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

Sammamish, WA

Gorham, ME

Gig Harbor, WA

Taneytown, MD

Lothian, MD

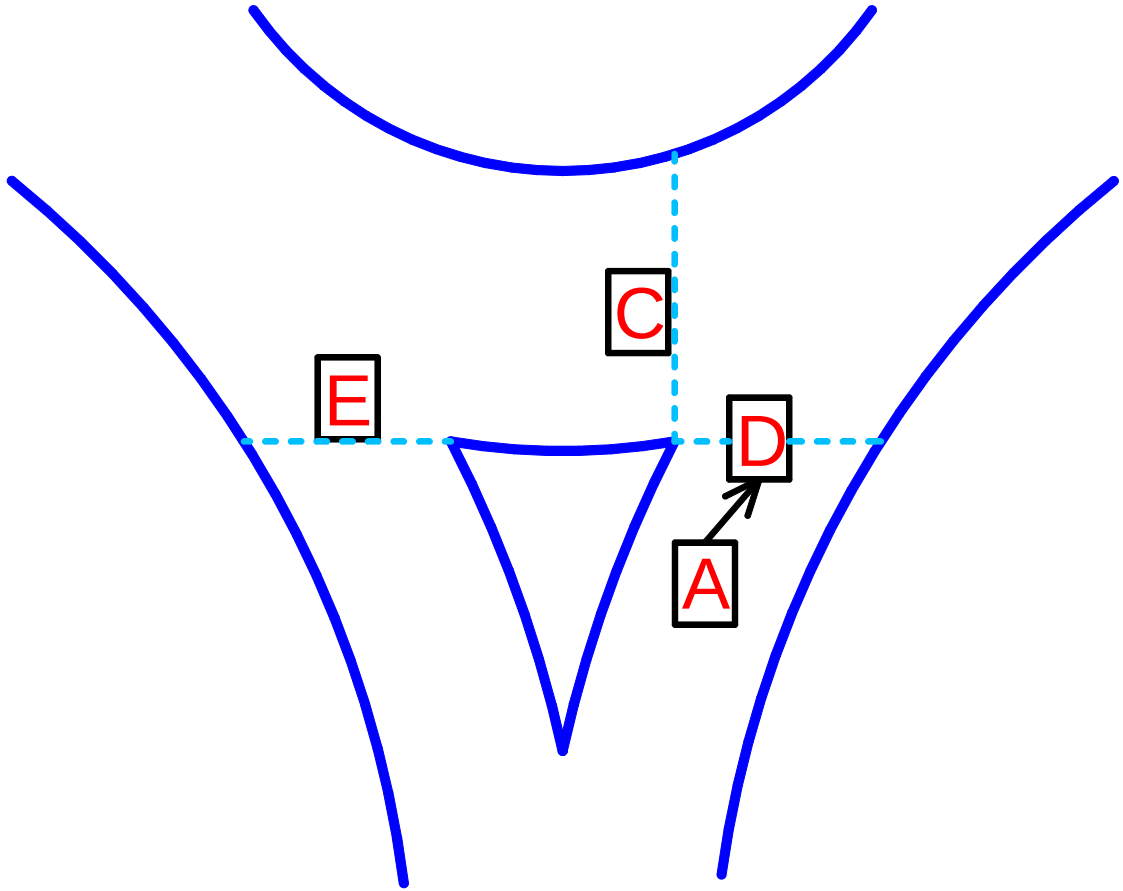
Port Orchard, WA

Bainbridge Island, WA

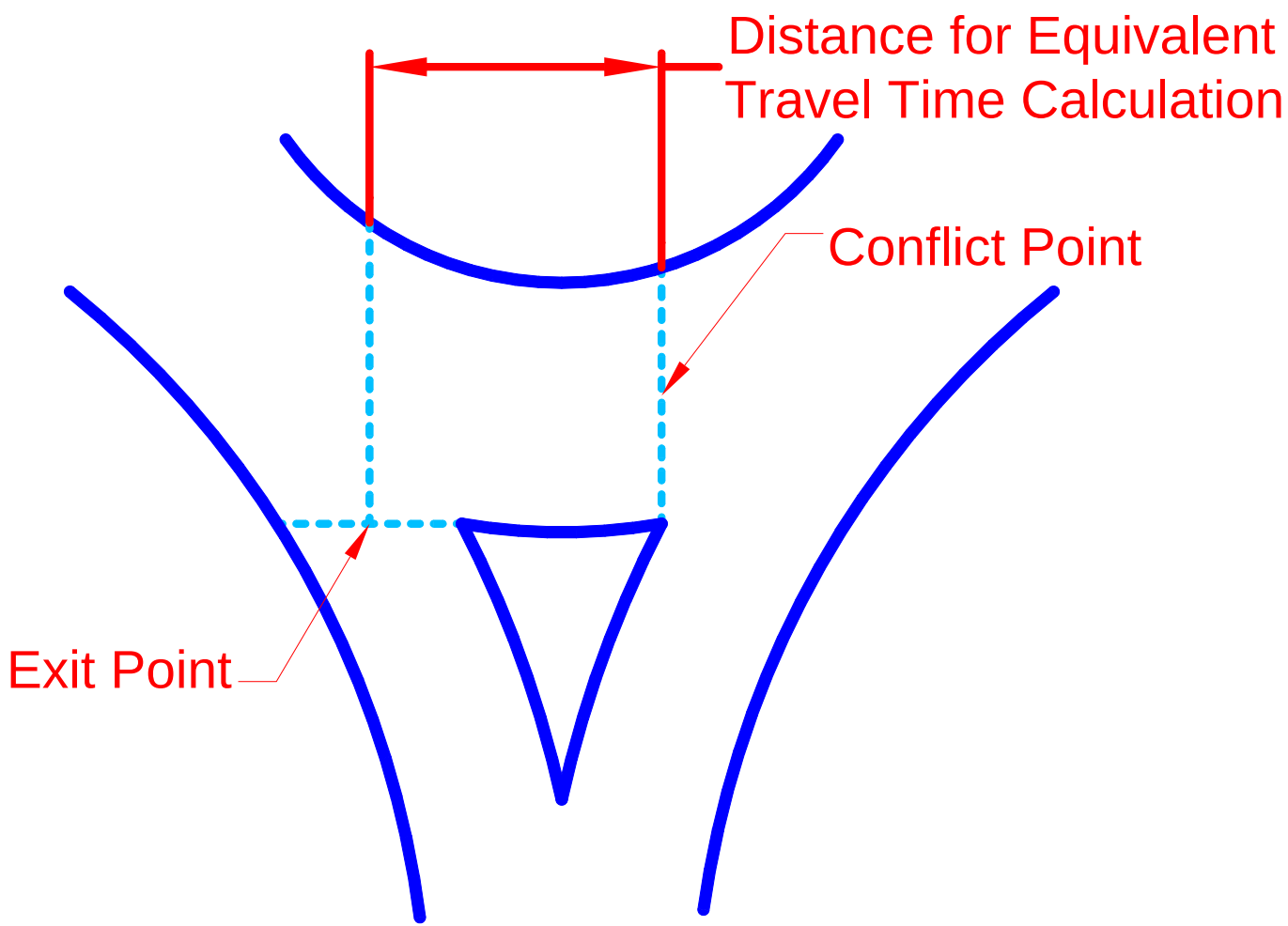
Bend, OR

Data Reduction

Location of Recorded Time Stamps

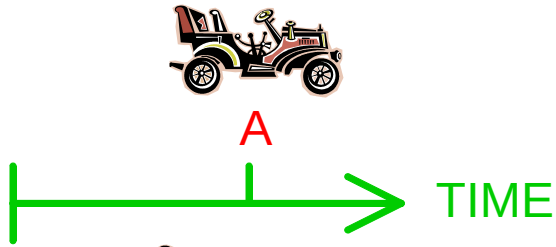


Equivalent Travel Time

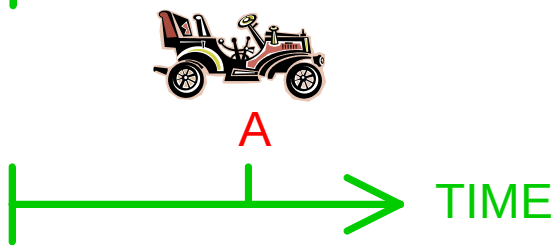


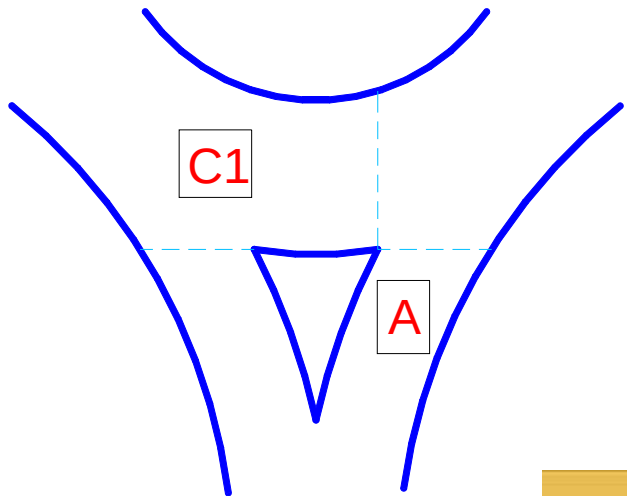
Definition of Gaps

Without Exit Vehicles:



With Exit Vehicles:





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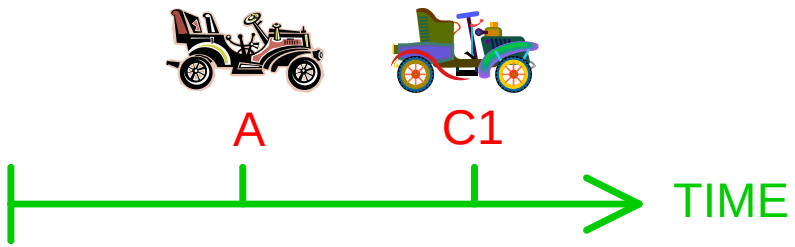
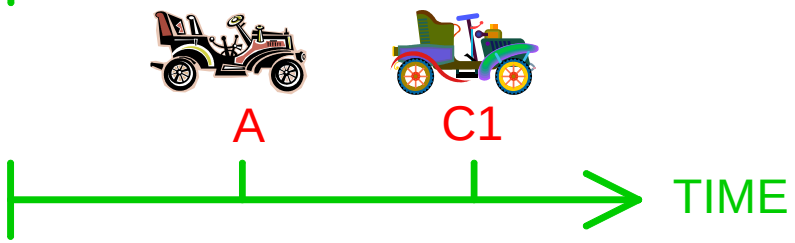
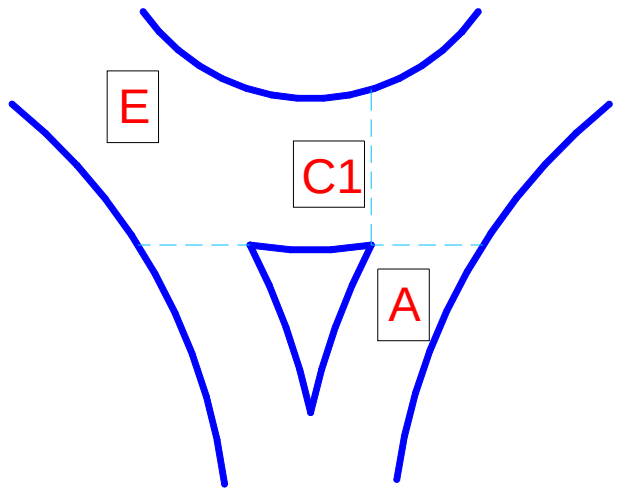


With Exit Vehicles:





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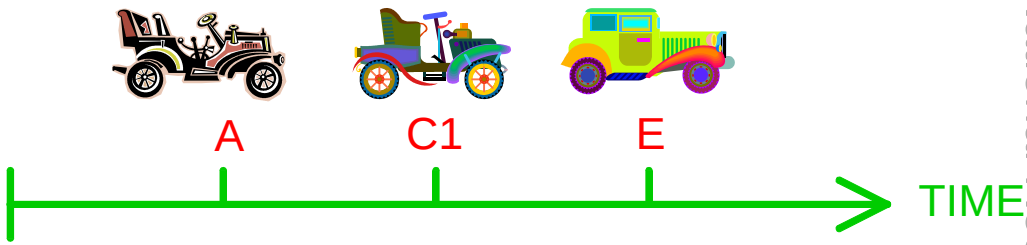

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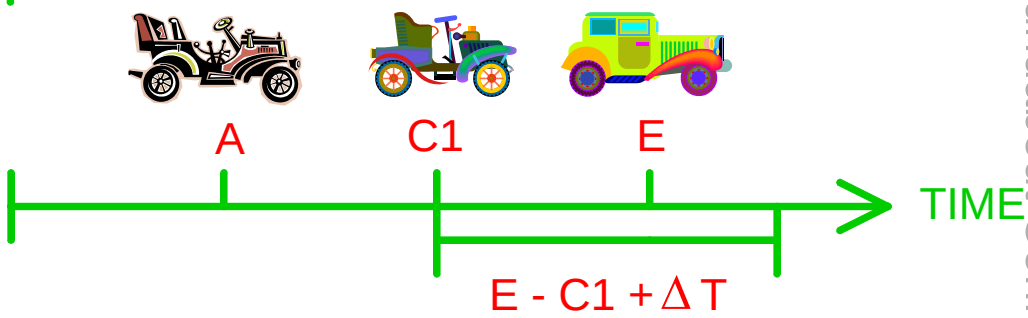

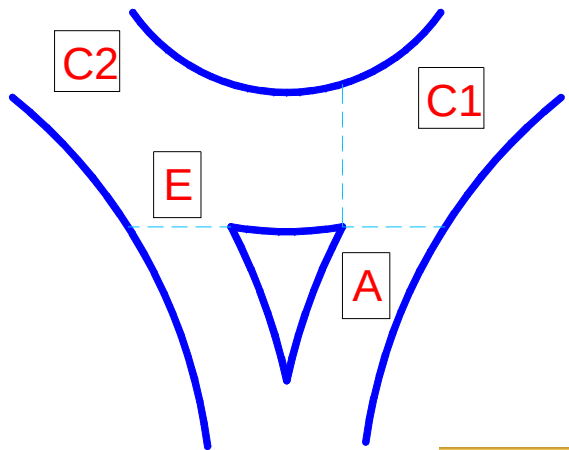

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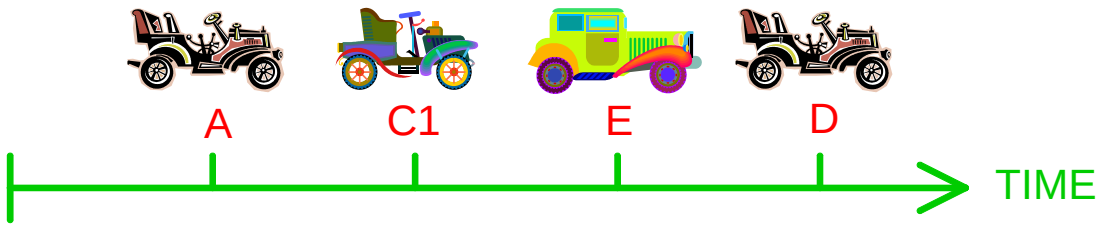

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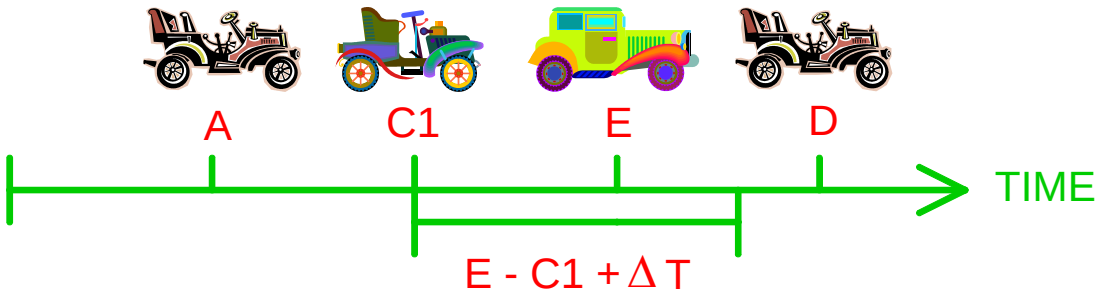

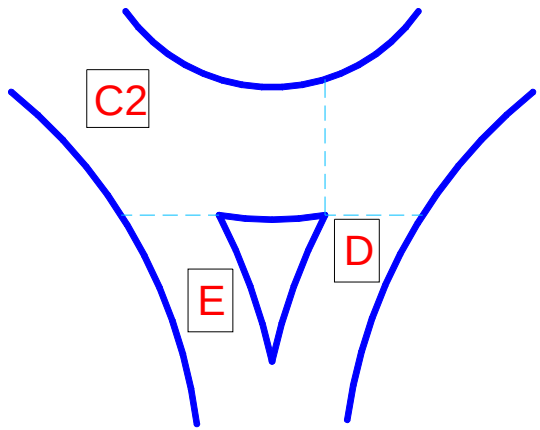

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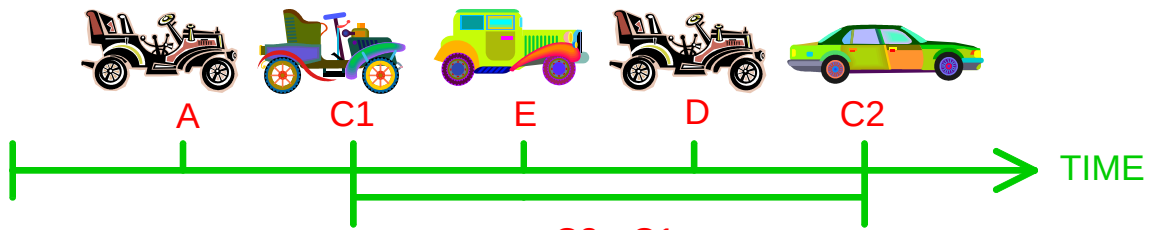

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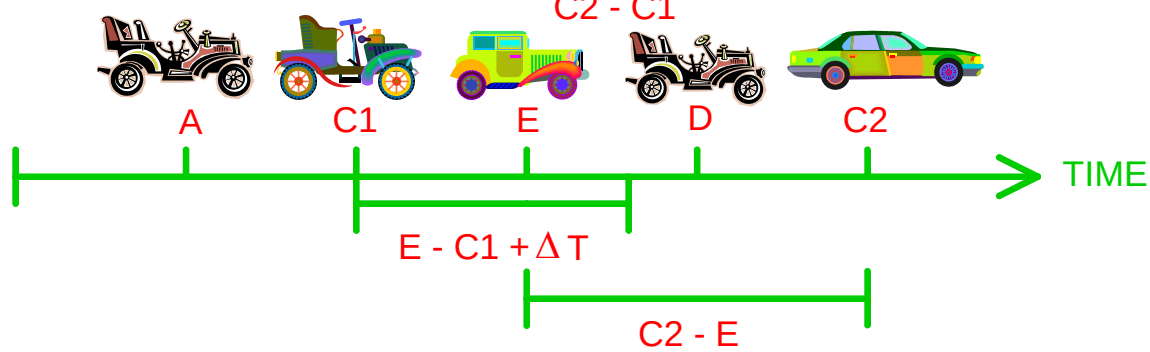
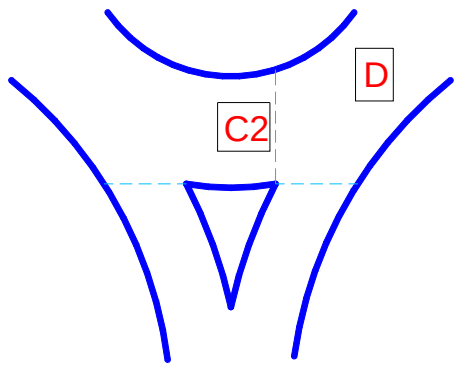




Assumptions in Definition of Gaps

- 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

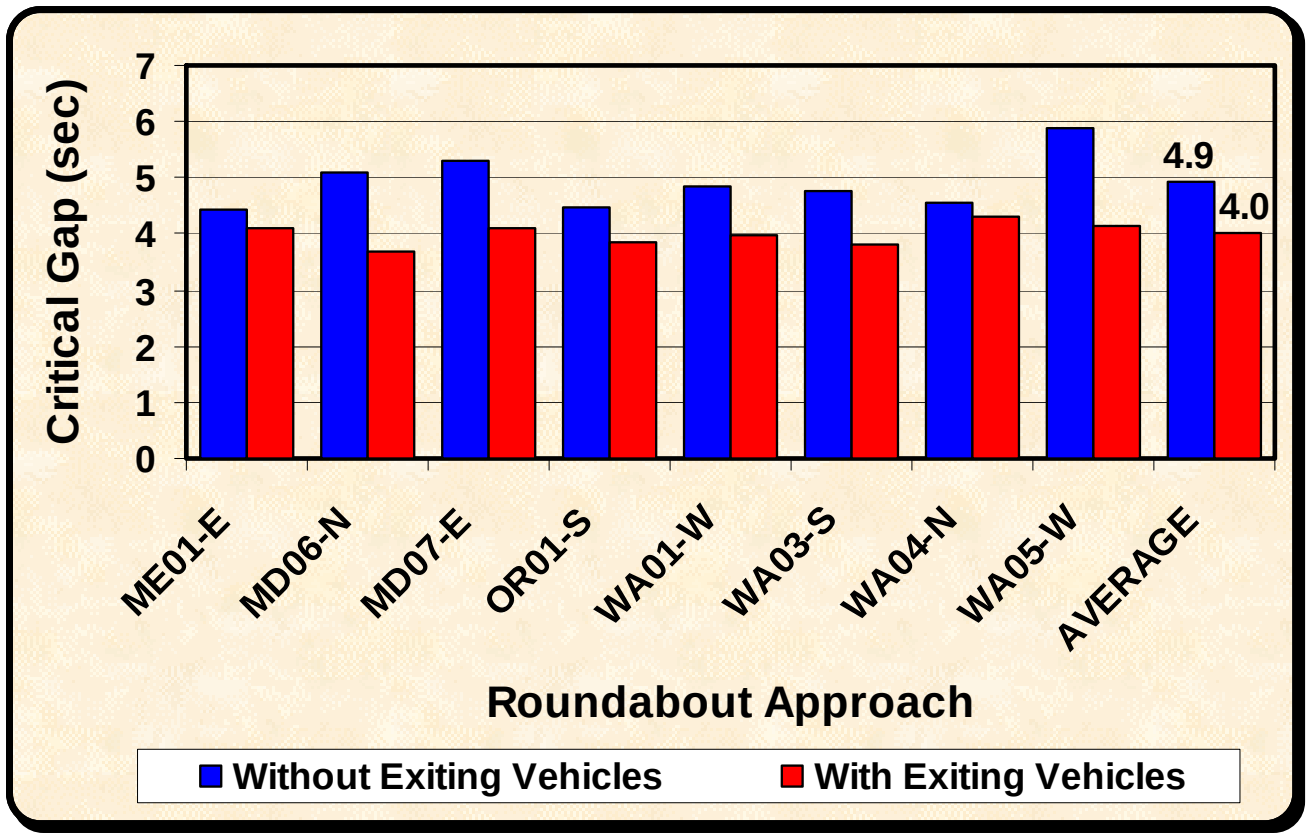
 = With the inclusion of 50% of exit vehicles

 = With the inclusion of 100% of exit vehicles

 = Field measurement

Critical Gap Comparison

- With Exit < Without Exit
- More Consistency With Exit



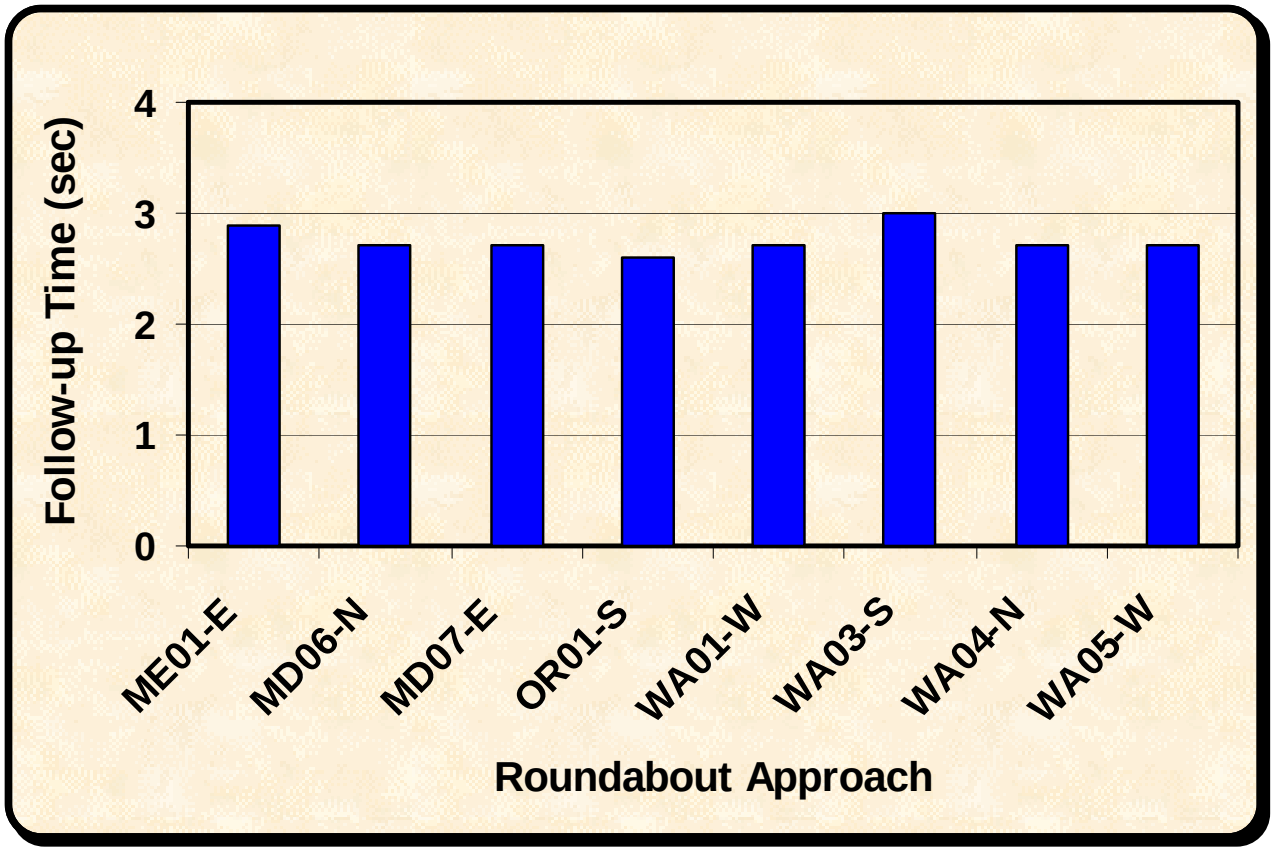
$$c_a = v_c \frac{e^{-v_c t_c / 3600}}{1 - e^{-v_c t_f / 3600}}$$

NIATT

University of Idaho

Follow-up Time Extraction

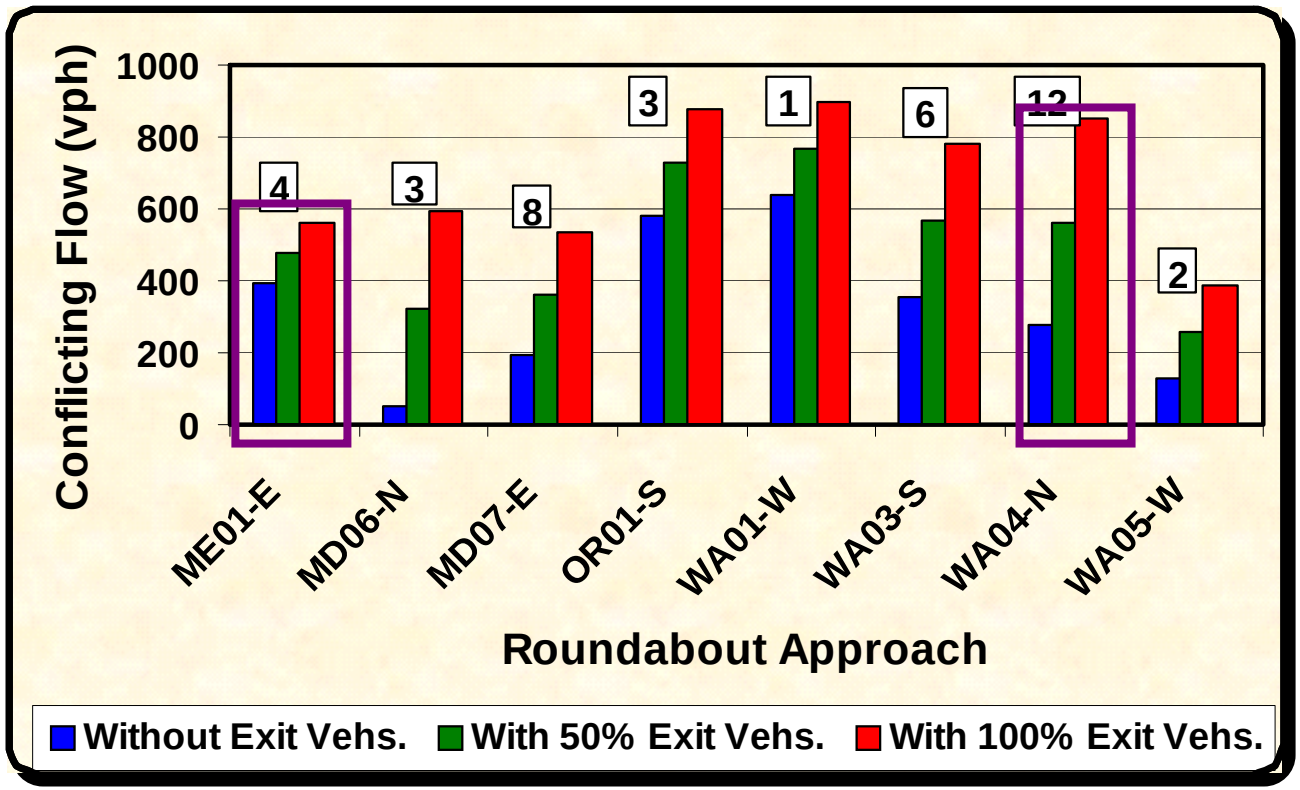
- **Between 2.6 – 3.0 seconds**



-- From Blogg, M. 2004 --

Conflicting Flow Comparison

- V_c Without Exit Vehicles = Circulating Flow
- V_c With Exit Vehicles = (P X Exit Flow) + Circulating Flow
  - P = 0.5 and P = 1.0

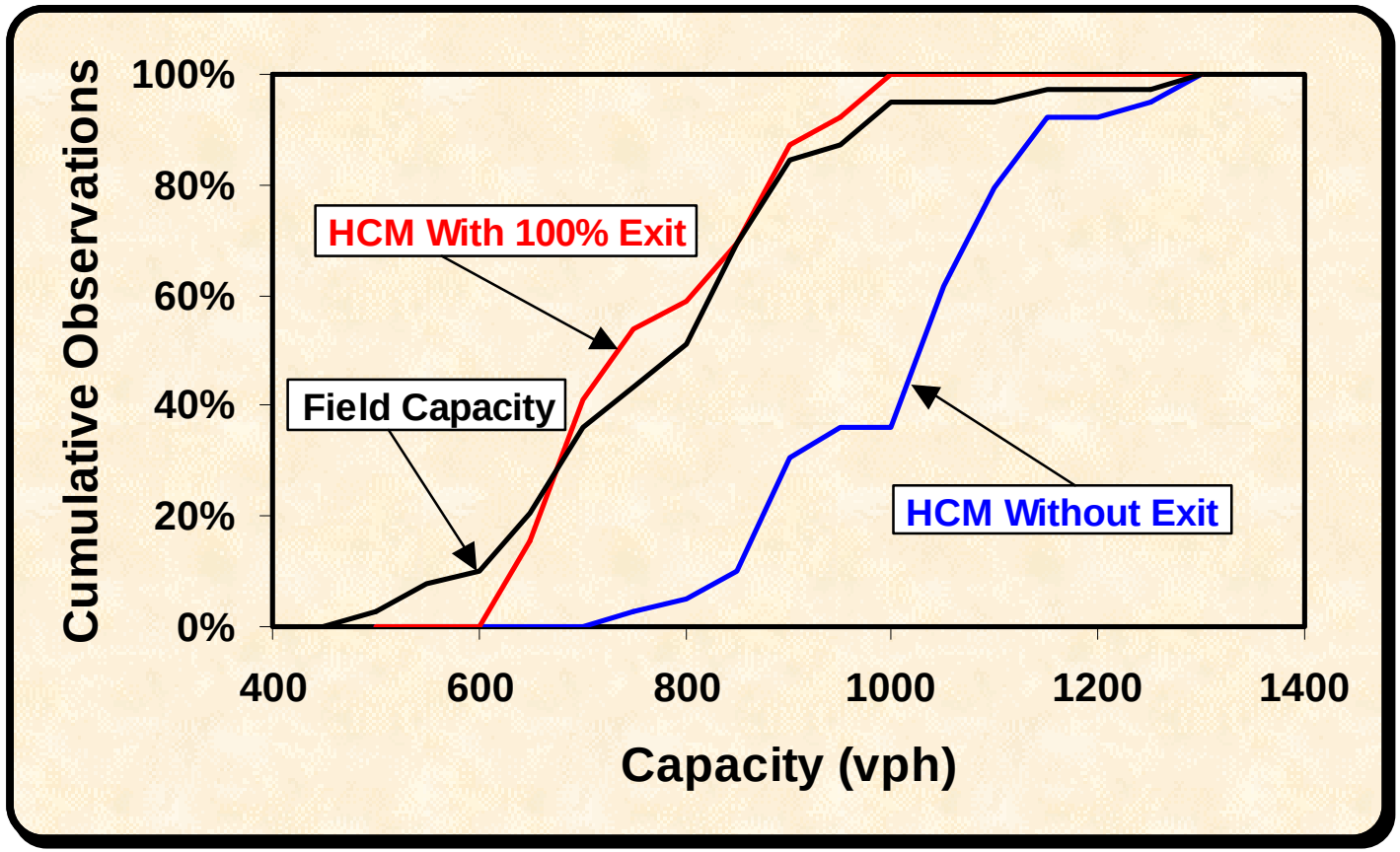


$$c_a = v_c \frac{e^{-v_c t_c / 3600}}{1 - e^{-v_c t_f / 3600}}$$

[#] = Number of 15-min samples

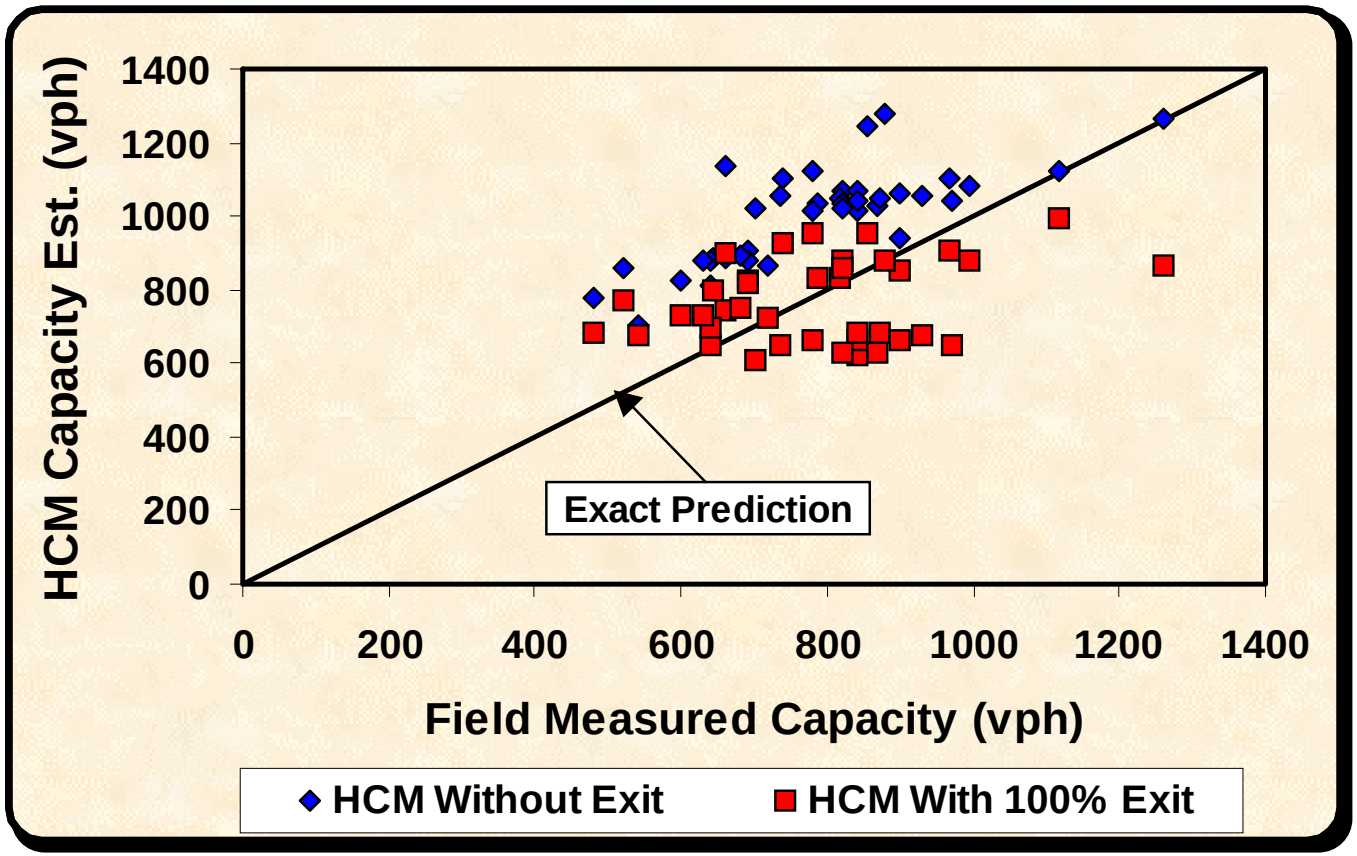
Capacity Comparison

- Cumulative distribution **with** exit vehicles **<u>matches</u>** the **field capacity** distribution



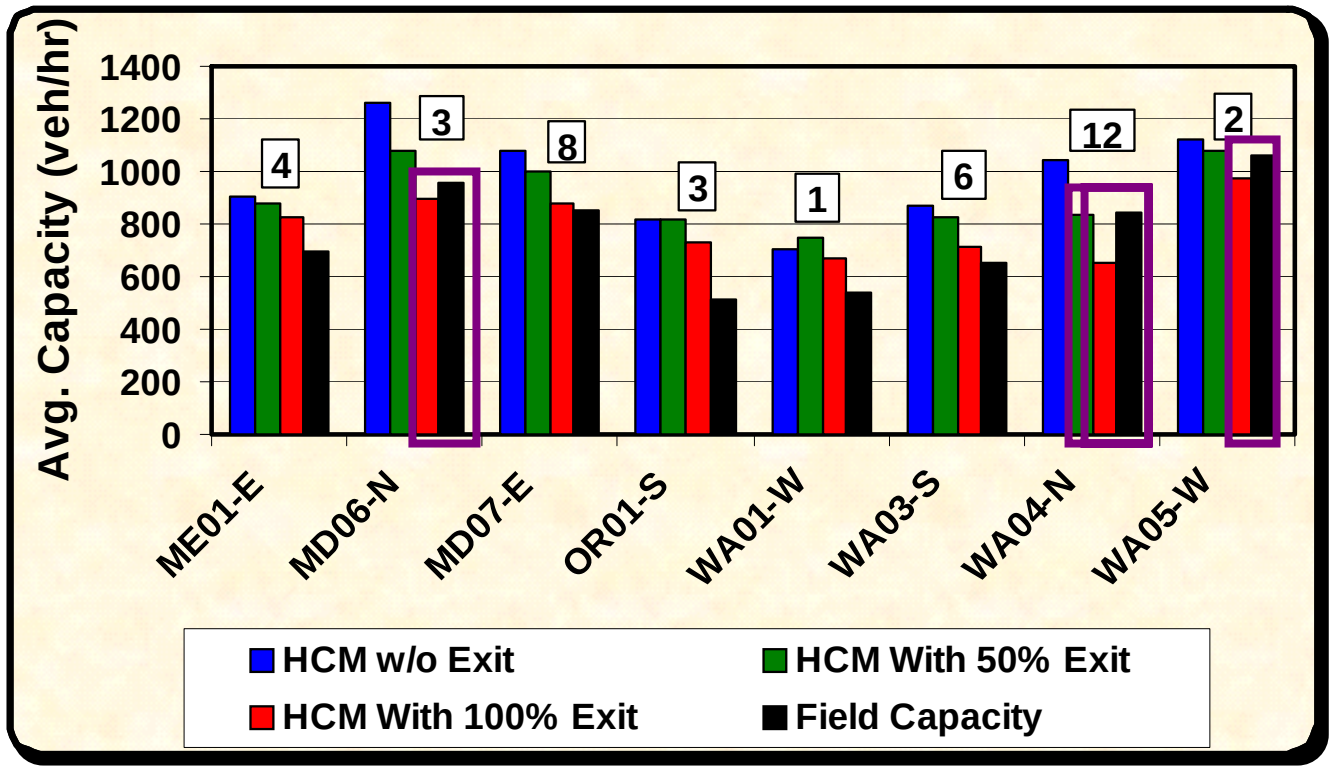
Capacity Comparison

- **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)**

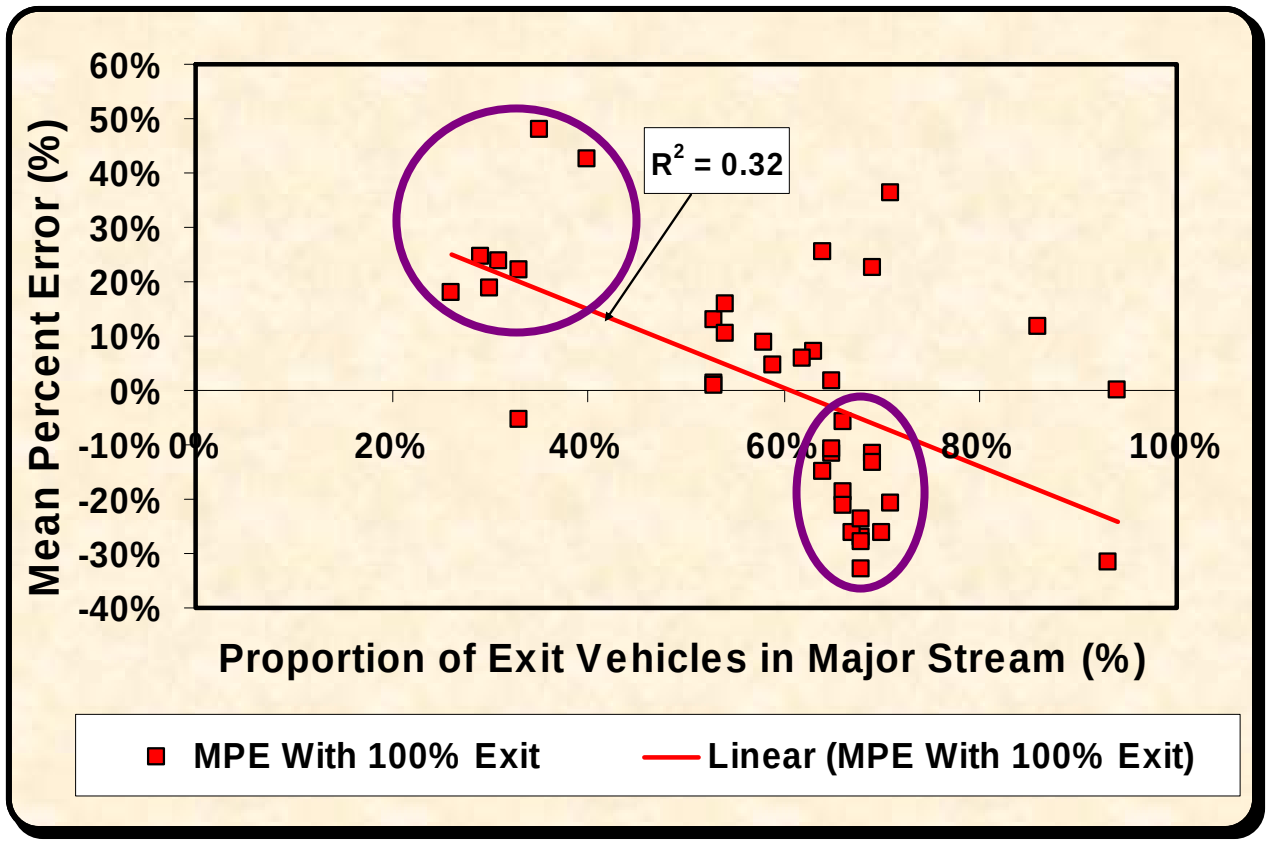
Calculation of Mean Percent Error (MPE)

$$MPE = \frac{\left(c_{est} - c_{field}\right)}{c_{field}} \times 100\%$$

Time Period	Capacity Estimate W/O Exit Veh. (vph)	Capacity Estimate W/ 100% Exit Veh. (vph)	Measured Field Capacity (vph)	Mean % Error (Without Exit)	Mean % Error (With 100% Exit)
1	943	851	900	4.8%	-5.4%

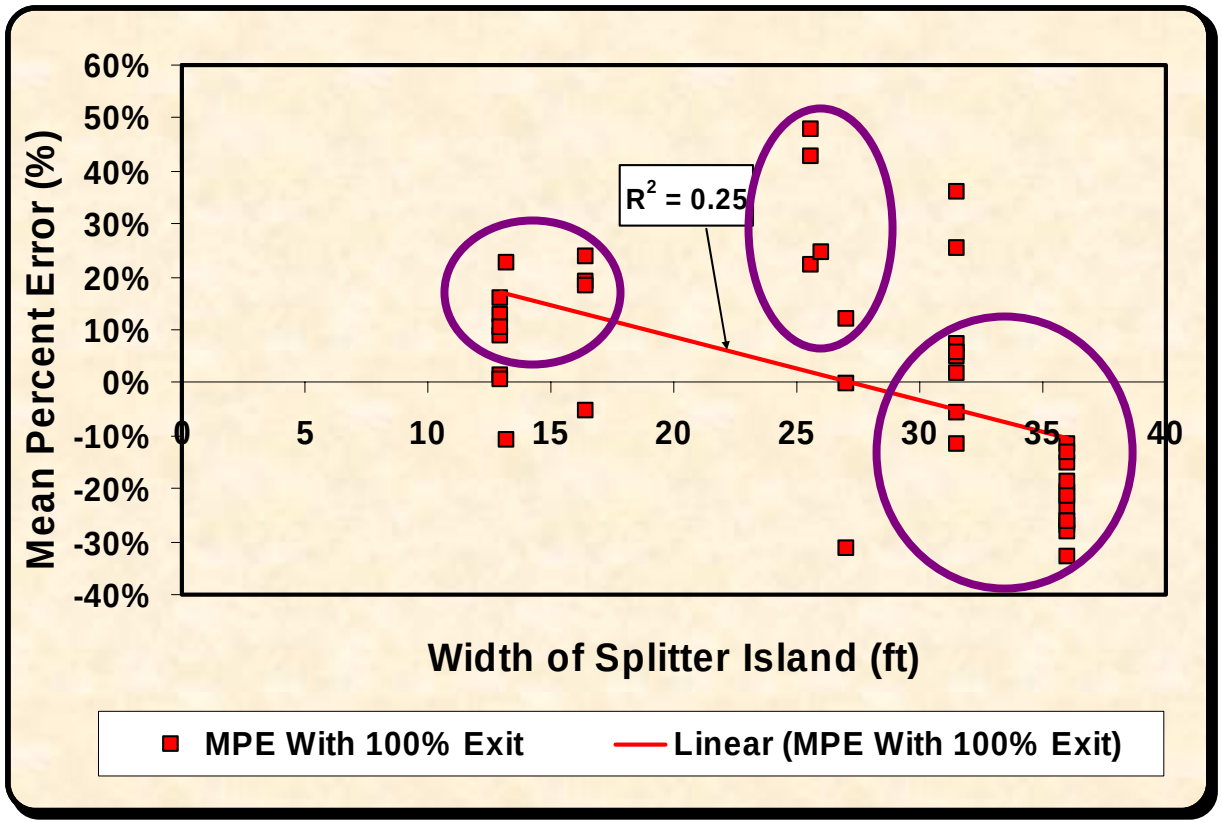
MPE vs. Proportion of Exit Vehicles

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



MPE vs. Width of Splitter Island

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



Conclusions

- **Account for Exiting Vehicles**
  - Improved Capacity Prediction
- **Weak Trends**
  - Proportion of Exiting Vehicles
  - Width of Splitter Island
- **Further Research**

Thanks to Those Who Made this Study a Reality

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  - Wayne Kittelson
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  - Brent Orton
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