>Average delay [sec/veh]</td>
</tr>
<tr>
<td>Level of Service</td>
</tr>
<tr>
<td>95th Percentile Queue Length [vehicles]</td>
</tr>
<tr>
<td>Construction Cost [$]</td>
</tr>
<tr>
<td>Operation &amp; Maintenance Cost [$]</td>
</tr>
</tbody>
</table>
TRAFFIC ANALYSIS
Spreadsheet Evaluation Tool

- Compare Performance (see “Comparison” tab)

Source: Google Maps, 2011
Geometric Design
GEOMETRIC DESIGN

Introduction

• Applications Part 1
  – Roundabouts near schools
  – High speed rural intersections

• Geometric Design: Fundamental Principles
  – Single lane considerations
  – Multi-lane considerations

• Applications Part 2
  – Access management considerations
  – Traffic control during construction

• Peer Review Overview
GEOMETRIC DESIGN

Introduction

- Balancing of competing design forces
- Slow speeds create a safer environment
- Geometric parameters governed by maneuvering requirements of the design vehicle
- Design objectives are different for roundabouts in rural versus urban areas.
GEOMETRIC DESIGN

Introduction

(Source: NCHRP 672)
Outline for Design Process

(Source: NCHRP 672)
GEOMETRIC DESIGN

Principles and Objectives

- Principles from NCHRP 672 [6.2]:
  - Using deflection, facilitate slow entry speeds and consistent speeds on and out of the circulatory roadway
  - Number of lanes and lane assignment should result in desired capacity, lane volume balance, and lane continuity.
  - Smooth channelization that makes it obvious to drivers where they should be.
  - Sufficient accommodation of design vehicle
  - Keep all users in mind by meeting the needs of pedestrians and cyclists
  - Create ample sight distance and visibility for driver recognition of intersection and conflicting users.
GEOMETRIC DESIGN

Single Lane Roundabouts

- Size, location, and alignment
- Horizontal details
- How to sketch a roundabout from scratch
# Geometric Design

## Inscribed Circle Diameter

- Typical ranges for categories and design vehicles

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

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

NCHRP Report 672 Exhibit 6-9
GEOMETRIC DESIGN

Approach Angles

- Perpendicular approaches often are more amenable to achieving desired speeds.
- However, perpendicular approaches are not a design requirement.
- If approaches skewed, make corresponding adjustments to other design components.
GEOMETRIC DESIGN

Approach Angles

- Possible remedies:
  - Changing the inscribed circle diameter
  - Offsetting the approach centerline to the left of the center of the roundabout
  - Reducing entry widths and entry radii
GEOMETRIC DESIGN

Approach Angles: Example

Poor deflection
GEOMETRIC DESIGN

Approach Angles: Example – Kennewick, WA

(Source: Kittelson & Associates, Inc.)
GEOMETRIC DESIGN

Approach Angles: Example – Kennewick, WA

- Size, location, and alignment
- Horizontal details
- How to sketch a roundabout from scratch
GEOMETRIC DESIGN

*Horizontal Geometry Details*

- Entry design
- Exit design
- Circulatory width
- Central island design
- Splitter island design
GEOMETRIC DESIGN

Entry Width

- Largest determinant of a roundabout’s capacity
- Dependent upon the number of lanes and the design vehicle
- Typical single-lane entry width: 13 - 18 ft (4.0 – 5.5 m)
- Typical single-lane circulatory width: 16 – 20 ft (4.8 – 6.0 m)
GEOMETRIC DESIGN

Entry Curves: Single Lane Roundabouts

- Range from 35 ft to 100 ft (10 - 30 m)
- Radii should be balanced against entry speeds and design vehicle needs
- Roundabouts with lower speeds and smaller design vehicles may have smaller radii
GEOMETRIC DESIGN

Entry Curves: Single Lane Roundabouts

Continuation of Inside entry curve tangential to central island

Entry width

Outside entry radius tangential to outside edge of circulatory roadway

NCHRP Report 672 Exhibit 6-14
GEOMETRIC DESIGN

Exit Geometry

- Designed to enforce a curved exit path
- Consider pedestrians
- Can be larger at rural locations
GEOMETRIC DESIGN

Exit Curves: Single Lane Roundabouts

Continuation of Inside exit curve tangential to central island

Outside exit radius tangential to outside edge of circulatory roadway

Exit width based on design vehicle requirements
GEOMETRIC DESIGN

Differing Exit Design Philosophies

Tangential exit design

Curved exit design
GEOMETRIC DESIGN

Exit Curvature

- Radial alignments with smaller exit radii and offset-left alignments with larger exit radii each have their place
- Each circumstance requires its own solution, with principles determining tradeoffs

NCHRP Report 672 Exhibit 6-15, 6-16
GEOMETRIC DESIGN

Circulatory Roadway Width: Single Lane Roundabouts

- Width should be comfortable for passenger cars
- Width should accommodate transit vehicle without using apron
- A truck apron can be used to minimize the width while accommodating trucks
GEOMETRIC DESIGN

Central Island

- Includes both raised non-traversable area and truck apron area
- Can be landscaped → consider maintenance
- Central island should not attract pedestrians
GEOMETRIC DESIGN

Central Island Example: Santa Barbara, CA
GEOMETRIC DESIGN

Central Island Example: Bend, OR
GEOMETRIC DESIGN

Splitter Islands

• Should be provided on all but the very small roundabouts
• Purpose is:
  – provide shelter for peds
  – assist in controlling speeds
  – positive guidance
  – physically separate entering and exiting traffic streams
  – deter wrong way movements
  – placement of signs
• Larger splitter islands can enhance safety by separating entering and exiting traffic streams
GEOMETRIC DESIGN

Pedestrian Crossing Detail

Detail "A"

- Detectable warning surface
- 24 in (600 mm)
- 6 ft (1.8 m) min.

- 20 ft (6 m)
- 10 ft (3 m)
- 100 ft (30 m) desirable
- 50 ft (15 m) minimum

See detail "A"

NCHRP Report 672 Exhibit 6-12
GEOMETRIC DESIGN

Splitter Island Details

Offset 3 ft (1 m)

Offset 1.5 ft (0.5 m)

R = 3 ft (1 m)

Offset 3 ft (1 m)
down to 1 ft (3 m)

R = 1 ft (0.3 m)

R = 1 ft (0.3 m)

R = 1 ft (0.3 m)

Offset 3 ft (1 m)
down to 1 ft (0.3 m)

R = 2 ft (0.6 m) min.

NCHRP Report 672 Exhibit 6-13
GEOMETRIC DESIGN

Channelization Example: Kennewick, WA

Photo: Lee Rodegerdts
GEOMETRIC DESIGN

*Single Lane Roundabouts*

- Size, location, and alignment
- Horizontal details
- How to sketch a roundabout from scratch
GEOMETRIC DESIGN

Single Lane Roundabouts

- Size, location, and alignment
- Horizontal details
- How to sketch a roundabout from scratch
GEOMETRIC DESIGN

How to Sketch a Roundabout from Scratch

- There is no one correct way to design a roundabout – each designer develops their own methods
- Keeps principles in mind when developing a sketch
- Test sketch after completion
- Iterate as needed to balance objectives
- The following method is but one way to sketch a single-lane roundabout
- Other techniques needed for multilane
GEOMETRIC DESIGN

Starting Up: Size and Locate Circle

1. Consider Roadway Center Lines

2. Determine Initial Inscribed Circle Diameter (ICD)

3. Determine Center of Roundabout

4. Determine Circulatory Roadway Width
GEOMETRIC DESIGN

Sketching a Roundabout: Construct Entries and Exits

5. Locate the Pedestrian “Box”

6. Start from the Inner Alignment

7. Then the Outer Alignment
GEOMETRIC DESIGN

Sketching a Roundabout: Add Details

8. Construct Splitter Island

9. Construct Pedestrian Crosswalk

10. Provide Truck Apron (If Needed)
GEOMETRIC DESIGN

Sketching a Roundabout: Complete Remaining Details

11. Show Sidewalk

12. Take Care of Bicyclists

13. Determine Access Locations

14. Preserve On-Street Parking
GEOMETRIC DESIGN

Sketching a Roundabout: Clean Up to “Presentation” Quality

15. Provide Details
16. Draw Roundabout Striping
17. Erase Construction Lines
GEOMETRIC DESIGN
Multilane Roundabouts

- All of the principles of the single-lane roundabout apply
- Additional considerations:
  - Lane numbers and assignments
  - Natural vehicle paths
  - Crossing versus merging/diverging paths
- Techniques that work for single-lanes may not work for multilanes
- Order of magnitude more complicated – care needed to produce good designs
GEOMETRIC DESIGN
Multilane Roundabouts: Elements

- Lane numbers and assignments
- Conflict area management
- Accommodating side-by-side vehicles
- Designing for future expansion
- Treatment of wide medians on divided highways
GEOMETRIC DESIGN

Multilane Roundabouts: Lane Numbers and Assignments

- Each entry, exit, and section of circulatory roadway should have the appropriate number of lanes, properly assigned
- Geometric design, signing/striping, and operational analysis need to agree
- OK to have mixture of single- and multilane entries
GEOMETRIC DESIGN

Multilane Roundabouts: Number of Lanes

- Use operational analysis to determine appropriate lane assignment
- Provide only as many lanes as needed for existing or anticipated demand
  - Wider entries and exits tend to be less safe for all modes
  - Consider building for near-term volumes and planning for future expansion
GEOMETRIC DESIGN

Match Geometric Design to Anticipated Lane Assignment

DOUBLE LEFT TURN = WIDER ENTRY

SINGLE-LANE EXIT = NARROWER EXIT
GEOMETRIC DESIGN

Flair: Adding a Full Lane

NCHRP Report 672 Exhibit 6-24
GEOMETRIC DESIGN

Multilane Roundabout Design Elements

- Lane numbers and assignments
- Conflict area management
- Accommodating side-by-side vehicles
- Designing for future expansion
- Treatment of wide medians on divided highways
GEOMETRIC DESIGN

Conflict Area Management

- Path overlap conflicts
- Exit-circulating conflicts
GEOMETRIC DESIGN

Natural Vehicle Path

Desirable vehicle path alignment

NCHRP Report 672 Exhibit 6-29
GEOMETRIC DESIGN

Natural Vehicle Path

- Path an approaching vehicle will take assuming there is traffic in all lanes
- Speed and orientation of vehicle at the yield line determines the natural path
- Natural path does not have sudden changes in curvature
- Consecutive curves should be of a similar radius
- If paths overlap, safety or capacity may be affected
GEOMETRIC DESIGN

Vehicle Path Overlap

Path overlap

Speed and trajectory of vehicle at yield point determines natural path

NCHRP Report 672 Exhibit 6-28
GEOMETRIC DESIGN

Capacity Problem Due to Entry Path Overlap

- Note poor lane utilization
GEOMETRIC DESIGN

Design Techniques to Avoid Path Overlap

- Median widened toward exit lanes to maximize entry deflection
- Range of alignments may be appropriate
- Projection of approach alignment offset to left of roundabout center
- Original centerline
- Small-radius entry curve (R = 65 to 120 ft [20 to 35 m] typical)
- Large-radius approach curve
- Large radius (R > 150 ft [45 m]) or tangent at yield point

NCHRP Report 672 Exhibit 6-30
GEOMETRIC DESIGN

*Multilane Roundabout Case Study: Clearwater, FL*

Photo: Bruce Robinson
GEOMETRIC DESIGN
Multilane Roundabout Case Study: Clearwater, FL
GEOMETRIC DESIGN

Multilane Roundabout Case Study: Clearwater, FL

Photo: Lee Rodegerdts
GEOMETRIC DESIGN

Multilane Roundabout Case Study: Clearwater, FL

Before (2001)

After (2005)
GEOMETRIC DESIGN

Multilane Design Elements

- Lane numbers and assignments
- Conflict area management
- Accommodating side-by-side vehicles
- Designing for future expansion
- Treatment of wide medians on divided highways
GEOMETRIC DESIGN

Circulatory Roadway Width: Double-Lane Example

NCHRP Report 672 Exhibit 6-36
GEOMETRIC DESIGN

Accommodating Trucks

- Truck occupying entire circulatory roadway
  - Common design approach for roundabouts with relatively few trucks
- Truck next to passenger car
  - Commonly a prudent design solution to provide a possible escape for a passenger car driver who pulls next to truck
- Truck next to truck
  - Likely rare occurrence, since truck drivers not likely to pull next to each other
  - May be needed at locations with high truck volumes
GEOMETRIC DESIGN

Accommodating Trucks

• Ongoing research in this area
  – Study by Wisconsin and Minnesota DOTs (primarily focused on treatments of normal design vehicles)
  – Pooled fund study led by Kansas DOT (primarily focused on oversized trucks)
GEOMETRIC DESIGN
Multilane Roundabouts Design Elements

- Lane numbers and assignments
- Conflict area management
- Accommodating side-by-side vehicles
- Designing for future expansion
- Treatment of wide medians on divided highways
GEOMETRIC DESIGN

Phased Construction Plan

Consider when:

- Multilane required for long-term traffic demand.
- Single-lane provides adequate capacity for near term traffic demand (5+ years).
- Single-lane offers safety benefits for near term.

Typical Design Approach:

- Design ultimate (multilane) geometry first.
- Then establish interim geometric plan.
GEOMETRIC DESIGN
Phased Multilane Construction Example

Interim Design

Outside curbs in ultimate location.

Wide median & splitter islands.

Truck apron in central island.
GEOMETRIC DESIGN

Phased Multilane Construction Example

Ultimate Design

Narrowed splitter islands.

Remove truck apron.
GEOMETRIC DESIGN

Multilane Roundabouts Sample Design

- Lane numbers and assignments
- Conflict area management
- Accommodating side-by-side vehicles
- Designing for future expansion
- Treatment of wide medians on divided highways
GEOMETRIC DESIGN

Treatment of Wide Medians on Divided Highways

High Speed

Slower Speed
GEOMETRIC DESIGN

Treatment of Wide Medians Example: Dublin, OH
Traffic Design
TRAFFIC DESIGN

• Resources:
  • Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)
  • NCHRP 672

(Source: NCHRP 672)
TRAFFIC DESIGN

Principles

• Principles from NCHRP 672 [7.2], Markings and Signs...
  • are an integral aspect of design (especially for multilane roundabouts) and should be included in early design stages.
  • are meant to make clear to users how to navigate through a roundabout but don’t provide safety as geometric features do.
  • should be used in such a way that they work with one another to clearly convey there message.
  • should guide vehicles to their appropriate lane on approach (providing sufficient time and distance to do so) and eliminate the need to change lanes within the circulatory roadway in order to get to their destination.
TRAFFIC DESIGN

Designation of Lanes

- These principles also apply to designation of lanes on approaches to roundabouts
  - Traffic volume considerations and roundabout operations
  - Balance lane use
  - Exit lane requirements
TRAFFIC DESIGN

Pavement Markings

- Approach and Departure Pavement Markings
  - Lane lines, edge lines, lane-use arrows, other pavement work and symbol markings, yield lines, and crosswalk markings

(Source: NCHRP 672)
TRAFFIC DESIGN

Pavement Markings

- Entrance and Yield Lines

(Source: NCHRP 672)
TRAFFIC DESIGN

Pavement Markings

- Pedestrian Crosswalk Markings

(Source: NCHRP 672)
TRAFFIC DESIGN

Signing

Yellow edgelines for channelization
White solid edge line
White lane use arrows
White lane line
White dotted lane line extension
Optional truck apron extension for channelization
White wide dotted entrance line

(Source: NCHRP 672)
TRAFFIC DESIGN

Signing

(Conditional)

Regulatory Signs

(Source: MUTCD 2009)
TRAFFIC DESIGN

Signing

- Other Regulatory Signs:
- Yield Here to Pedestrians and Stop Here for Pedestrians signs
- No-Left-Turn and No-U-Turn signs

(Source: NCHRP 672)
TRAFFIC DESIGN

Signs

Other Warning Signs:
- Object Markers
- Yield Ahead Sign
- Advance Pedestrian Crossing sign

[source: MUTCD 2009]
APPLICATIONS PART II

Agenda

• Applications Part 1
  – Roundabouts near schools
  – High speed rural intersections

• Geometric Design: Fundamental Principles
  – Single lane considerations
  – Multi-lane considerations

• Applications Part 2
  – Access management considerations
  – Traffic control during construction

• Peer Review Overview
APPLICATIONS PART II

Access Management in the Vicinity of Roundabouts

• Considerations
  – Flows downstream from roundabout are more randomly distributed than downstream from a signal
  – Space available between access point and roundabout?
  – Speed transition area near roundabout = more difficult for minor street drivers to judge gaps (particularly in higher speed locations)
  – Consider use of frontage roads, cul-de-sacs, cross-access agreements, etc.
  – Roundabouts provide safe u-turn opportunities

• What to do with driveways?

• Three typical cases
  – Driveways entering roundabout
  – Driveways near roundabout
  – Midblock driveways between roundabouts
APPLICATIONS PART II

Access Management: Driveways Entering a Roundabout

- Generally should avoid
- High-volume driveways should be designed as regular approach
APPLICATIONS PART II

Access Management: Driveways Near a Roundabout

- In general, same principles as for driveways near signalized intersections
- Driveways blocked by splitter island restricted to right-in/right-out
- Should avoid driveways between pedestrian crossing and yield line
APPLICATIONS PART II
Access Management: Full Access Near a Roundabout

What spacing is needed for full access with a left turn pocket?
APPLICATIONS PART II

Full Access Near Roundabouts: Example Calculation

20’ (6 m)  
75’ (22 m) min.  
15’ (5 m) min.  
90’ (30 m)  
10’ (3 m)  
25’ (7.5 m)  
varies

IMPORTANT: Adjust to local standards.
APPLICATIONS PART II

Full Access Near Roundabouts: Example Calculation, Cont.

235’ (~70 m) total

NOTE: Potential restricted access
APPLICATIONS PART II

Traffic Maintenance During Roundabout Construction

• Considerations
  – Public education – prior to, during, following construction
  – Phased construction?
  – Traffic conditions during construction
  – Work zone traffic control measures
    • Pavement markings and/or channelization devices place in same layout as final dimensions wherever possible
    • Signing – permanent signing should be installed where possible during first construction stage
    • Lighting
  – Contractor, designer, utility coordination
  – Maintenance after opening
    • Landscaping – Low maintenance, pullouts in central island for maintenance vehicles?
APPLICATIONS PART II

Traffic Maintenance: Phased Construction Plan

Consider when:
- Multilane required for long-term traffic demand
- Single-lane provides adequate capacity for near term traffic demand (5+ years)
- Single-lane offers safety benefits for near term

Design Approach:
- Design ultimate (multilane) geometry first
- Then establish interim geometric plan
APPLICATIONS PART II
Traffic Maintenance: Phased Multilane Construction Example

Interim Design

Outside curbs in ultimate location.

Wide median & splitter islands.

Truck apron in central island.
APPLICATIONS PART II
Traffic Maintenance: Phased Multilane Construction Example, Cont.

Ultimate Design

Narrowed splitter islands.

Remove truck apron.
APPLICATIONS PART II

Traffic Maintenance: Construction Traffic Control

- How to stage construction?

Photo: Lee Rodegerdts
APPLICATIONS PART II

Traffic Maintenance: Construction Staging

• Best: Detour all legs
• Ok: Detour two legs
• Possible staged construction sequence
  – install signing & lighting
  – construct widening
  – reconstruct or resurface approaches
  – construct splitter islands & delineate central island
  – construct central island
APPLICATIONS PART II

Construction Staging Example: Towson, MD

Photo: Ed Myers
APPLICATIONS PART II

Construction Staging Plan Examples

- **Stage 1** Temporary roadway construction
APPLICATIONS PART II

Construction Staging Plan Example: Oakland County, MI

- **Stage 2** Primary roundabout construction
APPLICATIONS PART II

Construction Staging Plan Example: Oakland County, MI

- **Stage 3** West approach construction
APPLICATIONS PART II

Construction Staging Plan Example: Oakland County, MI

- **Stage 4** South approach construction
PEER REVIEW

Agenda

• Applications Part 1
  – Roundabouts near schools
  – High speed rural intersections

• Geometric Design: Fundamental Principles
  – Single lane considerations
  – Multi-lane considerations

• Applications Part 2
  – Access management considerations
  – Traffic control during construction

• Peer Review Overview
PEER REVIEW

Introduction

- A review by a 3rd party to evaluate a design and/or supporting information.
  - Can be conducted at any time during the feasibility or design process.
    - An earlier peer review (such as at the field check level of plan preparation) can identify design flaws and allows time for correction.
    - A later peer review (such as at the 60% or 80% plan level) will focus more on signing, striping, lighting, and plan preparation issues.

- TXDOT: You should encourage and support reviews
  - Internally: Between TXDOT staff
  - Externally: Reviewing work completed by consultants

- Iowa DOT Transportation Safety Assistance Program
  - IADOT pays for any roundabout review requested
PEER REVIEW

Introduction

• A peer review can cover a single issue or be broad in scope.
• Two main types of peer reviews
  – Feasibility level
  – Geometric design
PEER REVIEW

Introduction

• Traffic operations
• Lane configurations
• Preliminary design layout – fatal flaws
  – Speed check
  – Natural paths
• Is a roundabout an appropriate treatment?
PEER REVIEW

Elements of Design

- Horizontal layout
- Vertical layout
- Pedestrian/bicycle accommodations
- Sight distance
- Signing/pavement marking
- Sight Distances
- Lighting
PEER REVIEW

Elements of Design: Horizontal Layout

- Fastest path vehicle speeds
PEER REVIEW

Elements of Design: Horizontal Layout

- Natural Vehicle Paths
PEER REVIEW

Elements of Design: Vertical Layout

- Approach grades
- Drainage
- Central island profile
PEER REVIEW

Elements of Design: Pedestrian/Bicycle Accommodations

- Pedestrian accommodations
  - Location of pedestrian crossing
  - Pedestrian crossing alignment
  - Design of pedestrian refuge
  - Presence of detectable warning surfaces
PEER REVIEW

Elements of Design: Pedestrian/Bicycle Accommodations

- Bicycle accommodations
  - Bike lane widths
  - Bike ramps off/on roadway
PEER REVIEW

Elements of Design: Sight Distance

• Stopping sight distance
  – Approach sight distance
  – Sight distance on circulatory roadway
  – Sight distance to Crosswalk on exit
• Intersection sight distance
PEER REVIEW

Elements of Design: Signing and Pavement Markings

- Signing
  - Sign selection and placement
  - Intersection context
  - Use of diagrammatic signs
  - Lane usage signs
- Pavement markings
  - Within the circulatory roadway
  - Pavement legends
  - Striping at the yield line
  - Pedestrian crossing markings
PEER REVIEW

Elements of Design: Lighting

- Location of lighting equipment
- Illumination level appropriate for location?
• Intersections having issues that make it difficult for a conventional form will be difficult with a roundabout.

• Solutions can be preconceived. Perform "intersection design studies,” versus “roundabout design studies.”
PEER REVIEW

Elements of Design: Experiences

• Be sure you know the problem (operations and safety) before you create the solution.

• Roundabouts are based on sound design PRINCIPLES, not standards—one size does not fit all.
PEER REVIEW

Elements of Design: Experiences

• Designers are often reluctant to make significant changes. The initial plan keeps getting tweaked with the same end result.

• Teams often underestimate the time needed for public awareness.

• Teams take risks with roundabouts in locations where they would not take risks for conventional roadway solutions.
PEER REVIEW

Elements of Design: Experiences

• People are surprised by how large (or small) roundabouts can be.

• People underestimate the impacts of trucks: WB-50 (WB-15) versus WB-67 (WB-20).
PEER REVIEW

Elements of Design: Test Your Understanding

• The following slides are photos of roundabouts from around the world

• Identify things that appear to be consistent with the roundabout principles shared and what you would change in an ideal world
PEER REVIEW

Test Your Understanding: Urban Single Lane Roundabout – Tallahassee, FL

Photo: Aimee Flannery
PEER REVIEW

Test Your Understanding: Urban Single Lane Roundabout – Truckee, CA
PEER REVIEW

Test Your Understanding: Traffic Calming Roundabout - Naples, FL

Photo: Lee Rodegerdts
PEER REVIEW

Test Your Understanding: Urban Compact Roundabout – Bradenton, FL

Photo: Lee Rodegerdts
PEER REVIEW

Test Your Understanding: Urban Single Lane Roundabout – Germany
PEER REVIEW

Test Your Understanding: Urban Compact Roundabout – Gainsville, FL
PEER REVIEW

Test Your Understanding: Urban Double Lane Roundabout – Towson, MD
PEER REVIEW

Test Your Understanding: Urban Double Lane Roundabout –Santa Barbara, CA

Photo: Lee Rodegerdts
PEER REVIEW

Test Your Understanding: Rural SingleLane Roundabout – Switzerland

Photo: Paul Ryus
PEER REVIEW

Test Your Understanding: Urban Double Lane Roundabout – Phoenix, AZ
PEER REVIEW
Recommended Geometric Revisions

- REALIGNED FRONTAGE ROAD TO IMPROVE EXIT ANGLE AND REDUCE EXIT SPEED.
- REALIGNED EXIT TO IMPROVE ANGLE BETWEEN SB FRONTAGE ROAD ENTRY.
- PEDESTRIAN RAMPS.
- OPTIONAL CIRCULATORY LANE STRIPING.
- EXISTING ENTRY LANE STRIPING (APPROX).
- NEW PEDESTRIAN REFUGE AREA IN EXISTING SPLITTER ISLAND.
- EXTENDED SPLITTER ISLAND AND RIGHT-TURN ISLAND TO PROVIDE PEDESTRIAN REFUGES.
- ENTRY GEOMETRY ADJUSTED TO REDUCE WIDTH AND MINIMIZE PATH OVERLAP.
- EXTENDED RIGHT-TURN ISLAND TO PROVIDE PEDESTRIAN REFUGE.
- WIDENED CIRCULATORY ROADWAY.
- ADJUSTED ENTRY GEOMETRY DUE TO WIDENED CIRCULATORY ROADWAY.
PEER REVIEW
Test Your Understanding: Urban Roundabout –Nashville, TN
PEER REVIEW

Test Your Understanding: Urban Single Lane Roundabout – Florida

Photo: Justin Bansen
CONCLUSION
CONCLUSION

- Is a roundabout a candidate?
- What makes a roundabout different from other intersections?
- Resources:
  - NCHRP 672, Roundabouts: An Informational Guide – 2nd edition
  - 2010 Highway Capacity Manual – Volume 3
  - 2009 MUTCD (Markings and Signage)
  - Implementation Workbook (Texas Roundabout Guidelines)