STEP 2 ROUNDABOUT B/C EVALUATION
USER GUIDE

TRADITIONAL INTERSECTION VS. ROUNDABOUT

FLORIDA DEPARTMENT OF TRANSPORTATION

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INTRODUCTION

The Step 2 Roundabout b/c Evaluation Spreadsheet is a tool that compares the life cycle cost of a roundabout to that of a signalized or stop-controlled intersection. For consistency within this Guide and the spreadsheet, signalized and stop-controlled intersections are referred to as “traditional intersections”. The spreadsheet considers roundabouts during the intersection planning and design analysis, including multiple factors such as safety, operations, maintenance and construction data that will be used in the benefit-to-cost comparison. The end result will be the selection of the most appropriate intersection control alternate.

The spreadsheet analyzes costs associated with the following metrics:

- Safety improvements
- Vehicular delay (when information is available)
- Operations improvements
- Maintenance costs
- Design costs
- Construction costs
- Utility relocation costs
- Right-of-way costs

Some costs are directly entered by the user, and others are computed by the spreadsheet based on typical costs used in Florida. The spreadsheet is one of the many tools that planners and designers have at their disposal during the intersection selection process. Other variable must be considered as well to account for public and stakeholder input, availability of capital funds, right-of-way impacts, multi-modal accommodation, utility relocation and future development planned along the corridor.

This Guide tells the user what inputs are required to perform the benefit to cost ratio analysis. Presents the concepts and methodologies used to compare the intersection alternatives and their corresponding installation, maintenance and operations costs. Gives step-by-step instructions on how to use the spreadsheet. Provides three examples illustrating the use of the spreadsheet.

For questions regarding the User Guide and the Step 2 Roundabout b/c Evaluation Spreadsheet, please contact the following staff:

David Amato, P.E.
Roadway Design Engineer
Roadway Design Office
FDOT Central Office
(850) 414-4792

Humberto Castillero, P.E., PTOE
Roadway Design Engineer
Roadway Design Office
FDOT Central Office
(850) 414-4667

CONCEPTS OVERVIEW

This section discusses the development of procedures, the methodologies used to compare intersection forms, and the conversion of performance measures to dollar amounts.

SCOPE AND TYPES OF COMPARISON

The spreadsheet compares a roundabout to a traditional intersection alternative. The spreadsheet is only capable of comparing two alternatives, and one must be a roundabout.

The spreadsheet supports three types of comparisons, referred to as Cases 1, 2, and 3. Users select the comparison type (i.e., the case) at the start of data entry. Differentiation between cases is based on the existing intersection control and alternatives under consideration. The three cases are defined below and explained in detail in the following sections.

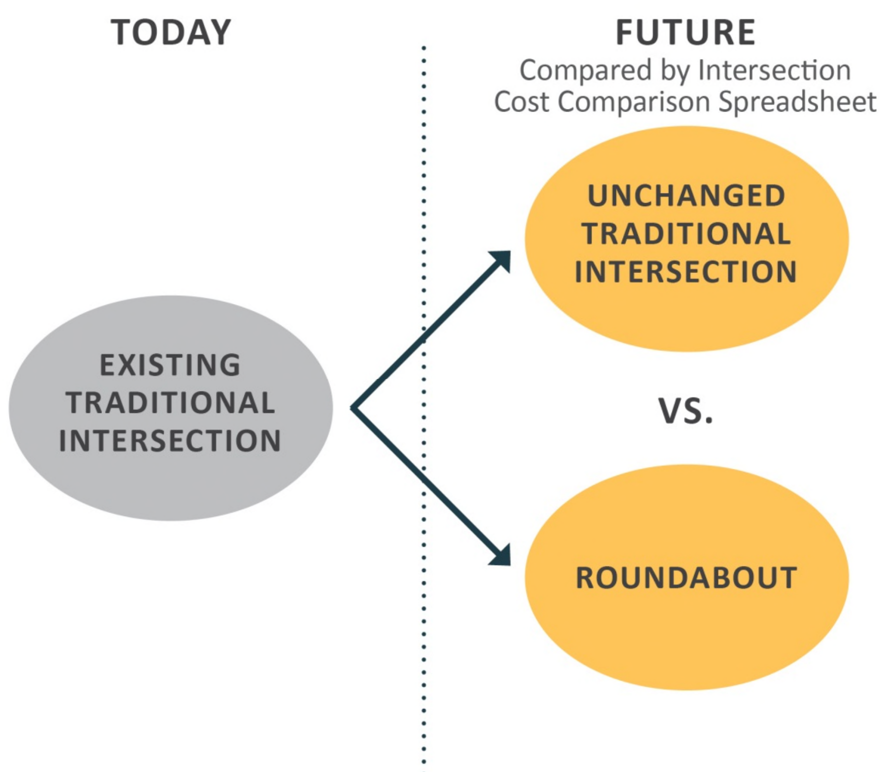
Case 1: an existing traditional intersection vs. a roundabout alternative

Case 2: a traditional intersection alternative vs. a roundabout alternative (at the site of an existing traditional intersection)

Case 3: a traditional intersection alternative vs. a roundabout alternative (at a site where there is currently no intersection)

Case 1 compares an existing traditional intersection (e.g., stop-controlled or signalized) to a roundabout alternative. The existing signalized or stop-controlled intersection is assumed to remain in place or be converted to a roundabout. Case 1 may be used in a roundabout screening study in which a District or local jurisdiction has already identified potential sites and needs to perform a ranking analysis of how to best use available funding to improve safety and operations at critical sites. Figure 1 illustrates the two intersection alternatives in a Case 1 comparison.

Figure 1. Case 1 Comparison

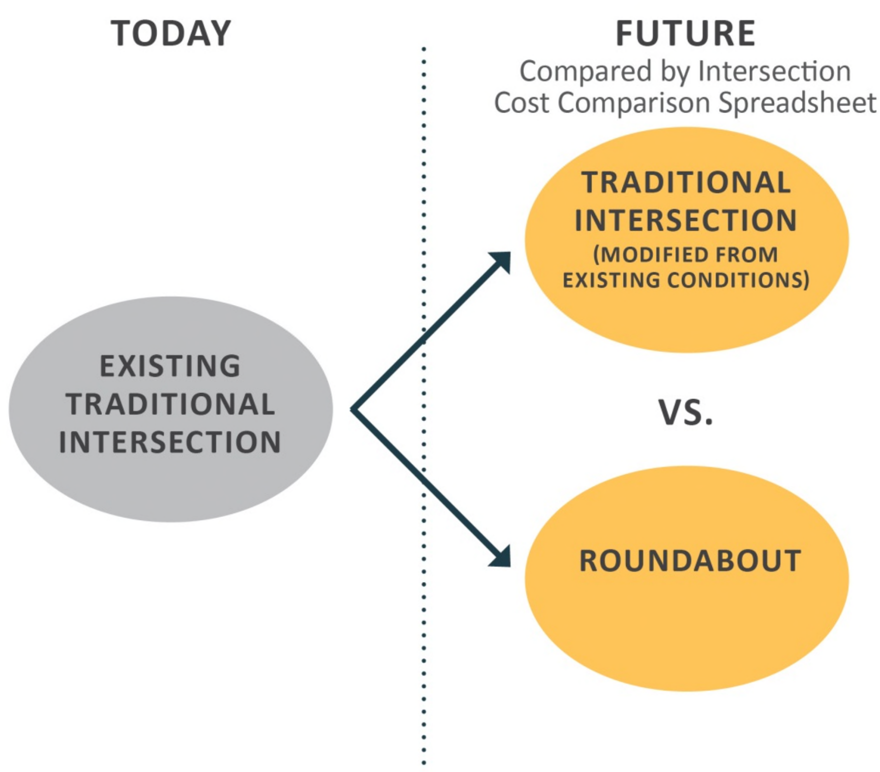


Case 2 compares a traditional intersection alternative to a roundabout alternative at the site of an existing traditional intersection. Two examples in which a Case 2 comparison may be applied are:

- A District plans to improve an existing stop-controlled intersection by converting it to a signal or to a roundabout. The spreadsheet compares the signal operations to the roundabout.
- A District plans to improve an existing stop-controlled intersection by adding turn lanes (while maintaining the stop control) or converting it to a roundabout.

Figure 2 illustrates the two intersection forms in a Case 2 comparison.

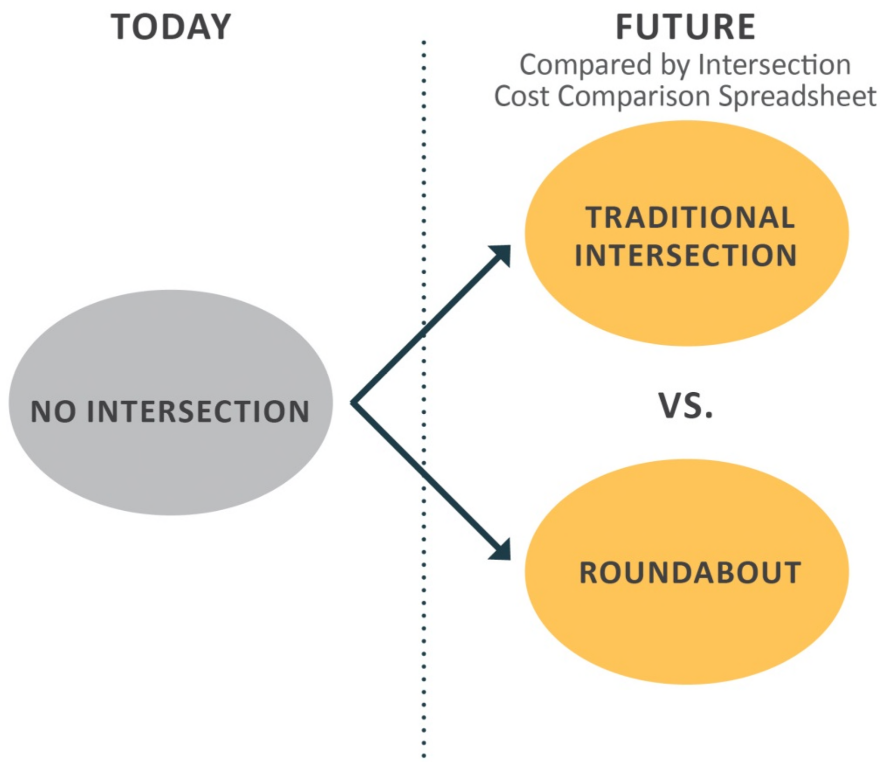
Figure 2. Case 2 Comparison



Case 3 compares a traditional intersection alternative to a roundabout alternative at a site where there is currently no intersection. Case 3 comparisons may be applied to intersections along new roadways or new intersections on existing roadways, such as access points to new or existing developments.

Figure 3 illustrates the two intersection alternatives in a Case 3 comparison.

Figure 3. Case 3 Comparison



COMPARISON PROCESSES AND METRICS

The comparison process uses four metrics including safety, delay (if available), operations and maintenance costs, and initial capital costs. Of the four metric methodologies, the methodology pertaining to safety is the most complex. The methodology used for each of these comparisons is described below.

Safety

The spreadsheet uses the crash prediction methodology from the Highway Safety Manual (HSM). Crash frequency and severity at traditional intersections is predicted using safety performance functions (SPFs). The SPFs are regression equations that estimate the frequency and severity of crashes based on multiple factors, including intersection geometry, lane configuration, and traffic volume. The SPFs listed in the HSM are based on national research and are intended to reflect a range of driver and roadway characteristics.

The spreadsheet estimates the crash frequency and severity for a roundabout by applying crash modification factors (CMFs) to the predicted crash frequency of the existing (traditional) intersection. CMFs are provided in Part D of the HSM for converting stop-controlled or signalized intersections to roundabouts. A range of CMFs are available to account for area types such as rural, urban, or suburban, as well as the number of lanes in the roundabout.

The CMFs in the HSM were originally developed as part of **NCHRP Report 572: Roundabouts in the United States.** CMFs are multiplicative factors used to compute the expected number of crashes at a site after a given countermeasure is implemented. For example, if an intersection experienced an average of 20 crashes per year and a treatment with a CMF of 0.50 was installed, an average of 10 crashes per year would be expected at the intersection in future years.

The crash prediction methodology in the HSM is recognized as the best one available in the industry. However, there are limitations to how much research has been done for countermeasures applied to various field conditions. The First Edition of the HSM only includes SPFs for a limited number of intersection types. For situations in which SPFs are not available, the spreadsheet uses historical crash data to estimate future safety performance. When historical crash data is used the spreadsheet warns users regarding potential uncertainty in the results for reasons related to regression to mean (discussed later in this Guide).

When crash prediction models are not available to predict crash frequency for both the traditional intersection and the roundabout, the safety metric is excluded from the overall intersection life cycle cost comparison.

Traditional Intersection Crash Prediction

Part C of the HSM provides SPFs for the various intersection configurations on three types of roadways: two-lane rural highways, multi-lane rural highways, and urban and suburban arterials. Table 1 lists the facility and intersection types for which SPFs are available. SPFs for other intersection configurations will be included in future editions of the HSM.

The classification of an area as urban, suburban, or rural is subject to the roadway characteristics, surrounding population, land uses, and is at the user's discretion. In the HSM, the definitions of "urban" and "rural" areas are based upon Federal Highway Administration (FHWA) guidelines, which classify "urban" areas as places inside urban boundaries where population is greater than 5,000 persons. "Rural" areas are defined as places outside urban areas where the population is less than 5,000. The HSM uses the term "suburban" to refer to outlying portions of an urban area. The predictive method in the HSM does not distinguish between urban and suburban portions of a developed area.

Table 1. SPF Availability for Traditional Intersections

	3 leg TWSC	4 leg TWSC	3 leg AWSC	4 leg AWSC	3 leg signal	4 leg signal
Rural Two-lane, Two-Way	SPF	SPF	No SPF	No SPF	No SPF	SPF
Rural Multi-Lane	SPF	SPF	No SPF	No SPF	No SPF	SPF
Urban and Suburban Arterials	SPF	SPF	No SPF	No SPF	SPF	SPF

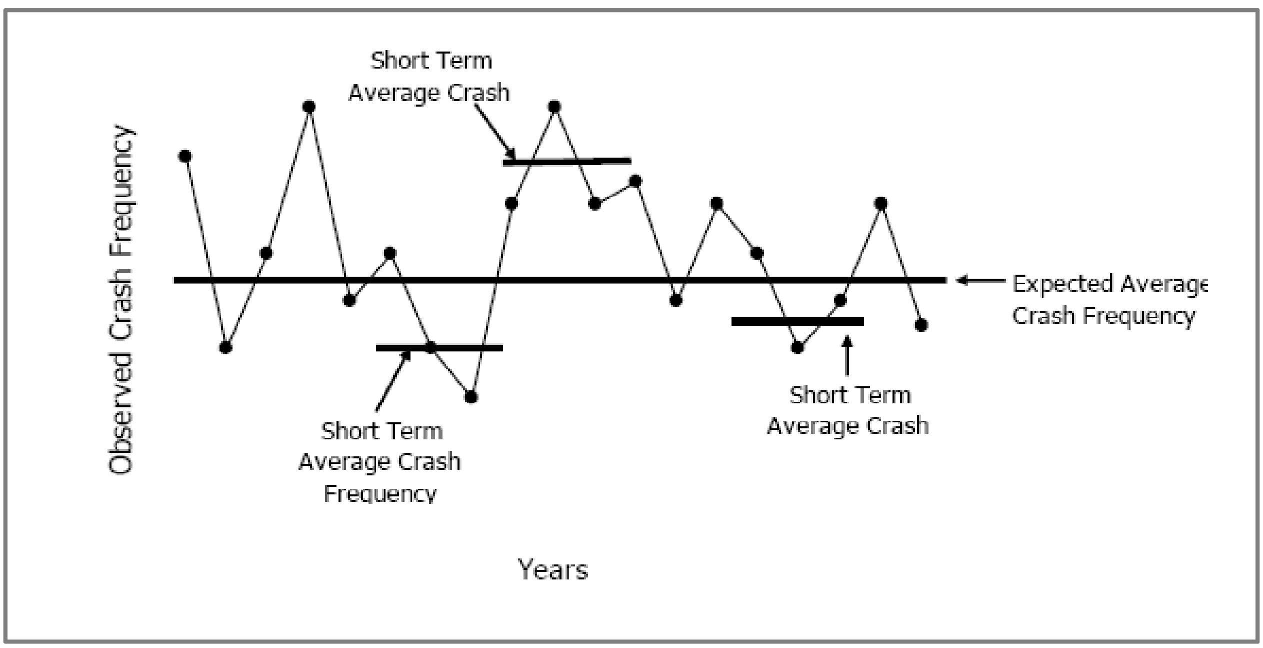
For each combination of facility and intersection type for which an SPF is available, the HSM predicts the expected number of Property Damage Only (PDO) crashes as well as the combined number of fatal and injury (FI) crashes.

The SPFs in the HSM assume certain base conditions related to lane configurations and geometry, as defined in Part C of the HSM. CMFs from part C are applied in the spreadsheet to account for variations between the study site and the SPF base conditions. Part C CMFs are generally referred to as "SPF Adjustments" in the spreadsheet to avoid confusion with HSM Part D CMFs.

In general, the HSM recommends that "default" SPFs be calibrated to local conditions or replaced with locally-derived SPFs. FDOT does not have calibration factors for HSM SPFs at present and uncalibrated SPFs from the HSM are used in the spreadsheet tool. The results of this spreadsheet should only be used in relative terms only, to compare one alternative to another or one site to another.

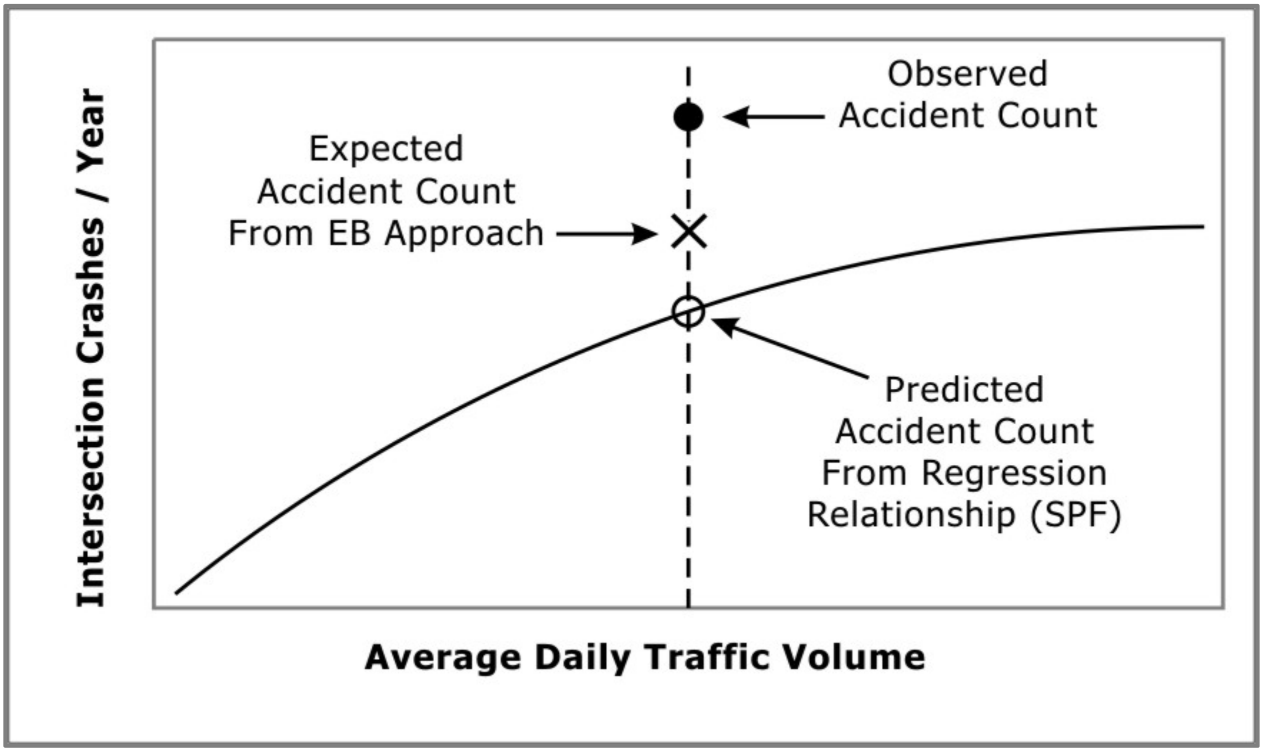
SPFs may not accurately predict future crash frequency, as they may not account for certain site-specific conditions that could influence safety. In addition, historical crash data may not accurately predict future crash frequency, potentially reflecting a short-term average that is higher or lower than the long-term average. Figure 4 describes short-term versus long-term average crash frequency.

Figure 4. Short-Term versus Long-Term Average Crash Frequency



When both SPF and historical crash data are available, the Empirical Bayes (EB) Method is applied to determine the expected average crash frequency. EB is a statistical inference method that modifies the predictive model to give a more accurately prediction of the site-specific conditions with the crash data provided. Essentially, the EB method provides a “weighted” average of historical crash frequency and predicted crash frequency by an SPF. The “weight” assigned to the results of the SPF and the historical data are determined by an over-dispersion parameter associated with the SPF. The EB method is graphically depicted in Figure 5, and fully described in Appendix A of Volume 2 of the HSM.

Figure 5. Empirical Bayes Method



The spreadsheet’s use of SPFs, historical data, and the EB method for each of the Case comparisons is described in a subsequent section of this Guide.

Roundabout Crash Prediction

The spreadsheet uses CMFs to predict the change in crash frequency or severity at a roundabout in comparison to the crash frequency or severity that is estimated for the traditional intersection Table 2 below identifies the types of conversions for which CMFs are available. For conversion of an AWSC intersection to a roundabout, the spreadsheet estimates crash frequency the same for both intersection configurations, as indicated in Table 2 by the CMF value of 1.0.

Table 2. CMF Availability for Conversion of Traditional Intersection to Roundabout

Convert from a _______ to a ____lane roundabout

	TWSC -> 1 ln	TWSC -> 2 ln	AWSC -> 1 ln	AWSC -> 2 ln	Signal -> 1 ln	Signal -> 2 ln
Rural	CMF	No CMF	Aggregated data indicates CMF ~1.0		No CMF	No CMF
Suburban	CMF	CMF			CMF	
Urban	CMF	CMF			CMF	

Case-Specific Safety Calculations

Safety calculations are described below for each case in which the spreadsheet uses SPFs, historical data, and CMFs to compute the expected number of crashes under the traditional intersection and roundabout alternatives.

Case 1: Existing Traditional Intersection vs. Roundabout Alternative

Under Case 1, an existing traditional intersection remains the same or is converted to a roundabout. For the traditional intersection future safety performance is predicted by an SPF, if one is available per Table 1. If historical crash data is available, the EB method is applied. If an SPF is not available but historical crash data is, then the future safety performance of the traditional intersection is assumed equivalent to the historical performance. In this situation, the spreadsheet provides a warning to users because there is more uncertainty in results than if an SPF were applied.

The crash frequency or severity at a roundabout is calculated by applying a CMF (if available) to the estimated crash frequency of the existing traditional intersection, resulting in an estimation of the relative difference in crash frequency between traffic control configurations.

Table 3 lists scenarios that may occur under Case 1 comparisons with the corresponding type of calculations performed by the spreadsheet. If there is insufficient data to predict crash frequency for both alternatives, then safety is omitted from the overall life-cycle cost comparison. Table 3. Case 1 Crash Prediction Scenario Methodologies

Scenario	Methodology Applied to Estimate Future Safety Performance		Method Reliability
	Traditional Intersection	Roundabout	
SPF available for traditional intersection, CMF available for conversion to roundabout	SPF, with EB applied if historical crash data available	CMF	HSM-Recommended Evaluation, Greatest Reliability
SPF not available for traditional intersection, but historical crash data available. CMF available for conversion to roundabout	Historical crash data	CMF applied to historical crash data	HSM Prediction Tools Applied, Moderate Reliability
SPF and historical crash data not available	No safety analysis		
CMF not available (except AWSC)	No safety analysis		
AWSC with historical crash data	Historical crash data	Same as traditional intersection (CMF = 1.0)	

Case 2: Reconstruction of a Traditional Intersection vs. Roundabout Alternative

Under Case 2, an existing traditional intersection is modified or it is converted to a roundabout. Improvements could retain the same traffic control or change it completely. For example, a TWSC intersection could remain TWSC with added turn lanes, or it could become a signalized intersection.

Safety performance of a traditional intersection alternative is predicted by an SPF if one is available. Otherwise, it is predicted by an SPF and/or historical crash data for the existing traditional intersection as well as by a Part D CMF for the conversion of the existing traditional intersection to the traditional intersection alternative.

Future safety performance of the roundabout is predicted both by knowledge of the future safety performance of the existing or alternatives traditional intersection (as detailed in Table 4) and by a CMF, if one is available. (See Table 2).

Table 4 lists scenarios that may occur under Case 2 comparisons with the corresponding type of calculations performed by the spreadsheet. If there is insufficient data to predict crash frequency for both alternatives, then safety is omitted from the overall life-cycle cost comparison.

Table 4. Case 2 Crash Prediction Scenario Methodologies (Assuming CMF for conversion of existing intersection to roundabout is available*)

Scenario	Methodology Applied to Estimate Future Safety Performance		Method Reliability
	Traditional Intersection Alternative	Roundabout	
SPF available for existing traditional intersection and traditional intersection alternative.	SPF for traditional intersection alternative	CMF applied to existing traditional intersection SPF	HSM Prediction Tools Applied, Moderate Reliability
SPF available for existing traditional intersection. SPF not available for traditional intersection alternative. HSM Part D CMF for conversion of existing traditional intersection to traditional intersection alternative.	SPF for existing traditional intersection is calculated and Part D CMF (for traditional intersection alternative) is applied	Roundabout CMF applied to traditional intersection SPF	HSM-Recommended Evaluation, Greatest Reliability
SPF available for existing traditional intersection. SPF not available for traditional intersection alternative. No Part D CMF for conversion of existing traditional intersection to traditional intersection alternative.	No safety analysis		N/A
SPF not available for existing traditional intersection. SPF available for traditional intersection alternative.	SPF for traditional intersection alternative	CMF applied to traditional intersection alternative SPF	HSM Prediction Tools Applied, Moderate Reliability
SPF not available for existing traditional intersection or traditional intersection alternative. Historical crash data available. Part D CMF for conversion of existing traditional intersection to traditional intersection alternative.	Part D CMF (for traditional intersection alternative) is applied to historical crash data	CMF applied to historical crash data.	HSM Prediction Tools Applied, Low Reliability
SPF not available for existing traditional intersection or traditional intersection alternative. Historical crash data not available. No Part D CMF for conversion of existing traditional intersection to traditional intersection alternative.	No safety analysis		N/A

* If a CMF for conversion of the existing traditional intersection to a roundabout is not available, no safety analysis is conducted. This applies to all scenarios listed in the table.

Case 3: New construction of Traditional Intersection vs. Roundabout Alternative

Under Case 3, historical crash data is not available, and only SPFs are used to predict the safety performance of the traditional intersection. CMFs are applied to SPF results to predict the safety performance of the roundabout.

Table 5 lists scenarios that may occur under Case 3 comparisons with the corresponding type of calculations performed by the spreadsheet. If there is insufficient data to predict crash frequency for both alternatives, then safety is omitted from the overall life-cycle cost comparison.

Table 5. Case 3 Crash Prediction Scenario Methodologies

Scenario	Methodology Applied to Estimate Future Safety Performance		Method Reliability
	Traditional Intersection	Roundabout	
SPF available for traditional intersection, CMF available for conversion to roundabout	SPF	CMF	HSM Prediction Tools Applied, Moderate Reliability
SPF not available for traditional intersection, CMF available for conversion to roundabout	No safety analysis, but spreadsheet provides the CMF for the user's reference		N/A
SPF not available for traditional intersection and/or CMF not available for conversion to roundabout	No safety analysis		N/A

Delay

The spreadsheet does not compute intersection delays. If the users have information available from previously collected data or performed delay analysis then the input data could inserted in the spread sheet for the benefit to cost analysis.

Delay data can be entered for up to five weekday, time-of-day periods and up to five weekend, time-of-day periods. Delay data is usually available for only two or three time periods of the week (such as the a.m. peak, p.m. peak, weekday midday, and/or Saturday midday). The user may enter the number of hours of the day that each period represents. For example, p.m. peak delay data may be based on a one-hour traffic count, but it may be assumed that to approximate conditions over a two-hour period.

The effect of delay on the overall intersection cost comparison is directly influenced by the number of hours in a weekday and a weekend day that a user chooses to analyze. For example, analyzing four hours of weekdays and weekend days instead of two hours of weekdays and weekend days doubles the "weight" of delay relative to other metrics in the overall intersection cost comparison.

After selection of analysis periods and corresponding durations, the user enters delay values (seconds per vehicle) and the number of total entering vehicles for the roundabout and the traditional intersection alternative. The spreadsheet then multiplies these inputs to obtain total vehicle delay in the analysis period. Subsequent calculations determine vehicle delay for all weekday and weekend days analyzed, total person delay for all weekday and weekend days analyzed, and total person delay for a one-year period. The year consists of 260 weekdays and 105 weekend days.

All delay data is entered for the opening year and the design year of the intersection. The spreadsheet uses linear interpolation to compute delay for all other years.

Occupants of vehicles are negatively impacted by delay time at intersections. The spreadsheet reports total person delay for the life cycle of the intersection, and uses a person delay unit cost.

Operations and Maintenance

Operations and maintenance costs are the ongoing costs associated with the intersection throughout the design life. The operations and maintenance costs will be determined based on the specific type of intersection control such as stop-control, traffic signal and roundabout. Table 6 lists all of the operations and maintenance costs the spreadsheet considers.

Table 6. Operation and Maintenance Cost Elements by Intersection Control

Operations and Maintenance Cost	Stop-Control	Traffic Signal	Roundabout
Luminaires – Electrical Consumption and Maintenance	Applicable	Applicable	Applicable
Electric Consumption by Traffic Signals	Not Applicable	Applicable	Not Applicable
Signal Retiming	Not Applicable	Applicable	Not Applicable
Signal Maintenance	Not Applicable	Applicable	Not Applicable
Roundabout Landscaping Maintenance	Not Applicable	Not Applicable	Applicable

The spreadsheet was designed to include the majority of the operations and maintenance costs identified in Table 6 as “applicable” in the life cycle cost of the intersection, requiring minimal user input.

Initial Capital Costs

The user may enter capital costs in three subtotals: preliminary engineering, right-of-way and utilities, and construction. Only the total capital cost is used in the spreadsheet’s calculations. The user can enter a single total cost value into any of the three subtotal entry cells if desired. The spreadsheet assigns all capital costs to the opening year.

ECONOMIC ANALYSIS

Life Cycle Cost

Table 7 identifies the way in which costs are computed for each performance metric in each year of the intersection’s life cycle.

Table 7. Computation of Costs by Year

Cost Element	Opening Year	Design Year	Intermediate Years
Safety	Spreadsheet computes based on opening year AADT input, other inputs, and unit costs.	Spreadsheet computes based on design year AADT input, other inputs, and unit costs.	Linear interpolation of opening year and design year costs
Delay	Spreadsheet computes based on opening year delay inputs, other inputs, and unit costs.	Spreadsheet computes based on design year delay inputs, other inputs, and unit costs.	Linear interpolation of opening year and design year costs
Operations and Maintenance	Spreadsheet computes based on default values, unit costs, and minimal user input	Same as opening year	Same as opening year
Capital Elements	All entered capital costs are incurred in the opening year	None	None

To account for the multi-year nature of an intersection investment, the spreadsheet accounts for changes in the value of money over time. On the Results Tab, the total life-cycle cost of the intersection is reported in opening year dollars. Cash flows for years other than the opening year are converted to opening year dollars by applying a discount rate. A discount rate of 3% is used in the spreadsheet, which is typical for infrastructure projects. Thus, for a future year *n* and a discount rate *i*, costs for that year are converted to opening year dollars by applying a factor of *1/(1+i)^n*. The spreadsheet applies the factor to costs in each year beyond the opening year and then sums all costs for each year of the project's life cycle to provide the total life cycle cost of the roundabout and the traditional intersection alternative.

Benefit-Cost Ratio

In addition to providing the life-cycle cost of both intersection forms, the spreadsheet provides a benefit-cost ratio of the roundabout in comparison to the traditional intersection alternative. The benefit cost ratio is calculated as follows:

Safety benefit of roundabout = Life-cycle safety cost of traditional intersection alternative – life-cycle safety cost of roundabout

Delay reduction benefit of roundabout = Life-cycle delay cost of traditional intersection alternative – life-cycle delay cost of roundabout

Added operations and maintenance (O&M) cost of roundabout = Life-cycle O&M cost of a roundabout – life-cycle O&M cost of traditional intersection alternative

Added capital cost of roundabout = Capital cost of roundabout – capital cost of traditional intersection alternative

$$\frac{Benefit}{Cost} = \frac{safety\ benefit\ of\ roundabout + delay\ reduction\ benefit\ of\ roundabout}{added\ O\&M\ cost\ of\ roundabout\ +\ added\ capital\ cost\ of\ roundabout}$$

The spreadsheet makes the following assumptions:

- A roundabout has fewer crashes and less delay than the traditional intersection alternative
- A roundabout has greater operations and maintenance costs and greater capital costs than the traditional intersection alternative.

If the total benefit and total cost are positive numbers and the ratio is greater than 1.0, a roundabout is considered beneficial compared a traditional intersection. If the ratio is less than 1.0, a roundabout is not considered beneficial.

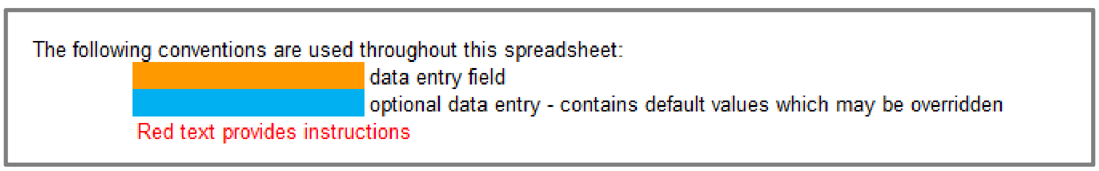
USING THE SPREADSHEET

The Step 2 Roundabout b/c Evaluation Spreadsheet was designed to assess the life cycle cost of a roundabout as compared to a traditional intersection alternative. A traditional intersection is defined as a stop-controlled or signalized intersection.

The spreadsheet tool evaluates comparative capital, operation, and maintenance costs as well as costs associated with safety and delay for all intersection types evaluated. A summary of the cost comparison may be found on the Results Tab following the input of conditional variables.

The User Guide serves as a step-by-step guide throughout the assessment of build scenarios. Brief instructional overview is presented on the Introduction Tab of the Step 2 Roundabout b/c Evaluation Spreadsheet. Throughout the spreadsheet tool, orange cells represent required fields, and blue cells denote optional inputs that are initially filled with default values. Red text provides instruction on each of the tabs.

Figure 6. Introduction Tab Field Entry Color Reference



Progression through the spreadsheet is as follows:

1. Open the Introduction Tab and read the instructions provided.
2. Move from the Introduction Tab to the MainENTRY Tab and enter the required information into the orange cells.
3. Move to the AdjustSPF Tab to enter roadway and intersection geometry information that is used in safety calculations.
4. Move to the DelayENTRY Tab to enter delay information.
5. Move to the Results Tab – Life Cycle Costs Tab to view results.

The last three tabs (O_SafetyCalculation, D_SafetyCalculation, and CostCalculation) only perform calculations and do not need to be viewed or modified.

When delay or safety information is not available at the time of the benefit-cost comparison the corresponding spreadsheet tool sections may be left blank.

MAINENTRY TAB

The MainENTRY Tab has several sections, each of which are described below.

Scenario

Scenario inputs are the basis for analysis throughout the spreadsheet tool and should be selected based upon the conditions that best apply to the user's project. The scenarios correspond to differing methodologies of safety calculations. For example, the "Existing Control" field applies to Case 1 and Case 2, and the only option available for the field is "N/A" when Case 3 is selected. Similarly, the "Traditional Intersection Alternative" field applies to Case 3 and Case 2 only, and will display "N/A" with the selection of Case 1. Figure 7 below shows the layout of this section.

Figure 7. MainENTRY Tab Scenario Selection

Scenario		
Type of Comparison	Case 1: Existing Traditional Intersection vs. Roundabout Option	Choose from list
Existing Control	Traffic Signal	Choose from list
Traditional Intersection Option	N/A (Case 1)	Choose from list
Timeframe		
Opening Year		Enter year
Life Span		Enter life space in years. Maximum life span is 50 years

In the Scenario section of the MainENTRY Tab, select the type of comparison to be analyzed. Three cases are available for selection:

- Case 1: Existing Traditional Intersection vs. Roundabout Alternative
- Case 2: Traditional Intersection Alternative vs. Roundabout Alternative at site of existing traditional intersection
- Case 3: Traditional Intersection Alternative vs. Roundabout Alternative at new site

Case 1 compares the life cycle cost of a new roundabout to an existing traditional intersection. Case 1 should be selected if a roundabout is the only alternative under consideration for the intersection improvements, otherwise the intersection remains unchanged if a roundabout is not constructed.

Case 2 compares the life cycle cost of a new roundabout with a traditional intersection alternative at the site of an existing intersection. Case 2 should be selected if the user is comparing the replacement of an existing intersection with either a roundabout or a modified traditional intersection. For example, Case 2 should be selected in the following scenarios:

- A two-way stop-control (TWSC) intersection will be converted to a traffic signal or a roundabout
- A TWSC intersection will be modified by the addition of a turn lane, removal of skew, addition of illumination, etc. or be converted to a roundabout

Case 3 compares the life cycle cost of a roundabout alternative with a traditional intersection alternative at a new site. Case 3 should be selected if the intersection is yet to be built.

Timeframe

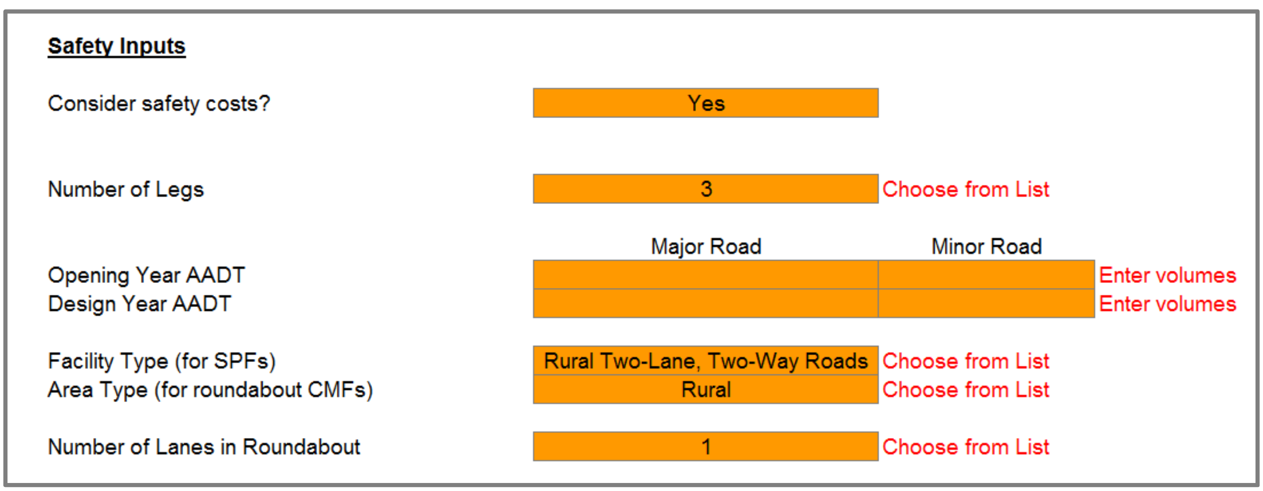
Under Timeframe (Figure 8), enter the opening year of the proposed project. Then enter the life span of the proposed project in years. The life span is used to calculate the life cycle costs associated with the project.

Figure 8. MainENTRY Tab Timeframe Input

Safety Inputs

The safety input section of the MainEntry tab is shown in Figure 9. The user has the option of omitting safety input with the selection of “No” on the first drop down list under the section. When “No” is selected, inapplicable sections of the spreadsheet, including all entries on the AdjustSPF Tab, will be grayed out. As a resultsafety costs will not be reflected in the life cycle costs computed by the spreadsheet.

Figure 9. MainENTRY Tab Safety Inputs



Should the user choose to consider safety costs, select the number of legs at the intersection. The spreadsheet accommodates intersections with 3, 4, or 5+ legs. However, no safety analysis is performed for intersections with 5+ legs due to a lack of SPFs and CMFs for this condition. Next, enter the

Annual Average Daily Traffic (AADT) for the major road and minor road for both the opening year and the design year.

The facility type input under this section is used to select an SPF for the site. The facility types are in accordance with the predictive methods (Part C) of the Highway Safety Manual as follows:

- Rural Two-Lane, Two-Way Roads (HSM Chapter 10)
- Rural Multilane Highways (HSM Chapter 11)
- Urban and Suburban Arterials (HSM Chapter 12)

For more information on each of the facility types, please see the Comparison Processes and Metrics section of the Concepts Overview in this Guide or Part C of the Highway Safety Manual.

Next, the number of lanes in the roundabout alternative is selected to reflect the HSM CMFs for conversion to either one-lane or two-lane roundabouts. The spreadsheet does not accommodate roundabouts with three or more lanes. However, the number of lanes in the roundabout is only used for safety analysis so a user could analyze a three-lane roundabout by choosing “no” in the “Consider Safety Costs?” field.

If the facility type is an urban or suburban arterial, the Area Type drop down list allows for the selection of either “Urban” or “Suburban”. Choose the relevant area type. The “Urban and Suburban Arterials” facility type requires more inputs than either “Rural Two-Lane, Two-Way Roads” or “Rural Multilane Highways.” When the “Urban and Suburban Arterials” selection is made, additional input cells are exposed, as shown in the boxed area at the bottom of Figure 10:

- Enter the maximum number of lanes to be crossed by a pedestrian on the urban or suburban arterial. Each stage of a multi-stage crossing is counted separately, and maximum number of lanes crossed in a single stage is entered. For example, a pedestrian would be considered to cross a maximum of four lanes at an intersection on an undivided four-lane major road. On the other hand, the maximum number of lanes crossed would reduce to twoif a median or raised island divided the roadway at the intersection.
- Enter the daily pedestrian volume, defined in the HSM as the sum of daily pedestrian volumes (pedestrians/day) crossing all intersection legs.

Figure 10. MainENTRY Tab Urban and Suburban Arterial Facility Type

For "Urban and Suburban Arterial" facility type:		
Max. number of lanes crossed by pedestrian		For any crossing at intersection. If raised island/median, count stages seperately.
Daily Pedestrian Volume		Sum of all legs crossed

Crash Data

Crash data may be entered under the Safety Inputs section of the MainENTRY Tab. As explained in Section 2 of this Guide, use of historical crash data improves the accuracy of the prediction of future crash frequency, and it should be entered when available.

If crash data is available, enter the time span for which crash history is considered, as shown in Figure 11. A minimum of two years of data is necessary. Then enter the total number of crashes across the timespan for each crash type: fatal crashes, injury crashes, and property damage only (PDO) crashes.

Figure 11. MainENTRY Tab Urban and Suburban Arterials Crash Inputs

Existing Crash Data Available?	Yes	hoose from list
Time Span of Record (years):		**Enter a minimum of 2 years**
Total Number of Crashes:	**0**	
- with Fatalities:		Enter total number for given time span.
- with Injuries:		Enter total number for given time span.
- with PDO:		Enter total number for given time span.
For "Urban and Suburban Arterial" facility type:		
Number of Single-Vehicle Crashes		Enter total number for given time span. Do not include pedestrian or bicycle crashes.
Number of Multi-Vehicle Crashes		Enter total number for given time span. Do not include pedestrian or bicycle crashes.
Number of Vehicle-Pedestrian Crashes		Enter total number for given time span.
Number of Bicycle-Pedestrian Crashes		Enter total number for given time span.

If the facility type is an urban or suburban arterial, a dialog box, shown at the bottom of Figure 11, will appear that requests additional crash data. The additional inputs are variables in the sub-models specific to this facility type, and apply to the EB method used for each sub-model. Enter the total number of crashes for single-vehicle crashes, multi-vehicle crashes, pedestrian crashes, and bicycle crashes. Pedestrian crashes are defined in the HSM as crashes involving a vehicle and a pedestrian. And bicycle crashes are defined as crashes involving a vehicle and a bicycle. For example, a crash involving one vehicle and one pedestrian is considered a pedestrian crash, not a single-vehicle crash.

The sum of fatal, injury, and PDO crashes should equal the sum of single-vehicle, multi-vehicle, pedestrian, and bicycle crashes. ***If the sums are not equal, the spreadsheet ignores the entered data and does not apply the EB method.*** In situations where no SPF is available and historical crash data is used as the sole predictor of future safety performance (i.e. AWSC intersections on urban and suburban arterials), only the number of fatal, injury, and PDO crashes are used by the spreadsheet and the number of single-vehicle, multi-vehicle, pedestrian, and bicycle crashes may be omitted if it is not known.

Use of Part D CMFs for Traditional Intersection Conversion in Case 2

In two situations, the spreadsheet uses a Part D CMF to estimate the safety performance of the traditional intersection alternative. In these situations there is no SPF for the traditional intersection alternative. The situations are:

- Conversion of a rural, three-leg, TWSC intersection to a signal

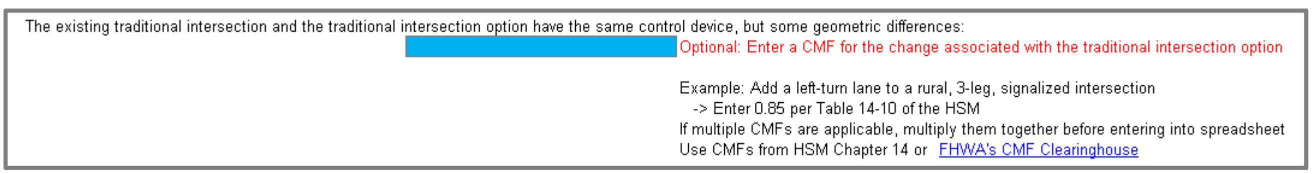
- Conversion of a rural TWSC intersection to AWSC.

The CMFs applied by the spreadsheet for these situations are 0.56 and 0.52, respectively.

Case 2 Guide CMF Input

Case 2 scenarios involve three intersection designs (one existing, and two proposed alternatives), making the comparison of intersection forms more complex than Case 1 or Case 3 and In some situations requiring the user manually to enter a CMF to quantify expected changes in safety performance. If the existing traditional intersection and the traditional intersection alternative have the same control device, and there is an SPF and/or crash data for the existing intersection, the user should enter a CMF. For example, if an existing urban, three-leg, TWSC intersection is proposed to remain TWSC but have a left turn lane added on the major roadway (or become a roundabout), the user should enter a CMF of 0.67 based Table 14-10 of the HSM to quantify the expected change in safety with the addition of the left turn lane. For the roundabout alternative, the spreadsheet still automatically applies a CMF. CMFs entered by the user should come from Chapter 14 of the HSM or other sources such as FHWA’s online CMF Clearinghouse. The alternative to enter a CMF for total crashes at the site of the traditional intersection alternative is displayed in Figure 12.

Figure 12. MainENTRY Tab Guide CMF Input for Case 2



Additional Safety Inputs

For ease of use, additional safety inputs are located on a subsequent tab.

Vehicle Delay

The Vehicle Delay section on the MainENTRY Tab refers the user to the DelayENTRY Tab to input information required for the consideration of delay costs.

Operations and Maintenance

Operations and maintenance costs are the ongoing costs associated with the intersection throughout the design life. The spreadsheet tool considers the following operations and maintenance costs:

- electrical consumption by and maintenance of luminaires,
- electricity consumption by traffic signals,

- signal retiming,
- signal maintenance, and
- roundabout landscaping maintenance.

To compute electrical consumption and maintenance of luminaires, users specify if an intersection has lighting as shown at the top of Figure 13. This is a relatively small component of the overall intersection cost comparison. Other operations and maintenance-related costs are automatically applied by the spreadsheet based on the form of the intersection. For example, roundabout landscaping maintenance costs are always included in the life cycle cost of the roundabout.

Figure 13. MainENTRY Tab Operations, Maintenance, and Capital Costs

Operations and Maintenance	Roundabout	Traffic Signal
Lighting?		
Capital Costs		
Cells in tables below should be left blank if consideration of capital costs is not desired.		
Preliminary Engineering		
Right-of-Way and Utilities		
Construction		
Total	$ -	$ -

Capital Costs

Capital costs are entered in the cells shown at bottom of Figure 13. Capital cost entry is broken down in to three subtotals: preliminary engineering, right-of-way and utilities, and construction. Only the total capital cost is used in the spreadsheet's calculations, and a user can enter a single total cost value into any of the three subtotal entry cells if desired.

Unit Costs

At the bottom of the MainENTRY Tab are blue entry fields for unit costs that are populated with values from FDOT and other sources. There is no need to change these values, and FDOT will periodically re-lease new versions of this spreadsheet as unit costs change over time. The basis of each unit cost is de-scribed below.

Crashes

FDOT has cost values for five severities of crashes and they are listed below in Table 9.

Table 8. Cost of Fatal-Injury Crashes

Severity	Cost

Fatality	$10,120,000
Severe Injury	$574,080
Moderate Injury	$155,480
Minor Injury	$96,000
Property Damage Only	$7,600

The HSM only predicts a total number of fatal-injury crashes. To obtain the typical cost of a fatal-injury crash, a weighted average value of the first four costs listed in Table 9 was computed. The weights were the statewide percentages of each fatal-injury crash severity category. The resulting cost is $363,470; this is the cost assigned to a fatal-injury crash in the spreadsheet. The FDOT cost value of a PDO crash is $7,600; this is the cost assigned to a PDO crash in the spreadsheet.

Vehicle-Hour Delay

The cost of an hour of delay is $16.79. This value is from the Texas Transportation Institute's 2012 Urban Mobility Report. This report quantifies the amount of congestion in cities across the US, and provides a number of cost-related impacts of congestion.

Retiming

Traffic signals are typically retimed every few years to account for changes in volume. The spreadsheet assigns a $_______ retiming cost to a signal once every three years. This cost reflects a typical timing plan developed by consultants and does not include any costs incurred by agency staff.

Power to Signal

The estimated annual cost of power supply to a signal is $______. This value is based on FDOT experience. Costs at specific intersections will vary based on the number of signal heads and the type of blubs (i.e. incandescent versus LED)

Luminaires

The annual cost of lighting an intersection includes maintenance and power supply. This cost is set at $______ based on FDOT experience.

Signal Maintenance

The typical annual maintenance cost for a signal in Florida is $_______.

Roundabout Landscaping

The typical annual maintenance cost is $2,000. This value is based on data provided by Bend, Oregon, which has over 25 roundabouts. A typical value for FDOT roundabouts is not available at this time.

Discount Rate

The discount rate, or the opportunity cost of investing in the intersection, is set at 3.0%. This is a typical value for infrastructure projects.

Unit Cost Summary

Table summarizes the cost values described above.

Table 9. Unit Cost Default Values (2013)

Unit Cost	Default Value*	Source
Cost per Fatal-Injury Crash	$165,424	Weighted average of FDOT values for various fatal-injury severity levels
Cost per PDO Crash	$7,600	FDOT standard value
Cost per Vehicle-Hour Delay	$16.79	2012 Texas Transportation Inst. Urban Mobility Report
Retiming Cost Every Five Years	$	FDOT
Annual Power Cost for Signal	$	FDOT
Annual Illumination Cost	$	FDOT
Annual Signal Maintenance Cost	$3,750**	FDOT
Annual Roundabout Landscaping Cost	$2,000	Typical cost
Discount Rate	3.0%	Typical for infrastructure projects
* 2013 Values ** $0 for stop-controlled intersection or roundabout		

ADJUSTSPF TAB

The AdjustSPF Tab is used to enter data that selects and computes HSM Part C Crash Modification Factors (CMFs). These CMFs are used to adjust the safety performance function (SPF) to predict more accurately the traditional intersection's average crash frequency in future years. For more information regarding these CMFs and the degree with which they influence the results of the SPF, refer to Safety under the Concepts Overview section of the User Guide or to Part C of the HSM.

If safety costs are omitted from analysis, input fields on the AdjustSPF Tab will be hidden and the message shown in Figure 14 will appear. If the message does not appear, the user should ensure that "No" is selected from drop-down menu under the Safety Inputs section of the MainENTRY Tab.

Figure 14. AdjustSPF Tab Safety Input Omission Message

2 - ADJUST SPF
SPF adjustments are not necessary as safety inputs have been omitted from analysis.
Enter intersection geometric conditions into orange cells on this sheet.

If the user choses to consider safety costs on the MainENTRY Tab, the facility type will appear at the top of the AdjustSPF Tab, and the facility type's corresponding inputs will appear below. For example, if the user selects Rural Two-Lane, Two-Way Roads under facility type on the MainENTRY Tab, "Rural Two-Lane, Two-Way Roads" will appear at the top of the AdjustSPF Tab and applicable input fields will display on the screen. Input fields for other facility types will be hidden.

Inputs for each of the HSM's three facility types are discussed below.

Rural Two-Lane, Two-Way Roads

Figure 15 shows input fields for CMFs used in the HSM's Rural Two-Lane, Two-Way Roads procedure. Note that entry fields for both a TWSC intersection and a signalized intersection are displayed. Users only need to enter data into the fields for the applicable control device if a Case 1 or Case 3 comparison is being conducted. Both sets of entry fields are displayed for Case 2 comparisons in which a TWSC intersection currently exists and a signal is an alternative (or vice versa). In this situation, the user should enter data for both the TWSC and signalized intersection. Guidance on entry field input is provided below.

Figure 15. AdjustSPF Tab Rural Two-Lane, Two-Way Roads Inputs

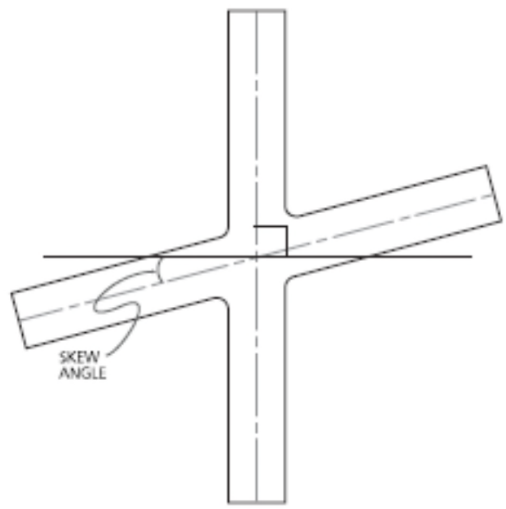
Enter intersection geometric conditions into orange cells on this sheet.

Selected Facility Type from MainEntry tab: Rural Two-Lane, Two-Way Roads

Rural Two-lane, Two-Way Roads - Two-Way Stop-Control Intersection (3 or 4 legs)		
Intersection Skew Angle	0	Enter Angle (positive number). See figure.
Major Street Approaches With Left-Turn Lanes	0	Choose from list
Major Street Approaches With Right-Turn Lanes	0	Choose from list
Lighting	No	Choose from list
Rural Two-lane, Two-Way Roads - Signalized Intersection (4 legs)		
Approaches With Left-Turn Lanes	0	Choose from list
Approaches With Right-Turn Lanes	0	Choose from list
Lighting	No	Choose from list

- Enter the intersection skew angle. Skew angle is defined as the deviation from an intersection angle of 90 degrees and is illustrated in Figure 16. For use in the spreadsheet tool, the skew angle carries a positive sign indicating the acute angle at which the minor road intersects the major road. The skew angle is zero if the intersection is perpendicular.

Figure 16. Skew Angle



Skew Angle is 0 if intersection is perpendicular.

- The number of approaches with left-turn and right-turn lanes from the drop-down list as applicable under each section. For TWSC intersections, the number of approaches with turn lanes pertains to the major street approaches only.
- Specify if lighting (illumination) is present.

Rural Multilane Highways

Figure 17 shows the entry fields for Rural Multilane Highways. Inputs are similar to Rural Two-Lane Two-Way Highways.

Figure 17. AdjustSPF Tab Rural Multilane Highway Inputs

Enter intersection geometric conditions into orange cells on this sheet.

Selected Facility Type from MainEntry tab: Rural Multilane Highways

Rural Multilane Highways - Two-Way Stop-Control Intersection (3 or 4 legs)

Intersection Skew Angle	0	Enter Angle (positive number). See figure.
Major Street Approaches With Left-Turn Lanes	0	Choose from list. Do not choose "2" for a 3-leg intersection
Major Street Approaches With Right-Turn Lanes	0	Choose from list. Do not choose "2" for a 3-leg intersection
Lighting	No	Choose from list

Rural Multilane Highways - Signalized Intersection (4 legs)

No crash modification factors for this safety performance function

Urban and Suburban Arterials

Figure 18 shows the entry fields for Urban and Suburban Arterials. Inputs for TWSC intersections are similar to Rural Two-Lane Two-Way Highways. For signalized intersections, the HSM requires additional inputs for the Urban and Suburban Arterial facility type. These additional inputs are:

- Number of approaches with protected/permissive or permissive/protected signal phasing for left turns
- Number of approaches with protected signal phasing for left turns
- Number of approaches on which right-turn-on-red is prohibited
- Presence/absence of red light running cameras
- Number of bus stops within 1000 feet of the intersection. Multiple bus stops at the same intersection (for example, an intersection with stops on the north leg and east leg) are counted separately. This CMF only adjusts the number of pedestrian crashes predicted by the vehicle-pedestrian crash sub-model. If the user did not enter the pedestrian volume on the MainEntry Tab, the predicted number of vehicle-pedestrian crashes is zero and this CMF will have no effect on the predicted number of vehicle-pedestrian or total crashes at the intersection.
- Presence/absence of schools within 1000 feet of the intersection. A school is considered present if any portion of the grounds is within 1000 feet of the intersection. This CMF only

adjusts the number of pedestrian crashes, and has no effect on results if the user did not enter the pedestrian volume on the MainEntry Tab.

- Number of alcohol sales establishments within 1000 feet of the intersection. This includes liquor stores, bars, restaurants, convenience stores, and grocery stores. This CMF only adjusts the number of pedestrian crashes, and has no effect on results if the user did not enter the pedestrian volume on the MainEntry Tab.

Figure 18. AdjustSPF Tab Urban and Suburban Arterial Inputs

Urban and Suburban Arterials - Two-Way Stop-Control Intersection (3 or 4 legs)		
Major Street Left-Turn Lanes	0	Choose from list
Major Street Right-Turn Lanes	0	Choose from list
Lighting	No	Choose from list
Urban and Suburban Arterials - Signalized Intersection (3 or 4 legs)		
Approaches with Left-Turn Lanes	0	Choose from list
Approaches with Protected/Permissive or Permissive/Protected left-turn phasing	2	Choose from list
Approaches with protected phasing	0	Choose from list
Approaches with Right-Turn Lanes	0	Choose from list
Approaches with RTOR Prohibited	0	Choose from list. RTOR is Right-Turn-on-Red
Lighting	Yes	Choose from list
Red-Light Cameras	No	Choose from list
Bus Stops within 1000 feet of Intersection	0	Choose from list. This CMF only affects the number of vehicle-pedestrian crashes
Presence of Schools within 1000 feet of Intersection	No school present	Choose from list. This CMF only affects the number of vehicle-pedestrian crashes
Number of Alcohol Sales Establishments within 1000 feet of Intersection	1 to 8	Choose from list. This CMF only affects the number of vehicle-pedestrian crashes

DELAYENTRY TAB

The DelayEntry Tab is used to input the results of traffic analysis previously conducted by the user. If the user chooses to omit delay costs from analysis, select "No" from the drop-down list at the top of the DelayENTRY Tab, shown in Figure 19. If "No" is selected, the remaining dialog boxes on the DelayENTRY Tab will be grayed out, and no further input is necessary.

Figure 19. DelayENTRY Tab Input Omission Message

3 - DELAY ENTRY

Enter delay data into orange cells on this sheet.

Consider delay costs?	No	Choose from list

Should the user choose to consider delay costs, select "Yes" from the dropdown menu shown above, and proceed to the vehicle occupancy dialog box on the DelayENTRY Tab. Each group of inputs on the Tab is described below.

Vehicle Occupancy

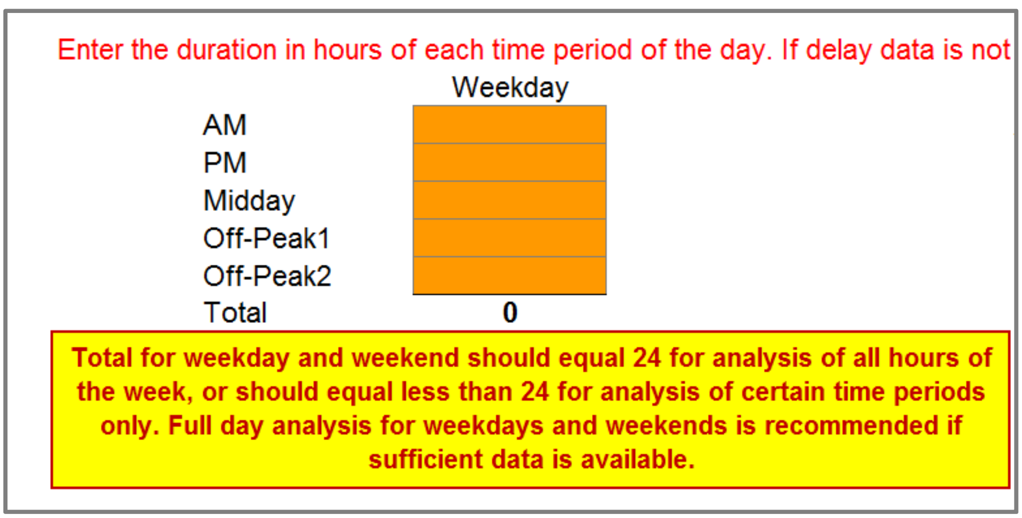
Enter the average occupancy of vehicles at the intersection. This value will generally be unknown, and users will need to input an assumed value. The spreadsheet has a default value of 1.1 persons per vehicle, which may be overridden. According to the US Department of Energy, national average vehicle occupancy is 1.59 persons per vehicle.

Vehicle occupancy directly "weights" delay costs in the overall intersection cost comparison. For example, an intersection with $1 million of life cycle delay and an average vehicle occupancy of 1.0 will change to $2 million of life cycle delay if average vehicle occupancy were set at 2.0.

Duration of Analysis Periods

Enter the corresponding time period duration (in hours) for weekday and weekend design year and opening year, as necessary. If delay data is not available for a particular time period, enter a duration of "0" hours in the corresponding cell, and a period of less than 24 hours will be analyzed. If a period of less than 24 hours is entered, a message, shown in Figure 20, will display that advises the user to use 24-hour data. While preferred, 24-hour data is not essential to continue with the analysis.

Figure 20. DelayENTRY Tab 24-Hour Time Period Message



Hourly Volume

The total number of vehicles approaching the intersection during each analysis period is entered into the cells shown in Figure 21. These volumes are used to convert average delay per vehicle (entered further down on the Tab) into total delay for all vehicles entering the intersection. They are not used for any other purpose

Users may omit certain analysis periods for which data is unavailable or analysis is not desired by leaving entry fields blank. Often, only weekday a.m. and p.m. traffic analysis is conducted. In this case, weekday midday, off-peak1, and off-peak2 field, and all weekend fields should be left blank.

Figure 21. DelayENTRY Tab Hourly Volume Inputs

Enter the hourly volume (total entering vehicles) for each time period of the day. This is used to convert average delay per vehicle to total delay.
If analysis of certain time periods is not desired, leave cells for that time period blank

	Weekday			Weekend	
	Opening Year	Design Year		Opening Year	Design Year
AM			AM		
PM			PM		
Midday			Midday		
Off-Peak1			Off-Peak1		
Off-Peak2			Off-Peak2		
ADT	**Requires 24**	**hour data**	ADT	**Requires 24**	**hour data**

ADT calculated from the hourly volumes above time period durations below.
Provided for informational purposes and not used in subsequent calculations.

Delay

Enter the delay by time period (in seconds per vehicle). Enter the roundabout delay in the first of the two rows of tables, and the traditional intersection delay in the second of the two rows of tables. (Figure 22) ***Roundabout and traditional intersection delay must be determined prior to use of this spreadsheet with the methodologies of the Highway Capacity Manual***. It is recommended that Highway Capacity Software (HCS) or SYNCHRO be used to compute delay at traditional intersections, and HCS or the "HCM 2010" model within SIDRA be used to compute delay at roundabouts.

As with previous sections on the DelayENTRY Tab, fields associated with time periods the user chooses to omit are left blank.

Figure 22. DelayENTRY Tab Time Period Delay Inputs

Orange cells in tables below can be left blank if consideration of time period is not desired.
For example, if it is desired to only analyze peak hours, delay entries for midday and off-peak may be left blank.

Weekday

Roundabout

	AM Delay sec/veh	**PM Delay** sec/veh	**Midday Delay** sec/veh	**Off-Peak1 Delay** sec/veh	**Off-Peak2 Delay** sec/veh
2015					
2035					

Traffic Signal

	AM Delay sec/veh	**PM Delay** sec/veh	**Midday Delay** sec/veh	**Off-Peak1 Delay** sec/veh	**Off-Peak2 Delay** sec/veh
2015					
2035					

The tables at the bottom of the DelayENTRY Tab calculate and display “daily” delay totals, which represent less than 24 hours of the day if the user did not enter data for 24 hours of the day. No user entry is required in this section.

RESULTS TAB

The Results Tab displays the following:

- Annual costs for both intersection forms,
- Life-cycle costs for both intersection forms,
- A benefit-cost ratio for the roundabout in comparison to the traditional intersection, and

There are no inputs on this Tab.

Annual Costs and Life-Cycle Costs

The first of the two tables on the Results Tab display safety, delay, operations and maintenance, and capital costs for the roundabout and the traditional intersection. The total life cycle cost, in opening year dollars, is displayed in the green row at the bottom of the second table.

Annual Costs	Roundabout		Traffic Signal	
Safety	**Predicted Annual Crashes**	**Safety Cost**	**Predicted Annual Crashes**	**Safety Cost**
Predicted Fatal/Injury Crashes	0.16	$ 52,613	0.36	$ 121,748
Predicted PDO Crashes	0.24	$ 2,178	0.71	$ 6,400
	Annual Costs of Predicted Crashes	$ 54,791	*Annual Costs of Predicted Crashes*	$ 128,148
Delay	**Annual Intersection Delay (person-hrs)**	**Delay Cost**	**Annual Intersection Delay (person-hrs)**	**Delay Cost**
Average Annual Person (in Vehicle) Delay	1903	$ 23,155	1257	$ 15,631
Operation and Maintenance	**Operation and Maintenance**	**O&M Cost**	**Operation and Maintenance**	**O&M Cost**
Annualized Cost of Signal Retiming		$ -	Signal Retiming Every 3 Years	$ 1,667
Annual Cost of Power for Signal		$ -	Power for Signal	$ 750
Annual Cost of Illumination	Intersection Illumination	$ 750	Intersection Illumination	$ 750
Annual Cost of Maintenance	Landscaping Costs	$ 2,000	Signal Maintenance Costs (power outage, detection, etc.)	$ 3,750
	Total Annual Operation and Maintenance Costs	$ 2,750	*Total Annual Operation and Maintenance Costs*	$ 6,917
Initial Capital Costs	**Total Capital Costs**	**Cost**	**Total Capital Costs**	**Cost**
Preliminary Engineering		$ 1,000,000		$ 600,000
Right-of-way and Utilities		$ -		$ -
Construction		$ -		$ -

*Delay cost is based upon a 2 hour analysis period.

Total Discounted Life Cycle Costs (2013 - 2033)	Roundabout		Traffic Signal	
Safety	**Total Predicted Crashes**	**Safety Cost**	**Total Predicted Crashes**	**Safety Cost**
Predicted Fatal/Injury Crashes	3.11	$ 782,742	7.20	$ 1,811,300
Predicted PDO Crashes	4.84	$ 32,407	14.22	$ 95,219
	Total Costs of Predicted Crashes	$ 815,149	*Total Costs of Predicted Crashes*	$ 1,906,519
Delay	**Total Intersection Delay (person-hrs)**	**Delay Cost**	**Total Intersection Delay (person-hrs)**	**Delay Cost**
Total Person (in Vehicle) Delay	39955	$ 486,263	26402	$ 328,243
Operation and Maintenance	**Operation and Maintenance**	**O&M Cost**	**Operation and Maintenance**	**O&M Cost**
Annualized Cost of Signal Retiming		$ -	Signal Retiming Every 3 Years	$ 24,796
Annual Cost of Power for Signal		$ -	Power for Signal	$ 11,158
Annual Cost of Illumination	Intersection Illumination	$ 11,158	Intersection Illumination	$ 11,158
Annual Cost of Maintenance	Landscaping Costs	$ 29,755	Signal Maintenance Costs (power outage, detection, etc.)	$ 55,791
	Total Annual Operation and Maintenance Costs	$ 40,913	*Total Annual Operation and Maintenance Costs*	$ 102,903
Initial Capital Costs	**Total Capital Costs**	**Cost**	**Total Capital Costs**	**Cost**
Preliminary Engineering		$ 1,000,000		$ 600,000
Right-of-way and Utilities		$ -		$ -
Construction		$ -		$ -
	Total Initial Capital Costs	$ 1,000,000	*Total Initial Capital Costs*	$ 600,000
Total Life Cycle Costs (Opening Year $)	**Net Present Value**	**$ 2,342,325**	**Net Present Value**	**$ 2,937,664**
		Roundabout		Traffic Signal

*Delay cost is based upon a 2 hour analysis period.

Life Cycle Benefit/Cost Ratio		
Safety Benefit of a Roundabout	$ 1,091,370	
Delay Reduction Benefit of a Roundabout	$ (158,020)	
Total Benefits	$ 933,350	
Added Operations&Maintenance Costs of a Roundabout	$ (61,989)	
Added Capital Costs of a Roundabout	$ 400,000	
Total Costs	$ 338,011	
Life Cycle Benefit/Cost Ratio	**2.8**	**Roundabout Compared to Traffic Signal**
	Roundabout Preferred	

Figure 23. Intersection Cost Comparison

Life Cycle Benefit/Cost Ratio

The life cycle benefit/cost ratio table near the bottom of the Results Tab is configured with the following assumptions:

- A roundabout has fewer crashes and less delay than the traditional intersection alternative
- A roundabout has greater operations and maintenance costs and capital costs than the traditional intersection alternative

The spreadsheet computes the safety and delay benefits of a roundabout, as well as the added operations and maintenance costs and capital costs of a roundabout compared to the traditional intersection alternative. When the assumptions listed above are true, the total benefit and total cost are positive numbers and the spreadsheet reports a life cycle benefit/cost ratio for the roundabout in comparison to the traditional intersection alternative. When one or more the assumptions noted above are not true, benefit or cost values may be negative. The spreadsheet provides messages notifying the user of this condition. Refer to the Concepts Overview section of the User Guide for a full discussion of these messages.

Figure 24. Results Tab Life Cycle Benefit/Cost Ratio

Life Cycle Benefit/Cost Ratio			
Safety Benefit of a Roundabout	$	-	
Delay Benefit of a Roundabout	$	-	
Total Benefits	**$**	**-**	
Added Operations&Maintenance Costs of a Roundabout	$	-	
Added Capital Costs of a Roundabout	$	-	
Total Costs	**$**	**-**	
Life Cycle Benefit/Cost Ratio		**0.0**	**Roundabout Compared to Traffic Signal**

No Data or No Preference
Costs and Benefits are Zero