



# Mobility Management VMT Reduction Calculator Tool – Design Document

June 2019

# Table of Contents

<b>Introduction</b> .....	<b>1</b>
<b>Main Page</b> .....	<b>2</b>
Overview .....	2
Instructions .....	2
Legend .....	2
Project Information .....	2
<b>FAQs Page</b> .....	<b>5</b>
<b>Project-Level Results Page</b> .....	<b>8</b>
<b>Community-Level Results Page</b> .....	<b>9</b>
<b>Employer Commute Program Strategies</b> .....	<b>10</b>
1A. Voluntary Employer Commute Program .....	10
1B. Mandatory Employer Commute Program .....	11
1C. Employer Carpool Program.....	12
1D. Employer Transit Pass Subsidy.....	13
1E. Employer Vanpool Program.....	14
1F. Employer Telecommute Program.....	15
<b>Land Use Strategies</b> .....	<b>17</b>
2A. Transit-Oriented Development.....	17
2B. Mixed Use Development .....	17
<b>Parking Management Strategies</b> .....	<b>19</b>
3A. Parking Pricing.....	19
3B. Parking Cash Out.....	19
<b>Neighborhood Enhancement Strategies</b> .....	<b>21</b>
4A. Street Connectivity Improvement.....	21
4B. Pedestrian Facility Improvement .....	21
4C. Bikeway Network Expansion .....	22
4D. Bike Facility Improvement .....	23
4E. Bikeshare .....	26
4F. Carshare .....	27
4G. Community-Based Travel Planning .....	28
<b>Transit Strategies</b> .....	<b>30</b>
5A. Transit Service Expansion .....	30
5B. Transit Frequency Improvements.....	31
5C. Transit-Supportive Treatments .....	32
5D. Transit Fare Reduction .....	33
5E. Microtransit NEV Shuttle .....	34

## Introduction

This report documents the design of the Mobility Management VMT Reduction Calculator Tool. The Microsoft Excel-based Tool produces estimates of the percent reduction in vehicle miles traveled (VMT) resulting from the application of mobility management strategies. The Tool is intended to act as a resource for evaluating and quantifying the impacts of mobility management strategies as part of the development review and transportation analysis process. The Tool supports the goals of Senate Bill 743 (Steinberg, 2013) (SB 743) by providing jurisdictions and developers with a resource to quantify VMT reductions resulting from implementation of a variety of mitigation strategies at various scales.

This report describes the user inputs, constants assumptions, formulas, and outputs for each strategy included in the Tool. Most of this information is available in the Tool itself, although this document provides some additional explanation of data sources and calculation methods.

The report is organized similarly to the Tool itself. The first four sections describe the Main page, FAQs page, Project-Level Results page, and Community-Level Results page. The remaining sections describe the 22 strategies included in the Tool, grouped into the following five categories:

- **Employer Commute Programs**
- **Land Use Strategies**
- **Parking Management**
- **Neighborhood Enhancements**
- **Transit Strategies**

## Main Page

### MOBILITY MANAGEMENT VMT REDUCTION CALCULATOR TOOL



Users of the Tool should begin on the Main page. The Main page is organized around the following five boxes:

### Overview

Describes the Tool and its purpose.

### Instructions

Describes how to use the Tool in a series of six steps.

### Legend

Describes the formatting for cells used in the VMT-reduction calculations for each strategy.

### Project Information

The user can enter the following optional information:

- Project Name (optional):
- Project Address (optional):
- Project Type (optional):

The user should enter the following information:

- Scale of Analysis:
  - Project/site *or*
  - City/community
- Analysis Location:
  - Using a drop-down menu, the user should select the city in which the analysis is located
- Community Plan Area (CPA), if applicable:
  - If the user selects San Diego or Unincorporated San Diego County, using the drop-down menu the user should select the CPA in which the analysis is located

### Mobility Management Strategies

The user will see a list of the 22 strategies included in the Tool, shown below. Each strategy name is a hyperlinked, and clicking on a name will take the user to that strategy. The color scheme in these tables is intended to match that used in the Guidebook. These tables also contain links to the Project-Level Results and Community-Level Results pages.

## Project/Site-Level Strategies

### Project-Level Results

#### Employer Commute Programs

Strategies implemented by employers that encourage workers to commute by modes other than auto

1A	Voluntary Employer Commute Program
1B	Mandatory Employer Commute Program
1C	Employer Carpool Program
1D	Employer Transit Pass Subsidy
1E	Employer Vanpool Program
1F	Employer Telework Program

#### Land Use Strategies

Strategies that modify the location or characteristics of development projects to encourage non-auto travel modes

2A	Transit Oriented Development
2B	Mixed Use Development

#### Parking Management

Strategies that discourage auto travel by modifying the price or supply of vehicle parking

3A	Parking Pricing
3B	Parking Cash Out

## Community/City-Level Strategies

### Community-Level Results

#### Neighborhood Enhancements

Strategies that improve or encourage neighborhood-level bicycle, pedestrian, and other multimodal travel options

4A	Street Connectivity Improvement
4B	Pedestrian Facility Improvement
4C	Bikeway Network Expansion
4D	Bike Facility Improvement
4E	Bikeshare
4F	Carshare
4G	Community-Based Travel Planning

#### Transit Strategies

Strategies that improve transit service and cause a mode shift from auto to transit

5A	Transit Service Expansion
5B	Transit Frequency Improvements
5C	Transit-Supportive Treatments
5D	Transit Fare Reduction
5E	Microtransit NEV Shuttle

## FAQs Page

This page contains frequently asked questions and associated answers.

### 1. What does this tool do?

The SANDAG VMT Reduction Calculator Tool can be used to estimate the percent reduction in VMT from various mobility management strategies. The tool operates at two geographic scales: project/site-level and community/city-level. The tool user must provide simple input information about a strategy in order to produce a VMT-reduction estimate. The tool is intended to act as a resource for evaluating and quantifying the impacts of mobility management strategies as part of the development review and transportation analysis process. The tool supports the goals of SB 743 by providing jurisdictions and developers with a resource to quantify VMT reductions resulting from implementation of a variety of mitigation strategies.

### 2. How do I enter strategy information?

Tool users enter information about a strategy of interest in the orange-colored cells found on each strategy page. Users cannot enter information in any other cells.

### 3. How do I see if the strategy has a VMT impact?

Each strategy page has a row labeled “Change in VMT.” A negative value in this row indicates a reduction in VMT; a positive value indicates an increase in VMT (denoted with a red outline of the cell).

### 4. What VMT reduction strategies are included in the tool?

The 22 strategies are listed on the Main page of this tool. Users can also review the Mobility Management Strategy Guidebook that serves as a companion resource to this tool for more information.

### 5. How do I select VMT reduction strategies?

From the Main page or the Results page, the user can click on a strategy hyperlink of interest. On the Strategy page, entering input values in all of the orange-colored cells will activate that strategy. If the user does not want the VMT-reduction results of a given strategy to be included in the summary results, either delete the Strategy page inputs in the orange-colored cells or click “Exclude from results” on the Strategy page.

### 6. Where can I learn more about how the reductions are calculated?

Each strategy page lists the references that were used to develop the VMT reduction estimates. Users can also review the Mobility Management Strategy Guidebook that serves as a companion resource to this tool for more information.

### 7. How is the total percent change in VMT adjusted when I select multiple strategies?

If only one strategy is selected, the user will see on the Results page (a) the percent change in VMT associated with that strategy and (b) the percent change in VMT (total) from all strategies. In this case, the values are the same. If more than one strategy is selected, the tool uses “multiplicative dampening” to adjust the sum of VMT reduction. Multiplicative dampening accounts for the diminished percent change in VMT that a strategy will have if other strategies are also selected. The total is calculated with the following formula:

$$\text{Total} = \{[100\% - (\text{Strategy A \% change in VMT})] \times [100\% - (\text{Strategy B \% change in VMT})] \times \dots \times [100\% - (\text{Strategy Z \% change in VMT})]\} - 100\%$$

## 8. How are the mode share, trip length, and VMT per capita data derived?

The mode share, trip length, and VMT per capita data found in this tool reflect travel by residents of the San Diego region only. The data are parsed by jurisdiction and, for the City of San Diego and the Unincorporated County of San Diego, by CPA. The data reflect the home origin of residents during an average 24-hour weekday. The analysis includes all trip purposes (all activities assigned to the home location). The data do not reflect travel for which the home origin is located outside of the San Diego region or by visitors to the San Diego region. It does not include travel made by heavy-duty trucks or travel for commercial purposes.

## 9. Can I calculate the total percent change in VMT from multiple strategies if the scales of analysis from my chosen strategies are not the same?

The tool safeguards against accidentally calculating the total percent change in VMT from strategies of different scales of analysis by graying out cells through conditional formatting and creating separate Print pages for the project/site-level results and the community/city-level results. While it may be possible that a user's project involves strategies that affect VMT at both scales, it is likely that combining the percentage VMT reduction from strategies of different scales would not be valid. If a user's project involves strategies that affect VMT at both scales, the user should use the tool as follows:

- a. Input project information on Main page
- b. Calculate VMT reductions from all applicable project/site-level strategies
- c. Print the project/site-level VMT results
- d. Open a clean version of the tool with no user inputs entered
- e. Repeat steps a through c for the community/city-level strategies

## 10. Why are there two totals displayed on the Results pages?

As discussed above in Question 7, the total percent change in VMT can be calculated when multiple strategies are selected. However, if the selected strategies reduce VMT from different types of trips (i.e., employee commute trips and all project-generated trips), it may not be valid to combine the total percent change in VMT. For example, parking pricing at a commercial facility affects VMT from all project-generated trips, while an employee vanpool program only affects VMT from the facility's employee commute trips. Of the ten project-level strategies, seven reduce VMT from employee commute trips and three reduce VMT from all project-generated trips (including non-commute trips). The seven are summed to an Employee Commute Trips Total using multiplicative dampening (see Question 7), and the three are separately summed to a Project-Generated Trips Total in the same way. This similarly occurs on the Community-Level Results page, where, of the 12 strategies, 11 reduce VMT from all city/CPA trips and one (4D Bike Facility Improvement) reduces VMT from trips on the roadway affected by a bikeway addition.

## 11. Can the tool be used to analyze strategies in rural areas?

There is little empirical research to support the estimation of VMT reduction in rural areas. Strategies that are likely to be most effective in rural areas include employer vanpool and telecommute programs. Many of the

strategies included in this tool will have little to no effectiveness in rural areas. Because of the lack of relevant research, analysis of strategies applied in a rural context should be done on a case-by-case basis and should generally not rely on the relationships contained in this tool.

## 12. How is the maximum VMT reduction calculated for each strategy?

On each strategy page below the “Type of VMT affected,” the “Max VMT reduction” is listed. Sometimes a strategy’s maximum VMT reduction is dependent only on user inputs, other times it is capped at a certain percentage, and other times it is based on regional parameters (e.g., mode share) specific to each city/CPA. Furthermore, the max VMT reduction can also be changed by optional user inputs that override default data. The max VMT reduction listed on each strategy page is meant to provide the user with a general estimate of the reduction potential for each strategy. The values listed were derived from the tool using the City of San Diego Downtown/City Centre CPA as the analysis location with all default data. The user may achieve a max VMT reduction that is different than the Max VMT reduction listed based on the differences in regional parameters of the selected city/CPA and any additional user overrides.

## 13. How is each place type defined?

**Low-density suburb:** Dispersed, low-density, single-use, automobile-dependent land use patterns, usually outside of the central city. Other characteristics may include: 20+ miles from regional central business district; more housing than jobs; buildings are one to two stories; curvilinear (cul-de-sac) street patterns; parking between street and office or retail and large-lot residential parking is common; ample parking and largely surface lot-based; no parking prices; limited bus service with peak headways 30+ minutes.

**Suburban center:** Cluster of multi-use development within dispersed, low-density, automobile-dependent land use patterns. Serves the population of a suburb with office, retail, and housing that is denser than the surrounding suburb. Other characteristics may include: 20+ miles from regional central business district; balanced jobs/housing ratio; buildings are two stories; grid street pattern; 0–20-foot setbacks; somewhat constrained parking supply on street and ample off-street; low to no parking prices; bus service at 20–30-minute headways; and/or a commuter rail station.

**Urban:** Located within a central city with multi-family housing and nearby office and retail. Other characteristics may include: within or less than five miles from the central business district; jobs/housing ratio > 1.5; buildings are at least six stories; grid street pattern; minimal setbacks; constrained parking supply; high parking prices; and high-quality rail service and/or comprehensive bus service.

## 14. There is text in a locked cell that is cut off, and I cannot click into the cell to read the remainder of the text. How can I read the cell text?

The margins of all cells have been adjusted so that at Excel’s 100% zoom level, all the text can be seen. Adjust your zoom level to 100% if you see that a cell’s text is cut off. This also applies to any text in comment bubbles.

## 15. What does “percent of employees eligible” mean, as used in strategies 1A through 1D?

This refers to the percentage of employees that would be able to participate in the strategy’s program if they desired to. This will usually be 100%. Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. This input does not refer to the percentage of employees who actually participate in the program.

## Project-Level Results Page

This page lists all the project-level strategies and displays the percentage reduction in VMT calculated for each strategy that the user analyzes. In the default state of the Tool, all strategies are “inactive,” so no VMT reduction results are initially shown on this page. As the user “activates” an individual strategy by providing inputs, the tool calculates the percentage reduction in VMT for the strategy, displaying the results on the individual strategy page and this results summary page.

The bottom of this page displays the total percentage reduction in VMT for multiple project-level strategies selected. The total VMT reduction formula applies multiplicative dampening so as not to double-count VMT impacts. For example, if one strategy reduces VMT by 10%, then only 90% of VMT remains to be affected by subsequent strategies. If a second strategy is applied that also reduces VMT by 10%, the combined resulting VMT would be 81% (10% reduction of 90% of VMT). Thus, the VMT reduction impact of both strategies is 19% rather than 20% if the impacts were purely additive. The following is the formula used to calculate the total VMT reduction if multiple strategies are selected:

$$\text{Total} = \{[100\% - (\text{Strategy A \% change in VMT})] \times [100\% - (\text{Strategy B \% change in VMT})] \times \dots \times [100\% - (\text{Strategy Z \% change in VMT})]\} - 100\%$$

The page shows two rows for total VMT reduction – one for strategies that affect employee commute trips and one for project strategies that affect all project-generated trips. This is because it may not be valid to combine VMT reductions for the two types. For example, parking pricing at a commercial facility affects VMT from all project-generated trips, while an employee vanpool program only affects VMT from the facility’s employee commute trips. Of the ten project-level strategies, seven reduce VMT from employee commute trips, and three reduce VMT from all project-generated trips (including non-commute trips). The seven are summed to an Employee Commute Trips Total using multiplicative dampening, and the three are separately summed to a Project-Generated Trips Total in the same way.

## Community-Level Results Page

This page lists all the community-level strategies and displays the percentage reduction in VMT calculated for each strategy that the user analyzes. The functionality of this page is similar to the Project-Level Results Page.

Like the Project-Level Results page, this page shows two total rows. Of the 12 strategies, 11 reduce VMT from all city/CPA trips and one (4D Bike Facility Improvement) reduces VMT from trips on the roadway affected by a bikeway addition. These should not be combined.

# Employer Commute Program Strategies

*Strategies implemented by employers that encourage workers to commute by modes other than autos.*

## 1A. Voluntary Employer Commute Program

**Description:** Employer offers a voluntary employer commute trip-reduction program. The program may include a carpool or vanpool program, subsidized or discounted transit passes, bike amenities, commute trip-reduction marketing, and preferential parking permit program. This strategy encompasses strategies 1C (Employer Carpool Program), 1D (Employer Transit Pass Subsidy), and 1E (Employer Vanpool Program) and cannot be analyzed in combination with these strategies. Unlike strategy 1B (Mandatory Employer Commute Program), this strategy does not require monitoring, reporting, or performance standards. If this strategy is selected, strategy 1B cannot be analyzed as part of the total VMT reduction.

**Formula:** % change in VMT = % of employees eligible × % change in commute VMT

### User Inputs:

- Is the program contractually required of the developer or property owner and accompanied by a regular performance monitoring and reporting program? [Yes/No]
  - If Yes, must use Strategy 1B
  - If No, use Strategy 1A
- Place type of project/site
  - Low-density suburb
  - Suburban center
  - Urban
- Percent of employees eligible
  - Refers to percentage of employees that would be able to participate in the strategy's program if they desired to. This will usually be 100%. Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. This input does not refer to the percentage of employees who actually participate in the program.

### Constants and Assumptions:

- Percent change in commute VMT:
  - Low-density suburb: –6.2%
  - Suburban center: –5.4%
  - Urban: –5.2%
- Strategy cannot be used in combination with 1B.
- Strategy encompasses strategies 1C, 1D, and 1E and cannot be analyzed in combination with these strategies.

### SANDAG Data:

None.

### Sources:

- California Air Pollution Control Officers Association. 2010. “Quantifying Greenhouse Gas Mitigation Measures.” [capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf](http://capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf)
- Cambridge Systematics. 2009. “Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.” Technical Appendices. Prepared for the Urban Land Institute. [reconnectingamerica.org/assets/Uploads/2009movingcoolerexecsumandappend.pdf](http://reconnectingamerica.org/assets/Uploads/2009movingcoolerexecsumandappend.pdf)
- Boarnet, Marlon G., Hsin-Ping Hsu, and Susan Handy. 2014. “Impacts of Employer-Based Trip Reduction Programs and Vanpools on Passenger Vehicle Use and Greenhouse Gas Emissions: Policy Brief.” [arb.ca.gov/cc/sb375/policies/ebtr/ebtr\\_brief.pdf](http://arb.ca.gov/cc/sb375/policies/ebtr/ebtr_brief.pdf)

## 1B. Mandatory Employer Commute Program

**Description:** Employer offers a mandatory employer commute trip-reduction program. The program may include a carpool or vanpool program, subsidized or discounted transit passes, bike amenities, encouragement for telecommuting and alternative work schedules, commute trip-reduction marketing, and preferential parking permit program. This strategy encompasses strategies 1C, 1D, and 1E and cannot be analyzed in combination with these strategies. Unlike strategy 1A (Voluntary Employer Commute Program), this strategy would be contractually required of the developer or property owner and is accompanied by a regular performance-monitoring and reporting program. If this strategy is selected, strategy 1A cannot be analyzed as part of the total VMT reduction.

**Formula:** % change in VMT = % of employees eligible × % change in commute VMT

### User Inputs:

- Is the program contractually required of the developer or property owner and accompanied by a regular performance-monitoring and reporting program? [Yes/No]
  - If Yes, use Strategy 1B
  - If No, must use Strategy 1A
- Percent of employees eligible
  - Refers to percentage of employees that would be able to participate in the strategy’s program if they desired to. This will usually be 100%. Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. This input does not refer to the percentage of employees who actually participate in the program.

### Constants and Assumptions:

- Percent change in commute VMT is –26%
- Strategy cannot be used in combination with 1A.
- Strategy encompasses strategies 1C, 1D, and 1E and cannot be analyzed in combination with these strategies.

### SANDAG Data:

None.

**Sources:**

- California Air Pollution Control Officers Association. 2010. "Quantifying Greenhouse Gas Mitigation Measures." [capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf](http://capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf)
- City of South San Francisco. 2015. "2015 Genentech Annual Report." [ci-ssf-ca.granicus.com/MetaViewer.php?view\\_id=2&clip\\_id=859&meta\\_id=62028](http://ci-ssf-ca.granicus.com/MetaViewer.php?view_id=2&clip_id=859&meta_id=62028)
- Cambridge Systematics. 2009. "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions." Technical Appendices. Prepared for the Urban Land Institute. [reconnectingamerica.org/assets/Uploads/2009movingcoolerexecsumandappend.pdf](http://reconnectingamerica.org/assets/Uploads/2009movingcoolerexecsumandappend.pdf)

## 1C. Employer Carpool Program

**Description:** Employers can encourage carpooling by providing ridematching assistance to employees, providing priority parking for carshare vehicles, and providing incentives for carpooling.

**Formula:** % change in VMT = % of employees eligible × % change in commute VMT

**User Inputs:**

- Place type of project/site
  - Low-density suburb
  - Suburban center
  - Urban
- Percent of employees eligible
  - Refers to percentage of employees that would be able to participate in the strategy's program if they desired to. This will usually be 100%. Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. This input does not refer to the percentage of employees who actually participate in the program.

**Constants and Assumptions:**

- Percent change in commute VMT:
  - Low-density suburb: -3%
  - Suburban center: -5%
  - Urban: -8%
- Strategy encompassed by strategies 1A and 1B and cannot be analyzed in combination with these strategies.

**SANDAG Data:**

None.

**Sources:**

- Ewing, R. 1993. "TDM, Growth Management and the Other Four out of Five Trips." Transportation Quarterly, Vol. 48, No. 3.

- Victoria Transport Policy Institute. “Ridesharing: Carpooling and Vanpooling.” TDM Encyclopedia. [vtpi.org/tdm/tdm34.htm](http://vtpi.org/tdm/tdm34.htm)
- California Air Pollution Control Officers Association. 2010. “Quantifying Greenhouse Gas Mitigation Measures.” [capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf](http://capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf)
- New York State Department of Transportation. 2019. Data from 511NYRideshare program participants.

## 1D. Employer Transit Pass Subsidy

**Description:** Employers can encourage employees to take transit by providing subsidized or discounted daily or monthly public transit passes to employees.

**Formula:** % change in VMT = % of employees eligible × % change in commute VMT

Where % change in commute VMT differs by place type (low-density suburb, suburban center, or urban) and level of daily transit subsidy (\$1 to \$4)

### User Inputs:

- Place type of project/site
  - Urban
  - Suburban center
  - Low-density suburb
- Transit subsidy per day
  - \$1
  - \$2
  - \$3
  - \$4
- Percent of employees eligible
  - Refers to percentage of employees that would be able to participate in the strategy’s program if they desired to. This will usually be 100%. Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. This input does not refer to the percentage of employees who actually participate in the program.

### Constants and Assumptions:

- Percent change in commute VMT

Place Type	Subsidy Level per Day			
	\$1.00	\$2.00	\$3.00	\$4.00
Low-Density Suburb	-0.1%	-0.2%	-0.4%	-0.6%
Suburban Center	-1.1%	-2.4%	-4.1%	-5.8%
Urban	-2.2%	-4.7%	-7.8%	-10.9%

- Estimated based on Nelson Nygaard (2010) and TCRP (2010). Subsidy levels in Nelson Nygaard were updated to reflect inflation. Also considers maximum VMT reductions suggested in Boarnet et al. (2014).
- Strategy encompassed by strategies 1A and 1B and cannot be analyzed in combination with these strategies.

**SANDAG Data:**

None.

**Sources:**

- Nelson Nygaard. 2010. "Santa Monica LUCE Trip Reduction Impacts Analysis." City of Santa Monica Land Use and Circulation Element, Final EIR. [smgov.net/Departments/PCD/Plans/2010-Land-Use-and-Circulation-Element/](http://smgov.net/Departments/PCD/Plans/2010-Land-Use-and-Circulation-Element/)
- Transportation Research Board. 2010. "TCRP Report 95 Chapter 19: Employer and Institutional TDM Strategies." [trb.org/Publications/TCRPReport95.aspx](http://trb.org/Publications/TCRPReport95.aspx)
- Boarnet, Marlon G., Hsin-Ping Hsu, and Susan Handy. 2014. "Impacts of Employer-Based Trip Reduction Programs and Vanpools on Passenger Vehicle Use and Greenhouse Gas Emissions: Policy Brief." [arb.ca.gov/cc/sb375/policies/ebtr/ebtr\\_brief.pdf](http://arb.ca.gov/cc/sb375/policies/ebtr/ebtr_brief.pdf)

## 1E. Employer Vanpool Program

**Description:** Vanpooling is a flexible form of public transportation that provides groups of 5–15 people with a cost-effective and convenient rideshare option for commuting. An employer can encourage ridesharing by subsidizing vanpooling for employees who have a similar origin and destination and by providing priority parking for employees who vanpool.

The SANDAG Vanpool Program provides a subsidy of up to \$400 per month to offset the vehicle lease cost.

**Formula:** % change in VMT =  $(M_A \times L_A + M_V \times L_V / O_V) / (M_A \times L_A + M_V \times L_V) - 1$

Where:

$M_A$  = auto (non-vanpool) mode share

$M_V$  = vanpool/long trip mode share

$L_A$  = length of average auto commute trip

$L_V$  = length of vanpool/long commute trip

$O_V$  = average vanpool occupancy

### User Inputs:

- Does the employer sponsor a vanpool program? [Yes/No]
  - If No, strategy does not apply to project and no change in VMT.
- Percentage of employees who participate in vanpool (optional override of regional default)
- One-way length of average auto commute (optional override of regional default)
- One-way length of long (vanpool) commute (optional override of regional default)

### Constants and Assumptions:

- If the user override of vanpool participation rate exceeds maximum of 15%, the default value will be used. This maximum is based on TCRP Report 95, Chapter 5 and ICF's experience implementing the 511NYRideshare program, the nation's largest regional TDM program.
- Strategy encompassed by strategies 1A and 1B and cannot be analyzed in combination with these strategies.

### SANDAG Data:

- Percentage of employees who participate in vanpool is 2.7%.
- Average one-way commute trip length is 12.71 miles.
- Average one-way vanpool trip length is 42 miles.
- Average vanpool occupancy (including driver) is 6.25 persons.

### Sources:

- SANDAG. 2018. Commute Behavior Survey.
- SANDAG. Activity Based Model. 2016. (v14.0.1, scenario ID 232)
- SANDAG. 2018. SANDAG Vanpool Program
- Transportation Research Board. 2005. "TCRP Report 95 Chapter 5 Buspools and Vanpools." [trb.org/Publications/TCRPReport95.aspx](http://trb.org/Publications/TCRPReport95.aspx)
- New York State Department of Transportation. 2019. Data from 511NYRideshare program participants.

## 1F. Employer Telecommute Program

**Description:** A telework program enables employees to work from home or a remote location one or more days per week. Depending on the nature of the work, schedules can range from full-time, specific days of the week, or as-needed. The VMT impacts of telework are similar to a flexible work schedule program, which enables employees to work long hours in exchange for one day off every week or two.

**Formula:** % change in VMT = % of employees who participate × % change in commute VMT for 1% of employees telecommuting X days/week

Where X = 1, 2, or 3

### User Inputs:

- Percentage of employees who participate
- Days per week the average employee telecommutes

**Constants and Assumptions:**

- Percent change in commute VMT for 1% of employees telecommuting at X days/week:
  - 1: -0.15%
  - 2: -0.29%
  - 3: -0.44%

**SANDAG Data:**

None.

**Sources:**

- Cambridge Systematics. 2009. "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions." Technical Appendices. Prepared for the Urban Land Institute. [reconnectingamerica.org/assets/Uploads/2009movingcoolerexecsumandappend.pdf](http://reconnectingamerica.org/assets/Uploads/2009movingcoolerexecsumandappend.pdf)
- California Air Pollution Control Officers Association. 2010. "Quantifying Greenhouse Gas Mitigation Measures." [capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf](http://capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf)

## Land Use Strategies

*Strategies that modify the location or characteristics of development projects to encourage non-auto travel modes.*

### 2A. Transit-Oriented Development

**Description:** Transit-Oriented Development (TOD) refers to projects built in compact, walkable areas that have easy access to public transit, ideally in a location with a mix of uses, including housing, retail, offices, and community facilities. TODs generally are described as places within a ten-minute walk of a high-frequency rail transit station (e.g., SPRINTER, COASTER, Trolley). They should, at a minimum, incorporate adequate bike and pedestrian access to transit, thereby encouraging transit use and reducing vehicle travel.

**Formula:** % change in VMT = difference in transit mode share with strategy × mode shift factor

#### User Inputs:

- Is the project within 0.5 mile of a rail transit station (e.g., SPRINTER, COASTER, Trolley)? [Yes/No]
  - If No, strategy cannot be used
- Existing transit mode share (optional override of city/CPA default)

#### Constants and Assumptions:

- Ratio of transit mode share for TOD area compared to transit mode share for surrounding city/CPA is 4.9.
- Maximum transit mode share is 27%, per Lund (2004).
- Mode shift factor is 0.70. Calculated as (1/average vehicle occupancy) or (1/1.42). Mode shift factor is an adjustment to reflect the reduction in vehicle trips associated with a reduction in person trips, since some vehicles carry more than one person.

#### SANDAG Data:

- Default transit mode share (all trips), by City/CPA

#### Sources:

- Tal, G., et al. 2013. "Technical Background Document on the Impacts of Transit Access (Distance to Transit) Based on a Review of the Empirical Literature." [arb.ca.gov/cc/sb375/policies/transitservice/transit\\_brief.pdf](http://arb.ca.gov/cc/sb375/policies/transitservice/transit_brief.pdf)
- SANDAG. Activity Based Model. 2016. (v14.0.1, scenario ID 232)
- Lund, H., et al. 2004. "Travel Characteristics of Transit-Oriented Development in California." [bart.gov/sites/default/files/docs/Travel\\_of\\_TOD.pdf](http://bart.gov/sites/default/files/docs/Travel_of_TOD.pdf)

### 2B. Mixed Use Development

**Description:** Mixed use projects incorporate a range of complementary land uses that provide a more balanced development approach relative to the surrounding neighborhood and encourage transportation alternatives. This could include co-location residential development, office space, retail shops, and others. Land use mix is measured using an entropy index. An index of 0 indicates a single land use while an index of 1 indicates equal distribution of all land uses. For ease of use, the strategy is calculated using only two land use types - residential (number of residents) and commercial (number of jobs).

**Formula:** % change in VMT = % change in land use index × elasticity

Where:

land use index =  $-A / (\ln[2])$

$A = (b1/a) \times \ln(b1/a) + (b2/a) \times \ln(b2/a)$

a = residents + jobs

b1 = residents

b2 = jobs

#### User Inputs:

- Existing land use index (optional override of city/CPA default)
- Residents added with project
- Jobs added with project

#### Constants and Assumptions:

- Elasticity of VMT with respect to land use index is  $-0.09$ , per Ewing and Cervero (2010).
- Percent change in land use index with strategy is capped at 500%, per CAPCOA (2010).
- Percent change in VMT is capped at  $-30\%$ , per CAPCOA (2010).

#### SANDAG Data:

- Default land use index, by city/CPA, is calculated based on SANDAG-provided data on population and jobs.

#### Sources:

- SANDAG Land Use Inventory (SPACECORE). 2016.
- Ewing, R., and Cervero, R. 2010. "Travel and the Built Environment – A Meta-Analysis." Journal of the American Planning Association.

## Parking Management Strategies

*Strategies that discourage auto travel by modifying the price or supply of vehicle parking.*

### 3A. Parking Pricing

**Description:** Priced parking can be implemented on- or off-street and helps to effectively manage the parking supply. Priced parking works best in areas where on-street parking is managed (e.g., priced parking, residential permit programs, time limits, etc.) to reduce unintended consequences of parking in adjacent neighborhoods.

**Formula:** % change in VMT = % change in parking price × elasticity

#### User Inputs:

- Parking price unit. User selects one of these options:
  - \$/hour
  - \$/day
  - \$/month
  - \$/year
- Existing parking price
- Parking price with project

#### Constants and Assumptions:

- Elasticity of vehicle trips with respect to parking price is –0.15.
- Change in vehicle trips assumed to equal change in VMT.
- A minimum 25% parking price change is needed to affect VMT.
- Change in parking price is capped at a minimum of –50% and a maximum of 50%.

#### SANDAG Data:

None.

#### Sources:

- Transportation Research Board. 2009. TCRP Report 95, Chapter 13, Parking Pricing and Fees. p13-4. [trb.org/Publications/TCRPReport95.aspx](http://trb.org/Publications/TCRPReport95.aspx)
- Cambridge Systematics. 2009. "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions." Technical Appendices. Prepared for the Urban Land Institute. [reconnectingamerica.org/resource-center/browse-research/2009/moving-cooler-an-analysis-of-transportation-strategies-for-reducing-greenhouse-gas-emissions/](http://reconnectingamerica.org/resource-center/browse-research/2009/moving-cooler-an-analysis-of-transportation-strategies-for-reducing-greenhouse-gas-emissions/)

### 3B. Parking Cash Out

**Description:** Employers can offer employees who are provided free parking the option to take the cash value of the space in lieu of the space itself. California state law (Assembly Bill 2109 [Katz, 1992]) requires that

certain employers who provide subsidized parking for their employees offer a cash allowance in lieu of a parking space. This strategy is only applicable where employers pay for or rent parking for their employees.

Parking cash-out is most successful when paired with incentives or programs that encourage the use of transportation alternatives.

**Formula:** % change in VMT = % of employees who participate × % change in commute VMT among participants

**User Inputs:**

- Percentage of employees who participate

**Constants and Assumptions:**

- 12% reduction in commute VMT among participants.

**SANDAG Data:**

None.

**Sources:**

- California Air Resources Board. 2009. "California's Parking Cash-Out Program: An Informational Guide for Employers." [arb.ca.gov/planning/tsaq/cashout/cashout\\_guide\\_0809.pdf](http://arb.ca.gov/planning/tsaq/cashout/cashout_guide_0809.pdf)
- Shoup, Donald C. 2005. "Parking Cash Out." Planners Advisory Service, American Planning Association. [shoup.bol.ucla.edu/ParkingCashOut.pdf](http://shoup.bol.ucla.edu/ParkingCashOut.pdf)

## Neighborhood Enhancement Strategies

*Strategies that improve or encourage neighborhood-level bicycle, pedestrian, and other multimodal travel options.*

### 4A. Street Connectivity Improvement

**Description:** A connected and complete street network improves accessibility, safety, and livability of the community. Traditional grid street patterns with short blocks offer a high degree of connectivity compared to street networks with curvilinear designs and cul-de-sacs. This strategy uses intersection density as a proxy for street connectivity improvements, which helps facilitate a greater number of short trips. Example projects that increase intersection density would be building a new street network in a subdivision or retrofitting an existing street network to improve connectivity (e.g., cul-de-sacs converted to grid streets).

**Formula:** % change in VMT = % change in intersection density × elasticity

#### User Inputs:

- Existing intersection density (intersections per square mile) (optional override of city/CPA default)
- Intersection density with strategy (intersections per square mile)

#### Constants and Assumptions:

- Elasticity of VMT with respect to intersection density is –0.12.
- Change in intersection density capped at a minimum of –50% and a maximum of 50%.

#### SANDAG Data:

- Default intersection density, by city/CPA, is provided by SanGIS (2016).

#### Sources:

- San Diego Geographic Information Source (SanGIS). 2016. "Roads\_All." San Diego Geographic Information Source – JPA. [sangis.org/download/index.html](http://sangis.org/download/index.html). Downloaded: May 1, 2019.
- Ewing, R., and Cervero, R. 2010. "Travel and the Built Environment – A Meta-Analysis." Journal of the American Planning Association.
- Handy, Susan, et al, 2014. "Impacts of Network Connectivity on Passenger Vehicle Use and Greenhouse Gas Emissions: Policy Brief." [arb.ca.gov/cc/sb375/policies/connectivity/network\\_connectivity\\_brief.pdf](http://arb.ca.gov/cc/sb375/policies/connectivity/network_connectivity_brief.pdf)

### 4B. Pedestrian Facility Improvement

**Description:** Enhancing pedestrian facilities (e.g., streetscape and pedestrian crossing improvements) within the jurisdiction or community helps encourage walking and reduce the reliance on the single-occupancy vehicle. This strategy applies to sidewalk enhancements that improve the existing streetscape and is not inclusive of greenfield developments with new roadways.

**Formula:** % change in VMT = % change in ratio of sidewalk length to street length × elasticity

#### User Inputs:

- Existing sidewalk length in city/CPA (miles)

- Existing street length in city/CPA (miles)
- Sidewalk length in city/CPA with project (miles)

**Constants and Assumptions:**

- Street length is assumed to remain constant, since the strategy involves adding sidewalks to the existing street network, not modifying street networks. Assuming a constant street length simplifies the user inputs and prevents users from erroneously entering unreasonable values.
- Elasticity of VMT with respect to sidewalk coverage ratio is –0.05.
- VMT change is capped at 1.4%, which is based on the following assumptions:
  - 10% of auto trips are short trips that could shift to walking (average 0.83 mile in length, per SANDAG)
  - 90% of auto trips are longer trips that cannot shift to walking (average 6.5 miles in length, per SANDAG)
  - So maximum VMT change =  $(10\% \times 0.83) / (90\% \times 6.5) = 1.4\%$

**SANDAG Data:**

- Regional average one-way walk trip length is 0.83 miles.
- Regional average one-way auto trip length is 6.5 miles.

**Sources:**

- Frank, L., Greenwald, M., Kavage, S. and Devlin, A. 2011. “An Assessment of Urban Form and Pedestrian and Transit Improvements as an Integrated GHG Reduction Strategy.” WSDOT Research Report WA-RD 765.1, Washington State Department of Transportation. [wsdot.wa.gov/research/reports/fullreports/765.1.pdf](http://wsdot.wa.gov/research/reports/fullreports/765.1.pdf)
- Handy, Susan, et al, 2014. “Impacts of Pedestrian Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions: Policy Brief.” [arb.ca.gov/cc/sb375/policies/ped/walking\\_brief.pdf](http://arb.ca.gov/cc/sb375/policies/ped/walking_brief.pdf)

## 4C. Bikeway Network Expansion

**Description:** A bikeway network includes an interconnected system of bike lanes, bike paths, and cycle tracks (Class I, Class II, and Class IV facilities). Bike facilities may share the roadway with vehicles or provide a dedicated pathway that separates bikes from cars or pedestrians. Increasing the network of bike facilities helps encourage biking as a safe and convenient alternative to driving. If this strategy is selected, strategy 4D (Bike Facility Improvement) cannot be analyzed as part of the total VMT reduction.

**Formula:**  $\% \text{ change in VMT} = (-1) \times \% \text{ change in bikeway miles} \times \text{elasticity} \times \text{existing bike mode share} \times \text{bike trip length} / (\text{existing auto mode share} \times \text{auto trip length})$

**Derivation of Formula:**

$$\begin{aligned} \% \text{ change in VMT} &= [\text{change in auto VMT}] / [\text{current auto VMT}] \\ &= (-1) \times [\text{change in bicycle miles traveled}] / [\text{current auto VMT}] \\ &= (-1) \times [\text{total trips in city/CPA} \times \text{bike mode share} \times \text{bike trip length} \times \% \text{ change in} \\ &\quad \text{bikeway density} \times \text{elasticity}] / [\text{total trips in city/CPA} \times \text{auto mode share} \times \text{auto trip} \\ &\quad \text{length}] \end{aligned}$$

### User Inputs:

- Would the project expand a network of bikeways or add a single bikeway? [Network of bikeways/  
Single bikeway]
  - If Network of bikeways, use Strategy 4C
  - If Single bikeway, must use Strategy 4D
- Existing bicycle mode share (optional override of city/CPA default)
- Existing auto mode share (optional override of city/CPA default)
- Are any of the current or proposed bikeways in the city/CPA classified as Class III? [Yes/No]
  - If Yes, Class III bike lane miles should be left out of the bikeway mile user inputs.
- Existing bikeway miles in city/CPA
- Additional bikeway miles in city/CPA with project
- One-way bicycle trip length (optional override of regional default)
- One-way auto trip length (optional override of regional default)

### Constants and Assumptions:

- Elasticity of bike trips with respect to bikeway miles per 10,000 population is 0.25.
- Maximum VMT change capped at 5.0%, which is based on the following assumptions:
  - 10% of auto trips are short trips that could shift to bicycling (average 2.9 mile in length, per SANDAG)
  - 90% of auto trips are longer trips that cannot shift to walking (average 6.5 miles in length, per SANDAG)
  - So maximum VMT change =  $(10\% \times 2.9) / (90\% \times 6.5) = 5.0\%$

### SANDAG Data:

- Default auto mode share, by city/CPA
- Default bicycle mode share, by city/CPA
- Regional average one-way bicycle trip length is 2.9 miles.
- Regional average one-way auto trip length is 6.5 miles.

### Sources:

- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)
- Pucher, J. and R. Buehler, 2011. "Analysis of Bicycling Trends and Policies in Large North American Cities: Lessons for New York." Report for U. S. Department of Transportation, Research and Innovative Technology Administration, Washington, D.C. and UTRC II New York.

## 4D. Bike Facility Improvement

**Description:** If a comprehensive bikeway network expansion (strategy 4C) is not feasible, the addition of a single bike lane (Class II), bike path (Class I), or protected bikeway (Class IV) to an existing bikeway network helps improve biking conditions within an area. Class I facilities are bike paths that are physically separated from motor vehicle traffic. Class II facilities are striped bicycle lanes that provide exclusive use to bicycles on a roadway. Class IV facilities are protected on-street bikeways, also called cycle tracks. Consider local or state

bike width standards when implementing facility improvements. If this strategy is selected, strategy 4C (Bikeway Network Expansion) cannot be analyzed as part of the total VMT reduction.

**Formula:** % change in VMT =  $-1 \times (\text{auto trips reduced by strategy}) \times (\text{bike trip length}) / (\text{existing auto trips on roadway}) \times (\text{auto trip length})$

Where auto trips reduced by strategy =  $\text{AADT} \times (\text{A} + \text{C})$

AADT = Existing average annual daily traffic volume on roadway affected by strategy

A = AADT adjustment factor

C = Credit for Activity Centers near project

### User Inputs:

- Would the project expand a network of bikeways or add a single bikeway? [Network of bikeways/  
Single bikeway]
  - If Network of bikeways, must use Strategy 4C
  - If Single bikeway, use Strategy 4D
- One-way bicycle trip length (optional override of regional default)
- One-way auto trip length (optional override of regional default)
- Existing Annual Average Daily Traffic (AADT) on roadway parallel to bicycle project
- Length of bike project (only Class I, II, or IV) in one direction (miles)
  - $\leq 1$
  - $> 1$  and  $\leq 2$
  - $> 2$
- Activity Centers near project
  - 3 within 0.5 mile
  - 4–6 within 0.5 mile
  - 7 or more within 0.5 mile
  - 3 within 0.25 mile
  - 4–6 within 0.25 mile
  - 8 or more within 0.25 mile

### Constants and Assumptions:

- Adjustment factor (A) of AADT for auto trips replaced by bike trips due to strategy

Average Daily Traffic	Bike Project Length (miles)	Adjustment Factor
0 – 12,000	≤ 1	0.0019
	> 1 and ≤ 2	0.0029
	> 2	0.0038
12,001 – 24,000	≤ 1	0.0014
	> 1 and ≤ 2	0.002
	> 2	0.0027
24,001 – 30,000	≤ 1	0.001
	> 1 and ≤ 2	0.0014
	> 2	0.0019

- Estimated based on California Air Resources Board (CARB) (2005). Based on assumption that at all municipalities would be either cities with a population greater than or equal to 250,000 or a non-university town with a population less than 250,000.
- Credit for activity centers based on number and distance
  - If 3 within 0.5 mile, 0.0005 credits
  - If 4–6 within 0.5 mile, 0.001 credits
  - If 7 or more within 0.5 mile, 0.0015 credits
  - If 3 within 0.25 mile, 0.001 credits
  - If 4–6 within 0.25 mile, 0.002 credits
  - If 8 or more within 0.25 mile, 0.003 credits
- Existing Annual Average Daily Traffic on roadway parallel to bicycle project (two-way traffic volume in trips/day on road parallel to proposed bike lane) cannot exceed 30,000, per CARB (2005).

**SANDAG Data:**

- Regional average one-way bicycle trip length is 2.9 miles.
- Regional average one-way auto trip length is 6.5 miles.

**Sources:**

- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)
- California Air Resources Board. 2005. “Methods to Find the Cost-Effectiveness of Funding Air Quality Projects.” [arb.ca.gov/planning/tsaq/eval/mv\\_fees\\_cost-effectiveness\\_methods\\_may05.doc](http://arb.ca.gov/planning/tsaq/eval/mv_fees_cost-effectiveness_methods_may05.doc)

## 4E. Bikeshare

**Description:** Bikeshare programs help to reduce traffic congestion and demand for parking by providing users with on-demand access to bikes for short-term rental. Bikeshare systems that feature electrified vehicles (scooters, e-bikes) help increase the range of the bike trip, making these services convenient and attractive to users. Providing discounted bikeshare memberships or dedicated bikeshare parking can encourage users and improve the user experience.

**Formula:** % change in VMT =  $-1 \times [\text{change in \% of population with access} \times \text{daily bike share trips per person} \times \text{auto substitution rate} \times \text{bike share trip length}] / [\text{average daily auto trips per person} \times \text{auto trip length}]$

### Derivation of Formula:

$$\begin{aligned} \text{\% change in VMT} &= [\text{change in VMT}] / [\text{total VMT}] \\ &= -1 \times [\text{total population} \times \text{change in \% with access to bikeshare} \times \text{daily bikeshare trips per person} \times \text{auto substitution rate} \times \text{bikeshare trip length}] / [\text{total population} \times \text{daily auto trips per person} \times \text{auto trip length}] \\ &= -1 \times [\text{change in \% with access to bikeshare} \times \text{daily bikeshare trips per person} \times \text{auto substitution rate} \times \text{bikeshare trip length}] / [\text{daily auto trips per person} \times \text{auto trip length}] \end{aligned}$$

### User Inputs:

- Major Statistical Area (MSA) of program expansion
  - Central
  - North City
  - South Suburban
  - East Suburban
  - North County West
  - North County East
  - East County
- Percentage of population in target community that will have access to the expanded bikeshare system
- One-way auto trip length (optional override of regional default)

### Constants and Assumptions:

- Bikeshare daily one-way trips per 1,000 residents based on MSA
  - If Central, 23
  - If North City, 23
  - If South Suburban, 6
  - If East Suburban, 6
  - If North County West, 6
  - If North County East, 6
  - If East County, 6

- Percentage of e-bike share trips replacing auto trips is 37%.

**SANDAG Data:**

- Regional average one-way auto trip length is 6.5 miles.
- Average daily one-way auto trips per adult, city/CPA.
- Average one-way e-bike trip length is 1.7 miles.

**Sources:**

- WSP. 2019. “Draft TDM Off-Model Methodology—March 2019 Revision.” Memo to SANDAG.
- MacArthur, J., M. Harpool, D. Scheppke. 2018. “North American survey of electric bike owners.” National Institute for Transportation and Communities: Washington D.C.
- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)
- SANDAG. 2018. Anonymized and aggregated data from bikeshare operators in San Diego.

## 4F. Carshare

**Description:** Carsharing offers people with convenient access to a vehicle for personal or commuting purposes. Carsharing helps to encourage transportation alternatives by reducing vehicle ownership. Roundtrip carshare providers require members to return the vehicle to a designated location. One-way carshare (i.e., free-floating) providers allow members to pick up the vehicle in one place and end their trip in another. Discounted carshare memberships and priority parking for carsharing vehicles help encourage use of carsharing services.

**Formula:** % change in VMT =  $-1 \times (\text{increase in \% of adults with access to carshare} \times \text{\% of adults with access who become members} \times \text{VMT reduction per member}) / (\text{trips per day} \times \text{average auto trip length})$

**Derivation of Formula:**

$$\begin{aligned} \text{\% change in VMT} &= [\text{change in VMT}] / [\text{total VMT}] \\ &= -1 \times [\text{total population} \times \text{change in \% of population with access to carshare} \\ &\quad \times \text{\% of adults with access who become members} \times \text{VMT reduction per member}] / \\ &\quad [\text{total population} \times \text{trips per day} \times \text{average auto trip length}] \\ &= -1 \times [\text{change in \% with access to carshare} \times \text{\% of adults with access who become} \\ &\quad \text{members} \times \text{VMT reduction per member}] / [\text{trips per day} \times \text{average auto trip length}] \end{aligned}$$

**User Inputs:**

- Percentage of cars providing round-trip carshare (vs. one-way carshare)
  - Represents the number of round-trip carshare cars divided by total carshare cars, where total cars includes both roundtrip and one-way providers. If all round-trip, enter 100.
- Percentage of adults in city/CPA with existing carshare access
  - Carshare access defined as at least one carshare pod within 0.5 mile of residence
- Percentage of adults in city/CPA with carshare access with strategy
- One-way auto trip length (optional override of regional default)

### Constants and Assumptions:

- Percentage of adults with carshare access who become members is 2%, per WSP (2019).
- VMT reduction per day per carshare member is 7 for roundtrip carshare (Cervero 2007) and 1.1 for one-way carshare (Martin 2016). Formula calculates a weighted average based on user input for percent round-trip.

### SANDAG Data:

- Average daily one-way auto trips per adult, by city/CPA.
- Regional average one-way auto trip length is 6.5 miles.

### Sources:

- WSP. 2019. "Draft TDM Off-Model Methodology—March 2019 Revision." Memo to SANDAG.
- Cervero, Robert, Golub, Aaron, Nee, Brendan. 2007. "City CarShare: Longer-Term Travel Demand and Car Ownership Impacts." Transportation Research Record: Journal of the Transportation Research Board, 1992, pp 70–80.
- Martin, E., and Shaheen, S. 2016. "The Impacts of Car2go on Vehicle Ownership, Modal Shift, Vehicle Miles Traveled, and Greenhouse Gas Emissions: An Analysis of Five North American Cities." [innovativemobility.org/wp-content/uploads/2016/07/Impactsofcar2go\\_FiveCities\\_2016.pdf](http://innovativemobility.org/wp-content/uploads/2016/07/Impactsofcar2go_FiveCities_2016.pdf)
- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)

## 4G. Community-Based Travel Planning

**Description:** Community-based travel planning is a residential-based approach to outreach that provides households with customized information, incentives, and support to encourage the use of transportation alternatives. The approach involves a team of trained Travel Advisors engaging residents at home or in their communities to offer information, incentives, and advice about how members of households can travel in alternative ways that meet their needs. Teams of trained Travel Advisors visit all households within a targeted geographic area, have tailored conversations about residents' travel needs, and educate residents about the various transportation options available to them. Due to the personalized outreach method, communities are typically targeted in phases.

**Formula:** % change in VMT =  $-1 \times$  % of households in community that are targeted  $\times$  % of targeted households that participate  $\times$  % reduction in single-occupancy vehicle trips among participating households

### User Inputs:

- Households in city/CPA that are targeted

### Constants and Assumptions:

- Percentage of targeted households that participate is 17%.
- Percentage of single-occupancy vehicle trip reduction among participating households is 12%.

### SANDAG Data:

- Households, by CPA/city

**Sources:**

- SANDAG. 2016. Land Use Inventory (SPACECORE).
- Results from program evaluations including King County Metro Transit. 2014, 2015, 2017; North Coast Corridor Program. 2014; Portland Bureau of Transportation. 2010; Community Transit. n.d. Curb @ Home.
- WSP. 2019. "Draft TDM Off-Model Methodology—March 2019 Revision." Memo to SANDAG.

# Transit Strategies

*Strategies that improve transit service and cause a mode shift from auto to transit.*

## 5A. Transit Service Expansion

**Description:** Expanding the transit network increases the transit system’s ability to accommodate existing and future travel demand, particularly for peak-period commute trips. This strategy provides an effective alternative to congested freeways and roadways for travelers and can reduce vehicle miles traveled by increasing transit ridership. Transit network service improvements should be coordinated closely with the operating transit agency.

**Formula:**  $\% \text{ change in VMT} = -1 \times (\text{existing transit mode share} \times \% \text{ change in network coverage} \times \text{elasticity} \times \text{mode shift factor}) / (\text{existing auto mode share})$

### Derivation of Formula:

$$\begin{aligned} \% \text{ change in VMT} &= [\text{change in auto VMT}] / [\text{current auto VMT}] \\ &= -[\text{change in transit passenger miles} \times \text{mode shift factor}] / [\text{current auto VMT}] \\ &= -[\text{total trips} \times \text{transit mode share} \times \text{trip length} \times \% \text{ change in network coverage} \\ &\quad \times \text{elasticity of transit ridership with respect to network coverage} \times \text{mode shift factor}] \\ &\quad / [\text{total trips} \times \text{auto mode share} \times \text{trip length}] \\ &= -[\text{transit mode share} \times \% \text{ change in network coverage} \times \text{elasticity} \times \text{mode shift} \\ &\quad \text{factor}] / [\text{auto mode share}] \end{aligned}$$

### User Inputs:

- Existing bus transit route length in city/CPA (miles)
- Bus transit route length in city/CPA with expansion (miles)
- Existing transit mode share (optional override of city/CPA default)
- Existing auto mode share (optional override of city/CPA default)

### Constants and Assumptions:

- Elasticity of transit ridership with respect to service coverage is 0.72.
- Percent change in bus network coverage is capped at 100%.
- If the user override of existing transit mode share exceeds maximum of 25%, the default value will be used.
- If the user override of existing auto mode share falls below minimum of 50%, the default value will be used.

### SANDAG Data:

- Default auto mode share, by city/CPA (all trips)
- Default transit mode share, by city/CPA (all trips)
- Mode shift factor is 0.70. Calculated as (1/average vehicle occupancy) or (1/1.42). Mode shift factor is an adjustment to reflect the reduction in vehicle trips associated with a reduction in person trips, since some vehicles carry more than one person.

**Sources:**

- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)
- Transportation Research Board. 2004. “TCRP Report 95 Chapter 10 Bus Routing and Coverage.” [trb.org/Publications/TCRPReport95.aspx](http://trb.org/Publications/TCRPReport95.aspx)

## 5B. Transit Frequency Improvements

**Description:** Transit frequency improvements can be implemented systemwide or on individual routes. Frequency improvements increase transit ridership by reducing travel times, which improves the user experience and increases the attractiveness of transit service. Transit network service improvements should be coordinated closely with the operating transit agency.

**Formula:** % change in VMT =  $-1 \times (\text{existing transit mode share} \times \text{\% change in transit frequency} \times \text{elasticity} \times \text{mode shift factor} \times \text{implementation adjustment}) / (\text{existing auto mode share})$

**Derivation of Formula:**

$$\begin{aligned} \text{\% change in VMT} &= ([\text{change in auto VMT}] / [\text{current auto VMT}]) \times \text{implementation adjustment} \\ &= (-1 \times [\text{change in transit passenger miles} \times \text{mode shift factor}] / [\text{current auto VMT}]) \times \text{implementation adjustment} \\ &= (-1 \times [\text{total trips} \times \text{transit mode share} \times \text{trip length} \times \text{\% change in transit frequency} \times \text{elasticity of transit ridership with respect to frequency} \times \text{mode shift factor}] / [\text{total trips} \times \text{auto mode share} \times \text{trip length}]) \times \text{implementation adjustment} \\ &= (-1 \times [\text{transit mode share} \times \text{\% change in transit frequency} \times \text{elasticity} \times \text{mode shift factor}] / [\text{auto mode share}]) \times \text{implementation adjustment} \end{aligned}$$

**User Inputs:**

- Existing peak period headway (minutes)
- Peak period headway with strategy (minutes)
- Existing total transit routes serving city/CPA
- Transit routes serving city/CPA that are improved
- Existing transit mode share (optional override of city/CPA default)
- Existing auto mode share (optional override of city/CPA default)

**Constants and Assumptions:**

- Elasticity of transit ridership with respect to frequency of service is 0.33.
- The percent change in transit frequency (arrivals per hour) is capped at a 300% increase or a 75% decrease.
- If the user override of existing transit mode share exceeds maximum of 25%, the default value will be used.
- If the user override of existing auto mode share falls below minimum of 50%, the default value will be used.

**SANDAG Data:**

- Default transit mode share, by city/CPA
- Default auto mode share, by city/CPA
- Mode shift factor is 0.70. Calculated as (1/average vehicle occupancy) or (1/1.42). Mode shift factor is an adjustment to reflect the reduction in vehicle trips associated with a reduction in person trips, since some vehicles carry more than one person.

**Sources:**

- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)
- Transportation Research Board. 2004. “TCRP Report 95 Chapter 9, Transit Scheduling and Frequency.” [trb.org/Publications/TCRPReport95.aspx](http://trb.org/Publications/TCRPReport95.aspx)

## 5C. Transit-Supportive Treatments

**Description:** Apply roadway infrastructure and/or traffic signal modifications to improve transit travel times and reliability, leading to mode shift to transit. Treatments can include transit signal priority, bus-only signal phases, queue jumps, curb extensions to speed passenger loading, and dedicated bus lanes. Transit-supportive treatments should be coordinated closely with the operating transit agency.

**Formula:**  $\% \text{ change in VMT} = -1 \times (\text{existing transit mode share} \times \% \text{ change in transit travel time} \times \text{elasticity} \times \text{mode shift factor}) / \text{existing auto mode share}$

**Derivation of Formula:**

$$\begin{aligned} \% \text{ change in VMT} &= [\text{change in auto VMT}] / [\text{current auto VMT}] \\ &= -1 \times [\text{change in transit passenger miles} \times \text{mode shift factor}] / [\text{current auto VMT}] \\ &= -1 \times [\text{total trips} \times \text{transit mode share} \times \text{trip length} \times \% \text{ change in transit travel} \\ &\quad \text{time} \times \text{elasticity of transit ridership with respect to travel time} \times \text{mode shift factor}] / \\ &\quad [\text{total trips} \times \text{auto mode share} \times \text{trip length}] \\ &= -1 \times [\text{transit mode share} \times \% \text{ change in transit travel time} \times \text{elasticity} \times \text{mode} \\ &\quad \text{shift factor}] / [\text{auto mode share}] \end{aligned}$$

**User Inputs:**

- Percentage of community transit routes that receive treatments with project
- Percent change in transit travel time due to treatments (optional override of default)
- Existing transit mode share (optional override of city/CPA default)
- Existing auto mode share (optional override of city/CPA default)

**Constants and Assumptions:**

- Default percent change in transit travel time due to treatments is –12%.
- Elasticity of transit ridership with respect to transit travel time is –0.4.
- If the user override of default percent change in transit travel time due to treatments value falls below minimum of –20% or exceeds maximum of 0%, the default value will be used.

- If the user override of existing transit mode share exceeds maximum of 25%, the default value will be used.
- If the user override of existing auto mode share falls below minimum of 50%, the default value will be used.

**SANDAG Data:**

- Mode shift factor is 0.70. Calculated as (1/average vehicle occupancy) or (1/1.42). Mode shift factor is an adjustment to reflect the reduction in vehicle trips associated with a reduction in person trips, since some vehicles carry more than one person.
- Default auto mode share, by city/CPA
- Default transit mode share, by city/CPA

**Sources:**

- Transportation Research Board. 2016. “TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies.” [trb.org/Main/Blurbs/173932.aspx](http://trb.org/Main/Blurbs/173932.aspx)
- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)
- Transportation Research Board. 2007. “TCRP Report 118: Bus Rapid Transit Practitioners Guide.” [trb.org/Publications/Blurbs/158960.aspx](http://trb.org/Publications/Blurbs/158960.aspx)

## 5D. Transit Fare Reduction

**Description:** Transit pricing strategies are designed to reduce the costs associated with using transit, thereby creating incentives for people to shift from other traveling modes. Fare reductions can be implemented systemwide or in specific fare-free or reduced fare zones. This strategy varies from Employer Transit Pass Subsidy (Strategy 1D), which can be offered through employer-based benefits programs in which the employer fully or partially pays the employee’s cost of transit.

**Formula:**  $\% \text{ change in VMT} = -1 \times (\text{existing transit mode share} \times \% \text{ change in transit fare} \times \text{elasticity} \times \text{mode shift factor}) / (\text{existing auto mode share})$

**Derivation of Formula:**

$$\begin{aligned} \% \text{ change in VMT} &= [\text{change in auto VMT}] / [\text{current auto VMT}] \\ &= -1 \times [\text{change in transit passenger miles} \times \text{mode shift factor}] / [\text{current auto VMT}] \\ &= -1 \times [\text{total trips} \times \text{transit mode share} \times \text{trip length} \times \% \text{ change in transit fare} \\ &\quad \times \text{elasticity of transit ridership with respect to fare} \times \text{mode shift factor}] / [\text{total trips} \\ &\quad \times \text{auto mode share} \times \text{trip length}] \\ &= -1 \times [\text{transit mode share} \times \% \text{ change in transit fare} \times \text{elasticity} \times \text{mode shift} \\ &\quad \text{factor}] / [\text{auto mode share}] \end{aligned}$$

**User Inputs:**

- Transit fare unit
  - \$/trip
  - \$/hour
  - \$/day

- \$/month
- \$/year
- Existing regular transit fare
- Regular transit fare with project
- Existing transit mode share (optional override of city/CPA default)
- Existing auto mode share (optional override of city/CPA default)

#### Constants and Assumptions:

- Elasticity of transit ridership with respect to transit fare is –0.3.

#### SANDAG Data:

- Default auto mode share, by city/CPA
- Default transit mode share, by city/CPA
- Mode shift factor is 0.70. Calculated as (1/average vehicle occupancy) or (1/1.42). Mode shift factor is an adjustment to reflect the reduction in vehicle trips associated with a reduction in person trips, since some vehicles carry more than one person.
- Percent change in transit fare is capped at 50%.
- If the user override of existing transit mode share exceeds maximum of 25%, the default value will be used.
- If the user override of existing auto mode share falls below minimum of 50%, the default value will be used.

#### Sources:

- SANDAG. 2016. Activity Based Model. (v14.0.1, scenario ID 232)
- California Air Resources Board. 2013. "Impacts of Transit Service Strategies on Passenger Vehicle Use and Greenhouse Gas Emission." [arb.ca.gov/cc/sb375/policies/transitservice/transit\\_bkgd.pdf](http://arb.ca.gov/cc/sb375/policies/transitservice/transit_bkgd.pdf)

## 5E. Microtransit NEV Shuttle

**Description:** Microtransit services utilize real-time ride-hailing, mobile tracking, and app-based payment to provide demand-based service to users. Microtransit services are flexible and can be designed to fulfill the mobility needs of a community. Neighborhood electric vehicles (NEVs) are a type of microtransit service that operate within a defined service area and fulfill trips that are short-distance in nature, typically less than two miles long. NEVs help to facilitate connections to and from transit stations and provide users with an alternative to driving for short trips.

**Formula:** % change in VMT =  $-1 \times (\% \text{ of city/CPA covered by new microtransit service} \times \text{microtransit share of person trips} \times \text{auto substitution rate} \times \text{average microtransit trip length}) / (\text{auto mode share} \times \text{average auto trip length})$

### Derivation of Formula:

$$\begin{aligned} \text{\% change in VMT} &= [\text{change in VMT}] / [\text{total VMT}] \\ &= -1 \times [\text{total daily person trips} \times \text{microtransit share of person trips} \times \text{change in \% with access to microtransit} \times \text{auto substitution rate} \times \text{average microtransit trip length}] / [\text{total daily person trips} \times \text{auto mode share} \times \text{auto trip length}] \\ &= -1 \times [\text{microtransit share of person trips} \times \text{change in \% with access to microtransit} \times \text{auto substitution rate} \times \text{average microtransit trip length}] / [\text{auto mode share} \times \text{auto trip length}] \end{aligned}$$

### User Inputs:

- Percentage of city/CPA covered by new microtransit service
- One-way microtransit trip length (optional override of regional default)
- One-way auto trip length (optional override of regional default)
- Existing auto mode share (optional override of city/CPA default)

### Constants and Assumptions:

- Microtransit share of all person trips is 0.41%.
- Auto trip substitution rate is 0.33.
- Average length of one-way microtransit trip is one mile.
- If the user override of existing auto mode share value falls below minimum of 50%, the default value will be used.

### SANDAG Data:

- Default existing auto mode share, by city/CPA
- Regional average one-way auto trip length is 6.5 miles.

### Sources:

- WSP. 2019. "Draft TDM Off-Model Methodology—March 2019 Revision." Memo to SANDAG.
- SANDAG. Activity Based Model. 2016. (v14.0.1, scenario ID 232)