Safe Waves Analysis Tool User Guide

The Speeding Opportunities Analysis Tool (SWAT) web-app can be accessed through this link or the following address:

http://newton.neu.edu:8080/massdot/

This app runs on a Northeastern University server and is free to be used. The instructions and explanation for users to be able to run the application is provided in the following sections.

1 Steps to Follow

1.1 Download the input file

The web app's opening page has a button for users to download an input file shell (Figure 1). It is a Microsoft Excel file. Users can skip this step if they already have an input file shell.

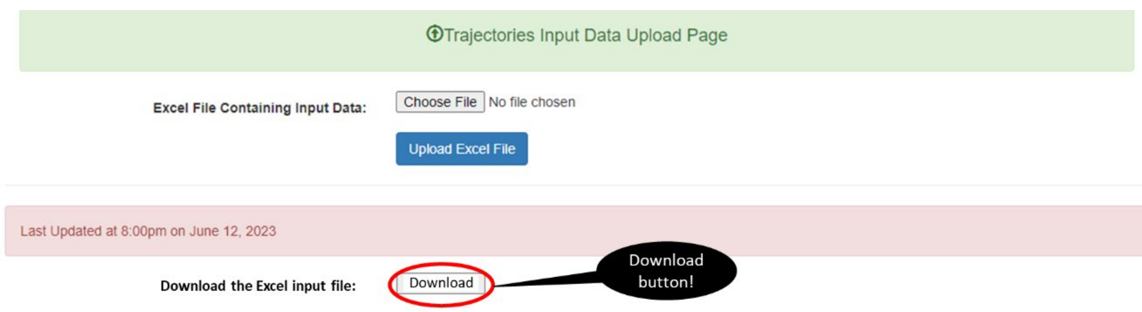


Figure 1-Download button in the first web page

1.2 Complete the input file

The app works for one direction at a time. Complete the input file for a chosen arterial direction. Instructions on completing the input file are provided in a later section.

Note: To analyze both directions of an arterial, two input files are needed. Because intersections must be listed in the order for the specified direction, the input file for one direction will list intersections in the opposite order to the other direction's input file.

1.3 Upload the input file

On the opening page of the web app (Figure 2), users can choose the input file they wish to upload and then and upload it.

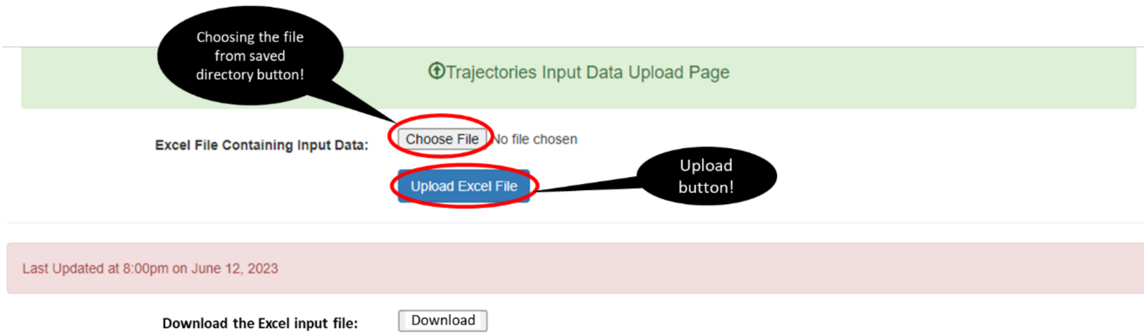


Figure 1-2-Choosing file and upload button in the first page

1.4 Review imported data and continue

The web-app opens a new page in which it echos the imported information from the input file (Figure 3). If everything seems OK, the user can click <Process Input>. The app will then generate all the vehicle trajectories.

Process Input

INTERSECTION 1		INTERSECTION 2		INTERSECTION 3		INTERSECTION 4		INTERSECTION 5		INTERSECTION 6	
Intn	3.0	Intn	6.0	Intn	8.0	Intn	12.0	Intn	15.0	Intn	18.0
Intn name	at I95	Intn name	at Avalon Bay	Intn name	at Honey Dew	Intn name	at Garden	Intn name	at Walmart	Intn name	at Brooksby
C	95.0	C	120.0	C	120.0	C	120.0	C	120.0	C	120.0
D_From	500.0	D_From	990.0	D_From	450.0	D_From	550.0	D_From	880.0	D_From	600.0
N_Lanes_Thru	2.0	N_Lanes_Thru	2.0	N_Lanes_Thru	2.0	N_Lanes_Thru	2.0	N_Lanes_Thru	2.0	N_Lanes_Thru	2.0
vRight_Art	191.0	vRight_Art	57.0	vRight_Art	1.0	vRight_Art	0.0	vRight_Art	0.0	vRight_Art	67.0
vThru_Art	1224.0	vThru_Art	1553.0	vThru_Art	1529.0	vThru_Art	1389.0	vThru_Art	1248.0	vThru_Art	1265.0
vLeft_Art	0.0	vLeft_Art	18.0	vLeft_Art	65.0	vLeft_Art	216.0	vLeft_Art	0.0	vLeft_Art	51.0
Sat_Flow_Art	3525.0	Sat_Flow_Art	3539.0	Sat_Flow_Art	3500.0	Sat_Flow_Art	3525.0	Sat_Flow_Art	3536.0	Sat_Flow_Art	3514.0
Offset	27.0	Offset	3.0	Offset	11.0	Offset	108.0	Offset	15.0	Offset	0.0
Change_Interval_Art	6.0	Change_Interval_Art	5.0	Change_Interval_Art	6.0	Change_Interval_Art	5.0	Change_Interval_Art	5.0	Change_Interval_Art	7.0
Eff_G_Art	68.1	Eff_G_Art	80.9	Eff_G_Art	95.5	Eff_G_Art	95.4	Eff_G_Art	89.5	Eff_G_Art	92.2
G_End_Art_Loc	95.0	G_End_Art_Loc	122.2	G_End_Art_Loc	114.3	G_End_Art_Loc	120.0	G_End_Art_Loc	110.2	G_End_Art_Loc	126.0
Len_LT_Lane	0.0	Len_LT_Lane	200.0	Len_LT_Lane	355.0	Len_LT_Lane	480.0	Len_LT_Lane	0.0	Len_LT_Lane	215.0
Len_RT_Lane	0.0	Len_RT_Lane	100.0	Len_RT_Lane	0.0	Len_RT_Lane	0.0	Len_RT_Lane	0.0	Len_RT_Lane	0.0
Leg_Name_RT	at I95	Leg_Name_RT	at Avalon Bay	Leg_Name_RT	at Honey Dew	Leg_Name_RT	at Garden	Leg_Name_RT	at Walmart	Leg_Name_RT	at Brooksby
V_RT	*	V_RT	*	V_RT	25.0	V_RT	*	V_RT	48.0	V_RT	49.0
GreenA_Start_RTX_Loc	*	GreenA_Start_RTX_Loc	*	GreenA_Start_RTX_Loc	0.0	GreenA_Start_RTX_Loc	*	GreenA_Start_RTX_Loc	0.0	GreenA_Start_RTX_Loc	0.0
EffA_RTX	*	EffA_RTX	*	EffA_RTX	7.3	EffA_RTX	*	EffA_RTX	10.7	EffA_RTX	6.2
Sat_Flow_A_RTX	*	Sat_Flow_A_RTX	*	Sat_Flow_A_RTX	1583.0	Sat_Flow_A_RTX	*	Sat_Flow_A_RTX	1583.0	Sat_Flow_A_RTX	1611.0
GreenB_Start_RTX_Loc	*	GreenB_Start_RTX_Loc	*	GreenB_Start_RTX_Loc	*	GreenB_Start_RTX_Loc	*	GreenB_Start_RTX_Loc	*	GreenB_Start_RTX_Loc	12.2
EffB_RTX	*	EffB_RTX	*	EffB_RTX	*	EffB_RTX	*	EffB_RTX	*	EffB_RTX	9.6
Sat_Flow_B_RTX	*	Sat_Flow_B_RTX	*	Sat_Flow_B_RTX	*	Sat_Flow_B_RTX	*	Sat_Flow_B_RTX	*	Sat_Flow_B_RTX	1611.0
Sat_Flow_RTOR_RTX	*	Sat_Flow_RTOR_RTX	*	Sat_Flow_RTOR_RTX	136.0	Sat_Flow_RTOR_RTX	*	Sat_Flow_RTOR_RTX	52.0	Sat_Flow_RTOR_RTX	75.0
V_Lanegroup_RTS	*	V_Lanegroup_RTS	59.0	V_Lanegroup_RTS	*	V_Lanegroup_RTS	2.0	V_Lanegroup_RTS	*	V_Lanegroup_RTS	*
p_RTS	*	p_RTS	0.35	p_RTS	*	p_RTS	0.33	p_RTS	*	p_RTS	*
GreenA_Start_RTS_Loc	*	GreenA_Start_RTS_Loc	0.0	GreenA_Start_RTS_Loc	*	GreenA_Start_RTS_Loc	0.0	GreenA_Start_RTS_Loc	*	GreenA_Start_RTS_Loc	*
EffA_RTS	*	EffA_RTS	18.3	EffA_RTS	*	EffA_RTS	14.6	EffA_RTS	*	EffA_RTS	*
Sat_Flow_A_RTS	*	Sat_Flow_A_RTS	1724.0	Sat_Flow_A_RTS	*	Sat_Flow_A_RTS	1614.0	Sat_Flow_A_RTS	*	Sat_Flow_A_RTS	*
GreenB_Start_RTS_Loc	*	GreenB_Start_RTS_Loc	*	GreenB_Start_RTS_Loc	*	GreenB_Start_RTS_Loc	*	GreenB_Start_RTS_Loc	*	GreenB_Start_RTS_Loc	*
EffB_RTS	*	EffB_RTS	*	EffB_RTS	*	EffB_RTS	*	EffB_RTS	*	EffB_RTS	*
Sat_Flow_B_RTS	*	Sat_Flow_B_RTS	*	Sat_Flow_B_RTS	*	Sat_Flow_B_RTS	*	Sat_Flow_B_RTS	*	Sat_Flow_B_RTS	*
Sat_Flow_RTOR_RTS	0.0	Sat_Flow_RTOR_RTS	38.0	Sat_Flow_RTOR_RTS	0.0	Sat_Flow_RTOR_RTS	4.0	Sat_Flow_RTOR_RTS	0.0	Sat_Flow_RTOR_RTS	0.0
Leg_Name_LT	at I95	Leg_Name_LT	at Avalon Bay	Leg_Name_LT	at Honey Dew	Leg_Name_LT	at Garden	Leg_Name_LT	at Walmart	Leg_Name_LT	at Brooksby
V_LT	*	V_LT	*	V_LT	*	V_LT	*	V_LT	*	V_LT	*
GreenA_Start_LTX_Loc	*	GreenA_Start_LTX_Loc	*	GreenA_Start_LTX_Loc	*	GreenA_Start_LTX_Loc	*	GreenA_Start_LTX_Loc	*	GreenA_Start_LTX_Loc	*
EffA_LTX	*	EffA_LTX	*	EffA_LTX	*	EffA_LTX	*	EffA_LTX	*	EffA_LTX	*
Sat_Flow_A_LTX	*	Sat_Flow_A_LTX	*	Sat_Flow_A_LTX	*	Sat_Flow_A_LTX	*	Sat_Flow_A_LTX	*	Sat_Flow_A_LTX	*
Priority_A_LTX	*	Priority_A_LTX	*	Priority_A_LTX	*	Priority_A_LTX	*	Priority_A_LTX	*	Priority_A_LTX	*
GreenB_Start_LTX_Loc	*	GreenB_Start_LTX_Loc	*	GreenB_Start_LTX_Loc	*	GreenB_Start_LTX_Loc	*	GreenB_Start_LTX_Loc	*	GreenB_Start_LTX_Loc	*
EffB_LTX	*	EffB_LTX	*	EffB_LTX	*	EffB_LTX	*	EffB_LTX	*	EffB_LTX	*
Sat_Flow_B_LTX	*	Sat_Flow_B_LTX	*	Sat_Flow_B_LTX	*	Sat_Flow_B_LTX	*	Sat_Flow_B_LTX	*	Sat_Flow_B_LTX	*
Priority_B_LTX	*	Priority_B_LTX	*	Priority_B_LTX	*	Priority_B_LTX	*	Priority_B_LTX	*	Priority_B_LTX	*
Sat_Flow_LTOR_LTX	0.0	Sat_Flow_LTOR_LTX	0.0	Sat_Flow_LTOR_LTX	0.0	Sat_Flow_LTOR_LTX	0.0	Sat_Flow_LTOR_LTX	0.0	Sat_Flow_LTOR_LTX	0.0
V_Lanegroup_LTS	*	V_Lanegroup_LTS	*	V_Lanegroup_LTS	15.0	V_Lanegroup_LTS	96.0	V_Lanegroup_LTS	*	V_Lanegroup_LTS	14.0
p_LTS	*	p_LTS	*	p_LTS	0.26	p_LTS	0.5	p_LTS	*	p_LTS	0.42
GreenA_Start_LTS_Loc	*	GreenA_Start_LTS_Loc	*	GreenA_Start_LTS_Loc	0.0	GreenA_Start_LTS_Loc	0.0	GreenA_Start_LTS_Loc	*	GreenA_Start_LTS_Loc	0.0
EffA_LTS	*	EffA_LTS	*	EffA_LTS	7.3	EffA_LTS	14.6	EffA_LTS	*	EffA_LTS	6.2
Sat_Flow_A_LTS	*	Sat_Flow_A_LTS	*	Sat_Flow_A_LTS	1397.0	Sat_Flow_A_LTS	1360.0	Sat_Flow_A_LTS	*	Sat_Flow_A_LTS	1726.0

Figure 3-Echo of imported information

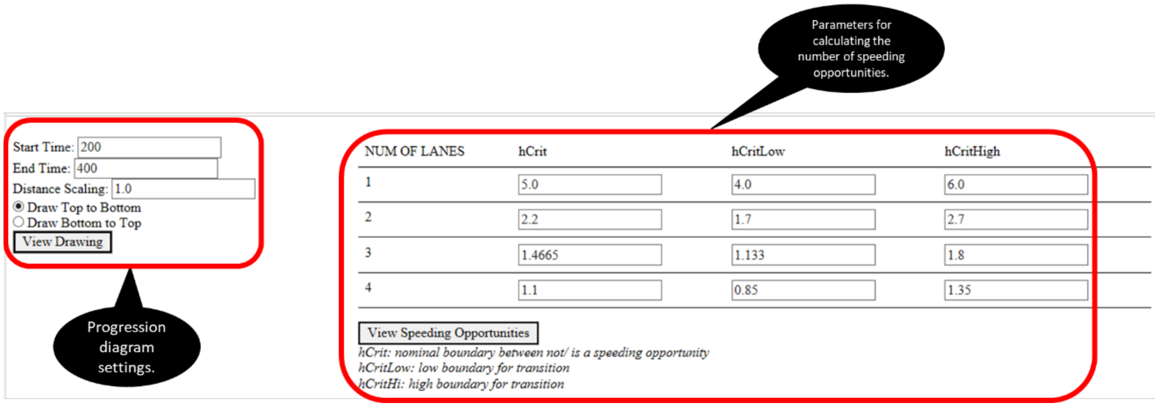


Figure 1-4-After process page

1.5 Choose parameters for viewing the progression diagram and for identifying speeding opportunities

After generating trajectories, the web-app will then display a page as shown in Figure 1-4.

On the left, enter preferences for drawing the progression diagram, as follow:

- Start and End Time: The horizontal axis of the progression diagram is time, in seconds. Users specify the start and end time of the displayed progression diagram. Minimum start time is 0; Maximum end time is 5000.
- Distance Scaling: The vertical axis is distance, which can be in feet or in meters (whichever is used in the input file). By default, the distance scaling factor is 1.0, which will fit the graph to the screen based on screen resolution. Users can choose a different scaling factor to zoom in or out.
- Choose either <Draw Top to Bottom> or <Draw Bottom to Top> to indicate whether the first intersection (based on the input file) goes at the top or bottom of the progression diagram. Typically, users will choose Top-to-Bottom when analyzing one direction and Bottom-to-Top when analyzing the other direction, so that intersections take the same location in either direction.

On the right, the default parameters used for identifying speeding opportunities will be displayed; users can change them if they wish. For each possible number of lanes N in the thru lane group, there is a critical headway h_{crit} as well as a pair of boundary headways, *hCritLow* to *hCritHigh*. H_{crit} is the nominal boundary between headways that are and aren't a speeding opportunity. When N=1, the boundary is 5 s, in keeping with the definition of speeding opportunity; for other values of N, h_{crit} = 5/N. Then, because vehicles are represented by deterministic trajectories when in fact there is some randomness in driver behavior, the probability than any given headway represents a speeding opportunity is modeled as a function that increases linearly from 0 to 1 as the headway increases from *hCritLow* to *hCritHigh*.

1.6 View the progression diagram and/or the Speeding Opportunities summary table

The web-app page shown in Figure 4 has a button <View Drawing> for viewing the progression diagram.

In the progression diagram, every horizontal line represents an intersection. The colors green and red represent the signal state for arterial thru traffic in the the direction of interest.

Blue lines represent vehicles, which move to the right (in the positive time direction). That can mean going either up or down, depending on users selected top-to-bottom or the opposite. Blue lines starting just after an intersection are midblock entries or turning movements a side street. Blue lines that end shortly before an intersection are midblock exits. Blue lines that end at an intersection are vehicles that turn off.

Where the vehicle trajectories cross an intersection line, some of them have a magenta flag (short vertical line). A full-height flag means the headway is greater than *hCritHigh* and so the vehicle has a full speeding opportunity. A half-height flag means the headway is between *hCritLow* and *hCritHigh*, which means that vehicle has a probability between 0 and 1 of being a speeding opportunity. While every vehicle with a “partial” speeding opportunity has the same height flag, calculations of speeding opportunities use the actual probability of each, which can range from 0 to 1.

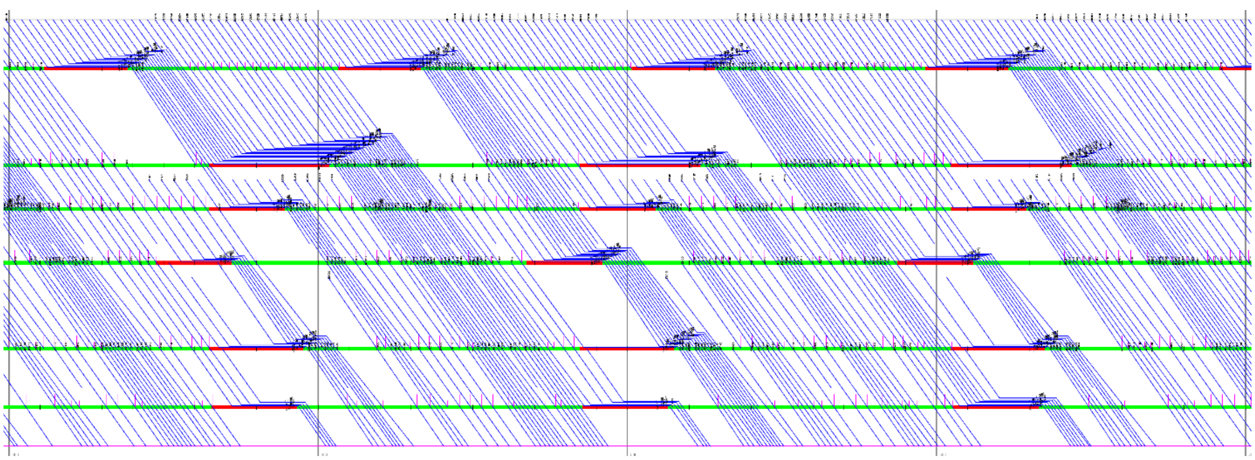


Figure 5-Progression diagram with speeding opportunity flags

1.7 View the Speeding Opportunities Table

The page shown in Figure 4 also has the button <View Speeding Opportunities> for viewing the speeding opportunities summary table. (Using the <back> button, users can navigate back to the page after leaving it to see the progression diagram.)

Figure 6 shows a sample speeding opportunities table. For each intersection, there are columns for the expected number of speeding opportunities per hour, thru volumes per hour in the study direction, and their ratio, which is the speeding opportunities as a proportion of thru traffic.

Speeding Opportunities Output

INTERSECTION	Expected Number of Speeding Opp	Thru Count (Veh/h)	Speeding Opp (%)
1. at I95	534.01	1223	43.66
2. at Avalon Bay	301.86	1164	25.92
3. at Honey Dew	450.15	1397	32.21
4. at Garden	331.14	1220	27.14
5. at Walmart	345.45	1303	26.51
6. at Brooksby	341.00	1039	32.81

Figure 6-Speeding Opportunities output table

2 Conventions for determining offsets and green start / end times

It is assumed that users will have already analyzed the corridor using a signal timing and intersection analysis app such as Synchro. (Instructions that follow assume Synchro as the signal timing app.) Transferring timing information from Synchro to the input file requires adhering to conventions described here.

2.1 Make Synchro's offset references follow the "end of last arterial green" convention

In the Synchro model, all intersections must use the follow reference point standard for offsets: Reference point = *end of green* for the coordinated phase that *ends last*. For example, in Figure 7, phases 2 and 6 are the coordinated phases, but the reference point (red marker) is NOT the end of both phases 2 and 6, but is end of green for phase 2 only.

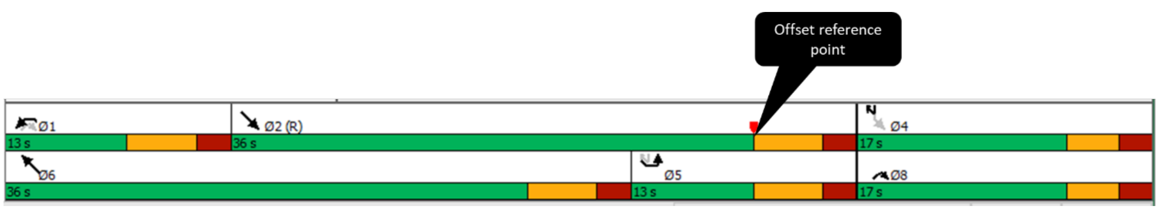


Figure 1- offset reference

If the Synchro model has intersections has offsets that do not follow this convention, Syncrho users can simply change the reference point in Synchro; Synchro will automatically recalculate offsets appropriately.

Many Syncrho users follow the practice of designating both coordinated phases as reference phases. If the two arterial phases end simultaneously, as is the case with leading lefts, having both designated as reference phase will not violate SWAT conventions. But at intersections with lagging lefts or lead-lag phasing for the arterial, *the Synchro model will have to adjusted so that only one coordinated phase, the one that ends later, is designated as the reference phase.* This is because in Synchro, where there are two reference phases, Sychro calculates offsets based on the reference phase whose green ends first, which is not consistent with the convention used by SWAT.

2.2 Adjusting Synchro ring diagrams for Local 0 and Actuated Effective Green Time

Synchro provides a very helpful ring diagram. To use its information in SWAT app, however, two things must be changed. First, in SWAT's convention, local time 0 is defined as the ***start of the next phase after the last arterial (coordinated) phase ends***, as illustrated in 8a. All timing information entered into SWAT for a given intersection should be calculated based on this local zero point. In 8b, the ring diagram has been rearranged so that it begins at local time 0.

Second, for green time, use ***actuated effective green*** for each phase, not the *programmed green* which is shown in Synchro's diagram. Actuated effective green times can be found in a Synchro report. In Figure 8c, actuated effective green times have been superimposed on the ring diagram (orange boxes), along with the length of the programmed change interval (yellow + redClear, blue boxes).

SWAT requires calculating when the actuated effective green starts and ends. In principle, one should be able to determine those start and end time either calculating forward from time 0 or backwards from the end of the cycle. As an example of calculating forwards, in Figure 8(c), to calculate *start of green* for phase 6, follow the lower ring: it's 10 + 6 = 16; to get phase 6's *end of green*, add 37.2, so it's 16 +37.2 = 53.2.

If none of an intersection's phases are ever skipped (i.e., all phases are on recall), it doesn't matter whether one calculates forwards or backwards.

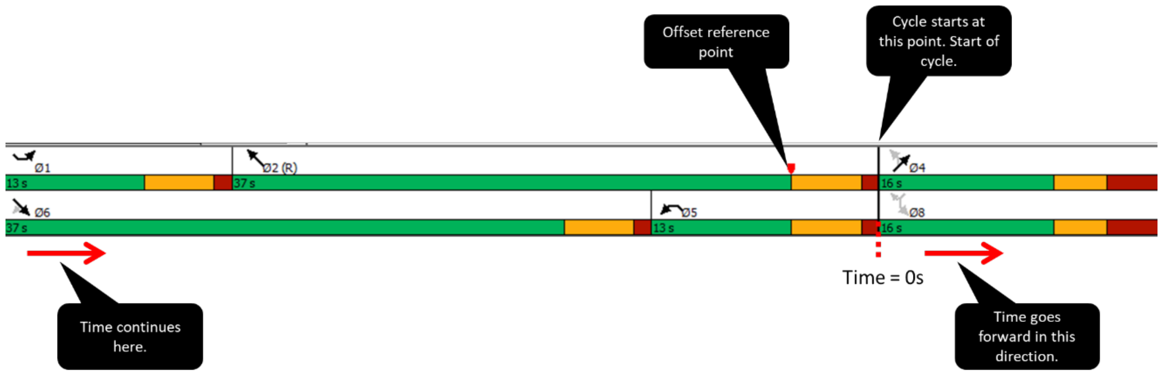
However, if the cycle has phases that are sometimes skipped for lack of a call, then the direction of calculation matters. (That is, one can get different results going forward vs. backwards, and one of them better represents the effective green time.) When should green times be determined by calculating forward, and when by calculating backward?

First determine *which phase in each ring is most likely to be skipped*. Often, the choice is obvious; if it isn't, make an educated guess. (The lower the ratio of actuated effective green to programmed green, the more likely it is that a phase is skipped.)

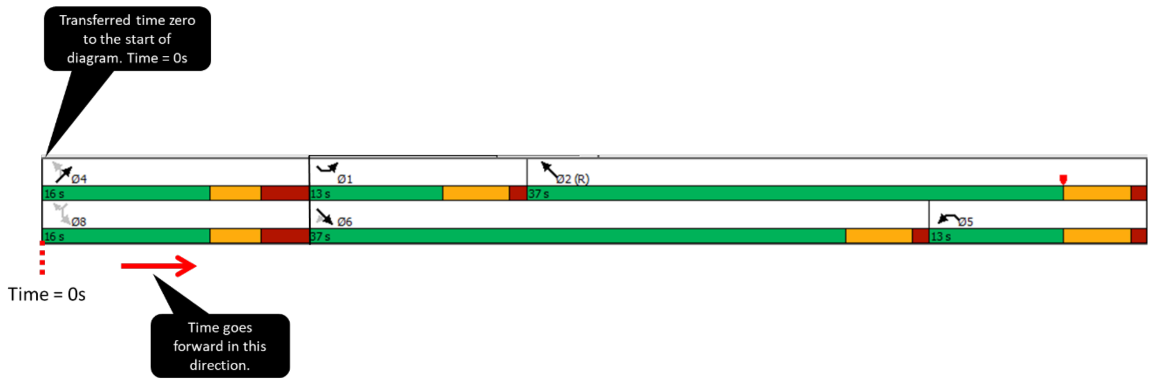
Then use the following rules for whether to calculate forwards or backwards:

- For coordinated phases whose split ends at local time 0: calculate backwards from the end of the cycle.
- For other phases, go forward from the cycle's 0 point up to the end of the phase most likely to be skipped, and go backward from the cycle's 0 point to the start of the phase that follows the phase most likely to be skipped.

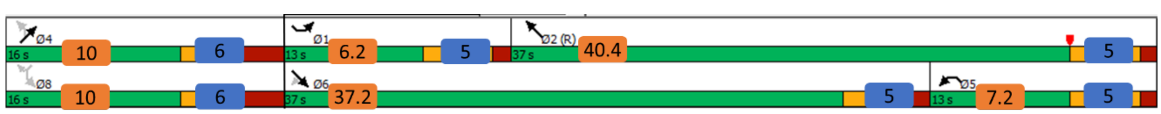
By following this rule, the phase designated as "most likely to be skipped" may get a change interval (yellow + redClear) that is shorter that its programmed change interval. This is appropriate, because the average duration of a change interval for a phase that is sometimes skipped is shorter than its programmed duration.



a) Actual ring diagram in Synchro



b) Rearranged to begin at local time zero



c) With actuated effective green times and change interval times added

Figure 2- Reading the local timing from Synchro ring diagram

In Figure 8(c), suppose phases 01 (upper ring) and 05 (lower ring) are most likely to be skipped. Then green start and ed times for the various phases should be calculated as follows:

- Calculate backward from the end of the cycle for phase 02. It's green end is at (66 – 5) =61, and its green start is 40.4 s before that, or time 20.6.
- Calculate forward from time 0 for all other phases. For example,
  - phase 8's green start at time 0 and ends at 10
  - phase 6's green starts at 10+6 = 16 and ends 37.2 s later, at 53.2

- phase 5’s green starts 5 s later at 58.2 and ends 7.2 s later, at 65.4. Because cycle length is 66 s, that leaves less than 1 s for phase 5’s average change interval during, which suggests that phase 5 is skipped most of the time (when skipped, its change interval duration is 0, of course).

3 Entering Input Data

The input file is a Microsoft Excel file. Users can download a shell, as explained earlier, and then fill it with data on the arterial being studied. Each input file applies to a single direction of the arterial.

3.1 Units

Time is in seconds.

Distances may be in either meters or ft. Distances shown in the progression diagram will be in the corresponding units.

Speed must be in units of distance per second, i.e., ft/s or m/s.

3.2 Colored Cells

By convention, input file cells that are light orange are headers that are not read as data inputs.

Input file cells that are blue are fixed; users must not change them.

3.3 Master Tab

The input file is a spreadsheet with two tabs, Master Tab and Direction 1 input Tab. The input file is only for one direction at a time. For a two-way arterial, users will need to create separate input files for each direction, using the “Direction 1” tab in both cases.

The Master Tab is for general information about the arterial that is being studied. This information includes the name of street, name of the direction, and time of study for report headings.

Also included are corridor-wide parameters: progression speed (speed that vehicles will go when unconstrained) and length per vehicle in the queue (typically 23 ft or 25 ft).

3.4 Direction 1 Tab:

In the Direction 1 tab, the first three columns are fixed and include variables names, units, and a short description for each row.

Beginning in the fourth column, there should be one column for every intersection in the study segment. Add columns as necessary.

Starting from the top, the sheet contains 4 main blocks, as shown in the right margin of Figure 9, with data for:

- Block 1: the arterial in the direction of interest

- Block 2: the side street approach from which cars turn right to join the arterial in the direction of interest.
    - This block is subdivided into two subblocks (left margin of Figure 9), one of which is filled while the other remains empty, depending on whether right turns are from an exclusive right turn lane.
- Block 3: the side street approach from which cars turn left to join the arterial in the direction of interest.
    - This block is subdivided into two subblocks (left margin of Figure 9), one of which is filled while the other remains empty, depending on whether left turns are from an exclusive left turn lane.
- Block 4: midblock entries and exits

Note: Any cell which is highlighted blue must not be changed. Some of them contain fixed text, while other contain a formula (so the calculated value may change, but the formula mustn't change). When adding new columns for additional intersections, be careful to copy those formula.

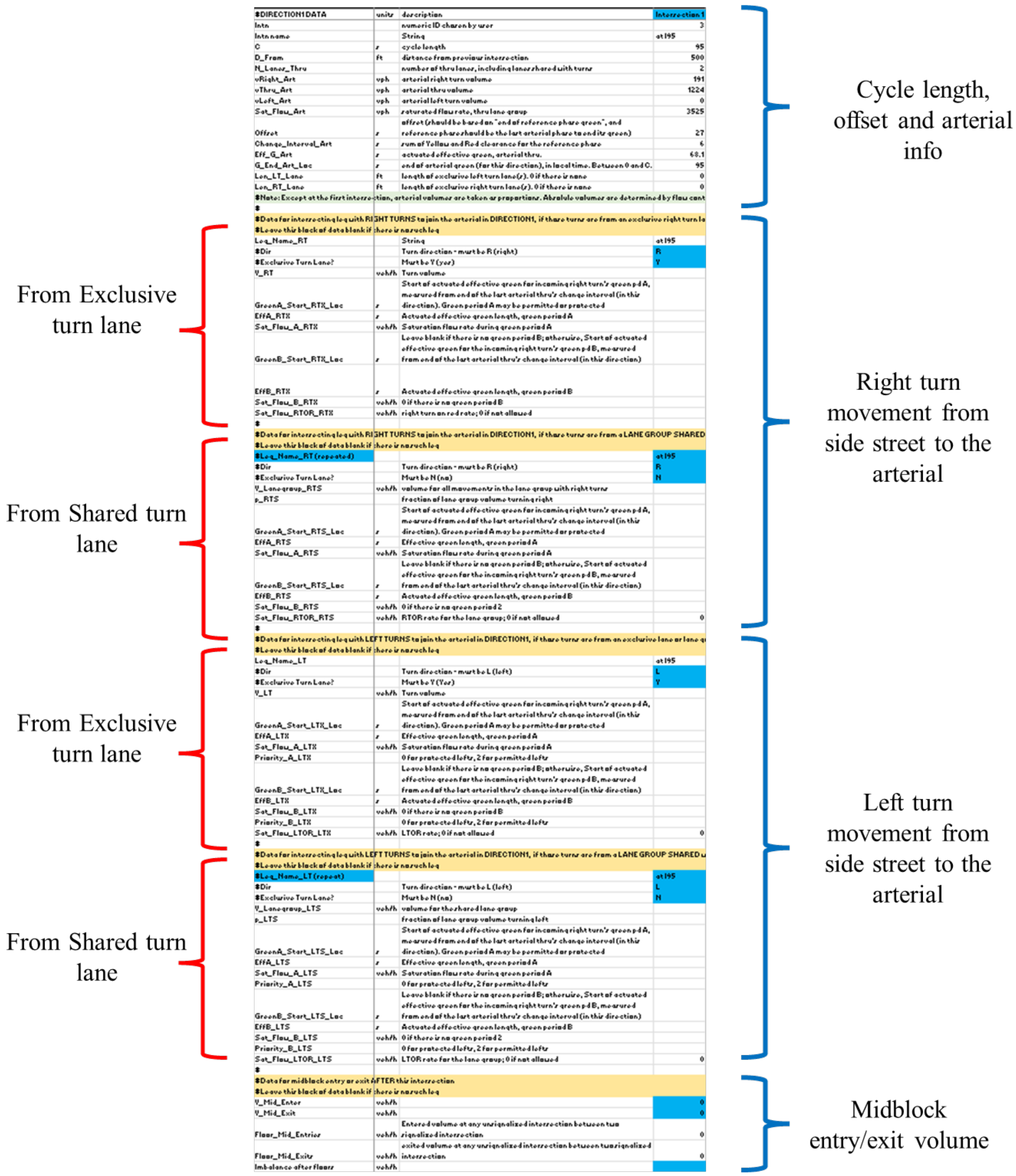


Figure 1- General sections of input file

3.4.1 Info on the Arterial

In this block, enter cycle length, arterial volumes going thru and turning and their saturation flow rates, and arterial phase offsets. (See earlier discussion about how offsets must be based on when the last arterial green ends.) Table 1-1 shows the definition of each parameter for arterial.

Table 1 - Arterial data

Parameter	units	description
Intn		numeric ID chosen by user
Intn name		Name of the side street
C	s	Cycle length
D_From	ft or m	Distance from previous intersection’s stop line to this intersection stop line (Enter 500 for the first intersection)
N_Lanes_Thru		Number of thru lanes, including lanes shared with turns for the study direction
vRight_Art	vph	Arterial right turn volume
vThru_Art	vph	Arterial thru volume
vLeft_Art	vph	Arterial left turn volume
Sat_Flow_Art	vph	Saturated flow rate, thru lane group
Offset	s	Offset (should be based on “end of reference phase green”, and reference phase should be the last arterial phase to end its green)
Change_Interval_Art	s	Sum of Yellow and Red clearance for the reference phase
Eff_G_Art	s	Actuated effective green length, (direction of interest)
G_End_Art_Loc	s	End of arterial green (for this direction), in local time. Between 0 (end of reference phase green) and C.
Len_LT_Lane	ft or m	length of exclusive left turn lane(s). 0 if there is none
Len_RT_Lane	ft/m	length of exclusive right turn lane(s). 0 if there is none

3.4.2 Info on right turns from the side street

SWAT assumes there will be at most one leg from which side street right turns will join the arterial in the direction being studied. The right turns block is for data on right turns from *that* approach of the side street. (To be clear: Typically, vehicles from a side street may turn right or left from both legs of the side street; but from only one leg will right turns join the arterial *in the direction of interest*.)

This block consists of two sub-blocks, as shown in Figure 3. One subblock gets completed and the other is left blank, depending on whether the right turns come from an exclusive turn lane or from a lane shared with thru and/or left turning traffic. (Leave both sub-blocks blank if there are no right turns at all joining the arterial in the direction of interest.)

The values entered in these sections are traffic volumes, timing data for the phase(s) that this movement uses, and saturation flow rate(s), as explained in Table 2. Note how inputs differ depending on whether turns come from an exclusive versus shared lane. Note also that data can be entered on two different green periods, one called period A and one called period B; this is explained under the next heading.

Table 2-right turn from side street data

Parameter	Unit	From Shared Lane	From Exclusive Lane(s)	Description
#Dir		✓	✓	Turn direction - must be R (right)
#Exclusive Turn Lane?		✓	✓	Must be N (no) for Shared Lane group and Y (yes) for exclusive lane(s)
V_Lanegroup_RTS = right turn volume	veh/h		✓	volume for all movements in the lane group with right turns – with an exclusive lane, it's right turn volume only
V_Lanegroup_RTS = volume for right turns and all other movements than belong to the same lane group	veh/h	✓		volume for all movements in the lane group with right turns – for right turns from a shared lane, it's right turn volume plus thru and possibly left turn volume
p_RTS		✓		fraction of lane group volume turning right
GreenA_Start_RTS_Loc	s	✓	✓	Start of actuated effective green for incoming right turn's green pd A, measured from end of the last arterial thru's change interval (in this direction). Green period A may be permitted or protected
EffA_RTS	s	✓	✓	Effective green length, green period A
Sat_Flow_A_RTS	veh/h	✓	✓	Saturation flow rate during green period A
GreenB_Start_RTS_Loc	s	✓	✓	Leave blank if there is no green period B; otherwise, start of actuated effective green for the incoming right turn's green pd B, measured from end of the last arterial thru's change interval (in this direction)
EffB_RTS	s	✓	✓	Actuated effective green length, green period B
Sat_Flow_B_RTS	veh/h	✓	✓	0 if there is no green period 2
Sat_Flow_RTOR_RTS	veh/h	✓	✓	RTOR rate for the lane group; 0 if not allowed

3.4.3 Timing periods for side street turning movements

Vehicles turning right from a side street may do so during green intervals with permitted turns, green intervals protected turns, and on red (right turn on red (RTOR) and, for one way streets turning onto one-way streets, left turn on red (LTOR)). Therefore, there is a place for entering data on two different green intervals as well as for turns on red.

The two green intervals are called A and B. Where there are both protected and permitted green intervals for the side street turns, interval A must be the one that comes first in the ring diagram. Thus, depending on which comes first, interval A may be for protected turns or for permitted turns.

If there isn't protected + permitted phasing and is therefore only one green interval, enter data for interval A and leave blank the fields for the second green interval (interval B).

Figure 4.shows the fields for right turns from exclusive turn lane.

	Leg_Name_RT		String
	#Dir		Turn direction - must be R (right)
	#Exclusive Turn Lane?		Must be Y (yes)
	V_RT	veh/h	Turn volume
Section A- first period.	GreenA_Start_RTX_Loc	s	Start of actuated effective green for incoming right turn's green pd A, measured from end of the arterial thru's change interval (in this direction). Green period A may be permitted or protected
	EffA_RTX	s	Actuated effective green length, green period A
	Sat_Flow_A_RTX	veh/h	Saturation flow rate during green period A
Section B- second period.	GreenB_Start_RTX_Loc	s	Leave blank if there is no green period B; otherwise, Start of actuated effective green for the incoming right turn's green pd B, measured from end of the arterial thru's change interval (in this direction)
	EffB_RTX	s	Actuated effective green length, green period B
	Sat_Flow_B_RTX	veh/h	0 if there is no green period B
Sat flow rate for turning on red if permitted!	Sat_Flow_RTOR_RTX	veh/h	right turn on red rate; 0 if not allowed

Figure 2 - turning movement into the arterial with inputs for two green intervals and the red interval

3.4.3.1 Left turns from side street to the arterial

As with right turns, there is usually at most one side street approach from which cars turn left to join the arterial in the direction of interest. Like the right turn block, the left turn block supports two green intervals (one protected, one permitted, to be entered in the order in which they occur) and turning on red.

The values entered in these sections are turning movement volume, timing data for the phase(s) that these movement use, and saturation flow rate(s), as explained below in Table 3.

Table 3-left turn from side street data

Parameter	Unit	From Shared Lane	From Exclusive Lane(s)	Description
#Dir		✓	✓	Turn direction - must be L (left)
#Exclusive Turn Lane?		✓	✓	Must be N (no) for Shared Lane group and Y (yes) for exclusive lane(s)
V_Lanegroup_LTS = right turn volume	veh/h		✓	volume for all movements in the lane group with left turns – with an exclusive lane, it's left turn volume only
V_Lanegroup_LTS = volume for left turns and all other movements than belong to the same lane group	veh/h	✓		volume for all movements in the lane group with right turns – in case of left turns from a shared lane case, it's left turn volume plus thru and possibly right turn volume
p_LTS		✓		fraction of lane group volume turning left
GreenA_Start_LTS_Loc	s	✓	✓	Start of actuated effective green for incoming right turn's green pd A, measured from end of the last arterial thru's change interval (in this direction). Green period A may be permitted or protected
EffA_LTS	s	✓	✓	Effective green length, green period A
Sat_Flow_A_LTS	veh/h	✓	✓	Saturation flow rate during green period A
Priority_A_LTS		✓	✓	0 for protected lefts, 2 for permitted lefts
GreenB_Start_LTS_Loc	s	✓	✓	Leave blank if there is no green period B; otherwise, start of actuated effective green for the incoming right turn's green pd B, measured from end of the last arterial thru's change interval (in this direction)
EffB_LTS	s	✓	✓	Actuated effective green length, green period B
Sat_Flow_B_LTS	veh/h	✓	✓	0 if there is no green period 2
Priority_B_LTS		✓	✓	0 for protected lefts, 2 for permitted lefts
Sat_Flow_LTOR_LTS	veh/h	✓	✓	LTOR rate for the lane group; 0 if not allowed

3.4.3.2 Midblock entries / exits:

The last block is for traffic that enters or leaves the arterial between the signalized intersections. The spreadsheet has a formula that will automically calculate these midblock entry and exit values based on minimizing total entries and exits needed to balance flows from one intersection to the next and. Normally, either midblock entries or exits will get the value 0.

However, it is also possible to make both midblock entries and exits non-zero if the user believes (say, based on counts at an unsignalized intersection or driveway) that there are non-zero entries as well as exits. For this case, the user only needs to enter the third and fourth rows of this block (Floor_Mid_Entries and Floor_Mid_Exits). The spreadsheet will then calculate the minimal midblock entries and exits needed to balance flows, subject to neither entries or exits being lower than their specified floor.