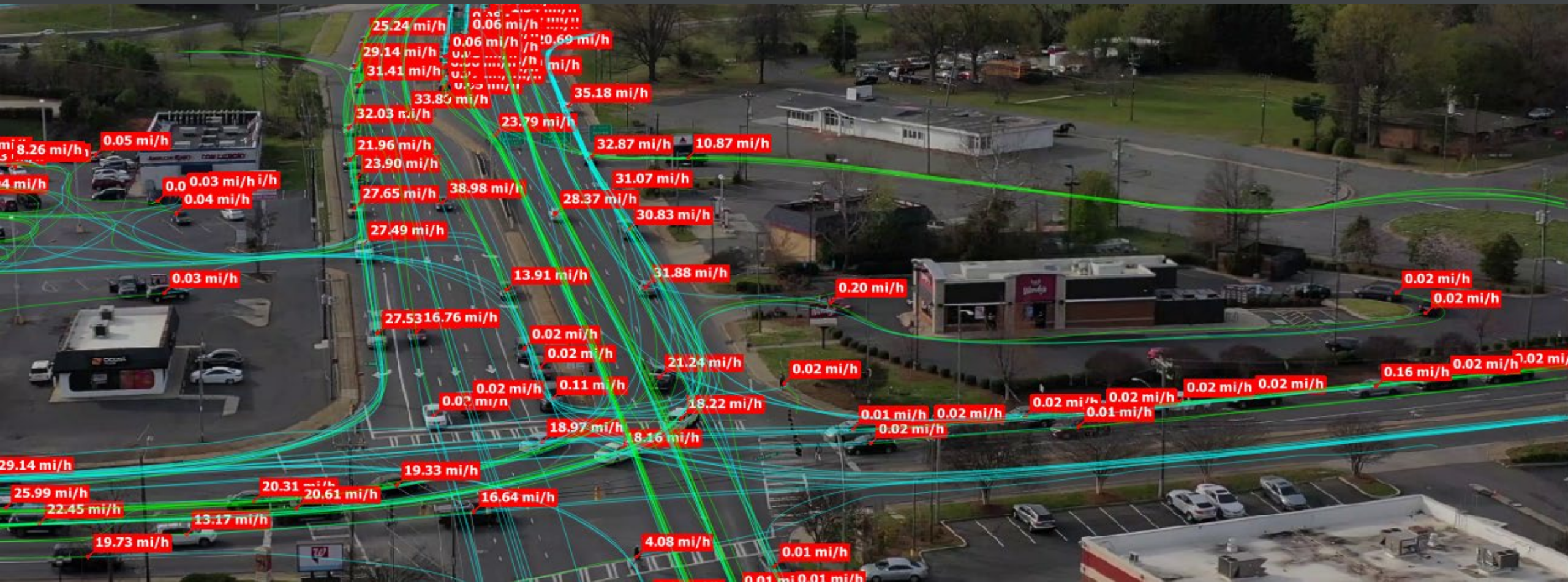
Plugging a 60-Year-Old Hole in the Highway Capacity Manual: Arterial Weaving



Christopher Kinzel, PE

NCHRP 15-66

Operational Performance and Safety Effects of Arterial Weaving Sections

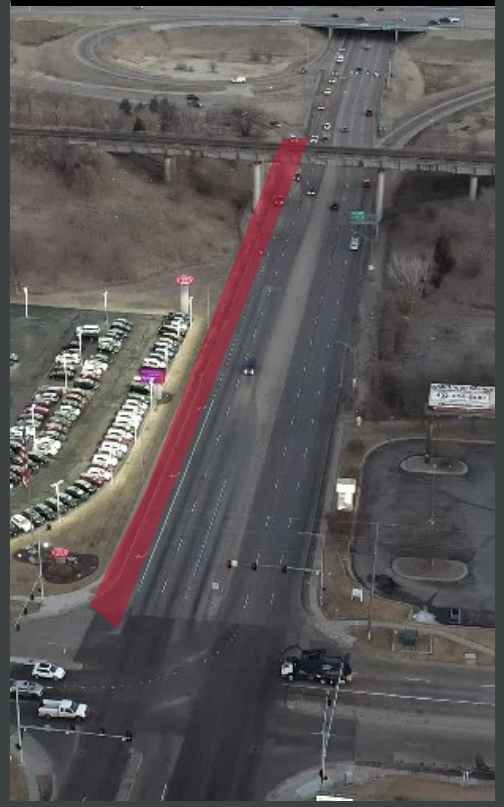
Problem
HCM7 does not consider arterial weaving

Primary objective
Develop a deterministic method for evaluating operational performance

Secondary objective
Identify the safety effects of varying geometric, volume, and traffic conditions

What is Arterial Weaving?

Right-side Ramp to Intersection



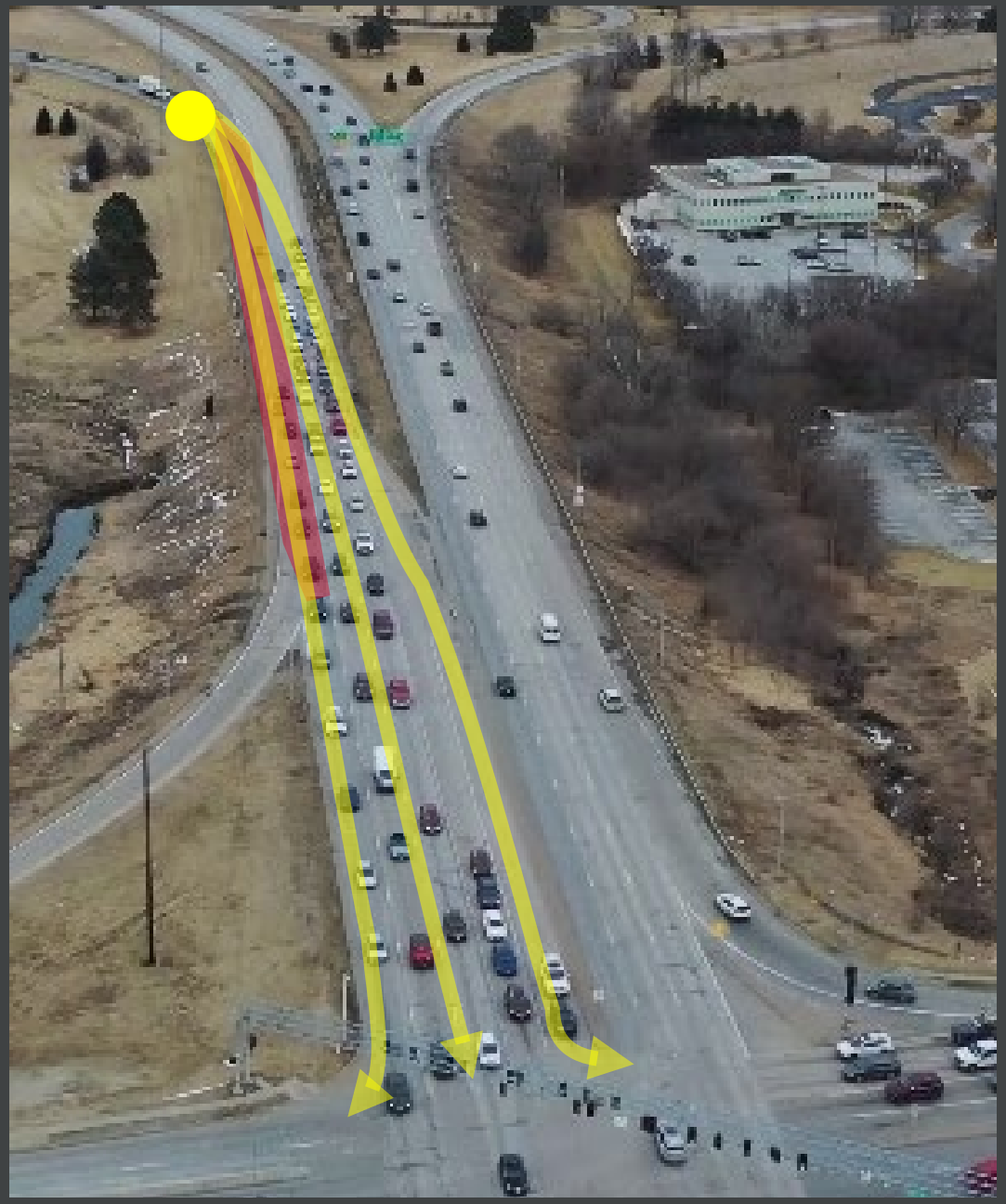
Right-side Ramp to Right-Side Ramp

Left-side Ramp to Intersection

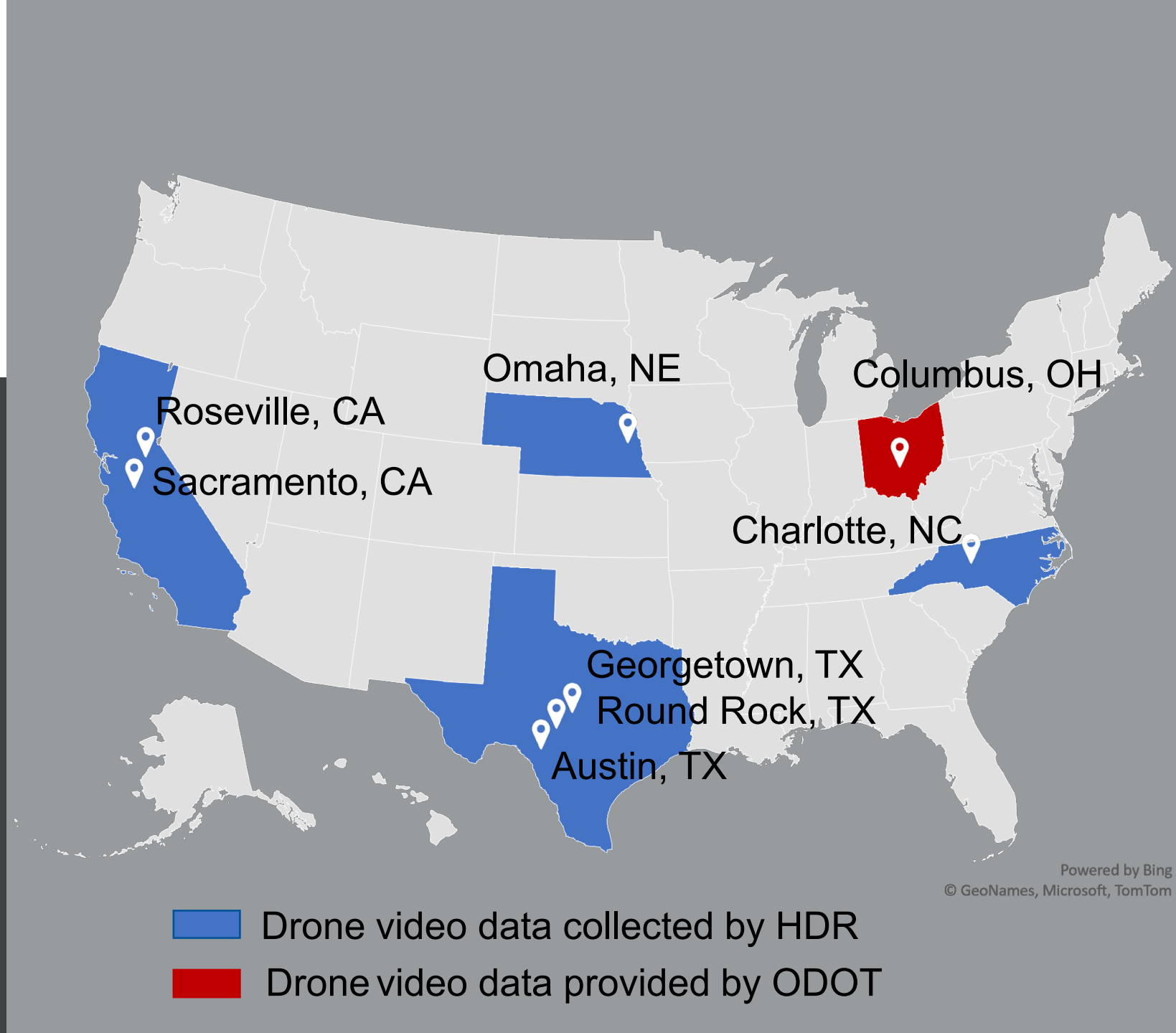
Right-side Ramp to Right-side Ramp (cloverleaf)

“The crossing of two or more traffic streams in the same direction between two or more access points on a multilane urban street with some kind of traffic control.”

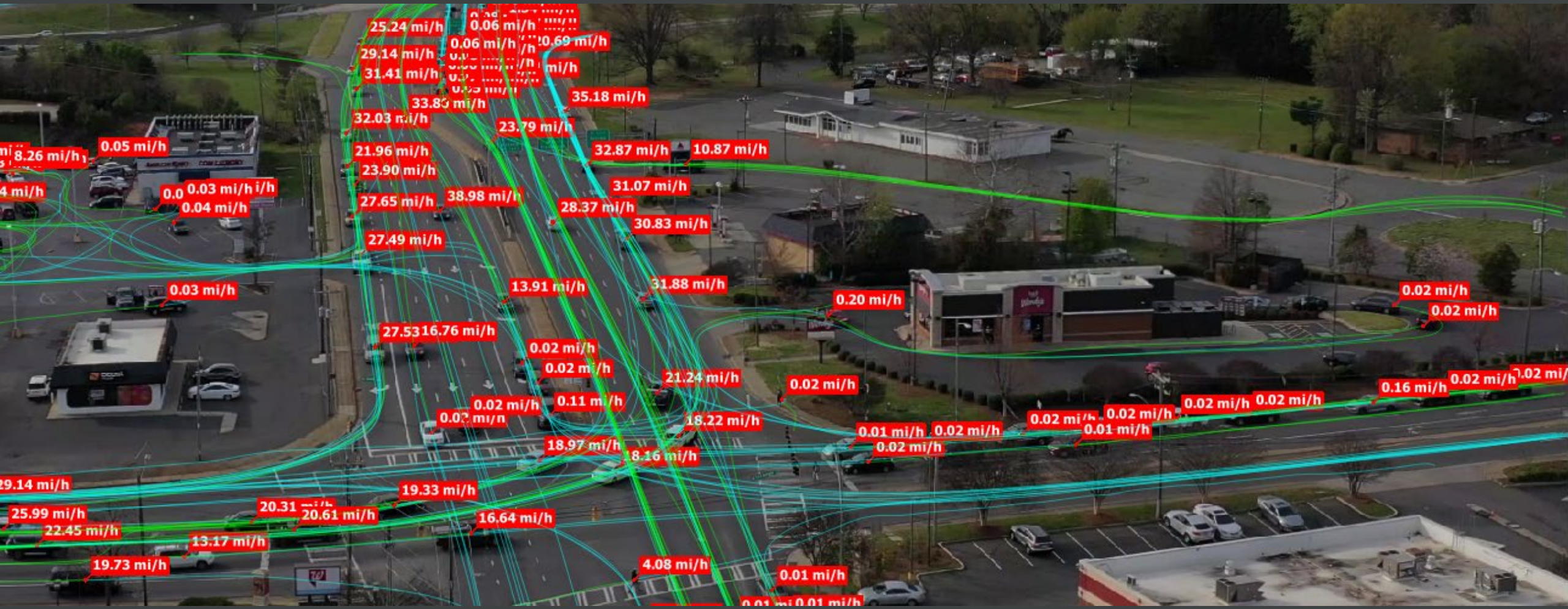
What is Arterial Weaving?



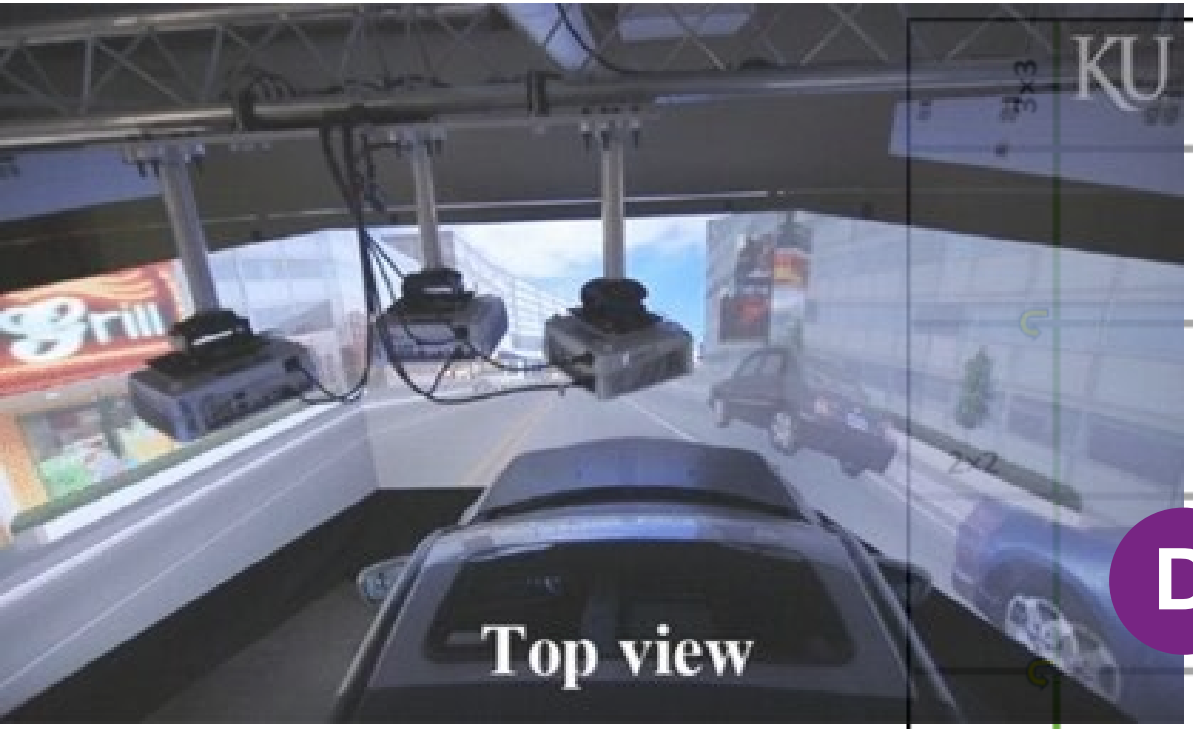
Video Data Collection

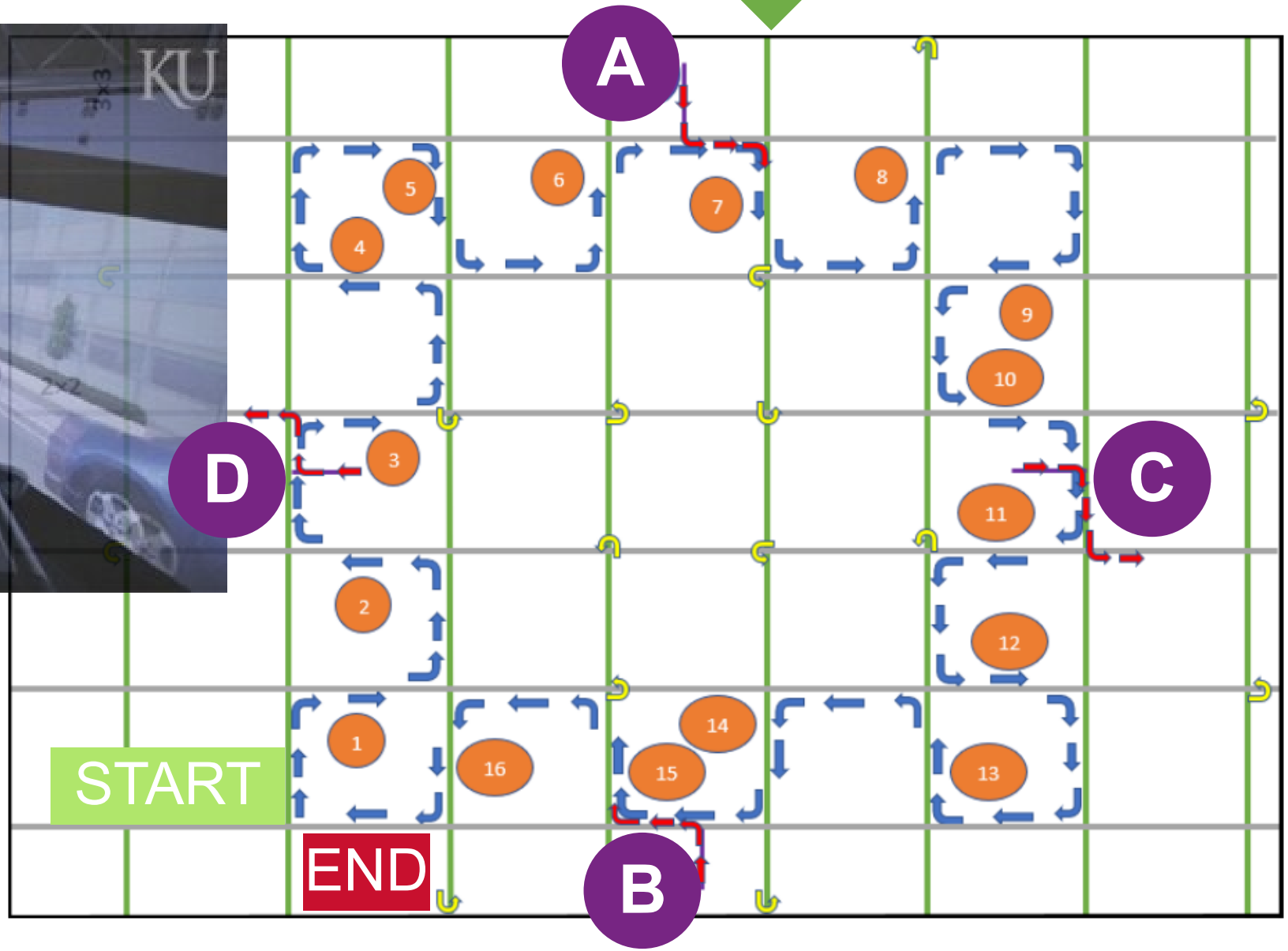


Video → Machine Vision → Trajectory Data



Driving Simulator | 39 Participants





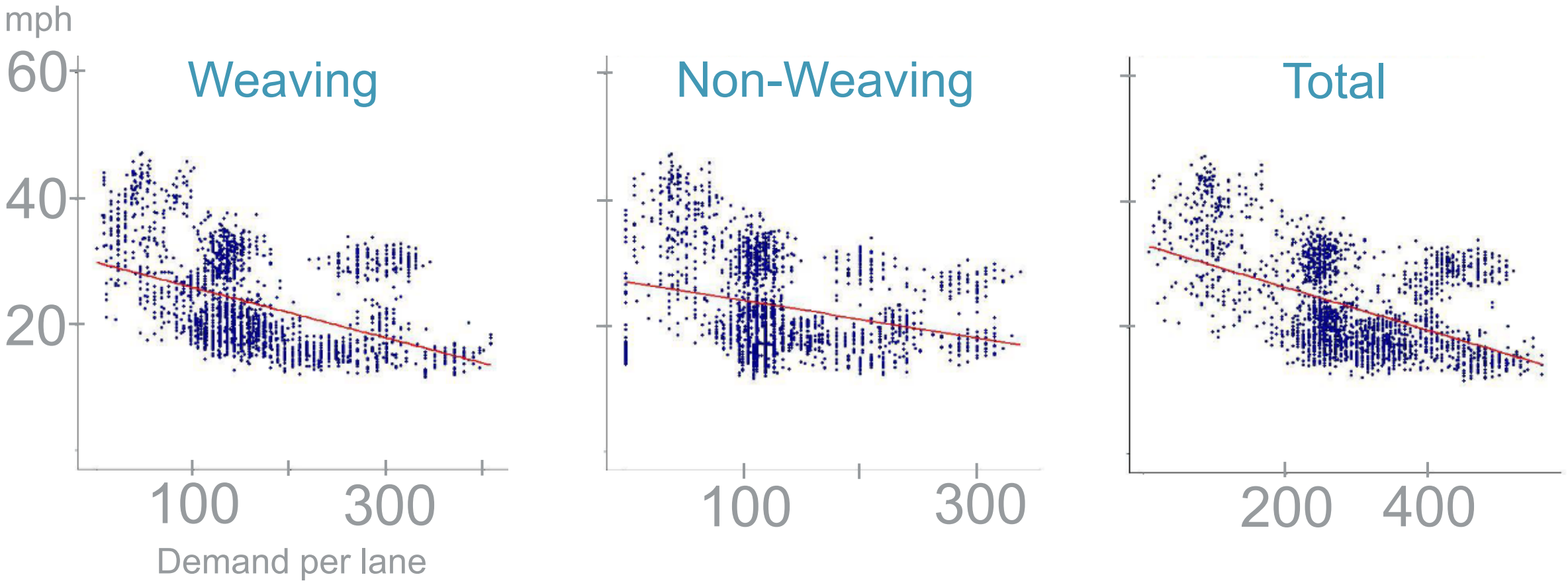
2 lanes / dir

Microsimulation | TransModeler

Site	Scenarios						
	Weaving Demand	Nonweaving Demand	No. of Lanes	Turning Bay	Signal Timing	Scenarios	Simulations (Scenarios × 12)
CA12	4	4	3	3	3	16	192
NC1	4	4	3	3	3	16	192
NC6	5	5	3	3	9	26	312
NE1	4	4	3	3	3	16	192
TX5	4	4	3	3	3	16	192
Total Simulations							1,080

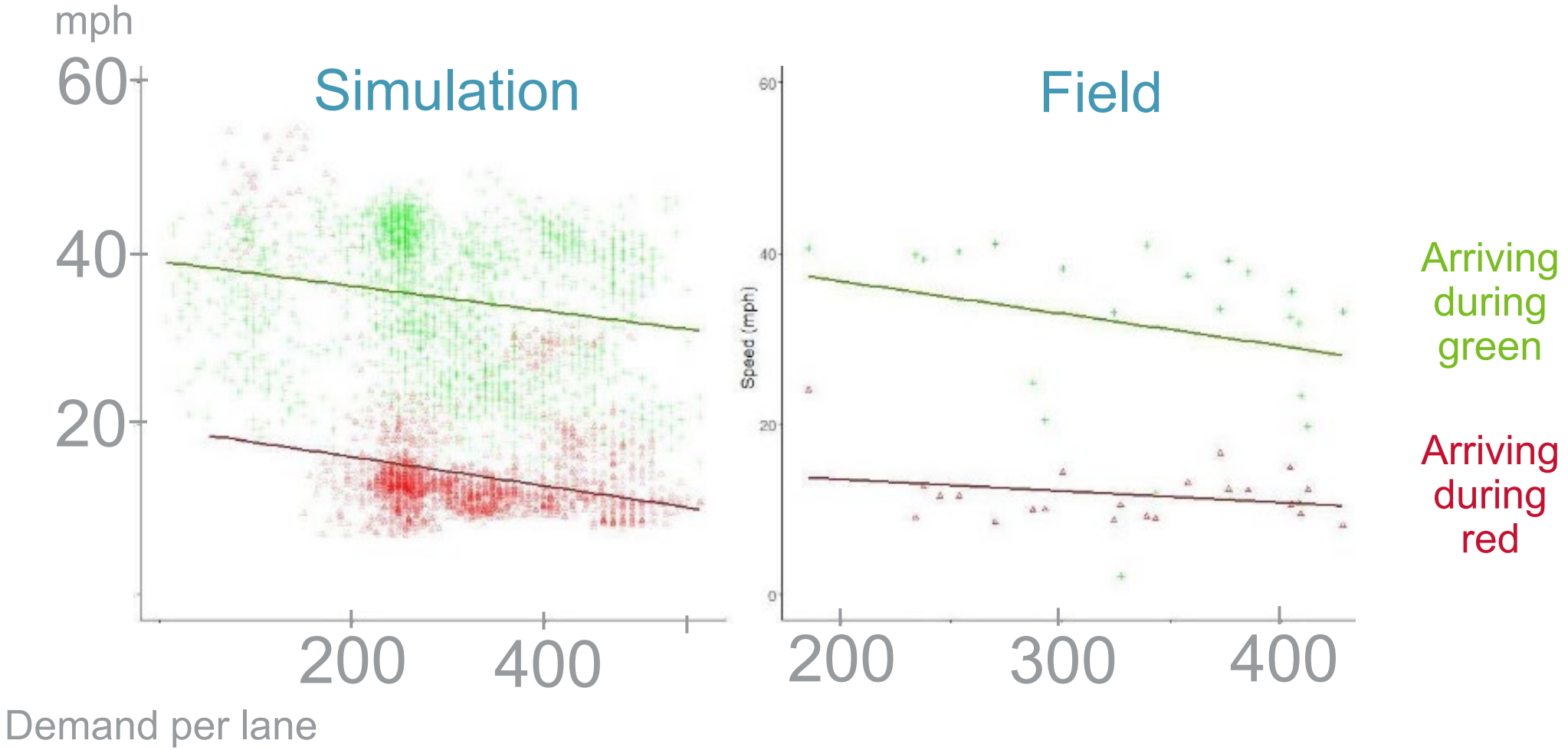
Initial Data Analysis

Speed vs. Demand | Simulation NC6



Initial Data Analysis

Speed vs. Total Demand | Simulation NC6

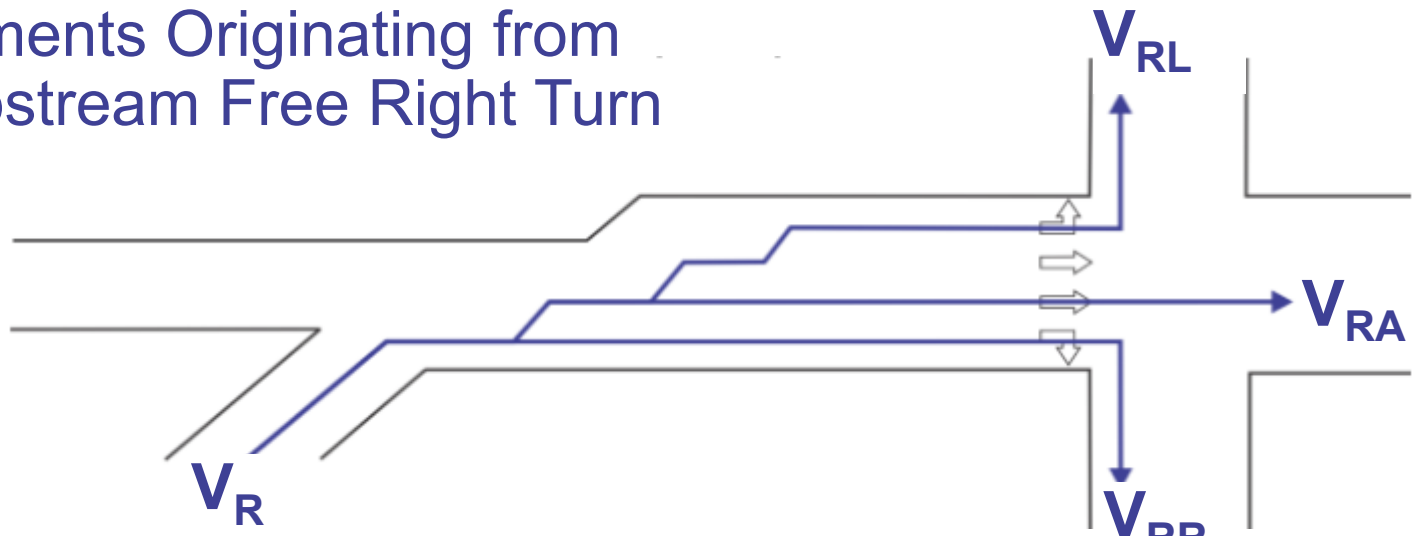


Speed is a desired **output**.

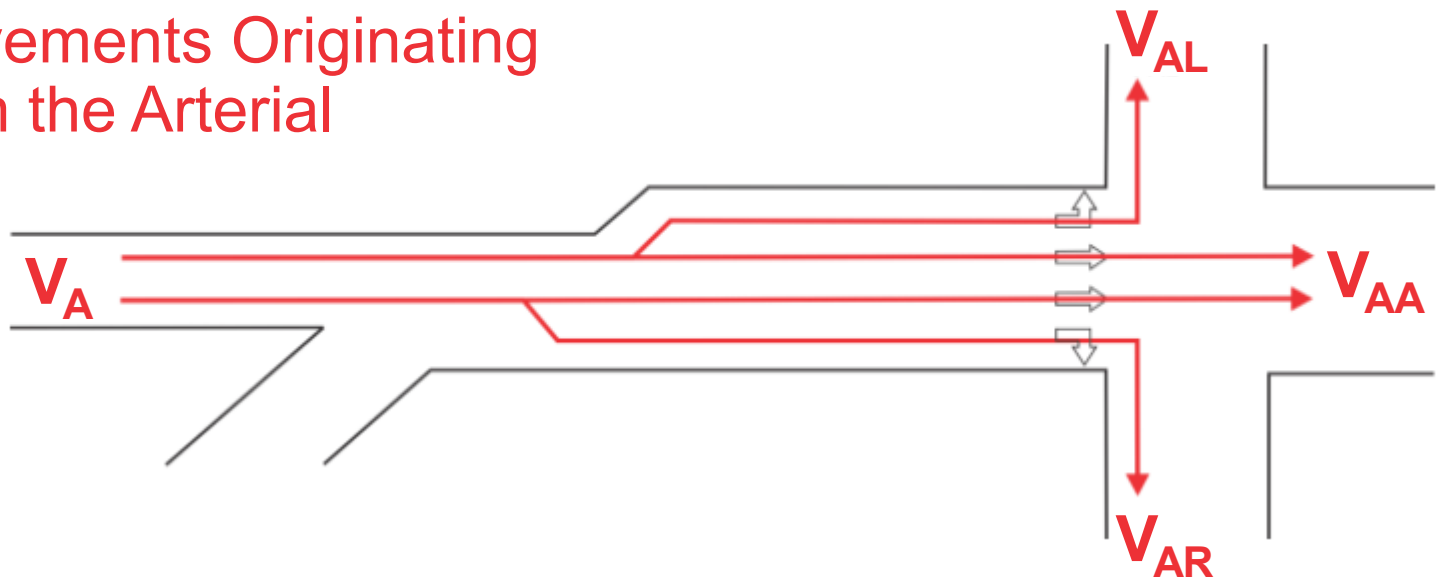
How to characterize the **“friction”** introduced by weaving, to use as an **input**?

Potential Conflict Occurrences (PCO)

Movements Originating from the Upstream Free Right Turn



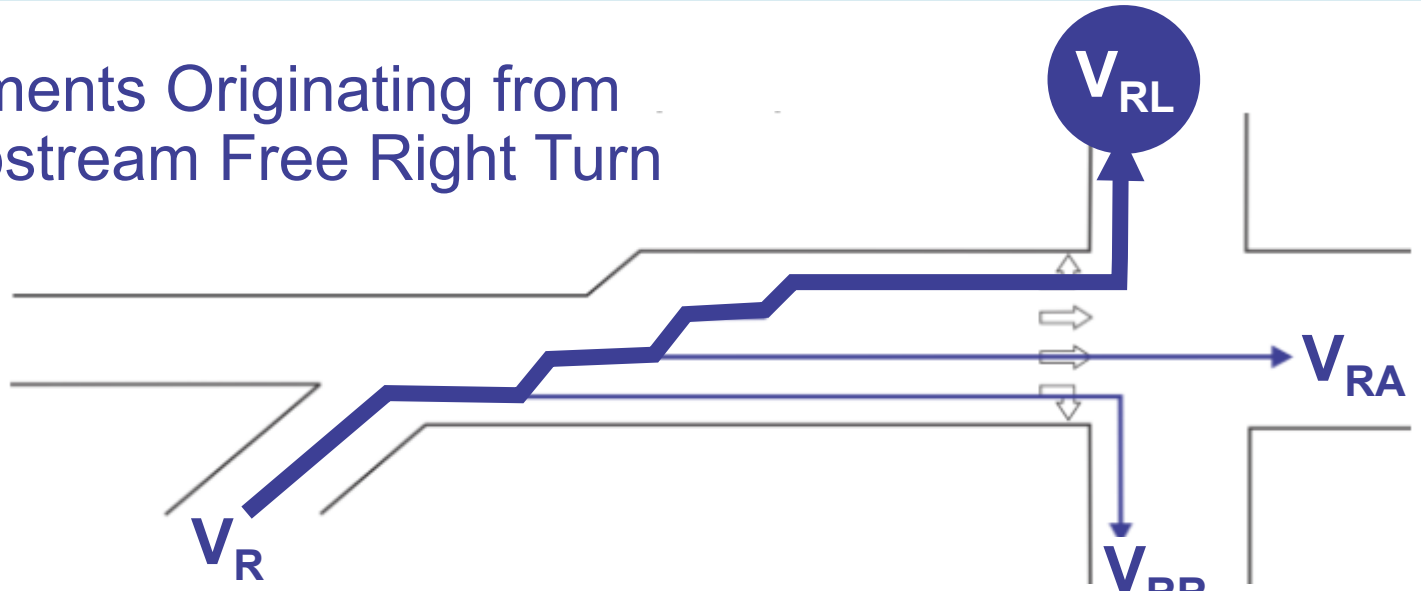
Movements Originating from the Arterial



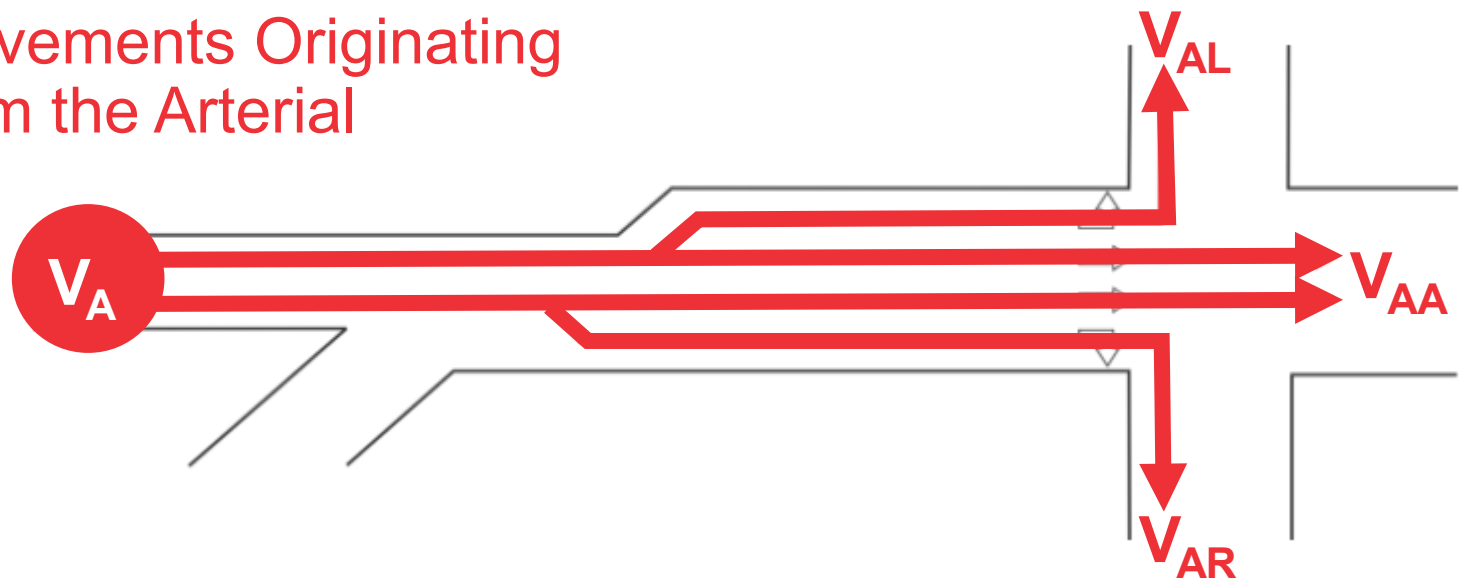
PCO = product of crossing volumes

Potential Conflict Occurrences (PCO)

Movements Originating from the Upstream Free Right Turn



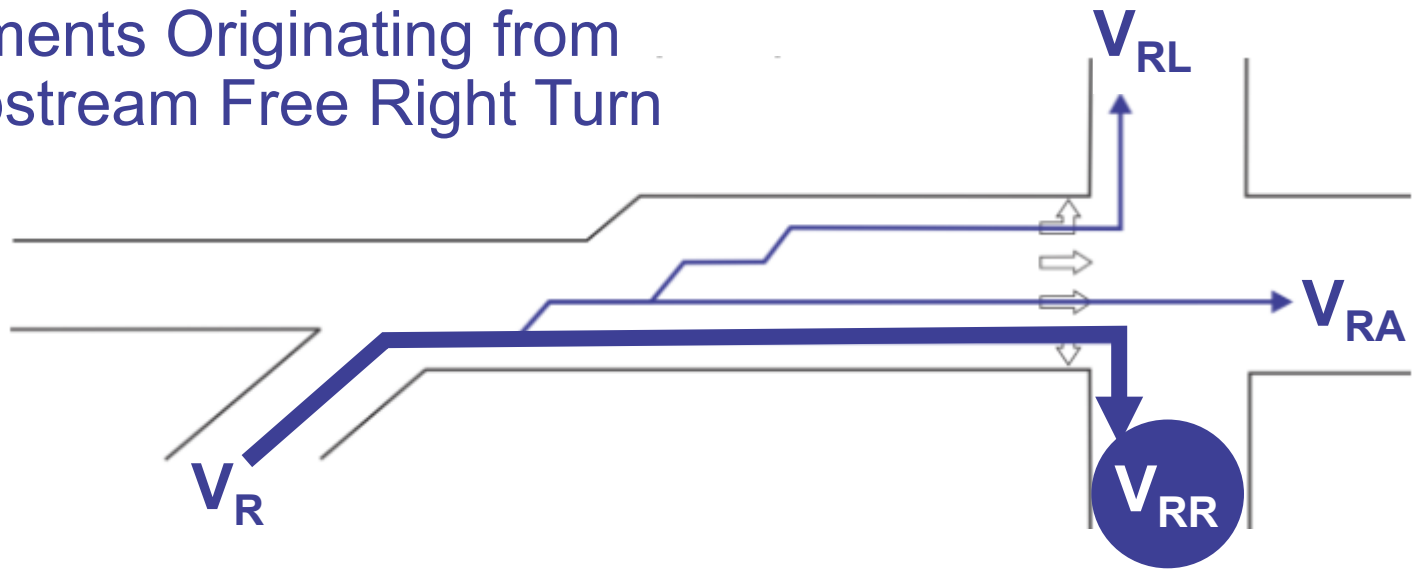
Movements Originating from the Arterial



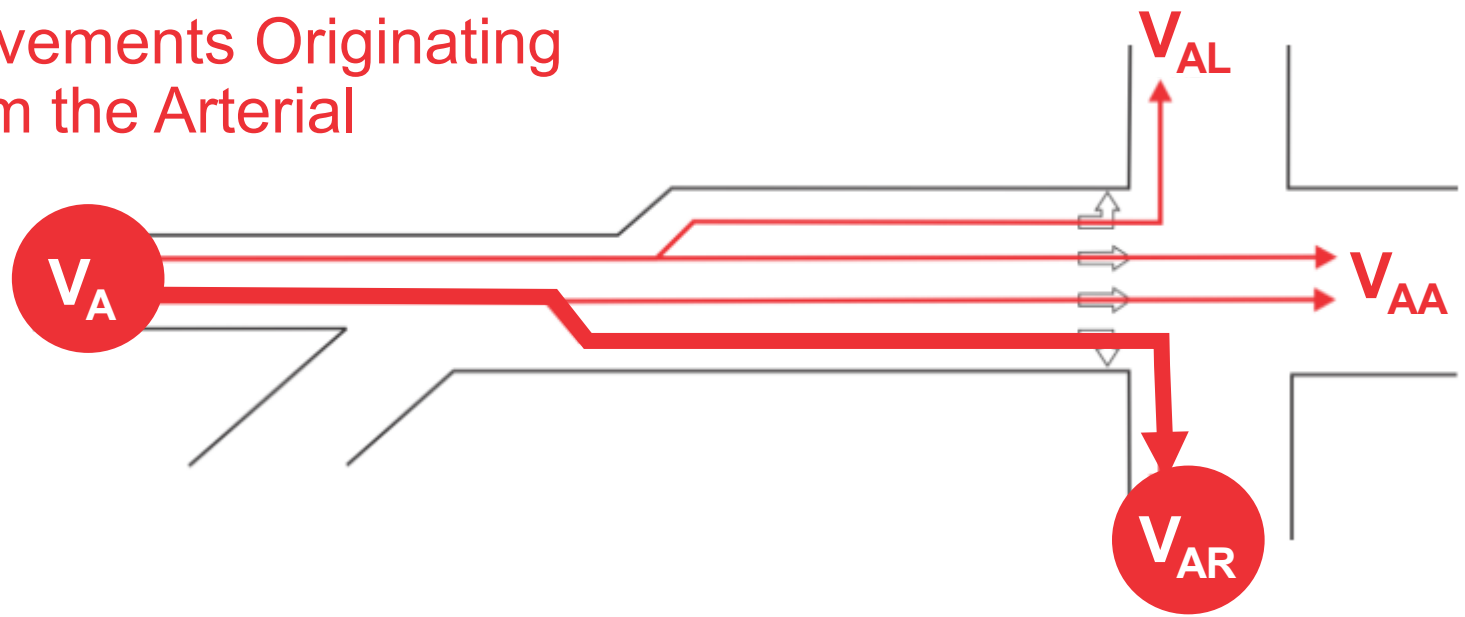
$$PCO_{VRL} = V_{RL} * V_A$$

Potential Conflict Occurrences (PCO)

Movements Originating from the Upstream Free Right Turn



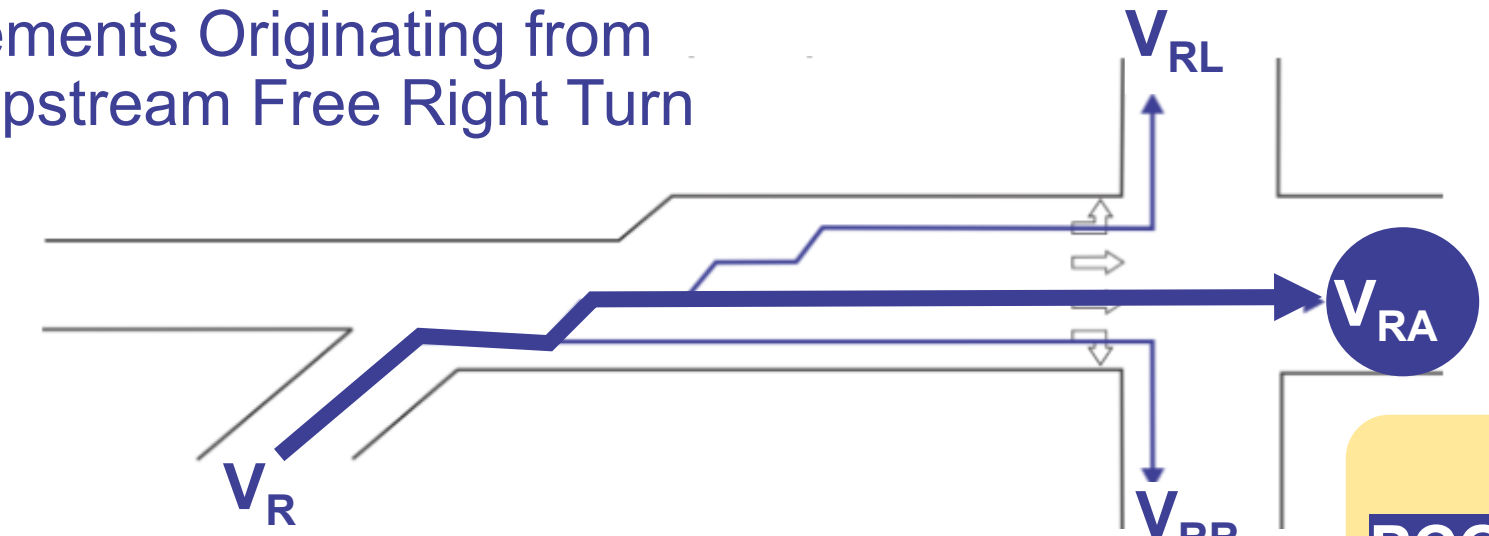
Movements Originating from the Arterial



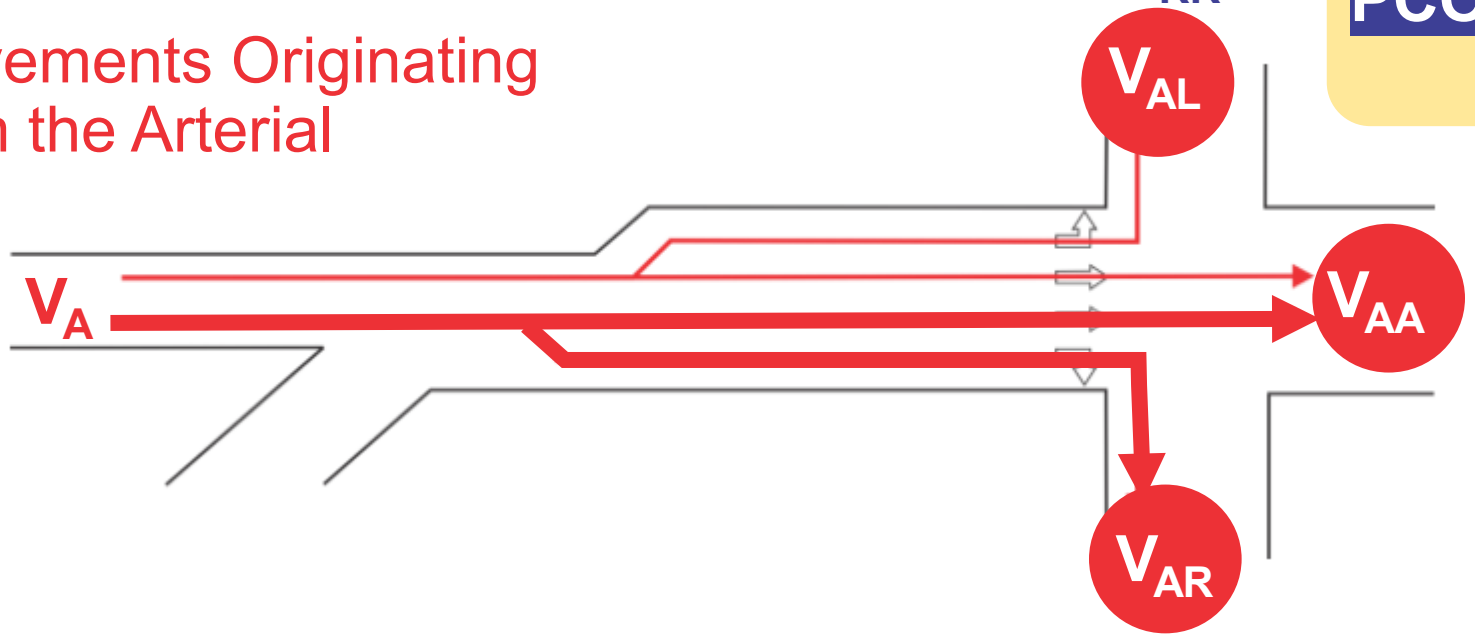
$$PCO_{VRR} = V_{AR} * V_{RR}$$

Potential Conflict Occurrences (PCO)

Movements Originating from the Upstream Free Right Turn



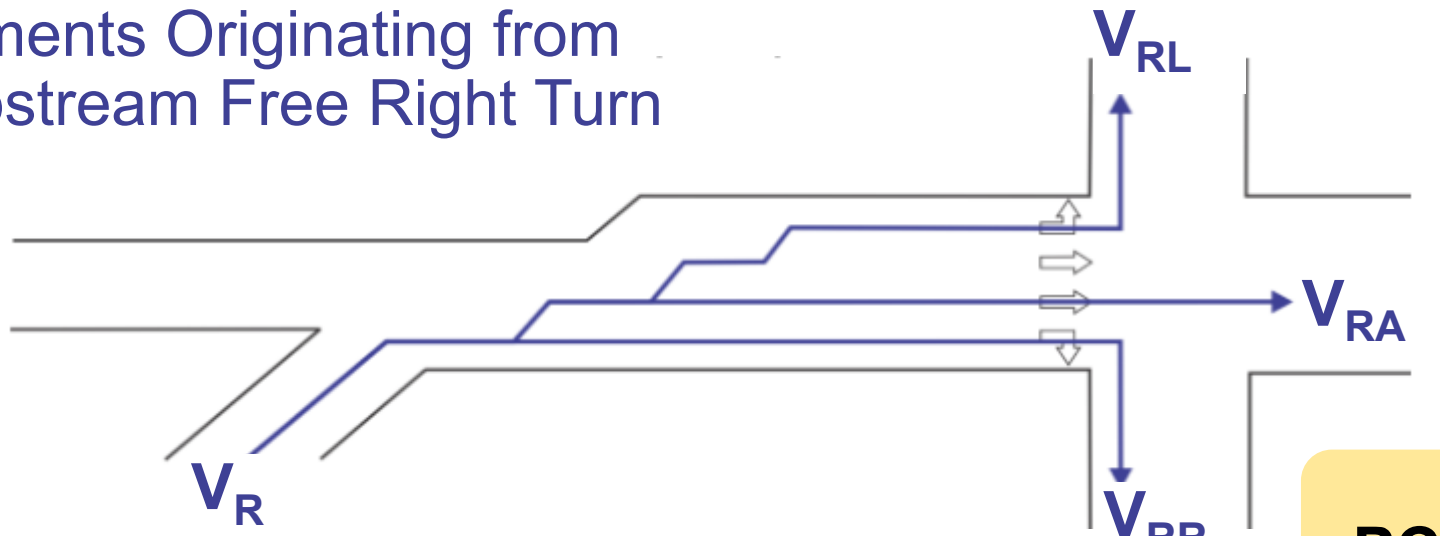
Movements Originating from the Arterial



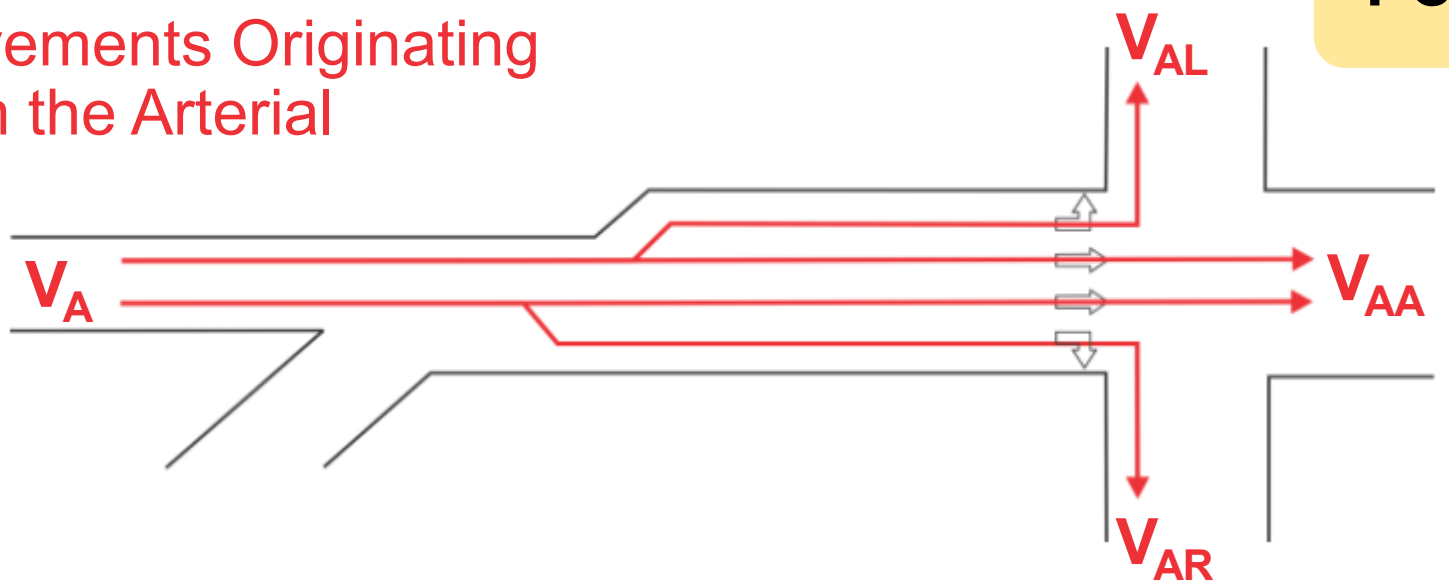
$$PCO_{VRA} = V_{RA} * \left(\frac{V_{AA} + V_{AL}}{N_{lanes}} + V_{AR} \right)$$

Potential Conflict Occurrences (PCO)

Movements Originating from the Upstream Free Right Turn

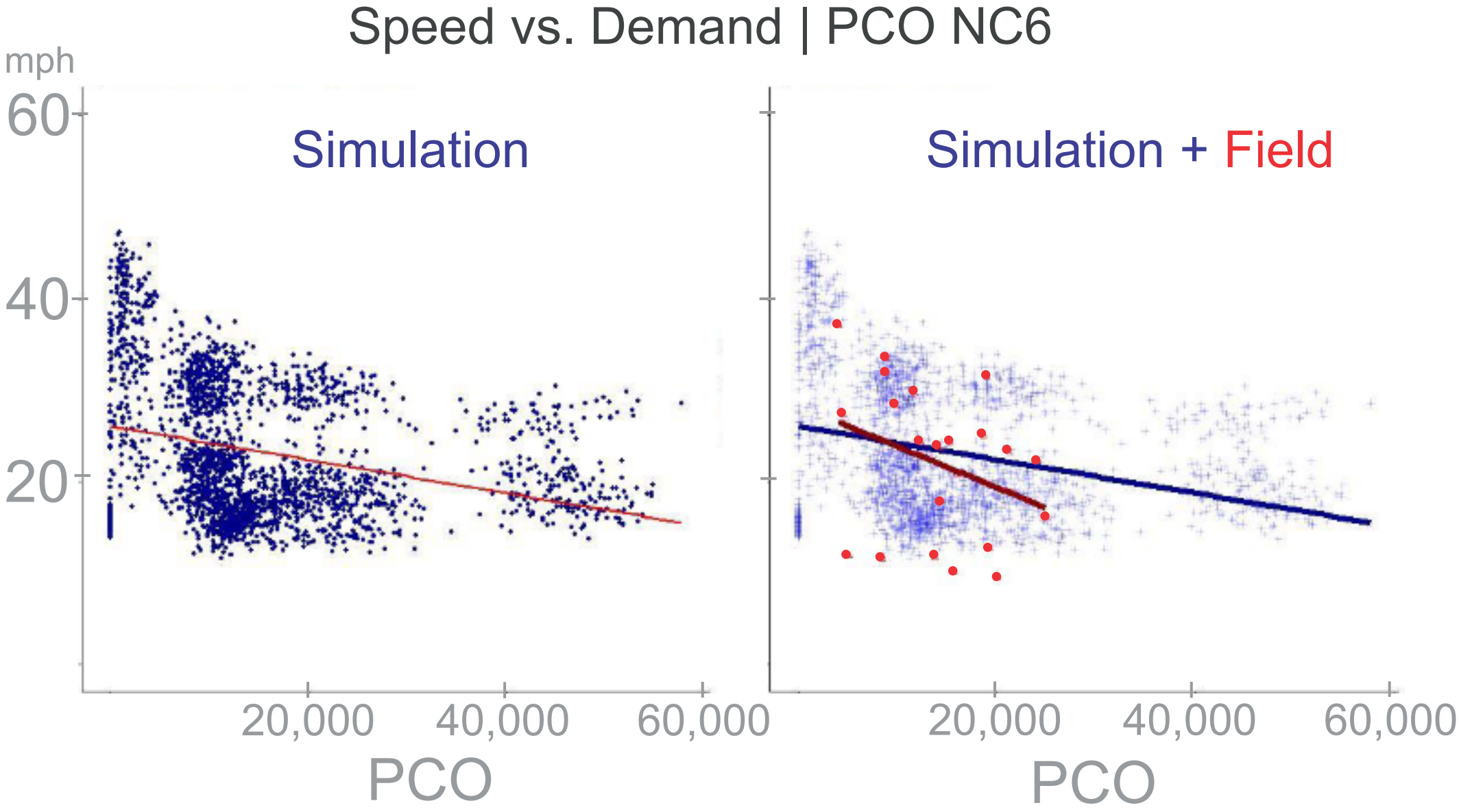


Movements Originating from the Arterial



$$\mathbf{PCO} = PCO_{RL} + PCO_{RA} + PCO_{RR}$$

Correlations with PCO



How to incorporate weave length?

Turbulence Index

Number of weaving movements in the weaving section

Potential Conflict Opportunities for weaving movement i

Turbulence Index

$$TI = \sum_{i=1}^{n} \frac{PCO_i}{SL_i}$$

Distance from gore of access point to stop bar for weaving movement i

Running Time (Modification to HCM7)

Running Time

$$t_R = \frac{6.0 - I_1}{0.025L} f_x + \frac{3600L}{5{,}280s} f_v + \sum_{i=1}^{N_{ap}} d_{ap,\,i} + d_{other}$$

intersection control term

basic segment travel time term

turning movement delay term

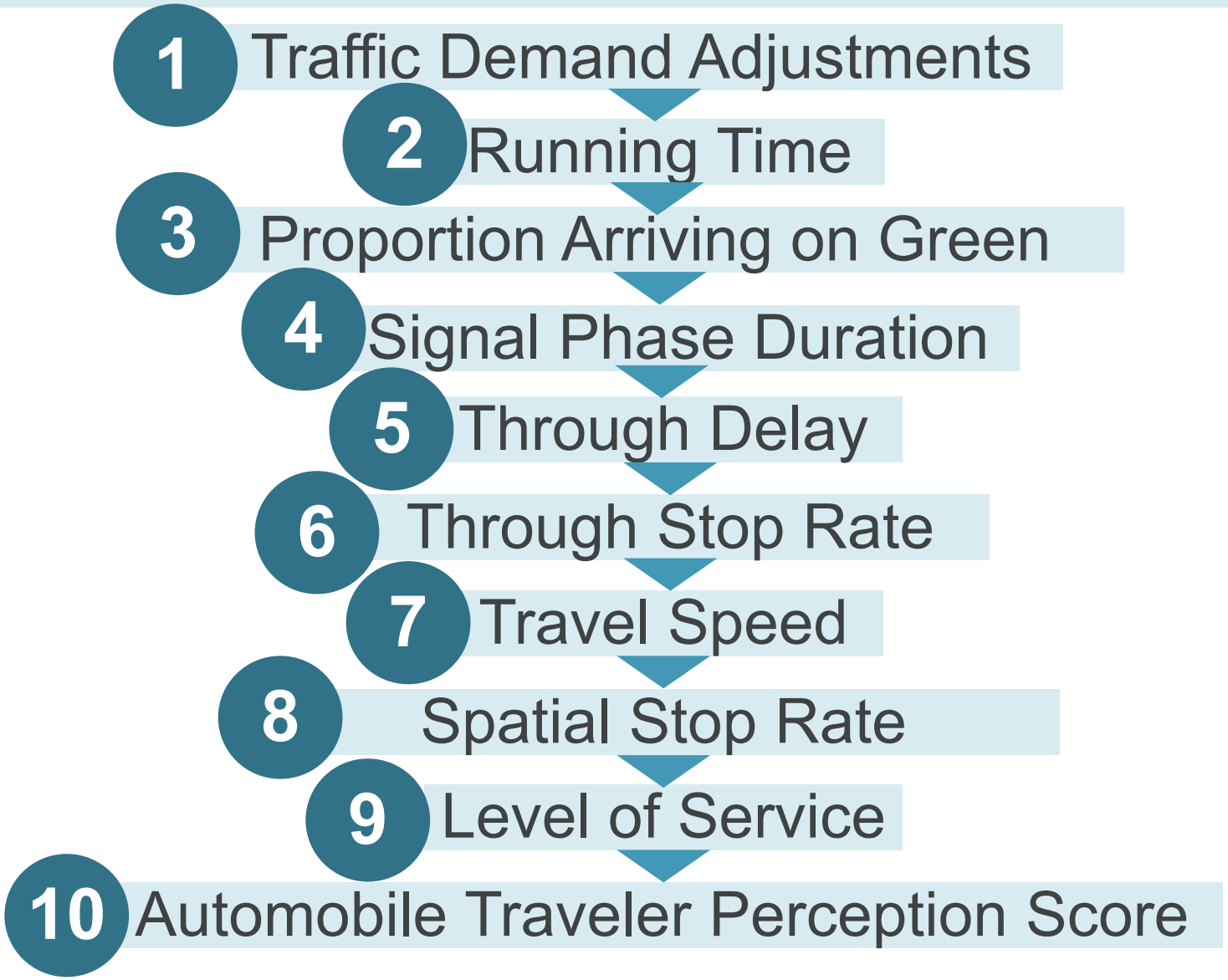
delay to to other sources aslong the segment

Running Time (Modification to HCM7)

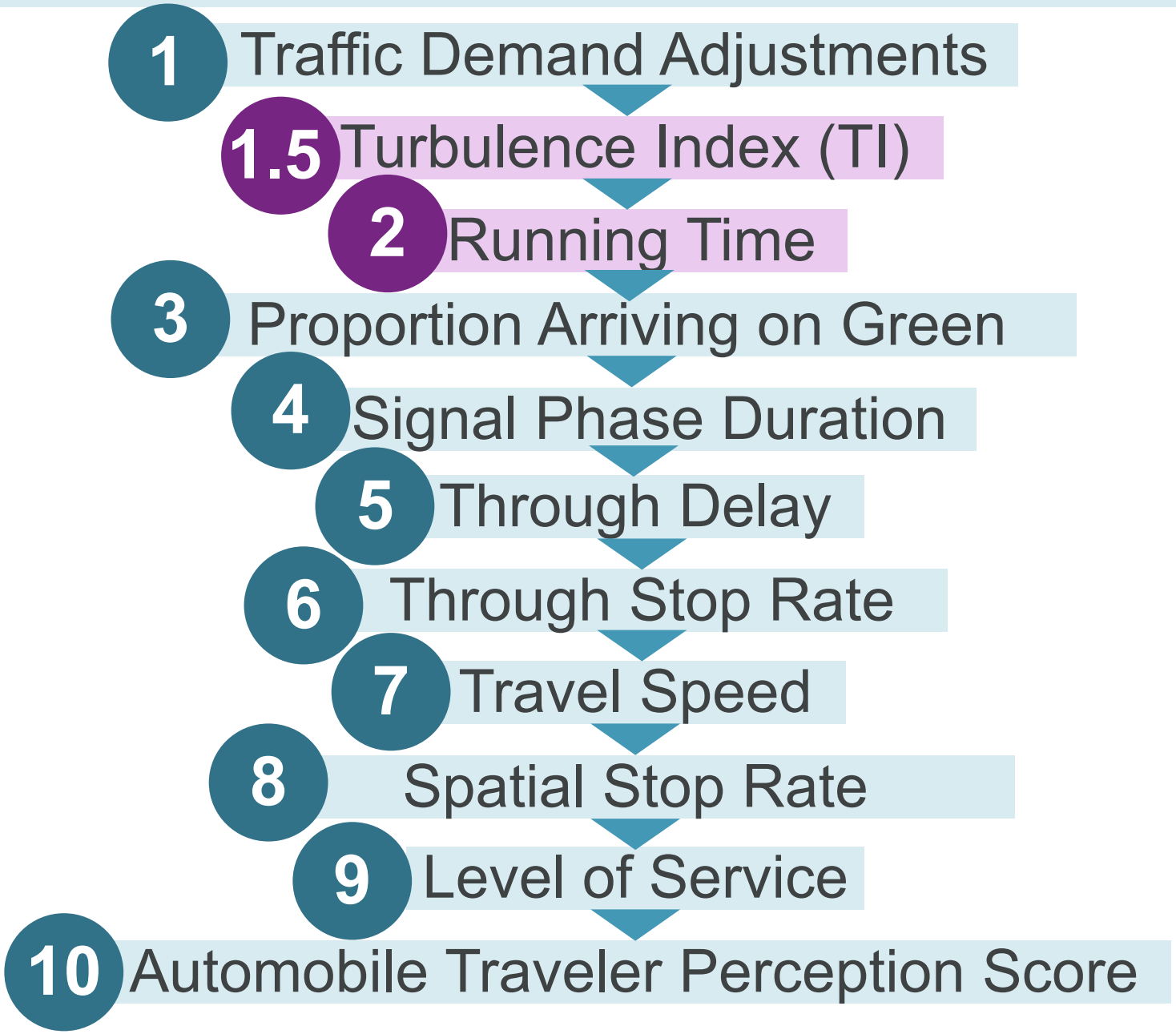
$$t_R = \frac{6.0 - I_1}{0.025L} f_x + \frac{3600L}{5{,}280s} f_v + \sum_{i=1}^{N_{ap}} d_{ap,\,i} + d_{other} + d_{wv}$$

$$0.05 \left(\frac{TI}{N_{th}}\right)^{0.06} + \left(\frac{V\text{-}150}{N}\right)^{0.86} * 0.1^{\left(\frac{g}{C}\right)}$$

Integration into HCM7 Urban Streets Method



Integration into HCM7 Urban Streets Method



LOS Criteria

No change from HCM7 Exhibit 18-1

LOS	Travel Speed Threshold by Base Free-Flow Speed (mi/h)							Volume-to-Capacity Ratio[a]
	55	50	45	40	35	30	25	
A	>44	>40	>36	>32	>28	>24	>20	≤ 1.0
B	>37	>34	>30	>27	>23	>20	>17	
C	>28	>25	>23	>20	>18	>15	>13	
D	>22	>20	>18	>16	>14	>12	>10	
E	>17	>15	>14	>12	>11	>9	>8	
F	≤17	≤15	≤14	≤12	≤11	≤9	≤8	
F	Any							> 1.0

Note: [a] Volume-to-capacity ratio of through movement at downstream boundary intersection.

Safety

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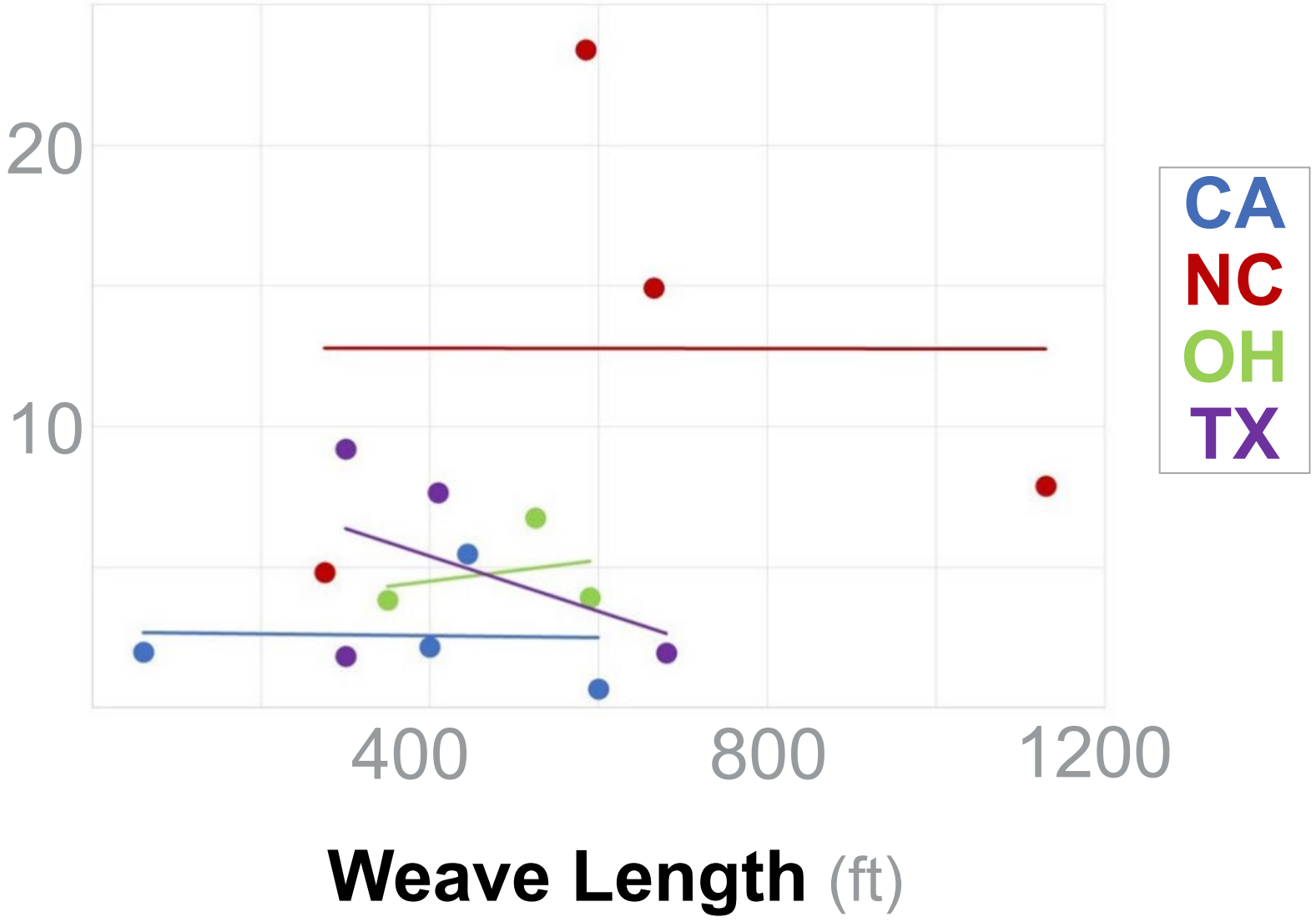
Crash Rate
(Crash/MVMT)



Safety

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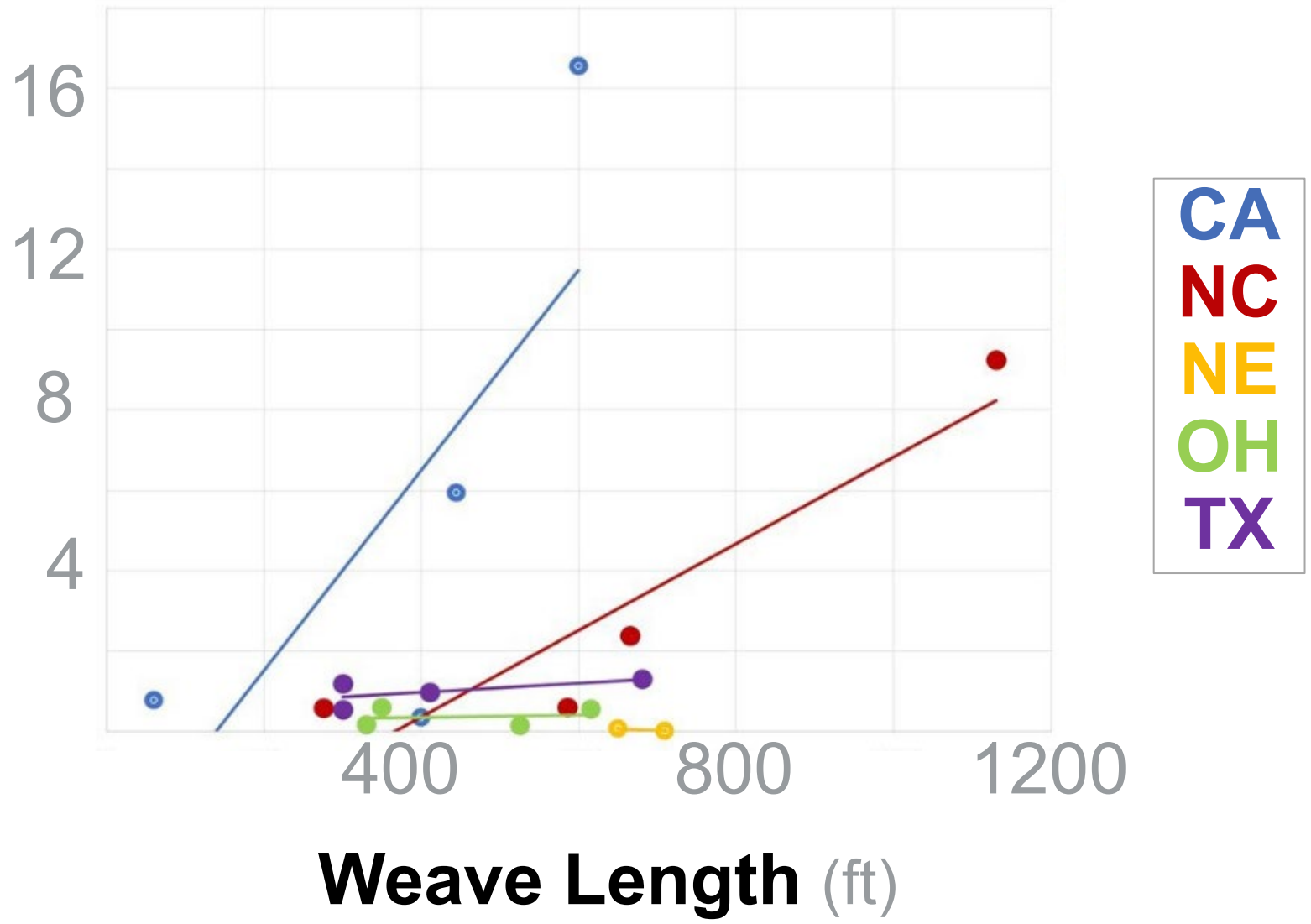
TTC Conflicts per VMT
(TTC/MVMT)



QUESTIONS