TransValU

TRANSPORTATION VALUE TO YOU

User Guide - TSM&O Module

Florida Department of Transportation
District Five
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TransValU Overview

What is TransValU?

TransValU (Transportation Value to You) is a spreadsheet-based tool designed for the economic and financial assessment of proposed transportation investments in Florida (District 5 in particular). Three forms of analyses are available within the tool: Benefit-Cost Analysis, Economic Impact Analysis, and Financial Analysis.

- **Benefit-Cost Analysis (BCA)** is a conceptual framework that monetizes as many of the costs and benefits of a project, program, or policy as possible to generate a single "bottom-line" estimate of value. BCA is primarily concerned with economic efficiency and the use of resources to maximize society's overall well-being ("social welfare"). The approach involves quantifying benefits and costs relative to a Base Case to determine whether the benefits of a project outweigh its costs. TransValU provides a comprehensive framework to include all capital and Operating & Maintenance (O&M) costs, as well as a wide range of benefits. Users of TransValU are able to identify the alternative or mix of alternatives that maximizes net benefits or social welfare per dollar invested. The tool provides a side-by-side comparison of multiple alternatives by calculating the Net Present Value, Benefit/Cost Ratio, Overall Rate of Return, and Discounted Payback Period.
- **Economic Impact Analysis (EIA)** looks at the effects of a project, program, or policy on the economy of a state or region. It is primarily concerned with changes in economic activity. Economic impacts are typically expressed as changes in business sales (output), Gross Regional Product (GRP) or "value added," employment, and earnings. TransValU estimates the short-term economic impacts resulting from spending on transportation projects. Long-term economic impacts are estimated in two situations: (i) for any freight project, given the lasting impacts resulting from improvements to a transportation facility, or (ii) for any transportation project that is likely to lead to increased visitor spending in the study area.
- **Financial Analysis** focuses on the flows of money to and from a project or organization, typically a firm or government agency. It helps identify the project or alternative that maximizes net inflows (e.g., total revenue minus total expenses). A financial analysis from the perspective of a government agency looks at the impacts of a project on government expenditures and receipt. It is a form of fiscal analysis.

In deciding which type of analysis to run, users should consider the following:

- Run a BCA to determine whether a project creates enough societal benefits (e.g., travel time saving, accident cost saving) to justify its costs.
- Run an EIA to assess the contribution of a project to a local economy, and estimate the number of jobs created or retained by the project.
- Run a Financial Analysis to assess the flow of money (inflows and outflows) to and from a project entity, firm, or government agency.

TransValU currently includes **five main modules**, each focused on different types of transportation projects.

- The first module can be used to assess capital investments in Highway, Transit, and Bicycle/Pedestrian projects, as well as combinations of these modes. It performs all three types of analyses listed above (BCA, EIA, and Financial Analysis).
- The second module focuses on freight projects and the movement of goods. It can be used to assess investments in Intermodal Logistics Centers (ILCs), Rail Freight, and Highway Freight projects. The first two modules are housed in the same Excel workbook, known simply as **TransValU**.
- The third module, **TransValU P&R**, focuses on Park-and-Ride facilities. It is housed in a standalone Excel workbook, and can be used for sketch-level P&R demand forecasting and benefit-cost assessments.
- The fourth module focuses on visitors' transportation needs and impacts. It can be used to estimate the benefits of roadway or transit projects accruing specifically to visitors, and the economic impacts of changes in visitor spending brought about by a transportation project. The module is housed in a standalone Excel workbook, **TransValU Visitor**.
- The fifth module can be used to evaluate the benefits of Transportation System Management and Operations (TSM&O) improvements. These include strategies used to maximize the efficiency and safety of existing transportation infrastructure, and generally do not require large (if any) capital investments. This standalone Excel workbook, **TransValU TSM&O**, focuses on benefit-cost analysis. It is based largely on the Tool for Operations Benefit-Cost Analysis (TOPS-BC) Version 1.2,[1] developed by FHWA.

This User Guide focuses on the last module listed above – TransValU TSM&O.

The TSM&O Module

The TSM&O Module is the latest to be included in the series of TransValU workbooks. While the Module is housed in its own Excel workbook, it is still part of the TransValU "family" and uses the same assumptions, formatting, and methodologies, as applicable.

The TSM&O Module performs benefit-cost analysis (BCA) of implementing certain transportation system management and operations improvement strategies. Specifically, the strategies analyzed in this tool include:[2]

- Traveler information strategies:
    - Dynamic message sign (DMS) – including comparative travel times, congestion warning, or alternative routes/modes options;
    - Highway advisory radio (HAR) – including comparative travel times, congestion warning, or alternative routes/modes options; and
    - Pre-trip traveler information.

[1] Note TOPS-BC version 1.2 was the most recent official version of the tool available at the time of this project.
[2] For strategy definitions, see glossary in Appendix II.

- Traffic signal coordination strategies:
    - Traffic signal coordination systems – including preset timing, traffic actuated, or central control options; and
    - Traffic signal retiming/control (for specific intersections), both preset (Time-of-Day, TOD), and adaptive.
- Other freeway system strategies:
    - Traffic incident management.
- Ramp metering system strategy – including preset timing, traffic actuated, or central control options.
- Active transportation and demand management strategies:
    - Speed harmonization;
    - Hard shoulder running;
    - Hard shoulder for evacuation route;
    - High occupancy toll (HOT) lane(s); and
    - Employer based travel demand management programs.[3]
- Other strategies:
    - Road weather management;
    - Work zone systems;
    - Traffic management centers (TMC);[4]
    - Loop detection;[5] and
    - Closed-circuit television (CCTV).[6]
- General link strategy: this is a 'blank' strategy where the user can enter the associated impacts and costs directly into the tool.

The user can select one or more strategies to implement, and the TransValU TSM&O calculates the economic benefits and costs of implementing these improvement(s). Thus, the 'project case' is referred to as the 'improvement case' in the TSM&O Module.

Benefits are calculated based on impacts associated with each strategy. These impacts include a percent or level change in one or more roadway performance measures (e.g. speed, roadway capacity, number of lanes, and others) associated with each strategy. Much of the strategy

[3] Only costs are considered, no benefits.
[4] Ibid
[5] Ibid
[6] Ibid

impacts, cost data, and methodologies used in the TransValU TSM&O are based on the BCA and desk reference workbook developed by FHWA — TOPS-BC, Version 1.2.[7]

In particular, the cell 'override' feature included in TransValU TSM&O is also based on the TOPS-BC tool. This feature allows the user to override various subtotal calculations throughout the tool. As an example, if the tool calculates average speed and the user believes the actual speed is different from this value, he or she can override the calculated value by entering the new data. The tool will incorporate this new value throughout the tool in other calculations. The override feature provides the user with more options for tailoring the analysis to the specific circumstances of the facility and improvements being evaluated. However, the override feature should only be used if the user has robust data to replace the calculated values.

While this override feature can be beneficial, it also risks producing results that are not internally consistent. For instance, assume the user overrides the average speed in the base case only. Without any adjustment to the calculated speed for the improvement case, the change in speed from the base case to the improvement case (and thus change in travel time) may not be accurate. As another example, imagine that the user overrides the traffic volume in the improvement case such that he or she creates induced traffic. Because the induced traffic is forced and is not based on a reduction in generalized travel costs, the tool may show both increasing costs and induced traffic, which does not make sense.[8] These examples demonstrates the importance of only using the override features if the user has consistent and robust data.

While the TransValU TSM&O and TOPS-BC share many similarities, there were also several key updates and changes made to the TransValU TSM&O that set it apart from the TOPS-BC. In particular, the TransValU TSM&O:

- Includes data and parameters specific to the Florida context (e.g. discount rate, emission rates, and crash rates);
- Complies with the latest USDOT recommendations for BCA (e.g. value of time, vehicle occupancy, and others);
- Adds two new benefit categories (emission cost savings, and non-fuel vehicle operating cost savings);
- Estimates benefits and costs over time, as is standard practice for most BCAs. This differs from the TOPS-BC approach of comparing a 'typical year' of costs and benefits;
- Provides the user with options for aggregating benefits when multiple strategies are selected for evaluation (average, summation, or maximum);
- Follows existing TransValU formatting and logic;

[7] The TOPS-BC Tool is available online at: https://ops.fhwa.dot.gov/plan4ops/topsbctool/ . Note TOPS-BC version 1.2 was the most recent official version of the tool available at the time when this project commenced.

[8] In regards to induced traffic, see the Parameters sheet cell F9 for further notes. As stated on the Parameters sheet, where possible, the tool calculates total benefits and costs in the base case, and compares these to the total benefits and costs in the improvement case. Where this is not possible, the increment will be determined based on the traffic volume selected by the user on the Parameters sheet (i.e. base case traffic, improvement case traffic, or the minimum of the two).

- Includes fewer locations where the user must enter data into the tool, and fewer sheets for the user to review compared to TOPS-BC;
- Adds three new strategies to those provided in TOPS-BC: traffic signal retiming, hard shoulder running for evacuation route, and bus on shoulder. While TransValU TSM&O does not include cost and strategy data for all three of these strategies, the user has the option to enter estimates based on his or her own research or knowledge of the project.

Main Characteristics

From the Introduction tab of the TSM&O Module, the user clicks "**START Benefit-Cost Analysis**" to access the Inputs sheet of the BCA. Next, the user will select the one or more strategies he or she wishes to evaluate, enter the traffic and improvement details required, and has the option to use existing strategy data associated with the strategies selected, or enter new strategy data. The Module calculates the BCA metrics, and the user can choose to review the calculation worksheets, or navigate directly to the results sheets.

Workbook Contents

Apart from the Introduction and Parameters worksheets, the TSM&O Module includes three categories of worksheets:

- **Inputs** – one sheet where the user selects the strategies desired and enters the required data for the benefit-cost analysis;
- **Calculations** – calculation sheets for each benefit category, the strategy costs, and one overall calculation sheet to aggregate total costs and benefits of the strategies; and
- **Results** – two results sheets to display the detailed and aggregate benefit-cost summary metrics, including tabular and graphic representations.

Getting Started

The TransValU TSM&O Module and this User Guide are available online for download, along with the other TransValU modules and User Guides, at http://www.cfgis.org/FDOT-Resources/TransValU.aspx.

The welcome screen of the TSM&O Module (on the Introduction tab) is shown in Figure 1 below. It does not require any input from the user. Users should simply click on the "**START Benefit-Cost Analysis**" button to begin the analysis.[9]

Figure 1: TransValU TSM&O Module Welcome Screen

Purpose and Organization of the User Guide

The purpose of this User Guide is to provide transportation practitioners with the information necessary to assess the economic benefits and costs of implementing various TSM&O strategies. The purpose of these strategies is to improve the efficiency and safety of existing transportation infrastructure, and generally do not require large (if any) capital investments. Careful conceptualization of the strategy improvements to be implemented and preparation of quality input data are required to perform a quality benefit-cost analysis.

The TSM&O Module User Guide first includes an overview of the purpose of each user-enabled worksheet in the tool along with an explanation of the structure of and calculations made on these sheets. Next, step-by-step instructions are provided for the user to run the BCA. The User Guide also includes three appendices. Appendix I lists the sources of the data used in the tool, and Appendix II provides a glossary of terms used in the tool and User Guide. For details on tool

[9] The four buttons in the lower right corner of the screen are reserved for the tool developers.

calculations, see structure and logic (S&L) diagrams in Appendix III. For more details on the conceptual framework of BCA in general, the user should review the main TransValU User Guide.

Using TransValU for Benefit-Cost Analysis of TSM&O Improvements

The TSM&O Module can be used to assess the economic benefits and costs of implementing transportation system management and operations strategies. Benefits and costs vary depending on which strategies are selected, and which method of benefit aggregation is chosen. The user also has the option to override subtotal results throughout the tool, as is done in TOPS-BC. However, the override feature should only be used if the user has robust data specific to the improvement being evaluated that supersedes the inputs or settings in the tool.

The use of a travel demand model is not required to run this tool. However, the user will need to estimate or gather data on high-level inputs such as traffic volume per period, roadway capacity, free flow speed, number of lanes, length of the roadway segment targeted for improvement, and others.

Users can find additional guidance and resources for BCAs in the OMB Circular A-94,[10] and the USDOT BCA Guidance for Discretionary Grant Programs.[11]

Data Requirements

The minimum data requirements to run the TSM&O Module are listed in Table 1. They are also shown in the Data Needs sheet of the Excel workbook.

[10] OMB Circular A-94 Revised, https://www.transportation.gov/regulations/omb-circular-94, October 29, 1992.
[11] USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs, https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/14091/benefit-cost-analysis-guidance-2018.pdf

Table 1: Minimum Data Requirements for TSM&O Module

Data Type	Data Title	Data Description
TSM&O Strategies	Select strategies	Select from list of strategies provided which to include in BCA
	Number of infrastructure deployments	Number of infrastructure deployments for each strategy selected
	Number of incremental deployments	Number of incremental deployments for each strategy selected
	Year of deployment	Enter year of deployment for each strategy selected
Improvement Details	Years of analysis	Years of analysis for BCA
	Year of base case data	Year of base case data entered on Inputs sheet
	Length of period	Length of period for traffic data entered, hours per day
	Annualization factor	Number of days per year to include in analysis
Facility Details and Traffic	District	District where improvement will be implemented
	Area type	Urban or rural area type
	Roadway access type	Restricted or unrestricted
	Link length	Miles of roadway targeted for TSM&O improvement on link, HOV, and ramp facilities, depending on strategies selected
	Percent truck traffic	Percent truck traffic on roadway targeted for TSM&O improvement
	Traffic growth	Average annual growth in traffic expected on targeted roadway
	Free flow speed	Base case free flow speed on link, HOV, and ramp facilities, depending on strategies selected
	Traffic volume	Base case vehicles per period on link, HOV, and ramp facilities, depending on strategies selected
	Number of lanes	Number of lanes (in both directions) on link, HOV, and ramp facilities, depending on strategies selected
	Roadway capacity	Capacity per hour per lane on link, HOV, and ramp facilities, depending on strategies selected
Strategy Impacts (optional)	Impacts by strategy	Use strategy impacts provided in tool or enter impacts desired for each strategy selected
Improvement Costs (optional)	Capital costs	Cost per deployment in constant dollars (year specified on Parameters sheet). Option to use costs provided in tool or override estimates
	Incremental O&M costs	Annual incremental O&M costs, per deployment, in constant dollars (year specified on Parameters sheet). User can use costs provided in tool or override estimates
	Labor costs	Annual labor costs, per deployment, in constant dollars (year specified on Parameters sheet). Option to use costs provided in tool or override estimates
	Useful life of improvement	Number of years an improvement will generate benefits before requiring replacement. Option to use estimates provided in tool or override

User Interface

The following sections describe the function of each of the 16 user-enabled worksheets in the TSM&O Module, aside from the Introduction sheet.

Parameters

The Parameters sheet displays critical assumptions and data sources used by TransValU. The sheet includes the value, units, and data source for each parameter. The values used on this sheet are the same for all TransValU modules, as they apply to the module in use.[12]

[12] Note that some modules may include additional parameters, which are only relevant to that particular module.

The Parameters sheet differs from those in other TransValU tools because it includes two sets of options for parameter values: one set of recommended values (based largely on USDOT guidance), and another set of values from the TOPS-BC Version 1.2 tool. The user has the option of selecting between either set of parameters. Note that if the user runs TransValU TSM&O with parameters from TOPS-BC, the results will not be exactly the same as those produced directly with the TOPS-BC tool. One of the reasons for this difference is the fact that TransValU TSM&O analyzes benefits and costs over time (rather than comparing a snapshot of a "typical year" of benefits versus costs). TransValU TSM&O also adjusts several of the benefit calculations from TOPS-BC to make the tool more aligned with traditional BCA guidelines, and corrects some discrepancies identified.

A partial screenshot of the Parameters sheet can be found below.

Figure 2: Parameters Sheet Screenshot

Model Parameter Values Used in Analyses

All Monetized Estimates are in Constant Dollars of 2017

Use TOPS-BC 1.2 Values | Use Recommended

PARAMETER NAME	ACTIVE - RECOMMENDED ($2017 VALUES)	UNIT OF MEASUREMENT	TOPS-BC 1.2 ($2015 VALUES)	RECOMMENDED ($2017 VALUES)	SOURCES FOR RECOMMENDED VALUES
OPTIONS FOR ANALYSIS					
First Year of Analysis	2016	year			
Base Year for all Monetization Assumptions	2017	year	2015	2017	
Real Discount Rate	4.0%	% per year	7.0%	4.0%	FDOT recommended discount rate for BCAs.
Real Discount Rate implicit in Social Cost of Carbon	7.0%	% per year	N/A	7.0%	US DOT BCA Guidance for Discretionary Grant Programs, December 2018
Select Volume for Calculating Benefits	Minimum				When the Base Case and the Improvement Case cannot be fully populated, the user can choose between calculating benefits with Base Case traffic volumes, Improvement Case traffic volumes, or the minimum of the two. The tool does not use 'Rule of Half' (ROH) to estimate benefits: because of the user override option, changes in traffic volumes may not be internally consistent with changes in unit costs.
UNIT CONVERSIONS					
Kilograms per Short U.S. Ton	907.185	kg		907.185	n/a
Kilograms per Metric Ton	1,000	kg		1,000	n/a
VALUATION OF TRAVEL TIME SAVING					
Value of Time Estimates					
Personal Travel	$14.8	$ per person-hour	$16.2	$14.8	US DOT BCA Guidance for Discretionary Grant Programs, December 2018
Business Travel	$26.5	$ per person-hour	$32.5	$26.5	ibid
Weighted Average	$15.3	$ per person-hour	$19.8	$15.3	
Hourly Wages of Vehicle Operators					
Truck drivers	$28.6		$32.5	$28.6	ibid
Personal vs. Business Travel					
Share of Personal Travel in Total Travel	95.4%	percent of auto trips	77.8%	95.4%	ibid
Share of Business Travel in Total Travel	4.6%	percent of auto trips	22.2%	4.6%	ibid
Year of Value of Time Estimates	2017	year	2015	2017	n/a
Annual Growth in Real Value of Time	0.00%	% per year	0.00%	0.00%	US DOT Guidance, September 2017
Average Daily Vehicle Occupancy					
Auto	1.68	persons per vehicle	1.67	1.68	US DOT BCA Guidance for Discretionary Grant Programs, December 2018
Trucks	1.00	persons per vehicle	1.67	1.00	ibid
VEHICLE OPERATING COSTS					
Select Method	HERS	*1*			*Note: selecting "TOPS-BC" will only capture changes in fuel consumption, excludes other non-fuel vehicle operating costs*
CPI fact			1.034		
Vehicle Fuel Economy					
Auto	HERS lookup	miles per gallon	21.60	*HERS lookup*	HERS Technical Report, 2005
Truck	HERS lookup	miles per gallon	18.50	*HERS lookup*	HERS Technical Report, 2005
Vehicle Operating Prices					
Automobiles					
Gasoline	time dependent	$ per gallon	$4.25	*time dependent*	EIA, Annual Energy Outlook 2018 Release, Petroleum Product Prices (see Fuel Cost sheet)
Oil	$10.16	$ per quart	*n/a*	$10.16	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SS47021
Tires	$88.47	$ per tire	*n/a*	$88.5	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SETC01
Maintenance & Repair	$176.19	$ per 1,000 miles	*n/a*	$176	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SETD
Vehicle Depreciation	$21,517.43	$ per vehicle	*n/a*	$21,517	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SS45011

Data Needs

This sheet identifies the key inputs required to run the TSM&O Module, as shown in Table 1 above.

Inputs

This sheet contains all of the input tables that users must fill in before running the TSM&O Module. The sheet also contains a legend explaining the formatting conventions for input tables and results formats within the tool.

The following describes the input tables available in the worksheet:

- **Table A –TSM&O Strategies**. Table A requires the user to select one or multiple TSM&O strategies to include in the BCA, entering details about the quantity of deployments to be implemented and related schedule.
- **Table B – TSM&O Improvement Details**. Table B is used to enter further details about the planned improvements.
- **Table C – Facility Details and Traffic**. Table C requires information on the roadway facility and location details that apply to all strategies.
- **Table C1 – Link Models**: If the user has selected one or more link models, Table C1 requires data on the base case traffic conditions on the roadway. Suggested values from TOPS-BC are also provided in the tool as.
- **Table C2 – Hot Lane Model**: If the user has selected the HOT Lanes strategy, Table C2 requires data on the base case traffic conditions on the HOV and General Purpose (GP) lanes. Suggested values from TOPS-BC are provided in the tool as suggestions.
- **Table C3 – Ramp Model**: If the user has selected the Ramp Metering strategy, Table C3 requires data on the base case traffic conditions on the ramps and associated link facilities. Suggested values from TOPS-BC are provided in the tool as suggestions.
- **Table D – Impacts due to TSM&O Strategies**. Table D lists the impacts associated with each strategy. The user can elect to use the estimated impact values provided, or enter alternative data.

A portion of the Inputs sheet (with sample data, for illustration) is shown in Figure 3.

Figure 3: Inputs Sheet – Sample Screenshot

Inputs for TSM&O Improvements

Review BCA Calculations

Note: much of the strategies, methodologies, and data used in this tool are sourced from the TOPS-BC Tool Version 1.2

A - TSM&O STRATEGIES

		Include Strategy? (Yes=1, No=0)	Specify Strategy Type (if applicable)	Number of Infrastructure Deployments	Number of Incremental Deployments	Year of Deployment	Model Category
	GENERIC LINK MODEL	0		3	1	2020	Link Models
	TRAVELER INFORMATION						
1	**Dynamic Message Sign (DMS)**	1	Comparative travel times	2	2	2020	Link Models
3	**Highway Advisory Radio (HAR)**	0	Alternative route/mode	3	1	2020	Link Models
	Pre-Trip Traveler Information	0		3	1	2020	Link Models
	TRAFFIC SIGNAL COORDINATION SYSTEMS						
2	**Traffic Signal Coordination Systems**	0	Traffic Actuated	3	1	2020	Link Models
1	**Traffic Signal Retiming**	0	Actuated/ Preset Control	3	1	2020	Link Models
	OTHER FREEWAY SYSTESM						
	Traffic Incident Management	0		3	1	2020	Link Models
3	**RAMP METERING SYSTEMS**	0	Central Control	3	1	2020	Ramp Model
	ACTIVE TRANSPORTATION AND DEMAND MANAGEMENT						
	Speed Harmonization	0		3	1	2020	Link Models
	Hard Shoulder Running	0		3	1	2020	Link Models
	Hard Shoulder Running for Evacuation Route	0		3	1	2020	Link Models
	Bus on Shoulder	0		3	1	2020	Link Models
(costs only)	**Employer Based Travel Demand Management (TDM) Program**	0		3	1	2020	Link Models
2	*** High Occupancy Toll (HOT) Lanes**	0	Method 2	3	1	2020	HOT Model
	OTHER STRATEGIES						
	Road Weather Management	0		3	1	2020	Link Models
	Work Zone Systems	0		3	1	2020	Link Models
(costs only)	**Traffic Management Center (TMC)**	0		3	1	2020	Link Models
(costs only)	**Loop Detection**	0		3	1	2020	Link Models
(costs only)	**Closed-Circuit Television (CCTV)**	0		3	1	2020	Link Models

* As in the TOPS-BC, the benefits of converting HOV to HOT lane(s) are derived by one of two methods, both of which are illustrated on the 'ImproveCaseCalc' sheet. Method 1 derives the HOT lanes traffic based on the base case traffic on the GP and HOV lanes, and the maximum capacity and V/C available, thus calculating the change in HOT capacity endogenously. Method 2 is based on an exogenous change in capacity on the HOT lanes. If method 2 is selected, user must enter change in capacity in Table D.

B - TSM&O IMPROVEMENT DETAILS

Improvement/alternative name	Dynamic message sign implemented on Freeway A
Scenario #	1
Years of analysis (after first year)	11
Last year of analysis	2026
Year of BASE CASE data	2017
Length of period, hours per day	3
Annualization factor, number of periods per year	260

C - FACILITY DETAILS AND TRAFFIC

Select district or county of planned TSM&O improvement	District 5
Select area type	Urban
Select roadway access type	Unrestricted
Facility type	Principal Arterial
Percent truck traffic, %	10.0%

Benefit Cost Calculations

The purpose of this worksheet is to aggregate the benefits and costs of all the strategies selected on the Inputs sheet. Results are discounted over the model period of analysis, and the benefit-cost ratio, net present value of benefits, and other standard BCA metrics are calculated on this worksheet.

Benefits and costs are calculated on other worksheets in terms of physical units (as opposed to dollar values), and then monetized on the Benefit Cost Calculations worksheet.[13] The BenefitCost Calculations sheet displays each benefit calculation in separate categories (i.e. travel time savings from reduced recurring delay, safety benefits, and others). Benefits are aggregated across strategies based on the aggregation method selected by the user at the top of the worksheet.

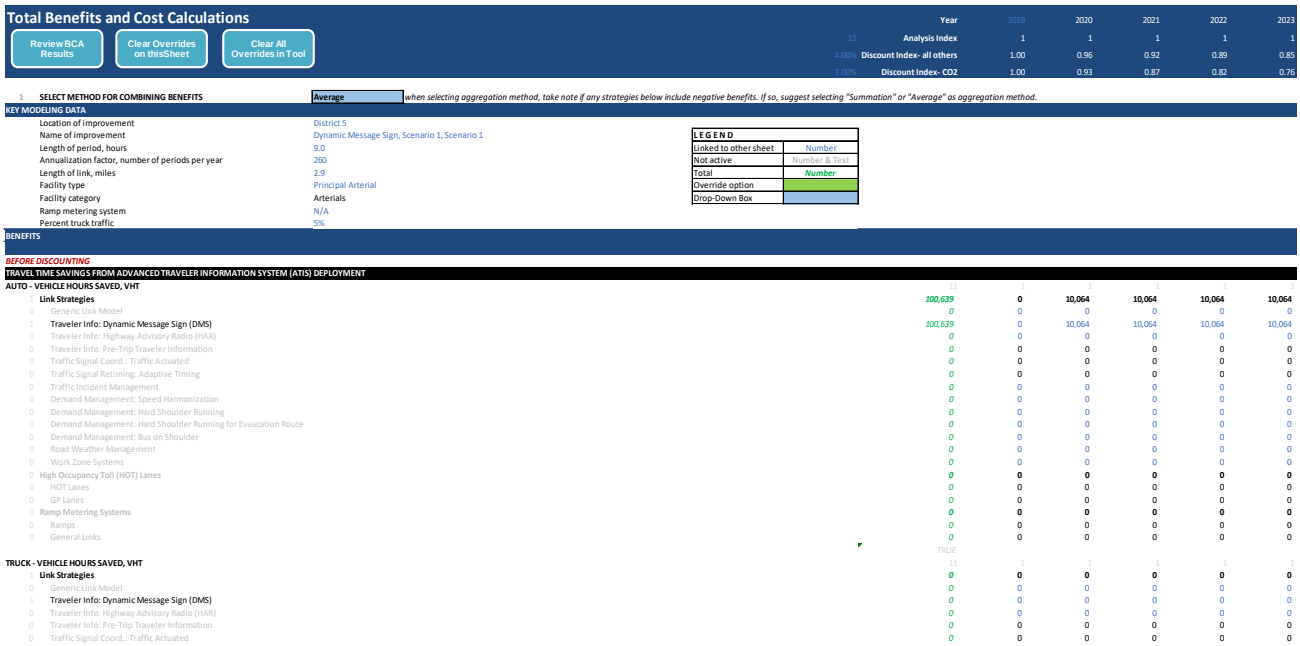
[13] One exception is the non-fuel vehicle operating costs calculation sheet, which monetizes benefits directly.

The top of the sheet also includes a formatting legend (as on the Inputs sheet), and a summary of the key modeling data. Both the legend and key data are repeated on all calculation worksheets. As stated in the legend, all cells in green on this worksheet allow the user to override the variables specified.

The bottom of the sheet calculates average traffic and roadway data for the improvement case based on the multiple 'link model' strategies selected on the Inputs sheet. These average traffic estimates are used to calculate the change in emissions and non-fuel vehicle operating costs on separate worksheets.

A portion of the Benefit Cost Calculations sheet is reproduced in Figure 4 below.

Figure 4: Benefit-Cost Calculations Sheet – Sample Screenshot



Total Benefits and Cost Calculations

Review BCA Results | Clear Overrides on thisSheet | Clear All Overrides in Tool

	Year	2019	2020	2021	2022	2023
11	Analysis Index	1	1	1	1	1
4.00%	Discount Index- all others	1.00	0.96	0.92	0.89	0.85
7.00%	Discount Index- CO2	1.00	0.93	0.87	0.82	0.76

1 SELECT METHOD FOR COMBINING BENEFITS: Average — *when selecting aggregation method, take note if any strategies below include negative benefits. If so, suggest selecting "Summation" or "Average" as aggregation method.*

KEY MODELING DATA

Location of improvement	District 5
Name of improvement	Dynamic Message Sign, Scenario 1, Scenario 1
Length of period, hours	9.0
Annualization factor, number of periods per year	260
Length of link, miles	2.9
Facility type	Principal Arterial
Facility category	Arterials
Ramp metering system	N/A
Percent truck traffic	5%

LEGEND	
Linked to other sheet	Number
Not active	Number & Text
Total	Number
Override option	
Drop-Down Box	

BENEFITS

BEFORE DISCOUNTING

TRAVEL TIME SAVINGS FROM ADVANCED TRAVELER INFORMATION SYSTEM (ATIS) DEPLOYMENT

	AUTO - VEHICLE HOURS SAVED, VHT	11	1	1	1	1	1
1	Link Strategies	100,639	0	10,064	10,064	10,064	10,064
0	Generic Link Model	0	0	0	0	0	0
1	Traveler Info: Dynamic Message Sign (DMS)	100,639	0	10,064	10,064	10,064	10,064
0	Traveler Info: Highway Advisory Radio (HAR)	0	0	0	0	0	0
0	Traveler Info: Pre-Trip Traveler Information	0	0	0	0	0	0
0	Traffic Signal Coord.: Traffic Actuated	0	0	0	0	0	0
0	Traffic Signal Retiming: Adaptive Timing	0	0	0	0	0	0
0	Traffic Incident Management	0	0	0	0	0	0
0	Demand Management: Speed Harmonization	0	0	0	0	0	0
0	Demand Management: Hard Shoulder Running	0	0	0	0	0	0
0	Demand Management: Hard Shoulder Running for Evacuation Route	0	0	0	0	0	0
0	Demand Management: Bus on Shoulder	0	0	0	0	0	0
0	Road Weather Management	0	0	0	0	0	0
0	Work Zone Systems	0	0	0	0	0	0
0	High Occupancy Toll (HOT) Lanes	0	0	0	0	0	0
0	HOT Lanes	0	0	0	0	0	0
0	GP Lanes	0	0	0	0	0	0
0	Ramp Metering Systems	0	0	0	0	0	0
0	Ramps	0	0	0	0	0	0
0	General Links	0	0	0	0	0	0
		TRUE					
	TRUCK - VEHICLE HOURS SAVED, VHT	11	1	1	1	1	1
1	Link Strategies	0	0	0	0	0	0
0	Generic Link Model	0	0	0	0	0	0
1	Traveler Info: Dynamic Message Sign (DMS)	0	0	0	0	0	0
0	Traveler Info: Highway Advisory Radio (HAR)	0	0	0	0	0	0
0	Traveler Info: Pre-Trip Traveler Information	0	0	0	0	0	0
0	Traffic Signal Coord.: Traffic Actuated	0	0	0	0	0	0

BCA Results

The BCA Results sheet summarizes the benefits calculated on the Benefit Cost Calculations worksheet, and reproduces the BCA metrics. These results are provided in two tables:

- **BCA Results Table**. This table contains benefit and cost estimates by category, total benefits and costs in present value, the Benefit-Cost Ratio and other BCA summary metrics for the TSM&O improvements analyzed. Benefits are also shown in a chart to illustrate the relative impact of each benefit category. As applicable, benefits are also reported in terms of physical units (i.e. vehicle hours saved, or crashes avoided).
- **Key Model Parameters & Assumptions Table**. This table shows a number of the key user inputs and parameter values taken from the Inputs sheet and the Parameters sheet. They are provided to remind the user of some of the key assumptions underlying the analysis.

Sample screenshots of the two tables in the BCA Results sheet are shown in Figure 5 and Figure 6.

Figure 5: BCA Results Sheet – BCA Results Table – Sample Screenshot

Benefit-Cost Analysis Results

View Multi Project Results

Select Units for Disply: Millions of $2017

Scenario 1: test
District 2
Real Discount Rate 4.0%

BCA RESULTS			
IMPROVEMENT BENEFITS, before discounting	**Millions of $2017**	**Value**	**Units**
Travel time savings from reduced recurring delay	**$87.0**		
Automobiles	$75.3	3.7	Millions of vehicle hours saved
Trucks	$11.7	0.4	Millions of vehicle hours saved
Travel time savings from reduced incident delay	**$251.4**		
Automobiles	$217.7	10.6	Millions of vehicle hours saved
Trucks	$33.7	1.2	Millions of vehicle hours saved
Travel time savings from ATIS deployment	**$0.8**		
Automobiles	$0.7	0.0	Millions of vehicle hours saved
Trucks	$0.1	0.0	Millions of vehicle hours saved
Persons	$0.0	0.0	Millions of person hours saved
Safety benefits	**$273.3**		
Fatal crash	$41.3	4.0	Fatal crashes avoided
Injury crash	$228.9	228.0	Injury crashes avoided
PDO crash	$3.2	239.3	PDO crashes avoided
Fuel cost savings	**($22.0)**		
Gasoline	($17.6)	(6.3)	Millions of gallons saved
Diesel	($4.5)	(1.4)	Millions of gallons saved
Non-fuel vehicle operating cost savings	**($5.0)**		
Automobiles	($2.0)		
Trucks	($3.0)		
Emission cost savings	**$0.0**		
NOX	$0.0	0.0	Tons avoided
CO2	$0.0	0.0	Tons avoided
VOC	$0.0	0.0	Tons avoided
PM	$0.0	0.0	Tons avoided
SO2	$0.0	0.0	Tons avoided
TOTAL IMPROVEMENT BENEFITS	**$585.5**		
Present Value of Total Benefits	**$379.2**		

IMPROVEMENT COSTS, before discounting	
Capital costs	$6.7
Incremental O&M costs	$1.4
Incremental labor costs	$14.9
TOTAL IMPROVEMENT COSTS	**$23.0**
Present Value of Total Costs	**$15.4**

SUMMARY RESULTS	
Net Present Value	$363.8
Benefit-Cost Ratio	24.60
First Year Project Breaks Even	2020
Overall Rate of Return	N/A

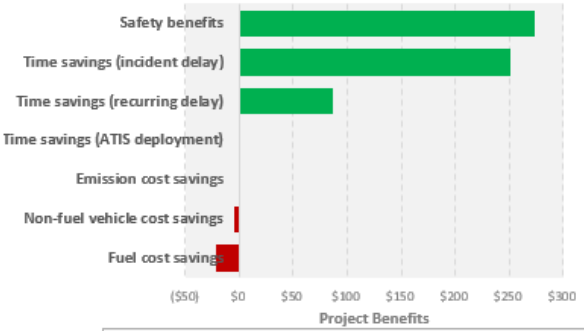


Figure 6: BCA Results Sheet – Key Model Parameters & Assumptions Table – Sample Screenshot

KEY MODEL PARAMETERS & ASSUMPTIONS

Traffic Data	
Length of period, hours	3.0
Annualization factor, number of periods per year	250
Length of link, miles	100.00
Facility type	Urban Freeway
Ramp metering system	Central Control
Percent truck traffic	10%
Number of vehicles affected, veh per period	
General link strategies	11,880
High Occupancy Toll (HOT) Lanes	
HOT Lanes	8,877
GP Lanes	17,397
Ramp Metering Systems	
Ramps	3,000
General Links	19,000

Strategies selected	Included?
Link Strategies	
Generic Link Model	no
Traveler Info : Dynamic Message Sign (DMS)	no
Traveler Info : Highway Advisory Radio (HAR)	yes
Traveler Info : Pre-Trip Traveler Information	yes
Traffic Signal Coord. : Traffic Actuated	yes
Traffic Signal Retiming	yes
Traffic Incident Management	no
Demand Management : Speed Harmonization	yes
Demand Management : Hard Shoulder Running	no
Demand Management : Hard Shoulder Running for I	yes
Demand Management : Bus on Shoulder	no
Road Weather Management	no
Work Zone Systems	yes
High Occupancy Toll (HOT) Lanes	yes, method 2
Ramp Metering Systems	yes
Aggregation method selected	Average

BCA Multi Project Results

The purpose of the BCA Multi Project Results sheet is to display summary BCA results of several different improvement strategies or alternatives side-by-side for comparison. The BCA Multi Project Results sheet displays the same summary results as reported on the BCA Results sheet. Each time new data is provided on the Inputs sheet, a new results summary can be produced on the BCA Multi Project Results sheet by clicking the "**Save BCA Results**" button located in the top left corner. The tool will save the current results to the right of the last set of saved results. Up to 10 scenario results can be saved at once.

A partial screenshot of this sheet is located in Figure 7.

Figure 7: BCA Multi Project Results Sheet – Sample Screenshot

DELETE All Saved Results | Save ACTIVE Results

	Scenario 1: test District 2			Scenario 1: test District 2		
Real Discount Rate: 4.0%				4.0%		
IMPROVEMENT BENEFITS, before discounting	Millions of $2017	Value	Units	Millions of $2017	Value	Units
Travel time savings from reduced recurring delay	$87.0			$87.0		
Automobiles	$75.3	3.7	Millions of vehicle hours saved	$75.3	3.7	Millions of vehicle hours saved
Trucks	$11.7	0.4	Millions of vehicle hours saved	$11.7	0.4	Millions of vehicle hours saved
Travel time savings from reduced incident delay	$251.4			$251.4		
Automobiles	$217.7	10.6	Millions of vehicle hours saved	$217.7	10.6	Millions of vehicle hours saved
Trucks	$33.7	1.2	Millions of vehicle hours saved	$33.7	1.2	Millions of vehicle hours saved
Travel time savings from ATIS deployment	$0.8			$0.8		
Automobiles	$0.7	0.0	Millions of vehicle hours saved	$0.7	0.0	Millions of vehicle hours saved
Trucks	$0.1	0.0	Millions of vehicle hours saved	$0.1	0.0	Millions of vehicle hours saved
Persons	$0.0	0.0	Millions of person hours saved	$0.0	0.0	Millions of person hours saved
Safety benefits	$273.3			$273.3		
Fatal crash	$41.3	4.0	Fatal crashes avoided	$41.3	4.0	Fatal crashes avoided
Injury crash	$228.9	228.0	Injury crashes avoided	$228.9	228.0	Injury crashes avoided
PDO crash	$3.2	239.3	PDO crashes avoided	$3.2	239.3	PDO crashes avoided
Fuel cost savings	($22.0)			($22.0)		
Gasoline	($17.6)	(6.3)	Millions of gallons saved	($17.6)	(6.3)	Millions of gallons saved
Diesel	($4.5)	(1.4)	Millions of gallons saved	($4.5)	(1.4)	Millions of gallons saved
Non-fuel vehicle operating cost savings	($5.0)			($5.0)		
Automobiles	($2.0)			($2.0)		
Trucks	($3.0)			($3.0)		
Emission cost savings	$0.0			$0.0		
NOX	$0.0	0.0	Tons avoided	$0.0	0	Tons avoided
CO2	$0.0	0.0	Tons avoided	$0.0	0	Tons avoided
VOC	$0.0	0.0	Tons avoided	$0.0	0	Tons avoided
PM	$0.0	0.0	Tons avoided	$0.0	0	Tons avoided
SO2	$0.0	0.0	Tons avoided	$0.0	0	Tons avoided
TOTAL IMPROVEMENT BENEFITS	$585.5			$585.5		
Present Value of Total Benefits	$379.2			$379.2		
IMPROVEMENT COSTS, before discounting						
Capital costs	$6.7			$6.7		
Incremental O&M costs	$1.4			$1.4		
Incremental labor costs	$14.9			$14.9		
TOTAL IMPROVEMENT COSTS	$23.0			$23.0		
Present Value of Total Costs	$15.4			$15.4		
SUMMARY RESULTS						
Net Present Value	$363.8			$363.8		
Benefit-Cost Ratio	24.60			24.60		
First Year Project Breaks Even	2020			2020		
Overall Rate of Return	N/A			N/A		
KEY MODEL PARAMETERS & ASSUMPTIONS						

Improvement Cost Calculations

The Improvement Cost Calculations sheet uses the strategy deployment data entered on the Inputs sheet and the unit cost and useful life data provided in TOPS-BC Version 1.2 to estimate the total costs of each strategy implemented, and the combined cost of all improvements made.

As on all calculations sheets, the top section also includes a legend summarizing the formatting styles used in the tool, as well as a summary of the key modeling data as defined on the Inputs sheet. As stated in the legend, all cells in green on this worksheet allow the user to override the variable values and labels specified.

The worksheet shows cost calculations by strategy, with link-based strategies (all strategies applied to a general link) labeled with blue horizontal banners, HOT Lanes strategy calculations with orange banners, and Ramp Metering strategy calculations with purple banners. Each strategy cost calculation block includes a set of 'flags' which indicate timing of deployment and operations. Based on these flags, capital costs,[14] incremental operations and maintenance (O&M) costs, and labor costs are calculated for each year over the period of analysis. Costs are shown per deployment in column C with the option to override in column D. Column E shows the costs used in the tool calculations. Columns F through H include the number of deployments, start year and opening year, and the "typical" cost per year. This is the cost calculated and used in the

[14] Note that capital costs are assumed to be fully re-invested after reaching the end of the asset's useful life. These are the same assumptions used in TOPS-BC Version 1.2.

TOPS-BC tool, and is calculated as the capital cost divided by the asset useful life plus any annual O&M and labor costs. Columns J through AM calculate the costs each year, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 8 includes a partial screenshot of the Improvement Cost Calculations sheet, with sample data.

Figure 8: Improvement Cost Calculations Sheet – Sample Screenshot

Improvement Cost Calculations																	
								Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
							20	Analysis Index	1	1	1	1	1	1	1	1	1
SUPPORTING STRATEGIES																	
1 TRAFFIC MANAGEMENT CENTER (TMC)	calculated	override	used in calcs														
FLAGS	useful life, years			deployments	start year	opening year											
OPERATIONS						2020	2021	15	0	0	0	0	0	1	1	1	1
ANALYSIS INDEX								16	0	0	0	0	1	1	1	1	1
INFRASTRUCTURE EQUIPMENT																	
Traffic Management Center	20.0		20.0					1	0	0	0	0	1	0	0	0	0
INCREMENTAL EQUIPMENT			0.0					0	0	0	0	0	0	0	0	0	0
COSTS	unit costs, $ per deployment			deployments	start year	"typical" cost per yr											
INFRASTRUCTURE EQUIPMENT				3.0	2020												
Capital Costs, $							$620,512										
Traffic Management Center	$4,136,750		$4,136,750				$620,512	$12,410,249	$0	$0	$0	$0	$12,410,249	$0	$0	$0	$0
							$0										
Annual O&M Costs, $																	
Traffic Management Center	$413,675		$413,675					$18,615,374	$0	$0	$0	$0	$0	$1,241,025	$1,241,025	$1,241,025	$1,241,025
Annual Labor Costs, $			$0					$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
INCREMENTAL EQUIPMENT				1.0	2020	$0											
Capital Costs, $			$0			$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Costs, $			$0			$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Labor Costs, $			$0					$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL COSTS							$1,861,537	$31,025,623	$0	$0	$0	$0	$12,410,249	$1,241,025	$1,241,025	$1,241,025	$1,241,025
Capital Costs, $								$12,410,249	$0	$0	$0	$0	$12,410,249	$0	$0	$0	$0
O&M Costs, $								$18,615,374	$0	$0	$0	$0	$0	$1,241,025	$1,241,025	$1,241,025	$1,241,025
Labor Costs, $								$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
SUPPORTING STRATEGIES																	
1 LOOP DETECTION	calculated	override	used in calcs														
FLAGS	useful life, years			deployments	start year	opening year											
OPERATIONS						2020	2021	15	0	0	0	0	0	1	1	1	1
ANALYSIS INDEX								16	0	0	0	0	1	1	1	1	1
INFRASTRUCTURE EQUIPMENT																	
Hardware/Software for Traffic Surveillance	20.0		20.0					1	0	0	0	0	1	0	0	0	0
System Integration	20.0		20.0					1	0	0	0	0	1	0	0	0	0
INCREMENTAL EQUIPMENT																	
Loop Detectors (2) for Supporting Strategies	25.0		25.0					1	0	0	0	0	1	0	0	0	0
Communication Line for Supporting Strategies	20.0		20.0					1	0	0	0	0	1	0	0	0	0
COSTS	unit costs, $ per deployment			deployments	start year	"typical" cost per yr											
INFRASTRUCTURE EQUIPMENT				3.0	2020												
Capital Costs, $	$413,675	$0	$413,675				$41,367	$1,241,025	$0	$0	$0	$0	$1,241,025	$0	$0	$0	$0
Hardware/Software for Traffic Surveillance	$155,128		$155,128				$15,513	$465,384	$0	$0	$0	$0	$465,384	$0	$0	$0	$0
System Integration	$258,547		$258,547				$25,855	$775,641	$0	$0	$0	$0	$775,641	$0	$0	$0	$0

Base Case Calculations

The Base Case Calculations sheet uses the existing traffic conditions entered on the Inputs sheet and calculates the roadway performance data (e.g. traffic, speed, capacity, etc.) and economic measures (e.g. travel time, incident delay, crashes, and others) over the model period of analysis for the base case scenario (i.e. assuming the strategies are not implemented).

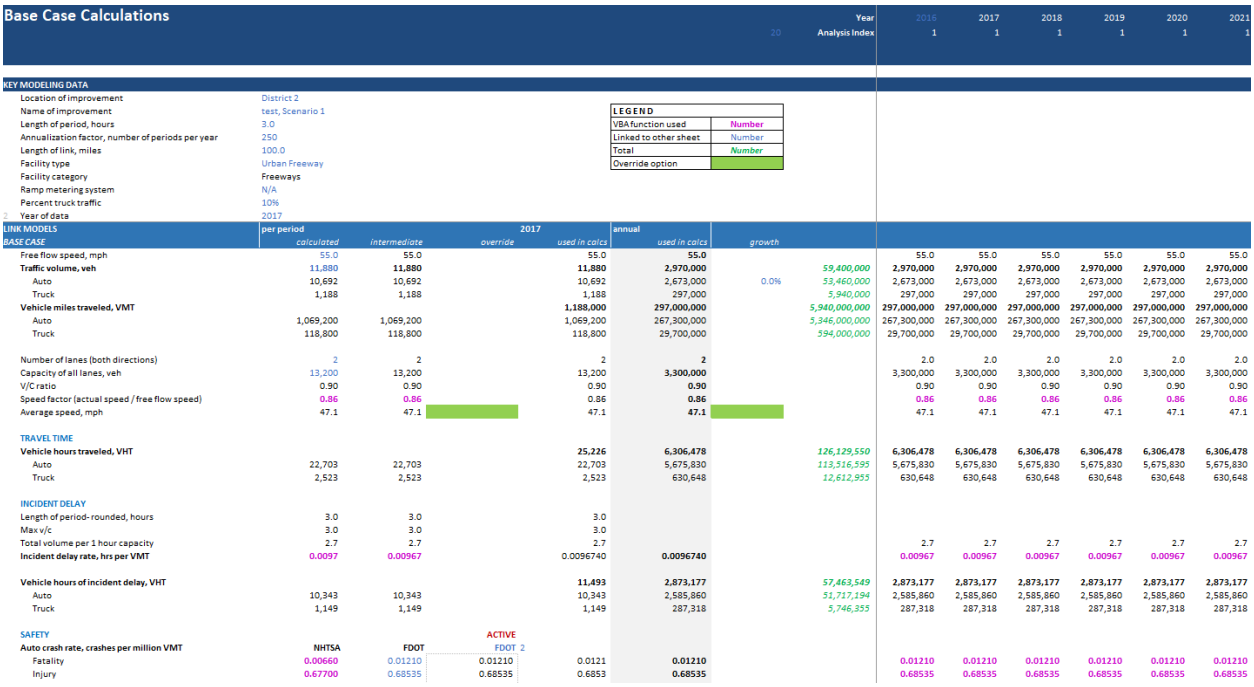
These variables are estimated separately for link models (all strategies applied to a general link), the HOT Lanes model (specific to the HOT Lanes strategy), and the Ramp Metering model (specific to the Ramp Metering strategy). Link models are indicated by blue horizontal banners, the HOT lanes model is indicated by orange horizontal banners, and Ramp Metering model is indicated by purple horizontal banners.

The top section also includes a formatting legend, and a summary of the key modeling data. Both the legend and key data are repeated on all calculation worksheets. As stated in the legend, all cells in green on this worksheet allow the user to override the variables specified.

All calculation worksheets, including this sheet, are structured to show calculations by period, by year, and totals over the period of analysis. Columns C through F show results per period and column G shows the annual estimate, both in the year of base case data. Columns J through AM calculate the annual values, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 9 includes a partial screenshot of the Base Case Calculations sheet, with sample data.

Figure 9: Base Case Calculations Sheet – Sample Screenshot



Base Case Calculations													
							Year	2016	2017	2018	2019	2020	2021
						20	Analysis Index	1	1	1	1	1	1
KEY MODELING DATA													
Location of improvement	District 2												
Name of improvement	test, Scenario 1												
Length of period, hours	3.0												
Annualization factor, number of periods per year	250												
Length of link, miles	100.0												
Facility type	Urban Freeway												
Facility category	Freeways												
Ramp metering system	N/A												
Percent truck traffic	10%												
2 Year of data	2017												
LINK MODELS	per period			2017	annual								
BASE CASE	*calculated*	*intermediate*	*override*	*used in calcs*	*used in calcs*	*growth*							
Free flow speed, mph	55.0	55.0		55.0	55.0			55.0	55.0	55.0	55.0	55.0	55.0
Traffic volume, veh	11,880	11,880		11,880	2,970,000		*59,400,000*	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000
Auto	10,692	10,692		10,692	2,673,000	0.0%	*53,460,000*	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Truck	1,188	1,188		1,188	297,000		*5,940,000*	297,000	297,000	297,000	297,000	297,000	297,000
Vehicle miles traveled, VMT				1,188,000	297,000,000		*5,940,000,000*	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000
Auto	1,069,200	1,069,200		1,069,200	267,300,000		*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck	118,800	118,800		118,800	29,700,000		*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Number of lanes (both directions)	2	2		2	2			2.0	2.0	2.0	2.0	2.0	2.0
Capacity of all lanes, veh	13,200	13,200		13,200	3,300,000			3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000
V/C ratio	0.90	0.90		0.90	0.90			0.90	0.90	0.90	0.90	0.90	0.90
Speed factor (actual speed / free flow speed)	0.86	0.86		0.86	0.86			0.86	0.86	0.86	0.86	0.86	0.86
Average speed, mph	47.1	47.1		47.1	47.1			47.1	47.1	47.1	47.1	47.1	47.1
TRAVEL TIME													
Vehicle hours traveled, VHT				25,226	6,306,478		*126,129,550*	6,306,478	6,306,478	6,306,478	6,306,478	6,306,478	6,306,478
Auto	22,703	22,703		22,703	5,675,830		*113,516,595*	5,675,830	5,675,830	5,675,830	5,675,830	5,675,830	5,675,830
Truck	2,523	2,523		2,523	630,648		*12,612,955*	630,648	630,648	630,648	630,648	630,648	630,648
INCIDENT DELAY													
Length of period- rounded, hours	3.0	3.0		3.0									
Max v/c	3.0	3.0		3.0									
Total volume per 1 hour capacity	2.7	2.7		2.7				2.7	2.7	2.7	2.7	2.7	2.7
Incident delay rate, hrs per VMT	0.0097	0.00967		0.0096740	0.0096740			0.00967	0.00967	0.00967	0.00967	0.00967	0.00967
Vehicle hours of incident delay, VHT				11,493	2,873,177		*57,463,549*	2,873,177	2,873,177	2,873,177	2,873,177	2,873,177	2,873,177
Auto	10,343	10,343		10,343	2,585,860		*51,717,194*	2,585,860	2,585,860	2,585,860	2,585,860	2,585,860	2,585,860
Truck	1,149	1,149		1,149	287,318		*5,746,355*	287,318	287,318	287,318	287,318	287,318	287,318
SAFETY			ACTIVE										
Auto crash rate, crashes per million VMT	NHTSA	FDOT	FDOT 2										
Fatality	0.00660	0.01210	0.01210	0.0121	0.01210			0.01210	0.01210	0.01210	0.01210	0.01210	0.01210
Injury	0.67700	0.68535	0.68535	0.6853	0.68535			0.68535	0.68535	0.68535	0.68535	0.68535	0.68535

LEGEND	
VBA function used	Number
Linked to other sheet	Number
Total	*Number*
Override option	

Improvement Case Calculations

The Improvement Case Calculations sheet uses the strategy impacts plus the existing traffic conditions data to calculate the roadway performance data (e.g. traffic, speed, capacity, etc.) over the model period of analysis for the improvement case scenario (i.e. assuming the strategies selected are implemented).

These variables are estimated separately for each strategy. Calculations for each link-based strategy (i.e. strategies other than HOT lanes or Ramps) are separated by blue horizontal banners. The HOT Lanes strategy calculations are separated by orange horizontal banners, and the Ramp Metering strategy is separated by purple horizontal banners. This sheet also allows for user overrides in any green cell.

As with other calculation sheets in this tool, this worksheet is structured to show calculations by period, by year, and totals over the period of analysis. Specifically, columns C through F show results per period and column G shows the annual estimate, both reported for the opening year of the strategy. This year varies by strategy, and is shown in Column F of each strategy banner. Columns J through AM calculate the annual values, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*. The sheet also displays relevant base case data for the Link models, HOT Lanes model, and Ramp Metering model, as calculated on the Base Case Calculations sheet.

Figure 10 includes a partial screenshot of the Improvement Case Calculations sheet, with sample data.

Figure 10: Improvement Case Calculations Sheet – Sample Screenshot

Improvement Case Calculations (Traffic, VMT, Speed)

								Year	2016	2017	2018	2019	2020	2021
							20	Analysis Index	1	1	1	1	1	1

KEY MODELING DATA

Location of improvement	District 2
Name of improvement	test, Scenario 1
Length of period, hours	3.0
Annualization factor, number of periods per year	250
Length of link, miles	100.0
Facility type	Urban Freeway
Facility category	Freeways
Ramp metering system	N/A
Percent truck traffic	10%
3 User selection for benefits calculation	Minimum

LEGEND	
VBA function used	Number
Linked to other sheet	Number
Total	*Number*
Override option	
User input	

LINK MODELS	per period			2017	annual								
BASE CASE	*calculated*	*intermediate*	*override*	*used in calcs*	*used in calcs*	*growth (%)*							
Free flow speed, mph				55	55			55	55	55	55	55	55
Traffic volume, veh				11,880	2,970,000		*59,400,000*	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000
Auto				10,692	2,673,000	0.0%	*53,460,000*	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Truck				1,188	297,000		*5,940,000*	297,000	297,000	297,000	297,000	297,000	297,000
Vehicle miles traveled, VMT				1,188,000	297,000,000		*5,940,000,000*	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000
Auto				1,069,200	267,300,000		*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck				118,800	29,700,000		*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Number of lanes (both directions)				2	2			2	2	2	2	2	2
Capacity of all lanes, veh				13,200	3,300,000			3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000
V/C ratio				0.90	0.90			0.90	0.90	0.90	0.90	0.90	0.90
Average speed, mph				47.1	47.1			47.1	47.1	47.1	47.1	47.1	47.1

DYNAMIC MESSAGE SIGN [DMS]	per period			2020	annual								
IMPROVEMENT CASE	*calculated*	*intermediate*	*override*	*used in calcs*	*used in calcs*	*growth (%)*							
Opening year	2020			2									
Improvement case traffic volume, veh	**11,880**	**11,880**		**11,880**	**2,970,000**		*59,400,000*	**2,970,000**	**2,970,000**	**2,970,000**	**2,970,000**	**2,970,000**	**2,970,000**
Auto	10,692	10,692		10,692	2,673,000	0.0%	*53,460,000*	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Truck	1,188	1,188		1,188	297,000		*5,940,000*	297,000	297,000	297,000	297,000	297,000	297,000
Existing or remaining traffic volume, veh				**11,880**	**2,970,000**		*59,400,000*	**2,970,000**	**2,970,000**	**2,970,000**	**2,970,000**	**2,970,000**	**2,970,000**
Auto				10,692	2,673,000		*53,460,000*	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Truck				1,188	297,000		*5,940,000*	297,000	297,000	297,000	297,000	297,000	297,000
Improvement case vehicle miles traveled, VMT				**1,188,000**	**297,000,000**		*5,940,000,000*	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**
Auto				1,069,200	267,300,000		*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck				118,800	29,700,000		*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Existing or remaining vehicle miles traveled, VMT				**1,188,000**	**297,000,000**		*5,940,000,000*	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**
Auto				1,069,200	267,300,000		*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck				118,800	29,700,000		*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Capacity of all lanes, veh	13,200	13,200		13,200	**3,300,000**			3,300,000	3,300,000	3,300,000	3,300,000	3,300,000	3,300,000
V/C ratio	0.90	0.90		0.90	**0.90**			0.90	0.90	0.90	0.90	0.90	0.90
Speed factor (actual speed / free flow speed)	0.86	0.86		0.86				0.86	0.86	0.86	0.86	0.86	0.86
Average speed, mph	47.1	47.1		47.1	**47.1**			47.1	47.1	47.1	47.1	47.1	47.1

Travel Time Savings Calculations

The Travel Time Savings Calculations sheet calculates the travel time savings from reduced recurring delay due to the strategy or strategies implemented. Specifically, for each strategy, the sheet links to the traffic and speed data calculated on the Improvement Case Calculation sheet, and compares this to the base case conditions reproduced from the Base Case Calculations sheet to calculate vehicle hours saved. These results are then used on the Benefit Cost Calculation sheet to monetize and combine the travel time benefits from the selected strategies.

Calculations for link-based strategies are separated by blue horizontal banners, HOT Lanes strategy calculations with orange banners, and Ramp Metering strategy calculations with purple banners. Columns C and D include calculated results per period, with the user override option in Column E. Columns F and G show the final estimates used in the tool calculations, per period and per year, respectively. Columns J through AM calculate the annual values, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 11 includes a partial screenshot of the Travel Time Savings Calculations sheet, with sample data.

Figure 11: Travel Time Savings Calculations Sheet – Sample Screenshot

Calculations of Travel Time Savings from Reduced Recurring Delay												
							Year	2016	2017	2018	2019	2020
						20	Analysis Index	1	1	1	1	1
LINK MODELS	per period		2017	annual								
BASE CASE			*used in calcs*	*used in calcs*	*growth (%)*							
Average speed, mph			47.1	**47.1**				47.1	47.1	47.1	47.1	47.1
Vehicle miles traveled, VMT			**1,188,000**	**297,000,000**	0.0%		***5,940,000,000***	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**
Auto			1,069,200	267,300,000			*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000			*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Vehicle hours traveled, VHT			**25,226**	**6,306,478**			***126,129,550***	**6,306,478**	**6,306,478**	**6,306,478**	**6,306,478**	**6,306,478**
Auto			22,703	5,675,830			*113,516,595*	5,675,830	5,675,830	5,675,830	5,675,830	5,675,830
Truck			2,523	630,648			*12,612,955*	630,648	630,648	630,648	630,648	630,648
1 TRAFFIC SIGNAL COORDINATION SYSTEMS : TRAFFIC ACTUATED	per period		2020	annual								
IMPROVEMENT CASE			*used in calcs*	*used in calcs*								
Opening year	2020		*3*				*16*	0	0	0	0	1
Average speed, mph			50.1	**50.1**				47.1	47.1	47.1	47.1	50.1
Improvement case vehicle miles traveled, VMT			**1,188,000**	**297,000,000**			***5,940,000,000***	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**
Auto			1,069,200	267,300,000			*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000			*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Vehicle hours traveled, VHT		*base case VHT*	**23,723**	**5,930,823**			***120,119,084***	**6,306,478**	**6,306,478**	**6,306,478**	**6,306,478**	**5,930,823**
Auto		22,703	21,351	5,337,741			*108,107,176*	5,675,830	5,675,830	5,675,830	5,675,830	5,337,741
Truck		2,523	2,372	593,082			*12,011,908*	630,648	630,648	630,648	630,648	593,082
SAVINGS	*calculated*	*intermediate*	*override*	**2020**		*growth (%)*						
Vehicle hours saved, VHT				**1,503**	**375,654**		***6,010,466***	**0**	**0**	**0**	**0**	**375,654**
Auto	1,352	1,352		1,352	338,089		*5,409,419*	0	0	0	0	338,089
Truck	150	150		150	37,565		*601,047*	0	0	0	0	37,565
1 TRAFFIC SIGNAL RETIMING	per period		2020	annual								
IMPROVEMENT CASE			*used in calcs*	*used in calcs*								
Opening year	2020		*3*				*16*	0	0	0	0	1
Average speed, mph			59.7	**59.7**				47.1	47.1	47.1	47.1	59.7
Improvement case vehicle miles traveled, VMT			**1,188,000**	**297,000,000**			***5,940,000,000***	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**
Auto			1,069,200	267,300,000			*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000			*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Vehicle hours traveled, VHT		*base case VHT*	**19,886**	**4,971,522**			***104,770,259***	**6,306,478**	**6,306,478**	**6,306,478**	**6,306,478**	**4,971,522**
Auto		22,703	17,897	4,474,370			*94,293,233*	5,675,830	5,675,830	5,675,830	5,675,830	4,474,370
Truck		2,523	1,989	497,152			*10,477,026*	630,648	630,648	630,648	630,648	497,152
SAVINGS	*calculated*	*intermediate*	*override*	**2020**		*growth (%)*						
Vehicle hours saved, VHT				**5,340**	**1,334,956**		***21,359,292***	**0**	**0**	**0**	**0**	**1,334,956**
Auto	4,806	4,806		4,806	1,201,460		*19,223,363*	0	0	0	0	1,201,460
Truck	534	534		534	133,496		*2,135,929*	0	0	0	0	133,496
1 TRAFFIC INCIDENT MANAGEMENT	per period		2020	annual								
IMPROVEMENT CASE			*used in calcs*	*used in calcs*								
Opening year	2020		*3*				*16*	0	0	0	0	1
Average speed, mph			47.1	**47.1**				47.1	47.1	47.1	47.1	47.1
Improvement case vehicle miles traveled, VMT			**1,188,000**	**297,000,000**			***5,940,000,000***	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**	**297,000,000**
Auto			1,069,200	267,300,000			*5,346,000,000*	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000			*594,000,000*	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000

Incident Delay Savings Calculations

The Incident Delay Savings Calculations sheet calculates the travel time savings from reduced incident delay due to the strategy or strategies implemented. Specifically, for each strategy, the sheet links to the strategy impacts from the Inputs sheet, the roadway performance results from the Improvement Case Calculation sheet and the Base Case Calculations sheet, and calculates the vehicle hours saved from reduced incident delays. These results are then used on the Benefit Cost Calculation sheet to monetize and combine the benefits from reduced incident delay for the selected strategies.

Calculations for link-based strategies are separated by blue horizontal banners, HOT Lanes strategy calculations with orange banners, and Ramp Metering strategy calculations with purple banners. Columns C and D include calculated results per period, with the user override option in Column E. Columns F and G show the final estimates used in the tool calculations, per period and per year, respectively. Columns J through AM calculate the annual values, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 12 below includes a partial screenshot of the Incident Delay Savings Calculations sheet, with sample data for illustration.

Figure 12: Incident Delay Savings Calculations Sheet – Sample Screenshot

Calculations of Travel Time Savings from Reduced Incident Delays						Year	2016	2017	2018	2019	2020	2021	2022
						Analysis Index	1	1	1	1	1	1	1
1 HIGH OCCUPANCY TOLL (HOT) LANES	per period		2020	annual									
IMPROVEMENT CASE	calculated		used in calcs	used in calcs									
2 ACTIVE Method													
Opening year	2020					16	0	0	0	0	1	1	1
HOT LANES													
Traffic volume, veh			10,652	2,663,100		51,486,600	2,219,250	2,219,250	2,219,250	2,219,250	2,663,100	2,663,100	2,663,100
Capacity of all lanes, veh			15,840	3,960,000		79,200,000	3,960,000	3,960,000	3,960,000	3,960,000	3,960,000	3,960,000	3,960,000
Length of period-rounded, hours	3.0												
Max v/c	3.0												
Total volume per 1 hour capacity	2.018						1.7	1.7	1.7	1.7	2.0	2.0	2.0
Incident delay rate, hrs per VMT	0.001056		0.0011	0.0011			0.0005	0.0005	0.0005	0.0005	0.0011	0.0011	0.0011
Improvement case vehicle miles traveled, VMT			95,872	23,967,900		463,379,400	19,973,250	19,973,250	19,973,250	19,973,250	23,967,900	23,967,900	23,967,900
Auto			86,284	21,571,110		417,041,460	17,975,925	17,975,925	17,975,925	17,975,925	21,571,110	21,571,110	21,571,110
Truck			9,587	2,396,790		46,337,940	1,997,325	1,997,325	1,997,325	1,997,325	2,396,790	2,396,790	2,396,790
Vehicle hours of incident delay, VHT			101.2	25,307		489,261	21,089	21,089	21,089	21,089	25,307	25,307	25,307
Auto			91.1	22,776		440,335	18,980	18,980	18,980	18,980	22,776	22,776	22,776
Truck			10.1	2,531		48,926	2,109	2,109	2,109	2,109	2,531	2,531	2,531
GP LANES													
Traffic volume, veh			15,633	3,906,400		79,883,400	4,349,250	4,349,250	4,349,250	4,349,250	3,906,400	3,906,400	3,906,400
Capacity of all lanes, veh			26,400	6,600,000		132,000,000	6,600,000	6,600,000	6,600,000	6,600,000	6,600,000	6,600,000	6,600,000
Length of period-rounded, hours	3.0												
Max v/c	3.0												
Total volume per 1 hour capacity	1.775						2.0	2.0	2.0	2.0	1.8	1.8	1.8
Incident delay rate, hrs per VMT	0.000204		0.0002	0.0002			0.0004	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003
Improvement case vehicle miles traveled, VMT			140,594	35,148,600		718,950,600	39,143,250	39,143,250	39,143,250	39,143,250	35,148,600	35,148,600	35,148,600
Auto			126,535	31,633,740		647,055,540	35,228,925	35,228,925	35,228,925	35,228,925	31,633,740	31,633,740	31,633,740
Truck			14,059	3,514,860		71,895,060	3,914,325	3,914,325	3,914,325	3,914,325	3,514,860	3,514,860	3,514,860
Vehicle hours of incident delay, VHT			28.7	7,183		183,324	17,101	17,101	17,101	17,101	7,183	7,183	7,183
Auto			25.9	6,464		164,994	15,391	15,391	15,391	15,391	6,464	6,464	6,464
Truck			2.9	718		18,333	1,710	1,710	1,710	1,710	718	718	718
SAVINGS	calculated	intermediate	override	used in calcs		growth (%)							
Vehicle hours of incident delay avoided on HOT lanes, VHT				(16.9)	(4,218)		(67,484)	0	0	0	0	(4,218)	(4,218)	(4,218)
Auto	(15.2)	(15.2)		(15.2)	(3,796)		(60,734)	0	0	0	0	(3,796)	(3,796)	(3,796)
Truck	(1.7)	(1.7)		(1.7)	(422)		(6,748)	0	0	0	0	(422)	(422)	(422)
Vehicle hours of incident delay avoided on GP lanes, VHT				39.7	9,919		158,697	0	0	0	0	9,919	9,919	9,919
Auto	35.7	35.7		35.7	8,927		142,828	0	0	0	0	8,927	8,927	8,927
Truck	4.0	4.0		4.0	992		15,870	0	0	0	0	992	992	992
Total vehicle hours of incident delay avoided, VHT				22.803	5,701		91,213	0	0	0	0	5,701	5,701	5,701
Auto				20.5	5,131		82,092	0	0	0	0	5,131	5,131	5,131
Truck				2.3	570		9,121	0	0	0	0	570	570	570

ATIS Time Savings Calculations

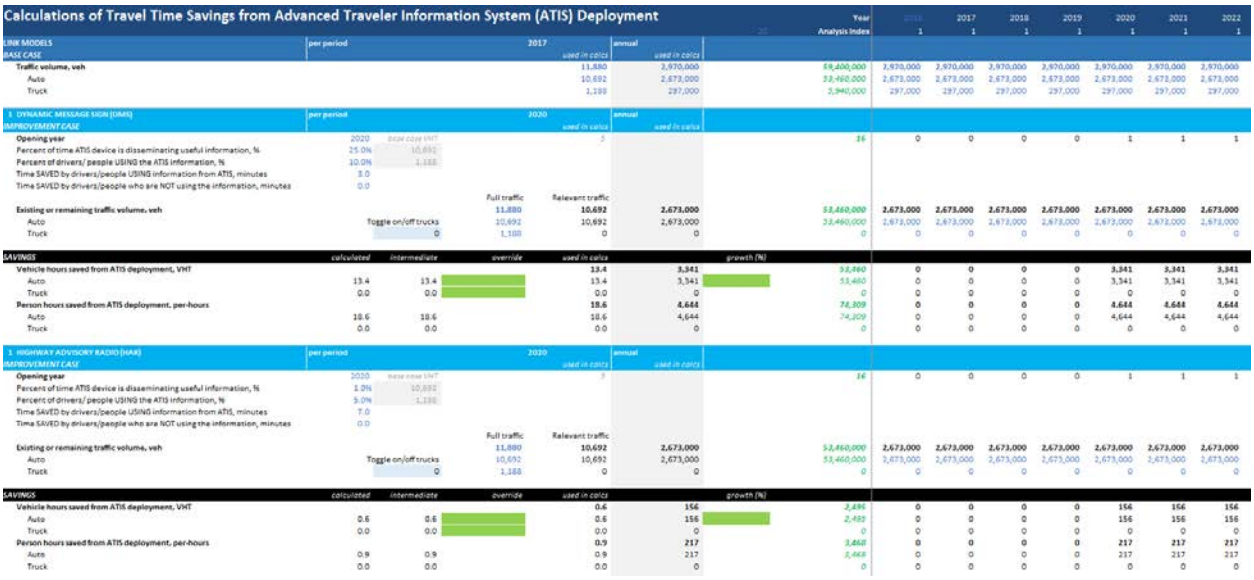
The Advanced Traveler Information System (ATIS) Time Savings Calculations sheet calculates the travel time savings from implementing strategies that inform travelers of traffic delays, alternative routes, or other roadway performance information, or which directly manage roadway demand in an effort to allow user to avoid delays.

For each strategy with ATIS elements, the sheet links to the strategy impacts from the Inputs sheet, the roadway performance results from the Improvement Case Calculation sheet and the Base Case Calculations sheet, and calculates the hours saved from the ATIS improvement. These results are then used on the Benefit Cost Calculation sheet to monetize and combine the travel time savings from ATIS improvements.

Calculations for link-based strategies are separated by blue horizontal banners. The HOT Lanes and Ramp Metering strategies do not include ATIS elements and thus no benefits are calculated for these strategies. Columns C and D include calculated results per period, with the user override option in Column E. Columns F and G show the final estimates used in the tool calculations, per period and per year, respectively. Columns J through AM calculate the annual values, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 13 below includes a partial screenshot of the ATIS Time Savings Calculations sheet, with sample data.

Figure 13: ATIS Time Savings Calculations Sheet – Sample Screenshot



Calculations of Travel Time Savings from Advanced Traveler Information System (ATIS) Deployment						Year	2016	2017	2018	2019	2020	2021	2022
						Analysis Index	1	1	1	1	1	1	1
LINK MODELS	per period		2017	annual									
BASE CASE			used in calcs	used in calcs									
Traffic volume, veh			11,880	2,970,000		59,400,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000
Auto			10,692	2,673,000		53,460,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Truck			1,188	297,000		5,940,000	297,000	297,000	297,000	297,000	297,000	297,000	297,000
1 DYNAMIC MESSAGE SIGN (DMS)	per period		2020	annual									
IMPROVEMENT CASE			used in calcs	used in calcs									
Opening year	2020	base case VMT	3			16	0	0	0	0	1	1	1
Percent of time ATIS device is disseminating useful information, %	25.0%	10,692											
Percent of drivers/ people USING the ATIS information, %	10.0%	1,188											
Time SAVED by drivers/people USING information from ATIS, minutes	3.0												
Time SAVED by drivers/people who are NOT using the information, minutes	0.0												
			Full traffic	Relevant traffic									
Existing or remaining traffic volume, veh			11,880	10,692	2,673,000	53,460,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Auto		Toggle on/off trucks	10,692	10,692	2,673,000	53,460,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Truck		0	1,188	0	0	0	0	0	0	0	0	0	0
SAVINGS	calculated	intermediate	override	used in calcs		growth (%)							
Vehicle hours saved from ATIS deployment, VHT				13.4	3,341	53,460	0	0	0	0	3,341	3,341	3,341
Auto	13.4	13.4		13.4	3,341	53,460	0	0	0	0	3,341	3,341	3,341
Truck	0.0	0.0		0.0	0	0	0	0	0	0	0	0	0
Person hours saved from ATIS deployment, per-hours				18.6	4,644	74,309	0	0	0	0	4,644	4,644	4,644
Auto	18.6	18.6		18.6	4,644	74,309	0	0	0	0	4,644	4,644	4,644
Truck	0.0	0.0		0.0	0	0	0	0	0	0	0	0	0
1 HIGHWAY ADVISORY RADIO (HAR)	per period		2020	annual									
IMPROVEMENT CASE			used in calcs	used in calcs									
Opening year	2020	base case VMT	3			16	0	0	0	0	1	1	1
Percent of time ATIS device is disseminating useful information, %	1.0%	10,692											
Percent of drivers/ people USING the ATIS information, %	5.0%	1,188											
Time SAVED by drivers/people USING information from ATIS, minutes	7.0												
Time SAVED by drivers/people who are NOT using the information, minutes	0.0												
			Full traffic	Relevant traffic									
Existing or remaining traffic volume, veh			11,880	10,692	2,673,000	53,460,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Auto		Toggle on/off trucks	10,692	10,692	2,673,000	53,460,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000	2,673,000
Truck		0	1,188	0	0	0	0	0	0	0	0	0	0
SAVINGS	calculated	intermediate	override	used in calcs		growth (%)							
Vehicle hours saved from ATIS deployment, VHT				0.6	156	2,484	0	0	0	0	156	156	156
Auto	0.6	0.6		0.6	156	2,484	0	0	0	0	156	156	156
Truck	0.0	0.0		0.0	0	0	0	0	0	0	0	0	0
Person hours saved from ATIS deployment, per-hours				0.9	217	3,468	0	0	0	0	217	217	217
Auto	0.9	0.9		0.9	217	3,468	0	0	0	0	217	217	217
Truck	0.0	0.0		0.0	0	0	0	0	0	0	0	0	0

Safety Benefits Calculations

The Safety Benefits Calculations sheet calculates the vehicle crashes avoided due to the TSM&O strategies implemented. Specifically, for each strategy, the sheet links to the relevant strategy impacts, the crash and roadway data from the Base Case Calculations sheet, and the roadway data from the Improvement Case Calculation sheet, and calculates the reduced fatal, injury, and property-damage only (PDO) crashes in the improvement case. These results are then used on the Benefit Cost Calculation sheet to monetize and combine the benefits from reduced incident delay for the selected strategies.

Calculations for link-based strategies are separated by blue horizontal banners, HOT Lanes strategy calculations with orange banners, and Ramp Metering strategy calculations with purple banners. Columns C and D include calculated results per period, with the user override option in Column E. Columns F and G show the final estimates used in the tool calculations, per period and per year, respectively. Columns J through AM calculate the annual values, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 14 below includes a partial screenshot of the Safety Benefits Calculations sheet.

Figure 14: Safety Benefits Calculations Sheet – Sample Screenshot

Safety Benefits Calculations						Year	2016	2017	2018	2019	2020	2021	2022	2023
						Analysis Index	1	1	1	1	1	1	1	1
1 RAMP METERING SYSTEMS : CENTRAL CONTROL	per period		2030	annual										
IMPROVEMENT / CASE	calculated		used in calcs	used in calcs										
Opening year	2020					16	0	0	0	0	1	1	1	1
Number of metered ramps implemented	2.0		2.0	2.0			2	2	2	2	2	2	2	2
RAMPS														
Change in crash rate, %	n/a													
Improvement case vehicle miles traveled per ramp, VMT			750	187,500		*3,750,000*	187,500	187,500	187,500	187,500	187,500	187,500	187,500	187,500
Auto			675	168,750		*3,375,000*	168,750	168,750	168,750	168,750	168,750	168,750	168,750	168,750
Truck			75	18,750		*375,000*	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750
V/C ratio			0.96	0.96			0.63	0.63	0.63	0.63	0.96	0.96	0.96	0.96
2 Auto crash rate, crashes per million VMT	NHTSA	FDOT	ACTIVE - FDOT											
Fatality	0.0066	0.0121	0.0121	0.0121			0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121
Injury	0.6948	0.6853	0.6853	0.6853			0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853
PDO	0.8874	0.7193	0.7193	0.7193			0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193
Truck crash rate, crashes per million VMT														
Fatality	0.0066	0.0121	0.0121	0.0121			0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121
Injury	0.6948	0.6853	0.6853	0.6853			0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853
PDO	0.8874	0.7193	0.7193	0.7193			0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193
Number of AUTO crashes by severity, crashes														
Fatality			0.00	0.00		*0*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Injury			0.00	0.12		*2*	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
PDO			0.00	0.12		*2*	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Number of TRUCK crashes by severity, crashes														
Fatality			0.00	0.00		*0*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Injury			0.00	0.03		*0*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PDO			0.00	0.03		*0*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Number of TOTAL crashes by severity, crashes														
Fatality			0.00	0.00		*0*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Injury			0.00	0.14		*3*	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
PDO			0.00	0.15		*3*	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
GENERAL LINKS														
Change in crash rate, %	-12.0%													
Improvement case vehicle miles traveled, VMT			19,000	4,750,000		*95,000,000*	4,750,000	4,750,000	4,750,000	4,750,000	4,750,000	4,750,000	4,750,000	4,750,000
Auto			17,100	4,275,000		*85,500,000*	4,275,000	4,275,000	4,275,000	4,275,000	4,275,000	4,275,000	4,275,000	4,275,000
Truck			1,900	-475,000		*9,500,000*	475,000	475,000	475,000	475,000	475,000	475,000	475,000	475,000
V/C ratio			1.28	1.29			1.44	1.44	1.44	1.44	1.29	1.29	1.29	1.29
2 Auto crash rate, crashes per million VMT	NHTSA	FDOT	ACTIVE - FDOT											
Fatality	0.0066	0.0121	0.0121	0.0121			0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121
Injury	0.7987	0.6853	0.6853	0.6853			0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853
PDO	1.1550	0.7193	0.7193	0.7193			0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193
Truck crash rate, crashes per million VMT														
Fatality	0.0066	0.0121	0.0121	0.0121			0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121
Injury	0.7987	0.6853	0.6853	0.6853			0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853	0.6853
PDO	1.1550	0.7193	0.7193	0.7193			0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193	0.7193

Fuel Savings Calculations

The Fuel Savings Calculations sheet calculates the change in fuel consumption due to the TSM&O strategies implemented. Specifically, for each strategy, the sheet links to the relevant strategy impacts, the speed and VMT data from the Base Case Calculations and Improvement Case Calculations sheets, and calculates the change in fuel consumption. These results are then used on the Benefit Cost Calculation sheet to monetize and combine the benefits from the change in fuel consumption.

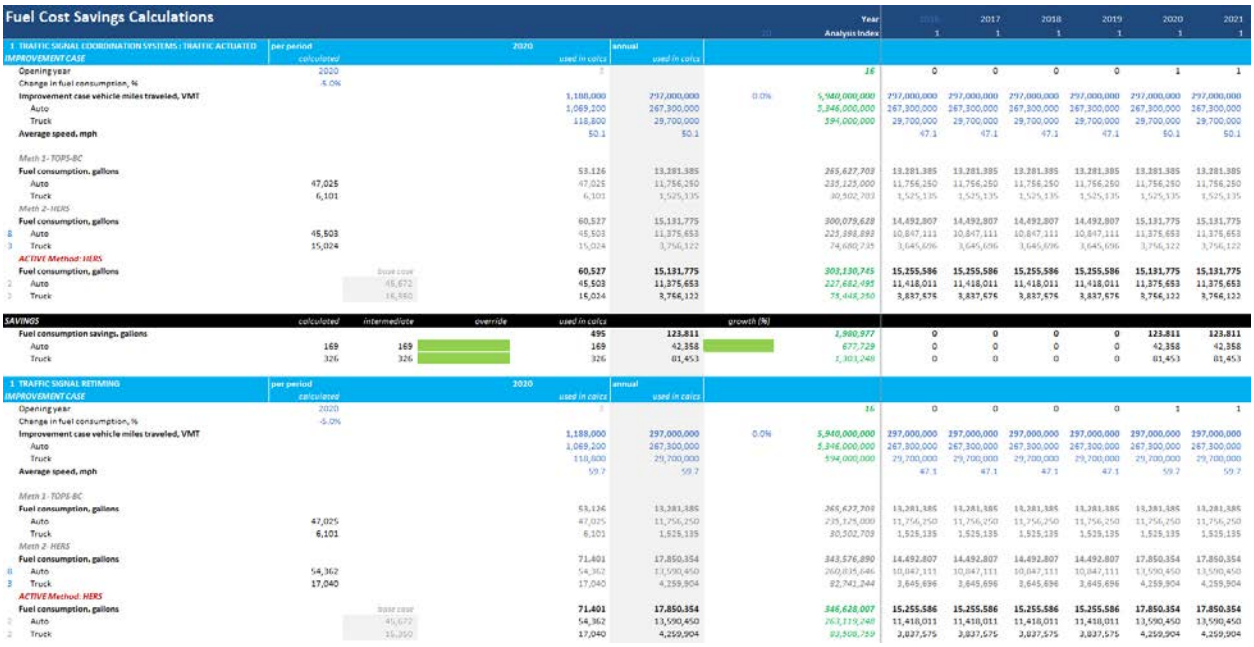
As with other TransValU modules, users have the option of using unit fuel consumption rates and cost data from Highway Economic Requirements System (HERS).[15] The tool also includes the method from TOPS-BC Version 1.2—fixed miles per gallon by vehicle type, monetized with a fixed dollar per gallon parameter.

Calculations for link-based strategies are separated by blue horizontal banners, HOT Lanes strategy calculations with orange banners, and Ramp Metering strategy calculations with purple banners. Columns C and D include calculated results per period, with the user override option in Column E. Columns F and G show the final estimates used in the tool calculations, per period and per year, respectively. Columns J through AM calculate the annual values, and Column I aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 15 includes a partial screenshot of the Fuel Savings Calculations sheet.

[15] Note that the fixed dollar per vehicle mile option referenced in the USDOT BCA Guidance for Discretionary Grant Programs is not provided in the TSM&O. This option does not estimate the consumption of fuel, and one of the strategy impacts involves a percent change in fuel consumption.

Figure 15: Fuel Savings Calculations Sheet – Sample Screenshot



Fuel Cost Savings Calculations														
								Year	2016	2017	2018	2019	2020	2021
								Analysis Index	1	1	1	1	1	1
1 TRAFFIC SIGNAL COORDINATION SYSTEMS : TRAFFIC ACTUATED	per period		2020	annual										
IMPROVEMENT CASE	calculated		used in calcs	used in calcs										
Opening year	2020							16	0	0	0	0	1	1
Change in fuel consumption, %	-5.0%													
Improvement case vehicle miles traveled, VMT			1,188,000	297,000,000		0.0%	5,940,000,000		297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000
Auto			1,069,200	267,300,000			5,346,000,000		267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000			594,000,000		29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Average speed, mph			50.1	50.1					47.1	47.1	47.1	47.1	50.1	50.1
Meth 1- TOPS-BC														
Fuel consumption, gallons			53,126	13,281,385			265,627,703		13,281,385	13,281,385	13,281,385	13,281,385	13,281,385	13,281,385
Auto	47,025		47,025	11,756,250			235,125,000		11,756,250	11,756,250	11,756,250	11,756,250	11,756,250	11,756,250
Truck	6,101		6,101	1,525,135			30,502,703		1,525,135	1,525,135	1,525,135	1,525,135	1,525,135	1,525,135
Meth 2- HERS														
Fuel consumption, gallons			60,527	15,131,775			300,079,628		14,492,807	14,492,807	14,492,807	14,492,807	15,131,775	15,131,775
8 Auto	45,503		45,503	11,375,653			225,398,893		10,847,111	10,847,111	10,847,111	10,847,111	11,375,653	11,375,653
3 Truck	15,024		15,024	3,756,122			74,680,735		3,645,696	3,645,696	3,645,696	3,645,696	3,756,122	3,756,122
ACTIVE Method: HERS														
Fuel consumption, gallons		base case	60,527	15,131,775			303,130,745		15,255,586	15,255,586	15,255,586	15,255,586	15,131,775	15,131,775
2 Auto		45,672	45,503	11,375,653			227,682,495		11,418,011	11,418,011	11,418,011	11,418,011	11,375,653	11,375,653
2 Truck		15,360	15,024	3,756,122			75,448,250		3,837,575	3,837,575	3,837,575	3,837,575	3,756,122	3,756,122
SAVINGS	calculated	intermediate	override	used in calcs		growth (%)								
Fuel consumption savings, gallons				495	123,811		1,980,977		0	0	0	0	123,811	123,811
Auto	169	169		169	42,358		677,729		0	0	0	0	42,358	42,358
Truck	326	326		326	81,453		1,303,248		0	0	0	0	81,453	81,453
1 TRAFFIC SIGNAL RETIMING	per period		2020	annual										
IMPROVEMENT CASE	calculated		used in calcs	used in calcs										
Opening year	2020							16	0	0	0	0	1	1
Change in fuel consumption, %	-5.0%													
Improvement case vehicle miles traveled, VMT			1,188,000	297,000,000		0.0%	5,940,000,000		297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000
Auto			1,069,200	267,300,000			5,346,000,000		267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000			594,000,000		29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Average speed, mph			59.7	59.7					47.1	47.1	47.1	47.1	59.7	59.7
Meth 1- TOPS-BC														
Fuel consumption, gallons			53,126	13,281,385			265,627,703		13,281,385	13,281,385	13,281,385	13,281,385	13,281,385	13,281,385
Auto	47,025		47,025	11,756,250			235,125,000		11,756,250	11,756,250	11,756,250	11,756,250	11,756,250	11,756,250
Truck	6,101		6,101	1,525,135			30,502,703		1,525,135	1,525,135	1,525,135	1,525,135	1,525,135	1,525,135
Meth 2- HERS														
Fuel consumption, gallons			71,401	17,850,354			343,576,890		14,492,807	14,492,807	14,492,807	14,492,807	17,850,354	17,850,354
8 Auto	54,362		54,362	13,590,450			260,835,646		10,847,111	10,847,111	10,847,111	10,847,111	13,590,450	13,590,450
3 Truck	17,040		17,040	4,259,904			82,741,244		3,645,696	3,645,696	3,645,696	3,645,696	4,259,904	4,259,904
ACTIVE Method: HERS														
Fuel consumption, gallons		base case	71,401	17,850,354			346,628,007		15,255,586	15,255,586	15,255,586	15,255,586	17,850,354	17,850,354
2 Auto		45,672	54,362	13,590,450			263,119,248		11,418,011	11,418,011	11,418,011	11,418,011	13,590,450	13,590,450
2 Truck		15,360	17,040	4,259,904			82,508,759		3,837,575	3,837,575	3,837,575	3,837,575	4,259,904	4,259,904

Emission Savings Calculations

The Emission Savings Calculations sheet estimates the change in emissions due to the TSM&O strategies implemented. The methodology behind this calculation sheet differs from the others mentioned above. The tool does not include strategy impacts specific to emissions,[16] but instead calculates the change in emissions based on the change in speed and VMT caused by other impacts. An average VMT and VHT are calculated for all link-based strategies, which is used to calculate average speed. These average roadway performance measures are used to calculate the tons of emissions produced in the improvement case. The change in emissions (due to changes in speed and VMT) are calculated directly for the HOT Lanes and Ramp Metering strategies. These results are then used on the Benefit Cost Calculation sheet to monetize and combine the benefits from the change in emissions.

As with other TransValU modules, the emission rates are specific to the district (or county within District 5) where the improvement is located, and are based on speed, mode and roadway type.[17] Emission data comes from the EPA Motor Vehicle Emission Simulator (MOVES).

Calculations for link-based strategies are separated by blue horizontal banners, HOT Lanes strategy calculations with orange banners, and Ramp Metering strategy calculations with purple banners. Columns C and D include calculated results per period, with the user override option in Column E. Columns F and G show the final estimates used in the tool calculations, per period and per year, respectively. Columns J through AM calculate the annual values, and Column I

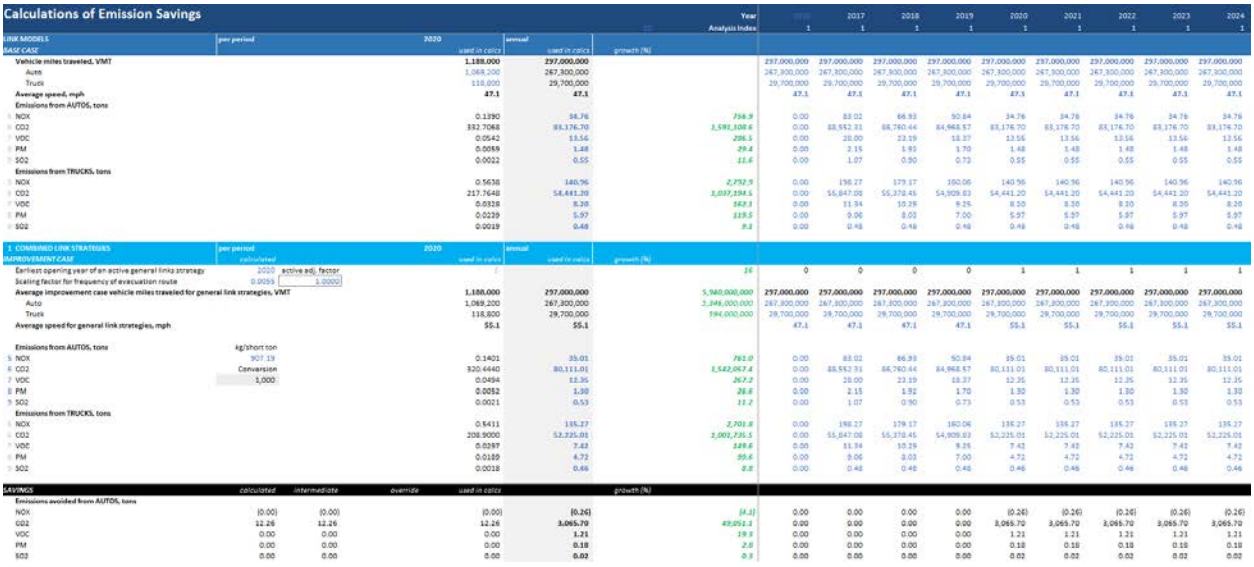
[16] No strategy impacts were provided for emissions in the TOPS-BC Version 1.2, and no other new emissions impact data were found for this study.

[17] Note that even though a strategy may lead to a change in speed, the difference in speed from the base case to improvement case must be large enough to produce different unit emission rates. This is based on the MOVES emission rates provided by speed bin.

aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 16 provides a partial screenshot of the Emission Savings Calculations sheet.

Figure 16: Emission Savings Calculations Sheet – Sample Screenshot



Calculations of Emission Savings																	
						Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
						Analysis Index	1	1	1	1	1	1	1	1	1
LINK MODELS	per period	2020		annual											
BASE CASE			used in calcs	used in calcs	growth (%)										
Vehicle miles traveled, VMT			1,188,000	297,000,000			297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000
Auto			1,069,200	267,300,000			267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000			29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Average speed, mph			47.1	47.1			47.1	47.1	47.1	47.1	47.1	47.1	47.1	47.1	47.1
Emissions from AUTOS, tons															
NOX			0.1390	34.76		758.9	0.00	88.02	66.93	50.84	34.76	34.76	34.76	34.76	34.76
CO2			332.7068	83,176.70		1,581,108.6	0.00	88,552.31	88,760.44	84,968.57	83,176.70	83,176.70	83,176.70	83,176.70	83,176.70
VOC			0.0542	13.56		206.1	0.00	20.00	23.19	18.37	13.56	13.56	13.56	13.56	13.56
PM			0.0059	1.48		29.4	0.00	2.15	1.92	1.70	1.48	1.48	1.48	1.48	1.48
SO2			0.0022	0.55		11.6	0.00	1.07	0.90	0.72	0.55	0.55	0.55	0.55	0.55
Emissions from TRUCKS, tons															
NOX			0.5638	140.96		2,752.9	0.00	196.27	179.17	160.06	140.96	140.96	140.96	140.96	140.96
CO2			217.7648	54,441.20		1,037,194.5	0.00	55,847.08	55,378.45	54,909.83	54,441.20	54,441.20	54,441.20	54,441.20	54,441.20
VOC			0.0328	8.20		162.1	0.00	11.34	10.28	9.25	8.20	8.20	8.20	8.20	8.20
PM			0.0239	5.97		113.5	0.00	9.06	8.02	7.00	5.97	5.97	5.97	5.97	5.97
SO2			0.0019	0.48		9.1	0.00	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
1 COMBINED LINK STRATEGIES	per period	2020		annual											
IMPROVEMENT CASE	calculated		used in calcs	used in calcs	growth (%)										
Earliest opening year of an active general links strategy	2020	active adj. factor				16	0	0	0	0	1	1	1	1	1
Scaling factor for frequency of evacuation route	0.0001	1.0000													
Average improvement case vehicle miles traveled for general link strategies, VMT			1,188,000	297,000,000		5,940,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000
Auto			1,069,200	267,300,000		5,346,000,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck			118,800	29,700,000		594,000,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Average speed for general link strategies, mph			55.1	55.1			47.1	47.1	47.1	47.1	55.1	55.1	55.1	55.1	55.1
Emissions from AUTOS, tons	kg/short ton														
NOX	907.19		0.1401	35.01		761.0	0.00	88.02	66.93	50.84	35.01	35.01	35.01	35.01	35.01
CO2	Conversion		320.4440	80,111.01		1,542,057.4	0.00	88,552.31	88,760.44	84,968.57	80,111.01	80,111.01	80,111.01	80,111.01	80,111.01
VOC	1,000		0.0494	12.35		267.2	0.00	20.00	23.19	18.37	12.35	12.35	12.35	12.35	12.35
PM			0.0052	1.30		28.6	0.00	2.15	1.92	1.70	1.30	1.30	1.30	1.30	1.30
SO2			0.0021	0.53		11.2	0.00	1.07	0.90	0.73	0.53	0.53	0.53	0.53	0.53
Emissions from TRUCKS, tons															
NOX			0.5411	135.27		2,701.8	0.00	196.27	179.17	160.06	135.27	135.27	135.27	135.27	135.27
CO2			208.9000	52,225.01		1,001,725.5	0.00	55,847.08	55,378.45	54,909.83	52,225.01	52,225.01	52,225.01	52,225.01	52,225.01
VOC			0.0297	7.42		149.6	0.00	11.34	10.29	9.25	7.42	7.42	7.42	7.42	7.42
PM			0.0189	4.72		99.6	0.00	9.06	8.03	7.00	4.72	4.72	4.72	4.72	4.72
SO2			0.0018	0.46		8.8	0.00	0.48	0.48	0.48	0.46	0.46	0.46	0.46	0.46
SAVINGS	calculated	intermediate	override	used in calcs		growth (%)									
Emissions avoided from AUTOS, tons															
NOX	(0.00)	(0.00)		(0.00)	(0.26)	(4.1)	0.00	0.00	0.00	0.00	(0.26)	(0.26)	(0.26)	(0.26)	(0.26)
CO2	12.26	12.26		12.26	3,065.70	49,051.1	0.00	0.00	0.00	0.00	3,065.70	3,065.70	3,065.70	3,065.70	3,065.70
VOC	0.00	0.00		0.00	1.21	19.5	0.00	0.00	0.00	0.00	1.21	1.21	1.21	1.21	1.21
PM	0.00	0.00		0.00	0.18	2.8	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18
SO2	0.00	0.00		0.00	0.02	0.3	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02

Non-Fuel Vehicle Operating Cost Savings Calculations

The Non-Fuel Vehicle Operating Cost Savings Calculations sheet estimates the change in vehicle operating costs, other than fuel, due to the TSM&O strategies implemented. Specifically, changes in VMT and speed can affect total spending over time on oil, tires, and vehicle maintenance and repair, as well as impact the rate of vehicle depreciation. Similar to the emission savings methodology, the change in non-fuel vehicle operating costs is based on the change in speed and VMT caused by other impacts. An average VMT and VHT are calculated for all link-based strategies, which is used to calculate average speed. These average roadway performance measures are used to calculate the non-fuel vehicle operating costs in the improvement case. The change in non-fuel vehicle operating costs (due to changes in speed and VMT) are calculated directly for the HOT Lanes and Ramp Metering strategies. These results are then used on the Benefit Cost Calculation sheet to combine the benefits across strategies from non-fuel vehicle operating cost savings.[18]

As with other TransValU modules, users have the option of using unit operating consumption rates and cost data from Highway Economic Requirements System (HERS).

Calculations for link-based strategies are separated by blue horizontal banners, HOT Lanes strategy calculations with orange banners, and Ramp Metering strategy calculations with purple banners. Columns C and D include calculated results per period, with the user override option in Column E. Columns F and G show the final estimates used in the tool calculations, per period and per year, respectively. Columns J through AM calculate the annual values, and Column I

[18] Note that often an improvement in speed will lead to higher non-fuel vehicle operating costs based on the HERS unit consumption rates.

aggregates the annual estimates over the period of analysis and reports totals in *green italicized text*.

Figure 17 provides a partial screenshot of the Non-Fuel Vehicle Operating Cost Savings Calculations sheet.

Figure 17: Non-Fuel Vehicle Operating Cost Savings Calculations – Sample Screenshot

Calculations of Non-Fuel Vehicle Operating Cost Savings							Year	2019	2020	2021	2022	2023
							Analysis Index	1	1	1	1	1
1 COMBINED LINK STRATEGIES	per period		2020	annual								
IMPROVEMENT CASE	calculated			used in calcs		used in calcs	growth (%)					
Earliest opening year of an active general links strategy	2020	active adj. factor					16	0	1	1	1	1
Scaling factor for frequency of evacuation route	0.0055	1.0000										
Average improvement case vehicle miles traveled for general link strategies, VMT				1,188,000		297,000,000	5,940,000,000	297,000,000	297,000,000	297,000,000	297,000,000	297,000,000
Auto				1,069,200		267,300,000	5,346,000,000	267,300,000	267,300,000	267,300,000	267,300,000	267,300,000
Truck				118,800		29,700,000	594,000,000	29,700,000	29,700,000	29,700,000	29,700,000	29,700,000
Average speed for general link strategies, mph				49.3		49.3		47.1	49.3	49.3	49.3	49.3
2 **Non-fuel vehicle operating unit consumption rates for AUTOS, units per 1,000 miles**												
Oil, quarts per 1,000 VMT				1.30		1.30		1.35	1.30	1.30	1.30	1.30
Tires, % of wear per 1,000 VMT				0.39%		0.39%		0.35%	0.39%	0.39%	0.39%	0.39%
M&R, % of average cost per 1,000 VMT				69.47%		69.47%		67.55%	69.47%	69.47%	69.47%	69.47%
Depreciation, % of vehicle value per 1,000 VMT				0.61%		0.61%		0.62%	0.61%	0.61%	0.61%	0.61%
3 **Non-fuel vehicle operating unit consumption rates for TRUCKS, units per 1,000 miles**												
Oil, quarts per 1,000 VMT				2.11		2.11		2.13	2.11	2.11	2.11	2.11
Tires, % of wear per 1,000 VMT				0.68%		0.68%		0.61%	0.68%	0.68%	0.68%	0.68%
M&R, % of average cost per 1,000 VMT				72.08%		72.08%		69.54%	72.08%	72.08%	72.08%	72.08%
Depreciation, % of vehicle value per 1,000 VMT				0.30%		0.30%		0.31%	0.30%	0.30%	0.30%	0.30%
Non-fuel vehicle operating costs for AUTOS, $		unit costs		$285,925		$71,481,205	$1,428,748,114	$71,262,208	$71,481,205	$71,481,205	$71,481,205	$71,481,205
Oil	tires per veh	$10	$ per quart	$14,154		$3,538,440	$71,246,233	$3,657,799	$3,538,440	$3,538,440	$3,538,440	$3,538,440
Tires	4	$88	$ per tire	$1,473.54		$368,384	$7,214,542	$330,098	$368,384	$368,384	$368,384	$368,384
Maintenance & Repair	conversion fact.	$176	$ per 1,000 miles	$130,874		$32,718,410	$650,750,664	$31,814,025	$32,718,410	$32,718,410	$32,718,410	$32,718,410
Vehicle Depreciation	1,000	$21,517	$ per vehicle	$139,423.88		$34,855,971	$699,536,675	$35,460,286	$34,855,971	$34,855,971	$34,855,971	$34,855,971
Non-fuel vehicle operating costs for TRUCKS, $				$90,265		$22,566,284	$449,799,527	$22,184,746	$22,566,284	$22,566,284	$22,566,284	$22,566,284
Oil	tires per veh	$4	$ per quart	$1,018		$254,397	$5,100,121	$257,441	$254,397	$254,397	$254,397	$254,397
Tires	6	$582	$ per tire	$2,804		$701,062	$13,733,351	$629,091	$701,062	$701,062	$701,062	$701,062
Maintenance & Repair	conversion fact.	$614	$ per 1,000 miles	$52,576		$13,143,949	$261,025,863	$12,680,670	$13,143,949	$13,143,949	$13,143,949	$13,143,949
Vehicle Depreciation	1,000	$94,632	$ per vehicle	$33,868		$8,466,876	$169,940,191	$8,617,544	$8,466,876	$8,466,876	$8,466,876	$8,466,876
SAVINGS	calculated	intermediate	override	used in calcs			growth (%)					
Non-fuel vehicle operating cost savings for AUTOS, $							($3,503,950)	$0	($218,997)	($218,997)	($218,997)	($218,997)
Oil	$477	$477		$477		$119,360	$1,909,753	$0	$119,360	$119,360	$119,360	$119,360
Tires	($153)	($153)		($153)		($38,286)	($612,379)	$0	($38,286)	($38,286)	($38,286)	($38,286)

Navigating the Tool

This section provides a detailed walk-through of each user-enabled sheet in the TSM&O Module, describing the user requirements on each sheet.

Note that all critical equations and data tabs used in the background are locked or hidden to the user, to avoid unintended modifications and allow for continuity between model runs. A new copy of the TSM&O Module should be saved each time a new improvement is evaluated. Each copy of the TSM&O Module should include in its filename the study area and name of the improvement being evaluated.[19]

Parameters Sheet

Users can view key assumptions and model parameters on the Parameters sheet. In particular, there are two sets of values the user can choose between on the Parameters sheet—either the TOPS-BC Version 1.2 values, or the recommended values, based on USDOT guidance and the Florida context. To select the TOPS-BC values, the user should click "**Use TOPS-BC 1.2 Values**" button at the top of the sheet. To use the recommended values, click "**Use Recommended**". Clicking either of these buttons will populate Column B, the active parameter values used in the tool. Note that electing to use the TOPS-BC 1.2 Values will automatically exclude two benefit categories from the analysis: emission cost savings, and non-fuel vehicle operating cost savings.

While it is not recommended that the user adjust the parameter values on this sheet, he or she may wish to adjust the real discount rate, highlighted in **purple text** on the Parameters sheet. By default, the tool uses a real discount rate of 4 percent, the value recommended by FDOT for

[19] Consistent folder and file naming conventions should help avoid confusing different TransValU TSM&O improvement analyses.

project evaluations within the State.[20] However, USDOT recommends a real discount rate of 7 percent for BCAs in support of BUILD and INFRA grant applications. Thus the user may wish to perform sensitivity testing by altering the discount rate and viewing the impact on BCA results. To adjust the discount rate, edit the value with the blue background in Column E.

There are three drop-down menus to select from on the Parameters sheet, indicated by dark blue cells. The first drop-down menu (located in **cell B9**) allows the user to select the default volume used in the tool for calculating incremental changes between the base case and improvement case. The options include: base case volume, improvement case volume, or the minimum of the two.[21] The default value is set to 'minimum' as this will yield the most conservative estimates.

The next drop-down menu (**cell B34**), allows the user to select the method for estimating vehicle operating cost savings. Options include: TOPS-BC,[22] or HERS. Clicking the "**Use TOPS-BC 1.2 Values**" button at the top of the sheet will automatically select the 'TOPS-BC' method, and the 'HERS' method will automatically be selected by clicking the "**Use Recommended**" button. However, the user can choose to override the vehicle operating cost method in use.

The final drop-down menu (**cell B56**) selects the source of crash rate data. Options include: NHTSA, or FDOT. The NHTSA crash rates are used in the TOPS-BC tool. These are national crash rates based on the v/c ratio, crash severity, and facility type. The FDOT option uses Florida district-level crash rates, by severity, from the Florida Integrated Report Exchange System (FIRES), and VMT from the FDOT highway mileage reports. Clicking the "**Use TOPS-BC 1.2 Values**" button at the top of the sheet will automatically select the 'NHTSA' method, and the 'FDOT' method will automatically be selected by clicking the "**Use Recommended**" button. However, the user can choose to override the crash rate data in use.

Data Needs Sheet

This sheet describes the data needed to run the TSM&O Module. No action is required by the user on this tab. A copy of the table can be found in this User Guide, as Table 1.

Inputs Sheet

The Inputs sheet is where users can enter all relevant cost, schedule, and transportation data required to run the BCA. This section provides a detailed description of all the input data that the user will need to provide in the tool, and all other actions the user can take on this sheet.

As noted earlier, the legend in the top right corner of the Inputs sheet shows the formatting conventions used for input tables and results within TransValU. The button in the top left corner (Review BCA Calculations) provide a hyperlink shortcut to the Benefit Cost Calculations sheet.

The Inputs sheet contains seven tables, including both required and optional inputs. Table A requires information on the strategy or set of strategies that the user wishes to evaluate in the

[20] FDOT, "Macroeconomic Analysis of Florida's Transportation Investments". January 2015. Appendix B-6. Accessed on 12/29/2016 at: http://www.fdot.gov/planning/policy/economic/macroimpacts0115.pdf.

[21] While most of the tool calculations estimate savings by comparing the total benefits and costs in the base case to the total benefits and costs in the improvement case, there are instances when only the 'increment' (change) can be calculated. In these cases, the volume selected by the user on the Parameters sheet will determine how this calculation is performed.

[22] TOPS-BC only quantifies fuel cost savings. Method includes a fixed miles per gallon by vehicle type multiplied by a fixed dollar per gallon value.

BCA. The table includes 18 strategy options, with several sub-options/types, organized into seven improvement categories. For each strategy, the user must enter the information described below.

Table A – TSM&O Strategies

1. **Include strategy? (Yes=1, No=0)** Enter 1 or 0 in Column C to include or exclude a strategy in the analysis.[23] Entering a 0 will grey out the remaining table inputs for that particular strategy.
2. **Specify strategy type (if applicable)**. Some strategies require further specification on the type of TSM&O improvement to be implemented. For these relevant strategies, choose from a drop-down menu in Column D to select a specific strategy type. For example, if the user selects the Dynamic Message Sign (DMS) strategy, he or she will need to further select if the sign will be used to provide comparative travel times, congestion warning, or alternative routes/modes; or if the user selects Traffic Signal Retiming, s/he will need to also select between Preset Control and Adaptive Control from the drop-down menu.
3. **Number of infrastructure deployments**. Enter the number of infrastructure deployments in Column E for each strategy selected. This is the equipment required to implement the strategy. For example, one type of infrastructure element required to implement the DMS strategy is the traffic management center (TMC) hardware for information dissemination. The user should visit the Improvement Cost Calculations sheet to view all suggested infrastructure elements by strategy.
4. **Number of incremental deployments**. Enter the number of incremental deployments in Column F for each strategy selected. This is the supporting equipment required for the infrastructure deployments. For example, one type of incremental equipment element required to implement the DMS strategy is a communication line for traveler information. The user should visit the Improvement Cost Calculations sheet to view all suggested incremental deployment elements by strategy
5. **Year of deployment**. Enter the year of deployment in Column G for each strategy. By default, the tool assumes that the strategies "open" in the same year they are deployed.[24]
6. **Model category**. Column H indicates the 'model type' of each strategy in the TransValU TSM&O tool. Specifically, the HOT Lanes and Ramp Metering strategies are modeled separately. All other strategies in the tool are considered 'link-based' strategies, since these effects can be aggregated and applied to the same link segment. No user inputs are required for this table element.

A completed sample of Table A on the Inputs sheet is shown below in Figure 18. Once the inputs have been entered in Table A for the specific project being evaluated, proceed to Table B, TSM&O Improvement Details.

[23] Note that turning off a strategy will not turn off all calculations associated with this strategy everywhere in the tool, but it will turn off the benefits and costs of this strategy on the Benefit Cost Calculations sheet, and the strategy will not be considered in the overall BCA metrics and results.

[24] This same assumption is made in TOPS-BC Version 1.2

Figure 18: Inputs, Sample Table A – TSM&O Strategies, Screenshot

A - TSM&O STRATEGIES

	Include Strategy? (Yes=1, No=0)	Specify Strategy Type (if applicable)	Number of Infrastructure Deployments	Number of Incremental Deployments	Year of Deployment	Model Category
GENERIC LINK MODEL	0		3	1	2020	Link Models
TRAVELER INFORMATION						
Dynamic Message Sign (DMS)	1	Comparative travel times	2	2	2020	Link Models
Highway Advisory Radio (HAR)	0	Alternative route/mode	3	1	2020	Link Models
Pre-Trip Traveler Information	0		3	1	2020	Link Models
TRAFFIC SIGNAL COORDINATION SYSTEMS						
Traffic Signal Coordination Systems	0	Traffic Actuated	3	1	2020	Link Models
Traffic Signal Retiming	0	Actuated/ Preset Control	3	1	2020	Link Models
OTHER FREEWAY SYSTESM						
Traffic Incident Management	0		3	1	2020	Link Models
RAMP METERING SYSTEMS	0	Central Control	3	1	2020	Ramp Model
ACTIVE TRANSPORTATION AND DEMAND MANAGEMENT						
Speed Harmonization	0		3	1	2020	Link Models
Hard Shoulder Running	0		3	1	2020	Link Models
Hard Shoulder Running for Evacuation Route	0		3	1	2020	Link Models
Bus on Shoulder	0		3	1	2020	Link Models
costs only) Employer Based Travel Demand Management (TDM) Program	0		3	1	2020	Link Models
* High Occupancy Toll (HOT) Lanes	0	Method 2	3	1	2020	HOT Model
OTHER STRATEGIES						
Road Weather Management	0		3	1	2020	Link Models
Work Zone Systems	0		3	1	2020	Link Models
sts only) Traffic Management Center (TMC)	0		3	1	2020	Link Models
s only) Loop Detection	0		3	1	2020	Link Models
sts only) Closed-Circuit Television (CCTV)	0		3	1	2020	Link Models

Table B – TSM&O Improvement Details

All elements in Table B are required for the BCA.

1. **Improvement/alternative name**. Enter the name of the improvement to be evaluated in this analysis in **cell C39**.
2. **Scenario #**. Select a scenario number from a drop-down menu to help identify the TSM&O improvement being analyzed. Scenario numbers can range from 1 to 10.
3. **Years of analysis (after first year).** Enter the model length of analysis.
4. **Last year of analysis.** The last year of analysis is displayed in **cell C42**. This value changes depending on the 'years of analysis' entered in the previous step of this table, and the 'first year of analysis' entered on the Parameters sheet. No user input is required in this step.
5. **Year of BASE CASE data**. Enter the year of data used for the base case estimates provided on this sheet.
6. **Length of period, hours per day**. Enter the number of hours per day to be considered in the period. Note that the annual results produced by the TransValU TSM&O are based on the data provided per period, not a full day.
7. **Annualization factor, number of periods per year**. Enter the annualization factor to scale up values per period to values per year.

A completed sample of Table B is shown in Figure 19. Once the improvement details have been entered in Table B, proceed to Table C.

Figure 19: Inputs, Sample Table B – TSM&O Improvement Details, Sample Screenshot

B - TSM&O IMPROVEMENT DETAILS	
Improvement/alternative name	Dynamic message sign implemented on Freeway A
Scenario #	1
Years of analysis (after first year)	20
Last year of analysis	2035
Year of BASE CASE data	2017
Length of period, hours per day	3
Annualization factor, number of periods per year	250

Table C – Facility Details and Traffic

All elements in Table C are required for the BCA.

1. **Select district or county of planned TSM&O improvement**. Select the location of the improvement from the drop-down menu in **cell C48**. Users can select from one of Florida's seven districts, or one of the nine counties within District 5.
2. **Select area type**. Select the area type of the targeted location for the TSM&O improvement. Select either urban or rural from the drop-down menu in **cell C49**.
3. **Select roadway access type**. Select the roadway access type (restricted or unrestricted) in **cell C50**. The roadway access type is used to select the most accurate emission rates.
4. **Percent truck traffic, %**. Enter the percent of truck traffic on the targeted facility for the TSM&O improvement. The suggested value from TOPS-BC Version 1.2 is provided in **cell E52**.
5. **Average annual growth in traffic, %**. Enter the average annual growth in traffic expected at the targeted facility for the TSM&O improvement.

A completed sample of Table C is shown in Figure 20.

Figure 20: Inputs, Sample Table C – Facility Details and Traffic, Sample Screenshot

C - FACILITY DETAILS AND TRAFFIC	
Select district or county of planned TSM&O improvement	District 5
Select area type	Urban
Select roadway access type	Unrestricted
Facility type	Principal Arterial
Percent truck traffic, %	10.0%
Average annual growth in traffic, % *	0.0%

Table C1 – Link Models

The following data applies only to the link-based models. As explained in Table A, these are for all strategies apart from the HOT Lanes, and Ramp Metering. This data is required if the user has selected one or more link-based models in Table A.

1. **Link length, miles**. Enter the length of the roadway segment expected to be affected by the TSM&O improvement.
2. **Free flow speed, mph**. Enter the free flow speed in the targeted link segment. The suggested value from TOPS-BC Version 1.2 is provided in **cell E60**. Note that this value changes depending on the facility type selected in Table C.

3. **Traffic volume, vehicles per period**. Enter the traffic on the targeted roadway segment in base case for the year indicated in the table.
4. **Number of lanes (both directions)**. Enter the total number of lanes on the targeted roadway segment in base case.
5. **Capacity, vehicles per hour per lane**. Enter the roadway capacity in the base case. The suggested value from TOPS-BC Version 1.2 is provided in **cell E63**. Note that this value changes depending on the facility type selected in Table C.
6. **Capacity, vehicles per period**. The total capacity per period is calculated based on the capacity per hour per lane entered in the previous step. No user input is required for this step.
7. **[Contingent] Number of people accessing information, persons per period**. If the user included the Pre-Trip Traveler Information strategy in the analysis (see Table A), then the user must enter the estimated number of persons accessing the information.
8. **[Contingent] Growth rate in people accessing information, %**. If the user included the Pre-Trip Traveler Information strategy in the analysis (see Table A), then the user must enter the estimated average annual growth over time in people accessing information from the improvement.
9. **[Contingent] Average number of days shoulder is open for evacuation, days per year**. If the user included the Hard Shoulder Running for Evacuation Route strategy in the analysis (see Table A), then the user must estimate the number of days per year that the shoulder will be open for evacuation.
10. **[Contingent] Scaling factor for frequency of evacuation route**. Based on the information provided in the previous step of this table, the tool calculates a scaling factor to apply to benefits from the Hard Shoulder Running for Evacuation Route strategy. No user input is required in this step.

A completed sample of Table C1 is shown in Figure 21.

Figure 21: Inputs, Sample Table C1 – Link Models, Sample Screenshot

C1- LINK MODELS

Link length, miles	100

	BASE CASE 2017
Free flow speed, mph	55
Traffic volume, vehicles per period	11,880
Number of lanes (both directions)	2
Capacity, vehicles per hour per lane	2,200
Capacity, vehicles per period	13,200
If Improvement(s) include Pre-Trip Traveler Information:	
Number of people accessing information, persons per period	10,000
Growth rate in people accessing information, %	0.0%
If Improvement(s) include Hard Shoulder Running for Evacuation Route	
Average number of days shoulder is open for evacuation, days per year	2

Table C2 – HOT Lane Models

The following data applies only to the HOT Lanes strategy. If the user did not select this strategy in Table A, skip Table C2.

1. **Link length for HOV/HOT strategy, miles**. Enter the length of the roadway segment where the HOV lane(s) will be converted to HOT lane(s).

HOV Lanes

2. **Free flow speed, mph**. Enter the free flow speed on the HOV lane(s). The suggested value from TOPS-BC Version 1.2 is provided in **cell E78**. Note that this value changes depending on the facility type selected in Table C.
3. **Traffic volume, vehicles per period**. Enter the traffic on the HOV lane(s) in the base case for the year indicated in the table.
4. **Number of lanes (both directions)**. Enter the total number of HOV lanes to be converted to HOT lanes.
5. **Capacity, vehicles per hour per lane**. Enter the capacity per HOV lane per hour. The suggested value from TOPS-BC Version 1.2 is provided in **cell E81**. Note that this value changes depending on the facility type selected in Table C.
6. **Capacity, vehicles per period**. The total capacity per period on the HOV lane(s) is calculated based on the capacity per hour per lane entered in the previous step. No user input is required for this step.

GP Lanes

For the following variables, the user can either enter each value directly, or click the "**Use Table C1 Link Data**". Clicking this button will automatically populate the GP Lanes data in Table C2 with the values entered in Table C1.

7. **Free flow speed, mph**. Enter the free flow speed on the GP lane(s). The suggested value from TOPS-BC Version 1.2 is provided in **cell E84**. Note that this value changes depending on the facility type selected in Table C.
8. **Traffic volume, vehicles per period**. Enter the traffic on the GP lane(s) in the base case for the year indicated in the table.
9. **Number of lanes (both directions)**. Enter the total number of GP lanes.
10. **Capacity, vehicles per hour per lane**. Enter the capacity per GP lane per hour. The suggested value from TOPS-BC Version 1.2 is provided in **cell E87**. Note that this value changes depending on the facility type selected in Table C.
11. **Capacity, vehicles per period**. The total capacity per period on the GP lane(s) is calculated based on the capacity per hour per lane entered in the previous step. No user input is required for this step.

A completed sample of Table C2 is shown in Figure 22.

Figure 22: Inputs, Sample Table C2 – Hot Lane Model, Sample Screenshot

C2- HOT LANE MODEL

Length of link for HOV/HOT strategy, miles	9.0

		BASE CASE 2017
HOV Lanes		
	Free flow speed, mph	66
	Traffic volume, vehicles per period	8,877
	Number of lanes (both directions)	2
	Capacity per hour per lane	2,200
	Capacity, vehicles per period	13,200
GP Lanes		
Use Table C1 Link Data	Free flow speed, mph	57
	Traffic volume, vehicles per period	17,397
	Number of lanes (both directions)	4
	Capacity per hour per lane per hour	2,200
	Capacity, vehicles per period	26,400

Table C3 – Ramp Model

The following data applies only to the Ramp Metering strategy. If the user did not select this strategy in Table A, skip Table C3.

1. **Number of metered ramps to be implemented in IMPROVEMENT CASE**. Enter the number of ramps to be implemented.
2. **Ramp length, miles**. Enter the length of the ramp(s) to be implemented.
3. **Link length for Ramp Metering strategy, miles**. Enter the length of the roadway link segment affected by the ramp metering.

Ramps

4. **Free flow speed, mph**. Enter the free flow speed on the ramp(s). The suggested value from TOPS-BC Version 1.2 is provided in **cell E98**.
5. **Traffic volume, vehicles per ramp per period**. Enter the traffic (both directions) per ramp per period in the base case for the year indicated in the table.
6. **Number of lanes per ramp**. Enter the number of ramp lanes (per ramp) to be metered.
7. **Capacity, vehicles per hour per lane**. Enter the capacity per ramp lane per hour. The suggested value from TOPS-BC Version 1.2 is provided in **cell E101**.
8. **Capacity, vehicles per period**. The total capacity per period on the ramp lane(s) is calculated based on the capacity per hour per lane entered in the previous step. No user input is required for this step.

General Links

For the following variables, the user can either enter each value directly, or click the "**Use Table C1 Link Data**". Clicking this button will automatically populate the general links data in Table C3 with the values entered in Table C1.

9. **Free flow speed, mph**. Enter the free flow speed on the roadway lane(s). The suggested value from TOPS-BC Version 1.2 is provided in **cell E104**. Note that this value changes depending on the facility type selected in Table C.
10. **Traffic volume, vehicles per period**. Enter the traffic on the roadway lane(s) in the base case for the year indicated in the table.
11. **Number of lanes (both directions)**. Enter the total number of lanes on the roadway affected by the ramp metering.
12. **Capacity, vehicles per hour per lane**. Enter the roadway capacity per lane per hour. The suggested value from TOPS-BC Version 1.2 is provided in **cell E107**. Note that this value changes depending on the facility type selected in Table C.
13. **Capacity, vehicles per period**. The total roadway capacity per period is calculated based on the capacity per hour per lane entered in the previous step. No user input is required for this step.

A completed sample of Table C3 is shown in Figure 23.

Figure 23: Inputs, Sample Table C3 – Ramp Model, Sample Screenshot

C3- RAMP MODEL

Number of metered ramps to be implemented in IMPROVEMENT CASE	2
Ramp length, miles	0.3
Link length for Ramp Metering strategy, miles	1.0

		BASE CASE 2017
Ramps		
	Free flow speed, mph	35
	Traffic volume, vehicles per ramp per period	3,000
	Number of lanes per ramp	1
	Capacity, vehicles per hour per lane	1,600
	Capacity, vehicles per period	4,800
General Links		
Use Table C1 Link Data	Free flow speed, mph	55
	Traffic volume, vehicles per period	19,000
	Number of lanes (both directions)	2
	Capacity, vehicles per hour per lane	2,200
	Capacity, vehicles per period	13,200

Table D – Impacts due to TSM&O Strategies

Table D includes the strategy impact data provided in TOPS-BC Version 1.2. Each of the 14 strategies with roadway improvements modeled in the tool is included in the table rows.[25] The

[25] Note that three of the strategies included in Table A are not listed in Table D (Employer Based TDM Program, Traffic Management Center, Loop Detection, and Closed-Circuit Television). This is because these strategies are modeled to only have costs, and do not produce benefits independently. This is based on the methodology from TOPS-BC Version 1.2.

columns list all of the potential impacts that these strategies can impose (e.g. change in speed, change in fuel consumption, and others).

Table D comes populated with strategy impact data provided in TOPS-BC Version 1.2. No user inputs are required for these strategies. However, the user can choose to override the strategy data if he or she has other data specific to the improvements being evaluated. To override the data, enter the new values in the blue cells corresponding to the strategy and impact desired.

For HOT Lanes, the tool will only consider the impact data entered in Table D if Method 2 was selected in Table A, as this indicates that the change in capacity is specified exogenously. If Method 1 was selected in Table A, then the strategy data will be greyed out, and no inputs are required from the user.

The Generic Link Model does not come populated with any strategy data. This is because it is considered a 'blank' strategy, available for the user to enter his or her own data. If the user does not enter any strategy impact data for the Generic Link Model in Table D, the tool will not calculate benefits for this strategy.

For the new strategies included in TransValU TSM&O (orange text), Table D includes some strategy impact data. Specifically, the Traffic Signal Retiming and Hard Shoulder Running for Evacuation Route include suggested values, but not the Bus on Shoulder strategy. These values are based on a literature review performed by HDR. The user can choose to keep these values, or override the data with his or her own values.

To return to the default values originally provided in Table D, click the "**Use Default Values**" button in the top left corner of the table. After clicking this button, the user cannot 'undo' the action. Thus, if the user wishes to save the data entered into Table D manually, first save a copy of the tool before clicking the button. Additionally, clicking the "**Use Default Values**" button automatically creates a copy of Table D and pastes this version of the table in **cell P112**. This provides the user with a copy of any changes made to Table D by the user.

A completed sample of Table D is shown in Figure 24.

Figure 24: Inputs, Sample Table D – Impacts due to TSM&O Strategies, Sample Screenshot

REQUIRED: click "use default values" to update table each time user changes strategies in Table.

D - IMPACTS DUE TO TSM&O STRATEGIES

A negative "change" value represents a decrease in the improvement case (e.g. a negative 'change in crash rate' represents a lower crash rate in the improvement case)

Use Default Values	Change in Speed (%)	Change in Link Capacity (%)	Change in Ramp Capacity (%)	Change in Lanes (#)	Change in Crash Rate (%)	Change in Crash Duration (%)	Change in Fuel Consumption (%)	Percent of time ATIS device is disseminating useful information (%)	Percent of drivers/ people using the ATIS information (%)	Time saved by drivers/people using information from ATIS deployment (minutes)
GENERIC LINK MODEL										
TRAVELER INFORMATION										
Dynamic Message Sign (DMS): Comparative travel times								25.0%	10.0%	4.00
Highway Advisory Radio (HAR): Alternative route/mode								1.0%	5.0%	7.00
Pre-Trip Traveler Info									22.0%	7.00
TRAFFIC SIGNAL COORDINATION SYSTEMS										
Traffic Signal Coordination Systems: Traffic Actuated		10.0%			-2.0%		-5.0%			
Traffic Signal Retiming: Actuated/ Preset Control	16.0%	17.5%			-4.5%		-5.0%			
OTHER FREEWAY SYSTESM										
Traffic Incident Management**					0.0%	-40.0%				
RAMP METERING SYSTEMS										
Central Control		12.0%	-35.0%		-12.0%		-10.0%			
ACTIVE TRANSPORTATION AND DEMAND MANAGEMENT										
Speed Harmonization					-7.0%					
Hard Shoulder Running				0.5						
Hard Shoulder Running for Evacuation Route				0.5						
Bus on Shoulder										
High Occupancy Toll (HOT) Lanes: Method 2										
OTHER STRATEGIES										
Road Weather Management	5.0%	5.0%			-7.0%			5.0%	10.0%	5.00
Work Zone Systems	5.0%				-5.0%	-10.0%				

Benefit Cost Calculations Sheet

The Benefit Cost Calculations sheet allows the user to review all of the total benefits and costs of all the strategies included in the BCA, and the overall BCA metrics calculated. Strategies excluded from the analysis will be greyed out.

There is one key input required from the user on this sheet—the selection of the method for aggregating benefits across strategies. In the top of the sheet in **cell C6**, the user must select from a drop-down menu from the following aggregation options: average, summation, or maximum (see Figure 25). When selecting the aggregation method, the user should note that sometimes strategies will yield dis-benefits (negative benefits) for certain benefit categories. In this case, averaging these results may not yield the most accurate aggregate results. The user should also note that the TOPS-BC uses summation to aggregate all benefits.

Figure 25: Benefit Cost Calculations, Aggregation Drop-Down Menu

This is also the first sheet in the tool that includes user override cells. The override feature is only available for certain variables in the tool, all of which are identified by bright green cells. To override the calculated value, enter the new data into the blank green cell. The calculated results in Columns J through AM will automatically update with the new values. On the Benefit Cost Calculations sheet, the user can choose to override the aggregate costs and benefits across strategies, by cost type and benefit category. For example, Figure 26 below illustrates the use of override cells to replace the calculated total vehicle hours saved from reduced recurring congestion from all strategies selected. By filling out any of the green cells on this sheet, the tool will automatically override the calculated results with those entered by the user.

Figure 26: Benefit Cost Calculations, Example of Override Cells

	--OVERRIDE--			TRUE		
TOTAL VEHICLE HOURS SAVED, VHT	VHT saved per year	opening year	growth	4,162	0	200
Auto	100	2017	1%	2,081	0	100
Truck	100	2017	1%	2,081	0	100
TRAVEL TIME SAVINGS, $	$ per hour	veh occupancy	growth	$102,232	$0	$4,912
Auto	$14.77	1.39	2017	$42,713	$0	$2,052
Truck	$28.60	1	0%	$59,519	$0	$2,860

Users should also visit the Benefit Cost Calculations sheet if they wish to clear override cells, and thus use the calculated results in the tool. In the top left corner of the sheet, click "**Clear Overrides on this Sheet**" to clear all override values filled out on the Benefit Cost Calculations sheet, or click the "**Clear All Overrides in Tool**" to clear all the override values filled out anywhere in the tool. Note that after clicking these buttons, the user cannot 'undo' this action to restore previous override values. Thus, it is important to first save a version of the tool with the overrides if the user wishes to keep these results. Finally, the user can review the summary results on the BCA Results sheet by clicking the "**Review BCA Results**" button.

Towards the bottom of this sheet, there is a drop-down menu allowing the user to toggle on/off the two benefit categories additional to TOPS-BC: emission cost savings and non-fuel vehicle operating cost savings. The default should be to leave this toggle on. However, if the user wishes to compare results to the TOPS-BC, he or she can turn off these additional benefit categories for a more direct comparison. Note that this toggle is automatically turned off if the user elects to "**Use TOPS-BC 1.2 Values**" on the Parameters sheet.

BCA Results Sheet

The BCA Results sheet allows the user to view summary BCA results by benefit and cost category, as well as total benefits and costs in present value terms, the net present value, benefit-cost ratio, breakeven year, and overall rate of return of the TSM&O improvement(s) analyzed. Negative values are highlighted in red font.

The user can also choose to view results in different units, selecting from a drop-down menu to either display results in terms of dollars, thousands of dollars, or millions of dollars. All monetary values are presented in constant dollars, and the dollar year is entered on the Parameters sheet.

Once the user is done viewing the summary results, he or she can click the "**View Multi Project Results**" button on the top left of the screen. This will direct the user to the BCA Multi Project Results sheet where the same summary results are displayed, but can be viewed for multiple projects at once.

BCA Multi Project Results Sheet

The Multi Project Results sheet allows the user to compare BCA results of several different improvement strategies or alternatives side-by-side. Once the user has filled out the Inputs sheet for one improvement alternative, go to the BCA Multi Project Results sheet and click the "**Save BCA Results**" button located in the top left of the tab. The tool will save the current results to the right of the last set of saved results.

Note that users should check that macros are enabled for this feature to work properly. Up to 10 scenario results can be saved at once. To reset the saved results and start again, click the "**Delete All Saved Results**" button. This will delete all saved results. If the user wishes to keep the original saved projects, copy results to a separate Excel workbook prior to deleting results.

Improvement Cost Calculations Sheet

The Improvement Cost Calculations sheet calculates the total costs, by strategy, of the overall TSM&O improvement. The user can choose to review this sheet, but for most strategies no inputs are required from the user. Instead, by default the tool uses cost data stored in the workbook.[26] However, the user can choose to override this data by entering values in the green override cells.

If the user selects one of the three strategies without data stored in the tool, he or she will need to visit the Improvement Cost Calculations worksheet to enter the cost data. These three strategies without data include:

- General Link Model;

[26] Cost data comes from TOPS-BC Version 1.2, inflated to the dollar year entered in the TransValU TSM&O.

- Hard Shoulder Running for Evacuation Route; or
- Bus on Shoulder.

When entering data for one of these three strategies, or overriding existing cost data in the tool for a different strategy, the user should only enter values in the green override cells. On this sheet, the user can choose to override the following variables:

- Equipment useful life, years (Column D);
- Unit capital costs, $ per deployment (Column D);
- Unit O&M costs, $ per year per deployment (Column D); and
- Unit labor costs, $ per year per deployment (Column D).

Base Case Calculations Sheet

The Base Case Calculations sheet calculates the roadway performance data (e.g. traffic, speed, capacity, etc.) and benefits-related measures (e.g. travel time, incident delay, crashes, and others) for the base case. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the following variables for the base case. Each variable is repeated for the Link model, HOT Lanes model, and Ramp Metering model.

- Average speed, mph (Column E); and
- Average annual growth in speed (Column H).

Improvement Case Calculations Sheet

The Improvement Case Calculations sheet calculates the roadway performance data (e.g. traffic, speed, capacity, etc.) in the improvement case for each strategy selected. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the following variables for the improvement case. These variables are repeated for each strategy selected on the Inputs sheet.

- Traffic volume, vehicles per period (Column E);
- Average annual growth in traffic, percent (Column H);
- Average speed, mph (Column E); and
- Average annual growth in speed, percent (Column H).

Travel Time Savings Calculations Sheet

The Travel Time Savings Calculations sheet calculates the travel time savings from reduced recurring delays due to the strategy or strategies selected. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the following variables, for each strategy selected. Note that only strategies with the potential to reduce recurring delays are included on the sheet.

- Vehicle hours saved from reduced recurring delay for autos, hours per period (Column E);

- Vehicle hours saved from reduced recurring delay for trucks, hours per period (Column E); and
- Average annual growth in vehicle hours saved, percent (Column H).

Incident Delay Savings Calculations Sheet

The Incident Delay Savings Calculations sheet calculates the travel time savings from reduced incident delays due to the strategy or strategies selected. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the following variables, for each strategy selected. Note that only strategies with the potential to reduce incident delays are included on the sheet.

- Vehicle hours of incident delay avoided for autos, hours per period (Column E);
- Vehicle hours of incident delay avoided for trucks, hours per period (Column E); and
- Average annual growth in delay avoided, percent (Column H).

ATIS Time Savings Calculations Sheet

This sheet calculates the travel time savings from deploying advanced traveler information system (ATIS) improvements. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the following variables, for each strategy selected. Note that only strategies that include ATIS improvements are included on the sheet.

- Vehicle hours of saved from ATIS improvements for autos, hours per period (Column E);
- Vehicle hours of saved from ATIS improvements for trucks, hours per period (Column E); and
- Average annual growth in vehicle hours saved, percent (Column H).

In addition to the override cells, the user also has the option (in column D) on this sheet to toggle on/off benefits to truck traffic for the following strategies:

- Generic Link Model;
- Dynamic Message Sign (DMS); and
- Highway Advisory Radio (HAR).

The default is to leave the toggle off, excluding benefits to trucks. This is the more conservative choice. Turning the toggle off implies that truck traffic will not use the information provided by the ATIS improvement(s) to change their travel decisions. The user should determine which case most accurately represents the truck traffic on the targeted area for TSM&O improvement(s) modeled, and turn the toggle on or off accordingly. Note that the TOPS-BC Version 1.2 excludes truck traffic when calculating benefits for these three strategies.

Safety Benefits Calculations Sheet

The Safety Benefits Calculations sheet calculates the reduced crashes due to the strategy or strategies selected. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the following variables, for each strategy selected. Note that only strategies with the potential for vehicle crashes are included on the sheet.

- Number of fatal crashes avoided, crashes per period (Column E);
- Number of injury crashes avoided, crashes per period (Column E);
- Number of property damage only (PDO) crashes avoided, crashes per period (Column E); and
- Average annual growth in crashes avoided, percent (Column H).

Fuel Savings Calculations Sheet

The Fuel Savings Calculations sheet calculates the reduction in fuel usage due to the strategy or strategies selected. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the following variables, for each strategy selected. Note that only strategies with the potential to result in a change in vehicle fuel usage are included on the sheet.

- Fuel consumption savings for autos, gallons per period (Column E);
- Fuel consumption savings for trucks, gallons per period (Column E);
- Average annual growth in fuel savings, percent (Column H).

Emissions Savings Calculations Sheet

The Emissions Savings Calculations sheet calculates the reduction in vehicle emissions due to the strategy or strategies selected. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the variables listed below. As explained earlier, the emission rates in the improvement case are calculated in the tool by estimating the average roadway conditions (VMT, VHT, and speed) for the strategies selected. Thus the following variables can be overridden for the combined general link strategies model, the HOT Lanes model, and/or the Ramp Metering model.

- Nitrogen oxide (NO_X) emissions avoided, tons per period (Column E);
- Carbon dioxide (CO_2) emissions avoided, tons per period (Column E);
- Volatile organic compound (VOC) emissions avoided, tons per period (Column E);
- Fine particulate matter (PM) emissions avoided, tons per period (Column E);
- Sulfur dioxide (SO_2) emissions avoided, tons per period (Column E); and
- Average annual growth in emissions avoided, percent (Column H).

Non-Fuel Vehicle Operating Cost Savings Calculations Sheet

This sheet calculates the non-fuel vehicle operating cost savings due to the strategy or strategies selected. The user can choose to review this sheet, but no inputs are required.

On this sheet, the user can choose to override the variables listed below. Similar to the emissions calculations, the non-fuel vehicle operating costs in the improvement case are calculated by estimating the average roadway conditions (VMT, VHT, and speed) for the strategies selected. Thus the following variables can be overridden for the combined general link strategies model, the HOT Lanes model, and/or the Ramp Metering model.

- Oil cost savings for autos, $ per period (Column E);
- Tire cost savings for autos, $ per period (Column E);
- Maintenance and repair cost savings for autos, $ per period (Column E);
- Vehicle depreciation cost savings for autos, $ per period (Column E);
- Average annual growth in non-fuel vehicle operating cost savings for autos, percent (Column H);
- Oil cost savings for trucks, $ per period (Column E);
- Tire cost savings for trucks, $ per period (Column E);
- Maintenance and repair cost savings for trucks, $ per period (Column E);
- Vehicle depreciation cost savings for trucks, $ per period (Column E); and
- Average annual growth in non-fuel vehicle operating cost savings for trucks, percent (Column H).

APPENDIX I: Data Sources

This appendix identifies the key data sources used the TransValU TSM&O Module. Note that only the 'recommended values' from the Parameters sheet are sourced below. The alternative parameters come from TOPS-BC Version 1.2. All TransValU modules use the same (recommended) assumptions, parameters, and methodologies, as applicable.

Table 2: Data Sources for the Valuation of Travel Time

Variable Name	Unit	Value	Source
Value of time for personal travel for AUTOS	$ per person-hour	$14.8	US DOT BCA Guidance for Discretionary Grant Programs, December 2018
Value of time for business travel for AUTOS	$ per person-hour	$26.5	ibid
Share of personal travel in total local travel	percent	88.2%	ibid
Share of business travel in total local travel	percent	11.8%	Ibid
Hourly earnings of truck drivers	$ per person-hour	$28.6	Ibid
Average Vehicle Occupancy for Automobiles	persons per vehicle	1.68	ibid
Average Vehicle Occupancy for Trucks	persons per vehicle	1.00	ibid
Annual growth in the value of time, in real terms	percent	0%	US DOT Guidance, September 2017

All dollar estimates are in dollars of 2017.

Table 3: Data Sources for Vehicle Operating Costs – HERS Method

Variable Name	Unit	Value	Source
Auto Operating Costs, Fuel	$ per gallon	varies by year	EIA, Annual Energy Outlook 2018 Release, Petroleum Product Prices
Auto Operating Costs, Oil	$ per quart	$10.16	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SS47021
Auto Operating Costs, Tires	$ per tire	$88.47	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SETC01
Auto Operating Costs, Maintenance and Repair	$ per vehicle per 1,000 mile	$176.19	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SETD
Auto Operating Costs, Vehicle Depreciation	$ per vehicle (depreciable value)	$21,517.43	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SS45011
Truck Operating Costs, Fuel	$ per gallon	*time dependent*	EIA, Annual Energy Outlook 2018 Release, Petroleum Product Prices
Truck Operating Costs, Oil	$ per quart	$4.06	HERS Technical Report, 2005, Updated to from 1997$ to 2017$ using BLS Series CUUR0000SS47021. Average of 4- and 5-axle trucks
Truck Operating Costs, Tires	$ per tire	$582.42	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SETC01. Average of 4- and 5-axle trucks
Truck Operating Costs, Maintenance and Repair	$ per vehicle per 1,000 mile	$614.00	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SETD. Average of 4- and 5-axle trucks
Truck Operating Costs, Vehicle Depreciation	$ per vehicle (depreciable value)	$94,631.50	HERS Technical Report, 2005, Updated from 1997$ to 2017$ using BLS Series CUUR0000SS45021. Average of 4- and 5-axle trucks

All dollar estimates are in dollars of 2017.

Table 4: Data Sources for Accident Costs

Variable Name	Unit	Value	Source
Minor injury (MAIS 1)	$ per injury	$28,800	US DOT BCA Guidance for Discretionary Grant Programs, December 2018
Moderate injury (MAIS 2)	$ per injury	$451,200	Ibid
Serious injury (MAIS 3)	$ per injury	$1,008,000	Ibid
Severe injury (MAIS 4)	$ per injury	$2,553,600	Ibid
Critical injury (MAIS 5)	$ per injury	$5,692,800	Ibid
Fatal injury (MAIS 6)	$ per injury	$9,600,000	Ibid
Property Damage Only (PDO) accidents	$ per damaged vehicle	$4,300	Ibid
Annual Growth in Real Injury Costs	% per year	0%	Ibid
Average Number of Fatalities per Fatal Crash	events per crash	1.07	Florida's Integrated Report Exchange System (FIRES) 2017
Average Number of Injuries per Injury Crash	events per crash	1.51	Ibid
Average Number of Vehicles Damaged per Fatal Crash	events per crash	1.65	California Department of Transportation, TASAS Unit, 2007 to 2009 average
Average Number of Vehicles Damaged per Injury Crash	events per crash	1.96	Ibid
Average Number of Vehicles Damaged per PDO Crash	events per crash	1.95	Ibid

MAIS stands for Maximum Abbreviated Injury Scale. All dollar estimates are in dollars of 2017.

Note: calculations assumed no injury costs included in PDO crash.

Table 5: Data Sources for Emission Costs

Variable Name	Unit	Value	Source
Nitrogen Oxides	$ per short ton	$8,300	US DOT Benefit-Cost Analysis Guidance for TIGER and INFRA Applications, December 2018
Volatile Organic Compounds	$ per short ton	$2,000	Ibid
Fine Particulate Matter	$ per short ton	$377,800	Ibid
Sulfur Dioxide	$ per short ton	$48,900	Ibid
Carbon Dioxide	$ per short ton	varies by year	ibid

All dollar estimates are in dollars of 2017.

APPENDIX II: Glossary of Terms

Many of the terms below come from the TOPS-BC tool, and thus most of the definitions are referenced from the TOPS-BC user manuals and guidance documents.

- **Active Transportation and Demand Management (ATDM)**: dynamic management, control, and influence of travel demand, traffic demand, and traffic flow of transportation facilities. ATDM strategies are used to continuously monitor and actively influence traveler behavior in real time to achieve operational goals, such as preventing delays, improving safety, and reducing emissions.
- **Advanced Traveler Information System (ATIS)**: any system that acquires, processes, and presents information used to assist transportation users. Often used to provide information on locations of incidents, weather and road conditions, and optimal routes.
- **Benefit/Cost Ratio (BCR):** the present discounted value of total benefits divided by the present discounted value of total investment costs, both estimated over the project's lifecycle. A BCR of 2.5, for example, implies that $2.50 in benefits would be generated for every dollar of investment. A BCR greater than 1.0 suggests that the proposed investment is economically justifiable, as benefits exceed costs.
- **Closed-Circuit Television (CCTV)**: use of video cameras to transmit signals to a particular place (not openly transmitted). Often used for monitoring freeway conditions, particularly when traffic incidents occur.
- **Discount Rate**: The annual percentage change in the present value of a future dollar or other unit of account. The discount rate used in BCA is typically the social time preference rate (the value society attaches to present as opposed to future consumption) or the opportunity cost of capital.
- **Discounted Payback Period**: the number of years it takes for a project to break even (that is, until cumulative discounted benefits exceed cumulative discounted investment costs); if the payback period is within the project useful life, NPV is positive.
- **Dynamic Message Sign (DMS)**: electronic traffic signs used on roadways to provide travelers with information.
- **En-route Traveler Information**: traveler information intended to reach the recipients while they are traveling. The information may be provided through several different channels, including telephone, in-vehicle system, roadside Dynamic Message Signs (DMS) or Highway Advisory Radio (HAR), or broadcast-media.
- **High-Occupancy Toll (HOT) Lanes**: allows single-occupancy vehicles (SOV) to pay a toll to use underutilized high-occupancy vehicle (HOV) lane capacity. The tolls charged may vary according to time-of-day schedules, or may be dynamically assessed in response to traffic conditions and available HOV lane capacity.
- **Highway Advisory Radio (HAR):** messages broadcast to motorists with roadway information. Provided on specific radio stations advertised by roadway signage.

- **Net Present Value (NPV):** the difference between the present discounted value of total benefits and the present discounted value of total investment costs; a positive NPV suggests that the proposed investment is economically justifiable.
- **Overall Rate of Return:** the discount rate at which the net present value is zero; an overall rate of return greater than the discount rate suggests that the proposed investment is economically justifiable.
- **Present Value (or Present Discounted Value)**: The value of future costs or benefits expressed in present terms by means of discounting.

- **Pre-trip Traveler Information**: traveler information provided through several different available channels (e.g., telephone, web-based, broadcast-media, social-media) intended to reach individuals prior to the initiation of their trip so that they may make informed decisions on destination, mode, route, time of travel, and even whether to forego the trip.
- **Ramp Metering**: applies signals to on-ramp or freeway-to-freeway ramp locations to control and manage the flow of vehicles into the merge area.
- **Road Weather Management**: monitoring roadway conditions in real time during poor weather conditions for the purpose of advising vehicles of conditions or restricting travel.
- **Speed Harmonization**: involves the implementation of variable speed limits and the communication of those limits through roadside signs. The speed limits are modified according to congestion levels to lessen stop-and-go conditions and lower the speed of vehicles as they approach downstream bottlenecks.
- **Traffic Incident Management (TIM)**: various combinations of incident detection, location verification, communication/coordination, and response strategies designed to lessen the time required to respond and clear traffic incidents.
- **Traffic Management Center (TMC)**: the hub of a freeway management center. It collects, processes, and provides data about the freeway system, which is then used by the media, transportation agencies, and the vehicles on the road.
- **Traffic Signal Coordination**: improves the coordination of traffic signal timing to improve flow and reduce delay.
- **Traffic Signal Retiming**: improves the traffic signal timing at a particular intersection to improve flow and reduce delay.
- **Transportation System Management and Operations (TSM&O)**: program or strategies used to optimize the operational performance of existing transportation infrastructure. These strategies typically do not involve adding capacity, and thus are typically low-cost options.
- **Traveler Demand Management (TDM)**: strategies used to lessen travel demand (number of trips) associated with work commuting traffic. These strategies may include employee-based subsidies for alternative mode use or alternative work hours, or employer-based investment in vanpools or alterative work campuses to lessen the number of trips made by their employees.
- **Vehicle Loop Detectors**: an electrical loop installed in the pavement to detect vehicles passing at a certain point. Often used to detect approaching vehicles at a traffic light.

- **Work Zone Management**: lessens the congestion, delay, and safety issues associated with construction or maintenance work zones.

APPENDIX III: Structure and Logic Diagrams

The following six structure and logic (S&L) diagrams provide a high-level overview of the calculations made in the tool to estimate the costs and benefits of TSM&O improvements.

Figure 27: S&L Diagram of Strategy Costs

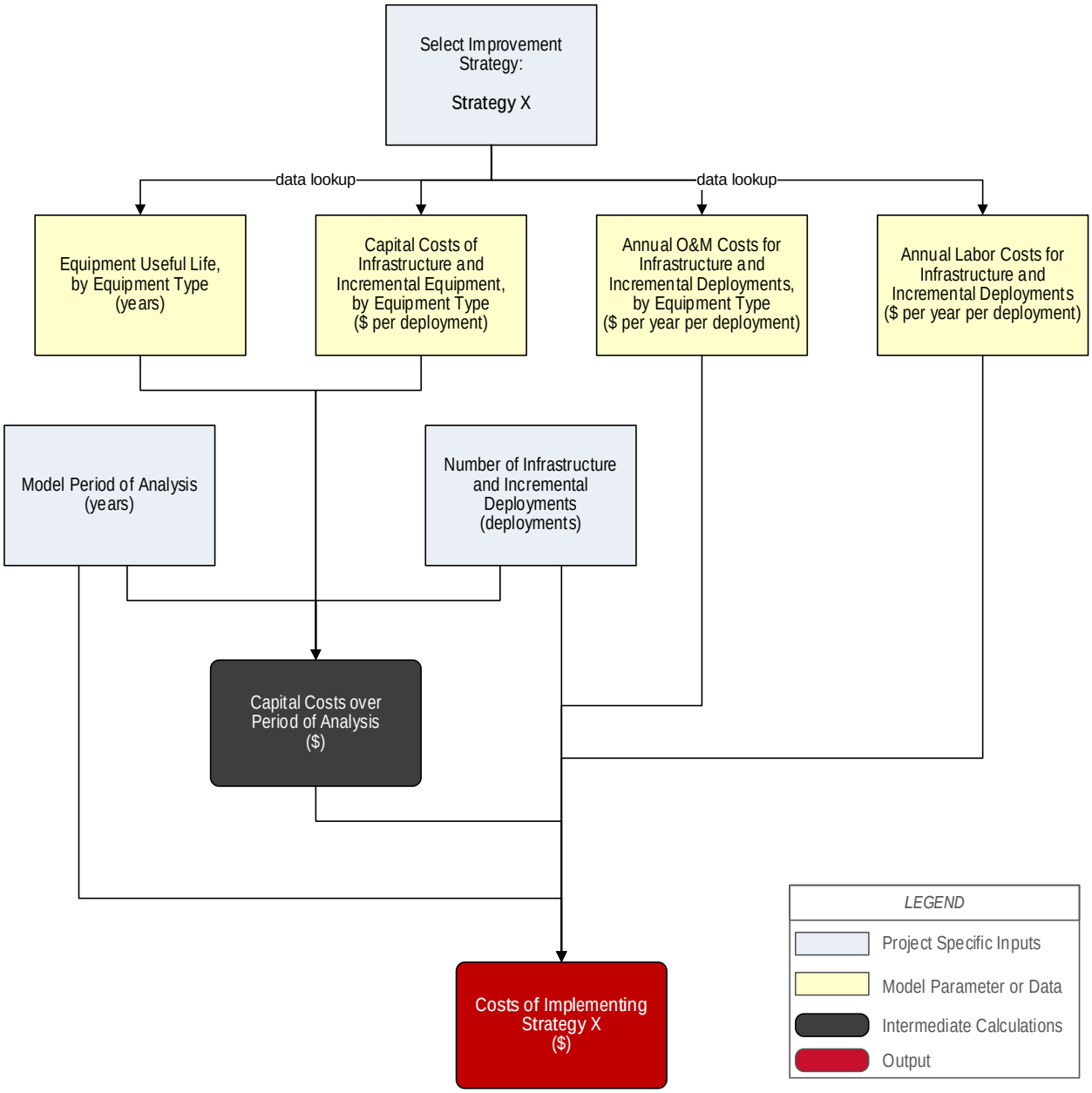


Figure 28: S&L Diagram for Benefits of Link-Based Strategies

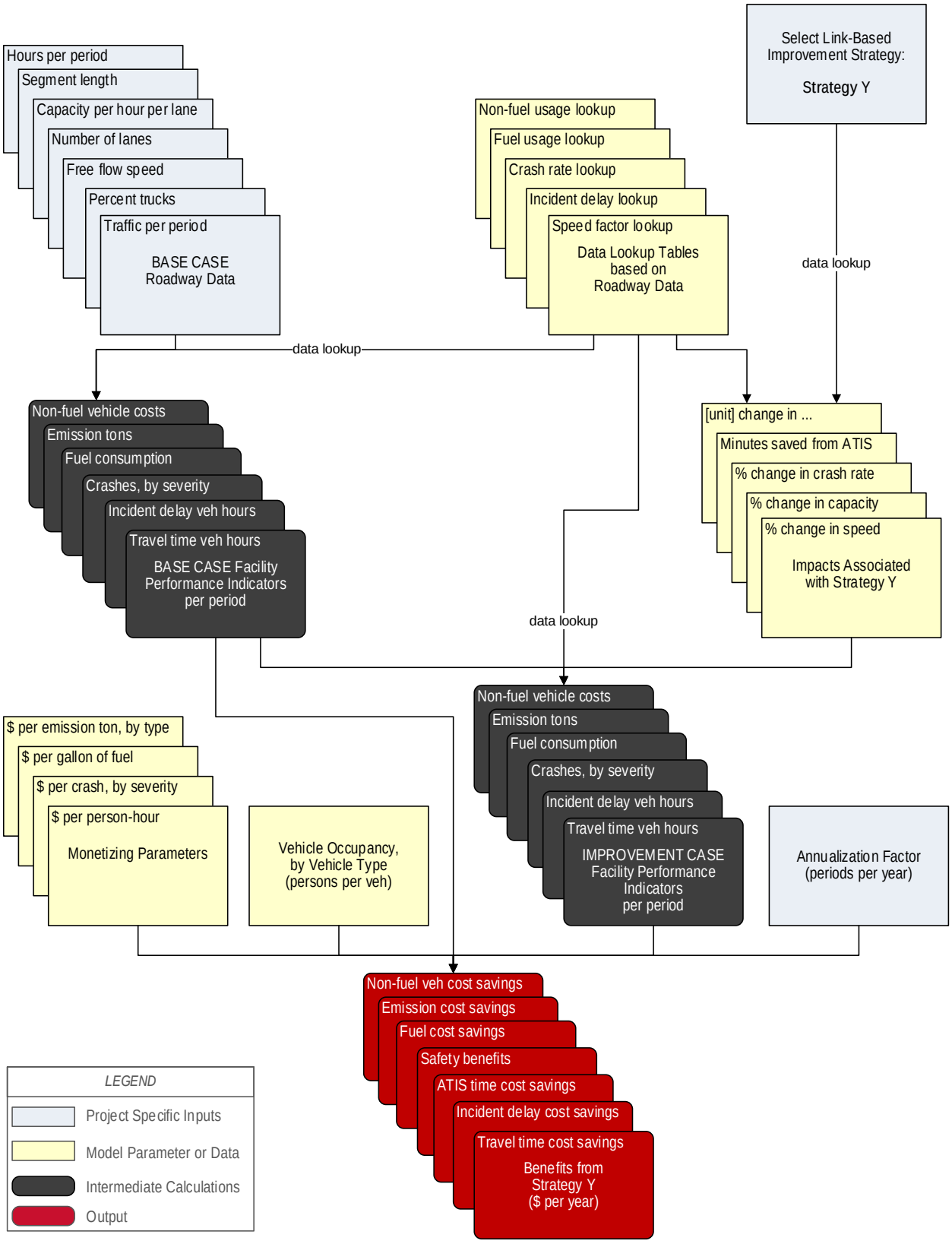


Figure 29: S&L Diagram for Benefits of Ramp Metering Strategy

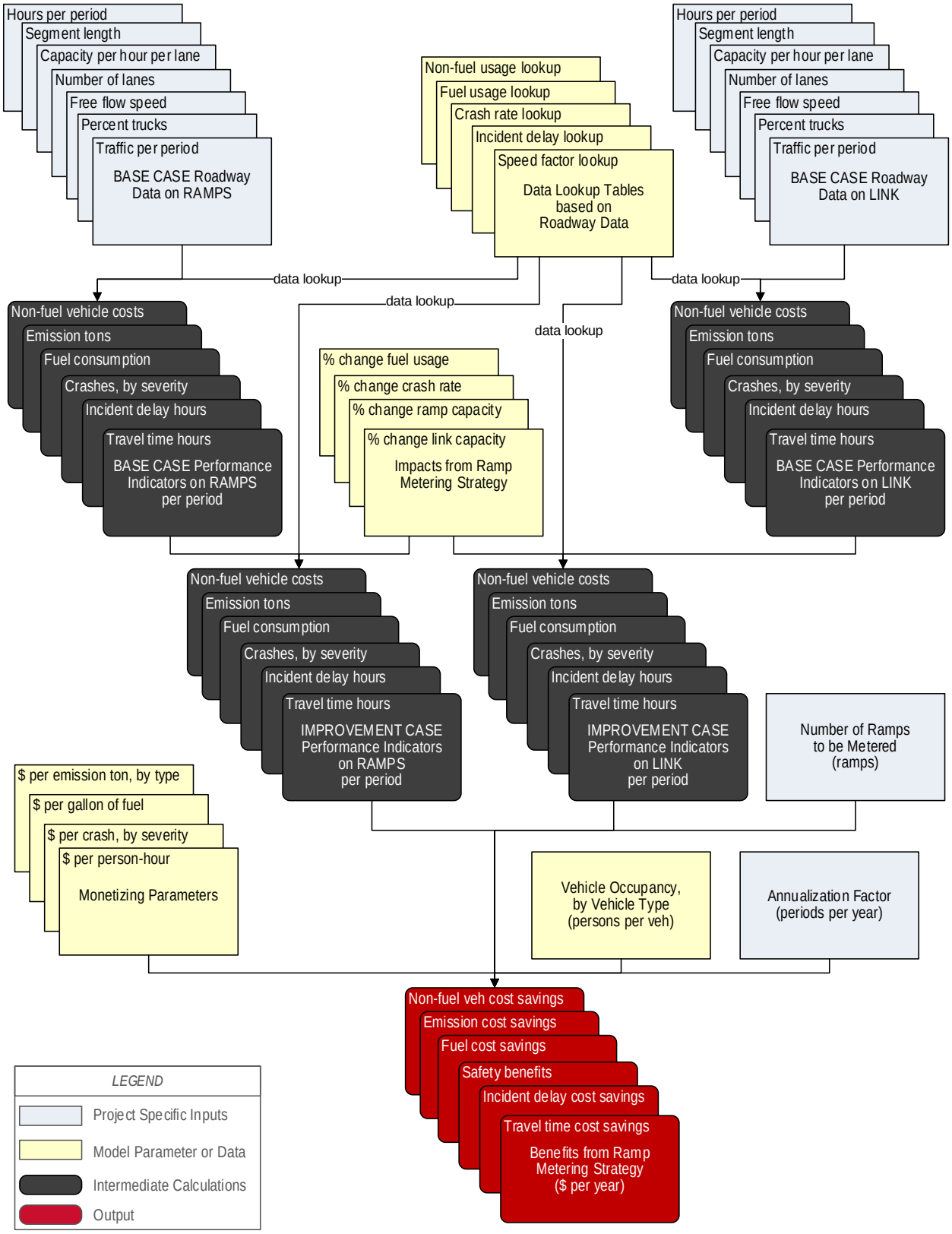


Figure 30: S&L Diagram for Traffic on HOT and GP Lanes (Method #1)

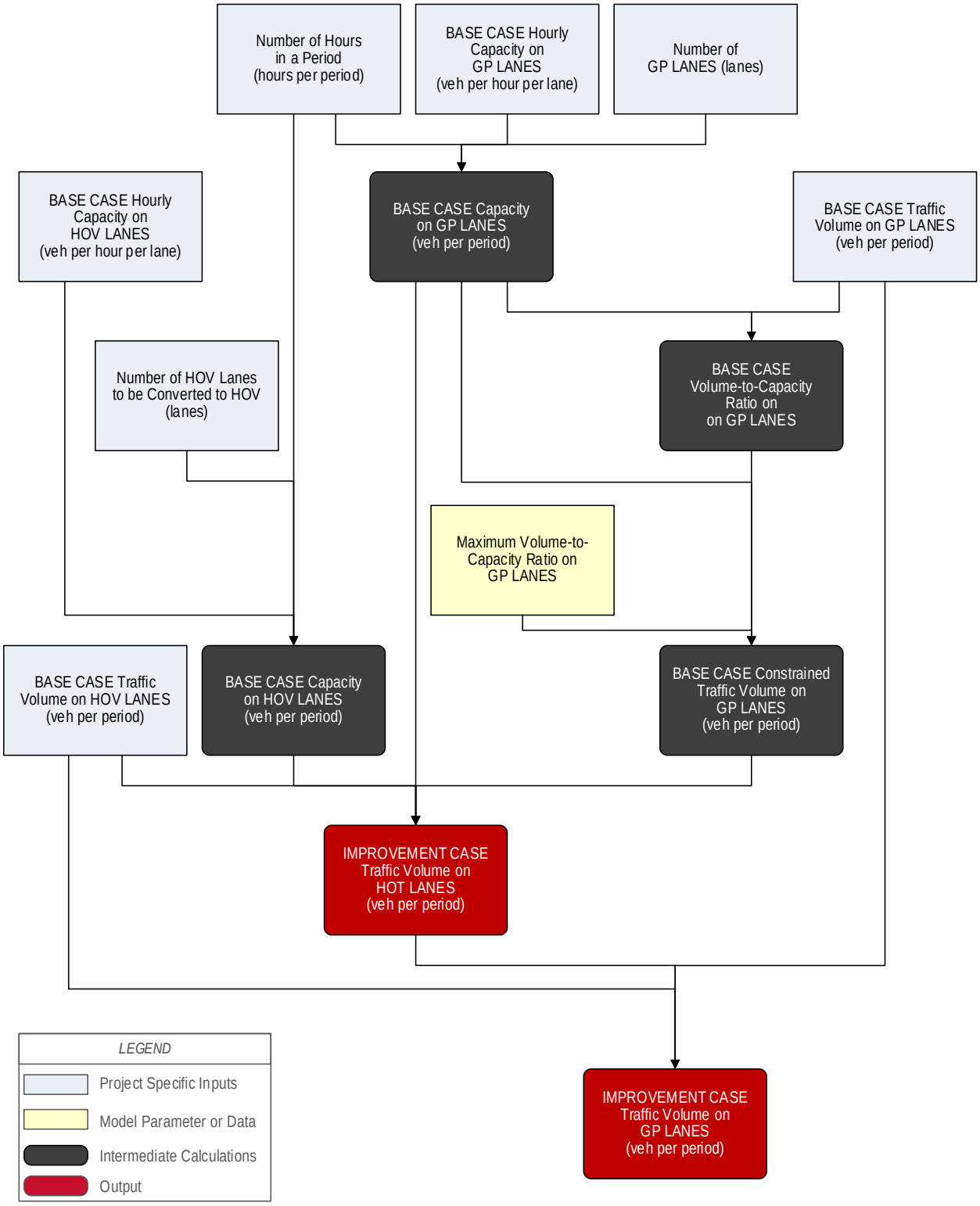


Figure 31: S&L Diagram for Traffic on HOT and GP Lanes (Method #2)

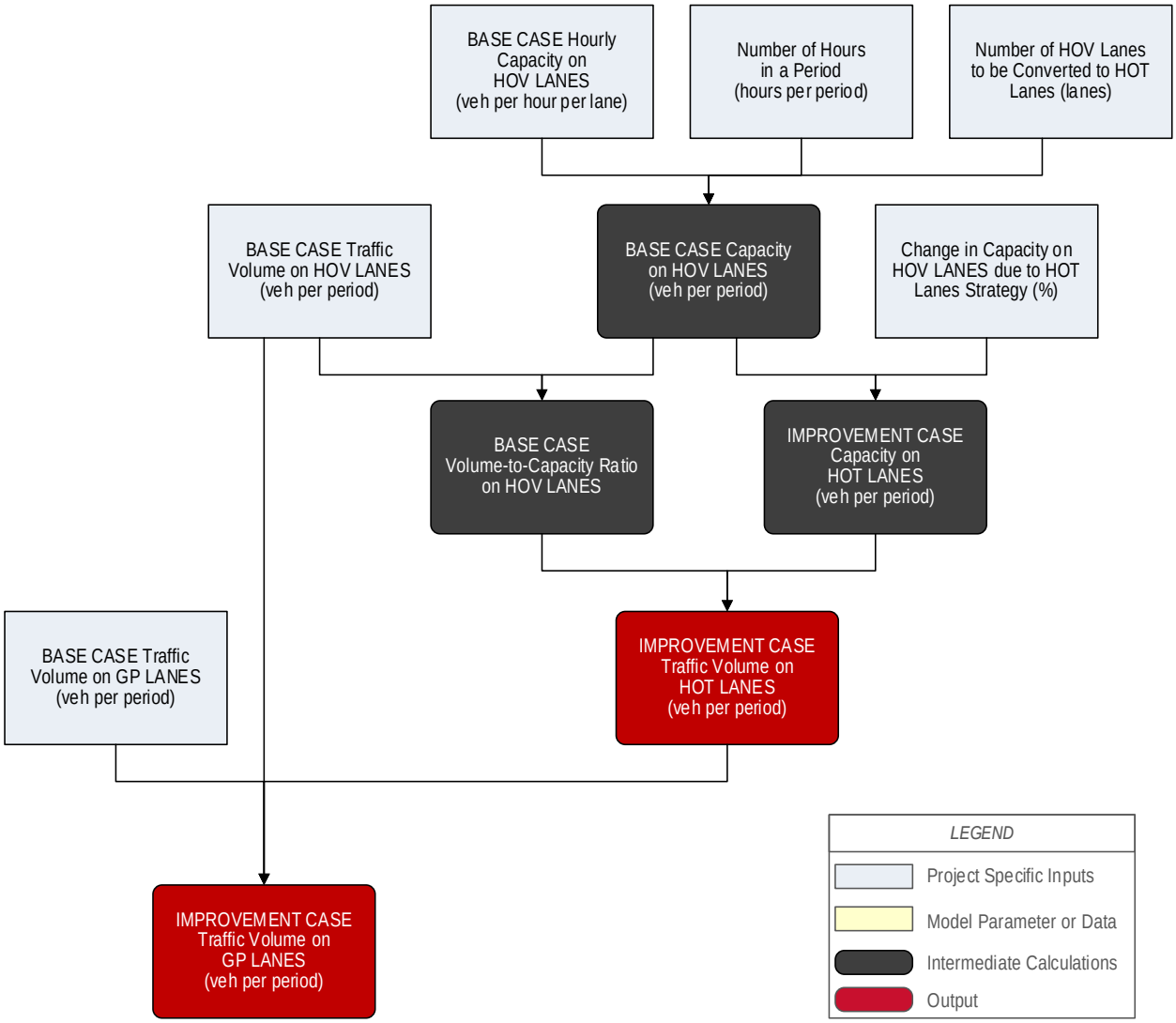
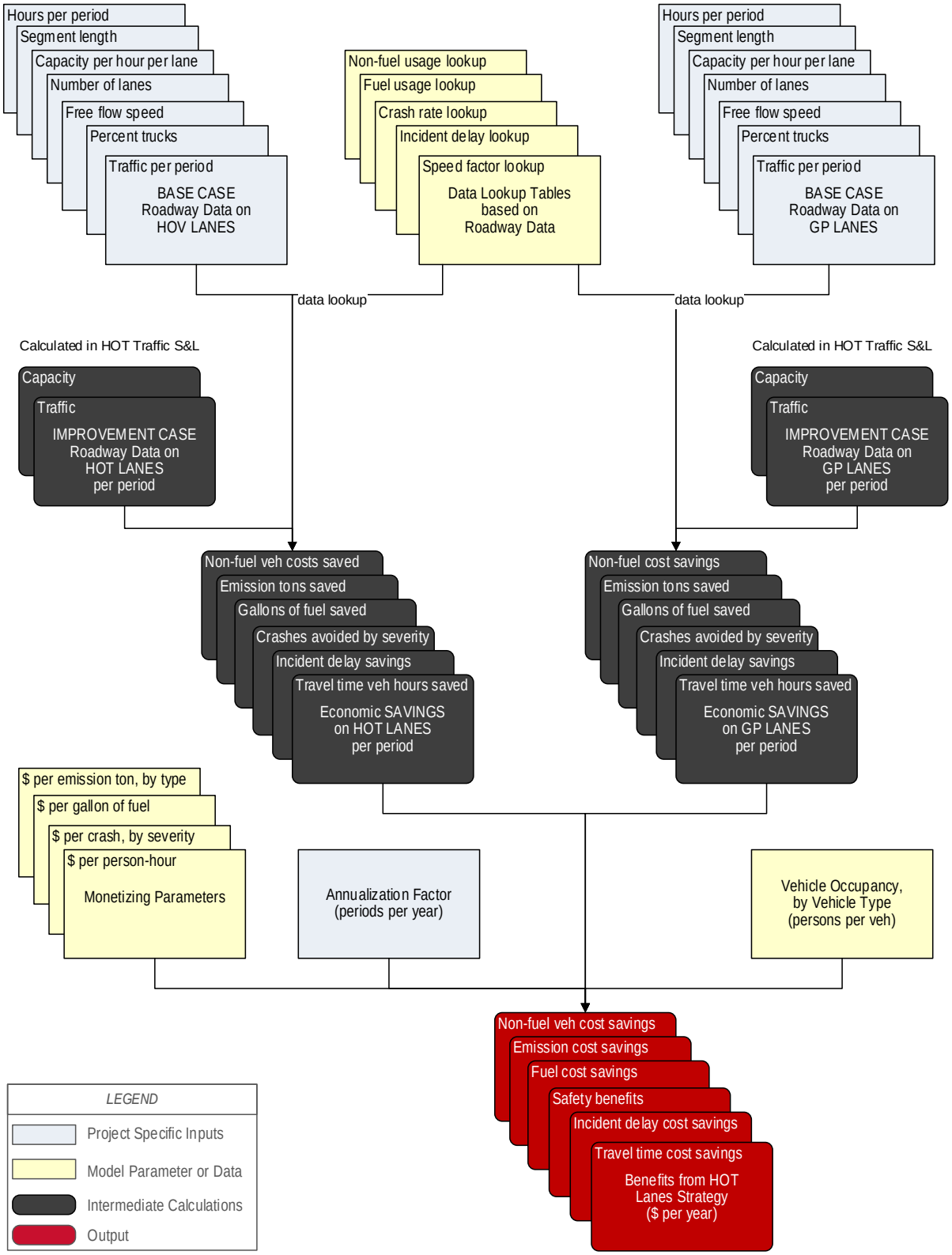


Figure 32: S&L Diagram for Benefits of HOT Lanes Strategy



Florida Department of Transportation
District Five
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