Incorporating Exiting Vehicles in Capacity Estimation at Single-Lane U.S. Roundabouts

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Research Hypothesis

- Exiting vehicles **should be accounted for** in estimating the capacity of a single-lane roundabout approach.

**Current HCM 2000 practice**
Conflicting volume \( (v_c) \) and critical gap \( (t_c) \) determined from **circulating stream only**

**This Study**
Conflicting volume \( (v_c) \) and critical gap \( (t_c) \) determined from both circulating and exiting streams
Review of Previous Work

• NCHRP 3-46
  – 50% right-turn vehicles incorporated at TWSC intersections

• Hagring (2001)
  – Proportion of Exiting Vehicles

• Troutbeck (1985 & 1990)
  – Geometry → Entry Driver Ability to Distinguish Vehicle Paths
Overview

• Research Objectives

• Data Collection & Reduction

• Definition of Gaps

• Capacity Estimation & Comparison

• Proportion of Exiting Vehicles and Width of Splitter Island in Capacity Prediction
Research Objectives

Objective 1
– Account for Exiting Vehicles
  • Does Capacity Prediction Improve?

Objective 2
– Explain Differences between Estimated Capacities and Measured Capacities
  • Proportion of Exit Vehicles
  • Width of Splitter Island
Data Reduction

Location of Recorded Time Stamps

National Roundabout Conference 2005 DRAFT

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Definition of Gaps

Without Exit Vehicles:

With Exit Vehicles:
Definition of Gaps

Without Exit Vehicles:

With Exit Vehicles:
Definition of Gaps

Without Exit Vehicles:

With Exit Vehicles:

\[ E - C1 + \Delta T \]
Definition of Gaps

Without Exit Vehicles:

With Exit Vehicles:
Definition of Gaps

Without Exit Vehicles:

With Exit Vehicles:
Assumptions in Definition of Gaps

• Distance covered in exactly the equivalent travel time

• Cannot distinguish future path prior to exit point

• Recognize vehicle exited at and after exit point
Orientation

- Without the inclusion of exit vehicles
- With the inclusion of 50% of exit vehicles
- With the inclusion of 100% of exit vehicles
- Field measurement
Critical Gap Comparison

- With Exit < Without Exit
- More Consistency With Exit

Roundabout Approach

\[ c_a = v_c \frac{e^{-\frac{v_a t_f}{3600}}}{1 - e^{-\frac{v_a t_f}{3600}}} \]
Follow-up Time Extraction

- Between 2.6 – 3.0 seconds

--- From Blogg, M. 2004 ---
Conflicting Flow Comparison

- $V_c$ Without Exit Vehicles = Circulating Flow
- $V_c$ With Exit Vehicles = $(P \times \text{Exit Flow}) + \text{Circulating Flow}$
  - $P = 0.5$ and $P = 1.0$

\[
\frac{c_a}{1 - e^{-V_{ce}/3600}} = \frac{V_c}{e^{-V_{ce}/3600}}
\]

# = Number of 15-min samples
Capacity Comparison

• Cumulative distribution with exit vehicles matches the field capacity distribution
Capacity Comparison

- Without exit vehicles: \( R^2 = 0.29 \)
- With exit vehicles: \( R^2 = 0.57 \)
Capacity Comparison

- On Average:
  - Without exit → always overpredict capacity
  - With 50% exit → overpredict at 7 out of 8 approaches
  - With 100% exit → overpredict at 5 out of 8 approaches

# = Number of 15-min samples
Explaining Differences in Capacity Estimates and Measured Capacities

• Proportion of Exit Vehicles in the Major Stream (%)

• Width of the Splitter Island (ft)
Calculation of Mean Percent Error (MPE)

\[
MPE = \left( \frac{C_{est} - C_{field}}{C_{field}} \right) \times 100\%
\]

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Capacity Estimate W/O Exit Veh. (vph)</th>
<th>Capacity Estimate W/ 100% Exit Veh. (vph)</th>
<th>Measured Field Capacity (vph)</th>
<th>Mean % Error (Without Exit)</th>
<th>Mean % Error (With 100% Exit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>943</td>
<td>851</td>
<td>900</td>
<td>4.8%</td>
<td>-5.4%</td>
</tr>
</tbody>
</table>
MPE vs. Proportion of Exit Vehicles

- Overpredict at lower proportions
- Underpredict at higher proportions
- Driver expectation?

\[ R^2 = 0.32 \]
MPE vs. Width of Splitter Island

- Overpredict at narrow widths
- Underpredict at wider widths
- Lack of data at intermediate widths

\[ R^2 = 0.25 \]
Conclusions

• Account for Exiting Vehicles
  – Improved Capacity Prediction

• Weak Trends
  – Proportion of Exiting Vehicles
  – Width of Splitter Island

• Further Research
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