Topic 7
Interrupted Facilities
(Part II)
Capacity and LOS (Chapters 8&10)

Input Parameters
- Geometry
- Traffic
- Signal

Lane Group and Demand
Saturation Flow Rate

Capacity and v/c
Performance Measures
  - Delay/LOS
  - Queue
Saturation Flow Rate

- Saturation headway and Saturation flow rates
  - saturation headway, $h_i$
  - saturation flow rate, $s_i$

$$s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{RT} f_{LT} f_{Rpb} f_{Lpb}$$
Lane Group

Lane group

- Basic entity for starting the analysis (only HCM 2000)
- Exclusive turn lane(s) is considered as a group
- Shared through/turn lanes are considered as a group
Required Green and Phase Time

- Required effective green, $g_i$ to achieve degree of saturation, $x_i$

\[
g_i = \frac{v_i}{s_i} \times \frac{C}{x_i} = y_i \frac{C}{x_i}
\]

- Minimum effective green, $g_i$

\[
g_i = y_i C
\]

- Minimum phase, $\Phi_i$

\[
\phi_i = g_i + \ell_i = y_i C + \ell_i
\]
Critical Phases

- **Critical phases**: conflicting phases that require the most time

- **Possible critical phases**
  - $\phi_1, \phi_2, \phi_3, \phi_4$
  - $\phi_1, \phi_2, \phi_7, \phi_8$
  - $\phi_5, \phi_6, \phi_3, \phi_4$
  - $\phi_5, \phi_6, \phi_7, \phi_8$
Example

Determine critical phases

<table>
<thead>
<tr>
<th>$\Phi_i$</th>
<th>Direction</th>
<th>$v_i$, vph</th>
<th>$s_i$, vph</th>
<th>$y_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WBL</td>
<td>120</td>
<td>1710</td>
<td>0.070</td>
</tr>
<tr>
<td>2</td>
<td>EBT</td>
<td>616</td>
<td>3600</td>
<td>0.171</td>
</tr>
<tr>
<td>5</td>
<td>EBL</td>
<td>147</td>
<td>1710</td>
<td>0.086</td>
</tr>
<tr>
<td>6</td>
<td>WBT</td>
<td>512</td>
<td>3600</td>
<td>0.142</td>
</tr>
<tr>
<td>3</td>
<td>NBL</td>
<td>78</td>
<td>1710</td>
<td>0.046</td>
</tr>
<tr>
<td>4</td>
<td>SBT</td>
<td>318</td>
<td>3600</td>
<td>0.088</td>
</tr>
<tr>
<td>7</td>
<td>SBL</td>
<td>174</td>
<td>1710</td>
<td>0.102</td>
</tr>
<tr>
<td>8</td>
<td>NBT</td>
<td>412</td>
<td>3600</td>
<td>0.114</td>
</tr>
</tbody>
</table>
Delay Studies

- Distance
- Time

- Total Delay (Control Delay)
- Stopped Delay
- Deceleration
- Acceleration

Stop Line
Uniform Delay

\[ d_1 = \frac{0.5C[1 - g / C]^2}{1 - \left[ \min(1, X) \times g / C \right]} \]
Delay (sec/veh)

\[ d = d_1 PF + d_2 + d_3 \]

\[ d_1 = \frac{0.5C[1 - \frac{g}{C}]^2}{1 - \left[ \min(1, X) \times \frac{g}{C} \right]} \]

\[ d_2 = 900T \left[ (X - 1) + \sqrt{(X - 1)^2 + \frac{8klX}{cT}} \right] \]
### Delay and LOS

<table>
<thead>
<tr>
<th>LOS</th>
<th>Delay (sec/veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;=10</td>
</tr>
<tr>
<td>B</td>
<td>10-20</td>
</tr>
<tr>
<td>C</td>
<td>20-35</td>
</tr>
<tr>
<td>D</td>
<td>35-55</td>
</tr>
<tr>
<td>E</td>
<td>55-80</td>
</tr>
<tr>
<td>F</td>
<td>&gt;80</td>
</tr>
</tbody>
</table>
HCM Procedure - Example

- **Other information**
  - Area type: non-CBD
  - Lane width: NS Left-turn lanes: 11 ft, all other 12 ft
  - Grade: NB: +2%; SB: -2%
  - Length of turn bays: LT: 150 ft; RT: 300 ft
  - Parking: No
  - PHF: 0.95
  - % HV: NS: 4%; EW: 2%
  - No bus stops
  - Pedestrian: 10/hr on each direction; WALK: 5 s; FDW: NS: 15 s; EW: 20 s
  - Arrival type: EW: 3; NS: 5

- **Geometry**

- **Traffic**

- **Signal Timing**
TRAFFIX Output
Signal Coordination

Intersection #1

Intersection #2

East Bound
Offset

- Offset is the time difference between two reference points.

- Offset must be specified by:
  - Phase
  - Begin/end phase

- Offset = 0 ~ cycle length
Offset

When the local zero occurs at 40 sec of the master clock
We say the Offset = 40 sec
Time-Space Diagram
One-way Street

#1

EB Band

#2

G=25  Y=5  R=30

G=35  Y=5  R=20

\phi_2  \phi_6

\phi_8  \phi_4

\phi_2  \phi_6

\phi_8  \phi_4

Time

CEE 362 – Spring 2006
Instructor: Zong Tian
Time-Space Diagram
Two-way Street

#1

G=25 Y=5 R=30

EB Band

φ2 φ6

φ8 φ4

#2

G=35 Y=5 R=20

WB Band

φ8 φ4

φ2 φ6

Time

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Instructor: Zong Tian
Questions

Question 1:
ϕ2 and ϕ6 at intersection #1 turn to green at 60 (0) sec, ϕ2 and ϕ6 at intersection #2 turn to green at 20 sec, what is the relative offset between intersection #1 and #2, assuming the offset is referenced to the start of green of ϕ2 and ϕ6?

Question 2:
Given the offset number in Q1, what the offset will be if the offset is referenced to the end of green of ϕ2 and ϕ6?

Question 3:
If the travel speeds are different for the two directions, will it affect the above offset results?
Bandwidth
(Dual LT Leading)
Bandwidth - Adjusted  
(Dual LT Leading)

#1
\[ \phi_1 \leftarrow \phi_2 \leftarrow \phi_6 \rightleftharpoons \phi_8 \rightarrow \uparrow \phi_4 \rightarrow \phi_5 \rightarrow \phi_6 \leftarrow \phi_2 \leftarrow \phi_1 \]

EB: 20 sec

#2
\[ \phi_8 \rightarrow \phi_4 \rightleftharpoons \phi_2 \leftarrow \phi_6 \rightarrow \phi_8 \rightarrow \phi_4 \leftarrow \phi_2 \leftarrow \phi_8 \rightarrow \phi_4 \]

WB: 12 sec
Bandwidth - Initial (Lead/Lag)

EB: 20 sec

WB: 12 sec
Bandwidth - Adjusted
(Lead/Lag)
MOEs

- Bandwidth Concept (PASSER II)
  - Bandwidth, seconds
  - Bandwidth Efficiency = Bandwidth/Cycle
  - Attainability = Bandwidth/$g_{min}$

- System-Wide Delay (Synchro)

- System-wide Stops and Delay (TRANSYT-7F)
“Yellow trap” is a situation faced by a left-turn movement when the display of “yellow” occurs to both the left-turn phase and the adjacent through phase, but the opposing through is not terminating.
Dallas phasing has louver that through vehicles cannot see
Left-turn phase about to end

PPLT - “Dallas Phasing”

1 Leading Left-turn

Adjacent Thru Head

Yellow Trap Condition
Through movements move both directions. Left-turn yield to opposing through.
Yellow trap occurs when the leading left-turn sees yellow and thinks the opposing through phase will also end.
Dallas phasing does not display yellow, and left-turn sees green ball and is supposed to still yield.
When left-turn sees yellow, the opposing phase also about to end
Main street phases end, side street phases begin
Yellow Trap

- Only the leading left-turn has the “yellow trap” with protected/permitted phasing
- Dallas Phasing solves the "yellow-trap" problem by holding a solid green indication.
- Louvers are used to shield the left-turn display so that the green display in the left-turn signal cannot be easily seen by thru drivers.

http://projects.kittelson.com/pplt/LearnAbout/Learn3.htm
Quiz

Based on what you see from the video, analyze the possible scenarios of this crash
What Could Have Happened?

- What kind of left-turn control for the main street (N/S direction)?
- What is the phasing sequence on the main street?
- According to the police report, the pedestrian signal was red at the time of the crash. Do you still think the above phasing possible?
- The video shows the southbound vehicles in both lanes came to stop, what is likely the signal indication when the vehicle stopped?
- What do you think of the speed of the side street? How could it possible if you think the speed is pretty high?
- What do you most likely to conclude about whose fault?