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TRB Webinar: New Facilities and Systems Methods in HCM7

July 14, 2022

1:30 – 3:00PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Beth Ewoldsen at Bewoldsen@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

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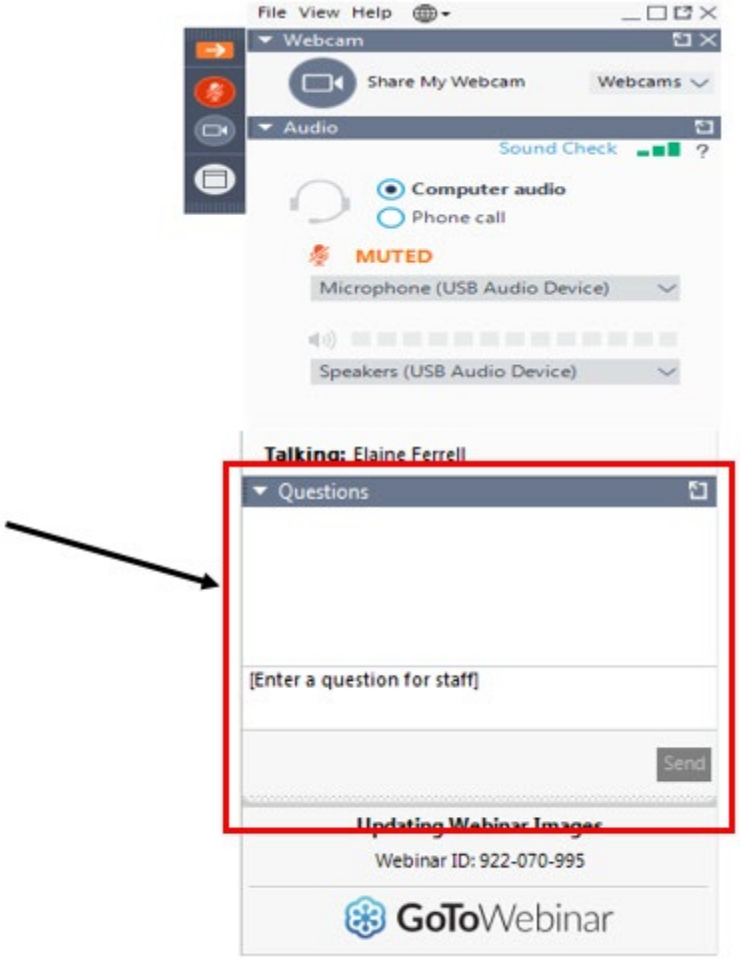
Learning Objectives

- Assess new materials and methods contained in HCM7 and understand the differences from prior versions of the manual
- Identify new facilities and systems that can be analyzed using HCM7 methods, including two-lane highways and arterial-freeway interaction

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

Scott Washburn
swash@ce.ufl.edu
University of Florida

Lily Elefteriadou
elefter@ce.ufl.edu
University of Florida

Tom Creasey
tom@caliper.com
Caliper Corporation

New Two-Lane Highway Analysis Methodology for the Highway Capacity Manual

Scott S. Washburn, Ph.D., P.E.
Civil and Coastal Engineering
University of Florida

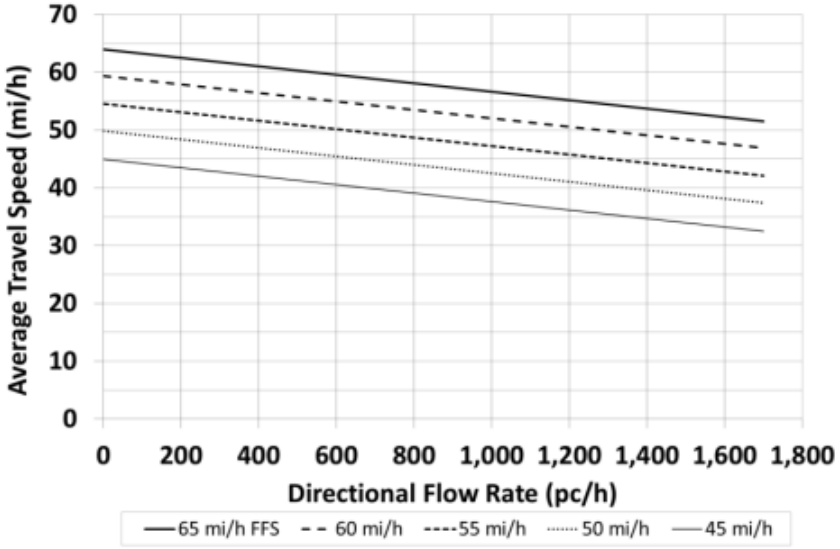
Background

- Analysis methodology and corresponding HCM material a product of NCHRP Project 17-65, “Improved Analysis of Two-Lane Highway Capacity and Operational Performance”

- Project finished March 2018
- Final report published June 2018
- https://www.nap.edu/catalog/25179/improved-analysis-of-two-lane-highway-capacity-and-operational-performance

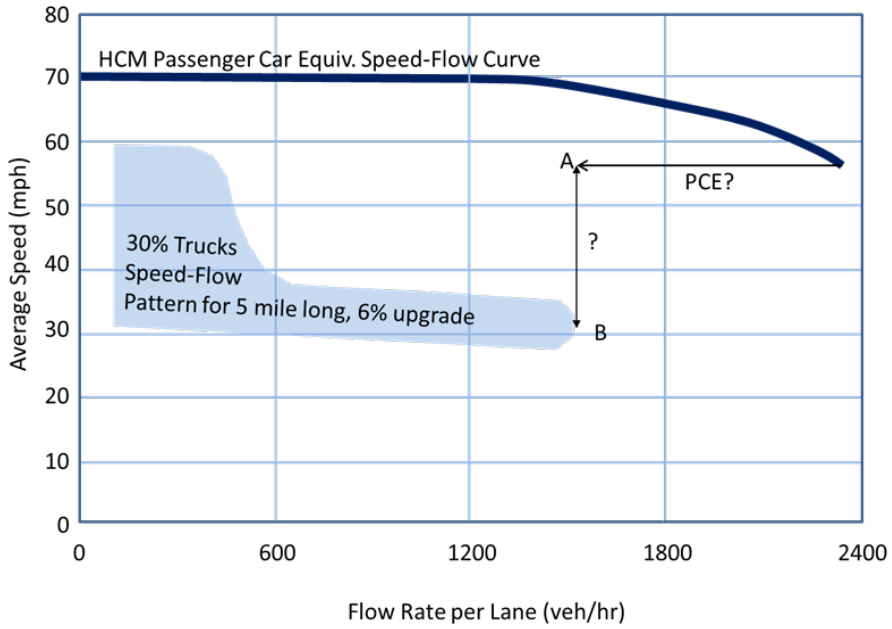
Motivation for New Analysis Method (Existing HCM Methodology Limitations/Issues)

- Speed-flow curve
  - Linear
  - Slope is not affected by FFS
- BFFS
  - Very limited guidance
- PTSF Service Measure
  - Very difficult to measure in field
  - Can be misleading in some cases (e.g., low volume, high truck %)
  - 3-s following headway surrogate criterion questionable
- ATS Service Measure
  - Does not necessarily correlate well with operational efficiency (e.g., low volume/high truck %, changing roadway conditions)



Motivation for New Analysis Method (Existing HCM Methodology Limitations/Issues)

- Truck impacts
  - PCEs differ by service measure (Speed, PTSF)
  - Not a function of % trucks
  - Originally iterative approach due to units
  - Do not properly account for moderate to steep grades
- Passing lane overestimates impact on service measures
- %No-Passing Zones input not sensitive to lengths of passing zones for a given %
- Capacity value based on very limited field data
- Not facility-oriented



Motivation for New Analysis Method (Existing HCM Methodology Limitations/Issues)

- Methodology ease of use
  - Multiple classifications and multiple service measures
  - PCE values that vary by service measure
  - Many adjustment factors in tabular format, often requiring interpolation (some 2-way and 3-way)

LOS	Class I Highways		Class II Highways	Class III Highways
	ATS (mi/h)	PTSF (%)	PTSF (%)	PFFS (%)
A	>55	≤35	≤40	>91.7
B	>50–55	>35–50	>40–55	>83.3–91.7
C	>45–50	>50–65	>55–70	>75.0–83.3
D	>40–45	>65–80	>70–85	>66.7–75.0
E	≤40	>80	>85	≤66.7
F	Demand exceeds capacity			

Note: For Class I highways, LOS is determined by the worse of ATS-based LOS and PTSF-based LOS.

New Analysis Methodology Overview

Segmentation

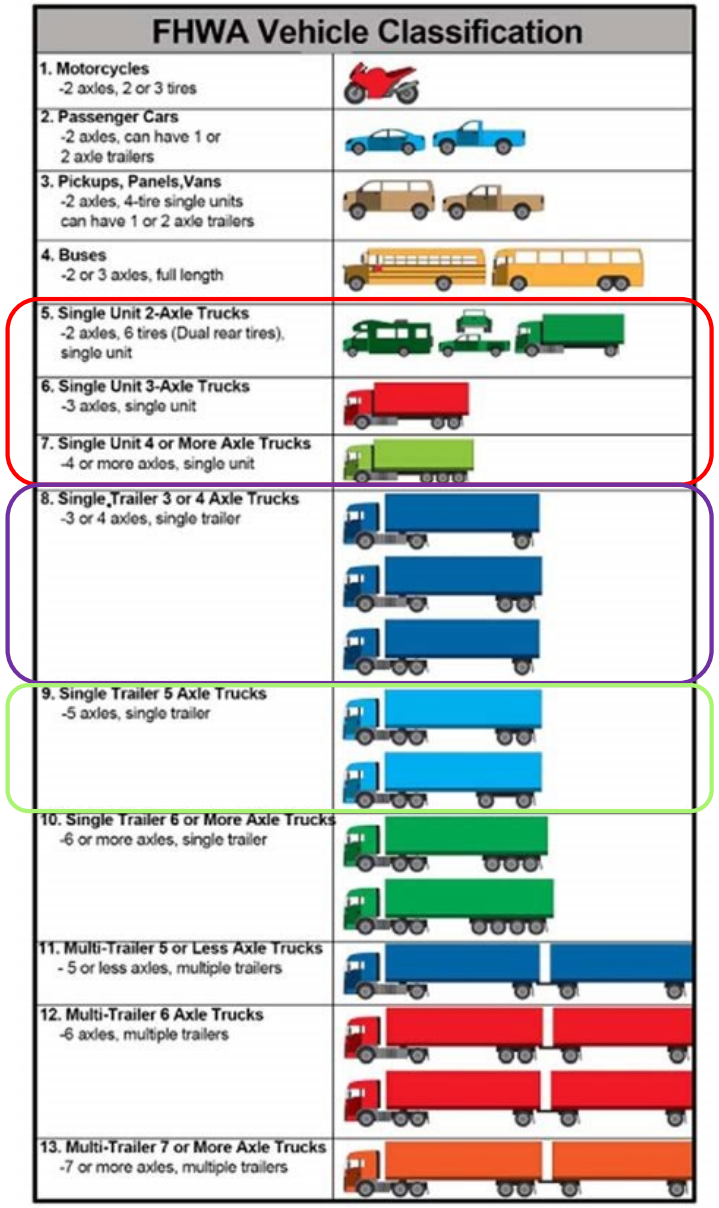
- Based on changes in terrain or passing opportunities and presence of intersections.
- Types
  - Passing constrained
    - Extended length of two-lane highway in which passing in the oncoming lane is either prohibited or effectively negligible due to lack of passing opportunities.
  - Passing zone
    - Section of two-lane highway for which passing in the oncoming lane is permitted, and the length and location of such passing zone provides for reasonable accommodation of passing maneuvers under certain traffic conditions.
  - Passing lane
    - This segment type consists of an added lane in the same direction as the analysis direction, with the intent to break up platoons that have formed upstream by allowing faster vehicles to pass slower vehicles.

Segmentation

- Eliminates use of ‘percent no-passing zones’.
- Explicitly accounts for length of passing zones.
- Supports facility-level analysis (i.e., multiple contiguous segments).

Treatment of Trucks

- Explicitly account for heavy vehicles in MOE-flow curves, rather than converting to passenger cars.
- Based on 50/25/25 split for FHWA Classes 5,6,7/8/9



Source: Texas Department of Transportation
http://onlinemanuals.txdot.gov/txdotmanuals/tri/vehicle_classification_using_fhwa_13category_scheme.htm

Treatment of Terrain

- 5 vertical classes

Classifications for Vertical Alignment (Downgrades in Parentheses)

Segment Length (mi)	Segment Slope (%)									
	≤1	>1 ≤2	>2 ≤3	>3 ≤4	>4 ≤5	>5 ≤6	>6 ≤7	>7 ≤8	>8 ≤9	>9
≤0.1	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	2 (1)	2 (2)	2 (2)
>0.1 ≤0.2	1 (1)	1 (1)	1 (1)	1 (1)	2 (1)	2 (2)	2 (2)	3 (2)	3 (3)	3 (3)
>0.2 ≤0.3	1 (1)	1 (1)	1 (1)	2 (1)	2 (2)	3 (2)	3 (3)	4 (3)	4 (4)	5 (5)
>0.3 ≤0.4	1 (1)	1 (1)	2 (1)	2 (2)	3 (2)	3 (3)	4 (4)	5 (4)	5 (5)	5 (5)
>0.4 ≤0.5	1 (1)	1 (1)	2 (1)	2 (2)	3 (3)	4 (3)	5 (4)	5 (5)	5 (5)	5 (5)
>0.5 ≤0.6	1 (1)	1 (1)	2 (1)	3 (2)	3 (3)	4 (4)	5 (5)	5 (5)	5 (5)	5 (5)
>0.6 ≤0.7	1 (1)	1 (1)	2 (1)	3 (2)	4 (3)	4 (4)	5 (5)	5 (5)	5 (5)	5 (5)
>0.7 ≤0.8	1 (1)	1 (1)	2 (1)	3 (3)	4 (4)	5 (4)	5 (5)	5 (5)	5 (5)	5 (5)
>0.8 ≤0.9	1 (1)	1 (1)	2 (1)	3 (3)	4 (4)	5 (5)	5 (5)	5 (5)	5 (5)	5 (5)
>0.9 ≤1.0	1 (1)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	5 (5)	5 (5)	5 (5)	5 (5)
>1.0 ≤1.0	1 (1)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	5 (5)	5 (5)	5 (5)	5 (5)
>1.1	1 (1)	1 (1)	2 (2)	4 (4)	4 (4)	5 (5)	5 (5)	5 (5)	5 (5)	5 (5)

Treatment of Terrain

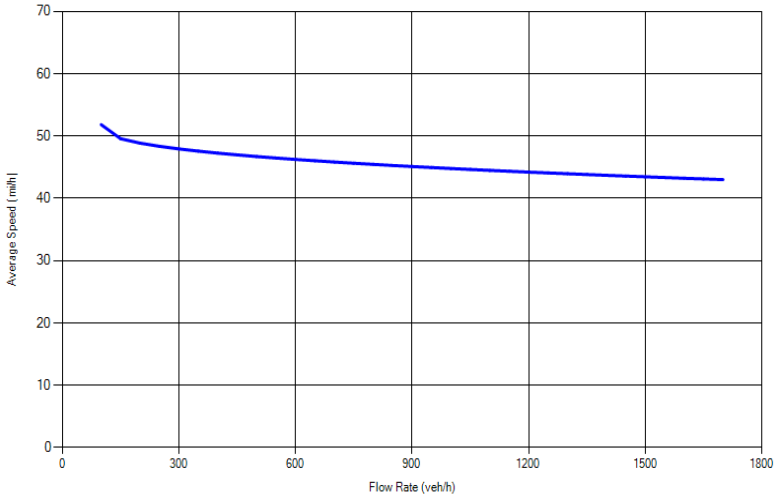
- 5 horizontal classes

Classifications for Horizontal Alignment

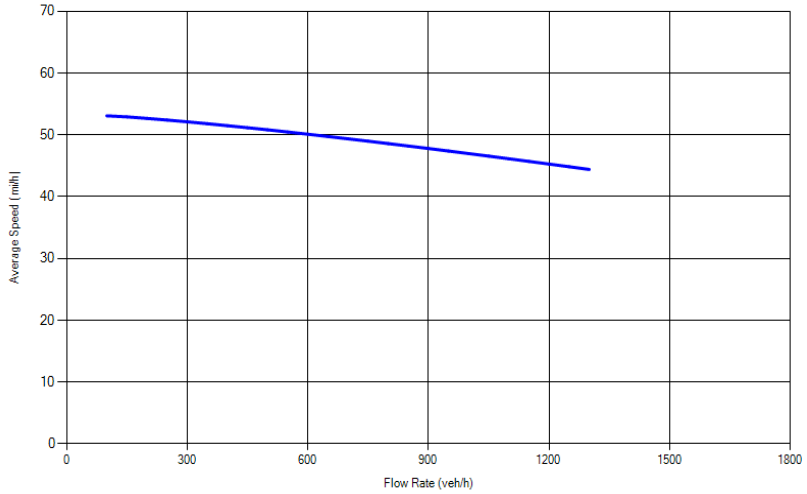
Radius (ft)	Superelevation (%)										
	<1	≥1 <2	≥2 <3	≥3 <4	≥4 <5	≥5 <6	≥6 <7	≥7 <8	≥8 <9	≥9 <10	≥10
<300	5	5	5	5	5	5	5	5	5	5	5
≥300 <450	4	4	4	4	4	4	4	4	4	4	4
≥450 <600	4	3	3	3	3	3	3	3	3	3	3
≥600 <750	3	3	3	3	3	3	2	2	2	2	2
≥750 <900	2	2	2	2	2	2	2	2	2	2	2
≥900 <1050	2	2	2	2	2	2	2	2	1	1	1
≥1050 <1200	2	2	2	2	1	1	1	1	1	1	1
≥1200 <1350	2	2	1	1	1	1	1	1	1	1	1
≥1350 <1500	1	1	1	1	1	1	1	1	1	1	--
≥1500 <1650	1	1	1	1	1	1	1	1	--	--	--
≥1650 <1800	1	1	1	1	1	1	--	--	--	--	--
≥1800 <1950	1	1	1	1	1	--	--	--	--	--	--
≥1950 <2100	1	1	1	1	--	--	--	--	--	--	--
≥2100 <2250	1	1	1	--	--	--	--	--	--	--	--
≥2250 <2400	1	1	--	--	--	--	--	--	--	--	--
≥2400 <2550	1	--	--	--	--	--	--	--	--	--	--
≥2550	--	--	--	--	--	--	--	--	--	--	--

Applicable Performance Measures

Speed



Passing Constrained Segment



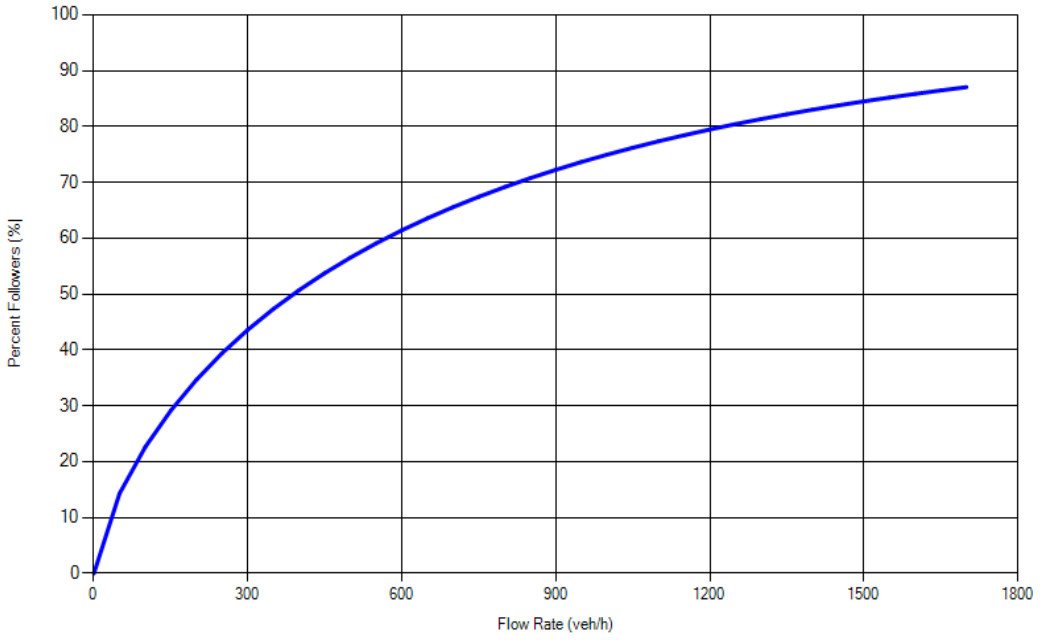
Passing Lane Segment

$$S = \begin{cases} FFS & |v_d \leq 100 \\ FFS - m\left(\frac{v_d}{1000} - 0.1\right)^p & |v_d > 100 \end{cases}$$

Slope (m) and power (p) coefficients are a function of vertical class, FFS, flow rate, HV%, segment type and length

Applicable Performance Measures

% Followers



$$PF = 100 \times \left[1 - e^{\left(m \times \left[\frac{v_d}{1000}\right]^p\right)}\right]$$

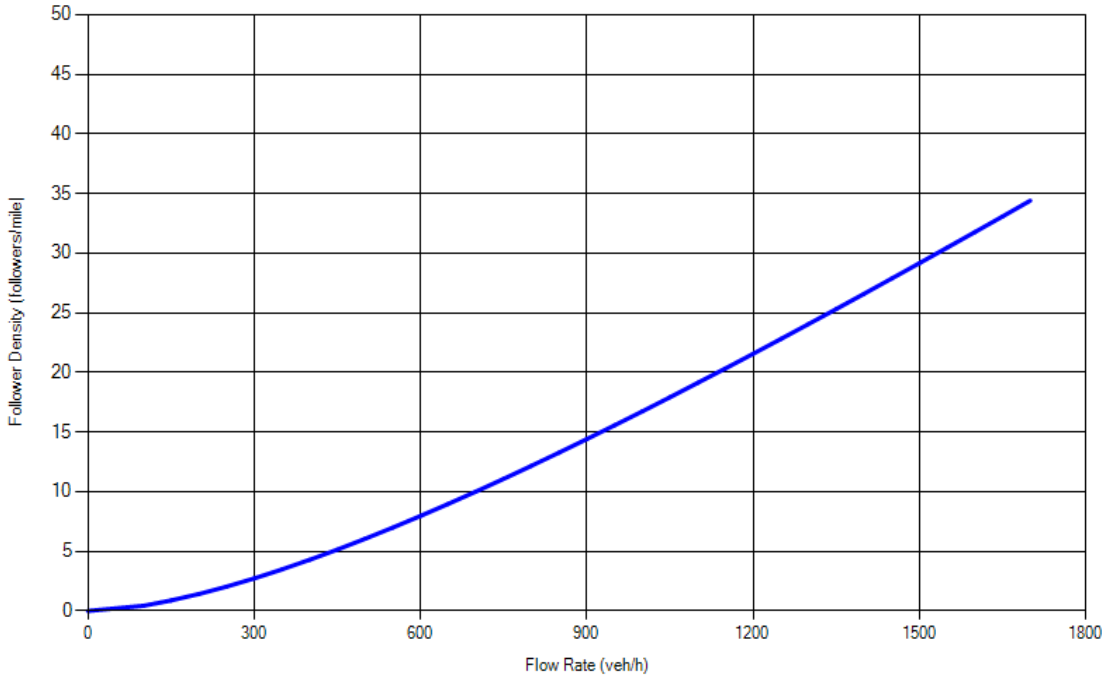
Slope (m) and power (p) coefficients are a function of vertical class, FFS, flow rate, HV%, segment type and length

Follower status

- 2.5-second headway
- favored simplicity, this value gets us close to results from more complicated methods

Applicable Performance Measures

Follower Density



$$FD = \frac{PF}{100} \times \frac{v}{S}$$

where:

FD = follower density in the analysis direction (followers/mi/ln),

PF = percent followers in the analysis direction,

v = flow rate in the analysis direction (veh/h/ln), and

S = average speed in the analysis direction (mi/h).

- Performance measure values are estimated for the end of the segment.
- Also estimated at mid-point of passing lane segment.

Level of Service

- Follower Density used as service measure
- Different thresholds for higher speed versus lower speed highways

LOS	Follower Density (followers/mi/ln)	
	Higher-Speed Highways Posted Speed Limit ≥ 50 mi/h	Lower-Speed Highways Posted Speed Limit < 50 mi/h
A	≤ 2.0	≤ 2.5
B	> 2.0 – 4.0	> 2.5 – 5.0
C	> 4.0 – 8.0	> 5.0 – 10.0
D	> 8.0 – 12.0	> 10.0 – 15.0
E	> 12.0	> 15.0
F	Demand exceeds capacity	

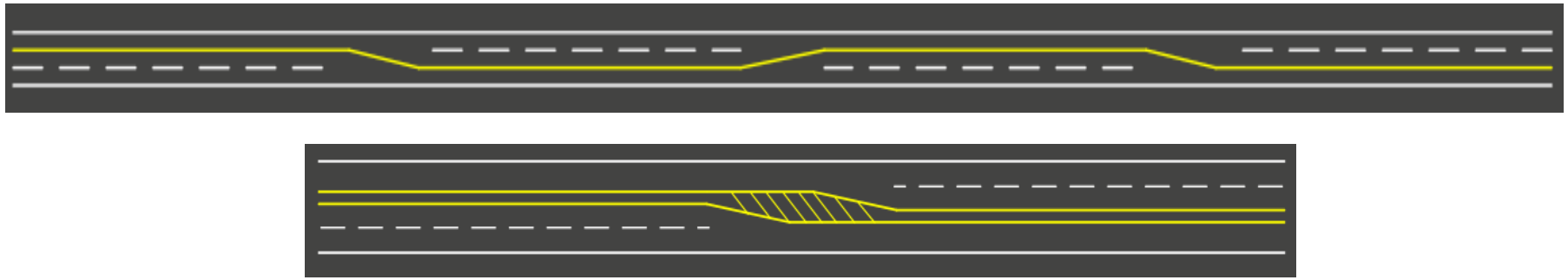
Other

- Capacity values
  - Non-passing lane segments
    - No change (1700 veh/h)
  - Passing lane segment, merge point
    - Lower values due to merging friction
    - Function of %HV and vertical classification
- Initial material for addressing 2+1 configuration
- Accommodate facility scope
  - Facility LOS based on length-weighted aggregation of segment follower density values
- Consistency with modern simulation tool(s)

Ease of Use Issues

- None of the lookup tables require interpolation
- Treating trucks explicitly, rather than through PCE values
- No separate grade adjustment factor, which also varied by service measure
- Single service measure; No separate analysis flow rate calculations for different service measures
- No ‘%No-Passing Zones’ input
- Elimination of the PTSF measure, which was difficult, if not impossible, to measure in the field

‘2+1’ Configuration



Germany

Sweden

Denmark

‘2+1’ Configuration

- Equations for estimating the change in performance between a 2+1 configuration and a comparable two-lane highway with no passing lanes, approximately 50% passing zones, and 15-20 miles in length.

$$\%Improve_{\%\text{Followers},2+1} = 147.5 - 15.8 \times ln(FlowRate) + 0.05 \times FFS + 0.11 \times \%HV - 3.1 \times \ln(0.3, PassLaneLength)$$

$$\%Improve_{AvgSpeed,2+1} = \max(0, 21.8 - 1.86 \times \ln(FlowRate) - 0.1 \times \max[0,\min(FFS, 70) - 30] - 0.05 \times \max[0,30 - \%HV] + 1.1 \times \ln[\max(0.3, PassLaneLength)])$$

$$FollowerDensity_{adj,2+1} = \frac{\%Followers}{100} \times \left(1 - \frac{\%Improve_{\%\text{Followers},2+1}}{100}\right) \times \frac{FlowRate}{S \times \left(1 + \frac{\%Improve_{AvgSpeed,2+1}}{100}\right)}$$

The End

Inquiries about the methodology can be directed to:
The Highway Capacity and Quality of Service Committee (ACP40) and/or
Scott Washburn at swash@ce.ufl.edu.

Analyzing Corridors and Systems with the Highway Capacity Manual

Presenter:

Lily Elefteriadou, Ph.D.

Professor of Civil Eng.

Director, UFTI

University of Florida

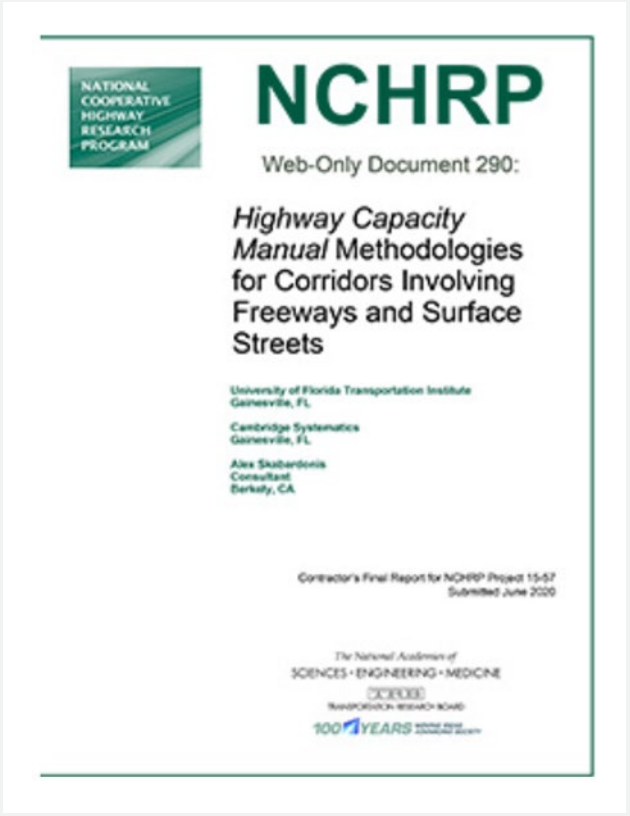
July 14, 2022

Background:

Based on NCHRP 15-57
"*Highway Capacity Manual Methodologies for Corridors Involving Freeways and Surface Streets*"

NCHRP Web-Only Document 290, July 2020
http://www.trb.org/main/blurbs/181364.aspx

HCM: New Chapter 38 – Network Analysis



Traditionally, the HCM has:

- Analyzed freeways and arterials separately
- Ignored spillback effects from one facility type to another
- Used different performance measures for different facility types

Now, the new network analysis methods can:

- Evaluate spillback
- Estimate travel time across facilities
- Conduct lane-by-lane analysis for freeways

Performance measurement for network analysis

Current HCM performance measurement framework

Freeway Segments
Density (pc/mi)

Signalized Intersections	Unsignalized Intersections
Control delay (s)	Control delay (s)

Urban streets facilities	Unsignalized Intersections
Speed	Experienced travel time (s)

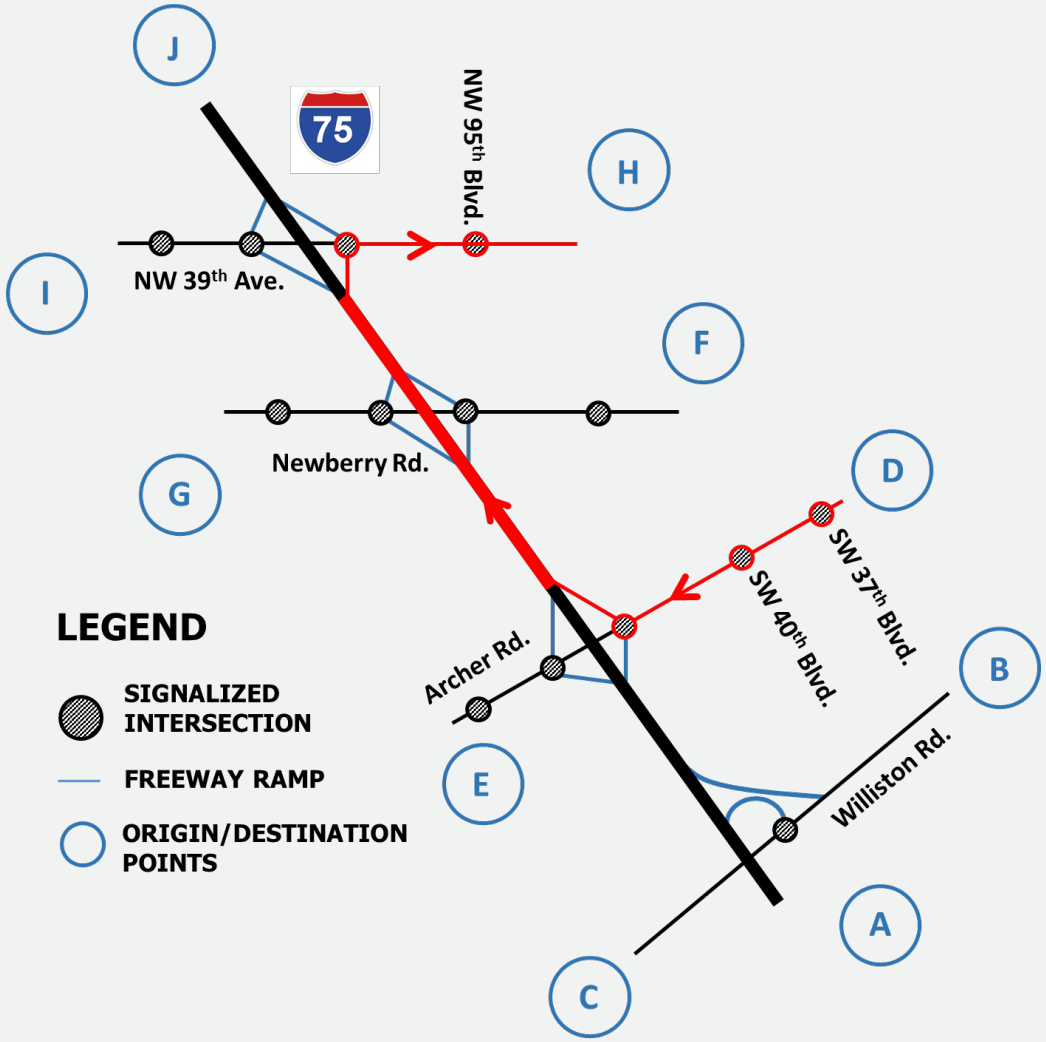
New approach:

Travel Time as a common performance measure

Origin – Destination (O-D) Analysis

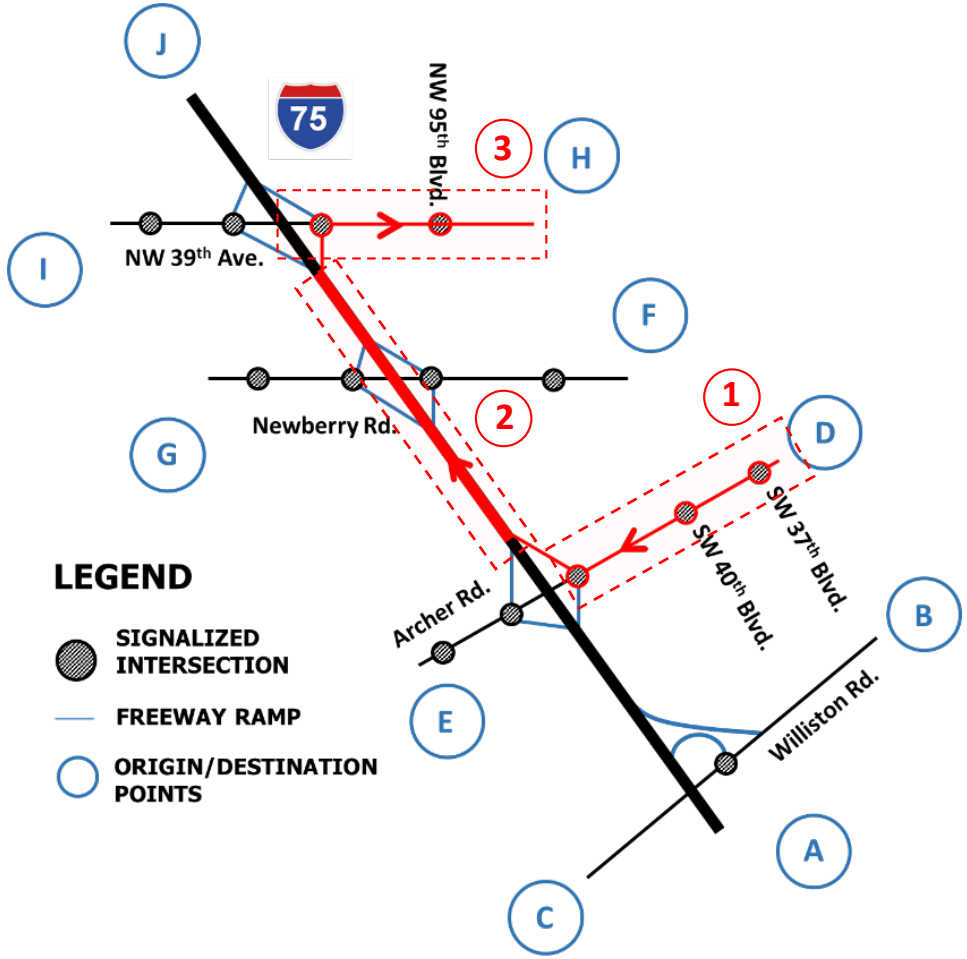
Performance estimates obtained for each origin-destination pair

Example: From Origin D to Destination H

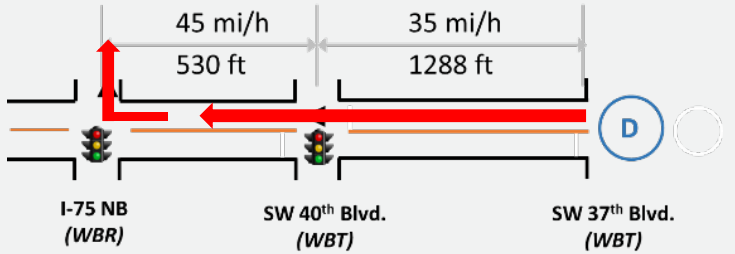


Sample network analysis (Gainesville/FL)

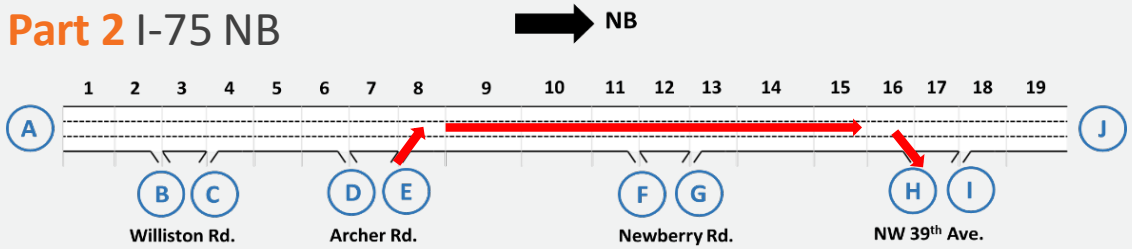
From Origin D to Destination H



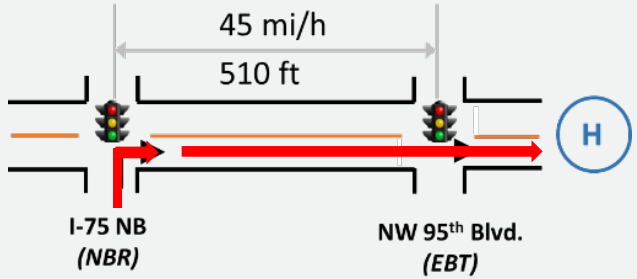
Part 1 Archer Rd WB.



Part 2 I-75 NB



Part 3 NW 39th Ave. EB.



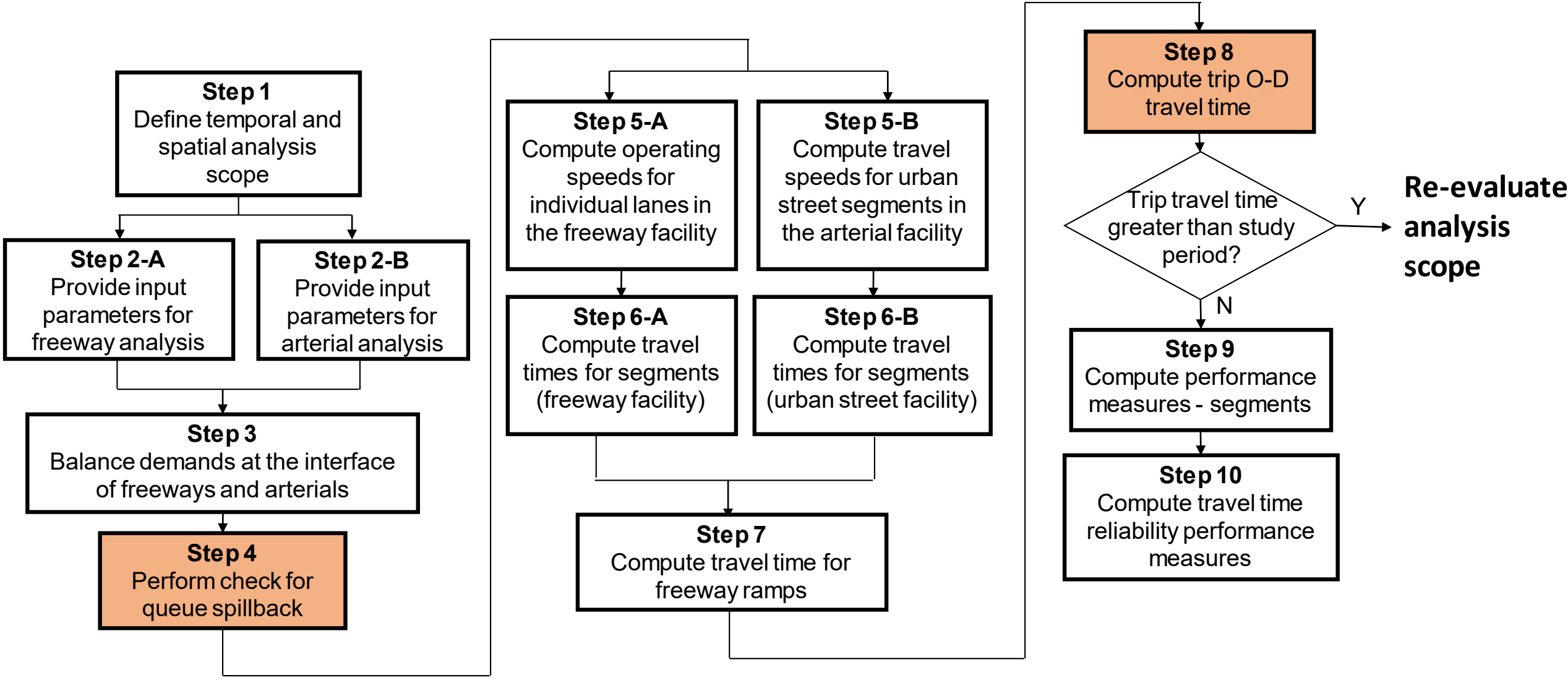
Computing the O-D Travel Time:

- Sum of travel times for all traveled segments
- If trip longer than the 15-min analysis period (900 s) → consider multi-period

Segment ID	Segment travel time (s)		Cumulative travel time (s)	Active time period	Selected travel time (s)
	Time Period 1	Time Period 2			
1	**34**	28	34	TP 1	34
2	**26**	29	60	TP1	26
3	**73**	86	133	TP1	73
4	**345**	390	478	TP1	345
5	**185**	195	663	TP1	185
6	**310**	359	973	TP1	310
7	240	**240**	1213	TP2	240
8	120	**122**	1335	TP2	122
9	20	**18**	1353	TP2	18
10	45	**53**	1406	TP2	53
	Total travel time (s):		**1406**		

Analysis Procedure

Methodology Flowchart



Analysis Concepts

Adjustments due to spillback

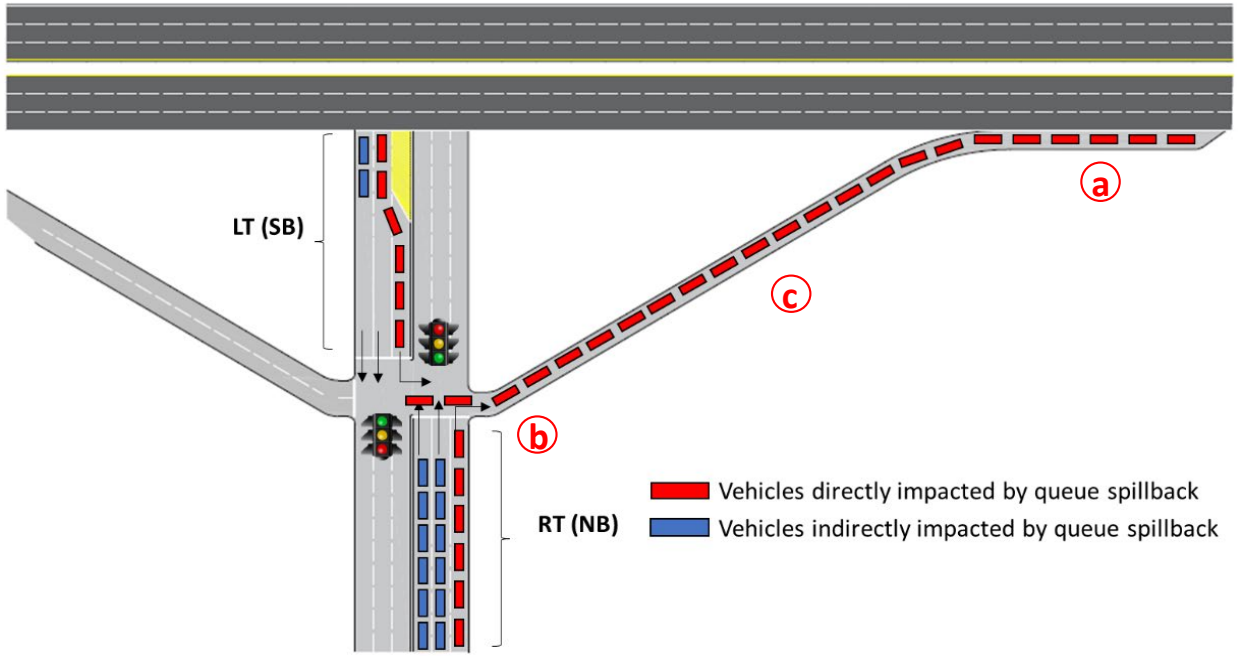
Spillback from on-ramp

Spillback from off-ramp

Spillback from on-ramp

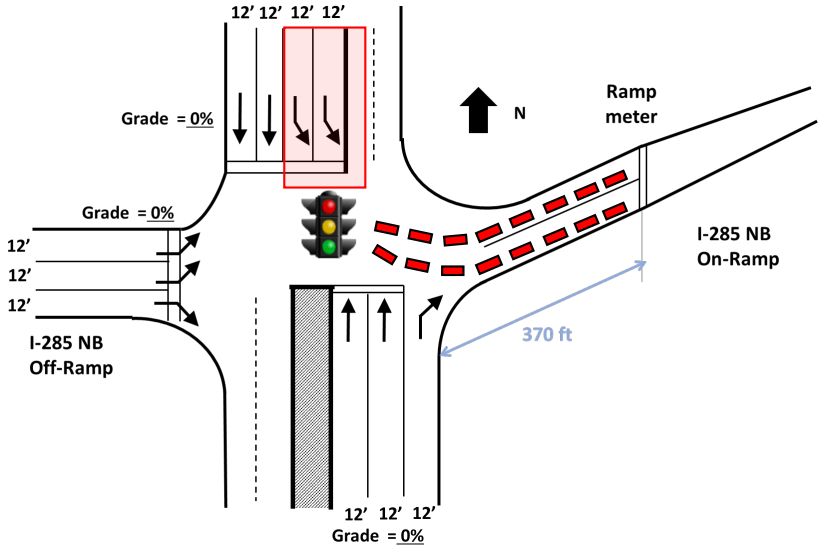
Occurs when two conditions are met:

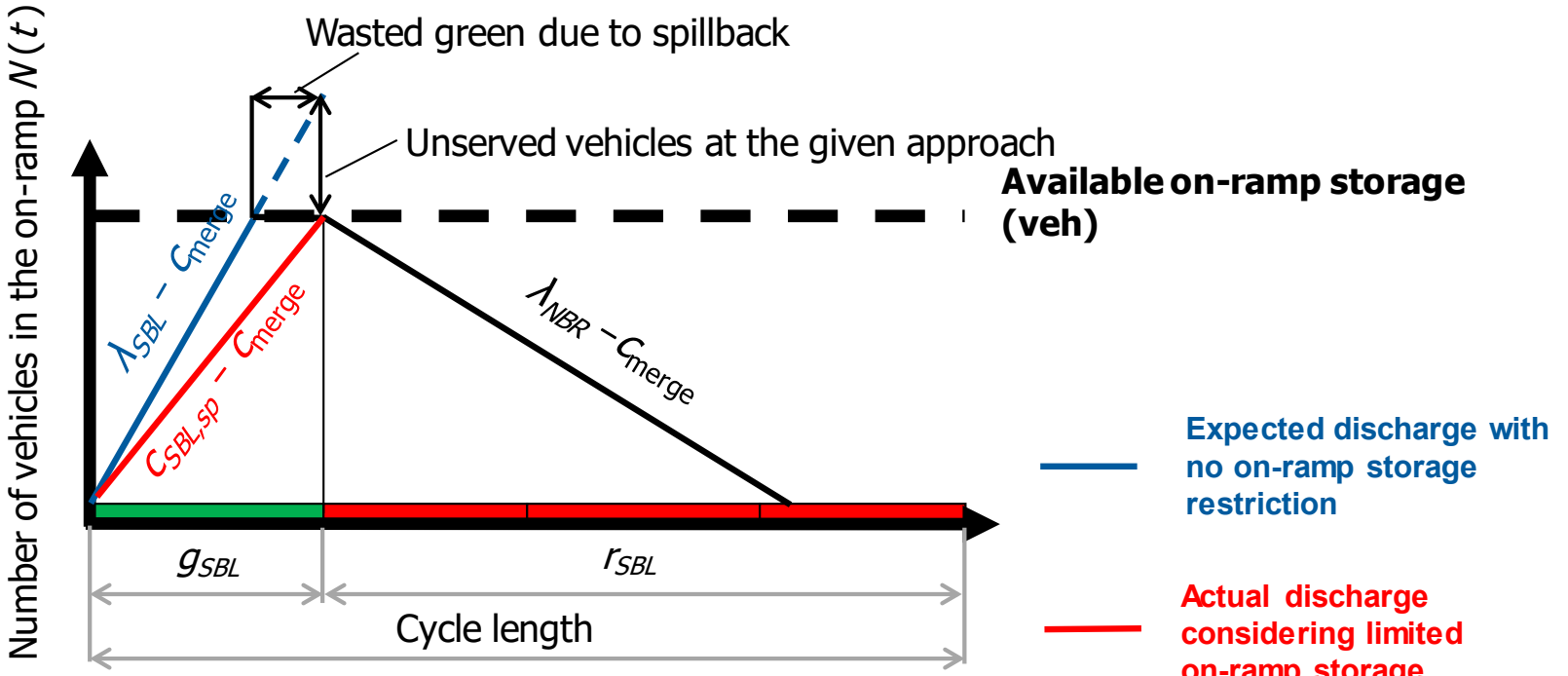
- Insufficient capacity at
  - a) freeway merge,
  - b) ramp roadway or
  - c) ramp meter; AND
- Insufficient storage length at the on-ramp;



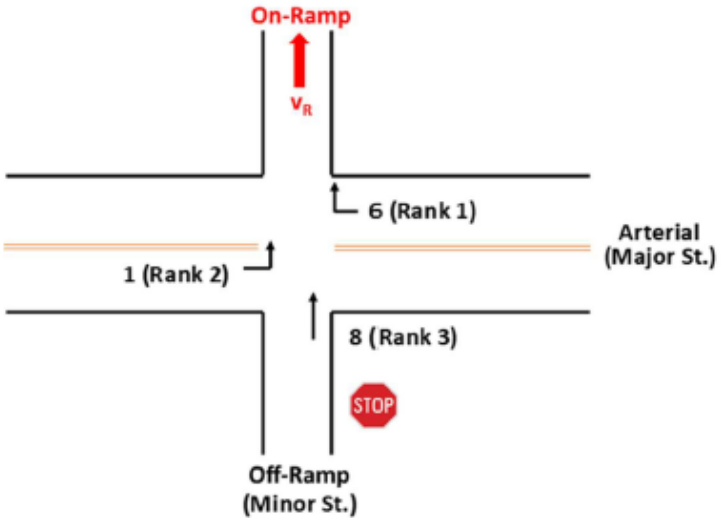
Spillback analysis - signalized intersections

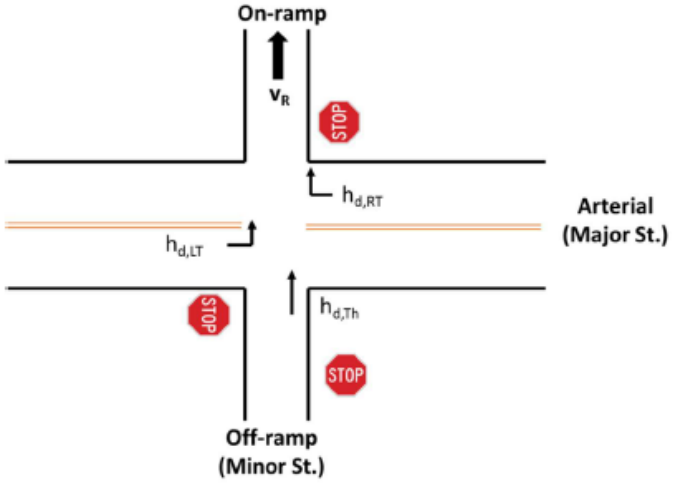
- Queues are modeled at the on-ramp for every cycle
- Number of vehicles at the on-ramp cannot exceed the maximum storage
- Reduced capacity is computed based on the maximum throughput

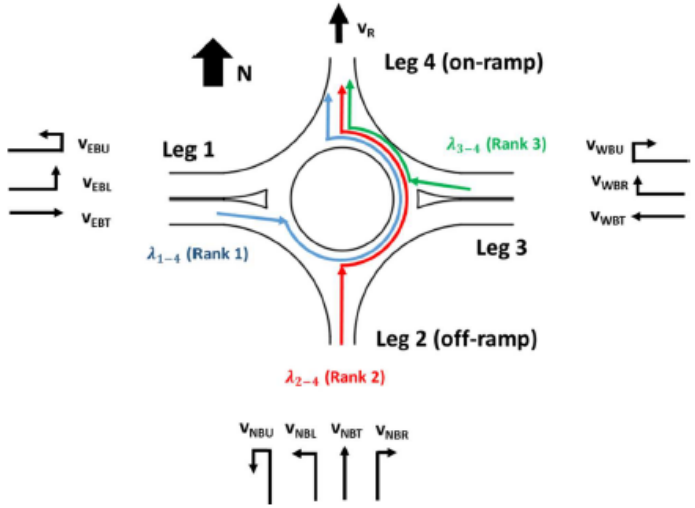




Spillback analysis considers stop-controlled intersections and roundabouts, based on existing HCM methods



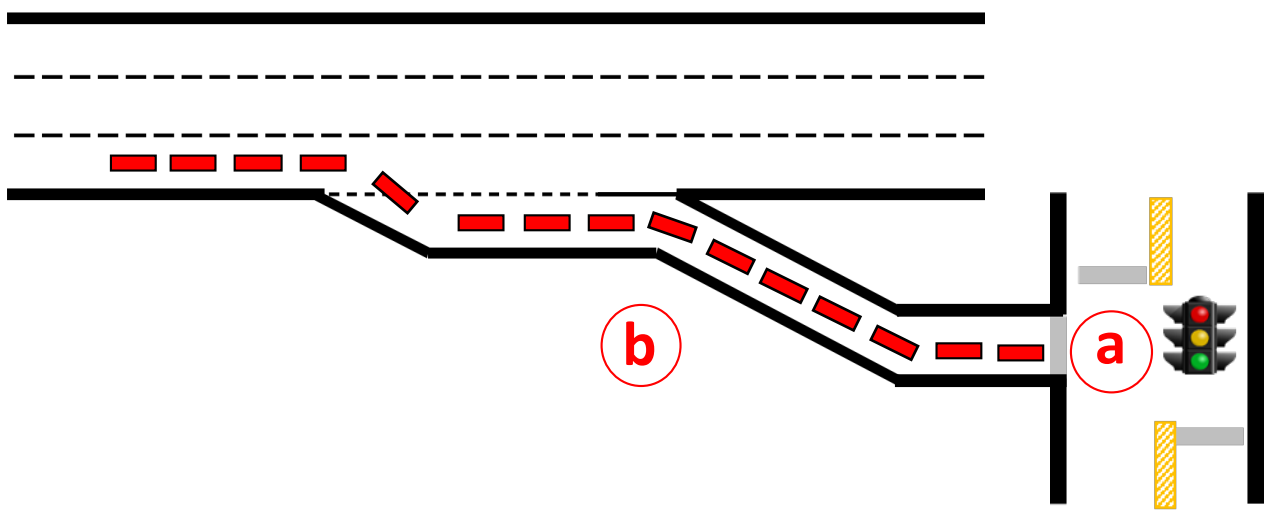




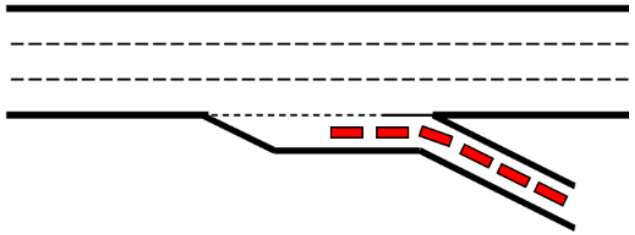
Spillback from off-ramp

Occurs when two conditions are met:

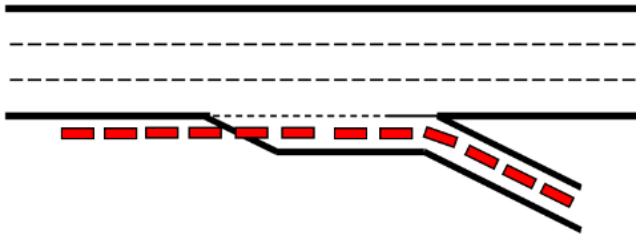
- Insufficient capacity at
  - a) downstream ramp terminal (intersection) or
  - b) ramp roadway; AND
- Insufficient storage length;



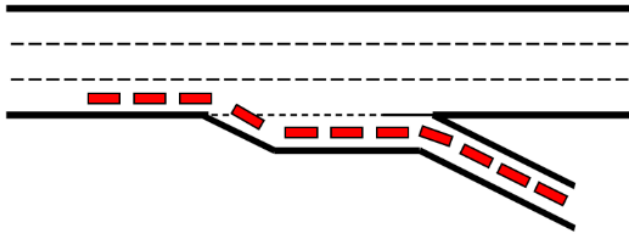
Spillback Regimes



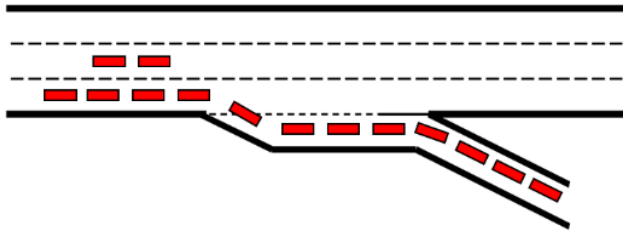
(a) Regime 1 – Queue at the deceleration lane



(b) Regime 2 – Queue along the shoulder

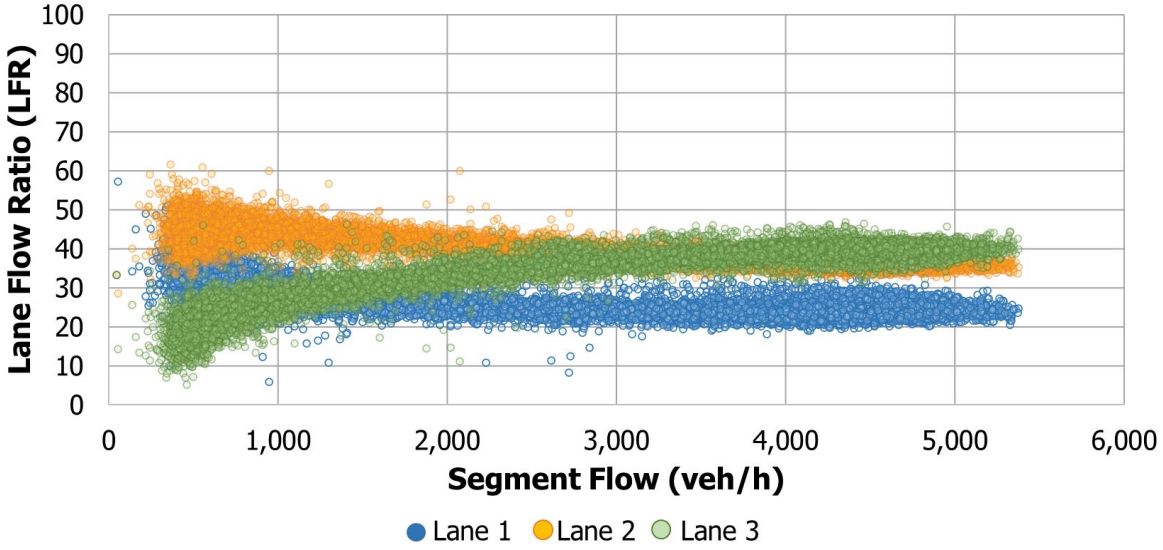


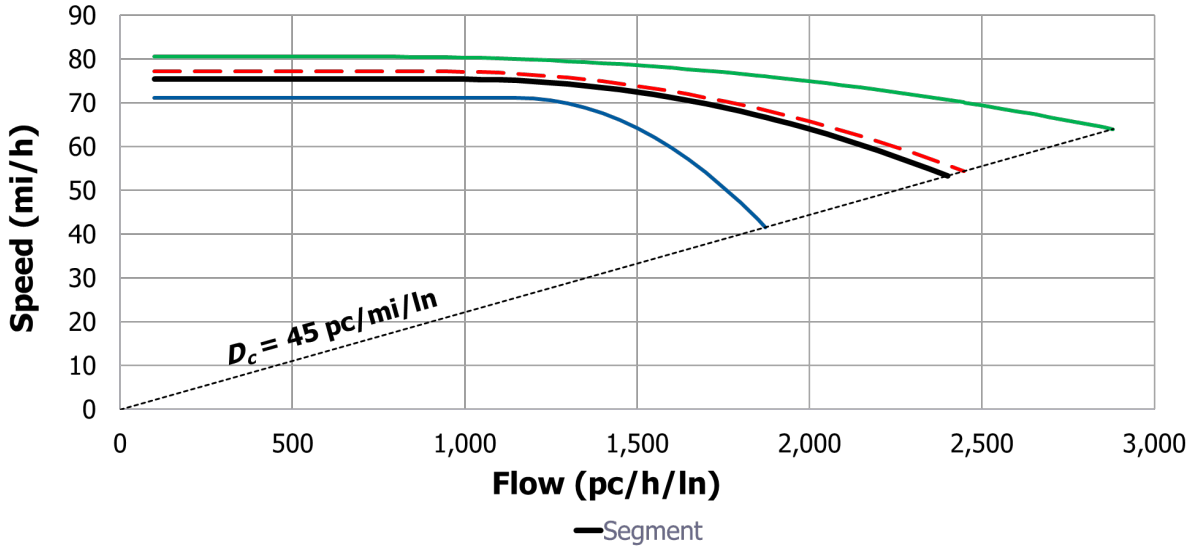
(c) Regime 3 - Queue along the rightmost lane



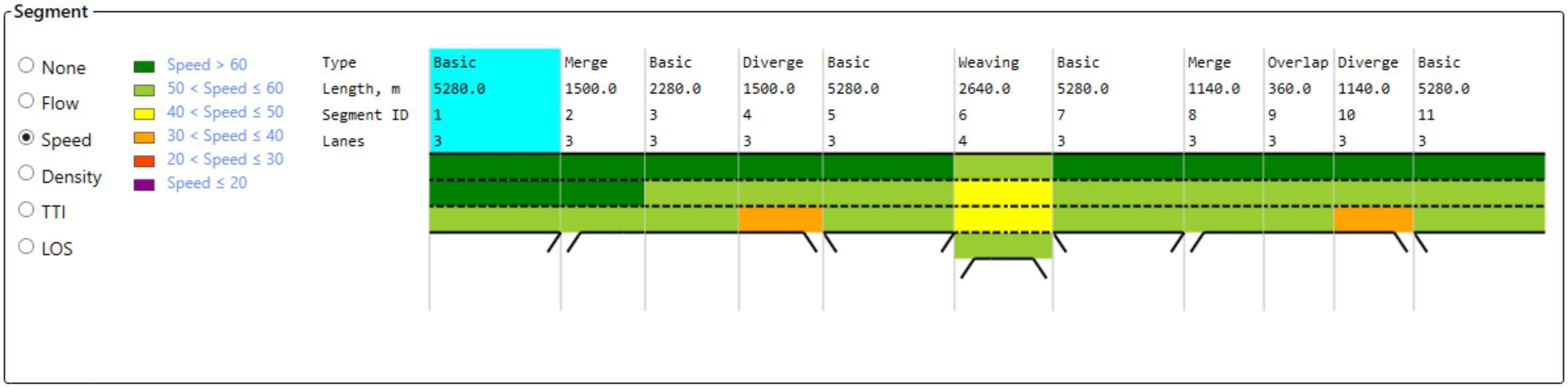
(d) Regime 4 – Queue blockage of the adjacent lane

Lane-by-lane performance along the freeway





For freeways, new method estimates speed by lane



Results

Step 8: Compute Travel Times for the Network and Each O-D

Facility		Segment Name or ID	Travel Time (s)	Cumulative Travel Time (s)	Analysis Period
Type	Name				
Urban Street 1	Archer Rd. WB	SW 37th Blvd. to SW 40th Blvd.	18.8	40.5	1
		SW 40th Blvd. to I-75 NB	36.4	76.8	1
Freeway	I-75 NB	On-ramp to I-75 NB	48.5	125.3	1
		8*	15.0	140.3	1
		9	63.8	204.1	1
		10	54.1	258.2	1
		11	16.5	274.6	1
		12	18.6	293.2	1
		13	13.9	307.1	1
		14	61.3	368.4	1
		15	23.4	391.8	1
		16*	19.3	411.0	1
		Off-ramp to NW 39th Ave.	122.8	533.8	1
Urban Street 2	NW 39th Ave. EB	I-75 NB to NW 95th Blvd.	75.9	609.7	1
		Total travel time (s)		**609.7**	

Today's presenters

Scott Washburn
swash@ce.ufl.edu

UF | Transportation Institute
UNIVERSITY of FLORIDA

Lily Elefteriadou
elefter@ce.ufl.edu

UF | Transportation Institute
UNIVERSITY of FLORIDA

Tom Creasey
tom@caliper.com

Caliper®

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Contact information:
Lily Elefteriadou
elefter@ce.ufl.edu