High Speed Approaches At Roundabouts

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INTRODUCTION

- Mobility & Growth = High Speed Roadways with Increasing Congestion & Crossroads
- Stop/Go/Slow-down/Speed-up/Stop/Go
- Enforced Pauses to Flow Unnecessary
- Slow All Traffic = Faster Travel Times
- Threat of Fast Vehicles on HSA is Eliminated
- Benefits of Slowing All vs. Stopping Phases
- Solution: Modern Roundabout Coupled with Good Geometric Design & Adequate Mitigation Measures for High Speeds
- Self Regulating Device – User Controlled
- Roadway Harmony, Multi-functional

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PURPOSE

More Roundabouts Are Being Proposed & Designed on High Speed Roadways

The Question Continually Asked Is: “Are Roundabouts Appropriate on High Speed Roadways?” (North America)

Most Other Countries Worldwide Prefer Roundabouts on High Speed Roadways, But What About North America?

Hence, RTE Was Asked to Produce In-Country Results For Several Roundabouts Proposed on High Speed Roadways

This Presentation Provides Brief Highlights of the High Speed Approaches At Roundabouts Publication

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High Speed Approaches At Roundabouts: Report Objectives

Objective 1: Evaluate Perceived Concern of High Speed Approaches at Roundabouts

Objective 2: Present Safety Statistics & Data of Roundabouts Worldwide with High Speed Approaches (H.S.A.)

Objective 3: Conduct Case Studies of Existing Roundabouts in N.America w/ H.S.A.

Objective 4: Demonstrate Geometric Design Treatments Currently Used for High Speed Conditions

Objective 5: Recommend Additional Design Treatments for H.S.A. at Roundabouts

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High Speed Approach Data

- Very Few of These Type Studies Exist in U.S.
- RTE & ORE Sought Worldwide Resources
- Safety Data Research (TRL, MSHA, WSDOT, IIHS, FHWA, ITE, QDMR, Design Specialists)
- Comparative Before/After Data at Roundabouts Converted from Signals
- High Speed Case Studies with Before & After Crash and/or Speed Data
- High Speed Geometric Design Treatments
- High Speed Non-Geometric Treatments

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Average Safety Statistics Summary
From Multiple Data Sources

- 40% Reduction in All Crash Types Combined / PDO
- 80% Reduction in Injury Accidents
- 90% Reduction in Fatalities
- 30% Reduction for Pedestrian and Bicycles
- Up to a 75% Reduction in Delay
- Results Consistent With International Studies
Why Are Roundabouts Safer Intersections?

Vehicle & Pedestrian Safety

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Why are Roundabouts Safer?

Lower Speeds = Shorter Braking Distance

Figure 2: Braking Distances & Speeds

- Braking Distance
- Perception/Reaction Distance

<table>
<thead>
<tr>
<th>Speed</th>
<th>Braking Distance</th>
<th>Perception/Reaction Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 MPH</td>
<td>125'</td>
<td>73'</td>
</tr>
<tr>
<td>50 MPH</td>
<td>150'</td>
<td>475'</td>
</tr>
</tbody>
</table>
Why Roundabouts...Safety

Accident Severity Much Less At Roundabouts!

Injury Producing Right Angle Crashes Are Eliminated

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Why are Roundabouts Safer?

**Accident Severity**

<table>
<thead>
<tr>
<th>Speed (MPH)</th>
<th>Accident Severity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>60</td>
<td>6</td>
</tr>
</tbody>
</table>

Roundabouts vs. Signalized Intersections

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Accidents Avoided At Roundabouts

One in Three Americans Know Someone Who Was Injured or Killed by a Red Light Runner

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Maryland State Hwy Administration

E. Myers’ *Accident Reduction with Roundabouts*
Reported 5 High Speed Intersections

Data: 3Yrs Before/ 3Yrs After Roundabout Constr.

Summary Results:
- 59% Overall Accident Reduction
- Avg of 5.56 Accidents Before
- Avg of 2.3 Accidents After
- Injury Accidents Reduced by 80%
- All Intersections: Reduced Frequency & Severity

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<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Number Of Accidents</th>
<th>Average Accident Cost</th>
<th>Total Accident Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td></td>
</tr>
<tr>
<td>Angle</td>
<td>62</td>
<td>8</td>
<td>$125,971</td>
</tr>
<tr>
<td>Rear-End</td>
<td>6</td>
<td>10</td>
<td>$80,231</td>
</tr>
<tr>
<td>Sideswipe</td>
<td>2</td>
<td>1</td>
<td>$60,819</td>
</tr>
<tr>
<td>Left-turn</td>
<td>11</td>
<td>1</td>
<td>$95,414</td>
</tr>
<tr>
<td>Opposite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direction</td>
<td>1</td>
<td>0</td>
<td>$307,289</td>
</tr>
<tr>
<td>Single Vehicle</td>
<td>3</td>
<td>20</td>
<td>$59,851</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>85</td>
<td>40</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Source: Accident Reduction With Roundabouts, Myers
Injury Accident Research Comparisons at 84 U.K. Roundabouts at Both Low & High Speeds

Further Analyzed Accident Type & Road User

Accident Freq. By Type are Related to Flow & Geometry Using Empirical Regression Eqns.

Data Conveys Less Crashes & Acc. Rate for Small ICDs with Flare on High-Speed Roads Compared to Low Speed Sites

Data Shows Accident Severity & Freq Less at High Speed Roundabouts vs. Low Speed

Entry Curvature and Angle Between Arms were Major Contributing Factors
### Table 3: Roundabout Crash Types & Rates

**Accidents Statistics By Roundabout Type & Speed**

<table>
<thead>
<tr>
<th>Roundabout Category</th>
<th>Operating Speeds (MPH)</th>
<th>Total # of Accidents</th>
<th>Average Accident Rate</th>
<th>Entering / Circulating</th>
<th>Approach</th>
<th>Single Vehicle</th>
<th>Other</th>
<th>Ped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>30 - 40</td>
<td>497</td>
<td>37.1</td>
<td>72.2%</td>
<td>6.6%</td>
<td>7.5%</td>
<td>9.7%</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>150</td>
<td>28.7</td>
<td>67.3%</td>
<td>8.0%</td>
<td>10.7%</td>
<td>12.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Conventional (No Flare)</td>
<td>30 - 40</td>
<td>146</td>
<td>21.2</td>
<td>16.4%</td>
<td>18.6%</td>
<td>37.6%</td>
<td>19.2%</td>
<td>8.2%</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>193</td>
<td>28.7</td>
<td>24.9%</td>
<td>26.9%</td>
<td>29.0%</td>
<td>17.1%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Two-Lane</td>
<td>30 - 40</td>
<td>244</td>
<td>22.5</td>
<td>21.7%</td>
<td>24.2%</td>
<td>24.2%</td>
<td>18.4%</td>
<td>11.5%</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>197</td>
<td>22.4</td>
<td>16.8%</td>
<td>29.9%</td>
<td>32.5%</td>
<td>17.8%</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

**Percentage By Accident Type**

Source: TRL, LR 1120
### TABLE 4: Roundabout Accident Severity

*Crash Statistics By Roundabout Type & Speed*

<table>
<thead>
<tr>
<th>Roundabout Category</th>
<th>Operating Speeds (MPH)</th>
<th>Number of:</th>
<th>Accidents</th>
<th>Accident Frequency/Junction/Yr</th>
<th>Severity %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sites</td>
<td>Junction Years</td>
<td>Fatal</td>
<td>Serious</td>
</tr>
<tr>
<td>Small</td>
<td>30 - 40</td>
<td>25</td>
<td>113.4</td>
<td>2</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>11</td>
<td>53</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Conventional (No Flare)</td>
<td>30 - 40</td>
<td>11</td>
<td>61.9</td>
<td>3</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>11</td>
<td>62.2</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Two-Lane</td>
<td>30 - 40</td>
<td>14</td>
<td>72.5</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>12</td>
<td>68.3</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>

Source: TRL, LR 1120

RTE High Speed Approach Tables.xls

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High Speed Case Study: Novelty Hill Washington DOT

- SR 203/124th St Stop Control, Rural High Speed, High Accidents
- Perceived: “Roundabouts are unsafe on high speed roads.” → Study Required
- Local Signal Comparison Freq/Severity at 9 HS/LS Intersections Prev. Stop
- Acc Results → Increase in Rates & Severity After Signal
- Compared HS Signals to HS Roundabouts in U.K.
- Resulted in 50-80% Reduction in Injury & Fatalities

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Washington DOT

- Final Decision: Build SR 203/124th Roundabout
- Completed October 2004
- Past Eight Months, No Reported Collision Problems
- No Speed Studies Planned

Positive Results Over Previous Intersection Control Type with No High Speed Problems Identified

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### HS Case Study: Ancaster Roundabout

- **Unsignalized Rural High Speed Arterial Intx 575’ from Hwy 403**
- **Before / After Crashes & Speeds Analyzed**
- **31 Crashes from 1988-2002 (10 Injuries)**
- **After Roundabout → 5 Single Vehicle Accidents Only – Why?**
- **All Night, All at HS EB Entry, 2 Drunk Drivers**
- **Design? High Speeds?**
- **Design Speed Study = OK**
- **Lack of Landscaping!**

**Before**

**After**

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Case Study: Ancaster Roundabout

Design Works With Rural High Speed Approach

Elongated Splitter Island

Adequate Deflection

6 Point Speed Corridor Study Conducted

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## HS Case Study: Ancaster Roundabout

### Results
- Tabulated
- 6 Point Speeds All Reduced
- Mostly Nearest Roundabout
- Due to Single Veh Acc, City Installed Delineators at High-Speed Approach
- See-through problem: Needs Landscaping!

### Table 9: Wilson Street Speeds Before & After Construction

<table>
<thead>
<tr>
<th>Survey Location</th>
<th>Direction</th>
<th>Before Roundabout</th>
<th>After Roundabout</th>
<th>Change of Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EB</td>
<td>48</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WB</td>
<td>48</td>
<td>36</td>
</tr>
<tr>
<td>Point 2</td>
<td></td>
<td>EB</td>
<td>47</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WB</td>
<td>48</td>
<td>32</td>
</tr>
<tr>
<td>Point 3</td>
<td></td>
<td>EB</td>
<td>46</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WB</td>
<td>50</td>
<td>24</td>
</tr>
<tr>
<td>Point 4</td>
<td></td>
<td>EB</td>
<td>44</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WB</td>
<td>47</td>
<td>36</td>
</tr>
<tr>
<td>Point 5</td>
<td></td>
<td>EB</td>
<td>42</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WB</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>Point 6</td>
<td></td>
<td>EB</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WB</td>
<td>43</td>
<td>41</td>
</tr>
</tbody>
</table>

**LOCATION OF MODERN ROUNDABOUT**

- Source: ORE/RTE

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HS Case Study: Chambly Roundabout

Speed Studies Conducted to Compare Predicted Design Speeds & Post Construction Speeds at Rural High Speed Site

- Long Splitter Island, Curvilinear Approach in Design
- Post Roundabout Speed Study at 5 Points along HS Roadway

1: 55mph, 85th=63mph, Avg=58
2: 85th=45mph, Avg=39mph
3 & 4: Speeds are Lower Than Predicted Fast Path Design Speed w/ Highest Actual Speed =20mph
5: 85th=41, Avg=39

Results are positive!
### Table 10: Chambly Speed Predictions Before Construction

**Based on Design Plan Set Fast Path Speeds**  
Fréchette & Anne-Le-Seigneur Boulevard

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Southbound</th>
<th>Northbound</th>
<th>Westbound</th>
<th>Eastbound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R1</td>
<td>R2</td>
<td>R1</td>
<td>R2</td>
</tr>
<tr>
<td>Radius (ft)</td>
<td>137.8</td>
<td>59.1</td>
<td>111.5</td>
<td>68.9</td>
</tr>
<tr>
<td>Speed (mph)</td>
<td>24</td>
<td>17</td>
<td>22</td>
<td>18</td>
</tr>
</tbody>
</table>

### Table 11: Chambly Speeds After Construction

**Calculations Based on Actual Measured Speeds**

<table>
<thead>
<tr>
<th>Survey Location</th>
<th>Average Speed</th>
<th>85th Percentile Speed</th>
<th>Highest Speed</th>
<th>Lowest Speed</th>
<th>Posted Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point 1</td>
<td>58</td>
<td>63</td>
<td>69</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>Point 2</td>
<td>39</td>
<td>45</td>
<td>54</td>
<td>26</td>
<td>55</td>
</tr>
<tr>
<td>Point 3</td>
<td>29</td>
<td>32</td>
<td>38</td>
<td>21</td>
<td>55</td>
</tr>
<tr>
<td>Point 4 (Entry)</td>
<td>13</td>
<td>16</td>
<td>20</td>
<td>8</td>
<td>55</td>
</tr>
<tr>
<td>Point 5</td>
<td>37</td>
<td>41</td>
<td>45</td>
<td>26</td>
<td>45</td>
</tr>
</tbody>
</table>

**LOCATION OF MODERN ROUNDABOUT**

<table>
<thead>
<tr>
<th>Survey Location</th>
<th>Average Speed</th>
<th>85th Percentile Speed</th>
<th>Highest Speed</th>
<th>Lowest Speed</th>
<th>Posted Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point 5</td>
<td>37</td>
<td>41</td>
<td>45</td>
<td>26</td>
<td>45</td>
</tr>
</tbody>
</table>

Source: ORE/RTE  
RTE High Speed Approach Tables.xls
Case Study: Chambly Roundabout

Again, Landscaping Needed

Looking NB at High Speed Approach

Looking SB at High Speed Approach
HS Case Study: Townline Roundabout

- Previous Stop Control had High Crash Rates due to High Speeds
- Studies Conducted to Compare Design Speeds & Post Construction Speeds along High Speed Roadway
- “T” Intersection, No Long Splitter Islands or Curvilinear Approaches
- Before: 85th = 47mph
- Predicted Fastest Path Speeds: 30 mph SB, 32 mph NB (at Entry)
- After: NB 85th = 20 mph, SB = 21 Highest Entry Speeds 23 / 26 mph
- No Accident Problems Identified
- Results are positive
- Good Maptype Signs!
- & Arrow-shaped Exits

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## Townline Case Study:

### Table 13: Townline Predicted Speeds
Based on Design Plans Fastest Path Speeds
Townline Road / Can Amera Parkway

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Southbound R1</th>
<th>R2</th>
<th>Northbound R1</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius (ft)</td>
<td>252.6</td>
<td>157.5</td>
<td>305.1</td>
<td>114.8</td>
</tr>
<tr>
<td>Speed (mph)</td>
<td>30</td>
<td>24</td>
<td>32</td>
<td>21</td>
</tr>
</tbody>
</table>

### Table 14: Townline Speeds After Construction
Based on Actual Measured Speeds Conducted After Construction
Townline Road / Can-Amera Parkway

<table>
<thead>
<tr>
<th>Speeds (mph)</th>
<th>Northbound</th>
<th>Westbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Entering</td>
<td>Exiting</td>
<td>Entering</td>
</tr>
<tr>
<td>Average</td>
<td>16</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>85th Percentile</td>
<td>20</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>High</td>
<td>23</td>
<td>37</td>
<td>29</td>
</tr>
<tr>
<td>Low</td>
<td>11</td>
<td>16</td>
<td>3</td>
</tr>
</tbody>
</table>

Source: ORF/RTF
REPORT CONCLUSIONS

- Report Provides Case Studies and Statistics at Hundreds of Roundabouts Studied by Roundabout Specialists, Jurisdictions & Organizations Throughout the Globe.
- Common Results ➔ Self Regulating Modern Roundabout is Proven to be The Safest At Grade Intersection Type
- Statistically, Roundabouts are the Most Appropriate Control for Intersections with High Speed Approaches
- Case Studies Acknowledge Roundabouts on High Speed Roadways Are Acceptable, Function Well, & Preferred
- Yet, Evidence is Still Needed to Form Geometric / Safety Performance Relationships on High Speed Approaches
- U.K. Relationships Should Not Be to the Contrary in N.A.
- Yet, Additional Design Treatments Are Still Recommended

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Recommended Geometric Design Treatments for H.S.A. at Roundabouts

- Sufficient **Deflection at Entry** is Key!
- Proper Entry Design Correlating to the Fastest Path Design Speeds that Are Consistently Slow For All Approaches
- Entry Design Correlates to Circulating Speeds with Appropriate Speed Differential (Less than 12 mph)
- Entries are Visible To Driver With Properly Extended Curb & Gutter

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Entry Design & Deflection is Key

Insufficient Entry Path Curvature

An Over-Deflected Entry

Cutting off the entry sight but too much deflection

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Inadequate Deflection!

Courtesy: Phil Demosthenes

US 6 / Post Rd - Avon, CO

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Recommended Geometric Design Treatments for H.S.A.R.

- Extend Splitter Islands to SSD Differential
- Curvilinear Approaches Still Need More Research, but May Prove Appropriate – *Recommend Caution*
- Appropriate Vertical Design of Roadways, Circulating Roadway, & Truck Apron (Visible)
- Consider Two-lane Entry with Short Flare Length
- Consult a Roundabout Specialist!

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Recommended Non-Geometric Design Treatments for H.S.A.R.

Proper Lighting Placement Before, At, and After Roundabout

Landscaping the Central Island Properly (SSD)

Landscaping Splitter Islands Prior to Entry

Detached Sidewalks

Landscaping Planters

Create a Tunnel Effect!

MONTGOMERY STREET / WASHINGTON AVENUE ROUNDABOUT

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Recommended Non-Geometric Design Treatments for H.S.A.R.

- Avoid Excessive Signing
- Increased Chevron Signs On Central Island
- Long Hatched Areas (Striping), as an Alternative to Long Splitter Islands
- Repeat Lane Assignment Arrows
- Thermoplastics Not Paint
- Transverse Yellow Bar Markings
- Internally Illuminated Bollards
- Internally Illuminated Exit Signs (i.e. Vail, CO)
Final Remarks

- Make Roundabout & Need to Slow Down Clear to Driver at SSD with Treatments such as Long Splitter Islands, Extended Curbing, Bar Markings, Thermoplastic, Hatching & Striping
- Make Roundabout Visible During Day with Foliage, Chevrons, and Illuminated Bollards;
- Avoid Excessive Signing: Hinders Driver’s Ability to See the Roundabout, Peds, & YIELD
- Make Roundabout Visible During Night with Illuminated Bollards, Extended Chevrons, Illuminated Signs (Internally/ Externally), & Street Lighting
- Add Side Friction with Planters, Curbing, Trees, Splitter Islands, Etcetera
- Ensure Proper Geometric Design: Deflection, Speeds, Fast Paths, Entry Radii
- Roundabouts With High Speed Approach Are Appropriate If Designed Correctly!