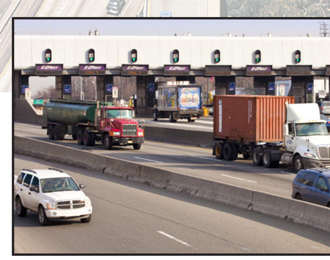
Analyzing Emission Reductions from Travel Efficiency Strategies:

A Guide to the TEAM Approach



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Analyzing Emission Reductions from Travel Efficiency Strategies:

A Guide to the TEAM Approach

Transportation and Climate Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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1. Introduction

Transportation is one of the largest and fastest-growing sources of greenhouse gas (GHG) in the country. Transportation and environmental agencies at all levels are looking for ways to reduce GHG emissions, and lessen the health and environmental impacts associated with transportation-related emissions. Urban areas provide the greatest opportunity for reducing GHG as well as other air pollutants through the adoption of specific policies and strategies to improve travel efficiency by reducing congestion and growth in vehicle miles traveled (VMT). The result is more efficient access to goods and services along with improved health and overall quality of life.

Travel efficiency strategies such as commuter programs, land use changes, transit improvements, increased parking charges, road pricing, and others have been shown to reduce VMT and travel in congested conditions, and correspondingly reduce air pollutant emissions. As states and regions look for additional ways to reduce emissions, travel efficiency strategies are becoming increasingly attractive because they are often less costly to implement, can have both short and long term impacts, and can create more sustainable and livable communities when compared to the construction of additional miles of new roadway. Although many areas have embraced such strategies for a variety of reasons, there is increasing interest in considering whether a comprehensive combination of these strategies can substantially contribute to reductions in transportation-related emissions.

The **T**ravel **E**fficiency **A**ssessment **M**ethod (TEAM) is intended to assist professionals in assessing the potential role travel efficiency strategies can play in reducing criteria and GHG emissions. TEAM supports a preliminary exploration of how specific transportation and land use changes may result in air quality improvements, whether air quality is the primary reason for adopting such changes or an associated co-benefit. The travel efficiency strategies tested using TEAM are based on existing and anticipated local conditions with data drawn from a traditional travel demand model or other sources.

Because it relies on a simple spreadsheet analysis, the TEAM approach provides a quicker assessment than an approach that uses a transportation model. This relationship with more detailed analysis means that TEAM augments and supports the existing analysis rather than competing with it. TEAM provides useful information for a planner or decision-maker to evaluate the potential impacts of certain policies. Practitioners can be assured that further detailed analysis will refine and enhance the TEAM results rather than produce conflicting information. In this way TEAM can save time and resources for the user. TEAM relies on EPA's Motor Vehicle Emissions Simulator (MOVES) model to estimate the potential emission reductions from changes in travel activity. Because TEAM is scalable from the level of a single site, zone, or region up to a multi-county region, there are many applications for its use in planning efforts as a screening tool for initial decision-making.

Air Quality Planning: Several areas that do not meet the National Ambient Air Quality Standards (NAAQS) must work with State authorities to develop and implement State Implementation Plans (SIPs) to improve air quality. In addition, the transportation conformity requirements ensure long range transportation plans (LRTP) and transportation improvement programs (TIP) prepared by metropolitan planning organizations (MPOs) are consistent with transportation emissions limits established by the

SIP. TEAM does not replace the procedures and methodologies used to support air quality planning, and should not be used for calculating emission reductions for SIP development or conformity determinations. [1] Instead it 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. The following bullets provide additional details on potential uses of the TEAM methodology.

- **SIP Development and Transportation Conformity Analysis:** Travel efficiency strategies can be included in LRTPs and TIPs where emission reductions are needed to meet transportation conformity requirements. TEAM can then be used to compare and shortlist travel efficiency options for further consideration and analysis.

- **Congestion Mitigation and Air Quality Improvement (CMAQ) Program:** CMAQ project eligibility requires that project and programs selected for funding result in emission reductions. TEAM can be used to evaluate individual projects as well as regional programs where data is available at the appropriate geographic scale.

- **Greenhouse Gas Analysis (GHG):** Many states and urban areas that have an interest in reducing GHGs lack appropriate tools and techniques to support this analysis. TEAM uses the latest vehicle emissions information available through the MOVES model to allow analysis of potential GHG reductions.

Transportation Planning: The decision making process that supports transportation planning in urban areas is defined by law and regulation. This process is supported by detailed analysis at various levels of sophistication across the country. TEAM does not alter the existing requirements for supporting analysis but rather allows a preliminary consideration of options using an “off-model” approach.

- **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 in order to inform decisions as well as focus limited technical resources on those strategies which appear most effective.

- **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

[1] For SIP and conformity purposes, state and local agencies should contact their EPA Regional Office and review relevant SIP and conformity guidance documents at: www.epa.gov/otaq/stateresources/index.htm.

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[2] and times away from congested facilities and times of day.

- **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 due to a reduction in 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.

Land Use Planning: The federal Partnership for Sustainable Communities, consisting of the U.S. Department of Housing and Urban Development (HUD), the U.S. Department of Transportation (DOT), and the U.S. Environmental Protection Agency (EPA) calls for the integrated consideration of housing, transportation, and the environment in planning and development decisions. TEAM supports policy-level analysis of the emission and VMT reduction benefits of smart growth compared to current growth patterns.

The TEAM approach provides a flexible and adaptable means of considering options to reduce transportation emissions. This guide is intended to help practitioners through the steps to conduct an analysis that is sufficiently rigorous to support comparison of strategies in order to make policy-level decisions as well as support more detailed analysis of promising strategies.

1.1. Background

In 2010, EPA developed an analysis approach to quantify the potential emissions reductions from "travel efficiency strategies" at the national level. EPA calls this approach the **T**ravel **E**fficiency **A**ssessment **M**ethod (**TEAM**). The term "travel efficiency" is used to refer to those strategies defined in Section 108(f)(1) of the Clean Air Act[3] such as employer-based transportation management programs, transit improvements, smart growth and related land use strategies, as well as road and parking pricing, and other strategies aimed at reducing mobile source emissions by reducing vehicle travel activity. TEAM uses available travel data and a sketch model analysis to quantify the change in VMT, combined with MOVES emission factors to calculate the emission reductions that can reasonably be expected by

[2] Note that the use of an alternative route may increase VMT and corresponding emissions, although this may be offset by the reduction in emissions resulting from travel in less congested conditions.

[3] The Clean Air Act lists 16 "transportation control measures" (Title 42, Chapter 85, Subchapter 1, Part A, Section 7408(f)) as "methods to reduce or control pollutants in transportation; reduction of mobile source related pollutants; reduction of impact on public health". There are additional strategies to those listed in the Clean Air Act such as road pricing and parking charges that result in similar benefits. Collectively these strategies are broadly useful to address all regulated pollutant emissions as well as GHG emissions. They also have other associated benefits such as reducing demand for foreign oil and decreasing fuel consumption costs.

applying these strategies. As described above, the results can be used to support many ongoing planning activities and analyses within state and local air quality, transportation and land-use agencies.

The TEAM approach was used to conduct a national-level analysis to estimate the potential emissions reductions that could result from the implementation of seven different travel efficiency scenarios comprising multiple strategies. A description of the analysis and results are documented in *Potential Changes in Emissions Due to Improvements in Travel Efficiency – Final Report* (available at: http://www.epa.gov/otaq/stateresources/policy/420r11003.pdf and referenced here as *EPA Final Report*). Because the approach was based on analysis of 15 different urban areas using data from the respective MPOs' travel demand models, the lessons learned in collecting data and modeling strategies can be relevant to other areas. Specific information from the national-level analysis is included throughout this guide as examples for users.

1.2. The TEAM Approach

Regional planning organizations as well as state and local transportation and air quality agencies can benefit from lower cost and less data-intensive sketch tools and methodologies to assess the air quality impacts of travel efficiency strategies. These sketch planning approaches, when appropriately applied, can provide useful information for decision makers. This level of analysis is conducted using existing outputs from the regional travel demand model without direct use of the model. It is therefore less data-intensive and less costly to run or implement. This approach can help planners effectively screen a broader range of alternatives or scenarios in order to reduce or eliminate the time and effort spent on modeling and maximize the time spent analyzing promising alternatives. The basic approach of using outputs from the travel demand model or other regional sources as inputs to a sketch planning analysis offers an efficient and defensible way in which to consider travel changes and related emissions benefits.

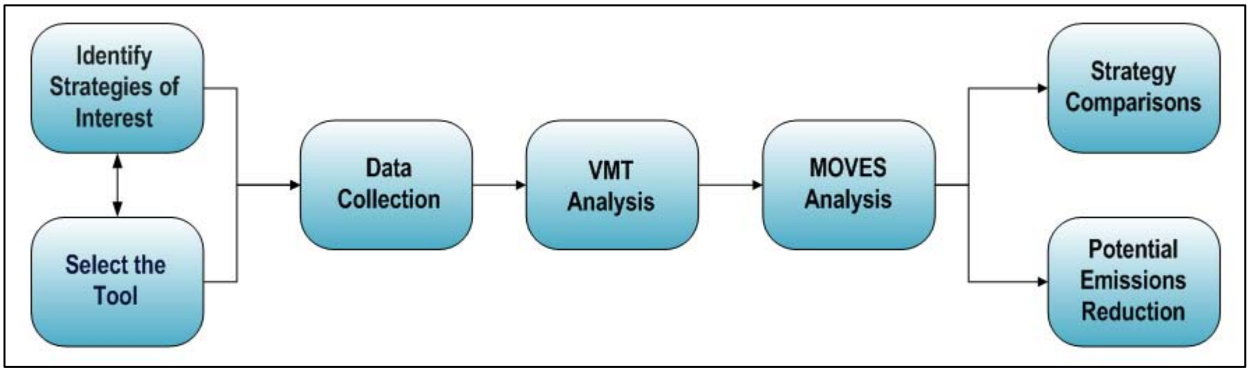
This guide describes the TEAM approach to estimating the emission reductions from travel efficiencies at the regional level using information that is typically readily available from a travel demand model. The analysis can also be conducted for local areas to the extent that local jurisdictions are covered by a travel demand model and the data for these jurisdictions can be extracted from the model. The guide describes the information and data required for analysis, step-by-step procedures for performing the analysis, considerations for making assumptions about the strategies of interest, and considerations for interpreting the results. In addition, it identifies default values, alternative sources of information, and data that can be used when local data and information is incomplete or absent. The analysis can be done for a single year, which may be the current year, or any future year for which transportation and demographic data are available.

The methodology presented here is not a substitute for travel demand modeling or emissions modeling required for SIP and/or conformity purposes. It is most useful to provide a starting point to evaluate promising strategies for further in-depth analysis.

2. Applying TEAM

TEAM begins with estimating the potential travel activity changes (measured in terms of trips and VMT) of selected travel efficiency strategies. The estimated change in trips and VMT can then be used to estimate the corresponding emission changes. These values can also be used to estimate other co-benefits associated with the reduction in VMT, such as fuel consumed and savings in vehicle operating costs, if desired. The following information describes in detail the steps that are the framework for the TEAM approach, illustrated in Figure 1 below. In instances where alternatives may exist, these are noted to provide choices about the data and analysis methods that best suit individual situations.

Figure 1. TEAM Approach Steps

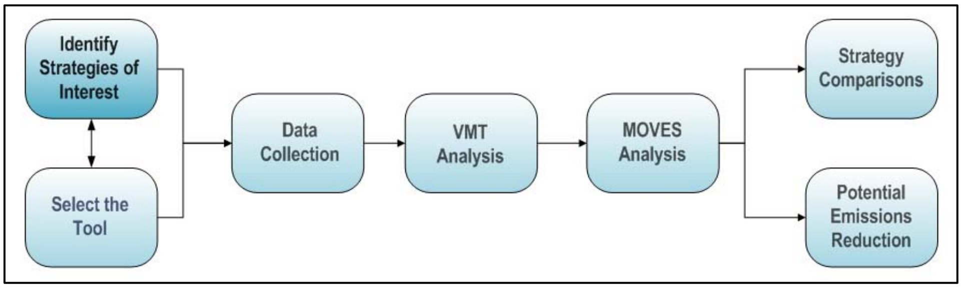


The methodology that supports TEAM has been tested and peer reviewed using a regional analysis approach to develop a national-level understanding of potential benefits from the use of travel efficiency strategies and documented in the *EPA Final Report*. That analysis was conducted using data from 15 metropolitan regions of varying population and transit mode share and provides the basis for the information in this guide. References are made to that analysis using the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS©[4]) model[5] along with detailed supporting information in the appropriate sections. Although TRIMMS was the sketch planning model used for this analysis, the TEAM approach is flexible with regard to the choice of sketch model. A minimum requirement is that the model selected allows the user to enter valid data inputs obtained from the regional travel demand model or other reliable local source, apply assumptions for the strategies of interest, and estimate reductions in trips and/or VMT. Several models are available for this purpose. A more complete discussion of sketch model choice follows in Section 2.2. Throughout this guide the descriptions will reference the use of the TRIMMS model.

[4] The TRIMMS© model is under copyright; the symbol is being used in this first reference to the model but will not be repeated in the text hereafter.

[5] At the time of publication, the newest version of TRIMMS was being prepared for release. The TRIMMS model and related documentation (Center for Urban Transportation Research (CUTR) (2009) *Quantifying the Net Social Benefits of Vehicle Trip Reductions: Guidance for Customizing the TRIMMS© Model,* prepared for Florida DOT, Tampa, FL: CUTR at the University of South Florida) are available at: www.trimms.com

2.1. Identifying Strategies of Interest



The first step in using TEAM is to develop an initial list of strategies to consider. In addition to the travel strategies listed in the CAA, there are numerous sources of information about travel efficiency strategies available to guide the development of an initial list. The existing travel characteristics of the area, forecasted growth, availability of data, and the willingness of decision makers to support new approaches to reducing emissions will further help refine the strategy list. In selecting the strategies that will be modeled, regions can consider results from previous studies for individual strategies or strategies that have been analyzed in other regions with similar characteristics.

The TEAM approach was applied to the following four categories of travel efficiency strategies in the national-level analysis (*EPA Final Report*). The examples describe considerations for developing a strategy for testing along with the required data for analysis. The descriptions below include reference to the TRIMMS model and the way the strategies can be analyzed using this particular tool because the TEAM approach was based on this. However, any sketch planning tool capable of analyzing these strategies can be used with this conceptual understanding.

- **Regional Transportation Demand Management:**
  Transportation demand management (TDM) includes a range of strategies that encourage travelers to use the transportation system in a way that contributes less to congestion and improves air quality. TDM covers many aspects of trip-making, including whether to make a trip, when to make the trip, what transportation mode to use, and what route to choose. TDM program choices available in TRIMMS include employer-based strategies such as flexible work hours, telecommuting, guaranteed ride home programs, transit subsidies, and incentives for carpooling, walking, and biking. TDM programs implemented at a regional scale may be analyzed in TRIMMS, based on the percentage of employees or working population in the region that are assumed to participate in these programs. Note that the TDM strategy applies only to work/commute trips; therefore, the population and other input data should pertain to these trips only. Although the TDM strategies do not have a direct impact on the cost of driving or the value of travel time in the model, they exert an indirect effect on the choice of alternative modes. Individual models will account for this indirect effect in different ways.

  The TRIMMS model considers TDM to be a “soft program” where employer-initiated strategies lead to voluntary changes in travel behavior. The term “soft program” refers to those program/strategies usually defined as support programs, which have an impact on travel behavior without necessarily having a direct impact on travel time or costs. For example, opportunities and incentives for employees to work flexible hours or to telecommute would fall under this category. The term "hard programs" refers to those strategies directly affecting the generalized cost of travel, such as transit frequency improvements, transit subsidies or parking surcharges. TRIMMS can analyze both types of programs either independently or jointly in a combined scenario. Soft programs rely on education or on internalizing some of the costs of driving to encourage travel behavior changes; programs include travel planning, advertising, and guaranteed ride home programs. Hard programs include both incentives and disincentives, such as parking pricing, modal subsidies, and land use strategies that affect transportation access and travel times. TRIMMS models the impacts of site-specific and region-wide TDM strategies using a set of previously estimated parameters based on an econometric analysis of the relationship between hard programs and soft programs like TDM.[6]

- **Transit strategies:**
  The national analysis (*EPA Final Report*) included the modeling of two transit-related strategies: (1) increased frequency of transit services and (2) lower transit fares through discounts, subsidies, free transfers or other policies.

  Transit service improvements in the form of improved service frequency and reduced time between buses or trains, can lead to a reduction in wait time and overall travel time for transit passengers. To model these improvements, assumptions must be made for the expected reduction in transit travel time and provided as inputs to the model. The results would then represent the VMT reduction possible from any of several strategies to improve transit service and operations. TRIMMS can be used to analyze these transit strategies with the application of transit travel time elasticity values documented in existing research.[7] These values indicate the degree to which transit ridership can be expected to increase when transit travel times are reduced.

  Another transit-related strategy that may be modeled is fare reduction, reflecting employer subsidies for transit use or commuter discounts offered by transit agencies. To analyze the impacts of transit fare discounts and subsidies, the TRIMMS model applies transit fare elasticities. The elasticities reflect the sensitivity of transit mode share to a change in the cost of commuting by transit, and the default values in TRIMMS have been obtained from a survey of the literature.

  Note that the impacts of improving qualitative aspects such as the level of comfort or quality of transit service cannot be captured in such an analysis.

- **Pricing strategies:**
  Pricing strategies such as peak hour tolls, variable pricing with charges varying by the time of day or level of congestion on new and existing lanes, and conversion of High Occupancy Vehicle

[6] Concas, S. & Winters, P.L. (2009). *Quantifying the Net Social Benefits of Vehicle Trip Reductions: Guidance for Customizing the TRIMMS© Model*. Final Report No. BD 549 WO 52 prepared by National Center for Transit Research for Florida Department of Transportation. Available at: http://www.nctr.usf.edu/pdf/77704.pdf.

[7] Litman, Todd, (2010), *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior,* (Victoria, BC: Victoria Transport Policy Institute); available at: http://www.vtpi.org/elasticities.pdf; CUTR (2009)

(HOV) lanes to High Occupancy Toll (HOT) lanes have been implemented in some regions of the U.S. in recent years.

The TEAM approach can be used to estimate the VMT and trip reduction impacts of pricing strategies that affect the operating costs of vehicles. These include higher parking charges, regional peak period tolls, and mileage fees. Peak period pricing charges can be modeled in TRIMMS since it breaks down results and inputs based on time of day. TRIMMS can also model mileage fees and facility tolls. Parking charges can be modeled if average baseline parking costs for the region are known or estimated from a regional travel demand model.

Other types of pricing strategies such as corridor-level tolls and cordon-based or area-specific pricing cannot be modeled using this method since these require detailed disaggregated information for sub-areas, such as mode shares and travel costs on particular corridors or in sub-areas of a region. This information can be effectively analyzed by the regional travel demand models or sub-area models.

In TRIMMS, congestion charges can be modeled by applying the increased cost to a specific proportion of all trips (e.g., peak hour trips only). Ongoing studies show that regions considering mileage fees favor a congestion pricing component that allows the fee to vary by location and time of day in future years. The analysis takes this into account and applies the higher mileage fees during peak hours, using data on the proportion of regional trips occurring in peak hours provided at the input stage. The mileage fees are applied to a baseline level of average auto operating costs also input by the user.

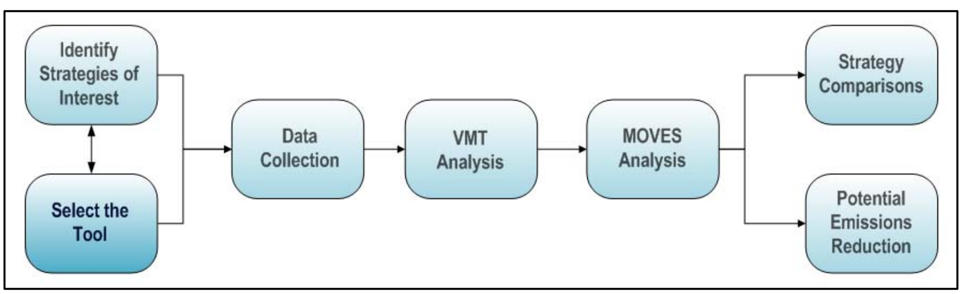
Although parking charges are best modeled at a disaggregate scale using zonal information, it is possible to do a sketch-level analysis at a regional scale using the TRIMMS model and data on baseline (existing) average daily parking charges.

- **Land use strategies:**
  Land use strategies are often modeled in terms of assumptions about one or more of the five "D" variables -- density, diversity of land uses, design (street network characteristics), destination accessibility, and distance to transit facilities. A common land use strategy is transit-oriented development (TOD), which calls for dense, mixed-use developments around transit stations that are designed to facilitate use of transit and walking and bicycling. Land use strategies can be assessed to a limited extent using sketch models and the TEAM approach; however, the results are subject to a number of uncertainties. The independent effects of land use strategies such as TOD, promotion of higher density, or incentives for mixed use development, are difficult to estimate in TRIMMS or any tool that does not analyze impacts at a relatively high resolution, typically at the level of traffic analysis zones, census tracts, or even land parcels. Since it is difficult to isolate the impacts of these strategies (or "D" variables) due to the interrelationships between them, these strategies are often combined together.

  Using the TEAM approach, a single land use scenario may be modeled that combines the effects of some common strategies including density increase, mixed use development, and TOD. In doing so, assumptions can be made, considering existing research or local information, for each mode with respect to changes in travel time and trip lengths resulting from the land use strategies considered. Assumptions for expected changes in travel conditions can be drawn from previous studies as was done for the national analysis (*EPA Final Report*).[8] For example, a doubling of housing density can be expected to result in a four to five percent reduction in VMT.[9]

To comprehensively define each strategy, the assumptions or parameters should be developed from a thorough review of strategies proposed regionally, a realistic judgment of what is appropriate to consider for the region being modeled, and professional and academic studies focusing on analysis of travel efficiency strategies. This thorough assessment will allow practitioners to identify the specific regional data needed for analysis as well as how to adjust data from sources outside the region, such as national default values so that they can be applied to the region. Strategies may be combined into scenarios and modeled simultaneously. This will limit model runs and help identify synergies or conflicts between the strategies. It is useful to consider how the strategies may be applied within a region in deciding whether to combine strategies or to analyze them individually. For example, TDM strategies are only applied to work trips, while land use strategies may be applied to all trips. This implies that these strategies are best modeled independently with different baseline input data, rather than modeled together in the same run. Table C-1 in the Appendix shows a range of strategies considered by regions around the country and quantitative estimates of the modeled or observed impacts. Not all of these strategies can be analyzed using the TRIMMS model (e.g., some types of pricing strategies as noted above and freight-related strategies), but these may be analyzed using other available tools.

2.2. Selecting the Sketch-Planning Tool



There are many sketch-planning tools that rely on different types of data inputs and provide various outputs (see Table 1). In addition, some transportation and air quality agencies develop in-house tools that meet a variety of needs. When selecting or developing a tool for the TEAM approach, users should pay particular attention to the following aspects:

- **Range of strategies that can be modeled**: Some tools may not directly model certain strategies but can still capture the impacts of those strategies via secondary inputs such as changes in travel time, costs, or trip distances that are expected to result from implementing the strategy. For example, transit-oriented development (TOD) cannot be modeled directly in TRIMMS since the model does not allow sub-regional analysis. However, if estimates for the reduction in

[8] Bartholomew and Ewing (2009); Ewing and Cervero (2010); Ewing et al. (2008); Rodier (2008)
[9] Ewing and Cervero (2001, 2010)

transit access or travel time resulting from TOD strategies are available these may be used as parameters for modeling TOD in TRIMMS.

- **Time periods of interest**: Some tools allow analysis for a single year based on data inputs for that year, while other tools allow the user to estimate impacts for multiple years over which a strategy will be implemented or over the life of a project.
- **Scale of analysis:** Some tools are applicable only for site-level or sub-regional analysis, while others can be used at a broader scale for regional analysis of strategies. Site-level analyses typically require specific and detailed data that may need to be gathered from the parties involved, whereas regional analyses can often take advantage of data available from travel demand models and other public data sources.
- **Data inputs**: Some tools have more intensive data needs, while others require fewer inputs but draw more information from surveys and existing data sources. Data inputs can sometimes be substituted with default values, but to accurately reflect local conditions this should be limited to the extent possible.
- **Outputs**: The outputs need to be in a format that can be converted into emissions changes. Tools that provide change in travel activity (VMT and trips) as an output are the most appropriate for use with the MOVES emissions model. The results from tools that convert changes in trip activity to emissions savings directly may still need to be manipulated if they are not consistent with EPA's MOVES emissions model.
- **Flexibility of the tool**: It is important that the selected tool allow users to alter the model parameters based on local data. For example, TRIMMS allows users to alter the travel time and cost elasticities based on information that may be available from studies or surveys done in the region, or from the travel demand model. This feature represents an additional value of the TRIMMS model and is not commonly found in sketch planning tools. Some models provide assumed values for vehicle occupancy. Since average occupancy varies by region and is often available at the regional scale, it is preferable if users are able to alter this parameter. Not only should the tool be transparent in its assumptions and data sources, but also flexible in permitting the user to alter common parameters based on updated data sources or more accurate local information that might be available.
- **Trip types to be analyzed**: For any tool that is used, users must familiarize themselves thoroughly with the assumptions related to trip types, regional population, and other parameters. For instance, some tools are meant to model work trips only, not all trips. Therefore, if strategies applicable to all trips are to be modeled, the user must either find a tool that allows analysis of all trips, or adjust the results obtained from work trip modeling tools to estimate the impact of the strategies on all trips.

There are several currently available tools that meet the above criteria to varying degrees and may be considered for use with the TEAM approach. The models/methodologies are listed below along with the year they were last updated. Table 1 summarizes the input requirements and output capabilities of each.

- Meta-analysis: this is not a tool but a methodology for estimating the impacts of a strategy based on modeled or observed impacts obtained from a meta-analysis of literature
- EPA's COMMUTER model, 2005
- Trip Reduction Impacts for Mobility Management Strategies (TRIMMS) model, 2009
- Center for Clean Air Policy (CCAP)'s Transportation Emissions Guidebook (TEG), 2006
- Transportation Control Measure (TCM) Tools, early 1990s
- TCM Analyst, 1994
- Travel Demand Management (TDM) Evaluation Model, 1993
- Surface Transportation Efficiency Analysis Model (STEAM), 2006
- MARKAL (Market Allocation)-MACRO
- National Energy Modeling System (NEMS): Transportation Sector Module (TRAN), 2006

Table 1. Input Requirements and Output Capabilities for Travel Efficiency Strategy Analysis Tools and Models										
	Spreadsheet-Based Tools/Methods						Models			
	Meta-analysis	EPA COMMUTER model	TRIMMS	CCAP-TEG	TCM Tools	TCM Analyst	TDM Evaluation Model	STEAM	MARKAL-MACRO	NEMS TRAN
INPUTS										
Population		X	X							X
Per capita income										X
New vehicle sales										X
Mode shares (no. of trips)	X	X	X	X	X	X	X	X		
Average vehicle occupancies by mode	X	X	X				X	X		
Travel times by mode (in-vehicle and out-of-vehicle)		X	X				X	X		
Average trip costs by mode (including parking, fees, tolls, fuel costs, transit fares)	X	X	X				X	X		X
Includes non-motorized trips	X	X	X	X				X		
Average trip lengths	X	X	X	X		X				
Baseline regional VMT		X			X				X	X
Trip tables							X	X		
Baseline vehicle speeds	X	X			X	X				
Vehicle fleet mix	X	X							X	X
Fuel price per gallon	X			X					X	X
Average fuel economy	X			X						X
Emissions factors	X					X				
OUTPUTS										
Change in mode shares (no. of trips by mode)	X	X	X		X	X	X			
Change in travel time								X		
Change in VMT	X	X	X	X	X	X	X	X	X	X
Change in emissions	X	X	X	X	X	X		X	X	X
Change in speeds					X	X				
Fuel demand			X						X	X
Benefits and costs			X					X		

Table C-2 in the appendix provides more detail on each tool or model listed in Table 1. This list is not exhaustive and new tools are expected to become available over time. Users may also choose to develop their own tool to fit their particular needs.

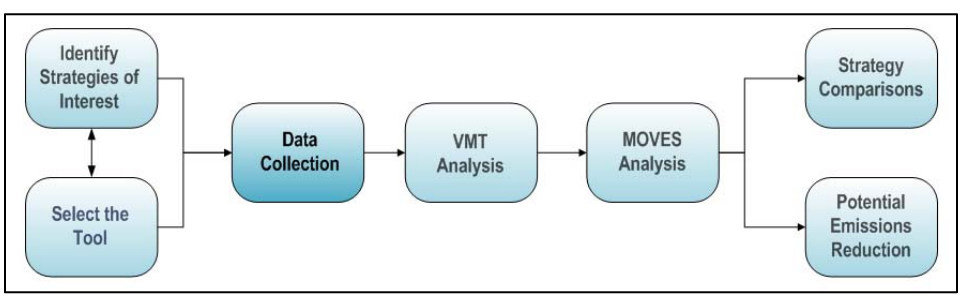
2.2.1. The TRIMMS Model

The Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) model[10] is used as the basis for this guidance because the TRIMMS model accepts regional inputs from travel demand models and allows alteration of assumed parameters such as travel time and travel cost elasticities. The TRIMMS model thus meets the needs of the TEAM approach well; however, other tools may be selected or developed to meet individual needs and available data following the TEAM framework. TRIMMS is a sketch planning tool that can be customized to analyze many types of strategies at a regional or sub-area scale, which would normally be analyzed using a regional travel demand model. For example, TRIMMS can be used to analyze strategies involving construction of new infrastructure such as new HOV/HOT lanes, new transit lines, and new bicycle/pedestrian facilities. In the TRIMMS model, such strategies can be modeled using the change in travel times and travel costs that such strategies represent. The TRIMMS model does not use trip tables. It requires average regional mode shares, average trip lengths and travel time by mode, average vehicle occupancy, parking costs, and trip costs as inputs. The user can change the price and travel time elasticity values. The tool provides changes in mode shares, trips, and VMT as outputs.

TRIMMS evaluates strategies that directly affect the cost of travel such as transit fare subsidies, parking pricing, pay-as-you-go pricing initiatives and other financial incentives. TRIMMS also evaluates the impact of strategies affecting access and travel times. The model allows the user to account for employer-based program support strategies, such as flexible working hours, teleworking, and guaranteed ride home programs. It allows the analyst to use local data or defaults from national research findings. The VMT impacts of either a single strategy or a given package of strategies are subsequently calculated.

Although the TRIMMS model can be used with regional inputs from sources like the American Community Survey and Census data, values obtained directly from a regional travel demand model will provide more accurate results. Although TRIMMS is primarily designed for the analysis of commute trips, the user can adapt the model for analysis of all trips by appropriately adjusting the inputs and the results obtained from the model.

2.3. Collecting the Data



When using the TEAM approach, it is important to use data that closely approximates local conditions. Some models, like TRIMMS, contain a built-in database of nationally-available data for metropolitan statistical areas (MSAs) or urbanized areas (UAs) in the United States, allowing the user to select the relevant region for modeling. However, these data

[10] The TRIMMS model and related documentation are available at: http://www.nctr.usf.edu/2009/04/trimms2/

may be drawn from surveys or databases for a particular year and may not reflect current local conditions, which can limit their accuracy. For instance, TRIMMS draws data for 85 MSAs from the American Community Survey for the years 2005-2007. Adjusting the model inputs and parameters to use more specific and current local data generates results that better reflect the expected impact of the strategies tested. For a strategy being applied and analyzed at the regional scale, the best input data will generally come from the local or regional travel demand model, which uses or provides most of the required data.

The TEAM approach was developed using the TRIMMS model, and the specific data requirements discussed below will refer primarily to that tool's requirements and capabilities. When using a different model, the specific details of data and parameters as well as the ability to customize will be based on that tool.

2.3.1. Data required in TRIMMS

The TEAM approach uses three sets of data inputs:

- Inputs for the 'base case' that reflect conditions in the absence of any strategy being applied
- The magnitude of change in travel time or cost that would result from the proposed strategy and that will be used to adjust the base case data
- Elasticities that measure the change in travel demand in response to changes in travel time or trip costs.

The current year base case or baseline reflects existing conditions in the region. When the analysis is done for a future year, the base case reflects anticipated population growth and socio-economic changes but without additional strategies included. The data inputs needed to establish the base case are provided in Table 2.

Table 2. Regional Data Inputs for TEAM Methodology	
Base Case Inputs	
Population	Total population
	Total working population (16 and over)
Modal information (light-duty vehicles, non-commercial trips) for: • Auto-drive alone • Auto-rideshare • Vanpool • Public transit • Cycling • Walking • (Other modes)	Mode share
	Average trip length (miles)
	Average vehicle occupancy (no. of persons) *For auto-rideshare, vanpool, and bus only*
	Trip costs (current $ per trip) – does not include parking costs or other costs such as tolls, feeds, and peak hour charges
	Automobile parking costs (current $ per auto per day) *For auto-drive alone and auto-rideshare only*
	Other auto trip costs not included in parking costs, e.g., tolls, peak hour fees, etc. (current $ per trip) *For auto-drive alone and auto-rideshare only*
	Average trip travel time (minutes)
	Detailed trip travel time – access time and travel time separately (minutes)
Peak and off-peak trips	Percentage of total trips in peak hours (%)
	Total trips in peak hours
	Total trips in off-peak hours

The second set of inputs establishes the parameters or limits for the selected strategy. In TRIMMS, these are primarily in the form of the magnitude of change in travel time or cost variables that would result from the proposed strategy. For example, the user may assume a dollar increase in auto driving costs or parking charges in to reflect the application of congestion charges or parking charges respectively. Similarly, the user may assume a reduced travel time in minutes for transit modes to reflect reduced wait times for transit resulting from improvements in service.

How the base case and strategy inputs will impact travel behavior is determined by the elasticity values. Elasticity is an economic concept that measures the change in demand or supply of a good (e.g. travel demand) in response to a change in some factor that influences that supply or demand (e.g. travel time). A negative sign indicates that the effect operates in the opposite direction from the cause (an increase in gas price causes a reduction in travel), while a positive sign indicates an effect in the same direction (e.g., an increase in transit frequency causes an increase in transit demand or mode share.[11] Cross-elasticities indicate how a change in the attractiveness of one mode (in cost or time) will affect another mode, thus reflecting the degree to which travelers substitute one mode for another when conditions change. For example, a cross elasticity of 0.040 for transit with respect to auto parking costs would

[11] Litman (2010)

indicate that a 10% increase in the cost of parking would cause a 0.4% increase in transit trips as some drivers stop driving and take transit instead.

Travel time and price elasticities provide the fine adjustments within TRIMMS that influence the potential impacts of a strategy, making this information very important. These elasticity values are usually an important consideration in several other models used for this purpose; however, few models allow these values to be altered by the user. Table 3 shows typical regional elasticity data that may be needed as inputs to TRIMMS or other sketch planning models, if the option to alter elasticities is available. TRIMMS comes loaded with default elasticity values with the option of setting customized values, if available.

<table>
<tr><th colspan="2">Table 3. Regional Elasticity Inputs (if available)</th></tr>
<tr><td>Elasticity with respect to parking/driving costs, for the following modes:
• Auto-drive alone
• Rideshare
• Public transit
• Other</td><td>By trip purpose:
• Commuting
• Business
• Education
• Other</td></tr>
<tr><td rowspan="4">Transit elasticities, for peak times, off-peak times, and on average</td><td>Transit ridership with respect to transit fare</td></tr>
<tr><td>Transit ridership with respect to transit service</td></tr>
<tr><td>Transit ridership with respect to auto operating costs</td></tr>
<tr><td>Auto travel with respect to transit costs</td></tr>
<tr><td>Travel time elasticities, for peak times, off-peak times, and on average</td><td>For modes:
• Auto-drive alone
• Rideshare
• Public transit</td></tr>
</table>

The data needed for analysis using TRIMMS is described in Table 2 with optional data included in Table 3 above. Other models will require different data inputs. Please refer to Table C-2 in the Appendix for a more complete listing of data needs of some existing models.

Average regional values may be used for all the required data; however, some inputs may be difficult to estimate at a regional scale. For example, parking charges typically vary by zone or sub-region and can further vary by time of day. To simplify the analysis, average daily parking charges per vehicle trip may be assumed from knowledge of average local hourly rates.

Note that the TRIMMS model allows analysis of a strategy for one year at a time. Therefore, if a region must analyze strategies for multiple years, baseline values for the data inputs must also be available for each future year. In some cases, future year inputs for data such as transit fares or parking charges may not be available. These can be estimated using reasonable inflation rates or trends of growth seen in the region.

2.3.2. Alternate data sources for missing inputs

Some regions will not have all the data that the model requires. The TRIMMS model includes default data and default travel behavior parameters tailored for 85 MSAs in the U.S., encompassing large and small urban areas.[12] This provides an immediate data source for those regions that may not have local input data for the base case. If the user's region is not included in the MSAs represented in TRIMMS, the model user guidance recommends selecting the geographical area that most closely matches the region. The TRIMMS user guidance also provides measurement methods to assist agencies in customizing some of the default values to their areas.

Future year data can be difficult to obtain in some cases and so assumptions may need to be made to extrapolate data for future years based on available information. For data that cannot be obtained from the regional model, alternate sources may be used as described below along with guidance on assumptions for conducting analyses for future years.

- **Mode share:** Given the importance of mode shares in the TRIMMS model, to the extent possible regions should use values from the travel demand model. Walk and bike mode shares are often not available, but can be estimated using regional surveys. If such local data are not available, values for walk and bike mode shares may be assumed based on data from other regions with similar characteristics or from national estimates. If such assumptions are made, the other mode shares must be adjusted accordingly so that the total of all mode shares does not exceed one hundred percent. For baseline mode shares in the future year, the user can assume that past trends seen in the region will hold in the future if travel demand model data is not available.

- **Trip length:** Where unavailable at the regional level, the TRIMMS default values may be considered for applicability to the region. These values are drawn from the 2001 National Household Travel Survey (NHTS) and are as follows for each mode. Note that these trip lengths are for commute trips and the user may wish to input their own values if the analysis pertains to all trips. Average commute trip lengths are typically higher than average trip lengths when all trips are considered.

Auto drive alone	12.2 miles
Auto rideshare	12.2 miles
Vanpool	20.4 miles
Public transport	12.2 miles
Cycling	2.9 miles
Walking	0.9 miles
Other	12.2 miles

[12] See user guidance for the TRIMMS model for model assumptions, guidelines on modifying input parameters, and list of 85 MSAs for which default data are included: CUTR (2009), *Quantifying the Net Social Benefits of Vehicle Trip Reductions: Guidance for Customizing the TRIMMS© Model,* prepared for Florida DOT, Tampa, FL: CUTR at the University of South Florida) are available at: http://www.nctr.usf.edu/2009/04/trimms2/

The user may refer to the most recent NHTS data, available for 2009, for updated data.[13] For future years, the user can assume that that trip lengths will be the same as in the base year or assume that past trends seen in the region will hold in the future.

- **Travel times:** Walk and bike travel times in particular may not be available from a regional travel model. Data from the American Community Survey, available by urban area, can be substituted instead.[14] Since this source groups walk, bike, and other modes into the category "other," no separate travel times are given for walk and bike and the travel times listed can be considered an average across these modes. For future years, changes in travel time can be estimated by using the Texas Transportation Institute's estimates for the increase in the travel time index for urban areas in the country by the year 2030, relative to the year 2010.[15]

- **Regional trip cost data by mode:** Data on trip costs, particularly for non-transit modes are not easily available from all regions. Where automobile operating costs are not available, trip cost can be calculated based on average trip lengths, fuel price and other cost components, and mileage data for the base year. Regions often face a problem in modeling parking charges; aggregate regional analysis severely underestimates baseline parking charges. Parking charges are therefore best modeled at a sub-regional or zonal level. For this analysis, the user may estimate an average daily parking charge based on data on average local hourly rates. The national analysis (*EPA Final Report*) consulted an annual survey of parking rates conducted by Colliers International that provides average daily parking charges in the central business districts (CBD) of U.S. cities.[16] Note that the national analysis did not use the regional average of parking charges as a baseline, but rather used the CBD-area charges for this purpose. This was considered acceptable because parking pricing is most likely to be implemented in locations that have high demand for parking, where parking prices are already at a premium, and where congestion levels are high enough to warrant creating a disincentive to driving by introducing parking pricing. These are typically the CBD areas within cities. For transit trip costs, information on average fares per trip can be collected from the transit authorities where it is not available at the regional level.

  There is no consistent methodology across regions to estimate future year trip costs. Most regions follow the practice of assuming constant auto operating costs in future years because of the uncertainty in how vehicle fuel efficiency and fuel prices will change in the future. This approach is valid for the TEAM analysis. The assumption can be considered acceptable because

[13] NHTS data for 2009 available at: http://nhts.ornl.gov/

[14] For the 2005-2007 period, see American Association of State Highway and Transportation Officials (AASHTO), (2010) *Census Transportation Planning Package (CTPP) Profile Sheets*, available at: http://download.ctpp.transportation.org/profiles_2005-2007/ctpp_profiles.html

[15] Schrank, D. and T. Lomax, eds. (2011), *The 2010 Urban Mobility Report*, (College Station: Texas Transportation Institute).

[16] Colliers International (2011), *North American Central Business District Parking Rate Survey 2011*, available at: http://www.colliers.com/Country/UnitedStates/content/colliersparkingratesurvey2011.pdf. The EPA analysis used the 2008 data.

even though fuel prices may be expected to increase, higher vehicle fuel efficiency is likely to help offset any increase in operating costs. In the absence of local data, analysts may use the Energy Information Administration's Annual Energy Outlook for 2011[17] for fuel price projections. Fuel efficiency projections can be based on the national default light duty vehicle fleet mix available in the MOVES model as in the TEAM approach (see Section 2.5 for details). Future year transit fares and parking costs can be assumed to follow past regional trends. Alternately, it may be assumed that transit fares rise with inflation (at about three percent per year), and future year parking costs increase slightly less (at about two percent per year), based on model assumptions used in some regions.

- **Elasticities:** Since travel time and cost elasticities are often not directly available from a regional travel demand model, they can be estimated at the regional level in one of three ways:

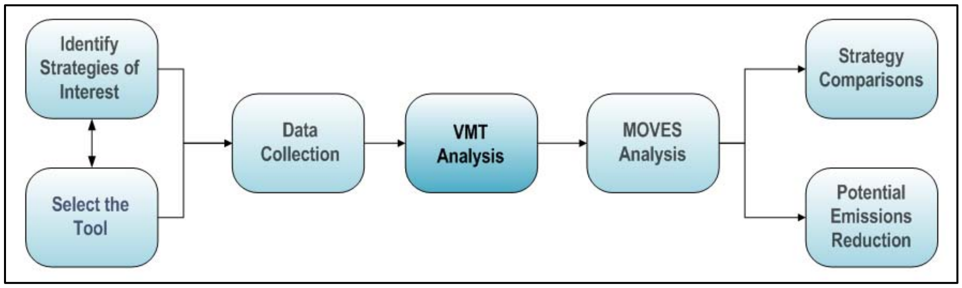
  (1) Using results from surveys providing information on expected or demonstrated changes in travel behavior from changes in travel costs or time
  (2) Using modeling results in a travel demand model for changes in trips resulting from a specific change in trips costs or travel time. For example, the user can quantify the price elasticity of auto travel demand using the change in the number of regional trips by auto estimated by the travel demand model in response to a 10% increase in the average cost of driving. The travel time elasticities can be similarly estimated.
  (3) Using default values obtained from a survey of the literature

  The first two methods are preferred because adjusting the elasticity values based on local data will enhance the accuracy of the analysis in predicting local impacts. Elasticities are typically divided between short term and long term estimates. For longer term estimates (10 years and longer), the elasticities are typically larger than for short term estimates (2-5 years) Long-term elasticities are recognized to be roughly two to three times short-term elasticities[18]. This reflects greater long-term impact owing to greater adoption and effectiveness of strategies over time and adaptation of travel behavior. For example, land use changes take effect over the longest period of time, either passively or through active policy intervention.

  TRIMMS has a default set of cross-elasticities but also allows users to specify their own elasticity values. Some of the default transit fare and price elasticities, parking price elasticities, and cross-elasticities used in TRIMMS appear lower (more conservative) than the values obtained from current literature. The default values are provided in Tables C-3 to C-5 in the Appendix with notes describing changes made for the national analysis (*EPA Final Report*).

[17] U.S. Department of Energy, Energy Information Administration (2011), *Annual Energy Outlook*, available at: http://www.eia.gov/forecasts/aeo/.
[18] Litman (2010): 14.

2.4. Completing the VMT Analysis



After the user has defined the strategies of interest, selected the tool and collected all data inputs that will be used, the next step is to conduct the VMT analysis. To begin the user must first assume parameters for modeling each strategy. In TRIMMS, these parameters are expressed in terms of changes in travel times by the different modes and/or changes in travel costs (examples shown in Table 4). Other sketch planning tools may require additional assumptions to completely define each strategy that will be modeled. The reasonableness of the assumptions should be checked by consulting the relevant literature. Users may also consult the regional information provided in the Appendix of the national analysis (*EPA Final Report*) to select values based on data from similar regions.

As mentioned in section 2.1, strategies can either be analyzed individually or combined into scenarios of complementary strategies, depending on how the strategies are likely to be applied in a region. Modeling multiple strategies in a single scenario has the advantage of capturing the synergies or trade-offs between them and will also help limit the number of times the model is run. However, a disadvantage is that isolated impacts of strategies will not be available.

2.4.1. Inputs required to define strategies

Table 4 illustrates how to take a general strategy and define it sufficiently for analysis purposes. This table provides two alternatives for parameters that were used to model the strategies of interest in the national analysis (*EPA Final Report*), the second alternative being more aggressive than the first.

Table 4. Illustrative Assumptions Used for Modeling Strategies in the EPA National Analysis				
Strategy	**Specific strategy**	**Strategy information**	**ALTERNATIVE 1**	**ALTERNATIVE 2**
Employer-based TDM strategies	▪ Flexible work hours ▪ Incentives for carpooling ▪ Guaranteed ride home programs ▪ Ride sharing/ ride matching ▪ TDM outreach/public outreach programs ▪ Subsidies/discounts for transit, pedestrian and bike modes ▪ Telecommuting	Whether or not employer offers (TRIMMS asks for a yes/no answer) to take these programs into consideration	30% of employers region-wide offer these programs; includes all TDM strategies except walk and bike subsidies	50% of employers region-wide offer these programs; includes all TDM strategies
Land use policies	TOD, smart growth, increase in density, mixed use developments	Change in travel times for all modes, change in average trip lengths	3% reduction in all access times, 5% reduction in transit travel time and walk/bike times; 5% increase in auto travel time due to density/ congestion effects	6% reduction in all access times, 10% reduction in transit travel time and walk/bike times; 10% increase in auto travel time due to density/ congestion effects
			Note: Access time taken as proxy for trip length[19].	
Transit projects and policies	Transit service expansion/increase in frequency, improved access	Improvement in transit travel time and access time	5% reduction in transit travel time	10% reduction in transit travel time
	Fare discounts, reduction, subsidies, or free transfers	Change in transit fares	10% reduction in transit fares	20% reduction in transit fares
Pricing policies	Parking charges	Increase in auto parking costs	$2 increase per day (may be modeled as a percentage increase)	$5 increase per day (may be modeled as a percentage increase)
	VMT fees or congestion pricing	Increase in peak hour driving costs	$0.10 increase per mile (may be modeled as a percentage increase)	$0.25 increase per mile (may be modeled as a percentage increase)

Refer to the TRIMMS model guidance[20] on exactly how the above strategy assumptions can be input into the model.

Figure 2 illustrates how the TRIMMS model provides the results after modeling a strategy or a combination of strategies. Once the user has completed the modeling, the results from TRIMMS can be validated against results obtained from modeling done using other tools, the regional model, or even results in other regions having a similar size and mode share profile. Results from representative regions are available in Appendix D. These results were developed as part of the EPA national analysis (*EPA Final Report*).

[19] TRIMMS does not allow detailed modeling of land use strategies such as smart growth. Therefore, the reduction in trip lengths and improved accessibility expected to result from these strategies were modeled in TRIMMS as a reduction in travel time and access time, factors correlated with trip length and accessibility.

[20] See user guidance for the TRIMMS model for model assumptions and guidelines on modifying input parameters, CUTR (2009).

Figure 2. TRIMMS 2.0 Model Results

TRIMMS 2.0 MODEL RESULTS

ANALYSIS INFORMATION

Agency Name	Agency 1
Analysis Title	Parking Charge from $1 to $2, Mileage fee from 0.2 to 0.4
Analyst	SC
Analysis Type	Area-Wide
Date	7/15/2009
Region	0
Total Affected Employment	2,500
Total Program Cost	$ 25,000

POLICY EVALUATED

	Site Access Improvements
	Transit Service Improvements
	Financial Incentives
X	Pay-as-you-go Programs
X	Parking Pricing
	Support Programs

MODE SHARE IMPACTS

Mode Share (%)	Baseline	Final	% Change
Auto-Drive Alone	79.12	78.18	-0.94
Auto-Rideshare	12.24	12.66	0.41
Vanpool	0.45	0.47	0.02
Public Transit	4.15	4.53	0.38
Cycling	0.45	0.46	0.02
Walking	2.70	2.79	0.09
Other	0.89	0.92	0.03
Total	*100.00*	*100.00*	-

TRAVEL IMPACTS

Unit	Peak	Off-Peak	Total
Baseline Trips	2,650	2,350	5,000
Final Trips	2,531	2,332	4,862
Trip Reduction	-119	-18	-138
% Trip Reduction	-4.50%	-0.78%	-2.75%
Baseline VMT	31,510	27,943	59,453
Final VMT	30,048	27,717	57,765
VMT Reduction	-1,462	-226	-1,688
% VMT Reduction	-4.64%	-0.81%	-2.84%

Some of the assumptions of the TRIMMS model may not apply in all cases. Approaches to work around inapplicable assumptions are described below.

1. The TRIMMS model is based on working population instead of total population, since it was originally meant to model strategies affecting work trips. As in the national analysis, if the user wishes to analyze some other sub-set of all trips or analyze all trips instead of work trips, an adjustment factor may be used to scale the results. In analyzing strategies that are likely to affect all travelers, not just commuters, the user should use the total regional population as an input in TRIMMS. Regardless of whether the model is run using either the total or the working population, the relationship of working population to total population may be used to adjust the final VMT and trip change estimates obtained at the end. One such adjustment that users may commonly need to make is described in the next point (2), below.

2. Since TRIMMS focuses on employee travel behavior, it always assumes a trip rate of two trips per person per day (i.e., one round trip, assuming a worker goes from his home to the employer site and back home). To cover all trip purposes, it is necessary to adjust the trip rate to the region's actual trip rate for all trips. This can be done by multiplying the TRIMMS model outputs by the best known trip rate for the urban area and dividing by 2.

3. TRIMMS also makes an assumption that only a subset of the population will be affected by these TDMs– i.e., only white collar employees (managerial and professional staff) and not blue-collar employees. This is based on the assumption that higher-level employees are more likely to have the flexibility to alter their travel behavior. Consequently, there is a difference between

the "total population" data input by the user on the first screen and the "population affected" by the strategy shown by TRIMMS on the results screen. This is based on data within TRIMMS on the proportion of workers of each type in each sector in each of the 85 MSAs, one of which the user selects at the start of the analysis. Since the elasticity values account for the proportion of people that will change travel behavior, no additional assumptions were considered in the EPA national analysis (*EPA Final Report*). To change or remove this assumption, the TRIMMS model outputs can be multiplied by the ratio of total regional population (from the MPO usually) to TRIMMS' affected population ("total affected employment" in the output).

It must be noted that these kinds of adjustments are not limited to the TRIMMS model but may be necessary for other sketch planning models as well, such as the COMMUTER model developed by EPA. Careful evaluation of the tool of choice can help avoid unintentional errors caused by inconsistency between model assumptions and available data.

2.4.2. Limitations of the analysis

As with any other sketch-planning tool, TRIMMS has limitations that come from the need to aggregate data and the assumptions related to estimating baseline trips and VMT. The limitations result from the need to strike a balance between the complexity and intensive data needs of traditional transportation analysis tools (like regional travel forecasting models) and the substantial time and cost savings of sketch-planning applications.[21] The user may find it useful to consider the impacts of these limitations, as discussed below.

- *Using regional averages as inputs:* The impacts of some of the strategies such as TDM strategies and land use strategies will vary by trip purpose. For example, land use strategies are likely to have a higher impact on non-work travel than work travel and vice versa for TDM strategies. However, the TRIMMS model uses regional averages for mode shares, trip lengths, and trip costs across trip purposes and this may underestimate the impacts of these strategies in particular locations.

- *Modeling pricing strategies using aggregate average inputs:* For the application of mileage fees, average trip length can be used as an input in TRIMMS to obtain an estimate of aggregate average impacts. However, such a policy will not affect all trips similarly. When applied to all VMT, longer trips are likely to be reduced. When applied to congested VMT, peak hour trips and VMT are likely to be reduced, with some trips being shifted to off-peak times, possibly increasing off-peak VMT. A shift to other modes may also lead to a slight increase in rideshare/vanpool VMT. For other pricing strategies, such as parking charges or tolls, the relative impact on trip cost is higher for shorter trips than longer trips; therefore, VMT reductions from shorter trips will be greater than from longer trips. Since the TEAM approach uses a sketch planning tool, the varying impacts on short and long trips or on trips made for different purposes cannot be captured. Apart from VMT reduction, congestion pricing and HOT lanes trigger other choices

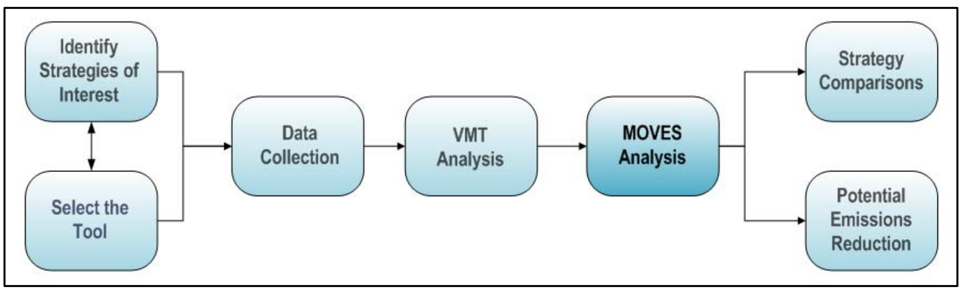
[21] CUTR (2009)

such as route changes and elimination of trips that cannot be captured with a sketch planning tool like TRIMMS.

- *Impact of vehicle speed on emissions:* Although both speed and VMT are used in emissions analysis, speed represents a response to congestion rather than a change in travel behavior as indicated by a reduction in VMT. It is true that congestion can have an impact on emissions; however, these impacts tend to be smaller and more localized than the impacts of VMT reduction. In addition, the consideration of speed requires data at a greater level of detail and is best accomplished using the regional travel demand model. Because congestion impacts are very context-specific, the data required to analyze them are significant, and the TRIMMS model is not adequate for this analysis.

Reduction in VMT and/or trips is the first result of the TEAM analysis and provides an indication of which strategies may be most effective in the individual region to increase travel efficiency. This information can then be used to consider benefits in reduced emissions for pollutants that are of particular interest to the region including GHGs.

2.5. Conducting the MOVES Analysis



In this step, the reductions in VMT and trips obtained from TRIMMS or another sketch-planning tool are combined with emissions factors to estimate potential emission reductions. Emission factors from various vehicle activities (e.g., starting, idling, refueling, and running) and processes (e.g., evaporative, exhaust, and physical wear) should be obtained from the MOVES model (or other emissions model, such as the EMission FACtors (EMFAC) model in California). The recommended approach for areas outside of California is to use the emissions factors from the MOVES model, EPA's current, state-of-the-science tool for estimating emissions from on-road motor vehicles. [22]

Air quality analysis is conducted by different groups depending on current practice within individual states. The guidance presented here applies emissions factors for on-road driving and vehicle starts from the MOVES model to the regional reduction in VMT for a given strategy. As far as possible, the analysis should include the existing assumptions used for air quality analysis within the region in order to reflect emissions reductions that are consistent with other regional analyses.

MOVES2010, originally released in December 2009 and updated to MOVES2010a in September 2010, can be used to analyze emissions and potential emission reductions from various strategies for urban (or

[22]Note that MOVES is not used in California. The latest EMission FACtors (EMFAC) model is used in California.

rural) road activities, including TDM and land use approaches for activity and emission reductions. The model is based on analysis of millions of emission test results and recent advances in understanding of vehicle emission processes. Under development since 2000, the MOVES emission model was designed as the replacement for MOBILE, which began development in 1978. Compared to MOBILE, MOVES enables more precise analysis of vehicle emissions, including GHGs. The update to MOVES2010a accounted primarily for newly adopted passenger vehicle energy and GHG standards affecting future year predictions. It is this version that was used in the national analysis for the EPA Final Report. Unless EPA notes otherwise, this guide is applicable to current and future versions of the MOVES model.

2.5.1. Setting the MOVES Parameters and Obtaining Results

MOVES offers strong support for the TEAM approach in that it provides a means of estimating emissions accurately at the regional or local scale through the input of data specific to the area. As stated previously, TEAM was initially used to provide national-level potential emissions reductions; however, the methodology followed in the *EPA Final Report* for emissions analysis is applicable at a regional scale as well. Although the previous analysis necessarily relied on national default fleet characteristics, the use of default values within MOVES is not recommended at the regional level. If regional or local data are only partially available, MOVES can be run at the county scale to employ county level default values that should be closer to actual regional values. In order to identify the specific data and decisions needed to use MOVES in the TEAM approach, the national-level analysis is explained in detail below. Tailoring MOVES for a regional or local analysis using the appropriate inputs is described later in this section.

While the MOVES model can directly produce emission factors for an area of interest, the approach described here involves the use of national-default values for all vehicle parameters. [23] This approach is generally faster and simpler while providing more generalized results. For the analysis reported in the *EPA Final Report*, the MOVES model was run using an emission inventory approach. This approach was useful to quickly quantify and compare future year emission reductions from a range of strategies. The resulting total “running emissions” (emissions due to on-road driving and brake and tire wear) from the MOVES outputs were then divided by the model’s total VMT output to calculate emission factors in grams per mile for all pollutants and GHGs. These emission factors were multiplied by the VMT reductions to calculate emission reductions. To further refine the potential emissions benefits of the strategies, emissions associated with vehicle starts and refueling, were developed with MOVES and are termed as “off-network emissions.” These emissions were developed using the same national default fleet characteristics and emissions inventory approach. Note that the unit for the off-network emission factors is grams per vehicle, which is different from the grams per mile unit for running emissions. Assuming one vehicle per trip and one start for each vehicle trip, these off-network emissions factors can be calculated in the same way as the running emission factors, but dividing by total trips instead of total VMT. Note that this is a simplifying assumption for this analysis that is not appropriate for any SIP or conformity analysis. Also note that MOVES offers the option of directly producing emission rate output with a much higher level of detail than is possible when using the approach described here.

[23] More information is available in U.S. EPA, (2009), *MOVES User’s Guide: Motor Vehicle Emission Simulator (MOVES) 2010 User Guide*, EPA-420-B-09-041, December.

The national analysis (*EPA Final Report*) determined emissions factors for criteria pollutants (CO, NOx, SO_2, PM, VOC), and the three principal GHG pollutants (CO_2, CH_4, N_2O, or, equivalently, CO_2e).Tailpipe and crankcase emissions were considered for all pollutant types. PM emissions also include brake and tire wear. VOC results included exhaust and refueling emissions, but not evaporative emissions. Total emissions reductions were determined by applying the national emission factors derived from MOVES to the regional reductions in VMT and trips as described above. If the user is interested in estimating the reduction in several pollutants an off-model spreadsheet analysis will be useful to collect and analyze the data from MOVES.

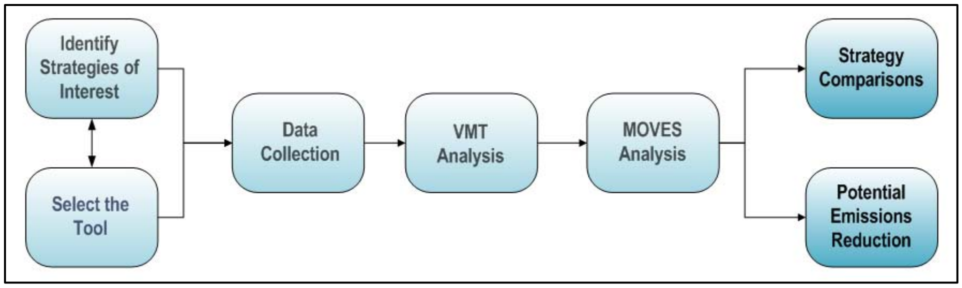
MOVES can be used to calculate emission factors for any year in the future out to 2050, based on assumptions about future vehicle standards and fleet distribution built into the model and the approaches discussed above. Employing regional activity forecasts, including VMT, for future years allows estimation of future year emissions. Comparison of baseline to forecast emissions allows a characterization of changes in emissions in future years. This approach is recommended to estimate future year emission reductions.

A national default approach was appropriate in the test analysis given the goal of estimating national-average emission changes. However, more localized scale approaches may be preferred for other analyses where a national scale approach would not adequately consider key factors that may differ between areas of the country, such as vehicle age distributions. If the analyst has the required local data to conduct a MOVES analysis for a specific area, the local data should be used instead of the national default data as inputs to MOVES to develop the appropriate emission factors. Use of local fleet activity and fuel information, if available, is encouraged to allow MOVES predictions to be more locally specific. The advantage of using as much locally representative data as possible is that resulting emission factors would be more representative of the local fleet. A model run for a specific county or group of counties using the national defaults may not provide an accurate portrayal of specific emission differences that are due to fuel, activity, and/or fleet characteristics, such as vehicle age distributions.

In order to use local data, the user will need to perform calculations at the county scale, where the model replaces national default allocations with user-supplied data for the specific county[24]. Local data are entered in MOVES through the County Data Manager (see Section 2.3.3 of the *MOVES 2010 User's Guide*).

[24] The use of appropriate local data is described in more detail in EPA's "Technical Guidance on the use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity" at www.epa.gov/otaq/models/moves/420b10023.pdf .

3. Considering Strategies and Potential Emissions Reductions



The TEAM approach provides the ability to make comparisons between strategies and draw conclusions about individual strategy effectiveness in a particular region. Using TEAM with region-specific data and assumptions can provide a preliminary assessment of the effectiveness of individual and grouped strategies. The results can help narrow the focus of more detailed and costly analysis as well as assist areas as they consider GHG emission reduction targets. The methodology is most applicable to support policy discussions at the regional or subarea level.

The national analysis (*EPA Final Report*) illustrated that regional differences play a significant role in the effectiveness of individual strategies. In all regions land use changes provide a strong foundation for other strategies. This is particularly important with respect to transit strategies such as TOD. Combinations of strategies were analyzed in this study which proved to be most effective in reducing emissions over time.

The impact of the modeled strategies will depend on several factors including rates of population growth, shares of other modes relative to autos, average trip lengths, and average travel costs. Regions that experience slow population growth may see a higher impact of certain strategies if the auto mode shares and vehicle trip lengths are higher. Regions that have relatively higher levels of ridesharing, transit, bicycling, and walking, compared to regions with low levels of ridesharing, shorter trip lengths, and lower population growth, show a lower impact. This means that areas already advanced in the use of travel efficiency strategies may need more aggressive strategies such as pricing to see a significant impact.

Consider the impacts that a scenario with parking pricing would have on regions in relation to their projected VMT growth and current parking price levels. In the national analysis, regions that project lower levels of VMT growth generally showed lower VMT reductions than regions that predict higher rates of VMT growth in response to travel efficiency strategy scenarios. At the same time, regions with lower parking costs currently saw more impact from increasing the costs of driving than did regions that already have higher parking costs. Combining these two factors, a region with high VMT growth and low parking costs would be expected to have greater VMT reduction in response to travel efficiency strategies than would regions with lower VMT growth and/or higher existing parking costs.

While it is unlikely that any one strategy will be effective in all regions, all strategies showed a reduction in VMT and emissions to some degree. The attractiveness of travel efficiency strategies is that they are the most easily implemented and any degree of behavioral change is valuable, especially in light of the supporting role or synergistic effects when combined with other strategies. See the *EPA Final Report* for additional discussion of these issues.

What works best in an individual region will be subject to the willingness of the public and policy makers to support change. There is today a broad interest in the effectiveness of transportation and related strategies for addressing GHG that not been seen on this scale previously. This methodology can help to inform that interest.

Appendices

A. List of Acronyms and Abbreviations

CAA: Clean Air Act

CBD: Central business district

CH_4: Methane

CMAQ: Congestion Mitigation and Air Quality Improvement program

CO: Carbon monoxide

CO_2: Carbon dioxide

CO_2e: Carbon dioxide equivalents

EPA: Environmental Protection Agency

GHG: Greenhouse gas

HOT: High occupancy toll

HOV: High occupancy vehicle

LRTP: Long range transportation plan

MOVES: Motor Vehicle Emission Simulator

MPO: Metropolitan planning organization

MSA: Metropolitan statistical area

N_2O: Nitrous oxide

NAAQS: National Ambient Air Quality Standards

NHTS: National Household Travel Survey

NOx: Oxides of nitrogen

PM: Particulate matter

SIP: State Implementation Plan

SO_2: Sulfur dioxide

TCM: Transportation control measures

TDM: Travel demand management

TEAM: Travel Efficiency Assessment Method

TIP: Transportation Improvement Program

TOD: Transit oriented development

TRIMMS: Trip Reduction Impacts of Mobility Management Strategies

UA: Urbanized area

VMT: Vehicle miles traveled

VOC: Volatile organic compounds

B. References

American Association of State Highway and Transportation Officials (AASHTO). (2010). *Census Transportation Planning Package (CTPP) Profile Sheets*. Available at: http://download.ctpp.transportation.org/profiles_2005-2007/ctpp_profiles.html.

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.

Colliers International. (2011). *North American Central Business District Parking Rate Survey 2011*. Available at: http://www.colliers.com/Country/UnitedStates/content/colliersparkingratesurvey2011.pdf

Concas, S. & Winters, P.L. (2007). Economics of Travel Demand Management: Comparative Cost Effectiveness and Public Investment. Final Report No. BD 549-26 prepared by National Center for Transit Research for Florida Department of Transportation. Available at: http://www.nctr.usf.edu/pdf/77704.pdf.

Concas, S. & Winters, P.L. (2009). Quantifying the Net Social Benefits of Vehicle Trip Reductions: Guidance for Customizing the TRIMMS© Model. Final Report No. BD 549 WO 52 prepared by National Center for Transit Research for Florida Department of Transportation. Available at: http://www.nctr.usf.edu/pdf/77805.pdf.

Ewing, Reid and R. Cervero. (2001). Travel and the built environment. *Transportation Research Record*, 1780, 87–114.

Ewing, Reid and R. Cervero. (2010). Travel and the Built Environment. *Journal of the American Planning Association*, 76:3, 265-294

Ewing, Reid, K. Bartholomew, S. Winkelman, J. Walters, and D. Chen. (2008). *Growing Cooler: Evidence on Urban Development and Climate Change*, prepared for Urban Land Institute, Washington, DC: Urban Land Institute.

Litman, Todd. (2011). *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior.* Victoria, BC: Victoria Transport Policy Institute. Available at: http://www.vtpi.org/elasticities.pdf

Rodier, Caroline J. (2008). *A Review of the International Modeling Literature: Transit, Land Use, and Auto Pricing Strategies to Reduce Vehicle Miles Traveled and Greenhouse Gas Emissions*, Paper presented at the Transportation research board Annual Meeting 2009.

Schrank, D. and T. Lomax, eds. (2011). *The 2010 Urban Mobility Report*. College Station: Texas Transportation Institute.

U.S. Department of Energy, Energy Information Administration. (2011). *Annual Energy Outlook*. Available at: http://www.eia.gov/forecasts/aeo/.

U.S. Department of Transportation. (2009). *National Household Travel Survey*. Available at: http://nhts.ornl.gov/.

U.S. Environmental Protection Agency (EPA). (2009). *MOVES User's Guide: Motor Vehicle Emission Simulator (MOVES) 2010 User Guide*. EPA-420-B-09-041. December.

U.S. EPA. (2011). *Potential Changes in Emissions Due to Improvements in Travel Efficiency – Final Report*. EPA-420-R-11-003. March. Available at: http://www.epa.gov/oms/stateresources/policy/420r11003.pdf

C. Data from Literature and Model Information

Table C-1. Quantitative Estimates of Travel Activity Impacts of Travel Efficiency Strategies from Literature	
Examples of Measures	Elasticity/ VMT Reduction %
Ridesharing Programs and Investments	
Park-and-ride facilities	Regional implementation: 0.1 to 0.5% reduction in VMT
High-Occupancy Vehicle (HOV) lanes	Long run (LR) travel time elasticity, regional: -1.0, urban: -0.6, rural: -1.3 0.2 to 1.4% VMT reduction
Rideshare matching programs	0.1 to 2.0% VMT reduction
Carpool/vanpool incentives	0.2 to 3.3% VMT reduction
Car-sharing	Limited quantitative data
Bicycle and Pedestrian Facilities and Programs	
Bike paths / lanes / routes	<0.1% VMT reduction
Bike/ped facilities to support transit	Limited quantitative data
Transit Projects and Policies	
Transit service expansion /increase in frequency	-0.6 to -1.0; for buses -0.5 (time between buses) for service frequency alone
Improved transit travel times and operations (busways, BRT, signal prioritization for transit vehicles, heavy and light rail, managed lanes)	-0.4 (travel time elasticity with respect to ridership)
Improved transit access through shuttle and feeder bus services, paratransit	Relates to improving travel time above, not measured separately
Transit service integration and intermodal transfer centers	Relates to improving travel time above
Fare integration for easy transfers	Relates to improving travel time above
Improved transit marketing, information, amenities	Limited quantitative data
Commuter discounts/fare reductions	-0.3 to -0.4 (fare elasticity with respect to ridership)
Peak/off-peak transit fares	-0.1 to -0.3 (peak fares) and -0.1 to -0.7 (off-peak fares, depending on trip purpose; lower for work trips)
Transit improvement policies, overall	Studies estimate 0 to 2.6% VMT reduction
Parking Management and Incentives	
Parking cash-out	Elasticities are not available; although some quantitative data on percentage reduction in regional VMT are available from specific projects and studies.
Preferential parking for carpools and vanpools	
Parking duration restrictions	
Employer-based Programs (effects depend on level of adoption)	
Flexible work schedules	Elasticities are not available; although some quantitative data on percentage reduction in regional VMT are available from specific projects and studies.
Telecommuting	
Compressed work weeks	
Employer-provided transit passes	
Guaranteed ride home programs	

Table C-1. Quantitative Estimates of Travel Activity Impacts of Travel Efficiency Strategies from Literature	
Examples of Measures	Elasticity/ VMT Reduction %
Pricing Policies	
Area-wide road pricing/congestion pricing	-0.1 to -0.4 (urban road pricing); 10-25% reduction in central city VMT with cordon pricing; 0.2 to 5.7% regional VMT reduction
Distance-based pricing or mileage fees	LR: -0.1 to -0.8 (price elasticity). Conservative LR estimate for the U.S. would be -0.3
Peak period pricing/ variably priced lanes	-0.03 to -0.4 (depending on time of day)
Parking pricing/fees	Overall LR elasticity: -0.1 to -0.5 LR regional: -0.3; at sites: -0.1 to -0.2 LR (non-commute): -0.2 to -0.4 Studies show 0.5-4% reduction in work-related VMT; 3.1 to 4.2% reduction in non-work VMT
High Occupancy Toll (HOT) lanes/toll increases	-0.1 to -0.4; data from specific projects are available
Pay-as-you-drive Insurance	-0.3
Fuel taxes	LR: -0.1 to -0.3, tending towards the lower end
Freight vehicle pricing	-0.25 to -0.35 (price elasticity); -0.3 to -0.7 (travel time elasticity)
Integrated Land Use and Transportation Strategies	
Transit-oriented development and incentives (Design and transit access)	-0.05 (vehicle trips) and -0.03 to -0.08 (VMT)
Smart growth and mixed use development (Diversity)	-0.03 (vehicle trips) and -0.05 (VMT)
Land use controls for compact, dense urban development (Density)	-0.05 (vehicle trips) and -0.05 to -0.12 (VMT)
Improved regional accessibility due to combined measures	-0.18 to -0.22 (VMT); studies estimate regional VMT reduction by 2-20% in 20 years with doubling of results in 40 years.
Land use measures, overall	Regional VMT reduction of 0 to 5.2%
Vehicle Restrictions by Geographic Area or in Peak Periods	
Freight vehicle controls	Elasticities are not available; although some quantitative data on percentage reduction in regional VMT are available from specific projects and studies.
No-drive days	
Urban non-motorized zones	
Public Education and Outreach Programs	
TDM outreach programs by employers	These measures are typically implemented as part of other measures. Difficult to estimate impacts separately as it could lead to double-counting.
Episodic programs (e.g. ozone action days)	
Public communication about the impacts of travel decisions	

Table C-2. Assessment of Methods for Analyzing Travel Impacts of Travel Efficiency Strategies*								
	Methodologies / Models	Developer	Last Update	Inputs Required	Outputs	Scale of Analysis (sub-area, regional, national)	Travel Efficiency Strategy Modeling Capability	Limitations
1	Travel Demand Management (TDM) Evaluation Model	COMSIS and R.H. Pratt Consultants for Federal Highway Administration	1993	Base case trip tables, vehicle occupancy, model coefficients (in-vehicle time, out-of vehicle time, transit time, transit fare, parking cost, HOV time saved), mode shares, and information about travel efficiency strategies	Change in VMT and trips	Sub-area and with limited capability, regional	Following travel efficiency strategies cannot be modeled: ▪ Land use strategies ▪ Incentives for bicycle use and pedestrians ▪ Travel time changes (alternative work hours or peak period pricing) ▪ Some pricing strategies, e.g., distance-based pricing and fuel price changes	▪ Has not been updated, although user can input new model coefficients ▪ Does not account for non-motorized trips ▪ Only evaluates home-based work trips for large regions ▪ Cannot model distance-based strategies ▪ Does not appear to have been used recently
2	EPA's COMMUTER model	Sierra Research; updated by Cambridge Systematics	2005	Population, mode shares, trip lengths, occupancy levels, baseline VMT, baseline speeds, mode choice time and cost coefficients, fleet mix, and details about the travel efficiency strategies	Change in mode shares, trips and VMT, and emissions impacts (based on emissions factors in EPA's MOBILE 6.2 model)	Sub-area and regional, with some adjustment	Cannot model: ▪ Regional land use strategies and any travel efficiency strategies that will change regional travel patterns ▪ Travel efficiency strategies that affect vehicle speeds ▪ Location-specific strategies such as area-wide pricing and higher parking charges in certain areas	▪ In order to analyze strategies in a large region, separate geographic areas must be defined that have somewhat homogenous travel characteristics such as mode shares and travel distances. Embedded emission factors from MOBILE should be replace by MOVES emission factors for accurate results

Table C-2. Assessment of Methods for Analyzing Travel Impacts of Travel Efficiency Strategies*								
	Methodologies / Models	Developer	Last Update	Inputs Required	Outputs	Scale of Analysis (sub-area, regional, national)	Travel Efficiency Strategy Modeling Capability	Limitations
3	Trip Reduction Impacts for Mobility Management Strategies (TRIMMS) model	Center for Urban Transportation Research, University of South Florida	2009	No trip tables Needs average regional mode shares, average trip length and travel time by mode, average vehicle occupancy, parking and trip costs, and details about the travel efficiency strategies	Changes in mode shares, trips, VMT, and emissions	Sub-area and regional, with some adjustment Practitioner-oriented sketch planning tool to measure travel impacts of regional and employer-based travel efficiency strategies	▪ Can model any strategy that affects the cost of using existing modes or travel times ▪ Can model packages of strategies. ▪ The user can change price and travel time elasticity values	▪ Cannot model regional land use/smart growth strategies accurately ▪ The user will have to make assumptions about the effects of land use strategies on trip lengths or travel times in order to model these strategies
4	Surface Transportation Efficiency Analysis Model (STEAM)	Cambridge Systematics	2006	Base case and improvement case trip tables, vehicle occupancy, model coefficients (trip time and cost), mode shares, and travel efficiency strategy characteristics (in terms of change in trip costs or travel time)	Change in VMT and person miles traveled, trips, travel time, and emissions	Regional and sub-area/corridor	Most travel efficiency strategies can be modeled	▪ Much data and effort required from agencies to model travel efficiency strategies using demand models ▪ Only a few test cities can be considered because extensive data inputs are required for STEAM
5	Transportation Emissions Guidebook (TEG)	Center for Clean Air Policy (CCAP)	2006 (?)	Number of trips by mode, mode split, trip lengths	VMT and Emissions	Regional and Sub-area	Spreadsheets providing rule of thumb guidance on impacts of travel efficiency strategies based on literature; most travel efficiency strategies can be modeled	▪ The user has to make several assumptions ▪ Cannot estimate mode shift or trip reduction impacts

Table C-2. Assessment of Methods for Analyzing Travel Impacts of Travel Efficiency Strategies*								
	Methodologies / Models	Developer	Last Update	Inputs Required	Outputs	Scale of Analysis (sub-area, regional, national)	Travel Efficiency Strategy Modeling Capability	Limitations
6	TCM Tools	Sierra Research	Early 1990s	Has separate Transportation and Emissions modules – trips, VMT, speed	Changes in mode share, vehicle-trips, VMT, travel speeds, and emissions	More applicable at regional scale; some sub-area policies can be modeled	Wide range of strategies can be modeled, including land use strategies, but cannot model scenarios well	▪ Spreadsheet-based sketch-planning tool ▪ User must make many assumptions to calculate travel impacts ▪ Emissions module cumbersome to run
7	TCM Analyst	Texas Transportation Institute	1994	Trips, distances, speeds, emissions factors, travel efficiency strategies details	Changes in trips, VMT, average travel speeds, and emissions	Regional or sub-area	Pricing strategies cannot be modeled	▪ Elasticities and other assumptions must be defined by the user ▪ Land use and pricing strategies cannot be modeled ▪ Sketch planning tool
8	MARKAL (Market Allocation)-MACRO	US Department of Energy and EPA	Used inter-nationally and currently in use	Baseline VMT by vehicle type, fuel costs	VMT, emissions, and fuel demand	National	Travel efficiency strategies relevant at sub-area, urban, or state level cannot be modeled	▪ More complicated and not as detailed as NEMS (see below) ▪ Can only model national level travel efficiency strategies such as fuel taxes, emissions taxes

Table C-2. Assessment of Methods for Analyzing Travel Impacts of Travel Efficiency Strategies*								
	Methodologies / Models	Developer	Last Update	Inputs Required	Outputs	Scale of Analysis (sub-area, regional, national)	Travel Efficiency Strategy Modeling Capability	Limitations
9	National Energy Modeling System (NEMS): Transportation Sector Module (TRAN)	Energy Information Administration, US Department of Energy	2006	Vehicle fleet (includes transit and freight), fuel prices, fuel economy, passenger miles, change in user cost, population, income, new vehicles sales	VMT, emissions, and fuel demand	Census region and national	Cannot model: ▪ Travel efficiency strategies relevant at sub-area, urban, or state level ▪ Travel efficiency strategies involving mode switching ▪ Includes useful feedback effects, and can be used to validate national estimates	▪ Will model strategies at the level of nine Census regions, not at urban or sub-region level ▪ Can only models travel efficiency strategies that affect the user cost of travel; for others, some meta-analysis is required before using NEMS ▪ Change in modes not easy to model
10	Spreadsheet analysis with elasticity factors from literature		--	Mode shares, trip costs by mode, average VMT	VMT change – followed by emissions analysis	Regional	Without trip tables, land use strategies are best modeled this way	

*The above list is current as of 2009

Table C-3. Fare and Price Elasticities used in TRIMMS				
Mode	Elasticity		Source	Notes
	Near term	Long term		
Auto - Drive Alone				
Direct	-0.11	-0.22	Litman (2011)	Table 22, pp.27 (TRIMMS default); long term auto drive alone elasticity may be assumed double of short run elasticity
Cross-Price: Transit	0.05	0.05	Litman (2011)	TRIMMS default uses the lower ranges; long term elasticity may be assumed same as near term if no better information available
Auto - Rideshare				
Direct	n/a	n/a		May be assumed same as auto drive alone if no information is available
Cross-Price: Transit	0.05	0.05	Litman (2011)	Same long term elasticity as auto-drive alone may be assumed
Vanpool				
Direct: Peak	-0.16	-0.16		TRIMMS default; if no information about near term vs. long term vanpool elasticities is available, the same value may be assumed
Direct: Off-peak	-0.32	-0.32		
Cross-Price: Transit	0.05	0.05		TRIMMS default
Transit				
Direct: Peak	-0.10	-0.10		TRIMMS default; if no information about near term vs. long term transit elasticities is available, the same value may be assumed
Direct: Off-Peak	-0.30	-0.30		TRIMMS default
Cross-Price: Auto Drive Alone	0.15	0.15	Litman (2011)	TRIMMS default uses the lower ranges
Cross-Price: Auto Rideshare	0	0.15		Long run elasticity may be assumed same as auto drive alone

Source: Adapted from CUTR (2009) and from TRIMMS model version 2.0 received from CUTR on July 15, 2009 pp 44-46

<table>
<tr><th colspan="4">Table C-4. Travel Time Elasticities</th></tr>
<tr><th rowspan="2">Mode</th><th colspan="2">Elasticity</th><th rowspan="2">Notes</th></tr>
<tr><th>Peak</th><th>Off peak</th></tr>
<tr><th>Auto - Drive Alone</th><td></td><td></td><td rowspan="16">TRIMMS default assumptions</td></tr>
<tr><td>Direct</td><td>-0.225</td><td>-0.170</td></tr>
<tr><td>Cross: Auto -Rideshare</td><td>0.037</td><td>0.001</td></tr>
<tr><td>Cross: Transit</td><td>0.036</td><td>0.001</td></tr>
<tr><th>Auto - Rideshare</th><td></td><td></td></tr>
<tr><td>Direct</td><td>-0.303</td><td>-0.189</td></tr>
<tr><td>Cross: Auto -Drive Alone</td><td>0.030</td><td>0.000</td></tr>
<tr><td>Cross: Transit</td><td>0.030</td><td>0.000</td></tr>
<tr><th>Vanpool</th><td></td><td></td></tr>
<tr><td>Direct</td><td>-0.60</td><td>n/a</td></tr>
<tr><td>Cross-Price: Auto -Rideshare/Drive Alone</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Cross: Transit</td><td>0.032</td><td>0.000</td></tr>
<tr><th>Transit</th><td></td><td></td></tr>
<tr><td>Direct</td><td>-0.129</td><td>-0.074</td></tr>
<tr><td>Cross: Auto -Drive Alone</td><td>0.010</td><td>0.000</td></tr>
<tr><td>Cross: Auto -Rideshare</td><td>0.032</td><td>0.000</td></tr>
</table>

Source: Litman (2011)Table 31, pp. 35

<table>
<tr><th colspan="5">Table C-5. Parking Pricing Elasticities</th></tr>
<tr><th colspan="5">Parking Elasticities</th></tr>
<tr><th>Trip Purpose</th><th>Auto – Drive Alone</th><th>Auto - Rideshare</th><th>Transit</th><th>Slow Mode</th></tr>
<tr><td>Commuting</td><td>-0.08</td><td>-0.02</td><td>-0.02</td><td>-0.02</td></tr>
</table>

Source: Litman (2011), Table 13, pp. 17

D. Regional Results from EPA National Analysis

In the EPA national analysis (*EPA Final Report*), national-level impacts of travel efficiency strategies were estimated by extrapolating modeled regional results for representative regions to regions with similar characteristics in the same 'cluster,' and then summing the results across clusters. All metropolitan areas across the country were placed into seven clusters, which were characterized by population and transit mode share. The representative metropolitan areas in each cluster were chosen with consideration for geographic diversity, their approaches and strategies to address climate change and GHG emissions, the ability for the metropolitan area to represent areas with similar characteristics, data availability, and MPOs' interest in providing useful data. The characteristics and representative metropolitan areas for each cluster are shown in Table D-1.

Table D-1. Cluster Definitions and Representative Areas

Cluster	Definition	Number of U.S. Regions Represented	Share of National Daily Urban VMT	Representative Areas
1	Population ≥2.9 million High Transit Share (>9%)	6	17%	San Francisco, CA Washington, DC
2	Population ≥2.9 million Low Transit Share (9% or less)	9	22%	San Diego, CA Seattle, WA
3	Population 1,500,000-2,899,999 High Transit Share (>4%)	7	6%	Portland, OR Denver, CO
4	Population 1,500,000-2,899,999 Low Transit Share (4% or less)	8	7%	Sacramento, CO Salt Lake City, UT
5	Population 750,000-1,499,999	21	12%	Memphis, TN Raleigh-Durham, NC
6	Population 250,000-749,999	87	18%	Fresno, CA Knoxville, TN Rochester, NY
7	Population < 250,000	313	17%	Burlington, VT Wilmington, NC

Figure D-1 below shows the cluster-level VMT reductions in 2050 under the seven scenarios modeled for the national analysis. Scenario strategies are briefly described along the horizontal axis and are related to the scenario examples described in Table 4 in this user guide. Note that the mileage fees were not modeled for clusters 5, 6, and 7. To interpret this figure correctly it is necessary to consider the input and assumption data behind these numbers. For example, Cluster 2 has a mild response across all scenarios because the forecasted growth in VMT for future years in that cluster is much lower than other clusters. Although a reasonable explanation, there may be additional reasons for the response illustrated. Users should keep this in mind and when comparing their results to this chart should consult the information on the assumptions and inputs behind this figure in the *EPA Final Report*.

Figure D-1. Cluster Response to Scenarios in 2050