

Alternative Modes as an Air Quality Mitigation Strategy

FINAL REPORT 566

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>					<u>LENGTH</u>				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
<u>AREA</u>					<u>AREA</u>				
in ²	square inches	645.2	square millimeters	mm ²	mm ²	Square millimeters	0.0016	square inches	in ²
ft ²	square feet	0.093	square meters	m ²	m ²	Square meters	10.764	square feet	ft ²
yd ²	square yards	0.836	square meters	m ²	m ²	Square meters	1.195	square yards	yd ²
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi ²	square miles	2.59	square kilometers	km ²	km ²	Square kilometers	0.386	square miles	mi ²
<u>VOLUME</u>					<u>VOLUME</u>				
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft ³	cubic feet	0.028	cubic meters	m ³	m ³	Cubic meters	35.315	cubic feet	ft ³
yd ³	cubic yards	0.765	cubic meters	m ³	m ³	Cubic meters	1.308	cubic yards	yd ³
NOTE: Volumes greater than 1000L shall be shown in m ³ .									
<u>MASS</u>					<u>MASS</u>				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")	Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
<u>TEMPERATURE (exact)</u>					<u>TEMPERATURE (exact)</u>				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
<u>ILLUMINATION</u>					<u>ILLUMINATION</u>				
fc	foot candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²	cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
<u>FORCE AND PRESSURE OR STRESS</u>					<u>FORCE AND PRESSURE OR STRESS</u>				
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

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GLOSSARY OF ACCRONYMS

ADOT	Arizona Department of Transportation
APCD	Air Pollution Control District
ATIS	Advanced Traveler Information Services
ATM	Automated Teller Machine
ATRC	Arizona Transportation Research Center
CAC	Clean Air Campaign
CARB	California Air Resources Board
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CTMA	Coronado Transportation Management Association
CTR	Commute Trip Reduction
DEQ	Department of Environmental Quality
DOT	Department of Transportation
ECO	Employee Commute Options program
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GRH	Guaranteed Ride Home (same as: Emergency Ride Home)
HC	Hydrocarbon
HOV	High Occupancy Vehicle
I/M	Inspection & Maintenance

MAG	Maricopa Association of Governments
MPO	Metropolitan Planning Organization
MTIP	Metropolitan Transportation Improvement Program
NO _x	Nitrous Oxide
PM ₁₀	Particulate Matter
P&R	Park & Ride
RSTP	Regional Surface Transportation Program
SANDAG	San Diego Association of Governments
SDF	State Dedicated Funding
SDRP	State Development and Redevelopment Plan
SIP	State Implementation Plan
SOV	Single Occupancy Vehicle
STP	Surface Transportation Program
TCM	Transportation Control Measures
TDA	Transit Development Act
TDM	Transportation Demand Management
TERM	Transportation Emission Reduction Measures
TIP	Transportation Improvement Program
TMA	Transportation Management Association
TRB	Transportation Research Board
TRP	Trip Reduction Program
VMEP	Voluntary Mobile Emission Reduction Program
VMT	Vehicle Miles Traveled

Executive Summary

The research conducted here did not point to a single model of how to facilitate the implementation of the most cost effective alternative mode strategies nor the role of state departments of transportation. This is because there is a broad range of experience and very limited comparative evaluation of the means to maximize the effectiveness of alternative modes.

There is no single, definitive “recipe for success.” The same set of strategies implemented at two different sites will likely produce different results due to site characteristics, traveler demographics, and the intangibles, such as political and management support and the “vigor” with which the program is marketed on a day-to-day basis.

It has been shown that financial incentives and disincentives exhibit several times the trip reduction of programs without subsidies and fees.

Alternative mode programs that involve the distribution of information about commute alternatives (such as transit schedules or ride-matching) or the provision of services (such as vanpool facilitation or shuttles) are far less effective in the absence of financial incentives and disincentives.

While transit plays an important part in many travel reduction programs, most of the impact of these programs has come from increases in carpooling and, to a lesser degree, gains in telecommuting.

There does not seem to be a correlation between the number of alternative mode strategies implemented and program effectiveness. In fact, some of the most effective programs are the simplest. For example, travel allowance programs are simple to administer and allow employees to make sound economic and personal decisions on the best commute alternative for their circumstances.

The key to marketing of alternative modes is tying such efforts to specific incentives and program elements (modes), as opposed to general information on modal alternatives. To do so, it is important to understand the behavior, demographics, and attitudes of the travelers that are being targeted. Another recommendation concerning marketing is not to underfund marketing efforts. Too often, good concepts are poorly used or poorly accepted because potential users were simply unaware of their existence or benefits.

The key seems to be having the knowledge and experience of what are the most effective and cost effective strategies, advising regions on this knowledge base, and then carefully evaluating the results of newer projects and programs to assess their effectiveness in a given context.

Several strategies might enhance the role of state DOTs in supporting the most cost effective alternative mode strategies that go beyond the pass-through of federal funds. Many of these strategies are focused on improving the coordination between various stakeholders, including state air agencies, regional planning organizations, and local service providers.

State DOTs can provide technical assistance to regional agencies in the evaluation of alternative mode projects to more accurately estimate the potential emission reductions. Many alternative mode projects are promoted as being able to achieve over-optimistically large reductions in emissions. State DOTs can provide objective guidance on how to project in advance and evaluate after implementation, the travel impacts of alternative mode strategies.

State DOTs can foster and undertake research into the cost effectiveness of alternative mode strategies implemented within their state and help develop better methods and procedures for quantifying the impacts during project planning, funding, and reporting. Washington state and Florida DOT each have ongoing, dedicated research programs to evaluate alternative mode programs and provide guidance to district offices, regional agencies, localities, service providers, and others.

While most alternative mode strategies are planned and implemented at the regional and local levels, state DOTs can also fund or facilitate several support activities to bolster efforts within the state. For example, some state DOTs (Connecticut, Michigan, New Mexico) coordinate fleet purchases of vanpools to lower the cost to the end user. Some underwrite vanpool insurance. Other states fund alternative mode pilot projects (Massachusetts, Oregon, and New York) to test new and innovative concepts that do not get funded under the Congestion Mitigation and Air Quality Improvement Program (CMAQ). Finally, some states fund statewide activities to provide services not being undertaken at the local level.

Finally, state DOTs control the management and operation of transportation facilities that affect how and when people travel and use their cars. Three notable facilities are HOV lanes, park-and-ride lots, and bicycle facilities on state roads. These facilities increase the convenience of ridesharing and using transit (park-and-ride), increase safety (bicycle lanes), and can provide travel time savings (HOV lanes) to alternative mode users. One major study of the HOV system in Los Angeles County pointed to the effectiveness of the HOV system, but the ongoing need to better coordinate HOV operations with ridesharing services and traveler information. Another area of integration is in highway reconstruction mitigation. Alternative modes are often a key part of the mitigation strategy for a major reconstruction project. However, states often perform this integration late in the planning process, not providing sufficient time or funding to realize the potential impacts of shifting travelers to alternative modes, routes, or time of day. State DOTs can develop clear guidelines for identifying candidate alternative modes and integrating these alternative modes into the planning process.

1. Purpose and Overview

1.1 Purpose

Many states, regions, localities and private entities promote the use of alternative modes, alternatives to single occupant automobile travel, for a variety of reasons. Private employers support the use of alternative commute modes among employees to address parking shortages or to provide new employee benefits. Some cities promote alternative modes to mitigate the impacts of new development on local streets. Regions often operate programs to promote alternative modes by offering vanpool and carpool matching services. Of interest to this research, many regions and states use the promotion of alternative modes as an air quality strategy. A reduction in the amount and timing of automobile travel is often one element of a region's air quality strategy.

In Arizona, the two largest urban areas, Maricopa and Pima Counties, each have travel or trip reduction programs, aimed at reducing automobile emissions by shifting commuters to alternative modes. The Arizona Department of Transportation (ADOT) commissioned this research to assess current experience with the use of alternative modes as an air quality mitigation strategy. This includes investigating what other state departments of transportation (DOTs) are doing to promote, support, and evaluate alternative modes. It is hoped that the information provided here will assist Arizona planners and program managers to inform state policy and provide the perspective and insights necessary for ADOT personnel to effectively communicate with their counterparts at the state's regional and local agencies and state air quality planners.

The research included in this report attempts to address the following questions:

- What are other states doing to promote and fund alternative modes? Why do they support alternative modes?
- What are the most effective and cost effective alternative mode strategies, in terms of emission reduction?
- How do the programs in Phoenix and Tucson compare with this national experience?
- What are some of the best practices for state DOT involvement in alternative modes?
- What practices, generally speaking, might ADOT consider enhancing or adopting?

This report is not an exhaustive treatise on each alternative mode strategy, nor air quality planning, nor current Arizona plans and programs. It should also be noted that the research did not include many of the technology-related strategies, such as inspection and maintenance of the current fleet, cleaner engines, alternative fuels, etc. The research focused on alternative modes

(carpool, vanpool, transit, telework, etc.) and the incentives/information to induce their use, often called Transportation Demand Management (TDM) programs. This research is intended to *highlight* the most cost effective alternative mode strategies and suggest an appropriate role for state DOTs.

1.2 Overview

The remainder of this report is organized into the following sections:

Section 2.0 provides a summary of the **research methodology** used to develop the best practices, findings, and recommendations of this report.

Section 3.0 presents **findings** from two key research elements: a literature review of relevant research on alternative mode strategy effectiveness and a summary of a survey of state DOTs and other agencies to assess the state of the practice in alternative mode promotion, funding, evaluation, etc. The literature review and survey summary are provided in the appendices. Information on the relevant programs in Phoenix and Tucson is also provided here.

Section 4.0 develops a set of **best practices**, both in terms of how to implement and support the most effective alternative mode strategies and in terms the role of state DOTs in doing so.

Section 5.0 suggests some **implications and recommendations** for ADOT, should it contemplate enhancement or expansion of programs and policies to support alternative modes.

2. Research Methodology

This research was conducted for the Arizona Transportation Research Center (ATRC). The research involved three distinct steps to collect information on the use and promotion of alternative mode strategies for air quality mitigation. These three steps included:

1. Preparation of a **literature review** on alternative modes as an air quality strategy (included as Appendix A).
2. Administration of a **survey** of state DOTs and other agencies to assess current practices and opinions (summary included in Appendix B).
3. **Expert review** of the literature review and survey summary by national experts on the topic.

Each research element is described below.

2.1 Literature Review

An initial task was to summarize the current knowledge base on alternative modes as an air quality strategy, in terms of what is most effective and cost effective in reducing emissions. It started with providing a typology of alternative mode strategies (provided in Section 3.0) and discussed some of the limitations of the existing research. The literature review included some 24 references from the United States and Europe. Two of the most important citations included a recent congressionally mandated assessment of the federal Congestion Mitigation Air Quality Improvement Program (CMAQ), the primary funding source for alternative mode programs in the United States and an evaluation of the *relative* cost effectiveness of some 60 transportation control measures in California. The main findings from the literature review are summarized in Section 3.0.

2.2 Survey of State Departments of Transportation

While the literature review encapsulated the known empirical findings on what works best to reduce emissions via alternative mode strategies, a survey of state DOTs created a snapshot of what states are currently doing to promote and fund alternative mode strategies and which strategies respondents felt are the most effective.

The survey was sent to 18 state DOTs that had known TDM programs and/or staff dedicated to TDM and alternative modes. This was done to assure that a specific person could be identified to complete the survey. The survey was also sent to two federal agencies and two metropolitan planning organizations (MPOs). Follow-up was conducted after the e-mail survey was sent to maximize the response rate. Responses were received from eight DOTs and the two MPOs as follows:

- Washington state DOT
- Oregon DOT
- Colorado DOT

- New Mexico (via MPO)
- Georgia DOT
- New York State DOT
- New Jersey DOT
- Massachusetts Highway Department
- San Diego Association of Governments
- Metropolitan Washington (DC) Council of Governments

The state DOTs represented by the responding states seem to be a good cross-section of the range of programs and policies exhibited across the United States. Some respondents described rather minimalist programs, in terms of DOT involvement, while others involved very specific statewide policies, special funding, and technical support. Unfortunately, the quality of the responses varied as some respondents misinterpreted questions and others chose not to respond to certain questions. Overall, however, the survey results provide a good snapshot of the kinds of programs and policies supported by states.

2.3 Expert Review

Once the literature review and survey results were compiled, a set of national experts in alternative modes and air quality were sent the information to provide comments on the findings, recommend best practices, and to suggest conclusions and recommendations for this final report. The expert review panel included:

- Barbara Joy, Consultant, EarthMatters Environmental Consulting, Prescott, AZ, expert in emissions analysis of Transportation Control Measures (TCMs) and State Implementation Plan (SIP) development.
- Philip Winters, TDM Program Manager, Center for Urban Transportation Research, University of South Florida, Tampa, FL, director of National TDM and Telework Clearinghouse.
- Lori Diggins, Consultant, LDA Consulting, Washington, DC, evaluator of emission reductions from TDM programs in Washington, DC, Atlanta, GA, and Los Angeles, CA.
- Kevin Shannon, Manager, Center for Transportation and the Environment, Atlanta, GA, manager of Atlanta regional Voluntary Mobile Emission Reduction Program (VMEP) evaluation and Executive Director, Association for Commuter Transportation.

The input from these experts is included in the findings, best practices, and recommendations provided in the next sections.

3. Research Findings

The findings from the research described in Section 2.0 can be organized into three elements:

- Typology – what are alternative mode strategies?
- Effectiveness – what works best at reducing emissions?
- Involvement – what is the role of state DOTs?

Included in this last element is a description of the alternative mode programs in the Phoenix and Tucson regions.

3.1 Typology of Alternative Mode Strategies

An important first step in the research was to define what is meant by alternative modes. The literature review provided a typology of the relevant alternative mode strategies, is updated per the expert review, and is provided below.

Alternative travel modes involve defining a range of non-single occupant vehicle (SOV) modes, incentives to use them, and supporting strategies to promote and facilitate their successful use. Increasing alternative travel mode use is at the core of Transportation Demand Management (TDM).

TDM is a variety of strategies to influence travel behavior by mode, cost, time, or route in order to reduce the number of vehicles and to provide mobility options. TDM strategies are often applied to achieve public goals such as reduced traffic congestion, improved air quality, and decreased reliance on energy consumption. TDM strategies are also used by employers to reduce overhead costs, enhance productivity, and address other business problems, such as employee turnover¹.

Some of these strategies have also been referred to as Transportation Control Measures (TCMs) as per the federal Clean Air Act.

Alternative travel *modes* include:

- Carpooling.
- Vanpooling.
- Public transit (bus, bus rapid transit, light rail, commuter rail, shuttles).
- Bicycling.
- Walking.

In addition to these alternatives, many TDM programs also promote *alternative work arrangements*:

- Flex-time.
- Compressed work weeks.

¹ <http://www.nctr.usf.edu/clearinghouse/tmterms.htm>

- Telecommuting.
- Decentralized work centers.

Some also include the use of alternative fuel vehicles for higher occupancy modes, such as compressed natural gas (CNG) buses or electric neighborhood car-sharing vehicles.

Incentives to use these alternative modes and work arrangements often include:

- Financial incentives (subsidies, travel allowances).
- Time incentives (high occupant vehicle, or HOV, lanes).
- Tax benefits (Commuter Choice).
- Preferential treatment (carpool and vanpool parking).
- Disincentives (parking fees, etc.).

Support strategies include:

- Regional ridesharing (ride-matching) services.
- Advanced Traveler Information Systems (ATIS).
- Assistance to employer travel reduction programs.
- Marketing and promotion of alternative modes.
- Other strategies tied to an alternative mode (e.g., vanpool leasing).

The literature review also identified some related strategies that affect alternative mode use for which limited empirical evidence exists as to their effectiveness in reducing emissions. These strategies might be termed “prospective” alternative mode strategies and include:

- Land use/transportation coordination – a potentially long-term strategy for reducing car travel and travel distance by encouraging, for example, transit-oriented development.
- Location-based mortgages – providing mortgage rate reductions for homes with good transit access that could reduce the need for one or more automobiles and related transportation costs.
- Car-sharing – cooperative arrangements to provide for short-term use of an automobile within neighborhoods or at rail stations, potentially reducing the need for an extra automobile.
- Individualized marketing – individualized travel planning that encourages people to make better decisions about the need for and timing and mode of travel. These programs have shown some encouraging evidence of trip and vehicle miles of travel (VMT) reduction, especially in terms of transit ridership per capita.
- Proximate commuting – allowing employees of large companies, such as banks, to work at branch offices closer to home, so as to reduce VMT.

3.2 Alternative Mode Effectiveness and Cost Effectiveness

An extensive literature review was conducted at the outset of the research to assess the level of knowledge regarding how effective alternative mode strategies are in reducing emissions. Before summarizing the findings, it should be noted that the evidence is based on a very limited number of studies. This is partly due to the fact that most alternative mode projects and programs are not rigorously evaluated to assess travel and emission impacts. For funding approvals, the emission reduction potential of most projects is forecast and these projections often become de facto results. The literature review (Appendix A) provides a discussion of the other limitations of the empirical evidence presented here.

It should also be stated that the results reported for any one region or alternative mode program are highly dependent on context, i.e., where and how programs were implemented. The most important information comes from syntheses, from which findings about alternative mode strategies implemented in a variety of settings and contexts may be generalized.

One major finding from the literature review was the differential between which alternative mode strategies were the most prevalent and which were the most cost effective. ***The research suggests that the most cost effective strategies were often the least prevalent***, in terms of funding allocated and the number of projects implemented.

One early study of the range of TCMs being implemented in response to the Clean Air Act Amendments of 1990 listed the most prevalent TCMs as being: traffic flow improvements, HOV lanes, employer-based transportation management (alternative modes), and vehicle use limitations/restrictions. The least prevalent TCMs were related to public transit and bicycle and pedestrian modes.² Therefore, more attention was being paid to *controlling vehicles* than promoting and managing alternative modes. A later study of the CMAQ funding program showed that three-quarters of all funding was going to transit and traffic flow improvements.³ Somewhat in contrast to the earlier study, transit projects (service expansion and capital acquisition) accounted for 44% of all CMAQ dollars spent, but only 21% of the projects.

So what were the most cost effective alternative mode strategies? The Transportation Research Board (TRB) CMAQ evaluation examined some 20 types of projects, broadly categorized as:

- Traffic flow improvements.
- Ridesharing.
- Transportation Demand Management.
- Telework.
- Bicycle/pedestrian.
- Transit improvements.

² Texas Transportation Institute, *The Use and Evaluation of Transportation Control Measures*, TTI Report 1279-6, September 1994.

³ Transportation Research Board, *The Congestion Mitigation Air Quality Improvement Program: Assessing Ten Years of Experience*, Special Report 264, National Academies, 2002.

- Fuels and maintenance.
- Pricing measures.

One part of this evaluation compared findings from almost 140 CMAQ-funded projects from all these categories. This assessment looked at projects for which actual impacts had been quantified. This may be the most rigorous, consistent, and thorough synthesis of emission-reduction cost effectiveness undertaken to date. It ranked the project types by the cost per pound of combined pollutants reduced as follows:

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Traffic signalization	\$10.05/lb.
Employer trip reduction	\$11.35/lb.
Conventional transit service upgrades	\$12.30/lb.
Park-and-ride lots (rideshare and transit).....	\$21.50/lb.
Modal subsidies and vouchers	\$23.30/lb.
New transit capital systems/vehicles	\$33.20/lb.
Bicycle and pedestrian programs	\$42.05/lb.
Shuttles, feeders, and paratransit	\$43.75/lb.
Freeway/incident management	\$51.20/lb.
Alternative fuel buses	\$63.20/lb.
HOV facilities	\$88.10/lb.
Telework	\$125.90/lb.

Therefore, among the top 10 strategies, *the most cost effective* alternative mode strategies are:

- Regional ridesharing programs (including carpool matching).
- Pricing programs (including parking pricing and congestion pricing).
- Vanpool programs.
- Miscellaneous TDM programs (efforts to promote alternative modes).
- Conventional transit service improvements (new lines, more frequency).
- Employer trip reduction.

Among *the least cost effective* strategies are:

- Telework programs.
- Transit shuttles or feeder lines.
- Bicycle and pedestrian facilities and programs.

Again, this evaluation made a key policy finding which concluded that the majority of CMAQ funds have been allocated to the least cost effective strategies, with a few exceptions (bicycle/pedestrian programs and telework). The analysis showed that as a group, traffic flow projects received 33% of all funds, but resulted in a cost per pound reduced of \$42.70. Rideshare programs accounted for only 4% of all funds, yet reduced a pound of emissions for \$10.25. Likewise, miscellaneous TDM programs accounted for 3% of all CMAQ funds but reduced a pound of emissions for \$7.66. Transit service improvements and new services (not including alternative fuels) as a group, were somewhere in the middle, receiving 28% of funding and reduced a pound of emissions for \$29.80.

This assessment seems to tell us three distinct things. First, projects that attempt to improve and enhance the availability of alternative modes (carpool matching, vanpools, transit service expansion), and promote options (TDM, employer programs), are among the most cost effective strategies. Second, the most cost effective strategy relates to technology improvements in automobiles, enhanced inspection and maintenance (I/M). This was by far the most cost effective strategy to reduce emissions. It can also be said that these technology-based strategies tend to deliver more total emissions reductions than alternative mode strategies that often reduce pollution by less than 1 ton per day. This is very important, because as the automobile fleet gets cleaner (via tailpipe standards, I/M, and alternative fuels), the benefits of VMT reduction measures diminish over time. Finally, funding decisions are not being made using this information as some of the more cost ineffective projects were receiving a disproportionate amount of funding. Many of these findings were corroborated by other, less extensive studies.

Finally, the literature review examined the cost effectiveness of alternative mode strategies as compared to other mobility solutions. The evidence is very scant here, but a handful of studies point to the comparative cost effectiveness of reducing vehicle trips and VMT via the promotion of alternative modes rather than by accommodating trips on new highway or transit capacity. This is not surprising when capital costs are included in the cost effectiveness analysis.

3.3 Involvement of State Departments of Transportation

Knowing the theoretic or empirical effectiveness of alternative mode strategies is only valid when viewed through the lens of practical experience and the policy environment in which the measures are considered and implemented. In order to assess the experience of other state DOTs with promoting, funding, and implementing alternative mode strategies, a survey was undertaken to assess the range of practices in these areas. Information was also gathered from a number of regional programs, the level at which most alternative mode programs are implemented.

Inquiries were made of eight state DOTs in the following areas:

- Policies and programs related to alternative modes.
- Relationship to air quality.
- Other policy objectives addressed via alternative modes.
- Funding.

- Relationship to alternative mode service providers.
- Agency opinions as to the most cost effective alternative mode strategies.

Not surprising, there is considerable variation in the nature and extent of support for alternative modes, even among these states with known statewide policies and programs. Before presenting any findings, it should be recognized that in most states, decisions as to which alternate modes will be an integral part of a region's transportation system are made at the regional and local level. Likewise, air quality plans are developed at the regional level. Most states, therefore, play a more reactive role in managing the flow of federal funds (CMAQ) and approving regional transportation and air quality plans.

So what roles are state DOTs playing? Some states have clear mandates and policies for the role of alternative modes. Washington state DOT provides assistance to urban areas subject to Commute Trip Reduction regulations requiring employer's to reduce trips and VMT to their worksites. New York and New Jersey have statewide TDM policies that provide an overall framework for the role of alternative modes in state programs. The state of Florida (not included in the survey) has a TDM policy within its statewide long-range plan. This also provides a framework for the technical and financial assistance Florida DOT provides to regional and local Commuter Assistance Programs. Florida DOT also supports research into alternative mode effectiveness and program evaluation. Georgia DOT funds an independent evaluation of all alternative mode strategies in the Atlanta area to account for CMAQ funds spent and assess emission reductions toward the region's attainment strategy.

Other states view their role as more of a pass-through of federal CMAQ dollars to fund related activities. Some view alternative modes as an important mitigation strategy for highway reconstruction projects. Several states maintain specific offices or staff positions for TDM coordination. It is not surprising that states in the Northeast tend to promote the use of their established transit networks as the primary alternative mode, while western states tend to support carpooling and vanpooling. Several states also have statewide telework initiatives.

However, in most cases, alternative modes were not being supported primarily for air quality reasons. Congestion relief was the most oft cited reasons for supporting alternative modes, followed by improved efficiency of existing infrastructure. Air quality improvement was viewed as an additional benefit. This is reflected in the fact that alternative modes are seldom the keystone of a region's air quality plan. Rather, they are listed as reasonably available control strategies that contribute to maintenance or conformity, but are not listed as a primary control measure for attainment.

Most states use CMAQ funds to support alternative mode initiatives. Colorado and Washington state have dedicated substantial resources to support alternative modes as part of highway reconstruction projects, not just to mitigate the impacts of construction, but to increase the use of alternative modes on the new facilities. New Jersey uses CMAQ dollars (\$4.2 million per year) to fund Transportation Management Associations throughout the state that provide services to residents, commuters, and employers. Others provide funding for demonstration projects to

assess the impact of innovative alternative mode strategies. Some states, Washington and Oregon, have special state funding to support TDM.

States tend, to varying degrees, to work closely with transportation service providers (e.g., ridesharing programs, transit, and vanpool providers, etc.), to provide technical support, grants administration, and to integrate alternative modes into state plans and programs. These providers and regional programs, however, view the primary role of the state as the source of funding and grant administration.

Finally, when asked which alternative mode strategies were the most cost effective, the responses varied considerably and were not, to a large part, supported by empirical evidence or specific evaluation studies. The most effective modes were listed as vanpooling and transit, and the most effective strategy to encourage their use was cited as incentive programs to provide a financial incentive for trying or maintaining an alternative mode (supported in Georgia and Colorado).

The programs in Maricopa County and Pima County are illustrative of the kinds of alternative mode strategies being implemented for both air quality and other policy objectives. The programs in the Phoenix and Tucson regions are very briefly summarized below:

Maricopa County/Phoenix

The TDM program in the Phoenix region is operated by Valley Metro, the regional transit agency. Maricopa County has had a Trip Reduction Program (TRP) requirement for employers and schools with 50+ employees/students for almost 15 years. Valley Metro also markets and provides public education to promote alternative modes through the Clean Air Campaign (CAC). The CAC has a public relations component as well as a modest paid media campaign that utilizes radio, billboards, on-line advertising, bus-side advertising and, at times, television and print. The pollutants driving Maricopa County's trip reduction efforts are carbon monoxide (CO), ozone, and particulate matter under 10 microns (PM₁₀). Maricopa County is close to being in full compliance with CO and the former one-hour ozone standard, but is still out of compliance under the new eight-hour standard for ozone and PM₁₀.

Phoenix uses about \$1.6 million federal CMAQ funds (via the Maricopa Association of Governments - MAG) to support most of the TDM and TRP. They also get a grant of about \$850,000 from Arizona Department of Environmental Quality (ADEQ) to help fund TRP and CAC activities. ADOT also provides a \$42,000 grant to support the CAC. MAG has also funded a telework and special ozone education program over the past several years at about \$300,000 per year, as well as a bicycle education program of about \$120,000 per year.

Program services include: carpool matching, transit information, a subsidized vanpool program with formation assistance and services (including the vehicle, insurance, etc.), a significant telework campaign, and assistance to employers that need to comply with the TRP regulations. Annual surveys

of valley residents reveal that 45% of commuters use alternative modes (including compressed work weeks and telework) at least one day each week.

TDM managers feel that the most effective alternative mode strategies include telework promotion and vanpooling. They estimate that telework participation is currently between 12 and 15% of nonhome-based employees. There are over 200 vanpools operating in the region. Valley Metro used Federal Transit Administration (FTA) capital funds to buy the vans and uses federal transit funds for public transit in urbanized areas (generated by vanpool miles) to maintain low vanpool fares. Some 85% of these vanpools are employer subsidized as well. Program managers also felt that employment sites that have benefited from transit service improvements are more likely to provide transit subsidies. Finally, marketing and advertising is important to reach the 60% of employment not covered by the TRP and to maintain alternative mode use as people move in and out of various arrangements.

Pima County/Tucson

The TDM program in the Tucson region is operated by the Pima Association of Governments and is divided into several components, including the Travel Reduction Program (employer requirements similar to that in the Phoenix area), the RideShare program, a voluntary No-Drive Day clean air program, and other efforts. Pima County is under a Limited Maintenance Plan for CO, which includes continuation of their Travel Reduction Program requirements at almost 270 worksites. The average "alternative mode use" is about 30% of employees at participating employers. In addition to energy (gas savings) and air quality impacts, the program reports it reduces the need for over 12,000 parking spaces in region.

Pima County does not receive CMAQ funding, and thus uses a variety of federal (Surface Transportation Program, STP, and FHWA), state and local monies to fund its TDM efforts. TDM program services include ride-matching, a "schoolpool" program, vanpool subsidies, and employer outreach activities. Many employers in the region subsidize bus passes, and the region has been converting its bus fleet to cleaner vehicles over the past several years. Telework is also a major part of the region's alternative mode efforts with many large employers part of the Governor's Telework Partnership.

Program managers in Tucson point to several successful alternative mode strategies, based on their experience with the Travel Reduction Program. They feel that the Guaranteed Ride Home service has helped increase ridesharing and transit use; flexible work schedules are low cost solutions that employees like; and subsidizing and selling bus passes on-site adds convenience as does having on-site amenities (e.g., automated teller machines, ATMs). Tucson also sees more potential for its vanpool program and the \$400 per month subsidy provided to eligible vanpools.

4. Best Practices

The research conducted here did not point to a single model of how to facilitate the implementation of the most cost effective alternative mode strategies nor the role of state departments of transportation. This is because there is a broad range of experience and very limited comparative evaluation of the means to maximize the effectiveness of alternative modes. Having said this, the research did uncover various practices and programs that have worked in some areas and these “pieces of the puzzle” may create future synergies in places like Arizona. Specific recommendations are provided in the next section.

The best practices can be divided into two categories:

- Suggestions on implementing the most cost effective alternative mode strategies.
- Strategies to enhance the role of state DOTs.

4.1 Implementing Cost Effective Alternative Mode Strategies

The TRB study extensively cited in this research enumerated several alternative mode strategies among the most cost effective in reducing emissions (\$3.70 - \$12.30 per pound of pollutants reduced), including:

- Regional ridesharing programs (including carpool matching).
- Vanpool programs and subsidies.
- Employer trip reduction programs.
- Pricing strategies (including parking and congestion pricing).
- Conventional transit service improvements.

However, this listing alone does not provide the necessary information to select the most appropriate set of alternative mode strategies for a region. Some other factors include:

- **There is no single, definitive “recipe for success.”** The same set of strategies implemented at two different sites will likely produce different results due to site characteristics, traveler demographics, and the intangibles, such as political and management support and the “vigor” with which the program is marketed on a day-to-day basis.
- The literature repeatedly points to the **effectiveness of financial incentives and disincentives**. In fact, it has been shown that programs employing such financial strategies exhibit several times the trip reduction of programs without subsidies and fees. Indirect subsidy programs, such as point and award systems also seem to be effective.
- Alternative mode programs that involve the distribution of **information** about commute alternatives (such as transit schedules or ride-matching) or the **provision of**

services (such as vanpool facilitation or shuttles) are **far less effective** in the absence of financial incentives and disincentives.

- While transit plays an important part in many travel reduction programs, especially where transit service is good, most of the impact of these programs has come from **increases in carpooling** and to a lesser degree gains in telecommuting. Vanpooling programs with subsidies are often very cost effective because they reduce a disproportionately large number of miles of travel and emissions due to the longer commute distances of most vanpoolers.
- There does not seem to be a correlation between the **number of alternative mode strategies** implemented and program effectiveness. In fact, some of the most effective programs are the simplest. For example, travel allowance programs are simple to administer and allow employees to make sound economic and personal decisions on the best commute alternative for their circumstance.
- The key to marketing of alternative modes is tying such efforts to **specific incentives and program elements (modes)**, as opposed to general information on modal alternatives. To do so, it is important to understand the behavior, demographics and attitudes of the travelers that are being targeted. This is true of any marketing effort – the need to focus your message on the target audience. Another recommendation concerning marketing is not to underfund marketing efforts. Too often, good concepts are poorly used or poorly accepted because potential users were simply unaware of their existence or benefits.

Again, the key seems to be having the knowledge and experience of what are the most effective and cost effective strategies, advising regions on this knowledge base, and then carefully evaluating the results of newer projects and programs to assess their effectiveness in a given context.

4.2 Strategies to Enhance the Role of State DOTs

Several strategies might enhance the role of state DOTs in supporting the most cost effective alternative mode strategies that go beyond the pass-through of federal funds. Many of these strategies are focused on improving the coordination between various stakeholders, including state air quality agencies, regional planning organizations, and local service providers. These include:

- Technical assistance.
- Research.
- Funding.
- Integration.

First, state DOTs can **provide technical assistance** to regional agencies in the evaluation of alternative mode projects to more accurately estimate the potential emissions reductions. Many alternative mode projects are promoted as being able to achieve over-optimistically large reductions in emissions. State DOTs can provide objective guidance on how to project in advance and evaluate after implementation, the travel impacts of alternative mode strategies, since VMT reduction is at the

heart of emission analysis. This can be made easier for other agencies through the development of software and on-line reporting that allows users to input simple data enabling the calculation of travel and emission impacts. State DOTs can take a leadership position in: 1) setting state-wide policy of the role of alternative modes in addressing air quality and other policy issues, 2) forming ideas on alternative mode projects, 3) providing insights in realistic emission reduction potential, 4) provide insights on funding restrictions applicable to these types of strategies, 5) communicating and coordinating with state air quality or health agencies, and 6) obtaining information from other states and national sources of information on alternative modes.

Next, state DOTs can **foster and undertake research** into the cost effectiveness of alternative mode strategies implemented within their state and help develop better methods and procedures for quantifying the impacts during project planning, funding, and reporting. Washington state and Florida DOT each have ongoing, dedicated research programs to evaluate alternative mode programs and provide guidance to district offices, regional agencies, localities, service providers, and others. Each maintains a TDM resource center for this purpose. Washington state biennially reports on the progress of its Commute Trip Reduction mandate to the state legislature, including what are the most effective strategies and how much it is costing employers to comply. The University of South Florida maintains the National TDM and Telework Clearinghouse for FDOT and FTA.

While most alternative mode strategies are planned and implemented at the regional and local levels, state DOTs can also **fund or facilitate several support activities** to bolster efforts within the state. For example, some state DOTs (Connecticut, Michigan, New Mexico) coordinate fleet purchases of vanpools to lower the cost to the end user. Some underwrite vanpool insurance or purchase ride-matching software and maintenance agreements. Other states fund alternative mode pilot projects (Massachusetts, Oregon, and New York) to test new and innovative concepts that do not get funded under CMAQ, but are worth exploring. Finally, some states fund statewide activities to provide services not being undertaken at the local level. Some state DOTs have performed ride-matching and information services in parts of the state not covered by existing programs. Others have funded statewide initiatives (rideshare week, bike-to-work week) or air quality public education campaigns (like Clean Across Texas, www.drivecleanacrosstexas.org).

Finally, state DOTs control the management and operation of transportation facilities that affect how and when people travel and use their cars. Three notable facilities are HOV lanes, park-and-ride lots, and bicycle facilities on state roads. These facilities increase the convenience of ridesharing and using transit (park-and-ride), increase safety (bicycle lanes), and can provide travel time savings (HOV lanes) to alternative mode users. The FHWA is redefining TDM as less of a planning function, and more of a set of strategies to be **integrated into the management and operations of transportation facilities** to improve the overall efficiency and effectiveness of the system. One major study of the HOV system in Los Angeles County pointed to the effectiveness of the HOV system, but the ongoing need to better coordinate HOV operations with ridesharing services and traveler information.⁴ Another area of integration is in highway reconstruction mitigation. Alternative modes are often a key part of the mitigation strategy for a major reconstruction project. However, states often

⁴ Metropolitan Transportation Authority, *HOV Performance Program*, Final Report, July 2002.

perform this integration late in the planning process, not providing sufficient time or funding to realize the potential impacts of shifting travelers to alternative modes, routes, or time of day. Some states, including California, have built transportation management planning functions into the overall planning process for reconstruction projects. State DOTs can develop clear guidelines for identifying candidate alternative modes and integrating alternative modes into this process.

5. Implications and Recommendations for ADOT

The purpose of this research was to examine the effectiveness of alternative modes as an air quality strategy. It also examined the role of state DOTs in supporting alternative modes for air quality. While not a primary objective of the research, this approach naturally leads to recommendations for ADOT and other DOTs wishing to enhance or expand their support of alternative modes. Some immediate recommendations include:

- Recommendation #1 ADOT could develop a statewide policy regarding alternative modes and their role in addressing air quality objectives as well as other issues such as congestion, growth management, asset management, etc. This might give ADOT a better foundation for commenting on CMAQ project selection decisions.
- Recommendation #2 ADOT should use the results of this research and the national studies it summarizes to provide enhanced technical assistance to regional agencies in Arizona with responsibility for planning and programming of TCMs. This could be in the form of guidance and calculation software to allow for realistic and accurate estimate of VMT and emission reductions. Most people making these decisions would welcome objective, up-to-date information on what works best for the lowest cost per ton reduced. ADOT could also more actively participate on CMAQ funding committees making these decisions.
- Recommendation #3 To accomplish this assistance, ADOT should assign one person from its headquarters staff (help-desk) and district offices to maintain the information and knowledge in this area and be the liaison to regional agencies and other state and federal agencies. Alternatively, several staff could be assigned to provide guidance, answer questions, and perhaps maintain a page on ADOT's website.
- Recommendation #4 ADOT should fund future research on evaluating the cost effectiveness of alternative mode strategies being implemented in Maricopa County and Pima County and similar urban areas in the west. One specific research project could analyze the employer trip reduction datasets (multiyear program and employee travel data from hundreds of mandated worksites) from these two regions to assess the types of alternative mode strategies that employers can implement that results in the greatest increase in alternative mode usage. Arizona can also participate in national efforts to improve the reporting of CMAQ project effectiveness, should they

be included in the next set of CMAQ guidelines. Arizona could be an early adopter of a stronger role for evaluation of CMAQ funded projects. This will provide ADOT with easily digestible information (tables and charts) for future planning and decision-making.

Recommendation #5 ADOT can implement a statewide program to promote alternative modes in general (such as the “Drive Clean Across Texas” campaign), and specifically, provide alternative mode information in areas outside the two major urbanized counties.

Clearly, ADOT can also consider some of other roles outlined in Section 4.2, in terms of special funding and integration into management and operations of the state system. However, the recommendations listed above provide for an immediate use of the findings of this research.

Appendix A – Literature Review

1.0 Introduction and Purpose

The overall purpose of this research effort is to assess the involvement of state departments of transportation (DOTs) in facilitating the use of alternative modes (to the single occupant vehicle, or SOV) as an air quality mitigation strategy. At the heart of this research is the question: which alternative mode strategies are most effective and cost effective in reducing harmful automobile emissions? The answer to this question, an assessment of the best practices of other states and government entities will be made and will form the primary product of the research.

The first substantive step in this effort is a review of existing research via a literature review. The literature review is designed to establish what is known about the use of alternative modes as an air quality strategy. It does not attempt to describe *who* is doing what in this regard, as no existing source was found on the incidence of alternative mode strategies among state DOTs. The literature review focuses primarily on the known cost effectiveness of alternative mode strategies in reducing emissions. In addition, some information is provided on the types of strategies that are most prevalent. The literature review also points to several shortcoming in the existing knowledge base in terms of what has been evaluated to date and how.

This information will be used to formulate the best practices, findings, and recommendations of this study. It also helps to identify key states and other entities to survey as part of the next research task.

One issue to be clarified up front regards the use of measured impact information. This research will ultimately base its best practices and findings on the documentation of actual experience and the measurement of emission reductions from implemented projects and programs. Most alternative mode programs, services, and pilot projects need to project potential emission reduction expected for funding approval. However, as is discussed later, many of these projections overestimate emission reductions. Future policy and funding decisions should be made on the basis of actual experience and empirical evidence. Therefore, this research focuses its findings and recommendations on actual and not projected impacts. While this limits the number of sources of information from which to draw conclusions, it should make those conclusions more realistic and replicable.

This literature review was based both on existing research studies, technical papers, and program evaluations (see Section 6.0) and on other literature reviews conducted for similar studies. (1, 8, 13, 17, 22)

The remainder of this literature review is organized into six more sections as follows:

- Section 2.0 provides the typology of alternative mode strategies included in the work plan and discusses related findings from the literature.

- Section 3.0 discusses some of the limitations of the existing knowledge on the comparative cost effectiveness of alternative mode strategies.
- Section 4.0 provides findings from the literature to assess which alternative mode strategies are the most cost effective.
- Section 5.0 includes some brief summary remarks.
- Section 6.0 enumerates the sources used in this literature review.

2.0 Typology of Alternative Mode Strategies

Background - Alternative travel modes involve defining a range of non-SOV modes, incentives to use them, and supporting strategies to promote and facilitate their successful use. Increasing alternative travel mode use is at the core of Transportation Demand Management (TDM). Some of these strategies have also been referred to as Transportation Control Measures (TCMs) per the federal Clean Air Act.

Alternative travel *modes* include:

- Carpooling.
- Vanpooling.
- Public transit (bus, bus rapid transit, light rail, commuter rail, shuttles).
- Bicycling.
- Walking
- Car-sharing.

In addition to these alternatives, many TDM programs also promote alternative work arrangements (flex-time, compressed work weeks, telecommuting, and decentralized work centers) and using alternative fuel vehicles for higher occupancy modes (such as compressed natural gas, or CNG, buses or electric neighborhood car-sharing vehicles).

Incentives to use these alternative modes often include:

- Financial incentives (subsidies).
- Time incentives (HOV lanes).
- Tax incentives (the Commuter Choice program).
- Preferential treatment (carpool and vanpool parking).
- Disincentives (parking fees, etc.).

Support strategies include:

- Regional ridesharing (ride-matching) services.
- Traveler information services (Advanced Traveler Information Systems).
- Assistance to employer travel reduction programs.
- Other strategies tied to an alternative mode (e.g., vanpool leasing).

Results from Literature Review – This typology of alternative mode strategies seems to be fairly consistent with other documents that categorize and evaluate travel or emission reduction strategies. There are a few exceptions. Some documents that focus on emission reduction include other strategies that reduce emissions, but not by encouraging travels to use an alternative mode. This might include alternative fuel programs to promote cleaner cars, traffic signalization, and freeway management measures that improve traffic flow and reduce idling, and inspection and maintenance programs. (22) These items will not be included within this study.

Some studies specifically delineate capital improvement projects related to alternative modes, such as HOV lanes, transit vehicles/systems or park-and-ride lots. (2, 16, 20, 22, 23) To the extent possible, these strategies are included in this review, based on the very limited evidence. More information is available on strategies that encourage or provide incentives for the use of these facilities, such as bus subsidies or other financial incentives to use alternative modes.

Many studies focus on alternative mode strategies as applied to employer worksites and commute travel. (3, 5, 6, 7, 8, 9, 10, 13, 17, 19). This is likely due to several reasons. First, there is a long history of experience with employer-related alternative mode strategies dating back to the mid-1970s. Second, alternative mode strategies tend to work best with commute travel, as the scheduling and opportunity for new group travel is greater than other trip purposes. Finally, among all the TCMs included in the Clean Air Act Amendments of 1990, only Employee Commute Options programs were mandated for some urban areas. This focused attention on the actual costs and impacts of these programs.

Finally, other studies introduce related strategies that affect alternative mode use for which little or no empirical evidence exists as to their effectiveness in reducing emissions. These strategies might be termed “prospective” alternative mode strategies and include:

- Land use/transportation coordination – potentially long term strategies for reducing car travel and travel distance by encouraging, for example, transit-oriented development.
- Location efficient mortgages – providing mortgage rate reductions for homes with good transit access, which could reduce the need for one or more automobiles and related transportation costs.
- Car-sharing – cooperative arrangements to provide for short-term use of an automobile within neighborhoods or at rail stations, reducing the need for an extra automobile.
- Travel blending – individualized travel planning that encourages people to make better decisions about the need for and timing and mode of travel. These programs have shown some encouraging evidence of vehicle miles of travel (VMT) reduction.

- Proximate commuting – allowing employees of large companies, such as banks, to work at branch offices closer to home so as to reduce VMT.

These studies are not cited here as they generally did not provide empirical evidence of emissions reductions. Most are just now being introduced in the United States.

3.0 Limitations on Known Effectiveness

In reviewing the literature associated with alternative modes as an air quality mitigation strategy, several issues emerge regarding the nature and reliability of the results from the existing body of knowledge. These issues form several key limitations on the use of these studies to quantify actual emission reduction. These limitations include:

- Use of projected emission reduction.
- Inconsistent evaluation methods used to compare results.
- Focus on users, but not travel or emission reduction.
- Focus on trip and VMT reduction, but not emissions.
- Few comparisons across alternative mode strategies.
- Fewer comparisons of cost effectiveness.
- Fewer comparisons to capital improvement.

Each limitation is discussed below.

Use of projected emission reduction – many of the available estimates on emission reduction attributable to various TCMs, including those focusing on alternative modes, use projected reductions, not actual measured reductions. (22) One prevalent funding requirement for most of these efforts is the *a priori* estimation of emission reductions so that decision-makers can rank projects according to their potential for reducing emissions. Many, if not most of these projects, do not conduct *ex ante* evaluations of their efforts to report if these reductions were actually realized. When project reporting is required, many simply reiterate the projections made up front. However, assessments of projected versus actual emission reductions reveals some serious overestimation of impacts. One study concludes “modeled estimates have generally tended to overstate emission reductions.” (22) Another study of 15 TDM projects in southern California showed that the forecast emission reductions were nine to over 400 times the measured impacts (21). Therefore, as stated earlier, this research will base its findings and recommendations on empirical evidence of emission impacts and avoid using projected emissions reduction where possible.

Inconsistent evaluation methods – in order to evaluate the effectiveness and cost effectiveness of alternative mode strategies, it is important that the analytic methods used to measure impacts are consistent or at least produce comparable results. This is vital when amassing several examples for a given alternative mode or trying to compare the effectiveness of one strategy for reducing emissions to another. Because of this, the research bases its findings, on which alternative mode strategies are most effective and cost effective, on a limited number of studies that carefully maintain consistent methods and comparable results. (18, 22)

Focus on users – one pervasive criticism of many evaluations of alternative mode programs or projects is their focus on counting all users and basing emissions reductions on total riders or participants. For example, carpool, vanpool, or transit services tend to report the total number of users (riders) and base emission reductions on this total. However, in order to assess emission *reduction*, some amount of change needs to be recorded. By counting all users, the assumption is made that all users previously drove alone. We know this to not be the case as alternative mode users often switch between higher occupancy modes. For example, many riders of new transit services come from other transit lines or from carpooling. (15) Some carpoolers have switched from riding the bus. Therefore, it is vital to know the prior mode of alternative mode users so as to accurately assess the emission reductions that are attributable to the program. This means only taking “credit” for those new riders who have switched from driving alone or from a lower occupancy mode. A related issue is accounting for the mode of access to vanpooling or transit and accounting for the emissions from driving alone access to these alternative modes.

Focus on travel reductions – there are several outstanding studies on the comparative effectiveness of alternative mode strategies that do not include air quality impacts. (4) (16) These were sponsored by transportation organizations and tended to focus on the impact of alternative modes on congestion relief as opposed to air quality. However, they tend to form similar conclusions as to which alternative mode strategies are most effective. This because they use VMT reduction as a central measure of effectiveness, and this is the foundation of emission reduction. These studies can be used to corroborate emission reduction findings, but were not used as primary source documents.

Limited evaluation across alternative modes – most of the studies performed to date focus on a single project or single mode, such as carpool matching, telecommuting, or transit service improvements. (15) Others provide information on each strategy, but provide little comparison. (11, 12, 16, 20) They tend not to compare one alternative mode to another. Given they use very different approaches and evaluation methods, they are less useful in making comparative assessments. The purpose of many of these case studies is to simply document the experience of a given project or set of projects.

Cost effectiveness – most evaluative studies have focused on travel and emission impacts to assess the effectiveness of alternative modes. However, as policymakers began demanding accountability for funds spent, more attention is being given to the cost effectiveness of alternative mode strategies. In other words, how cost effective are these strategies in reducing emissions? Which strategies are the most cost effective? This has resulted in some recent evaluations calculating the cost per pound or cost per ton of emissions reduced. (5, 7, 10, 18, 22) While this was common practice for projected impacts and ranking for prospective funding, only recently have evaluation begun to calculate the actual cost per unit of emissions reduction from empirical studies of actual costs and impacts.

Comparisons to other strategies – perhaps the type of evaluative results that are most lacking are comparisons of alternative mode strategies to other potential emission reduction strategies,

especially those involving capital investment. Policymakers, when faced with new investment to combat congestion and air pollution, also want to know if other, lower cost alternatives exist. The primary capital improvements include HOV lanes and transit investment, especially rail. Two studies cited here compare alternative mode strategies to these capital investments. (2, 7, 11, 15, 22) However, these are based on limited examples and in the case of the comparison to light rail, comparisons are often made between empirical evidence (alternative modes) and project light rail ridership and costs.

The implication of these limitations is to reduce the number of useable sources of impact information. However, among the growing number of reports and studies on TDM and alternative modes, a few have emerged that provide recent and reliable information. Fortunately, these limited sources tend to point to relatively consistent findings in terms of which strategies work best in reducing emissions at the least cost. These findings are discussed in the next section.

4.0 Findings from the Literature Review

The findings, as to which alternative mode strategies are most effective and cost effective, are based on research that largely addresses the limitations mentioned in Section 3.0. In other words, it focuses on:

- Empirical evidence of emission reductions, not projections.
- Use of relatively consistent evaluation methods for comparable results.
- Consideration of prior mode and access mode to determine reductions.
- Use of cost per ton or pound of emissions reduced as the measure.

The information gathered as part of the literature review was meant to allow for a relative ranking of alternative mode strategies based on which strategies reduced emissions for the lowest cost. However, in providing this assessment, an important caveat is warranted. One study concluded that the *“wide range of cost effectiveness results for many TCMs, even within the same project categories, suggests that performance depends largely on context, that is, on where and how projects are executed.”* (22)

These findings are presented in four progressive sections:

- An assessment of which alternative mode strategies are most prevalent.
- Comparative findings on the effectiveness of alternative mode strategies based on program evaluations (an evaluation of one region’s efforts).
- Comparative findings across alternative mode strategies based on synthesis research (compilation of research findings from multiple programs).
- Comparison of alternative mode strategies to capital investments (“operational” strategies versus new investment in vehicles or facilities).

4.1 Most prevalent alternative mode strategies

Much of the data on alternative mode strategies comes from the primary federal funding source, Congestion Mitigation Air Quality (CMAQ) funds and information on the Section 108(f) TCMs enumerated in the Clean Air Act Amendments of 1990. According to one early study on the “Use and Evaluation of TCMs” among the 33 largest metropolitan areas, the most prevalent TCMs being implemented were:

- Traffic flow improvements.
- HOV lanes.
- Employer-based transportation management.
- Vehicle use limitations/restrictions.

Among the least popular in the early 1990s, were improved public transit and bicycle and pedestrian programs. (23)

The most important study reviewed here was the 2002 Transportation Research Board (TRB) Special Report 264 – “The Congestion Mitigation Air Quality Improvement Program: Assessing Ten Years of Experience.” (22) This involved a congressionally-mandated review of the CMAQ program to assess its overall effectiveness and the relative effectiveness of CMAQ-funded projects in comparison to other air quality strategies.* Using a database of all projected funded between 1992 and 1999, the report shows the distribution of funds to various categories, including:

- 44% of funds to transit projects, including: transit service expansion and vehicle acquisition.
- 33% to traffic flow improvements, including HOV lanes.
- 4% to shared-ride programs, including carpool and vanpool programs.
- 3% to demand management programs, including employer trip reduction efforts.
- 3% to pedestrian/bicycle programs.
- 13% to other categories, including inspection and maintenance.

Therefore, among the alternative mode strategies outlined in Section 2.0, transit improvements were the most commonly funded, in terms of total dollars spent. However, in terms of the number of projects funded, transit represented only 21% of all the projects funded (given the larger size of many transit projects to include vehicle acquisition). Shared-ride accounted for 10% of all projects, pedestrian/bicycle 9% of all projects, and demand management 6%. This means that a greater number of smaller projects were funded in these three categories.

Three broad conclusions can be reached from these studies. First, traffic flow improvements were the most popular type of project funded. Second, transit-related projects were fewer, but still accounted for a third of all CMAQ funding spent in the 1990s. Shared-ride and non-motorized strategies were among the least popular.

* The TRB Special Report 264 can be accessed at <http://www.trb.org/publications/sr/sr264.pdf>

4.2 Comparative findings based on program evaluations

Several recent program evaluations have attempted to assess the cost effectiveness of program elements related to alternative mode strategies. For example, recent evaluations have been conducted of TDM programs in three locations: Coronado, Los Angeles, and San Luis Obispo, California. These studies calculate the cost per pound of emissions reduced for various alternative mode strategies to determine which strategies are the most cost effectiveness in anticipation of future funding decisions.

Coronado Transportation Management Association – In 1999, an evaluation was conducted of the alternative mode programs offered by the Coronado Transportation Management Association (CTMA). (5) This evaluation compared the cost effectiveness of a vanpool subsidy program, a bicycle club, and a transit pass subsidy program. The evaluation concluded that the *bicycle effort* reduced a pound of combined pollutants for 62 cents; the transit pass subsidy for \$1.63; and the vanpool subsidy for \$1.99 per pound. These cost effectiveness results compared favorably with other studies from California in that the cost per pound reduced was within the range experience by other programs in state.

Los Angeles Rideshare Evaluation – a 2002 evaluation of the Los Angeles County Metropolitan Transportation Authority's rideshare program compared the cost effectiveness of its ride-matching services, offer of financial incentives for ridesharers, and a vanpool incentive program. The *vanpool program* reduced a pound of emissions for \$3.13; the ride-matching program for \$26.65; and the financial incentive for \$27.98 per pound reduced. (7)

Cuesta Grade TDM Evaluation – a 2003 evaluation assessed the cost effectiveness of various elements of a mitigation program aimed at easing traffic during the reconstruction of U.S. Route 101 through the Cuesta Grade north of San Luis Obispo, California. This evaluation concluded that a *carpool subsidy* was the most cost effective, reducing a pound of combined pollutants for \$25.71. The vanpool element realized a cost of \$79.30 per pound reduced, and transit service improvements in the corridor reduced a pound of emissions for \$92.93. (10)

Finally, an analysis of the cost effectiveness of TDM programs conducted by staff at the California Air Resources Board (CARB) estimated that a 10-person vanpool traveling 55 miles each way to work is as cost effective as 58 two-person carpools traveling 16 miles round-trip. (24) This is because vanpools tend to have very long commute distances and these VMT reductions and relatively low costs lead to relatively high emission reductions and good cost effectiveness. CARB also estimates that alternative mode programs are cost effective if they reduce a pound of pollution for \$10 or less, based on the comparative cost effectiveness of stationary source measures.*

* CARB has developed two outstanding Cost Effectiveness Analysis Tools to evaluate the alternative mode strategies and employer based trip reduction programs. They can be accessed at <http://www.arb.ca.gov/planning/tsaq/eval/eval.htm>

So what can be concluded from these program evaluations and analyses? First, as stated in the caveat above, the cost effectiveness results vary significantly from area to area. Even though each program included a vanpool element, in only one case was it deemed the most cost effective. Second, because each evaluation only assessed a small number (three) of specific alternative mode strategies, the relative cost effectiveness of all strategies cannot be established. To do so, evaluation efforts that synthesize comparative findings across many projects and studies are required so as to build from an adequate comparative experience base. The next subsection discusses several of these synthesis studies.

4.3 Comparative findings based on synthesis research

Several recent studies have synthesized the findings of program evaluations in order to increase the number and type of project experiences to compare the empirical evidence of a range of alternative mode strategies. As mentioned earlier, a few of these studies compare the travel impacts of alternative mode strategies, but not air quality impacts.

TRB Special Report 264 - Among the synthesis studies that assess emission reduction and comparative cost effectiveness, the most important is the TRB Special Report 264 mentioned earlier. (22) This seminal research project assembled the best work conducted to date and provides a comprehensive, reliable, and rigorous look at the cost effectiveness of various projects funded with CMAQ monies, including most of the alternative mode strategies that are of interest in this study. The list of strategies included in the TRB Special Report are:

Traffic Flow Improvements

- Signalization.
- Freeway/incident management.
- HOV facilities.

Ridesharing

- Regional rideshare.
- Vanpool programs.
- Park-and-ride lots (evaluated with transit lots).

Transportation Demand Management

- Miscellaneous TDM.
- Employer trip reduction.

All Telework

All Bicycle/Pedestrian

Transit Improvements

- Shuttles, feeders, and paratransit.
- New transit capital systems/vehicles.
- Conventional service upgrades.
- Park-and-ride lots (evaluated with rideshare lots).

Fuels and Maintenance

- Conventional fuel replacement buses.
- Alternative fuel buses.
- Alternative fuel vehicle programs.
- Inspection and maintenance.

Pricing Measures

- Modal subsidies and vouchers (alternative mode subsidies).
- Charges and fees (parking price, congestion pricing).

Appendix E of TRB Special Report #264 entitled, “Cost Effectiveness of CMAQ Strategies,” provides the key research for this study. This analysis is very well documented, draws upon extensive literature, includes 139 projects with costs and empirical impacts, and derives findings that are consistent and comparable. This evaluation compared the median cost per ton of emissions reduced for the 19 strategies enumerated above (with park-and-ride combined into a single category). The list of strategies, from most cost effective to least, converted to cost per pound reduced, is as follows (with the alternative mode strategies in italics):

<u>CMAQ Strategy</u>	<u>Cost per Pound of Emissions Reduced</u>
Inspection and maintenance.....	\$0.95/lb.
<i>Regional rideshare programs</i>	\$3.70/lb.
<i>Charges and fees</i>	\$5.15/lb.
<i>Vanpool programs</i>	\$5.25/lb.
<i>Miscellaneous TDM</i>	\$6.25/lb.
Conventional fuel bus replacement.....	\$8.05/lb.
Alternative fuel vehicles	\$8.09/lb.
Traffic Signalization	\$10.05/lb.
<i>Employer trip reduction</i>	\$11.35/lb.
<i>Conventional transit service upgrades</i>	\$12.30/lb.
<i>Park-and-ride lots (rideshare and transit)</i>	\$21.50/lb.
<i>Modal subsidies and vouchers</i>	\$23.30/lb.
New transit capital systems/vehicles	\$33.20/lb.
<i>Bicycle and pedestrian programs</i>	\$42.05/lb.
<i>Shuttles, feeders, and paratransit</i>	\$43.75/lb.
Freeway/incident management	\$51.20/lb.
Alternative fuel buses	\$63.20/lb.
HOV facilities	\$88.10/lb.
<i>Telework</i>	\$125.90/lb.

Therefore, among the top 10 strategies, *the most cost effective* alternative mode strategies are:

- regional ridesharing programs (including carpool matching).
- pricing programs (including parking pricing and congestion pricing).
- vanpool programs.
- miscellaneous TDM programs (efforts to promote alternative modes)
- conventional transit service improvements (new lines, more frequency).
- employer trip reduction.

Among *the least cost effective* strategies are:

- telework programs.
- transit shuttles or feeder lines.
- bicycle and pedestrian facilities and programs.

This evaluation also included a key policy finding, which concluded that the majority of CMAQ funds have been allocated to the least cost effective strategies, with a few exceptions (bicycle/pedestrian programs and telework). The analysis showed that as a group, traffic flow projects received 33% of all funds, but resulted in a cost per pound reduced of \$42.70. Rideshare programs accounted for only 4% of all funds, yet reduced a pound of emissions for \$10.25. Likewise, miscellaneous TDM programs accounted for 3% of all CMAQ funds but reduced a pound of emissions for \$7.66. Transit service improvements and new services (not including alternative fuels) as a group, were somewhere in the middle, receiving 28% of funding and reduced a pound of emissions for \$29.80.

One key difference between this comparative evaluation and others was the weight placed on each of the four regulated pollutants. The TRB Special Report included ozone precursors (hydrocarbon, HC, and nitrous oxide, NO_x), but not carbon monoxide (CO) and particulate matter (PM) in the analysis. In fact, the study weighted NO_x four times higher than HC reductions given the predominance of NO_x in both federal policy and regional policies regulating clean air. However, one part of the analysis showed that the rankings would have been similar had both pollutants been equally weighted. Evaluations in California often do not include CO, for similar reasons and due to the nature of the strategies being evaluated. In all cases, the pollutants of interest or combined into one total emission reduction finding. Likewise, all costs are included in the cost effectiveness evaluation, both CMAQ funds and all other public and private costs, on an annualized basis.

Comparative Evaluation of 58 TCMS – one study, that the TRB Special Report used extensively, was summarized in a Transportation Research Record article entitled “Comparative Evaluation of the Cost Effectiveness of 58 Transportation Control Measures.” (18). This study used a consistent methodology to calculate the cost per trip, mile and pound of emissions reduced for 58 projects implemented in southern California among three pilot programs. The project categories included in this study included:

TDM

- bicycle facilities and programs.
- financial incentives and disincentives.
- organizational TDM.
- telework and teleconferencing.
- vanpool programs.

Fixed Route Transit

- Line haul transit service improvements.
- Shuttles and feeders.
- Ferry service.

Alternative Fuel Projects

Comparing within and between categories, this analysis concluded that *TDM strategies*, as a group, *were the most cost effective*, again, excluding telecommuting. It also showed that among transit projects, line haul service enhancements were more cost effective than shuttles and feeders. When effectiveness (total emissions reduced) is evaluated with cost effectiveness (lowest cost per trip reduced), financial incentives and disincentives appeared to very successful, as were the vanpool projects, and some of the bicycle projects and transit service improvements.

Other Synthesis Reports – several other studies have assembled project-level information on the cost effectiveness of various TCMs, TDM projects, and related alternative mode strategies.

One study, conducted for the U.S. Environmental Protection Agency (EPA), included a “Summary Review of the Costs and Emissions Information for 24 CMAQ Program Projects.” (11) This report, also used in the TRB Special Report cost effectiveness analysis, simply reported costs and emissions reductions and did not provide a comparative assessment across project categories. These categories included: ridesharing, bicycle/pedestrian, traffic flow, transit, TDM, and other (alternative fuels). The costs and total emission reductions exhibited a large range of experience, even within categories.

An earlier study of all the TCMs named in Section 108(f) of the Clean Air Act Amendments concluded that the most cost effective TCMs (those reducing a pound of emissions for \$12.50 or less) were: regional ridesharing programs, VMT or emission taxes, buy backs of older cars, and signal timing. (2) Some of this work was based on very limited empirical evidence (it was performed in 1994) and on projected emission reduction. Transit improvements, employer trip reduction programs, and bicycle/pedestrian facilities were deemed among the least cost effective (> \$50 per pound of emissions reduced). While this study has been extensively cited for almost 10 years, the TRB Special Report will likely become the primary reference on comparative cost effectiveness.

There are also several studies that have compared experience across many projects within the same alternative mode strategy, such as employer trip reduction programs. Within employer trip reduction programs, one study found that those employers who provided new alternative modes (transit, vanpools) and financial incentives to use them realized a much higher average trip reduction (25%) than those who simply provided incentives (16%), or alternatives (9%) or information (0%). (3). Another study from Washington state was based on employer program data from over a thousand worksites. It concluded that parking charges, allowing for telework, flexible hours, guaranteed ride home programs, maintaining access to transit, and subsidies for walking were associated with the greatest reductions in driving alone and, therefore, the greatest increases in the use of alternative modes. (19). Finally, one article concluded “in almost all cases, one major conclusion stands out – some level of incentive or disincentive must be present to encourage automobile users to change their travel behavior.” (14)

4.4 Comparison to capital investments

As mentioned earlier, many policymakers not only want to know the comparative cost effectiveness among alternative mode strategies, but also want to know how some of these “operational” strategies compare to other mobility and air quality solutions, such as HOV lanes, new transit vehicle acquisition, or transit facilities, such as light rail lines.

In very general terms, the limited evidence suggests that emission reduction projects that require significant capital expense are less cost effective than “operational” projects that support alternative modes. In the TRB Special Report 264 widely-cited in this study, HOV lanes and new transit systems were among the least cost effective, reducing a pound of emissions for \$33.20 (transit infrastructure) and \$88.10 (HOV lanes) as compared to an overall average of \$33.15 per pound for all projects studied and compared to \$10.25 per pound for ridesharing and other TDM projects. (22)

The 1994 study of TCM cost effectiveness also rated HOV lanes and transit service improvements among the least cost effective strategies (2). The documentation of the costs and emissions from 24 CMAQ projects included two capital projects to buy light rail or commuter rail vehicles, at a cost of between \$30 and \$129 per pound of emissions reduced. (11) This is higher than the ridesharing and transit service projects also evaluated in the study.

One program evaluation of the rideshare program in Los Angeles County compared the cost effectiveness of the rideshare program to rail improvements planned for the region. (7) The cost per trip reduced and cost per person placed into the rideshare program was compared to forecasts of the cost per new rider on a proposed light rail extension. The cost per trip reduced was \$2.80 for the rideshare program and the cost per person placed into a new ridesharing arrangement was \$0.82 per day. The comparative cost per new light rail rider per day was \$9.60 to \$10.76 in capital and operating costs and \$2.66 to \$2.99 in operating cost alone (for the two primary alternatives).

Finally, another study on “The Potential of Public Transit as a TCM” concluded that “investments in high capacity transit infrastructure are typically not cost effective from the standpoint of emission reductions.” (15) However, the study does point to other benefits to be derived from investment in public transit.

5.0 Conclusions

A brief summary of the limitations and findings from this literature review include:

- There is still a relatively limited database of project and program evaluations that involve sound assessments of the actual cost and emission reduction experience.
- Many of the existing assessments are based on projected emission reduction and suffer from other methodological limitations.
- The cost effectiveness of any given program or project is highly context dependent and this accounts for the significant variation in some of the findings.
- Thus, there are few comparative evaluations as to which alternative mode strategies are the most effective and cost effective.
- However, based on the limited evidence available to date, notably the TRB Special Report 264, it appears the following alternative mode strategies are relatively cost effective when compared to other strategies, including those requiring large capital investment:
 - Regional ridesharing programs and other TDM promotion.
 - Vanpool programs and subsidies.
 - Employer trip reduction program.
 - Pricing strategies (including parking and congestion pricing).
 - Conventional transit service improvements.
- The same study also concluded that CMAQ funds (a primary funding mechanism for alternative mode programs) were not being spent on these more cost effective strategies.
- Other comparative studies tend to reinforce this set of cost effective strategies and provide additional detail on specific strategies, such as employer trip reduction programs.

The next step in this research study will be to survey selected state DOTS, and other state and regional agencies, to assess their use of alternative mode programs to address air quality issues.

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Appendix B – Summary of State DOT Survey

Q.1: SUMMARY

Does your agency have any specific policies or programs to encourage the use of alternative modes?

- ✓ All 10 surveyed agencies differ in the extent and variety of programs they offer to encourage the use of alternative modes.
- ✓ As expected, Carpooling and Vanpooling are the most supported alternative modes throughout all surveyed states and agencies.
- ✓ *Massachusetts, New Jersey and New York State* have a very extensive public transit system, offering several types of public transportation (rail, bus) to ensure high frequency and wide coverage.
- ✓ Most DOTs write about road construction projects and infrastructure design - such as HOV-lanes, HOV-ramps, Park & Ride (P&R)-lots or priority parking spaces - to make streets more attractive to Carpooling/Vanpooling. Bicycle and Pedestrian facilities are often mentioned as well (see Washington State, New York State, Oregon, New Jersey).

Please note: *Colorado, Georgia and Washington DC* do not give detailed answers on their TDM programs within this question. But later questions reveal some of their offered and promoted types of transportation and are included in this chart.

Measures specifically mentioned were:

	<i>WS</i>	<i>OR</i>	<i>WDC</i>	<i>COL</i>	<i>GEO</i>	<i>NMEX</i>	<i>MASS</i>	<i>NY</i>	<i>SAND</i>	<i>NJ</i>
Mandated CTR Program	X									
Supporting Carpooling	X	X	X			X	X	X	X	X
Subsidizing GRH			X						X	
HOV-lanes and HOV-ramps	X							X		
P&R-lots	X							X		X
Supporting Vanpooling	X					X			X ²	
Supporting Telecommuting			X		X					
Flextime/Compressed work week					X	X				

Plans for major corridors must be multi-modal	X	X					X	X		X
Public Transit Investments (rail, bus, shuttles, on-demand services, etc.)							X	X		X
Sponsoring bikers and pedestrians			X			X	X	X		X
TDM Resource Center	X									
(Statewide) commuter assistance services	X	X	X					X	X	X
Employer services program			X							X
TMA's							X			X
Traffic calming techniques								X		
Provide CMAQ-\$ to MPO program administration				X					X	

^aSales tax-exemption; reserved parking spaces and reduced rates on ferries; limited funding to purchase vans

^b(Acquisition) Subsidy

^c... such as: carpooling education and promotion, ride-matching, vanpooling coordination, worksite-events, training of staff, incentive programs

Q.2: SUMMARY

How, specifically, do you support alternative modes?

- ✓ Funding often derives from the state’s DOTs, with CMAQ as the principal source.
→ NJDOT provides the most CMAQ funds with approx. \$4.2 million per year.
- ✓ The amount of funding varies strongly between the states
- ✓ Several TDM programs seem quite extensive due to the quoted amount of money they receive (see New Jersey, Georgia, Oregon).
- ✓ Little information has been given on technical support, coordination and evaluation, except by the following states/agencies:
Colorado, Massachusetts, New Jersey and Washington DC
- ✓ Little information has also been given on the divisions/departments within the DOT that handle TDM, except by the following:
Oregon - Public Transit Division
New Jersey - Division of Systems Planning and Research
Massachusetts - Bureau of Transportation Planning and Development

Funding Sources specifically mentioned were:

	<i>WS</i>	<i>OR</i>	<i>WDC</i>	<i>COL</i>	<i>GEO</i>	<i>NMEX</i>	<i>MASS</i>	<i>NY</i>	<i>SAND</i>	<i>NJ</i>
Direct DOT Funding	X	X	X	X	X	X		X		X
→ CMAQ funds		X	X	X	X		X		X	X

Q.3: SUMMARY

How do these programs and/or policies relate to air quality?

- ✓ Several agencies either do not provide a clear answer to the question or state that their primary goal for TDM programs is not air quality, but rather traffic reduction, due to congestion or mobility (New York State, New Jersey, New Mexico, Georgia).
- ✓ Many agencies argue that by receiving CMAQ funding, they obviously must show some success towards improving air quality with alternative mode programs (Massachusetts, Colorado, Oregon, Washington State, New Jersey).
- ✓ Some of the surveyed states/agencies have programs that are not directly funded through CMAQ money but by other sources instead. Either way, the goal of these programs is the same: Clean Air!
 - see: TERM - Washington DC
 - ECO (DEQ) - Oregon
 - APCD - San Diego
- ✓ As an example: SANDAG regularly reports the corresponding decrease in smog forming pollutants by monitoring the reduction in trips due to Carpooling Programs, as does Washington DC, Georgia and others.

Q.4: SUMMARY

How much relative emphasis is placed on alternative modes vs. other air quality strategies

- ✓ Most surveyed agencies use TDM programs for strategies other than air quality, such as:
 - Increasing Mobility
 - Reducing Congestion
 - Decreasing Parking costs; ease parking supply deficits
 - Reducing VMT
- Except Oregon: The **only** air quality strategy that is promoted by this agency is alternative modes.
- ✓ Some of the agencies argue that offering alternative modes of transportation must have a high impact on air quality because they would not receive CMAQ dollars otherwise (Colorado, Washington DC).
- ✓ Only *New Mexico* provides answers about other projects that are (more) effective in improving air quality, such as:
 - Maintenance status for carbon monoxide
 - Maintenance status for any other pollutant
 - Biennial vehicle inspection maintenance program
 - “no-burn” program

Please note: Some agencies have misinterpreted the question.

Q.5: SUMMARY

Other than air quality, what other policy objectives are being addressed with alternative mode strategies?

- ✓ The “decrease of traffic” (Congestion management) seems to be the main goal of most of the surveyed states/agencies for implementing TDM programs.
- ✓ SANDAG and New Jersey show the highest number of policy objectives.

Please note: Colorado and Georgia either do not answer this question correctly or feel that the question is not applicable to their agency.

Other policy objectives:

	WS	OR	WDC	COL	GEO	NMEX	MASS	NY	SAND	NJ
Increase mobility / mobility options	X	X					X	X	X	X
Congestion management / reduce traffic		X	X			X	X	X		X
Gain more efficient use of roadways	X									
Increase access (to dispersed locations)	X								X	
Increase attractiveness of transportation services										X
Reduce infrastructure costs							X			
Encourage “higher” density development / smart growth						X	X		X	X
Reduce user fees										X
Increase effectiveness / efficiency									X	X
Promote economic development / equity									X	X
Other ^a			X						X	X
No answer / n.a.				X	X					

^aOther = sustainability, livability, reliability, improving life quality for user, operations

Q.6: SUMMARY

How are the alternative mode efforts funded?

- ✓ CMAQ as well as various kinds of state funding are the primary financial sources for TDM efforts.
- ✓ SANDAG and New York State provide detailed descriptions of the funding they receive.

Please note: Georgia and Massachusetts misinterpreted the question or did not provide any answer.

Funding sources of alternative mode efforts:

	WS	OR	WDC	COL	GEO	NMEX	MASS	NY	SAND	NJ
Federal funds		X _{STIP}		X				X _{STP}		X
CMAQ funds		X	X		(X)	X		X	X	X
State funds (Transportation trust, APCD, RSTP)			X						X	X
FTA								X	X	
EPA								X		
Local (Sales tax funds, city)				X		X			X	
TDA Planning									X	
Statewide TDM funding		X								
Others	X					X		X		
No / Incorrect answer					X		X			

Q.7: SUMMARY

What is the relationship of your agency to alternative mode service providers?

- ✓ All surveyed agencies work to some extent with their regional/local transportation providers and usually provide some kind of funding.
- ✓ Most of the transportation providers seem to be included in statewide plans and work together to ensure multi-modal programs that allow all people in need of transportation to choose their ideal mode.
- ✓ Only *SANDAG* and *New Jersey* provide specific information on their relationship:
 - *SANDAG* is the transit agency
 - NJ Transit is the sister agency of NJDOT

Relationship to alternative mode service providers:

<i>WS</i>	Indirect relationship but maintaining good relationship while including them in the statewide plans; Some special state funds to local transit agencies
<i>OR</i>	ODOT is grant administrator for TDM funding
<i>DC</i>	“Our agency is the MPO in the region”
<i>COL</i>	Passes through funding source and technical consultants and contract administrators for federal dollars
<i>GEO</i>	Supports multi agency / partner metro Atlanta TDM program
<i>NMEX</i>	MPO coordinates the allocation of federal funds for transit capital projects and for Albuquerque Transit TDM program; very limited state DOT role (<i>this survey was completed by MPO</i>)
<i>MASS</i>	Transit providers: coordination, consultation, cooperation and some joint projects Rideshare organizations: funding of statewide commuter options contractor, which in turn, provides outreach and education to worksite transportation coordinators TMA: funding of special projects
<i>NY</i>	Works strongly with New York’s transportation providers to develop a common agenda; Gives limited financial support
<i>SAND</i>	<i>SANDAG</i> is the transit agency for the San Diego region; Wholly operates and funds regional ridesharing programs; no role for Caltrans these days
<i>NJ</i>	NJ Transit is the sister agency of NJDOT and receives FTA funding directly; Private bus operators sometimes receive fleet vehicles, but NOT money; Contracts with 8 TMAs on an annual basis

Q.8: SUMMARY

Which alternative modes and support strategies does your agency consider the most cost effective in reducing emissions or VMT? And How do you know this?

- ✓ There exists a general belief that all modes that offer high occupancy have a positive effect on air quality but the believed degree of effectiveness differs between agencies.
- ✓ Most agencies infer that the alternative mode showing the strongest effect on air quality is Public Transit.
- ✓ *Washington State, Georgia, New Mexico, Massachusetts* and *New Jersey* appear to do some extensive research on the effectiveness of their TDM programs but do not mention their calculation/estimation formulas.
- ✓ *New Mexico* is the only state that provides more specifics about its calculation model.

Please note: Many of the surveyed agencies do not have any methods of evaluating their programs at this time. It seems, however, that evaluation measurements have become obligatory for most agencies and that they are working on developing such methods and calculations.

Effective alternative modes/strategies and measurements:

	<i>WS</i>	<i>OR</i>	<i>WDC</i>	<i>COL</i>	<i>GEO</i>	<i>NMEX</i>	<i>MASS</i>	<i>NY</i>	<i>SAND</i>	<i>NJ</i>
<i>Most effective alternative modes:</i>										
Vanpooling	X						X		X	
Carpooling / GRH				X					X	
Transit				X		X	X	X	X	X
Bicycle and Pedestrian programs							X			
Telecommuting										X
<i>Most effective strategies:</i>										
CTR Program	X									
Managed Lanes									X	
Incentive Programs (e.g. Parking Cash-out)							X			X
Interdependence of all			X							
<i>Practiced measurements:</i>										
Calculation of saved VMT						X				
Mobile 6 benefits										X
Annual measurement program (no specifics)					X					
Periodic evaluations	X						X			
Mobility 2003 Plan (Performance measures)									X	
No measurements			X	X				X		
No measurements BUT current development		X							X	X

OVERALL SUMMARY

The goal of this survey was to assess state involvement in the use of alternative modes as an air quality strategy in the state or within key urban areas. 10 out of 20 states/key agencies completed the survey and were summarized in the above analysis. The points listed below serve as an overall personal commentary on all questions.

- ✓ Of those surveyed, *Washington State, New York State, New Jersey* and *SANDAG* seem the most involved states/agencies in providing, offering and promoting TDM-programs and strategies.

The answers to their surveys are by far the most extensive. Their answers get right to the point. They show enthusiasm in working for those services and are actually receiving impressive results.

- ✓ All states/agencies appear to be quite familiar with TDM-programs and strategies and have worked towards the goals of reducing traffic congestion, increasing mobility and improving air quality. However, air quality is rarely the main purpose for implementing alternative modes, but definitely another argument for including them in their regional development plans.
- ✓ Reading the surveys, it gives the impression that Carpooling and/or Vanpooling are especially favored in those areas where Public Transit does not play a significant role. The regions/cities with a widespread and strong public transportation system show high enthusiasm and state that the acceptance within the population justifies the infrastructure and maintenance costs.
- ✓ The generally strong relationship between the agencies and their regional/local transportation provider shows a healthy communication between all partners and ensures the planning of multi-modal programs.
- ✓ Unfortunately, within these surveys, no conclusion can be drawn on as to why the amount of funding varies so drastically between the states/agencies.
- ✓ It would be interesting to know, who within the agency has answered the survey to get a better understanding of the person's involvement and perspective on TDM programs (e.g. what is his/her title, what are the responsibilities/tasks, how long has he/she been working for this agency, etc.).
- ✓ Almost all answers to question 3, regarding the relationship between TDM-Programs and air quality, do not provide any clear or insightful information. This can be interpreted as the development and implementation of TDM-Programs focuses primarily on resolving traffic issues and air quality is a beneficial "side-effect", as stated in question 5.

- ✓ Overall, the surveys contain insightful information about a generally strong awareness of the advantage of promoting alternative modes. Although in varying degrees, all surveyed key agencies are working towards the goal of reducing SOV-traffic and therefore on improving air quality.

Appendix C – State-by-State DOT Survey Detail

Question 1: Does your agency have any specific policies or programs to encourage the use of alternative mode?

Washington State

- Mandated CTR-program
- 200 +/- miles of freeway HOV-Lanes
- P&R lots to support HOV-use
- HOV bypass ramps onto freeways
- Priority loading for HOVs on ferries
- Reserved spaces and reduced rates for vanpools on ferries
- Sales tax exemptions for private vanpools
- tax credits for employer CTR programs
- Limit funds available for employers to purchase vans to vanpool
- Award-winning TDM Resource Center
- Plans for all major corridors must be multi-modal

Oregon

- Six TDM programs exist and they are located in the state's MPO areas
- Goal: encourage citizens to take advantage of a variety of travel options existing in their communities
- Oregon's residents: Increase in usage of alternative modes, flexible work hours, telecommuting
- Plans state that TDM programs and alternative-mode friendly construction have active priority

Washington DC

- No specific answer, just: "Yes, several measures." Some measures are given in Question 8

Colorado

- Provides CMAQ dollars to MPOs to administer the programs locally
- Specific programs are given in Questions 5 and 8

Georgia (answered this question as an employer, not agency; GDOT supports \$6M TDM program in ATL)

- Teleworking
- Flextime / Flexible working hours

New Mexico

- MPO allows employers to offer compressed work-week
- NMDOT subsidizes acquisition of vans for the state employee commuter program
- Examples:

- Transit Department with locker and shower rooms in Administration Bldg.

Albuquerque City: funds fixed-route and paratransit services and receives funds for TDM business outreach program

Massachusetts (also supports Transportation Management Agencies)

- Investments in extensive system of mass transportation *Mass Bay Transportation Authority* provides:
 - Commuter rail, light rail, electric trolley bus, local bus, express bus, subway, ferry and handicapped busses to greater Boston Metro Area
 - Commuter rail extends to other cities/suburbs around Boston
 - Frequent express bus service to airline terminals
 - 15 other regular transit authorities provide local public transportation and paratransit services throughout the state
 - Demand-responsive van services for elderly and handicapped persons
- Statewide commuter assistance services (for 25 years):
 - Carpool education and promotion
 - Ride-matching, Vanpool coordination
 - Worksite events
 - Training of staff, Incentive programs
- State transportation and energy plans with regard to carpooling and draft for sustainable development and climate change active plan
- Sponsor of many pedestrian and bicycle plans and programs

New York State

- NYSDOT has a policy that emphasizes the implementation and use of alternative commuter modes or TDM strategies in order to maximize movement of people (not cars!)
- Most extensive transit systems (bus and commuter rail) in the U.S.: NYSDOT helps to ensure capital investments in transit infrastructure, and services are maintained at a high level (approx. \$2 billion per year)
- NYSDOT has fully integrated alternative mode and TDM planning into its capital program for construction:
 - Pedestrian and Bicycle trails and facilities
 - HOV-Lanes and anything related to it (e.g. ramps, P&R etc.)
 - Traffic calming techniques
- TDM focus areas include monitoring, program funding and evaluation of voluntary TDM programs
- PLUS, several initiatives were undertaken over the past few years, such as:
 - Bus and Vanpool/Shuttle services
 - Public relations and Media promotion of alternative modes
 - Funding to assist private employers in implementing TDM programs

San Diego (SANDAG) = Transit Agency for the San Diego Region

- Sponsors carpooling programs that seek to encourage area employers to develop and implement TDM-programs
- Funds carpooling programs with CMAQ funds
- Offers subsidies to encourage vanpooling and GRH-Programs

New Jersey

- “Transportation Choices 2005” with studies and concepts to identify priority transportation projects:
 - New Jersey’s Development and Redevelopment Plan (SDRP)
 - Goal #6: Improve Life Quality for users of transportation system + those affected by its use

- TDM programs which support TDM strategies such as:
 - TMA Program
 - Bicycle and Pedestrian Program
 - Traffic Mitigation Program
 - P&R Program
 - Smart Moves for Business Program
 - Employer Services Program
 - Transit Village Program
 - Rideshare Matching Services
- New Jersey Transit is NJDOT's sister agency and provides, in cooperation with 5 private carriers, all of the train and bus services throughout New Jersey

Question 2: How, specifically, do you support alternative modes?

Washington State

- Direct support is fairly limited, except on the Investment of HOV-Lanes
- Some funding is received for P&R lots or van purchases
- Some tolls on the ferry are foregone
- Some funding for TDM comes as 'construction mitigation'

Oregon

- ... 3 different funding sources:
 - Regional MTIP, using partially the region's CMAQ funding allotment
 - STIP, using FHWA STP funds → ODOT partly funds TDM programs
 - 2003 Legislature approval for additional \$750,000 for statewide TDM funding
- PLUS: ODOT has its own TDM Program Manager in the Public Transit Division

Washington DC

- Programs are adopted in the regional Transportation Improvement Program (TIP) on an annual basis
- Programs are funded by the 3 DOTs and are operated at the MPO level
- Program evaluation results are used in congestion management planning and in the region's air quality conformity determination

Colorado

- CDOT provides annual CMAQ dollars to MPO with technical support and active evaluation of programs

Georgia

- ... GDOT funds an annual TDM measurement program at about \$850,000 per year (we also know that GDOT supports TDM framework and Clean Air Campaign with funds for vanpooling, employer outreach, alternative mode cash incentive, etc.)

New Mexico

- State subsidizes the acquisition of vans for state employee commuter van programs
- Federal funds for a TDM business outreach program

Massachusetts

- CMAQ is principal source of funding
- Bureau of Transportation Planning and Development has a transportation program unit that oversees commuter options, TDM, CMAQ, P&R, bicycle and pedestrian programs

New York State

- Supports alternative modes and TDM initiatives directly through the funding of key initiatives by the Department's capital program scoping, development, and programming processes

San Diego (SANDAG)

- CMAQ funding for carpooling programs
- SANDAG offers subsidies to vanpooling and GRH
- SANDAG allocated funds to market carpooling programs to employers

New Jersey

- NJDOT provides approx. \$4.2 million per year in CMAQ funds for the TMA program which covers the entire state
- NJDOT provides some technical support through contract with Urbitran/LDA/ESTC
- Coordination of TDM programs is handled mainly in the *Division of Systems Planning & Research*
- NJ Transit has its own P&R-Program that is now being consolidated into the NJDOT P&R-Program
- NJ Transit also has a vanpooling sponsorship program as well as a community shuttle program

Question 3: How do these programs and/or policies relate to air quality?

Washington State

- CTR program was primarily set up as an air quality program under the old state energy office
- HOV lane system = part of air quality achievement and maintenance
- Most of the work of the TDM Resource Center has been funded by the CMAQ in regional competition

Oregon

- ODOT recognizes the part auto traffic plays in air quality, esp. for the Portland area
- The Department of Environmental Quality's (DEQ) Employee Commute Options (ECO) Program states that employers must provide commute alternatives to employees to reduce the number of cars driven to work in Portland and its surrounding areas
- ECO plan: keep air clean for the next 10 years
- Plan was adopted in July 12, 1996
- ECO program receives portion of Portland's CMAQ TDM funding

Washington DC

- The programs adopted are called TERMS (Transportation Emission Reduction Measures)
- Evaluation results calculate emission impacts and are post-processed in the region's air quality conformity determination

Colorado

- Some programs seem to improve air quality as they receive CMAQ dollars
- But if they don't, Colorado tries to obtain funding through community programs

Georgia

- Policies are to help meet conformity requirements
- TDM measurements provide data of conformity requirements to the state's EPA

New Mexico

- Answer is not related to air quality, only to the general reduction of SOV and traffic congestion

Massachusetts

- As CMAQ is the main source of funding, an air quality analysis must be conducted to show eligibility under federal guidance

New York State

- The initiatives undertaken by the state are primarily implemented as strategies that address *Mobility* and *Congestion Mitigation*, NOT air quality BUT if the department can identify quantifiable impacts on air quality through these mode strategies, then they will look at them in that context

San Diego (SANDAG)

- SANDAG monitors the reduction in trips due to carpooling programs and regularly reports the corresponding decrease in smog forming pollutants
- Some funding for regional vanpooling comes from a grant administered by the San Diego County Air Pollution Control District (APCD)

New Jersey

- No direct connection between TDM and air quality can be given as the State Implementation Plan (SIP) does not include any Transportation Control Measures (TCM)
- But over the years, TMA programs have been evaluated for air quality benefits to obtain federal authorization for CMAQ funds
- General belief: all programs have some (modest) effect on air quality

Question 4: How much relative emphasis is placed on alternative modes vs. other air quality strategies?

Washington State

- Air quality is dealt with on a regional level → many different air quality strategies exist
- "Alternative modes get a fairly high emphasis relatively speaking, but use of alternative modes has not been increasing."

Oregon

- ODOT currently only promotes alternative modes as an air quality strategy
- ODOT partners with other state agencies (Land Conservation, Environment Quality and Energy) to support their programs in the area

Washington DC

- The alternative mode TERMS are probably the largest of the TERMS adopted, with regards to the funding and air quality impacts

Colorado

- \$1.7 billion in Highway construction and transit projects (highest funding within the U.S.) These programs will help air quality as well as congestion

Georgia

- “A lot, because it works”

New Mexico

- Use of alternative modes is not the major program element of the air quality program
- It’s rather:
 - Maintenance status for carbon monoxide
 - Maintenance status for any other pollutant
 - Biennial vehicle inspection maintenance program
 - “no-burn” program

Massachusetts

- Alternative transportation is mainly promoted for reasons other than air quality, such as:
 - Decrease VMT
 - Decrease traffic
 - Decrease parking costs

New York State

- Alternative transportation is mainly promoted for reasons other than air quality, such as:
 - Mobility
 - Congestion

San Diego (SANDAG)

- ... SANDAG’s 7 guiding policy objectives seek improvements in all 7 areas (mobility, efficiency, reliability, equity, sustainability, accessibility, and livability)
- Indecisive if TDM efforts are based more upon reduced VMT or improved air quality

New Jersey

- Alternative modes are encouraged as they reduce VMT and have some modest air quality benefits
- BUT: most TCM/TDMs are not included in the SIP

Question 5: Other than air quality, what other policy objectives are being addressed with alternative mode strategies?

Washington State

- Gaining more efficient use of roadways
- Providing increased access to dispersed locations
- Maximizing mobility options

Oregon

- Reduce traffic congestion
- Improve personal mobility

Washington DC

- Congestion Management
- Operations

Colorado

- Misunderstands question: Writes about other TDM programs, such as telework/flex place and flextime, coordination of Bike and Walk days, carpooling, vanpooling etc.

Georgia

- “n.a.”

New Mexico

- Reduce corridor specific congestion
- Within specific corridors, encourage ‘higher’ density development

Massachusetts

- Congestion
- Mobility
- Concentration of development
- Infrastructure cost

New York State

- Mobility
- Congestion

San Diego (SANDAG)

- 7 policy objectives:
 1. Mobility
 2. Efficiency
 3. Reliability
 4. Equity
 5. Sustainability
 6. Accessibility
 7. Livability

New Jersey

- 9 policy objectives:
 1. Congestion
 2. Mobility
 3. Promoting economic development
 4. Effectiveness
 5. Efficiency
 6. Attractiveness of transportation services
 7. User fee reduction
 8. Smart growth
 9. Improving life quality for users

Question 6: How are the alternative mode efforts funded?

Washington State

- The transit agencies have their own dedicated tax sources

Oregon

- Regional MTIP (CMAQ)
- STIP (FH STP)
- Statewide TDM funding program

Washington DC

- Through the 3 state DOTs (Virginia, Maryland and District of Columbia)
- Funds used are a mixture of CMAQ and state dollars

Colorado

- 80% federal dollars
- 20% local match

Georgia

- “n.a.”

New Mexico

- The TDM program is funded with CMAQ funds
- Albuquerque Transit:
 - Operating funds are from the city’s General Fund (major source)
 - A portion of ¼ cent gross receipts tax for transportation (roads, bike, transit)
 - Fare box revenues

Massachusetts

- Misinterprets the question: Writes about incentive programs, such as transit passes, fuel cards for carpoolers, subsidizing empty seats of vanpools while recruiting new riders and rewarding bikers and pedestrians

New York State

- Transit initiatives are primarily funded through FTA capital and/or operating assistance fund sources
- Typical alternative commute mode and TDM initiatives are primarily funded through CMAQ, state dedicated funding (SDF), and STP flex funding sources
- Other funding: EPA grants, federal special project appropriations, NYSDOT’s Innovative Mobility Demonstration grants, transit earmarks

San Diego (SANDAG)

- CMAQ
- TDA Planning
- Local (Sales Tax Funds)
- FTA, APCD, RSTP

New Jersey

- Federal funds from the FTA directly
- Most private bus operators do not receive federal funds, but some do receive fleet vehicles

Question 7: What is the relationship of your agency to alternative mode service providers?**Washington State**

- Indirect relationship but maintaining good relationship while including them in the statewide plans
- Some special state funds to local transit agencies

Oregon

- ODOT is grant administrator for TDM funding

Washington DC

- “Our agency is the MPO in the region”

Colorado

- Passes through funding source and technical consultants and contract administrators for federal dollars

Georgia

- Supports multi agency / partner metro Atlanta TDM program

New Mexico

- MPO coordinates the allocation of federal funds for transit capital projects and for Albuquerque Transit TDM program

Massachusetts

- Transit providers: Coordination, consultation, cooperation and some joint projects
- Rideshare organizations: Funding of statewide commuter options contractor, which in turn, provides outreach and education to worksite transportation coordinators
- TMA: Funding of special projects

New York State

- Works strongly with New York’s transportation providers to develop a common agenda
- Gives limited financial support

San Diego (SANDAG)

- SANDAG is the transit agency for the San Diego region and wholly operates and funds regional ridesharing programs

New Jersey

- NJ Transit is the sister agency of NJDOT and receives FTA funding directly
- Private bus operators can receive fleet vehicles, but NOT money
- Contracts with 8 TMAs on an annual basis

Question 8: Which alternative modes and support strategies does your agency consider most effective in reducing emissions or VMT? How do you know and measure this?

Washington State

- Maintaining and expanding the CTR program and also expanding vanpooling, as vanpooling can be expanded easier than bus services
- Extensive evaluation of CTR programs for 10 years as well as extensive research on vanpooling market

Oregon

- No substantive work has been done to determine most effective measures
- Since the new 2003 funding, ODOT is working on developing a set of measurement criteria and standards

Washington DC

- Believes that interdependence of all programs offered⁵ make the programs effective
- But no measurements have been conducted of one strategy versus another, only of the combined effects of all programs together

Colorado

- Provides \$30/commute check to their employees as well as GRH
- No measurements have been done, but the light rail in Denver has been so successful that more lines are being built; within 2 weeks, the lines are at maximum capacity

Georgia

- No effective modes are mentioned
- Annual TDM measurement program (\$850,000 per year) but no specifics about the measurements

New Mexico

- “The MPO can impute the air quality and VMT reduction benefits of transit service by assuming a percentage of transit ridership comes from individuals who have a transportation choice, and then use regional travel distances for determining ‘saved’ VMT.”

Massachusetts

- Most effective programs are: a comprehensive transit system, an empty seat vanpool subsidy, incentive programs and improvements for bikers and pedestrians
- Periodic evaluation through the agency or the Central Transportation Planning staff and commuter choice program contractors

New York State

- Public Transit seems to be the most effective alternative mode of transportation, as stated in Question 1

⁵ Programs include a Commuter Operations Center, a regional GRH Program, Traveler Information kiosks, rideshare software upgrades, a Telework Resource Center, a regional consumer Mass Marketing Campaign, an Employer Outreach program, and an Employer Outreach for Bicycling program

- No rigorous quantitative programs have been undertaken for emission reduction as their primary goal is mobility and congestion mitigation

San Diego (SANDAG)

- Emphasis on Managed Lanes → Public Transit, Carpooling and Vanpooling
- Mobility 2030 Plan → State of the Commute Report → empirical data → performance measures

New Jersey

- The most effective mode is public transit, as New Jersey is a very dense area. But in general, all modes that more people use are effective, but the degree of effectiveness depends on the worksite situation (telecommuting, parking cash-out, expensive parking)
- Mobile 6 measures benefits today; vehicle inspection & maintenance program;
- Development of off-model air quality estimator to calculate potential of air quality benefits;