Wisconsin Roundabout Crash Pattern

**Abstract**

This paper provides a comprehensive analysis of roundabout crash patterns, including:
1. An improved method was used to calculate crash type percentages for Wisconsin roundabouts.
2. The crash type patterns were compared between roundabout types and between at-fault driver residency types. It was found that the entering-circulating crashes were most severe at single-lane roundabouts while the sideswipe crash had a higher percentage at multilane roundabouts. Local drivers were more involved in rear-end crashes while drivers from outside of the city committed more sideswipe crashes.
3. Twelve types of inappropriate negotiations were defined and quantified through video data. The conflict exposure rates were then defined and measured to interpret the crash patterns. The results from the conflict exposure analysis showed why a high percentage of sideswipe crashes appeared at multilane roundabouts.

**Introduction**

There are three safety advantages of using a roundabout: 1) fewer conflict points, 2) acute weaving angles, and 3) entering yield to circulating (favor inside negotiation). These result in a particular crash pattern at roundabouts. This paper aims to address the following problems:
1. Perform unbiased estimates on Wisconsin roundabout crash patterns;
2. Compare the patterns between categories;
3. Interpret the patterns based on the negotiation observations.

**Crash Patterns**

Different roundabouts do NOT have exactly the same distributions of types of crashes. However, among a certain category (i.e., single or multi lane roundabouts, local or outside driver related, etc.), the distributions are roughly similar. The averages represent the estimated crash patterns:

**Observation of Roundabout Negotiation**

**Targeted Inappropriate Negotiations**

A vehicle’s path can be classified into one of the 12 categories:
1. CI → C2;
2. CI → Ex2;
3. C2 → CI;
4. C2 → Ex1;
5. Enl → C2;
6. Enl → Ex2;
7. En2 → CI;
8. En2 → Ex1;
9. C2 → C2;
10. CVOL (Circulating Vehicle On lane line): A vehicle enters the quadrant in either of the circulating lanes, travels on the lane line for a while, and exits mostly in the right exiting lane. This is similar to CI → Ex2;
11. FY: An entering vehicle fails to yield to the upcoming circulating vehicle;
12. WY: A circulating vehicle wrongly yields to the entering vehicle.

**Negotiation Counting System**

The inappropriate negotiation related data was collected via recorded videos at the roundabout locations. Two multilane 4-leg roundabouts were chosen for video recording from 7:00 am to 7:00 pm. Since the video system was located between two adjacent approaches, the view of the roundabout quadrant where the video was located was relatively larger and more focused (Figure 3), leading to a quadrant-based video review.

A self-developed program (Figure 3) was used to review the videos and record the time stamps of two groups of events: 1) vehicles entering the quadrant and 2) inappropriate negotiations. The selected time periods were 7:00 am – 9:00 am and 2:00 pm – 4:00 pm for both roundabouts. The final counts of different events are presented in Table 1.

**Observed Results**

**Counts of Inappropriate Negotiations**

<table>
<thead>
<tr>
<th>Category</th>
<th>CI → C2</th>
<th>CI → Ex2</th>
<th>C2 → CI</th>
<th>C2 → Ex1</th>
<th>Enl → C2</th>
<th>Enl → Ex2</th>
<th>En2 → CI</th>
<th>En2 → Ex1</th>
<th>C2 → C2</th>
<th>CVOL</th>
<th>FY</th>
<th>WY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>130</td>
<td>90</td>
<td>40</td>
<td>50</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>20</td>
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</tbody>
</table>

**Calculated Conflict Exposure Rates**

**Findings**

1. For single-lane roundabouts, it is difficult for entering vehicles to determine in advance whether or not a circulating vehicle will exist or continue, resulting in a potential entering-circulating conflict. Single-lane roundabouts generally have inadequate approaching-sight-distances that result in a higher percentage of entering-circulating crashes.
2. Multilane roundabouts have more sideswipe crashes because most sideswipes happened between circulating vehicles. Multilane roundabouts have higher frequencies in all types of crashes than single-lane roundabouts, possibly explained by the heavier traffic at multilane roundabouts.
3. Local drivers are more involved in rear-end crashes, resulting from the high approaching speeds encountered by familiarity. On the contrary, outside drivers have a larger percentage of sideswipe crashes related to improper negotiations due to unfamiliarity. In terms of crash frequency, local drivers are higher in those crashes which are mainly caused by high speed (run-off-road, rear-end, and entering-circulating), and outside drivers have more sideswipe crashes which are commonly caused by inappropriate negotiation.
4. The conflict exposure analysis helps explain the high percentage of sideswipe crashes at multilane roundabouts. Vehicles traveling from the inside circulating lane to the outside exiting lane play the most significant role for multilane roundabout conflict exposure.

**Table 1**

<table>
<thead>
<tr>
<th>Description</th>
<th>CI → C2</th>
<th>CI → Ex2</th>
<th>C2 → CI</th>
<th>C2 → Ex1</th>
<th>Enl → C2</th>
<th>Enl → Ex2</th>
<th>En2 → CI</th>
<th>En2 → Ex1</th>
<th>C2 → C2</th>
<th>CVOL</th>
<th>FY</th>
<th>WY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>130</td>
<td>90</td>
<td>40</td>
<td>50</td>
<td>20</td>
<td>10</td>
<td>10</td>
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**Table 2**

<table>
<thead>
<tr>
<th>Description</th>
<th>CI → C2</th>
<th>CI → Ex2</th>
<th>C2 → CI</th>
<th>C2 → Ex1</th>
<th>Enl → C2</th>
<th>Enl → Ex2</th>
<th>En2 → CI</th>
<th>En2 → Ex1</th>
<th>C2 → C2</th>
<th>CVOL</th>
<th>FY</th>
<th>WY</th>
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