NEW SIGNALIZED INTERSECTION METHODOLOGY

Housekeeping

- All participant phone lines are muted to avoid distractions during presentations.

- Questions can be asked via the Question Pod. Only the instructor and moderator will see the questions submitted.

- Questions & Answer session at the end of the presentation or at specific time during the presentation.

Successful completion of this Web briefing includes:

- Verification of attendance
- Completion of course evaluation
- Passage of assessment

These requirements must be met to earn 1.5 PDH/.2 IACET CEU.

At the conclusion of the course you will receive an email with directions to the online course evaluation and quiz.

Instructor

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  - Senior Research Engineer
  - Texas Transportation Institute
  - College Station, Texas, USA
Introductory Session

- Overview and Background
  - Instructor
  - Briefing series overview
  - Objectives and scope
  - Background
  - Presentation overview

Briefing Series Overview

- HCM 2010 Overview – April 12
- New Active Traffic Mgmt. Chapter – April 14
- Unsignalized Intersections – April 26
- Multi-modal Urban Streets – April 28
- New Signalized Intersections – May 17
- Multi-modal Urban Streets: Auto Mode – May 19
- Alternative Tools: Micro simulation models – June 21
- New Freeway Weaving Methodology – June 23
- Enhancements to the Freeway Facilities – July 19
- Enhanced Planning Methods – July 21
Objectives and Scope

- **Learning Objectives**
  - Learn about new capabilities of the signalized intersections methodology
  - Understand how the methodology can be used to evaluate intersection operation

- **Scope of Presentation**
  - HCM 2010
  - Signalized intersections
    - Automobile methodology

Background

- **Research Leading to HCM 2010**
  - 35 references in Signalized Intersections chapter
Background

Research Leading to HCM 2010

- Prassas and Roess. “Left-Turn Adjustment for Permitted Turns from Shared Lane Groups.” TRR 1398, 1993.

Reports Available At:

Background

Research Leading to HCM 2010


Reports Available At:
Presentation Overview

- Session 1 – Content and Structure
- Session 2 – Methodology Basics
- Session 3 – New Capabilities

Questions

- Format for Questions
  - Enter questions/comments in the Question Pod.
  - After each session, I will spend about five minutes addressing as many as possible
Presentation Overview

- Session 1 – Content and Structure
- Session 2 – Methodology Basics
- Session 3 – New Capabilities

Session 1

- Content and Structure
  - Background
  - HCQSC vision for chapter
  - HCM 2010 organization
  - Chapter outline
Background

- HCM 2000 Signalized Intersections
  - Chapter 10 – Urban Streets Concepts
    - Terminology and variables
    - Required inputs and default values
    - 19 pages
  - Chapter 16 – Signalized Intersections
    - Influence of upstream signal based on arrival type
    - Requires phase duration as an input
    - Auto performance
    - Worksheet description
    - 161 pages

HCQSC Vision for HCM 2010

- Multi-Modal Evaluation
  - Incorporate pedestrian and bicycle methodologies
- Improve Procedures
  - Add procedure for actuated phase duration
  - Improve delay and queue length procedures
- Manual Worksheet Description not Required
  - Computational intensity of some calculations more than can be worked with worksheet
  - Working with software developers to implement
HCM 2010 Organization

- Volume 1 - Concepts
- Volume 2 – Uninterrupted Flow
- Volume 3 – Interrupted Flow
- Volume 4 – Applications Guide

http://www.hcm2010.org/

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HCM 2010 Organization

- Volume 1 - Concepts
- Volume 2 – Uninterrupted Flow
- Volume 3 – Interrupted Flow
  - Chapter 18: Signalized Intersections
- Volume 4 – Applications Guide
  - Chapter 31: Signalized Intersections: Supplemental
Chapter 18

- Signalized Intersections
  - Introduction
    - Level of service criteria
    - Required input data
    - Scope and limitations
  - Methodology
    - Automobile mode (refers to Chapter 31 for some details)
    - Pedestrian mode
    - Bicycle mode
  - Applications
    - Default values
  - Example Problems
- 107 pages

Chapter 31

- Signalized Intersections: Supplemental
  - Traffic Signal Concepts
  - Capacity and Phase Duration
  - Queue Accumulation Polygon
  - Queue Storage Ratio
  - Quick Estimation Method
  - Field Measurement Techniques
    - Control delay; Saturation flow rate
  - Computational Engine Documentation
- 124 pages
Questions?

- Content and Structure
  - Background
  - HCQSC vision for chapter
  - HCM 2010 organization
  - Chapter outline

- Questions on Content or Structure?
  - Enter questions/comments in the Question Pod.

Presentation Overview

- Session 1 – Content and Structure
- Session 2 – Methodology Basics
- Session 3 – New Capabilities
Session 2

- Methodology Basics
  - Calculation framework
  - New terms
  - New concepts
  - New input data
  - Performance measures

Calculation Framework

- Ten Steps
  - Determine groups
  - Movement group flow
  - Lane group flow
  - Saturation flow
  - Arrivals on green

Diagram:

1. Determine Movement Groups and Lane Groups
2. Determine Movement Group Flow Rate
3. Determine Lane Group Flow Rate
4. Determine Adjusted Saturation Flow Rate
5. Determine Proportion Arriving During Green
Calculation Framework

- Ten Steps
  - Phase duration
  - Capacity
  - Delay
  - LOS
  - Queue length

New Terms

- Movement Group
  - A turn movement in an exclusive lane is a group
  - All remaining lanes are one group

- Lane Group
  - A turn movement in an exclusive lane is a group
  - Any shared lane is a group
  - All remaining lanes are one group

- Difference Between Group Types
  - Apparent for mix of shared and exclusive lanes
New Terms

- **Movement Group**
  - Useful for describing needed input data

- **Lane Group**
  - Used as basis for analysis

<table>
<thead>
<tr>
<th>Number of Lanes</th>
<th>Movements by Lanes</th>
<th>Movement Groups (MG)</th>
<th>Lane Groups (LG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Left, thru., &amp; right:</td>
<td>MG 1:</td>
<td>LG 1:</td>
</tr>
<tr>
<td>5</td>
<td>Exclusive left:</td>
<td>MG 1:</td>
<td>LG 1:</td>
</tr>
<tr>
<td></td>
<td>Through:</td>
<td>MG 2:</td>
<td>LG 2:</td>
</tr>
<tr>
<td></td>
<td>Thru. &amp; right:</td>
<td></td>
<td>LG 3:</td>
</tr>
</tbody>
</table>

New Concepts

- **Peak Hour Factor (PHF)**
  - Converts peak hour to peak 15-min flow rate

- **HCM 2010 uses “Intersection” PHF**
  - PHF is based on total entering volume during common 15-min period
  - Each movement has same value of PHF

- **HCM 2000 used “Movement” PHFs**
  - Each movement can have unique value of PHF
  - Approach tended to overestimate flow during the common 15-min peak period
New Concepts

- Level of Service Criteria (LOS)
  - No change in threshold values
  - V/C ratio now used (with delay) for lane group LOS

<table>
<thead>
<tr>
<th>Control Delay (s/veh)</th>
<th>LOS by Volume-to-Capacity Ratio*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤1.0</td>
</tr>
<tr>
<td>≤10</td>
<td>A</td>
</tr>
<tr>
<td>&gt;10–20</td>
<td>B</td>
</tr>
<tr>
<td>&gt;20–35</td>
<td>C</td>
</tr>
<tr>
<td>&gt;35–55</td>
<td>D</td>
</tr>
<tr>
<td>&gt;55–80</td>
<td>E</td>
</tr>
<tr>
<td>&gt;80</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>&gt;1.0</td>
</tr>
<tr>
<td></td>
<td>F</td>
</tr>
</tbody>
</table>

Note: * For approach-based and intersection-wide assessments, LOS is defined solely by control delay.

New Concepts

- Movement Numbers

![Diagram of Traffic Movements]

- Major Street
  - Vehicle Movements
  - Pedestrian Movements

- Minor Street
  - 5
  - 12
  - 14
  - 6P
  - 16
  - 6
  - 1

- Movement Numbers
  - 2
  - 4P
  - 8P
  - 3
  - 8
  - 18
New Concepts

Dual-Ring Structure

- Ring defines sequence of conflicting movements
- Barrier separates movements on each street
- Example sequence for two one-way streets

![Diagram of Dual-Ring Structure]

New Concepts

Dual-Ring Structure

- Example sequence for leading left-turn phases
  - Left-turn phase times first, then opposing through phase

![Diagram of Dual-Ring Structure with left-turn phases]
New Input Data

- Traffic
  - Approach speed

- Controller Settings
  - Passage time (vehicle interval, unit extension)
  - Maximum green
  - Minimum green
  - Walk + pedestrian. clear
  - Recall (min, max, ped)

- Detector Design
  - Detector length

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New Input Data

- **PPLT w/ Flashing Yellow (Dallas Phasing)**
  - Permissive left period is concurrent with conflicting through phase

- **Traditional PPLT**
  - Permissive left period is concurrent with adjacent through phase (less green arrow)
New Input Data

- HCM 2000 Input
  - Average phase duration for actuated control
  - No longer an input for HCM 2010
- Replicating Pretimed Control
  - Set maximum green to desired duration
  - Set Recall to “max”

Performance Measures

- Measures in HCM 2010
  - Control delay
  - Volume-to-capacity ratio
  - Queue storage ratio
    - Ratio of back-of-queue to available storage
    - Ratio > 1.0 indicates queue spillover
  - Probability of phase termination by max out
Questions?

- Methodology Basics
  - Calculation framework
  - New terms
  - New concepts
  - New input data
  - Performance measures
- Questions on Methodology Basics?
  - Enter questions/comments in the Question Pod.

Presentation Overview

- Session 1 – Content and Structure
- Session 2 – Methodology Basics
- Session 3 – New Capabilities
Session 3

- New Capabilities
  - Actuated phase duration
  - Uniform delay
  - Queue length
  - Evaluation possibilities

Actuated Phase Duration

- Procedure Overview
  - Compute queue service time ($g_s$)
  - Compute green extension time ($g_e$)
  - Example: exclusive lane, through movement

```
<table>
<thead>
<tr>
<th>Number of Vehicles in Queue</th>
<th>0</th>
<th>1</th>
<th>1</th>
<th>s - q_q</th>
</tr>
</thead>
<tbody>
<tr>
<td>time, s</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

```
\begin{align*}
\text{Queue length} & = Q_r \\
\text{Green extension time} & = g_e \\
\text{Actuated phase duration} & = g + g_e
\end{align*}
```
Actuated Phase Duration

Procedure Overview

- Process is iterative
- Choose a starting value, compute other variables, find convergence
- Green = f(queue service time, green extension)
  - Queue service time = f(lane vol., sat. flow rate, cycle)
  - Cycle length = f(green)
  - Green extension = f(green, queue service time, cycle)
- Sat. flow rate for lefts = f(green)
- Lane volume = f(sat. flow rate)

Calibration

- Simulation data
- Data point – one-hour average for one phase

\[
y = 0.97x + 0.50
\]

\[R^2 = 0.97\]

Standard Deviation = 2.1 s
Uniform Delay

HCM 2000 Procedure for Estimating Delay

- Equation based on area of triangle
- Works well for protected movements in an exclusive lane (or lanes)

\[ d_1 = \frac{0.5C(1 - \frac{q}{C})^2}{1 - \min(1, X) \frac{q}{C}} \]

Uniform Delay

2010 HCM Procedure for Estimating Delay

- Computes delay as area of queue polygon
- Works for all movements and lane assignments
- Permitted, protected, protected-permitted
- Exclusive lane, shared lane

\[ d_{in} = \frac{0.5 \sum_{i=1}^{n} (Q_{i-1} + Q_i)t_{i,j}}{qC} \]
Uniform Delay

Calibration
- Simulation data
- Data point – one-hour average for one phase

Queue Length
- Back-of-Queue
  - Maximum backward extent of queued vehicles during a typical cycle
  - When back-of-queue reached, not likely to be more than one vehicle stopped
- Queued Vehicle
  - Vehicle that fully stops because of signal
- Full Stop
  - Vehicle slows to zero (or crawl speed) because of change from green to red

\[ y = 1.03x - 1.70 \quad R^2 = 0.92 \]
Queue Length

- Components of Back-of-Queue, $Q$
  - $Q = Q_1 + Q_2 + Q_3$
  - First term ($Q_1$)
    - Queue due to signal cycle
  - Second term ($Q_2$)
    - Queue due to cycle failure (random overflow)
    - Queue due to oversaturation
  - Third term ($Q_3$)
    - Queue due to initial queue at start of analysis period

Queue Length

- First Term Back-of-Queue
  - HCM 2010 is based on stopped vehicles
  - HCM 2000 is based on slowing + stopped vehicles
Queue Length

- New Capabilities
  - Focus on fully stopped vehicles
  - Models for predicting all three terms refined
  - Percentile queue length equation refined

Evaluation Possibilities

- Possible Scenarios
  - Impact of flashing yellow prot.-perm. left-turn
  - Impact of providing protected right-turn phase
  - Impact of changes to various actuated controller settings
    - Maximum green
    - Passage time
    - Phase recall (ped., min., max)
  - Impact of signal operation on ped. or bicyclist
Software Availability

- **HCS 2010 (McTrans)**
  - HCS+ users with active support subscriptions will receive HCS 2010 automatically by mail
- **VISUM 11.5 (PTV)**
  - May 2011 service pack will include HCM 2010 method for pretimed signalized intersections
- **TEAPAC Complete 2010 (Strong Concepts)**

Questions?

- **New Capabilities**
  - Actuated phase duration
  - Uniform delay
  - Queue length
  - Evaluation possibilities
- **Questions on New Capabilities?**
  - Enter questions/comments in the Question Pod.
Closure

- Forthcoming Briefings
  - Multi-modal Urban Streets: Auto Mode – May 19
  - New Material on the Use of Alternative Tools – June 21
  - New Freeway Weaving Methodology – June 23
  - Enhancements to the Freeway Facilities – July 19
  - Enhanced Planning Methods & Application of Generalized Service Volume Tables – July 21

- Thanks for your time!

Thank You

Please provide your feedback. A link to an online Web briefing evaluation will follow in an e-mail to Web briefing registrants. Please distribute this email to participants at your site. The evaluation will close in one week.

Questions/Comments
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