QEM User's Guide

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Quick Estimation Method (QEM) for Traffic Signal Timing

Introduction

One of the biggest challenges in meso and macrosimulation is the estimation of signalized intersection capacities. These simulation tools lack a good signal control emulator that would provide realistic signal timing and phasing data, and simplify the exporting process of signalized intersections. Almost all signal timing adjustments had to be set manually once they are exported from meso/macrosimulation to microsimulation, or Synchro-like software. For existing networks, this process can somewhat be simplified by importing field traffic control data, but it becomes more complex for predicted and estimated traffic conditions, when the field data are not available. Therefore, the development of a tool for quick estimation of signal timings is an important step in simplifying the cross resolution modeling efforts. The QEM_SIG Excel spreadsheet that accompanies the NeXTA software represents a computational engine for estimating signalized intersections operation. It is relying on the HCM 2010 methodology for signalized intersection analysis and the HCM QEM method, but it is also using other methodologies for computing parameters of signalized intersections (as described in the Signal Timing Manual (STM), 2008 edition). It can be used as a stand-alone application, or integrated with NeXTA.

Methodology

The methodology of the QEM application is given by sections, and they are defined as follows (different tabs in the spreadsheet):

- Sheet 1 – input/output sheet for communication with NeXTA
- Input sheet – data input section; this is the only section where the user needs to input intersection data if the spreadsheet is used as a stand-alone application
- Phase designation – assigning phases to intersection movements, determining left turn treatment and defining ring-barrier structure
- Lane volumes – calculation of lane volumes (HCM 2010 Chapter 31)
- Phase calculation – calculation of the cycle length, green time (splits) allocations, movement capacities, V/C ratios, and Levels of Service (LOS)
- Phasing – calculate phasing data for correct export to Synchro
- Summary sheet – output sheet with calculation results

Sheet 1 communicates with NeXTA during mesosimulation, and it reads and writes signal control data. For each intersection in the simulation, Sheet 1 reads lane configurations, turning volumes, and main movement speeds, and uses them in the calculation procedure. Then it returns data for phase designation (that includes protected/permitted phases for left turns), detector phases, effective green, capacity, V/C ratio, delay, LOS, and the complete array of phasing data. NeXTA can further use these outputs to export traffic data in the UTDF format for use with Synchro or VISSIM. When the QEM spreadsheet is used as a stand-alone application, Sheet 1 must not be deleted nor amended, since it actively communicates with other sections. It does not provide outputs in a user-friendly format, but these outputs can be used to manually export lanes/volumes/phasing/timing data to Synchro. The look of Sheet 1 is shown in Figure 1.

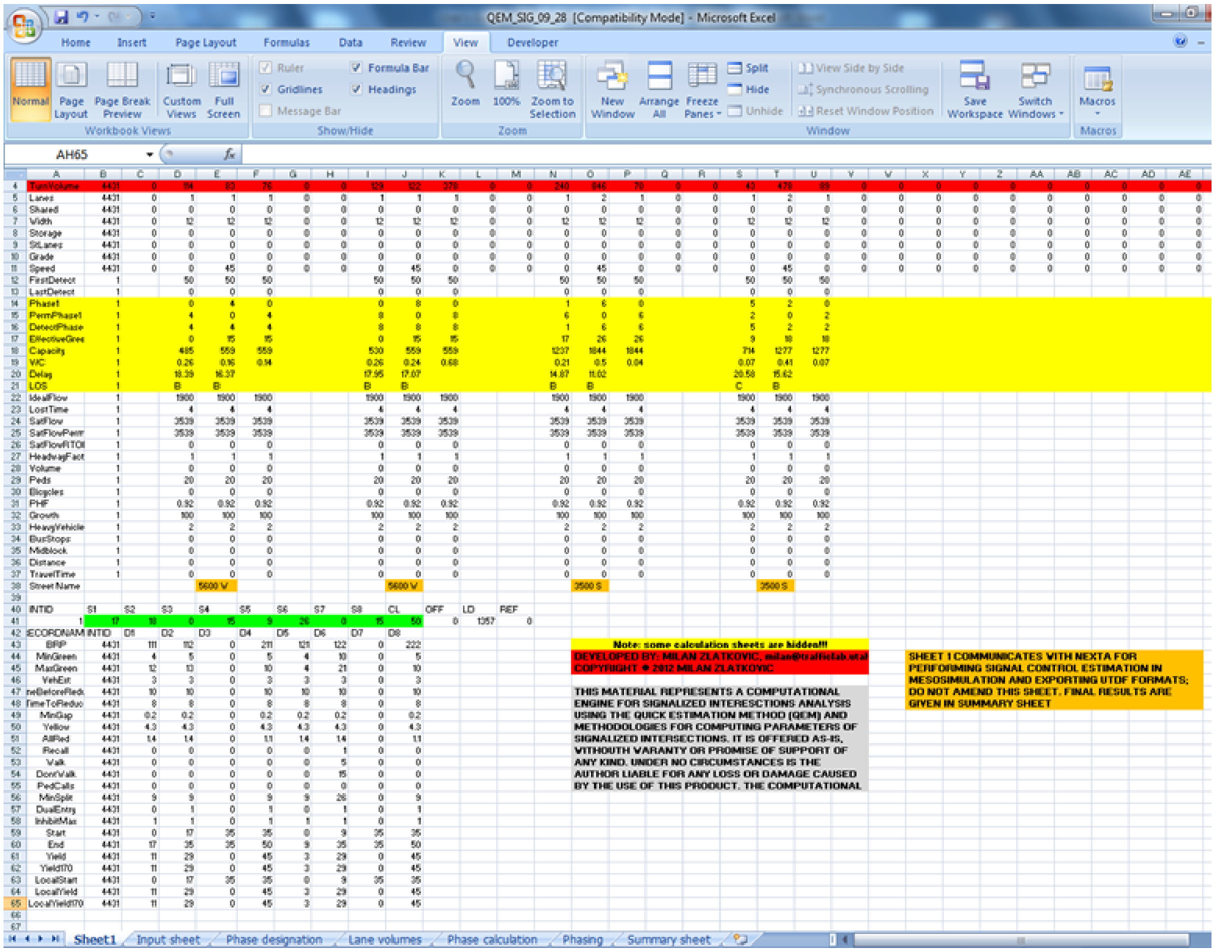


Figure 1. *The look of Sheet 1.*

The **Input sheet** is the only section where the user is asked to enter intersection data. This sheet is important only if the QEM is used as a stand-alone application. The following inputs are needed:

- Street names – optional.
- Intersection lane configuration – required (number of lanes for each approach and each movement).
- Turning volumes for each movement – required.
- Approach through speeds – important if these speeds are greater than 45 mph, since this is one of the requirements for protected only left turn treatments.
- Presence of pedestrians – select option (Yes/No) from the drop-down menu. If pedestrians are present, pedestrian timing will be included in minimum splits and cycle calculation. For urban intersection, this option should generally be enabled. If QEM is used with the NeXTA software, this option can be set only once, and it will be the same for all intersection that NeXTA is estimating.

- Manual selection of left turn treatment – if used as a stand-alone version and field data regarding left turn treatment are known, this entry allows for a manual selection of left turn treatment. If activated, this option will allow left turn treatment for each approach to be selected from the drop-down menu. The options are: Protected, Permitted, Protected + permitted, or blank. This entry will override the automatic designation of left turn treatments.

Note: if used with NeXTA, this option should be disabled. Also, if for some approaches the selection is not defined ("blank"), left turns for that approach will be assigned automatically.

- Ideal saturation flow rate – by default, this value is 1900 vphpl; needed only if the user has calibrated saturation flow rate for local conditions.
- Peak Hour Factor (PHF) – if known, it can be entered in this field. Otherwise, it can be set to the value of 1.0.
- Percentage of heavy vehicles (HGV %) – if known, it can be entered in this field. Otherwise, the default value can be set to 3%.
- Cycle calculation method selection – two options are offered: CS/RS, which follows the HCM methodology (this is the recommended default value), or Webster, which uses an older method for cycle length calculation.

After the input values are defined, the user should not change any other values in other sheets. Figure 2 shows the layout of the Input sheet.

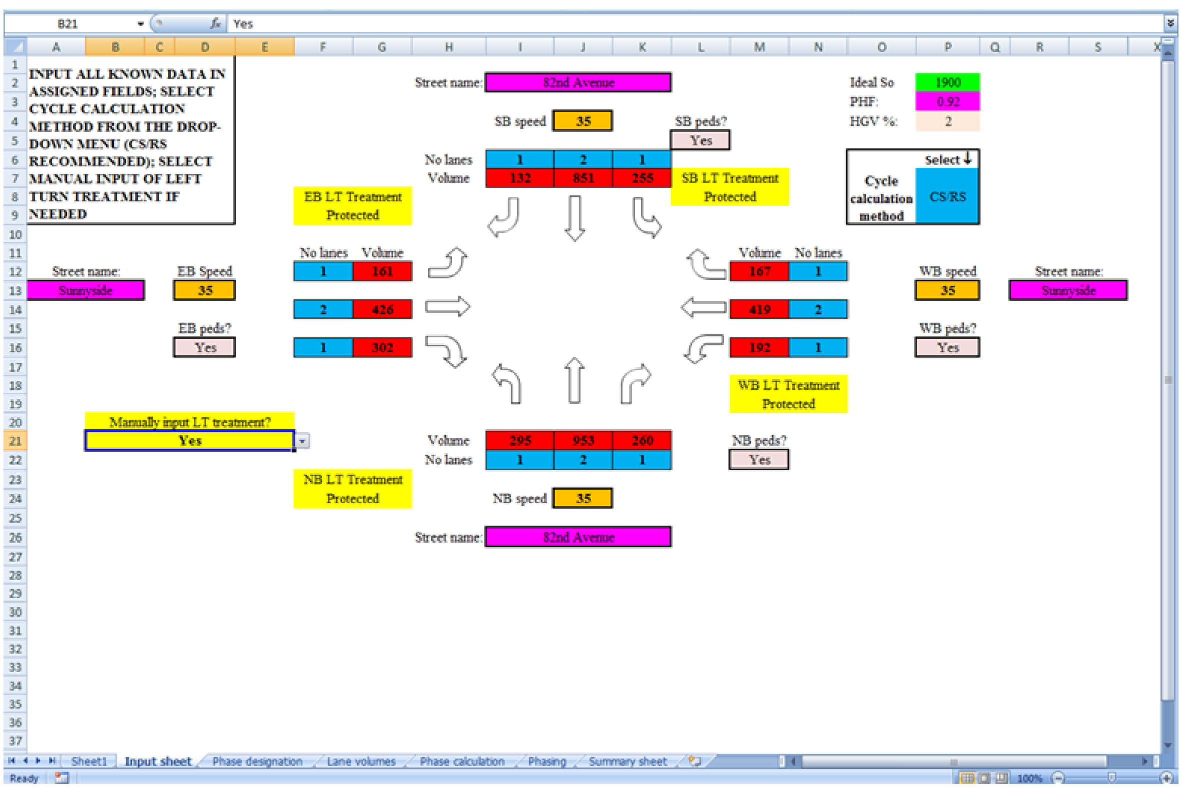


Figure 2. *The layout of the Input sheet.*

The **Phase designation** sheet determines the major street (NS or EW), defines phases for each movement, and determines the left turn treatment based on the criteria defined in the HCM and STM (Protected only, Permitted only, or Protected + permitted). If the left turn treatment is manually selected in the Input sheet, this selection will be implemented, and the automatic designation overridden. In the case of a 3-leg intersection, the left turn is treated as permitted (the through phase is shown). For phase numbering, the Utah Department of Transportation (UDOT) standard is used: if NS is the major movement, the NB through movement is phase 2; if EW is the major movement, the WB through movement is phase 2. Once the phases and left turn treatments are known, the program defines the standard dual ring-barrier structure for the given case, which is used in follow-up calculations. The Phase designation sheet is shown in Figure 3.

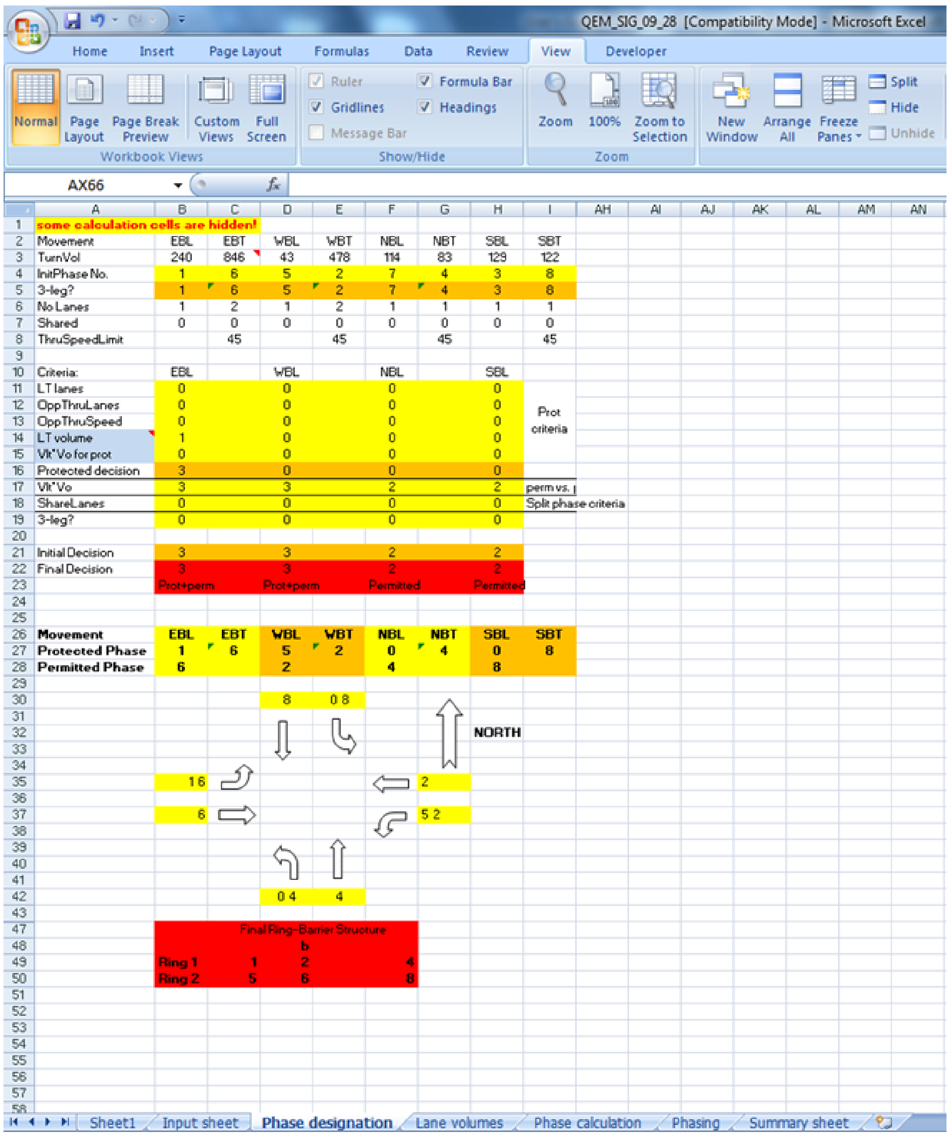


Figure 3. *Phase designation sheet.*

The **Lane volumes** sheet calculates critical lane volumes for each intersection approach. It follows the methodology defined in the HCM 2010, Chapter 31. The computed lane volumes are later used in cycle length calculation. This sheet is shown in Figure 4.

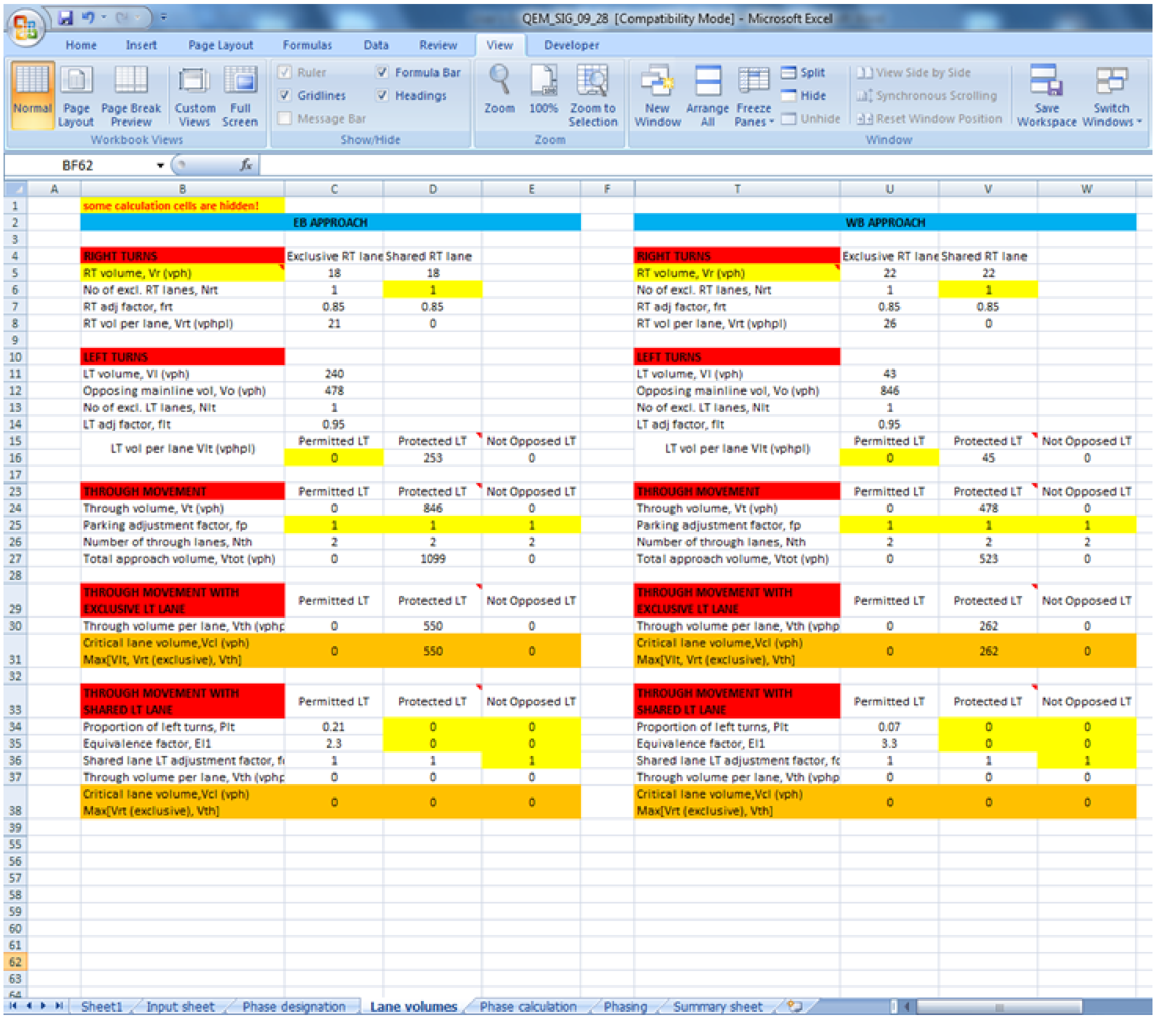


***Figure 4.** Lane volumes sheet.*

The **Phase calculation** sheet, shown in Figure 5, performs calculations of all signal control parameters. It is using inputs defined by the user, and outputs from the previous steps. The critical movement methodology is used in both CS/RS and Webster's cycle length calculations. The cycle length calculation is in this version limited to 10 second increments, in the range between 50 seconds (Cmin) and 150 seconds (Cmax). Once the cycle length is determined, the following steps are implemented in parameters calculation:

1. For the given cycle length, phasing and turning volumes, the minimum and maximum phase green times are determined.
2. The corresponding splits (green time + exchange interval) are assigned to each phase in the ring-barrier structure.

3. The splits are recalculated for each phase based on the cycle length and the critical ring split summation.
4. The splits are recalculated again for each barrier, following the critical barrier split summation. This step ensures the simultaneous barrier crossing and prevents phase conflicts.
5. The calculated splits are compared to the minimum splits (see Phasing), and are reassigned if necessary.
6. When the phase splits are know, the HCM procedure is followed to calculate movement capacities, V/C ratios, control delays and LOS.

This section goes beyond the typical QE methodology, since it gives realistic signal timing parameters common in all North American ring-barrier controllers. This is especially significant for a fast conversion process used in cross-resolution modeling (when the application is used in conjunction with NeXTA).

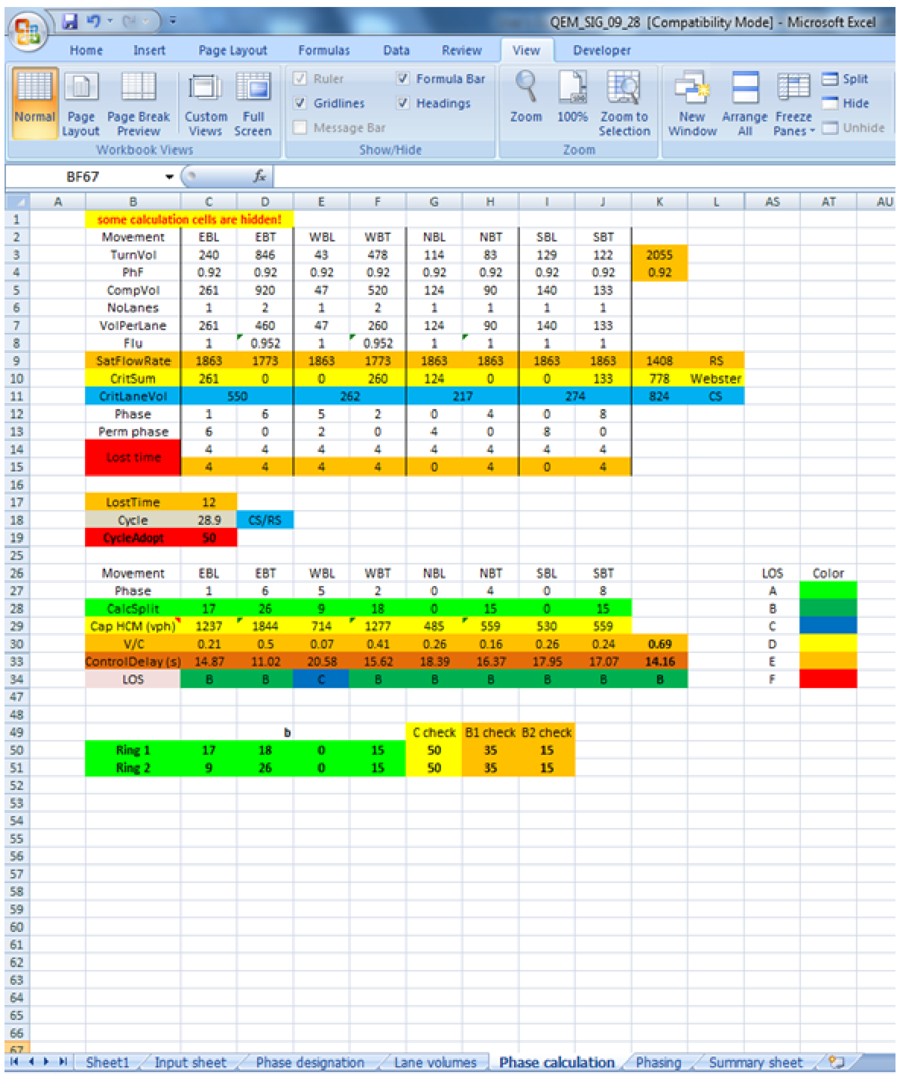
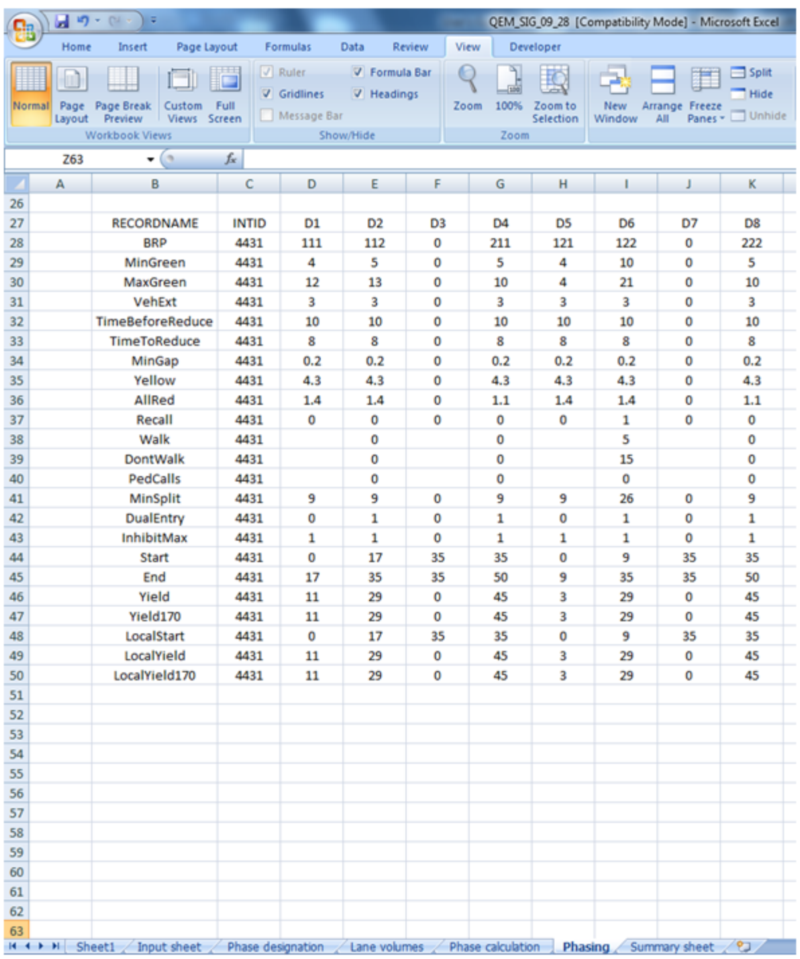


Figure 5. *Phase calculation sheet.*

The **Phasing sheet**, given in Figure 6, calculates all the phasing data required by Synchro for an error-free analysis. It is using default tables from the STM for different parameters. The parameters calculated in this sheet are:

Minimum green	Minimum phase recall	Phase end time
Maximum green	Walk time	Phase yield time
Vehicle extension	Don’t walk time	Phase yield for type 170 controllers
Time before reduce	Pedestrian recalls	Local start time
Time to reduce	Minimum split	Local yield time
Minimum gap	Dual entry	Local yield time for type 170 controllers
Yellow time	Max time call inhibition	
All red time	Phase start time	



RECORDNAME	INTID	D1	D2	D3	D4	D5	D6	D7	D8
BRP	4431	111	112	0	211	121	122	0	222
MinGreen	4431	4	5	0	5	4	10	0	5
MaxGreen	4431	12	13	0	10	4	21	0	10
VehExt	4431	3	3	0	3	3	3	0	3
TimeBeforeReduce	4431	10	10	0	10	10	10	0	10
TimeToReduce	4431	8	8	0	8	8	8	0	8
MinGap	4431	0.2	0.2	0	0.2	0.2	0.2	0	0.2
Yellow	4431	4.3	4.3	0	4.3	4.3	4.3	0	4.3
AllRed	4431	1.4	1.4	0	1.1	1.4	1.4	0	1.1
Recall	4431	0	0	0	0	0	1	0	0
Walk	4431		0		0		5		0
DontWalk	4431		0		0		15		0
PedCalls	4431		0		0		0		0
MinSplit	4431	9	9	0	9	9	26	0	9
DualEntry	4431	0	1	0	1	0	1	0	1
InhibitMax	4431	1	1	0	1	1	1	0	1
Start	4431	0	17	35	35	0	9	35	35
End	4431	17	35	35	50	9	35	35	50
Yield	4431	11	29	0	45	3	29	0	45
Yield170	4431	11	29	0	45	3	29	0	45
LocalStart	4431	0	17	35	35	0	9	35	35
LocalYield	4431	11	29	0	45	3	29	0	45
LocalYield170	4431	11	29	0	45	3	29	0	45

Figure 6. *Phasing sheet.*

The **Summary sheet** (see Figure 7) gives all the main outputs from previous steps in is a user-friendly graphical representation. The following parameters are shown:

- Turning volumes (vph)
- Phase designations
- Split durations (s)
- Movement capacities (vph)
- V/C ratios
- Control delays (s)
- Intersection LOS

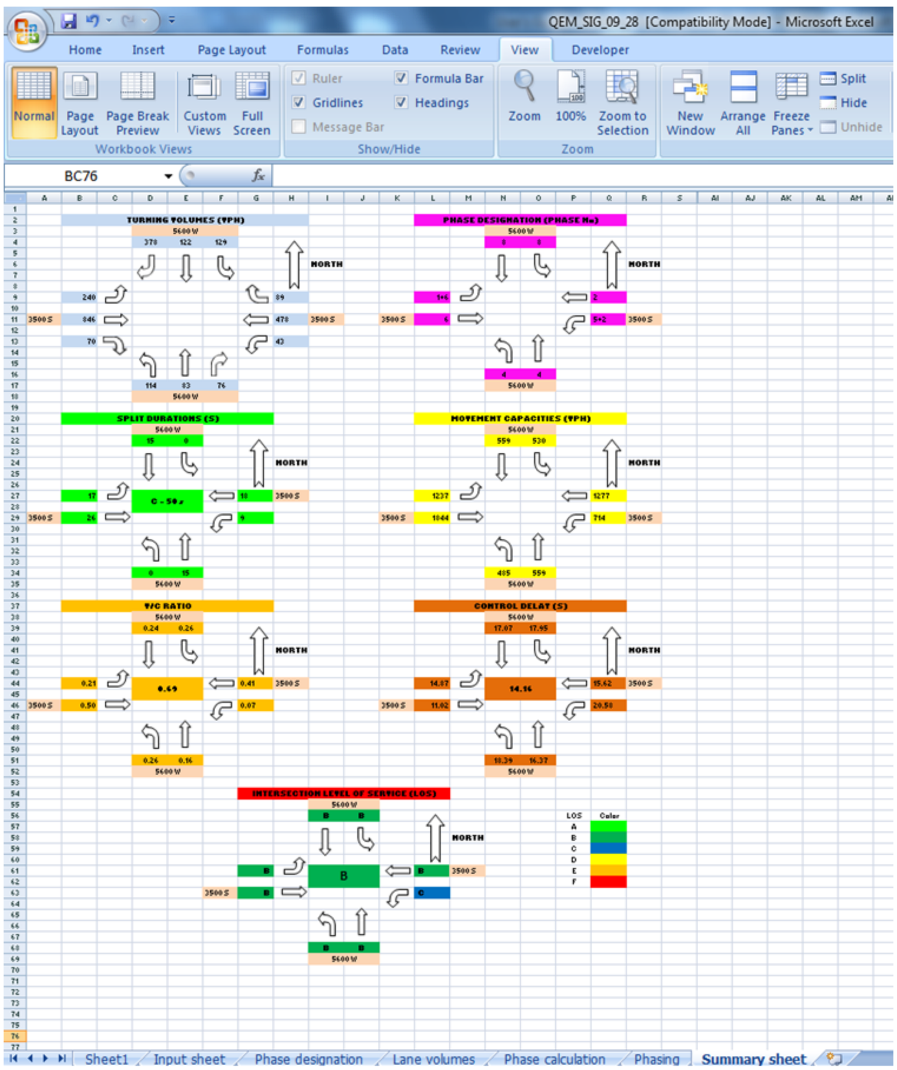


Figure 7. *Summary sheet.*

Using QEM as a Stand-Alone Application

The QEM Excel application was initially designed and developed to work with NeXTA during cross-resolution modeling integration. However, the current version can work as a stand-alone application and it allows for manual user inputs. For this purpose, the user communicates with the Input sheet to input the data that are needed for quick signal timing estimation. The following inputs are needed:

- Street names – optional.
- Intersection lane configuration – required (number of lanes for each approach and each movement).
- Turning volumes for each movement – required.
- Approach through speeds – important if these speeds are greater than 45 mph, since this is one of the requirements for protected only left turn treatments.
- Presence of pedestrians – select option (Yes/No) from the drop-down menu for each approach separately. If pedestrians are present, pedestrian timing will be included in the minimum splits and cycle calculations. For urban intersection, this option should generally be enabled.
- Manual selection of left turn treatment – if the field data regarding left turn treatment are known, this entry allows for a manual selection of left turn treatment. If activated, this option will allow left turn treatment for each approach to be selected from the drop-down menu. The options are: Protected, Permitted, Protected + permitted, or blank. This entry will override the automatic designation of left turn treatments.
- Ideal saturation flow rate – by default, this value is 1900 vphpl; needed only if the user has calibrated saturation flow rate for local conditions.
- Peak Hour Factor (PHF) – if known, it can be entered in this field. Otherwise, it can be set to the value of 1.0.
- Percentage of heavy vehicles (HGV %) – if known, it can be entered in this field. Otherwise, the default value can be set to 3%.
- Cycle calculation method selection – two options are offered: CS/RS, which follows the HCM methodology (this is the recommended default value), or Webster, which uses an older method for cycle length calculation.

Example 1: Typical 4-leg Intersection

The first example is provided for the intersection of 5600 W and 3500 S in West Valley City, UT. Both approaches on 5600 W have two lanes for through, one lane for left turns, and separate right turn lanes. The speed limit along 5600 W is 45 mph. The approaches on 3500 S have two lanes for through movements, where the right-most lane is shared with right turns, and a left turn lane. The speed limit on 3500 S is 40 mph. Traffic data for this intersection date from 2007, and the counts used are for the PM peak hour, 5:00 – 6:00 pm. The peak hour factor is 0.92, and the percentage of heavy vehicles is 2%. Pedestrian crossings are present at all approaches. The intersection layout is given in Figure 8.

Figure 8. *5600 W 3500 S intersection layout.*

These data are used as inputs for QEM. Figure 9 shows the QEM input data configuration. Manual selection for left turn treatment is disabled in this case.

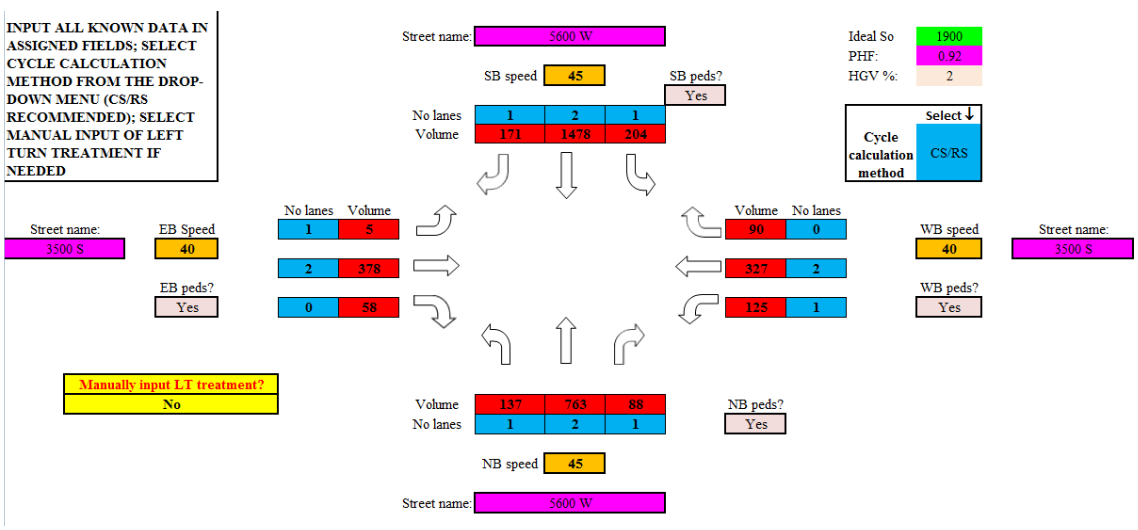


Figure 9. *QEM inputs for 5600 W 3500 S intersection.*

Based on the given inputs, the QEM spreadsheet yields the results as shown in Figure 10:

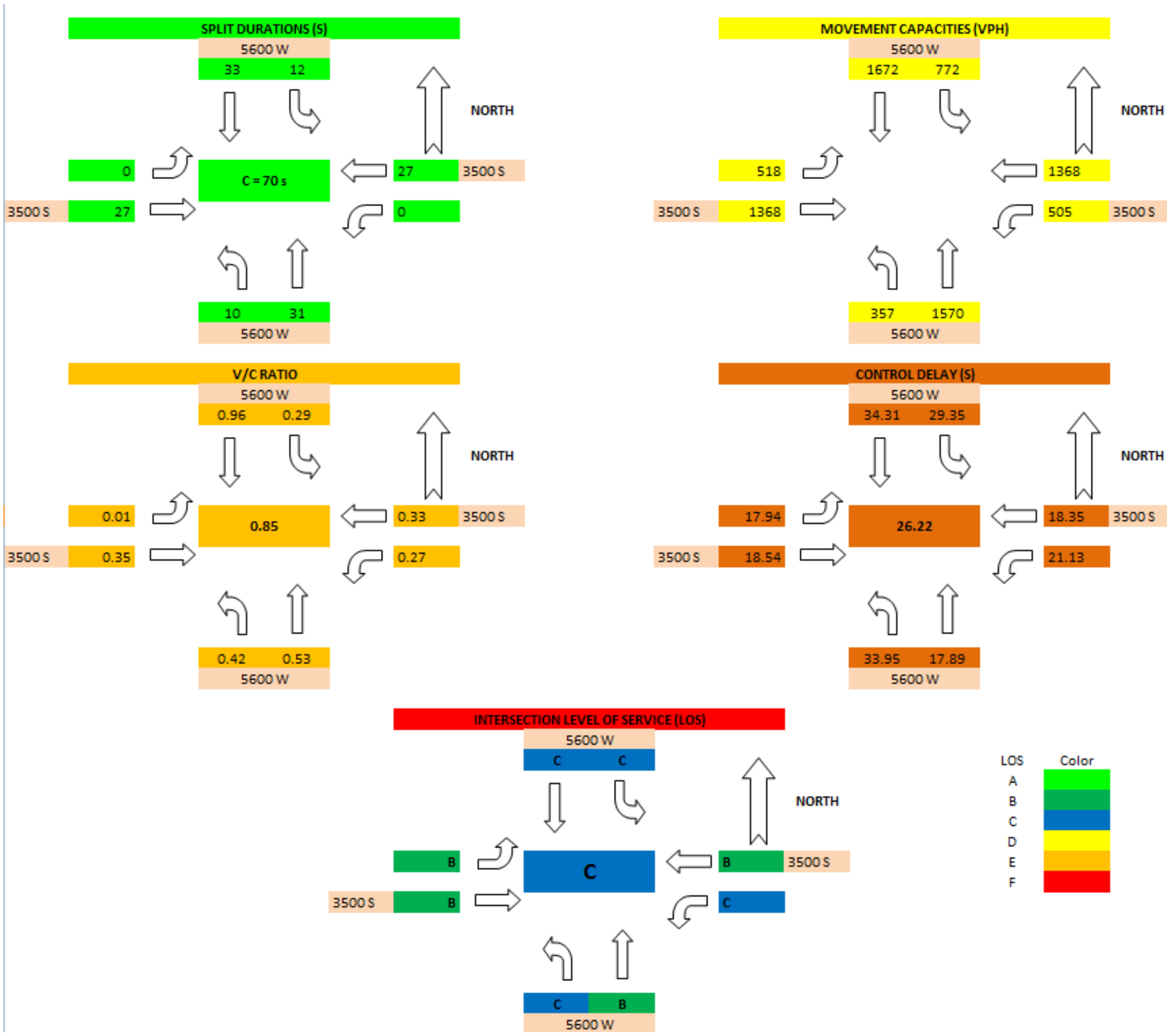
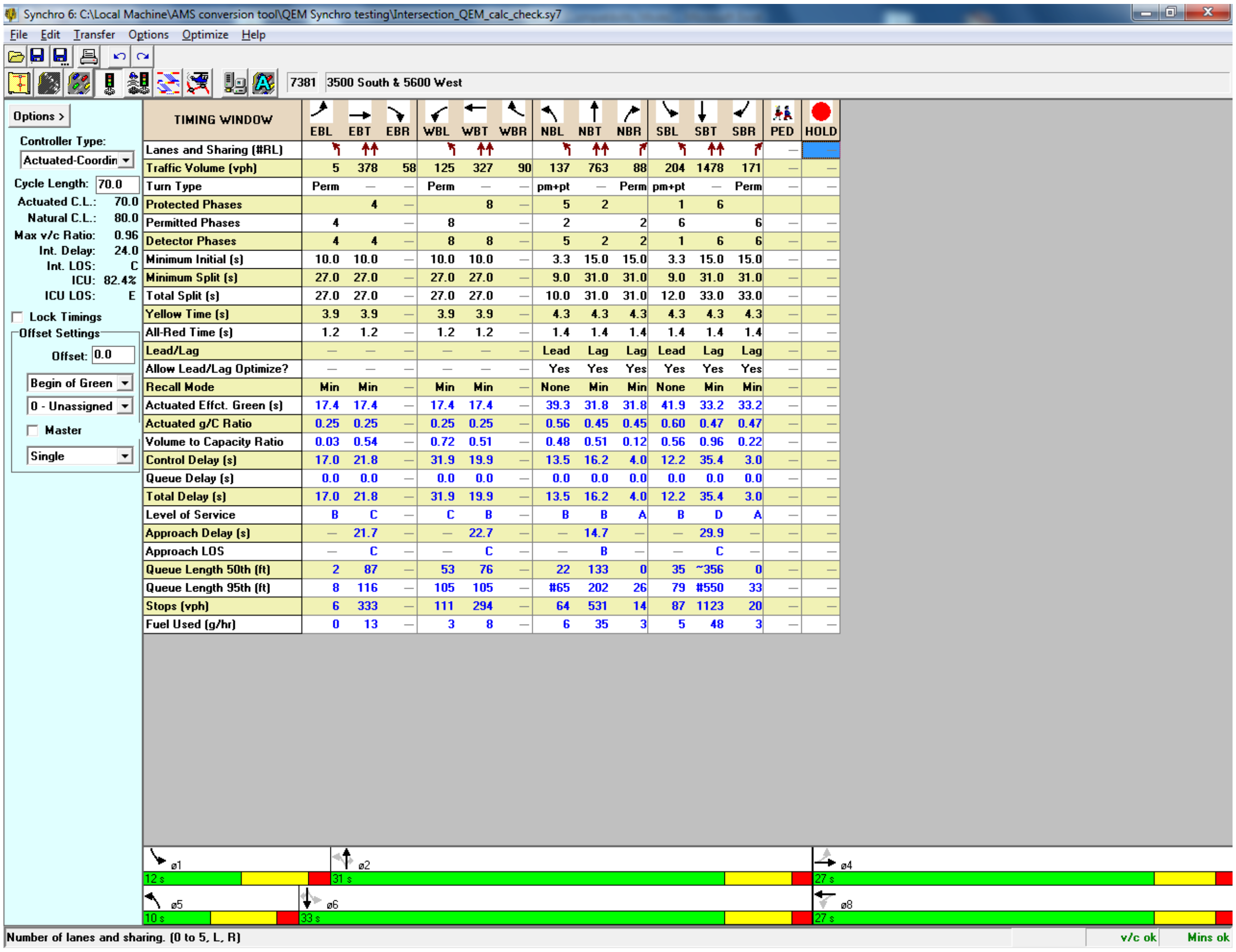


Figure 10. *QEM results for 5600 W 3500 S intersection.*

QEM assigns protected + permitted left turns to NB and SB movements, and permitted only left turns for EB and WB movements. The cycle length is estimated to 70 s, intersection delay is 26.2 s, and LOS is C.

When the same inputs, phasing and timing data are transferred to Synchro, the following results are obtained (Figure 11):



TIMING WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Lanes and Sharing (#RL)													—	—
Traffic Volume (vph)	5	378	58	125	327	90	137	763	88	204	1478	171	—	—
Turn Type	Perm	—	—	Perm	—	—	pm+pt	—	Perm	pm+pt	—	Perm	—	—
Protected Phases		4	—		8	—	5	2		1	6			
Permited Phases	4		—	8		—	2		2	6		6	—	—
Detector Phases	4	4	—	8	8	—	5	2	2	1	6	6	—	—
Minimum Initial (s)	10.0	10.0	—	10.0	10.0	—	3.3	15.0	15.0	3.3	15.0	15.0	—	—
Minimum Split (s)	27.0	27.0	—	27.0	27.0	—	9.0	31.0	31.0	9.0	31.0	31.0	—	—
Total Split (s)	27.0	27.0	—	27.0	27.0	—	10.0	31.0	31.0	12.0	33.0	33.0	—	—
Yellow Time (s)	3.9	3.9	—	3.9	3.9	—	4.3	4.3	4.3	4.3	4.3	4.3	—	—
All-Red Time (s)	1.2	1.2	—	1.2	1.2	—	1.4	1.4	1.4	1.4	1.4	1.4	—	—
Lead/Lag	—	—	—	—	—	—	Lead	Lag	Lag	Lead	Lag	Lag	—	—
Allow Lead/Lag Optimize?	—	—	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	—	—
Recall Mode	Min	Min	—	Min	Min	—	None	Min	Min	None	Min	Min	—	—
Actuated Effct. Green (s)	17.4	17.4	—	17.4	17.4	—	39.3	31.8	31.8	41.9	33.2	33.2	—	—
Actuated g/C Ratio	0.25	0.25	—	0.25	0.25	—	0.56	0.45	0.45	0.60	0.47	0.47	—	—
Volume to Capacity Ratio	0.03	0.54	—	0.72	0.51	—	0.48	0.51	0.12	0.56	0.96	0.22	—	—
Control Delay (s)	17.0	21.8	—	31.9	19.9	—	13.5	16.2	4.0	12.2	35.4	3.0	—	—
Queue Delay (s)	0.0	0.0	—	0.0	0.0	—	0.0	0.0	0.0	0.0	0.0	0.0	—	—
Total Delay (s)	17.0	21.8	—	31.9	19.9	—	13.5	16.2	4.0	12.2	35.4	3.0	—	—
Level of Service	B	C	—	C	B	—	B	B	A	B	D	A	—	—
Approach Delay (s)	—	21.7	—	—	22.7	—	—	14.7	—	—	29.9	—	—	—
Approach LOS	—	C	—	—	C	—	—	B	—	—	C	—	—	—
Queue Length 50th (ft)	2	87	—	53	76	—	22	133	0	35	~356	0	—	—
Queue Length 95th (ft)	8	116	—	105	105	—	#65	202	26	79	#550	33	—	—
Stops (vph)	6	333	—	111	294	—	64	531	14	87	1123	20	—	—
Fuel Used (g/hr)	0	13	—	3	8	—	6	35	3	5	48	3	—	—

Figure 11. *Synchro results for 5600 W 3500 S intersection.*

It can be seen that the QEM application and Synchro yield very similar results for this intersection:

	QEM	Synchro
Intersection delay (s)	26.2	24.0
Intersection LOS	C	C
Intersection V/C	0.85	0.82

Optimization in Synchro yields cycle length of 80 s, intersection delay of 21.2 s, and intersection LOS C.

In the field, this intersection operates in an actuated-coordinated mode on a 120 s cycle, and all left turns are protected + permitted. The left turn treatment can be set manually in QEM and results re-checked. Setting all left turns as protected + permitted gives following results (Figure 12):

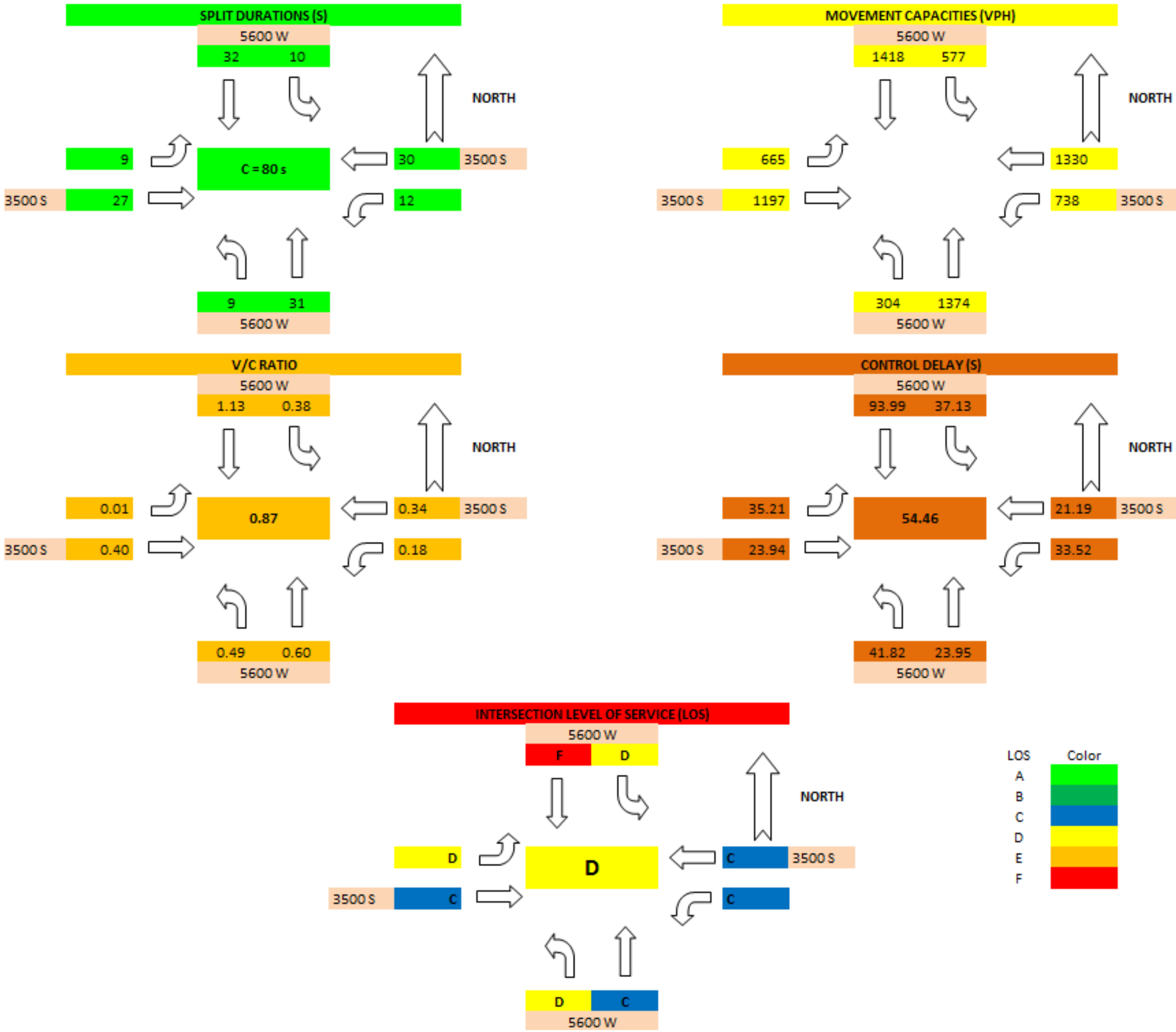
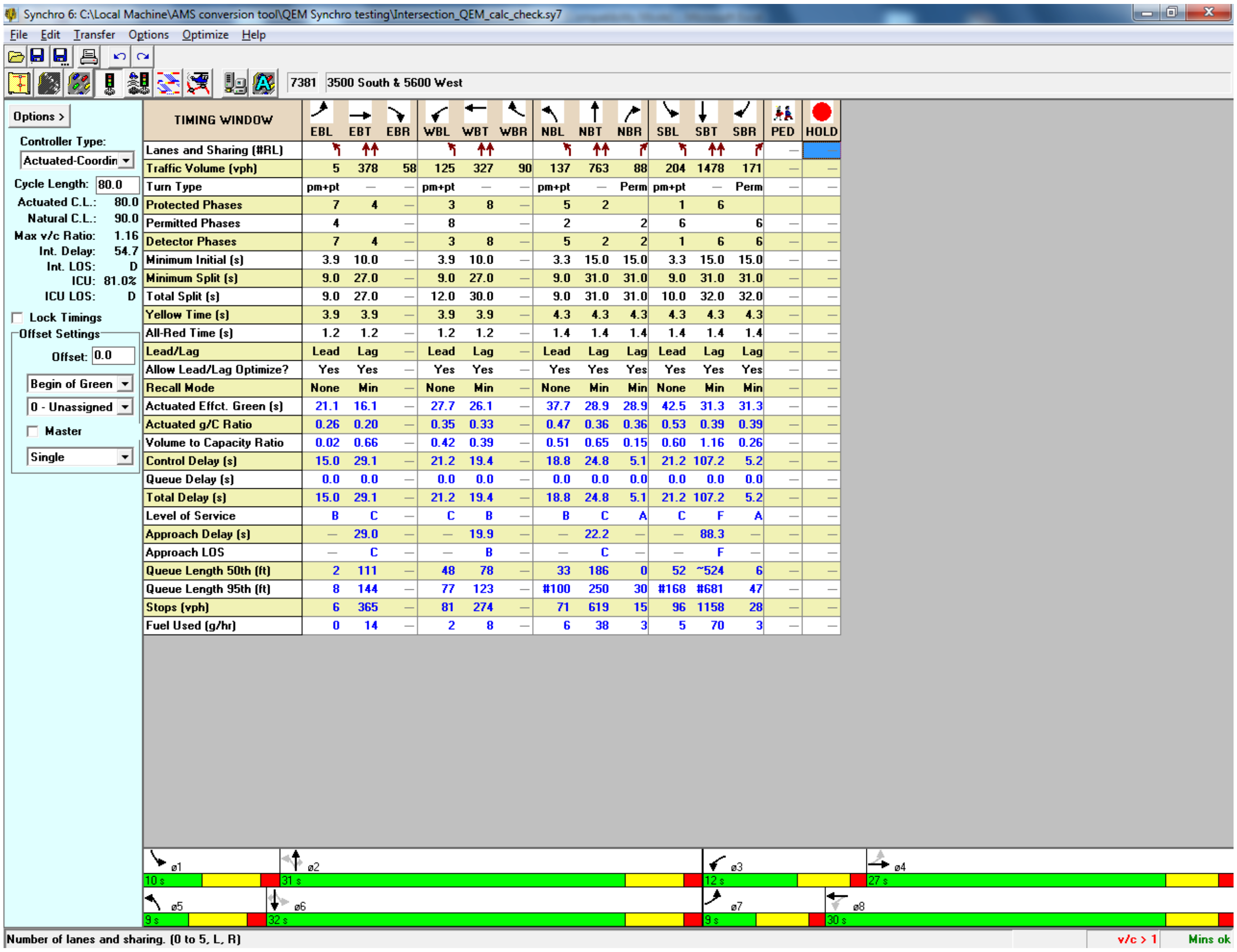


Figure 12. *QEM results for 5600 W 3500 S intersection with manual LT treatment selection.*

The cycle length is recalculated to 80 s, with added left turn splits for EB and WB movements, and small redistribution of split lengths. The intersection LOS falls to LOS D, and the SBT movement fails with a delay of 94 s.

Exporting to Synchro gives the following results:



TIMING WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Lanes and Sharing (#RL)													—	—
Traffic Volume (vph)	5	378	58	125	327	90	137	763	88	204	1478	171	—	—
Turn Type	pm+pt	—	—	pm+pt	—	—	pm+pt	—	Perm	pm+pt	—	Perm	—	—
Protected Phases	7	4	—	3	8	—	5	2		1	6			
Permitted Phases	4		—	8		—	2		2	6		6	—	—
Detector Phases	7	4	—	3	8	—	5	2	2	1	6	6	—	—
Minimum Initial (s)	3.9	10.0	—	3.9	10.0	—	3.3	15.0	15.0	3.3	15.0	15.0	—	—
Minimum Split (s)	9.0	27.0	—	9.0	27.0	—	9.0	31.0	31.0	9.0	31.0	31.0	—	—
Total Split (s)	9.0	27.0	—	12.0	30.0	—	9.0	31.0	31.0	10.0	32.0	32.0	—	—
Yellow Time (s)	3.9	3.9	—	3.9	3.9	—	4.3	4.3	4.3	4.3	4.3	4.3	—	—
All-Red Time (s)	1.2	1.2	—	1.2	1.2	—	1.4	1.4	1.4	1.4	1.4	1.4	—	—
Lead/Lag	Lead	Lag	—	Lead	Lag	—	Lead	Lag	Lag	Lead	Lag	Lag	—	—
Allow Lead/Lag Optimize?	Yes	Yes	—	Yes	Yes	—	Yes	Yes	Yes	Yes	Yes	Yes	—	—
Recall Mode	None	Min	—	None	Min	—	None	Min	Min	None	Min	Min	—	—
Actuated Effct. Green (s)	21.1	16.1	—	27.7	26.1	—	37.7	28.9	28.9	42.5	31.3	31.3	—	—
Actuated g/C Ratio	0.26	0.20	—	0.35	0.33	—	0.47	0.36	0.36	0.53	0.39	0.39	—	—
Volume to Capacity Ratio	0.02	0.66	—	0.42	0.39	—	0.51	0.65	0.15	0.60	1.16	0.26	—	—
Control Delay (s)	15.0	29.1	—	21.2	19.4	—	18.8	24.8	5.1	21.2	107.2	5.2	—	—
Queue Delay (s)	0.0	0.0	—	0.0	0.0	—	0.0	0.0	0.0	0.0	0.0	0.0	—	—
Total Delay (s)	15.0	29.1	—	21.2	19.4	—	18.8	24.8	5.1	21.2	107.2	5.2	—	—
Level of Service	B	C	—	C	B	—	B	C	A	C	F	A	—	—
Approach Delay (s)	—	29.0	—	—	19.9	—	—	22.2	—	—	88.3	—	—	—
Approach LOS	—	C	—	—	B	—	—	C	—	—	F	—	—	—
Queue Length 50th (ft)	2	111	—	48	78	—	33	186	0	52	~524	6	—	—
Queue Length 95th (ft)	8	144	—	77	123	—	#100	250	30	#168	#681	47	—	—
Stops (vph)	6	365	—	81	274	—	71	619	15	96	1158	28	—	—
Fuel Used (g/hr)	0	14	—	2	8	—	6	38	3	5	70	3	—	—

Figure 13. *Synchro results for 5600 W 3500 S intersection for new TL treatment selection.*

The comparison of results between Synchro and QEM is as follows:

	QEM	Synchro
Intersection delay (s)	54.5	54.7
Intersection LOS	D	D
Intersection V/C	0.87	0.81
Maximum V/C	SBT 1.16	SBT 1.13

The results are again very similar between QEM and Synchro. Optimization in Synchro gives an optimal cycle length of 90 s, intersection delay of 28.4 s, and LOS C.

Example 2: 3-leg Intersection

The second example is provided for the neighboring intersection of 5200 W and 3500 S in West Valley City, UT, which is a 3-leg intersection with no SB approach. Both approaches on 3500 W have two lanes for through movements. The WB approach on 3500 S has a separate left turn lane, while the EB approach shares the rightmost through lane with right turns. 5200 W NB approach has separate lanes for left and right turn movements. The speed limit along 3500 W is 40 mph, while the speed limit on 5200 W is 35 mph. Traffic data for this intersection date from 2007, and the counts used are for the PM peak hour, 5:00 – 6:00 pm. The peak hour factor is 0.92, and the percentage of heavy vehicles is 2%. There is no WB pedestrian crossing. The intersection layout is given in Figure 14.

Figure 14. *5200 W 3500 S intersection layout.*

These data are used as inputs for QEM. Figure 15 shows the QEM input data configuration.

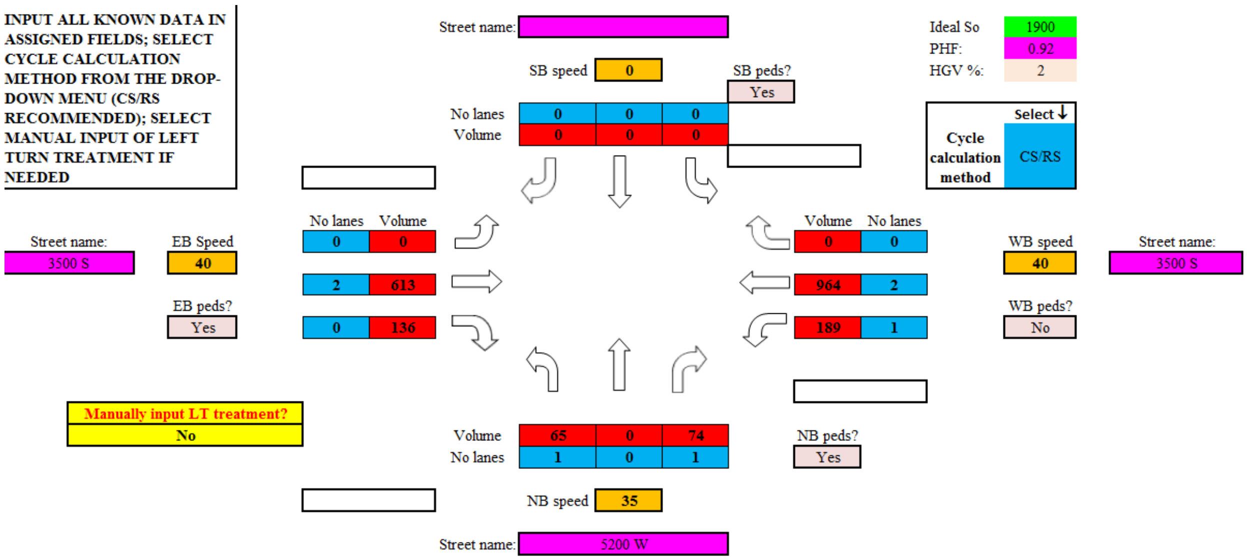


Figure 15. *QEM inputs for 5200 W 3500 S intersection.*

Based on the given inputs, the QEM yields the results given in Figure 16:

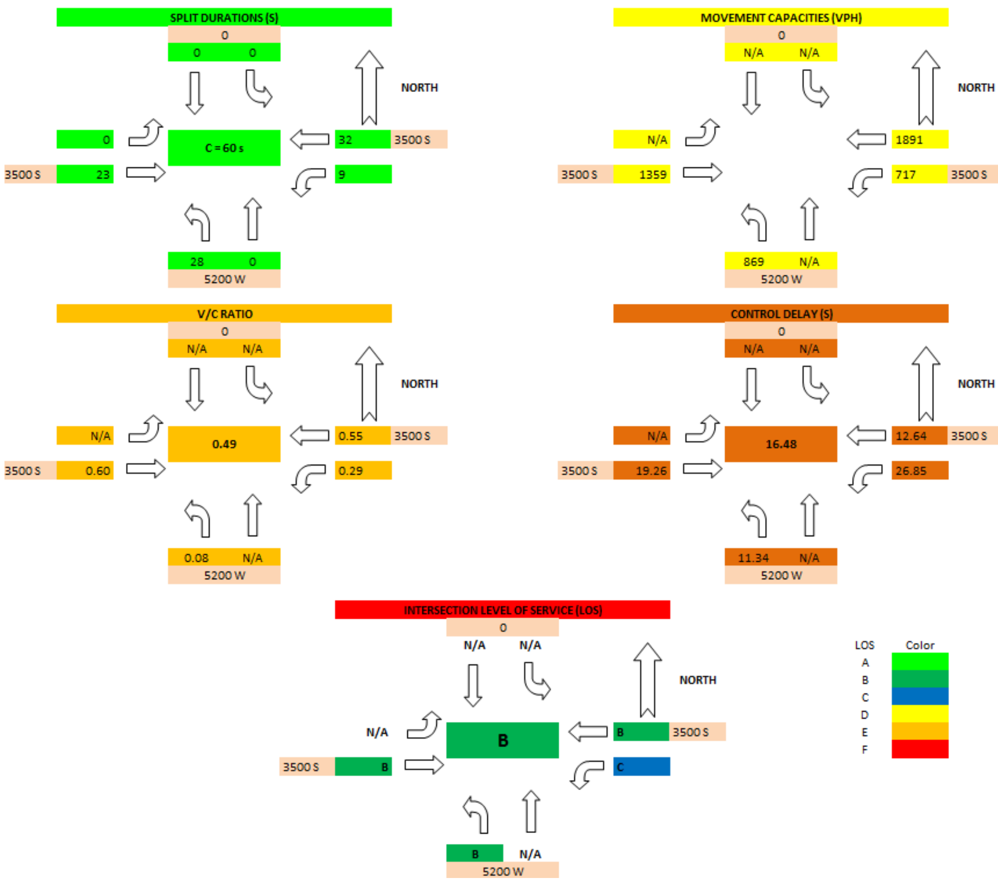
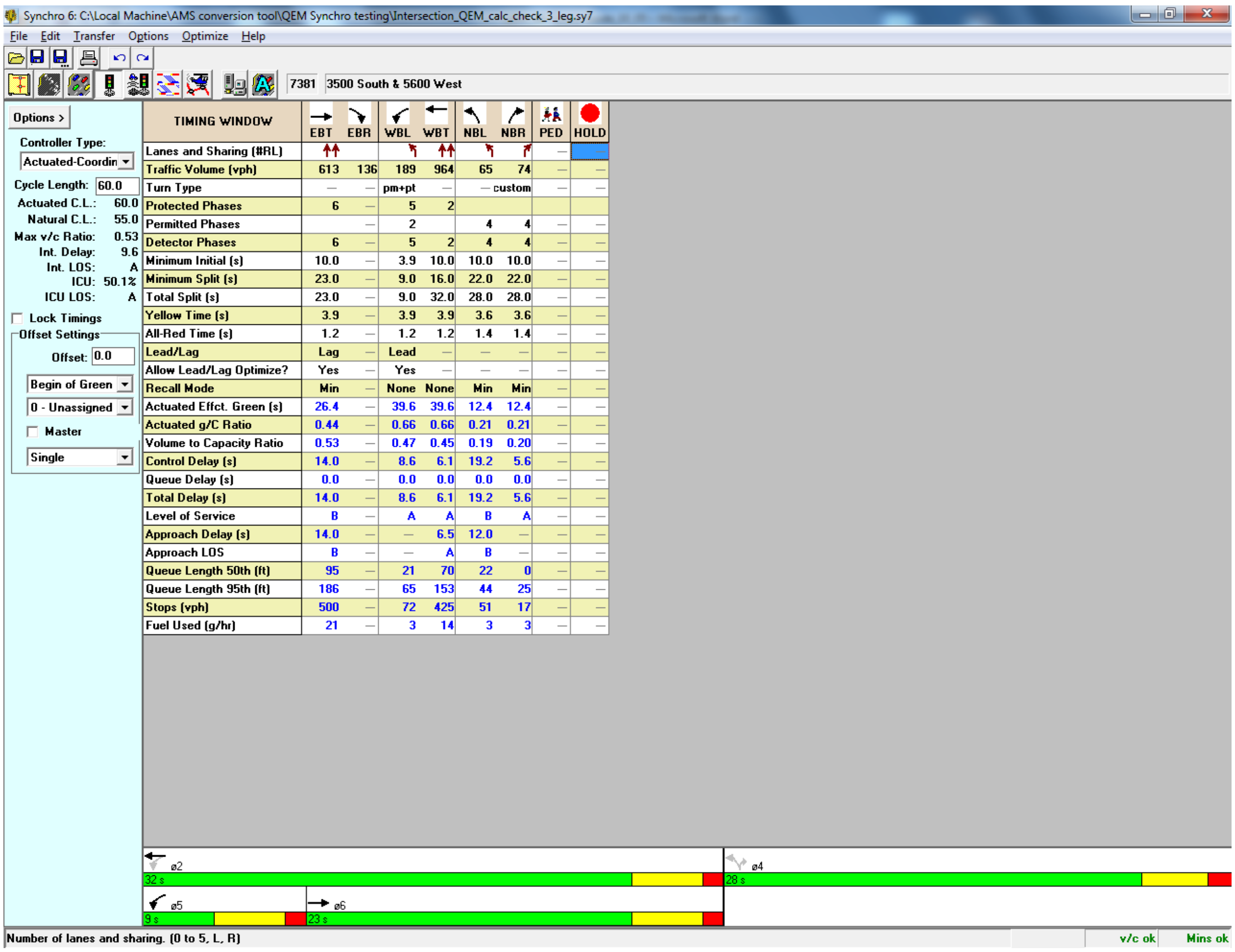


Figure 16. *QEM results for 5200 W 3500 S intersection.*

QEM calculates the cycle length to 60 s, and assigns WB left turns as protected + permitted, and NB left turns as permitted only. When the same inputs, phasing and timing data are transferred to Synchro, the following results are obtained:



TIMING WINDOW	EBT	EBR	WBL	WBT	NBL	NBR	PED	HOLD
Lanes and Sharing (#RL)							—	
Traffic Volume (vph)	613	136	189	964	65	74	—	—
Turn Type	—	—	pm+pt	—	—	custom	—	—
Protected Phases	6	—	5	2				
Permitted Phases		—	2		4	4	—	—
Detector Phases	6	—	5	2	4	4	—	—
Minimum Initial (s)	10.0	—	3.9	10.0	10.0	10.0	—	—
Minimum Split (s)	23.0	—	9.0	16.0	22.0	22.0	—	—
Total Split (s)	23.0	—	9.0	32.0	28.0	28.0	—	—
Yellow Time (s)	3.9	—	3.9	3.9	3.6	3.6	—	—
All-Red Time (s)	1.2	—	1.2	1.2	1.4	1.4	—	—
Lead/Lag	Lag	—	Lead	—	—	—	—	—
Allow Lead/Lag Optimize?	Yes	—	Yes	—	—	—	—	—
Recall Mode	Min	—	None	None	Min	Min	—	—
Actuated Effct. Green (s)	26.4	—	39.6	39.6	12.4	12.4	—	—
Actuated g/C Ratio	0.44	—	0.66	0.66	0.21	0.21	—	—
Volume to Capacity Ratio	0.53	—	0.47	0.45	0.19	0.20	—	—
Control Delay (s)	14.0	—	8.6	6.1	19.2	5.6	—	—
Queue Delay (s)	0.0	—	0.0	0.0	0.0	0.0	—	—
Total Delay (s)	14.0	—	8.6	6.1	19.2	5.6	—	—
Level of Service	B	—	A	A	B	A	—	—
Approach Delay (s)	14.0	—	—	6.5	12.0	—	—	—
Approach LOS	B	—	—	A	B	—	—	—
Queue Length 50th (ft)	95	—	21	70	22	0	—	—
Queue Length 95th (ft)	186	—	65	153	44	25	—	—
Stops (vph)	500	—	72	425	51	17	—	—
Fuel Used (g/hr)	21	—	3	14	3	3	—	—

Figure 17. *Synchro results for 5200 W 3500 S intersection.*

The comparison of the results is as follows:

	QEM	Synchro
Intersection delay (s)	16.5	9.6
Intersection LOS	B	A
Intersection V/C	0.49	0.50

In the field, this intersection operates in an actuated-coordinated mode on a 60 s cycle, with all left permitted only turns. Manual input of permitted left turns yields the following results from QEM and Synchro:

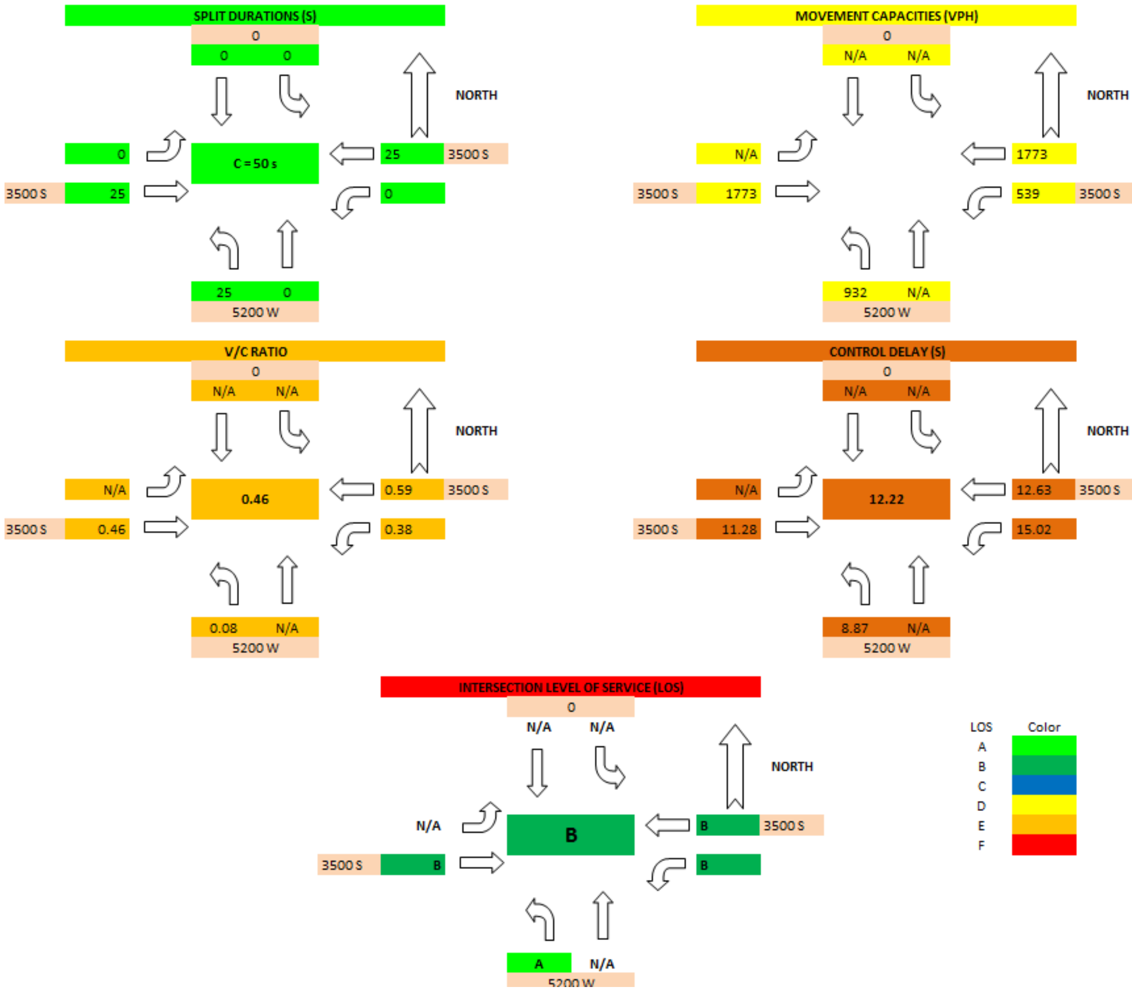
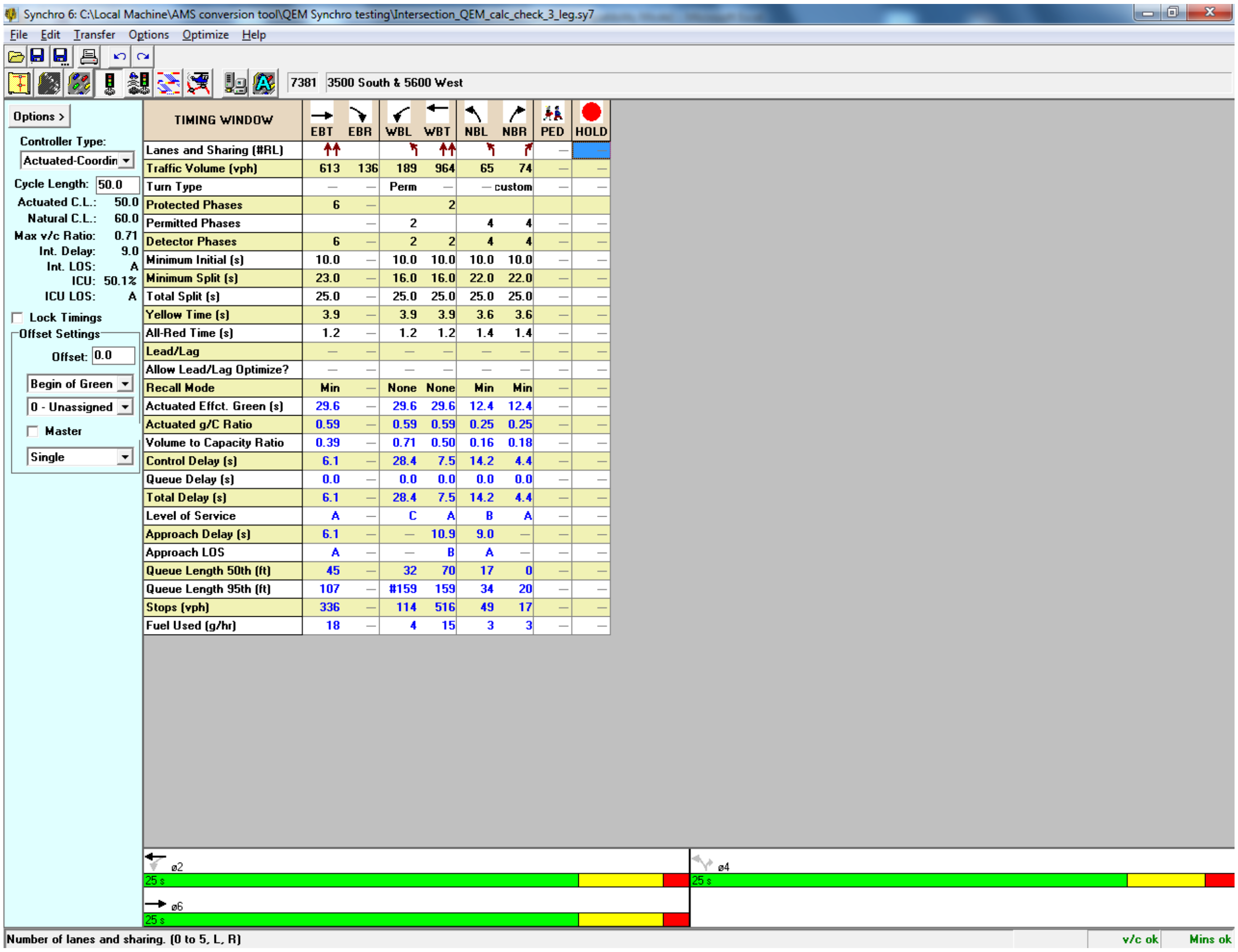


Figure 18. *QEM results for 5200 W 3500 S intersection for manual LT treatment selection.*

In this case, QEM calculates cycle length to 50 s.



TIMING WINDOW	EBT	EBR	WBL	WBT	NBL	NBR	PED	HOLD
Lanes and Sharing (#RL)							—	—
Traffic Volume (vph)	613	136	189	964	65	74	—	—
Turn Type	—	—	Perm	—	—	custom	—	—
Protected Phases	6	—		2				
Permitted Phases		—	2		4	4	—	—
Detector Phases	6	—	2	2	4	4	—	—
Minimum Initial (s)	10.0	—	10.0	10.0	10.0	10.0	—	—
Minimum Split (s)	23.0	—	16.0	16.0	22.0	22.0	—	—
Total Split (s)	25.0	—	25.0	25.0	25.0	25.0	—	—
Yellow Time (s)	3.9	—	3.9	3.9	3.6	3.6	—	—
All-Red Time (s)	1.2	—	1.2	1.2	1.4	1.4	—	—
Lead/Lag	—	—	—	—	—	—	—	—
Allow Lead/Lag Optimize?	—	—	—	—	—	—	—	—
Recall Mode	Min	—	None	None	Min	Min	—	—
Actuated Effct. Green (s)	29.6	—	29.6	29.6	12.4	12.4	—	—
Actuated g/C Ratio	0.59	—	0.59	0.59	0.25	0.25	—	—
Volume to Capacity Ratio	0.39	—	0.71	0.50	0.16	0.18	—	—
Control Delay (s)	6.1	—	28.4	7.5	14.2	4.4	—	—
Queue Delay (s)	0.0	—	0.0	0.0	0.0	0.0	—	—
Total Delay (s)	6.1	—	28.4	7.5	14.2	4.4	—	—
Level of Service	A	—	C	A	B	A	—	—
Approach Delay (s)	6.1	—	—	10.9	9.0	—	—	—
Approach LOS	A	—	—	B	A	—	—	—
Queue Length 50th (ft)	45	—	32	70	17	0	—	—
Queue Length 95th (ft)	107	—	#159	159	34	20	—	—
Stops (vph)	336	—	114	516	49	17	—	—
Fuel Used (g/hr)	18	—	4	15	3	3	—	—

Figure 19. *Synchro results for 5200 W 3500 S intersection for manual LT treatment selection.*

Intersection delay (s)	12.2	9.0
Intersection LOS	B	A
Intersection V/C	0.46	0.5

Optimization in Synchro provides cycle length of 60 s, intersection delay of 6.9 s, and LOS A.

Using QEM in NeXTA

The QEM application is fully integrated with NeXTA. It performs on-the-fly signal parameters estimation using turning volumes obtained through NeXTA/DTALite simulation. The current running speed is about one signalized intersection per second, and it can handle any number of signalized intersections in the given network. The estimated signal timing parameters are placed into a separate QEM_Log file, and they are used for exporting to Synchro or other software. All the signal timing and phasing data are provided in the UTDF format, which enables exchange among different traffic software applications.

The accompanying QEM_SIG.xls file needs to be copied to the NeXTA's home folder. The user should disable manual selection of left turn treatment when QEM is used with NeXTA, and select whether the pedestrian inputs will be included. The QEM is called through NeXTA's menu by going to File>Export>Microscopic Network and Traffic Control Data, and then selecting the Perform Quick Estimation Method (QEM) for Signals option in the dialog box, as shown in Figure 20. This operation will call the Excel QEM spreadsheet and perform the estimation of signal timing parameters for each defined signalized intersection in the network.

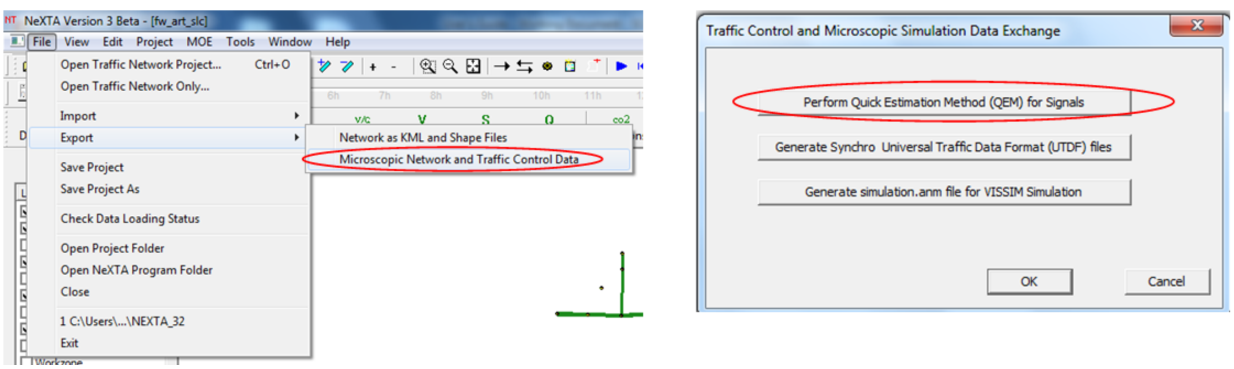


Figure 20. *Starting QEM through NeXTA interface.*

<u>Example: Freeway and Arterial Network from Salt Lake County</u>

The example given here is for a part of the I-15 urban freeway + arterial network from Salt Lake County, UT, spanning between 4500 S and I-80 interchanges. Before calling the QEM application, the user needs to open the desired network in NeXTA and perform DTA simulation. When the simulation is completed, the user calls the QEM application following the described procedure.

Note: make sure that all Excel files are closed before starting this process

When the QEM is started, it will automatically call Excel, which will appear in the toolbar, as given in Figure 21. If the user opens the Excel file, he/she can see how the procedure of signal timing estimation is being performed intersection by intersection.

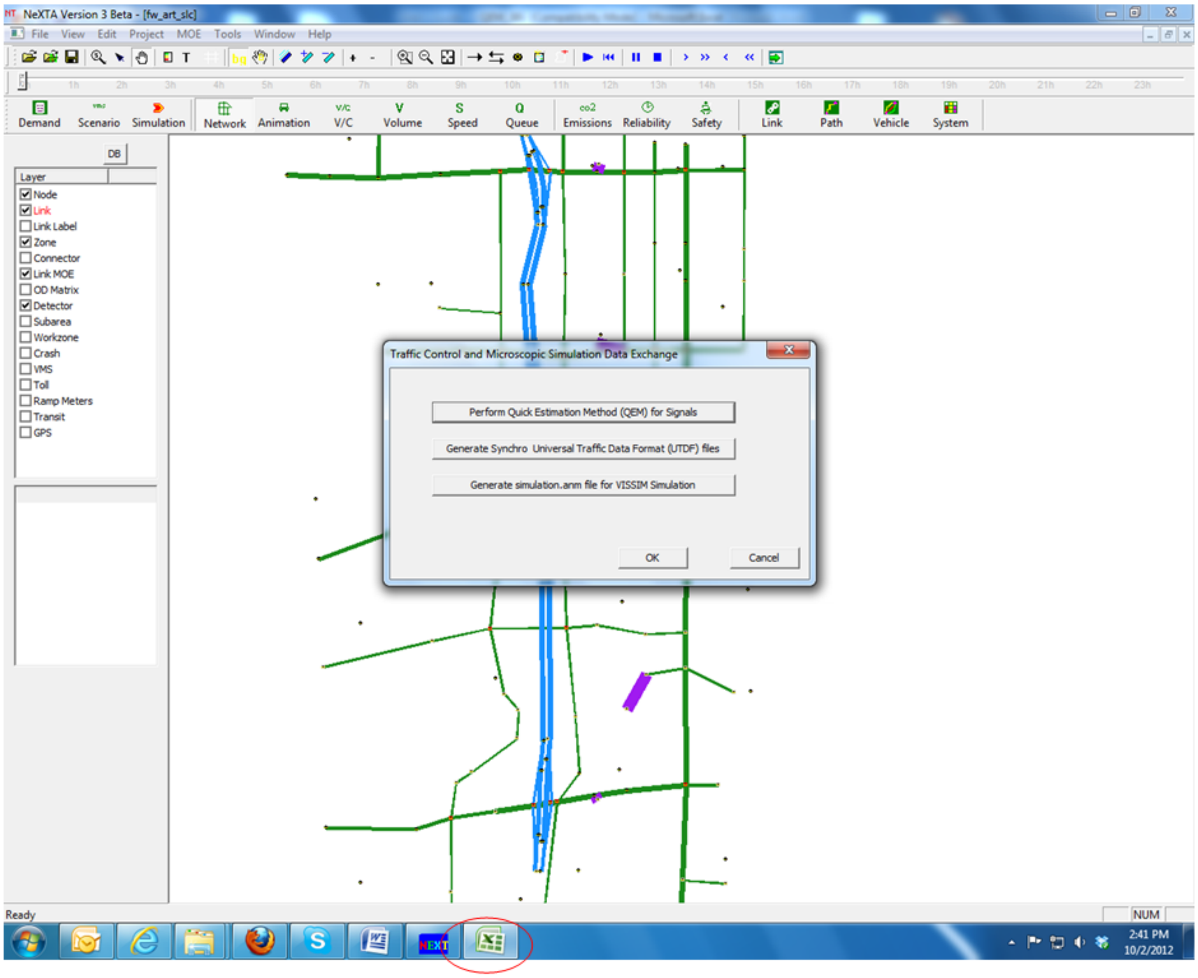


Figure 21. *Automatic signalized intersection estimation through NeXTA/QEM interface.*

The duration of this process depends on the number of signalized intersections in the network. Roughly, it takes about a second per intersection (this time will depend on the PCU speed). When the QEM procedure is completed, the user will be notified about the number of intersections that have estimated capacities and signal timing plans, as shown in Figure 22.

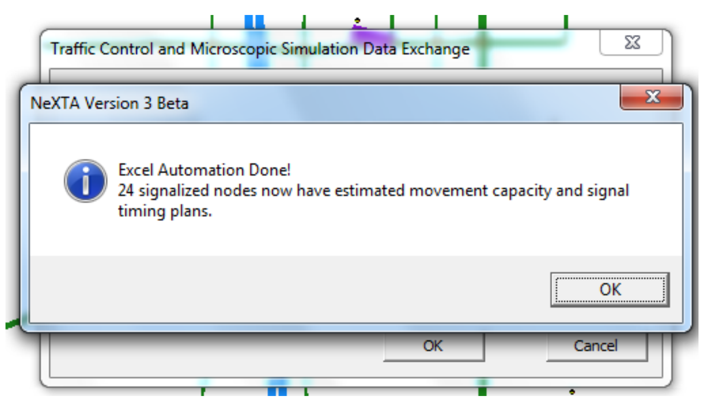


Figure 22. *QEM automation completion message.*

The QEM output data will be written to the accompanying QEM_log.csv file, which is also located in NeXTA's home folder. These data are used to write lanes/volume/phasing/timing data for Synchro export.

Now the Synchro export can be completed by pressing the "Generate Synchro Universal Traffic Data Format (UTDF) files" button. This operation will create a new folder in the project folder, named "Exporting_Syncro_UTDF", which consists of five .csv files: Lanes, Layout, Phasing, Timing and Volume. These are the files used to create the same network in Synchro.

To import the network to Synchro, complete with signal timing/phasing data, follow these steps (**Note**: these procedure is for Synchro Version 6):

1. Open a new project in Synchro, select Transfer tab from the menu, and go to Data Access…

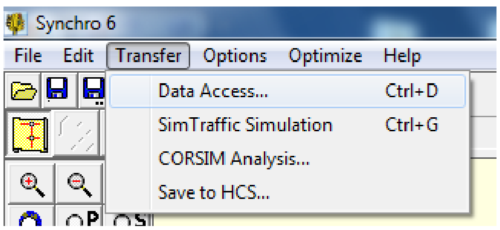


Figure 23. *Data Access in Synchro.*

2. In the opened dialog box, Go to the Layout tab, press Select, and go to the Exporting_Synchro_UTDF folder in the project folder.

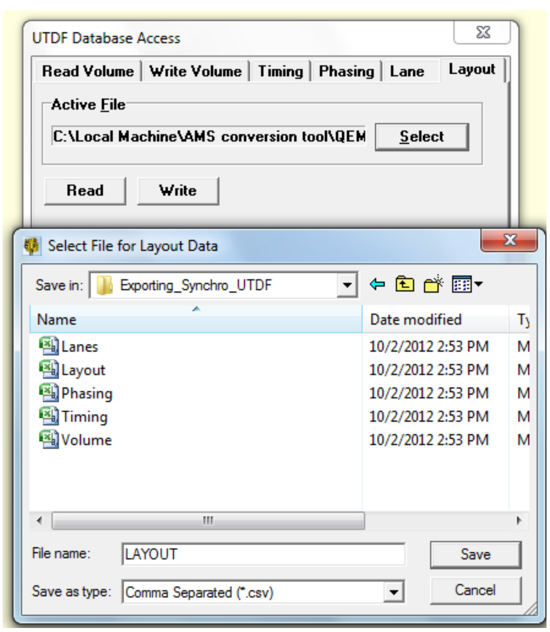


Figure 24. *Reading Layout.csv file.*

3. Click on the Layout file, press Save, and then Read. Synchro will report a warning in the Layout file reading. This is OK, since Synchro needs to reconfigure the intersection numbering. Press Resume, and the Layout file will be read.
4. While still in the Layout tab, press Select again, and rename the layout file to Synchro_Layout. Press Save, and then Write. Synchro will replace the layout file with the new that has a consistent intersection node numbering.

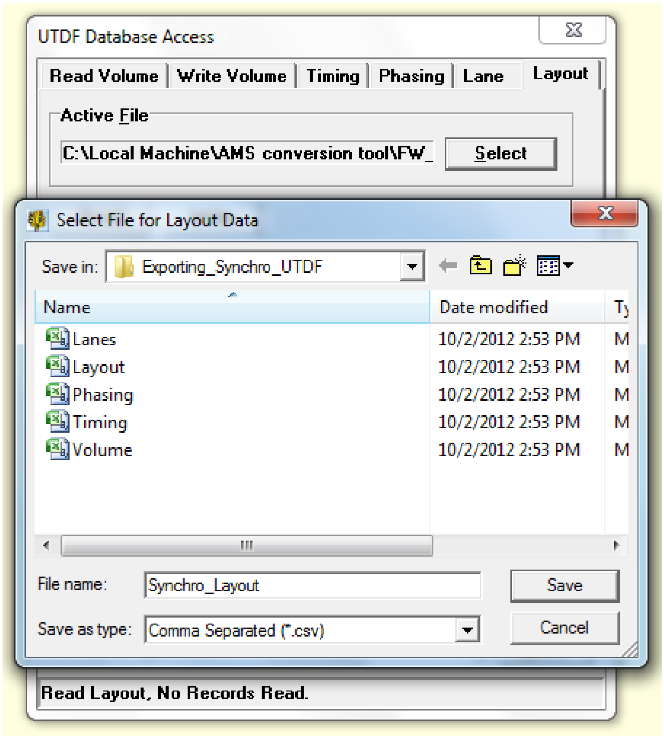


Figure 25. *Writing Syncrho_Layout.csv file.*

5. Go to the Lane tab, make sure that the "Include Volume Related Data" box is checked, press Select, and select the Lanes file from the Exporting_Synchro_UTDF folder. Press Read. Syncro will read the lanes data and return a message on the number of records written.
6. Repeat step 5 for phasing data in the Phasing tab.
7. Repeat step 6 for timing data in the Timing tab. Make sure to change the "Timing Plan Name" from "Default" to "1" to read the correct timing plan.
8. Go to the Read Volume tab and read volumes from the Exporting_Synchro_UTDF folder following the same procedure as in the previous steps.

After all the steps are completed, the network from NeXTA will be imported to Synchro. The user can access any signalized intersection and read Synchro signal parameters. If needed, a network-wide signal timing optimization can be performed in Synchro. The converted network is shown in Figure 26.

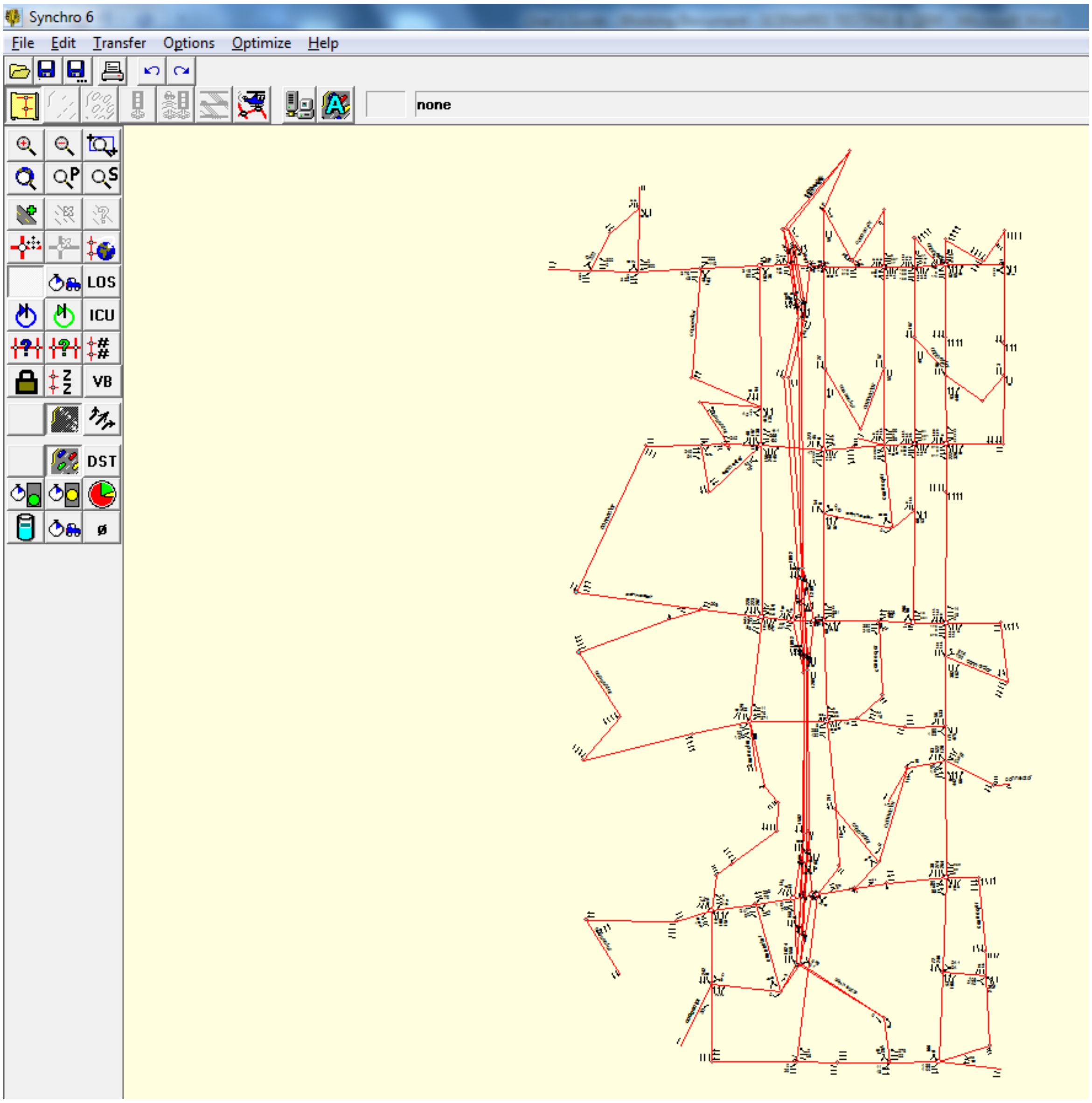


Figure 26. *NeXTA network exported to Synchro, with QEM signal timing data.*