

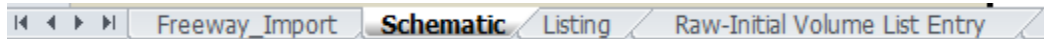
Intersection Volume Balancing Excel Tool

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Prepare Files

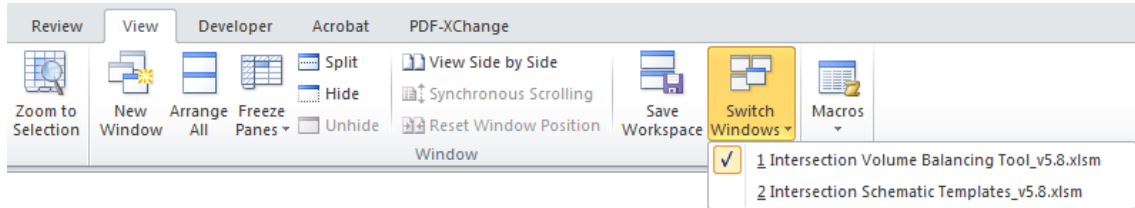
1. Make a copy of the intersection volume balancing tool file. The tool file is called “**Intersection Volume Balancing Tool_*.xism**” (* is the current tool version)
2. Rename the copied file to be relevant to the project and balancing time period (e.x. “STH 99_Existing AM Peak.xism”).
 - a. **Tip:** Complete the volume balancing process for one time period, then make a copy of the completed file to use as the basis for additional balancing periods (e.x. complete AM, then copy it and use it as a basis for PM).
3. Open the file from step 2. The workbook is organized into 4 worksheets.



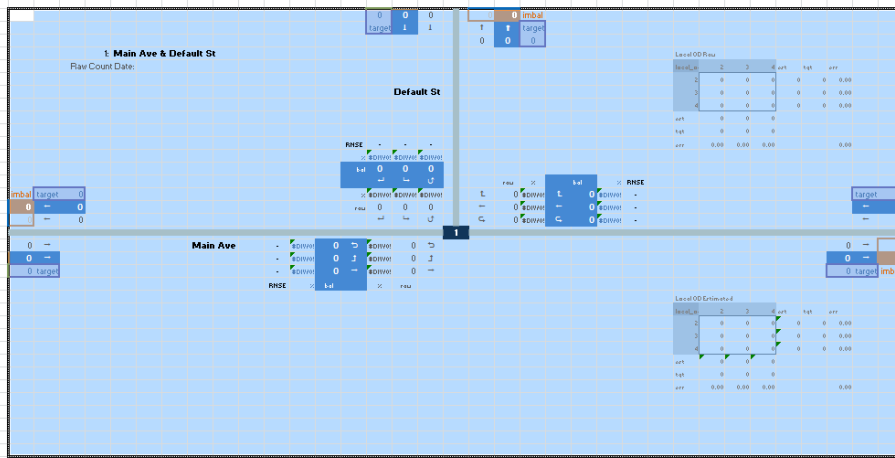
Worksheet	Contents
Freeway_Import	Provides a table for importing volumes from the freeway volume balancing tool. Not needed for projects that are not using the freeway volume balancing tool.
Schematic	The primary worksheet you will be working in to balance volumes. Contains space to build a schematic of the corridor and volumes.
Listing	Lists all the intersections and the turning volumes in the schematic.
Raw-Initial Volume List Entry	Provides an alternative to the schematic for raw/initial volume data entry. Volumes can be entered on this worksheet in list format, then transferred to the schematic

Build Schematic Network

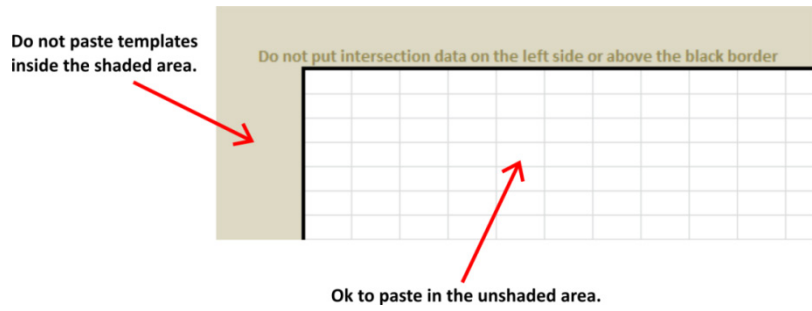
1. With the intersection volume balancing file open from Step 3 above, also open the “**Intersection Schematic Templates_*.xlsm**” file. This puts both files in the same instance of Excel so formulas can be copied between workbooks, otherwise cells would be pasted as values-only. You can check that both files are open in the same instance of Excel by going to:
View ->Switch Windows -> *should see both files listed.*



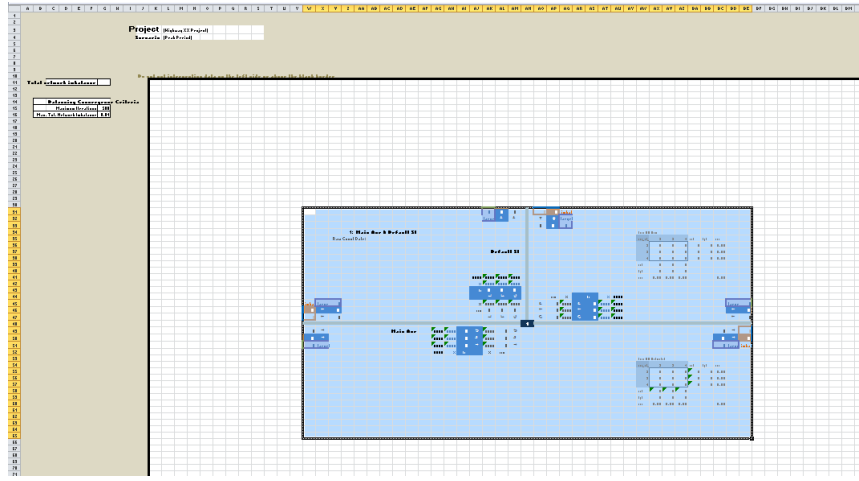
2. Build a schematic of your corridor by copying intersections from the templates file and pasting into the balancing file. The templates file has multiple worksheets, each representing a different intersection or interchange layout. Current templates include
 - **4 leg intersection**
 - **3 leg intersection** - 4 orientations of the minor road available
 - **Diamond interchange** –oriented north-south, or east-west. Half-diamonds also included
 - **Partial Cloverleaf (Parclo)** – oriented north-south or east-west, loops in 1 or 2 quadrants
 - **Single point interchange** – oriented north-south or east-west
- a. From the “**Intersection Schematic Templates_*.xlsm**” file, select all the cells in an intersection template. (Each template has thin dotted gridlines outlining its extent.)



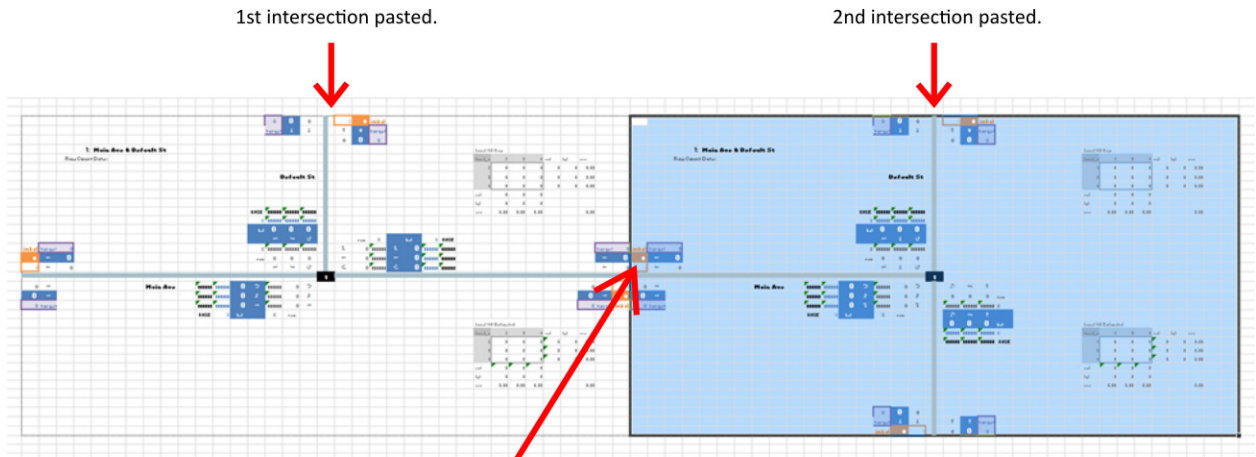
- b. Use ctrl+c to copy.
- c. Paste it into the volume balancing workbook on the **Schematic** worksheet. Be generous on the number of blank cells you leave around the intersection so that you have enough space to paste in adjacent intersections. Do not paste templates in the tan shaded area.



Example of a 3-leg intersection template after pasting:



- d. By pasting intersection templates directly next to each other, the formulas in the templates will reference the correct cells in adjacent intersections. Below is an example of pasting another 3-leg intersection to the right of the previous example. Some volumes have been filled in to show how the imbalance between intersections was automatically calculated.

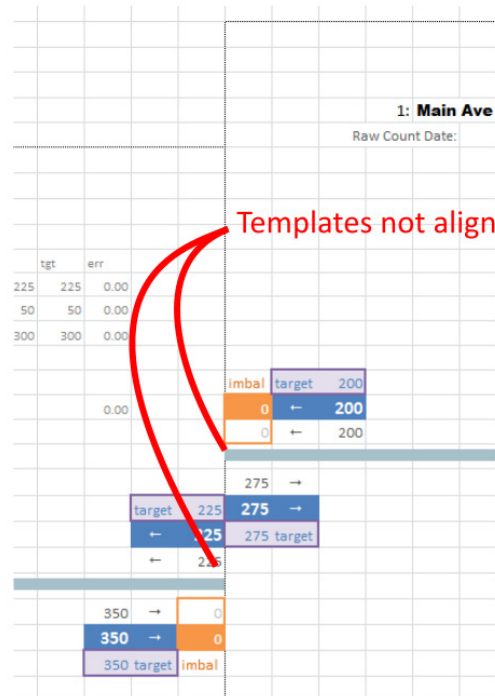


target	213	imbal	target	213
←	225	25	←	200
←	225	25	←	200
350	→	-75	275	→
350	→	-75	275	→
313	target	imbal	313	target

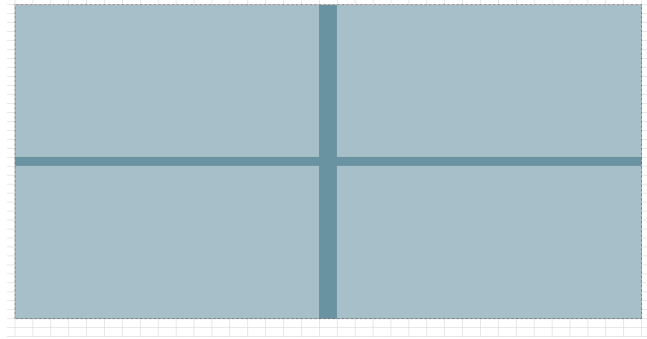
By pasting templates next to each other, the volume balance between intersections is automatically calculated.

- e. Pasting intersection templates is not always easy. The example shown at right is an instance where the pasted template is not lined up with its neighbor. Fix this condition by either:
- Using undo (ctrl+z) immediately after pasting, or
 - Deleting the misaligned intersection, clearing all the formats, and deleting any remaining road lines.

Do not drag the misaligned intersection to a new position. Dragging will break formulas in the templates!

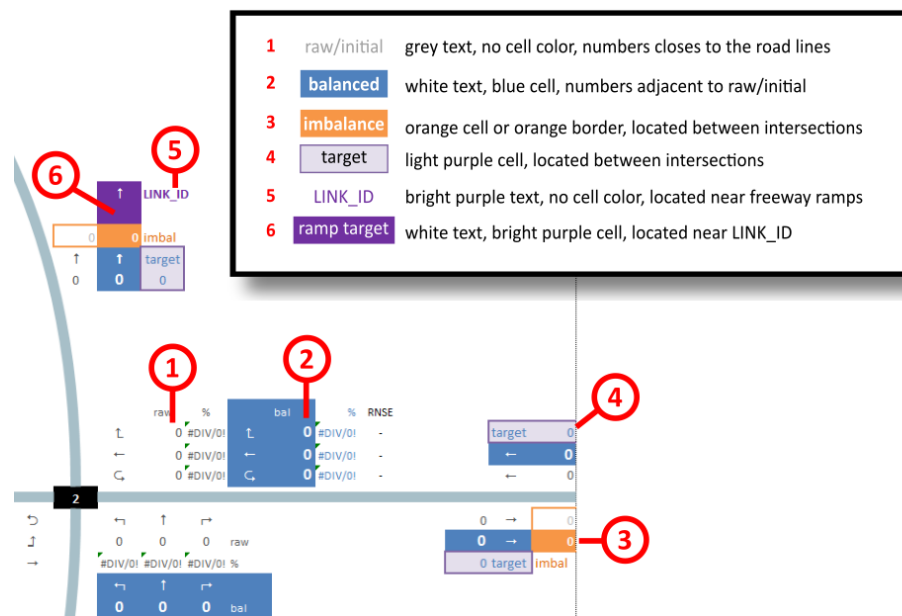


Tip: If your network is large or complicated, you may need to plan the size and shape of your schematic network before copy/pasting templates at-will. There are blank placeholder intersections in the templates file that look like the following screenshot. These do not contain formulas, so in a completely blank volume balancing workbook they can be copy/pasted and dragged around to help you plan. Paste over the placeholders with real templates when you are done.



3. Intersection templates have special colors to highlight various volumes. The most common cell colors are shown below.

1	Raw/initial unbalanced volume.
2	Balanced volume output after running the volume balancing tool, or from manually inputting balanced volumes.
3	Imbalance between two adjacent intersections
4	Target volume between two adjacent intersections. Volume balancing tries to meet this volume to remove the imbalance between intersections
5	LINK_ID is a unique identifier for an interchange ramp
6	Ramp volume target. This is the volume that the intersection turning volumes should meet in order to match the freeway volume balancing.



4. Intersection templates also include OD matrices. These are not something the user needs to adjust, but are important for understanding how the automatic volume balancing macro works. The macro does all of its work using turning movement data in OD matrix format.
- The raw/initial turning movement OD is used as a seed for estimating the balanced volume OD.
 - The blue balanced volume cells in the schematic point to the balanced (estimated) matrix. This is why the blue balanced volume cells show the raw/initial volumes before running the balancing macro.

4a Raw/initial turning movement OD matrix.

Local OD Raw	1	2	3	4	est	tgt	err
1	0	110	1051	570	1731	1731	0.01
2	87	0	15	33	135	135	0.00
3	343	14	0	51	408	408	0.00
4	120	13	0	0	157	157	0.00
est	550	137	1090	654			
tgt	537	137	1090	654			
err	0.02	0.00	0.00	0.00			0.04

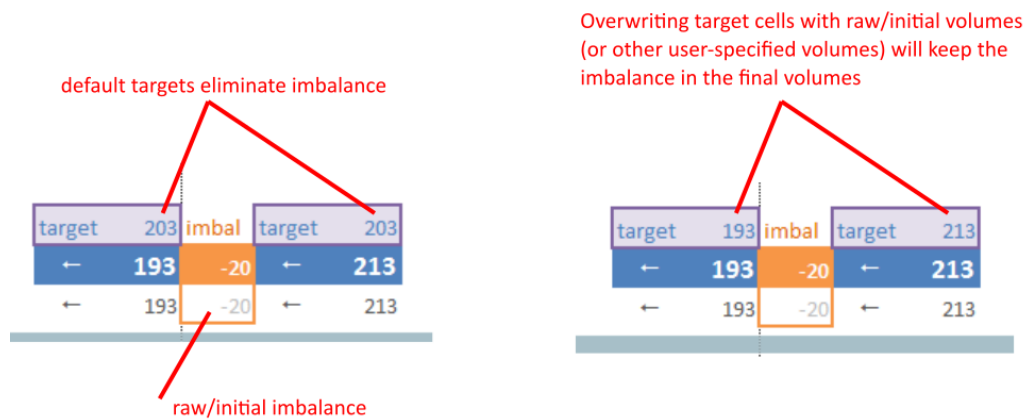
4b Balanced (estimated) turning movement OD matrix.

Local OD Estimated	1	2	3	4	est	tgt	err
1	0	110	1051	570	1731	1731	0.01
2	87	0	15	33	135	135	0.00
3	343	14	0	51	408	408	0.00
4	120	13	24	0	157	157	0.00
est	550	137	1090	654			
tgt	537	137	1090	654			
err	0.02	0.00	0.00	0.00			0.04

raw	%	bal	%	RNSE		
T	15	11%	T	15	11%	0.0
←	33	24%	←	33	24%	0.0
↔	87	64%	↔	87	64%	0.0
C	0	0%	C	0	0%	-

Balanced volumes initially equal the raw volumes as a "seed" for the automatic volume balancing macro.

5. Driveways between intersections can be handled in multiple ways for volume balancing:
 - a. Include a driveway template between intersections (described below)
 - b. Include the driveway as an intersection in the schematic. This is a good approach for high volume driveways, especially if you have collected volume data at the driveway.
 - c. Overwrite the targets on either side of the driveway to allow an imbalance in the final output from the balancing macro. You could also first run the volume balancing macro without considering the driveway, then manually specify upstream and downstream targets to create an imbalance, and finally re-run the volume balancing macro.



(5a) Using a driveway template:

1. Locate where the driveway should go in the volume balancing workbook **Schematic** worksheet (north, south, west, or east leg of the intersection)

2: Main Ave & Default St

Raw Count Date:

tgt	err				
55	155	0.00			
93	203	0.05			
87	187	0.00			
23	123	0.00			
		0.08			
	target	203	imbal	target	203
	←	193	-20	←	213
	←	193	-20	←	213
	156	→	10	166	→
	156	→	10	166	→
	161	target	imbal	161	target

Main Ave

Want to include a driveway here in this example.

2. In the intersection templates workbook, **Driveways** worksheet, find the corresponding driveway location. The templates file has driveways on the north, south, west, and east legs of an intersection. For the example above, you would copy the driveway on the east leg of the template intersection.

Corresponding driveway location
(east leg driveway for this example)

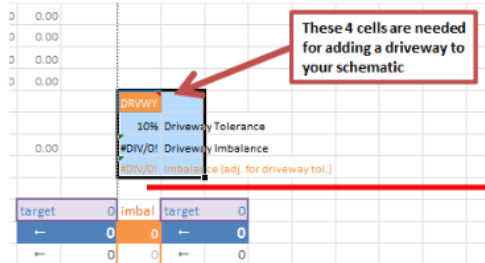
Driveway Template Intersection

(west leg driveway)

(north leg driveway)

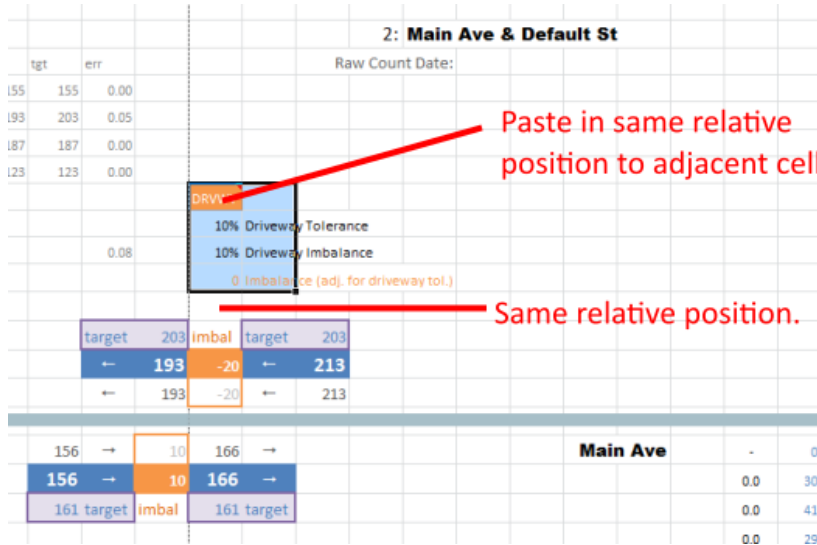
(south leg driveway)

- Copy the applicable driveway cells from the intersection templates workbook, **Driveways** worksheet. You only need the 4 cells pointed at in the template, but the adjacent labels are nice to copy too. Take note of where the driveway cells are located relative to other volume cells in the template.



Relative position:
The driveway cells on the east leg
leave 1 blank cell above the
imbalance cells.

- Paste the driveway cells in your volume balancing workbook, **Schematic** worksheet at the same relative position to other volume cells. You will need to adjust the DRVWY cell formula if you cannot paste it at the same relative location (see below for further instructions).



- Adjust the driveway tolerance. The driveway template cells include the following:

DRVWY	Header cell that contains a formula to reference adjacent cells. You only need to change the formula in this cell if you cannot paste the driveway in the same relative location as shown in the intersection templates file. See below for how this formula works.
10%	Driveway Tolerance. Adjust this to the maximum % imbalance you will allow between intersections.
10%	Driveway Imbalance This is not a user input. The cell shows the final driveway imbalance after the balancing macro has been run. The final imbalance may be less than the tolerance specified above.
0	Imbalance This is not a user input. This is a cell the balancing macro uses to determine if the imbalance is within tolerance.

Example DRVWY formula:

DRVWY cell formula:
 =CHOOSE(1,"DRVWY",CG67,CG64,CG63,CG62,CF66,CI66,CF67,CI67)
 1 2 3 4 5 6 7 8

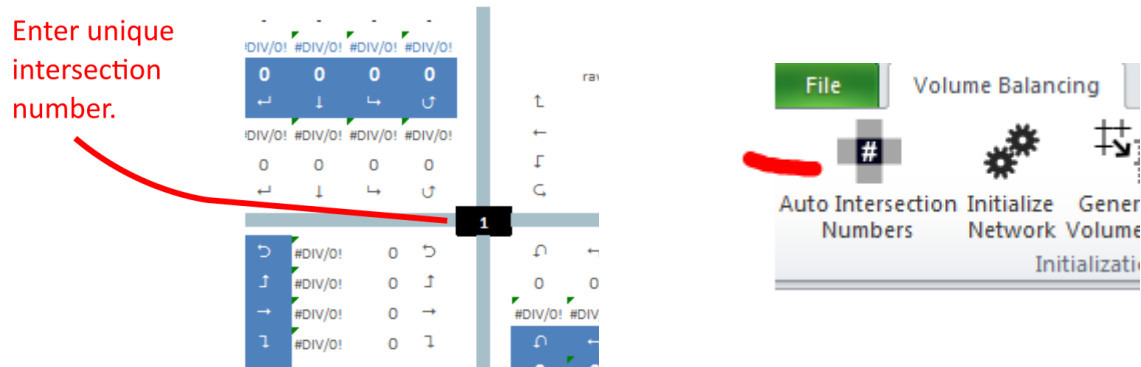
	CC	CD	CE	CF	CG	CH	CI	CJ	CK
60	0	0	0.00						
61					DRVWY				
62					4.0%	Driveway Tolerance			
63			0.00		#D/0!	Driveway Imbalance			
64					#D/0!	Imbalance (adj. for driveway tol.)			
65									
66		target	5	0	imbal	target	6	0	
67		←	7	0	1	0	←	8	0
68		←		0	0		←		0
69									

- 1 - imbalance cell,
- 2 - adjusted imbalance cell,
- 3 - % Driveway Imbalance,
- 4 - % Driveway Tolerance,
- 5 - downstream target cell,
- 6 - upstream target cell,
- 7 - downstream balanced volume,
- 8 - upstream balanced volume

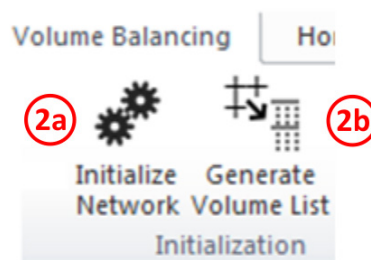
Initialize Network

After the schematic network has been drawn, the “Intersection Schematic Templates_*.xslm” file can be closed and the remainder of the steps occur within your **Volume Balancing** workbook. Initializing the network occurs on the **Schematic** worksheet.

1. All intersections need to be assigned a unique number manually, or by using the Auto Intersection Numbers button on the Volume Balancing ribbon tab.



2. Finish initializing the network by sequentially running the following two buttons on the Volume Balancing ribbon tab:
 - a. **Initialize Network** – This runs code to help the volume balancing macros understand the network schematic. **Anytime the schematic network geometry is changed, the Initialize Network button needs to be run.**
 - b. **Generate Volume List** – Populates the **Listing** worksheet with a list of all the turning volumes in the network.

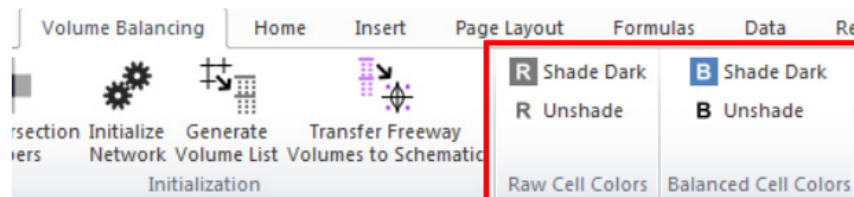


1: Main Ave & Default St				
Raw Count Date:		1/1/2018		

- d. Enter raw/initial counts. Raw/initial counts are located closest to the road lines in the schematic.

	RNSE	-	-	-	-
	%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	bal	0	0	0	0
		←	↓	↘	↻
	%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Enter raw/initial counts	raw	0	0	0	0
		←	↓	↘	↻
	#DIV/0!	0	↶	#DIV/0!	0
	#DIV/0!	0	↑	#DIV/0!	0
					...

- i. If you are distracted by the blue shaded (balanced volume) cells while entering raw data, use the cell shading buttons on the Volume Balancing ribbon tab to change the cell colors.



- ii. If you want to enter data in a list format rather than a schematic format, use the [Raw Volume List Entry](#) worksheet. Each intersection is listed with turning movements oriented to the schematic, this is why this worksheet uses terms like “top leg” and “left leg.” Be careful if the schematic orientation is not the same as the data collection or physical intersection orientation. For example, the top leg that looks like it is southbound in the schematic could be eastbound in real life.

See example below:

- (1) Enter the turning movement data for each intersection in the list.
- (2) Run the Transfer to Schematic button to copy the volumes from the list to the schematic.

1. Enter data in list
2. Use Transfer to Schematic button

Transfer **to** Schematic Transfer **from** Schematic

Turn Number	12	11	10	9	8	7
		↓				←
Intersection Number	Top Leg			U-Tn	Right Leg	
Name	Right	Thru	Left	Right	Thru	Left
1 A St & Default St	50	0	0	0	0	0
2 B St & Default St	0	0	0	0	0	0
3 C St & Default St	0	0	0	0	0	0

R/NSE	0.0	-	-	-
%	100%	0%	0%	0%
bal	50	0	0	0
	↔	↓	↔	↕
%	100%	0%	0%	0%
raw	50	0	0	0
	↔	↓	↔	↕

e. Enter any target volumes that the balanced volumes must exactly match.

The default target volume between intersections is the average of the upstream raw/initial volumes. Overwrite the purple target cells here to use your own formula or hard-coded value.

Upstream volumes will be adjusted to try and match this target number

197	142	142
target	↓	↓
imbal	109	109
197	251	251
target	↓	↓

Downstream volumes will be adjusted to try and match this target number

Default target is 197 (average of raw/initial 142 and 251).

- f. Enter freeway ramp Link ID's and volume targets. (Only needed if your network needs to balance with freeway ramp volumes from the freeway volume balancing tool)
 - i. Copy the volumes from the freeway volume balancing tool, **Export to Intersection Balancer** worksheet.
 - ii. Paste values and formats only into to the intersection volume balancing tool, **Freeway_Import** worksheet (pasting formulas may cause errors)

Copy data from the Freeway Volume Balancing Tool "Export To Intersection Balancer" worksheet

Copy this Data to the Turning Movement Balancing Workbook						
LINK_ID (no prefix)	LINK_ID	Corridor	Corridor & Direction	Type	Location	Balanced Volume
1000	LINK_1000	NB I-39/90	NB I-39/90	mainline	Badger I/C	3660
1010	LINK_1010	NB I-39/90	off	NB WIS 30		580
1020	LINK_1020	NB I-39/90	off	to EB I-94		480
1030	LINK_1030	NB I-39/90	mainline	b/n ramps		2600
1040	LINK_1040	NB I-39/90	on	EB WIS 30		370
1050	LINK_1050	NB I-39/90	on	m WB I-94		680
1060	LINK_1060	NB I-39/90	mainline	to US 151		3650
1070	LINK_1070	NB I-39/90	CD	crossing CD		2000
1080	LINK_1080	NB I-39/90	off	h Crossing		470
1090	LINK_1090	NB I-39/90	off	NB US 151		1420
1100	LINK_1100	NB I-39/90	CD	b/n ramps		110
1110	LINK_1110	NB I-39/90	on	NB US 151		70
1120	LINK_1120	NB I-39/90	off	SB US 151		110

Paste values & formats (no formulas) into Intersection Volume Balancing Tool "Freeway_Import" worksheet

Project: Sample Freeway & Intersection Balancing						
Scenario Year 2012 AM Peak						
LINK_ID	Corridor	Corridor & Direction	Type	Location	Balanced Volume	
LINK_1000	NB I-39/90	NB I-39/90	mainline	Beltline I/C to Badger I/C	3660	
LINK_1010	NB I-39/90	off	off to WB WIS 30		580	
LINK_1020	NB I-39/90	off	off to EB I-94		480	
LINK_1030	NB I-39/90	mainline	b/n ramps		2600	
LINK_1040	NB I-39/90	on	on from EB WIS 30		370	
LINK_1050	NB I-39/90	on	on from WB I-94		680	
LINK_1060	NB I-39/90	mainline	Badger to US 151		3650	
LINK_1070	NB I-39/90	CD	off to US 151/High Crossing	CD	2000	
LINK_1080	NB I-39/90	off	CD: off to High Crossing		470	
LINK_1090	NB I-39/90	off	CD: off to NB US 151		1420	
LINK_1100	NB I-39/90	CD	CD: b/n ramps		110	
LINK_1110	NB I-39/90	on	CD: on from NB US 151		70	
LINK_1120	NB I-39/90	off	CD: off to SB US 151		110	

On schematic interchange templates, replace the placeholder LINK_ID text with the corresponding LINK_ID in the table below. Copy/Paste the LINK_ID or use formulas to help reduce errors.

- iii. Assign Link ID's in the intersection volume balancing workbook, **Schematic** worksheet. Overwrite the purple text cells that contain "LINK_ID" by copy/pasting the Link ID's from the **Freeway_Import** worksheet, or use formulas.
- iv. Run the Transfer Freeway Volumes to Schematic button located on the Volume Balancing ribbon tab.

iii. Replace placeholder LINK_ID text with LINK_# where # is the number used in the freeway volume balancing tool. This example shows LINK_1080.

iv. Use the Transfer Freeway Volumes to Schematic button on the volume balancing toolbar. The LINK_# is used as a lookup to retrieve the volumes shown on the Freeway_Import worksheet.

raw	%	bal	%	RNSE
323	100%	323	100%	0.0
0	0%	0	0%	-

High Crossing Blvd

raw	%	bal	%	RNSE
141	100%	145	100%	0.0
0.0	0.0%	0.0	0.0%	-

raw	%	bal	%	RNSE
141	26%	394	74%	
26%	74%			
0.0	0.0%			

target	imbal
470	65
535	65

LINK_1080

File Volume Balancing Home Insert Page

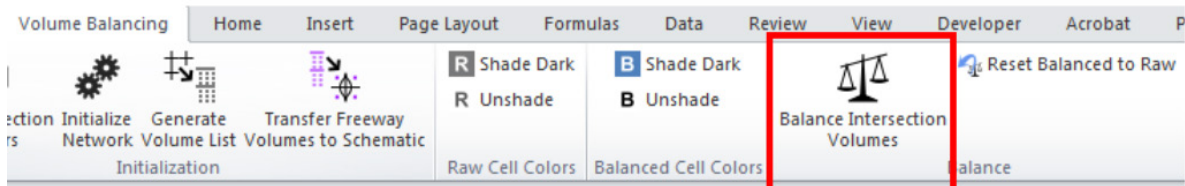
Auto Intersection Numbers Initialize Network Volume List Initialization Generate Transfer Freeway Volumes to Schematic

Balance Volumes

The following steps occur in your **Volume Balancing** workbook, on the **Schematic** worksheet.

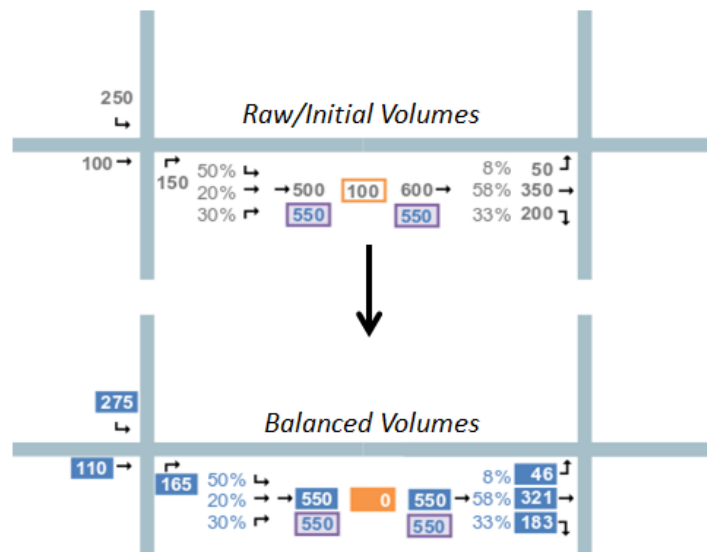
1. After initializing the network, and after entering the raw/initial volumes, the Balance Intersection Volumes macro button can be run from the Volume Balancing ribbon tab. A pop-up will show some statistics about the end result when the macro finishes.

Tip: Running the balancing macro multiple times in a row may not improve the balancing, and may make the end results worse.



2. A simplified example of how the balancing macro works is shown below. The raw/initial volumes have an imbalance of 100. Based on the turning volume proportions at each intersection, the raw/initial volumes are adjusted up or down to eliminate the imbalance. The automatic balancer does this by looking at the turning proportions in an OD matrix format, and iteratively multiplying the rows and columns of the OD matrix until the row and column sums meet the targets. The automatic balancing procedure targets the average incoming and outgoing volumes (550) to resolve the imbalance.

Targets “float” by default. The average of the balanced incoming and outgoing volumes is recalculated during every iteration, and the result may be higher or lower than the initial average. The resulting balanced volumes in this simple example meets the initial target of 550.



Inspect and Adjust

1. Balanced volumes should be inspected and manually adjusted as necessary, especially where the user can contribute project-specific knowledge. Comparisons between the raw/initial volumes and balanced volumes are shown in the **Schematic** worksheet and **Listing** worksheet. Generally:

- RNSE less than 3.0 are typically acceptable,
- RNSE 3.0 to 4.9 may be acceptable,
- RNSE 5.0 or greater require further investigation

Example **Schematic** worksheet:

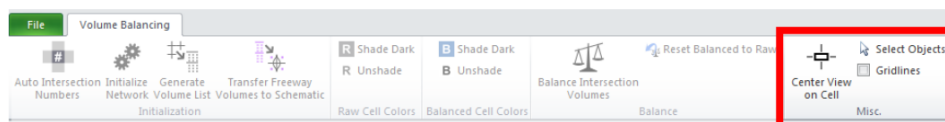


Example **Listing** worksheet:

Table can be sorted by RNSE to diagnose results. Restore to original order by sorting low to high on the SORT column.

Project: Sample Freeway & Intersection Balancing									
Scenario: Year 2012 AM Peak									
Intersection Turning Movement Volume Comparison									
SORT	TURN_ID	Intersection Number	Intersection	Intersection	Turn	Volume		Diff. (Bal - Raw)	RNSE
						Raw	Balanced		
9	1 TURN_001_03	1	US 51 & NB I-39/90/94 Ramps	US 51 & NB I-39/90/94 Ramps	NBT	312	308	-4	0.2
10	2 TURN_001_04	1	US 51 & NB I-39/90/94 Ramps	US 51 & NB I-39/90/94 Ramps	NBR	143	110	-33	2.8
11	3 TURN_001_06	1	US 51 & NB I-39/90/94 Ramps	US 51 & NB I-39/90/94 Ramps	WBL	91	88	-3	0.3
12	4 TURN_001_08	1	US 51 & NB I-39/90/94 Ramps	US 51 & NB I-39/90/94 Ramps	WBR	217	212	-5	0.3
13	5 TURN_001_11	1	US 51 & NB I-39/90/94 Ramps	US 51 & NB I-39/90/94 Ramps	SBT	1193	1168	-25	0.7
14	6 TURN_001_12	1	US 51 & NB I-39/90/94 Ramps	US 51 & NB I-39/90/94 Ramps	SBR	12	40	28	8.1

Clicking the hyperlink selects the corresponding cell in the Schematic worksheet. Hyperlinks are not very good at putting the selected cell in the center of the view. Use the Center View on Cell button on the Volume Balancing ribbon tab.



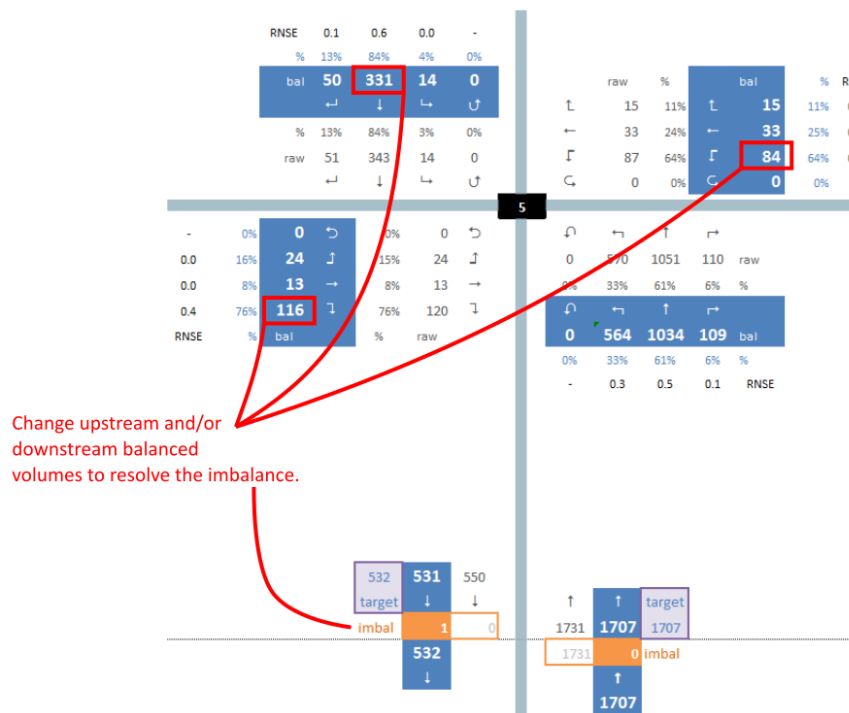
The **Listing** worksheet also lists the values in all the imbalance cells. This is useful for identifying where any remaining imbalances are occurring.

Hyperlink to imbalance cell on the Schematic worksheet.

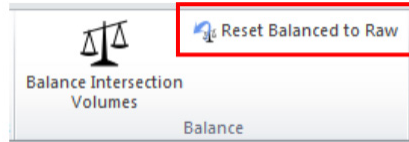
Imbalance Cells	
Cell	Value
[Intersection EXAMPLE (Tool v5.7).xism]Schematic!\$DG\$147	1
[Intersection EXAMPLE (Tool v5.7).xism]Schematic!\$DG\$182	1
[Intersection EXAMPLE (Tool v5.7).xism]Schematic!\$AY\$27	0
[Intersection EXAMPLE (Tool v5.7).xism]Schematic!\$AF\$42	0
[Intersection EXAMPLE (Tool v5.7).xism]Schematic!\$BO\$42	0
[Intersection EXAMPLE (Tool v5.7).xism]Schematic!\$BN\$46	0

Clean up any remaining issue by manually adjusting the balanced volumes.

- The automatic balancing macro may leave behind some imbalances due to rounding. These must be fixed manually by changing the balanced volumes in the blue cells. If you want volumes rounded to the nearest 5 vph, you will have to manually change all the balanced volumes.



3. If you need to re-run the volume balancing macro, for example after correcting an error in the raw/initial volumes:
- Use the Reset Balanced to Raw button on the Volume balancing ribbon tab. **Caution:** This button will overwrite any manually typed values in the balanced volumes.



- Use the Balance Intersection Volume button to run the balancing again.

Tip: Running the balancing macro multiple times in a row may not improve the balancing, and may make the end results worse. Only run it again if making changes to raw/initial volumes, targets, or driveways.