Turns5 – V2014
Tool Documentation

Prepared for:

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Turns5 – V2014 Tool Documentation

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1.0   Introduction

Estimating vehicle turning movements at intersections is an important step in forecasting future traffic volumes. These forecasted turning movements are useful in determining intersection operational characteristics and plan for intersection geometric improvements. The number of turning vehicles is needed to determine whether turn lanes are warranted. Turning vehicle demand is used to determine the number and length of turn lanes at intersections. Turning vehicle demand can be difficult to estimate. Existing turn patterns can be recorded manually through electronic count machines or through vehicle sensing cameras. These methods are costly in both man-hours and equipment.

An alternate method of estimating turning movements uses the annual average daily traffic (AADT) on each approach of the intersection and the functional classification of each approach. This method of estimating turning flows is used throughout the Turns5 software and is described within this document.

This document is meant to further explain the inner workings of Turns5. It is not meant as a User's manual but as a document that could provide detail on each tab and what the 'Run Turn Counts Macro' button really does. For a User's manual please refer to the 2012 Project Traffic Forecasting Handbook (or latest version).

The main updates to Turns5 – V2014 include the ability to estimate turning volumes for a 3-way intersection, the change from using ½*AADT as an approach volume to AADT*K*D, and the addition of new 'First Guess Turning Percentages' methodologies.

The 'Explanation of Tabs within Workbook' chapter goes into detail about what each tab does and how they relate to each other. A sample project has been provided in **Appendix A**. The input sheet, the turning volume summary, and the output graphics of the sample project have been provided. This document is only meant for illustrative purposes and does not reflect existing conditions.

2.0   Literature Review

The Turns5 software is based on the traffic theories developed by E. Hauer, E. Pagitsas, and B.T. Shin. The publication, "Estimation of Turning Flows from Automatic Counts," can be found in Transportation Research Record 795, published in 1981 (Hauer, Pagitsas and Shin). This methodology is based on hourly traffic counts from 145 intersections in urban Toronto, Ontario. Their method requires two pieces of information: (1) the hourly counts of both entering and leaving vehicles, and (2) the proportions of left-turn, right-turn, and straight-through traffic. This information can be easily obtained through traffic counters and using an estimate of the functional classification of each approach.

Additional publications referenced for the methodologies used in this software include "Estimation of Intersection Turning Movements from Approach Counts," (Schaefer), and National Cooperative Highway Research Program (NCHRP) 255, "Highway Traffic Data for Urbanized Area Project Planning and Design" (Samdahl).   Both of these publications incorporate portions of the Hauer turning assignment methodologies developed in 1981.

3.0   Methodology

Turns5 references the methodology of "Estimation of Turning Flows from Automatic Counts" by E. Hauer et al (Hauer, Pagitsas and Shin) which closely follows the theory proposed by van Zuylen (van Zuylen). The method involves an iterative process which is why an excel macro is used. Traffic flows approaching the intersection are labeled i while departures from the intersection are labeled j. The total approach volume to a link is labeled O_i while the total departure volume from a link is labeled D_j. The turning percentage from approach i to approach j is labeled p_{ij}. See **Figure 3.1** for an illustration of the variables.
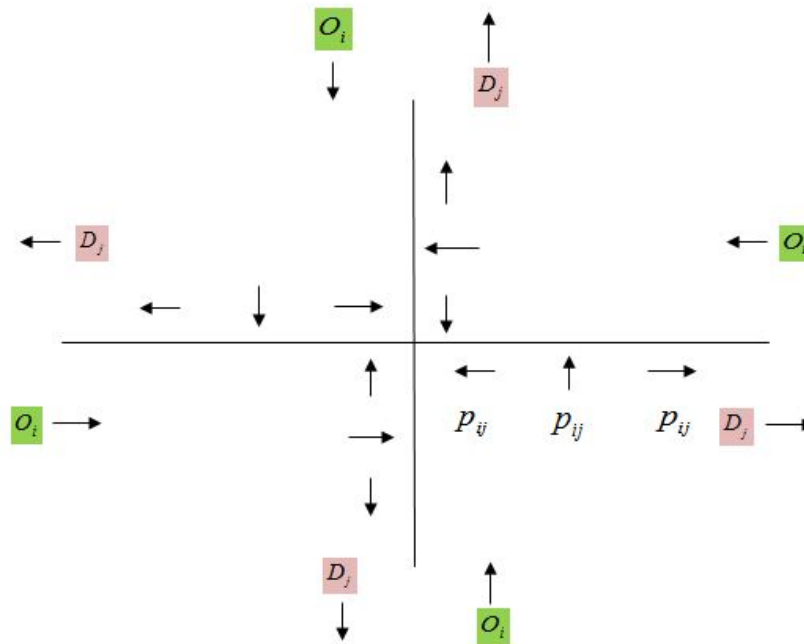
Figure 3.1: Intersection Diagram Using i and j Designations

In the Turns5 spreadsheet i and j take on the numbers 1-4 depending on which approach they define. The eastbound approach is designated '1', the westbound approach is designated '2', the southbound approach is designated '3', and the northbound approach is designated '4' (**Figure 3.2**). For example, the eastbound left turning percentage enters the intersection via approach 1 and departs through approach 3; therefore it is labeled p_{13}. The number of approaches are designated by m (1,2,3,or 4).

O_3

3

D_3

P_{23}

D_1 P_{31} P_{34} P_{32} P_{21} O_2

P_{24}

1 ———————————————————— 2

P_{13}

O_1 P_{41} P_{43} P_{42} D_2

P_{12}

P_{14}

D_4

4

O_4
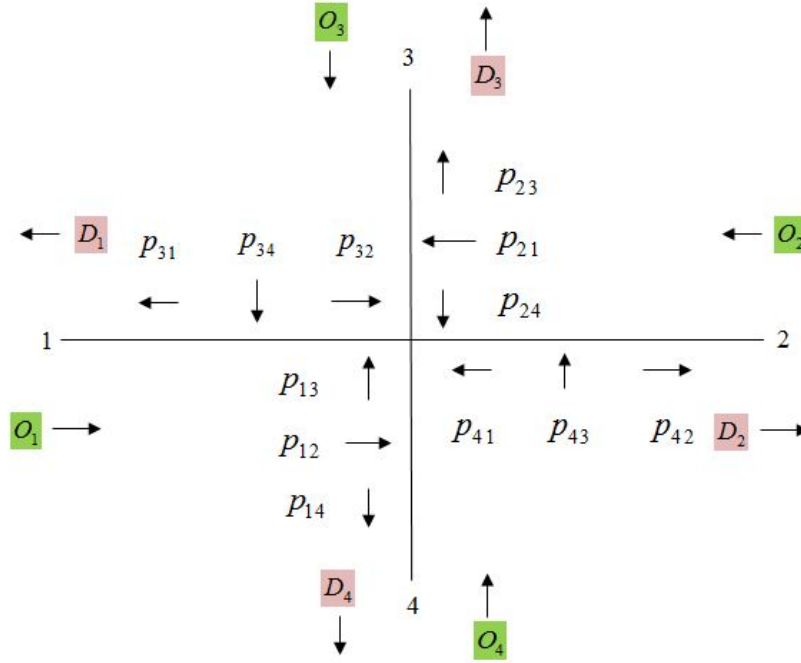
Figure 3.2: Intersection Diagram Using Numerical Designations

Using this nomenclature, the future turning volumes will be estimated. The following steps are an iterative process involving the factors A_i and B_j.

The methodology requires that the total volume of vehicles entering the intersection (S_{enter}) **equal** the total volume of vehicles exiting the intersection (S_{exit}). Due to this fact S will refer to the total amount of vehicles entering (or exiting) the intersection.

$$S = S_{enter} = S_{exit}$$

Step 1 is to calculate A_i for each approach. A_i is the total approach volume for approach i divided by the square root of the total volume entering the intersection, S.

$$A_i = \frac{O_i}{\sqrt{S}}$$

$$A_1 = \frac{O_1}{\sqrt{S}} \qquad A_2 = \frac{O_2}{\sqrt{S}} \qquad A_3 = \frac{O_3}{\sqrt{S}} \qquad A_4 = \frac{O_4}{\sqrt{S}}$$

For step 2, calculate B_j by dividing the total departure volume for approach j by the sum of the product of the turning percentages incoming to approach j and its respective A_i. Calculate B_j for all approaches.

$$B_j = \frac{D_j}{\sum_{i=1}^{m} p_{ij} \cdot A_i}$$

$$B_1 = \frac{D_1}{p_{21} \cdot A_2 + p_{31} \cdot A_3 + p_{41} \cdot A_4} \qquad B_2 = \frac{D_2}{p_{12} \cdot A_1 + p_{32} \cdot A_3 + p_{42} \cdot A_4}$$

$$B_3 = \frac{D_3}{p_{13} \cdot A_1 + p_{23} \cdot A_2 + p_{43} \cdot A_4} \qquad B_4 = \frac{D_4}{p_{14} \cdot A_1 + p_{24} \cdot A_2 + p_{34} \cdot A_3}$$

In step 3 calculate new A_i's using the B_j's calculated in step 2.

$$A_i = \frac{O_i}{\sum_{j=1}^{m} p_{ij} \cdot B_j}$$

$$A_1 = \frac{O_1}{p_{12} \cdot B_2 + p_{13} \cdot B_3 + p_{14} \cdot B_4} \qquad A_2 = \frac{O_2}{p_{21} \cdot B_1 + p_{23} \cdot B_3 + p_{24} \cdot B_4}$$

$$A_3 = \frac{O_3}{p_{31} \cdot B_1 + p_{32} \cdot B_2 + p_{34} \cdot B_4} \qquad A_4 = \frac{O_4}{p_{41} \cdot B_1 + p_{42} \cdot B_2 + p_{43} \cdot B_3}$$

Now compare the new A_i's calculated in step 3 to the original A_i's calculated in step 1. If the difference between the new A_i and original A_i is 0.01 or less, stop. Closure, the maximum tolerance between values allowed, has been reached. If not, repeat steps 2 and 3 until it is. The macro will likely repeat this procedure many times to achieve closure.

The final A_i and B_j will be used to calculate the future turning volume T_{ij}. T_{ij} is the product of the input tuning percentage of interest and its respective A_i and B_j. Each turning volume can now be calculated.

$$T_{ij} = p_{ij} \cdot A_i \cdot B_j$$

$$T_{12} = p_{12} \cdot A_1 \cdot B_2 \qquad T_{13} = p_{13} \cdot A_1 \cdot B_3 \qquad T_{14} = p_{14} \cdot A_1 \cdot B_4$$

$$T_{21} = p_{21} \cdot A_2 \cdot B_1 \qquad T_{23} = p_{23} \cdot A_2 \cdot B_3 \qquad T_{24} = p_{24} \cdot A_2 \cdot B_4$$

$$T_{31} = p_{31} \cdot A_3 \cdot B_1 \qquad T_{32} = p_{32} \cdot A_3 \cdot B_2 \qquad T_{34} = p_{34} \cdot A_3 \cdot B_4$$

$$T_{41} = p_{41} \cdot A_4 \cdot B_1 \qquad T_{42} = p_{42} \cdot A_4 \cdot B_2 \qquad T_{43} = p_{43} \cdot A_4 \cdot B_3$$

Future turning percentages can be calculated using the future turning volumes calculated above.

4.0 Explanation of Tabs within Workbook

4.1. MainMenu

TURNS5 Turning Movement Analysis Tool - V2014
Main Menu

Enter Input
- Clear Sheet for New Data
- Enter Data
- Run Turn Counts Macro
- Save Data File

Check Input
- Check Data

Print All Sheets
This button will print the input sheet, the turning volume summary, and the output graphics all at once. You will have the oppurtunity to preview the pages before printing.
- Print Preview and Print

- Export XML

NOTES
The input process is fully menu driven - just fill in data at the prompts.
Manually changing the data on the InputSheet page will NOT invoke the macros.
The input last entered into the workbook will automatically be shown in prompts.
If the shapes (arrows, boxes, buttons) on any tab become distorted, switch to Page
Break Preview and back to Normal and the format will be corrected.

Figure 4.1: 'MainMenu' Tab

The 'MainMenu' tab contains the Main Menu, **Figure 4.1**, which has many action options.

- '**Clear Sheet for New Data**' erases any previous information input into the spreadsheet. This action cannot be 'undone'.
- '**Enter Data**' prompts the pop up input menus where the user can input data. The menus will reference the data currently in the workbook, presumably the information the User last input.
- '**Run Turn Counts Macro**' will activate the iterative macro. This action cannot be 'undone'.
- '**Save Data File**' will activate the Excel Save As menu.
- '**Check Data**' will search for any error messages previously generated by the iterative macro. For example, if the 'Run Turn Counts' macro has not been run since reactivating the 'Enter Data' menu and proceeding to page 2, the message "Turn

counts macro was not run after changing input. Click the 'Run Turn Counts Macro' button" will appear. The macro assumes that information was changed since the 'Enter Data' menu was activated and the information from page 1 was rewritten into the appropriate cells. However, if information was not changed through the 'Enter Data' menu but by manually editing the 'InputSheet' tab, the previously mentioned error message will not appear.

- **'Print Preview and Print'** will activate Print Preview within Excel. The input sheet, the turning volume summary and the output graphics will be available to preview before printing. If ready to print, click the 'Print' button and select the desired printer. To exit Print Preview, click 'Close Print Preview'.
- **'Export XML'** will export an XML file.

Within the notes section, it is pointed out that the shapes within the workbook, arrows, buttons, boxes, have known to become distorted while using the workbook. If this occurs in a tab, click the tab in question and switch to Page Break Preview (View > Page Break Preview). Then switch back to Normal and the shape format will be corrected. Printing the output pages will result in the proper arrow format even if the 'TurnSheets' tab shows extremely large arrows.

4.1.1. 'Enter Data' Menus

There are two pages to the 'Enter Data' menus. Page 1 (**Figure 4.2**) contains the location information, mainline orientation, availability of Florida Standard Urban Transportation Model Structure (FSUTMS) model data, study years, the option of a 4- or 3-way intersection, available approaches if it is a 3- way intersection, K factors, and D factors. The text boxes will be filled with the last value input into the menu or 'InputSheet' tab. If 'Cancel' is hit, no values will be updated anywhere in the workbook and the User will be returned to the 'MainMenu' tab. When 'OK' is hit, the information entered in page 1 is updated in the 'InputSheet' tab and 'Data' tab and page 2 of the menu appears (**Figure 4.3**). If 'Cancel' is hit, the menu closes and no information is updated in any cells. Page 2 of the menu contains the existing year AADTs, FSUTMS AADTs (if FSUTMS data is available), mainline and side street growth rates (if FSUTMS data not available), types of growth factors, the desired closure value (recommended 0.01), the 'First Guess Turning Methodology' options, turning volumes, and turning percentages. If a 3-way intersection is chosen, traffic volumes that do not exist for the appropriate movements will be grayed out with zero values.

Figure 4.2: 'Enter Data' Menu Page 1

If a 3-way intersection is chosen, the User <u>must</u> check 3 of the 4 approach directions available. If less than 3 are chosen and 'OK' is clicked, an error message will read "A 3 way intersection has been chosen. Please select 3 check boxes indicating the available approaches." When 3 approach directions have been chosen, the fourth direction and its D factor will gray out. The grayed out D factor box will have a value within the menu but when the 'OK' button is clicked, a value of zero will be placed in the correct cell in the 'Input Sheet'.

Traffic Counts (2-way AADT)

	From West (EB Approach)	From East (WB Approach)	From North (SB Approach)	From South (NB Approach)
Existing Year 2014	0	0	0	0

Growth Rate

Mainline: 0 %

Side Street: 0 %

What type of growth factor should be used for the mainline?
- ● Linear ○ Exponential ○ Decaying Exponential

What type of growth factor should be used for the side street?
- ● Linear ○ Exponential ○ Decaying Exponential

Maximum Error

Desired Closure

0.01

First Guess Turning %'s

○ Existing Year AADTs

● Existing Turning Movement Counts

○ FSUTMS Model Year AADTs

The turning percentages first guess is the same as the actual distribution of turning volumes entered. No balancing technique is used.

SB RT	SB Thru	SB LT
0	0	0
0 %	0 %	0 %

EB LT	0	0 %		0 %	0	WB RT
EB Thru	0	0 %		0 %	0	WB Thru
EB RT	0	0 %		0 %	0	WB LT

0 %	0 %	0 %
0	0	0
NB LT	NB Thru	NB RT

OK   Cancel   Back

Figure 4.3: 'Enter Data' Menu Page 2

The turning percentages can be calculated by utilizing one of three 'First Guess Turning %'s'. The three options are 'Existing Year AADTs', 'Existing Turning Movement Counts', and 'FSUTMS Model Year AADTs' (**Figure 4.4**).

First Guess Turning %'s

○ Existing Year AADTs

● Existing Turning Movement Counts

○ FSUTMS Model Year AADTs

The turning percentages first guess is the same as the actual distribution of turning volumes entered. No balancing technique is used.

Figure 4.4: First Guess Turning % Options

The simplest option is 'Existing Turning Movement Counts'. This takes the actual turning volume counts input into the menu and calculates the turning percentages based on them.

For example, for the eastbound (EB) approach,

$$EBL\% = \frac{100 * EBL}{EBL + EBT + EBR}$$

$$EBR\% = \frac{100 * EBR}{EBL + EBT + EBR}$$

$$EBT\% = 100 - EBL - EBR$$

Where $EBL\%$ is the percentage of vehicles turning left,
$EBR\%$ is the percentage of vehicles turning right,
$EBT\%$ is the percentage of vehicles traveling through the intersection,
EBL is the volume of vehicles turning left,
EBR is the volume of vehicles turning right, and
EBT is the volume of vehicles traveling through the intersection

'Existing Year AADTs' and 'FSUTMS Model Year AADTs' utilize a different estimation methodology. Each calculates the turning percentage based on a ratio of departure volumes calculated from the entered AADTs. They differ in the AADTs used to calculate the departure volumes.

For example, for the eastbound approach (**Figure 4.5**),

$$p_{13} = \frac{100 \cdot D_3}{D_3 + D_2 + D_4}$$

$$p_{14} = \frac{100 \cdot D_4}{D_3 + D_2 + D_4}$$

$$p_{12} = 100 - p_{13} - p_{14}$$

Where p_{13} is the percentage of vehicles turning left from the eastbound approach,
p_{14} is the percentage of vehicles turning right from the eastbound approach,
p_{12} is the percentage of vehicles traveling through the intersection from the eastbound approach,
D_2 is the eastbound departure volume,
D_3 is the northbound departure volume, and
D_4 is the southbound departure volume
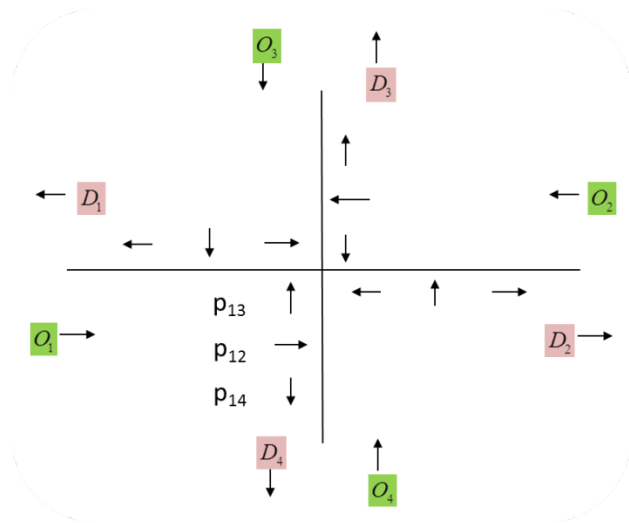
Figure 4.5: Turning Diagram

The departure volumes are calculated as followed,

$$EBDep = AADT_{WB} \cdot K \cdot (1 - D_{WB})$$
$$WBDep = AADT_{EB} \cdot K \cdot (1 - D_{EB})$$
$$SBDep = AADT_{NB} \cdot K \cdot (1 - D_{NB})$$
$$NBDep = AADT_{SB} \cdot K \cdot (1 - D_{SB})$$

For the 'Existing Year AADTs' option, use the existing year AADTs entered to calculate the departure volumes. For the 'FSUTMS Model Year AADTs' option, use the FSUTMS model year AADTs entered to calculate the departure volumes.

4.2.   InputSheets

The 'InputSheets' tab contains all of the information that the user entered into the 'Enter Data' menus on the 'MainMenu' tab. The user may also update information in this tab without having to activate the 'Enter Data' menus. The gray cells are the cells that can or should be edited. The spreadsheet will update the rest of its information accordingly. However, if any information is changed, the 'Run Turn Counts Macro' button should be clicked in order to run the macro with the updated information.

At the bottom of the input section is the area reserved for the initial turning percentages, **Figure 4.6**. See Appendix A for the complete input sheet of the sample project. Three macro assigned buttons next to it offer the same 'First Guess Turning %' options that the 'Enter Data' menu does. The percentages will update with each clicked option. The text box in the upper right hand corner of **Figure 4.6** will reflect the last first guess method used, either via the 'Enter Data' menu or last button clicked on the 'InputSheet' tab.

		1st Guess Turning %'s for AADT Balancing	Actual/Counted Traffic for 2012		
(EB LT)	West-to-North	36.1%	735	**Existing Year AADTs**	First Guess Turning % Option Used — Existing Turning Movement Counts
(EB THRU)	West-to-East	58.3%	1186		Only the existing year total departure volumes [AADT*K*(1-D)] will be used to calculate the turning percentages first guess.
(EB RT)	West-to-South	5.6%	115		
(WB LT)	East-to-South	14.1%	103		
(WB THRU)	East-to-West	20.5%	150		
(WB RT)	East-to-North	65.4%	478	**Existing Turning Movement Counts**	The turning percentages first guess is the same as the *actual distribution of turning volumes entered*. No balancing technique is used.
(SB LT)	North-to-East	70.6%	473		
(SB THRU)	North-to-South	18.2%	122		
(SB RT)	North-to-West	11.2%	75		
(NB LT)	South-to-West	5.9%	96	**FSUTMS Model Year AADTs**	Only the FSUTMS model year departure volumes [AADT*K*(1-D)] will be used to calculate the turning percentages first guess.
(NB THRU)	South-to-North	59.2%	955		
(NB RT)	South-to-East	34.9%	564		
Desired Closure:		0.01			

Figure 4.6: 'First Guess Turning %' Buttons in 'InputSheet'

The blue titled tables labeled 'Linear Calcs', 'Exponential Calcs', and 'Decaying Exponential (Logarithmic) Calcs' contain the AADT projections based on the type of growth selected by the User. Each growth method contains two tables (**Figure 4.7**). The first, 'Calculated by Extrapolation Using Rates', utilizes the rate of growth entered by the User. The second, 'Calculated by Interpolation Using Model Output', utilizes the FSUTMS Model AADTs entered by the User. This table references the AADTs input for the base and model year and interpolates the opening and mid-year AADTs. The spreadsheet automatically uses the growth method based on the User's input. The sample project in Appendix A utilized a

growth rate to achieve the future AADTs so the bottom table within **Figure 4.7** has no values in this case.

Linear Calcs

Calculated by Extrapolation using Rates

Year	From West: EB Approach	From East: WB Approach	From North: SB Approach	From South: NB Approach	TOTAL
2012	38000	34000	30500	30500	133000
2020	42560	38080	32940	32940	146520
2030	48260	43180	35990	35990	163420
2040	53960	48280	39040	39040	180320
Rates	1.50%	1.50%	1.00%	1.00%	

Calculated by Interpolation Using Model Output

Year	From West: EB Approach	From East: WB Approach	From North: SB Approach	From South: NB Approach	TOTAL
0	0	0	0	0	0
0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Figure 4.7: 'InputSheet' Linear Calcs Table

The appropriate AADTs (based on growth method chosen by the User) for each year are summarized in a table in cells Z7:AC10 (**Figure 4.8**). The summary table is only used as a reference for the AADT value for each approach within the 'TurnSheets' tab.

Summarized AADT (Only used for TurnSheets graphic)

Year	From West: EB Approach	From East: WB Approach	From North: SB Approach	From South: NB Approach	S_{enter} TOTAL
2012	38000	34000	30500	30500	133000
2020	42560	38080	32940	32940	146520
2030	48260	43180	35990	35990	163420
2040	53960	48280	39040	39040	180320
calc method	1	1	1	1	

Figure 4.8: AADT Summary Table

Once the AADTs are projected they are used to calculate the approach and departure volumes for the intersection. A set of six tables are used to achieve final approach and departure volumes (**Figure 4.9**). It could take up to three steps to balance the final volumes due to the possibility of the initial total volume of vehicles entering the intersection, S_{enter}, not equaling the initial total volume of vehicles exiting the intersection, S_{exit}.

Step 1a	Approach Volumes: Summarized AADT*K*D						Step 1b	Departure Volumes: Summarized AADT*K*(1-D)						Difference between Senter and Sexit. If positive, Sexit<Senter. If negative Sexit>Senter.
	From West:	From East:	From North:	From South:		S_{enter}		To West:	To East:	To North:	To South:		S_{exit}	
Year	EB Approach	WB Approach	SB Approach	NB Approach		TOTAL	Year	WB Departure	EB Departure	NB Departure	SB Departure		TOTAL	
2012	2032	732	657	1631		5052	2012	818	1818	1631	657		4924	128
2020	2276	820	709	1761		5566	2020	916	2036	1761	709		5422	144
2030	2581	929	775	1925		6210	2030	1039	2309	1925	775		6048	162
2040	2886	1039	840	2088		6853	2040	1161	2582	2088	840		6671	182
calc method	1	1	1	1			calc method	1	1	1	1			

Step 2a	Approach Volumes to be distributed						Step 2b	Departure Volumes to be distributed					
	From West:	From East:	From North:	From South:				To West:	To East:	To North:	To South:		
Year	EB Approach	WB Approach	SB Approach	NB Approach		TOTAL	Year	WB Departure	EB Departure	NB Departure	SB Departure		TOTAL
2012						0	2012	21	47	42	18		128
2020						0	2020	24	54	47	19		144
2030						0	2030	28	62	52	20		162
2040						0	2040	32	70	57	23		182

Step 3a	Final Approach Volumes						Step 3b	Final Departure Volumes						Difference between Senter and Sexit. Should be 0 on this step.
	From West:	From East:	From North:	From South:				To West:	To East:	To North:	To South:			
Year	EB Approach	WB Approach	SB Approach	NB Approach		TOTAL	Year	WB Departure	EB Departure	NB Departure	SB Departure		TOTAL	
2012	2032	732	657	1631		5052	2012	839	1865	1673	675		5052	0
2020	2276	820	709	1761		5566	2020	940	2090	1808	728		5566	0
2030	2581	929	775	1925		6210	2030	1067	2371	1977	795		6210	0
2040	2886	1039	840	2088		6853	2040	1193	2652	2145	863		6853	0

Figure 4.9: Balancing Initial Approach and Departure Volumes

The Step 1a table calculates the approach volumes by pulling the appropriate AADT (based on growth method chosen by the User) and multiplying it by the appropriate K and D factor stored in the 'InputSheet' (**Figure 4.10**). For example, to calculate the eastbound (EB) approach volume,

$$EB\ Approach\ Volume =\ AADT_{EB} * K_{EB} * D_{EB}$$

Step 1a	Approach Volumes: Summarized AADT*K*D				S_{enter}
	From West:	From East:	From North:	From South:	
Year	EB Approach	WB Approach	SB Approach	NB Approach	TOTAL
2012	2032	732	657	1631	5052
2020	2276	820	709	1761	5566
2030	2581	929	775	1925	6210
2040	2886	1039	840	2088	6853
calc method	1	1	1	1	

Figure 4.10: Table Step 1a

The Step1b table calculates the departure volumes by pulling the appropriate AADT (based on growth method chosen by the User) and multiplying it by the appropriate K and (1-D) factor stored in the 'InputSheet' (**Figure 4.11**). For example, to calculate the eastbound departure volume,

$$EB\ Departure\ Volume =\ AADT_{WB} * K_{WB} * (1 - D_{WB})$$

Step 1b	Departure Volumes: Summarized AADT*K*(1-D)				S_{exit}	Difference between Senter and Sexit. If positive, Sexit<Senter. If negative Sexit>Senter.
	To West:	To East:	To North:	To South:		
Year	WB Departure	EB Departure	NB Departure	SB Departure	TOTAL	
2012	818	1818	1631	657	4924	128
2020	916	2036	1761	709	5422	144
2030	1039	2309	1925	775	6048	162
2040	1161	2582	2088	840	6671	182
calc method	1	1	1	1		

Figure 4.11: Table Step 1b

Figure 4.12 illustrates the nomenclature used for this section's tables.
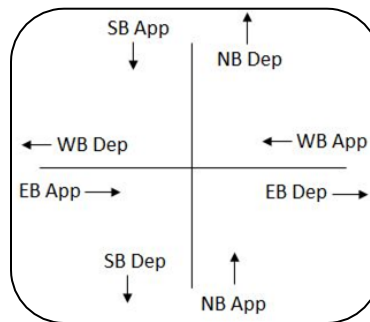
Figure 4.12: Step 1a and Step 1b diagram

In order for the macro to run, the total volume of vehicles entering the intersection, S_{enter}, **must equal** the total volume of vehicles exiting the intersection, S_{exit}. In the event that the total approach volume in Step 1a does not equal the total departure volumes in Step 1b, additional balancing must occur. If the difference column, cells V7:V10, shows positive values then the total departure volume is less than the total approach volume. In this case, in table Step 2b, additional vehicles will be spread among the departure volume links based on a weighted distribution. The links with more traffic will carry a greater proportion of the difference.

If the difference column shows negative values, then the total approach volume is less than the total departure volume. In this case, in table Step 2a, additional vehicles will be spread among the approach volume links based on a weighted distribution. The links with more traffic will carry a greater proportion of the difference. It should be noted that the northbound approach volumes in Table Step 2a, cells M16:M20, absorb the rounding error for any intersection configuration with the exception of the case where the northbound approach doesn't exist. In most cases cells M16:M20 follow this formula so that the sum of the vehicles to be distributed in cells N16:N20 equal the original difference determined in cells V7:V10,

$$NB\ Approach\ Volume = (S_{enter} - S_{exit}) - EB\ App - WB\ App - SB\ App$$

In the case where the northbound approach does not exist in a 3 way intersection, the southbound approach will absorb the rounding error using this formula,

$$SB\ Approach\ Volume = (S_{enter} - S_{exit}) - EB\ App - WB\ App$$

In Step 3, the final volumes used in the macro are produced. Any balancing that occurred in the Step 2 tables will be added to the Step 1 tables to reach a final volume table in Step 3. For example, as seen in **Figure 4.13,** if the departure volume total is less than the approach volume total (positive values in the difference column), the Step 2b table will contain redistributed vehicle volumes. The volumes in table Step 2b will be added to the original volumes calculated in Step 1b to obtain a set of final volumes in Step 3b. In this case the approach volumes were left completely alone and the original volumes calculated are fed into the Step 3a final volumes tables. These final volumes, boxed in orange, are used in the macro. The difference between the total approach volumes and total departure volumes is now zero.

Step 1b — Departure Volumes: Summarized AADT*K*(1-D)

Year	To West: WB Departure	To East: EB Departure	To North: NB Departure	To South: SB Departure	S_{exit} TOTAL	Difference between Senter and Sexit. If positive, Sexit<Senter. If negative Sexit>Senter.
2012	818	1818	1631	657	4924	128
2020	916	2036	1761	709	5422	144
2030	1039	2309	1925	775	6048	162
2040	1161	2582	2088	840	6671	182
calc method	1	1	1	1		

Step 2b — Departure Volumes to be distributed

Year	To West: WB Departure	To East: EB Departure	To North: NB Departure	To South: SB Departure	TOTAL
2012	21	47	42	18	128
2020	24	54	47	19	144
2030	28	62	52	20	162
2040	32	70	57	23	182

Step 3b — Final Departure Volumes

Year	To West: WB Departure	To East: EB Departure	To North: NB Departure	To South: SB Departure	TOTAL	Difference between Senter and Sexit. Should be 0 on this step.
2012	839	1865	1673	675	5052	0
2020	940	2090	1808	728	5566	0
2030	1067	2371	1977	795	6210	0
2040	1193	2652	2145	863	6853	0

Figure 4.13: Balancing Steps 1b-3b

4.3.   Calcs

The 'Calcs' tab is where the macro performs its iterative process for each study year. For the purposes of the explanation, the base year calculations will be focused on but it is the same for each study year with a different set of cell references.

The original values of A_i are calculated in cells B30:B33, respectively.

$$A_i = \frac{O_i}{\sqrt{S}}$$

O_i is the approach volume and is pulled from 'InputSheet' cells J24:M27 depending on the direction of the approach. S is the total volume of vehicles entering or exiting the intersection and is pulled from 'InputSheet' cells N24:N27.

The next step is to calculate B_j. Cells B36:B39 use the below equation to do so.

$$B_j = \frac{D_j}{\sum_{i=1}^{m} p_{ij} \cdot A_i}$$

This is where the macro comes into play. D_j is the departure volume and is pulled from 'InputSheet' cells Q24:T27. p_{ij} is the turning percentage and is pulled from 'InputSheet' cells D65:D79. The macro copies the original A_i values from B30:B33 and pastes them into cells C30:C33 labeled 'Adjusted' (black set of cells). The B_j equation will always reference cells C30:C33 for A_i.

Next the new A_i is calculated. Cells B42:B45 use the below equation to do so.

$$A_i = \frac{O_i}{\sum_{j=1}^{m} p_{ij} \cdot B_j}$$

O_i is still pulled from 'InputSheet' cells J24:M27 while p_{ij} is still pulled from 'InputSheet' cells D65:D79. B_j is pulled from cells B36:B39.

Now it is determined if closure has been met. Cells B51:B54 compute the difference between the original A_i and the new A_i. At this point, since the process is still in its first attempt, Cells C30:C33 are still the true original values of A_i. Cells C51:C54 take the absolute value of cells B51:B54. C55 takes the maximum value of cells C51:C54. Cells D51:D54 determine if closure has been met for each A_i. If the difference between the original A_i and new A_i is less than 0.01 (closure value) then a 0 is reported back. If not, a 1

is reported back. Cell D55 takes the maximum value of cells D51:D54. If any of the A_i's did not reach closure, the difference is greater than 0.01, then a 1 will be reported in one or more of the cells D51:D54 and therefore a 1 will be reported in cell D55. If a 1 is reported in cell D55, then a 1 is reported in cell E55. If not, a 0 is reported.

Cell E55 is important to the macro. If closure is not met, E55>0, the macro will repeat the process by copying the new A_i's from cells B42:B45 into cells C30:C33. The new A_i's now become the 'Adjusted' A_i's, replacing the original A_i's from the first time the process was initiated. From now on, every time closure is not met, the new A_i's will be copied into the 'Adjusted' A_i cells and will be used for calculating B_j.

The macro will loop this process until closure is met, E55=0, or until the maximum difference between the new A_i and Adjusted A_i is greater than 1,000,000, C55>1,000,000. If C55>1,000,000 the difference between the new A_i and Adjusted A_i will most likely never converge upon 0.01 so the macro stops looping the process and moves on to the next study year. After all of the study years have been processed, an error message will appear reporting each study year that could not converge upon 0.01. Turning percentages and turning volumes will not be available for these study years. The user should check 'InputSheet' cells V24:V27 to ensure that the difference between the total entering volumes and the total exiting volumes is 0. If the difference is not 0, the macro will not reach closure. If closure is met for all study years, a message will appear stating 'Turning movement calculations completed. No errors were reported'. Turning percentages and turning volumes will be available for all study years.

The turning volumes are calculated in cells C60:C77 using the below equation.

$$T_{ij} = p_{ij} \cdot A_i \cdot B_j$$

p_{ij} is pulled from 'InputSheet' cells D65:D79. Since closure has been met, the new A_i's are the final A_i's and are pulled from cells B42:B45. B_j is pulled from cells C36:C39. Cells D60:D77 calculate the turning percentages within the intersection based on cells C60:C77. Cells D60:D77 are used in the 'TurnSheets' tab.

This iterative process is applied to each study year.

4.4.   OutputSheet

The 'OutputSheet' tab provides a tabular version of the results (**Figure 4.14**). The title block, cells B4:I7, reference 'InputSheet' for data entered by the user. The table of values reference the 'TurnSheets' graphics for turning percentages and turning volumes. The 'TurnSheets' tab ensures that there is no rounding error within each approach. Cells B14:B34 reference 'InputSheet' cells D65:D79 for the initial turning percentages.

TURNS5 INITIAL TURNING VOLUME SUMMARY

Highway:	Tennessee Street - PM Peak	County:	Leon
Intersection:	Monroe Street - PM Peak		
Project:	Tennessee Street Capacity Analysis	Analyst:	Engineers Inc.
		Date:	3-Jan-14

Approach-To-Approach	2012 Initial Estimate	2012 Final Estimate	2012 Calculated Volume	2020 Final Estimate	2020 Calculated Volume	2030 Final Estimate	2030 Calculated Volume	2040 Final Estimate	2040 Calculated Volume
West-To-North (LT)	0.361	0.313	636	0.307	699	0.301	777	0.297	857
West-To-East (Thru)	0.583	0.537	1091	0.546	1242	0.556	1435	0.563	1625
West-To-South (RT)	0.056	0.150	305	0.147	335	0.143	369	0.140	404
Total Flow From West:			2032		2276		2581		2886
East-To-South (LT)	0.141	0.222	163	0.217	178	0.212	197	0.208	216
East-To-West (Thru)	0.205	0.445	325	0.456	374	0.467	434	0.476	495
East-To-North (RT)	0.654	0.333	244	0.327	268	0.321	298	0.316	328
Total Flow From East:			732		820		929		1039
North-To-East (LT)	0.706	0.419	275	0.423	300	0.428	332	0.431	362
North-To-South (Thru)	0.182	0.314	207	0.306	217	0.295	228	0.288	242
North-To-West (RT)	0.112	0.267	175	0.271	192	0.277	215	0.281	236
Total Flow From North:			657		709		775		840
South-To-West (LT)	0.059	0.207	338	0.212	373	0.217	418	0.221	461
South-To-North (Thru)	0.592	0.487	794	0.478	842	0.468	901	0.460	961
South-To-East (RT)	0.349	0.306	499	0.310	546	0.315	606	0.319	666
Total Flow From South:			1631		1761		1925		2088

Figure 4.14: 'OutputSheet' Table

4.5.   TurnSheets

The 'TurnSheets' tab utilizes two graphics to represent the output. The first graphic displays the design hour turning movement volumes and percentages for each study year as well as the AADT, DDHV, K factor, and D factor for each approach. The value preceding each approach in parenthesis, (XXXXX), is the AADT as input by the User or projected within the 'InputSheet' tab. The AADTS are pulled from 'InputSheet' cells Z7:AC10 and rounded according to AASHTO 2012 standards. The bolded value before each approach, **XXXX**, is the approach design hour volume originally calculated in 'InputSheet' cells J7:M10. If any balancing occurred involving the approach volumes to ensure that the macro could run, these balanced volumes are not used. The true approach volume calculated by AADT*K*D is used. The next set of values is the turning percentages. For a 4-way intersection, the eastbound left (EBL) and eastbound right (EBR) percentages reference the macro calculated turning percentages from the 'Calcs' tab and round the value to the nearest tenth. The eastbound through (EBT) percentage is then calculated by

$$EBT\% = 100 - EBL\% - EBR\%$$

to correct for any rounding errors. The through movement is most likely, though not always, to be the largest volume of the three. Therefore it will absorb any rounding errors to ensure that the approach percentages sum up to 100%. The next set of values and last set is the turning volumes. They are calculated by the following equations:

$$EBL = DDHV_{EB} * EBL\%$$

$$EBR = DDHV_{EB} * EBR\%$$

$$EBT = DDHV_{EB} - EBL - EBR$$

This also ensures that the sum of the turning volumes add up to the DDHV. **Figure 4.15** displays one study year of the first output graphic for the Sample Project in Appendix A.
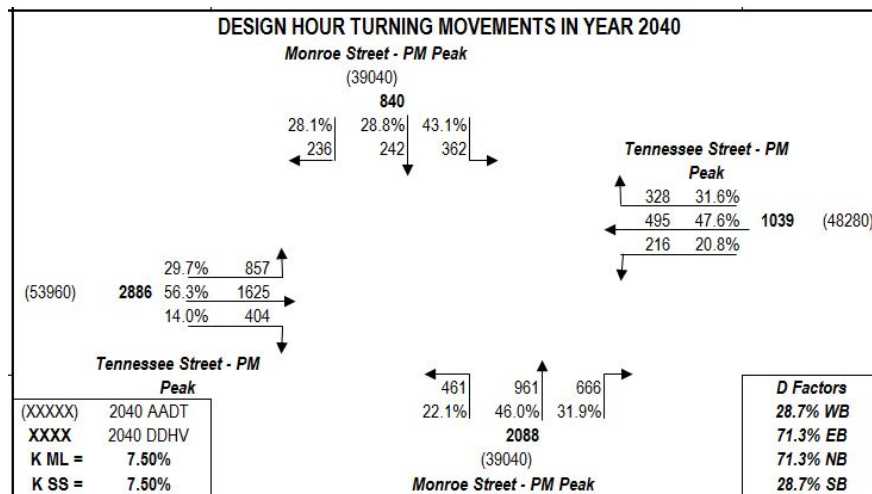
Figure 4.15: 'TurnSheets' Output Graphic 1 from Sample Project

However, if the intersection is a 3-way intersection, if-then statements ensure that the correct movements are zero and rounding error is accounted for elsewhere if the through movement does not exist. For example, the intersection of Tharpe Street and Meridian Road is a 3-way intersection with the northbound, southbound, and eastbound approaches. **Figure 4.16** displays the output turning movement volumes from the 'TurnSheets' tab for year 2035.
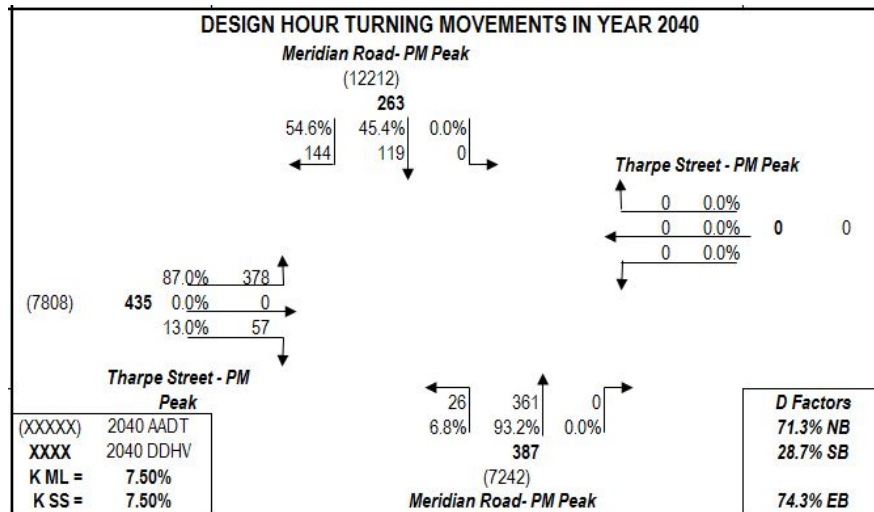
Figure 4.16: 3-way Intersection Example

Focusing on the missing westbound approach, the DDHV and AADT cells are zero because the input AADT from 'InputSheet' is zero. The WBR and WBL movements are also zero due to the initial lack of traffic entered. In order to accurately represent 0% of traffic traveling in the WBT movement, a value of zero will be reported if no approach traffic exists (DDHV=0) thereby avoiding a misleading 100%. In this same example the SBL, NBR, and EBT movements do not exist. On the approaches where the left and right turn movements do not exist, the through movement still has the ability to absorb the rounding error. However, if the through movement does not exist, such as the EBT movement in this example, then a zero will be reported in the turning percent and turning volume cells. With the absence of a through movement, the right turn movement will absorb the rounding error, in this case,

$$EBR\% = 100 - EBL\%$$

$$EBR = DDHV_{EB} - EBL$$

This will ensure that the turning percentages will always add up to 100% and the turning movements will always add up to the DDHV.

The second graphic compares the existing year turning movement volumes, if available, to the ones calculated by the macro for each study year. The values in each approach in parentheses are the existing year turning movement volumes. These cells reference the

'InputSheet' tab cells E65:E79. If no volumes are entered by the user, these cells will report zeroes and the graphic will not be very useful.

Next, the bolded values are the turning movement volumes as calculated by the macro. These values will always populate the graphic as long as the macro has been run since traffic data has been entered. These cells reference the above graphic for each turning movement.

The last set of values calculates the ratio of the macro calculated turning movement volume to the existing turning movement volume. If no existing turning movement volume is available, "N/A" is reported in the cell.

Figure 4.17 displays one study year of the second output graphic for the Sample Project in Appendix A.
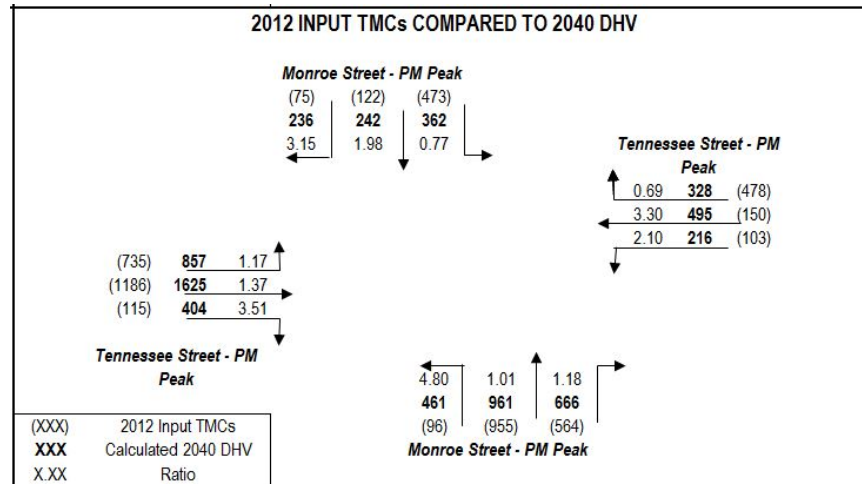
Figure 4.17: 'TurnSheets' Output Graphic 2 from Sample Project

4.6.   Data

The 'Data' tab is used for the purpose of being a reference to the data input by the user for certain cells of the workbook. This tab is updated by menu input changes, changes to the gray cells in the 'InputSheet' tab, or the 'Run Count Turns' macro. This tab's data is utilized throughout the workbook.

Cell B1 records whether or not the mainline road is oriented with the north and south direction. The 'Enter Data' menu page 1 or 'InputSheet' option buttons in cells C12:C13 will determine whether the value is 'yes' or 'no'.

Cell B2 records whether or not FSUTMS model data is available. The 'Enter Data' menu page 1 or 'InputSheet' option buttons in cells F23:F24 will determine whether the value is 'yes' or 'no'.

Cell B3 records whether the intersection is a 4-way or 3-way intersection. The 'Enter Data' menu page 1 or 'InputSheet' option buttons in cells F4:G12 will determine whether the value is '4' or '3'.

Cells A4:E4 are dormant cells that were once used by the macro for a previous function (two-way intersections). It has been left alone in the event that it is activated later.

Cells B5:E5 record which approaches exist in the intersection. If a 4-way intersection is selected from the 'Enter Data' menu page 1 or 'InputSheet' option buttons (cells F4:G12), a '1' will be recorded in each of the four cells in the 'Data' tab. If the User indicates that only 3 approaches exist, those three approaches will record '1' while the fourth, missing approach will record '0'. Cell B5 corresponds to the northbound approach. Cell C5 corresponds to the southbound approach. Cell D5 corresponds to the eastbound approach. Cell E5 corresponds to the westbound approach.

Cell B6 records whether or not the macro has been run since the data has been updated. When data in the 'Enter Data' menu is updated, this cell is changed to 'no'. Once the macro is run again, the cell will change to 'yes'.

Cell B6 records whether the macro has been run since the 'Enter Data' menu has been activated. If the menu has been activated but no data has been necessarily changed, the cell will still report "no". The 'Check Data' button on the 'MainMenu' tab references this cell and will provide the error message "Turn counts macro was not run after changing input. Click the 'Run Turn Counts Macro' Button" if "no" is reported.

Cells C6:F6 record whether any study year could not converge when the macro was run. If the base year could not converge, cell C6 would report "Base Year No Converge". Cell D6 corresponds to the opening year. Cell E6 corresponds to the mid-year. Cell F6 corresponds to the design year. These cells are used for the potential error message that could pop up after the macro has been run.

Cells A8:A21 will contain any error messages generated by the 'Check Data' button on the 'MainMenu' tab. If no errors exist, clicking the 'Check Data' button will yield 'No errors or warning reported'.

Cells B8:C8 record which type of growth method the User has entered into the 'Enter Data' menu page 2 or selected on 'InputSheet' option buttons contained in cells F30:F38. Cell B8 corresponds with the mainline road while C8 corresponds with the side street road. '1' corresponds to linear growth, '2' corresponds to exponential growth, and '3' corresponds to decaying exponential growth.

Cells C10:C11 record the names of the north/south road and the east/west road. These cells are filled by the 'Enter Data' menu from page 1. The 'XML' tab refers to these cells.

Cell F1 records the type of 'First Guess Turning Percentage' option that was chosen in the 'Enter Data' menu on page 2 or by clicking one of the buttons on the 'InputSheet' tab. A value of '1' means that the 'Existing Year AADTs' option was chosen. A value of '3' means that the 'Existing Turning Movement Counts' option was chosen. A value of '4' means that the 'FSUTMS Model Year AADTs' option was chosen.

Cell J1 records the PIN entered by the User in the 'Enter Data' menu on page 1.

4.7.   XML

The 'XML' tab stores the information needed for creating the XML file. When the 'Export XML' button is clicked on the 'MainMenu' tab, a macro references the 'XML' tab for the data required to create the XML file. The cells of the 'XML' tab are linked to sheets throughout the workbook. When those sheets are updated, the 'XML' tab cells are updated.

Works Cited

Hauer, E., E. Pagitsas and B.T. Shin. "Esitmation of turning Flows from Automatic Counts." 1981.

Samdahl, N.J. *NCHRP 255: Highway Traffic Data for Urbanized Area Project Planning and Design*. Washington, D.C.: Transportation Research Board, 1982.

Schaefer, Mark C. "Estimation of Intersection Turning Movements from Approach Counts." 1988.

van Zuylen, Henk J. "The Estimation of Turning Flows on a Junction." November 1979.

Appendix A: Sample Project

TURNS5 ANALYSIS SHEET - INPUT

Analyst: Engineers Inc.
Date: 3-Jan-14
Highway: Tennessee Street - PM Peak
Intersection: Monroe Street - PM Peak
Project: Tennessee Street Capacity Analysis
County: Leon

Enter Yes or No

Is the Mainline Oriented North/South?
○ Yes
◉ No

Is this a 4 way intersection?

◉ Yes, my intersection has four approaches

If not, which 3 approaches exist in the intersection?
○ EB, WB, and SB
○ EB, WB, and NB
○ EB, SB, and NB
○ WB, SB, and NB

K Factors

	Mainline		**D Factors**	*Mainline*
	7.50%		Westbound (WB)	28.7%
	Side street		Eastbound (EB)	71.3%
	7.50%			*Side street*
			Northbound (NB)	71.3%
			Southbound (SB)	28.7%

Do you have FTSUTMS Model Year traffic from which you would like to interpolate/extrapolate for project years? (Y/N)

Enter Yes or No
○ Yes
◉ No

If "Yes" go to cell C47   If "No" go to cell C31

Enter Year and Growth Rates from Base Year:

	Year	*Rate* (1.0% = 0.01)	
		Mainline	**Side Street**
Base	2012		
Opening	2020		
Mid	2030	1.50%	1.00%
Design	2040		

Mainline Growth Function
◉ Linear
○ Exponential
○ Decaying

Side Street Growth Function
◉ Linear
○ Exponential
○ Decaying

Enter Base Year AADTs for Volume Comparison:
(growth rates are used to calculate other project years)

From West:	*From East:*	*From North:*	*From South:*	
EB Approach	WB Approach	SB Approach	NB Approach	**TOTAL**
38000	34000	30500	30500	133000

Enter Project and Model Years

	Year
Base	
Opening	
Mid	
Design	
Model	

Enter Base and Model Year AADTs for Volume Comparison:
(volumes for other project years are calculated by interpolation)

	From West:	*From East:*	*From North:*	*From South:*	
	EB Approach	WB Approach	SB Approach	NB Approach	**TOTAL**
0	0	0	0	0	0
0	0	0	0	0	0

		1st Guess Turning %'s for AADT Balancing	Actual/Counted Traffic for 2012
(EB LT)	West-to-North	36.1%	735
(EB THRU)	West-to-East	58.3%	1186
(EB RT)	West-to-South	5.6%	115
(WB LT)	East-to-South	14.1%	103
(WB THRU)	East-to-West	20.5%	150
(WB RT)	East-to-North	65.4%	478
(SB LT)	North-to-East	70.6%	473
(SB THRU)	North-to-South	18.2%	122
(SB RT)	North-to-West	11.2%	75
(NB LT)	South-to-West	5.9%	96
(NB THRU)	South-to-North	59.2%	955
(NB RT)	South-to-East	34.9%	564

Desired Closure: 0.01

First Guess Turning % Option Used
Existing Turning Movement Counts

Existing Year AADTs
Only the existing year total departure volumes [AADT*K*(1-D)] will be used to calculate the turning percentages first guess.

Existing Turning Movement Counts
The turning percentages first guess is the same as the *actual distribution of turning volumes entered*. No balancing technique is used.

FSUTMS Model Year AADTs
Only the FSUTMS model year departure volumes [AADT*K*(1-D)] will be used to calculate the turning percentages first guess.

TURNS5 INITIAL TURNING VOLUME SUMMARY

Highway:	Tennessee Street - PM Peak	County:	Leon
Intersection:	Monroe Street - PM Peak		
Project:	Tennessee Street Capacity Analysis	Analyst:	Engineers Inc.
		Date:	6-Jan-14

Approach-To-Approach	2012 Initial Estimate	2012 Final Estimate	2012 Calculated Volume	2020 Final Estimate	2020 Calculated Volume	2030 Final Estimate	2030 Calculated Volume	2040 Final Estimate	2040 Calculated Volume
West-To-North (LT)	0.361	0.313	636	0.307	699	0.301	777	0.297	857
West-To-East (Thru)	0.583	0.537	1091	0.546	1242	0.556	1435	0.563	1625
West-To-South (RT)	0.056	0.150	305	0.147	335	0.143	369	0.140	404
Total Flow From West:			**2032**		**2276**		**2581**		**2886**
East-To-South (LT)	0.141	0.222	163	0.217	178	0.212	197	0.208	216
East-To-West (Thru)	0.205	0.445	325	0.456	374	0.467	434	0.476	495
East-To-North (RT)	0.654	0.333	244	0.327	268	0.321	298	0.316	328
Total Flow From East:			**732**		**820**		**929**		**1039**
North-To-East (LT)	0.706	0.419	275	0.423	300	0.428	332	0.431	362
North-To-South (Thru)	0.182	0.314	207	0.306	217	0.295	228	0.288	242
North-To-West (RT)	0.112	0.267	175	0.271	192	0.277	215	0.281	236
Total Flow From North:			**657**		**709**		**775**		**840**
South-To-West (LT)	0.059	0.207	338	0.212	373	0.217	418	0.221	461
South-To-North (Thru)	0.592	0.487	794	0.478	842	0.468	901	0.460	961
South-To-East (RT)	0.349	0.306	499	0.310	546	0.315	606	0.319	666
Total Flow From South:			**1631**		**1761**		**1925**		**2088**

PROJECT TRAFFIC FOR Tennessee Street - PM Peak AT Monroe Street - PM Peak

DESIGN HOUR TURNING MOVEMENTS IN YEAR 2012

Monroe Street - PM Peak
(30500)
657

26.7%	31.4%	41.9%
175	207	275

Tennessee Street - PM Peak

244	33.3%		
325	44.5%	**732**	(34000)
163	22.2%		

31.3%	636
(38000) **2032** 53.7%	1091
15.0%	305

Tennessee Street - PM Peak

338	794	499
20.7%	48.7%	30.6%

1631
(30500)
Monroe Street - PM Peak

	D Factors
(XXXXX) 2012 AADT	28.7% WB
XXXX 2012 DDHV	71.3% EB
K ML = 7.50%	71.3% NB
K SS = 7.50%	28.7% SB

DESIGN HOUR TURNING MOVEMENTS IN YEAR 2020

Monroe Street - PM Peak
(32940)
709

27.1%	30.6%	42.3%
192	217	300

Tennessee Street - PM Peak

268	32.7%		
374	45.6%	**820**	(38080)
178	21.7%		

30.7%	699
(42560) **2276** 54.6%	1242
14.7%	335

Tennessee Street - PM Peak

373	842	546
21.2%	47.8%	31.0%

1761
(32940)
Monroe Street - PM Peak

	D Factors
(XXXXX) 2020 AADT	28.7% WB
XXXX 2020 DDHV	71.3% EB
K ML = 7.50%	71.3% NB
K SS = 7.50%	28.7% SB

DESIGN HOUR TURNING MOVEMENTS IN YEAR 2030

Monroe Street - PM Peak
(35990)
775

27.7%	29.5%	42.8%
215	228	332

Tennessee Street - PM Peak

298	32.1%		
434	46.7%	**929**	(43180)
197	21.2%		

30.1%	777
(48260) **2581** 55.6%	1435
14.3%	369

Tennessee Street - PM Peak

418	901	606
21.7%	46.8%	31.5%

1925
(35990)
Monroe Street - PM Peak

	D Factors
(XXXXX) 2030 AADT	28.7% WB
XXXX 2030 DDHV	71.3% EB
K ML = 7.50%	71.3% NB
K SS = 7.50%	28.7% SB

DESIGN HOUR TURNING MOVEMENTS IN YEAR 2040

Monroe Street - PM Peak
(39040)
840

28.1%	28.8%	43.1%
236	242	362

Tennessee Street - PM Peak

328	31.6%		
495	47.6%	**1039**	(48280)
216	20.8%		

29.7%	857
(53960) **2886** 56.3%	1625
14.0%	404

Tennessee Street - PM Peak

461	961	666
22.1%	46.0%	31.9%

2088
(39040)
Monroe Street - PM Peak

	D Factors
(XXXXX) 2040 AADT	28.7% WB
XXXX 2040 DDHV	71.3% EB
K ML = 7.50%	71.3% NB
K SS = 7.50%	28.7% SB

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PROJECT TRAFFIC FOR Tennessee Street - PM Peak AT Monroe Street - PM Peak

2012 INPUT TMCs COMPARED TO 2012 DHV

Monroe Street - PM Peak

(75)	(122)	(473)
175	**207**	**275**
2.33	1.70	0.58

Tennessee Street - PM Peak

0.51	**244**	(478)
2.17	**325**	(150)
1.58	**163**	(103)

(735)	**636**	0.87
(1186)	**1091**	0.92
(115)	**305**	2.65

Tennessee Street - PM Peak

3.52	0.83	0.88
338	**794**	**499**
(96)	(955)	(564)

(XXX)	2012 Input TMCs
XXX	Calculated 2012 DHV
X.XX	Ratio

Monroe Street - PM Peak

2012 INPUT TMCs COMPARED TO 2020 DHV

Monroe Street - PM Peak

(75)	(122)	(473)
192	**217**	**300**
2.56	1.78	0.63

Tennessee Street - PM Peak

0.56	**268**	(478)
2.49	**374**	(150)
1.73	**178**	(103)

(735)	**699**	0.95
(1186)	**1242**	1.05
(115)	**335**	2.91

Tennessee Street - PM Peak

3.89	0.88	0.97
373	**842**	**546**
(96)	(955)	(564)

(XXX)	2012 Input TMCs
XXX	Calculated 2020 DHV
X.XX	Ratio

Monroe Street - PM Peak

2012 INPUT TMCs COMPARED TO 2030 DHV

Monroe Street - PM Peak

(75)	(122)	(473)
215	**228**	**332**
2.87	1.87	0.70

Tennessee Street - PM Peak

0.62	**298**	(478)
2.89	**434**	(150)
1.91	**197**	(103)

(735)	**777**	1.06
(1186)	**1435**	1.21
(115)	**369**	3.21

Tennessee Street - PM Peak

4.35	0.94	1.07
418	**901**	**606**
(96)	(955)	(564)

(XXX)	2012 Input TMCs
XXX	Calculated 2030 DHV
X.XX	Ratio

Monroe Street - PM Peak

2012 INPUT TMCs COMPARED TO 2040 DHV

Monroe Street - PM Peak

(75)	(122)	(473)
236	**242**	**362**
3.15	1.98	0.77

Tennessee Street - PM Peak

0.69	**328**	(478)
3.30	**495**	(150)
2.10	**216**	(103)

(735)	**857**	1.17
(1186)	**1625**	1.37
(115)	**404**	3.51

Tennessee Street - PM Peak

4.80	1.01	1.18
461	**961**	**666**
(96)	(955)	(564)

(XXX)	2012 Input TMCs
XXX	Calculated 2040 DHV
X.XX	Ratio

Monroe Street - PM Peak