Updates

With updates to Synchro and with changes and/or clarifications to the Year 2010 Highway Capacity Manual, it may be necessary to revisit the information presented in this document. Trafficware expects to issue periodic updates, when necessary, to describe ongoing development and support of HCM 2010 features within Synchro 9. This section is reserved to identify and track periodic updates to this document.
Quick Reference Guide

If you’re interested in simply knowing how Synchro incorporates the HCM 2010 methodologies without all the extra information, this section is for you. One word of caution, though. Take the time to read this document at least once. The limitations of the HCM 2010 methodologies are critical elements to understand as you compare it to other analysis methodologies. It is Trafficware’s goal to match the methods as they are described in the manual.

Signalized Intersections

- Auto, Pedestrian, and Bike modes available
- NEMA Phasing adherence
- Stop-bar detection
- Be sure to input right turns on red (RTOR)
- Calibration parameters can be adjusted by user
- Coordination effects are taken into account for intersections within 0.60 miles
- Platoon ratio is calculated by Synchro, but can be adjusted by the user

Two-Way Stop Control Intersections

- Auto and Pedestrian modes available
- One and two-stage maneuvers are coded using a pull-down menu
- U-turns and six-lane arterials
- Flared right turn approaches
- Coordination effects are taken into account for signalized intersections within 0.60 miles

All-Way Stop Control Intersections

- Overall intersection delay and LOS is displayed

Roundabouts

- One, two-lane, and combination of one/two lane circulatory roadways
- Yielding and free-flowing slip ramps
- Follow-up and Critical Headways are user adjustable
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Executive Summary

Welcome to Trafficware’s White Paper summarizing the Synchro Version 9 implementation of the methodologies included within the Transportation Research Board’s 2010 Highway Capacity Manual (HCM 2010). This document is intended to be a ‘living document’ or working paper that is maintained and disseminated online at www.trafficware.com. If you are also a user of Synchro 8, be sure to review the Working White Paper for Synchro 8.

As updates to Synchro become available, or when changes and/or clarifications are made to the HCM 2010, this document will be revised and an updated version posted online. The intent of this document is to highlight key issues related to the HCM 2010 rather than an exhaustive account of the various methodologies. It is highly recommended that you review the HCM 2010 manual in addition to this white paper. It is Trafficware’s goal to match the methods as they are described in the manual.

Overview of the HCM 2010

The HCM 2010 is a publication of the National Academy’s Transportation Research Board (TRB). The 2010 version is the fifth major edition of the manual and synthesizes more than 50 years of transportation-related research into the concepts and procedures for evaluating the multimodal performance of highway and street facilities. The HCM 2010 includes a significant set of changes as compared with the earlier Year 2000 Edition. These latest changes are substantial both in terms of scope and complexity and many of the methodologies require intense calculations that are not feasible for manual or worksheet-based operation.

The HCM 2010 includes several new chapters and is reorganized into four major volumes, including an electronic-only Volume 4 that would house many of the supplemental chapters, example problems, a technical reference library, and various computational engines developed for several of the more complex procedures. It should be noted that the computational engines were developed by TRB to evaluate some, but not necessarily all, of the procedures described within the various chapters of the HCM 2010. Based on information provided by the TRB Committee on Highway Capacity and Quality of Service (HCQS), electronic versions of the Volume 4 material would be maintained online at www.hcm2010.org. Changes and clarifications to the HCM 2010 would also be posted at this web address.

In addition to the traditional focus on vehicular movement, the manual also includes various methods aimed at analyzing the ever increasing nonautomotive modes of travel. The integration of pedestrians and bicyclists within each chapter of the HCM provides transportation professionals the ability to assess the overall transportation experience from the user’s perspective. Trafficware’s intent is to include the nonautomotive analysis methods within Synchro.

One of the new methodologies included within the HCM 2010 allows users to analyze roundabouts. The new method is based on actual field data collected within the U.S. The methodology is based on the work of the National Cooperative Highway Research Project (NCHRP) Project 3-65, Roundabouts in the United States (NCHRP Report 572). Overall, the new gap-based methodology yields lower capacity values compared to similar roundabout methods.

As with any operational analysis methods, there will always be a set of limitations that surround the use of the various methodologies. Most of the limitations set forth by TRB for the HCM 2010 are similar to those of the HCM 2000. As you begin to use Synchro to conduct a HCM 2010 analysis, one should review the HCM 2010 to confirm that use of HCM 2010 is applicable. Each section of this white paper includes a list of the primary limitations, as noted by TRB.
Implementation of the HCM 2010

Synchro 9.0 (releases 900) currently supports the signalized intersection, all-way stop control (AWSC), two-way stop control (TWSC), and the roundabout methods. Table 1 depicts a summary of the various HCM 2010 analysis methods and which methods have been incorporated within Synchro 9.

Table 1 - HCM 2010 Operational Methods

<table>
<thead>
<tr>
<th>HCM 2010</th>
<th>Description</th>
<th>Modes Within HCM 2010</th>
<th>Modes Within Synchro 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 18</td>
<td>Signalized Intersections</td>
<td>A, P, B</td>
<td>✓</td>
</tr>
<tr>
<td>Chapter 19</td>
<td>Two-Way Stop-Controlled Intersections</td>
<td>A, P</td>
<td>✓</td>
</tr>
<tr>
<td>Chapter 20</td>
<td>All-Way Stop-Controlled Intersections</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>Chapter 21</td>
<td>Roundabouts</td>
<td>A</td>
<td>✓</td>
</tr>
</tbody>
</table>

Notes: 1. A = Auto, P = Pedestrian, B = Bicycle, T = Transit
2. na = not applicable. HCM 2010 does not support a method at this time.
3. ✓ = HCM 2010 Method included within Synchro 9.
4. Coordination between intersections is based on the methods described in Chapter 17.

To facilitate an HCM 2010 analysis, a new icon has been added to the primary toolbar across the top of the screen. To access this icon, select the desired link or node and left click this icon:

Upon pressing the HCM 2010 icon, a screen that mimics the various HCM 2010 methodologies will appear. Trafficware has implemented the operational methods as they are presented within the HCM 2010 Manual. It should be noted that each of the methods have various limitations and applicability set forth by TRB based on the various methods that were developed. It is strongly recommended that you review these limitations as outlined by TRB. The limitations for each method (as defined by TRB) are also summarized in the following sections of this white paper.

A report can be generated for all of the HCM 2010 analysis methods. Select the desired node and either press [CTRL] + [R] or go to ➔ FILE, ➔ CREATE REPORT, ➔ HCM 2010 REPORTS of your choice.
Section 1 – Signalized Intersections (Auto Mode)

This section summarizes what’s new in the HCM 2010 for the automobile mode at isolated signalized intersections and how Synchro has implemented the applicable sections of Chapter 18 (Signalized Intersections) and Chapter 31 (Supplemental Signalized Intersections). It should be noted that additional calculations, as described in Chapter 17 (Urban Street Segments), are required for actuated-coordinated intersections. Appendix A provides a brief summary of the new method for shared-lane analysis that was incorporated since the release of Build 804.

Introduction

There are several significant and complex changes to the automobile methodologies for signalized intersections. Many of these changes require the user to provide additional inputs as compared with the previous Year 2000 Edition of the HCM. Many of these new inputs are in fact already inputs for Synchro. The computational steps for these procedures are outlined in Chapter 18 and Chapter 31 of the HCM 2010, but are fully-realized within the details of the material in Volume 4’s computational engine 7.12. Some of the major changes as compared with the 2000 HCM include:

- Modeling of fully-actuated controllers.
- One saturation flow rate for the entire intersection.
- One PHF for the entire intersection.
- Two new concepts, Timers and Lane Groups, are used during the analysis.
- The use of dual-ring NEMA signal phasing (See Page 5) that accounts for actuated control.
- A new method for calculating green time referred to as the iterative phase duration estimation procedure.
- A new method for calculating delay referred to as the incremental queue accumulation method that is more flexible in accounting for changes in saturation flow rates with different combinations of left-turn phasing operation, sequence, and lane usage. The method accounts for changing capacities and arrival rates during a signal cycle.
Timers and Lane Groups

A basic understanding of these new concepts within the HCM 2010 signalized intersection methodology is vital to understanding some of the limitations described below. Once a user has completed entering an intersections’ signal phasing, each signal phase is assigned to one of the eight available timers. **Timers** are similar to the NEMA ring structure and must operate in number sequence with timers 1 through 4 in ring 1 and timers 5 through 8 in ring 2. For a standard eight phase intersection, the timers will most likely match the phase numbers. However, for a split-phased intersection (for example) some timers may be associated to a different phase number. Synchro automatically determines the appropriate timers, thus requiring no additional user input. Figure 1 depicts an example of the timer concept.

![Figure 1 – HCM 2010 Timer Concept](image)

The concept of **Lane Groups** is another key concept that is new to the analysis of signalized intersections. This new concept analyzes operations based on lane groups versus that of turning movements. The HCM 2010 specifies a series of lane groups that are to be used throughout the average delay and queue calculations. Figure 2 depicts an example of a Synchro HCM 2010 report and the relationship between lane groups and turning movements.

![Figure 2 – HCM 2010 Timer Concept](image)
Delay & Level of Service Thresholds
The LOS thresholds for lane groups now take into account the volume-to-capacity (v/c) ratio, in addition to control delay, such that any value above 1.0 would denote LOS ‘F’ regardless of the corresponding value of control delay. Values for approach and overall intersection LOS are still based on just control delay. The following table lists the LOS thresholds for the automobile mode at a signalized intersection:

Table 2 – Signalized Intersection (Auto Mode) LOS Thresholds

<table>
<thead>
<tr>
<th>Control Delay (seconds per vehicle)</th>
<th>Level of Service (v/c ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10.0</td>
<td>≤ 1.0 A</td>
</tr>
<tr>
<td>&gt; 10.0 – 20.0</td>
<td>&gt; 1.0 F</td>
</tr>
<tr>
<td>&gt; 20.0 – 35.0</td>
<td>&gt; 1.0 F</td>
</tr>
<tr>
<td>&gt; 35.0 – 55.0</td>
<td>&gt; 1.0 F</td>
</tr>
<tr>
<td>&gt; 55.0 – 80.0</td>
<td>&gt; 1.0 F</td>
</tr>
<tr>
<td>&gt; 80.0</td>
<td>&gt; 1.0 F</td>
</tr>
</tbody>
</table>

Known Issues and Limitations
As with any operational analysis methods, there will always be a set of limitations that surround the use of the various methodologies. Most of the limitations set forth by TRB for the HCM 2010 are similar to those of the HCM 2000. As you begin to use Synchro to conduct a HCM 2010 analysis, one should review the HCM 2010 to confirm that use of HCM 2010 is applicable. The following bullets highlight the key limitations as identified by TRB:

Overall Intersection
- Intersections with three (3) or four (4) approaches.
- Isolated from nearby intersections. Adjustments for actuated-coordinated networks only.
- Phasing must adhere strictly to standard NEMA phasing.

Auto Mode
- Turn bay overflow
- Multiple advance detectors per travel lane
- Demand starvation due to closely spaced intersections
- Queue spillback between intersections
- Phase overlaps (i.e. typical diamond interchange phasing)
- Right-turn movements not under signal control
- Right-turn on red (RTOR) delays are considered negligible and are not calculated
- Turn movements served by more than two exclusive lanes
- Drop or add lanes along intersection approaches
- Rest-in-walk mode for actuated and non-coordinated phases
- Stop Line detection only
**Synchro’s Signalized Intersection Screen (Auto Mode)**

Once a user has created a signalized intersection, pressing the HCM 2010 icon allows the user to interactively view the results based on the HCM 2010 methods. Several of the displayed values are carried over from the Synchro LANE, VOLUME, TIMING, PHASING, and/or DETECTOR setting windows. There are, however, many new input parameters based on the HCM 2010 procedures. The figure below depicts the HCM 2010 screen within Synchro. It should be noted that the “calibration parameters” as defined by the HCM 2010 Manual, are located along the left window pane (HCM Intersection) portion of the screen.
Overview of Methodology for Select Input Parameters

Since the new HCM 2010 method focuses on actuated signal control, there are a few input parameters related to signal timing/phasing that we would like to define. These parameters have been in previous versions of Synchro, but have not been identified as a key parameter by earlier versions of the HCM.

- **Ring & Barrier Structure** – A ring is a term that is used to describe a series of conflicting phases that occur in an established order. A good understanding of the ring structure is a good way to understand the operation of multiphase controllers. A barrier (compatibility line) is a reference point in the preferred sequence of a multi-ring controller unit at which all rings are interlocked. Barriers assure there will be no concurrent selection and timing of conflicting phases for traffic movements in different rings. The traffic actuated controller usually employs a "dual ring concurrent" timing process. As noted above, if the phasing numbering scheme coded within Synchro does not comply with NEMA, Synchro will display to the user that the intersection is non-compliant. It should be noted that this is a limitation of the computational engine and not Synchro.

- **Recall Mode** – A parameter which results in a phase being called by the controller regardless if a vehicle or pedestrian has been detected. Minimum green, maximum green, or pedestrian recalls are the most common.

- **Dual Entry** – A parameter that is used to call vehicle phases that can time concurrently even if only one of the phases is receiving an active call.

- **Simultaneous Gap-Out** – A parameter that, when enabled, requires defined phases that are timing concurrently to simultaneously reach a point of being committed to terminate before they can be allowed to jointly terminate. It should be noted that this parameter is Off by default within Synchro.

- **Fixed Force-Off** – A parameter that, when enabled, allows time to be allocated to phases later in the cycle rather than directly to the coordinated phases. It should be noted that this parameter is Off by default within Synchro.

A few other input parameters required by the HCM 2010 methods are also worth highlighting. Users are encouraged to refer to the HCM 2010 Manual for additional details.

- **Right-Turn On Red Flow Rate (veh)** – The number of vehicles that turn right on red during the specified analysis period. The user should input a value based on field observations.

- **Platoon Ratio** – This is a critical parameter that describes the quality of progression for a platoon of vehicles arriving on green at the upstream or downstream coordinated intersection. Platoon Ratio is a calculated value ranging from 0 to 2.0. The operational assessment of coordinated intersections is described in Chapter 17 (Urban Street Segments) and was not incorporated within TRB’s computational engine. Table 3 includes a brief description of the HCM 2010 platoon ratios.

- **Opposing Right-Turn Lane Influence** – This parameter should be reviewed, when an exclusive right turn lane exists, to determine whether or not the gap acceptance of the opposing left turn is influenced.
Table 3 – Signalized Intersection Platoon Ratios

<table>
<thead>
<tr>
<th>Platoon Ratio</th>
<th>Arrival Type</th>
<th>Description of Traffic Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.333</td>
<td>1</td>
<td>Very poor progression</td>
</tr>
<tr>
<td>0.667</td>
<td>2</td>
<td>Unfavorable progression</td>
</tr>
<tr>
<td>1.000</td>
<td>3</td>
<td>Uncoordinated signals or random arrivals</td>
</tr>
<tr>
<td>1.333</td>
<td>4</td>
<td>Favorable progression</td>
</tr>
<tr>
<td>1.667</td>
<td>5</td>
<td>Highly favorable progression</td>
</tr>
<tr>
<td>2.000</td>
<td>6</td>
<td>Exceptional progression</td>
</tr>
</tbody>
</table>

Synchro calculates a platoon ratio based on the user input Reference Phase along each approach of a coordinated intersection based on the following:

✓ Upstream signalized coordinated intersection within 0.60 miles.
✓ Cycle Length of the upstream intersection must be equal to study intersection’s.
✓ Reference phase of upstream intersection points towards study intersection.

The user can override the calculated value based on field conditions.

- **Upstream Filtering Adjustment Factor** – The upstream filtering adjustment factor accounts for the effect of an upstream signal on vehicle arrivals to the subject movement group. Specifically, this factor reflects the way an upstream signal changes the variance in the number of arrivals per cycle. The variance decreases with increasing volume-to-capacity ratio, which can reduce cycle failure frequency and resulting delay. This value ranges from 1.0 for an isolated intersection to as low as 0.09 if an upstream intersection is within 0.60 miles of the study intersection.

- **Base Saturation Flow Rate** – The maximum rate of flow for an individual traffic lane. The default value based on the HCM 2010 is 1,900 pc/h/ln. A value of 1,700 pc/h/ln can be used for areas with a population less than 250,000. A new parameter has been added within the HCM 2010 Intersection pane to allow users to set the saturation flow rate for the entire intersection.

In addition to the above noted input values required by the HCM 2010 method, there are several calibration parameters that can be adjusted by the user, if deemed necessary, to match field conditions. See HCM 2010 manual for additional information.

**Additional Discussion of Known Issues and Limitations**

With the initial implementation of the HCM2010 signalized intersection procedures in Synchro, several issues are apparent and there are implicit and explicit limitations that the user should bear in mind. With pending clarifications and/or changes to the supporting text and computation code, some of these conditions may be addressed in the near future. These items are not exhaustive and may not address all possible issues the user might encounter. Updates are expected to address some of these issues; however, they currently include the following:
• There are a number of limitations of the HCM 2010 methodologies as stated in Chapter 18 that are handled by capabilities already offered in Synchro, including but not necessarily limited to: impacts on delay as the result of queue spillback, starvation, and storage blocking; multiple detectors in the same lane; turn movements served by more than two exclusive lanes; through movements served by more than 4 lanes; the inhibition of maximum settings or the allocation of unused time to non-coordinated phases; gap reduction of variable initial settings associated with actuated volume-density control.

• The HCM 2010 procedures rely on a strict adherence to a standard 2-ring NEMA 8-phase configuration and design, such that phases 1 and 5 are intended for use as the primary roadway left-turn phases, phases 2 and 6 are intended for use as the primary roadway through phases, phases 3 and 7 are intended for use as the secondary roadway left-turn phases, and phases 4 and 8 are intended for use as the secondary roadway through phases. If the given signalized intersection deviates from this convention, Synchro currently issues a warning message and the HCM 2010 results are not displayed.

The methods do in fact support several combinations of left-turn phase operation and sequence, split phasing, right-turn overlaps during supporting left-turn phases, and leading or lagging left-turn operations; however, several common phasing situations are not supported and results would not be generated with the following:

  o Exclusive pedestrian or hold phases;
  o More than one intersection on the same controller (group or cluster control);
  o Phasing Overlap (other than right-turn overlap phasing);
  o A-typical phase numbering; and
  o More than 8 phases, or more than 2 phases in either ring on either side of the barrier.

• Synchro does not currently support the HCM 2010 option to disable simultaneous gap-out under actuated control. In most situations, simultaneous gap-out would be enabled such that concurrent phases would terminate together at the barrier and not independently. Synchro assumes that simultaneous gap-out would be enabled and that concurrent phases would terminate together at the barrier before servicing a conflicting call.

• Certain lane geometries are not currently support by the HCM 2010 computational engine. For example, a left turn movement that operates from both an exclusive and a shared lane. A future clarification and/or change to the HCM 2010 is expected to address this issue and provide improved computational code and/or supporting text; however, in the meantime, this limitation exists in the HCM 2010 module as implemented by Synchro. Appendix A includes information related to the new method included within Build Release 804.
Section 2 Signalized Intersections (Pedestrian Mode)

This section identifies what’s new in the HCM 2010 for the pedestrian mode at signalized intersections and how Synchro has implemented the applicable sections of Chapter 18 (Signalized Intersections) and Chapter 31 (Supplemental Signalized Intersections). It should be noted that a “quality of service” score is calculated along each approach of the intersection instead of the traditional average intersection delay.

Introduction

The new HCM 2010 method consists of five key steps focused on pedestrian activity at an intersection’s corners as well as the crosswalk. The new method requires additional pedestrian and geometric data that typically would not have been collected at an intersection. A few of these include:

- Directional pedestrian volumes at each corner
- Type of pedestrian control
- Individual corner dimensions
- Individual crosswalk dimensions

If you are interested in this analysis method, one should review the HCM 2010 Manual along with this section to determine how to conduct your analysis.

Delay & Level of Service Thresholds

Steps 1 & 2, identified above, provide engineers and planners with the amount of circulation area that pedestrians have at each intersection corner and crosswalk. These values can be compared to the thresholds included in Table 4 to evaluate an intersection’s circulation experience. The descriptions can be used to determine an appropriate set of improvements to improve the pedestrian experience. Steps 3-5 are then completed to calculate a Score that can be compared to the threshold values listed in Table 5. A level of service can then be determined for each of the crosswalks. An overall intersection pedestrian score is not, however, attainable.

<table>
<thead>
<tr>
<th>Pedestrian Space (ft²/p)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 60</td>
<td>Ability to move in desired path, no need to alter movements</td>
</tr>
<tr>
<td>&gt; 40 – 60</td>
<td>Occasional need to adjust path to avoid conflicts</td>
</tr>
<tr>
<td>&gt; 24 – 40</td>
<td>Frequent need to adjust path to avoid conflicts</td>
</tr>
<tr>
<td>&gt; 15 – 24</td>
<td>Speed and ability to pass slower pedestrians restricted</td>
</tr>
<tr>
<td>&gt; 8 – 15</td>
<td>Speed restricted, very limited ability to pass slower pedestrians</td>
</tr>
<tr>
<td>≤ 8</td>
<td>Speed severely restricted, frequent contact with other users</td>
</tr>
</tbody>
</table>
Table 5 – Signalized Intersection (Pedestrian Mode) Quality of Service Thresholds

<table>
<thead>
<tr>
<th>Score</th>
<th>Level of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2.0</td>
<td>A</td>
</tr>
<tr>
<td>&gt; 2.0 – 2.75</td>
<td>B</td>
</tr>
<tr>
<td>&gt; 2.75 – 3.50</td>
<td>C</td>
</tr>
<tr>
<td>&gt; 3.50 – 4.25</td>
<td>D</td>
</tr>
<tr>
<td>&gt; 4.25 – 5.00</td>
<td>E</td>
</tr>
<tr>
<td>&gt; 5.00</td>
<td>F</td>
</tr>
</tbody>
</table>

Known Issues and Limitations

As you begin to use Synchro to conduct a HCM 2010 analysis, please review this section (as well as the HCM 2010 itself) to familiarize yourself with the various methods and their limitations. The following bullets highlight the key limitations:

**Overall Intersection**
- Intersections with three (3) or four (4) approaches.
- Isolated from nearby intersections. Adjustments for actuated-coordinated networks only.
- Phasing must adhere strictly to standard NEMA phasing.

**Pedestrian & Bicycle Modes**
- Crosswalk grades > 2%
- Presence of railroad crossings
- Unpaved sidewalks
- Free channelized right turn lanes with multiple lanes or high travel speeds
Synchro’s Signalized Intersection Screen (Pedestrian Mode)

Once a user has created a signalized intersection, pressing the HCM 2010 icon allows the user to interactively view the results based on the HCM 2010 methods. Several of the displayed values are carried over from the Synchro LANE, VOLUME and TIMING setting windows. There are, however, many new input parameters based on the HCM 2010 procedures. The figure below depicts the HCM 2010 screen within Synchro. Figure 3 includes a sketch of the pedestrian data coded within the Synchro screen.

Figure 3 – Signalized Intersection (Pedestrian Mode) Crosswalk Example
Overview of Select Input Parameters
Since some of the input parameters used for the pedestrian methodology, we would like to highlight a few. Here are a few that may be new to you:

- **Type of Control** – This is the type of control that the pedestrian has available to them. Is there a push-button available?
- **Veh. Perm L. Flow in Walk (v/h)** – This is the permitted left-turn demand flow rate, in units of vehicles per hour. This number is NOT the total hourly left-turn flow rate, it’s only the flow rate of the permitted turns.
- **Veh. Perm R. Flow in Walk (v/h)** – This is the permitted right-turn demand flow rate, in units of vehicles per hour. This number is assumed to be the TOTAL permitted right-turn flow rate, including RTOR's.
- **Veh. RTOR Flow in Walk (v/h)** – This is the right-turn on red flow rate, in units of vehicles per hour. This would be the RTOR within the right-turning flow rate that could otherwise turn permissively into the crosswalk while the crosswalk is being used by pedestrians.
Section 3 Signalized Intersections (Bicycle Mode)

This section identifies what’s new in the HCM 2010 for the bicycle mode at signalized intersections and how Synchro has implemented the applicable sections of Chapter 18 (Signalized Intersections) and Chapter 31 (Supplemental Signalized Intersections). It should be noted that a “quality of service” score is calculated along each approach of the intersection instead of the traditional average intersection delay.

Introduction

The new HCM 2010 method consists of three key steps aimed at determining the LOS of bicyclists traveling through an intersection. The method is applicable of bicyclists within the flow of traffic and is not intended for shared-use paths. A few additional parameters are required for this method, so be sure to collect the additional data from the field. A few of these include:

- Presence of a Bicycle Lane
- Presence of Paved Shoulder
- If a Curb is Present?

If you are interested in this analysis method, one should review the HCM 2010 Manual along with this section to determine how to conduct your analysis.

Delay & Level of Service Thresholds

Based on the intersection data, a Score for each approach is calculated and the appropriate LOS threshold, as indicated in Table 6, is assigned. An overall intersection pedestrian score is not, however, attainable.

Table 6 – Signalized Intersection (Bicycle Mode) Quality of Service Thresholds

<table>
<thead>
<tr>
<th>Control Delay (s/pedestrian)</th>
<th>Level of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2.0</td>
<td>A</td>
</tr>
<tr>
<td>&gt; 2.0 – 2.75</td>
<td>B</td>
</tr>
<tr>
<td>&gt; 2.75 – 3.50</td>
<td>C</td>
</tr>
<tr>
<td>&gt; 3.50 – 4.25</td>
<td>D</td>
</tr>
<tr>
<td>&gt; 4.25 – 5.00</td>
<td>E</td>
</tr>
<tr>
<td>&gt; 5.00</td>
<td>F</td>
</tr>
</tbody>
</table>
Known Issues and Limitations

As you begin to use Synchro to conduct a HCM 2010 analysis, please review this section (as well as the HCM 2010 itself) to familiarize yourself with the various methods and their limitations. The following bullets highlight the key limitations:

Overall Intersection

- Intersections with three (3) or four (4) approaches.
- Isolated from nearby intersections. Adjustments for actuated-coordinated networks only.
- Phasing must adhere strictly to standard NEMA phasing.

Pedestrian & Bicycle Modes

- Crosswalk grades > 2%
- Presence of railroad crossings
- Unpaved sidewalks
- Free channelized right turn lanes with multiple lanes or high travel speeds

Synchro's Signalized Intersection Screen (Bicycle Mode)

Once a user has created a signalized intersection, pressing the HCM 2010 icon allows the user to interactively view the results based on the HCM 2010 methods. Several of the displayed values are carried over from the Synchro LANE, VOLUME and TIMING setting windows. There are, however, many new input parameters based on the HCM 2010 procedures. The figure below depicts the HCM 2010 screen within Synchro.

Overview of Select Input Parameters

At this time, no additional discussion is required.
Section 4 Two-Way Stop Control Intersections (Auto Mode)

This section identifies what’s new in the HCM 2010 for two-way stop control (TWSC) intersections and how Synchro has implemented the applicable sections of Chapter 19 (TWSC Intersections) and Chapter 32 (Supplemental Stop-Controlled Intersections).

Introduction

The HCM 2010 method for TWSC intersections is very similar to the HCM 2000 method. The method is still based upon gap-acceptance but has been enhanced to accommodate a few additional volume and geometric scenarios. These include:

- U-Turns
- Flared Approaches
- Six-Lane Roadways

As you begin to code a TWSC intersection within Synchro, there are a few additional input parameters that may be new to you. This section highlights the new TWSC screen within Synchro.

Delay & Level of Service Thresholds

The LOS thresholds for lane groups now take into account the volume-to-capacity (v/c) ratio, in addition to control delay, such that any value above 1.0 would denote LOS ‘F’ regardless of the corresponding value of control delay. Values for approach and overall intersection LOS are still based only on control delay. The following table lists the LOS thresholds for the automobile mode at a TWSC intersection:

<table>
<thead>
<tr>
<th>Control Delay (seconds per vehicle)</th>
<th>Level of Service (v/c ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10.0</td>
<td>A</td>
</tr>
<tr>
<td>&gt; 10.0 – 15.0</td>
<td>B</td>
</tr>
<tr>
<td>&gt; 15.0 – 25.0</td>
<td>C</td>
</tr>
<tr>
<td>&gt; 25.0 – 35.0</td>
<td>D</td>
</tr>
<tr>
<td>&gt; 35.0 – 50.0</td>
<td>E</td>
</tr>
<tr>
<td>&gt; 50.0</td>
<td>F</td>
</tr>
</tbody>
</table>

Within the new HCM 2010 window pane, a few new notations have been added to account for specific issues related to the HCM 2010 methodology. These notations will also be displayed if a report is created and the notes are applicable to the intersection.

- $ Delay more than 300 seconds.
- * All conflicting volume is present in crossing platoon. No conflicting volume in random arrival phase.
- ! Computation is not supported by HCM 2010 Methodology.
- ‐ Not applicable.
Known Issues and Limitations

As with any operational analysis methods, there will always be a set of limitations that surround the use of the various methodologies. As you begin to use Synchro to conduct a HCM 2010 analysis, one should review the HCM 2010 to confirm that use of HCM 2010 is applicable. The following bullets highlight the key limitations as identified by TRB:

**TWSC Overall Intersection/Auto Mode**

- Intersections with three (3) or four (4) approaches.
- Major Roadway – Maximum of three through lanes (shared or exclusive).
- Minor Roadway – Maximum of three through lanes with no more than one exclusive lane per movement.
- Accounts for coordinated intersection effects only.

**Synchro’s Two-Way Stop Control Intersection Screen (Auto Mode)**

Once a user has created a TWSC intersection, pressing the HCM 2010 icon allows the user to interactively view the results based on the HCM 2010 methods. Several of the displayed values are carried over from the Synchro LANE, VOLUME and TIMING setting windows. The figure below depicts the HCM 2010 screen within Synchro.
Overview of Select Input Parameters

Based on the methodology of the HCM 2010, there are a few parameters within Synchro that requires a brief overview. The following parameters should be coded if a two-stage analysis or the effects of flared approaches are desired:

- **Vehicles in Median Storage (#)** – To account for a two-stage maneuver, users should select (1) for one vehicle and (2) for two vehicles stored in the median. Two vehicles is the storage limit based on HCM 2010 methodology. It should be noted that for the HCM 2000 method, selecting TWLTL Median will automatically assume two vehicles can be stored in the median.

- **Flared Approaches** – To account for flared approaches, users should select Right Turn Channelized-Stop Controlled with a value of 40’. For use in SimTraffic, consider reducing Crosswalk Width (ft.) to three feet in the simulation settings table.

- **Time Blocked by Platoon (%)** – This value represents the percentage of time that the vehicles along the stop-controlled approach are blocked by platoons of vehicles traveling along the coordinated arterial. For Synchro to calculate this value, the Include Upstream Signal? parameter in the HCM 2010 Intersection window pane should be set to Yes. Synchro calculates a Timer Blocked by Platoon (%) value based on the following:
  
  ✓ Upstream signalized intersection within 0.60 miles.
  ✓ Signal must be within a coordinated arterial.
  ✓ Reference phase of upstream intersection points towards study intersection.

The user can override the calculated value based on field conditions.

Additional Discussion of Known Issues and Limitations

- Under certain scenarios with upstream or downstream signals, HMC 2010 Equation 19-35 yields undesirable values when zero is selected as $v_{c_{u},k}$ based on Equation 19-33. This assumes all conflicting flow happens during the platoon block time. In these situations, Synchro assigns a value of one (1) for use in Equation 19-35. It is represented with “**” superscript preceding the value within the Synchro HCM 2010 window pane as well as in the report. This prevents zeroing of the Capacity in Equation 19-35, and the results are observed to be closer to expected.

- HCM references various tables with parameters used in the calculations based on the total number of through lanes along the study roadway (2, 4, and 6 lanes). Trafficware uses these values but divides them up to number of lanes by approach (1, 2, and 3 lane approach). This allows the user to analyze an intersection with an unequal number of through approach lanes in the calculations as it relates to conflicting volumes for various movements.
Section 5 Two-Way Stop Control Intersections (Pedestrian Mode)

This section identifies what’s new in the HCM 2010 for the pedestrian mode at two-way stop control intersections and how Synchro has implemented the applicable sections of Chapter 19 (TWSC Intersections) and Chapter 32 (Supplemental Stop-Controlled Intersections).

Introduction

The new HCM 2010 method consists of six steps focused on pedestrians crossing the major street of a TWSC intersection. The new method requires pedestrian and driver characteristics at the intersection. A few of these include:

- Do pedestrians cross in one or two stages?
- Is Pedestrian Platooning present?
- Driver yield rates

If you are interested in this analysis method, one should review the HCM 2010 Manual along with this section to determine how to conduct your analysis.

Delay & Level of Service Thresholds

Once the average pedestrian delay is calculated, the LOS thresholds listed in Table 8 are applied to the overall intersection.

Table 8 – TWSC Intersection (Pedestrian Mode) LOS Thresholds

<table>
<thead>
<tr>
<th>Control Delay (seconds per pedestrian)</th>
<th>Level of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>A</td>
</tr>
<tr>
<td>5 - 10</td>
<td>B</td>
</tr>
<tr>
<td>10 - 20</td>
<td>C</td>
</tr>
<tr>
<td>20 - 30</td>
<td>D</td>
</tr>
<tr>
<td>30 - 45</td>
<td>E</td>
</tr>
<tr>
<td>&gt; 45</td>
<td>F</td>
</tr>
</tbody>
</table>

Known Issues and Limitations

As with any operational analysis methods, there will always be a set of limitations that surround the use of the various methodologies. As you begin to use Synchro to conduct a HCM 2010 analysis, one should review the HCM 2010 to confirm that use of HCM 2010 is applicable. The following bullets highlight the key limitations as identified by TRB:

TWSC Overall Intersection

- Intersections with three (3) or four (4) approaches.
- Major Roadway – Maximum of three through lanes (shared or exclusive).
- Minor Roadway – Maximum of three through lanes with no more than one exclusive lane per movement.
- Accounts for coordinated intersection effects only.

TWSC Pedestrian Mode
- Midblock crossings.
- Crossing of up to four through lanes.
- Random arrivals, equal directional and lane distribution on the major street.
- Upstream signals not accounted for.
- Pedestrians walking parallel to roadway do not impact crossing pedestrians.

Synchro’s Two-Way Stop Control Intersection Screen (Pedestrian Mode)

Once a user has created a TWSC intersection, pressing the HCM 2010 icon followed by the Pedestrian Mode Tab allows the user to interactively view the results based on the HCM 2010 method. Several of the displayed values are carried over from the Synchro LANE setting window. Be sure that the values for Crosswalk Length and Lanes Crossed match those in the field.
Overview of Select Input Parameters

Based on the methodology of the HCM 2010, there are a few parameters within Synchro that require a brief overview. The following characteristics of the pedestrian crossing are critical inputs to the HCM 2010 method:

- **Median Present?** – If the roadway has a median or pedestrians cross the roadway in two-stages, be sure to code the median width within the Simulation Settings window. This will populate the appropriate number of crosswalk segments that are required for the analysis. The total delay to pedestrians is calculated per crosswalk (consists of two segments if pedestrians cross in two-stages).

- **Marked/Unmarked Crosswalk** – HCM 2010 Exhibit 19-17 includes a list of the effect of various pedestrian crossing treatments on motorist yield rates. Refer to this table for Yield Rates.

- **Pedestrian Platooning** – If pedestrians cross the roadway in groups, then select Yes for this parameter. This parameter affects the spatial distribution of pedestrians.
Section 6 All-Way Stop Control Intersections

This section identifies what’s new in the HCM 2010 for all-way stop control (AWSC) intersections and how Synchro has implemented the applicable sections of Chapter 20 (AWSC Intersections) and Chapter 32 (Supplemental Stop-Controlled Intersections).

Introduction

The HCM 2010 method for AWSC intersections is very similar to the HCM 2000 method. The method is still based upon gap-acceptance along with determining the probability of over 500 different arrival patterns.

Delay & Level of Service Thresholds

The LOS thresholds for lane groups now take into account the volume-to-capacity (v/c) ratio, in addition to control delay, such that any value above 1.0 would denote LOS ‘F’ regardless of the corresponding value of control delay. Values for approach and overall intersection LOS are still based on just control delay. The following table lists the LOS thresholds for the AWSC intersections:

<table>
<thead>
<tr>
<th>Control Delay (seconds per vehicle)</th>
<th>Level of Service (v/c ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10.0</td>
<td>A</td>
</tr>
<tr>
<td>&gt; 10.0 – 15.0</td>
<td>B</td>
</tr>
<tr>
<td>&gt; 15.0 – 25.0</td>
<td>C</td>
</tr>
<tr>
<td>&gt; 25.0 – 35.0</td>
<td>D</td>
</tr>
<tr>
<td>&gt; 35.0 – 50.0</td>
<td>E</td>
</tr>
<tr>
<td>&gt; 50.0</td>
<td>F</td>
</tr>
</tbody>
</table>

Within the new HCM 2010 window pane, a few new notations have been added to account for specific issues related to the HCM 2010 methodology. These notations will also be displayed if a report is created and the notes are applicable to the intersection.

$ Delay more than 300 seconds.

* All conflicting volume is present in crossing platoon. No conflicting volume in random arrival phase.

! Computation is not supported by HCM 2010 Methodology.

- Not applicable.
Known Issues and Limitations

As with any operational analysis methods, there will always be a set of limitations that surround the use of the various methodologies. Most of the limitations set forth by TRB for the HCM 2010 are similar to those of the HCM 2000. As you begin to use Synchro to conduct a HCM 2010 analysis, one should review the HCM 2010 to confirm that use of HCM 2010 is applicable. The following bullets highlight the key limitations as identified by TRB:

AWSC Overall Intersection (Auto Mode Only)
- Intersections with three (3) or four (4) approaches.
- Isolated from nearby intersections.
- Up to three lanes per approach.
- Pedestrian effects not considered.

Synchro’s All-Way Stop Control Intersection Screen

Once a user has created a AWSC intersection, pressing the HCM 2010 icon allows the user to interactively view the results based on the HCM 2010 methods. Several of the displayed values are carried over from the Synchro LANE, VOLUME and TIMING setting windows. The figure below depicts the HCM 2010 screen within Synchro.

Overview of Select Input Parameters

At this time, no additional discussion is required.
Section 7 – Roundabouts

This section identifies what’s new in the HCM 2010 for roundabouts and how Synchro has implemented the applicable sections of Chapter 21 (Roundabouts) and Chapter 33 (Supplemental Roundabouts).

Introduction

The new HCM 2010 methodology for analyzing roundabouts is based on a gap-acceptance paradigm. The method was developed from empirical data collected at roundabouts within the U.S. Unlike the 2000 HCM method, an analysis of slip-ramps and two-lane roundabouts can be conducted. Field data collected at U.S. roundabouts were used in developing the methodology.

Delay & Level of Service Thresholds

The LOS thresholds for lane groups now take into account the volume-to-capacity (v/c) ratio, in addition to control delay, such that any value above 1.0 would denote LOS ‘F’ regardless of the corresponding value of control delay. Values for approach and overall intersection LOS are still based on just control delay. The following table lists the LOS thresholds for the AWSC intersections:

<table>
<thead>
<tr>
<th>Control Delay (seconds per vehicle)</th>
<th>Level of Service (v/c ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10.0</td>
<td>A</td>
</tr>
<tr>
<td>&gt; 10.0 – 15.0</td>
<td>B</td>
</tr>
<tr>
<td>&gt; 15.0 – 25.0</td>
<td>C</td>
</tr>
<tr>
<td>&gt; 25.0 – 35.0</td>
<td>D</td>
</tr>
<tr>
<td>&gt; 35.0 – 50.0</td>
<td>E</td>
</tr>
<tr>
<td>&gt; 50.0</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>&gt; 1.0</td>
</tr>
<tr>
<td></td>
<td>F</td>
</tr>
</tbody>
</table>
Known Issues and Limitations

As with any operational analysis methods, there will always be a set of limitations that surround the use of the various methodologies. As you begin to use Synchro to conduct a HCM 2010 analysis, one should review the HCM 2010 to confirm that use of HCM 2010 is applicable. The following bullets highlight the key limitations as identified by TRB:

Roundabout Overall Intersection/Auto Mode

- Intersections with three (3) or four (4) approaches.
- Isolated from nearby intersections, including nearby roundabouts or signalized intersections.
- Not intended for rotaries, neighborhood traffic circles, or signalized approaches.
- Up to two entry lanes and up to one bypass lane per approach.
- Maximum of two circulating lanes.
- Short-flared lanes.
- Extremely high traffic volumes.
- A moderate level of pedestrian or bicycle activity.

Synchro’s Roundabout Screen

Once a user has created a roundabout, pressing the HCM 2010 icon allows the user to interactively view the results based on the HCM 2010 methods. Several of the displayed values are carried over from the Synchro LANE, VOLUME, and TIMING setting windows. The figure below depicts the HCM 2010 screen within Synchro.
Overview of Select Input Parameters

The new HCM 2010 methodology for analyzing roundabouts is based a gap-acceptance model. The analysis is conducted on a lane-by-lane basis along each approach of the roundabout. Capacities for each entry lane are calculated based on circulating and exiting flow rates. Coding roundabouts within Synchro is easy. The user, however, should be aware of a few parameters that are critical in assessing the operational performance of the roundabout. A few of these are:

- **Conflicting Lanes** – This is the internal conflicting circular lanes within the roundabout. The number of lanes can vary by approach.

- **By-Pass Lanes** – Several roundabout configurations include by-pass lanes (also referred to as slip ramps) to reduce the volume/lane. The new method accommodates either yielding or free right turn by-pass lanes.

- **Follow-Up Headway** – The amount of time between vehicles entering roundabout. The maximum entry flow is given by 3,600 s/h divided by the follow-up headway, which is analogous to the saturation flow rate for a movement receiving a green indication at a signalized intersection.

- **Critical Headway** – This parameter is based on the amount of time required for a vehicle to safely enter the conflicting stream.

It should be noted that the defaults values for follow-up and critical headway generally provide conservative capacity values, especially for regions of the U.S. that have existing roundabouts. Chapter 32 of the HCM 2010 includes a discussion for “calibrating” these parameters based on field data.
Section 8 – Appendix A

Intersections that include approach geometrics with an exclusive left/right turn lane and a shared left/right turn /through lane are not fully supported by the HCM 2010. To overcome this limitation, Trafficware has developed a method to estimate volumes (using equivalency factors) by lane group categories that are HCM 2010 compliant.

The method is relatively straight-forward and focuses the analysis of the shared lane(s) functioning as a de facto lane. The shared volume components are used to determine if the shared lane functions as a de facto lane, i.e. if the shared Left-Thru lane has a much higher presence of Lefts, than Through movements, then the shared lane can be analyzed as a de facto Left, and vice versa.

The method consists of the following three key steps;

- **Step 1**: Distribution of volumes based on a Lane-by-Lane assignment – An average volume is computed using the exclusive left/right turn volume plus volume attributed to an exclusive through lane. The average is determined based on the number of left/right and through lanes per approach.

- **Step 2**: Comparing the Left/Right Volume in Shared Lanes – Once the volumes have been distributed, a preference factor (0.90) is used to bias the preference towards the Through movement. Depending on the greater volume of the two shared components, the Shared Lane is identified either as a de facto left, through, or right.

- **Step 3**: Adjustment of Volumes – The volumes are multiplied by an equivalency factor to account for lane assignment. The table below highlights the current default values.

<table>
<thead>
<tr>
<th></th>
<th>Left Lane</th>
<th>Thru Lane</th>
<th>Right Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Vehicle</td>
<td>1.00</td>
<td>1.40</td>
<td>0.90</td>
</tr>
<tr>
<td>Thru Vehicle</td>
<td>0.70</td>
<td>1.00</td>
<td>0.67</td>
</tr>
<tr>
<td>Right Vehicle</td>
<td>1.07</td>
<td>1.50</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Let’s consider an example to highlight the steps described above. Consider the illustrated approach geometry (shown below) with one exclusive left and right turning lanes, and one thru lane share with lefts. Let the original volumes be represented as VL, VT and VR respectively.

Based on the methodology listed above, the following two approach lane geometrics are possible;

The table below includes a summary of eight possible volume scenarios and the corresponding shared lane that is determined based on the methodology above.

<table>
<thead>
<tr>
<th>#</th>
<th>Approach Type</th>
<th>Original Volumes</th>
<th>Adjusted Volumes</th>
<th>Shared Lane acting as:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>600</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>325</td>
<td>275</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>600</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>350</td>
<td>250</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>600</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>375</td>
<td>225</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>600</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>500</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>275</td>
<td>225</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>500</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>500</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>325</td>
<td>175</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>Single Left, Shared Left/Thru Single Right</td>
<td>500</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>350</td>
<td>150</td>
<td>50</td>
</tr>
</tbody>
</table>