TDM Cost Effectiveness
How VMT Reduction Translates to Congestion Mitigation and Improved Air Quality

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One of the most elusive and difficult aspects of Transportation Demand Management (TDM) is determining the effectiveness of projects. Demand Management strategies are the cost effective partners to capacity improvements (e.g. highway or capacity widening). Although it is easy to see when a new freeway lane is built, it is more subtle to notice changes in commute behavior based on the effectiveness of TDM strategies.

Most large metropolitan areas concede that there is no way to build their way out of ever-increasing traffic congestion, and worsening air quality. The opportunity to mitigate some of these problems is to decrease the demand for the roadway capacity. The challenge for TDM is to be taken seriously and to be valued in a world of civil engineers who like to build infrastructure, and elected officials who can point to things that can be seen and are more easily identified.

Transportation dollars are becoming tighter due to budget problems at the Federal, State and local levels. Since many rideshare programs are funded by Congestion Mitigation Air Quality (CMAQ) or local Air District funds, it is now more important than ever to determine the effectiveness of projects and demonstrate how that translates to congestion management or air quality benefits.

TDM strategies are 'softer' and less tangible mitigation methods than capacity enhancements. To ensure an appreciation of the benefits of TDM strategies, it is more important than ever for advocates and TDM professionals to provide more substantive results. Calculating the cost effectiveness (based on performance measures) of projects can be challenging, however the reward for monitoring, tracking and documenting the cost effectiveness can make the difference if the project is to compete well for future funding.

The basis for this analysis of cost effectiveness is a list of program elements of a comprehensive TDM Program implemented by the Contra Costa Commute Alternative Network (CC CAN) in northern California. A brief project description of each element is included, with the corresponding methodology for determining the cost effectiveness for each. These will serve as sample project types in order to show examples of ways to calculate effectiveness for some projects. These particular projects are subject to the cost effectiveness criteria established by the Bay Area Air Quality Management District (BAAQMD) in the San Francisco Bay Area. Although some projects in Contra

Costa are funded by local half cent sales tax funds, and in some cases CMAQ funds, the more stringent BAAQMD cost effectiveness criteria are used for all projects. This is not only easier due to the standard monitoring methodology, but also provides more credibility to the programs due to these high standards. As a note, the BAAQMD re-evaluates its calculations on a biennial basis, making them more and more stringent, due to the cleaner newer vehicles on the road. Cleaner vehicles means that programs must take more single occupant vehicle (SOV) trips off the road to achieve the same cost effectiveness levels each year. In FY 2002/03 the BAAQMD required the cost effectiveness ratio to be lower than $50,000/ton of emissions reduction to qualify for TFCA funding (Transportation Fund for Clean Air).

The projects evaluated in this report include:

- Carpool Incentive Program
- Employer Based Trip Reduction
- Vanpool Incentive Program
- Transit Incentive Program
- Guaranteed Ride Home
- Bicycle Rack/Locker Project
- SchoolPool Program

Each project type is calculated separately due to different default trip lengths, different vehicle miles traveled (VMT) reduction, varying numbers of days per year of effectiveness, and the fluctuating cost of each project. At the end of each fiscal year (usually 2-3 months after the end of the year), follow-up surveys are conducted for all projects to retrieve information in determining one-way trip lengths, frequency of use of the alternative commute mode, and duration of use. Most project types are calculated on an annual basis, however some infrastructure projects (such as bicycle racks and lockers) are calculated based on 20 years (the reasonable useful life of the racks/lockers). This information gathering produces information about each project which is used to determine its cost effectiveness. The maximum number of days/year for which any project can receive credit is 240 days. Projects such as EBTR, vanpool and bicycle projects often receive 240 days of credit, whereas some transit projects receive only 90 days, for instance.

Cost Effectiveness (Performance) Measurements

The cost effectiveness measures calculated for each project type include the following:

1. Vehicle trips reduced is based on the number of participants, multiplied by 2 to determine one-way trips reduced, multiplied by the number of days/year of effectiveness. For instance if a carpool project has 800 participants averaging 189 days of carpooling during the year, the number of vehicle trips reduced would be 800 X 2 X 189 = 302,400 VTR

2. Vehicle miles reduced is based on the number of one-way trips, multiplied by the number of days of effectiveness per year, multiplied by the average one-way trip length. The carpool project calculation would read:

1600 (one-way trips/day, based on 800 participants) multiplied by 189 (days per year) multiplied by 32 (average one-way trip length) = 9,676,800 VMT reduction

3. Days of effectiveness (DOE) is based on the average number of days that participants use the commute alternative. The total number of days of participation for all participants is added together and then divided by the number of participants. The BAAQMD has certain default DOE rates based on its own statistics, however if a project proponent can demonstrate a higher number of DOE for a given project, that will be considered. For instance, the BAAQMD default number of DOE for a transit rider is only 90 days, whereas based on Contra Costa follow-up surveys over 85% of respondents continue to take transit over 180 days after receiving the incentive.

4. Tons of emissions reduction includes calculations for ROG (Reactive Organic Gases), Nox (Oxides of Nitrogen), PM 10 (Particulate Matter), and CO2 (Carbon Dioxide). The ultimate reduction number is calculated by taking the total VMT and multiplying by various factors for each type of emission. The attached tables include the formulas for the various types of emissions reduced for each project. The sum of the emissions reduction provides the basis by which the cost effectiveness per tons of emissions reduction is calculated.

5. Cost savings per commuter is calculated by taking the average one-way trip length, multiplied by two (for the total round-trip savings), multiplied by the number of days, multiplied by the cost per trip (California DOT 2003 average cost per mile is $.36, however the 2003 AAA average cost is even higher at $.48 per mile).

Carpool Incentive Program (see Attachment A)
The CC CAN Carpool Incentive Program offers a $40 gas card to anyone who forms a new carpool or joins one. Based on origin/destination calculations from follow-up surveys, the average one-way trip length for a carpool in Contra Costa is 32 miles. The average in the Bay Area is 16 one-way miles. (Contra Costa provides much of the residential housing for employment destinations such San Francisco and Silicon Valley/San Jose).

Attachmentments A-G provide spreadsheets for each project which automatically applies the macro formulas and calculates the cost per tons of emissions. If any of the factors including the total TFCA Cost (in the upper right hand corner), or columns A (# trips/day), B (days/year), or C (one-way trip length) change, then the calculations across the page also change, as each one of those factors determines the cost effectiveness. This project had 800 participants which totaled 800 round trips, or 1600 one-way trips. (Calculations are actually computed differently, based on the number of carpool riders in each carpool, however for the purposes of this exercise it is assumed only one rider per carpool.)

At a cost of $146,000, the Carpool Incentive Program calculation indicates:

- 1600 (# one-way trips) X 189 (days/year) X 32 (one-way miles) =9,676,800 VMT reduced. This translates to a total cost effectiveness ratio of $10,081/ton of emissions reduction. The emissions reduced include:
- ROG = 5.52 tons
- NOx = 6.83 tons
- PM = 2.13 tons
- CO_2 = 4504.7

The cost savings for each carpool participant totals:
32 (one-way trip length) X 2 (for round trip) X 189 (days/year) X $.36 (cost to drive per mile) = $4,354.56 savings per year

Employer Based Trip Reduction (EBTR) Program (See attachment B)
The EBTR program includes a budget of $96,000 with many activities to promote the use of commute alternatives to all workplaces in Contra Costa, regardless of size or type (multi-tenant buildings are included, as well as retail big box). Due to the voluntary trip reduction environment in the San Francisco Bay Area, employers are *encouraged* to survey their employees each year. CC CAN conducts marketing campaigns such as California Rideshare Week, Bike to Work Day, Spare the Air, and Vanpool Appreciation Day, as well as the promotion of the Countywide Incentive Programs (including the Carpool Incentive Program, Vanpool Incentive Program, Transit Incentive Program and a Guaranteed Ride Home Program).

Due to the difficulties in determining changes in overall countywide employee commute modes, the BAAQMD default for the number of employees who likely change to a commute alternative based on the above efforts is 1% of the database employee population. CC CAN uses a 1.5% ratio instead, based on several factors including: CC CAN has an extensive residential marketing program, working with developers, Home Owner Associations, Chambers of Commerce, service organizations, title companies, realtors, and colleges; Contra Costa has the highest rate of BART train ridership in the Bay Area; and finally, in a voluntary trip reduction environment, only about 10% of the active employers survey each year, and even then, not all of the same ones survey each year. The Central/East Contra Costa EBTR Program, includes over 250 active employers with 41,000 employees, the effectiveness ratio includes:

- 1.5% of 41,000 employees = 615 participants, multiplied by 2 (for one-way trips) =1230, multiplied by 240 days per year, multiplied by 34 one-way miles = 10,036,800 VMT reduced

The days/year for EBTR is 240 days (working 50 weeks/year and receiving 2 weeks vacation and 10 holiday days off = 240). In addition, for projects which access transit, any 'new' trips generated when commuters access transit must be added back into the equation. For EBTR it is estimated that 10% of the total trips require 'new' trips to access transit. (No new trips are generated accessing standard bus lines). This addition is posted on Line 31 (and more below if necessary) on each cost effectiveness spreadsheet (Attachments A-G).

The CC CAN EBTR cost effectiveness ratio is $3,549/ton of emissions reduction.

The emissions reduced include:

- ROG = 5.62 tons
- NOx = 6.98 tons
- PM = 2.19 tons
- CO2 = 4631.1

The cost savings for each EBTR participant equals:
34 (trip length) X 2 (for round trip) X 240 (days/year) X $.36 (cost to drive per mile) = $5,875.20 per year savings

Vanpool Incentive Program (see Attachment C)
The Vanpool Incentive Program offers half off to new riders for the first three months after joining a vanpool. In addition, vanpool drivers who keep an active van on the road for one year receive a $1,000 bonus. In Contra Costa, the default one-way trip length for vanpools is 41.5 miles. Since vanpoolers ride in vans 5 days/week, the number of days/year is 240.

- 250 participants, multiplied by 2 (one-way trips), multiplied by 240 days/year, multiplied by 41.5 one-way miles = 4,980,000 VMT reduction

The Vanpool Incentive Program budget is $90,000 with a cost effectiveness which calculates to $17,246/ton of emissions reduction.

Emissions reductions include:

- The emissions reduced include:
- ROG = 1.38 tons
- NOx = 1.73 tons
- PM = .55 tons
- CO2 = 1154.9

The cost savings for each Vanpool participant equals:
41.5 (trip length) X 2 (for round trip) X 240 (days/year) X $.36 (cost to drive per mile) = $7,171.20 per year

Transit Incentive Program (see Attachment D)
At a cost of $170,000, the Transit Incentive Program offers free transit passes for new riders traveling to, from, or through Contra Costa. Commuters must sometimes trip link in order to get to work (using more than one form of transit). As a further complication, there are 27 transit agencies in the Bay Area. Due to the differing one-way trip distances, each type of transit has a different default for not only trip length, but number of days of effectiveness/year too. More details can be seen on Attachment D. In the notes to the

right of the table are explanations for the varying defaults as well as new trips generated by accessing transit. To illustrate the way defaults can differ, a one-way trip on BART averages 27 one-way miles, and a total days of effectiveness of 240 days/year, whereas a standard bus trip averages only 4.3 miles with a total days of effectiveness of 90/year. Consequently, the calculations have to be listed separately.

BART trips total:

- 1004 (# one-way trips) X 240 (days/year) X 27 (one-way miles) = 6,505,920 VMT reduction

Bus trips total:

- 400 (# one-way trips) X 90 (days/year) X 4.3 (one-way miles) = 154,800 VMT reduction

Express Bus trips total:

- 214 (# one-way trips) X 240 (days/year) X 46 (one-way miles) = 2,362,560 VMT reduction

Amtrak/ACE train trips total:

- 40 (# one-way trips) X 240 (days/year) X 60 (one-way miles) = 576,000 VMT reduction

Total VMT reduction for this project is 9,599,280 one-way trips.

New trips accessing transit also differ. No new trips are generated by commuters catching the local bus. For Express Bus service, 10% are SOVs to the pick up point. BART riders average a 30% SOV ridership to the BART station. All of these new trips accessing transit hubs average 3 one-way miles. These new trips must all be added back into the calculation to determine the true cost effectiveness.

The total cost effectiveness ratio for the Transit Incentive program is $12,200/ton of emissions reduction. The emissions reduced include:

- ROG = 5.3 tons
- NOx = 6.58 tons
- PM = 2.06tons
- CO_2 = 4357.0

The cost savings for each transit participant equals:

For bus riders: 4.3 (trip length) X 2 (for round trip) X 90 (days/year) X $.36 (cost to drive per mile) = $139.32 per year

For BART riders: 27(trip length) X 2 (for round trip) X 240 (days/year) X $.36 (cost to drive per mile) = $2332.80 per year

For Express bus riders: 46 (trip length) X 2 (for round trip) X 240 (days/year) X $.36 (cost to drive per mile) = $3,974.40 per year

For Amtrak/ACE train riders: 60 (trip length) X 2 (for round trip) X 240 (days/year) X $.36 (cost to drive per mile) = $10,368 per year

Guaranteed Ride Home (see Attachment E)

At a cost of $115,500 the GRH Program offers six free taxi vouchers or a rental car six times per year in the event of personal or family illness, a loss of a rideshare ride home, or unscheduled overtime. This program has 3,360 participants in an annually updated and purged database. It includes over 750 registered employment sites. The BAAQMD does not equate all registrants to be reduced trips, therefor only 1,680 (50% of the total) are considered participants for the purpose of calculating the effectiveness. As a result, the 3,360 total equals 1,680 multiplied by 2 for # one-way trips/day.

- 1,680 (participants) multiplied by 2 (one-way trip), multiplied by 240 days/year, multiplied by 34 (one-way miles) = 27,417,600 VMT reduction

An additional 336 new trips are added back into the formula (10% of the total trips accessing rideshare options to GRH), averaging 3 one-way miles. The GRH budget is $115,500 with a cost effectiveness which calculates to $2,858/ton of emissions reduction.

Emissions reductions include:
- ROG = 15.34 tons
- NOx = 19.08 tons
- PM = 5.99 tons
- CO_2 = 12,650.7

For GRH participants: 34 miles (trip length) X 2 (for round trip) X 240 (days/year) X $.36 (cost to drive per mile) = $5875.20 per year

Countywide Bicycle Rack/Locker Program (see Attachment F)
The Countywide Bicycle Rack/Locker Program provides racks and lockers to both public and private locations throughout the County, with public agencies receiving priority. CC CAN maintains a waiting list annually for locations requesting bicycle infrastructure. With $36,000 available for this program (all of which goes toward capital costs only), many locations were able to be served. The project includes the installation of a total of: four wave racks with a 7 bike capacity; sixteen double lockers with a 32 bike capacity; and four 15 loop racks with a 60 bike capacity, totaling 99 spaces/participants. The BAAQMD default number of days of effectiveness for bicycle projects is 240 days/year. The average one-way bicycle commute trip is 3 miles.

- 99 (participants) multiplied by 2 (one-way trips), multiplied by 240 days/year, multiplied by 3 (one-way miles) = 142,560 VMT reduction/year, for a total of 2,851,200 total VMT reduction.

The overall cost effectiveness calculates to $25,585/ton of emissions reduction:
Emissions reductions include:
- The emissions reduced include:
- ROG = .03 tons
- NOx = .03 tons

- PM = .01 tons
- CO_2 = 25.1

The cost savings for bicycle riders is: 3 (trip length) X 2 (for round trip) X 240 (days/year) X $.36 (cost to drive per mile) = $518.40 per year

SchoolPool Program (see Attachment G)
The SchoolPool Program provides ridematch services for schools in West/Central and East areas of Contra Costa County (public and private). In addition, since there is little, or no school busing in most districts, public bus tickets are offered to those students for whom a carpool doesn't work. Since there are four bus operators in the County, tickets must be distributed based on the location of the school and the corresponding operator. The operators assist in providing specialized transit schedules indicating which routes serve which schools, and in some cases even time schedules. For those parents who wish for their students to try the bus, a $20 pass is given.

For those students who take the bus, it constitutes one trip to school, and one trip home. For those with non-siblings in carpools, it is actually four one-way trips. The parent drives the children to school, then drives home, and then the two way trip is repeated in the afternoon again. Based on follow-up surveys, about 25% of the four trips are reduced by parents either dropping children off on the way to work, or children getting home by some other means in the afternoon. Therefor for SchoolPoolers in a carpool, the number of trips saved is actually 3 one-way trips/day. In order to do the calculations to determine total VMT reduction:

- 450 (SchoolPoolers/participants) multiplied by 3 (one-way trips) added to 550 (bus riders), multiplied by 2 (one-way trips) multiplied by 180 days/year, multiplied by 4.3 (one-way miles) = 1,896,300 VMT reduction

The overall cost effectiveness calculates to $20,274/ton of emissions reduction:
Emissions reductions include:

- The emissions reduced include:
- ROG = 1.58 tons
- NOx = 1.58 tons
- PM = .41 tons
- CO_2 = 864.7

The cost savings for SchoolPoolers is: 4.3 (trip length) X 3 (for three one-way trips), X 180 (days/year) X $.36 (cost to drive per mile) = $835.92 per year

As is evidenced by the descriptions above, there are not only many cost effectiveness and performance measures for TDM projects, but there are also many variables within each project which can affect the overall cost effectiveness. In addition, the methods listed here are only some of the many ways in which to determine cost effectiveness or on which to base performance. With the ability to quantify the effectiveness of each however, the importance of these Demand Management strategies becomes more supportable by being the necessary elements to complement roadway enhancement projects.