

What is New in HCM 6.1?

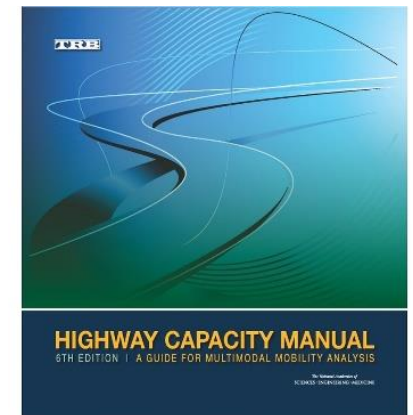
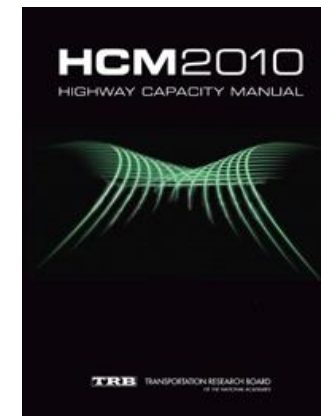
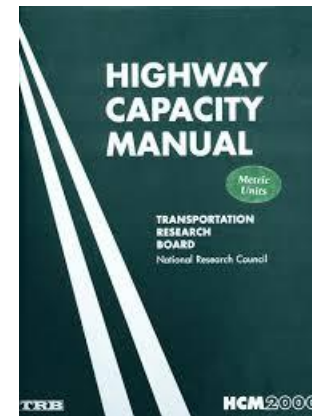
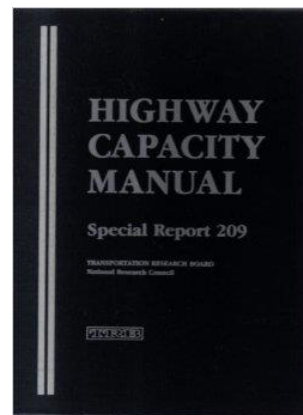
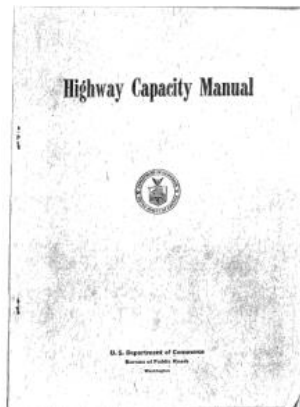
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HCM Versions/Editions

- 1950 – 1st Edition (Bureau of Public Roads)
- 1965 – 2nd Edition (Highway Capacity Committee)
- 1985 – 3rd Edition (TRB, NCHRP and FHWA)
1994 – Major Upgrade & 1997 – Major Upgrade
- 2000 – 4th Edition (Completely Reorganized)
- 2010 – 5th Edition (Some Engines)
- 2016 – 6th Edition (Much Research with 37 Chapters)
- **2021 – 6.1 Edition**



New Research – Updating to HCM6.1

Research Project	Leading Institution	Project Title	HCM Chapter(s) updated
NCHRP 17-65	University of Florida	Improved Analysis of Two-Lane Highway Capacity and Operational Performance	New Chapter 15
FHWA	Leidos	Active Transportation and Demand Management (ATDM) Analytical Methods for Urban Streets	Updated Chapters 17 & 37
NCHRP 17-87	Kittelson & Associates	Enhancing Pedestrian Volume Estimation and Developing HCM Pedestrian Methodologies for Safe and Sustainable Communities	Updated Chapters 18, 19, 20, 30, 31 & 32
Pooled Fund	Kittelson & Associates	Capacity Adjustment Factors for Connected and Automated Vehicles (CAV) in the Highway Capacity Manual	Updated Chapter 26, 31 & 33
NCHRP 15-57	University of Florida	Highway Capacity Manual Methodologies for Corridors Involving Freeways and Surface Streets	New Chapter 38

HCM 6.1-Chapter 15: Summary of Changes

New Two-Lane Highway Method

	HCM6 Methodology	New Methodology
Segmentation	Simplified - % of passing zones and length of passing lanes are provided	- Segment types: Passing zones, passing constrained and passing lanes - Subsegments based on horizontal alignment
Classification	Class I, Class II, Class III	N/A
Performance Measures	- Average Travel Speed - Percent Time Spent Following - Percent of Free-Flow Speed	- Average Speed - Percent Followers - Follower Density
LOS Measure	Depends on class	Follower Density
Heavy vehicles	Passenger Car Equivalent (pc/h)	- Flow as veh/h % HV as a direct input for performance measures
Capacity	1,700 pc/h	1,700 veh/h for passing zones and passing constrained - Variable for passing lanes

HCM 6.1-Chapter 15: Capacity

Passing Zones / Passing Constrained: 1,700 veh/h/ln

Passing Lanes: function of %HV and vertical alignment

Heavy Vehicle Percentage (%)	Maximum Flow Rate (veh/h) by Vertical Class				
	1	2	3	4	5
< 5	1,500	1,500	1,500	1,500	1,500
≥ 5 < 10	1,500	1,500	1,500	1,500	1,400
≥ 10 < 15	1,400	1,400	1,400	1,300	1,300
≥ 15 < 20	1,300	1,300	1,300	1,300	1,200
≥ 20 < 25	1,300	1,300	1,300	1,200	1,100
≥ 25	1,100	1,100	1,100	1,100	1,100

Note: Capacity is governed by merge point at end of passing lane segment.

HCM 6.1-Chapter 15: Service Measure

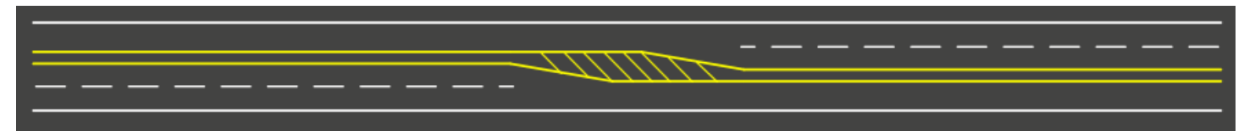
Follower Density

- Follower Density calculated as a function of segment type and characteristics
- Follower state defined as headway < 2.5s

LOS	<u>Follower Density (followers/mi/ln)</u>	
	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 exceed capacity	

HCM 6.1-Chapter 15: 2+1 Highways

- Continuous 3-lane section
- Middle lane is a passing lane that alternates directions
- More common in Europe, not so much in the USA



HCM 6.1-Chapter 17&37: Arterial's ATDM



Exhibit 37-8
Reversible Center Lanes in
Utah



Exhibit 37-7
Upstream DLG Signage in
Maryland

HCM 6.1-Chapter 17&37: Arterial's ATDM

- An important application of the methodology is in the evaluation of Active Traffic and Demand Management (ATDM) tactics.
- Primarily focuses on these three strategies:
 - Dynamic Lane Assignments
 - Reversible Lanes
 - Dynamic Turn Restrictions
- It uses the travel time reliability as the basis of analysis which can include the effects of non-recurring sources of congestion.

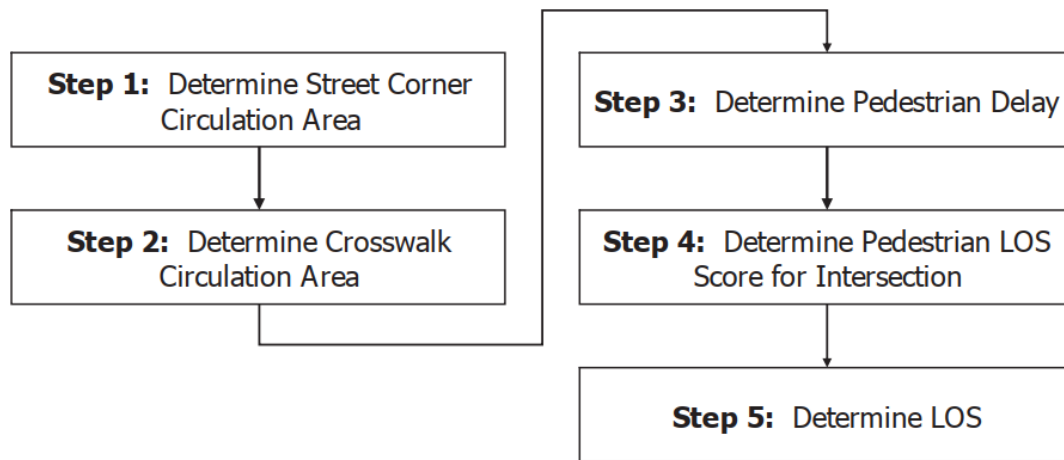
HCM 6.1- New Pedestrian Method

- Pedestrian methodology updates on chapters and supplementals (methodological details):

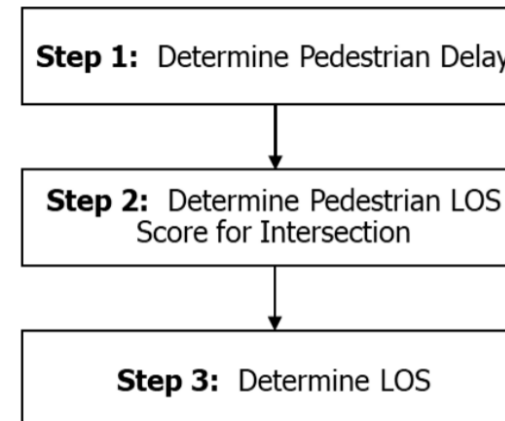
Method	Updated Chapter	Supplemental
Urban Streets Segment	Chapter 18	Chapter 30
Signalized Intersections	Chapter 19	Chapter 31
Two-Way Stop-Controlled Intersections	Chapter 20	Chapter 32

HCM 6.1- New Pedestrian Method

- Signalized intersections
 - Steps reordered for clarification
 - Steps 1 and 2 were not necessary to determine LOS and were made optional

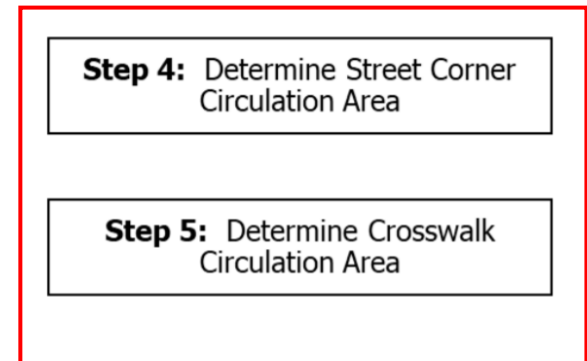


HCM 6 methodology



HCM 6.1 methodology

(Optional steps)



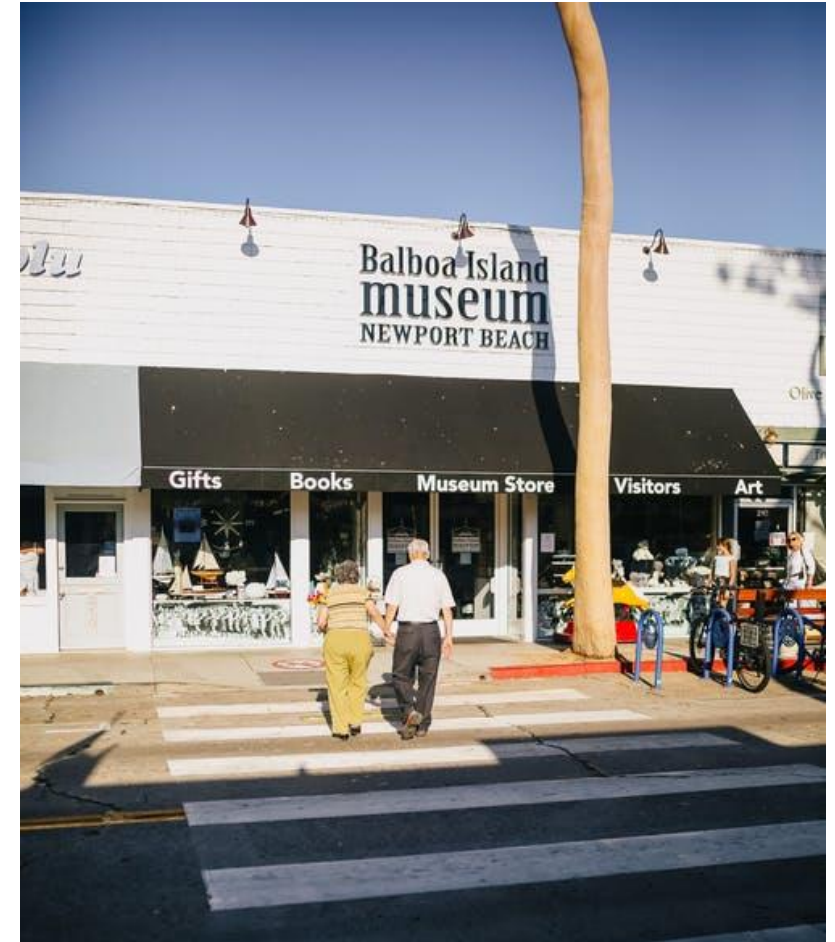
HCM 6.1- New Pedestrian Method

- Signalized intersections
 - Two-stage crossing
 - Two-leg crossing
 - Crosswalk closure
 - Exclusive pedestrian phase
 - Coordinated actuated signal with permissive period
 - New example problems (Chapter 31)



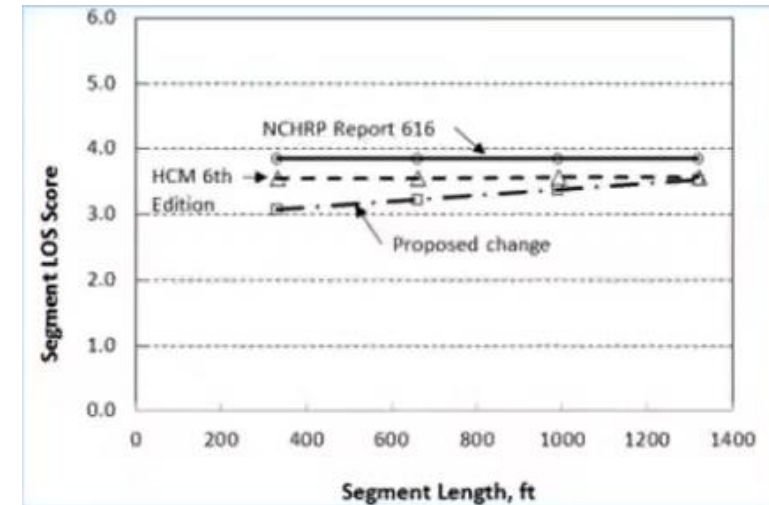
HCM 6.1- New Pedestrian Method

- Unsignalized intersections
 - Corrections to equations estimating pedestrian delay reduction due to driver yielding
 - Updated table of driver yielding rates for different types of crossing treatments based on recent research
 - New method predicting pedestrian satisfaction with crossing experience
 - Sensitive to crossing treatments (crosswalk markings, median refuge island, RRFB)



HCM 6.1- New Pedestrian Method

- Urban Streets
 - Revised roadway crossing difficulty factor
 - Made it more sensitive to segment length



HCM 6.1: CAVs Impact on Capacity

- Research has produced new sections on several chapters
- Intended for planning-level applications
- CAV impact on capacity is characterized as Capacity Adjustment Factor (CAF) for freeways, and Sat. Flow Adjustment for signals
- Impacts on capacity and sat. flow are a function of CAVs market penetration
- Chapter 26 provides hourly and daily Service Volume Tables for CAVs.
- Chapters 31 and 33 provide adjustments for signalized intersections and roundabouts.

HCM 6.1: CAVs Impact on Capacity

Facility Type	New Material for CAV Impact Assessment
Freeways and Highways	Chapter 26 - Freeway and Highway Segments Supplemental v6.2
Signalized Intersections	Chapter 31 - Signalized Intersections: Supplemental v6.1
Roundabouts	Chapter 33 - Roundabouts: Supplemental v6.1

HCM 6.1: CAVs Impact on Capacity

In the form of “Capacity Adjustment Factor (CAF)” for freeways, and
“Adjustment to Sat. Flow rate” for signalized intersections and arterials.

Proportion of CAVs in Traffic Stream	Adjusted Segment Capacity		
	2,400 pc/h/ln	2,100 pc/h/ln	1,800 pc/h/ln
0	1.00	1.00	1.00
20	1.02	1.02	1.15
40	1.07	1.10	1.27
60	1.13	1.25	1.40
80	1.22	1.37	1.60
100	1.33	1.52	1.78

CAV = connected and automated vehicle, defined here as a vehicle with an operating cooperative adaptive cruise control system.

Interpolate for other CAV proportions and adjusted segment capacities.

Assumptions: Average intervehicle gap within CAV platoons = 0.71 s based on a distribution (see text),
CAV interplatoon gap = 2.0 s, maximum CAV platoon size = 10 pc, human-driven vehicles operate with
average gaps calibrated to the given adjusted segment capacity.

Exhibit 26-15

Capacity Adjustment Factors
for CAVs for Basic Freeway
and Freeway Diverge
Segments

HCM 6.1: CAVs Impact on Signalized Intersections

Adjusted values for different model parameters:

- Base Saturation Flow Rate

Proportion of CAVs in Traffic Stream	Base Saturation Flow Rate (pc/h/ln)
0	
20	
40	
60	
80	
100	

Exhibit 31-64
Base Saturation Flow Rates for CAVs for Through Movements at Signalized Intersections

- Permitted Left Turns:

Exhibit 31-66
Saturation Flow Rate CAV Adjustments for Permitted Left Turns at Signalized Intersections

Proportion of CAVs in Traffic Stream	Saturation Flow Rate Adjustment for Permitted Left Turns $f_{CAV,perm}$ by Opposing Through Volume Per Lane (pc/h/ln)			
	300	450	600	750
0	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00
100	1.00	1.00	1.00	1.00

- Protected Left Turns:

Proportion of CAVs in Traffic Stream	Saturation Flow Rate Adjustment for Protected Left Turns, $f_{CAV,prot}$
0	
20	
40	
60	
80	
100	

Exhibit 31-65
Saturation Flow Rate CAV Adjustments for Protected Left Turns at Signalized Intersections

HCM 6.1: CAVs Impact on Roundabouts

Adjustment for roundabout capacity elements:

- f_A (critical headway)
- f_B (follow-up headway)

$$c_{e,pce} = Ae^{-Bv_{c,pce}}$$

$$c_{e,adj,pce} = f_A Ae^{-f_B Bv_{c,pce}}$$

where

$c_{e,pce}$ = entry lane capacity, adjusted for heavy vehicles (pc/h);

A = intercept parameter, from Exhibit 33-12;

B = slope parameter, from Exhibit 33-12;

$v_{c,pce}$ = conflicting flow rate (pc/h);

$c_{e,adj,pce}$ = entry lane capacity, adjusted for CAVs and heavy vehicles (pc/h);

f_A = adjustment factor for the intercept parameter, from Exhibit 33-13; and

f_B = adjustment factor for the slope parameter, from Exhibit 33-13.

Entry Lane Type	A	B
One-lane entry conflicted by one circulating lane	1,380	1.02×10^{-3}
Two-lane entry conflicted by one circulating lane (both entry lanes)	1,420	0.91×10^{-3}
One-lane entry conflicted by two circulating lanes	1,420	0.85×10^{-3}
Two-lane entry conflicted by two circulating lanes (right entry lane)	1,420	0.85×10^{-3}
Two-lane entry conflicted by two circulating lanes (left entry lane)	1,350	0.92×10^{-3}

Source: Equations 22-1 through 22-5.

Exhibit 33-12

Roundabout Entry Lane Capacity Model Parameters (without CAVs)

Proportion of CAVs in Traffic Stream	1-Lane Entry				2-Lane Entry					
	1 Circulating Lane		2 Circulating Lanes ^a		1 Circulating Lane, Both Lanes ^a		2 Circulating Lanes, Left Lane		2 Circulating Lanes, Right Lane	
	f_A	f_B	f_A	f_B	f_A	f_B	f_A	f_B	f_A	f_B
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	0.99	1.00	0.99	1.00	0.99	1.00	0.99	1.00	0.99
40	1.12	0.97	1.00	0.96	1.12	0.97	1.00	0.96	1.12	0.97
60	1.22	0.96	1.00	0.95	1.22	0.96	1.00	0.95	1.22	0.97
80	1.28	0.96	1.00	0.96	1.28	0.96	1.00	0.96	1.27	0.96
100	1.30	0.95	1.00	0.95	1.30	0.95	1.00	0.95	1.26	0.95

Notes: ^a These cases were not specifically analyzed in the research and thus are suggested approximations.
 CAV = connected and automated vehicle, defined here as a vehicle with an operating cooperative adaptive cruise control system.
 Interpolate for other CAV proportions.
 Assumptions: Human-driven vehicles operate with average gaps calibrated to the entry lane capacity given by Chapter 22.

Exhibit 33-13

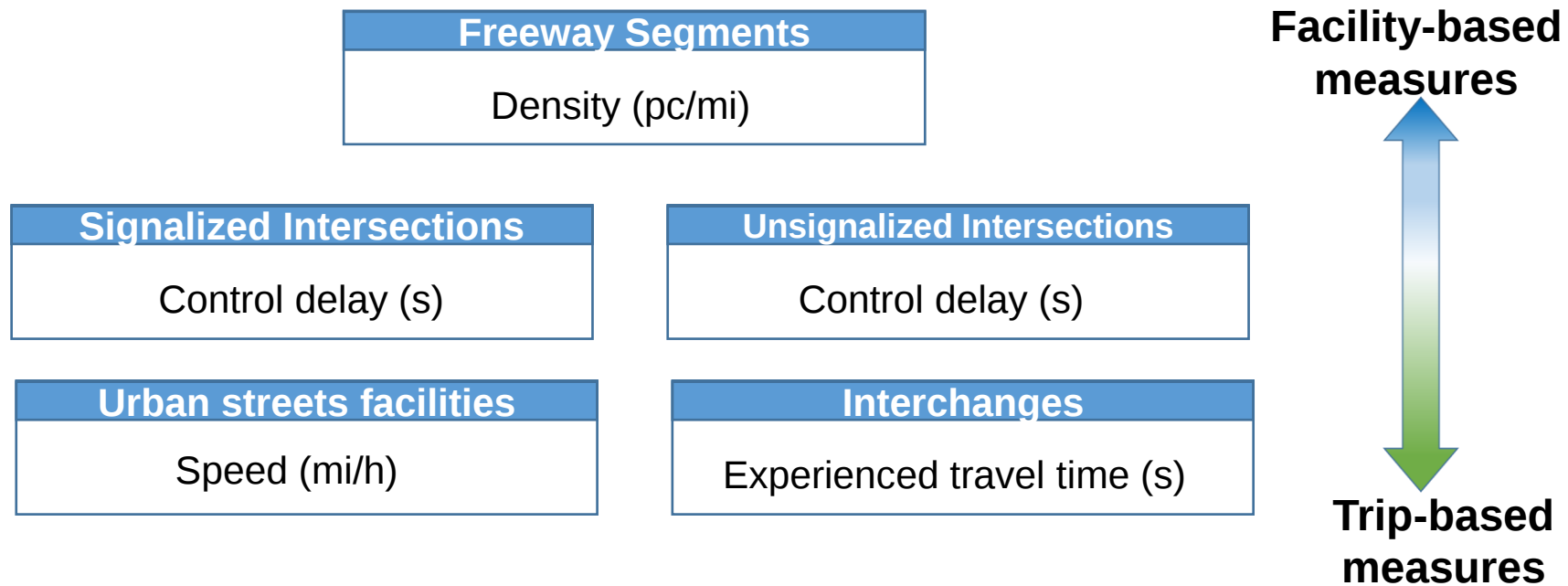
Capacity Adjustment Factors for CAVs for Roundabouts

HCM 6.1-Chapter 38: Network Analysis

Objective:

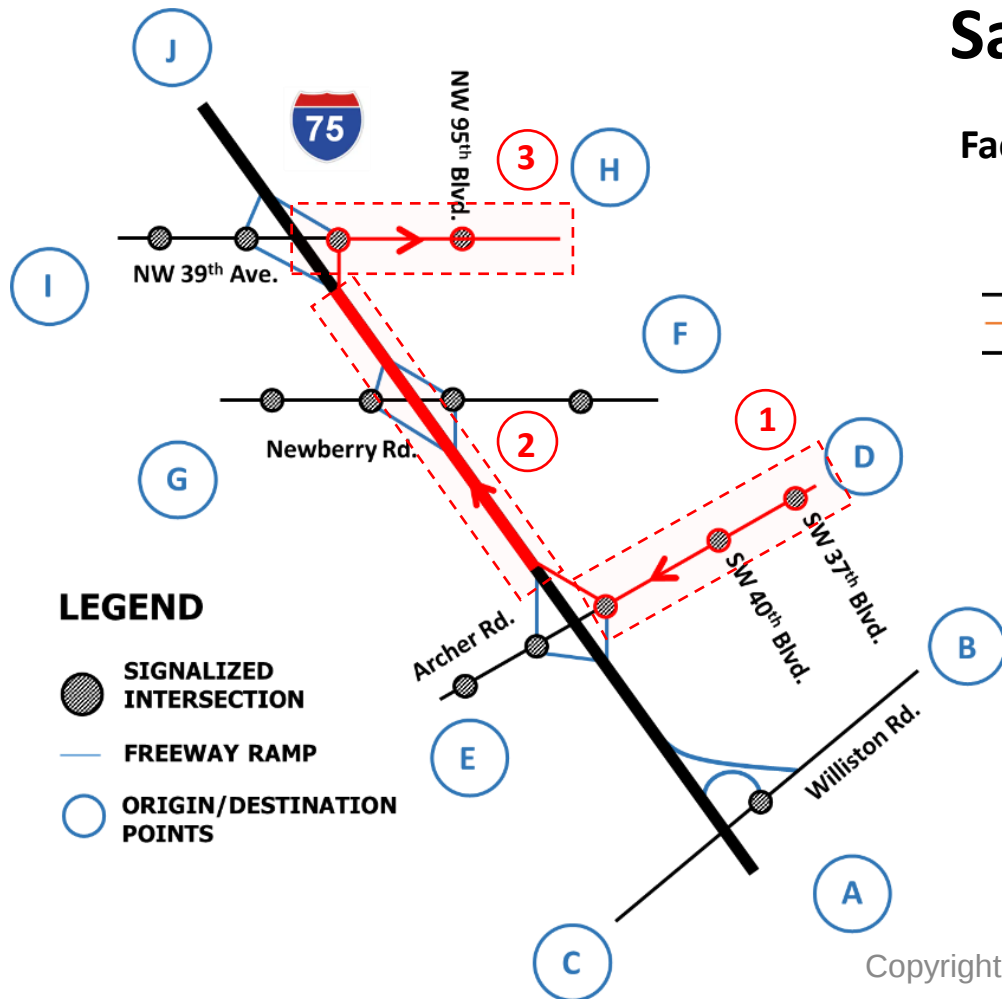
Evaluate performance measures of corridors with freeways and arterial facilities

- Travel time** defined as the key performance measure across all facilities

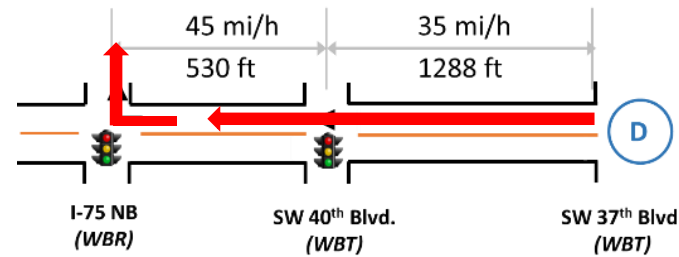


HCM 6.1-Chapter 38: Network Analysis

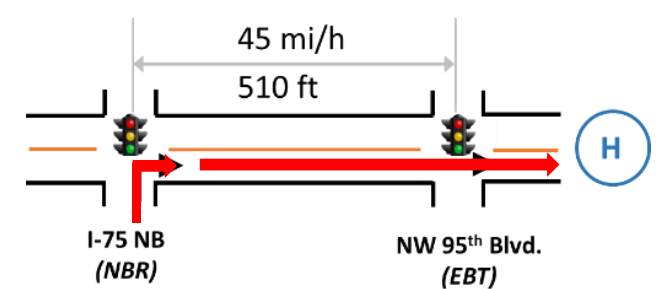
Sample network analysis



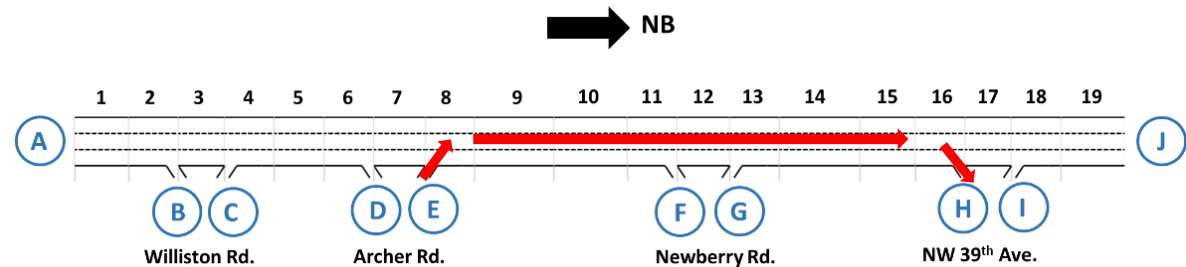
Facility 1 (Urban Street):



Facility 3 (Urban Street):



Facility 2 (Freeway):



HCM 6.1-Chapter 38: Network Analysis

Queue Spillback between freeways and urban streets

- Not addressed by HCM methods
- Typically addressed with microsimulation



Off-ramp spillback

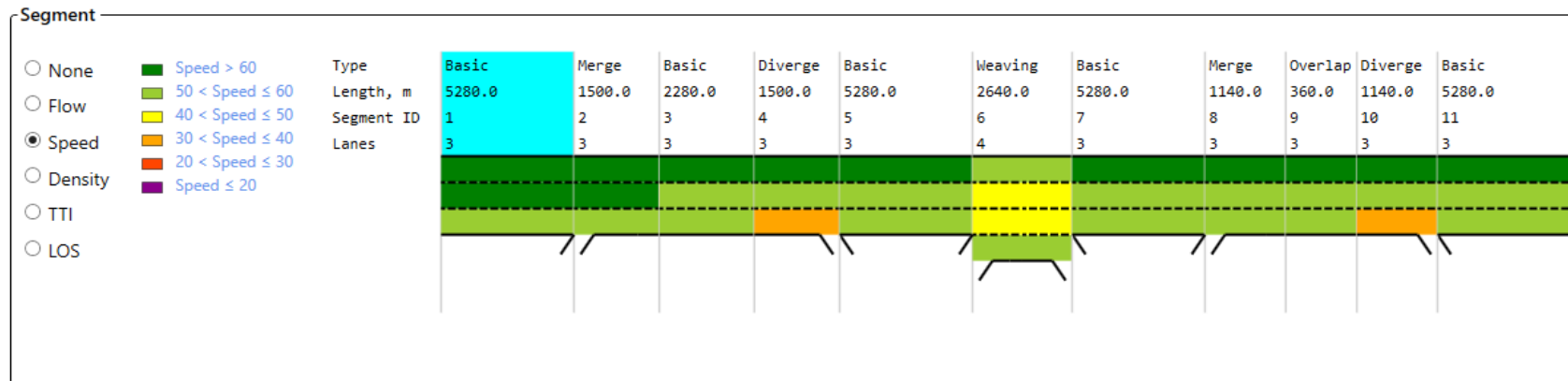


On-ramp spillback

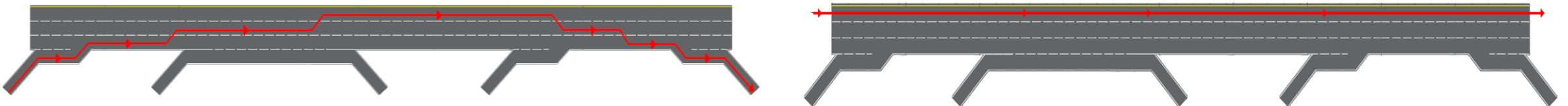
HCM 6.1-Chapter 38: Network Analysis

New lane by lane analysis for freeways

- Flows and speeds are determined for every individual lane



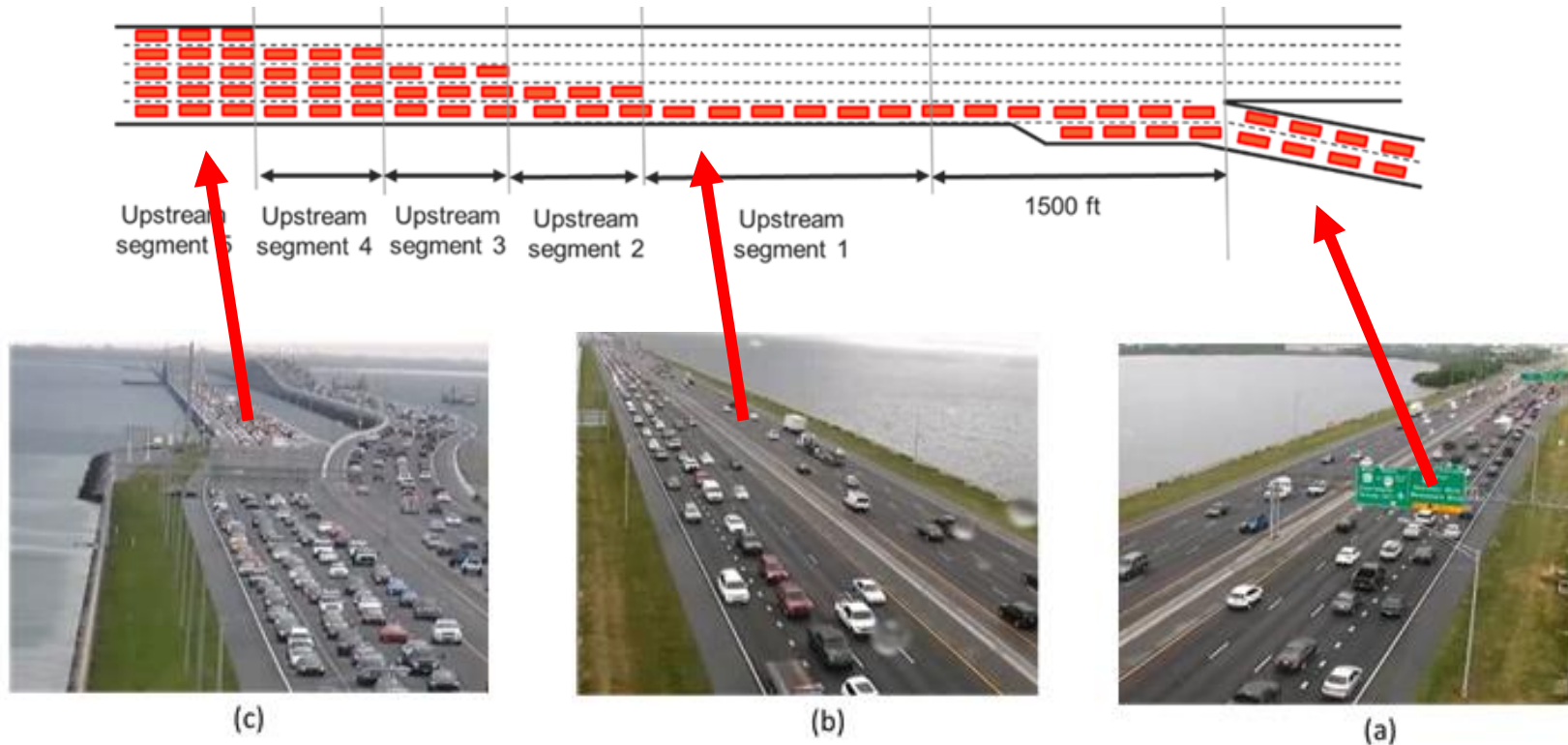
- Lane selection function of specific O-D



HCM 6.1-Chapter 38: Network Analysis

Off-ramp Queue Spillback

Freeway impact is more localized close to exit and spreads further upstream:

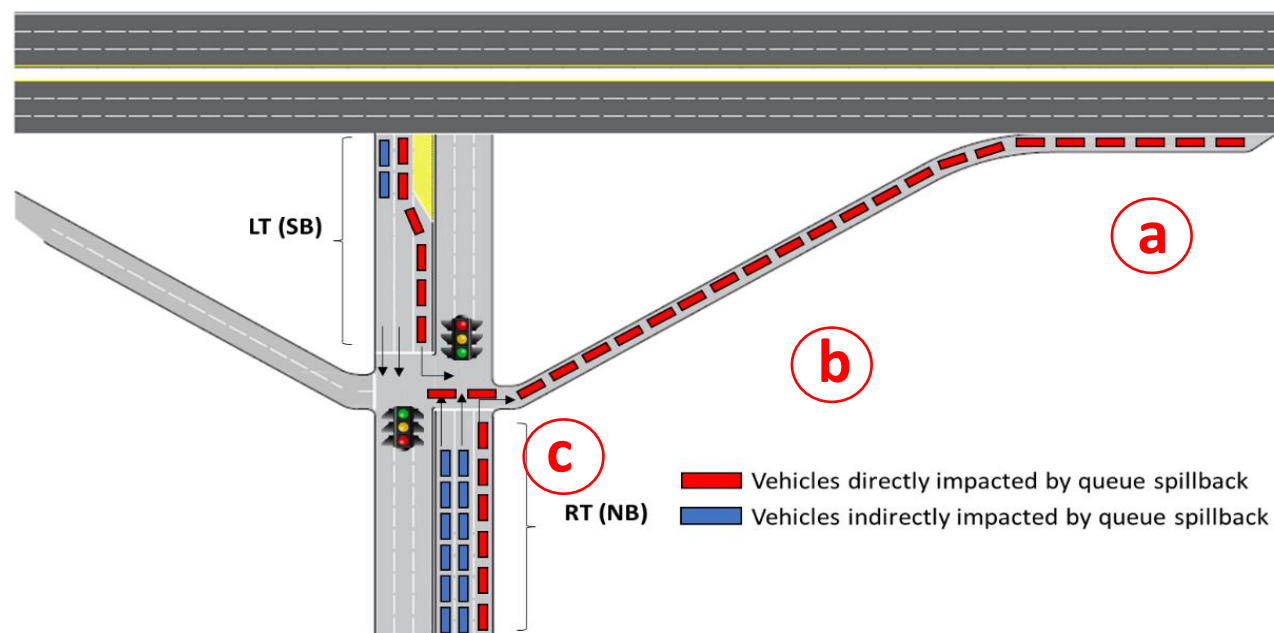


HCM 6.1-Chapter 38: Network Analysis

On-ramp Queue Spillback

Occurs when:

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



* Reduced merge capacity only for oversaturated conditions at the freeway (LOS F)

Software Implementation

- The new material in HCM6.1 are under implementation in HCS7.
- McTrans is planning to release the software (HCS7) at the time of publication of HCM6.1 (sometime in 2021).



Additional information

For additional information:

- Highway Capacity and Quality of Service Committee:
<https://www.hcqstrb.org/>
- Become a friend of the committee at <https://www.mytrb.org/>
- Follow us on our McTrans page for the latest news about HCM and HCS:
<https://mctrans.ce.ufl.edu/>
- Join our HCS user group to get the latest news about the HCS:
<https://www.linkedin.com/groups/9032179/>



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Questions?



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