Assessing Robustness of Planning Level Tools for Predicting Roundabout Behavior

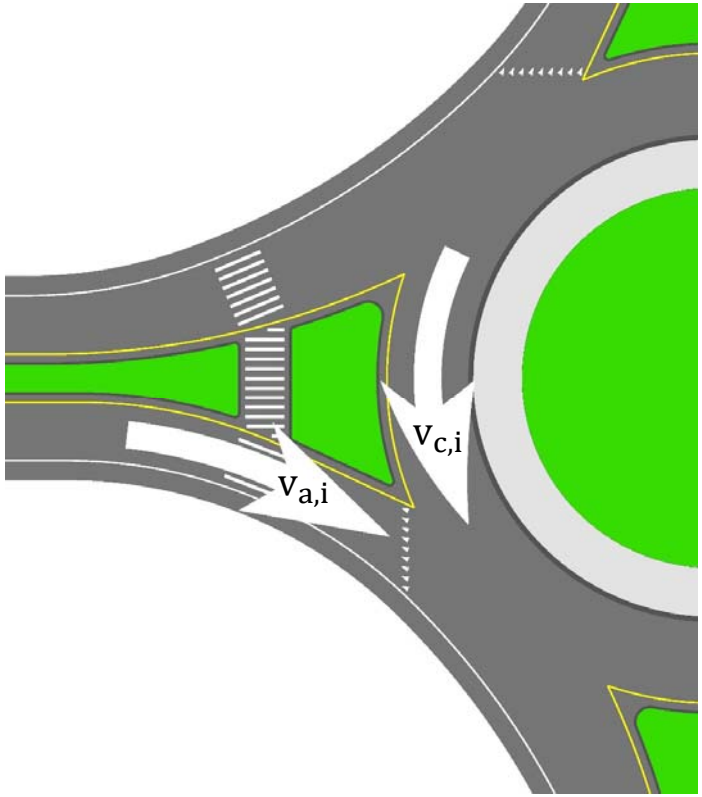
Ahmed Buasali

John Sangster, PE, PTOE, Ph.D.

University of Nebraska Lincoln

May, 2017

How well does it map?



Critical Sum Analysis

- $CS_i = v_{a,i} + v_{c,i}$
  - $v_{a,i}$ = the demand flowrate on approach *i* (veh/hr)
  - $v_{c,i}$ = the circulating flowrate passing in front of approach *i* (veh/hr)

HCM 6th Analysis

- $c_i = 1380 * exp^{(-0.00102 * v_{c,i})}$
- $d_i = \frac{3600}{c_i} + 900T\left[x_i - 1 + \sqrt{(x_i - 1)^2 + \frac{\left(\frac{3600}{c_i}\right)x_i}{450T}}\right] + 5 * min[x_i, 1]$
  - d_i = average control delay for approach *i* (seconds/vehicle)
  - x_i = volume-to-capacity ratio of approach *i* (unitless)
  - c_i = capacity of approach *i* (vehicles/hour)
  - T = analysis time period (hour)

How can we say a method is robust?

Primary questions:

1. Is there a well defined relationship (correlation) between critical sum and delay?

2. Among all of the volume scenarios that result in a certain critical sum, do they also result in the same delay?

3. Are there aspects of the volume scenario that impact how closely critical sum predicts delay?

Experiment Design to Assess Robustness

Origin-Destination Volume Combination	• Volume by approach (100-2000) • Split Percentage (0.5–0.7) • Turn Percentage (0.05-0.25)
Algorithmic Formulation	• CS_{MAX} (max value of all approaches) • $CS_{weighted}$ (weighted average)
Model Fit	• Mean correlated value • Percent of values within ±5 sec of the predicted mean

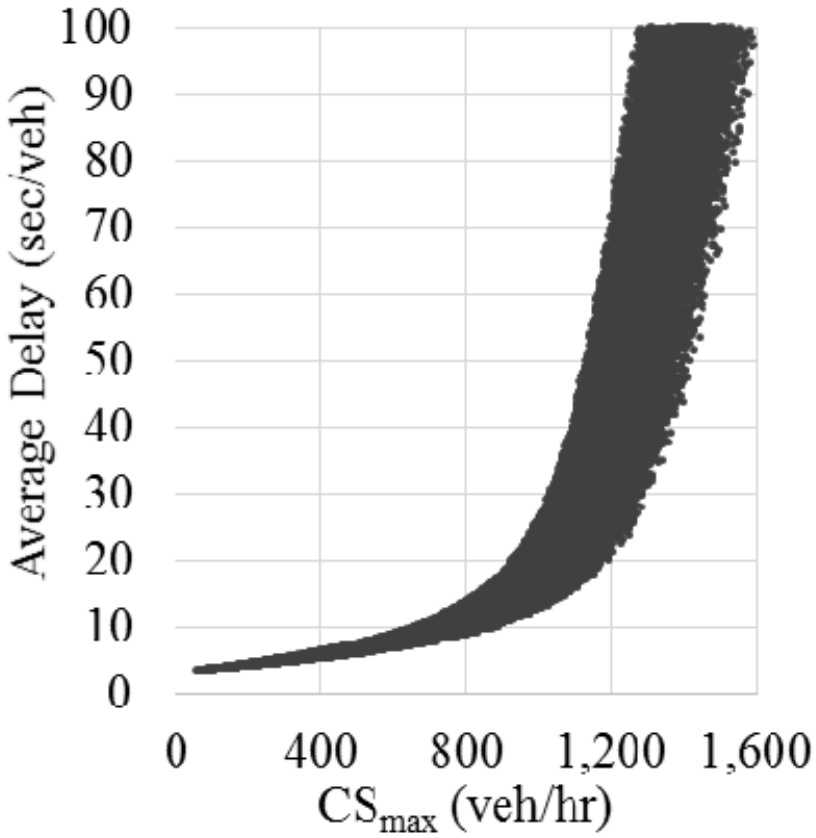
Volume Scenario Permutations and Perturbations

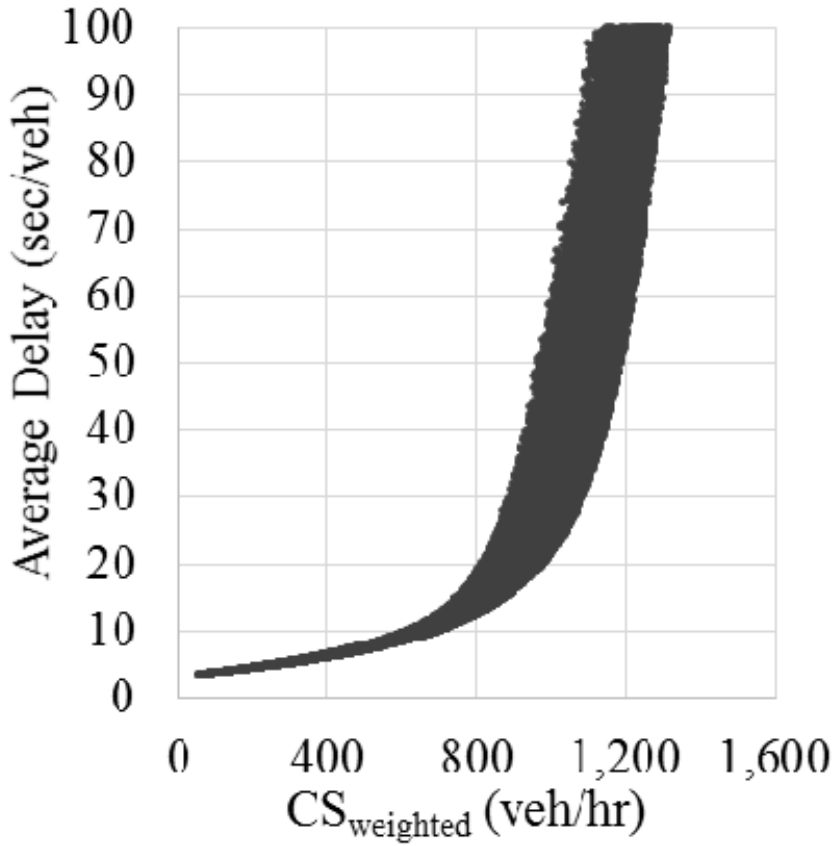
Direction	Parameter	Units	Min	Max	Step	Values	Randomization
EW	2 Way Volume	pceph	100	2,000	100	20	-50+[100*Rand(0,1)]
	Split percent	%	0.5	0.7	0.05	5	-0.025+[0.05*Rand(0,1)]
	Turn percent	%	0.05	0.25	0.05	5	-0.025+[0.05*Rand(0,1)]
NS	2 Way Volume	pceph	100	2,000	100	20	-50+[100*Rand(0,1)]
	Split percent	%	0.5	0.7	0.05	5	-0.025+[0.05*Rand(0,1)]
	Turn percent	%	0.05	0.25	0.05	5	-0.025+[0.05*Rand(0,1)]
Total	250,000 volume scenarios						

Sample Volume Scenario Application

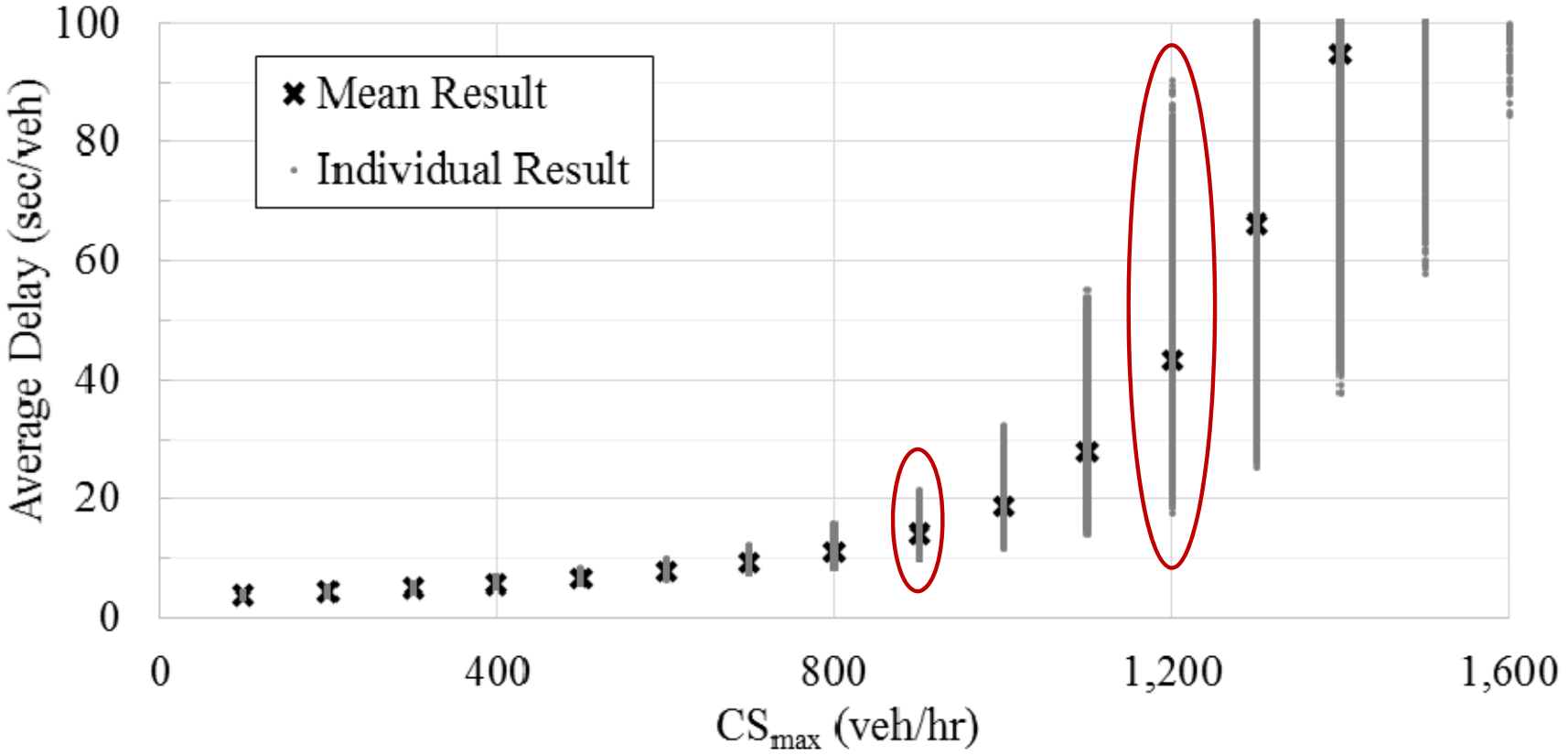
Input Parameters T = 60 min					Volume Application					Critial Sum Method			HCM 6th Method			
Approach		**road vol**	**dir split**	**turn %**	**app vol**	**L**	**T**	**R**	**circ vol**	**CS**	**CS (max)**	**CS (weight)**	**cap.**	**v/c ratio**	**app delay**	**int. delay**
1	**EB**	800	0.6	0.1	480	48	384	48	359	839	839	758	957	0.50	10.0	8.58
3	**WB**				320	32	256	32	316	636			1000	0.32	6.9	
2	**SB**	700	0.55	0.15	385	58	269	58	335	720			981	0.39	8.0	
4	**NB**				315	47	221	47	490	805			837	0.38	8.8	

Impact of Max or Weighted Critical Sum Values

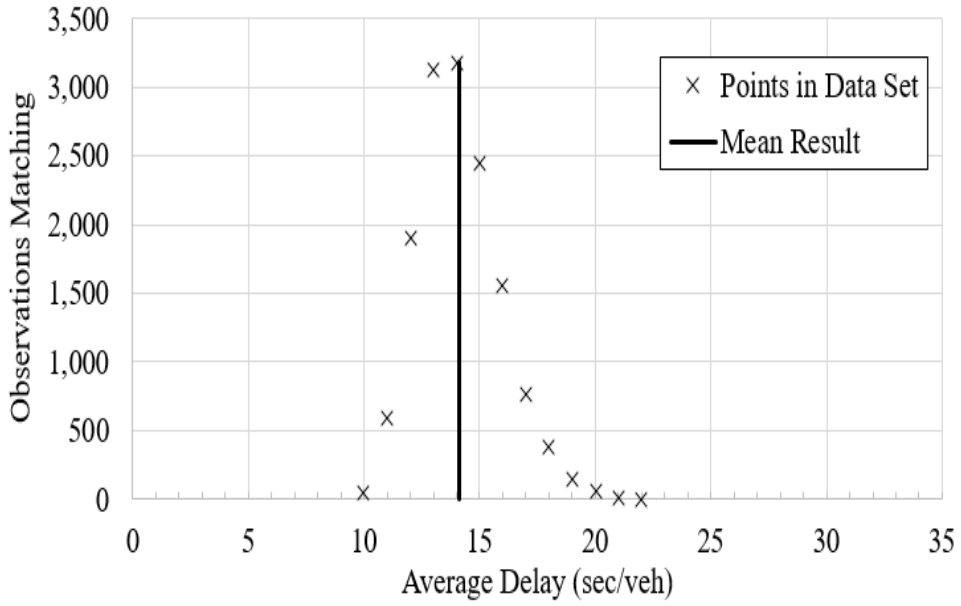


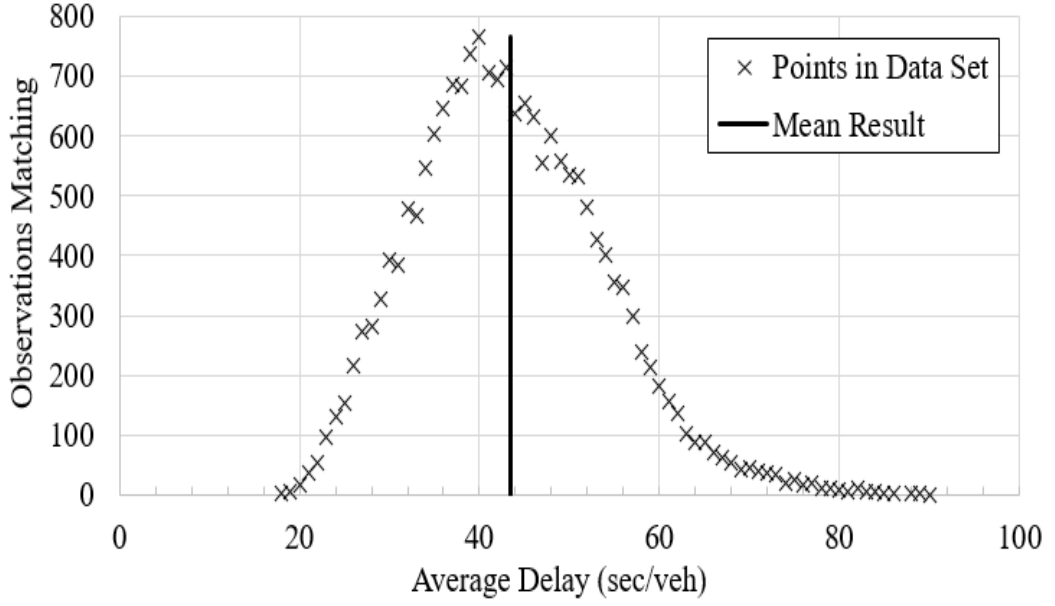


Assessing Reliability of Results



Assessing Reliability of Results

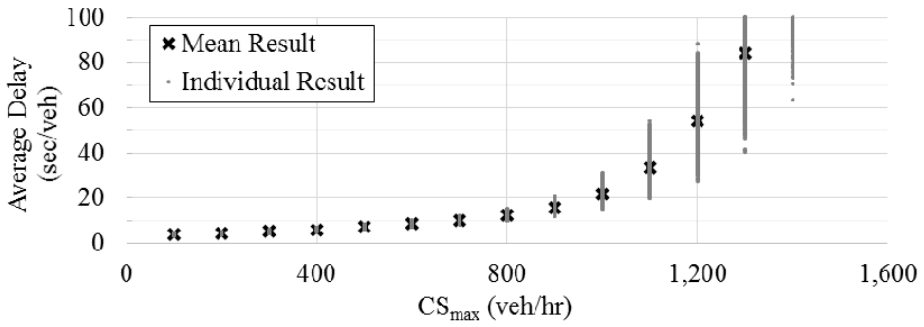




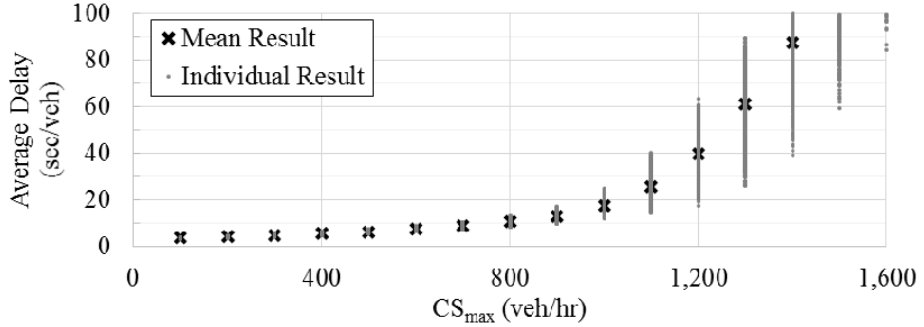
CS_{MAX}= 900 ± 50

CS_{MAX}= 1,200 ± 50

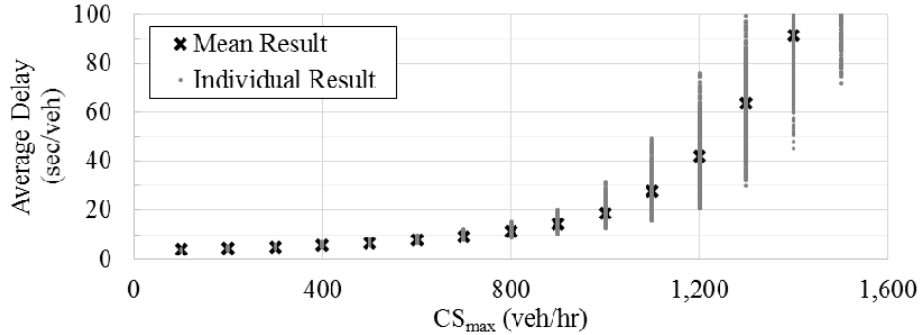
Impact of Volume Scenario Parameters



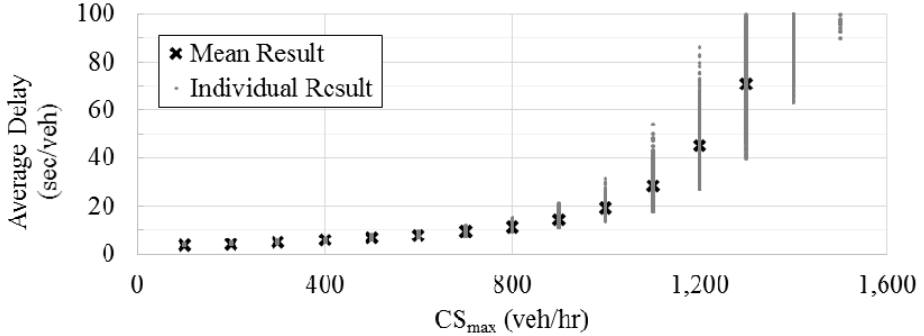
Directional Split: NB/SB = EB/WB = 0.5



Directional Split: NB/SB = EB/WB = 0.7



Turn Percentage: NB,SB,EB,WB = 5% (min)



Turn Percentage: NB,SB,EB,WB = 25% (max)

Conclusion

- Regardless of the volume scenario conditions…
  - Critical sum fails to be an accurate indicator of average roundabout delays greater than 15 seconds.

Paper : Assessing Robustness of Planning Level Tools for Predicting Roundabout Behavior

Authors:

Ahmed Buasali
University of Nebraska-Lincoln
Department of Civil Engineering
Email: ahmedaziz_90@hotmail.com

John Sangster, PE, PTOE, Ph.D.
University of Nebraska-Lincoln
Department of Civil Engineering
Email: john.sangster@unl.edu