WSDOT SYNCHRO & SIMTRAFFIC PROTOCOL – AUG 2018

Synchro version 10

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Introduction

Description of Synchro and SimTraffic

Synchro is an analytical/deterministic tool that is distributed by Trafficware. WSDOT recommends that Synchro be considered when analyzing arterials, signalized and unsignalized intersections. Synchro is not recommended for analyzing roundabouts. SimTraffic is a very basic microsimulation model, which is part of the Synchro Studio Package. WSDOT recommends that SimTraffic be considered for use as an error check/validation tool for a Synchro model, as well as a tool to gather additional measures of effectiveness (MOE's) for "simple networks." In SimTraffic (version 10) it is only possible to effectively define a route through two intersections, not the entire network. Therefore, WSDOT recommends limiting MOE extraction from SimTraffic to only those networks that require routing two or less intersections, or "simple networks." While it is possible to simulate more than two intersections (a long straight corridor for examples), only do so when there is no need to route through more than two intersections.

For further discussion on recommended uses of Synchro or SimTraffic, along with the current version adopted by WSDOT, refer to the WSDOT Traffic Analysis Guidebook.

Purpose

This protocol assumes the user has a basic knowledge of Synchro and SimTraffic. In addition, it is assumed that Synchro or SimTraffic has already been determined to be the appropriate tool (through the use of the WSDOT Traffic Analysis Guidebook). If you come across any of the following scenarios: oversaturated conditions, starvation from upstream intersection, or spillback from downstream intersections, please consult the Synchro User Guide (provided by Trafficware and available through the *Help* dropdown menu within the Synchro software).

This protocol is intended for use on WSDOT project to promote consistent Synchro application and provide guidance. WSDOT requires results to be reported using Highway Capacity Manual (HCM) 6th ed. methodology.

Using Synchro for Alternative Intersection and Interchange Design such as those listed below should be discussed with the WSDOT Region Traffic office prior to developing a model. For more information on these alternative intersections and interchanges see FHWA's Alternative Intersection/Interchanges: Informational Report (AIIR)[1] and Cap-X (see HQ Traffic to obtain the excel spreadsheet).

- Displaced Left Turn Intersection and Displaced Left Turn Interchange
- Median U-Turns
- Restricted Crossing U-Turn Intersection
- Diverging Diamond Interchanges (DDI)
- Quadrant Roadway Intersections
- Single Point Urban Interchange (SPUI)

Parameters are divided into three categories together with various levels of guidance (see below). To propose a value other than what is recommended or outside the thresholds listed in this protocol, discuss the proposal with the Region Traffic Office and document the decision in the Methods and Assumptions document (WSDOT Methods and Assumptions Document template can be found on the Access and Hearings website: http://www.wsdot.wa.gov/design/accessandhearings/).

Synchro

Synchro is used for various types of analysis. Typically, these analyses can be broken down into two categories: analysis of existing condition and analysis of future condition- generally defined as 10 or more years from the time of analysis. Examples of existing conditions are: use in Signal Operations work, or analyzing an existing network for a proposed project. An example of a future condition would be, analyzing the opening year of a developer project, or analyzing the alternatives (including the "No Build" scenario) of a proposed project for the horizon year. Design/horizon years are defined and discussed in the WSDOT Design Manual 1103 – Design Control Selection.

The subsequent sections will provide recommendations for parameters within Synchro. For some parameters the recommendation varies depending on the type of analysis.

Input parameters: Categories A, B, C

For analysis of existing conditions, field measurements and observations are the preferred inputs. This includes signal timing information, which can be obtained from the entity responsible for maintaining the timing (It is also recommended to check with WSDOT's Region Traffic office to request any base or existing Synchro file as a starting point, this may help reduce duplication of efforts, as well as speed up

[1] https://www.fhwa.dot.gov/publications/research/safety/09060/

the review process). All parameters within Synchro have been identified as one of the following categories:

Category A: Input parameters with specific thresholds or values are provided in this protocol.

Category B: Input parameters that are dependent on project data and/or are unique to a particular project. Minimal guidance provided.

Category C: Input parameters that should remain as the default value. Modifying these parameters requires written justification and approval from Region traffic office or HQ Traffic office. These parameters consist of all parameters not listed in Category A or Category B, a list will not be provided in this protocol.

Synchro Standard Input Parameters Category A

- Geometric/Analysis Input Parameters
  - Link distance
  - Volumes
- Lane Settings
  - Link Speed
  - Ideal Saturation Flow Rate
- Volume Settings
  - Peak Hour Factor
- Timing Settings
  - Control Type
  - Cycle Length
  - Optimizing guidance
  - Detector guidance
  - Minimum initial
  - Minimum Split
  - Total Split
  - All-Red Time
  - Yellow Time
  - Lagging phase
  - Recall Mode
- Phasing Settings
  - Walk Time
  - Flash Don't walk
  - Pedestrian Calls

- Geometric/Analysis Input Parameters
  - Link distance – Use field measurements for analysis of existing conditions. Use existing field measurements or design plans for analysis of a future conditions.
  - Volumes – Use field measurements for analysis of an existing conditions. For field measurements gathered during congested conditions, make sure the data accounts for unserved demand. Projected future condition volumes should be obtained from a combination of the following (depending on availability), listed in no particular order:
    - Travel Demand Model – volumes should be post processed (a proposed methodology should be outlined in the Methods and Assumptions document)
    - Contact WSDOT Transportation Data, GIS & Modeling Office (TDGMO) http://www.wsdot.wa.gov/mapsdata/tdgo_home.htm for assistance establishing an appropriate growth rate, access to the Traffic Data Geoportal which lists tube counts and permanent traffic recorders (PTR), or request additional information.
    - WSDOT ECM Portal also provides previously conducted counts. This site is only available to WSDOT employees. For those outside WSDOT interested in information

from this portal, contact the region traffic for assistance. http://wwwi.wsdot.wa.gov/IT/ECM/Portal/default.htm

- Contact Region Traffic office for previously conducted intersection counts, previously completed analysis, and other local information not available through above mentioned sources.

- Lane Settings
    - Link Speed – Use existing speed data or posted speed
    - Ideal Saturation Flow Rate – The preferred methodology for determining the appropriate value is to conduct a field study. However, when that is not available, or feasible, the recommended values are 1750 urban areas, 1900 for rural. Guidance can vary by region:
        - Olympic Region – Unless otherwise directed by Region Traffic Office, use 1800 vphpl

- Volume Settings
    - Peak Hour Factor (PHF)
        - Analysis of existing conditions: One PHF should be calculated for each intersection, not per approach or per movement. See HCM for calculation. It is not recommended to use a PHF below 0.80.
        - Analysis of future conditions: Calculating a PHF requires 15-minute increment volumes. Future volumes are typically only known in hour increments. In addition, future volumes are based on the land use information entered into a Travel Demand Model, or engineering judgment to propose a growth rate. Neither provide 15-minute increment information. A PHF between 0.92 and 1.0 is acceptable, however, justification must be provided if PHF other than 1.0 is used.

- Timing Settings
    - Control Type – For analysis of existing conditions the control type can be determined by contacting the entity responsible for the timing at that signal. Control type for analysis of future conditions will be determined via analysis or surrounding network conditions (ex: a new signal is proposed in the middle of an already coordinated corridor, use Actuated Coordinated).
        - Pretimed: this is primarily used to analyze existing pretimed signals
        - Actuated Uncoordinated: this is primarily used for an isolated signalized intersection.
        - Semi Actuated Uncoordinated: not typically used by WSDOT
        - Actuated Coordinated: this is primarily used for network progression situations
        - Unsignalized: this is used for stop controlled intersections
        - Roundabout: as of Synchro version 10, WSDOT does not recommended Synchro for roundabout analysis
    - Cycle Length – For analysis of existing conditions contact the entity responsible for timing the signal. For analysis of future conditions, cycle lengths should be approved by WSDOT Region traffic or WSDOT HQ traffic.

- Optimizing guidance – Do not use the Optimize Cycle length or Optimize Splits feature for analysis of existing conditions, use existing timing. For analysis of future conditions, it is recommended to use the timing based on similar intersections rather than optimized timings, as the optimized timing may be unrealistic. Do not allow the optimization to shorten cycles/splits to the point where pedestrians are not accommodated (see "Walk Time" below).
- Detector guidance – Contact the entity responsible for the timing at the signal. For analysis of future conditions, in general, for WSDOT, stop bar loops are typically three 6 ft round loops (36' detection zone) and where mainline has a speed limit greater than 35 mph, include two advance loops per lane. See WSDOT Design Manual Chapter 1330: Traffic Control Signals
- Minimum initial – for analysis of existing conditions contact the entity responsible for the timing at the signal. For analysis of future conditions use 5 seconds.
- Minimum Split – set to Minimum Green + Yellow + Red, or if there is a pedestrian phase to Walk + FDW + Yellow + Red.
- Total Split – for analysis of existing conditions contact the entity responsible for the timing at the signal. For analysis of future conditions set according to similar intersections.
- All-Red Time – For analysis of existing conditions contact the entity responsible for the timing. For analysis of future conditions use the same value as existing, or set to 1 second. For intersections with larger clearance time (example: SPUI or DDI), consider an all-red time of longer than 1.0 second and consult with Region Traffic office.
- Yellow Time –For analysis of existing conditions contact the entity responsible for the timing. For analysis of future conditions utilize the same timing unless the speed limit or roadway grade is to be changed. The yellow time shall be a minimum of 3 seconds and a maximum of 6 seconds. Yellow time for left turns will equal the yellow time for the adjacent through movement. Yellow time for concurrent phases will match (use highest yellow time).
- Lagging phase – for analysis of existing conditions contact the entity responsible for the timing at the signal. Do not check "Allow Lead/Lag Optimize."
- Recall mode – for analysis of existing conditions contact the entity responsible for the timing at the signal. For analysis of future conditions of actuated signals, mainline phases are set to Min and side streets are set to None. For coordinated signals set mainline to C-Min or C-Max.

- Phasing Settings
    - Maximum Split – typically range from 20 seconds to 80 seconds.
    - Walk Time -contact the entity responsible for the timing at the signal. For analysis of future conditions, use the same value as existing or 7 seconds, whichever is larger.
    - Flash Don't Walk - contact the entity responsible for the timing at the signal. For analysis of future conditions, use total pedestrian crossing distance (measured curb to curb) ÷ 3.5 fps. For example, for a roadway with five 12 ft lanes and two 8 ft shoulders the FDW will be 76 ft ÷ 3.5 fps=22 seconds.
    - Pedestrian Calls – For analysis of existing conditions, utilize manual pedestrian counts if available. Be mindful to use pedestrian calls not pedestrian volumes if multiple pedestrians are served in the same pedestrian phase. For analysis of future conditions see the Synchro User Guide (developed by Trafficware and available through the *Help* dropdown menu within the Synchro software). Document methodology for converting pedestrian volume into pedestrian calls.

Synchro Standard Input Parameters Category B

Less guidance is provided for Category B parameters. This is due to the project specific nature of these parameters. It is anticipated that several will be adjusted from their default parameters, and the value/justification used will be based on field measurements, observations, or design plan data.

- Lane Settings
    - Grades: enter existing or proposed grades, this parameter will impact the ideal saturation flow rate.
    - Storage Length: use effective storage length (typically the distance from the stop bar back to the taper's width reduction point) of existing field measurements for analysis of existing conditions and existing field measurements, design plan data, necessary length for acceptable v/c, or a combination of these.

- Volume Settings –
    - Conflicting peds: enter the number of pedestrians per hour based on pedestrian counts (Note: this is different than the Pedestrian Call value, which is number of calls per hour).
    - Adjacent Parking: if on street parking is present, check the appropriate affected lane group and enter the corresponding maneuvers per hour. Note that entering zero maneuvers per hour is not the same as coding no available parking.
    - Heavy Vehicle (%): when available, enter in the HV% by movement. If HV% is not broken down by movement, a HV% by approach is acceptable.
    - Traffic from midblock: this parameter can be used to code in the proportion of traffic that enters from either a driveway or minor unsignalized intersection that is not specifically coded. This can help to simplify coding.

Reviewing and Reporting Guidance

- Volume Balance between adjacent nodes
- Addressing "#" and "m" footnotes in a report
- Coding Error Check
- Appropriate use of MOE's
- Analyzing intersections that don't fit HCM 2010 methodology

- Volume balance between adjacent nodes:
  - For intersections with no access points in between (driveways, intersections, etc.), such as a many ramp terminals, the volume balance should be zero.
  - Although it is not uncommon to have a minor difference in volume between nodes, corrections should be made and justification should be provided for locations that exceed the thresholds listed below. In some cases, volumes may not be balanced between urban intersections due to driveways and approaches, therefore, a reasonable variance is acceptable.
    - A difference of ± 15 vph for links with ≤ 100 vph (one direction,)
    - A difference of ± 25 vph for links with ≥ 101 and ≤ 250 vph (one direction,)
    - A difference of ± 35 vph for links with ≥ 251 vph (one direction, per lane)
    - A difference of ± 5% for links over 700 vph (one direction, per lane)

    If new counts are to be conducted for the analysis, it is recommended that as many intersections along the corridor as possible be counted on the same day to reduce the potential for volume discrepancies.
- Addressing reported footnotes (~, #, m):
  - As outlined in the Synchro User Guide (provided by Trafficware and available through the *Help* dropdown menu within the Synchro software), " ~ " indicates the approach is above capacity for the 50th percentile traffic and the queue length could be longer; "#" indicates that the volume for the 95th percentile cycle exceeds capacity; and "m" indicates that volume for the 95th percentile queue is metered by an upstream signal.
  - Approaches or movements with these footnotes should be reviewed and documentation should be provided if it is determined that no adjustments will be made to Synchro.
- *Coding Error Check*: this can be found under the *Options* drop down in the main toolbar. Before any analysis is finalized or reports are run, all errors or warnings should be justified or corrected.
- Appropriate use of MOE's
  - It is not recommended to use any queue length from an analysis of future conditions as the sole source of turn length justification.

  - Contact entity responsible for the timing of the signal to determine desired reported MOEs. Commonly reported MOEs include but are not limited to 95% queue, % blocking and network delay.
- Analyzing intersections that don't fit HCM 6th ed. methodology: certain signal configurations may not be compatible with the latest HCM methodology. Here are a few possible examples that existed under the 2010 HCM:
  - Clustered Intersections
  - An existing condition without stop-line detection. Detectors cannot be further than 20 ft from the stop bar for HCM methodology to be utilized.
  - Signals that do not follow typical NEMA phasing
  - Intersections with more than four approaches
  - Turning movements with shared and exclusive lanes
  - If speed limits are less than 25 mph, or exceed 55 mph
  - Exclusive pedestrian or hold phases

  For these locations, if a reasonable workaround cannot be found, it is recommended that results be submitted using HCM 2000 methodology. In addition, these locations should be called out in the Methods and Assumptions document prior to beginning analysis. Based on the total percentage of intersections that don't fit HCM methodology and how critical those intersections are to the project (out skirts of the study area vs. main intersection of concern) discuss with HQ Traffic or Region Traffic Office regarding whether to conduct the entire analysis in HCM 2000 or just those that don't fit the methodology.

SimTraffic

NOTE: This section is currently being written. An updated protocol will be provided on the WSDOT website when this section is completed. For now, please refer to the following table:

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per SimTraffic v. 10.1.1.1)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
GLOBAL SETTINGS (Adjusted within SimTraffic)	*Driver Parameters*	Yellow Deceleration (ft/s^2)	7.0 - 12.0	8 to 10	Yes	Increase to make drivers less prone to running red lights.
		Speed Factor (%)	0.85 - 1.15	No range specified	Yes	Can be changed to increase or decrease the range of driver speeds (e.g. for a link speed of 50 mph and a speed factor of 1.1, the driver will attempt to maintain a speed of 55 mph).
		Courtesy Deceleration (ft/s^2)	3.0 - 10.0	7 to 9	Yes	Amount of deceleration a vehicle will accept in order to allow a vehicle ahead to make a mandatory lane change. Higher value = more courteous driver.
		Yellow Reaction Time (s)	0.7 - 1.7	No range specified	No	Amount of time it takes a driver to respond to a signal changing to yellow. More aggressive drivers will have a longer reaction time to yellow lights. Longer reaction times tends to reduce red light running for higher speed approaches and vehicles slowing to make a turn, however, may increase red light running for low speed approaches.
		Green Reaction Time (s)	0.2 - 0.8	0.5 to 2.0	Yes	Amount of time it takes the driver to respond to a signal changing green. More aggressive drivers will have a shorter reaction time to green lights.
		Headway at 0 mph (s)	0.35 - 0.65	No range specified	Yes, typically modify last	Interpolation used between these factors. May be necessary to change to match local driver parameters. The default headways provide an Saturation Flow Rate similar to the HCM (1900 vphpl) from 25 to 50 mph.
		Headway at 20 mph (s)	0.80 - 1.80	2 to 2.5		
		Headway at 50 mph (s)	1.00 - 2.20	1.7 to 2.0		
		Headway at 80 mph (s)	1.00 - 2.20	2.0 to 2.5		
		Gap Acceptance Factor	0.85 - 1.15	No range specified	Yes	Gap vehicles will accept at unsignalized intersections, for permitted left-turns, and for right turns on red. Higher values represent more conservative drivers.
		Positioning Advantage (veh)	1.2 - 15.0	Use defaults	No	Drivers will make a positioning lane change when there is ≥x vehicles ahead in the target lane than in the current lane. Higher values are associated with more conservative drivers and cause drivers to line up in correct lane. Lower values are associated with aggressive drivers and cause drivers to avoid lining up in the correct lane until reaching the mandatory lane change point.
		Optional Advantage (veh)	0.5 - 2.3	Use defaults	No	Drivers will make a desired lane change when ≤x vehicles are ahead in the target lane than in the current lane. Higher values are associated with more conservative drivers and cause drivers to have unbalanced lane use. Lower values are associated with aggressive drivers and cause drivers to use lanes evenly.
		Mandatory Distance Adjustment (%)	50 - 200	No range specified	Yes	Global multiplier for local lane change settings.
		Positioning Distance Adjustment (%)	60 - 150	No range specified	Yes	Global multiplier for local lane change settings.
		Average Lane Change Time (s)	10 - 55	No range specified	No	Average time between lane change maneuvers. Applies only to optional lane changes, which are made to choose a lane with less congestion. Less time applies to more aggressive drivers.
		Lane Change Variance +/- (%)	10 - 30	No range specified	No	Adjustment similar to Average Lane Change Time, but base on driver type. Applies only to optional lane changes, which are made to choose a lane with less congestion. Higher percentage leads to increased awareness of lane change.
	Vehicle Parameters	Vehicle parameters (Occurrence, acceleration, dimensions, etc.)	See Synchro Studio 10 User Guide, Chapter 26 (page 26-7)	Defaults typically acceptable Modify vehicle fleet based on field classification counts if needed	Yes	Modify vehicle percentages based on nearest classification count. Fleet mix should add up to 100% for all truck types and 100% for all car types.

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per SimTraffic v. 10.1.1.1)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
LOCAL SETTINGS (Adjusted within Synchro)	*Synchro Settings*	Link Speed (Lane Settings)	30	Start with posted. Adjust to reflect free flow speed (typically posted + 5 mph), if needed.	Yes	May be adjusted to match field speeds if data is available and speeds are not being used for validation
		Ideal Saturation Flow Rate (Lane Settings)	1,900	Adjust to match field if field data is available	Yes	Refer to TEOpS 16-15-5 for additional guidance on saturation flow rates for through lanes
		Growth Factor (Volume Settings)	1.0	Use for sensitivity testing or future year scenarios. Do not use for RTOR	No	
		Headway Factor (Simulation Settings)	1.0	0.8 to 1.2	Yes	Can be set on a per-movement basis. Can be used to calibrate the Saturated Flow Rates.
		Turning Speed (Simulation Settings)	9 mph (right-turns) 15 mph (left-turns)	Right turns = 12 to 15 mph	Yes	Default speeds are set for small radius urban intersections. With large suburban intersections, turning speeds may be significantly higher. Right-turns speeds need to be adjusted to or near the freeway speeds when simulating entrance ramps. At low speeds, the Saturated Flow Rate is highly sensitive to small changes in speed. Right-turns: SimTraffic = 9 mph (1545 vph). HCM for protected rights = 1615 vphpl Left-turns: SimTraffic = 15 mph (1883 vph). HCM for protected left-turns = 1805 vph.
		Mandatory Distance (Simulation Settings)	333	Base on field conditions	Yes	Distance ahead vehicle is forced to make lane change. Measured from Stop bar. Increase to allow vehicles to shift into correct lane earlier. Decrease to allow vehicles to shift into lane at the last possible moment. Large cities: Shorter mandatory distances Small towns: Longer mandatory distances. Useful to adjust with congested signals or lane drops after signals. With long turn bays consider setting this to less than the storage distance to allow for some late lane changes.
		Positioning Distance (Simulation Settings)	1320	Base on field conditions	Yes	Distance ahead vehicle starts to attempt lane change. Measured from Stop bar.
		Mandatory Distance2 (Simulation Settings)	880	Base on field conditions	Yes	Additional mandatory distance to make 2 lane changes. Measured from Stop bar. Typically used more for high-speed facilities. See Synchro Studio 10 User Guide, Chapter 28 (pages 28-5 to 28-18)
		Positioning Distance2 (Simulation Settings)	1760	Base on field conditions	Yes	Additional positioning distance to make 2 lane changes. Measured from Stop bar. Typically used more for high-speed facilities. See Synchro Studio 10 User Guide, Chapter 28 (pages 28-5 to 28-18)
		Lane Alignment (Simulation Settings)	Right for right-turns Left for left-turns and thru movements Right-NA for U-turns	Base on field conditions	Yes	
		Enter Blocked Intersection (Simulation Settings)	"No" for intersections	Code 1 vehicle if used Yes for driveways No for high speed movements	Yes	Enter "No" for high speed approaches and movements. "Yes" can help capacity of driveways. In general, controls gridlock avoidance.
		Taper Length (Simulation Settings)	25	Code as part of storage based on field conditions	Yes	Impacts when vehicles can start entering the storage.

Submitting Synchro Results

These recommendations can be applied to both consultants submitting work to WSDOT, as well as internal review (either within region or to HQ).

- All results should be submitted using the HCM 6th ed. methodology, unless the intersection cannot be analyzed with it.
- At minimum, the following should be included when submitting analysis for review
  - A memo or email outlining any essential assumptions made during the creation of the model (.syn and .sim files) that will help clarify decisions for the reviewer.
  - All Synchro models (.syn and .sim files): base/existing file and potential operations
- When feasible submit base Synchro models prior to proposed alternative models.
- It is also recommended that models are reviewed and comments are addressed prior to presenting results to a larger group, such as stakeholder's committee or Executive Committee.