HCM – Sixth Edition
What’s New in the HCM Sixth Edition

Plus More

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Transportation Research Board
National Cooperative Highway Research Program
Project No. 03-115
“Production of a Major Update to the 2010 Highway Capacity Manual”

For Assistance in Preparation of This Presentation
The first 25 slides are selected by Bob Bryson
HCM 6th Edition

- Tentatively Scheduled for Release in Mid-2016

- New Title:

HIGHWAY CAPACITY MANUAL  
6th Edition

A Guide for Multimodal Mobility Analysis
New Research Since HCM 2010

- NCFRP 41: truck analysis
- NCHRP 03-96: managed lanes
- NCHRP 03-100: roundabouts in corridors
- NCHRP 03-107: work zone capacity
- NCHRP 03-115: HCM production
- NCHRP 07-22: planning guide to HCM
- SHRP 2 L08: travel time reliability
- FHWA: ATDM, roundabouts, alternative intersections
Post-2010 Emerging Topics Chapters

- After HCM 2010 was published, four emerging topics chapters (35–38) were released online:
  - Active Transportation and Demand Management (ATDM) update (Ch. 35)
  - Travel time reliability (Ch. 36, 37)
  - Managed lanes (Ch. 38)
- Interim chapters and research completed integrated into HCM
  - Allows the use of all methods in combination
Major New Improvements
Standardized Volume 2 & 3 Chapter Outline

- Introduction
- Concepts
- Core Motorized Vehicle Methodology
- Extensions to the Methodology*
- Mode-specific Methodologies*
- Applications

*if provided
Freeway Facilities

- Core method described in Chapter 10
  - New freeway work zone method
  - New managed lanes method
  - New research on truck effects on freeway operations
  - Guidance on evaluating ATDM strategies on typical-day freeway operations
  - Improved guidance on segmenting freeways and matching section data from external databases to HCM segments
Freeway Reliability Analysis

- New Chapter 11
- Integrates reliability analysis methodology
  - Applies Chapter 10 method repeatedly with adjusted demands, capacities, lanes, and free-flow speeds to develop a travel time distribution
  - Incorporates demand variation, weather, incident, work zone, and special event effects
  - Produces a variety of useful reliability-related performance measures
Freeway/Multilane Highway Segments

- Chapter 12 merges the previous individual chapters on basic freeway segments and multilane highways.
- Uses one unified speed–flow equation applicable to both freeway and multilane highway segments, but the form of the curves are different.
Unified Speed–Flow Equation

\[ S = FFS_{adj} \]

\[ S = FFS_{adj} - \left( \frac{FFS_{adj} - \frac{c_{adj}}{D_c}}{c_{adj} - BP} \right)^a (v_p - BP)^a \]

- \( v_p \leq BP \)
- \( BP < v_p \leq c \)

Density = 45 pc/mi/ln
Freeway and Multilane Highway Segments

- Other changes include:
  - Revised truck PCE tables
  - Increased emphasis on calibration through capacity and speed adjustment factors (CAFs and SAFs)
  - Driver population effects now handled by CAFs and SAFs
  - For multilane highways:
    - Density at capacity = 45 pc/mi/ln
    - Revised LOS E–F range to reflect revised density
    - New speed–flow curves for 65 and 70 mi/h highways
Chapter 26 provides additional details:

- Truck performance on extended (long and/or steep) grades
- New method for measuring capacity in the field
- Updated example problems

Users guided to bicycle method in Chapter 15, Two-Lane Highways, for evaluating bicycle operations on multilane highways
Freeway Weaving, Merges and Diverses

- Chapter 13 and 14 integrate material on managed lane weaving sections and cross-weave effects in the general-purpose lanes

- Emphasis on the use of CAFs and SAFs for calibration
- Chapter 27 and 28 provide new example problems demonstrating the new capabilities
Urban Street Facilities

- Service measure changed to **average travel speed** from average travel speed as percent of free-flow speed

- LOS A/B threshold lowered to the equivalent of 80% of free-flow speed

- New method for evaluating spillback

- Pedestrian and bicycle LOS now weighted by travel time instead of length

- Example problems moved to Chapter 29

<table>
<thead>
<tr>
<th>LOS</th>
<th>Travel Speed Threshold by Base Free-Flow Speed (mi/h)</th>
<th>Volume-to-Capacity Ratio*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>A</td>
<td>&gt;44</td>
<td>&gt;40</td>
</tr>
<tr>
<td>B</td>
<td>&gt;37</td>
<td>&gt;34</td>
</tr>
<tr>
<td>C</td>
<td>&gt;28</td>
<td>&gt;25</td>
</tr>
<tr>
<td>D</td>
<td>&gt;22</td>
<td>&gt;20</td>
</tr>
<tr>
<td>E</td>
<td>&gt;17</td>
<td>&gt;15</td>
</tr>
<tr>
<td>F</td>
<td>≤17</td>
<td>≤15</td>
</tr>
</tbody>
</table>

* F = Any

≥ 1.0
Urban Street Reliability and ATDM

- New Chapter 17
  - Integrates material previously appearing in Chapter 35 and interim Chapters 36 and 37
- Reliability calculation process similar to that used for freeway reliability analysis
  - Repetitive application of Chapter 16 core method with varying inputs
- New guidance on analyzing ATDM strategies
Urban Street Segments

- Same service measure changes as described for urban street facilities
- New method for evaluating segments with midsegment lane blockage
- Improved procedure for predicting segment queue spillback time
- New adjustment factor for parking activity that affects free-flow speed estimation
Urban Street Segments

- Procedure can now evaluate segments with roundabouts at one or both ends
- Right-turn-on-red vehicles incorporated into volume-balancing method for flows into and out of a segment
- Pedestrian and bicycle LOS scores now use time-based weighting
- Changes to bicycle and bus default values
Signalized Intersections

- Delay of unsignalized movements can now be considered (user-supplied input)
- Combined saturation flow adjustment factor for heavy vehicles and grade
- New saturation flow adjustment factors for intersection work zone presence, midsegment lane blockage, and downstream spillback
Signalized Intersections

- Chapter 31 provides an improved planning method with reduced input data requirements and simplified calculations.
- Example problems moved to Chapter 31.

### PLANNING-LEVEL ANALYSIS: INPUT WORKSHEET

<table>
<thead>
<tr>
<th>General Information</th>
<th>Site Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyst</td>
<td>Intersection</td>
</tr>
<tr>
<td>Agency or Company</td>
<td>Jurisdiction</td>
</tr>
<tr>
<td>Date Performed</td>
<td>Analysis Time Period</td>
</tr>
<tr>
<td>Analysis Time Period</td>
<td>Analysis Year</td>
</tr>
</tbody>
</table>

#### Intersection Geometry

- Through
- Right
- Left
- Through + Right
- Left + Through
- Left + Right
- Left + Through + Right

#### Volume and Signal Input

<table>
<thead>
<tr>
<th>Required Data</th>
<th>BR</th>
<th>BL</th>
<th>WB</th>
<th>WL</th>
<th>NR</th>
<th>NL</th>
<th>SR</th>
<th>SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (veh/h)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of lanes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane use (exclusive or shared)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Optional Data**

- Heavy vehicles (%)
- On-street parking presence (No, Yes)
- Pedestrian activity (none, low, med., high, extreme)
- Left-turn operation and phase sequence
- Effective green time (s)\(^3\)\(^a\)
- Progression quality (good, random, poor)\(^4\)
- Peak hour factor  
- Cycle length (s)  
- Base saturation flow rate (pc/h/ln)

**Notes**

1. Optional input data (guidance is provided for estimating these data if they are not known).
2. Combinations addressed: (a) protected operation—with left-turn phase, (b) permitted operation—no left-turn phase, (c) protected operation—split phasing, (d) protected-permitted operation—with left-turn phase
3. Data required for Part I analysis if “protected-permitted operation—with left-turn phase” is present.
4. Data required for Part II analysis.
Ramp Terminals and Alternative Intersections

- The former Interchange Ramp Terminals chapter has been expanded to include a greater variety of distributed intersections
  - Two or more intersections with close spacing and displaced or distributed traffic movements that are operationally inter-dependent and are best analyzed as a single unit
Ramp Terminal Forms Addressed

PARCLO

DIAMOND

SPUI

DDI
Intersection Forms Addressed

Displaced Left Turn

Restricted Crossing U-Turn

Median U-Turn

DLT

RCUT

MUT
Ramp Terminals and Alternative Intersections

- New service measure: experienced travel time
  - Sum of control delays at each node and extra distance travel time experienced by rerouted movements

- New and updated example problems are located in supplemental Chapter 34
Briefing Series Overview

- New Features in Freeway Analysis Chapter
- Freeway Reliability and Strategy Assessment
- Urban Streets Segment Chapter
- Urban Streets Facility Chapter
- Signalized Intersection Chapter
- Signalized Intersection Planning Method
- Roundabouts
- Ramp Terminals and Alternative Intersections
- Planning and Preliminary Engineering Applications
Guide to the HCM
PLUS MORE

Slides added by Ray Benekohal
HCM 2016, has 37 chapters

1. Vol 1-Concept; Vol 2, Uninterrupted Flow; Vol 3 Interrupted flow; loose leaf printed

For Basic Freeway Segments
- Handles managed lanes (HOV, HOT, Express Toll)
- Speed adj. factor (SAF),
  - due to weather (0.88-1.00)
- Capacity adj. factor (CAF):
  - due to weather (0.7757-1.0000)
  - due to incident (.50-.93)
- Driver popu. factor is applied to CAF and SAF
- Free Flow speed NOT rounded to nearest 5.
- New procedure for trucks
- Two terrains: level (PCE=2.0) and rolling (PCE=3.0)
Weaving Segments
   Managed lane procedure
   SAF and CAF

Merge and Diverge Segments
   Managed lane access
   SAF and CAF
   Density = flow / speed,
       finds weighted average speed

Freeway Facilities
   Managed lanes, Travel Time Reliability, ATDM,
   Capacity Calibration
   Work zones
Estimate the WZ Capacity... by Estimating QDR

Find Queue Discharge Rate ($QDR_{wz}$)

Then, compute capacity as:

$$c_{wz} = \frac{QDR_{wz}}{100 - \alpha_{wz}} \times 100$$

($c_{wz}, QDR_{wz}$ in pcp/hpl)

average $\alpha_{wz} = 13.4\%$
How to Estimate $QDR_{WZ}$

$$QDR_{WZ} = 2093 - (154 \times f_{LCSI}) - (194 \times f_{Br}) - (179 \times f_A) + (9 \times f_{LAT}) - (59 \times f_{DN})$$

$f_{LCSI} =$ Lane closure severity index (*next slide*)

$f_{Br} =$ **Barrier type**

- 0  Concrete and hard barrier separation
- 1  Cone, plastic drum, or other soft barrier separation

$f_A =$ **Area type**

- 0  Urban areas (High development densities or concentrations of population)
- 1  Rural areas (widely scattered development and low housing and employment densities)

$f_{LAT} =$ “**Lateral distance** from the edge of travel lane adjacent to the work zone to the barrier, barricades, or cones (0-12 ft)”

$f_{DN} =$ **Daylight/night**

- 0  Daylight
- 1  Night
How to Estimate $QDR_{wz}$

$$QDR_{wz} = 2093 - (154 \times f_{LCSI}) - (194 \times f_{Br}) - (179 \times f_{A}) + (9 \times f_{LAT}) - (59 \times f_{DN})$$

$f_{LCSI} = 2$ lanes total, 1 lane closed = 2.0

$f_{Br} = 0$  Concrete and hard barrier separation

$f_{A} = 1$  Rural area

$f_{LAT} = 2$ ft

$f_{DN} = 0$  Daylight

$$QDR_{wz} = 2093 - (154 \times 2) - (194 \times 0) - (179 \times 1) + (9 \times 2) - (59 \times 0)$$

$QDR_{wz} = 1624 \text{ pcphpl}$
• Estimate WZ presence Adjustment Factor and apply it to Sat flow

• Adj factors for trucks and grade are combined now (13 adj factors)

\[ s = s_o f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb} f_{wz} f_{ms} f_{sp} \]

Adjustment factor for WZ presence at the intersection
Adjustment factor for WZ presence at the intersection \((f_{wz})\)

\[
f_{wz} = 0.878 \times f_{wid} \times f_{reduce} \leq 1.0
\]

\[
f_{wid} = \frac{1}{1 - 0.0055(a_w - 12)} \quad f_{reduce} = \frac{1}{1 + 0.0484(n_o - n_{wz})}
\]

- \(f_{wid}\) = Adj. factor for approach width
- \(f_{reduce}\) = Adj. factor for reducing lanes during WZ presence
- \(a_w\) = Approach lane width during WZ (ft)
- \(n_o\) = Number of left-turn and through lanes open during normal operation (lanes)
- \(n_{wz}\) = Number of left-turn and through lanes open during WZ presence (lanes)

**Note:** one value is computed for (and is applicable to) all lane groups on the subject intersection approach
Roundabouts

\[ c_{pce} = 1,130e^{-1.0 \times 10^{-3} v_{c,pce}} \]

2010, one-lane entry one-lane circulating

\[ c_{e,pce} = 1,380e^{-1.02 \times 10^{-3} v_{c,pce}} \]

2016, one-lane entry one-lane circulating

\[ c_{e,pce} = 1,420e^{-0.85 \times 10^{-3} v_{c,pce}} \]

2016, one-lane entry two-lanes circulating