An Evaluation of the CATS CMAQ Division’s Method for Analyzing Bicycle, Pedestrian and HOV Project Proposals

By Monique Stinson

Transportation Management Cadre

April, 2005

Chicago Area Transportation Study

300 W. Adams Street, Chicago, Illinois 60606
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Abstract

This paper examines the methods used by the Chicago Area Transportation Study (CATS) to evaluate the benefits of non-motorized and high-occupancy vehicle (HOV) projects that compete for Congestion Mitigation and Air Quality (CMAQ) funds. CATS staff prioritizes projects by estimating demand and comparing potential emissions reductions from each proposed project. This report describes these methods, reviews methods used at other agencies, explores alternate evaluation tools and recommends improvements to the current CATS methods.

The report concludes that the sketch planning method CATS utilizes ranks non-motorized projects with reasonable accuracy, although imperfections in the data sources and formulas detract from the accuracy of the demand forecasts. Future studies could generate better data to improve demand estimation for non-motorized projects.

The report also concludes that the formulas used to estimate emissions reductions associated with HOV facility implementation are satisfactory. The data used in these evaluations are supplied by the CATS M&O department, which uses FREQ-12 software to estimate changes in demand for specific HOV configurations. Analysts are responsible for ensuring the accuracy of demand forecasts. Therefore, this report recommends no change in the evaluation process for HOV projects.
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CATS Evaluation of CMAQ Proposals

Report Overview

This report evaluates the methods CATS utilizes to analyze CMAQ proposals for bicycle, pedestrian and HOV projects. The report includes the following elements:

- a description of available methods for demand estimation
- a summary of the methods CATS current utilizes
- a review of methods used at other agencies
- recommendations.

Purpose and Need

Overview of the CMAQ Project Selection Process

Congestion Mitigation and Air Quality Improvement (CMAQ) funds are distributed to metropolitan areas with air quality problems by the United States Federal Highway Administration (FHWA). The regional metropolitan planning organization (MPO) is usually responsible for coordinating the distribution of CMAQ funds. In the northeastern Illinois region, CATS is the designated MPO.

The FHWA published the Congestion Mitigation and Air Quality Improvement (CMAQ) Program under the Transportation Equity Act for the 21st Century (TEA-21): Program Guidance (April 1999) to guide the planning process for allocating CMAQ funds. The program guide states the following:

“The purpose of the CMAQ program is to fund transportation projects or programs that will contribute to attainment or maintenance of the national ambient air quality standards (NAAQS) for ozone and carbon monoxide (CO).

“States and metropolitan planning organizations (MPOs) are…encouraged to consider and give priority to strategies that would help them meet their attainment deadlines and maintain the NAAQS into the future.

“The FHWA and FTA continue to recommend that States and MPOs develop their transportation/air quality programs using complementary measures that simultaneously provide alternatives to single-occupant vehicle (SOV) travel while reducing demand through pricing, parking management, regulatory or other means.”

Projects that qualify as non-motorized transportation enhancements historically have been an important component of the package of projects used to help the region strive to meet the NAAQS. (In the Chicago region, only a handful of HOV projects have been submitted.)

The FHWA Program Guide also suggests guidelines for selecting projects:
“States, MPOs and transit agencies are encouraged to develop procedures for assessing the emission reduction benefits of CMAQ projects… It is particularly important to assess and quantify the benefits of projects that increase or improve basic transportation services. This includes assessing emission reductions… Across the country, State and local transportation/air quality agencies have different approaches, analytical capabilities and technical expertise with respect to such analysis. At the national level, it is not feasible to specify a single method of analysis applicable in all cases. While no single method is specified, every effort must be taken to ensure that determinations of air quality benefits are credible and based on a reproducible and logical analytical procedure that will yield quantitative results of emission reductions.”

In summary, the FHWA requires that technical staff at the selecting agency determine the methods used to quantify the estimated emissions benefits of proposed projects.

**Research Need**

CMAQ evaluation staff members at CATS believe the non-motorized evaluation process currently used at CATS has room for improvement. The process relies on approximate formulas and factors that were developed nearly 15 years ago. Therefore, they asked the author (a researcher from another department) to review their current analytical process and to determine how to improve the method.

The CATS Transportation Management and Operations Division requested that HOV project analysis be included in the study. The CMAQ staff stated that their primary need is a review of the non-motorized evaluation process, and they currently do not plan to alter the HOV evaluation process. As a result, this report focuses largely on evaluation of demand for non-motorized projects; however, it also includes an overview of the HOV evaluation process.

**Organization of this Paper**

The rest of this report is organized as follows. First, available techniques for estimating non-motorized demand are reviewed. This provides a framework for discussing advantages and disadvantages to methods used at CATS and other agencies. Second, the CATS method for evaluating non-motorized projects is described. Third, a survey of methods used at other agencies is presented. Samples of these methods are appended to the report. Fourth, the report reviews the HOV evaluation method used by CATS, as well as methods used at other agencies. Finally, conclusions and recommendations are presented.
Non-Motorized Demand Evaluation

This section discusses non-motorized demand evaluation. First, several techniques that are available for estimating non-motorized demand are described. Second, the method CATS utilizes to evaluate non-motorized demand is reviewed. The underlying data sources for the CATS evaluation process are detailed. Third, a survey of methods used at other agencies is discussed. Finally, recommendations for improving CATS methods are made.

Available Tools for Estimating Non-Motorized Demand

This section describes various methods that are used to evaluate demand for non-motorized projects, based on descriptions and categories devised for the FHWA Guidebook on Methods to Estimate Non-Motorized Travel\(^1\). Each category is briefly described, and its potential applicability to the CMAQ evaluation methods utilized by CATS staff is assessed. Each method estimates demand either for a facility or an area/region (some methods can do both). The methods differ in ease of use, accuracy, data requirements and sensitivity to design factors. Facility “design factors” can include attributes such as lane width, pavement type and lateral separation from motor vehicles. Some demand methods are more insensitive to design factors (e.g., the CATS method offers no distinction between off-street paths and on-road facilities such as bicycle lanes) than others. In this paper, the overall facility quality is called the Level of Service (LOS).

In a separate paper\(^2\), the authors of the Guidebook categorize bicycle and pedestrian travel forecasting as follows:

- **Aggregate-level methods**
  1. measures of potential demand – estimate an ‘upper bound’ of potential facility use
  2. comparison studies – compare levels of before-and-after usage for facilities with similar characteristics
  3. aggregate behavior studies – models predict mode split
  4. sketch planning – a series of simple calculations that estimate facility usage

- **Attitudinal surveys** – used to estimate potential impacts of various bicycle/pedestrian improvements

- **Discrete choice models** – based on individual behavior, these models have numerous uses

- **Regional travel models** – the standard four-step models that are used to predict travel behavior; can incorporate many aspects of or formulas from aggregate-level, attitudinal and discrete choice methods.

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Market Analysis (Area/Regional Level)

This approach is used to estimate the potential or maximum demand for a mode. Elizabeth Deakin’s 1985 work, *Utilitarian Bicycling: A Case Study of the Bay Area and Assessment of the Market for Commute Bicycling*, is a well-known study that estimated the demographics of the existing non-motorized market, and subsequently the size of the potential market. Once established, this analysis technique is easy to use. However, it is not sensitive to design factors and is not appropriate for use at the facility level.

Facility Demand Potential (Facility Level)

This method, which is similar to the market analysis approach, might be appropriate for the CMAQ evaluation process at CATS. This analysis estimates relative maximum usage on various facilities depending on land use and demographics of the surrounding area. (In this sense, the technique is similar to market analysis.) The current CATS method incorporates few land use or demographic variables. One disadvantage to this analysis is that it does not forecast the actual number of users; therefore, it would be difficult to estimate a realistic cost/benefit ratio.

Comparison Studies (Facility Level)

Comparison studies involve forecasting usage on a proposed facility by comparing the facility to another facility already in existence. Comparison studies excel in providing a benchmark for estimating the order of magnitude of demand for a proposed facility. The method is quick and easy to do, but it has low accuracy and low sensitivity to design factors (LOS). Overall, comparison studies are inferior to the methods CATS currently uses.

Aggregate Behavior Studies (Area/Regional Level)

Aggregate-level behavioral studies are fairly simple and require little data. However, they have limited accuracy and are insensitive to facility design factors. In general, aggregate factors and formulas are not transferable between regions. Aggregate studies at the area-wide level might be used to predict possible effects of non-motorized facilities on demand for each mode. However, CATS would have to collect more data to create formulas — that effort would be better spent collecting data for a better method (such as discrete choice modeling).

Sketch Plan Methods (Facility Level)

CATS currently uses sketch planning methods for estimating non-motorized demand. Data requirements are minimal, and the process is simple to understand and explain; yet sketch planning can deliver moderate accuracy. If the formulas are carefully chosen (or estimated with good data) and good data is available to use in the calculations, then sketch planning can provide a reasonable rough estimate of demand for an individual facility and for relative demand among facilities. Overall, this method is sufficient for evaluating non-motorized project demand.

Preference Surveys (Facility Level or Area/Regional Level)

Preference surveys (stated preference surveys) ask survey respondents either to choose among hypothetical alternatives or to rate the importance of various improvements. They are relatively data intensive and difficult to use. Furthermore, respondents might possess inadequate real-world
experience with the alternatives or factors they are asked to consider. Finally, preference surveys are not good for predicting actual changes in demand unless the results are calibrated with revealed preference data. However, stated preference data that has been calibrated with revealed preference data provides an excellent framework for creating discrete choice models — in conjunction with revealed preference data, stated preference data can be an extremely useful tool for estimating absolute demand. Another benefit to preference surveys is their sensitivity to design factors.

**Discrete Choice Models (Facility Level or Area/Regional Level)**

Discrete choice models are formulas based on disaggregate data from specially designed surveys. These models generally are considered the most accurate tool available for estimating impacts of new or improved non-motorized facilities on non-motorized demand. For example, the Regional Transit Authority in Chicago developed a set of discrete choice models to predict the impacts of bicycle/pedestrian accessibility improvement on transit access mode choice. Using this type of model requires significant technical ability and training — however, most large MPOs currently have capable staff who can lead the development of discrete choice models for their agencies. The main obstacle, therefore, is that this method is data intensive. Collecting data in a household travel survey might be the best way for CATS to gather data for estimating discrete choice models for non-motorized demand.

**Environment Factors (Area/Regional Level)**

Portland’s Pedestrian Environment Factor (PEF) is perhaps the most well-known environment factor (EF) in existence. EFs are moderately easy to use and are very sensitive to design factors. However, they are data intensive, based on subjective ratings (usually), and (as of 1998) their validity has not been tested. They have not been widely used to estimate actual demand for facilities. However, the formulations account for non-motorized facilities (including their LOS) in estimating mode choice — if CATS continues to use average distances for different trip purposes (as it does now), then the number of trips eliminated and Vehicle Miles Traveled (VMT) eliminated can be estimated at an area or regional level.

**Regional Travel Models (Facility Level or Area/Regional Level)**

The accuracy of these models depends on the accuracy of the underlying analysis technique(s). For instance, if the model uses specially developed discrete choice models, then its accuracy is probably very good. However, models that use inferior data or formulations are not as accurate. In general, these models also require extensive expertise and data, and the spatial scale used is frequently inappropriately large for non-motorized trips and individual facilities.

**Geographic Information Systems (Facility Level or Area/Regional Level)**

GIS is more difficult and data-intensive than most of the other methods listed here. However, because GIS software is so widely used, finding staff with sufficient expertise would not be difficult. Similar to regional travel models, GIS programs are only as accurate as the underlying formulas and data permit. Using well-developed discrete choice models in either framework would probably lead to sound results.
Bicycle and Pedestrian Compatibility Measures (Facility Level)

These measures do not predict the actual number of trips. However, if CATS wishes to make its demand estimation sensitive to the facility’s LOS, a measure like the FHWA’s Bicycle Compatibility Index (BCI) would be extremely useful for understanding the impacts of pavement quality, separation from motor vehicles, etc., on non-motorized demand.

Summary

Each method described in this section has advantages and disadvantages in terms of accuracy, ease of use, data requirements and sensitivity to design factors. In general, achieving higher accuracy involves more data and more technical skill. Most of the methods being used at MPOs today are easy to use but sacrifice accuracy.

CATS currently uses sketch planning (an aggregate-level method suitable for the facility level) to estimate the impact of proposed facilities on bicycle/pedestrian travel. While this method is simple and uses readily available data, accuracy is limited by the use of numerous assumptions and by excluding factors that may have a significant impact. The next section further describes the CATS method for evaluating non-motorized projects.

Current Method Used at CATS

Bicycle and Pedestrian Travel

The procedure currently used by CATS for estimating emissions reductions associated with increased non-motorized trip-making is based on a sketch-planning method used by the Pennsylvania Department of Transportation3 (PennDOT). Stuart Goldsmith of the Seattle (Washington) DOT developed a similar method4 -- this method heavily influenced the development of the PennDOT method.

The procedure differs somewhat for bicycle throughway, pedestrian throughway and bicycle parking/miscellaneous projects. In general, though, the process is as follows. First, CATS analysts use GIS software to create a buffer with a radius of one mile around each project. Using Census data, the following values are calculated for each area: population, working population and university workers. Population density is computed, then used to determine diversion rates and usage factors. Trip lengths and work trip, non-work trip, other trip, bike use coordinator, bikeway mileage, mean trip distance, and other factors are assumed. Finally, an analyst computes VMT and the number of tons of Volatile Organic Compounds (VOC) that are forecast to be eliminated for each project. The procedures are summarized in the flowcharts shown in Figures 1-3.

After completing the calculations, CATS ranks the projects in each category by cost per ton of VOC eliminated. The CMAQ Project Selection Committee uses these rankings to help decide what projects to fund. Secondary criteria include cost per 1,000 VMT eliminated, cost per 1,000 trips eliminated and cost per ton of nitrous oxides (NOx) eliminated.

The CMAQ staff at CATS presents the cost/benefit analysis to the CMAQ Selection Committee. Committee members use these numbers as a guide, but they use their judgment for making the final decisions in awarding funds.

Figure 1. Demand for pedestrian projects.
Figure 2. Demand for bicycle projects.

- Calculate buffer area around facility
- Calculate workers
- Calculate university employees
- Calculate miles of connecting trails
- Calculate existing work trips
- Calculate #work trips after trail
- Calculate #SOV trips eliminated
- Calculate VMT eliminated
- Select trip length
- Select DR
- Calculate #trips
- Select trip factor
- Non-Work & Other
- Sum VMT eliminated by each trip type
- Terminate procedure
- Calculate workers
- Calculate university employees
- Calculate existing work trips
- Inflated to account for connectivity with other trails
- Make seasonal adjustment
- Terminate procedure
Figure 3. Demand for bicycle parking and miscellaneous projects.
Sources of Data, Factors and Other Values Used in Calculations

The formulae CATS utilizes are comprised of numerous factors and average values that have been derived from data gathered in studies performed by CATS and PennDOT. Population, employment and land estimates come from Census and NIPC data. The three main sources of bicycle- and pedestrian-specific data are the 1995 CATS Trail Survey (TS), the 1990 CATS Home Interview (HHTS) and a study by PennDOT. Tables 1-3 below list the factors used in each evaluation, as well as the source of each factor (the three sources are referenced as TS, HHTS, and PA).

Table 1. Factors used in the Pedestrian Facility Analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversion Rate (DR) – Work Trip</td>
<td>0.5</td>
<td>HHTS</td>
</tr>
<tr>
<td>Non-Work Trip DR</td>
<td>0.33(^5)</td>
<td>HHTS</td>
</tr>
<tr>
<td>Other DR</td>
<td>0.11</td>
<td>HHTS</td>
</tr>
<tr>
<td>Work Trip Length</td>
<td>0.586 - City, (0.786 - Suburbs)</td>
<td>HHTS</td>
</tr>
<tr>
<td>Non-Work Trip Length</td>
<td>0.508 (0.664)</td>
<td>HHTS</td>
</tr>
<tr>
<td>Other Trip Length</td>
<td>0.547 (0.725)</td>
<td>HHTS</td>
</tr>
<tr>
<td>Non-Work Trip Factor</td>
<td>0.78 (1.87)</td>
<td>HHTS</td>
</tr>
<tr>
<td>Other Trip Factor</td>
<td>1.55 (3.24)</td>
<td>HHTS</td>
</tr>
</tbody>
</table>

\(^5\)Cairns, S., and P. DuBernat. 2001. *Congestion Mitigation and Air Quality Improvement Analysis for Bicycle and Pedestrian Projects for Federal Fiscal Year 2002*. Chicago: Chicago Area Transportation Study. The Cairns/DuBernat document lists this as 0.27 rather than 0.33. The source of this discrepancy is unknown. Here we list 0.33 because the CMAQ evaluation process currently uses 0.33.
### Table 2. Factors used in the Bicycle Path Analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Trip DR</td>
<td>0.43</td>
<td>TS</td>
</tr>
<tr>
<td>Non-Work Trip DR</td>
<td>0.37</td>
<td>TS</td>
</tr>
<tr>
<td>Other Trips DR</td>
<td>0.24</td>
<td>TS</td>
</tr>
<tr>
<td>Work Trip Length</td>
<td>1.28 (City), 1.87 (Suburbs)</td>
<td>HHTS</td>
</tr>
<tr>
<td>Work Trip Length</td>
<td>3.6 (Major Trail)</td>
<td>TS</td>
</tr>
<tr>
<td>Non-Work Trip Length</td>
<td>1.58, 1.41</td>
<td>HHTS</td>
</tr>
<tr>
<td>Non-Work Trip Length</td>
<td>3.2 (Major Trail)</td>
<td>TS</td>
</tr>
<tr>
<td>Other Trip Length</td>
<td>1.43, 1.64</td>
<td>HHTS</td>
</tr>
<tr>
<td>Other Trip Length</td>
<td>4.7 (Major Trail)</td>
<td>TS</td>
</tr>
<tr>
<td>Non-Work Trip Factor</td>
<td>1.63, 1.65&lt;sup&gt;6&lt;/sup&gt;</td>
<td>HHTS</td>
</tr>
<tr>
<td>Non-Work Trip Factor</td>
<td>1.65 (Major Trail)</td>
<td>TS</td>
</tr>
<tr>
<td>Other Trip Factor</td>
<td>1.6, 2.37</td>
<td>HHTS</td>
</tr>
<tr>
<td>Other Trip Factor</td>
<td>2.9 (Major Trail)</td>
<td>TS</td>
</tr>
</tbody>
</table>

### Table 3. Factors used in the Bike Parking and Miscellaneous Method

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustment Factor for Bikeway Mileage and Mean Trip Distance (MADJ)</td>
<td>1.0-1.1</td>
<td>PA</td>
</tr>
<tr>
<td>Adjustment Factor for Bike Use Coordinator (BADJ)</td>
<td>1.0-1.1</td>
<td>PA</td>
</tr>
<tr>
<td>Work, Non-Work, and Other DRs&lt;sup&gt;7&lt;/sup&gt;</td>
<td>0.43, 0.37, 0.24</td>
<td>HHTS</td>
</tr>
<tr>
<td>Work, Non-Work, and Other Trip Lengths&lt;sup&gt;8&lt;/sup&gt;</td>
<td>1.28, 1.58, 1.43</td>
<td>HHTS</td>
</tr>
<tr>
<td>Non-Work and Other Trip Factors&lt;sup&gt;9&lt;/sup&gt;</td>
<td>1.63, 1.60</td>
<td>HHTS</td>
</tr>
</tbody>
</table>

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<sup>6</sup> CATS documentation lists 1.58 (in the HHTS-based data), but the CATS CMAQ analyst spreadsheet uses 1.65.

<sup>7</sup> The origin of these values is unclear, but the author speculates that they are derived from some combination of bicycle and pedestrian data gathered in the 1990 HHTS.

<sup>8</sup> These values are the values originally derived to calculate City trips.

<sup>9</sup> These values are the values originally derived to calculate City trips.
Evaluation of Data Sources

These data sources vary widely in quality. U.S. Census and NIPC data are standard, comprehensive and regularly updated. Aside from these sources, the best data are from the 1995 Major Suburban Trail Survey. These data are well suited for estimating non-motorized demand for major trails in the Chicago suburbs. However, CATS relies most heavily on data from the 1990 HHTS. Travel patterns have changed significantly in the past 15 years, detracting from the accuracy of the estimations. Furthermore, the HHTS did not directly inquire about bicycle use, therefore this data could be unreliable for estimating bicycle facility demand.

Finally, although land use characteristics impact individual mode choices and travel distances, these characteristics are omitted almost entirely from the demand estimation process. Population density, number of workers and number of university employees are the only demographic or land use variables that are included in the calculations. Other variables (such as retail or manufacturing acreage) might be important determinants of non-motorized mode choice.

Summary

While the methods currently used at CATS appear to satisfactorily rank relative demand for the projects, significant improvements in overall accuracy are possible. CATS can make overall improvements to its evaluation process by making changes to two components of its process: methods and data sources. CATS currently uses sketch planning, a technique that involves numerous assumptions and incorporates few (if any) design features. In addition, the sketch planning formulas are based on data sources that are old, have been transferred from another region, or did not directly obtain information on bicycle use.

Methods Used at Other Agencies

A small survey of MPOs and similar organizations called Councils of Governments (COGs) was conducted to determine how other agencies currently evaluate CMAQ proposals classified as bicycle, pedestrian and HOV projects. For comparative purposes, this survey primarily focused on agencies representing other large metropolitan areas; however, it also included agencies from small areas in order to better understand the applications of different methods to regions with different characteristics (see Table 4).

There are several reasons for reviewing methods used at other agencies. First, it lets us know if there is a standard method for evaluating CMAQ bicycle, pedestrian or HOV proposals. Second, commonly used methods probably have some distinct practical advantages over other methods. Surveying other agencies helps us understand practical implications of using each existing method. Third, we can compare our techniques to others to help evaluate the strengths and weaknesses of our program and to help determine if we can improve our methods.
<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Size</th>
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<tbody>
<tr>
<td>Maricopa Association of Governments</td>
<td>Phoenix, Arizona</td>
<td>X</td>
</tr>
<tr>
<td>Metropolitan Transportation Commission</td>
<td>San Francisco, California</td>
<td>X</td>
</tr>
<tr>
<td>Southern California Association of Governments</td>
<td>Los Angeles, California</td>
<td>X</td>
</tr>
<tr>
<td>Lee County MPO</td>
<td>Florida</td>
<td>X</td>
</tr>
<tr>
<td>Atlanta Regional Commission</td>
<td>Atlanta, Georgia</td>
<td>X</td>
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<tr>
<td>Central Transportation Planning Staff</td>
<td>Boston, Massachusetts</td>
<td>X</td>
</tr>
<tr>
<td>Southeast Michigan COG</td>
<td>Detroit, Michigan</td>
<td>X</td>
</tr>
<tr>
<td>Metropolitan Council</td>
<td>Minneapolis/St Paul, Minnesota</td>
<td>X</td>
</tr>
<tr>
<td>East-West Gateway Coordinating Council</td>
<td>St. Louis, Missouri</td>
<td>X</td>
</tr>
<tr>
<td>South Jersey Transportation Planning Organization</td>
<td>New Jersey</td>
<td>X</td>
</tr>
<tr>
<td>New York Metropolitan Transportation Council</td>
<td>New York, New York</td>
<td>X</td>
</tr>
<tr>
<td>Northeast Ohio Areawide Coordinating Agency</td>
<td>Cleveland, Ohio</td>
<td>X</td>
</tr>
<tr>
<td>Metro</td>
<td>Portland, Oregon</td>
<td>X</td>
</tr>
<tr>
<td>Delaware Valley Regional Planning Commission</td>
<td>Philadelphia, Pennsylvania</td>
<td>X</td>
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<tr>
<td>Texas Department of Transportation</td>
<td>(all of Texas), Texas</td>
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<tr>
<td>Capital Area MPO</td>
<td>Austin, Texas</td>
<td>X</td>
</tr>
<tr>
<td>Southwest Washington Regional Transportation Council</td>
<td>Washington</td>
<td>X</td>
</tr>
<tr>
<td>Puget Sound Regional Council</td>
<td>Seattle, Washington</td>
<td>X</td>
</tr>
</tbody>
</table>
Results of Agency Survey

Most agencies use sketch planning methods or a scoring/weighting system to evaluate and compare projects that have been submitted for CMAQ funding. For example, the Metropolitan Council (METC) of Minneapolis/St. Paul, Minnesota, gives the greatest weight to air quality benefits, but it also assigns projects points for cost effectiveness, safety and security, integration of land use and transportation, integration of modes, affordable housing performance and project readiness. According to Donald Koski, a transportation planner with the agency, high occupancy vehicle (HOV) projects would compete in the Transportation Demand/System Management category against Transportation Management and Operations (TM&O) projects, Intelligent Transportation Systems (ITS) projects, and miscellaneous related projects — however, METC does not receive many HOV proposals for CMAQ funds.

The analysis is somewhat different for every agency. However, most agencies use either an aggregate/sketch planning method or a simple weighting method to evaluate and compare projects. Larger areas, which presumably have more bicycle/pedestrian project proposals, generally use the most complicated sketch planning methods. In the past few years, some areas have begun to include non-motorized travel demand in their regional travel demand models.

Regional travel demand models can sometimes be used to assess demand for projects seeking CMAQ funding. Some of these models (Portland, OR; Montgomery County, MD; and Sacramento, CA) estimate non-motorized demand by evaluating the bicycle/pedestrian “friendliness” of individual zones. Other models (Albany, NY; New York, NY; and Edmonton, Alberta, Canada) include non-motorized facility networks. The latter can be used to predict both mode choice and route choice impacts of modifying or adding facilities. Regional travel demand models include mode choice models in their formulations.

Appendix A includes documentation from a few of the agencies that were surveyed to demonstrate the variety of methods used today. Documentation is provided for an all-mode scoring system (South Jersey TPO) and sketch planning systems (Texas) for bicycle/pedestrian and HOV projects (see Appendix B for HOV evaluation process). The Texas MOSER (The Texas Guide to Acceptable Mobile Source Emission Reduction Strategies) evaluation is very similar to CATS methodology. (Documentation for the regional models was not readily available, so there are no examples from this category in the appendix.)

Potential Improvements to the CATS Process

As noted previously, CATS estimates demand for non-motorized facilities and programs using a sketch planning method based primarily on recent NIPC and U.S. Census data, and on data collected by CATS in the 1990s. On average, the CATS’ method is about as accurate as methods used in other very large regions.

Data Sources

The data sources used for evaluating non-motorized projects are as follows: Census, NIPC, the 1990 CATS Household Travel Survey, the 1995 CATS Suburban Trail Survey and the Pennsylvania DOT. The quality of these data ranges from below average to excellent.
The U.S. Census and NIPC provide sound data sources for our purposes. Furthermore, they are widely used and accepted as valid data and have been recently updated.

The 1995 CATS Suburban Trail Survey provides good data for non-motorized usage of major trails throughout the Chicago suburbs. However, the survey did not include Chicago trails or any non-trail facility (such as bicycle lanes) — in other words, the formulas are not sensitive to design factors. Nevertheless, data from this survey is used to predict demand for all types of facilities (including bike lanes and sidewalks) in all areas (Chicago and its suburbs). We can reasonably assume that there is a significant loss in accuracy when the method is used for non-trail and non-suburban facilities.

However, the evaluation process results in a ranking of projects by their relative cost/benefit ratios. Since the process uses relative demand instead of absolute demand, improving the accuracy of the absolute demand forecasts is not essential as long as the relative demand forecast yields reasonable estimates. Furthermore, the judgment of individuals on the CATS CMAQ Project Selection Committee is the ruling factor in the decision to fund projects.

Another disadvantage of the 1995 Trail Survey is the age of its data. As of 2004, the data is nearly a decade old and is becoming outdated. Data should be periodically updated.

The 1990 CATS Household Travel Survey and Pennsylvania factors are below average in quality. The HHTS, for instance, is out of date by about 15 years. Automobile congestion and average travel distances have grown significantly over this period. Furthermore, the HHTS does not explicitly ask about bicycle usage — those data are imputed from other answers. Imputed data may not be valid. Therefore, the 1990 HHTS is a reasonable source for pedestrian data, but is not a good source for bicycle data.

The PennDOT data are below average in quality because aggregate-level factors and formulas generally do not transfer accurately from one region to another. The main reason for using PennDOT’s factors seems to be their availability and an apparent lack of enthusiasm for collecting data specific to this region.

Formulas

The sketch planning method that CATS uses has the same advantages and disadvantages as the data sources used. The two formulae used to predict demand for major suburban trails are very suitable because they are based on data collected in an extensive survey of major suburban trails. The other formulas are simple calculations that might not accurately estimate demand; nevertheless, they are easy to use and to understand. They require data that are readily available to CATS staff. When used in conjunction with staff judgment, the formulas are a satisfactory tool for ranking projects according to benefits.

Potential Use of Other Methods

Some of the methods described earlier could enable CATS to improve the accuracy of its non-motorized demand forecasts. The most promising method (in terms of accuracy) is discrete choice modeling, which uses disaggregate behavior and facility design data in the form of discrete choice models. However, the challenges imposed by data requirements and
computational complexity may outweigh the benefit provided by the enhanced accuracy. More study is needed to determine if using this method would be cost-effective.

Suggested Improvements

Revising and re-administering surveys periodically is a good way to keep data sources suitable for their intended uses. This process should be undertaken approximately every 10 years.

In addition, the CMAQ staff at CATS should periodically evaluate the effectiveness of its sketch-planning methods. Some questions they may ask are as follows: Is this method accurate enough for our purposes? Are the available data adequate for the needs of the entire agency? If the method needs improvement, should we simply improve the method or use a different method?

As part of this study, the author created a survey strategy and survey questions that could help CATS obtain better data for its estimation of bicycle/pedestrian demand. Appendix C documents this strategy and recommended survey questions.

Evaluation of HOV Projects

CATS Method

HOV projects are evaluated according to a sketch planning method that is similar to the method CATS utilizes to evaluate projects that alleviate bottlenecks. The current method evaluates two sources of emissions reductions: decrease in running emissions due to fewer vehicles, and average speed increase in the bottleneck due to fewer vehicles. First, for each SOV user who switches to HOV, there is one less vehicle creating “running emissions” on the road. The second component follows from the first: one less vehicle creates a marginal improvement in congestion and, therefore, a marginal increase in average speed. An increase in average speed can result in lower running emissions because the average engine is most efficient when operating near 40 mph. So, if the expressway is heavily congested with an average speed of 20 mph, increased HOV use can bring the average speed closer to the 40 mph range.

Agencies or individuals who submit projects supply CATS information to help analyze the cost effectiveness of the project. These data include project cost, completion year, current average speed and estimated future speed on the corridor. CMAQ staff at CATS also use current-year Vehicle Miles Traveled (VMT) and Average Daily Traffic (ADT) data from the CATS Travel Atlas in the calculations. Average trip length is the length of the bottleneck section under study. CATS also supplies growth factors to estimate future-year ADT and VMT eliminated.

Emissions are calculated with the MOBILE 6.2 model developed by the U.S. Environmental Protection Agency. This software allows the CMAQ staff at CATS to consistently evaluate emissions reductions associated with each project. Alternatively, CATS could allow project sponsors to submit their own emissions estimates — however, different software yields different results, making project comparisons difficult. It is best for the evaluation process to be centrally controlled by the objective methods used at CATS. Another advantage to using MOBILE 6.2 is that the emissions benefits calculated by the program are directly applied to the CATS regional air quality conformity analysis, which is required to use MOBILE 6.2.
**Case Study**

Agencies and individuals in the Chicago region rarely submit HOV lane projects for CMAQ funding. For example, during FY 2004, only one such project\(^\text{10}\) was submitted (by the Transportation Management and Operations Division of CATS). The project sought to ease or eliminate three bottlenecks on the Dan Ryan/I-57 northbound corridor in the A.M. peak period with metered ramp HOV bypass lanes. These lanes are HOV lanes that are placed next to SOV+ lanes on metered ramps to encourage motorists to carpool or use transit in order to bypass the queue of SOV+ vehicles waiting for the ramp meter to signal them onto the freeway. CATS M&O staff used a HOV demand estimation software package called FREQ to estimate the change in demand for HOV.

Using this software, project analysts estimated that the average speed in three bottleneck locations would increase from 23 mph to 63 mph. The CMAQ staff at CATS used this data to calculate the reduction in running emissions. Furthermore, they estimated the total number of trips eliminated using the sketch-planning formula \((0.14 \times \text{Current ADT}) \times 2600\). This number is used to estimate reductions in start-up emissions and running emissions caused by decreased demand.

**Review of Other MPOs**

Most regions do not use CMAQ funds for HOV facilities. This scarcity of CMAQ-funded HOV projects makes it difficult to find thorough documentation of analytical methods used at other MPOs to evaluate HOV projects. Only one documented process was found: the State of Texas provides very good documentation of its process, known as Mobile Source Emission Reduction Strategy, or MOSERS. The procedure described in the MOSERS document is virtually identical to the CATS procedure of calculating emissions reductions to be the sum of effects on emissions by reduced demand (fewer start-ups and running emissions) and increased speeds on the freeway. Both procedures qualify as “sketch planning methods,” and both seem to provide reasonable accuracy.

Appendix B contains documentation from the MOSERS manual for evaluating impacts of HOV facilities. The Texas process is nearly identical to the CATS process.

**Conclusion and Recommendations**

The method CATS uses for evaluating HOV projects is sufficient for the limited number of projects in the HOV category that compete for funding. Therefore, this report recommends no change in the HOV emissions reduction analysis procedure. However, if CATS wishes to improve the accuracy of its HOV-CMAQ analysis in the future, then CMAQ staff could improve the method by collecting data that is specifically tailored toward evaluating demand for HOV projects.

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\(^{10}\) Pace Suburban Bus Company provides a vanpool service that typically receives CMAQ funding. Vanpool is a form of HOV, however the program fits another category as well. So, it is not evaluated alongside HOV facility projects.
Summary and Conclusions

This report reviewed the methods used at CATS to evaluate non-motorized and HOV facility projects whose sponsors seek CMAQ funding. It also judged the accuracy of each method, discussed other available methods, and compared the methods used at CATS with methods used at other metropolitan planning organizations.

In summary, CATS staff analyzes non-motorized projects using sketch planning factors and formulas based on data collected by the agency throughout the 1990s. HOV projects are analyzed with a sketch planning method that accounts for three types of emissions reductions resulting from reductions in SOV use. Sketch planning, a common tool for MPOs to use for evaluating demand, provides a satisfactory level of accuracy for ranking projects according to relative emissions benefits. Greater accuracy is possible with other methods (especially discrete choice modeling). Some regions use discrete choice modeling and regional travel demand models to evaluate demand for projects.

Despite imperfections in the data and the uncertainty regarding the transferability of various factors, the data and formulas currently in use seem to perform satisfactorily in terms of enabling CATS to rank projects according to their estimated cost/benefit ratios. The main problem is that projects of different types are ranked side-by-side — in other words, the process is not sensitive to LOS. For instance, among the 2004 submissions, the benefits of on- and off-street facilities were estimated with the same procedure, and these projects competed with each other for funding. The CMAQ Evaluation Committee attempts to remedy this deficiency (and other deficiencies) by using human judgment in conjunction with the absolute demand estimates.

If CATS decides to enhance the accuracy of its non-motorized and HOV forecasts, it is recommended that the agency embark on a data collection effort that would enable the formulation/calibration of discrete choice models. The agency should collect more and better data. Appendix C outlines some questions CATS might ask in a survey. It also suggests a strategy for soliciting respondents who are willing to answer an in-depth survey.
BIBLIOGRAPHY


APPENDIX A

CMAQ Evaluation Methods

In South New Jersey and the State of Texas
South Jersey Transportation Planning Organization

FY 04 CMAQ Proposal Evaluation

project: ____________________  reviewer: ____________________

sponsor: ____________________

STEP 1 Mark yes or no.

A. APPLICATION CLEAR & COMPLETE
   Points to consider
   • Anticipated strategy well defined & complete
   • Specific content & description
   • Rational reasoning

B. CMAQ COMPATIBLE
   Points to consider
   • On the CMAQ-qualifying projects list in the Eligibility section
   • Potential to reduce emissions or traffic congestion

STEP 2 Score each category 0 - 10, with 10 being the most favorable. If a category exhibits exceptional merit, it can be scored up to 15 points with written documentation. 60 points maximum for Step 2.

A. EASY TO IMPLEMENT AND DELIVER
   Points to consider
   • Category evaluation
   • Environmental issues
   • Realistic time & cost parameters
   • Be authorized in proposed FY of implementation

B. REGIONALLY COMPATIBLE & COMPLEMENTARY
   Points to consider
   • Relationship to current regional situation
   • Consistency with current & future regional projects
   • Significant regional benefits
   • Addresses one or more regional or county planning goals

C. INTERMODALLY CONNECTIVE
   Points to consider
   • New or improved connection
   • Ease of use
   • Increase of transportation efficiency
   • Improves mobility / access

D. INTERJURISDICTIONAL
   Points to consider
   • Involves multiple agencies, municipalities, counties, other groups
   • Public involvement / use
   • Synergistic effects

E. AIR QUALITY
   Points to consider
   • Cost per emissions reduced
   • Significant emissions reduction
   • Short vs. long term effects

F. OTHER
   Points to consider
   • Innovation
   • Safety
   • Geographic equity
   • Cost effectiveness
   • Additional funding provided

C/JTEWP/Patrick CMAQ Evaluation Form 7.1.3.doc
The Texas Guide to Accepted Mobile Source Emission Reduction Strategies

Texas Department of Transportation

Prepared by the
Texas Transportation Institute
in cooperation with the
Texas Department of Transportation
and in association with
Environmental Protection Agency
Federal Highway Administration
Federal Transit Administration
Texas Commission on Environmental Quality

August 2003
11.0 BICYCLE AND PEDESTRIAN PROGRAMS

Programs to limit portions of road surfaces or certain sections of the metropolitan area

to the use of non-motorized vehicles or pedestrian use, both as to time and place
Section 108 (b), CAAA

Programs for secure bicycle storage facilities and other facilities, including bicycle
lanes, for the convenience and protection of bicyclists, in both public and private areas
Section 108 (a), CAAA

Programs for new construction and major reconstructions of paths, tracks, or areas
solely for the use by pedestrian or other non-motorized means of transportation when

economically feasible and in the public interest. For purposes of this clause, the
Administrator shall also consult with the Secretary of the Interior
Section 108 (xv), CAAA

Bicycling and walking represent viable alternatives to most SOV trips. Every trip shifted
from an SOV to a bicycle or walking results in a 100 percent reduction in vehicle
emissions for that trip.

Bicycle and pedestrian programs can be adapted to a community's characteristics (e.g.,
topography, population, and existing infrastructure) and the budget of the administering
agency. Common types of bicycle and pedestrian facilities include the following:

- Routes, lanes, and paths,
- Sidewalks and walkways,
- Plans and maps,
- Bicycle coordinators,
- Racks and other storage facilities,
- Shower facilities and clothing lockers,
- Connections with transit,
- Ordinances for bicycle parking,
- Education, media, and promotions,
- Sidewalk furniture, and
- Pedestrian safety modifications.

According to EPA studies, bicycling and walking can substitute for short trips, 5 miles or
less in length for bicycle trips and less than one-half mile for walking trips. The amount
of VMT reduced may be small, but the air emissions benefits can be much greater
because cold-start and hot-soak emissions comprise a large portion of the total emissions
per vehicle trip.

Bicycle and pedestrian programs are often packaged with other strategies. EPA notes
that many employers provide bike and pedestrian facilities as part of their employer-
based transportation management program. Many public transit improvement plans also
support bicycle and pedestrian programs by incorporating elements to improve access to
transit facilities. Municipal and regional trip-reduction ordinances can mandate these
types of programs. Traffic flow improvements may indirectly support bicycle and
pedestrian programs by improving signal intersections and increasing safety for bicyclists
and pedestrians.

Costs for developing, maintaining, and operating a bicycle or pedestrian program may
include the following:

- Salary and benefits for a program coordinator and staff;
- Land acquisition;
- Bike lane construction;
- Bike path construction;
- Bicycle lockers and racks;
- Publications;
- Signage striping;
- Maintenance;
- Enforcement, and
- Educational materials.

Except for equipment, direct cost to travelers is minimal.

Three main factors affect the viability of bicycling and walking as alternative
transportation:

- Trip distance, defined above as 5 miles or less for bicycles and less than one-half
  mile for pedestrians;
- Safety, both along the path or lane and at the destination site; and
- Weather conditions, since inclement weather is not conducive to either mode.

EPA reports that the following local factors help to ensure a successful program:

- Short travel distances between residential areas and key trip attractions;
- High concentrations of people under age 40;
- Compatible infrastructure that can be modified into appropriate facilities;
- Areas with localized congestion or crowded parking facilities, and
- Marketing and education efforts including maps and plans, safety training,
  promotions, and media events.

Factors that negatively affect bicycle and pedestrian programs are:

- Missing links in the network of lanes and trails;
- Lack of safe routes to work destinations;
- Conflicts with traffic laws that give preference to autos, and
- Lack of facilities to accommodate activities.

B.11.2
11.1 Bicycle and Pedestrian Lanes or Paths

**Strategy:** Replacement of vehicle trips and VMT with bicycle and pedestrian travel.

**Description:** A large number of bicycle and pedestrian projects are available to practitioners for implementation in air quality mitigation efforts. With ISTE A and TEA-21, funding for these types of programs has increased dramatically in the last decade. They include:

- Reallocation of right-of-way to accommodate bicycles and pedestrians;
- Traffic calming programs;
- Median refuges at key minor street crossings and bike-friendly signals;
- Independent bicycle/pedestrian structures or those in conjunction with other existing or planned transportation facilities;
- New trails, connecting existing trail segments, and encouraging developers to include trails in their developments;
- Improved connections between residential areas and transit stops, providing secure bicycle parking at stops and providing for carrying bicycles on the system;
- On bridges, reallocation of bridge deck width by shifting lane lines, modifying surface for better bicycle stability, modifying ramps to discourage high-speed turning movements, and, as a last resort, developing bicycle connections independent of the bridge in question;
- Safety upgrades at intersections;
- Bicycle-sensitive loop detectors in new installations and existing installations retrofitted where needed;
- Replacing bad drain grate standards with bicycle-safe models; replacing or modifying existing installations; and as a routine practice, consider bicyclists when locating new utilities;
- Providing smooth paved shoulders on all new construction and reconstruction; and
- Increasing bike parking regularly.

**Application:** Areas where travel distances (residential/work or retail sites, for example) are short enough for bicycle/pedestrian travel to be practical.

**Variables:**

- **AADT:** Average annual daily traffic in corridor (vehicles/day)
- **EF_{on}:** Speed-based running exhaust emission factor for participants' trip before participating in the bike/pedestrian program (NOx, VOC, or CO) (grams/mile)
- **HH_{HEL}:** Number of households in strategy area
- **HH_{TRIPS}:** Average number of trips per household in strategy area

B.11.3
L: Length of facility (miles)

PMS: Percentage mode shift from driving to bike/ped (decimal)

TLB: Average auto trip length before implementation (miles)

Equation:

For a facility parallel to an existing roadway:

\[ \text{Daily Emission Reduction} = \text{AADT} \times \text{PMS} \times L \times E_{FB} \]

The average annual daily traffic of the corridor multiplied by the percentage of drivers shifting to bike/ped multiplied by the length of the project facility multiplied by the speed-based running exhaust emission factor for participants' trip before participating in the bike/pedestrian program

Final unit of measure: grams/day
Source: CAMPO

For a facility without a parallel roadway:

\[ \text{Daily Emission Reduction} = \text{HH}_{AREA} \times \text{HH}_{TRIPS} \times \text{PMS} \times TLB \times E_{FB} \]

The number of households in the area affected by the strategy multiplied by the average number of household trips in the strategy area by the percentage of drivers shifting to bike/ped multiplied by the length of the project facility multiplied by the speed-based running exhaust emission factor for participants' trip before participating in the bike/pedestrian program

Final unit of measure: grams/day
Source: El Paso MPO

B.11.4
11.2 Bicycle and Pedestrian Support Facilities and Programs

Strategy: Enhance replacement of vehicle trips and VMT through provision of facilities for bicycle and pedestrian travel.

Description: Many support facilities are provided as part of employer-based transportation management programs and improving transit. They can include sidewalks, intersection improvements, sidewalk furniture, bicycle racks on buses, lockers and shower facilities, education, and promotions.

Application: Areas where travel distances (residential/work or retail sites, for example) are short enough for bicycle/pedestrian travel to be practical.

Variables:

- \( E_{F_5} \): Speed-based running exhaust emission factor for the average speed of participants' trip before participating in the bike/pedestrian program (NO\(_x\), VOC, or CO) (grams/mile)
- \( F_{Bw, 20v} \): Percentage of new participants in the bike/pedestrian programs who previously drove single-occupancy vehicles (decimal)
- \( N_{Bw} \): Number of new participants in the bike/pedestrian programs
- \( TEF_{AUTO} \): Auto trip-end emission factor (NO\(_x\), VOC, or CO) (grams/trip)
- \( TL_w \): Average auto trip length to work (miles)
- \( VMT_R \): Reduction in daily auto vehicle miles traveled
- \( VT_R \): Reduction in number of daily auto vehicle trips

Equation:

**Daily Emission Reduction** = A + B

\[
A = (VT_R \times TEF_{AUTO})
\]

Reduction in auto start emissions from trip reductions

\[
B = (VMT_R \times E_{F_5})
\]

Reduction in auto running exhaust emissions from trip reductions

B.11.5
Where,

\[ VT_R = N_{BW} \times F_{BW, 2C} \times 2 \text{ trips/day} \]

The number of bicycle and pedestrian program participants multiplied by the fraction of participants that shifted from single occupant vehicle use multiplied by two trips per day (round trip).

\[ VMT_R = VT_R \times TL_W \]

The vehicle trips reduced multiplied by the average auto commute trip length.

Final unit of measure: grams/day
Source: CalTrans/CARB
APPENDIX B

CMAQ Evaluation Method for HOV Facilities

In the State of Texas
The Texas Guide to Accepted Mobile Source Emission Reduction Strategies

Texas Department of Transportation

Prepared by the
Texas Transportation Institute
in cooperation with the
Texas Department of Transportation
and in association with
Environmental Protection Agency
Federal Highway Administration
Federal Transit Administration
Texas Commission on Environmental Quality

August 2003
4.0 HIGH-OCUPANCY VEHICLE FACILITIES

According to EPA, high-occupancy vehicle (HOV) lanes are one of the most frequently implemented mobile source emission reduction measures. HOV lanes are designated exclusively for use by vehicles with multiple occupants such as carpools, vanpools, and transit vehicles. Implementing HOV facilities can involve adding entirely new capacity or reallocating existing capacity. Along with a range of physical options, HOV facilities have operate options such as full-time HOV-only use, peak-time use, and reversing the travel direction of facilities during peak times. HOV lanes can increase transit use and car occupancy for work-related trips in congested urban travel corridors.

The most effective HOV lane improvements generally involve regional networks of linked lanes, with a system of supporting facilities and services. Historically, the most successful HOV applications have been along “radial” corridors into major central cities where HOV users can save at least 10 minutes travel time compared to using mixed traffic lanes. EPA studies show that HOV lanes are generally more effective if implemented along with transit improvements, park-and-ride lots, employer-based transportation programs, and commuter parking subsidies.

Because of substantial physical and financial requirements, state DOTs usually implement HOV lanes. Historically, EPA has found the typical time frame for implementing HOV lanes is 3 to 5 years for planning, design, and construction. Private or nonprofit authorities may construct and operate HOV facilities along the lanes of a toll road (high-occupancy toll, or HOT lanes). Operators can use discriminatory pricing strategies such as granting toll discounts to HOVs to promote utilization.

Potential land acquisition often determines feasibility and the time required to implement the project. Also, HOV project planning and design is a political process involving various parties, including political leaders, business groups, and citizen groups. Discussions and negotiation among them, while very important, may add time to the project.

HOV projects can be very expensive, depending on such factors as right-of-way acquisition or cost of land; bridge and overpass modifications; and interchange and ramp modifications to provide access. Total costs of some HOV projects have exceeded several hundred million dollars.

HOV impacts on air quality are fairly complex, but Los Angeles, San Francisco, Washington D.C., and Portland have documented emissions impacts from their HOV projects. Assessments of the effectiveness of HOV lane facilities in reducing system-wide emissions have generally found reductions amounting to less than 1 percent.
HOV lanes reduce air pollution emissions by reducing running and trip-end emissions. Reductions in running emissions are derived by increasing average speeds from low speeds in congested traffic to 50 mph in HOV lanes. Increasing the use of buses, vanpools, and carpools results in less VMT. If riders do not take additional trips, HOV lanes will also reduce trip-end emissions. However, if users of HOV lanes meet their pool or bus through a park-and-ride arrangement, these trip-end emissions may offset the reduced air emissions benefits. When calculating the effectiveness of HOV lanes in reducing emissions, trip-end emissions resulting from using linkages must be considered.

Two important factors in implementing a successful HOV program have been identified. Enforcement is critical. EPA studies show that early and substantial enforcement of HOV rules on a new facility is the best determinant of long-term public compliance. Also, education and marketing programs that promote the benefits and use of the HOV facilities, both during and after construction, increase potential users of the facility.
4.1 Freeway HOV Facilities

Strategy: Reduction of emissions by decreasing VMT and increased average speeds on the lane.

Description: Separate lanes on controlled access highways are created for vehicles containing a specified minimum number of passengers. The lane may be concurrent flow, barrier/buffer separated, or have a separate right-of-way.

Application: Highways in areas of traffic congestion with sufficient available right-of-way.

Variables:

AVO

Average vehicle occupancy of rideshare (persons/vehicle)

EFs: Speed-based running exhaust emission factor before implementation (NOx, VOC, or CO) (grams/mile)

EFH: Speed-based running exhaust emission factor on HOV facility (NOx, VOC, or CO) (estimate)

EFG: Speed-based running exhaust emission factor after implementation of HOV facility (general purpose lanes) (NOx, VOC, or CO) (estimate)

FRS: Percentage of people attracted to the HOV facility using rideshare (decimal)

FRS,sov: Percentage of people attracted to the HOV facility using rideshare that previously were vehicle drivers (decimal)

FT: Percentage of people attracted to the HOV facility using a transit vehicle (decimal)

FT,sov: Percentage of people using a transit vehicle that previously were vehicle drivers (decimal)

L: Length of HOV facility (miles)

Np: Total number of expected people using the HOV lanes per day

NPH: Number of peak hours (AM and/or PM)

TEF,auto: Auto trip-end emission factor (NOx, VOC, or CO) (grams/trip)

B.4.3
\( T_{L,R} \): Average auto trip length (miles)

\( V_{GP,A} \): Average hourly volumes on general-purpose lanes during peak hours after implementation of HOV facility

\( V_{GP,B} \): Average hourly volumes on general-purpose lanes during peak hours before implementation of HOV facility

\( V_{H,L} \): Average hourly volumes on HOV lanes during peak hours

\( V_{T,R} \): Reduction in number of daily automobile vehicle trips (estimate)

\( V_{M,T,R} \): Reduction in daily automobile VMT

**Equation:**

\[
\text{Daily Emission Reduction} = A + B + C + D
\]

\[
A = V_{H,A} \cdot (EF_B - EF_{H,A}) \cdot N_{PH} \cdot L
\]

*Change in running exhaust emissions from vehicles shifting from general purpose lanes to HOV lanes*

\[
B = (V_{GP,B} \cdot EF_B - V_{GP,A} \cdot EF_{GP,A}) \cdot N_{PH} \cdot L
\]

*Change in running exhaust emissions of vehicles in general purpose lanes as a result of vehicles shifted away from general purpose lanes*

\[
C = V_{T,R} \cdot TEF_{AUTO}
\]

*Reduction in auto start exhaust emissions from trip reductions*

\[
D = V_{M,T,R} \cdot EF_B
\]

*Reduction in auto running exhaust emissions from trip reductions*

Where,

\[
V_{T,R} = N_e \cdot (F_T \cdot F_{T,XX} + F_{B} \cdot F_{B,XX}) \cdot (1 - 1/AO_{SO})
\]

*Number of HOV users multiplied by the sum of the fraction of users selecting transit multiplied by the percentage that previously drove single occupant vehicles added by the fraction of users selecting ridesharing multiplied by the*
percentage that previously drove single occupant vehicles multiplied by the percentage of ridehikers that are passengers.

\[ VMT_R = VT_R \times TL_P \]

*Number of vehicle trips reduced multiplied by the average auto trip length*

Final unit of measure: grams/day
Source: CalTrans (adapted by Texas Transportation Institute)
APPENDIX C

Proposal for Soliciting Respondents to Answer an
In-Depth Survey on Bicycle/Pedestrian Travel

CATS will soon administer a Household Travel Survey (HHTS), which will provide the agency’s staff with data for calibrating its regional travel demand models. The data and the subsequent modeling efforts focus on private automobile and transit use. It would be useful for the agency to devote similar efforts to collecting data on bicycle/pedestrian travel.

Therefore, the author suggests the following be included in the HHTS:

1. A few rudimentary questions about bicycling/walking trips that the respondents make.

2. A question asking the respondent if s/he is willing to complete an additional survey (to be included as an appendix) that will ask for information on their non-motorized usage, preferences, etc.

Alternatively, the HHTS could simply provide “bicycle” as a separate category in the mode choice section of the travel diary. Including bicycling in the HHTS like this has the significant advantage of gathering bicycle survey data with one survey instrument and the same funding source(s) that is used to administer the HHTS. One disadvantage is a potentially small sample size. Bicycle mode share is small (on the order of 1%), so the HHTS would have to be very large in order to obtain reasonable sample sizes for all sorts of facilities. Including bicycling in an ideal travel demand model would necessitate an even larger sample size.

Route preferences could be addressed by asking respondents to draw their routes on a map, or (more simply) by providing a multiple-choice question for respondents to indicate the type of route (major street, bike path, no predominant type, etc.). Additional questions could inquire about riding conditions (weather, trip-chaining required, etc.), and alternate modes used.