Safety Auditing of Roundabouts: In-service or at Design
Design Principles:

• Effective Geometry
• Entry Deflection & Speed Consistency
• Design Vehicle
• Forward Visibility
• Signs and Markings
• Needs of Non-Motorized Users (VRU’s)
• Lighting

• Composition based on principles is what determines the functionality

• If you only focus on the components the final assembly may be totally overlooked
Principles Based Safety Evaluation

Demands of Safe Intersection Design:
1. Clarity of the situation for approaching drivers
2. Visibility between road users
3. Comprehensibility of traffic operations
4. Space for the largest permitted vehicles

Design Elements:
1. geometric layout; lateral and forward visibility
2. lateral and forward visibility
3. geometric layout; pedestrians; cyclists; signs and lighting
4. geometric layout
## Common Problems With Roundabouts

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signs</td>
<td>15%</td>
</tr>
<tr>
<td>New Markings</td>
<td>9%</td>
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<tr>
<td>Cyclists</td>
<td>7%</td>
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<tr>
<td>Inadequate Deflection</td>
<td>7%</td>
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<tr>
<td>Delineation</td>
<td>6%</td>
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<tr>
<td>Lane Configuration</td>
<td>6%</td>
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<tr>
<td>Pedestrians</td>
<td>6%</td>
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<tr>
<td>Visibility</td>
<td>6%</td>
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<td>Sight Lines</td>
<td>6%</td>
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<tr>
<td>Pole Location</td>
<td>5%</td>
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<tr>
<td>Lighting</td>
<td>5%</td>
</tr>
</tbody>
</table>

Traffic Design Group for Transfund New Zealand, The Ins and Outs of Roundabouts - Safety Auditors’ Perspective, 2002
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• Lighting
Effective Geometry

Geometric Parameters in the Predictive Relationship:

- Entry Path Curvature
- Entry Width
- Approach lane(s) width
- Angle between arms
- Inscribed Circle Diameter/Central Island Diameter

(U.K. Research TRL Report LR 1120)
Safety Issue: Inadequate Deflection

CAUSE/RESULTS:
• Speed of entry too fast
• Impacts pedestrian safety
• Entry circulating crashes
• SMV crashes

SOLUTIONS:
• Adjust ICD size
• Adjust entry radius
• Offset entry alignment
• Apply EPC based on traffic flows - ACCIDENT CHANGE IS A NET EFFECT
Good EPC = Deflection

Slow entry (R1&R2)
Safety Issue: Entry/Exit Path Overlap

CAUSE/RESULTS:
- Unnatural vehicle paths
- Sideswipe or rear-end entry-entry or exiting crashes (lane change)

SOLUTIONS:
- Increasing entry and/or exit radii
- Modify entry angle (compound radii and tangential entry/exit)
- Road markings (exit striping)
Safety Issue:
Entry/Exit Path Overlap

Perpendicular entries

Entry Path Overlap

Tight exit radii

Exit Path Overlap
Non-Tangent Exit Path Design
Entry Angle & Entry Radius

- Perpendicular approaches:
  - Large entry angle
  - Small entry radius
  - Lots of deflection

Combined Net Effect:
- Low capacity
- Abrupt braking at entries and potential for rear-end crashes (especially in high-speed locations)
Safety Issue:
Avoiding or repairing Entry/Exit Path Overlap
Safety Issue: Markings
Safety Issue: Markings

CAUSE/RESULTS:
• Violation of regulatory traffic circulation
• Incorrect lane choice – exit crashes (sideswipe)
• Sudden lane changes
• Improper left turns
• Navigational and way-finding errors

SOLUTIONS:
• Lane arrows on circulatory opposite splitter islands
• Use lane designation arrows
• Use of exit stripes
• Use of spiral marking
• Design the geometry & markings
FWHA Guide gets arrows / stripes wrong

1. Use only for heavy left turns and where two receiving lanes are provided.

2. Use only for heavy right turns and where two receiving lanes are provided.
Safety Issue: Signage

CAUSE/RESULTS:
- Violation of regulatory traffic circulation
- Incorrect lane choice – exit crashes (sideswipe)
- Single motor vehicle crashes
- Poor guidance – warning of hazards – fixed objects e.g. splitter island
- Poor spacing of signs
- Improper left turns
- Navigational and way-finding errors

SOLUTIONS:
- Enlarge central island chevrons
- Use lane designation signs
- Use of illuminated signs
- Use of map-type guide signs
Safety Issue: Signage
Combined Signs and Markings – Promotes Holistic Operation
Yellow Bar Markings
APPLYING ENTRY PATH CURVATURE

- Reduces Entry Circulating Accidents
- Increases Approach Accidents
- Increases Single Vehicle Accidents
- ACCIDENT CHANGE IS A NET EFFECT
  - Depends on traffic flows

EPC: R1<70m for Single Lane Entries
R1<100m for Multi-lane Entries
Safety Issue:
Failure to Accommodate Large Vehicles
ACCOMODATION OF LARGE VEHICLES
Safety Issue: Visibility
Sight Distance Check
VERTICAL SIGHT CLEARANCE REQUIREMENTS

Visibility to the left at entry

All other visibility

Object
2.0m (6.6')
1.05m (3.4')
0.26m (0.85')

Bottoms of Sign Panels
Tops of Plants and Walls

Driver's Eye
2.0m
1.05m
Safety Issue: Central Island and Splitter Island Conspicuity

CAUSE/RESULTS:
- Inconspicuous central island or splitter islands
- Poor guidance - surprise condition
- Single motor vehicle crashes
- Improper left turns

SOLUTIONS:
- Increasing height of central island through grading and or planting
- Signage
Central Island Conspicuity
Use Scale and Definition of Plantings

< 0.75m
< 1.05m
> 2.0m
Central Island Delineation
Safety Issue:
Non-motorized Users
Pedestrian Safety Considerations

- Provide adequate deflection to reduce entry speed
- Provide splitter islands as large as the site allows.
- Provide clearly defined splitter island crossings.
- Prohibit parking on approaches
- Assure street lighting illuminates the pedestrian from the drivers view - not shadow back lighted
- Locate signs so users perceive an easily recognizable intersection layout.
Cross Walk Location

Ferry Circle, Buffalo

- Too close
- 6m back
Accommodating Visually Impaired
Signalized Split Crosswalk
Tactile Crossing Areas and Angled Crossings

Truncated Domes
U.S. Access Board
Approved
Contrast Lighting and Vertical Illumination
(Approach Mounted Lighting  8-250W HPS)

Courtesy DMD Electrical
CONFLICT & TRADE-OFF

- Often the aims conflict
- Trade-offs are needed
- Optimisation required
- No Finish Line (Design Domain)

Explore objective triangle for optimum trade-off