Chapter 10, Freeway Facilities

Page 10-23 (Clarification, approved January 2013): Change the third paragraph to read: “If the distance between the merge and diverge points is greater than $L_{wMAX}$, then the merge and diverge segments are too far apart to form a weaving segment. As shown in Exhibit 10-13(b), the merge and diverge segments are treated separately, and any distance remaining between the merge and diverge influence areas is treated as a basic freeway segment.” Replace Exhibit 10-13(b) with the following:

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![Exhibit 10-13(b)](image)

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Chapter 11, Basic Freeway Segments

Page 11-16 (Correction, approved January 2012): In Exhibit 11-11, change the $E_T$ value for >6% upgrade, 0.00–0.25 mi length, \(\geq 25\%\) trucks and buses from 1.0 to 2.0.

Chapter 12, Freeway Weaving Segments

Page 12-16 (Clarification, approved January 2014): Change the heading in the first row of Exhibit 12-9 from “Number of Weaving Lanes” to “Maximum Weaving Length (ft)”.

Page 12-23 (Correction, approved January 2014): The LOS E/F boundary was originally set at 43 pc/mi/ln. It is possible to have densities greater than 43 pc/mi/ln without exceeding capacity, but speeds and maneuverability at these densities will be too high to maintain acceptable operations for drivers. Consequently, in Exhibit 12-10, change the LOS E densities from \(>35\) and \(>36\) to \(>35–43\) and \(>36–40\), make the LOS F density for freeway weaving segments “\(>43, or demand exceeds capacity\)”, and make the LOS F density for multilane highways and C-D roadways “\(>40, or demand exceeds capacity\)”.

Page 12-25 (Correction, approved June 2012): Change the second sentence under Default Values to read: “Default values for freeways are summarized in Chapter 10, Freeway Facilities Chapter 11, Basic Freeway Segments.”
Page 12-43 (Correction, approved January 2014): In the final equation under Step 5, change the value “> 4,150 veh/h” to “> 4,415 veh/h”, which is (4,150) / PHF, with the PHF = 0.94.

Chapter 13, Freeway Merge and Diverge Segments

Page 13-14 (Correction, approved January 2012): In the list of variables below Equation 13-8, change the definition of $P_{FD}$ from “proportion of diverging traffic...” to “proportion of through freeway traffic...”

Page 13-14 (Correction, approved June 2012): Add the following to the side of Equation 13-10: when $v_{LU}/L_{UP} \leq 0.2$ and add the following below Exhibit 13-7: When $v_{LU}/L_{UP} > 0.2$, use Equation 13-9.

Page 13-15 (Correction, approved June 2012): Add the following paragraph immediately before the paragraph starting “A special case exists...”: In cases where Equation 13-12 indicates that Equation 13-10 should be used to determine $P_{FD}$, but $v_{LU}/L_{UP} > 0.20$, Equation 13-9 must be used as a default. This is due to the valid calibration range of Equation 13-10, and the fact that it will yield unreasonable results when $v_{LU}/L_{UP}$ exceeds 0.20. This will lead to step-function changes in $P_{FD}$ for values just below or above $v_{LU}/L_{UP} = 0.20$.

Page 13-22 (Clarification, approved January 2013): Add the following new subsection following the first paragraph of the “Special Cases” section:

**Single-Lane Ramp Additions and Lane Drops**

On-ramps and off-ramps do not always include merge and diverge elements. In some cases, there are lane additions at on-ramps or lane drops at off-ramps.

Analysis of single-lane additions and lane drops is relatively straightforward. The freeway segment downstream of the on-ramp or upstream of the off-ramp is simply considered to be a basic freeway segment with an additional lane. The procedures in Chapter 11 should be applied in this case.

The case of an on-ramp lane addition followed by an off-ramp lane drop may be a weaving segment, and should be evaluated using the procedures of Chapter 12. This configuration may either be a weaving segment or a basic segment, depending on the distance between the ramps. Note that some segments may be classified as a weaving segment at higher volumes and as a basic segment at lower volumes.

Ramps with two or more lanes frequently have lane additions or drops for some or all of the ramp lanes. These cases are covered below.

Page 13-28 (Correction, approved June 2012): Change the second sentence of the second paragraph to read: “Chapter 10, Freeway Facilities, Chapter 11, Basic Freeway Segments, provides a summary of the default values for freeways.”
Page 13-30 (Correction, approved June 2012): Change the second sentence in the second paragraph under Planning and Preliminary Engineering Analysis to begin: “Many of the default values specified in Chapter 11, Basic Freeway Segments; Chapter 12, Freeway Weaving Segments; and Chapter 13, Freeway Merge and Diverge Segments for freeway facilities in Chapter 10 would be applied;”

Chapter 14, Multilane Highways

Page 14-16, Exhibit 14-13 (Correction, approved January 2012): Change the $E_T$ value for >6% upgrade, 0.00–0.25 mi length, ≥25% trucks and buses from 1.0 to 2.0.

Chapter 15, Two-Lane Highways

Page 15-28, list of variables below Equations 15-12 and 15-13 (Correction, approved January 2012): Change the units for $c_{dATS}$ and $c_{dPTSF}$ from pc/h to veh/h.

Page 15-37, two lines above Equation 15-25 (Correction, approved January 2014): Change the definition of $V$ from “hourly directional volume” to “hourly directional volume per lane”.


Page 15-38, list of variables at the top of the page (Correction, approved January 2012 and January 2014): Change the definition of $V$ from “hourly directional volume (veh/h)” to “hourly directional volume per lane (veh/h/ln)”.

Page 15-44, Example Problem 1 (Correction, approved January 2012): Change the units for demand volume in “The Facts” from pc/h to veh/h.

Chapter 19, Two-Way STOP-Controlled Intersections

Page 19-15, Exhibit 19-10 and page 19-16, Exhibit 19-11 (Correction, approved January 2012): Add the following note below each table: Note: “Narrow” U-turns have a median nose width < 21 ft; “wide” U-turns have a median nose width ≥21 ft.

Chapter 20, All-Way STOP-Controlled Intersections

Page 20-15 (Correction, approved January 2012):

- Change the first sentence of Step 10 as follows: “The departure headway of the approach lane is the expected value of the saturation headway distribution, given by Equation 20-28.”
• Change the paragraph under Step 12 as follows: “The capacity of each approach lane in a subject approach is computed under the assumption that the flows on the opposing and conflicting approaches are constant. The given flow rate on the subject lane is increased and the departure headways are computed for each approach lane on each approach until the degree of utilization for the subject lane reaches 1. When this occurs, the final value of the subject approach lane flow rate is the maximum possible throughput or capacity of this lane.”

Page 20-25 (Correction, approved January 2012): Change the first sentence of Step 10 as follows: “The departure headway of the approach lane is the sum of the products of the adjusted probabilities and the saturation headways as follows (eastbound illustrated):”

Page 20-26 (Correction, approved January 2012):

• Change the first sentence of the first paragraph of Step 12 as follows: “The capacity of each approach lane in a subject approach is computed by increasing the given flow rate on the subject lane (assuming the flows on the opposing and conflicting approaches are constant) until the degree of utilization for the subject lane reaches 1.”

• Change the second paragraph of Step 12 as follows: “Here, the eastbound approach lane capacity is approximately 720 veh/h, which is lower than the value that could be estimated by dividing the approach lane volume by the degree of utilization (368/0.492 = 748 veh/h). The difference is due to the interaction effects among the approaches: increases in eastbound traffic volume increase the departure headways of the lanes on the other approaches, which in turn increases the departure headway of the lanes on the subject approach.”

• Change the second sentence of Step 13 as follows: “For the eastbound approach lane (using a value for m of 2.0 for Geometry Group 1), the calculation is as follows:”

• Change the first sentence of Step 14 as follows: “The control delay for each approach lane is computed with Equation 20-30 as follows (eastbound approach illustrated):”.

• Change the sentence after the first equation in Step 14 as follows: “By using Exhibit 20-2, the eastbound approach lane (and thus approach) is assigned LOS B. A similar calculation for the westbound and southbound approaches lanes (and thus approaches) yields 13.5 and 10.6 s, respectively.”

Chapter 31, Signalized Intersections: Supplemental
Note: All page numbers refer to the original December 2010 version of the chapter.

Page 31-34 (Correction, approved December 2013): Add the following text immediately before Section B, Estimate Shared-Lane Lane Group Flow Rate: “If the opposing approach has two lanes serving through vehicles and the inside lane serves through and left-turn vehicles, then Equation 31-54a is used to compute the adjusted duration of permitted left-turn green time that is not blocked by an opposing queue \( g_v \). This variable is then used in Equation 31-59 in replacement of the variable \( g_v \). This adjustment is intended to reflect the occasional hesitancy of drivers to shift from the inside lane to the outside lane during higher-volume conditions for this approach lane geometry. In all other
cases of opposing approach lane geometry, the variable $g_u^*$ is not computed and Equation 31-59 is used as described in the text.

\[ g_u^* = g_u + (g_{\text{diff}} \times P_c) \]  

Equation 31-54a

where

$g_u^*$ = adjusted duration of permitted left-turn green time that is not blocked by an opposing queue (s), and

$g_{\text{diff}}$ = supplemental service time for shared single-lane approach (s).

An equation for calculating $g_{\text{diff}}$ is provided in Section 3 (Equation 31-103).”

Page 31-35 (Correction, approved June 2012): Change Equation 31-59 from:

\[ s_{sl} = \frac{s_{th}}{g_p} \left( g_f + \frac{g_{\text{diff}}}{1 + P_L (E_{L2,m} - 1)} + \frac{\min(g_p - g_f, g_u)}{1 + P_L (E_{L1,m} - 1)} \right) \geq s_{\text{perm}} \]

to:

\[ s_{sl} = \frac{s_{th}}{g_p} \left( g_f + \frac{g_{\text{diff}}}{1 + P_L (E_{L2,m} - 1)} + \frac{\min(g_p - g_f, g_u)}{1 + P_L (E_{L1,m} - 1)} + \frac{3,600n_s}{s_{th}} \right) \]

Page 31-46 (Correction, approved June 2012): Add the following paragraphs after the “where” paragraph following Equation 31-87: “The opposing demand flow rate $v_o$ is determined to be one of two cases. Case 1: $v_o$ equals the sum of the opposing through and right-turn volumes. Case 2: $v_o$ equals the opposing through volume. Case 2 applies is there is a through movement on the opposing approach and one of the following conditions applies: (a) there is an exclusive right-turn lane on the opposing approach and the analyst optionally indicates that this lane does not influence the left-turn drivers’ gap acceptance, or (b) there is no right-turn movement on the opposing approach. Case 1 applies whenever Case 2 does not apply.

When an exclusive right-turn lane exists on the opposing approach, the default condition is to assume that this lane does influence the subject left-turn drivers’ gap acceptance. The determination that the exclusive right-turn lane does not influence gap acceptance should be based on knowledge of local driver behavior, traffic conditions, and intersection geometry.”

Page 31-55 (Correction, approved June 2012): Add these same two paragraphs following the list of variables following Equation 31-97.

Page 31-52, Exhibit 31-16 (Correction, approved June 2012): Revise footnote (a) to read: “$G_{q2}$ is computed for each opposing lane (excluding any opposing shared left-turn lane) and the value used corresponds to the lane requiring the longest time to clear.”
The approach is considered to have one lane for this step if (a) there is one lane serving all vehicles on the approach, and (b) the left-turn movement on this approach shares the one lane.

The approach is considered to have one lane for this step if (a) there is one lane serving all vehicles on the approach, and (b) the left-turn movement on this approach shares the one lane.

There is one lane on the opposing approach when this approach has one lane serving through vehicles, a left-turn movement that shares the through lane, and one of the following conditions applies: (a) there is an exclusive right-turn lane on the opposing approach and the analyst optionally indicates that this lane does not influence the left-turn drivers’ gap acceptance, (b) there is a right-turn movement on the opposing approach and it shares the through lane, or (c) there is no right-turn movement on the opposing approach.

When an exclusive right-turn lane exists on the opposing approach, the default condition is to assume that this lane does influence the subject left-turn drivers’ gap acceptance. The determination that the exclusive right-turn lane does not influence gap acceptance should be based on knowledge of local driver behavior, traffic conditions, and intersection geometry.

The value of 0.278 in Equation 31-100 represents the approximate saturation flow rate (in vehicles per second) of vehicles in the opposing shared lane. This approximation simplifies the calculation and provides sufficient accuracy in the estimation of \( n_q \).

The value of 0.278 in Equation 31-100 represents the approximate saturation flow rate (in vehicles per second) of vehicles in the opposing shared lane. This approximation simplifies the calculation and provides sufficient accuracy in the estimation of \( n_q \).
Chapter 32, STOP-Controlled Intersections: Supplemental

Page 32-58 (Correction, approved January 2012):

- Change the first sentence of Step 10 as follows: “The departure headway of the approach lane is the sum of the products of the adjusted probabilities and the saturation headways.”
- Change the first sentence of the first paragraph of Step 12 as follows: “As noted in the procedure, the capacity of each approach lane in a subject approach is computed by increasing the given flow rate on the subject lane (assuming the flows on the opposing and conflicting approaches are constant) until the degree of utilization for the subject lane reaches 1.”
- Change the second paragraph of Step 12 as follows: “For this example, the capacity of eastbound Lane 1 can be found to be approximately 420 veh/h. This value is lower than the value that could be estimated by dividing the approach lane volume by the degree of utilization (56 / 0.1265 = 443 veh/h). The difference is due to the interaction effects among the approaches: increases in eastbound traffic volume increase the departure headways of the lanes on the other approaches, which increases the departure headway of the lanes on the subject approach.”

Page 32-59 (Correction, approved January 2012):

- Change the first sentence of Step 14 as follows: “The control delay for each approach lane is computed with Equation 20-30 as follows (eastbound Lane 1 illustrated).”
9. GENERALIZED DAILY SERVICE VOLUMES

Exhibit 31-69 shows an illustrative generalized service volume table for a signalized intersection. This particular exhibit has been prepared for illustrative purposes only and should not be used for any specific planning or preliminary engineering application because the values in the table are highly dependent on the assumed input variables. Care must be taken in constructing a table that the analyst believes is representative of a “typical” signalized intersection within the planning area. In the example table, the volumes represent the total approach volume (sum of the left, through, and right turn movements). This particular table illustrates how hourly service volumes vary with the number of through lanes on the approach and the through movement $g/C$ ratio.

The hourly service volumes could easily be converted to daily service volumes with the application of appropriate $K$- and $D$-factors. Step-by-step instructions are provided in Appendix B of Chapter 6 for users wishing to learn more about constructing one’s own service volume table.

<table>
<thead>
<tr>
<th>$g/C$ Ratio</th>
<th>Number of Through Lanes</th>
<th>LOS B (veh/h)</th>
<th>LOS C (veh/h)</th>
<th>LOS D (veh/h)</th>
<th>LOS E (veh/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40</td>
<td>1</td>
<td>130</td>
<td>610</td>
<td>730</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>270</td>
<td>1,220</td>
<td>1,430</td>
<td>1,550</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>380</td>
<td>1,620</td>
<td>1,980</td>
<td>2,000</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>320</td>
<td>720</td>
<td>840</td>
<td>910</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>630</td>
<td>1,410</td>
<td>1,610</td>
<td>1,740</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>840</td>
<td>1,780</td>
<td>2,000</td>
<td>2,250</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>490</td>
<td>830</td>
<td>940</td>
<td>1,020</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>940</td>
<td>1,580</td>
<td>1,790</td>
<td>1,930</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,180</td>
<td>1,930</td>
<td>2,000</td>
<td>2,500</td>
</tr>
</tbody>
</table>

Notes: LOS E threshold defined by control delay greater than 80 s/veh or $v/c > 1.0$. Assumed values for all entries:
- Heavy vehicles: 0%
- PHF: 0.92
- Lane width: 12 ft
- Grade: 0%
- Separate left-turn lane: yes
- Separate right-turn lane: no
- Pre-timed control
- Cycle length: 90 s
- Lost time: 4 s/phase
- Protected left-turn phasing: yes
- $g/C$ ratio for left turn movement: 0.10
- Parking maneuvers/hour: 0
- Buses stopping per hour: 0
- Percent left turns: 10%
- Percent right turns: 10%