Travel Efficiency Assessment Method (TEAM) User Guide:

Analyzing Passenger Travel Impacts and Emission Reductions from Travel Efficiency Strategies

EPA United States Environmental Protection Agency

Office of Transportation and Air Quality
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Transportation and Climate Division
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List of Abbreviations

BAU	business as usual
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
LRTP	Long Range Transportation Plan
MOVES	Motor Vehicle Emission Simulator (EPA's motor vehicle emissions model)
MPO	Metropolitan Planning Organization
MSA	Metropolitan Statistical Area
NOx	nitrogen oxides
PM	particulate matter
SOV	single occupancy vehicle
TAZ	traffic analysis zone
TDM	Transportation Demand Management
TEAM	Travel Efficiency Assessment Method
TE	travel efficiency
TRIMMS	Trip Reduction Impacts of Mobility Management Strategies
VMT	vehicle miles traveled
VOCs	volatile organic compounds

1 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

Air quality in the United States has improved over the years as emission control technologies have reduced emissions from all pollution sectors. Yet the transportation sector continues to be a major source of criteria pollutant and greenhouse gas (GHG) emissions across the country. While emissions per mile traveled have decreased, growth in travel activity has offset those reductions and presents a challenge to achieving and maintaining air quality and protecting public health. For transportation and air quality planners, the ability to estimate the emission reduction potential of strategies aimed at reducing travel activity is critical to long range planning and programmatic investments. The purpose of this document is to help transportation and air quality planners estimate the emission reduction potential of strategies aimed at reducing or changing travel activity.

In contrast to strategies that affect vehicle technology or fuel properties, travel efficiency (TE) strategies affect how often, how far, and by what mode people choose to travel. These strategies include travel demand management (e.g., telecommuting, transit subsidies, etc.), public transit fare changes and service improvements, road and parking pricing, land use/smart growth strategies, and provision of bicycle and pedestrian facilities. Some of these strategies can be implemented quickly, and some, especially land use changes, take time to be implemented. Regardless, these types of strategies can be adopted by state or local entities, e.g., on a local or regional level, to reduce emissions and improve quality of life.

This document describes how to assess the role TE strategies can play in reducing GHG and criteria pollutant emissions using the U.S. Environmental Protection Agency (EPA) **T**ravel **E**fficiency **A**ssessment **M**ethod (TEAM). EPA intends for this document to help air quality and transportation planners, transit agencies, city, state, tribal, and local agencies, and others in the air quality and transportation fields to more easily estimate the emission reduction potential of TE strategies to incorporate them into their planning activities.

This user guide presents a step-by-step approach to applying TEAM using information that is typically available from a travel demand model and national travel and transportation datasets, along with an emissions analysis using EPA's Motor Vehicle Emission Simulator (MOVES) model. This document discusses sketch planning modeling, off-model calculation options, and EPA's MOVES emissions model. However, this guide does not repeat detailed information on how to run the various models or tools that are included in other documents. Instead, this user guide covers the methodologies and sources of input data that are recommended for conducting a TEAM analysis and refers readers to those other sources for "how-to" information. This user guide replaces the September 2011 document *Analyzing Emission Reductions from Travel Efficiency Strategies: A Guide to the TEAM Approach* and reflects the lessons learned from the work completed to date applying TEAM in case studies conducted with state and local partners.

1.2 Introduction to the Travel Efficiency Assessment Method (TEAM)

EPA developed TEAM to quantify the potential emission benefits of TE strategies without having to run an area's travel demand model, saving time and resources. TEAM uses available travel data and a transportation sketch planning tool analysis to quantify the change in vehicle miles travelled (VMT) resulting from TE strategies and uses EPA's MOVES model to estimate the emissions benefits of those strategies. In contrast to emission control strategies that are based on vehicle technologies or alternative fuels, TE strategies refer to a broad range of strategies designed to reduce travel activity from light-duty passenger vehicles, especially of single-occupancy vehicle (SOV) travel.[1] Therefore, TEAM estimates VMT and emissions impacts only for personal passenger vehicles (i.e., passenger cars and passenger trucks). The TE strategies that can be estimated with TEAM include strategies in the following categories:

- employer-based transportation management programs,
- transit improvements,
- transportation pricing,
- land use changes, and
- bicycle and pedestrian programs.

TEAM uses available travel data and a transportation sketch planning tool analysis to quantify the change in VMT resulting from TE strategies. In a TEAM analysis, a future analysis year is chosen. VMT and emissions are estimated in the future "business as usual" (BAU) case that does not include the TE strategies. Then VMT and emissions estimated in future TE strategy scenarios are compared against the BAU case. Emission factors are developed using the current version of MOVES, EPA's emissions model for both onroad and nonroad mobile sources, to estimate emissions for transportation-related emissions. TEAM can be used to model any pollutants included in MOVES, including criteria pollutants and their precursors such as fine particulate matter ($PM_{2.5}$), nitrogen oxides (NOx), and volatile organic compounds (VOCs) as well as GHGs and mobile source air toxics.

1.3 Introduction to Travel Efficiency Strategies

As discussed, the term travel efficiency strategies refers to a broad range of approaches to reduce travel activity, especially SOV travel. In contrast to emission control strategies that focus on reducing the emissions through cleaner vehicle technology or fuels, TE strategies focus on reducing emissions by changing how and when people decide to travel. TE strategies build on the traditional Transportation Control Measures (TCMs) listed in the Clean Air Act such as employer-based transportation management programs and transit improvements by adding smart growth and related land use strategies, road and parking pricing, and other strategies aimed at reducing vehicle travel activity and mobile source emissions.[2]

As areas look for ways to reduce emissions, TE strategies may become increasingly attractive because they are often less costly to implement, can have both short- and long-term impacts, can achieve multi-pollutant reductions for air pollution and climate goals, and can create more sustainable and livable

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[1] Motorcycles are a small percentage of light-duty vehicle passenger vehicle travel activity and emissions and not included in a TEAM analysis.

[2] Clean Air Act, 42 U.S.C. §108(f)(1)(A)

communities when compared to the construction of additional miles of new roadway. In addition, TE strategies can help strengthen community connections and improve access to the places where people live, learn, play, and work. Many areas have embraced such strategies for a variety of reasons, and EPA's efforts to date have demonstrated that a comprehensive combination of these strategies has the potential to substantially reduce transportation-related emissions.

In TEAM, some TE strategies can be directly analyzed using the selected sketch planning tools. While the sketch planning tool described in this document does include a method of estimating land use changes, EPA has developed two "off-model" approaches for estimating the effects of land use changes for use in TEAM analyses (*see Section 8.2 Land Use Analysis* for more information).[3] EPA has also adapted a method for estimating the effects of bicycle and pedestrian strategies (see *Section 5.6 Bicycle and Pedestrian Strategies*). Table 1 below contains the five main categories of TE strategies and examples of the strategies (see *Table 3. Examples of Travel Efficiency Strategy Selection and Operationalization for a more comprehensive list of strategy examples*).

Table 1. Travel Efficiency Strategies Analyzed in TEAM

Strategy Category	Examples of Strategy Options
Travel Demand Management (TDM) and Employer Incentives	• Subsidies for alternative modes • Guaranteed ride home, ride match, telework, and flexible work schedules
Transit	• Free or reduced fares, bundled transit passes • Reduced transit travel times or wait times • Expanded service (geographic area, time of day)
Transportation Pricing	• Parking pricing • VMT pricing • Road pricing
Land Use	• Shifting population and employment growth to more compact neighborhoods/lower VMT generating neighborhoods • Workforce-housing balance initiative • Transit-Oriented Development (TOD)
Bicycle and Pedestrian Improvements	• Expanded sidewalk coverage • Expanded bike lane coverage

Additionally, TEAM is not applicable to all strategies that may affect emissions, only the categories of TE strategies listed above. For example, strategies that involve switching to alternative fuel vehicles, such as electric vehicles, may not significantly affect VMT and trips, and can be modeled in MOVES directly without first needing to estimate the change in VMT or trips.[4]

[3] For the purposes of this user guide, off-model refers to analytical approaches that are conducted outside of the sketch planning tool selected.

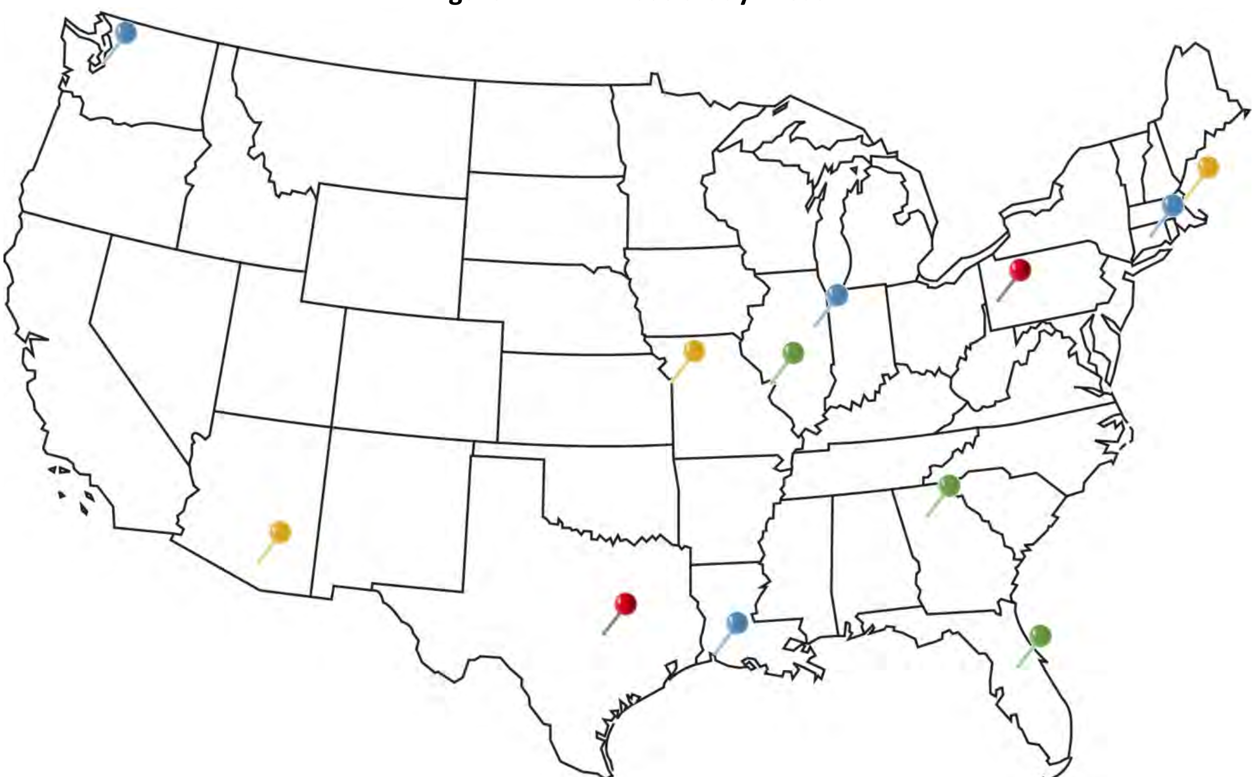
[4] For example, see this FAQ for more information: https://www.epa.gov/moves/how-can-hybrid-and-electric-vehicles-be-modeled-moves.

1.4 BACKGROUND ON TEAM WORK TO DATE

In 2011, EPA developed TEAM as a tool to quantify onroad mobile source impacts from reducing vehicle travel. The TEAM approach was used to conduct a national-level assessment to estimate emissions reductions that could result from implementing multiple TE strategies in all urban areas across the country. The analysis and results are documented in *Potential Changes in Emissions Due to Improvements in Travel Efficiency - Final Report*.[5]

Since 2012, EPA has partnered with state and local transportation planning agencies, non-governmental organizations, and others interested in applying TEAM. EPA has provided technical assistance to twelve agencies to evaluate the emissions reduction potential of transportation scenarios in specific areas across the country, as shown in Figure 1.[6]

Figure 1. TEAM Case Study Areas



2014	2016	2018	2020
Tucson, AZ	St. Louis, MO	Lake Charles, LA	Austin, TX
Kansas City, KS-MO	Atlanta, GA	Seattle, WA	Pittsburgh, PA
Boston, MA	Orlando, FL	Champaign, IL	
		Connecticut	

[5] U.S. Environmental Protection Agency. (2011). *Potential Changes in Emissions Due to Improvements in Travel Efficiency - Final Report*. March. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100CZFS.txt.

[6] TEAM case studies are available on the EPA Travel Efficiency website at www.epa.gov/state-and-local-transportation/estimating-emission-reductions-travel-efficiency-strategies. They are also discussed in Section 7.3 of this document.

One goal of these efforts was to illustrate TEAM's applicability to areas of different sizes and different levels of transportation planning resources. These case studies indicate TEAM's flexibility both in terms of geographic area as well as data available for use in the analysis. In these case studies, TEAM was applied to specific corridors, specific subsets of populations, entire metropolitan areas, and in one case, an entire state.

1.5 Applications of TEAM Analyses

TEAM analyses can be used to produce estimates of emissions from various transportation and land use scenarios. TEAM analyses can inform different types of planning exercises in the fields of air quality, transportation, and land use.

1.5.1 Air Quality Planning

TEAM can be used for assessing the relative contributions of TE strategies before regulatory modeling is done. While TEAM does not replace the procedures and methodologies used to support air quality planning and cannot be used for calculating emission reductions for SIP development or conformity determinations, it can be used to screen potential emissions reduction strategies for some of the air quality analyses listed below.[7]

- **SIP Development**: Where areas are designated "nonattainment" for one or more of the National Ambient Air Quality Standards (NAAQS), and where areas are redesignated to attainment (under Clean Air Act section 175A – "maintenance areas"), States develop and implement State Implementation Plans (SIPs) to improve or maintain air quality. TEAM can be used to consider what TE strategy or combination of strategies may be most effective in addressing emissions from the transportation sector, since it can be run quickly and iteratively. Promising alternatives that have been identified and their potential emission reductions can be considered for further analysis.

- **Transportation Conformity Analyses**: In nonattainment and maintenance areas, the Clean Air Act's transportation conformity requirements apply to ensure that long range transportation plans and transportation improvement programs (TIPs) prepared by metropolitan planning organizations (MPOs) are consistent with the area's SIP. TE strategies can be included in transportation plans and TIPs where emission reductions are needed to meet transportation conformity requirements. TEAM provides a means to compare potential strategies and groups of strategies to help quickly screen options and identify promising alternatives and their potential emission reductions for further consideration and analysis.

- **GHG Analysis**: Many state and local governments that have an interest in reducing GHGs seek appropriate tools and techniques. TEAM uses the latest MOVES model and can be used to analyze potential GHG reductions of various strategies and combinations of strategies.

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[7] For more information about EPA's SIP and transportation conformity programs, see EPA's website at: https://www.epa.gov/state-and-local-transportation. Transportation conformity analyses must be developed in accordance with the requirements at 40 CFR Part 93, (e.g., 40 CFR 93.122). Specific questions about SIPs and transportation conformity can be directed to the appropriate EPA Regional Office. Contact information can be found on EPA's website at: https://www.epa.gov/state-and-local-transportation/epa-regional-contacts-regarding-state-and-local-transportation.

1.5.2 Transportation Planning

The decision-making process that supports transportation planning in urban areas is supported by detailed analysis at various levels of sophistication. Activity-based and traditional four-step travel demand models are complex and require a high-level of expertise and input data to develop, calibrate, and maintain. In contrast, TEAM is based on sketch planning tools that are less data intensive, less costly, and less time-consuming to run. TEAM allows for the preliminary consideration and comparison of options outside of the transportation demand model, saving time and resources. TEAM can be used to explore TE options in the transportation planning processes listed below.

- **Comprehensive and Long-Range Transportation Planning**: Decision makers need an understanding of how different strategies might help achieve regional goals such as reduction in emissions or VMT. TEAM can be used to screen options to inform decisions as well as focus limited technical resources on those strategies which appear most effective.

- **Public Transit Service Plans**: Public Transit agencies need a method of understanding how policy changes and broader land use changes may impact ridership and service demand. TEAM can help transit planners find themselves involved in discourse with urban-land-use issues such as transit-oriented development. Transit planners are also responsible for developing routes and networks of routes for urban transit systems. These may follow one or more models depending on the character of the communities they serve.

- **Travel Demand Management (TDM):** Commuter programs include incentives for ridesharing, walking, cycling, or using transit and vanpools, opportunities for telecommuting, flexible work hours, and so on. These strategies can be analyzed at the level of an individual site or employer or a regionwide level using data appropriate for the scale of analysis. These strategies can reduce emissions by reducing total VMT and reducing peak period travel. TEAM provides a way to compare effectiveness of TDM strategies based on the estimated level of support within the region.

- **Transportation Pricing Analysis**: Strategies such as parking pricing, tolling, VMT fees, and other road pricing strategies that change the user costs of driving, as well as strategies affecting transit fares, are incentives/disincentives with respect to travel behavior. These strategies also have an impact on emissions by altering travelers' choices towards modes like transit, ridesharing, walking, and cycling, and altering their choices of travel routes.

- **Multi-modal Considerations**: Travel time improvements include improvements in transit service and frequency. They can also include reduction in access time that may occur due to land use strategies such as transit-oriented development, increased density, and mixed-use developments as part of smart growth plans. These strategies, along with supporting strategies such as better amenities for transit, walking and cycling can potentially impact transportation emissions by making modes other than automobiles more attractive to the traveler by reducing overall travel time. Better amenities for transit, walking, and cycling can result in a shift to these modes, thus reducing VMT and emissions from automobile travel.

1.5.3 Land Use Planning

TEAM can be used to analyze and compare the emission and VMT reduction effects associated with different types of proposed development so that their transportation and thus emissions effects can be compared. TEAM can be used to see the emissions and VMT reductions associated with smart growth compared to current development patterns. TEAM could be coupled with general area plans, such as regional or area-wide land use, circulation, and housing plans, or area-specific plans, such as neighborhood or corridor level plans that assess transportation infrastructure needs or local land use.

1.5.4 General Policy Analysis

TEAM is well suited to policy analyses beyond what would traditionally be considered strictly transportation planning. TEAM can be used to evaluate potential policies and programs for effectiveness and generally augment the decision-making steps for many public policy and planning processes. TEAM can also be used to explore the provisioning of public resources. For example, a past case study with the Puget Sound Regional Council explored the equitable access to transportation services through expanded services and access to free transit within environmental justice/low-income (EJLI) populations. This resulted in a refined analysis that identified EJLI populations within existing service areas and included an analysis of expanding service to underserved EJLI areas. It also evaluated the impact of fully subsidizing transit fares for these populations. This application of TEAM provided the agency with the framework to identify environmental justice target populations with a regional scope while overlaying transit service maps to pinpoint areas of underrepresentation service which can provide a practical basis for service access based on need.

1.6 Benefits of the TEAM Approach

The TEAM approach provides a flexible and adaptable means of considering options to reduce onroad, transportation-related emissions from passenger vehicle travel. TEAM can be used to compare different levels of implementation of strategies or different combinations of strategies iteratively because of its ease of use. It works with widely varying levels of resources and data. Agencies involved in transportation and air quality planning can benefit from TEAM as a lower cost and less data-intensive tool to initially assess the impacts of TE strategies, helping planners effectively screen a broader range of alternatives or scenarios to identify the most promising alternatives for more detailed analysis.[8]

TEAM is accessible to a wide variety of agencies with varying degrees of technical expertise, including:

- large MPOs with populations in the millions and significant experience with transportation planning,
- smaller MPOs and rural planning organizations with more limited technical expertise, and
- state and local air agencies, non-governmental organizations, and other organizations interested in transportation and air quality issues.

TEAM is flexible and can be used for hypothetical "what-if" exercises early in the planning process, and strategic planning decision-making. It can also be used to analyze a range of strategy types with varying degrees of implementation.

[8] For additional lessons learned from the work completed to date using TEAM, please see the TEAM fact sheet *Travel Efficiency Assessment Method: Key takeaways from state and local case studies to reduce transportation emissions* available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ZN95.pdf.

TEAM is scalable and can be used to analyze strategies applied at a variety of scales (e.g., to a corridor/project, a city or metropolitan region, or an entire state). EPA has even applied TEAM in a nationwide study.[9] It can be applied to a region's entire population, or to a specific subset of that population, such as "commuters associated with a university," or "all state government employees."

1.7 Key Definitions

Throughout this User Guide there are terms that have specific meaning in the TEAM approach. These terms may be interpreted differently depending on the context, and therefore are defined here for application to this Guide.

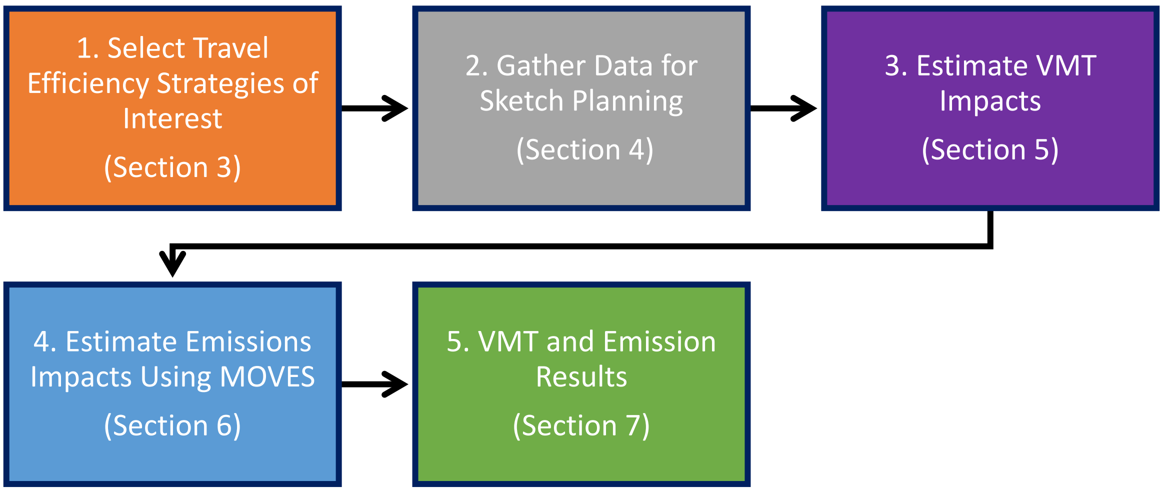
- **Analysis Year**: the future year for which the analysis is being conducted.
- **Base Year Analysis**: analysis of a starting point year that is used to measure relative changes in VMT and emissions in a future year(s).
- **Business as usual (BAU) Analysis**: analysis that includes a specified future year (i.e., analysis year) and associated future-state travel assumptions without the TE strategies included.
- **Commuters Affected**: The population to which the TE strategy being considered applies. This term is meant to broadly encompass travelers, regardless of trip purpose, that will be impacted by the strategy and not just those commuting for work purposes.
- **Operationalize**: specifying how and the extent to which a TE strategy will affect travel choice in the analysis year.
- **Region**: The largest geographic area that applies to the analysis. This is usually a metropolitan area, but may also be a state, city, a county/multi-county area, neighborhood, major transportation corridor, or other area type. The scope of the region should encompass all the areas affected by the strategies.
- **Regional Parameters**: a set of data inputs that define the regional or subarea population, travel behavior, employment, etc. profile for use in the sketch planning tool analysis.
- **Sketch Planning**: an exercise using tools that produce general order-of-magnitude estimates of transportation and land use demand and impacts.
- **Subarea**: A portion or subset of the larger region used in the analysis, such as a downtown core or specific city or county within a multi-county area.
- **Scenario**: A projected future based on a strategy or a combination of strategies that work together to reach the outcome.
- **Scenario Analysis**: analysis that includes a specified analysis year and associated future-state travel assumptions for the analysis region with the TE strategies included.
- **Travel Efficiency (TE) Strategy**: a specific approach selected to reduce VMT.

[9] See EPA's case studies and national TEAM assessment on EPA's website at: https://www.epa.gov/state-and-local-transportation/estimating-emission-reductions-travel-efficiency-strategies#Case-Reports.

2 PLANNING A TEAM ANALYSIS

A TEAM analysis explores the changes in the amount and type of travel, and associated emissions under specific conditions resulting from the adoption of TE strategies. The key steps of a TEAM analysis are depicted in the figure and briefly described in the narrative below.

Figure 2. TEAM Analysis Roadmap



1. **Select Travel Efficiency Strategies of Interest**: Select the TE strategies of interest that fit the relevant policy goals.
    a. Determine the affected geographic area (or subarea) or population (e.g., commuters affected) to which the strategy will be applied.
    b. Determine how the strategy will be "operationalized" (described or defined) within sketch planning tool platform.
    c. Select the analysis years.
2. **Gather Data for Sketch Planning**: collect the data needed to describe the regional demographic and travel conditions and how the TE strategy will be implemented within the sketch planning tool selected.
    a. Gather "regional parameters" data to define the regional or subarea population, travel behavior, employment, etc. for use in the sketch planning tool.
    b. Gather data to define how the strategy will be described in the sketch planning tool.
3. **Estimate VMT Impacts**: estimate VMT impacts through sketch planning tool analysis for the necessary analysis cases and process the VMT results to compare changes in travel demand between cases.
    a. Perform sketch planning tool analysis to get VMT, mode share, and trip results.
    b. Process sketch planning tool results for use in emissions analysis.
4. **Estimate Emissions Impacts Using MOVES**: perform emissions analysis using MOVES emissions model to produce emission rates and combine with VMT results.
5. **VMT and Emission Results**: evaluate how the different strategies impact VMT and emissions individually and compared to one another within the region.

2.1 Considerations For Planning a TEAM Analysis

There are several factors that users should consider when planning a TEAM analysis. The following section highlights some major considerations and decision points.

2.1.1 Analysis Geography and Commuters Affected

As noted in Step 1 of the TEAM Analysis Roadmap, a consideration for the scenario case is deciding how and where the TE strategy would be applied. A TE strategy can be applied broadly to an entire region and affect the full regional population or can be tailored to a specific subarea (e.g., neighborhood) or population (e.g., low-income households, worker-specific industry, etc.). For example, past TEAM case studies have included transit enhancements within a specific neighborhood and transportation pricing strategies applied across a multi-county region.

In TEAM, both types of analyses can be performed by using the "commuters affected" value to reflect the population subject to the TE strategy. For a full regional analysis, the commuters affected value would be the entire regional population. However, if the strategy is targeted to a particular subarea or subset of the regional population, the user would need to:

- Define and gather data for each strategy subarea or affected sub-population separately.
- Define the commuters affected value to reflect the population subject to the TE strategy being considered.
- Run the sketch planning tool once for each analysis geography, and sum VMT and trip reductions across each sketch planning tool run.

Gathering data to define the "commuters affected" value for strategies targeted to a specific population can be more challenging though most population, demographic, and employment data can be accessed through U.S. Census datasets.

Each unique strategy subarea requires its own set of sketch planning runs. It is possible to recombine/scale results back to the regional level. This is discussed further in *Section 7 VMT and Emission Results.*

2.1.2 Base Year, BAU, and Scenario Cases, and Analysis Years

As noted in Step 3 of the TEAM Analysis Roadmap, TEAM utilizes different cases to conduct the analysis:

Table 2. Base Year, BAU, and Scenario Case Comparison

Case	Description	Analysis Year
Base Year Case (optional)	a starting point analysis year that is used to measure relative changes in VMT and emissions	Convenient reference year (current year)
Business as Usual (BAU) Case	a specified future year and associated future-state consistent with latest long-range transportation planning assumptions without the TE strategies included.	Future year (same as scenario case)
Scenario Case	a specified future year and associated future-state consistent with latest long-range transportation planning assumptions with the TE strategies included.	Future Year (same as BAU case)

An analysis year must be chosen for the base year case, and a later analysis year chosen for the BAU/scenario cases. The optional base year can simply be a reference point in time that is useful to compare future years back to (i.e., current year, etc.). The analysis year for the BAU and scenario cases should be the same future year (e.g., the year in which the TE strategy will be fully implemented, or the last year of the regional long-range transportation plan, etc.).

The purpose of the analysis will help determine the base and future analyses years. Generally, the base year case analysis year could be a recent year for which data is available or can be easily collected; the base year case could be skipped, depending on the purpose of the analysis. The base year case, if chosen, and BAU case results will serve as the basis of comparison by which to judge the relative effectiveness of the selected TE strategies.

2.1.3 Understanding Elasticities

In general, an individual's transportation mode choice reflects sensitivities to factors like travel cost, travel time, comfort, etc. Any changes in these factors may influence an individual to change their travel demand or travel mode (e.g., an individual may opt for transit over driving a personal vehicle in response to increasing fuel prices). In most sketch planning tools, elasticities are used to predict changes in travel mode choices. An elasticity is the percent change in demand for a good or service expected in response to a one percent change in a particular attribute such as price, quality, time, etc. For example, a price elasticity for driving of -0.2 means that a 1% increase in price per mile results in a 0.2% decrease in miles driven. A cross-elasticity compares a change in demand for a good or service in response to a change in the attributes of a related good. In the case of travel mode options, if the price or travel time of one mode increases, users may select an alternate option, resulting in a shift in mode share.

When available, the best option is to use elasticities based on research specific to the region and populations being analyzed. However, most sketch planning tools use generic (default) elasticities from literature. TRIMMS' built-in elasticities can be accessed and changed by the user by clicking the "Elasticities" button within the "Advanced Options" in the TRIMMS toolbar; EPA recommends these values not be changed without significant supporting evidence. The TRIMMS user manual extensively documents elasticity values and sources from empirical literature and are a reasonable starting point in the absence of more regionally specific data.

2.1.4 Operationalizing Strategies

To analyze a TE strategy using sketch planning tools, it must be "operationalized" with respect to the elasticities built into the tools. Within this context, to operationalize a TE strategy means turning an abstract strategy concept into something concrete, i.e., by specifying how the strategy would change travel time and cost and thus affect travel choice. In general, many TE strategies can be operationalized in the sketch planning tool by changing travel costs and travel time.

Within sketch planning tools, travel costs can take the form of incentives or subsidies that lower the cost of using alternate travel modes or policies geared at penalizing the cost of SOV use, such as parking pricing changes, transportation pricing schemes (e.g., VMT pricing), and other policies that affect the cost of driving. Below are some examples of how to operationalize TE strategies impacting travel cost.

- A 50% reduction in transit fares for public sector employees.
- Increasing parking meter rates by $1.00 per hour during peak hours.

Sketch planning tools can also operationalize impacts to travel time. Travel time can be broken down in two components: in-vehicle travel time (IVTT), and out-of-vehicle travel time (OVTT). IVTT is simply the time spent in transit from origin to destination while in a vehicle. OVTT, or access time, is the spent walking to and from stops, waiting for vehicles, and transferring between vehicles commonly associated

with transit usage. These two components of travel time can be targeted through TE strategies. This is especially important in the evaluation of transit accessibility improvements.
For example, several different strategies could be used to improve public transportation access, any of which could reduce the overall time it takes to reach a destination:

- Increase the frequency of transit on existing routes (reducing OVTT),
- Expand the geographic area covered by transit routes (again, reducing OVTT), or
- Add dedicated bus-only lanes at intersections (reducing IVTT).

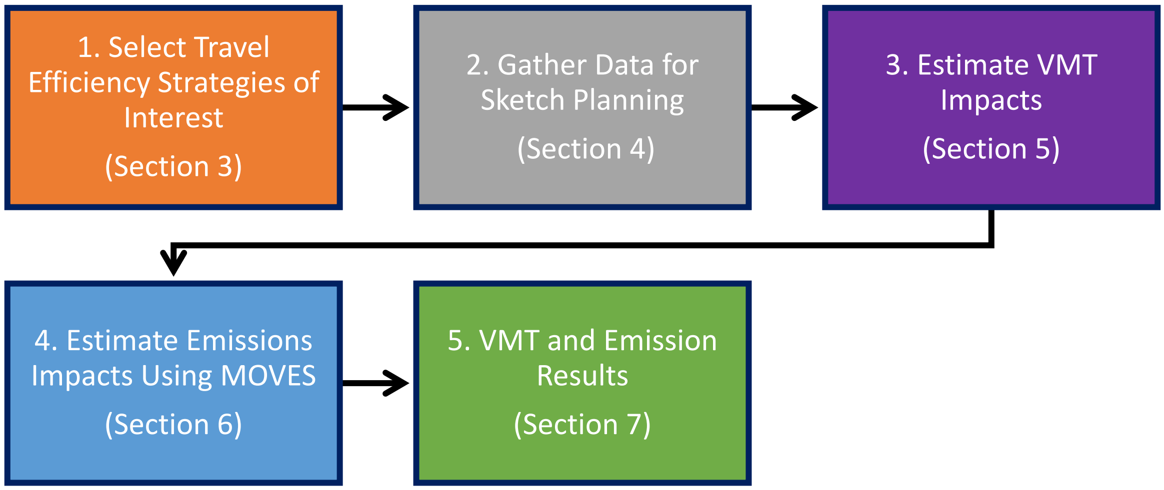
By considering these components of travel time, the sketch planning tools can estimate the mode share changes based on making transit more convenient (or time-cost competitive with driving) through any of these strategies.

In sum, operationalizing a strategy is the process of considering the specific impacts of the strategy on the elasticities within the sketch planning tools. Adding specificity to the TE strategies being considered will result in a greater usefulness of the analysis. For example, instead of "improving transit", the strategy should describe how the transit would be improved, e.g.: "improving transit by providing dedicated transit lanes." Then this specific strategy can be operationalized in the model by reducing the transit travel times by some percentage.

2.1.5 Analysis Goals

If the purpose of the analysis is only to analyze the VMT, trip, and mode share impacts of selected TE strategies, the analysis can conclude with Step *5.7 Process Sketch Planning Results* and still provide useful information for ongoing transportation planning decisions. If the purpose of the analysis is to explore the emissions impacts of selected TE strategies, the analysis should include the process described in *Section 6 Estimate Emissions Impacts Using MOVES*. The MOVES model step allows the user to assess the emissions impacts of strategies, for many pollutants including GHGs, fine particulate matter ($PM_{2.5}$), nitrogen oxides (NOx), volatile organic compounds (VOCs), and others.

3 Select the Travel Efficiency Strategies of Interest



Step 1 of a TEAM analysis is to define the bounds of the analysis, and in this step, the user would:

- select strategies for analysis,
- determine the affected geographic area or population,
- operationalize the strategy, and
- select the analysis years.

Selecting strategies for analysis using TEAM is done by considering the ways in which the region could reduce VMT across the general categories of TE strategies provided in *Section 1.3 Introduction to Travel Efficiency Strategies*. Before beginning the analysis, it may be helpful to identify the policy questions or general categories of interest that are consistent with regional goals and conversations (i.e., collected through public engagement activities, regional government objectives, or defined as part of regional planning, etc.). Some examples of hypothetical questions to start considering TE strategies may be:

- What if transit service is increased in a particular part of the region?
- What might happen if a ridesharing/matching service is provided, either generally or to a specific sector of the workforce?
- What would be the impact of increasing the cost of parking in downtown?
- What would be the travel impacts of increasing residential density and mixed-use development in the area?

Once a strategy is selected, determine the affected geographic area or population to which the strategy will be applied, and how the strategy will be "operationalized" within sketch planning tool platform.

Table 3. Examples of Travel Efficiency Strategy Selection and Operationalization

Strategy Category	Examples of Strategy Options	Examples of Affected Geographic Area or Population	Examples of Strategy Operationalization
Travel Demand Management (TDM) and Employer Incentives	• Subsidies for alternative modes	• University students	• Provide a 50% reduced transit fare for university students.
	• Guaranteed ride home, ride match, telework, and flexible work schedules	• Hospital employees	• Provide guaranteed ride home services for hospital employees
Transit	• Reduced transit travel times or wait times	• Residents living along the "orange" transit line	• Increase the frequency of buses along the "orange" transit route by 2 buses per hour during peak travel hours, reducing wait time by 10 minutes.
	• Expanded service (geographic area, time of day)	• Residents in the "north end" neighborhood	• Expand transit service into the "north end" neighborhood consistent with the service level regionally.
Transportation Pricing	• VMT pricing	• Full region	• Impose a $0.08/mile VMT fee for all regional light-duty vehicle travel.
	• Parking pricing	• Downtown parking customers	• Increase the price of metered parking and structured parking by $0.50 per hour within the downtown boundary.
Land Use	• Shifting population and employment growth to more compact neighborhoods/lower VMT generating neighborhoods • Workforce-housing balance initiative • TOD program	• Residents along the "blue" transit line	• Increase residential density by 20% within ½ mile of the "blue" transit line.
Bicycle and Pedestrian Improvements	• Expanded bike lane coverage	• Full region	• Expand bike lane miles by 10% within the region.

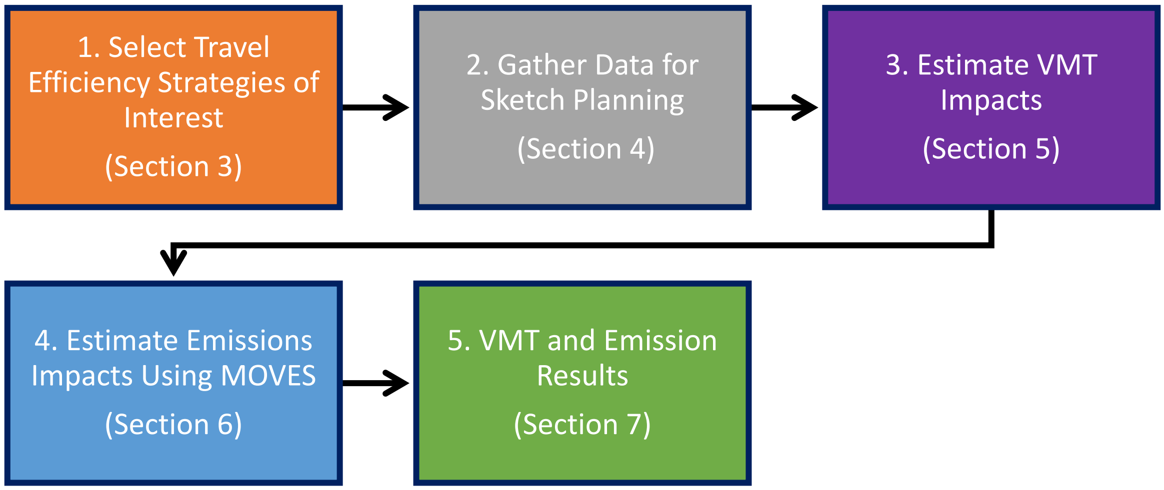
Last, in this step analysis years should be chosen. Recall that the purpose of the analysis should be considered in determining the base year and future analyses years covered by the analysis. The base year can simply be a reference point in time that is useful to compare future years back to (i.e., current year, etc.). Generally, the base year case analysis year should be a recent year for which data is available or can be easily collected. The base year case is optional, and if included, should be completed first followed by the BAU case, and last the scenario case. The BAU and scenario cases analysis years should be the same future year (e.g., the year in which the TE strategy will be fully implemented, or the last year of the regional long-range transportation plan, etc.). The base year case and BAU case results will serve as the basis of comparison by which to judge the relative effectiveness of the selected TE scenario cases.

At the end of Step 1, the user should have:

- A set of strategies to analyze,
    - The number of different geographies (including subareas) or sub-populations to which the strategies will be applied.
    - The details of how the strategy will be operationalized (the extent, or how much to which, the strategy will be applied
- Analysis years chosen for the base year case, and BAU and scenario cases.

In Step 2, users will collect the data needed to analyze each strategy, which is covered in *Section 4*.

4 GATHER DATA FOR SKETCH PLANNING



Step 2 of a TEAM analysis is to gather data used in the sketch planning tool. The user would:

- Gather the "regional parameters" data to define the regional or subarea population, travel behavior, employment, etc. profile for use in the sketch planning tool for the base year analysis year and the BAU/scenario case analysis year.
- Gather strategy data to define strategy operationalization.

4.1 OVERVIEW OF SKETCH PLANNING TOOLS AND THE TRIMMS MODEL

The previous section provided an overview of major considerations when planning a TEAM analysis. This section will introduce some of the tools used to quantify the VMT and trip impacts of TE strategies. Sketch planning tools are used to produce general order-of-magnitude estimates of transportation and land use changes resulting from various scenarios. These tools are typically easier to implement and less costly than sophisticated software packages used to conduct in-depth engineering analysis. Often, they are spreadsheet-based tools that apply aggregated or generalized data. There are many tools available for estimating VMT impacts from policy and built environment changes and the tool selected will determine some aspects of conducting a TEAM analysis. For the purposes of this User Guide, the tool selected for illustration is a free downloadable sketch planning tool developed by the National Center for Transit Research and the Center for Urban Transportation Research at the University of South Florida called TRIMMS (Trip Reduction Impacts of Mobility Management Strategies).[10,11]

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[10] TRIMMS Version 4.0 is the basis of the discussion, procedures described, and screenshots provided in this document. Past TEAM case studies used either TRIMMS Version 3.0 or TRIMMS Version 4.0 depending on the version availability at the time when the case study was developed. The current version of the TRIMMS model and the TRIMMS model user manual can be found at www.trimms.com.

[11] There are many resources that provide lists and evaluations of various sketch planning tools. For example, the Washington State Department of Transportation Research Report titled "Tools for Estimating VMT Reductions from Built Environment Changes", available at https://www.wsdot.wa.gov/research/reports/fullreports/806.3.pdf, provides a useful list of tools. Another resource is The National Center for Sustainable Transportation's "Evaluation of Sketch-Level VMT Quantification Tools" available at https://escholarship.org/uc/item/08k3q8m5.

TRIMMS is a spreadsheet-based model that estimates the impacts of a broad range of transportation demand initiatives. TRIMMS evaluates strategies directly affecting the cost of travel, like public transportation subsidies, parking pricing, pay-as-you-go pricing, and other financial incentives. TRIMMS also evaluates the impact of strategies affecting access and travel times and a host of employer-based program support strategies, such as alternative work schedules, telework and flexible work hours, and worksite amenities. This User Guide reflects TRIMMS data requirements. Users should compare this to any sketch planning model they have selected for this work.

TRIMMS works using three basic steps:

1. The user defines the target population and regional characteristics
2. The user inputs changes in variables, such as price and travel time by mode
3. TRIMMS applies elasticities to determine changes in travel by mode

The TRIMMS model is used as the basis for the on-model analyses in TEAM because it tailors the analyses with regional inputs from travel demand models and allows alteration of assumed parameters such as travel time, travel cost, and underlying modal cross-elasticities. The TRIMMS model thus meets the needs of the TEAM approach well; however, other tools may be selected or developed that work equally well.

The following section introduces the basic operation of TRIMMS to provide an overview of the model for context. Later sections of this document provide additional detail for using TRIMMS for a TEAM analysis and analyzing specific strategies. Users can also consult the TRIMMS User Guide for more detailed explanations.

4.1.1 Notes About Assumptions and Terminologies in TRIMMS

TRIMMS is a useful tool for estimating the order of magnitude impacts of TE strategies but there are some limitations and simplifying assumptions inherent within the calculations. Note that TRIMMS uses the following simplifying assumptions:

- TRIMMS was designed to analyze commute trips only, but it can be used to analyze all types of trips. For the purposes of TEAM, the TRIMMS “commuters affected” input means the total area population subject to the TE strategy being considered, not just the commuter population.
- Values of zero in the elasticity tables mean that TRIMMS assumes no relationship between the two variables that the elasticity relates. For example, TRIMMS default for the elasticity of drive-alone travel with respect to the price of rideshare is zero. (More information on elasticities can be found in *2.1.3 Understanding Elasticities*.)

These simplifying assumptions can be worked around if need be, either in TRIMMS or in a post-processing step.

VMT is not a user-supplied input into TRIMMS; it is an output on the TRIMMS Results Worksheet. For an area-wide analysis, the “commuters affected” input defines the size of the commuting population under study and is used to compute baseline vehicle trips and vehicle miles of travel (VMT) provided in the TRIMMS results. If total trips and VMT for motorized, passenger vehicle modes are known for the geographic area or population under consideration, this information could be used to ground truth the

TRIMMS results. More about this is discussed in this document at *Section 5.7 Process Sketch Planning Results.*

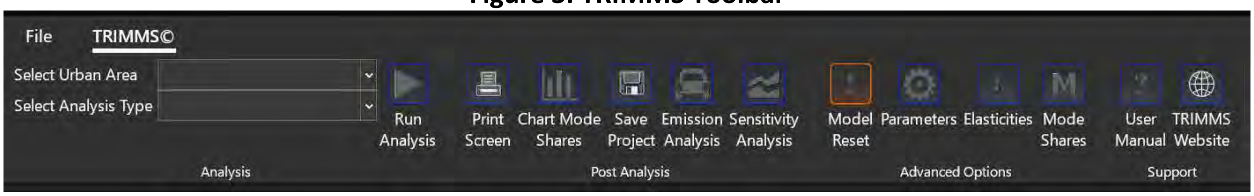
4.2 TRIMMS USER INTERFACE

This section discusses the main components of the TRIMMS user interface including the toolbar and relevant worksheets for performing an analysis. This section is an introduction to the TRIMMS user interface that establishes common terminology used in the remainder of this user guide. However, specific directions for running TRIMMS for a TEAM analysis are found in *Section 5 Estimate VMT Impacts*.

4.2.1 TRIMMS Toolbar

Upon launching TRIMMS, a customized toolbar appears in place of the Excel ribbon toolbar.

Figure 3. TRIMMS Toolbar

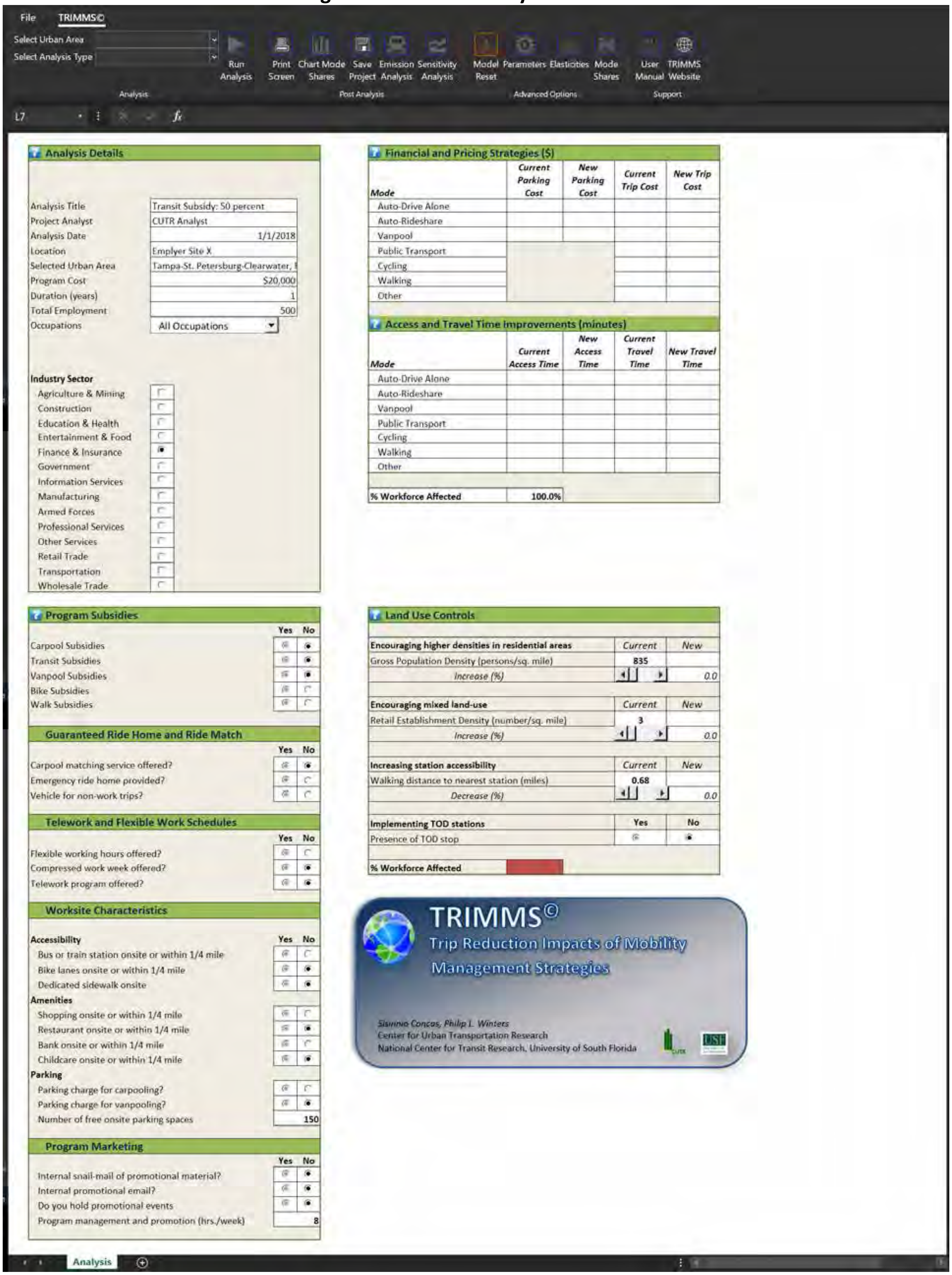


Actions can be performed by clicking on the appropriate buttons of this toolbar. There are four main groups of buttons:

1. **Analysis**: contains three buttons required to run the analysis.
    a. **Select Urban Area**: this drop-down allows users to pick the proximate U.S. metropolitan statistical area (MSA) for which the analysis is being conducted. This allows users to access and utilize various default parameters in the model.
    b. **Select Analysis Type**: this drop-down allows the user to specify whether the analysis is area-wide or worksite specific.
    c. **Run Analysis**: this button runs the analysis once the user has entered the desired parameter and strategy data.
2. **Post Analysis**: contains a set of buttons to perform actions, such as printing the current screen, charting mode shares, saving the project, conducting sensitivity analysis.
3. **Advanced Options**: includes a “Model Reset” option, which resets the model to its default parameter values. Clicking the “Parameters” button accesses the default input parameters page. The “Elasticities” button displays underlying trip demand elasticities.
4. **Support**: includes the “User Manual” button and the option to access the TRIMMS website containing User Manual and the users Frequent Asked Questions.

4.2.2 TRIMMS Analysis Worksheet

Figure 4. TRIMMS Analysis Worksheet



The Analysis Worksheet is the first screen that users will see upon opening the model. In this worksheet, users can enter details about the analysis being conducted and define the TE strategies under consideration. This worksheet is divided into four main sections:

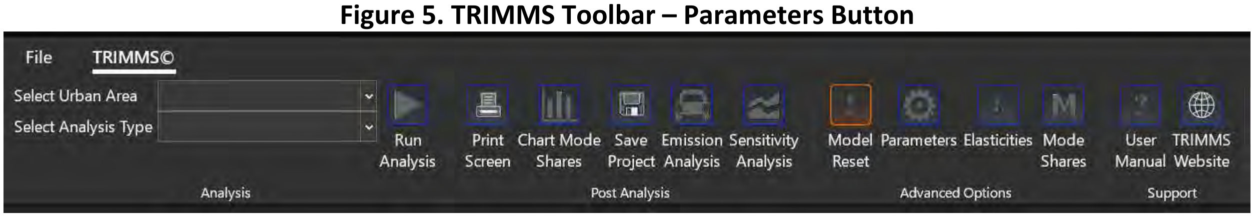
1. Analysis Details
2. Employer-Based Commuter Programs
3. Strategies Affecting Travel Costs and Travel Times
4. Land Use Controls[12]

For additional help, each section contains a clickable help icon ( ) located on top left corner of each section that opens a dialog box with more information and tips.

4.2.3 TRIMMS Parameters Worksheet

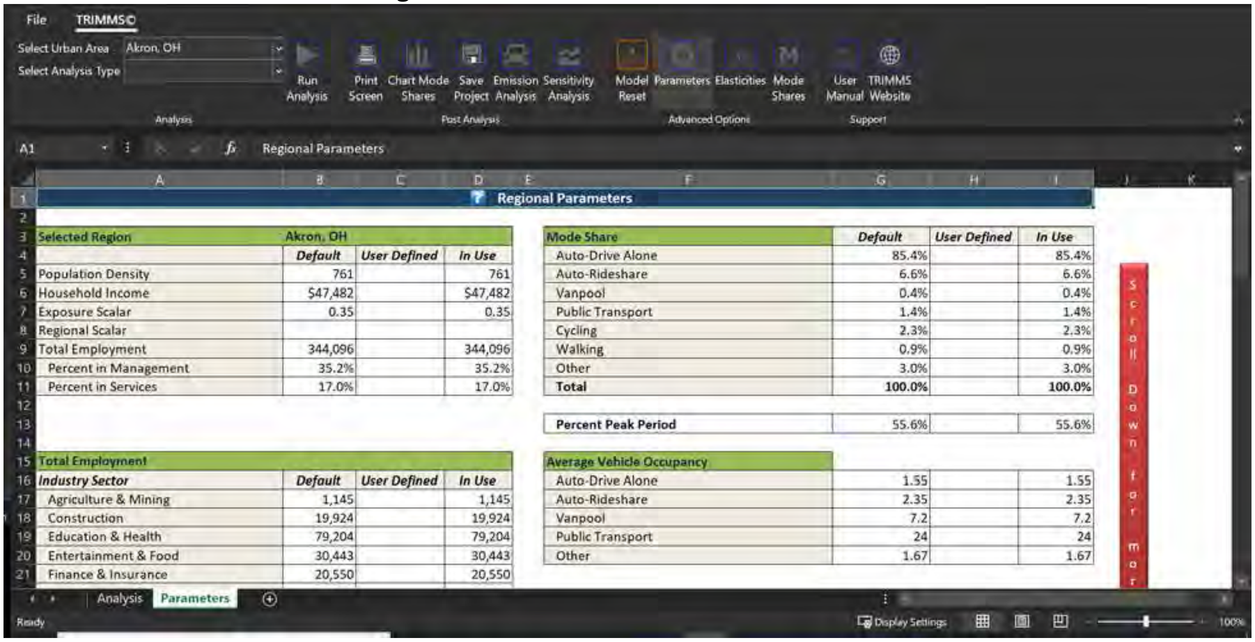
TRIMMS uses global and regional parameters to define conditions use in the analysis. Users can access the global and regional default input parameters by clicking on the "Parameters" button located in the TRIMMS toolbar (see *Figure 5. TRIMMS Toolbar – Parameters Button*), which displays the "Parameters" worksheet. Pressing the button again hides the worksheet and returns the user to the to the "Analysis" worksheet. Global parameters (not shown in *Figure 6. TRIMMS Parameters Worksheet)* but are available lower on the worksheet) are default values that do not change by MSA. Regional parameters are values that are specific to a given area.

Figure 5. TRIMMS Toolbar – Parameters Button



[12] Note: TRIMMS does include a land use function though previous EPA's TEAM case studies found that earlier versions of the land use functions were underpredicting VMT impacts, the EPA developed some off-model approaches for estimating land use VMT impacts.

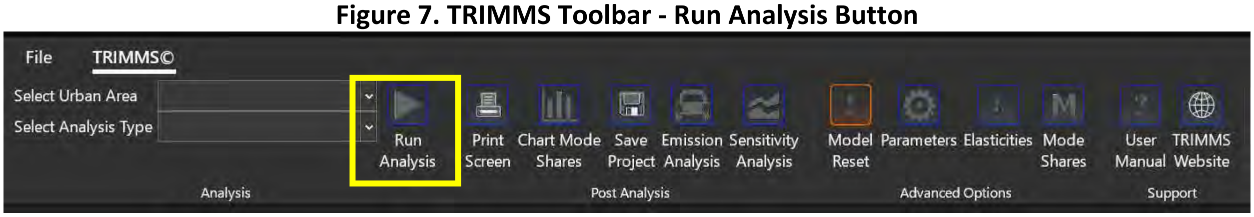
Figure 6. TRIMMS Parameters Worksheet



4.2.4 TRIMMS Results Worksheet

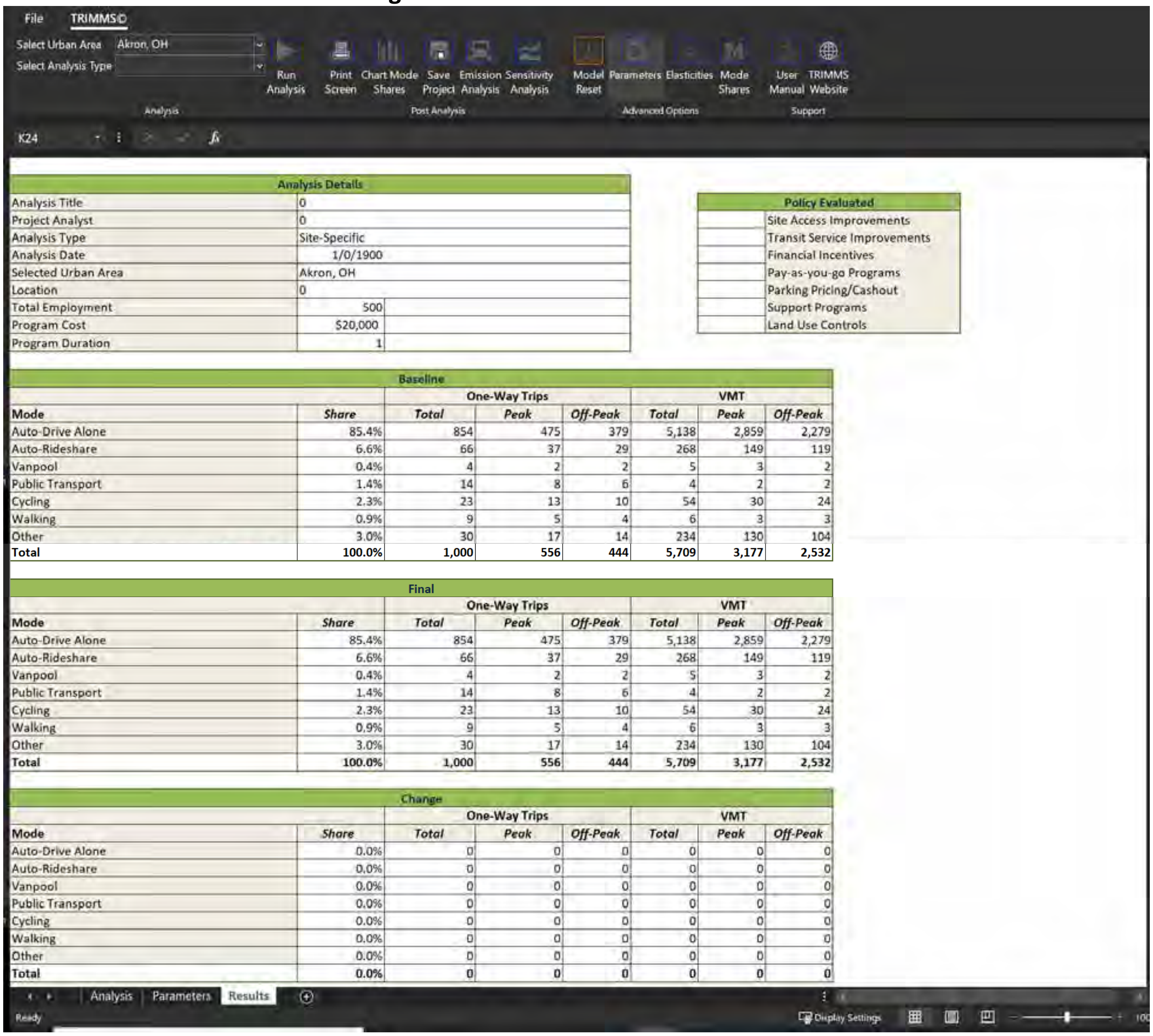
After entering the project information, the model is run by clicking on the "Run Analysis" button located on the toolbar (see *Figure 7. TRIMMS Toolbar - Run Analysis Button*).

Figure 7. TRIMMS Toolbar - Run Analysis Button



TRIMMS performs all calculations and reports changes in mode share, trips, and VMT. A summary of results is displayed in the "Results" worksheet (see *Figure 8. TRIMMS Results Worksheet*).

Figure 8. TRIMMS Results Worksheet



Analysis Details	
Analysis Title	0
Project Analyst	0
Analysis Type	Site-Specific
Analysis Date	1/0/1900
Selected Urban Area	Akron, OH
Location	0
Total Employment	500
Program Cost	$20,000
Program Duration	1

	Policy Evaluated
	Site Access Improvements
	Transit Service Improvements
	Financial Incentives
	Pay-as-you-go Programs
	Parking Pricing/Cashout
	Support Programs
	Land Use Controls

Baseline		One-Way Trips			VMT		
Mode	Share	Total	Peak	Off-Peak	Total	Peak	Off-Peak
Auto-Drive Alone	85.4%	854	475	379	5,138	2,859	2,279
Auto-Rideshare	6.6%	66	37	29	268	149	119
Vanpool	0.4%	4	2	2	5	3	2
Public Transport	1.4%	14	8	6	4	2	2
Cycling	2.3%	23	13	10	54	30	24
Walking	0.9%	9	5	4	6	3	3
Other	3.0%	30	17	14	234	130	104
Total	**100.0%**	**1,000**	**556**	**444**	**5,709**	**3,177**	**2,532**

Final		One-Way Trips			VMT		
Mode	Share	Total	Peak	Off-Peak	Total	Peak	Off-Peak
Auto-Drive Alone	85.4%	854	475	379	5,138	2,859	2,279
Auto-Rideshare	6.6%	66	37	29	268	149	119
Vanpool	0.4%	4	2	2	5	3	2
Public Transport	1.4%	14	8	6	4	2	2
Cycling	2.3%	23	13	10	54	30	24
Walking	0.9%	9	5	4	6	3	3
Other	3.0%	30	17	14	234	130	104
Total	**100.0%**	**1,000**	**556**	**444**	**5,709**	**3,177**	**2,532**

Change		One-Way Trips			VMT		
Mode	Share	Total	Peak	Off-Peak	Total	Peak	Off-Peak
Auto-Drive Alone	0.0%	0	0	0	0	0	0
Auto-Rideshare	0.0%	0	0	0	0	0	0
Vanpool	0.0%	0	0	0	0	0	0
Public Transport	0.0%	0	0	0	0	0	0
Cycling	0.0%	0	0	0	0	0	0
Walking	0.0%	0	0	0	0	0	0
Other	0.0%	0	0	0	0	0	0
Total	**0.0%**	**0**	**0**	**0**	**0**	**0**	**0**

Each sketch planning tool run of the cases for a given scenario will have a unique Results Worksheet. Data on this worksheet can be copied and post-processed to compare the cases to determine the VMT and trip impacts of a strategy scenario against the base year case (optional) and the BAU case.

4.3 Regional Parameter Data

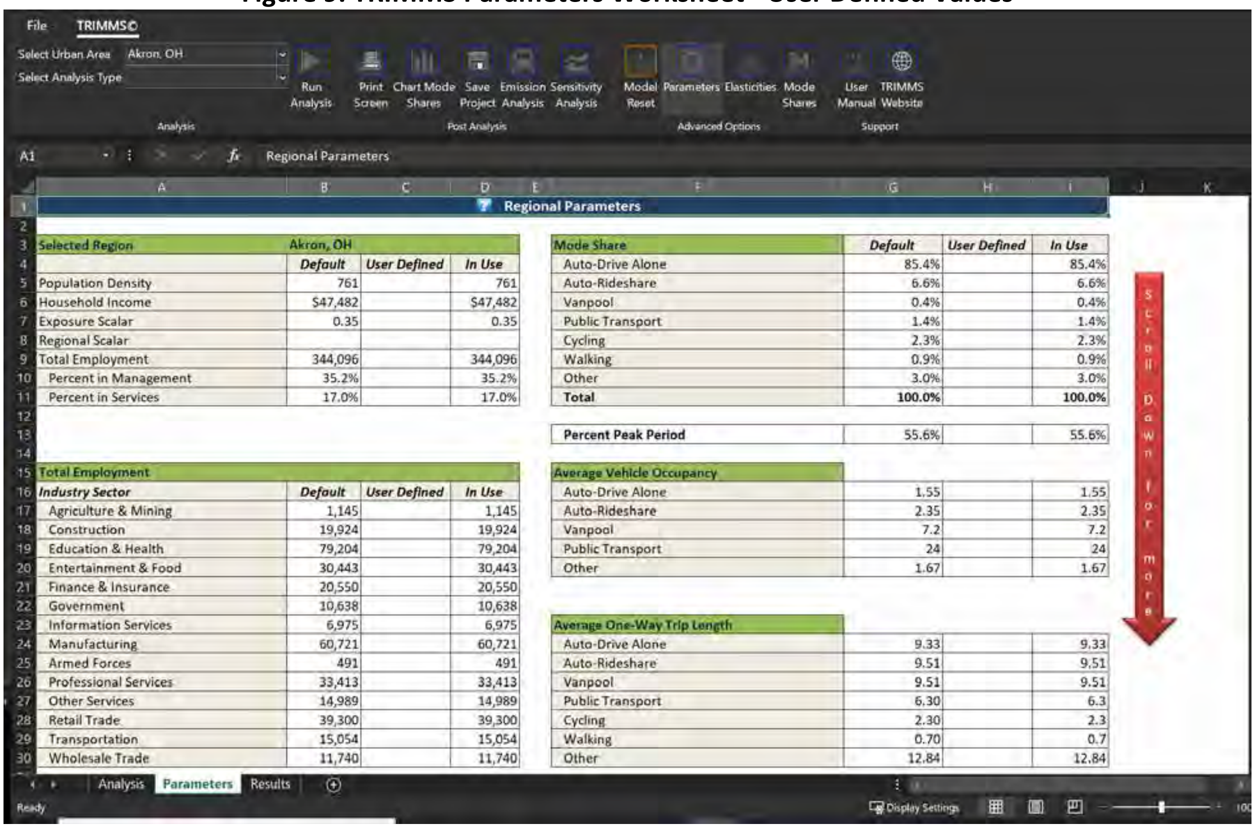
Step 2 of a TEAM analysis involves reviewing and gathering "regional parameter" data. The user must gather regional parameter data for the base year case analysis year (optional) and the BAU/scenario case analysis year. Regional parameters are data inputs that define the regional or subarea population, travel behavior, employment, etc. profile for use in sketch planning analysis. TRIMMS utilizes two sets of parameters to inform the conditions of the analysis: global and regional parameters:

- Global parameters are default values that do not change by metropolitan statistical area (MSA). For TEAM, EPA recommends not changing the global parameter values.
- Regional parameters are values that are specific to a given area.

Once an "Urban Area" is selected in the Analysis section of the TRIMMS Toolbar, users can access the TRIMMS regional default input parameters. If the user's region is not included in the MSAs represented in TRIMMS, the TRIMMS user manual recommends selecting the geographical area that most closely matches the region. TRIMMS includes default regional parameter data and default travel behavior data for 100 Metropolitan Statistical Areas (MSAs) in the U.S.[13] These defaults provide an immediate data source for those regions that may not have local input data but this default model data may not be the latest available data or applicable to future travel behavior and demand in future years.

Default regional parameter data are found within the Analysis Worksheet, in the Analysis Details section by clicking on the "Parameters" button located in the toolbar, which displays the "Parameters" worksheet (*Figure 9. TRIMMS Parameters Worksheet - User Defined Values*).

Figure 9. TRIMMS Parameters Worksheet - User Defined Values



Regional Parameters

Selected Region	Akron, OH		
	Default	User Defined	In Use
Population Density	761		761
Household Income	$47,482		$47,482
Exposure Scalar	0.35		0.35
Regional Scalar			
Total Employment	344,096		344,096
Percent in Management	35.2%		35.2%
Percent in Services	17.0%		17.0%

Total Employment			
Industry Sector	Default	User Defined	In Use
Agriculture & Mining	1,145		1,145
Construction	19,924		19,924
Education & Health	79,204		79,204
Entertainment & Food	30,443		30,443
Finance & Insurance	20,550		20,550
Government	10,638		10,638
Information Services	6,975		6,975
Manufacturing	60,721		60,721
Armed Forces	491		491
Professional Services	33,413		33,413
Other Services	14,989		14,989
Retail Trade	39,300		39,300
Transportation	15,054		15,054
Wholesale Trade	11,740		11,740

Mode Share	Default	User Defined	In Use
Auto-Drive Alone	85.4%		85.4%
Auto-Rideshare	6.6%		6.6%
Vanpool	0.4%		0.4%
Public Transport	1.4%		1.4%
Cycling	2.3%		2.3%
Walking	0.9%		0.9%
Other	3.0%		3.0%
Total	100.0%		100.0%
Percent Peak Period	55.6%		55.6%

Average Vehicle Occupancy			
Auto-Drive Alone	1.55		1.55
Auto-Rideshare	2.35		2.35
Vanpool	7.2		7.2
Public Transport	24		24
Other	1.67		1.67

Average One-Way Trip Length			
Auto-Drive Alone	9.33		9.33
Auto-Rideshare	9.51		9.51
Vanpool	9.51		9.51
Public Transport	6.30		6.3
Cycling	2.30		2.3
Walking	0.70		0.7
Other	12.84		12.84

However, TRIMMS default regional parameters are extracted from large, publicly available national datasets such as the National Household Travel Survey and American Community Survey and are often based on a recent past year.[14] For a future year, assumptions may need to be made to extrapolate data based on available information or future regional travel estimates. Therefore, EPA encourages users to

[13] For more information on TRIMMS default data, see the "Regional Parameters" section of the TRIMMS user guide.

[14] For more information on data sources in TRIMMS, see Section 5.6 of the TRIMMS User Manual Version 4.0.

provide "user defined" local data, especially for future-year analyses such as the BAU and Scenario case analyses.
Table 4. TRIMMS Regional Parameter Data Inputs and Typical Sources of These Data identifies some sources where local data may be obtained in addition to referencing a region's latest local long-range planning assumptions.

Table 4. TRIMMS Regional Parameter Data Inputs and Typical Sources of These Data

<table>
<tr><th colspan="2">Regional Parameter Inputs</th><th>Typical Data Sources</th></tr>
<tr><td rowspan="2">Selected Region data</td><td>Population Density</td><td>• U.S. Census Bureau
• Local planning assumptions</td></tr>
<tr><td>Total working population (16 and over)</td><td>• U.S. Bureau of Labor Statistics
• Local planning assumptions</td></tr>
<tr><td rowspan="3">Modal information for:
• Auto-drive alone
• Auto-rideshare
• Vanpool
• Public transit
• Cycling
• Walking
• (Other modes)</td><td>Mode share</td><td>• American Community Survey
• Local travel demand model</td></tr>
<tr><td>Average trip length (miles)</td><td>• National Household Travel Survey
• Local travel demand model</td></tr>
<tr><td>Average vehicle occupancy for motorized modes (number of persons)</td><td>• Travel Demand Model
• Local Transit Agencies
• U.S. Bureau of Transportation Statistics</td></tr>
</table>

EPA has identified additional source of regional parameter data in *Section 8.1 Potential Data Sources for Conducting a TEAM Analysis* of the Appendix.

While there are many parameters for which modelers can provide data, for the purposes of a TEAM analysis, EPA believes it is important for modelers to review "population density" and "total employment" rows in the Selected Region section and update these with local data if needed, and supply "user defined" values for the Mode Share, Average Vehicle Occupancy, and Average One-Way Trip Length sections of the Parameters Worksheet.

The sources of data identified in the table above are often based on a recent past year. For a future year, assumptions may need to be made to extrapolate data based on available information or future regional travel estimates.

4.4 Strategy Data

Once regional parameter data has been collected, it is necessary to gather data to specify the "commuters affected" by the strategy and further define strategy operationalization. The data needed and the level of effort required to collect the TE strategies selected in Step 1 depend on:

1. The type of strategies selected, and
2. The specific geographic area, or sub-area, or population to which each of the strategies applies.

As noted, TRIMMS was designed to analyze commute trips only, but it can be used to analyze all types of trips. For the purposes of TEAM, the concept of "commuters affected" means the total population subject to the TE strategy being considered, not just the commuting population.

- If a TE strategy is being broadly applied across a region, the commuters affected would be equal to the regional population.
- If the TE strategy is being targeted at a particular subarea or population, the commuters affected value should reflect those groups. For example, for a public transit subsidy targeted toward healthcare workers, the commuters affected value would be equal to the number of healthcare workers to which the subsidy could apply. For a proposed transit service expansion, the commuters affected value could be counted as population living within a specified radius of transit stops.

The table below provides examples of the types of inputs needed in this step by TE strategy category.[15] *Section 5* contains a more in-depth discussion of different TE strategies.

Table 5. TE Strategies and Examples

Strategy Category	On/Off Model	Examples of Strategy Options	Examples of Typical Data Needs by Strategy Option
Travel Demand Management (TDM) and Employer Incentives	On-Model	• Subsidies for alternative modes	• Number of regional commuters affected covered by subsidy • Average subsidy offered to employees (by mode) – OR – whether subsidies are offered (by modes being subsidized) • Current trip cost (by modes being subsidized) • New trip cost (by modes affected)
		• Guaranteed ride home, ride match, telework, and flexible work schedules	• Number of regional commuters affected by program • Whether or not guaranteed ride home, ride match, telework, and flexible work schedules are offered (radio buttons in TRIMMS)
Transit	On-Model	• Free or reduced fares, bundled transit passes	• Number regional population affected • Current trip cost (for public transport) • New trip cost (for public transport)
		• Reduced transit travel times or wait times	• Number of regional commuters affected by program • Current average public transit access time and travel time • New average public transit access time and travel time

[15] Recall that this User Guide reflects TRIMMS data requirements. Users should compare the data needs identified in this section with those for the sketch planning model they have selected for this work.

Strategy Category	On/Off Model	Examples of Strategy Options	Examples of Typical Data Needs by Strategy Option
Transit (continued)	On-Model	• Expanded service area	• Current (BAU case) number of regional commuters affected (generally counted as population living within a specified radius of current transit stops) • New number (Scenario case) of regional commuters affected (generally counted as population living within a specified radius of proposed transit stops but could also include expected users of a new park and ride facility)
Transportation Pricing	On-Model	• Parking pricing ($/hr)	• Number of regional commuters affected parking (average daily parking customers) • Average current parking cost (avg. hrs. x $/hr) per trip • Average new parking cost (avg. hrs. x $/hr) per trip
		• VMT pricing ($/mile)	• Number of regional commuters affected • Average trip length in miles (by modes affected) • Current trip cost ($/mile x mile/trip) • New trip cost ($/mile x mile/trip)
		• Road pricing	• Number of regional commuters affected (daily users of specific roadway) • Current trip cost (toll cost) for modes affected • New trip cost (toll cost) for modes affected
Land Use	Off-Model	• Shifting population and employment growth to more compact neighborhoods/lower VMT generating neighborhoods • Workforce-housing balance initiative • TOD program	**Neighborhood approach:** • share of regional population in affected areas • percent population by neighborhood type
			Multivariate approach: • share of regional population in affected areas • increase in weighted average residential density (persons per square mile) • increase in job accessibility by car • increase in job accessibility by transit • average decrease in distance to transit • average increase in land use mixing
Bicycle and Pedestrian Improvements	Off-Model	• Expanded sidewalk coverage	• Number regional commuters affected (generally counted as population living within a specified radius of current transit stops) • Increase in miles of sidewalk coverage
		• Expanded bike lane coverage	• Number regional commuters affected (generally counted as population living within a specified radius of current transit stops) • Increase in miles of bicycle routes

TDM, transit, and transportation pricing strategies can be directly evaluated with TRIMMS. For these TE strategies, the data needed generally includes the “commuters affected” value and data for the “Financial and Pricing Strategies ($)” and “Access and Travel Time Improvements (minutes)” sections of the Analysis worksheet (see *Figure 10. Financial and Pricing Strategies ($) and Access and Travel Time Improvements (minutes) Section of the Analysis Worksheet in TRIMMS*). Note: No values are needed for modes or aspects (current/new parking costs, current/new trip costs, current/new access time, and current/new travel time) not affected by the selected TE strategy.

Figure 10. Financial and Pricing Strategies ($) and Access and Travel Time Improvements (minutes) Section of the Analysis Worksheet in TRIMMS

Financial and Pricing Strategies ($)

Mode	*Current Parking Cost*	*New Parking Cost*	*Current Trip Cost*	*New Trip Cost*
Auto-Drive Alone				
Auto-Rideshare				
Vanpool				
Public Transport				
Cycling				
Walking				
Other				

Access and Travel Time Improvements (minutes)

Mode	*Current Access Time*	*New Access Time*	*Current Travel Time*	*New Travel Time*
Auto-Drive Alone				
Auto-Rideshare				
Vanpool				
Public Transport				
Cycling				
Walking				
Other				
% Workforce Affected	**100.0%**			

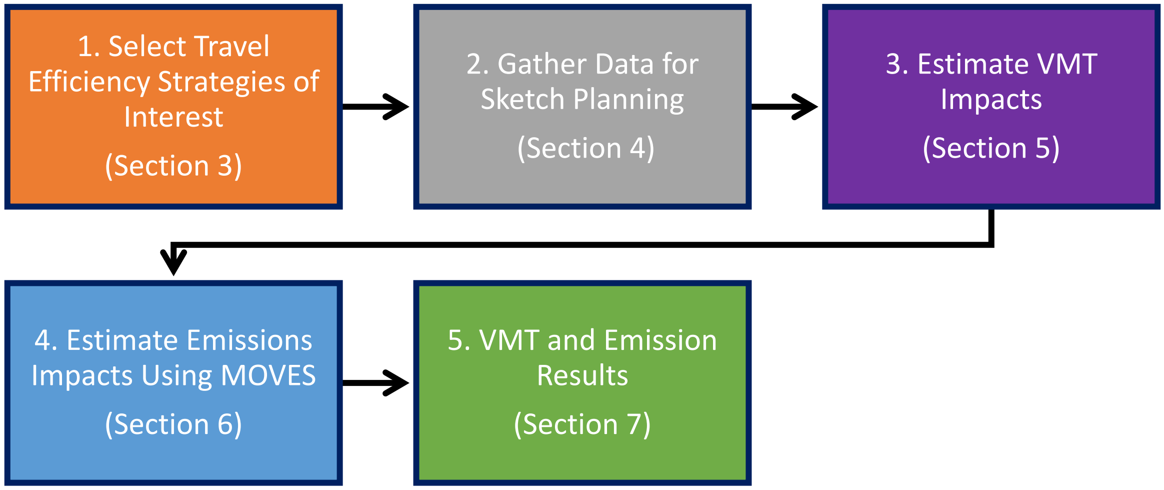
Land use strategies and bicycle/pedestrian strategies can be analyzed using a separate spreadsheet analysis. More on this is discussed in *Section 5.5 Land Use Strategies* and *Section 5.6 Bicycle and Pedestrian Strategies.*

At the end of Step 2, the user should have:

- All regional parameter data for the base year case and BAU/Scenario cases,
- All strategy data to define strategy operationalization

- In TRIMMS, the “commuters affected” value and data for the “Financial and Pricing Strategies ($)” and “Access and Travel Time Improvements (minutes)” sections of the Analysis worksheet.
- If Land Use strategies are selected, compiled data to support the needed variables for the off-model approaches (see Section 38*5.5 Land Use Strategies*).
- If Bicycle and Pedestrian Improvements are selected, compiled data to support the off-model bicycle and pedestrian sketch planning tools (see Section *5.6 Bicycle and Pedestrian Strategies*).

5 ESTIMATE VMT IMPACTS



In step 3, the user will estimate the VMT impacts of the selected TE strategies. This involves entering the data gathered in step 2 (regional parameter data and strategy data) into the sketch planning tool for the cases needed for the analysis.

5.1 PERFORM SKETCH PLANNING

Each travel efficiency strategy analysis is comprised of two or three runs: for the base year case (optional), the BAU case, and the scenario case, as described in *Section 7 VMT and Emission Results. Base Year, BAU, and Scenario Cases, and Analysis Years*. The following table shows the analysis year for each of these cases and the inputs needed when using TRIMMS:

Table 6. Analysis Cases Used in TEAM

Run	Analysis Year	Regional Parameters Worksheet Inputs	Analysis Worksheet Inputs
Base Year Case (Optional)	Convenient reference year (current year)	Data for reference year analysis year	• Commuters affected
Business as Usual (BAU) Case	Future year (same as scenario case)	Data for future year analysis year	• Commuters affected
Scenario Case	Future Year (same as BAU case)	Data for future year analysis year	• Commuters affected • Strategy Operationalization Data

In TRIMMS, the general steps for each analysis run are as follows:

<u>Analysis Worksheet</u>

1. In the TRIMMS Toolbar, click the “Select Urban Area” drop down and select the MSA for which the analysis is being conducted.
2. In the TRIMMS Toolbar, click the “Select Analysis Type” drop down and select “Area-Wide”.
3. In the Analysis Details section, input the “Commuters Affected” value for the selected TE strategy.
4. In the Analysis Details section, ensure that “All Occupations” is selected in the Occupations drop down.

5. In the Access and Travel Time Improvements (minutes), ensure 100% is entered in the %Workforce Affected field.

Parameters Worksheet – (Click the "Parameters" button on the ribbon at the top of the screen to access the "Parameters" tab).

1. Review 'Default' values and provide 'User Defined' values where necessary, based on the data collected (see *Section 4.3 Regional Parameter Data*), in the following four areas:
    a. Selected Region
    b. Mode Share
    c. Average Vehicle Occupancy
    d. Average One-Way Trip Length
2. Click the 'Elasticities' button on the ribbon at the top of the screen to reveal the 'Elasticities' tab. On the 'Elasticities' tab, input User Defined values according to Step 2b in the following areas:
    a. Cost/Fare Peak and Off-Peak
    b. Parking Peak and Off-Peak
    c. Access/Travel Time Peak and Off-Peak

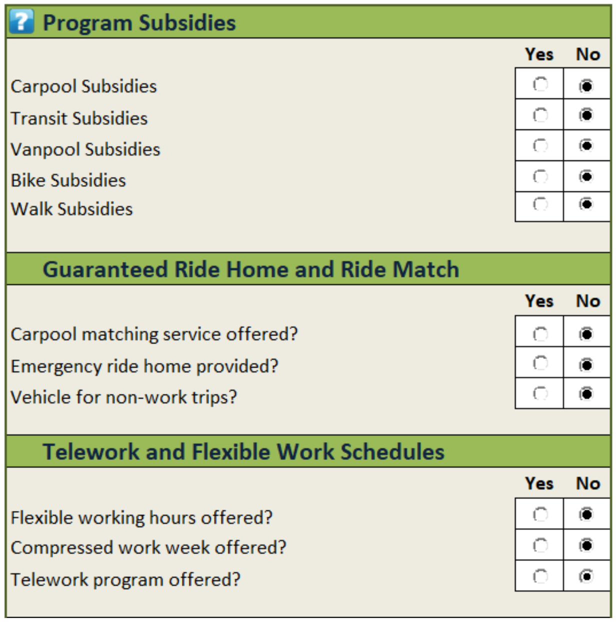
A unique TRIMMS run is needed for each unique geographic area or sub-population. To run TRIMMS, click the 'Run Analysis' button at the top of TRIMMS to produce the 'Results' tab. Everything necessary for the TEAM analysis is found in the Baseline, Final, and Change boxes of the 'Results' tab, including the VMT produced by the scenario modeled.

The following sections provide detailed instructions about how to analyze specific TE strategies in TRIMMS. Instructions are based on experience using TRIMMS for assessing TE strategies in the case studies produced by EPA. If a different sketch planning tool is used, the specific steps for analyzing each strategy will likely differ. However, the basic principles of each sketch planning tool, i.e., allowing the user to modify trip cost and travel time, are likely to be the same.

5.2 Transportation Demand Management

TRIMMS can be directly used to evaluate various TDM strategies, which include guaranteed ride home and ride matching, telework and flexible work schedules, and others. To analyze these strategies in TRIMMS, users can select several options via radio buttons in the section of the Analysis worksheet, depicted in *Figure 11. TRIMMS TDM Strategies*.

Figure 11. TRIMMS TDM Strategies



If these types of strategies are part of a project evaluation, users can estimate the impacts of one or a combination of several of these TDM program strategies in TRIMMS. For an area-wide analysis, the selection of occupation type will affect the results. Select the "all occupations" option so that TRIMMS will apply employer support programs to all commuters specified in the "commuters affected" field in the Analysis Details portion of the Analysis worksheet.

5.3 Transit Strategies

This category encompasses a variety of strategies that enhance or expand transit service. The table below gives examples of these strategies.

Table 7. Example Transit Strategies

Transit Strategy	Main Strategy Impact	Examples of Typical Data Needs by Strategy
Subsidized (free or reduced) transit fares, bundled transit passes	Reduction in transit trip cost	• Number regional population affected • Current trip cost (for public transport) • New trip cost (for public transport)
Adding additional vehicles to existing routes to increase transit frequency	Reduction in transit access time	• Number of regional commuters affected by program • Current average public transit access time • New average public transit access time
Provision of dedicated bus-only lanes and/or bus-priority signalization	Reduction in transit travel time	• Number of regional commuters affected by program • Current average public transit travel time • New average public transit travel time
Expanded service area	Increase the number of commuters affected	• Current (BAU case) number of regional commuters affected (generally counted as population living within a specified radius of current transit stops) • New number (Scenario case) of regional commuters affected (generally counted as population living within a specified radius of proposed transit stops)

The table above is not exhaustive of all potential TE transit strategies and EPA recognizes that there are several other types transit enhancements that may make transit a more attractive option. However, some of these may not be easily analyzed in TEAM. These could include enhancements that make transit more convenient such as early morning or late-night service whereby increasing the number of service hours that transit is available in an area. They also could include "soft improvements" to increase safety, cleanliness, and comfort such as the provision of amenities for transit stops, such as covered waiting areas or seating. EPA recognizes the importance of such additional enhancements to transit service however alternative methods may need to be developed if an area is interested in analyzing these types of improvements.

A major consideration across all transit strategies is defining the "commuters affected" value for the strategy. For transit strategies affecting the entire region, the "commuters affected" value can be entered as the regional population. However, for transit strategies targeted to a specific population (e.g., low-income households, workers specific industry, etc.) or geographic area (e.g., corridor, neighborhood, etc.), a different approach is needed. For strategies that target a specific population enter that population for the "commuters affected" value (see *Section 2.1.1 Analysis Geography and Commuters Affected* for additional discussion). For transit strategies targeted at a specific geographic sub-area, past TEAM analyses have used a simplified proxy for potential transit ridership using the walking service shed based on a 10-minute walk at a 3-mph walking speed. This results in an approximately ½-mile service shed around any current/proposed transit stops along a current or proposed corridor. This tabulation is generally conducted using a geographic information systems (GIS) analysis using Census Block Group shapefiles and shapefiles of the current/proposed transit infrastructure. This user guide does not cover aspects of using GIS software, therefore, familiarity with GIS software, performing a buffer analysis, and field calculation is needed if this approach is used to determine the "commuters affected" value.

There are other analysis cases where this approach to defining the "commuters affected" value should be modified. As noted, the approach above is specific for projects that focus on users who walk to access to transit. Different travel sheds could be used for projects that focus on cycling or driving to transit stops and ride the rest of the way on a transit vehicle. For example, a transit project that includes park and ride (also known as park-and-ride, park & ride, park-n-ride, etc.) facilities should consider how to define the "commuters affected" value taking into consideration aspects such as parking turnover, space utilization, and other use information. Regardless of the approach used to derive the commuters affected value of a transit strategy, it is important to document the method and assumptions used.

As noted in *Table 7. Example Transit Strategies*, transit strategies analyzed in TEAM generally affect the cost and travel time of transit trips but could also include increasing the number of commuters affected. There are different options for determining the Analysis tab input values (trip cost and/or access and travel times) for these types of strategies.

Current travel costs for transit strategies should reflect the transit fare as paid by the customer. This could be expressed as the average fare paid across an entire system (total farebox revenue/total trips provided) or simply as the posted single-ride fare. Future travel costs for transit strategies should be based on or scaled from the current costs.

Travel time can be broken down in two components: in-vehicle travel time (IVTT), and out-of-vehicle travel time (OVTT). IVTT, or travel time, is simply the time spent in transit from origin to destination while in a vehicle. OVTT, or access time, is the spent traveling to and from stops, waiting for vehicles, and transferring between vehicles commonly associated with transit usage. These two components of travel time can be targeted through TE strategies. For example, a strategy like transit signal prioritization or dedicated bus lanes may reduce IVTT whereas increasing the frequency of transit vehicles or adding additional stops could reduce OVTT. OVTT could include both the headway, or time between vehicles in a transit system, and the amount of time it takes to reach an access point such as a bus stop or transit terminal. Therefore, estimating OVTT could be as simple as looking at the scheduled time between transit vehicles or could include the average time it takes a system user to reach a transit stop. This is especially important in the evaluation of transit accessibility improvements. IVTT is entered into TRIMMS as current and new travel time. OVTT is entered into TRIMMS as current and new access time. Note, a strategy impacting travel times may impact either or both IVTT and OVTT depending on how it is operationalized.

To calculate the benefits of a transit strategies, the following method can be applied:

1. Ensure that the appropriate regional parameters have been entered in the Parameters tab for the scenario in TRIMMS.
2. Define the number of regional commuters affected. For some strategies, potential transit commuters affected could be calculated as the number of residents that live within ½-mile of the current/proposed transit stops along a current or proposed corridor.
3. Operationalize the strategy impact within the Financial and Pricing Strategies ($) section or Access and Travel Time Improvements (minutes) section within the Analysis worksheet.
    a. For transit strategies that impact transit trip cost, enter the current transit trip cost, estimated using the methods discussed above, into the public transit current trip cost cell. Then enter the trip costs as effected by the strategy into the public transit new trip cost cell. For transit strategies that do not impact trip cost, leave the cells in this section blank.
    b. For transit strategies that impact transit access times, determine the current and new access time and enter it into the public transit current and new access time cells.
    c. For transit strategies that impact transit travel times, determine the current and new travel time and enter it into the public transit current and new travel time cells.
4. Run the analysis.
5. Examine the results.

An example transit strategy VMT calculation is provided in the Appendix in *Section 8.3.1 Example Transit Strategy Calculation*.

5.4 Pricing Strategies

Based on EPA's experience to date, transportation pricing strategies that target single occupancy vehicles tend to be among the most effective at reducing VMT with the co-benefits of reducing traffic, cutting pollution, and encouraging transit alternatives.[16] Pricing strategies are generally disincentives for single occupancy vehicle driving and could include parking pricing, roadway tolls, and or dynamic pricing schemes such as congestion pricing. Many past TEAM case studies partners have included pricing strategies to explore options for alternative sources of revenue to make up shortfalls in funds available

[16] See EPA's factsheet, *Travel Efficiency Assessment Method: Key Takeaways from State and Local Case Studies to Reduce Transportation Emissions*, EPA-420-F-20-042, July 2020, available on the web at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ZN95.pdf.

to support their transportation plans. Considerations of a specific price to apply for this type of strategy should be based on what might be reasonable in the region.

5.4.1 Vehicle In-Use Pricing

Vehicle in-use pricing are a set of strategies that levy a distance-based fee on vehicle use. This kind of program is expected to reduce single occupancy vehicle travel and encourage commuters to use other forms of transportation, including public transit, carpool, or vanpool where costs are spread across multiple riders. There are several different forms that a vehicle in-use pricing strategy may take, but some strategies analyzed using TEAM include:

- Facility or partial facility pricing: pricing on facilities (e.g., roads, bridges, tunnels) introduces tolls on facilities that are currently free, or already have flat tolls. If flat tolls are already in place, the introduction of increased or variable tolling is the key element of pricing strategy of interest.

- Congestion pricing: motorists are charged a fee to use a specific facility or enter a defined zone within a region during temporary or cyclic increases in demand. (e.g., London, Stockholm, and Milan have implemented various zone-based pricing schemes).

- Distance-based pricing: sometimes called VMT pricing or a mileage-based user fee, these fees are distance-based fees levied on motorists for use of a roadway system. As opposed to tolls, which are facility-specific and not necessarily levied strictly on a per-mile basis, these fees are based on the distance driven on a defined network of roadways.

- Other effects on vehicle marginal operating cost: this could include generic strategies indexed to vehicle use such as pay-as-you-go insurance.

To calculate the benefits of a vehicle in-use pricing strategies, the following method can be applied:

1. Ensure that the appropriate regional parameters have been entered in the Parameters tab for the scenario in TRIMMS.
2. Define the number of regional commuters affected. For vehicle in-use pricing strategies, some research must be conducted to determine how, where, and to whom the in-use pricing strategy will be applied. If commuter trips are included that will not be subject to pricing in the sketch planning tool (e.g., the entire region when only trips to downtown will be priced) results will be too high.
3. Enter the current trip cost for the affected trips. For simplification, the “current trip cost” field of the “Financial and Pricing Strategies ($)” section of the Analysis Worksheet in TRIMMS can be entered as “0” for the affected modes.
4. Determine and enter the new trip cost for the affected trips
    a. For zonal pricing, this may take the form of a flat fee per trip within the zone; if so, this could be as simple as entering the zonal pricing fee into “new trip cost” field of the “Financial and Pricing Strategies ($)” section of the Analysis Worksheet in TRIMMS for the affected modes.
    b. For congestion pricing with a dynamic cyclic or demand-based effect, for simplification, uses should consider deriving an average, activity-weighted new trip cost. For example, if it is anticipated that, in a given day, 1000 vehicle trips will be subject to the base congestion price and 500 vehicle trips will be subject to the peak congestion price, the following simple weighting is proposed:

new trip cost = ((1000 x $\$_{base}$) + (500 x $\$_{peak}$)) / (1000 + 500)

   c. For distance-based pricing, the new trip cost may simply be entered as the average one-way trip distance subject to the fee multiplied by the fee per mile.
      new trip cost = miles per one-way trip x $/mile
5. Run the analysis.
6. Examine the results.

5.4.2 Parking Pricing

Parking pricing strategies directly impact the fees charged for using a parking space. Effective parking pricing can provide numerous benefits including improved parking allocation, reduced traffic, and promote alternative travel modes. This type of strategy could be operationalized broadly to apply to a large geographic area or, more specifically, to a particular worksite, such as a college campus. It can also be used to analyze increases to hourly parking rates or evaluate changes to parking permit fee structures. Generally, a parking pricing strategy should be applied to an area or population with similar parking pricing and/or facility type. For example, a parking pricing strategy may work best when targeted to a specific area, like downtown parking structures, where parking prices are relatively consistent versus when applied broadly across a region.

To calculate the benefits of a parking pricing strategies, the following method can be applied:

1. Ensure that the appropriate regional parameters have been entered in the Parameters tab for the scenario in TRIMMS.
2. Define the number of regional commuters affected.
3. Enter the current parking cost for the affected trips. For simplification, the “current parking cost” field of the “Financial and Pricing Strategies ($)” section of the Analysis Worksheet in TRIMMS can be simplified as the average price per trip. This can be calculated as in a variety of methods as noted above. Note, averaging parking or VMT pricing over a broad area for input to a sketch planning tool, when many trips are not priced, overestimates mode shift.
4. Run the analysis.
5. Examine the results.

An example transportation pricing strategy VMT calculation is provided in the Appendix in *Section 8.3.2 Example Transportation Pricing Calculation.*

5.5 LAND USE STRATEGIES

Land use strategies are one of the most important—and one of the most complex—means by which regions can reduce VMT. Land use patterns affect how people travel, and therefore an area’s geographic size and density have an impact on emissions. Areas that are more compact will have shorter average trip lengths and fewer vehicle trips. Supportive land use policies can provide for the commercial and residential densities to enable transit to be viable and cost effective. While the TRIMMS sketch planning tool includes land use strategies, EPA developed two land use analytical approaches to assess land use impacts within a region for TEAM instead. These are identified as the Neighborhood Classification approach and the Multivariate Elasticity approach. These analyses can be conducted outside of the TRIMMS analysis and are discussed in greater detail in *Section 8.2 Land Use Analysis* of the Appendix.

Land use strategies can encompass a wide variety of policies to improve environmental sustainability, better adapt and mitigate climate changes, improve resilience to disasters, make development and access to transportation more equitable, or other goals. For more information about land use strategies, visit EPA's website at: https://www.epa.gov/smartgrowth. This page includes links to "About Smart Growth" and "Examples of Smart Growth" in addition to many other topics.

5.6 Bicycle and Pedestrian Strategies

The two strategies relevant to TEAM in this category are: bicycle infrastructure expansion and pedestrian infrastructure expansion. As noted earlier, the TEAM approach is not based on TRIMMS, but instead on an off-model approach that EPA developed. This approach can be used to quantify the impacts of building new bicycle and pedestrian infrastructure (e.g., bike lanes and sidewalks). Also, this approach does not include the benefits of "soft" bicycle and pedestrian programs such as those that promote awareness and education or those that provide amenities such as secure bike storage or showering facilities. The approaches for these strategies are also limited in that they do not consider qualitative aspects of the facility such as facility type (e.g., protected bike lanes versus shared lanes, sidewalk versus mixed-use paths, etc.), facility quality (e.g., pavement condition, Americans with Disabilities Act compliance, etc.). Areas interested bicycle and pedestrian strategies should consider how these factors and other soft programs enhance the user experience and ultimately encourage bicycle and pedestrian mode shift. Use the examples below to follow this spreadsheet analysis approach.

5.6.1 Bicycle Infrastructure Expansion

This approach is based on the research of Jennifer Dill and Theresa Carr that found that each additional linear mile of bike lanes per square mile of city area is associated with an increase of roughly one percentage point in the share of bike commuters, even after controlling for days of rain, automobile ownership, and state spending on walking and cycling. [17] Because the research on induced bicycle facility demand is limited, VMT reduction results tend to be relatively small To calculate the benefits of bicycle strategies, the following method can be applied.

1. Prepare data on total existing and future bicycle lane miles and total existing and future new land area.
2. Calculate BAU and scenario bike lane miles per area (miles bike lane/sq. mile) and the percent increase.
3. Use Dill and Carr elasticity to determine increase in bike mode share (1% increase for every 1 bicycle lane mile per square mile).
4. Determine the expected BAU cycling mode share.
5. Calculate the increase in cycling mode share resulting from the strategy.
6. Decrease mode shares for non-cycling modes to bring the total of all mode shares back to 100%. To do this, assume that new bicycle trips are converted from other modes in proportion to the BAU share of each mode.
7. Calculate trips reduced for non-cycling modes.
8. Calculate reduction in VMT for auto-modes using the average bicycle trip length:
    a. For auto drive-alone, VMT reduced = trips reduced * bicycle trip length

[17] Dill, Jennifer & Carr, Theresa. (2003). Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them. Transportation Research Record. 1828. 116-123. 10.3141/1828-14.

b. For auto rideshare, VMT reduced = trips reduced / carpool occupancy * bicycle trip length

An example calculation using the steps above is provided in the appendix in section *8.3.1 Example Bicycle Strategy Calculation*.

5.6.2 Pedestrian Infrastructure Expansion

To calculate the benefits of pedestrian strategies, the following method can be applied.

- Prepare data on total existing and future facility miles.
- Calculate the percent change in facility miles from existing to future strategy scenario.
- Multiply the percent increase in facility miles by the elasticity value of 0.27 for walk commuters with respect to walk route miles per 10,000 miles to determine the percent increase in pedestrian commuters.[18]
- Determine the BAU walking mode share.
- Calculate the increase in walking mode share resulting from the strategy: the percent change in the number of walk trips per 10,000 miles from the BAU case to the strategy case.
- Adjust mode shares for non-walk modes downwards to bring the total of all mode shares back to 100%. To do this, assume that new walking trips are converted from other modes in proportion to the BAU share of each mode.
- Calculate trips reduced for non-walk modes.
- Calculate reduction in VMT for auto-modes using the average walk trip length:
  - For auto drive-alone, VMT reduced = trips reduced * walk trip length
  - For auto rideshare, VMT reduced = trips reduced / carpool occupancy * walk trip length

An example calculation using the steps above is provided in the appendix in section *8.3.2 Example Pedestrian Strategy Calculation*.

5.7 Process Sketch Planning Results

In this step, changes in travel activity from the selected strategies are calculated. Results from this step are BAU VMT and trips, Scenario VMT and trips, and change in VMT and trips by mode. EPA recommends exporting the results from the sketch planning tool exercise to a spreadsheet. Doing so will allow results from different strategies to be adjusted and combined and will help with later emissions analysis. If multiple different geographies were used for the strategies, VMT reductions can be quantified for each sub-population or sub-geography. The post-processing spreadsheet will allow VMT reductions across the entire region and population to be summed, to calculate VMT reductions relative to total regional VMT.

Recall that TRIMMS produces 3 tables in the Results worksheet:

- Baseline - reflects the values with the parameters, as defined on the Parameters worksheet, but without the strategy implemented. This represents the BAU values for the TEAM analysis.
- Final - reports the estimated new mode share, counts of trips, and counts of VMT with the strategy implemented. This represents the Scenario values for the TEAM analysis.

[18] Bartholomew, Keith and R. Ewing. (2009). Land Use-Transportation Scenarios and Future Vehicle Travel and Land Consumption: A Meta-Analysis. Journal of the American Planning Association, 75 (1), 13-27.

- Change - provides the difference between "Final" and "Baseline" table values to gauge the impact on travel behavior of the selected strategy.

Figure 12. Example TRIMMS Results

Baseline							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	77.7%	777	433	345	4,680	2,606	2,074
Auto-Rideshare	10.9%	109	61	48	440	245	195
Vanpool	1.1%	11	6	5	14	8	6
Public Transport	1.7%	17	9	7	4	2	2
Cycling	1.8%	18	10	8	41	23	18
Walking	2.4%	24	13	11	17	9	8
Other	4.4%	44	25	20	341	190	151
Total	**100.0%**	**1,000**	**557**	**443**	**5,538**	**3,083**	**2,454**

Final							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	76.6%	761	424	337	4,584	2,552	2,031
Auto-Rideshare	10.8%	108	59	48	435	240	195
Vanpool	1.0%	10	6	5	14	8	6
Public Transport	2.8%	28	14	14	7	4	4
Cycling	1.8%	18	10	8	41	23	18
Walking	2.4%	24	13	11	17	9	8
Other	4.5%	44	25	20	341	190	151
Total	**100.0%**	**994**	**551**	**442**	**5,439**	**3,026**	**2,413**

Change							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	-1.1%	-16	-9	-7	-96	-54	-43
Auto-Rideshare	-0.1%	-1	-1	0	-5	-5	0
Vanpool	0.0%	0	0	0	0	0	0
Public Transport	1.1%	11	5	6	3	1	2
Cycling	0.0%	0	0	0	0	0	0
Walking	0.0%	0	0	0	0	0	0
Other	0.0%	0	0	0	0	0	0
Total	**0.0%**	**-6**	**-6**	**-1**	**-99**	**-58**	**-41**

Though the TRIMMS results tables provide many interesting datapoints such as mode share and peak and off-peak distributions, this additional information is not directly used for a TEAM analysis. As noted, TRIMMS results all represent daily values (i.e., daily trips, and daily VMT), therefore, TRIMMS results values should be multiplied by 365 to scale to annual results. TEAM primarily uses the Total VMT values from TRIMMS for the later emissions analysis. Therefore, a post processing spreadsheet for a single scenario could be as simple as the example on *Table 8. Example Annual VMT Results Spreadsheet* (available on the next page) that compares the BAU and scenario VMT, by mode, alongside the change between the BAU and scenario expressed in VMT and percent change in VMT.

Table 8. Example Annual VMT Results Spreadsheet

Scenario:	Scenario 1			
Commuters Affected:	500			
Mode	BAU Total VMT	Scenario Total VMT	Change Total VMT	Percent Change VMT
Auto-Drive Alone	1,708,183	1,673,029	-35,154	-2.06%
Auto-Rideshare	160,728	158,887	-1,842	-1.15%
Vanpool	5,087	5,029	58	-1.15%
Public Transport	1,603	2,655	1,052	65.66%
Cycling	14,965	14,965	-	0.00%
Walking	6,205	6,205	-	0.00%
Other	124,465	124,465	-	0.00%
Total	2,021,370	1,985,235	-36,135	-1.79%

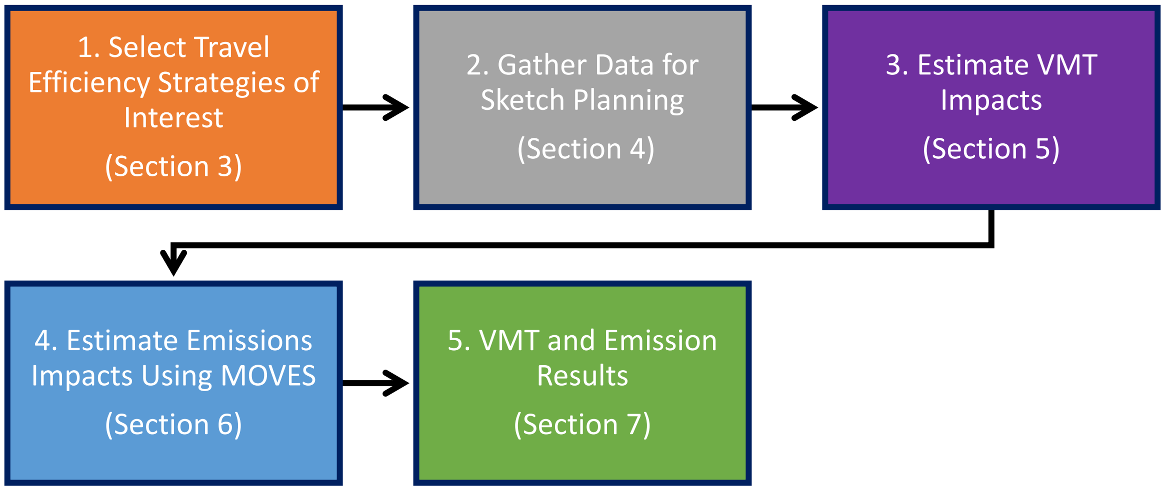
A results table provides an opportunity to perform a basic check on the VMT values produced by TRIMMS. If the scenario is applied to the entire region and the user knows the light-duty VMT for their region, the user could sum the Total VMT values of the TRIMMS light-duty modes (Auto-Drive Alone, Auto-Rideshare) to compare the values. If there is deviation between the TRIMMS light-duty VMT and known VMT, a simple ratio correction can be applied to the TRIMMS values. This same VMT scaling factor can be applied to other VMT estimates produced by TRIMMS.

If the purpose of the analysis is simply to consider VMT effects, the user would have these results at this point in the process. However, if the aim of the analysis is to explore the impact of TE strategies on regional emissions, continue onto *Section 6 Estimate Emissions Impacts Using MOVES*.

At the end of Step 3 the user should have:

- VMT results by strategy by mode.

6 Estimate Emissions Impacts Using MOVES



Depending on the purpose of the analysis, users may want to estimate the potential emissions impacts resulting from in changes in VMT and mode shares of the selected TE strategies. The emissions analysis in TEAM may be a useful exercise for areas that want to assess the effect of TE strategies to mitigate air quality issues. This section discusses how users can use EPA's MOVES model to develop representative, composite emission rates for the region of interest.

In this optional step, users will:

- Prepare and run EPA's MOVES model,
- Obtain output data from the model, and
- Work with the MOVES output data to calculate composite emission rates.

6.1 Introduction to MOVES and Options for Analysis

MOVES is EPA's state-of-the-science model for estimating air pollution emissions from mobile sources under a wide range of user-defined conditions. MOVES incorporates analysis of millions of emission test results and considerable advances in the EPA's understanding of vehicle emissions. MOVES can estimate emissions from running and evaporative processes as well as brake and tire wear emissions for all types of onroad vehicles across multiple geographic scales for any part of the country, except California. MOVES is EPA's best tool for estimating GHG emissions from onroad mobile sources. EPA's MOVES model can be used to estimate emissions of air pollutants from onroad vehicles directly or to develop emission rates that can be used to create an inventory of air pollutants outside of the model. MOVES can be used to calculate emission rates for future years. For TEAM, users should develop regionally representative emission rates.

This user guide reflects MOVES3, the latest version of the model, and refers to "MOVES" to mean this version unless otherwise noted.[19] EPA periodically updates the MOVES model to account for revisions to emissions, vehicle emission standards, and fuel economy standards as well as other new information.

Some experience with emissions modeling is necessary to conduct the MOVES analysis. This portion of the TEAM user guide assumes familiarity with running MOVES and is not intended to serve as a teaching guide. EPA has documentation that can help new users, including the MOVES Technical Guidance, that covers aspects of using the model detail.[20] In addition, EPA has developed a MOVES training course. Materials for this course can be downloaded from EPA's MOVES training webpage and used as a self-guided course.[21]

Many state and local air quality agencies may already be familiar with MOVES, as it is currently used across the country, except in California, to develop onroad emission inventories of transportation-related criteria pollutants and their precursors.[22] These criteria pollutant inventories are needed either for state air quality plans (state implementation plans, or SIPs) or transportation conformity determinations, and existing EPA guidance describes how and when to use MOVES for these regulatory purposes.[23] If the TEAM analysis is being conducted in an area with experience with the MOVES model, some or all of the information needed to conduct the modeling may be readily available. This will ensure emission rates and emissions reductions are consistent with other regional analyses.

To perform the emissions analysis in MOVES, there are three main steps:

1. The user must first set up a run specification or RunSpec. The RunSpec is produced by filling out the various panels of the MOVES graphic user interface (GUI) and serves to specify the characteristics of the region, analysis years, etc. to be modeled in MOVES.
2. If local data is available, users will enter regionally specific data through the "county data manager". If no local data is available, MOVES will use default data in the emissions calculation.
3. Last, users will run the model and process results and obtain emission rates using a post-processing script.

There are multiple ways to use MOVES to develop emission rates for use in a TEAM analysis, and there are tradeoffs with the different approaches. The following sections explores how MOVES can be run and provides recommendations for selections in MOVES user interface panels.

6.1.1 Calculation Type Options

MOVES has two calculation types - Inventory or Emissions Rates.

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[19] The latest version of the MOVES model is available at https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves. EPA recommends using the latest MOVES model for a TEAM analysis to take advantage of the latest information EPA has about emissions.

[20] EPA's MOVES3 Technical Guidance and other useful MOVES documentation can be found at https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

[21] See EPA's website at: https://www.epa.gov/moves/moves-training-sessions

[22] Onroad emissions include those emissions that result from the operation of on-highway vehicles such as passenger cars and trucks, commercial trucks, buses, motorcycles, and motorhomes. Transportation-related criteria pollutants are carbon monoxide (CO), ozone, nitrogen dioxide (NO_2), and particulate matter ($PM_{2.5}$ and PM_{10}).

[23] Available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010LY2.pdf.

- Inventory: MOVES using Inventory produces emission totals, and emission rates can be generated from the results using a post-processing script. This method is simpler and may be preferable when the user wants to minimize manually managing and processing large MOVES output datasets and thus avoid inadvertent errors. Another advantage of the inventory calculation type is shorter model run times.
- Emissions Rates: With Emission Rates, MOVES output data include emissions per unit of distance for running emissions, emissions per vehicle or per start for start emissions, and emissions per vehicle or per idle hour for hotelling emissions. The output dataset is generally very large and must be post-processed to generate average emissions rates for use in TEAM.

EPA recommends using the Inventory calculation type and using EPA developed post-processing scripts to develop emission rates for TEAM analysis.

6.1.2 Options for Selecting the Modeling Domain/Scale in MOVES for TEAM Analysis

MOVES allows users to analyze mobile emissions at various scales. For a TEAM analysis, users have two options for defining the Domain/Scale in MOVES: Default Scale and County Scale.

- Default Scale uses the national and county-level default information in MOVES to calculate inventories at the national, state, or county level.[24] The user can select one or more counties (and counties can be in different states) in the Geographic Bounds panel. The Default Scale may be most helpful when access to local data inputs are limited. At this scale, the user does not need to create or supply inputs. Because this scale relies on MOVES default data to perform inventory calculations, it provides less regionally representative emission rates.
- County Scale relies on local data that the user imports through the County Data Manager to model the emission from a single county. This scale allows users to define inputs specific to their region such as vehicle population and age distribution, meteorological conditions, and policies such as vehicle inspection and maintenance (I/M) programs or summer fuel formulations, etc. Providing local data significantly improves the precision of the emission rates produced for TEAM analysis.

Either the Default or County scale can be used to develop emission rates for TEAM analysis. The choice can be made based on the availability of local data as well as the amount of time and interest there is on getting a more precise or representative emissions result.

6.1.2.1 Default Scale

For a TEAM analysis, MOVES may be used at the Default scale, however, users should understand the tradeoffs of estimates based on the Default scale. The Default scale is simple and convenient for developing emission rates for TEAM analyses. As noted above, the Default scale allows the user to model the entire nation or any smaller geographic region. Similarly, this scale allows the user to simultaneously model more than one geographic region (i.e., multiple counties or multiple states). The Default scale also allows the user to model more than one year in one model run. However, this

[24] In previous versions of MOVES, “Default Scale” was called “National Scale.” EPA has changed the name of this scale to better describe the attributes of this scale (as it can be used to model states and counties in addition to the entire country by using built-in default data).

convenience comes at the cost of significantly reduced precision of local analysis. A Default scale analysis relies primarily on MOVES default data for data inputs. Default data are typically not the most current or best available information for any specific county. Users should consider the application of the analysis when selecting the Default scale for a TEAM analysis.

There may be instances when estimates using the Default scale will be sufficient for a user's purpose. For example, because the user does not have to input local data, the Default scale may help new users become familiar with the model. The Default scale may be sufficient for users in areas that are not already using MOVES for other purposes (e.g., SIP and conformity, etc.). In addition, the Default scale may be helpful as a screening analysis to inform more detailed subsequent analyses, or for some types of comparative, where the relative difference in emissions between different scenarios is more important than the precision of the absolute level of emissions. In summary, the Default scale utilizing MOVES default database information produces a less precise estimate of onroad emissions but may be sufficient for many applications of TEAM and be a simpler method of deriving emission rates to estimate the emissions impacts of TE strategies.

6.1.2.2 County Scale

A TEAM analysis may also be conducted using the County Scale. As noted, the County Scale relies on local data that the user imports through the County Data Manager to model the emission from a single county. Because this scale allows users to define inputs (vehicle age distribution, fuel type, I/M) specific to their region, the resultant emissions and emission rates may be more representative of the vehicle fleet within the area whereby improving the precision of the TEAM analysis. County scale data inputs may already be available in areas already using MOVES. However, collecting these data inputs from scratch may be a difficult and labor-intensive process.

6.1.3 Options for Selecting the Appropriate Geographic Bounds in MOVES for TEAM Analysis

Since the purpose of this step is to develop representative emission rates for the region of interest, there is flexibility regarding the "geographic bounds" selection in MOVES. In MOVES, selections in the Geographic Bounds panel allows the user to define the region to model.

If the area is larger or smaller than one county, it is reasonable to select a single county that represents the geography of the analysis. For regions entirely within a single county, that county should be selected.

For both domain/scale options, Default and County, discussed above the selection options in this panel are the same. Begin by selecting the state in which the analysis is being conducted, then select the representative county and click "Add".

6.1.4 Options for Selecting Onroad Vehicles in MOVES for TEAM

The focus of a TEAM analysis is to estimate the effect of a TE strategy primarily on personal passenger vehicles. In MOVES, vehicles are classified into "source types", which are groups of vehicles with similar activity and usage patterns. Since TRIMMS provides VMT and trip counts by modes that that do not directly align with the vehicle types in MOVES, emission rates are derived by combining MOVES vehicle types and fuel types to match the TRIMMS modes. For emissions analysis in TEAM, MOVES source types can be mapped to the VMT and trip changes for the modes in TRIMMS per the table below.

Table 9. MOVES Onroad Vehicle Source Types Mapped to TRIMMS Modes for Emissions Analysis

<table>
<tr><th>Source Type ID</th><th>Source Type</th><th>TRIMMS Mode</th></tr>
<tr><td>21</td><td>Passenger Car</td><td rowspan="2">Auto-Drive Alone
Auto-Rideshare</td></tr>
<tr><td>31</td><td>Passenger Truck</td></tr>
<tr><td>32</td><td>Light Commercial Truck</td><td>Vanpool</td></tr>
</table>

As depicted in the table above, the TRIMMS mode categories auto drive alone and auto rideshare, can be represented by composite emission rates calculated from the MOVES model's output for passenger cars and passenger trucks. For the TRIMMS vanpool mode category, users can use emission rates for MOVES vehicle type light commercial trucks.

6.1.5 Options for Selecting Pollutants and Processes in MOVES for TEAM

MOVES can provide onroad vehicle emissions for many pollutants including criteria air pollutants, greenhouse gases, and air toxics. If the TEAM analysis is for a nonattainment or maintenance area for one or more criteria pollutants, it would make sense for those pollutants and their precursors to be selected in this panel. EPA's TEAM analyses to date have focused on carbon dioxide equivalents (CO2e), oxides of nitrogen (NOx), particulate matter 2.5 micrometers and smaller ($PM_{2.5}$), and volatile organic compounds (VOC). TEAM users could choose these pollutants if they want to compare their results to other TEAM case studies that EPA has done.

6.2 Setting Up the RunSpec for TEAM

This section introduces how to set up a RunSpec for TEAM but is not intended to provide specific steps for creating the RunSpec files, input databases, or use of MOVES. Please refer to the MOVES3 Technical Guidance that cover each of these topics in greater detail.[25]

In MOVES, the selections and inputs are implemented through a RunSpec file. In this step the user selects analysis year(s), geographical area, source types, etc. to be included in the modeling. These elements are defined in a series of panels in the MOVES GUI. When setting up a County Scale RunSpec for a TEAM analysis, the following selection are recommended:

1. Scale Panel: Select "Onroad" model and either "Default Scale" or "County" for domain/scale depending on data availability. Calculation type should be specified as "Inventory" (see *Section 6.1.1* above).
2. Time Spans Panel: Select the inventory year (e.g., 2040 for emissions related to the BAU/Scenario out year), all months, both day types (weekday/weekend), and all hours to ensure the inventory includes the entire year.
3. Geographic Bounds Panel: Select the county containing the region or which reasonably represents the region to which the strategies will be applied in the Geographic Bounds panel.
4. Onroad Vehicles Panel: Select and add the Passenger Car, Passenger Truck, and Light Commercial Truck source use types.
5. Road Type Panel: Select all the road types. Always select Off-Network to include calculation of emissions from engine starts from parked vehicles.
6. Pollutants and Processes Panel: Select all pollutants and processes of concern (such as CO2e, NOx, PM2.5, and VOC). (See *Section 6.1.5, Options for Selecting Pollutants and Processes in*

[25] Available at https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves#guidance.

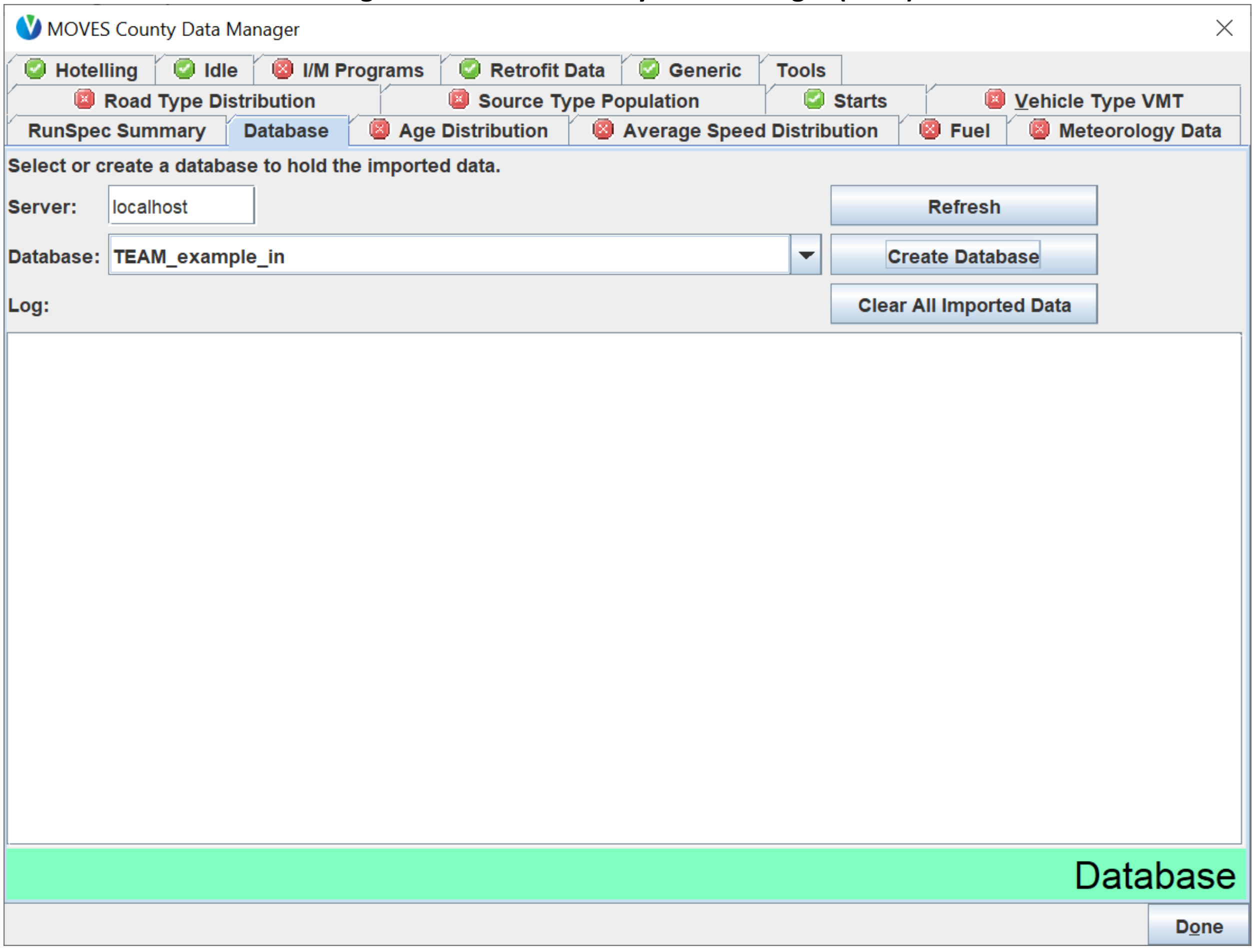
MOVES for TEAM). If $PM_{2.5}$ is of interest, then in addition to $PM_{2.5}$ exhaust, $PM_{2.5}$ brake wear and $PM_{2.5}$ tire wear should be selected on this panel as well. Similarly, for PM_{10}, select PM_{10} exhaust, PM_{10} brake wear, and PM_{10} tire wear.

7. General Output Panel: Choose units for emissions and distance. EPA recommends choosing "grams" and "miles" for these units. EPA also recommends selecting "Distance Travelled" and "Population" under the "Activity" heading.
8. Output Emissions Detail Panel: Choose "Year" for the time period to get annual results for easier post-processing.
9. Create Input Database Panel: Only used if user selects County Scale in Scale Panel. Not used if user selects Default Scale in Scale Panel.
10. Advanced Features Panel: This panel is not needed and should be skipped.

6.3 Using the County Data Manager to Enter Local Data

As noted in *Section 6.1.2 Options for Selecting the Modeling Domain/Scale in MOVES for TEAM Analysis,* when available, using local data can provide more regionally representative emission rates for a TEAM analysis. If the user has selected the County Scale modeling domain and has completed the RunSpec in MOVES, the next step of the analysis is to enter local data into the County Data Manager (CDM) (see *Figure 13. MOVES County Data Manager (CDM)*). Note, entering local data via the CDM is not needed if the Default scale is selected.

Figure 13. MOVES County Data Manager (CDM)



The CDM is used to enter local data to describe the characteristics of the area of analysis including aspects of the vehicle fleet such as vehicle populations, ages, activity, and other regional attributes such as meteorology and regional fuels. For a typical TEAM analysis using the county scale, the user should enter information that applies to the entire county into the CDM. For more information on data needs and entering data into the CDM, see the MOVES Technical Guidance.[26] The EPA developed MOVES training course also provides step-by-step instructions for entering data into the CDM[27]. In this step, users should enter the various input data required for a County Scale MOVES runs.[28]

[26] EPA's MOVES3 Technical Guidance and other useful MOVES documentation can be found at https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

[27] See EPA's website at: https://www.epa.gov/moves/moves-training-sessions

[28] All input data will need to be processed into the correct format for each table and imported into MOVES. The County Data Manager can provide templates for each data table, but data formatting is not discussed in this user guide. More information about how these inputs are developed can be found in Section 4 of the MOVES3 Technical Guidance.

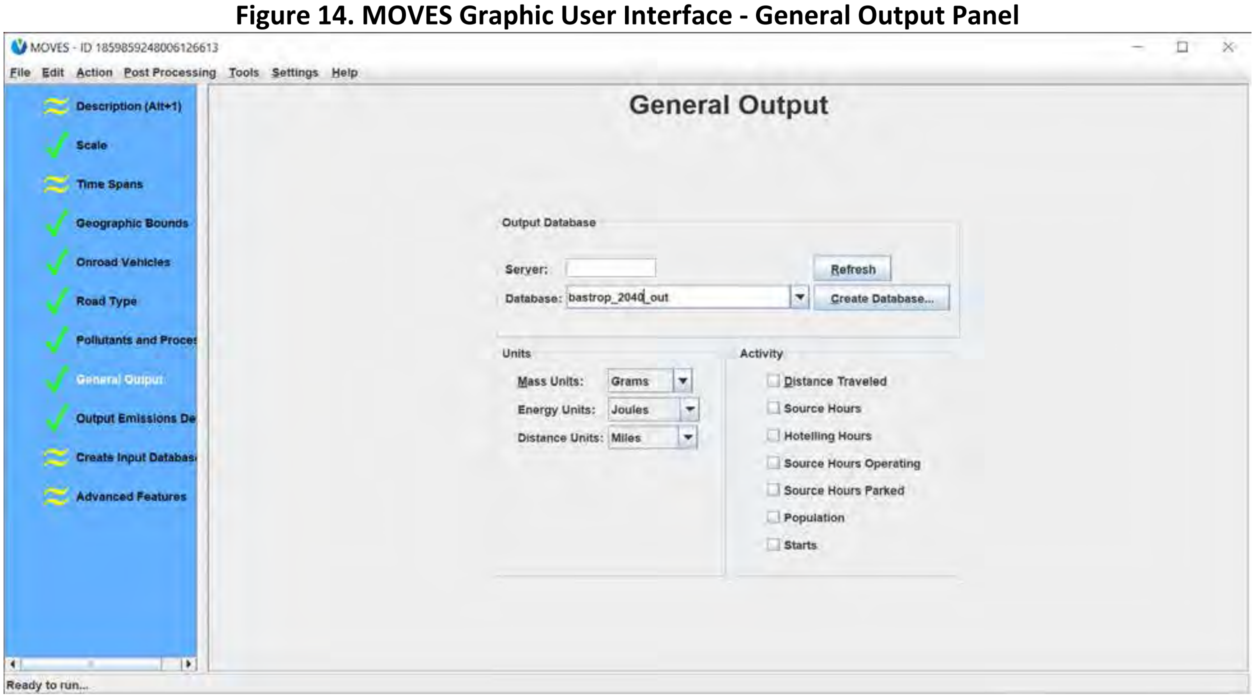
6.4 Running MOVES and Deriving Average Emission Rates for TEAM

MOVES can be run once the input database is complete. Emission rates can be derived by running a ready-made post-processing script for converting MOVES output to emission rates after the MOVES run has completed. The script requires that users select the inventory calculation type in the Domain/Scale options in the Scale Panel and the “Distance Traveled” check box under the “Activity” heading in the General Output Panel when setting up the RunSpec. This script produces a table, called “movesrates”, in the output database which reports onroad emission results in units of mass per distance. This emission factors are produced by joining the activity table with the inventory output results and performing a simple calculation.

This script combines emissions from running, starts, and evaporative processes into a single emissions quantity and divides it by VMT. The result is a single grams per mile (g/mi) emissions rate for each of the selected pollutants. This script provides a useful “back of the envelope” calculation of fleet average emissions and differences in average emissions by source type.

To access this script and apply it to a MOVES output database, first open MOVES and select the output database using the General Output panel Database dropdown.

Figure 14. MOVES Graphic User Interface - General Output Panel

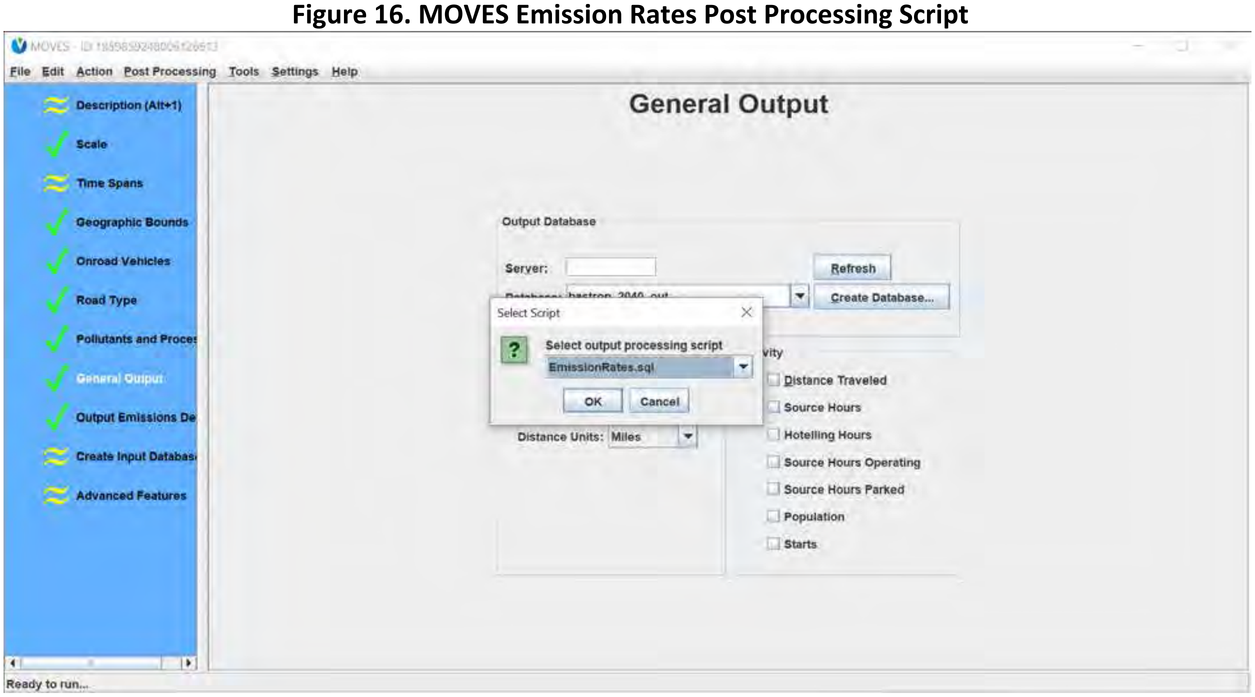


Once an output database is identified in the Database dropdown, click Post Processing on the MOVES menu and click “RunMySQL” Script on Onroad Output Database.

Figure 15. MOVES Post Processing Script Menu

Then select EmissionRates.sql in the dropdown and click OK.

Figure 16. MOVES Emission Rates Post Processing Script



The script creates a "movesrates" table that will now be available in the output database specified in the General Output panel. Users can access this table using MySQL Workbench or MariaDB to review and export the table for use in further analysis.

Table 10. Example Emission Rates from "EmissionRates.sql" script[29]

yearID	countyID	pollutantID	sourceTypeID	activity	emissionRate	massUnits	distanceUnits
2040	48453	110	21	2768159	0.002	g	mi
2040	48453	98	21	2768159	198.736	g	mi
2040	48453	87	21	2768159	0.005	g	mi
2040	48453	3	21	2768159	0.020	g	mi
2040	48453	110	31	878879	0.003	g	mi
2040	48453	98	31	878879	243.789	g	mi
2040	48453	87	31	878879	0.006	g	mi
2040	48453	3	31	878879	0.048	g	mi
2040	48453	110	32	223855	0.003	g	mi
2040	48453	98	32	223855	283.852	g	mi
2040	48453	87	32	223855	0.009	g	mi
2040	48453	3	32	223855	0.047	g	mi
2040	48453	110	42	3950	0.011	g	mi
2040	48453	98	42	3950	1335.720	g	mi
2040	48453	87	42	3950	0.050	g	mi
2040	48453	3	42	3950	1.008	g	mi

Table 10, above, is a simplified version of what would be produced from the output database of a MOVES run of a TEAM analysis. It includes the primary data that is available. The column labeled "emissionRate" provides a gram per mile for each pollutant included in the analysis. For example, for light commercial trucks (sourceTypeID = 32), the CO2e (pollutant ID = 98) emission rate is 283.852 g/mi. Based on "*Table 9. MOVES Onroad Vehicle Source Types Mapped to TRIMMS Modes for Emissions Analysis*," this emission rate for light commercial trucks can be used for vanpools. That is, the CO2e emission rate for Vanpools is 283.852 g/mi.

For TRIMMS modes that are mapped to more than one MOVES source type, such as Auto-Drive Alone which is mapped to both the passenger car and passenger truck source types, the composite emission rate is a simple activity-weighted average for each pollutant. Using the data in *Table 10*, above, the CO2e emission rate emission rate for Auto-Drive Alone is:

$$\left(\left(\text{activity (source type ID 21)} \times \text{emissionRate (sourcetype 21, pollutant ID 98)}\right) + \left(\text{activity (source type ID 31)} \times \text{emissionRate (sourcetype 21, pollutant ID 98)}\right)\right) / \left(\text{activity sum (source type ID 21 + 31)}\right)$$

$$\left(\left(2768159\text{ mi} \times 198.736\text{ g/mi}\right) + \left(878879\text{ mi} \times 243.789\text{ g/mi}\right)\right) / \left(2768159\text{ mi} + 878879\text{ mi}\right)$$

$$= \mathbf{209.593\ g/mi}$$

Using the values in *Table 10* above, the following emission rates table can be constructed:

[29] Note, data in this table is for illustrative purposes only, and some rows and columns generated by the post processing script have been omitted for easy viewing of the table. The pollutantID and sourceTypeIDs can be found on the "MOVES3 Onroad Cheat Sheet" found at: https://github.com/USEPA/EPA_MOVES_Model/blob/master/docs/MOVES3CheatsheetOnroad.pdf.

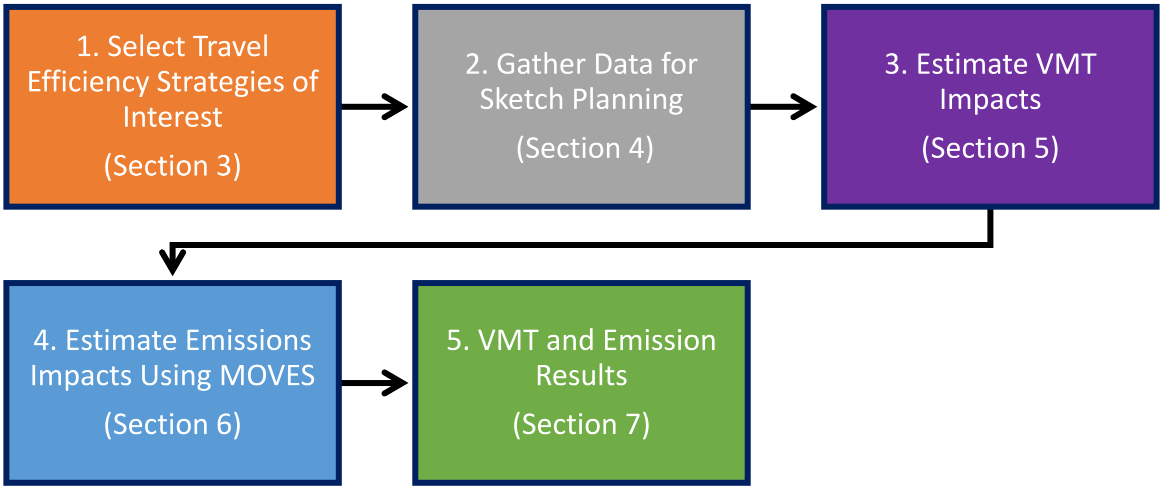
Table 11. Example Outyear Emission Rates by TRIMMS Mode for Selected Pollutants

TRIMMS Mode	Emission Rates (g/mi)			
	$PM_{2.5}$	CO2e	VOCs	NOx
Auto (Auto-Drive Alone and Auto-Rideshare)	0.002	209.593	0.005	0.026
Vanpool	0.003	283.852	0.009	0.047
Transit	0.011	1335.72	0.050	1.008

At the end of Step 4, the user should have:

- A set of emission rates by mode and pollutant.

7 VMT AND EMISSION RESULTS



The result of the emissions modeling is the calculation of *total emissions for each scenario*, assembled from both the emission rate outputs and VMT modeling results. This calculation can be done in an off-model spreadsheet. The emission reductions can be shown as absolute values but are typically presented as *relative* emission reductions. This more clearly illustrates the comparison to the BAU case and across strategies.

If Step 3 and Step 4 have been completed, the user should have:

- VMT impacts, by mode, for the BAU and strategies
- Emission rates by mode and pollutant.

The next section will help the user to combine the VMT impacts and emission rates, explain the results, and provides suggestions for taking TEAM even further.

7.1 COMBINING VMT AND EMISSIONS RESULTS

Total emissions, by pollutant, are computed as the product of the VMT values for emission rates in g/mi using the relationships in *Table 9. MOVES Onroad Vehicle Source Types Mapped to TRIMMS Modes for Emissions Analysis*. Using the VMT values from *Table 8. Example Annual VMT Results Spreadsheet*, recreated below, and emission rates from *Table 11. Example Outyear Emission Rates by TRIMMS Mode for Selected Pollutants*, the following types of results table can be developed for a scenario. Since this portion of the TEAM analysis is concerned with emissions, zero-emission modes, like cycling and walking, are excluded from these tables.

Table 12. Example Annual VMT Results Spreadsheet (repeat of Table 8.)

Scenario:	Scenario 1			
Commuters Affected:	500			
Mode	BAU Total VMT	Scenario Total VMT	Change Total VMT	Percent Change VMT
Auto-Drive Alone	1,708,183	1,673,029	-35,154	-2.06%
Auto-Rideshare	160,728	158,887	-1,842	-1.15%
Vanpool	5,087	5,029	58	-1.15%
Public Transport	1,603	2,655	1,052	65.66%
Cycling	14,965	14,965	-	0.00%
Walking	6,205	6,205	-	0.00%
Other	124,465	124,465	-	0.00%
Total	2,021,370	1,985,235	-36,135	-1.79%

Table 13. Example BAU Annual Light-Duty Emissions Results (in grams) Table

Scenario:	Scenario 1				
Commuters Affected:	500				
Mode	BAU Total VMT	$PM_{2.5}$	CO2e	VOCs	NOx
Auto-Drive Alone	1,708,183	3,416	358,023,185	8,541	44,413
Auto-Rideshare	160,728	321	33,687,521	804	4,179
Total	1,868,911	3,737	391,710,706	9,345	48,592

Table 14. Example Scenario Annual Light-Duty Emissions Results (in grams) Table

Scenario:	Scenario 1				
Commuters Affected:	500				
Mode	BAU Total VMT	$PM_{2.5}$	CO2e	VOCs	NOx
Auto-Drive Alone	1,673,029	3,346	350,655,174	8,365	43,499
Auto-Rideshare	158,887	318	33,301,504	794	4,131
Total	1,831,916	3,664	383,956,678	9,159	47,630

Table 15. Example Change in Annual Light-Duty Emissions Results (in grams) Table

Scenario:	Scenario 1				
Commuters Affected:	500				
Mode	Total VMT	$PM_{2.5}$	CO2e	VOCs	NOx
Auto-Drive Alone	-35,154	70	7,368,011	176	914
Auto-Rideshare	-1,842	4	386,018	9	48
Total	-36,996	74	7,754,029	185	-36,996

In summary, the effect of scenario 1, affecting 500 commuters, is estimated to reduce light-duty VMT by 36,996 miles and avoid 74 grams of $PM_{2.5}$, 7.75 metric tons of CO2e, 185 grams of VOCs and 36,996 grams of NOx.

7.2 Interpreting Results

Results for strategies applied to subareas or specific population can examined both at this smaller scale and more broadly at the regional level. This allows the relative effectiveness of strategies to be directly compared. The value of the results for a subarea and sub-regional populations can be obscured when results are reported at the regional scale. The corresponding percent VMT and emission reductions are often relatively small when compared to the VMT of the entire region. For example, a strategy that reduces VMT by 2% among 10% of the regional population will reduce total regional VMT by just 0.2%. However, VMT and emission reductions can be significant for the sub-geography or affected population covered by a strategy and thus valuable to consider for implementation, even if the reductions are minor at the regional level. For example, a parking pricing strategy may reduce VMT by 11.4% for the affected population, but regional VMT may only be reduced by 2%. In general, contextualizing the results both within the sub-region/affected population at the regional level is useful to see the effect of the strategy or strategies.

7.3 Comparing Results to Other Studies

It can be useful to benchmark TEAM results against the findings of other studies to see if they are of a similar magnitude. EPA's previous TEAM analyses can be used for this purpose and results can be found in the following documents, available on EPA's Travel Efficiency website:

- Potential Changes in Emissions Due to Improvements in Travel Efficiency – This report contains an analysis of various strategies across several urban clusters in the U.S. Results can be compared against results estimated for urban regions similar to the selected region in population and transit availability.
- Estimating Emission Reductions from Travel Efficiency Strategies: Three Sketch Modeling Case Studies – This report contains an analysis of strategies in Tucson, Arizona; Boston; and Kansas City using the TEAM approach.
- Applying TEAM in Regional Sketch Planning: Three Case Studies in Atlanta, Orlando, St. Louis – This report contains an analysis of strategies in Atlanta, Orlando, and St. Louis using the TEAM approach in its current iteration.
- Applying TEAM in Regional Sketch Planning: A Case Study in Austin, Texas – This report examines the application of TEAM, in partnership with the Capital Area Council of Governments, to estimate the travel activity, emissions, and greenhouse gas impacts of potential travel efficiency scenarios in Austin, Texas.
- Applying TEAM in Regional Sketch Planning: A Case Study in Pittsburgh, Pennsylvania – This report examines the application of TEAM, in partnership with the Southwestern Pennsylvania Commission, to estimate the emissions, and greenhouse gas impacts of potential travel efficiency scenarios in Pittsburgh, Pennsylvania.
- Applying TEAM in Regional Sketch Planning: Four Case Studies in Puget Sound, WA; Champaign, IL; Lake Charles, LA; State of Connecticut – This report documents 4 case studies of the application of TEAM (Travel Efficiency Assessment Method) to estimate the travel activity and emissions impacts of potential travel efficiency scenarios. The case studies provide a useful planning resource for modeling and estimating greenhouse gas and criteria air pollutant emission inventories and calculating emission reductions possible from the implementation of future travel efficiency strategies.

8 Appendix

8.1 Potential Data Sources for Conducting a TEAM Analysis

The table below lists potential sources of demographic and travel data for use in a TEAM analysis.

Table 16. Potential Data Sources for Conducting a TEAM Analysis

Data Resource	Authors	Information Offered
National Personal Transportation Survey (NPTS)	U.S. Department of Transportation, Bureau of Transportation Statistics	The NPTS is a household travel survey conducted every five years that provides data on the amount and nature of personal travel in the U.S.
State and Metropolitan Area Data Book	U.S. Census Bureau	Summary of socioeconomic and demographic data for regions, census divisions, states, standard consolidated areas and SMSAs for selected years. Data are derived from censuses and various other federal government and private sources.
City and County Data Book	U.S. Census Bureau	Summary of socioeconomic and demographic data for counties and cities for selected years. Data are derived from censuses and various other federal government and private sources.
Commuting in America - A National Report on Commuting Patterns and Trends	The American Association of State Highway and Transportation Officials	Describes patterns in commuting over the past 30 years, including changes that have occurred that affect current transportation policy. Includes many statistics related to commuting, including number of workers, relationships between urban development and commuting behavior, and mode of travel to work.

Data Resource	Authors	Information Offered
Highway Capacity Manual	Transportation Research Board	A text that provides techniques for estimating highway capacity and level of service. Includes information on traffic characteristics and performance and new procedures for capacity analysis of freeways and rural roads. Discusses pedestrian traffic flow and facilitates the effect of bicycles in the traffic stream.
Traffic Engineering Handbook	Institute of Transportation Engineers (ITE)	A text that provides various general values related to transportation (including elasticities, mode split, general impacts), along with explanations of many widely used concepts in traffic engineering.
Census Data Explorer	U. S. Bureau of the Census.	Release of summary information from the decennial census, including worker statistics and journey to-work, available for 1-year, 5-year and 10-year estimates.
American Community Survey (ACS)	U.S. Census Bureau	Includes data on: • means of transportation to Work, • travel time to work, • time leaving home to go to work, • private vehicle occupancy, • other travel to work characteristics.
Census Transportation Planning Products (CTPP)	U.S. Federal Highway Administration	A set of special tabulations from decennial census demographic surveys designed for transportation planners. From 1970 to 2000, the CTPP and its predecessor, UTPP, used data from the decennial census long form. Because of the large sample size, the data are reliable and accurate.
County Employment and Wages	U.S. Department of Labor, Bureau of Labor Statistics	Includes industry, employment, and wages by state and country (for the 318 largest counties).

Data Resource	Authors	Information Offered
National Household Travel Survey	U.S. Department of Transportation, Federal Highway Administration	National data on the travel behavior of the American public. The dataset allows analysis of daily travel by all modes, characteristics of the people traveling, their household, and their vehicles.
National Transit Database	U.S. Department of Transportation, Federal Transit Administration	Information and statistics on more than 660 transit systems in the United States. The types of data reported include operational characteristics, services characteristics, capital revenues and assets, and financial operating statistics.
National Transportation Statistics	U.S. Department of Transportation, Bureau of Transportation Statistics	Statistics on the U.S. transportation system, including its physical components, safety record, economic performance, the human and natural environment, and national security. More than 260 data tables plus data source and accuracy statements. Internet edition is updated quarterly. Each table includes date of last update.
State Transportation Statistics	U.S. Department of Transportation, Bureau of Transportation Statistics	A series of reports highlighting major federal databases and other national sources related to each state's infrastructure, safety, freight movement and passenger travel, vehicles, economy and finance, and energy and the environment. Along with tables generated for each state, the reports describe databases and give information on access, formats, and contact points.

8.2 Land Use Analysis

During EPA's experiences partnering with other agencies in applying TEAM to various areas to create case studies, EPA identified the need for a new approach to analyzing land use strategies within TEAM that would be both simple and reasonably accurate. The land use analysis from the first case studies produced results that diverged from national studies analyzing the effect land use can have on vehicle travel and raised questions about the land use algorithms included in that earlier version of TRIMMS.[30] While new versions of TRIMMS have been released since that time, EPA's subsequent TEAM case studies used the two alternative approaches EPA developed, which are described below.

8.2.1 Background

The existing literature on the relationship between land use patterns and VMT generally focuses on 'D' variables, particularly those that have become known in the field as the '5Ds':

- Density
- Diversity (land use mixing)
- Design
- Destinations (distance to regional destinations)
- Distance to transit

While the individual variables used vary from study to study, most fit under these five "D" categories. Comparison of individual studies illustrated that each used between three and five "D" variables. A 2010 Ewing and Cervero study[31] provided elasticities calculated as a weighted average of results from more than 50 studies, including both national and regional studies. An elasticity is a measure of how a change in the price of one good may affect the demand for that good, or for a related good (referred to as a "cross-elasticity"). In the case of land use, elasticities measure how a change in a land use measure, which effectively changes the "price" of walking, transit, and other car-free modes in terms of travel time, affects VMT. This approach of using a weighted average elasticity fits well with the TEAM approach and can be applied to all U.S. regions. The analysis approach based on these elasticities is identified here as the "Multivariate Elasticity" approach.

8.2.2 Multivariate Elasticity Approach

The Multivariate approach calculates the change in VMT from land use strategies by comparing the following variables for the BAU and scenario cases:

- Density: Household/ population density
- Diversity: Land use diversity (typically defined as the level of mixing of different land use types such as residential, commercial, and industrial)
- Destinations:
  - Job access by auto
  - Job access by transit
- Distance to transit: Distance to nearest transit stop

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[30] TEAM case studies can be found at: https://www.epa.gov/state-and-local-transportation/estimating-emission-reductions-travel-efficiency-strategies#Case-Reports.

[31] Ewing and Cervero, "Travel and the Built Environment: A Meta-Analysis", Journal of the American Planning Association, 2010

This method provides an estimate of reduced VMT by focusing on shifts in these land use variables. To use this method, a value will be needed for each variable under both the BAU and strategy scenarios.

The Design (street network density) variable is omitted from this approach for two reasons. First, regions whose travel demand models do not include local roads would not be able to accurately calculate this variable. Second, increasing street network density is a strategy that is only applicable in select local circumstances, such as redevelopment of large commercial and industrial properties and would thus be difficult to estimate for an entire region.

Data for all traffic analysis zones (TAZs) is needed to create population-weighted averages for all ‘D’ variables. Population densities are first calculated for the Business as Usual (BAU) and Scenario cases for all TAZs. Then, a single regional population density is calculated for the BAU by taking the population-weighted average of the TAZ population densities. The following example illustrates the difference between the population density of a region calculated with an average, and the population-weighted density.

Average Population Density vs. Population-Weighted Density

Suppose a region is composed of two TAZs:

- TAZ A has an area of 1 square mile and a population of 10
- TAZ B has an area of 2 square miles and a population of 5

To calculate the average population density of the region (people per square mile), divide the total regional population by the total number of square miles: 15 people/3 square miles = average population density of 5 people per square mile.

To measure population-weighted density of the region, first calculate the population density of each TAZ individually:

- TAZ A population density = 10 people//1 square mile = 10 people per square mile
- TAZ B population density = 5 people//2 square miles = 2.5 people per square mile

Next calculate the proportion of regional population in each TAZ:

- TAZ A proportion of regional population = 10/15 = 0.66
- TAZ B proportion of regional population = 5/15 = 0.33

Finally, calculate the region's population-weighted average density:

- 10 people per square mile * 0.66 + 5 people per square mile * 0.33 = 8.25 people per square mile

The weighted density is higher than the average density, because the weighted density accounts for the fact that the residents of TAZ A, who live at a higher density, make up a greater proportion of the region's residents. The population-weighted average of 8.25 people per square mile is more representative of what the typical regional resident experiences than the average density of 5 people per square mile.

Population weighted averages can be calculated for other D variables as well. The weighting factor is always the proportion of regional population, while the calculated variable can be diversity, distance to transit, or something else.

The same steps are followed to obtain the Scenario values. This approach allows for meaningful variations in land use characteristics by shifting growth within the region between the BAU and scenario cases, whereas calculating population density at a gross regional level would show no change without increasing regional population growth.

The Multivariate approach can be applied outside of TRIMMS in a simple spreadsheet analysis. Results from the spreadsheet analysis can be readily combined with results from other strategies analyzed in TRIMMS in a post-processing spreadsheet, a standard part of the TEAM approach. In the post-processing spreadsheet, percentage reductions in VMT calculated for each scenario or strategy are applied sequentially to the BAU VMT projection for the region. These reductions are calculated by multiplying changes in land use variables (such as population density) by elasticity values in the table below.

Table 17. Ewing and Cervero (2010) "Table 3. Weighted average elasticities of VMT with respect to built-environment variables" used in Multivariate Land Use Analysis

"D" Category	Variable	Weighted Average Elasticity of VMT Value
Density	Household/ population density	−0.04
	Job density	0.00
Diversity	Land use mix (entropy)	−0.09
	Jobs−housing balance	−0.02
Design	Intersection/ street density	−0.12
	% 4−way intersections	−0.12
Destinations	Job access by auto	−0.2
	Job access by transit	−0.05
	Distance to downtown	−0.22
Distance to Transit	Distance to nearest transit stop	0.05

The 2010 Ewing and Cervero study also includes elasticity values for walking and transit use with respect the variables identified in the table above.

8.2.3 Neighborhood Classification Approach

The Neighborhood approach is significantly simpler in terms of data collection and calculation than the Multivariate approach. It relies on the idea that individual neighborhoods can be classified in terms of typical driving habits of their residents, and that land use planning can shift growth patterns away from more driving-intensive neighborhood types towards less driving-intensive ones. For example, generally neighborhoods closer to an urban core tend to have lower emissions per household, while neighborhoods further away have higher emissions per household.

With this approach, the change in VMT from land use strategies is estimated by comparing the percent of household, population, and jobs within separate neighborhood types before and after each strategy. Each neighborhood type has a unique VMT metric, such as VMT/household or VMT/day. The land use strategies shift households, population, and/or jobs to from neighborhood types with higher VMT to neighborhood types with lower VMT, producing a net reduction in VMT. This method provides an estimate of reduced VMT just by focusing on shifts in populations among neighborhood types.

To use this method, average VMT metrics for each neighborhood type and the percent of households, population, and/or jobs within each neighborhood type are needed for both the BAU and strategy scenarios. The resulting VMT reductions can be calculated outside of TRIMMS. Calculating a weighted average of VMT per capita across the five classifications for both BAU and Scenario and then comparing these yields the percentage reduction in VMT for the entire analysis area. As with the Multivariate approach, this approach can be conducted in a simple spreadsheet analysis, and the results combined with the results of other strategies in a post-processing spreadsheet.

8.3 Example Strategy Calculations

8.3.1 Example Transit Strategy Calculation

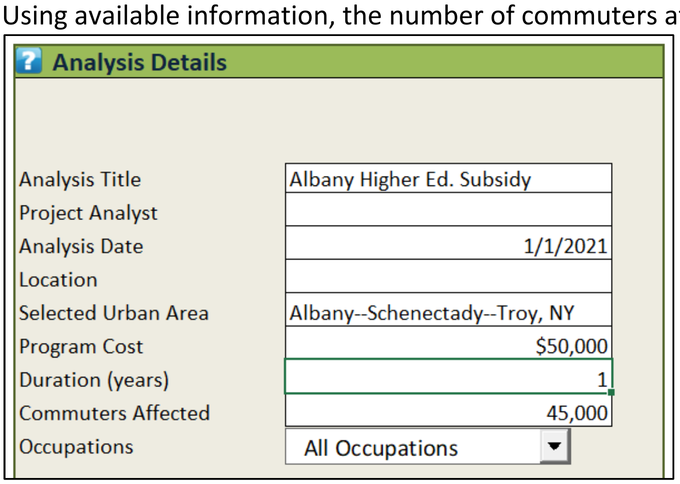
This example highlights the process estimating the impacts of a transit subsidy. The general process for estimating the impacts of a transit strategy are as follows:

1. Ensure that the appropriate regional parameters have been entered in the Parameters tab for the scenario in TRIMMS.
2. Define the number of regional commuters affected. For most strategies, potential transit commuters affected could be calculated as the number of residents that live within ½-mile of the current/proposed transit stops along a current or proposed corridor.
3. Operationalize the strategy impact within the Financial and Pricing Strategies ($) section or Access and Travel Time Improvements (minutes) section within the Analysis worksheet.
    a. For transit strategies that impact transit trip cost, enter the current transit trip cost, estimated using the methods discussed above, into the public transit current trip cost cell. Then enter the trip costs as effected by the strategy into the public transit new trip cost cell. For transit strategies that do not impact trip cost, leave the cells in this section blank.
    b. For transit strategies that impact transit access times, determine the current and new access time and enter it into the public transit current and new access time cells.
    c. For transit strategies that impact transit travel times, determine the current and new travel time and enter it into the public transit current and new travel time cells.
4. Run the analysis.
5. Examine the results.

Scenario: An agency in Albany, New York would like to explore the impact of providing a $0.75 transit fare subsidy for area university workers and students. The current cash transit fare is $1.75. The agency has determined that the number of enrolled area college and university students is 34,000 and the number of university workers is 11,000.

Using the steps provided above:

1. Start by selecting the appropriate urban area and entering the analysis details. For this analysis, the urban area is Albany – Schenectady--Troy, NY.
2. Using available information, the number of commuters affected is 34,000+11,000 = 45,000.



3. The current cash transit fare trip cost is $1.75 and is reduced to $1.00. This is entered into TRIMMS in the Financial and Pricing Strategies ($) box on the transit line as:

Financial and Pricing Strategies ($)				
Mode	Current Parking Cost	New Parking Cost	Current Trip Cost	New Trip Cost
Auto-Drive Alone				
Auto-Rideshare				
Vanpool				
Public Transport			1.75	1.00
Cycling				
Walking				
Other				

Access and Travel Time Improvements (minutes)				
Mode	Current Access Time	New Access Time	Current Travel Time	New Travel Time
Auto-Drive Alone				
Auto-Rideshare				
Vanpool				
Public Transport				
Cycling				
Walking				
Other				
% Workforce Affected	**100.0%**			

4. Run the analysis.
5. The last step is to run the analysis and examine the results.

Baseline							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	79.3%	71,334	39,785	31,549	429,385	239,478	189,907
Auto-Rideshare	8.5%	7,627	4,254	3,373	30,864	17,214	13,651
Vanpool	0.4%	343	191	152	453	253	201
Public Transport	3.0%	2,744	1,530	1,213	720	402	319
Cycling	3.7%	3,297	1,839	1,458	7,582	4,229	3,353
Walking	1.2%	1,090	608	482	763	426	337
Other	4.0%	3,566	1,989	1,577	27,414	15,290	12,125
Total	**100.0%**	**90,000**	**50,195**	**39,805**	**497,182**	**277,290**	**219,892**

Final							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	78.5%	70,108	39,101	31,007	422,004	235,363	186,641
Auto-Rideshare	8.5%	7,551	4,178	3,373	30,556	16,906	13,651
Vanpool	0.4%	338	186	152	446	246	201
Public Transport	3.7%	3,331	1,786	1,546	874	469	406
Cycling	3.7%	3,297	1,839	1,458	7,582	4,229	3,353
Walking	1.2%	1,090	608	482	763	426	337
Other	4.0%	3,566	1,989	1,577	27,414	15,290	12,125
Total	**100.0%**	**89,280**	**49,685**	**39,594**	**489,640**	**272,927**	**216,713**

Change							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	-0.7%	-1,226	-684	-543	-7,381	-4,116	-3,266
Auto-Rideshare	0.0%	-76	-76	0	-308	-308	0
Vanpool	0.0%	-5	-5	0	-7	-7	0
Public Transport	0.7%	587	255	332	154	67	87
Cycling	0.0%	0	0	0	0	0	0
Walking	0.0%	0	0	0	0	0	0
Other	0.0%	0	0	0	0	0	0
Total	**0.0%**	**-720**	**-510**	**-210**	**-7,542**	**-4,364**	**-3,179**

The resultant reduction in daily light-duty vehicle mode (Auto-Drive Alone, Auto-Rideshare) VMT is 7,381 + 308 = 7,689 miles.

8.3.2 Example Transportation Pricing Calculation

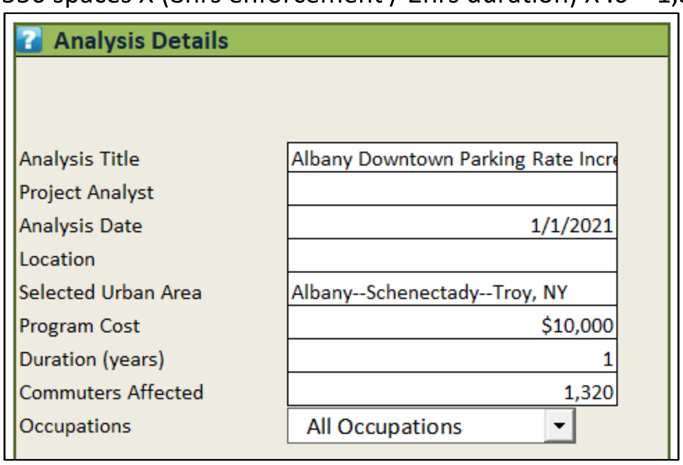
This example highlights the process of calculating the benefits of a parking pricing strategy. There are various other transportation pricing strategies, but they follow a similar process of calculating a current and future the trip cost, whether parking costs or trip costs, for the affected modes. For this example, the following method can be applied:

1. Ensure that the appropriate regional parameters have been entered in the Parameters tab for the scenario in TRIMMS.
2. Define the number of regional commuters affected.
3. Enter the current and new parking cost for the affected trips. For simplification, the current and new parking cost fields of the "Financial and Pricing Strategies ($)" section of the Analysis Worksheet in TRIMMS can be simplified as the average price per trip.
4. Run the analysis.
5. Examine the results.

Scenario: An agency in Albany, New York would like to explore the impact of increasing downtown on-street parking rates by $0.75 per hour from $1.50/hr to $2.25/hr. On a given weekday, the average on-street parking utilization in the downtown area is 60% during normal enforcement hours (8 am-4 pm) and the total parking supply is 550 spaces with an average duration of 2 hrs.

Using the steps provided above:

1. Start by selecting the appropriate urban area and entering the analysis details. For this analysis, the urban area is Albany – Schenectady--Troy, NY.
2. Using available information, the number of commuters affected can be estimated as:
   550 spaces X (8hrs enforcement / 2hrs duration) X .6 = 1,320.



3. The current parking cost per trip is 2 hrs/trip X $1.50/hr = $3.00/trip. The new parking cost per trip is 2 hrs/trip X $2.25/hr = $4.50/trip.

Financial and Pricing Strategies ($)				
Mode	***Current Parking Cost***	***New Parking Cost***	***Current Trip Cost***	***New Trip Cost***
Auto-Drive Alone	3.00	4.50		
Auto-Rideshare	3.00	4.50		
Vanpool				
Public Transport				
Cycling				
Walking				
Other				

Access and Travel Time Improvements (minutes)				
Mode	***Current Access Time***	***New Access Time***	***Current Travel Time***	***New Travel Time***
Auto-Drive Alone				
Auto-Rideshare				
Vanpool				
Public Transport				
Cycling				
Walking				
Other				
% Workforce Affected	**100.0%**			

4. Run the analysis.
5. The last step is to run the analysis and examine the results.

Baseline							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	79.3%	2,092	1,167	925	12,595	7,025	5,571
Auto-Rideshare	8.5%	224	125	99	905	505	400
Vanpool	0.4%	10	6	4	13	7	6
Public Transport	3.0%	80	45	36	21	12	9
Cycling	3.7%	97	54	43	222	124	98
Walking	1.2%	32	18	14	22	12	10
Other	4.0%	105	58	46	804	448	356
Total	**100.0%**	**2,640**	**1,472**	**1,168**	**14,584**	**8,134**	**6,450**

Final							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	78.6%	1,972	1,104	868	11,867	6,642	5,225
Auto-Rideshare	8.4%	212	118	94	856	477	379
Vanpool	0.4%	10	6	4	13	7	6
Public Transport	3.2%	81	45	36	21	12	9
Cycling	3.9%	97	54	43	224	125	99
Walking	1.3%	32	18	14	23	13	10
Other	4.2%	105	59	47	811	452	359
Total	**100.0%**	**2,510**	**1,404**	**1,106**	**13,816**	**7,729**	**6,087**

Change							
		One-Way Trips			VMT		
Mode	***Share***	***Total***	***Peak***	***Off-Peak***	***Total***	***Peak***	***Off-Peak***
Auto-Drive Alone	-0.7%	-121	-64	-57	-728	-382	-346
Auto-Rideshare	0.0%	-12	-7	-5	-49	-27	-22
Vanpool	0.0%	0	0	0	0	0	0
Public Transport	0.2%	1	0	0	0	0	0
Cycling	0.2%	1	0	0	2	1	1
Walking	0.1%	0	0	0	0	0	0
Other	0.2%	1	0	0	7	4	3
Total	**0.0%**	**-130**	**-69**	**-62**	**-768**	**-405**	**-364**

Since this analysis was primarily focused on trips during the enforcement hours from 8 am to 4pm, the useful values are the peak trip and VMT values for the light-duty vehicle mode (Auto-Drive Alone, Auto-Rideshare). The estimated resultant reduction in daily light-duty vehicle VMT is 7,381 + 308 = 409 miles.

8.3.3 Example Bicycle Strategy Calculation

The process of calculating the impacts of a bicycle strategy are as follows:

1. Prepare data on total existing and future bicycle lane miles and total existing and future new land area.
2. Calculate BAU and scenario bike lane miles per area (miles bike lane/square mile) and the percent increase.
3. Use Dill and Carr elasticity to determine increase in bike mode share (1% increase for every 1 bicycle lane miles per square mile).
4. Determine the expected BAU cycling mode share.
5. Calculate the increase in cycling mode share resulting from the strategy.
6. Decrease mode shares for non-cycling modes to bring the total of all mode shares back to 100%. To do this, assume that new bicycle trips are converted from other modes in proportion to the BAU share of each mode.
7. Calculate trips reduced for non-cycling modes.
8. Calculate reduction in VMT for auto-modes using the average bicycle trip length:
    a. For auto drive-alone, VMT reduced = trips reduced * bicycle trip length
    b. For auto rideshare, VMT reduced = trips reduced / carpool occupancy * bicycle trip length

Scenario: For a region totaling 2,500 square miles, there are 500 existing bike lane miles. Under the strategy, 500 more bike lane miles will be added for a total of 1,000 future bike lane miles. The BAU cycling mode share is 0.5%. The total regional daily trips are 5,000,000 trips. Also given is the average bike trip length is 2.5 miles and average carpool vehicle occupancy is 2 people per vehicle.

Using the steps provided above:

1. BAU bike lane miles per square mile = 500/2,500 = 0.2 lane miles/square mile, the future scenario bike lanes per square mile = 1000/2,500 = 0.4 lane miles/square mile.
2. Using Dill and Carr elasticity (1% increase for every 1 bicycle lane miles per square mile), the increase in cycling mode share = 0.4 - 0.2 = 0.2%
3. BAU cycling mode share is 0.5%; strategy bike mode share = 0.5% + 0.2% = 0.7%
4. Total decrease in other modes = -0.2%
5. Calculate new mode shares:

Mode	**BAU Mode Shares (A)** ***Provided by agency (or TRIMMS default)***	**Percentage of Non-Bike Mode Shares (B)** ***= A ÷ Sum of Non-Bike Modes (99.5%)***	**Change in Mode Share (C)** ***= -0.2% * B***	**Future Mode Shares (D)** ***= A + C***
Auto-drive alone	52.00%	52.26%	-0.10%	51.90%
Auto-rideshare	38.00%	38.19%	-0.08%	37.92%
Vanpool	0.00%	0.00%	0.00%	0.00%
Public transit	3.50%	3.52%	-0.01%	3.49%
Cycling	0.50%	-	0.20%	0.70%
Walking	5.00%	5.03%	-0.01%	4.99%

Mode	BAU Mode Shares (A) ***Provided by agency (or TRIMMS default)***	Percentage of Non-Bike Mode Shares (B) ***= A ÷ Sum of Non-Bike Modes (99.5%)***	Change in Mode Share (C) ***= -0.2% * B***	Future Mode Shares (D) ***= A + C***
Other	1.00%	1.01%	0.00%	1.00%
Total	*100.00%*	*100.00%*	*0.00%*	*100.00%*

6. Total trips = 5,000,000; average bike trip length = 2.5 miles; average carpool vehicle occupancy = 2; the change in trips and VMT is:

Mode Share	**Change in Trips (E)** *= C * 5,000,000*	**Change in VMT (F)** *= E / vehicle occupancy * 2.5*
Auto-drive alone	-5,226	-13,065
Auto-rideshare	-3,819	-4,774
Vanpool	0	0
Public transit[32]	-352	0
Cycling	10,000	25,000
Walking	-503	-1,256
Other	-101	-251
Total	*0*	*0*

7. The total reduction in VMT = 13,065 + 4,774 = 17,839

[32] Assume that reductions in transit trips do not affect overall transit VMT.

8.3.4 Example Pedestrian Strategy Calculation

The process of calculating the impacts of a pedestrian strategy are as follows:

1. Prepare data on total existing and future facility miles.
2. Calculate the percent change in facility miles from existing to future strategy scenario.
3. Multiply the percent increase in facility miles by the elasticity value of 0.27 for walk commuters with respect to walk route miles per 10,000 miles to determine the percent increase in pedestrian commuters.[33]
4. Determine the BAU walking mode share.
5. Calculate the increase in walking mode share resulting from the strategy: the percent change in the number of walk trips per 10,000 miles from the BAU case to the strategy case.
6. Adjust mode shares for non-walk modes downwards to bring the total of all mode shares back to 100%. To do this, assume that new walking trips are converted from other modes in proportion to the BAU share of each mode.
7. Calculate trips reduced for non-walk modes.
8. Calculate reduction in VMT for auto-modes using the average walk trip length:
    a. For auto drive-alone, VMT reduced = trips reduced * walk trip length
    b. For auto rideshare, VMT reduced = trips reduced / carpool occupancy * walk trip length

Scenario: A region currently has 8,000 existing sidewalk miles and will have 10,000 future sidewalk miles under the strategy. The BAU pedestrian mode share is 5% (other mode shares are consistent with the BAU Mode Shares column in the table below). The total regional daily trips are 5,000,000 trips. Also given are the average walk trip length equals 0.7 miles and the average carpool vehicle occupancy is 2,

Using the steps provided above:

1. The current sidewalk miles is 8,000 miles, and the future sidewalk miles is 10,000 miles.
2. The percent increase in sidewalk miles = (10,000 – 8,000) ÷ 8,000 = 25%
3. The percent increase in pedestrian commuters = 25% * 0.27 = 6.8% (see note below)
4. BAU walk mode share is 5%; BAU walk trips per 10,000 miles = 5% ÷ 10,000 = 500; strategy walk trips per 10,000 miles = 500 * (1 + 6.8%) = 534; strategy walk mode share = 534 ÷ 10,000 = 5.3%; the percent increase in pedestrian mode share = 5.3% - 5.0% = 0.3%
5. The total decrease in other modes = -0.3%
6. Step 5. Calculate new mode shares:

Mode	**BAU Mode Shares (A)** *Provided by agency (or TRIMMS default)*	**Percentage of Non-Walk Mode Shares (B)** *= A ÷ Sum of Non-Walk Modes (95%)*	**Change in Mode Share (C)** *= -0.3% * B*	**Future Mode Shares (D)** *= A + C*
Auto-drive alone	52.00%	54.74%	-0.18%	51.82%
Auto-rideshare	38.00%	40.00%	-0.14%	37.87%
Vanpool	0.00%	0.00%	0.00%	0.00%
Public transit	3.50%	3.68%	-0.01%	3.49%

[33] Bartholomew, Keith and R. Ewing. (2009). Land Use-Transportation Scenarios and Future Vehicle Travel and Land Consumption: A Meta-Analysis. Journal of the American Planning Association, 75 (1), 13-27.

Mode	**BAU Mode Shares (A)** *Provided by agency (or TRIMMS default)*	**Percentage of Non-Walk Mode Shares (B)** *= A ÷ Sum of Non-Walk Modes (95%)*	**Change in Mode Share (C)** *= -0.3% * B*	**Future Mode Shares (D)** *= A + C*
Cycling	0.50%	0.53%	0.00%	0.50%
Walking	5.00%	-	0.34%	5.34%
Other	1.00%	1.05%	0.00%	1.00%
Total	100.00%	100.00%	0.00%	100.00%

7. Total trips = 5,000,000; average walk trip length = 0.7 miles; average carpool vehicle occupancy = 2; the change in trips and VMT is:

Mode Share	**Change in Trips (E)** ***= C * 5,000,000***	**Change in VMT (F)** ***= E /vehicle occupancy* 0.7***
Auto-drive alone	-5,226	-6,466
Auto-rideshare	-3,819	-2,363
Vanpool	0	0
Public transit[34]	-352	0
Cycling	10,000	-62
Walking	-503	11,813
Other	-101	-124
Total	*0*	0

8. The total reduction in VMT = 6,466 + 2,363 = 8,829

[34] Assume that reductions in transit trips do not affect overall transit VMT.