Towards a *Universal Design* Approach to Accommodating the Needs of Pedestrians at Modern Roundabouts:

Treatments Evaluated Under NCHRP Project 3-78a

Bastian J. Schroeder, Ph.D.

**Institute for Transportation Research and Education (ITRE) at North Carolina State University (NCSU)**

International Mobility Conference (IMC)
Marburg, Germany – July 2009

---

**NCHRP3-78 Overview**

- **Multi-disciplinary research team**
  - NC State University
  - Western Michigan University
  - Accessible Design for the Blind
  - Kittelson and Associates, Inc.

- **Project objectives**
  - Improve access for blind pedestrians
  - Maintain acceptable vehicle operations
  - Consider system costs and impacts
  - A *universal design* solution

- **Facility types: Complex Intersections**
  - Single-lane roundabout
  - Two-lane roundabout
  - Channelized turn lane
Problem Definition

- The crossing task for blind pedestrians
  - Finding the crosswalk
  - Aligning to cross
  - Deciding when it is safe to cross
  - Maintaining alignment during crossing

- Confounding challenges
  - Uninterrupted flow (no signal)
  - Unassisted crossing (no signal)
  - Potentially high speeds
  - Ambient noise
  - Non-straight geometry (vehicle trajectories)

Treatments: Impact vs. Cost

Source: www.walkinginfo.org
4-Step Analysis Framework

I: Crossing Opportunity Criterion
- Are there sufficient crossing opportunities in the form of yields or crossable gaps?

II: Crossing Opportunity Utilization Criterion
- Are the crossing opportunities detected and/or utilized by the pedestrian?

III: Delay Criterion
- Is a crossing opportunity taken within a reasonable time?

IV: Safety Criterion
- Does the crossing interaction occur without a significant degree of risk?


The ‘Short List’ of Treatments

- Channelized turn lane
  - Sound strips
  - Sounds strips + ped.-actuated flashing beacon

- Single-lane roundabout
  - Panel direction that no treatment may be needed

- Two-lane roundabout
  - Raised crosswalk
  - HAWK signal
Study-Design

• Pre-post within-subject with treatment installation
• O&M orientation and supervision throughout trials
• Independent crossings (with O&M)
• Volunteers can stop participation at any time

Channelized Turn Lane
Providence Rd. @ NC51, Charlotte, NC
Sound strips, flashing beacon, and lane delineators

Sound Strip Demo
Single-Lane Roundabout
9th St. @ Davidson St., Charlotte, NC

Panel direction is no treatment is needed!

Given adequately low speed, courteous driver behavior, and appropriate surface treatments (detectable warnings), single-lane roundabouts appear to be accessible to and usable by pedestrians who are blind.
Two-Lane Roundabout
Golden Rd. @ Johnson Rd., Golden, CO

Raised Crosswalk
### HAWK Beacon

![HAWK Beacon Image](image)

### Signal Phasing – HAWK Signal

#### Table: Conventional Signal vs HAWK Signal

<table>
<thead>
<tr>
<th>Conventional Signal</th>
<th>HAWK Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLES</td>
<td>VEHICLES</td>
</tr>
<tr>
<td>G</td>
<td>DW</td>
</tr>
<tr>
<td>PEDESTRIANS</td>
<td>blank</td>
</tr>
<tr>
<td>FY</td>
<td>DW</td>
</tr>
<tr>
<td>DW</td>
<td>FY</td>
</tr>
<tr>
<td>PEDESTRIANS</td>
<td>blank</td>
</tr>
<tr>
<td>DW</td>
<td>DW</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>PEDESTRIANS</td>
<td>blank</td>
</tr>
<tr>
<td>DW</td>
<td>DW</td>
</tr>
<tr>
<td>PEDESTRIANS</td>
<td>blank</td>
</tr>
<tr>
<td>DW</td>
<td>DW</td>
</tr>
<tr>
<td>PEDESTRIANS</td>
<td>blank</td>
</tr>
<tr>
<td>DW</td>
<td>DW</td>
</tr>
<tr>
<td>PEDESTRIANS</td>
<td>blank</td>
</tr>
<tr>
<td>DW</td>
<td>DW</td>
</tr>
</tbody>
</table>

![HAWK Signal in Tucson, AZ](image)
Findings

- Final report forthcoming in 2010 with detailed results
- **Channelized turn lanes** are challenging and are more frequent (in the US) than roundabouts.
  - High O&M intervention rate
  - Long delays and frequent time-outs
  - High noise pollution from adjacent traffic
  - Difficult to discern turning from through traffic
  - Treatments helped, but more drastic measures may be needed
  - Should test raised crosswalk and signal
Findings

• **Single-Lane Roundabouts** appear to be accessible to most blind travelers, provided that
  - Speeds are low through good roundabout design
  - Drivers are courteous and yield the right-of-way
  - Appropriate surface treatments are installed
  - Blind travelers receive adequate O&M instruction

Findings

• **Two-lane roundabouts** are challenging without additional treatments
  - Speed and volumes are higher
  - Multiple-threat situations are biggest risk
  - Good roundabout design may help: Low speeds, ‘tight feel’, landscaping, and pedestrian-friendly atmosphere
  - Treatments proved highly effective in reducing speed, increasing yields, and creating crossing opportunities
  - Early observations at three-lane roundabout indicate that signalization or grade separation may be the only option
Roundabout “Universal Design” … it’s more than a pretty picture!

- No crosswalk provided
- Unassisted two-lane crossings
- No curb delineation
- Vehicle queuing into the circle
- Large turning radii = high speeds

Better Design 1: Pullen-Stinson roundabout, Raleigh, NC with one-lane crossings, low speeds, and landscaping strip

Credit: www.skysiteaerial.com
Better design 2: Two-lane roundabout in Gatineau, Canada with zig-zag signalized crossing and landscaping that guides to crosswalk

Better-Design 3: Multi-Lane roundabout in Bad Aibling, Germany with ped./bike underpass and distal crosswalks
Thank You for Your Time!

Dr. Bastian J. Schroeder
+1-919.515.8565
Bastian_Schroeder@ncsu.edu

Principal Investigator:

Dr. Ron G. Hughes
+1-919.515.8523
Run_Hughes@ncsu.edu

Institute of Transportation Research & Education (ITRE)
North Carolina State University
Centennial Campus, Box 8601
Raleigh, NC 27695-8601
Fax: (919) 515-8898

http://itre.ncsu.edu

ADDITIONAL SLIDES
Principles of O&M Instruction for Roundabouts

- Use of tactile map for orientation
- Guided crossings to judge distances
- Listen to traffic
- Point out features in the road and tactile map simultaneously
- Practice crossings with O&M supervision
- No fully independent crossings were performed in this research for liability reasons

Yielding and the Law

- US State Laws vary between “in” and “at” the crosswalk.
- Common Motor Vehicle Code:
  - “The vehicular traffic shall yield the right of way to pedestrians lawfully within an adjacent crosswalk and to other traffic lawfully using the intersection. ... Pedestrians have the right-of-way when actively crossing in an un-signalized crosswalk.”
- Pedestrian has to be in the crosswalk to legally have the right of way.
- Anecdotally, enforcement of US Yield laws is poor.
“White Cane Laws”

• Intended to give added protection to blind travelers
  • A driver of a vehicle shall not approach a crosswalk or any other pedestrian crossing without taking all necessary precautions to avoid injury to a blind pedestrian carrying a cane or using a dog guide or walker.
  • A driver who approaches a crosswalk or any other pedestrian crossing without taking all necessary precautions to avoid accident or injury to a blind pedestrian carrying a cane or using a dog guide or walker shall be liable in damages for any injuries caused the blind person.
• Language is unclear and vague at best

Complex Intersections

All Images by www.bing.com, © 2009 Microsoft Cooperation
Observational Studies – I
Treatments intended to encourage yielding

SOURCE: NCHRP Report 562, Slide by Shawn Turner, TTI

1) Midblock Signal
2) Half Signal
3) Hawk Beacon
4) In-Street Ped Sign
5) Pedestrian Flag
6) Beacon, Active
7) Refuge Island
8) HV Markings
9) Beacon, Passive

Motorist Yielding (%)
Observational Studies – II
Yielding to (Regular) Pedestrians at Roundabouts
SOURCE: NCHRP Report 572, Kittelson and Associates

Yielding Behavior when Pedestrian Crossed from Entry Side

Observational Studies – III
Yielding to Blind Pedestrians at Roundabouts
SOURCE: NCHRP 3-78 and NIH/NEI Project

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlotte, NC</td>
<td>Entry</td>
<td>10.8%</td>
<td>0.0%</td>
<td>21.3%</td>
<td>8.9%</td>
</tr>
<tr>
<td></td>
<td>Exit</td>
<td>11.8%</td>
<td>0.0%</td>
<td>33.3%</td>
<td>7.9%</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>11.3%</td>
<td>0.0%</td>
<td>33.3%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Raleigh, NC</td>
<td>Entry</td>
<td>41.5%</td>
<td>13.9%</td>
<td>66.7%</td>
<td>18.2%</td>
</tr>
<tr>
<td></td>
<td>Exit</td>
<td>32.8%</td>
<td>9.4%</td>
<td>70.0%</td>
<td>17.9%</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>37.2%</td>
<td>9.4%</td>
<td>70.0%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Golden, CO</td>
<td>Entry</td>
<td>65.6%</td>
<td>21.1%</td>
<td>100.0%</td>
<td>20.2%</td>
</tr>
<tr>
<td></td>
<td>Exit</td>
<td>36.1%</td>
<td>9.1%</td>
<td>66.7%</td>
<td>17.2%</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>50.8%</td>
<td>9.1%</td>
<td>100.0%</td>
<td>23.8%</td>
</tr>
</tbody>
</table>