WHEN ROUNDABOUTS NEED SIGNALS WHAT ARE THE OPTIONS?

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Dennis Eyler, P.E., P.T.O.E.

Presentation Overview

• Roundabout Features and Geometric Issues
• Examples of Other Junctions with Circular Features
• When Would Signals Be Needed?
• Ways to Add Signals
• Can the Signals Operate Part Time?
• Simulation Results – VISSIM Was Used
• Conclusions and Recommendations
• Issues, Questions and Needed Research
• There is Often Tension Between Roundabout Designers and Signal Engineers

Roundabout Features and Issues Which May Require Adding Signals

• Safety – Roundabouts Have an Excellent History of Safe Operation
• Efficiency – Less Delay and Fewer Stops, Off Peak, But Typically Less Capacity Than a Signal
• Capacity – Signals Can Add Capacity Without Sacrificing Safety
• Congestion – Added Signals Can Handle Short Periods of Recurring Congestion
• Incidents – Ability to Respond
• ADA – “Desires” and Requirements for Pedestrian Crossings

What is a Modern Roundabout?

• It is not a circular roadway that connects a series of “T” intersections – that is a “rotary” or traffic circle
• A properly designed roundabout is a compact junction of one-way roadways

Critical Lane Calculation From the U.K.

Note: Left side driving

Single Lane Roundabouts – Less Than Optimal Designs

The ability for multi-lane roundabouts to succeed has been hindered by sub-optimal designs for single lane roundabouts

- A diverge shouldn’t be a conflict
- It’s really a 1 to 1 conflict
- This is actually a rotary!
Examples of “Rotaries” From Europe

France
Switzerland

So What’s The Problem, the Rotary Looks to Be Safe?

- The splitter island is too narrow
- Vehicles spend more time in the conflict area
- Capacity is reduced
- Drivers familiar with single lane roundabouts that are “rotaries”, won’t know how to drive a properly designed multi-lane roundabout
- What purpose is served by the inside lane?

Benefits of Wide Splitter Islands

The British discovered that this distance is critical. It shows up in RODEL as phi versus 2 phi

Two Lane Rotary or Concentric - Compared to Two Lane Modern Roundabout

It’s really a 1 to 1 conflict

Benefits of Wide Splitter Islands

- 120 foot ICD
- Medium width splitter

EFFECTS OF SPLITTER WIDTH
WITH ROUNDABOUT NEAR CAPACITY

(1) Measured using the Wisconsin FDM method of examining laser conflict area segments under 100 feet in length, therefore phi applies for RODEL.
Controlling the Fastest Path

• Having a wide splitter should not create a fastest path issue
• Control fastest path with approach geometry
  • Not with a small diameter
  • Not with a small exit radius
• Approaches should be offset to the left – aim left curb 40 to 50 feet left of center
• Approaches should provide visual and physical occlusion

Roundabout Approach Geometry

For speed control provide deflection, aim 40 to 50 feet left of center
Occlude straight line into the roundabout
Try to keep this distance under 100 feet

Other Geometric Issues

• For Through Route Alignment, Connect Reversing Curves With Tangents
  • Reduces truck swaying
  • Fewer curb hits and helps side-by-side traffic stay in lanes
  • For roundabouts on a major highway, through trucks should not need to use the apron
• Avoid More Than 4 Entering Legs
  • Upon seeing a 5 or 6 leg intersection, planners, landscape architects and politicians immediately say “That’s the place for a roundabout”
  • Try to get to 4 legs or use a roundabout pair – designing for lane keeping by drivers is a critical goal
  • BUT, if necessary, 5 or 6 entering legs can be done

5 Leg – Hamilton New Zealand

Reducing 5 Approaches to 4

Example of Optimal Approach Geometry

Stadium Road at Victory in Mankato

Positive Roadway Design Features

Right turn happens center on "inside" lanes
Tangents ends

Left curb of entry tangent to center island
Splitter islands obscure portion of approach right edge
**Pavement Crowns**

- Some agencies use crowns on the central (circulatory) roadway
  - Wisconsin – 2/3 inward slope (to avoid truck tipping)
- Others use outward slopes
- **Issues**
  - Crowns on the central roadway may convey the idea of a circular roadway connecting a series of "T's"
  - Drainage structures needed in the central island and on outside
  - Apron, inside curb height, and inward slope could cause snow plowing problems
- **Suggestion**
  - If crowns are used, they could be run out the exit legs
  - May help on multi-lane to convey inside lane is exiting

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**Roundabouts Compared to “Conventional” Intersections**

**The Roundabout’s Problem - Left Turns**

*The Roundabout’s Problem - Left Turns*

**Left Turns at an Intersection**

**Left Turns at a Roundabout**

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**From the TRB Paper**

**WHEN ROUNDBOUNDS NEED SIGNALS WHAT ARE THE OPTIONS?**

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**The Purpose of A Traffic Signal**

*A traffic signal and the intersection geometry are ways a traffic engineer can leave their intelligence at a intersection to operate it in their absence. — Matt Huber, Professor at the University of Minnesota*

- This can also be said about roundabout design
How Can A Signal Help A Roundabout?

- The flow rate through a conflict area can be higher with signal control than with YIELD control
  - Roundabout = approx. 1200 vph
  - Signal = 1400+ vph
- One approach failing on a roundabout while the other 3 are fine, may be due to unusual demand.
- One approach failing at a signal is due to improper timing.
- Multi-lane approaches at roundabouts can be intimidating, signal control can help pedestrians.
- High pedestrian volumes crossing a roundabout can cause problems, a signal can allocate capacity on the approach.

TRB Paper Objectives

- Inventory junction designs having roundabout or circular roadway features
- Inventory junctions with added signal control and the type of signal control
- Propose additional signal control methods
- Look at some innovative intersection designs
- Test in simulation
  - Not done to establish a “best” concept
  - Done to identify issues related to geometry and signal control

Alternatives Evaluated

- Circular Junctions
  - Modern, multi-lane roundabouts with 2 or more entry lanes
  - Large rotary junctions and with enhancements
  - Turbo roundabouts from the Netherlands
  - Adding “turbo” treatment to the typical modern U.S. roundabout design
- Innovative Intersections with Roundabout Features
  - Through-about (hamburger) junction
  - Offset, split through-about (RCI 1999)
  - A double roundabout
  - A standard intersection with signals (for comparison purposes)

Roundabouts

- 2 Lanes in, 2 lanes out
  - Used as a base for testing
  - Adding capacity while keeping 2 lane exits

Rotary - Concentric Striping

- Large Rotary
  - 4 Lanes in, 2 lanes out

From Spain
Enhanced Rotary – Spiral Striping

From Ireland - Left side driving Dublin Airport Entrance

Turbo Roundabouts

Compact Turbo Roundabout

Through-abouts

Popular in Europe, there are some in the U.S. and 1 in Australia, often used with LRT in the median

The original RCI
Throughabouts in the U.S.

- Washington, D.C.
- Fairfax, VA

Throughabout For LRT
Salt Lake City

Rural Throughabout
Spain

Through-abouts on Rural Two Lane Roadways

**Advantages**
- Deflect side street traffic
- Reduce number of conflict points
- Avoid re-alignment of mainline
- Accel and decel lanes can be easily provided

**Disadvantages**
- Cost
- Space
- Lefts from heavy mainline flow must exit to the right and then cross heavy flow

Double Roundabout and
Standard Intersection with Signal

Use where opposing mainline
lefts are heavy

Which Signals Can be Added to
Roundabouts and Circular Intersections

- RRFB’s
- Pedestrian signals
- HAWKS
- Metering signals
- Full signal control with part-time operation
- Partial signal control (only at key conflict points)
  - Example: 1 entry point at a rotary

Throughabout For LRT
Salt Lake City

Rural Throughabout
Spain

Through-abouts on Rural Two Lane Roadways

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Adding Signals to a Roundabout - Meters

- Typically installed at crosswalks upstream
- Queuing or delay on an approach, signal on the approach causing the problem turns red
- Detectors on the congested approach extend the red time on the approach causing the problem
- The signal going to red to clear the queue is usually on the first leg to the left

Adding Signals to a Roundabout - Meters

- Roundabout entry is still controlled by YIELD signs.
- Can be applied to all approaches using just one controller
- Ped signals on exits could be independent but may be coordinated with inbound ped signals or exit leg for an approach getting a queue clearance
- Splitters should have width to allow two-stage crossing

Where Are Meters in Use?

- A few locations in the U.S.
  - Clearwater, FL – ped signal
  - Olympia, WA – adjacent signal controlling a merge
  - Ellicott City, MD – "emergency" style flasher/signal
  - Carmel, IN – HAWKS at an interchange near a school
- Ped signals widely used in the United Kingdom
  - Some are far upstream at mid-block
- Other variations
  - Ramp meter style used in Australia
  - New Zealand - a signal 300 feet upstream of the roundabout. It turns red and remains red until the queue on the other approach is cleared. Some have signs which read: “Signals activated by roundabout queues”.

Clearwater, Florida

This pedestrian signal predates the roundabout

Olympia, Washington

The signal controls a merge of two exits from a parking garage. It has 3 phases. The third phase is all red and called by roundabout queues.

Howard County, Maryland

Queue detection

Maryland SR 100 at Snowden River Parkway
The use of a HAWK has been questioned, because there is no crosswalk.

Here there is a crosswalk.

**Carmel Hawk Signal Phasing**

Queue/delay detector on ramp calls and extends phase 2

**Effects of Circulatory Flow Source**

- Roundabouts at interchange ramp terminals have become common.
- The flow away from the bridge is “different” than that at a standard junction.
- With fewer sources of entering traffic, the flow between the ramps is “smoothed out.”
- This results in fewer usable gaps than would be expected at a 4 leg roundabout.
- Ramp roundabouts may need signal assistance sooner.
- This effect was further tested at a 5 leg roundabout.

**Roundabouts at Interchange Ramp Terminals**

**Effects of Circulatory Flow Source**

A. Diamond interchanges with fewer flow sources and added distance for traffic to “spread out” have poorer operation than would be expected at a single 4 leg roundabout with similar flows.

B. The “peanut” design reduces the distance between roundabouts and performs better than a standard diamond under the conditions tested.

C. The 4 leg and 5 leg test intersections continued the trend of more and closer traffic spurs producing more gaps and more capacity.
Adding Signals to Large Roundabouts and Rotaries

- Signal indications are on the circular roadway
- Ped signals on exits should be independent or coordinated with inbound ped signals
- Splitters should have width to allow two-stage crossing
- Pedestrian crossings to central island may be provided either from splitter or downstream

Large Rotary

1. Each entry point is an intersection and has a controller
2. Coordination is either as a one way street or by opposing legs depending on left turn demand versus storage
3. Some circles in D.C. used flashing yellow right turn arrows for the phase 1 “green” with sign “Enter on flash yellow after yielding to traffic in the circle”

Enhanced Rotary

1. One controller or 4 coordinated
2. Operates with leading opposing entry phases during moderate traffic
3. During heavy traffic could run lead-lag
4. Pedestrian crossings of exit legs could have separate control

Issues

- Speed control is accomplished within the roundabout
- Size and Cost
Turbo Roundabout (Netherlands)

1. Near side signal heads at each conflict area
2. One controller operating as; a 2 phase with opposite legs green or a 4 phase with clockwise rotations and with timed and extendable “overlaps” and “underlaps” to add capacity or with lead-lag opposing lefts
3. It would be possible to vary phasing based on volumes
4. When signals are off, yield signs at entry points control traffic
5. Pedestrian movements are often grade separated

Compact Turbo Roundabout (Proposed)

1. Signal control at entry lines
2. Signal heads in left turn slots are independent of through signal heads
3. No signals on circulating roadway
4. One controller which operates as an 8 phase with lead-lag left turn phasing
5. When signals are off, blank-out yield signs are on at entry points to control traffic
6. Pedestrian movements are grade separated or placed far away with separate controls
7. This is a theoretical concept, none have been built

Compact Turbo Signal Phasing

Through-about

1. Phases 2 and 6 are timed or extendable overlaps. Inbound rights could be 1-2 and 5-6
2. Cycle length may be affected by circle diameter and left turn volumes
3. Side street lefts could be made to use circle
4. Right turn bypasses on side street approaches greatly improve operations
5. Side street junctions with circle could just have yield control
6. One controller
7. Pedestrian movements are on the outside
8. Could be considered for 5 or 6
9. Leg intersections
Offset/split Through-about
1. One controller with one ring per mainline roadway
2. Optional ring barriers depending on crossing demand
3. Mainline conflict points operate as permitted-protected with phases called based on queues or delay
4. Minor street and circular roadway conflict points may have full or part time signal control
5. Approaches to mainline operate with flashing red right arrows

Double Roundabout
1. Conceptual design to avoid conflicting opposing left turns
2. Metering signals may be added

RCUT
1. One controller with one ring per mainline roadway or up to 4 controllers
2. May have no ring barriers depending on crossing demand
3. Mainline conflict points operate as permitted-protected with phases called based on queues or delay
4. Approaches to mainline operate with flashing red right arrows
5. Advance warning flashers could be used on the mainline approaches

Standard Intersection With Signal
1. Standard 8 phase controller
2. Left turns are all protected-only
3. Dual left turns on all approaches

Volumes Used in Simulation
Intersection at Capacity

Simulation Results
M.L. 50k
Side Street 17k
Volumes Used in Simulation
Nearly Equal and Heavy

Volumes Used in Simulation
Just Meeting Signal Warrants

Signal Placement Issues
- Upstream on the approaches at the crosswalks
  - What happens when a queue is clearing and a ped call comes in?
- Downstream on the exit at the crosswalk
  - Can the median width and "policy" allow for two stage crossings?
  - Can the outbound signal be coordinated with an inbound queue clearing phase?
- At the yield line – not recommended
  - What is the indication - R-Y-G or arrows?
  - Where is the ped crossing?
  - What controls entry when the signal is at rest? A flashing yellow right arrow is not the answer
- On the central roadway
  - A large ICD is needed – 300 ft + to have signals there

Simulation Results
M.L. 30k
Side Street 20k

Simulation Results
M.L. 20k
Side Street 6k

Conclusions – Signals at Roundabouts
- Metering signals can increase capacity and reduce travel times as the roundabout approaches capacity
- Demand based signals at roundabouts provide the safety benefits of roundabout geometry plus the ability to increase capacity when needed
- Ped crossings on exits could be independent of ped crossings on entries (two stage)
- However, single stage crossings for pedestrians may be required for high ped volumes
Conclusions – Signals at Roundabouts

- Large rotaries with signals do not have significantly more capacity than a modern roundabout design
- Dutch style "Turbo Roundabouts" are not worth the space and complexity
- Standard size roundabouts (200 ft. ICD) with turbo features may be worth investigating
- Initial signal additions to roundabouts will typically be at one entry
- The signal indications should be placed at the crosswalks with YIELD signs at the roundabout entry, regardless of signal strategy – to provide consistency for drivers and pedestrians

Future Research Needs

- If traffic signals are placed at roundabout entry points and with part time operation -
  - What are the conditions for switching from full signal control to yield control?
  - If signals are placed at the roundabout entry points, how is yield conveyed when signal is off or at "rest"?
  - How should pedestrian crossings be coordinated with the overall signal operation?
- The features and issues for two stage pedestrian crossings?
- For larger rotary and through-about junctions
  - What kind of signal coordination?
  - Which geometric features are best?
- What are the key geometric questions and the answers for using a compact turbo design

Conclusions – Continued

You Will Probably Be Working On Roundabouts Somewhere Between These Two

Questions?
Sample Signing and Striping for a 6 Leg Roundabout – Clearwater, Florida