CONGESTION MITIGATION RESOURCES AND STRATEGIES FOR ARIZONA'S STATE HIGHWAY SYSTEM

Final Report 542

Volume II – Congestion Mitigation Strategies Resources

Prepared by:
Nayan S. Amin, Virginia A. Sapkota, & Cody T. Christensen
Bucher, Willis & Ratliff Corporation
18001 North 79th Avenue, Glendale, Arizona 85308
7920 Ward Parkway, Kansas City, Missouri 64114

October 2002

Prepared for:
Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007
in cooperation with
U.S. Department of Transportation
Federal Highway Administration

DISCLAIMER

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-AZ-02-542		

4. Title and Subtitle	5. Report Date
CONGESTION MITIGATION RESOURCES AND STRATEGIES FOR ARIZONA'S STATE HIGHWAY SYSTEM Volume II: Congestion Mitigation Strategies Resources	October 2002
	6. Performing Organization Code
7. Author Nayan S. Amin, Virginia A. Sapkota, & Cody T. Christensen	8. Performing Organization Report No.
9. Performing Organization Name and Address Bucher, Willis & Ratliff Corporation 18001 North 79th Avenue, Glendale, Arizona 85308 7920 Ward Parkway, Kansas City, Missouri 64114	10. Work Unit No.
	11. Contract or Grant No. SPR-PL-1-(61)542
12. Sponsoring Agency Name and Address Arizona Department of Transportation 206 S. 17th Avenue Phoenix, Arizona 85007 ADOT Project Manager: Stephen R. Owen, P.E.	13.Type of Report & Period Covered FINAL REPORT- December 2001 to October 2002
	14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. Abstract –

Growing traffic congestion is one of the most significant problems for the transportation system in Arizona, and the nation. Our propensity for single-occupant vehicles has produced not only the well documented metropolitan congestion but has become a universal problem, spreading to smaller urban and rural locations. Congestion affects the movement of people, the flow of goods to market, quality of life, energy consumption and the environment, including regional air quality. It impacts the ability to compete in the modern marketplace. As Arizona's population grows, congestion on the state's urban freeways and rural highways will only worsen. A challenge for the Arizona Department of Transportation (ADOT) will be to use a variety of practical, relevant congestion mitigation options in appropriate, collaborative and innovative ways to address current and future congestion problems.

To meet this challenge, ADOT has undertaken the development of a comprehensive Congestion Mitigation Methodology for the implementation of a consistent and sustained approach to assess and manage the growing congestion problem on all elements of the state highway system. This effort has resulted in the development of practical strategies to solve Arizona's mobility and congestion problems. A significant step in the development of the Congestion Mitigation Methodology was building a consensus among traffic management stakeholders on effective definitions for congestion and for congestion management. Input on the definitions and state of the practice in congestion mitigation came from a national survey of Metropolitan Planning Organizations and state Departments of Transportation and from a state-wide conference on congestion mitigation. The research project has produced recommendations for systematically quantifying congestion on Arizona's highways using a state-specific congestion index, and has also produced a database of available congestion mitigation strategies in Microsoft Access. The Arizona congestion index, mitigation strategies database, and a set of sound, practical project programming procedures are the primary elements of the emerging ADOT congestion mitigation toolset.

17. Key Words		18. Distribution Statement		23. Registrant's Seal
Congestion Index, Performance Measures, Rural Congestion, Urban Congestion, Congestion Mitigation Strategies, Congestion Measures, Monitoring Congestion, Measuring Congestion, Institutional Issues		Document is available to the U.S. Public through the National Technical Information Service, Springfield, Virginia, 22161		
19. Security Classification Unclassified	20. Security Classification Unclassified	21. No. of Pages 294	22. Price	

SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or “metric ton”)	mg (or “t”)
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
		ILLUMINATION		
fc	foot candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE AND PRESSURE OR STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	Square millimeters	0.0016	square inches	in^2
m^2	Square meters	10.764	square feet	ft^2
m^2	Square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	Cubic meters	35.315	cubic feet	ft^3
m^3	Cubic meters	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or “metric ton”)	1.102	short tons (2000lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE AND PRESSURE OR STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

TABLE OF CONTENTS

VOLUME I

EXECUTIVE SUMMARY 1

1. INTRODUCTION 3
   - 1.1 PROJECT BACKGROUND 3
   - 1.2 PROJECT REQUIREMENTS 3
   - 1.3 RESEARCH SCOPE 4
   - 1.4 INTENDED USE OF RESEARCH RESULTS 6
   - 1.5 REPORT ORGANIZATION 6

2. IDENTIFICATION AND DEFINITION 9
   - 2.1 INTRODUCTION 9
   - 2.2 CURRENT AGENCY PRACTICES IN ARIZONA 9
   - 2.3 REVIEW STATE TRANSPORTATION PLAN AND RELATED STUDIES 13
   - 2.4 NATIONAL INDUSTRY SURVEY 15
   - 2.5 CURRENT LITERATURE REVIEW 18
   - 2.6 REGIONAL CONFERENCE AND WORKSHOP 20
   - 2.7 TECHNICAL ADVISORY COMMITTEE PROJECT GUIDANCE 21
   - 2.8 SUMMARY 22

3. PERFORMANCE-BASED ENVIRONMENT 29

4. CONGESTION MITIGATION TOOLBOX FOR ARIZONA'S STATE HIGHWAY SYSTEM 31
   - 4.1 INTRODUCTION 31
   - 4.2 CONGESTION INDEX 31
   - 4.3 CONGESTION MITIGATION STRATEGIES DATABASE 32

5. SELECTION PROCESS OF RECOMMENDED STRATEGIES 35
   - 5.1 INFORMATION DEFINED FOR EACH STRATEGY 35
   - 5.2 SELECTION OF CANDIDATE STRATEGIES 39
   - 5.3 APPLICATION OF DATABASE FIELDS 40

5.4 Recommended Strategies 51

6. RELATIONAL DATABASE IN MS ACCESS 55

6.1 Multiple Characteristics 55
6.2 Extracting Information 55
6.3 Linking the Congestion Index and the Strategies Database 55

7. SUMMARY AND RECOMMENDATIONS 57

7.1 Summary 57
7.2 Congestion Mitigation Strategies Recommendations 58
7.3 Proposed Congestion Index Recommendations 58

BIBLIOGRAPHY 63

APPENDIXES 67

Appendix A Agency and National Industry Survey Questionnaire 68
Appendix B Arizona Transportation Studies Reviewed 71
Appendix C Review of Current Literature of Congestion Mitigation Research and Practices in the United States 75
Appendix D-1 Arizona Congestion Conference and Workshop: Pre-Conference White paper 129
Appendix D-2 Arizona Congestion Conference and Workshop: Post-Conference White paper 149

TABLE OF CONTENTS

VOLUME II

APPENDIX E PROPOSED CONGESTION INDEX FOR THE STATE HIGHWAY SYSTEM IN ARIZONA 171

APPENDIX F TWO-PAGE SUMMARY FOR EACH RECOMMENDED STRATEGY 185

APPENDIX G USER GUIDE TO THE CONGESTION STRATEGIES DATABASE IN MS ACCESS ENVIRONMENT 391

LIST OF FIGURES

FIGURE 1 PROJECT OVERVIEW 5
FIGURE 2 FIELDS DEFINED FOR EACH STRATEGY 36
FIGURE 3 SAMPLE DATABASE FORM SHOWING STRATEGY ATTRIBUTES...............................56

LIST OF TABLES

TABLE 1 LEVEL-OF-SERVICE DEFINITION..11
TABLE 2 DRAFT MITIGATION STRATEGIES BY CATEGORY..25
TABLE 3 LONG-RANGE TRANSPORTATION GOALS AND PERFORMANCE FACTORS...............41
TABLE 4 ALPHABETICAL LIST OF PERFORMANCE MEASURES IN THE STRATEGIES TOOLBOX 43
TABLE 5 RECOMMENDED STRATEGIES GROUPED BY CATEGORY 52

ACRONYMS

AAA	American Automobile Association
AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
ADOT	Arizona Department of Transportation
ATMS	Advanced Traffic Management Systems
ATRC	Arizona Transportation Research Center
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
BRT	Bus Rapid Transit
BWR	Bucher, Willis & Ratliff Corporation
CAAG	Central Arizona Association of Governments
CMS	Congestion Management System
CVO	Commercial Vehicle Operations
DEQ	Department of Environmental Quality
DMS	Dynamic Message Signs
DPS	Department of Public Safety
FHWA	Federal Highway Administration
FMS	Freeway Management System
HAR	Highway Advisory Radio
HCM	Highway Capacity Manual
HCRS	Highway Closure and Restriction System
HOV	High Occupancy Vehicle
HOT	High Occupancy Toll
HPMS	Highway Performance Monitoring System
ISTEA	Intermodal Surface Transportation Efficiency Act
ITS	Intelligent Transportation System
LOD	Level of Development
LOS	Level of Service
MAG	Maricopa Association of Governments
MARC	Mid-America Regional Council
MCDOT	Maricopa County Department of Transportation
MOE	Measures Of Effectiveness
MPO	Metropolitan Planning Organization
NAU	Northern Arizona University
NCHRP	National Cooperative Highway Research Program
PAG	Pima Association of Governments
PMT	Person Miles Traveled
ROW	Right-of-Way
RPTA	Regional Public Transportation Authority
RWIS	Road Weather Information Systems
SOV	Single Occupant Vehicle
TAC	Technical Advisory Committee
TDM	Travel Demand Management
TPD	Transportation Planning Division
TSM	Transportation System Management
TTI	Texas Transportation Institute
V/C	Volume-to-Capacity Ratio
VMS	Variable Message Signs
VMT	Vehicle Miles Traveled

ACKNOWLEDGEMENTS

ADOT Transportation Technology Group's Tim Wolfe served as champion and ADOT ATRC's Steve Owen served as the ADOT project manager for the **Congestion Mitigation Resources and Strategies for Arizona's State Highway System** research project. A Technical Advisory Committee (TAC), listed below, guided the consultant team in the project.

Technical Advisory Committee

(TAC alternates in parentheses)

Team Member	Agency
Tim Wolfe (Project Champion)	ADOT Transportation Technology Group
Victor Mendez (Debra Brisk)	ADOT Director / Core Team
David Jankofsky / Terry Trost	OSPB / Core Team
Dale Buskirk (John Pein)	ADOT Transportation Planning
Frank McCullagh	ADOT Asset Management
Tom Parlante	ADOT Traffic Engineering
John Louis	ADOT Roadway Design
Tom Buick (Mike Sabatini; Dave Wolfson)	Maricopa County DOT
Mark Schlappi	Maricopa Association of Governments
Paul Casertano	Pima Association of Governments
Ed Stillings	Federal Highway Administration
Stephen Owen – ADOT Project Manager	Arizona Transportation Research Center

Team Member	Agency
Nayan Amin – Consultant Project Manager	Bucher, Willis & Ratliff Corp.
Virginia Sapkota	Bucher, Willis & Ratliff Corp.
Cody Christensen	Bucher, Willis & Ratliff Corp.
Andrew Kolcz	DKS Associates
Craig Roberts	Northern Arizona University
Shawn Turner	Texas Transportation Institute
Tim Lomax	Texas Transportation Institute
Robert Mickelson	Independent Consultant
Sharon Hansen	PBS&J

APPENDIX E

PROPOSED CONGESTION INDEX FOR THE STATE HIGHWAY SYSTEM IN ARIZONA

PROPOSED CONGESTION INDEX FOR THE STATE HIGHWAY SYSTEM IN ARIZONA

INTRODUCTION

This document summarizes key issues and recommendations related to developing a congestion index for the State Highway System in Arizona. The concepts presented in the document have been developed and refined by the Texas Transportation Institute over the course of the past 10 years. The concepts were derived and have been refined from numerous congestion research studies, technical debates and discussions with other transportation professionals, and an ongoing dialogue with non-technical audiences (e.g., media, elected officials, etc.). In particular, there are several congestion research activities that fully document key congestion concepts:

- *Urban Mobility Study*, http://mobility.tamu.edu/ums, sponsored by 10 state DOTs
- *Mobility Monitoring Program*, http://mobility.tamu.edu/mmp, sponsored by Federal Highway Administration with 23 participating cities
- *Quantifying Congestion*, sponsored by the National Cooperative Highway Research Program, published as NCHRP Report 398
- *Travel Time Data Collection Handbook*, sponsored by Federal Highway Administration, available at http://tti.tamu.edu/

CONGESTION MEASURES

The research team recommends the use of the travel time index as the key measure of congestion on the State Highway System. The travel time index is defined as the ratio of peak travel times to free-flow travel times (Equation 1).

Equation 1

$$Travel\ Time\ Index\ (TTI) = \frac{Peak\ Travel\ Time}{Free-Flow\ Travel\ Time}$$

Travel times for this index can be obtained using numerous methods:

- directly measured or collected using a variety of techniques (e.g., see TTI's Travel Time Data Collection Handbook);
- estimated from spots speeds that are directly measured or collected;
- estimated from traffic volume and roadway characteristics using empirical relationships or computer models.

Free-flow travel times for the index can be estimated with several techniques:

- using empirical data from other studies (e.g., 60 mph for urban freeway, etc.);
- using posted speed limits on uninterrupted-flow roadways (in the absence of empirical data); or
- using signal timing parameters on interrupted-flow roadways.

The travel time index can be averaged or combined for different trip or facility lengths by simply weighting each trip or facility's travel time index value by its respective person-miles of travel (PMT) or vehicle-miles of travel (VMT) for highway-only averages. Equation 2 illustrates the weighting concept and how it can be used to calculate summary or aggregate travel time index values.

Equation 2

$$TTI_{summary} = \frac{[TTI \times PMT]_{trip\ or\ facility\ 1} + [TTI \times PMT]_{trip\ or\ facility\ 2} + \ldots}{Total\ PMT}$$

In Equation 2, note that VMT could be used in place of PMT if no vehicle occupancy data is available or the average vehicle occupancy is not expected to change. Similarly, the travel time index can be averaged or combined for streets, freeways, bus and carpool lanes, bus and rail transit, bicycle facilities and even sidewalks. The travel time index values are combined by simply weighting each travel time index value by its respective PMT or VMT value (Equation 2). All of these system elements have a free-flow travel time and when crowded, the travel time increases. A corridor value can be developed using the number of persons traveling on each facility or mode to calculate the weighted average of the conditions on adjacent streets, freeways, HOV lanes, bus routes and/or rail transit lines. The corridor values can be computed for hourly conditions and weighted by the number of travelers to estimate peak-period or daily index values.

The use of a continuous numerical scale with the travel time index remedies a shortcoming in the level-of-service (LOS) technique that uses letter grades. Letter grades are easy to communicate, but the calculation procedures can produce some discontinuities where the next letter grade is only 10 vehicles from the volume being used for analysis. This "jump" in grade produces somewhat artificial differences between alternatives. Additionally, LOS is difficult to accurately average across different modes and road classifications because of different LOS definitions and criteria. For example, density is used to define LOS on freeways yet travel speed is used on arterial streets. The travel time index corrects this deficiency by using a ratio of peak to free-flow travel times as the consistent comparison across different roadway functional classifications.

Applying the Travel Time Index in Rural Areas

The travel time index has been extensively tested and used for urban area applications where the magnitude of congestion is significant enough to create a wide range of travel time index values. However, the use of the travel time index in rural areas has not been extensively tested to ensure that the index is sensitive to rural congestion concerns. Although congestion in rural areas in Arizona is likely a small to modest portion of the overall statewide congestion picture, it is still desirable to identify and accurately reflect the rural congestion outside of urban areas.

There have been concerns about the travel time index being sensitive to detect “isolated pockets” of congestion on long statewide corridors. For example, even a 30-minute delay might seem insignificant for a 4-hour trip across the state, as this translates to a travel time index value of 1.12). One approach to make the travel time index more sensitive to isolated congestion is to split long stretches of state highway into several analysis segments, which could range from 20 to 50 miles in length.

Another approach (either in combination with the “segmentation” or separately) could be to keep the acceptable travel time index value at near 1.00 (e.g. free-flow travel times) in rural areas, but accept higher index values in urban areas. For example, a travel time index value of 1.00 could be the “mobility target” for rural areas and an index value of 1.20 could be the target for urban areas. The approach of setting different targets by location is also illustrated later in this document as Table 1. The approach of using different mobility targets for different area types also was a common strategy as revealed in this project’s industry survey of other state DOTs.

Other possible approaches could involve a different or a composite congestion measure for rural areas. With this approach, the rural congestion index could be weighted by other factors that relate to one or several of the following factors:

- driver level of comfort
- speed distributions
- vehicle headways or gaps
- vehicle mix; and
- terrain conditions.

A rural traveler survey could help immensely in identifying those key congestion factors (e.g., driver comfort, travel time, reliability, etc.) that are of interest in rural areas.

As revealed in the industry survey of practice, most other state DOTs were dealing with the urban-rural congestion issue by using similar or identical congestion measures but defining different standards or targets for rural areas. The research team recommends a similar course of action for Arizona DOT. That is, we recommend using some variation of the travel time index in rural areas, but perhaps weight the index value by an appropriate factor to be determined. However, more work is needed (via rural traveler surveys and experimentation) to confirm the most desirable approach to implementing a congestion index in rural areas.

Applying the Travel Time Index to Roadways and Corridors

Application of the travel time index measure to more than one roadway or mode can extend the "reach" of summary congestion statistics. Individual modes or routes can be evaluated, but it is particularly useful for corridor, sub-area and regional analyses. The travel time index generally indicates the intensity of congestion problems; that is, large index values represent more travel time. There is also a congestion duration component when the travel time index is calculated for a peak period. Larger travel time index values are only possible for areas where mobility problems exist for more than one peak hour in the morning and evening.

A system-based travel time index can also reflect the effect of new land use arrangements and increases in non-motorized travel modes. For most areas in the near term, including these "green" options will not have much effect on an areawide congestion index if the index uses the amount of person travel as the method of averaging conditions across modes. The effect of new land use arrangements will not be noticed on an areawide scale until the new approaches are a significant portion of the land use. The index may have its application in future analyses that illustrate the effect of different development strategies.

The peak period should be the basic period of analysis, but depending on the type of improvement alternative or issue being examined, the full day (split into different analysis periods such as early morning, morning peak, mid-day, evening peak, and late evening) may also be appropriate time periods for analysis. Peak hour information might be useful in relatively uncongested areas, but if slow speeds extend beyond one hour (or are projected to extend beyond an hour in the future) a longer time period is appropriate. In some cases daily traffic volume information might be used to estimate peak period conditions. Daily averages should not used if those statistics will result in significant problems being obscured by free-flow travel during other portions of the day.

Other Relevant Congestion Measures

In addition to this key measure, we recommend several other travel time-based measures that quantify different attributes of congestion. These other measures include:

- delay per traveler (minutes per person);
- percentage of travel that is congested (i.e., vehicle, person, or freight-miles of travel); and
- buffer time index (i.e., a measure of travel time reliability).

The delay per traveler measure is designed to resonate with travelers and other transportation system users by reporting delay in terms that travelers can understand and relate to (as opposed to aggregate delay reported in thousands of vehicle-hours). The delay values can be directly collected from travel time data or can be estimated using numerous empirical methods or computer modeling techniques. The basic delay equation is shown below as Equation 3.

Equation 3 $\mathit{Delay\ per\ traveler} = \mathit{Actual\ Travel\ Time} - \mathit{Free\text{-}Flow\ Travel\ Time}$

The percentage of travel that is congested can be expressed in numerous ways depending upon the particular application or analysis:

- % of VMT that is congested, useful for highway-only analyses;
- % of PMT that is congested, useful for multi-model analyses; and,
- % of freight ton-miles that are congested, useful for freight and commodity analyses.

All of the congestion measures presented thus far reflect the average level of congestion and mobility. However, a number of empirical studies have demonstrated that travelers value not only the time it usually takes to complete a trip but also the reliability in travel times. For example, many commuters will plan their departure times based on an assumed travel time that is greater than the average to account for this unreliability.

From a performance monitoring standpoint, reliability must be considered because incident management and traveler information strategies target the atypical events that decrease reliability. This is important because it is typical for the value of travel time savings to dominate the benefits assigned to major transportation improvement projects. Simply focusing on average conditions would miss a large share of the benefits that accrue from these operational strategies.

Therefore, in addition to the above three congestion measures, the research team recommends that Arizona DOT consider a travel reliability measure. At this time, we recommend using the buffer time index, which is a measure of the extra time that transportation system users have to budget to arrive on-time with some degree of confidence.

TTI has defined the buffer time index as follows: the percentage of an average trip time that would have to be added as an extra "buffer" to ensure an on-time arrival 95 percent of the time (e.g., commuters would be late only 1 of 20 workdays per month with 95 percent on-time arrivals). Calculation of the measure is presented in Equation 4. Indexing the reliability measure (i.e., dividing by the average travel time) provides a time and distance neutral measure, but the actual travel time values could be used by an individual traveler for a particular trip length. The index is calculated for each road segment and a weighted average is calculated using PMT or VMT as the weighting factor.

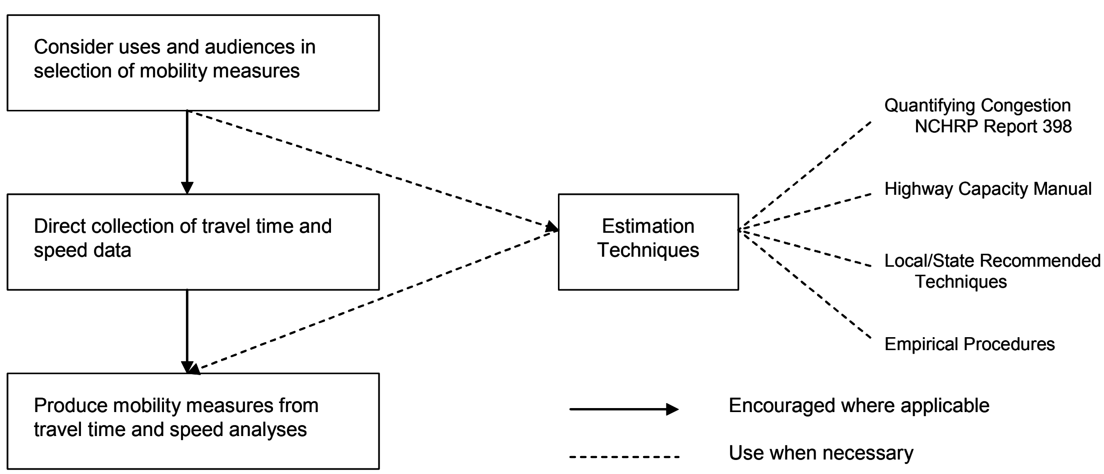
Equation 4
$$BT_{Index} = W_{Average}\left[\frac{\text{95th Percentile Travel Time - Average Travel Time}}{\text{Average Travel Time}} \text{ x } 100\%\right]$$

where BT_{Index} means buffer time index and $W_{Average}$ is the weighted average of all sections using PMT or VMT.

CONGESTION DATA COLLECTION TECHNIQUES

The travel time data to calculate the travel time index and other congestion measures does not have to be difficult or expensive to collect. The travel time data can be either directly measured using various types of field equipment, or can be estimated using traffic volumes and roadway cross-section information. In the Phoenix and Tucson regions, travel time and speed data are already being collected by the metropolitan planning organizations and/or traffic operations centers. Data collection can be concentrated on the locations with significant congestion problems. The remaining system can be sampled and a range of analytical methods can be used to estimate travel times. Some basic data collection concepts are summarized in the following paragraphs. These concepts are documented fully in NCHRP Report 398, *Quantifying Congestion*, and the *Travel Time Data Collection Handbook*.

Concerns about the cost and feasibility of collecting travel time data are frequently the first issue mentioned in discussions of travel time-based congestion measures. There are many ways to collect or estimate the travel time and speed quantities; data collection should not be the determining factor about which measures are used. Figure 1 makes the point that while the direct collection of data is the desirable method of obtaining travel time/speed information, the selection of the proper measures should be the first step. While it is not always possible to separate data collection issues from measure selection, this should be the goal.



Source: Quantifying Congestion

Figure 1 Role of Data Collection Issues in Measuring Congestion Mobility

Sampling procedures and estimation techniques can provide useful travel time information with limited data collection budgets. Advanced technologies already provide a significant improvement in travel time data and the number of transportation analyses that use this real-time data is growing. As these systems are installed in cities, travel time information will be more readily available in at least some corridors.

Travel time and speed data can be collected on a sample set of roads, routes or modes in the analysis area. A strategic approach to sampling can be used—focus the travel time collection efforts on the problem or opportunity areas, and estimate travel conditions on the rest of the system with a combination of limited data collection and estimating procedures. Techniques such as this allow mobility assessment programs to be more effective and affordable, especially for annual monitoring purposes or for complex study areas. Specific procedures and recommendations for data collection are included in the FHWA's *Travel Time Data Collection Handbook*.

The results of any estimate should be used with an allowance for the potential error that can be introduced when such estimates are derived. Travel time estimation procedures are most applicable for policy, programming, or planning purposes—situations where the future is not known with precision, but it is important to select between alternative actions. This selection process often calls for mixing direct data and estimates. In these cases, a separate estimate of the speed must be made for existing and future conditions. The future rate should be calculated using Equation 5, which combines estimated travel rates for existing and future conditions with existing travel rates. This process reduces the error that would be induced by comparing actual rates to estimated rates—the difference may be related to the method used to obtain the estimate.

Equation 5

$$\begin{matrix}\textit{Future} \\ \textit{Travel Rate}\end{matrix} = \begin{matrix}\textit{Existing} \\ \textit{Travel Rate}\end{matrix} \times \frac{\textit{Estimate of Future Conditions}}{\textit{Estimate of Existing Conditions}}$$

Highway Capacity Manual (HCM) procedures are the basis for many national, state and local analytical processes. These count-based procedures are relatively detailed, with default factors provided when data are not available. The procedures and statistics have been developed for planning and operational analyses and the products have not always been useful for communicating to audiences beyond transportation professionals. The HCM procedures have been developed from analysis of physical limitations of road systems at critical points. As such, the interaction between road sections that determines travel time along a congested road, as well as the spread of congested conditions beyond the peak hour, have not been a prominent aspect of HCM.

The incorporation of HCM procedures into computerized operations models has extended the usefulness of HCM to corridor and system analysis needs. Efforts to revise the 2000 Highway Capacity Manual are developing travel speed and delay estimates for all the key analytical procedures and encouraging computer models for corridor analyses. HCM-based procedures will always have a role in producing mobility measures, but the direct collection of travel time data can assist in calibrating computer models and estimation techniques.

Vehicle occupancy data may be important for some analyses where modal, ridesharing or other actions are being studied. The analysis may be able to use a set of regularly conducted studies in the urban area as a start for the analysis. Focused vehicle occupancy studies in locations where the average rate is likely to be different from the remainder of the urban area can be used to identify the effect of actions and assess locations where modal alternatives have been enacted. There may be many studies in an area where the use of general occupancy rates will be sufficient to adjust vehicle quantities to person values for economic analysis and presentation of results.

The key to developing good mobility measures is to recognize the interaction between elements of the transportation system. Changes in one mode, operating system/procedure or demand patterns can have effects that go beyond the original intent of the analysis. These potential effects should be considered in developing data collection plans.

SETTING MOBILITY TARGETS OR CONGESTION "BENCHMARKS"

The research team recommends that "mobility targets" (i.e. acceptable congestion benchmarks) be developed that are based on location, roadway functional classification, time of day, and other factors. The travel time index compares peak period travel times to free-flow travel times. In some cases, however, free-flow travel times may not be possible or desirable given local growth patterns, funding and environmental constraints, and public/political support. Thus, the Arizona DOT should develop "mobility targets" that define the acceptable travel time index values (analogous to defining an acceptable level of service). The initial mobility targets could be developed by calculating existing congestion (e.g., benchmarking), then setting appropriate but realistic mobility targets. The mobility targets could be developed through a community consensus process, similar to the input obtained during long-range transportation plan updates. This concept of mobility targets is illustrated in Table 1.

Table 1. Illustrative Example of Mobility Targets Using Acceptable Travel Time Index Values

Location	Acceptable Travel Time Index Value by Roadway Classification			
	National Highway System	Other State Highways	Strategic Regional Arterials	Other roadway designations, etc.
Large Urban				
Small Urban				
Rural				
Activity Center				

Note: The acceptable values to be listed in this table should be identified through a consensus process that gathers input from both technical and non-technical groups.

National or statewide comparisons of travel conditions will be the most frequent use of free-flow conditions as the "benchmark." Analyses of system adequacy, the need for improvements or time-series analyses conducted in a corridor or area can benefit from comparisons using "acceptable" travel time index values.

Free-flow conditions will not be the goal of most large urban transportation improvement programs, but using them provides one consistent benchmark relevant for year-to-year and city-to-city comparisons. The "attainment of goals" standard might also be used at the national or state level, but more often during a discussion of planning and project prioritization techniques.

The use of "acceptable" or "target" travel time index values can improve the guidance provided to system planners and engineers. If the target travel time index values are a product of public discussion, they will illustrate the balance that the public wishes to have between road space, social effects, environmental impacts, economic issues and quality of life concerns. Areas or system elements where the performance is worse than the target can be the focus of more detailed study. A corridor analysis, for instance, might indicate a problem with one mode, but the solution may be to improve another mode or program that is a more cost-effective approach to raising the corridor value to the target.

Using target travel time index values for local analyses provides the public input on priorities and concerns that might otherwise require extensive opinion surveys. The input is available to the agency staff level where projects and programs are developed, so that alternative improvements can be quantitatively compared to the targeted conditions. The amount of corridor or areawide person travel that occurs in conditions worse than the locally determined targets can be used to monitor progress toward transportation goals and identify problem areas.

FINDINGS AND RECOMMENDATIONS

This appendix has summarized the definition and calculation of a proposed congestion index that could be implemented for the 6,200-mile State Highway System in Arizona. The research team has the following recommendations:

- **Use the travel time index as the key measure of congestion** - As their key congestion measure, the Arizona DOT should use the travel time index, which is defined as the ratio of peak period travel time to free-flow travel times. The travel time index may need to be adjusted or weighted to be sensitive to rural congestion concerns, but more work is needed to confirm the best approach. In addition to this key measure, we recommend several other travel time-based measures that quantify different dimensions of congestion. These other measures include delay per traveler (minutes per person), percentage of travel that is congested (i.e., vehicle, person, or freight ton-miles of travel), and the buffer time index (i.e., a measure of travel time reliability). These concepts are summarized here but documented fully at http://mobility.tamu.edu.

- **Utilize existing data and information systems to estimate congestion** - The recommended short-term approach for congestion monitoring on Arizona state highways should rely on three primary sources of data to estimate both recurring congestion (where travel demand regularly exceeds available roadway capacity) and non-recurring congestion (where planned or unplanned "events" either disrupt smooth traffic flow or exacerbate regular traffic problems). These three primary sources of data are: 1) archived operations (or ITS) data from traffic operations centers or arterial street signal systems; 2) ADOT's Highway Closure and Restriction System (HCRS) that is currently used to report special conditions or events on Arizona's state highways; and 3) ADOT Transportation Planning Division (TPD) highway traffic database that is currently used to estimate congestion (via level of service measures) on a statewide basis. All three of these recommended resources will require work and expense to fully develop and integrate their capabilities as required for calculation of the travel time index.

- **Recognize that the congestion monitoring process will evolve over the next 5 to 10 years** – ADOT should recognize that the congestion data sources and estimation procedures would evolve and improve over time. For example, operations-based traffic sensors will continue to be deployed in efforts to manage congested traffic and provide traveler information. Although operations sensors currently cover less than 2 percent of state highway mileage, it includes about 25 percent of the state's total vehicle-miles of travel (VMT) and an even greater portion of the congestion. The data from these operations sensors can also be used to improve and validate the travel time estimation procedures in the HCRS and TPD databases. The benefits will come from improved archived operations data, and enhanced congestion estimation procedures in the HCRS and TPD databases.

- **Develop "mobility targets" (i.e. acceptable congestion standards) based on location, functional classification, and/or route level of development** - The travel time index compares peak period travel times to free-flow travel times. In some cases, however, free-flow travel times may not be possible or desirable given local growth patterns, funding and environmental constraints, and public/political support. Thus, the Arizona DOT should develop "mobility targets" that define the acceptable travel time index values (analogous to defining an acceptable level of service). Initial mobility targets can be established by benchmarking existing congestion levels and then setting appropriate but realistic targets given policy goals and existing conditions. Input to the mobility targets can also be obtained during transportation plan updates.

- **Use mobility targets to differentiate between acceptable urban and rural congestion -** It is envisioned that the mobility targets will be one of the mechanisms that is used to equitably distribute congestion mitigation funds between the urban and rural areas of the state. This can be accomplished by setting "higher" mobility targets in rural areas than in urban areas. For example, the mobility target for rural areas could be a travel time index value of 1.00 (free-flow travel), whereas the mobility target for urban areas could be a travel time index value of 1.20 (peak period travel times 20% higher than free-flow). Thus, congestion mitigation “triggers” would occur at higher speeds on rural roadways than urban roadways.

- **Periodically examine and update mobility targets based upon congestion benchmarks and customer satisfaction** – The initial mobility targets could be developed by calculating existing congestion (e.g., benchmarking), then setting appropriate but realistic mobility targets. Data from customer satisfaction surveys can also serve as a critical indicator of acceptable congestion levels. Once developed through a congestion benchmarking process, these mobility targets could be updated to reflect changing customer expectations and preferences. Thus, we recommend that customer satisfaction surveys be a part of the ongoing congestion monitoring process.

- **Consider a pilot project and/or phased implementation as a means to fully develop the congestion monitoring and mitigation program** – A pilot project could be used to test the application of the recommended congestion measures, data estimation techniques, and mitigation strategies. A pilot project would also help move this project’s recommendations a step closer to implementation within ADOT.

Recommended Implementation Approach for Congestion Monitoring in Arizona

The recommended short-term approach for congestion monitoring on Arizona state highways should rely on three primary sources of data to estimate both recurring congestion (where travel demand regularly exceeds available roadway capacity) and non-recurring congestion (where planned or unplanned "events" either disrupt smooth traffic flow or exacerbate regular traffic problems). These three primary sources of data and how they contribute to the "Arizona congestion picture" are as follows:

1. **Archived Operations (or ITS) Data** - Archived operations data should be used to directly measure roadway congestion in large metropolitan areas where ITS has been deployed. Archived operations data typically consist of traffic volume and speed data on major freeways and some arterial streets in large metropolitan areas, and are collected continuously (24 hours a day, 365 days per year) in detailed time (5 minutes or less) and space (1 mile or less typical) intervals. The archived operations data serves as one of the best measurements of congestion where it is available, and this data source is being pursued widely by numerous DOTs for congestion/performance monitoring. Two major advantages are that 1) this data source covers many of the most congested state highways in Arizona, and 2) the data source captures both recurring and non-recurring congestion. A major limitation is that this data source covers a small portion of Arizona's total state highway system. A disadvantage is that operations sensors currently cover less than 5 percent of the total statewide highway system. There are also issues of comparability between direct measurements of congestion (as with archived operations data) and congestion estimates from other empirical processes (like #2 and #3 below).

2. **Highway Closure and Restriction System (HCRS)** - The HCRS database should be used to estimate non-recurring congestion that occurs on state highways with no operations sensor coverage (the principal majority of Arizona's state highway system). The HCRS database currently captures a wide variety of events that produce traffic congestion outside of major metropolitan areas, such as work zones, incidents, and weather events. Non-recurring congestion will be estimated by traffic models using data entered into HCRS by ADOT district personnel and other local government entities. The traffic models will utilize HCRS data such as location and length of event (milepost-based), number of lanes closed/affected, estimated duration of event, and other data necessary to compute travel times and delays using traffic flow models. The traffic models to estimate non-recurring congestion may also require baseline traffic conditions and roadway geometry, which is available in transportation planning databases (see #3 below). Major advantages of using HCRS to estimate non-recurring congestion are 1) the database is already in place and has widespread acceptance and use throughout Arizona and 2) it enables an estimate for non-recurring congestion, which may be a large portion of the total congestion picture on many state highways. A limitation is that the congestion is only an estimate, and not a direct measurement of congestion.

3. **Transportation Planning Division (TPD) Database** – ADOT TPD's traffic database, which consists of planning-level roadway traffic and geometry data, should be used to estimate recurring congestion on state highways with no operations sensor coverage. TPD currently uses this same database to generate statewide roadway level of service (LOS) estimates. For numerous reasons described previously, we are recommending that ADOT migrate from LOS-based congestion measures to travel time-based congestion measures. The same underlying TPD database, though, can be used to estimate the travel time-based congestion measures. Various travel time estimation procedures from planning-level data have already been developed for other applications; however, it will be necessary to adapt and validate these estimation procedures for Arizona state highways. A major advantage of using the TPD database is that this same database is already being used to generate statewide congestion estimates, albeit congestion via LOS measures. A limitation is that the congestion is only an estimate, and not a direct measurement of congestion.

If ADOT pursues this short-term approach of utilizing three existing databases, the primary implementation challenge will be integrating data from the three "legacy" systems. All three of these recommended resources will require work and expense to fully develop and integrate their capabilities as required for the recommended congestion index concept.

As has been described previously, the recommended long-term approach for congestion monitoring in Arizona includes travel time/speed sensor deployment along Arizona key/strategic state highways. These sensors could logically be used for multiple purposes beyond congestion monitoring, such as traveler information, traffic control, and/or incident management.

BIBLIOGRAPHY

Highway Capacity Manual: HCM2000. Transportation Research Board, National Research Council, 2000.

Industry Survey On Congestion Monitoring And Mitigation Practices. Conducted by the BWR Project Team for Arizona DOT, June 2002.

Lomax, T.J., S.M. Turner and R. Margiotta. *Monitoring Urban Roadways: Using Archived Operations Data for Reliability and Mobility Measurement*. Report FHWA-OP-02-029. Federal Highway Administration, Texas Transportation Institute, December 2001.

Lomax, T.J., S.M. Turner, G. Shunk, H.S. Levinson, R.H. Pratt, P.N. Bay, and G.B. Douglas. *Quantifying Congestion: Final Report*. NCHRP Report 398, Volume I. National Cooperative Highway Research Program, Transportation Research Board, September 1996.

Lomax, T.J., S.M. Turner, G. Shunk, H.S. Levinson, R.H. Pratt, P.N. Bay, and G.B. Douglas. *Quantifying Congestion: Users Guide*. NCHRP Report 398, Volume II. National Cooperative Highway Research Program, Transportation Research Board, September 1996.

Schrank, D.L. and T.J. Lomax. *2001 Urban Mobility Report*. Sponsored by Departments of Transportation in California, Colorado, Florida, Kentucky, Maryland, Minnesota, New York, Oregon, Texas, Virginia, and Washington, May 2001, http://mobility.tamu.edu/ums.

Texas Transportation Institute. *The Keys to Estimating Mobility: Applying Definitions and Measures that Everyone Understands*. Sponsored by Departments of Transportation in California, Colorado, Florida, Kentucky, Maryland, Minnesota, New York, Oregon, Texas, Virginia, and Washington, January 2000, http://mobility.tamu.edu/.

Turner, S.M. et al. *Travel Time Data Collection Handbook*. Report No. FHWA-PL-98-035. Federal Highway Administration, Texas Transportation Institute, March 1998, http://tti.tamu.edu/inside/hdv/ama/its%5Fdata/tt%5Fbook.stm.

APPENDIX F

TWO-PAGE SUMMARY FOR EACH RECOMMENDED STRATEGY

This Appendix F provides a detailed two-page summary of information pertaining to each of the 99 recommended strategies outlined in Section 5.4 of the main report. Table 5 of the main report lists the recommended strategies, and is reproduced below.

Recommended Strategies Grouped by Category

CATEGORY / STRATEGY NUMBER AND NAME	
Access Management	
#1 Driveway Management	#3 Median Management
#2 Frontage Roads	
Advanced Public Transportation Systems	
#4 Automatic Vehicle Location System	#6 Vehicle Management Systems
#5 Electronic Fare Payment	
Advanced Traffic Management Systems	
#7 Alternate Routing Information System	#12 Freeway Management
#8 Automatic Anti-Icing System	#13 Highway-Rail Intersections Management
#9 Electronic Border Crossing	#14 Smart Corridors
#10 Electronic Toll Collection (ETC)	#15 Special Event Plans
#11 Emergency Management	
Advanced Traveler Information Systems	
#16 Dynamic Message Sign	#18 Regional Multimodal Traveler Information
#17 Kiosk	#19 Road Weather Information Systems (RWIS)
Advanced Vehicle Control Systems	
#20 Collision Avoidance System	#21 Vehicle Guidance System
Alternative Work Arrangements	
#22 Compressed Work Weeks	#24 Staggered Work Hours
#23 Flex-Time	
Arterials and Collectors	
#25 Add Lanes to Existing Facilities	#26 Construct New Facilities
Commercial Vehicle Improvements	
#27 Advanced Port Processing Plans	#30 Intermodal Facilities
#28 Commercial Vehicle Facilities	#31 Truck Routes
#29 Geometric Improvements	
Commercial Vehicle Operations (CVO)	
#32 Electronic Credential Checking	#33 Weigh-in-Motion System
Communication Substitution	
#34 Online Shopping	#36 Teleconferencing
#35 Telecommuting	#37 Teleshopping
Construction Management	
#38 Advance Notice	#41 Lane Closures Management
#39 Construction Management Plans	#42 Signing
#40 Detours	
Expressways	
#43 Add Lanes to Existing Facilities	#44 Construct New Facilities

Freeways			
#45	Add Lanes to Freeways	#48	Freeway Express Lanes
#46	Construct New Freeways	$49	Freeway Ramp Lane Additions
#47	Freeway Auxiliary Lanes	#50	Freeway to Freeway Connections
HOV Measures			
#51	HOV Priority Systems	#52	HOV Support Services
Incident Management			
#53	Hazardous Material Incident Response	#56	Incident Information/Routing
#54	Incident Clearance	#57	Incident Response
#55	Incident Detection/Verification		
Land Use/Zoning and Growth Management			
#58	Compact Development	#61	Mixed Use Development
#59	Corridor Land Use and Transportation Coordination	#62	Transit-Oriented Development
#60	Jobs/Housing Balance		
Non-Motorized Measures			
#63	Bike Lanes	#66	Pedestrian Overpass/Underpass
#64	Bike Route Marking/Signing	#67	Shared-Use Paths
#65	Bike/Pedestrian Support Services	#68	Sidewalks
Road Pricing			
#69	Parking Fees	#70	Road User Fees
Roadway Geometric Improvements			
#71	Acceleration/Deceleration Lanes	#78	One-way Couplets
#72	Bus Turnouts	#79	Passing Lanes
#73	Channelization	#80	Providing Additional Lanes without Widening
#74	Climbing Lanes	#81	Reversible Lanes
#75	Grade Separation	#82	Turn Lanes
#76	Improve Shoulders	#83	Vehicle Pullouts
#77	Lane Widening		
Time-of-Day Restrictions			
#84	Parking Restrictions	#86	Turning Restrictions
#85	Truck Restrictions		
Traffic Operational Improvements			
#87	Ramp Metering	#88	Traffic Signal Improvements
Transit Capital Improvements			
#89	Exclusive Right-of-Way Facilities	#91	Transit Support Facilities
#90	Fleet Improvements		
Transit Operational Improvements			
#92	Fare Incentives	#94	Transit Marketing/Information
#93	Traffic Operations for Transit	#95	Transit Service Improvements
Travel Demand Measures			
#96	Guaranteed Ride Home Programs	#98	Ridesharing Programs
#97	Parking/Site Management	#99	Transit/Carpool Incentives

Some of the strategies include more information than can be printed in the format of this Appendix. The strategies with additional material are listed below, and this extra material follows the 99 strategy listings.

STRATEGY NO.	STRATEGY NAME	COMPLETE INFORMATION	PAGE NO.
#12	Freeway Management	Institutional Factors	387
#16	Dynamic Message Sign	Examples	387
#88	Traffic Signal Improvements	Examples	388

STRATEGY #	1	Driveway Management	ORIENTATION	Supply
CATEGORY	Access Management			

DESCRIPTION

Driveway management involves controlling the number and/or location of driveways along a roadway. Examples of driveway management include shared use-driveways, consolidation of multiple driveways, driveway removal, side-street or alley access, and cross-access between properties. Driveway management is facilitated through state or municipal policies and requirements including policies on driveway spacing, location, and width; the number of accesses allowed per parcel or development; and conditions for reuse of existing accesses. Access permitting processes, local planning/zoning regulations, and enforcement can ensure uniform application of driveway criteria. Land use/zoning and growth management is a complementary strategy.

Application of this strategy is ideal where access related problems occur or in areas that are being developed to prevent access related issues in the future. Driveway management is also beneficial in areas with large numbers of accesses, large driveway widths that do not channelize movements, driveways adjacent to intersections that interfere with the operation of the intersection, and offset driveways that create turning movement conflicts. Agencies can take advantage of reconstruction projects to implement access changes.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Other	All locations	All congestion types	All Day
Adjacent Development	Minor Arterial			All Year
Frequency of Access Points	Major Collector			
	Minor Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Travel Speeds	Accident rates	Accident rates
Increase Capacity	Average speed	Development density
Reduce Conflicts	Delay on minor street	Distance between access points
Reduce Frequency of Accidents	Effects on business	Driveway volumes
	Miles of congested roadway	Moving car runs
		Number of access points
		Traffic counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity	Improve travel speeds	Improve safety
Reduce conflicts	Reduce delay	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Low	Medium

RELATIVE BENEFIT NOTES

Vehicles leaving or entering a roadway from adjacent properties naturally conflict with through vehicles causing them to slow down. This, in turn, leads directly to delays and is a principal cause of congestion safety concerns on roadways with no access control. Reduction of driveway movements decreases side friction, effectively increasing roadway capacity. Through vehicles experience improved travel speeds, fewer speed reductions, and reduced conflicts. Driveway management may also result in lower accident rates.

EFFECTS EVALUATION

Criteria for the application of driveway management measures include the number of conflict points, their proximity to each other and intersections, traffic volumes, driveway volume and development density. Utilizing basic highway capacity concepts and/or simulation models like CORSIM, the planner can generate analytical justification for implementing driveway management measures. For a long corridor or in a regional setting, impacts can be estimated using a regional model.

Businesses often fear a major impact from access restrictions. Data may be needed to support a finding that impacts were minimal. Most difficult part of traffic analysis is gauging effect on side street delay or ease of access.

STRATEGY # **1** Driveway Management

RELATIVE COST NOTES

DISADVANTAGES

Potential disbenefits are increased travel distances and times for those accessing adjacent properties and reduced accessibility to these properties. In addition there may also be adverse impact on businesses

INSTITUTIONAL FACTORS

State law requires that access be provided between public roads and private properties. Driveway management standards and regulations are the responsibility of the agency with jurisdiction over the affected roadway. Many agencies have established uniform policies for application throughout their jurisdictions. New or revised access management policies are sometimes accompanied by changes in legislation at the state level.

Driveway management in developed areas can be difficult to implement, especially when prevailing conditions suggest the need for stricter control of access. For sites undergoing redevelopment, driveway management can be implemented through application of standards in the same way as for new development. In many areas, however, driveway management has not been tightly regulated, and making changes in access policies, driveway standards, permitting and zoning that affect existing entrances is often politically challenging. For other currently developed areas, it is necessary to gain the support of affected property owners. In this case, alternative access arrangements may need to be implemented.

WARRANTS

No definite warrant

EXAMPLES

Fifty-two percent of all accidents in Colorado were access-related; 32 percent of all fatalities. In Oklahoma, 57 percent of the accidents are access-related; in Michigan 55 percent.

A. Irvine, CA: (1990 pop –110,330); Alton Parkway; City of Irvine; cost not available; 8.5 mile, four-lane, raised median roadway; two-lane roadway converted to a four-lane roadway with a raised median; access management is a major component in land planning and development in this “young” community, incorporated in 1971.
B. Melbourne Area, FL: (1990 pop –60,034); New Haven Avenue; Florida DOT; $4,230,000 cost; 5.1 mile four-lane divided arterial; 16 median openings were closed and 42 full openings were modified to directional median openings; traffic volumes increased dramatically and travel speeds increased.
C. Atlanta, GA: (1990 pop –393,929); Memorial Drive (State Route 10); $3,919,876 cost; Georgia DOT; 4.34 mile section replaced two-way left turn lane with raised median; 7 large intersections were not provided with median openings.
D. Overland Park, KS: (1990 pop –111,790); 135th Street (Kansas State Highway 150); Cities of Overland Park, Leawood, and Olathe; cost not available; study produced concept of 9 mile multi-lane arterial with median, and limited right-turn-only access; median openings every half-mile, right-turn-only access, and reverse frontage roads (along the back sides of properties) every quarter-mile in areas of intensive development; concept applied as uniformly as possible with exceptions handled on a case-by-case basis.
E. Plano, TX: (1990 pop –127,885); Access Management / Custer Road; $6,326,992 cost; City of Plano; 6-lane roadway with 24-foot median; design follows Thoroughfare Standards Rules and Regulations Manual, which outlines City’s policies concerning access management.

STRATEGY #	2	Frontage Roads	ORIENTATION	Supply
CATEGORY	Access Management			

DESCRIPTION

Frontage roads are the construction of parallel roadways adjacent to a highway or arterial providing access to parcels along the facility. Access to properties is maintained and vehicle throughput and capacity along the main roadway is preserved. Vehicles then access the major facility at selected locations. Frontage roads are the most effective access management strategy, but are also the most expensive due mostly to right of way issues as well as cost for construction.

Frontage roads can be applied to a specific section or along an entire corridor. Application of this strategy is ideal where access related problems occur or in areas that are being developed to prevent access related issues in the future. Frontage roads are also beneficial in areas with large numbers of accesses, large driveway widths that do not channelize movements, and offset driveways that create turning movement conflicts. The largest requirement to consider in applying this strategy is the availability of right-of-way. The implementation of frontage roads should consider secondary impacts on adjacent roadways due to the redistribution of traffic.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	Urban	All congestion types	All Day
Facility Expansion Feasibility	Principal Arterial Expressway	Metropolitan		All Year
Frequency of Access Points	Principal Arterial Other			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Travel Speeds	Accident rates	Accident rates
Increase Capacity	Average speed	Moving car runs
Reduce Frequency of Accidents	Delay on minor street	Traffic counts
	Effects on business	
	Miles of congested roadway	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity	Improve travel speeds	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

Implementation of frontage road strategies frees existing lanes for through movements, increasing capacity and separating slower traffic bound for adjacent property from the through traffic stream. This increases travel speeds and reduces accident rates for through vehicles by removing most centerline and driveway conflicts. Turning vehicles will also benefit from this improved safety.

EFFECTS EVALUATION

Frontage road actions reduce the number of conflict points, reduce deceleration requirements, and remove turning vehicles from through lanes. The analyst must define the proposed program and estimate speed changes due to contemplated frontage road improvements. Using basic Highway Capacity Manual techniques or sophisticated modeling, the comparison of speed change results with travel delay reductions is useful in a frontage road analysis.

Businesses often fear a major impact from access restrictions. Data may be needed to support a finding that impacts were minimal. Most difficult part of traffic analysis is gauging effect on side street delay or ease of access.

STRATEGY # 2 Frontage Roads

RELATIVE COST NOTES

Frontage roads are the most effective of access management strategies, but also the most expensive due to construction and ROW costs.

DISADVANTAGES

An inadequate frontage road system can result in worse problems for adjacent intersections and roadways.

INSTITUTIONAL FACTORS

The implementation of frontage roads is the responsibility of the agency with jurisdiction over the affected roadway. ADOT can work with local governments, land owners an developers to implement frontage roads. These improvements require expensive right of way, roadway construction, intersection modifications, traffic signal improvements and median alterations, along with changes in access control. They are only applied in dense development situations where adjacent property owners support such an improvement and needed right of way can be obtained.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 3 Median Management

ORIENTATION Supply

CATEGORY Access Management

DESCRIPTION

Median management involves the installation of center medians within a roadway that limit left turning movements as well as cross movements. The removal of left turns and cross traffic increases capacity and improves vehicle throughput and safety along the major roadway. Median management also involves the establishment of median breaks where left turn and through movements are allowed. Bi-directional left turn lanes can also be installed to allow left-turns from the major roadway while restricting through and left-turns from the cross street. Median management is typically facilitated through state or municipal regulatory policies and requirements that are applied to one or more functional classes of roadway. The regulatory requirements detail policies on median placement, median break locations, and median break spacing. Land use/zoning and growth management is a complementary strategy.

Application of this strategy is ideal where access related problems occur or in areas that are being developed to prevent access related issues in the future. Median management is also beneficial in areas with large numbers of accesses that create turning movement conflicts, at roadway sections with too many median breaks, when median breaks adjacent to intersections interfere with the operation of the intersection, at bi-directional turn lanes that are near capacity, and at locations that do not currently have bi-directional turn lanes. Uncontrolled strip development often leads to the need for median management and other access management strategies to restore capacity vehicle throughput to desired levels. Agencies can take advantage of reconstruction projects to implement median changes.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Frequency of Access Points	Principal Arterial Other	All locations	All congestion types	All Day
Number of Lanes	Minor Arterial			All Year
	Major Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Accident rates	Accident rates
Improve Travel Speeds	Average speed	Moving car runs
Increase Capacity	Delay on minor street	Traffic counts
Reduce Conflicts	Effects on business	
Reduce Delay	Miles of congested roadway	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity	Improve travel speeds	Improve safety
Reduce conflicts	Reduce delay	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Medium	Medium

RELATIVE BENEFIT NOTES

Managing access for vehicles to turn across centerlines reduces vehicle conflicts and traffic flow friction, therefore effectively increasing capacity and improving safety. Through vehicles experience increased travel speed, fewer deceleration incidents, and less delay. Turning vehicles benefit form improved safety.

EFFECTS EVALUATION

Planners can estimate the impact of median management measures by analyzing basic traffic data, including roadway configuration, driveway locations, turning movement counts, through vehicle counts, accident history and travel speed. Basic highway capacity concepts and/or simulation models like CORSIM may be used for this analysis. Over a long corridor or in a regional setting, estimation of impacts can be accomplished through use of a regional model. In some instances the implementation of median management measures requires drivers to use alternate routes or make detours to make their desired move. If this additional travel is significant, it can negate the positive impacts of median management measures.

Businesses often fear a major impact from access restrictions. Data may be needed to support a finding that impacts were minimal. Most difficult part of traffic analysis is gauging effect on side street delay or ease of access.

STRATEGY # **3** Median Management

RELATIVE COST NOTES

Continuous median strip for left turns - $2,000 per block

DISADVANTAGES

Turning vehicles may experience increased travel distances and times if alternative routing is necessary. The possibility of reduced accessibility to adjacent properties is also a concern.

INSTITUTIONAL FACTORS

The implementation of median management measures is the responsibility of the agency with jurisdiction over the affected roadway. An agency may have a long standing policy of median management, but may not make significant changes in median configuration unless in conjunction with a roadway improvement. In limited circumstances, businesses have successfully petitioned an agency for reestablishing a median cut, citing adverse conditions and access.

WARRANTS

No definite warrant

EXAMPLES

A study in Wichita, Kansas, reported that prohibition of turns between intersections by use of a median reduced accidents between intersections by amounts ranging from 43 percent to 69 percent during the first three years after the median was installed. During the same period, accidents at intersections where turns were not prohibited increased by amounts ranging from 12 percent to 38 percent. However, because accidents between intersections originally represented more than 60 percent of the total accidents on the street section affected by the construction, the median construction resulted in a net accident reduction ranging from 12 percent to 38 percent (see section on Arterial Access Management).

STRATEGY #	4	Automatic Vehicle Location System	ORIENTATION	Supply
CATEGORY	Advanced Public Transportation Systems			

DESCRIPTION

Automatic vehicle location (AVL) systems utilize GPS and communications technology to give real-time information on vehicle location. Information on the position of a transit vehicle can be relayed back to a central command center to be used by transit agency personnel to monitor resources, scheduling, and safety. By knowing where transit vehicles are located, maintenance and emergency response can be expedited. Information can also be conveyed to transit users in the form of real-time schedules and delays. AVL technology can be applied to transit, commercial trucking, or any agency with a fleet of vehicles. Related strategies include other advanced public transportation system strategies, regional multimodal traveler information, kiosks, other transit improvements, and commercial vehicle operations strategies.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Make Real-time Adjustments	Mode share/shift On-time arrivals Transfer time Transit ridership	Mode shift Ridership Schedule adherence monitoring Transit in-vehicle travel time Usage/customer satisfaction surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Allow real-time adjustments Allows monitoring of transit system	Enhance security	Expedite response to maintenance and security p

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Difficult

RELATIVE BENEFIT NOTES

Transit AVL can improve a transit agency's ability to make real-time adjustments in transit runs and to respond to maintenance and security problems.

The benefits of APTS vary depending upon the type of system implemented. Electronic fare payment reduces boarding times and reduces cash management costs and theft problems. An integrated vehicle management system is useful for monitoring the transit system and improving efficiency.

Surveillance measures reduce security problems and perception of such problems. Vehicle maintenance systems help identify maintenance needs more exactly, reducing breakdowns and allowing for more effective maintenance programs. Dynamic ridesharing increases the potential for reducing vehicle trips and reducing transportation costs for travelers.

EFFECTS EVALUATION

Each type of APTS strategy would need to be analyzed differently. Transit maintenance, fare management, and security systems have benefits to internal efficiency and would need to be evaluated from a cost-management standpoint. Dynamic ridesharing, AVL, and fare management systems can be analyzed in terms of potential attraction of transit trips and reduction in delay. Benefits can be derived through simple sketch-planning techniques.

The methods employed for evaluation will depend on the type of APTS strategy. "After" data may be easily collected using installed systems. Problem will usually be collecting "before" data. Surveys of riders can be used to gauge views on new APTS systems.

STRATEGY # | **4** | Automatic Vehicle Location System

RELATIVE COST NOTES

The cost of implementing AVL depends on the size of the system, its level of sophistication, and the components to be included.

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy requires that regional policy be oriented to pursue the use of technology to improve transit operations and service.

Additional issues can involve software development, existing software compatibility, institutional relationships, establishment of GIS database, consistency with National Intelligent Transportation Systems Architecture, technical expertise, reluctancy of staff to learn maintenance and operation, addition of staff, communications, and GPS reception.

WARRANTS

No definite warrant

EXAMPLES

Automatic vehicle location (AVL) systems based on signpost, triangulation, LORAN, and more recently GPS technologies have been in use as part of transit management systems. The most direct improvement enabled by AVL systems relates to schedule adherence. Some examples of AVL implementations are described:

A) The Mass Transit Administration in Baltimore, Maryland, reported a 23% improvement in on-time performance by AVL-equipped buses.

B) The Kansas City Area Transportation Authority in and around Kansas City, Missouri, improved on-time performance by 12% in the first year of operation using AVL, compared to a 7% improvement as the result of
a coordinated effort between 1986 and 1989.

C) Preliminary results from Milwaukee, Wisconsin, indicate a 28% decrease in the number of buses more than one minute behind schedule.

D) In Denver, AVL systems with silent alarms have supported a 33% reduction in bus passenger assaults. It also decreased customer complaints by 26%. Moreover, it has improved on-time bus performance by 9 to 23%.

E) In San Jose, AVL has reduced paratransit expense from $4.88 to $3.72 per passenger.

STRATEGY # 5 Electronic Fare Payment

ORIENTATION Supply

CATEGORY Advanced Public Transportation Systems

DESCRIPTION

Electronic fare payment utilizes advanced communications and information technologies to automate fare collection for transit. This strategy is among other advanced applications to improve the efficiency and use of transit. Electronic fare payment utilizes "smart cards". Cards can be read as the rider enters the transit vehicle. Fees are automatically deducted from the rider's account. Additional fees can be automatically transferred to the cards. This strategy is typically implemented on the entire system. Electronic fare payment can improve vehicle loading time and enhance cash management.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Reduce Boarding Time Reduce Cash Management Costs	Mode share/shift On-time arrivals Transfer time Transit ridership	Mode shift Ridership Transit in-vehicle travel time Usage/customer satisfaction surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce boarding times Reduce cash management and theft proble	Reduced boarding times	Reduces cash management costs and theft probl

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Difficult

RELATIVE BENEFIT NOTES

Electronic fare payment reduces boarding times and reduces cash management costs and theft problems.

The benefits of APTS vary depending upon the type of system implemented. Transit AVL can improve a transit agency's ability to make real-time adjustments in transit runs and to respond to maintenance and security problems. An integrated vehicle management system is useful for monitoring the transit system and improving efficiency.

Surveillance measures reduce security problems and perception of such problems. Vehicle maintenance systems help identify maintenance needs more exactly, reducing breakdowns and allowing for more effective maintenance programs. Dynamic ridesharing increases the potential for reducing vehicle trips and reducing transportation costs for travelers.

EFFECTS EVALUATION

Each type of APTS strategy would need to be analyzed differently. Transit maintenance, fare management, and security systems have benefits to internal efficiency and would need to be evaluated from a cost-management standpoint. Dynamic ridesharing, AVL, and fare management systems can be analyzed in terms of potential attraction of transit trips and reduction in delay. Benefits can be derived through simple sketch-planning techniques.

The methods employed for evaluation will depend on the type of APTS strategy. "After" data may be easily collected using installed systems. Problem will usually be collecting "before" data. Surveys of riders can be used to gauge views on new APTS systems.

STRATEGY # | **5** | Electronic Fare Payment

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy requires that regional policy be oriented to pursue the use of technology to improve transit operations and service.

WARRANTS

No definite warrant

EXAMPLES

Europe has enjoyed between 71 to 87 percent user acceptance of smart cards for transit/city coordinated services.

In New York, the Metro Card System resulted in savings of approximately 70 million dollars per year.

STRATEGY #	6	Vehicle Management Systems	ORIENTATION	Supply
CATEGORY	Advanced Public Transportation Systems			

DESCRIPTION

Vehicle management systems are similar to freeway management systems in that they incorporate several ITS components together to improve the efficiency and use of public transportation systems. Technological components include: electronic fare payment, automatic vehicle identification (AVI) systems, automatic vehicle location (AVL) systems, and advanced communications. Information from AVI and AVL systems can be used to allow transit providers to efficiently manage personnel and resources. Information can also be conveyed to transit users in the form of real-time schedules and delays. This strategy can help address issues regarding vehicle reliability, schedule adherence, and safety. Regional multimodal traveler information, kiosks, and other transit improvements are related strategies.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Mode share/shift	Mode shift
Make Real-time Adjustments	On-time arrivals	Ridership
Reduce Boarding Time	Transfer time	Transit in-vehicle travel time
Reduce Cash Management Costs	Transit ridership	Usage/customer satisfaction surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Allows monitoring of transit system Improve system efficiency	No specific benefit to user	Improve air quality

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Difficult

RELATIVE BENEFIT NOTES

An integrated vehicle management system is useful for monitoring the transit system and improving efficiency.

The benefits of APTS vary depending upon the type of system implemented. Electronic fare payment reduces boarding times and reduces cash management costs and theft problems. Transit AVL can improve a transit agency's ability to make real-time adjustments in transit runs and to respond to maintenance and security problems.

Surveillance measures reduce security problems and perception of such problems. Vehicle maintenance systems help identify maintenance needs more exactly, reducing breakdowns and allowing for more effective maintenance programs. Dynamic ridesharing increases the potential for reducing vehicle trips and reducing transportation costs for travelers.

EFFECTS EVALUATION

Each type of APTS strategy would need to be analyzed differently. Transit maintenance, fare management, and security systems have benefits to internal efficiency and would need to be evaluated from a cost-management standpoint. Dynamic ridesharing, AVL, and fare management systems can be analyzed in terms of potential attraction of transit trips and reduction in delay. Benefits can be derived through simple sketch-planning techniques.

The methods employed for evaluation will depend on the type of APTS strategy. "After" data may be easily collected using installed systems. Problem will usually be collecting "before" data. Surveys of riders can be used to gauge views on new APTS systems.

STRATEGY # **6** Vehicle Management Systems

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy requires that regional policy be oriented to pursue the use of technology to improve transit operations and service.

WARRANTS

No definite warrant

EXAMPLES

A) The Mass Transit Administration in Baltimore, Maryland, reported a 23% improvement in on-time performance by AVL-equipped buses.

B) The Kansas City Area Transportation Authority in and around Kansas City, Missouri, improved on-time performance by 12% in the first year of operation using AVL, compared to a 7% improvement as the result of
a coordinated effort between 1986 and 1989.

C) Europe has enjoyed a 71-87% user acceptance of smart cards for transit/city coordinated services.

D) In New York, the Metro Card System resulted in savings of approximately 70 million dollars per year.

STRATEGY # 7 — Alternate Routing Information System

ORIENTATION Supply

CATEGORY Advanced Traffic Management Systems

DESCRIPTION

An alternate routing information system is an interactive, GIS-based software tool that lets users review suitable detour options, and select and initiate the optimal alternate routes. The system incorporates existing alternate route and detour plans and allows flexible display of "what-if" scenarios such as forest fires or closed bridges. Closely related strategies include regional multi-modal traveler information and construction detours.

Another system that is not advanced is the low-cost route diversion system concept which uses static guide signs and route markers to define permanent alternates to primary routes with recurrent problems.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Allow Informed Decisions Improve Vehicular Travel Times Manage Traffic Flow Reduce Demand	Amount/proportion of traffic diverted Delay Travel time	Delay Travel time Alternate routes

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Allow real-time adjustments Diversion of traffic Efficient use of available capacity Improve traffic flow	Allow informed decisions Reduce delay Reduce travel time	Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Medium	Difficult

RELATIVE BENEFIT NOTES

Alternate routing information systems can improve system efficiency by allowing transportation agencies and officials to select optimal alternate routes. By redirecting traffic around closures due to weather, incidents, or construction, traffic flows are improved and delay and travel time are minimized.

STRATEGY # **7** Alternate Routing Information System

RELATIVE COST NOTES

DISADVANTAGES

The system needs continuous updates and long-term maintenance.

INSTITUTIONAL FACTORS

ADOT has been involved in an Alternate Routing Information System (ARIS) research study that attempts to incorporate the recent Statewide Alternate Route Plan and ADOT District Detour Plans into an interactive GIS software tool.

WARRANTS

No definite warrant

EXAMPLES

ADOT is currently involved in an Alternate Routing Information System (ARIS) research study that attempts to incorporate the recent Statewide Alternate Route Plan and ADOT District Detour Plans into an interactive GIS software tool.

This low-cost route diversion option is applied in Virginia to effectively redirect traffic during typically congested tourists seasons. Hampton Roads has a number of predefined alternate routes to heavily traveled tourist routes. Each alternate route is assigned a distinctly shaped and colored identifier (e.g., triangle, square, circle, diamond). Frequent diversion confirmation is given along the route by placing the appropriate colored symbols on existing static signs and the end of the diversion route. In addition, Hampton Roads also utilizes HAR and flashing lights to indicate when the alternate route is recommended. The system is operational and is used heavily between Memorial Day and Labor Day. Costs vary according to the number of signs used, and typically only include sign costs. HAR systems could be added for $10,000-20,000.

STRATEGY #	8	Automatic Anti-Icing System	ORIENTATION	Supply
CATEGORY	Advanced Traffic Management Systems			

DESCRIPTION

Automatic anti-icing systems provide spontaneous application of anti-icing materials to roadways once certain conditions are reached. This strategy addresses weather related safety issues by eliminating ice at specific problem areas such as bridge decks or shady areas. Automatic anti-icing systems can detect ice and treat the roadway before conditions become dangerous for drivers. Implementation of this strategy requires environmental or in-road sensors, a processor to gauge when conditions for de-icing have been reached, and a device to remove the ice. Application is particularly useful at key spots that freeze earlier than other spots, in particularly vulnerable locations, or places that are difficult for maintenance vehicles to reach. Agencies can take advantage of reconstruction projects to incorporate automatic anti-icing systems at a much lower cost and effort.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment Terrain	All Functional Classes	Urban Activity Centers Rural	Recurring un-predictable	Seasonal

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Safety Reduce Delay	Accident rates Administrative efficiency improvements Delay	Accident rates Delay Maintenance and operation costs

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce conflicts Better resource utilization Reduce maintenance and operation costs	Reduce delay Enhance security Customer satisfaction	Improve safety Reduce emissions Reduce the probability of secondary accidents

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Low	Medium

RELATIVE BENEFIT NOTES

Anti-icing impacts include an increase in roadway safety in areas that are prone to icy and potentially hazardous conditions, and a reduction in maintenance costs. This strategy has the potential to avoid incidents and congestion; therefore reducing emissions, reducing the possibility for secondary collisions, reducing delay, etc.

STRATEGY # 8 Automatic Anti-Icing System

RELATIVE COST NOTES

Incorporated of this strategy into reconstruction projects can greatly reduce installation costs.

DISADVANTAGES

Anti-icing systems can fail to work when nozzles are clogged with debris or damage by snowplows.

INSTITUTIONAL FACTORS

System failure and subsequent accidents, and the replacement of personnel duties with the automated system are issues that need to be addressed.

WARRANTS

No definite warrant

EXAMPLES

A) The City of Ft. Collins installed and deployed two anti-icing systems on a bridge at the bottom of steep hill, a short distance before a railroad grade crossing. The anti-icing systems are capable of operating automatically using a sensor, via remote control, by way of a wireless paging system or manual activation. The system is programmed with the number of activations necessary to fully de-ice the specified area and the amount of time the pump needs to run. A trailer containing the chemical tanks and the decision-making processor is located near the road and the only requirement is a 120-volt single-phase power source. The Fort Collins system covers 200 feet of a two-lane highway but may be adjusted to cover a larger surface area. Installation and testing of the anti-icing system in Ft. Collins took roughly 16 to 24 hours, while estimated time for installation for a bridge deck system is roughly 40 to 50 man-hours. Scheduled maintenance must be done four times a year, at the start of the winter, twice during winter, and once at the beginning of spring. The city of Ft. Collins plans to install and deploy an additional anti-icing system that will surround the perimeter of a roundabout. Total costs include; utilities, communications costs (i.e., transmit road and weather information), de-icing solution, nozzles, sensors, spray pumps, and tanks. Total cost was estimated at $15,000.

B) Anti-Icing Systems are currently in use in the following states; Kansas, Michigan, Kentucky, Maryland, Minnesota, Nebraska, New Mexico, New York, North Carolina, Pennsylvania, Utah, Virginia, and Wisconsin.

STRATEGY #	9	Electronic Border Crossing	ORIENTATION	Demand
CATEGORY	Advanced Traffic Management Systems			

DESCRIPTION

Bottlenecks often occur on highways that cross international boundaries. Truck freight movement has increased since development of Free Trade Zones and NAFTA. Queues at border crossings can extend onto the traffic network of the adjacent cities, creating congestion at both the crossings and the adjacent cities.

Electronic border crossings utilize communications and electronic technologies to expedite processing and crossing at national and international borders. Many recent studies to apply technologies have focused on the accuracy and improvements in vehicle identification. Technologies are now capable of identifying vehicles at mainline speeds and at a high rate of accuracy. As a result, throughput is optimized, and delay that would occur at border crossings is significantly reduced (FHWA, 1999). The application of these technologies can increase system throughput, reduce delays, enhance customer service, improve safety, and reduce environmental impacts.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate Principal Arterial Other Minor Arterial Major Collector Minor Collector	Rural Special Venue	All congestion types	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Reduce Delay	Delay per ton-mile	Delay at weigh stations/border crossings Number of access points

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow Improve throughput	Reduce delay Reduce waiting time	Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

EFFECTS EVALUATION

George Bays of ADOT MVD, stationed in Sierra Vista manages all southern Arizona border crossings and can provide evaluation information.

STRATEGY # 9 Electronic Border Crossing

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

There are institutional factors involved at international crossings.

WARRANTS

No definite warrant

EXAMPLES

A. San Diego, CA: (1990 pop – 1,110,623); San Ysidro and Otay Mesa Land-Border Ports; cost not available; U.S. Customs Department, Immigration and Naturalization Service, and the Department of Agriculture; Otay port opened in 1985; San Ysidro port was the largest land-border port in the world in 1996.

B. Detroit, MI: (1990 pop – 1,027,974); Detroit/Windsor Tunnel and Ambassador Bridge Border Crossing; cost not available; the Ambassador Bridge is the most heavily used port for commercial traffic traveling to Canada and recently installed a commuter card and a PORTPASS system.

C. El Paso, TX: (1990 pop – 515,342); Zaragoza Bridge and Bridge of the Americas; $8.0 million upgrade cost for each bridge; Texas DOT and City of El Paso; primary services included an increase in the number of structures and lanes for passenger and commercial traffic, safer pedestrian walkways, and greater number of check points.

D. Laredo, TX: (1990 pop – 122,899); Laredo Northwest International Bridge; $59.3 million; U.S. DOT and Texas DOT; primary services included an eight lane international bridge, a Laredo-managed toll plaza and export lot, federal inspection offices and processing facilities, and state-managed highway facilities.

STRATEGY #	10	Electronic Toll Collection (ETC)	ORIENTATION	Supply
CATEGORY	Advanced Traffic Management Systems			

DESCRIPTION

Electronic Toll Collection (ETC) systems utilize communications and electronic technologies (through AVI or automatic vehicle identification) to support the automated collection of payment at toll booths and other collection points. Smartcards can be placed in the dashboards of cars that can be read as the driver travels through the toll collection facility allowing non-stop travel through the toll collection point. Fees are automatically deducted from the drivers account. The application of these technologies can increase system throughput, reduce delays, enhance customer service, improve safety, and reduce environmental impacts.

Electronic Toll Collection (ETC) is an area of ITS where benefits due to impacts on the cost of toll administration, management and collection have been demonstrated. Vehicle delay reduction and throughput at toll plazas have been proven to be very high. Many recent studies to apply ETC have focused on the accuracy and improvements in vehicle identification. Technologies are now capable of identifying vehicles at mainline speeds and at a high rate of accuracy. As a result, throughput is optimized, and delay that would occur at toll plazas is significantly reduced (FHWA, 1999).

ETC systems are also applied to CVO (Commercial Vehicle Operations).

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	Principal Arterial Interstate	Urban	Recurring predictable	Peak Hour
Vehicle Mix	Principal Arterial Expressway	Metropolitan	Recurring un-predictable	All Day
				All Year
				Seasonal

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Average speed	Real time speed
Reduce Delay	Average service times	Total average weekday daily volume through toll
Savings on Cost for Tollbooths	Savings in vehicle hours per weekday or year	Total average weekend daily volume through toll
		Percentage volumes with electronic tolls

EFFECTS EVALUATION

It will be important to determine the proper mix of ETC and manual lanes to allow for optimal road use and traffic flow. One key issue is the need for regional architecture standardization, but first the boundaries that constitute a “region” must be determined. The industry is debating the merits of discounting tolls for ETC users to encourage use, or charging them for the convenience of ETC.

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety	Reduce delay	Reduce emissions
Improve throughput		
Reduce delay		
Save operating costs at toll plazas		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

Electronic Toll Collection has been shown to reduce emissions, decrease delay, improve throughput, and save on the operating costs at toll plazas. It is estimated that the number of people required to operate toll collection booths can be reduced by 43%. Roadway and building maintenance cost can be reduced approximately 14% and 2%, respectively. Some examples that demonstrates the benefits of ETC implementation are given in the "Examples" section.

STRATEGY # | **10** | Electronic Toll Collection (ETC)

RELATIVE COST NOTES

The components of cost for ETC implementation includes: installation cost that widely varies depending on site location, operating and maintenance cost.

DISADVANTAGES

Experiences in Lee County proved that a poorly designed and poorly implemented ETC systems can be quite costly and can negatively impact traffic and the environment. Lee County reported that with tens of thousands of transactions per day, the problems created from a small percentage of incorrect transactions are significant (Burris 1998). Verification of the system's accuracy before making a selection was critical to the success of many early ETC programs.

INSTITUTIONAL FACTORS

WARRANTS

No definite warrant

EXAMPLES

Deployment of ETC is occurring throughout the United States and overseas at a rapid pace and is being driven by cost savings to the operator. Some examples of implementations include:

A) The Pike Pass ETC program on the Oklahoma Turnpike started operation on the first of January 1991. As of June 1994, 250,000 passes had been issued, of which over 90% (226,000) were still active, accounting for 35% of the turnpike association's revenue.

B) ETC can greatly improve throughput on a per-lane basis compared
with manual toll collection techniques. On the Tappan Zee Bridge toll plaza, a manual toll lane can accommodate 400–450 vehicles per hour while an electronic lane peaks at 1000 vehicles per hour.

C) 20% of travelers on two bridges in Lee County, Florida, adjusted their departure times as a result of value pricing using electronic tolling.

D) The new Jersey Turnpike Authority (NJTA) E-Zpass system has reduced vehicle delay by 85%. In addition, the NJTA models indicate E-Zpass saves: 1.2 mil gallons of fuel/year, 0.35 tons of VOC/day, and 0.056 tons Nox/day.

E) A protocol, prepared by the Northeast States for Coordinated Air Use Management, is used to estimate toll booth emissions at three locations. The locations are the Muskogee Turnpike in Oklahoma, the Asbury Plaza on the Garden State Parkway in New Jersey, and the Western Plaza on the Massachusetts Turnpike. The protocol is based on dynamometer tests and toll road observation. The Clean Air Action Corp. report uses the experiences gained with the Pike Pass project and applies them to the other two freeways. It projects significant reduction in tons of pollutants for the 260 day commuter case. The overall percent change is dependent upon the frequency of toll plazas. The average emissions reductions are 72% for carbon monoxide, 83% for hydrocarbons, and 45% for oxides of nitrogen per mile of impacted operation.

F) Japan initiated a test operation of ETC at the Odawara Toll Gate on March 31, 1997 to confirm that safe and smooth traffic operation can be secured at actual toll gates. Where conventional toll collection takes 14 seconds per car in Japan on average, ETC takes only about 3 seconds per car.

STRATEGY # 11 Emergency Management

ORIENTATION Supply

CATEGORY Advanced Traffic Management Systems

DESCRIPTION

Emergency management services aim to improve response time of emergency service personnel. The improved response time can save lives and reduce property damage. Time savings can be improved in both the time it takes to let response providers know of an emergency and the time it takes for responders to get to the scene. Emergency notification can be performed with cellular telephones, call boxes, and mayday systems (ITS Deployment Tracking Database 2000).

Emergency management systems can have significant effects, both on accident survival and on motorist peace of mind. Of drivers testing the Puget Sound Help Me (PuSHMe) mayday system, 95 percent stated that they felt more secure operating a vehicle with the system installed.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	All locations	All congestion types	All Day
	Principal Arterial Expressway			All Year
	Principal Arterial Other			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Provide Improved Knowledge of Maintenan	Average duration of incident	Moving car runs
Reduce Delay	Average speed	Real time speed
Reduce Frequency of Accidents	Intersection delay	Real time traffic volume
	Number of stops	Traffic counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety	Reduce delay	Improve safety
Reduce delay		Improved interagency coordination and decision-
		Improved knowledge of maintenance problems

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Medium

RELATIVE BENEFIT NOTES

The benefits of ATMS primarily include reductions in delay for recurring and non-recurring congestion, and reduction in accidents. A number of studies have indicated that computerized signal systems can achieve as much as a 25% increase in average speeds when compared against situations with older timing plans. One of the significant benefits of surface street ATMS is that it provides the capability to interactively adjust timing plans in response to unique conditions, such as incidents and special events. In addition, there may be internal management efficiencies for some systems, such as the benefits of improved knowledge of maintenance problems with controllers or detectors. Improved interagency coordination and decision-making is often a side benefit of such systems.

EFFECTS EVALUATION

There are several tools available to assist with the analysis of ATMS. On the expressway side, these include several simulation models, such as FREQ, FREFLO, FRESIM, and INTEGRATION. For surface streets, TRANSYT-7F and NETSIM can be used to estimate benefits, primarily the impact on vehicle delay. INTEGRATION allows for full interaction between expressway and arterial systems. Recently, FHWA has also provided an integrated version of FRESIM and NETSIM, called CORSIM, allowing for the analysis of expressway and arterial networks as a unit.

To conduct an evaluation, the analyst must select the appropriate tools and provide the inputs that will replicate the ATMS techniques to be employed. Some of the tools may not be able to directly accommodate some ATMS measures.

Ability to access surveillance data before system control functions are operational is the main determinant of whether data can be used from the surveillance system. Calibration of the system is critical.

STRATEGY # **11** Emergency Management

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy requires training of personnel, procurement of special equipment, and coordination and communication between agencies.

WARRANTS

No definite warrant

EXAMPLES

In Palm Beach, the use of GPS/AVL systems have reduced police response times by 20%.

95% of drivers equipped with PushMe Mayday system felt more secure.

STRATEGY #	12	Freeway Management	ORIENTATION	Supply
CATEGORY	Advanced Traffic Management Systems			

DESCRIPTION

Freeway management systems (FMS) are developed to address growing congestion experienced on roadways. The focal point of an FMS is usually a traffic operation center (TOC). Real-time information is available within the TOC, allowing operators, planners, and engineers to interact and make immediate, informed decisions regarding transportation. Information about incidents, accidents, road and bridge closures, and emergency situations are gathered through equipment, such as loop detectors and closed circuit television, and then disseminated to the public. Advanced technologies within an FMS include integrated expressway/arterial operation, computerized signal control systems, and advanced signal optimization programs. Automated congestion detection, automated response plans, freeway ramp meters, traffic signals, and video cameras can be used to support and control traffic and incidents from within the TOC. This equipment helps reduce the time required to detect and respond to congestion-causing incidents by allowing immediate identification of a problem and determining the proper response. TOC personnel, along with agencies such as state DOTs, local agencies, and emergency response teams, coordinate and develop plans to use this technology in order to quickly provide important information to motorists. Variable message signs and highway radio advisory release incident information, alternative routes, or possible detours to aid motorists in their daily commute.

Freeway management systems can be applied to freeways and surface streets. Related strategies include ramp metering, traffic signal improvements, incident detection/verification, incident information/routing, and regional multimodal traveler information. The critical element of freeway management is the communication system which ties the detection and surveillance equipment with the TOC.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	Urban	All congestion types	Peak Hour
	Principal Arterial Expressway	Metropolitan		All Year
		Activity Centers		
		Rural		

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Make Real-time Adjustments	Average speed	Moving car runs
Provide Improved Knowledge of Maintenan	Intersection delay	Real time speed
Reduce Delay	Number of stops	Real time traffic volume
Reduce Frequency of Accidents		Traffic counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Allow real-time adjustments	Reduce delay	Improve safety
Efficient use of available capacity		Improved interagency coordination and decision-
Improve traffic flow		Improved knowledge of maintenance problems
Reduce localized traffic congestion		Reduce emissions
Reduce maintenance and operation costs		
Imrprove incident management		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

The benefits of ATMS primarily include reductions in delay for recurring and non-recurring congestion, and reduction in accidents. A number of studies have indicated that computerized signal systems can achieve as much as a 25% increase in average speeds when compared against situations with older timing plans. One of the significant benefits of surface street ATMS is that it provides the capability to interactively adjust timing plans in response to unique conditions, such as incidents and special events. In addition, there may be internal management efficiencies for some systems, such as the benefits of improved knowledge of maintenance problems with controllers or detectors. Improved interagency coordination and decision-making is often a side benefit of such systems.

EFFECTS EVALUATION

There are several tools available to assist with the analysis of ATMS. On the expressway side, these include several simulation models, such as FREQ, FREFLO, FRESIM, and INTEGRATION. For surface streets, TRANSYT-7F and NETSIM can be used to estimate benefits, primarily the impact on vehicle delay. INTEGRATION allows for full interaction between expressway and arterial systems. Recently, FHWA has also provided an integrated version of FRESIM and NETSIM, called CORSIM, allowing for the analysis of expressway and arterial networks as a unit.

To conduct an evaluation, the analyst must select the appropriate tools and provide the inputs that will replicate the ATMS techniques to be employed. Some of the tools may not be able to directly accommodate some ATMS measures.

Ability to access surveillance data before system control functions are operational is the main determinant of whether data can be used from the surveillance system. Calibration of the system is critical.

STRATEGY # **12** Freeway Management

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Arizona is a leader in ATMS, and regional policy supports continued growth in this area. The Phoenix metropolitan area's surveillance and control system is operated through the ADOT Freeway Management System's Traffic Operations Center (TOC). The TOC has been in operation for 11 years. Fifty-five of ADOT's 85 operational ramp meters in the Phoenix area are tied to the Freeway Management System.

The TOC was built in 1991 for the Arizona Department of Transportation. It was originally proposed for the sole purpose of housing the Freeway Management System (FMS), but it was not long before the building's full potential was realized. In addition to FMS components the TOC is also home to several other Intelligent Transportation Systems (ITS) being used in Arizona. A statewide, simulcast radio system; the I-10 deck tunnel monitoring system including lighting, fans, fire detection and cameras; and elk alert sign control are several systems currently contained within the building. With the extensive computer network purchased for the FMS, however, the capability exists to bring more systems into the TOC at very little extra cost. Not only can systems be controlled directly from the TOC, but the network has the potential to be utilized by other agencies to simply collect and disseminate data to users at

WARRANTS

No definite warrant

EXAMPLES

A. Atlanta, GA: (1990 pop – 2,959,500); Navigator; Federal, state, and Atlanta Regional Commission; $11.0 million start-up; primary services include automated incident detection, 317 fixed black/white TV units, 56 radar units, 400 video monitors, 25 variable message signs, highway advisory radio, 5 ramp meters, helicopter-mounted gyroscope camera; 49 TMC freeway miles.
B. Minneapolis, MN: (1990 pop – 2,538,776); Transportation Management Center; sponsor not available; $40.0 million (from 1970-1995); primary services include 380 ramp meters, 156 closed circuit television cameras, communication system with 135 miles of fiber optic cable, 400 field microprocessors, 54 variable message signs, 3,000 traffic detectors, and information via radio programming and cable TV, telephone call-in capability, and web-site; 203 freeway miles.
C. Providence, RI: (1990 pop – 1,134,350); Transportation Management Center; Federal and state; $1.95 million start-up; primary services include automated incident detection, variable message signs, closed circuit TV, highway advisory radio; 52 TMC freeway miles.
D. San Antonio, TX: (1990 pop – 1,324,749); Transguide; Federal and state; $32.0 million (phase I); primary services include inductive loops, 59 cameras, 359 lane control signals, 52 variable message signs; 109 TMC freeway miles.
E. Milwaukee, WI: (1990 pop – 1,432,149); Monitor; sponsor not available; $8.5 million start-up; primary services include 90 ramp meters, 14 variable message signs, closed circuit TV, highway radio advisories; 80 TMC freeway miles.

STRATEGY #	13	Highway-Rail Intersections Management	ORIENTATION	Supply
CATEGORY	Advanced Traffic Management Systems			

DESCRIPTION

Highway-Rail Intersection (HRI) strategy is aimed at further improving safety at railroad crossings and to improve the coordination between rail operations and traffic management functions. HRI could include the following elements: surveillance systems, signal coordination, audio/visual display such as use of dynamic message signs, highway advisory radio and in-vehicle signing, and enforcement.

Several operational tests involving coordinating traffic signals and notifying vehicles of approaching trains at intersections are currently being developed and implemented. A few pilot projects have produced results, but are insufficient to develop overall conclusions. Several other projects are being planned or are now in progress and are expected to produce quantitative data on benefits.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	All Functional Classes	Urban Metropolitan Rural	All congestion types	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Accident rates Customer satisfaction Delay Cost savings Environmental factors	Number of incidents Total number of train-miles

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce conflicts	Customer satisfaction	Improve safety Reduce noise impact

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Low	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # | **13** | Highway-Rail Intersections Management

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Requires interagency cooperation and coordination. Coordination is also needed to establish standards.

WARRANTS

No definite warrant, but safety reasons could be warranted.

EXAMPLES

A) Glencoe County, Minnesota
An in-vehicle train crossing warning system for school buses has been implemented in Glencoe County, Minnesota . Transmitters mounted at five rail crossings transmitted warning signals to school buses in the vicinity of the crossings. The system notified drivers of both the presence of the crossing and whether or not a train was approaching. The evaluation of the project consisted of a questionnaire distributed to drivers and train operators. Drivers felt that the system enhanced awareness of the crossings and approaching trains; however, there were no significant changes in driver behavior. The drivers' confidence in the system's reliability was evenly divided.

B) In developing Highway-Rail Intersections the U.S. DOT was involved or is currently involved in seven projects as pilot tests of ITS technologies at Highway-Rail Intersections (HRIs). The projects include:

In-Vehicle Warning System (Minnesota Guidestar and 3M Corporation) to warn of approaching trains. Installed in 30 school buses in Glencoe, MN, west of the Twin Cities. Project completed in September 1998;

Second Train Warning System (Maryland Mass Transit Administration). Demonstrated that dynamic message signs, warning drivers and pedestrians that a second train was approach the HRI, significantly decreased risky behavior. Project completed Winter 1999;

Advanced Warning for Railroad Delays - AWARD (San Antonio Metropolitan Model Deployment Initiative). Uses dynamic message signs on the highway to alert drivers to exits blocked by passing trains and recommending that an alternative route be taken;

Four Quadrant Gate System (Connecticut DOT). Uses Four-Quadrant gates to guard HRIs and advises locomotives if an obstacle is in the crossing. Project completed in December 1999;

In-Vehicle Warning System (Illinois DOT and Raytheon E-Systems). In-vehicle warning systems installed in 300 school buses, public safety vehicles, and commercial vehicles covering five commuter train HRIs. Project in progress;

Light-Rail Second Train Warning (Los Angeles County Metropolitan Transportation Authority). Fiber optic message sign to warn pedestrians about the approach of a second train. Project in progress; and

Improved Crossing (NY DOT and Alstom Signaling). Provides a number of warning and surveillance improvements, plus emergency vehicle priority at a crossing of the Long Island Railroad. Project in progress.

STRATEGY # 14 Smart Corridors

ORIENTATION Supply

CATEGORY Advanced Traffic Management Systems

DESCRIPTION

Smart corridors strive for smooth progression of vehicles from one jurisdiction to the next in both incident and normal congestion conditions. Smart corridors integrate advanced technologies and real-time system management techniques, including closed circuit television, dynamic message signs, and coordinated signal timings. This strategy can improve traffic management capabilities as well as transit operations on freeways and arterials. Smart corridors can implement communication links to allow information sharing between agencies and to the public.

Related strategies include freeway management, ramp metering, traffic signal improvements, incident detection/verification, incident information/routing, and regional multimodal traveler information.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Frequency of Access Points	Principal Arterial Expressway	All locations	All congestion types	Peak Hour
	Principal Arterial Other			All Year
	Minor Arterial			
	Major Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Make Real-time Adjustments	Average speed	Moving car runs
Provide Improved Knowledge of Maintenan	Intersection delay	Real time speed
Reduce Delay	Number of stops	Real time traffic volume
		Traffic counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Allow real-time adjustments	Improve travel speeds	Improve safety
Improve system efficiency	Reduce delay	Improved interagency coordination and decision-
	Reduce travel time	Improved knowledge of maintenance problems
		Reduce energy consumption

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Overcome Institutional Hurdles

RELATIVE BENEFIT NOTES

The benefits of ATMS primarily include reductions in delay for recurring and non-recurring congestion, and reduction in accidents. A number of studies have indicated that computerized signal systems can achieve as much as a 25% increase in average speeds when compared against situations with older timing plans. One of the significant benefits of surface street ATMS is that it provides the capability to interactively adjust timing plans in response to unique conditions, such as incidents and special events. In addition, there may be internal management efficiencies for some systems, such as the benefits of improved knowledge of maintenance problems with controllers or detectors. Improved interagency coordination and decision-making is often a side benefit of such systems.

EFFECTS EVALUATION

There are several tools available to assist with the analysis of ATMS. On the expressway side, these include several simulation models, such as FREQ, FREFLO, FRESIM, and INTEGRATION. For surface streets, TRANSYT-7F and NETSIM can be used to estimate benefits, primarily the impact on vehicle delay. INTEGRATION allows for full interaction between expressway and arterial systems. Recently, FHWA has also provided an integrated version of FRESIM and NETSIM, called CORSIM, allowing for the analysis of expressway and arterial networks as a unit.

To conduct an evaluation, the analyst must select the appropriate tools and provide the inputs that will replicate the ATMS techniques to be employed. Some of the tools may not be able to directly accommodate some ATMS measures.

Ability to access surveillance data before system control functions are operational is the main determinant of whether data can be used from the surveillance system. Calibration of the system is critical.

STRATEGY # | **14** | Smart Corridors

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Interagency standards and teams must be formed to deal with corridors falling within multiple jurisdictions.

WARRANTS

No definite warrant

EXAMPLES

Smart corridor applications have been made to many Phoenix metro corridors including Scottsdale/Rural Road, Bell Road, Glendale Avenue, Grand Avenue, Southern Avenue, Baseline Road, Cave Creek Road, Tatum Boulevard, and 7th Street. Future applications are planned for Indian School Road, Thunderbird Road, Shea Boulevard, 59th Avenue, Broadway Road, University Drive, Chandler Boulevard, SR 87 (Beeline Highway - Arizona Avenue), Gilbert Road, and McClintock/Hayden Road.

STRATEGY #	15	Special Event Plans	ORIENTATION	Demand
CATEGORY	Advanced Traffic Management Systems			

DESCRIPTION

Special event plans are pre-prepared traffic management plans to deal with special events such as one-time, seasonal or once-a-year events. This strategy makes use of personnel, advance information, signing including portable message signs, and alternate routes. Special event plans strive to maximize available capacity and roadway networks and mitigate impacts in order to efficiently and effectively move traffic to and from events. Special event plans can restrict opposing-direction travel on facilities during peak ingress and egress times. Related strategies include freeway management, construction management plans, regional multimodal traveler information, dynamic message signs, reversible lanes, detours, and alternate routing information systems.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	Activity Centers	Non-recurring predictable	Off-Peak
		Special Venue	Special event	Weekend
			Duration	Seasonal

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Delay	Delay
Improve Traffic Flow	Travel time	Traffic counts
Improve Vehicular Travel Times		Travel time
Reduce Delay		Alternate routes

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Diversion of traffic	Allow informed decisions	Improve safety
Efficient use of available capacity	Reduce delay	Reduce emissions
Improve system efficiency	Reduce travel time	
Improve traffic flow		
Reduce localized traffic congestion		
Redistribute traffic		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Low	Medium

RELATIVE BENEFIT NOTES

Special event plans can serve to improve traffic flow coming and going from an event. Improved traffic flow can lead to reduced delay, improved travel times, and improved safety.

STRATEGY #	15	Special Event Plans

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Special event plans require mobilization of personnel and resources and coordination of efforts between different agencies.

WARRANTS

No definite warrant, but safety would be an overriding factor.

EXAMPLES

A) Scottsdale, Tempe, and Phoenix develop timing plans and detour strategies for major events.

B) Phoenix is implementing a downtown parking/event management system with integrated parking structure availability (e.g. real-time signs posting space availability).

STRATEGY #	16	Dynamic Message Sign	ORIENTATION	Supply
CATEGORY	Advanced Traveler Information Systems			

DESCRIPTION

A Dynamic Message Sign (also called Variable Message Sign) offers the ability to effectively communicate traffic, weather, and event information to motorists. The information can be changed quickly to match the immediate traffic conditions. DMS can be portable or permanent.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	All Functional Classes	All locations	All congestion types	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Accident rates	Number of incidents

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Diversion of traffic Improve system efficiency	Reduce delay Reduce travel time	Improve safety Reduce the probability of secondary accidents

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Medium	Medium

RELATIVE BENEFIT NOTES

Benefits associated with incident information/routing activities include: minimizing vehicle delay in and around the incident area; reducing the potential for secondary incidents; and providing safety for incident response personnel. Incident information may be used by motorists to adjust their trip time or route. Incident information/routing measures will result in a significant lessening of potential delay and safety impacts in the incident area.

EFFECTS EVALUATION

There are several tools available to assist with the analysis of an incident management program. These include several simulation models, such as FREQ, FREFLO, FRESIM, and INTEGRATION, each of which is capable of simulating an incident. Another spreadsheet-based tool (DELAY) provides a sketch-planning level approach to estimating incident-induced delays on an expressway.

The approach to analysis for incident for incident information/routing differs from those incident management strategies that involve reducing incident duration. The analysis requires an estimate of the amount of traffic diverted and the potential delay savings of that diversion. The delay savings can be approximated using one or more of the above tools. Unfortunately, there are many combinations of origins and destinations, and the analyst will need to make a number of assumptions regarding how traffic may be redistributed.

Field evaluation of traveler information and routing systems in response to incidents is very difficult. A before/after comparison is not usually practical. Documenting travel responses to information may be possible in some cases.

STRATEGY # **16** Dynamic Message Sign

RELATIVE COST NOTES

DISADVANTAGES

Transportation-related impacts (delays, accidents) may result along diversion routes.

INSTITUTIONAL FACTORS

The existing incident management systems include a variety of activities to provide information to the traveling public. Congestion information produced by the ADOT Freeway Management System is broadcast over a highway advisory radio system, as well as over commercial radio stations. The surveillance system automatically indicates the location and extent of congestion on various parts of the network. The Traffic Operations Center (TOC) plays an important role in gathering and distributing the relevant information. Dynamic message signs have been installed in key locations to provide additional information.

WARRANTS

No definite warrant

EXAMPLES

A. Cleveland, OH: (1990 pop – 2,202,069); Federal and state; $34,000 per sign; one permanent and two portable signs.

B. Houston, TX: (1990 pop – 3,321,926); State; $75,000 to $100,000; 75 permanent signs.

C. Laredo, TX: (1990 pop – 133,239); State; $150-$200,000; 2 permanent and 2 portable flap signs.

D. Madison, WI: (1990 pop – 367,085); State; $32,000; signs with 12 flap/flip disk, solid matrix LED.

E. Cheyenne, WY: (1990 pop – 20,008); State; $30,000 per sign; 6 permanent overhead and 1 roadside signs.

F. Dane County Dynamic Message Sign Deployment (Wisconsin)
Goals: To notify the traveling public of upcoming construction or maintenance. Approach: A dynamic message sign is deployed a few weeks prior to construction or road maintenance to notify roadway users to take an alternative route, for example. Or, if construction is in progress, it may advise motorists of lane restrictions. Location: Dane County, Wisconsin. Any location where traffic will be impacted, including construction and maintenance sites, special events, and emergencies. Current Status: As of January 2001, Dane County has four portable Dynamic Message Signs. Future Activities: The DMS are useful. Anecdotal feedback has been positive and use of the DMS will continue. The county would like to add more signs for a few permanent and semi permanent locations. Impacts: Travelers respond well to the advance notification of construction and maintenance activities. Phone calls from angry or distressed citizens regarding traffic delays have stopped. County officials appreciate having another form of communication available in times of crisis and/or emergency. Cost Information: Each DMS costs $25,000. Dane county is currently funding them through Capital Improvement funds and Federal grants.
Participating Institutions: Dane County; FHWA

G. Colorado Incident Management Using Dynamic Message Signs (Colorado)
Goals: To enable corridor incident management using dynamic message signs. Approach: The Colorado Department of Transportation is installing 23 DMS on an interstate corridor. The signs are controlled from a central hub, with an on-screen visualization of the network being available to the operator. This corridor experiences heavy seasonal traffic and the objective is to place signs at interchanges where alternate routes can be taken to enable travelers to bypass congested areas and any incidents that occur. Location: The signs are located on the I-70 corridor between Utah and Vail Pass, Colorado. Current Status: The signs have been installed and are in use. Future Activities: The DOT is looking to link the signs to a central location using a planned fiber optic network. Impacts: No results are available at this time, but from previous experiments with dynamic message signs, it is shown that they can mitigate traffic flow during incidents. Cost Information: Mobile DMS units cost $25,000 each plus cellular telephone connection. Permanent installations cost $18,000 to $20,000, depending on the availability of communications infrastructure. DMS may also be rented or leased. There are also installation and integration costs, which may

STRATEGY # 17 Kiosk

ORIENTATION Demand

CATEGORY Advanced Traveler Information Systems

DESCRIPTION

Kiosks are information bulletins, public internet stations, or other electronic self-service and information terminals that provide real-time information to motorists on construction, weather, transit, or other traffic-related data. Kiosks can use commercial internet technology and web pages or use agency specific systems. Providing traveler information regarding several modes of travel can be beneficial to both the traveler and service providers. Kiosks can provide linked information from the National Weather Service, Road/Weather Information Systems (RWIS), statewide database of construction work zones, closures, and detours. Kiosks can also provide local information and have the capability to print coupons and maps.

Several transit agencies have started using traveler information kiosks and web sites to provide schedules, expected arrival times, expected trip times, and route planning services to patrons. Also, several traffic management centers are providing current traffic conditions and expected travel times using similar approaches. These services allow users to make a more informed decision for trip departures, routes, and mode of travel, especially in bad weather. They have been shown to increase transit usage, and may help to reduce congestion when travelers choose to defer or postpone trips, or to select alternate routes. Kiosks should be placed in well-traveled walkthrough areas such as large employment centers, downtown areas, rest-stops, visitor centers, tourist attractions, or activity centers. Displays showing where other kiosks are located throughout the state can direct users to additional information sites.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Allow Informed Decisions Improve Efficiency Improve Traffic Flow Improve Transit Convenience Improve Vehicular Travel Times Increase HOV Trips Reduce Delay Reduce Frequency of Accidents	Accident rates Delay Transit ridership Travel time Wait time	Accident rates Delay Real time traffic volume Ridership Travel time

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow Increase transit use	Allow informed decisions Improve transit convenience Reduce delay Reduce travel time Reduce waiting time	Improve safety Decrease accident rates

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Varies Widely	Medium

RELATIVE BENEFIT NOTES

STRATEGY # | **17** | Kiosk

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

The cost of telephone communication for kiosks can be a major concern.

WARRANTS

Requires a location with a substantial amount of daily foot traffic.

EXAMPLES

A) The Utah Department of Transportation (UDOT) is about to deploy three state-of-the-art kiosks at the UDOT Calvin Rampton Complex, the Salt Lake City Hall, and the Salt Lake County Public Works building. The kiosks will provide real-time information on road conditions, travel speeds, incidents, and construction activities.

B) ADOT has deployed three AZTech kiosks along I-40 and is in the process of installing a fourth. The non-commercial kiosks convey information on road conditions, weather, area attractions, and local communities.

STRATEGY #	18	Regional Multimodal Traveler Information	ORIENTATION	Supply
CATEGORY		Advanced Traveler Information Systems		

DESCRIPTION

Providing traveler information regarding several modes of travel can be beneficial to both the traveler and service providers. Regional multimodal traveler information can include real-time traffic conditions, congestion locations, transit delays, information on specific transit vehicles, incident location and severity, construction, alternative routes, and special events. Several transit agencies have started using traveler information kiosks and web sites to provide schedules, expected arrival times, expected trip times, and route planning services to patrons. Also, several traffic management centers are providing current traffic conditions and expected travel times using similar approaches. These services allow users to make a more informed decision for trip departures, routes, and mode of travel, especially in bad weather. They have been shown to increase transit usage, and may help to reduce congestion when travelers choose to defer or postpone trips, or to select alternate routes.

Information on impacts of traveler information systems are separated into those which provide pre-trip and en-route information. Pre-trip information can be relayed by information kiosks, the internet and cable TV, telephone through 511 or other call-in numbers, and TV and radio reports. En-route information can be conveyed by dynamic message signs, highway advisory radio, pager services, cell phones through 511 or other call-in numbers , and commercial radio reports.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Allow Informed Decisions Improve Efficiency Provide Incident Conditions Information to Reduce Delay	Average travel time from origin to destination Traffic volume on segments used for diversion	Traffic counts Trip logs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Increase transit use	Allow informed decisions Reduce delay Customer satisfaction	Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

A summary of demonstrated benefits from various implementations include: (a) reduction of 0.5% crash rate for drivers using web traveler information in San Antonio while modeling results indicate a 5.4% reduction in delay for web site users; (b) about 38% of TravTek users found in-vehicle navigation useful in unfamiliar places; (c) the SmartTraveler in Boston provides tangible environmental effects with an estimated reductions in Nox of 1.5% and 33% CO; (d) the ROUTES system in London provides an estimated cost savings of 1.3 million pounds sterling due to increased transit ridership.

EFFECTS EVALUATION

Evaluation of implemented traveler information systems reveals that the systems are well received by those who make use of them. Field tests providing traveler information through a variety of in-vehicle and portable devices have received widespread support from project participants. The number of travelers using the information systems
generally represents a small portion of the total travelers in a region. Consequently, the evaluated systems have little, if any, impact on travel times across the regional transportation network. Individual users of the systems do perceive significant benefit from them and are generally satisfied with the service.

STRATEGY # **18** Regional Multimodal Traveler Information

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Arizona already has multiple information delivery systems in place. The Freeway Management System for the Phoenix metropolitan area gathers data which is conveyed over the radio, phone, and internet. A real-time traffic flow map is available on the internet. The highway closure restrictive system conveys information on incidents, lane and road closures, weather and construction. The 511 phone system is in place to provide current construction and traffic information. Variable message signs have been installed in key locations to provide additional information.

Implementation involves a long timeframe and needs outreach to local officials and the media.

WARRANTS

No definite warrant

EXAMPLES

A) IDAS models show the ARTIMIS traveler information system has reduced fatalities by 3.2% in Cincinnati and Northern Kentucky.

B) A model of SW Tokyo shows an 80% decrease in delay if 15% of vehicles shift their departure time by 20 minutes.

C) About 38% of TravTek users found in-vehicle navigation systems useful when travelling in unfamiliar areas.

D) EPA model estimates of SmarTraveler impacts on Boston show 1.5% less Nox, and 25% less VOC emissions.

E) Models of Seattle show freeway-ATIS is two times more effective at reducing delay if integrated with arterial ATIS.

STRATEGY #	19	Road Weather Information Systems (RWIS)	ORIENTATION	Supply
CATEGORY	Advanced Traveler Information Systems			

DESCRIPTION

Remote weather informational systems provide real time information via standard communication tools (phone lines and computer network) statewide. These sites are located in strategic locations to provide accurate real time weather information. This information allows ADOT personnel to schedule personnel and equipment based on current weather and pavement surface conditions. Real time weather information improves response time, increases winter maintenance efficiency and minimizes the traveling public's exposure to hazardous weather related roadway conditions. Real time weather information can also be conveyed to the traveling public via TV and radio reports, highway advisory radio, the internet, information kiosks, , pager services, cell phones through 511 or other call-in numbers , and commercial radio reports allowing informed decisions.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	All Functional Classes	All locations	Recurring un-predictable Non-recurring un-predictable	Seasonal

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Emergency Response Improve Safety	Customer perception of safety	Usage/customer satisfaction surveys

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety	Improve safety	Decrease accident rates

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # **19** Road Weather Information Systems (RWIS)

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

WARRANTS

No definite warrant

EXAMPLES

A) Upper Mississippi Valley, with expansion to a continent-wide system within 5 years. System is currently concentrating on the Upper Mississippi Valley region. User needs definition and initial system architecture work has been completed. System development is completed, with minor modifications continuously made to further improve the system. Initial user feedback for the system occurred during the spring of 1999 with full-scale testing and operations during the winter of 1999-2000. Testing and operations within the Upper Mississippi Valley is scheduled for the winters of 1999-2000 and 2000-01. North American expansion of the system is planned within 5 years. Initial user feedback has been extremely positive and system operations and testing during the winter season will provide further details on the impacts to winter maintenance activities. Cost Information: $4.45 million using funds and in-kind matches from federal, state and private participants. States involved in the initial operational test contributed $300,000 each. States wishing to join FORETELL for the remainder of the operational test should contact the individuals listed below.

B) I-81 Road/Weather Advisory System. Lake effect winter storms along I-81 in New York State frequently produce white-out snow conditions and near zero visibility. NYSDOT has deployed a system for acquiring radar observations from Buffalo, Binghamton, West Leyden and Albany. This information is collated and transmitted to satellite computer installations for display on color monitors for field use, and, in conjunction with reports from a private weather service in Rochester and the statewide RWIS system (which includes visibility sensors), serves as the basis for developing a real-time short range storm forecast system. Using the forecasted conditions, it can be determined whether road closings are required, and what information to post on VMS located along the Interstate highway.

C) Minnesota Road and Weather Information System. The Minnesota Department of Transportation (Mn/DOT) is developing a statewide road and weather information collection and dissemination system. This system will collect information from a variety of sensors types and data sources within Minnesota and neighboring states and provinces. Information will be disseminated to assist Mn/DOT maintenance and operations and to provide real-time information to Minnesota travelers. Through a partnership, Mn/DOT is seeking greater participation by the private sector in ownership of the system.

D) Sierra Project - "Snow Wars". The Sierra Project is a weather, traffic and highway condition gathering and destination system for rural Interstate 80. The project has several components: a SCAN Roadway Weather Information System to collect meteorological information, weather radar to track storm cells, pavement sensors to determine pavement condition, a traffic monitoring system, changeable message signs (CMS), highway advisory radio (HAR) and the California Highway Information Network (CHIN) to provide information to travelers, and the Kingvale Snow Management Control Center to collect and disseminate information.

E) Idaho Storm Warning System. The purpose of this project is to investigate sensor systems that could provide accurate and reliable visibility and weather data, and use that data to provide general warnings, speed advisories, and possible road closure and routing information. Three different sets of sensors at a single location collect environmental and visibility data. Information is relayed to a local weigh station via telephone lines where a computer analyses the data. If the data indicates that visibility has fallen below 1,200 feet, a flag is posted to a monitor. Idaho DOT personnel then activate appropriate VMS announcing the advisory or closure.

STRATEGY # 20 Collision Avoidance System

ORIENTATION Supply

CATEGORY Advanced Vehicle Control Systems

DESCRIPTION

Collision avoidance systems provide in-vehicle technology capable of detecting imminent impact with a moving or stationary object. This technology notifies the driver of the presence of potentially hazardous situations and the need for immediate collision avoidance action. Collision avoidance sensors can illuminate a display on the dashboard or produce audible sounds to warn drivers of other vehicles in the driver's blind spot. The systems can warn of vehicles or objects ahead, behind or to the side. Many applications have been directed toward rear-end, lane change/merge, departure from roadway, and intersection type accidents. This strategy has the potential to reduce accidents, increasing safety and reducing delay resulting from incidents.

Examples of collision avoidance applications include "Mayday" systems or on-board safety monitoring systems and in-vehicle driver impairment sensors. Other advanced vehicle control systems (AVCS) include in-vehicle headway sensor systems, in-vehicle route guidance, in-vehicle "probe" (surveillance), in-vehicle speed control, and fully automated highway system. Depending on the type of technology these applications can be used on a single vehicle, a corridor or an entire region.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Manage Traffic Demand Reduce Frequency of Accidents Reduce Impacts of Accidents	Accident rates for equipped vs. non-equipped vehicles Volume throughput	Accident rates Link volume

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow Increase capacity Reduce impact of highway accidents	Improve safety	Reduce frequency of highway accidents

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

Benefits vary depending on the type of system being implemented. In general, these systems are intended to manage traffic demands and flows along the transportation system and to reduce the frequency or impacts of highway accidents.

Safety related applications include in-vehicle driver impairment, headway and collision avoidance systems. A "Mayday" system also provides safety benefits by aiding in emergency response.

Operations monitoring systems may be used to improve vehicle maintenance and repair functions.

EFFECTS EVALUATION

Given the range of AVCS activities existing, planned and under development, the potential impacts associated with these activities are wide ranging. Proposed applications may be assessed on a highway segment, highway, corridor, or regional bases. The approach to analysis varies widely, depending on the application. Generally, analysis will be confined to those elements for which state and local governments may have responsibility.

It will be well into the future before significant penetration of most of these devices will occur.

STRATEGY # **20** Collision Avoidance System

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

AVCS falls primarily in the domain of the private sector. Many AVCS elements will be implemented by vehicle manufacturers as the technology becomes available and a market is created. At present, several trucking companies have installed "Mayday" systems; some higher-end cars also come equipped with these systems.

A number of AVCS elements, particularly the more sophisticated elements that involve a transfer of vehicle control from the driver to automated systems, will require increased public and political acceptance before they are implemented. Regional policy should seek to accommodate those applications that will have a benefit for overall regional mobility and safety.

WARRANTS

No definite warrant

EXAMPLES

One study evaluated a vehicle-guidance system designed to give safe driver-assistance to freeway traffic in heavy fog. A benefit-cost analysis was conducted to estimate the performance of the system prior to deployment. The proposed system was designed to use administrative pace-vehicles equipped with Millimeter Radio Wave Sensors and GPS technology to lead freeway traffic through heavily fogged areas subject to road closures.

The Japan Highway Public Corporation (JH) tested the sensor technology and found it had little ability to detect small or rounded objects such as tires or rubber cones. The sensors were; however, able to detect vehicles (or a corrugated board case 0.375 x 0.475 x 0.375m) through 100 meters of heavy fog.

The proposed system would attach sensors to leading-vehicles and allow groups of freeway traffic to follow using a warning vehicle in the rear. The Emergency Management center would monitor each ITS-vehicle using GPS and enable them to track each others position.

The results showed that traffic control using guidance-vehicles was cost effective.

STRATEGY #	21	Vehicle Guidance System	ORIENTATION	Supply
CATEGORY	Advanced Vehicle Control Systems			

DESCRIPTION

An in-vehicle technology that makes use of in- or on-roadway or other off-site information systems to assist in informational, guidance, or navigational systems for highway and transit vehicles. The AVCS activities may range from individual vehicle systems, like "Mayday" systems or on-board safety monitoring systems, to systems comprising vehicle groups, like the several alternative concepts identified as the "Automatic Highway Systems." Many additional concepts are in the research and development stage.

The range of AVCS applications include: "Mayday" system, in-vehicle driver impairment sensors, in-vehicle headway sensor systems, in-vehicle route guidance, in-vehicle "probe" (surveillance), in-vehicle speed control, and fully automated highway system.

The strategy to implement AVCS systems will vary by specific application. Most are initiatives that would be taken on by the vehicle manufacturing industry. They may be applicable to individual vehicles (on-board system monitoring), highways ("Mayday" system), or corridors/regions (Automated Highway Systems). Many of these systems are in development and under operational testing and may be five to ten years away from regular application by an operable level of vehicles along a highway or corridor.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Manage Traffic Demand Reduce Frequency of Accidents Reduce Impacts of Accidents	Accident rates for equipped vs. non-equipped vehicles Volume throughput	Accident rates Link volume

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow Increase capacity Reduce impact of highway accidents	Improve safety	Reduce frequency of highway accidents

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

Benefits vary depending on the type of system being implemented. In general, these systems are intended to manage traffic demands and flows along the transportation system and to reduce the frequency or impacts of highway accidents.

Safety related applications include in-vehicle driver impairment, headway and collision avoidance systems. A "Mayday" system also provides safety benefits by aiding in emergency response.

Operations monitoring systems may be used to improve vehicle maintenance and repair functions.

EFFECTS EVALUATION

Given the range of AVCS activities existing, planned and under development, the potential impacts associated with these activities are wide ranging. Proposed applications may be assessed on a highway segment, highway, corridor, or regional bases. The approach to analysis varies widely, depending on the application. Generally, analysis will be confined to those elements for which state and local governments may have responsibility.

It will be well into the future before significant penetration of most of these devices will occur.

STRATEGY # **21** Vehicle Guidance System

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

AVCS falls primarily in the domain of the private sector. Many AVCS elements will be implemented by vehicle manufacturers as the technology becomes available and a market is created. At present, several trucking companies have installed "Mayday" systems; some higher-end cars also come equipped with these systems.

A number of AVCS elements, particularly the more sophisticated elements that involve a transfer of vehicle control from the driver to automated systems, will require increased public and political acceptance before they are implemented. Regional policy should seek to accommodate those applications that will have a benefit for overall regional mobility and safety.

WARRANTS

No definite warrant

EXAMPLES

Vehicle guidance applications to snowplows are currently being researched by ADOT. These studies involve guidance, AVL, and collision warning systems. The vehicle guidance used magnets and magnetic tape on the roadway as well as in-vehicle sensors.

STRATEGY #	22	Compressed Work Weeks	ORIENTATION	Demand
CATEGORY	Alternative Work Arrangements			

DESCRIPTION

A scheduling program which consists of condensing standard number working hours into fewer than five days per week or fewer than 10 days per two week period. Employees work more hours a day but over fewer days a week than the usual work schedule.

Employees can commute only 3 or 4 days per week when employers allow a compressed work week. Scheduling policies such as compressed work weeks allow employees to avoid commuting during peak traffic periods. The compressed work week is generally more viable for employers that have very large numbers of employees at one facility or office.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	Urban Metropolitan	Recurring predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Reduce Total Vehicle Trips	Percentage of trips in peak hour Number of people working at home Person trips Vehicle miles traveled (VMT) by congestion level	Traffic counts at site Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce vehicular trips	Time flexibility Potential to reduce total travel cost Eliminate time for making trip	Improve air quality Reduce energy consumption

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

This strategy may reduce congestion in different ways depending on the measure implemented. This strategy may lead to reduced vehicle trips (compressed work week, telecommuting), reduced peak period travel (staggered work hours, flex-time), or reduced VMT or trip length (regional work centers). By reducing the number of total or peak period trips, this strategy can help lessen the spreading of the peak travel period. By spreading demand over a longer period or to other areas (e.g. away from downtown to an outlying work center), the transportation system may handle more commuters without additional peak capacity.

These programs are generally inexpensive to implement, and generally receive a positive reaction from employees.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips during the peak periods. Unlike other TDM strategies, supporting strategies are not important for compressed work week strategy.

Surveys are the most direct measurement technique. Traffic counts can quantify extent to which peak is spreading.

STRATEGY # **22** Compressed Work Weeks

RELATIVE COST NOTES

DISADVANTAGES

This strategy may counter some of the benefits of strategies like ridesharing programs and transit/carpool incentives by disrupting the common work schedules of employees who rideshare.

INSTITUTIONAL FACTORS

This strategy falls largely under the domain of individual employers, thus the public agency response has been one of supporting the concept rather than specific action. It is recognized that alternative work arrangement support TDM objectives and can be used to encourage use of alternative modes.

WARRANTS

Criteria need to be established to determine when alternative work arrangements are appropriate.

EXAMPLES

A. Princeton, NJ: (1990 pop – 325,824); Educational Testing Services; no operating cost; 700 employees participate; employees work 37.5 hours per week and can choose either a 12.5 hour/3days or 9.5 hours/3 days plus one 9 hour day; employees indicated that the program cut down on their amount of commuting time. After one year of operation, 30% of the employees switched to the program; of these, 93% preferred the four-day week.

B. San Antonio, TX: (1990 pop – 1,324,749); United Services Automobile Association; costs quoted as none; 12,000 employees participate; employees can work a four-day work week and spread those four days among any of the seven days of a calendar week. Employees can also work 4-, 5-, and 6- day work weeks of varying hours. Employees reduced commuting costs by 20%.

STRATEGY #	23	Flex-Time	ORIENTATION	Demand
CATEGORY	Alternative Work Arrangements			

DESCRIPTION

Flex-time is a scheduling policy that gives employees the option of varying their starting and stopping times each work day (e.g. 9:00 am to 5:00 pm) when all employees are required to be present. The intent is to allow employees greater flexibility to adjust work hours to individual time schedules and commuting. This scheduling policy allow employees to avoid commuting during peak traffic periods, thus the strategy has the potential to contribute to peak spreading.

Flex-time arrangements are similar to compressed work weeks, but allow employees to select the hours they work each week.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	All locations	Recurring predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Shift Trip Time	Percentage of trips in peak hour Number of people working at home Person trips Vehicle miles traveled (VMT) by congestion level	Traffic counts at site Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduced peak period travel	Reduce travel time Time flexibility Potential to reduce total travel cost Reduce stressful driving	Reduce emissions Reduce energy consumption

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

This strategy may reduce congestion in different ways depending on the measure implemented. This strategy may lead to reduced vehicle trips (compressed work week, telecommuting), reduced peak period travel (staggered work hours, flex-time), or reduced VMT or trip length (regional work centers). By reducing the number of total or peak period trips, this strategy can help lessen the spreading of the peak travel period. By spreading demand over a longer period or to other areas (e.g. away from downtown to an outlying work center), the transportation system may handle more commuters without additional peak capacity.

These programs are generally inexpensive to implement, and generally receive a positive reaction from employees.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips during the peak periods. Travel models can be used for evaluating the potential of various TDM measures. In addition, a sketch-planning spreadsheet analysis can be used to determine environmental impacts. In general, sketch-planning analysis can suggest the approximate impacts of a program by considering the number of employees expected to participate and the current mode choices of these individuals. Results from similar programs in other areas may also be used to estimate the impacts of future applications.

Unlike other TDM strategies, supporting strategies are not important for Flex-time.

Surveys are the most direct measurement technique. Traffic counts can quantify extent to which peak is spreading.

STRATEGY # | **23** | Flex-Time

RELATIVE COST NOTES

DISADVANTAGES

This strategy may counter some of the benefits of strategies like ridesharing programs and transit/carpool incentives by disrupting the common work schedules of employees who rideshare.

Flex-time may meet with some resistance from employers.

INSTITUTIONAL FACTORS

This strategy falls largely under the domain of individual employers, thus the public agency response has been one of supporting the concept rather than specific action. It is recognized that alternative work arrangement support TDM objectives and can be used to encourage use of alternative modes.

WARRANTS

Criteria need to be established to determine when alternative work arrangements are appropriate.

EXAMPLES

Commonly applied strategy.

STRATEGY # 24 Staggered Work Hours

ORIENTATION Demand

CATEGORY Alternative Work Arrangements

DESCRIPTION

A scheduling policy in which the times that groups of employees begin and end work are staggered over a range from 15 minutes to two hours. The intent is to spread out commuting peaks. For example, staggered work hours can be arranged so that employees work 8-hour shifts, but starting and ending times vary.

Staggered work hours are similar to flex-time except that it applies to groups of employees rather than individuals. Like other alternative work arrangements, this strategy allows employees to avoid commuting during peak traffic periods.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	All locations	Recurring predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Shift Trip Time	Percentage of trips in peak hour Number of people working at home Person trips Vehicle miles traveled (VMT) by congestion level	Traffic counts at site Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduced peak period travel	Time flexibility	Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

This strategy may reduce congestion in different ways depending on the measure implemented. This strategy may lead to reduced vehicle trips (compressed work week, telecommuting), reduced peak period travel (staggered work hours, flex-time), or reduced VMT or trip length (regional work centers). By reducing the number of total or peak period trips, this strategy can help lessen the spreading of the peak travel period. By spreading demand over a longer period or to other areas (e.g. away from downtown to an outlying work center), the transportation system may handle more commuters without additional peak capacity.

These programs are generally inexpensive to implement, and generally receive a positive reaction from employees.

EFFECTS EVALUATION

Like other alternative work arrangement techniques, the effect of this strategy is generally measured by the reduction in vehicle trips during the peak periods. Unlike other TDM strategies, supporting strategies are not important for alternative work arrangements.

Surveys are the most direct measurement technique. Traffic counts can quantify extent to which peak is spreading.

STRATEGY # **24** Staggered Work Hours

RELATIVE COST NOTES

DISADVANTAGES

This strategy may counter some of the benefits of strategies like ridesharing programs and transit/carpool incentives by disrupting the common work schedules of employees who rideshare.

INSTITUTIONAL FACTORS

This strategy falls largely under the domain of individual employers, thus the public agency response has been one of supporting the concept rather than specific action. It is recognized that alternative work arrangement support TDM objectives and can be used to encourage use of alternative modes.

WARRANTS

Criteria need to be established to determine when alternative work arrangements are appropriate.

EXAMPLES

Commonly applied strategy.

STRATEGY # 25 Add Lanes to Existing Facilities

ORIENTATION Supply

CATEGORY Arterials and Collectors

DESCRIPTION

This strategy involves adding lanes over long distances to existing arterial and collector facilities. Addition of lanes increases available capacity and can relieve traffic congestion. Planning and right-of-way preservation allow for lane additions to be less costly in built-up areas. Public involvement can assess the level of support for addition of lanes to a facility. Capacity additions should evaluate the effects from redistribution of vehicle trips and relocation of bottlenecks or other impacts.

Capacity expansion may directly conflict with other strategies that encourage transit, HOV, or non-motorized use. Agencies can take advantage of construction projects to implement other improvements like bike lanes, median and driveway management, and signal timing improvements. Roadway geometric improvements, such as adding acceleration/deceleration lanes, adding turn lanes, or lane widening, to smaller sections of roadway are related strategies.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Adjacent Development	Principal Arterial Other	All locations	Recurring predictable	Peak Hour
Number of Lanes	Minor Arterial		Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Vehicular Travel Times	Average cost per lane-mile constructed	Link volume
Increase Capacity	Average speed	Travel time
Reduce Delay	Delay	
	Level of service	
	Miles of congested roadway	
	Mode share/shift	
	Traffic volumes	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow	Reduce delay	None
Increase capacity	Reduce travel time	
Reduce localized traffic congestion		
Reduce localized traffic congestion		

EFFECTS EVALUATION

The urban-scale benefits of arterial lane additions can be difficult to assess, but this is best done using the regional travel demand model. Corridor-scale benefits and impacts of these strategies can be assessed using procedures described in the Highway Capacity Manual and simulation analysis packages such as TRANSYT, PASSER, SYNCHRO, NETFLO and NETSIM.

Full evaluation should include evaluation of parallel routes, as well as impact on transit ridership.

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

As part of a system wide plan to improve travel times via arterials, this strategy can be more effective than widening a parallel expressway. Arterial lane additions can provide an opportunity to implement complementary strategies, such as bike lanes and upgraded signal systems.

STRATEGY # **25** Add Lanes to Existing Facilities

RELATIVE COST NOTES

Planning and right of way preservation is recommended in order to minimize high costs associated with acquisition of right of way in built up areas.

DISADVANTAGES

Can be costly if additional right of way is required.
May induce traffic.

Financial constraints, land use densities, and air quality issues may prevent the addition of lanes or addition of capacity.

The widening of arterials may adversely impact pedestrian travel and traffic operations. Wide arterials are perceived by pedestrians as a barrier and will inhibit pedestrian travel. Wide arterials also increase the required pedestrian-crossing time at a signalized intersection resulting in more delay for vehicles. Wider arterials may also require multi-phase traffic signals which improve safety, but reduce efficiency due to longer clearance times between different conflicting turning movements.

INSTITUTIONAL FACTORS

Arterial lane additions may be appropriate for "pipeline" projects where substantial planning resources have been spent and where adequate public interest and support exists to construct the project.

WARRANTS

No definite warrant

EXAMPLES

A. Wichita, KS: (1990 pop – 304,017); Maize Road Projects; $7.112 million; City of Wichita; widened two-lane county highway to a four-lane urban section; increased capacity has led to less congestion and higher levels of safety.
B. Amarillo, TX: (1990 pop – 157,571); S.W. 9th Avenue, Washington Street, Coulter Street., S.W. 45th Avenue, and Eastern Street; costs respectively are $2,000, not available, $493,928, $499,851, and $1,105,621; Craig Methodist Retirement Center and City of Amarillo; increased lanes via striping and/or reconstruction; inconclusive assessment suggests that restriping has had a beneficial effect on traffic flow and decreased the number of traffic collisions.
C. Waco, TX: (1990 pop – 103,590); Garden Drive Widening and Extension Project; $1.6 million; City of Waco and Texas DOT; four travel lanes and a center turn line resulted from the extension and widening of a two lane facility; no effects have been reported.

STRATEGY # 26 Construct New Facilities

ORIENTATION Supply

CATEGORY Arterials and Collectors

DESCRIPTION

This strategy involves both the extension of existing arterial and collector facilities and the construction of new arterials and collectors. Constructing new facilities increases available capacity and can relieve traffic congestion. Transportation and land use planning is required to determine need and establish alignment of new facilities. Right-of-way preservation should be pursued as planning identifies needed corridors. Public involvement can assess the level of support for construction and alignment alternatives. Capacity additions should evaluate the effects from redistribution of vehicle trips and relocation of bottlenecks or other impacts.

Capacity expansion may directly conflict with other strategies that encourage transit, HOV, or non-motorized use. Complementary strategies include traffic signal improvements, access management, and advanced traffic management systems. Agencies can take advantage of construction projects to implement other improvements like bike lanes, median and driveway management, and signal timing improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	Principal Arterial Other	All locations	Recurring predictable	Peak Hour
	Minor Arterial		Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Vehicular Travel Times	Average cost per lane-mile constructed	Travel time
Increase Capacity	Average speed	
Reduce Delay	Delay	
	Level of service	
	Miles of congested roadway	
	Mode share/shift	
	Traffic volumes	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity	Reduce delay	None
Reduce localized traffic congestion	Reduce travel time	
Reduce localized traffic congestion		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

As part of a system wide plan to improve travel times via arterials, this strategy can be more effective than widening a parallel expressway.

Arterial lane additions can provide an opportunity to implement complementary strategies, such as bike lanes and upgraded signal systems.

EFFECTS EVALUATION

The urban-scale benefits of arterial lane additions can be difficult to assess, but this is best done using the regional travel demand model. Corridor-scale benefits and impacts of these strategies can be assessed using procedures described in the Highway Capacity Manual and simulation analysis packages such as TRANSYT, PASSER, SYNCHRO, NETFLO and NETSIM.

Full evaluation should include evaluation of parallel routes, as well as impact on transit ridership.

STRATEGY # 26 Construct New Facilities

RELATIVE COST NOTES

Planning and right of way preservation is recommended in order to minimize high costs associated with acquisition of right of way in built up areas.

DISADVANTAGES

Can be costly if additional right of way is required.
May induce traffic.

Financial constraints, land use densities, and air quality issues may prevent the addition of lanes or addition of capacity.

INSTITUTIONAL FACTORS

Arterial lane additions may be appropriate for "pipeline" projects where substantial planning resources have been spent and where adequate public interest and support exists to construct the project.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # **27** Advanced Port Processing Plans

ORIENTATION Supply

CATEGORY Commercial Vehicle Improvements

DESCRIPTION

Port processing plans are plans to expedite the processing of vehicles entering port of entries. Advanced port processing may include technologies such as electronic credential checking and weigh-in-motion systems. Plans can also incorporate the efficient use of staff and facilities during peak hours.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix	All Functional Classes	Urban	Recurring un-predictable	All Day
Not Facility Specific		Rural	Non-recurring predictable	All Year
			Duration	

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Delay	Delay at weigh stations/border crossings
Improve Traffic Flow	Traffic volumes	Traffic counts
Reduce Delay	Wait time	
Improve Throughput		

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Reduce delay	Improve safety
Improve traffic flow	Reduce waiting time	
Improve throughput		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Low	Medium

RELATIVE BENEFIT NOTES

Port processing plans can improve traffic flow and vehicle processing procedures to significantly reduce waiting time for port users and stakeholders. Advanced port processing plans provide means to more quickly review documents, manifests, insurance, and other credentials.

STRATEGY # | **27** | Advanced Port Processing Plans

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

WARRANTS

No definite warrant

EXAMPLES

In a 1997 Arizona Port Efficiency Study, recommendations were made to improve traffic flow and reduce waiting time. Recommendations included: redesign and restructure of a commercial cargo facility, provision of a dedicated commuter lane, and the refinement of customer service oriented management practices.

STRATEGY #	28	Commercial Vehicle Facilities	ORIENTATION	Supply
CATEGORY	Commercial Vehicle Improvements			

DESCRIPTION

Enhanced commercial vehicle facilities such as improved loading facilities can improve the operation of commercial vehicles and reduce the impact of commercial vehicles to peak period congestion. This strategy is most applicable in locations with high volumes of trucks (one source suggests locations with truck VMT over 20% of total), on roadways that provide access to major truck facilities, or at locations where truck activity obstructs other vehicles. Related strategies include geometric improvements, signal improvements, designation of truck routes, truck restrictions, intermodal facilities, and commercial vehicle operational improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix	All Functional Classes	All locations	All congestion types	All Day
Not Facility Specific				All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Accident rates	Accidents rates for heavy vehicles
Improve Travel Speeds	Average travel speed by heavy vehicles	Truck tracking (e.g. GPS)
Increase Capacity		Truck travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Improve travel speeds	None
Increase capacity	Enhance vehicle operations	
	Improve user efficiency	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

Commercial vehicle improvements are intended to increase the capacity or operational efficiency of roadways by helping trucks move through the network more easily or by removing commercial traffic from congested routes. Enhancing truck movements will increase speeds for all vehicles and may have economic and safety benefits. Truck route designation can be an important strategy if the designated routes have the capacity, geometry, operational characteristics and physical condition to absorb increased commercial traffic.

Restrictions on truck movements and delivery times can increase roadway capacity and passenger vehicle speeds by removing low-performing trucks from the vehicle mix.

EFFECTS EVALUATION

Evaluation of the potential benefit from implementing commercial vehicle improvements can be estimated by calculating total delay on various links by modifying truck volumes. Typical analysis tools include the truck adjustment impact tables in the Highway Capacity Manual. By calculating total delay with existing and modified truck volumes, the analyst can determine potential ideal applications.

A wealth of data may be available from trucking companies, but most would be reluctant to release such information. Evaluations would need to be targeted to the specific improvements made.

STRATEGY #	28	Commercial Vehicle Facilities

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

If costs are high or facilities are inconvenient, there may be opposition from the commercial vehicle industry.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	29	Geometric Improvements	ORIENTATION	Supply
CATEGORY	Commercial Vehicle Improvements			

DESCRIPTION

Geometric improvements for commercial vehicles include modifying signal operations to accommodate the deceleration/acceleration characteristics of trucks, increasing turn radii, widening lanes, signing for vertical clearance, and removing vertical obstacles. These improvements focus on improving the operation of commercial vehicles by removing operational and physical constraints. This strategy is most applicable in locations with existing constraints, locations with high volumes of trucks (one source suggests locations with truck VMT over 20% of total), on roadways that provide access to major truck facilities, or at locations where truck activity obstructs other vehicles. Related strategies include signal improvements, enhanced commercial vehicle facilities, designation of truck routes, truck restrictions, intermodal facilities, and commercial vehicle operational improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Travel Speeds Increase Capacity	Accident rates Average travel speed by heavy vehicles	Accidents rates for heavy vehicles Truck tracking (e.g. GPS) Truck travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Increase capacity	Improve travel speeds	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Medium

RELATIVE BENEFIT NOTES

Commercial vehicle improvements are intended to increase the capacity or operational efficiency of roadways by helping trucks move through the network more easily or by removing commercial traffic from congested routes. Enhancing truck movements will increase speeds for all vehicles and may have economic and safety benefits. Truck route designation can be an important strategy if the designated routes have the capacity, geometry, operational characteristics and physical condition to absorb increased commercial traffic.

Restrictions on truck movements and delivery times can increase roadway capacity and passenger vehicle speeds by removing low-performing trucks from the vehicle mix.

EFFECTS EVALUATION

Evaluation of the potential benefit from implementing commercial vehicle improvements can be estimated by calculating total delay on various links by modifying truck volumes. Typical analysis tools include the truck adjustment impact tables in the Highway Capacity Manual. By calculating total delay with existing and modified truck volumes, the analyst can determine potential ideal applications.

A wealth of data may be available from trucking companies, but most would be reluctant to release such information. Evaluations would need to be targeted to the specific improvements made.

STRATEGY # **29** Geometric Improvements

DISADVANTAGES

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	30	Intermodal Facilities	ORIENTATION	Supply
CATEGORY	Commercial Vehicle Improvements			

DESCRIPTION

A multimodal facility is a transfer point at which various modes of travel converge. For commercial vehicles, a multimodal facility is a central place for the transfer of goods between different modes such as automobile and rail. Intermodal centers facilitate the flow of commercial vehicles (trucks) and/or minimize their contribution to peak period congestion. Related strategies include geometric improvements, signal improvements, designation of truck routes, truck restrictions, enhanced commercial vehicle facilities, and commercial vehicle operational improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix	All Functional Classes	All locations	All congestion types	All Day
Not Facility Specific				All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Accident rates	Accidents rates for heavy vehicles
Improve Other Environmental/Socioecono	Average travel speed by heavy vehicles	Truck tracking (e.g. GPS)
Improve Travel Speeds		Truck travel time
Increase Capacity		

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Improve travel speeds	None
Increase capacity	Enhance vehicle operations	
	Improve user efficiency	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Difficult

RELATIVE BENEFIT NOTES

Commercial vehicle improvements are intended to increase the capacity or operational efficiency of roadways by helping trucks move through the network more easily or by removing commercial traffic from congested routes. Enhancing truck movements will increase speeds for all vehicles and may have economic and safety benefits. Truck route designation can be an important strategy if the designated routes have the capacity, geometry, operational characteristics and physical condition to absorb increased commercial traffic.

Restrictions on truck movements and delivery times can increase roadway capacity and passenger vehicle speeds by removing low-performing trucks from the vehicle mix.

EFFECTS EVALUATION

Evaluation of the potential benefit from implementing commercial vehicle improvements can be estimated by calculating total delay on various links by modifying truck volumes. Typical analysis tools include the truck adjustment impact tables in the Highway Capacity Manual. By calculating total delay with existing and modified truck volumes, the analyst can determine potential ideal applications.

A wealth of data may be available from trucking companies, but most would be reluctant to release such information. Evaluations would need to be targeted to the specific improvements made.

STRATEGY # **30** Intermodal Facilities

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

If costs are high or facilities are inconvenient, there may be opposition from the commercial vehicle industry.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	31	Truck Routes	ORIENTATION	Demand
CATEGORY	Commercial Vehicle Improvements			

DESCRIPTION

Truck routes are the designation through signs and markings of specific corridors to be used for trucks. Implementation of truck routes focus on improving the operation of commercial vehicles and reducing the impact of commercial vehicles to peak period congestion. This strategy is most applicable in locations with high volumes of trucks (one source suggests locations with truck VMT over 20% of total), on roadways that provide access to major truck facilities, or at locations where truck activity obstructs other vehicles. Designation of truck routes should only be done if the facility can accommodate the increased truck use, and if the roadway has sufficient clearances, lane widths, and turning radii. Related strategies include geometric improvements, signal improvements, enhanced commercial vehicle facilities, truck restrictions, intermodal facilities, and commercial vehicle operational improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Travel Speeds Increase Capacity	Accident rates Average travel speed by heavy vehicles	Accidents rates for heavy vehicles Truck tracking (e.g. GPS) Truck travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Increase capacity	Improve schedule reliability Improve travel speeds	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Low	Easy

RELATIVE BENEFIT NOTES

Commercial vehicle improvements are intended to increase the capacity or operational efficiency of roadways by helping trucks move through the network more easily or by removing commercial traffic from congested routes. Enhancing truck movements will increase speeds for all vehicles and may have economic and safety benefits. Truck route designation can be an important strategy if the designated routes have the capacity, geometry, operational characteristics and physical condition to absorb increased commercial traffic.

Restrictions on truck movements and delivery times can increase roadway capacity and passenger vehicle speeds by removing low-performing trucks from the vehicle mix.

EFFECTS EVALUATION

Evaluation of the potential benefit from implementing commercial vehicle improvements can be estimated by calculating total delay on various links by modifying truck volumes. Typical analysis tools include the truck adjustment impact tables in the Highway Capacity Manual. By calculating total delay with existing and modified truck volumes, the analyst can determine potential ideal applications.

A wealth of data may be available from trucking companies, but most would be reluctant to release such information. Evaluations would need to be targeted to the specific improvements made.

STRATEGY # | **31** | Truck Routes

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

If truck routes are inconvenient, there may be opposition from the commercial vehicle industry.

DISADVANTAGES

Restrictive measures may have negative economic impacts for truck operators and the shippers or receivers of goods.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # | **32** | Electronic Credential Checking

ORIENTATION Supply

CATEGORY Commercial Vehicle Operations (CVO)

DESCRIPTION

Electronic credential checking is an element of CVO which utilizes automatic vehicle identification (AVI) technology to identify a vehicle (trucks) and compares the vehicle identity with a database. This strategy is aimed at improving the flow of commercial vehicles, enhancing safety, and minimizing truck stops at weigh stations and ports of entry. Electronic credential checking tries to identify a vehicle and compares the vehicle identity with a database. If the vehicle is identified and there are no complications with the vehicle's weight the truck is able to proceed. If there are complications with weight the vehicle has to proceed to a static weigh station. Electronic credential checking is associated with weigh-in-motion and is used conjointly expedite the processing of vehicles at border crossings. Many recent studies to apply technologies have focused on the accuracy and improvements in vehicle identification. Technologies are now capable of identifying vehicles at mainline speeds and at a high rate of accuracy. As a result, throughput is optimized, and delay that would occur at border crossings is significantly reduced (FHWA, 1999). The application of these technologies can increase system throughput, reduce delays, enhance customer service, improve safety, and reduce environmental impacts.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix	Principal Arterial Interstate	Rural	All congestion types	Off-Peak
Not Facility Specific	Principal Arterial Expressway	Special Venue		All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Administrative efficiency improvements	Delay at weigh stations/border crossings
Reduce Delay	Delay reductions	Labor expended

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce administrative costs	Reduce delay	Reduce administrative costs
Reduce delay for trucks		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

Electronic credential checking can produce significant delay reductions for trucks that qualify. Such systems can also result in reduced administrative costs for agencies. AVL and GPS systems are used to improve the efficiency of individual truck operations. Information systems can reduce delay, primarily through optimizing route choice. Implementation of ITS commercial vehicle services will reduce both travel time (the need to stop at inspection stations is removed) and regulatory time (reduce processing times at ports of entry). Electronic communications and automated monitoring tools can reduce the time required to acquire credentials and perform inspections. Dispatch systems reduce time and telephone charges required for communications with dispatch centers.

As a practical matter, CVO applications are likely to have only a limited impact on peak period congestion relief for a number of reasons. First, the percentage of trucks tends to be higher in the off-peak hours, therefore, the greatest potential for impact may be during the off-peak. Second, weigh stations are generally located outside the urban area or on the fringes, so that weigh-in-motion and electronic credential checking would result

EFFECTS EVALUATION

The analysis technique will depend on the specific CVO application being analyzed. Possible delay-reduction from weigh-in-motion and electronic credential checking can be estimated based on assumed penetration/eligibility levels and the volume of trucks at the specific locations. The analysis of delay savings due to information-based approaches can be analyzed using the same basic techniques as for Advanced Traveler Information Systems (ATIS). However, the analysis would focus on the CVO subset of all traffic. The benefits of vehicle location systems is mainly internal to the trucking industry and usually does not need to be analyzed within the public sector.

Gauging the penetration of CVO systems into the overall fleet is an important evaluation component.

STRATEGY # 32 Electronic Credential Checking

RELATIVE COST NOTES

DISADVANTAGES

Results in little direct benefit to urban congestion relief or peak hour congestion relief.

INSTITUTIONAL FACTORS

CVO measures may be applied at various levels, but often require considerable inter-agency and private sector participation. At one end, a weigh-in-motion station can be a spot application and involve only the regulatory agency. Electronic credential checking must be integrated over a long stretch of roadway (usually interstate) with multiple stations to be of significant benefit. One-stop shopping is also typically applied over a large, sometimes multi-state, area and can involve numerous public agencies. Information systems can benefit the trucking industry when implemented at both the regional level and for specific locations.

There are many decisions on CVO systems, like equipping fleets with GPS systems, that are made solely by private industry for purposes of improving the efficiency of their operations.

WARRANTS

No definite warrant

EXAMPLES

A survey was done in states in the mid-continent transportation corridor along interstate highway IH-35 from Duluth, Minnesota to Laredo, Texas. Electronic Screening data was derived from 19 static scales. The following were evaluated: hours of operation, the number of trucks weighed, and the number of safety inspections performed (level I,II, or III).

Electronic Screening benefits for carriers included savings on fuel and time as carriers were able to bypass static-scales and reduce mainline delays. Benefits to states included reduced weigh station pavement repair costs and other labor savings. The deployment cost to motor carriers included the purchase of electronic transponders at a price of approximately $50 per vehicle. The cost to state agencies was much higher and included the purchase of automatic vehicle identification readers (AVI), weigh-in-motion (WIM) scales, and other equipment and maintenance at a cost of approximately 150,000 to 780,000 dollars per station.

The benefits of Electronic Screening exceeded the costs for both motor carriers and state agencies . The B/C levels were positive even at low truck volumes and low enforcement levels. The relative low cost of deployment contributed to the increased levels of benefits.

STRATEGY # 33 Weigh-in-Motion System

ORIENTATION Supply

CATEGORY Commercial Vehicle Operations (CVO)

DESCRIPTION

Weigh-in-motion is one component of Commercial Vehicle Operations aimed at improving the flow of commercial vehicles, enhancing safety, and minimizing truck stops at weigh stations and ports of entry. Weigh-in-motion refers to various technologies that enable vehicle weights to be determined without the need for a vehicle to physically stop on a scale. The technology allows for dynamic measurement of axle weight at highway or slower speeds. Weigh-in-motion is associated with automatic vehicle identification and is used conjointly expedite the processing of vehicles at border crossings. Many recent studies to apply technologies have focused on the accuracy and improvements in vehicle identification. Technologies are now capable of identifying vehicles at mainline speeds and at a high rate of accuracy. As a result, throughput is optimized, and delay that would occur at border crossings is significantly reduced (FHWA, 1999). The application of these technologies can increase system throughput, reduce delays, enhance customer service, improve safety, and reduce environmental impacts.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix	Principal Arterial Interstate	Rural	All congestion types	Off-Peak
Not Facility Specific	Principal Arterial Expressway	Special Venue		All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Administrative efficiency improvements	Delay at weigh stations/border crossings
Reduce Delay	Delay reductions	Labor expended

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce delay for trucks	Reduce delay	Reduce administrative costs

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

Weigh-in-motion systems can produce significant delay reductions for trucks that qualify. Such systems can also result in reduced administrative costs for agencies. AVL and GPS systems are used to improve the efficiency of individual truck operations. Information systems can reduce delay, primarily through optimizing route choice.

As a practical matter, CVO applications are likely to have only a limited impact on peak period congestion relief for a number of reasons. First, the percentage of trucks tends to be higher in the off-peak hours, therefore, the greatest potential for impact may be during the off-peak. Second, weigh stations are generally located outside the urban area or on the fringes, so that weigh-in-motion and electronic credential checking would result in little direct benefit to urban congestion relief. However, information systems can help trucks avoid, and therefore not contribute to, congested facilities and time periods. Furthermore, CVO applications could be considered as a strategy to foster transportation and economic efficiency.

EFFECTS EVALUATION

The analysis technique will depend on the specific CVO application being analyzed. Possible delay-reduction from weigh-in-motion and electronic credential checking can be estimated based on assumed penetration/eligibility levels and the volume of trucks at the specific locations. The analysis of delay savings due to information-based approaches can be analyzed using the same basic techniques as for Advanced Traveler Information Systems (ATIS). However, the analysis would focus on the CVO subset of all traffic. The benefits of vehicle location systems is mainly internal to the trucking industry and usually does not need to be analyzed within the public sector.

Gauging the penetration of CVO systems into the overall fleet is an important evaluation component.

STRATEGY # **33** Weigh-in-Motion System

RELATIVE COST NOTES

DISADVANTAGES

Results in little direct benefit to urban congestion relief or peak hour congestion relief.

INSTITUTIONAL FACTORS

CVO measures may be applied at various levels, but often require considerable inter-agency and private sector participation. At one end, a weigh-in-motion station can be a spot application and involve only the regulatory agency. Electronic credential checking must be integrated over a long stretch of roadway (usually interstate) with multiple stations to be of significant benefit. One-stop shopping is also typically applied over a large, sometimes multi-state, area and can involve numerous public agencies. Information systems can benefit the trucking industry when implemented at both the regional level and for specific locations.

There are many decisions on CVO systems, like equipping fleets with GPS systems, that are made solely by private industry for purposes of improving the efficiency of their operations.

WARRANTS

No definite warrant

EXAMPLES

A) Colorado DOT installed a new weigh-in-motion/automatic vehicle identification (WIM/AVI) system at the Limon Port of Entry in 1999. The new system will speed port operations and reduce mobile unit clearance time by almost 50%.

B) A state of the art facility was constructed in St. George, Utah and is a joint port with Arizona. The facility has served as a model for other states and foreign countries to use to build their own systems. The Utah facility was one of the pioneers in the industry which allowed trucks to use ITS technology to by-pass with out stopping.

STRATEGY # 34 Online Shopping

ORIENTATION Demand

CATEGORY Communication Substitution

DESCRIPTION

Online shopping is the substitution of online communication for trips taken to make purchases.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Reduce Total Vehicle Trips	Percentage of trips in peak hour Person trips Vehicle miles traveled (VMT) by congestion level	Traffic counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce vehicular trips	Reduce costs for personal vehicle maintenance and care Eliminate time for making trip	Improve air quality

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

This strategy may lead to reduced vehicle trips.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips during the peak periods. The FHWA TDM Model can be used for evaluating the potential of various TDM measures. In addition, a sketch-planning spreadsheet analysis can be used to determine environmental impacts.

Surveys are the most direct measurement technique. Traffic counts can quantify extent to which peak is spreading.

STRATEGY # | **34** | Online Shopping

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy falls under the domain of individuals.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	35	Telecommuting	ORIENTATION	Demand
CATEGORY	Communication Substitution			

DESCRIPTION

Telecommuting is the partial or total substitution of telecommunications for the daily commute to/from work. A work arrangement program where employees work at a location other than the conventional office to transport information rather than people to and from the workplace. This place may be the home, or an office close to home, but not the central headquarters of a company.

A enhancement for telecommuting is regional work centers, which are suburban locations where workers from the same or different offices can work at a location closer to their home (instead of a downtown office).

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	Urban Metropolitan	All congestion types	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Reduce Total Vehicle Trips	Percentage of trips in peak hour Number of people working at home Person trips Vehicle miles traveled (VMT) by congestion level	Employer records of telecommuting Traffic counts at site Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce vehicular trips	Reduce costs for personal vehicle maintenance and care Eliminate time for making trip	Reduce energy consumption

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

This strategy may reduce congestion in different ways depending on the measure implemented. This strategy may lead to reduced vehicle trips (compressed work week, telecommuting), reduced peak period travel (staggered work hours, flex-time), or reduced VMT or trip length (regional work centers). By reducing the number of total or peak period trips, this strategy can help lessen the spreading of the peak travel period. By spreading demand over a longer period or to other areas (e.g. away from downtown to an outlying work center), the transportation system may handle more commuters without additional peak capacity.

These programs are generally inexpensive to implement, and generally receive a positive reaction from employees.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips during the peak periods. The FHWA TDM Model can be used for evaluating the potential of various TDM measures. In addition, a sketch-planning spreadsheet analysis can be used to determine environmental impacts. In general, sketch-planning analysis can suggest the approximate impacts of a program by considering the number of employees expected to participate and the current mode choices of these individuals. Results from similar programs in other areas may also be used to estimate the impacts of future applications.

Surveys are the most direct measurement technique. Traffic counts can quantify extent to which peak is spreading.

STRATEGY # | **35** | Telecommuting

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

This strategy falls largely under the domain of individual employers, thus the public agency response has been one of supporting the concept rather than specific action. It is recognized that alternative work arrangement support TDM objectives and can be used to encourage use of alternative modes.

DISADVANTAGES

Telecommuting may affect non-work trips. Telecommuters or family members may make more midday shopping trips as a result of flexibility in work time or a vehicle normally parked at work.

This strategy may counter some of the benefits of strategies like ridesharing programs and transit/carpool incentives by disrupting the common work schedules of employees who rideshare.

Telecommuting may meet with some resistance from employers.

WARRANTS

No definite warrant

EXAMPLES

A. Irvine, CA: (1990 pop – 2,410,688); Packard-Hughes Interconnect (formerly Hughes Electronics); cost not available; 60 employees participated in a pilot program; employees participating had an average reduced driving distance of 60 miles per week.

B. Bellevue, WA: (1990 pop – 2,033,128); Washington State Telework Center; $135,000 setup cost; participation not available; center setup in 1991 provided telecommuting workstations for employers and their employees living in the Seattle and Bellevue area. These employees had a commute of one hour or more. The center saved telecommuters a total commuting distance of 60,000 miles annually.

C. Redmond, WA: (1990 pop – 2,033,128); City of Redmond; $4,500-$7,500 setup costs; center set up as pilot project had 10 telecommuters who eliminated 450 commute miles and 35 commute hours per week.

STRATEGY #	36	Teleconferencing	ORIENTATION	Demand
CATEGORY	Communication Substitution			

DESCRIPTION

Teleconferencing, or the substitution of television and telephone communication for trips taken to meet directly with other people, usually used for business purposes.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Reduce Total Vehicle Trips	Percentage of trips in peak hour Number of people working at home Person trips Vehicle miles traveled (VMT) by congestion level	Traffic counts Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce vehicular trips	Reduce costs for personal vehicle maintenance and care Eliminate time for making trip	Improve air quality

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

This strategy may lead to reduced vehicle trips.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips during the peak periods. The FHWA TDM Model can be used for evaluating the potential of various TDM measures. In addition, a sketch-planning spreadsheet analysis can be used to determine environmental impacts. In general, sketch-planning analysis can suggest the approximate impacts of a program by considering the number of employees expected to participate and the current mode choices of these individuals. Results from similar programs in other areas may also be used to estimate the impacts of future applications.

Surveys are the most direct measurement technique. Traffic counts can quantify extent to which peak is spreading.

STRATEGY # | **36** | Teleconferencing

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy falls largely under the domain of individual employers, thus the public agency response has been one of supporting the concept rather than specific action.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	37	Teleshopping	ORIENTATION	Demand
CATEGORY	Communication Substitution			

DESCRIPTION

Teleshopping is the substitution of telephone communication for trips taken to make purchases.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Reduce Total Vehicle Trips	Percentage of trips in peak hour Person trips Vehicle miles traveled (VMT) by congestion level	Traffic counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce vehicular trips	Reduce costs for personal vehicle maintenance and care Eliminate time for making trip	Improve air quality

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

This strategy may lead to reduced vehicle trips.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips during the peak periods. The FHWA TDM Model can be used for evaluating the potential of various TDM measures. In addition, a sketch-planning spreadsheet analysis can be used to determine environmental impacts.

Surveys are the most direct measurement technique. Traffic counts can quantify extent to which peak is spreading.

STRATEGY # 37 Teleshopping

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy falls under the domain of individuals.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	38	Advance Notice	ORIENTATION	Supply
CATEGORY	Construction Management			

DESCRIPTION

By providing as much information as possible to the public, including alternate routes, transportation agencies can realize less public resistance to construction projects. Some agencies even make the public an active part of the process, a step that can even gain public support of the project. Public awareness of projects is done with informal workshops and public hearings. Many agencies have formed project teams with the specific duty of informing the public of upcoming projects, as well as projects scheduled to begin several years in the future. Other methods include brochures, press releases, media kits, telephone hotlines, television (public access channels), highway advisory radio (HAR), and the Internet. Construction public awareness usually requires cooperation between the FHWA, DOTs, public safety agencies, and other local agencies.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Allow Informed Decisions Improve Travel Speeds Reduce Delay	Accident rates Amount/proportion of traffic diverted Delay Duration of queues Travel time	Mode shift Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Diversion of traffic Efficient use of available capacity	Allow informed decisions Improve travel speeds Reduce delay	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Low	Medium

RELATIVE BENEFIT NOTES

The principal benefit of construction management is that of minimizing the duration and/or magnitude of traffic disruption. Mitigation measures can improve the efficiency of traffic flow and increase available capacity during construction, particularly in peak periods. While they may be unavoidable, vehicle delays and speed reductions can be minimized. The congestion-related benefits of certain strategies (e.g., night-time construction) need to be balanced against the safety and cost considerations.

EFFECTS EVALUATION

The analysis approach for construction management strategies is similar to the approach for incident management. However, the approach may require adjustment of traffic volumes to account for the type of construction management technique employed. There are several tools available to assist with the analysis of a construction management program. These include several simulation models, such as FREQ and NETSIM, both of which are capable of simulating construction effects through assumed capacity reductions. The spreadsheet-based tool, QUEWZ, provides a sketch-planning level approach to estimating construction-induced delays on an expressway.

For the most part, adjustments are made at construction sites to deal with traffic congestion problems. An evaluation of a total construction management program may be helpful in some cases (e.g. experience with TDM measures, diversion, etc.)

STRATEGY # **38** Advance Notice

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

ADOT and local transportation agencies maintain policies on construction periods and procedures. Additional procedures may be written into construction contracts. Methods to minimize traffic disruption during construction are promoted.

WARRANTS

No definite warrant

EXAMPLES

A. Montgomery, AL: (1990 pop –292,517); $90,000 annual cost; primary services include press releases, bulletins, Internet, and TV; staffing not available.
B. Detroit Lakes, MN: (1990 pop –7,141); $45,000 annual cost; primary services include media kits, press releases, radio, Internet, and media interviews; one public relations employee (Detroit Lakes, District 4)
C. Raleigh, NC: (1990 pop –858,485); cost not available; primary services include newspaper advertisements, public hearings, Internet, radio, and mailing list; five public relations employees (statewide).
D. Columbia, SC: (1990 pop –453,932); cost not available; primary services include highway advisory radio, Internet, brochures, and phone line; six public relations employees (statewide).
E. Fort Worth, TX: (1990 pop –1,361,034); cost not available; primary services include TV, radio, brochures, bulletin, and press releases; three pubic relations employees (Fort Worth District).

STRATEGY #	39	Construction Management Plans	ORIENTATION	Demand
CATEGORY	Construction Management			

DESCRIPTION

Construction management plans attempt to mitigate delays, maximize efficiency of available capacity during construction, and expedite the construction process. Construction management plans involves lane closures management, modification of driver behavior, and improvements to the construction process. Construction management plans can contain the following actions: restricting construction activities to non-peak hours, phasing of work, maintaining a specific number of open lanes, removing on-street parking to provide an additional travel lane, using innovative construction materials that speed the construction process, encouraging use of transit and carpools, designating and/or improving alternative routes, distributing public notices regarding construction timing and alternate routes, and improving signal timing. Complementary strategies include travel demand measures, transit improvements, as well as traffic signal improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Travel Speeds Reduce Delay	Accident rates Delay Duration of queues Travel time	Mode shift Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve throughput	Improve travel speeds Reduce delay	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Low	Medium

RELATIVE BENEFIT NOTES

The principal benefit of construction management is that of minimizing the duration and/or magnitude of traffic disruption. Mitigation measures can improve the efficiency of traffic flow and increase available capacity during construction, particularly in peak periods. While they may be unavoidable, vehicle delays and speed reductions can be minimized. The congestion-related benefits of certain strategies (e.g., night-time construction) need to be balanced against the safety and cost considerations.

EFFECTS EVALUATION

The analysis approach for construction management strategies is similar to the approach for incident management. However, the approach may require adjustment of traffic volumes to account for the type of construction management technique employed. There are several tools available to assist with the analysis of a construction management program. These include several simulation models, such as FREQ and NETSIM, both of which are capable of simulating construction effects through assumed capacity reductions. The spreadsheet-based tool, QUEWZ, provides a sketch-planning level approach to estimating construction-induced delays on an expressway.

For the most part, adjustments are made at construction sites to deal with traffic congestion problems. An evaluation of a total construction management program may be helpful in some cases (e.g. experience with TDM measures, diversion, etc.)

STRATEGY # | **39** | Construction Management Plans

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Implementation involves thorough planning and public education.

ADOT and local transportation agencies maintain policies on construction periods and procedures. Additional procedures may be written into construction contracts. Methods to minimize traffic disruption during construction are promoted.

WARRANTS

No definite warrant

EXAMPLES

A. Los Angeles, CA: (1990 pop – 8,863,052); public perception is that complaints re highest if work is still in progress when early morning commute hours begin.
B. St. Louis, MO: (1990 pop – 2,492,348); it has been reported that the levels of frustration that motorists had regarding bumper-to-bumper traffic associated with daytime construction projects has decreased.
C. Columbus, OH: (1990 pop – 1,345,450); many in the public want to know why more construction work cannot be performed at night. Public enjoys faster completion when projects done at night and also find use of tower lighting and portable lighting very helpful.
D. Harrisburg, PA: (1990 pop – 587,986); public almost always prefers night construction. Pennsylvania Turnpike Commission has determined that the less inconvenience there is for motorists, the more support there is for the project. The fact that traffic is not inhibited makes construction work more tolerable in the eyes of the public.
E. Seattle, WA: (1990 pop – 2,033,128); a University of Washington survey reported that the public felt that night construction was a very effective and efficient way to complete roadway projects more quickly.

STRATEGY # | **40** | Detours

ORIENTATION | Supply

CATEGORY | Construction Management

DESCRIPTION

Detours are planned alternate routes that are utilized for construction related closures or as part of incident management plans. By communicating alternate route information to the public, transportation agencies can realize less public resistance to construction projects. Effective alternate routes involve proper and adequate signage, as well as thorough planning and public education. Supporting strategies include TDM measures, transit improvements, and TSM actions.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Travel Speeds Reduce Delay	Accident rates Delay Duration of queues Travel time	Mode shift Moving car runs Alternate routes

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Diversion of traffic	Improve travel speeds Reduce delay	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Low	Medium

RELATIVE BENEFIT NOTES

The principal benefit of construction management is that of minimizing the duration and/or magnitude of traffic disruption. Mitigation measures can improve the efficiency of traffic flow and increase available capacity during construction, particularly in peak periods. While they may be unavoidable, vehicle delays and speed reductions can be minimized. The congestion-related benefits of certain strategies (e.g., night-time construction) need to be balanced against the safety and cost considerations.

EFFECTS EVALUATION

The analysis approach for construction management strategies is similar to the approach for incident management. However, the approach may require adjustment of traffic volumes to account for the type of construction management technique employed. There are several tools available to assist with the analysis of a construction management program. These include several simulation models, such as FREQ and NETSIM, both of which are capable of simulating construction effects through assumed capacity reductions. The spreadsheet-based tool, QUEWZ, provides a sketch-planning level approach to estimating construction-induced delays on an expressway.

For the most part, adjustments are made at construction sites to deal with traffic congestion problems. An evaluation of a total construction management program may be helpful in some cases (e.g. experience with TDM measures, diversion, etc.)

STRATEGY # | **40** | Detours

RELATIVE COST NOTES

DISADVANTAGES

Transportation-related impacts (delays, accidents) may result along diversion routes.

INSTITUTIONAL FACTORS

ADOT and local transportation agencies maintain policies on construction periods and procedures. Additional procedures may be written into construction contracts. Methods to minimize traffic disruption during construction are promoted.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	41	Lane Closures Management	ORIENTATION	Supply
CATEGORY	Construction Management			

DESCRIPTION

For a variety of reasons, lanes must be closed to increase the safety and maneuverability of constructing crews. High capacity roadways with four or more lanes are less sensitive to lane closures. Low capacity roadways with two or three lanes can be severely affected by lane closures causing significant travel time delays or requiring roadway detours. Lane closures also reduce the capacity of those lanes that remain open (per-lane capacities in construction zones range from 1200-1500 vph versus 1800-2000 vph in non-construction areas). Lane closure management actions include: restricting construction activities to non-peak hours, phasing of work, maintaining a specific number of open lanes, removing on-street parking to provide an additional travel lane, and designating and/or improving alternative routes. Complementary strategies include travel demand measures and transit improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Travel Speeds Reduce Delay	Accident rates Delay Duration of queues Travel time	Mode shift Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Diversion of traffic Efficient use of available capacity	Improve travel speeds Reduce delay	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	Low	Medium

RELATIVE BENEFIT NOTES

The principal benefit of construction management is that of minimizing the duration and/or magnitude of traffic disruption. Mitigation measures can improve the efficiency of traffic flow and increase available capacity during construction, particularly in peak periods. While they may be unavoidable, vehicle delays and speed reductions can be minimized. The congestion-related benefits of certain strategies (e.g., night-time construction) need to be balanced against the safety and cost considerations.

EFFECTS EVALUATION

The analysis approach for construction management strategies is similar to the approach for incident management. However, the approach may require adjustment of traffic volumes to account for the type of construction management technique employed. There are several tools available to assist with the analysis of a construction management program. These include several simulation models, such as FREQ and NETSIM, both of which are capable of simulating construction effects through assumed capacity reductions. The spreadsheet-based tool, QUEWZ, provides a sketch-planning level approach to estimating construction-induced delays on an expressway.

For the most part, adjustments are made at construction sites to deal with traffic congestion problems. An evaluation of a total construction management program may be helpful in some cases (e.g. experience with TDM measures, diversion, etc.)

STRATEGY # | **41** | Lane Closures Management

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

Implementation involves thorough planning and public education.

ADOT and local transportation agencies maintain policies on construction periods and procedures. Additional procedures may be written into construction contracts. Methods to minimize traffic disruption during construction are promoted.

DISADVANTAGES

WARRANTS

No definite warrant

EXAMPLES

A. Little Rock, AR: (1990 pop –513,117); state DOT only allows lane closures at night between 7:00 pm and 7:00 am; elements used include barricades, lane striping, local newspaper, and local traffic reports; the policy of conducting lane closures during the evening and early morning hours resulted from the public outcry against their occurrence during daytime hours.

B. Tallahassee, FL: (1990 pop –233,609); Florida DOT only allows lane closures during non-peak periods; elements used include signing, radio, TV, and newspaper.

C. Baltimore, MD: (1990 pop –2,382,172); Maryland DOT uses nighttime lane closures, with few peak-time closures; elements included posted signs, variable message signs, public meetings, toll-free number, and radio.

D. Dallas, TX: (1990 pop –2,676,248); City of Dallas and Texas DOT Dallas District allow no peak hour lane closures; requiring that lane closures be conducted at non-peak periods actually save the taxpayers substantially more in cost due to travel time savings and inconvenience that the additional daily cost of the construction project itself.

STRATEGY #	42	Signing	ORIENTATION	Demand
CATEGORY	Construction Management			

DESCRIPTION

Effective signing of construction zones can provide motorists with construction related information to ensure ease within the construction area. Signage is also important in directing motorists to detour routes. Advance notice through signage can allow time for motorists to divert to alternate routes.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Travel Speeds Reduce Delay	Accident rates Delay Duration of queues Travel time	Mode shift Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Efficient use of available capacity	Improve travel speeds Reduce delay	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

The principal benefit of construction management is that of minimizing the duration and/or magnitude of traffic disruption. Mitigation measures can improve the efficiency of traffic flow and increase available capacity during construction, particularly in peak periods. While they may be unavoidable, vehicle delays and speed reductions can be minimized. The congestion-related benefits of certain strategies (e.g., night-time construction) need to be balanced against the safety and cost considerations.

EFFECTS EVALUATION

The analysis approach for construction management strategies is similar to the approach for incident management. However, the approach may require adjustment of traffic volumes to account for the type of construction management technique employed. There are several tools available to assist with the analysis of a construction management program. These include several simulation models, such as FREQ and NETSIM, both of which are capable of simulating construction effects through assumed capacity reductions. The spreadsheet-based tool, QUEWZ, provides a sketch-planning level approach to estimating construction-induced delays on an expressway.

For the most part, adjustments are made at construction sites to deal with traffic congestion problems. An evaluation of a total construction management program may be helpful in some cases (e.g. experience with TDM measures, diversion, etc.)

STRATEGY # | **42** | Signing

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

ADOT and local transportation agencies maintain policies on construction periods and procedures. Additional procedures may be written into construction contracts. Methods to minimize traffic disruption during construction are promoted.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 43 Add Lanes to Existing Facilities

ORIENTATION Supply

CATEGORY Expressways

DESCRIPTION

This strategy involves adding lanes to existing expressways. Addition of lanes increases available capacity and can relieve traffic congestion. Transportation and land use planning is required to determine the need for additional lanes. Right-of-way preservation can allow lane additions to be less costly in built-up areas. Public involvement can assess the level of support for addition of lanes. Capacity additions should evaluate the effects from redistribution of vehicle trips and relocation of bottlenecks or other impacts.

Capacity expansion may directly conflict with other strategies that encourage transit, HOV, or non-motorized use. Complementary strategies include traffic signal improvements, access management, and advanced traffic management systems. Agencies can take advantage of construction projects to implement other improvements like HOV and bicycle/pedestrian facilities. Roadway geometric improvements, such as adding acceleration/deceleration lanes, adding turn lanes, or lane widening, to smaller sections of roadway are related strategies.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	Principal Arterial Expressway	Urban	Recurring predictable	Peak Hour
Number of Lanes		Metropolitan	Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Vehicular Travel Times	Average cost per lane-mile constructed	Link length
Increase Capacity	Average speed	Number of lanes
Reduce Delay	Delay	Speeds
	Level of service	
	Miles of congested roadway	
	Mode share/shift	
	Traffic volumes	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety	Reduce delay	None
Improve traffic flow	Reduce travel time	
Increase capacity		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

In some cases, safety benefits are included. Other benefits may include shorter peak periods for congested urban conditions, and considerable congestion relief on parallel arterials.

EFFECTS EVALUATION

The urban-scale benefits of expressway lane additions can be assessed using the regional travel demand model. The corridor-scale benefits and impacts of these strategies can be assessed using procedures described in the Highway Capacity Manual and simulation packages such as FREQ, CORFLO, and CORSIM.

Full evaluation should include evaluation of parallel routes, as well as impact on transit ridership.

STRATEGY # **43** Add Lanes to Existing Facilities

RELATIVE COST NOTES

Planning and right of way preservation is recommended in order to minimize high costs associated with acquisition of right of way in built up areas.

DISADVANTAGES

Expressway lane additions are high cost, typically require additional right-of-way, and consume years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts of expressway lane additions. These impacts can include relocation of people from adjacent homes and businesses, increases in noise and some air pollutants, destruction of habitats, and traffic congestion on local streets particularly at expressway interchanges.

INSTITUTIONAL FACTORS

Expressway lane additions may be appropriate for "pipeline" projects where substantial planning resources have been expended and where sufficient public interest and support exists to construct the project.

Expressway lane additions consume years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts of expressway lane additions.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	44	Construct New Facilities
CATEGORY		Expressways

ORIENTATION Supply

DESCRIPTION

This strategy involves the extension of existing expressways and the construction of new expressways. Constructing new expressways increases available capacity and can relieve traffic congestion. Intensive planning is required to determine need and establish alignment of new facilities. Planning efforts can often take several years. Right-of-way preservation should be pursued as planning identifies needed corridors. Public involvement can assess the level of support for construction and alignment alternatives. Capacity additions should evaluate the effects from redistribution of vehicle trips and relocation of bottlenecks or other impacts.

Capacity expansion may directly conflict with other strategies that encourage transit, HOV, or non-motorized use. Complementary strategies include traffic signal improvements, access management, and advanced traffic management systems. Agencies can take advantage of construction projects to implement other improvements like HOV and bicycle/pedestrian facilities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	Principal Arterial Expressway	Urban Metropolitan	Recurring predictable Recurring un-predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Vehicular Travel Times Increase Capacity Reduce Delay	Average cost per lane-mile constructed Average speed Delay Level of service Miles of congested roadway Mode share/shift Traffic volumes	Link length Link volume Number of lanes Speeds

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety Improve traffic flow Increase capacity	Reduce delay Reduce travel time	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

In some cases, safety benefits are included. Other benefits may include shorter peak periods for congested urban conditions, and considerable congestion relief on parallel arterials.

EFFECTS EVALUATION

The urban-scale benefits of expressway lane additions can be assessed using the regional travel demand model. The corridor-scale benefits and impacts of these strategies can be assessed using procedures described in the Highway Capacity Manual and simulation packages such as FREQ, CORFLO, and CORSIM.

Full evaluation should include evaluation of parallel routes, as well as impact on transit ridership.

STRATEGY # **44** Construct New Facilities

RELATIVE COST NOTES

Planning and right of way preservation is recommended in order to minimize high costs associated with acquisition of right of way in built up areas.

DISADVANTAGES

Construction of new expressways is high cost, typically requires additional right-of-way, and consumes years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts of expressway construction. These impacts can include relocation of people from adjacent homes and businesses, increases in noise and some air pollutants, destruction of habitats, and traffic congestion on local streets particularly at expressway interchanges.

INSTITUTIONAL FACTORS

Expressway lane additions may be appropriate for "pipeline" projects where substantial planning resources have been expended and where sufficient public interest and support exists to construct the project.

Expressway lane additions consume years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts of expressway lane additions.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	45	Add Lanes to Freeways	ORIENTATION	Supply
CATEGORY	Freeways			

DESCRIPTION

This strategy involves adding lanes to existing freeways. Addition of lanes increases available capacity and can relieve traffic congestion. Transportation and land use planning is required to determine the need for additional lanes. Right-of-way preservation can allow lane additions to be less costly in built-up areas. Public involvement can assess the level of support for addition of lanes. Capacity additions should evaluate the effects from redistribution of vehicle trips and relocation of bottlenecks or other impacts.

Capacity expansion may directly conflict with other strategies that encourage transit, HOV, or non-motorized use. Complementary strategies include traffic signal improvements and advanced traffic management systems. Agencies can take advantage of construction projects to implement other improvements like HOV and bicycle/pedestrian facilities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	Principal Arterial Interstate	All locations	Recurring predictable	Peak Hour
Number of Lanes			Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Vehicular Travel Times	Average cost per lane-mile constructed	Link length
Increase Capacity	Average speed	Number of lanes
Reduce Delay	Delay	Speeds
	Level of service	
	Miles of congested roadway	
	Mode share/shift	
	Traffic volumes	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce localized traffic congestion	Reduce delay	None
Improve safety	Reduce travel time	
Improve traffic flow		
Increase capacity		

EFFECTS EVALUATION

The urban-scale benefits of freeway lane additions can be assessed using the regional travel demand model. The corridor-scale benefits and impacts of these strategies can be assessed using procedures described in the Highway Capacity Manual and simulation packages such as FREQ, CORFLO, and CORSIM.

Full evaluation should include evaluation of parallel routes, as well as impact on transit ridership.

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

In some cases, safety benefits are included. Other benefits may include shorter peak periods for congested urban conditions, and considerable congestion relief on parallel arterials.

STRATEGY # 45 Add Lanes to Freeways

RELATIVE COST NOTES

Planning and right of way preservation is recommended in order to minimize high costs associated with acquisition of right of way in built up areas.

DISADVANTAGES

As with any supply based strategy, added capacity may induce traffic. It may also discourage transit and HOV use. Complementary HOV measures include freeway to freeway HOV ramps.

Freeway lane additions are high cost, typically require additional right-of-way, and consume years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts of freeway lane additions. These impacts can include relocation of people from adjacent homes and businesses, increases in noise and some air pollutants, destruction of habitats, and traffic congestion on local streets particularly at freeway interchanges.

INSTITUTIONAL FACTORS

Freeway lane additions may be appropriate for "pipeline" projects where substantial planning resources have been expended and where sufficient public interest and support exists to construct the project.

Freeway lane additions consume years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts of freeway lane additions.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	46	Construct New Freeways	ORIENTATION	Supply
CATEGORY	Freeways			

DESCRIPTION

This strategy involves the extension of existing freeways and the construction of new freeways. Constructing new freeways increases available capacity and can relieve traffic congestion. Intensive planning is required to determine need and establish alignment of new facilities. Planning efforts can often take several years. Right-of-way preservation should be pursued as planning identifies needed corridors. Public involvement can assess the level of support for construction and alignment alternatives. Capacity additions should evaluate the effect from redistribution of vehicle trips and relocation of bottlenecks or other impacts.

Capacity expansion may directly conflict with other strategies that encourage transit, HOV, or non-motorized use. Complementary strategies include traffic signal improvements, access management, and advanced traffic management systems. Agencies can take advantage of construction projects to implement other improvements like HOV and bicycle/pedestrian facilities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	Principal Arterial Interstate	Urban	Recurring predictable	All Day
	Principal Arterial Expressway	Metropolitan	Recurring un-predictable	All Year
		Rural		

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Average cost per lane-mile constructed	Delay
Improve Traffic Flow	Delay	Traffic counts
Improve Vehicular Travel Times	Traffic volumes	Travel time
Increase Capacity	Travel time	
Reduce Delay		

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce localized traffic congestion	Reduce delay	None
Improve system efficiency	Reduce travel time	
Improve traffic flow		
Increase capacity		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # 46 Construct New Freeways

RELATIVE COST NOTES

Planning and right of way preservation is recommended in order to minimize high costs associated with acquisition of right of way in built up areas.

DISADVANTAGES

As with any supply based strategy, added capacity may induce traffic. It may also discourage transit and HOV use. HOV measures can be incorporated into new freeway construction.

Construction of new freeways is high cost, typically requires additional right-of-way, and consumes years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts of freeway construction. These impacts can include relocation of people from adjacent homes and businesses, increases in noise and some air pollutants, destruction of habitats, and traffic congestion on local streets particularly at freeway interchanges.

INSTITUTIONAL FACTORS

Construction of new freeways may be appropriate for "pipeline" projects where substantial planning resources have been expended and where sufficient public interest and support exists to construct the project.

The construction of new freeways consume years to plan, design, and construct. The approval process can also be lengthy due to the potential impacts, especially environmental impacts.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	47	Freeway Auxiliary Lanes	ORIENTATION	Supply
CATEGORY	Freeways			

DESCRIPTION

An auxiliary lane is a lane that is added at one interchange and then dropped at the next. Essentially, the on-ramp becomes an additional travel lane but then becomes an exit-only lane at the next interchange. Auxiliary lanes allow vehicles entering a freeway time to reach the speed of other vehicles already on the roadway. Auxiliary lanes also provide a place for vehicles exiting the freeway to slow down without impeding other vehicles on the freeway.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	Urban	Recurring predictable	Peak Hour
Facility Expansion Feasibility	Principal Arterial Expressway	Metropolitan	Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Accident rates	Accident rates
Improve Traffic Flow	Average speed	Delay
Reduce Delay	Delay	Traffic counts
	Freeway mainline/ramp accidents	Traffic volume - mainline, ramps, and arterials
	Ramp queue lengths and delays	
	Traffic volumes	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow	Improve travel speeds	Improve safety
Increase capacity	Reduce delay	Reduce frequency of highway accidents
	Reduce vehicle conflict	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Medium

RELATIVE BENEFIT NOTES

Auxiliary lanes help to maintain traffic flow in the through lanes by pulling exiting cars out of the through lanes. Auxiliary lanes improve safety by reducing conflicts due to speed differences and by providing longer sections of roadway for motorists to transition on or off the freeway.

EFFECTS EVALUATION

The corridor-scale benefits and impacts of auxiliary lane additions can be assessed using procedures described in the Highway Capacity Manual and simulation packages such as FREQ, CORFLO, and CORSIM.

STRATEGY # **47** Freeway Auxiliary Lanes

RELATIVE COST NOTES

DISADVANTAGES

Freeway auxiliary lane additions are high cost, and may require additional right-of-way. Potential impacts include relocation of people from adjacent homes and businesses, increases in noise and some air pollutants, and destruction of habitats.

INSTITUTIONAL FACTORS

This strategy is commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of this strategy where appropriate.

WARRANTS

No definite warrant

EXAMPLES

An auxiliary lane was recently added on Eastbound Loop 101 between 67th Avenue and 59th Avenue in Glendale. Other auxiliary lanes exist along I-10, I-17 and other urban freeways.

STRATEGY #	48	Freeway Express Lanes	ORIENTATION	Supply
CATEGORY	Freeways			

DESCRIPTION

Express lanes provide dedicated capacity on freeways for vehicles that are traveling a significant distance within or through a portion of a metropolitan area. Motorists are able to bypass several interchanges and the associated congestion while driving in express lanes. Some express lanes exist for short distances (less than 2 miles) while others span several miles. Designs include separate overhead structures to same-grade adjacent lanes. Express lanes are generally very expensive and there use is somewhat limited to cities of greater size or corridors between cities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate Principal Arterial Expressway	Metropolitan	Recurring predictable Recurring un-predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety Improve Traffic Flow Improve Travel Speeds Improve Vehicular Travel Times Reduce Conflicts	Accident rates Average cost per lane-mile constructed Traffic volumes Travel time Throughput	Traffic counts

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow Increase capacity Reduce conflicts	Improve travel speeds Reduce delay Reduce vehicle conflict	Improve air quality Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # | **48** | Freeway Express Lanes

RELATIVE COST NOTES

Express lanes are generally very expensive.

DISADVANTAGES

INSTITUTIONAL FACTORS

WARRANTS

No definite warrant

EXAMPLES

A. Chicago, IL: (1990 pop – 7,410,858); Kennedy Expressway; part of a $435 million overall highway reconstruction; Illinois DOT; ten reversible express lanes totaling 7.5 miles; benefits are lowered commute times and increased safety for travelers coming to or from the Chicago area.
B. State of Maryland: (1990 pop – not applicable); Interstate 270; part of a $200 million project; Maryland DOT; eight express lanes divided from four local lanes by Jersey Barriers; benefits are reduced amount of weaving and reduction in speeds that result on adjacent local lanes.
C. San Antonio, TX: (1990 pop – 1,324,749); "Downtown Y" Project; $272 million; Texas DOT; 10 miles of double-decked, 8 to 10 lane, segmental winged-T bridge; benefits include 38% increase in Average Daily Traffic between 1990 and 1996 and good travel times to the central business district.
D. Austin, TX: (1990 pop – 846,227); I-35 Elevated Express Lanes; $5,617,809 cost; Texas DOT; two, double lane, 1.3 mile long elevated express lanes; positive safety benefits are inferred from more frequent and more severe accidents occurring on the lower levels of I-35 (non-express lanes).
E. Seattle, WA: (1990 pop – 2,033,128); I-5 and I-90 Express Lanes; cost not available; Washington DOT; cost not available; HOV and SOV manually reversible lanes; benefits not definable since widening occurred simultaneously with addition of express lanes; observations indicate that traffic is not as peak-directional as engineers had predicted. Inbound traffic is nearly as heavy as outbound traffic during evening peak hours. Drive times are reportedly shorter on the express lanes but congestion is prevalent at ingress and egress points in the express lane.

STRATEGY # 49 Freeway Ramp Lane Additions

ORIENTATION Supply

CATEGORY Freeways

DESCRIPTION

The addition of lanes on freeway on or off ramps can sometimes be accomplishing through restriping in locations with sufficient roadway width. Other locations require the addition of pavement to accommodate the additional lanes.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	Urban	Recurring predictable	Peak Hour
Facility Expansion Feasibility	Principal Arterial Expressway	Metropolitan	Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Traffic Flow	Delay	Delay
Increase Capacity	Level of service	Traffic counts
Reduce Delay	Ramp queue lengths and delays	Traffic volume - mainline, ramps, and arterials
	Traffic volumes	

EFFECTS EVALUATION

The corridor-scale benefits and impacts of ramp lane additions can be assessed using procedures described in the Highway Capacity Manual and simulation packages such as FREQ, CORFLO, and CORSIM.

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow	Reduce delay	None
Increase capacity		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Medium	Medium

RELATIVE BENEFIT NOTES

Freeway ramp lane additions can increase the capacity of a ramp allowing more vehicles to enter or exit the freeway. Additional ramp lanes can also provide additional storage of vehicles preventing backup onto the freeway or onto arterials and signalized intersections.

STRATEGY # | **49** | Freeway Ramp Lane Additions

RELATIVE COST NOTES

DISADVANTAGES

Freeway ramp lane additions can be medium cost, and may require additional right-of-way. Potential impacts include relocation of people from adjacent homes and businesses, and increases in noise and some air pollutants.

INSTITUTIONAL FACTORS

This strategy is commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of this strategy where appropriate.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	50	Freeway to Freeway Connections	ORIENTATION	Supply
CATEGORY	Freeways			

DESCRIPTION

Freeway to freeway connections provide continuous travel from one freeway to another. HOV measures can be incorporated into new freeway construction including freeway to freeway HOV ramps.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	Principal Arterial Interstate Principal Arterial Expressway	Urban Metropolitan	Recurring predictable Non-recurring un-predictable	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Traffic Flow Improve Vehicular Travel Times Increase Capacity Reduce Delay	Average cost per lane-mile constructed Delay Traffic volumes Travel time	Delay Traffic counts Travel time

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow Increase capacity	Reduce delay Reduce travel time	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # | **50** | Freeway to Freeway Connections

RELATIVE COST NOTES

Can be costly if additional right of way is required.

DISADVANTAGES

As with any supply based strategy, added capacity may induce traffic. It may also discourage transit and HOV use. Complementary HOV measures include freeway to freeway HOV ramps.

Construction of freeway to freeway ramps can be costly if right-of-way is required. Potential impacts from the construction of freeway to freeway connections include relocation of people from adjacent homes and businesses, increases in noise and some air pollutants, destruction of habitats, and traffic congestion on local streets.

INSTITUTIONAL FACTORS

Planning and right of way preservation is recommended in order to minimize high costs associated with acquisition of right of way in built up areas.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	51	HOV Priority Systems	ORIENTATION	Demand
CATEGORY	HOV Measures			

DESCRIPTION

HOV priority systems work to alleviate congestion by reducing the number of single occupant vehicles (SOVs). HOV priority systems are exclusive facilities for multiple occupant vehicles including carpools, vanpools, and buses. It is common to allow one person motorcycles to drive the HOV lane. Some jurisdictions prohibit trucks over certain threshold weights from driving in HOV lanes. Benefits of using HOV lanes include travel time savings, increases in transit use, and overall increased capacity of the highway facilities for both HOV lanes and general purpose (GP) lanes. HOV priority systems include freeway and arterial HOV lanes, HOV bypass lanes at ramp meters, exclusive HOV ramps entering the freeway at all-purpose or HOV lanes or exiting the freeway from HOV lanes, and HOV turning lanes.

HOV facilities can be designated for vehicles with at least two or three passengers, or for transit vehicles only. The threshold should be set at a vehicle occupancy that will maintain travel time benefits for users. If the occupancy level is set too low, excessive demand will negate the benefits received. Restrictions for using HOV facilities can be implemented all day or during peak hours and even peak direction only. HOV lanes can be directly beside all-purpose lanes or can be separated by markings or barriers. HOV lanes can be provided in both directions or be reversible. This strategy is most applicable on facilities with heavy congestion, with speeds less than 30 mph, where congestion drastically affects transit travel times and speeds, or where rail transit is over-capacity or unavailable. Complementary strategies include travel demand measures and transit improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	Urban	Recurring predictable	Peak Hour
Facility Expansion Feasibility	Principal Arterial Expressway	Metropolitan	Recurring un-predictable	All Year
	Principal Arterial Other			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve HOV Travel Times	Average vehicle occupancy	Moving car runs
Improve Travel Speeds	HOV lane travel time	Travel time
Increase HOV Trips	HOV use	Vehicle occupancy
Increase Person Throughput	Park-and-ride-lot utilization	Volume counts by vehicle class
Reduce Total Vehicle Trips	Person throughput	
Reduce VMT		

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Improve schedule reliability	Improve air quality
Increase capacity	Improve travel speeds	
Increase HOV trips	Reduce travel time	
Increase person throughput		
Increase transit use		
Reduce vehicular trips		
Reduce VMT		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

From a system perspective, the primary purpose of HOV systems is to increase person capacity or throughput. Experience in northern Virginia, Seattle and San Francisco shows that HOV lanes can lead to increased person throughput by achieving an AVO of around 7, compared to 1.25 typically found in general purpose lanes. For users of an HOV system, the primary benefit is faster travel speeds. In turn, HOV systems can encourage HOV use, and thereby reducing the number of vehicles and VMT.

EFFECTS EVALUATION

When analyzing HOV facilities, there are two key issues to be addressed: will the volume of HOVs on the new facility be greater than its capacity, and will the travel time savings for HOVs be enough to justify the new facility? V/C ratios on the HOV facility should be less than the mixed-flow facility, and time savings on the order of one minute per mile of HOV lane during the peak may be used as a benchmark to justify HOV lane construction.

There are a variety of analysis methodologies for HOV facilities, but a modeling effort is generally required. To screen potential strategies, a sketch-planning analysis may be used, but ultimately a more detailed simulation model (e.g., FREQ) and/or travel demand model is appropriate.

Conducting a comprehensive evaluation of HOV priority systems is very difficult. Existing HOVs may have been attracted from other routes or time periods. Usually a survey on mode shift is needed in addition to counts.

STRATEGY # 51 HOV Priority Systems

RELATIVE COST NOTES

Costs can be high if additional facilities have to be built.

DISADVANTAGES

In some instances, the shift to carpools and vanpools may come at the expense of transit ridership. Depending on the configuration of the HOV system, cost and ROW requirements may be significant.

INSTITUTIONAL FACTORS

The state has various HOV priority systems.

Implementing HOV facilities requires extensive planning, multi-agency cooperation, public education and marketing. The transfer of a general flow lane for use as a high-occupancy lane can be met by public opposition.

WARRANTS

No definite warrant

EXAMPLES

In an effort to improve user travel times and bus reliability in Manhattan, a comprehensive HOV program for buses only was developed by the New York City DOT Ten concurrent flow bus lanes operating under special regulations were designated between June 1982 and November 1982 for a total of 11 miles. Two of the 10 bus lanes were entirely new. Success has been achieved through emphasis upon a three part approach of engineering treatments, enforcement strategies, and public education programs. "Before and after" results revealed that the average bus saved two to four minutes, representing a 15 to 25 percent increase in speed. Non-bus traffic speeds also increased by 10 to 20 percent due to the separation of buses and autos. Over 3,100 buses and 140,000 riders utilized the lanes on 20 local and 68 express bus routes. These high volumes and time savings translated into large savings in total person-minutes for bus passengers. In Pittsburgh, Pennsylvania, a contraflow right curb bus lane was implemented in June, 1981 along a 0.4 mile length of a downtown arterial. The lane was installed in order to carry buses diverted from a parallel street, which was being reconstructed. The bus lane was implemented by removing curb parking from the arterial, which initially had two westbound lanes plus parking. After the bus lane was implemented, there were still two remaining westbound lanes, one of which is used for short-term parking and loading during off peak hours. The bus lane was so successful that it was made permanent. The bus lane carries approximately 50 to 70 buses in the peak hour. The lane is marked with overhead signs, double yellow line delineation, and the diamond symbol.

A. Minneapolis, MN: (1990 pop – 2,538,776); I-394; Minnesota DOT, FHWA, Metropolitan Council, Metropolitan Transit Commission, Hennepin County, and the City of Minneapolis; $17.3 million; 11 HOV miles with 3 miles of reversible HOV lanes and 8 miles of concurrent-flow HOV lanes; 330 freeway miles.
B. Long Island, NY: (1990 pop – 2,609,212); I-495; NY state DOT; $107.0 million; 12 HOV miles, painted buffer zone, concurrent; 720 freeway miles.
C. Dallas, TX: (1990 pop – 2,676,248); I-30, I-35E North, and I-635; Texas DOT, Dallas Area Rapid Transit; $12.2 million (I-30), $7.0 million (I-35E), and $16.3 million (I-635); 35.4 HOV miles, barrier-separated, contraflow and buffer-separated concurrent flow; 579 freeway miles.
D. Seattle, WA: (1990 pop – 2,033,128); I-5; Federal and state; $7.6 million, 7.7 miles southbound HOV, 6.2 northbound HOV miles; 240 freeway miles.

STRATEGY #	52	HOV Support Services	ORIENTATION	Supply
CATEGORY	HOV Measures			

DESCRIPTION

HOV support services provide users with appendages and enhancements to HOV facilities to encourage use of these facilities. HOV support services include park-and-ride facilities, casual carpool areas, and reduced or free tolls. Casual carpool areas are formal or informal places marked by signs or markings where potential riders wait for the next available carpool. HOV support services should be implemented with an HOV facility, and should concentrate on the corridor that has the HOV facility. Park-and-ride lots can be located near the facility, close to housing, and far from employment centers. Related strategies include travel demand measures such as ridesharing, transit/carpool incentives, parking/site management, and guaranteed ride home programs.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve HOV Convenience Increase HOV Trips Reduce Total Vehicle Trips	Average vehicle occupancy HOV use Park-and-ride-lot utilization	Counts of carpoolers Mode shift Parking counts at park-and-ride facilities

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve HOV convenience Improve system efficiency Increase HOV trips Reduce demand Reduce SOV trips	Reduce costs for personal vehicle maintenance and care Reduce travel time	Improve air quality Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Medium

RELATIVE BENEFIT NOTES

HOV support services are intended to make HOV travel more convenient and/or less costly. In turn, they help to achieve the reduction in SOV travel that is the goal of HOV priority systems. These support services may have little impact by themselves, but can help to ensure the success of an HOV system.

EFFECTS EVALUATION

Supporting strategies should be analyzed in terms of their support for the HOV facility, and specifically in terms of the number of HOVs who use the facility. Park-and-ride lots should be designed to be close to or at capacity during the day, wither for current or future demand. These supporting strategies are typically analyzed at a sketch planning level.

Usage of a carpool/park-and-ride facility does not mean that these are new riders. A full evaluation would need to track (e.g. through a survey) how many shifted from other modes.

STRATEGY # **52** HOV Support Services

RELATIVE COST NOTES

The costs of providing park-and-ride facilities will vary significantly by the type of facility. Shared ride facilities where no additional major capital investment is necessary could be put in place simply through highway signing and pavement marking, with a fee or liability insurance paid by the lot operator. Larger scale lots often built in conjunction with the construction of new interchanges or transit lines could cost significantly more, with the most expensive lost being those that provide parking structures adjacent to major transit lines. Costs can range from $400,000 to $4 or $5 million depending on the circumstances.

DISADVANTAGES

INSTITUTIONAL FACTORS

The region has many park-and-ride lots to support the HOV priority system.

Responsibility for funding the building and operation of HOV support services can be a debatable issue.

WARRANTS

No definite warrant

EXAMPLES

Many park-and-ride lots are established throughout the state. Valley Metro has an online map showing lots throughout the metropolitan Phoenix area at: http://www.valleymetro.org/VM/parknride/index.html

A 1986 study of 305 park-and-ride facilities found that the previous mode of work travel for those now using park-and-ride lots in conjunction with some form of HOV use ranged from 11 to 65 percent who drove alone (with an average across all lots of 49 percent); from 5 to 28 percent (with an average of 23 percent) who carpooled; from 5 to 49 percent (with an average of 10 percent) who used transit; and from 0 to 29 percent (with an average of 15 percent) who did not previously make the trip (Bowler et al 1986).

STRATEGY #	**53**	Hazardous Material Incident Response	**ORIENTATION** Supply
CATEGORY	Incident Management		

DESCRIPTION

Hazardous material (HAZMAT) incident response systems aim at improving the accuracy and availability of HAZMAT information provided to emergency response personnel. The strategy involves providing an appropriate level of safety for the public in the event of an incident. Plant personnel, security guards, police, highway workers, fire fighters and EMTs may be first on the scene of a hazardous materials incident and need timely and accurate information about the contents of HAZMAT shipments and the appropriate response protocol (U.S. DOT, Hazardous Material Response, Sep. 1998). Incident clearance time can be improved by use of a hazardous materials manual and by training personnel to deal with hazardous materials. This strategy also involves the procurement or construction of hazardous materials facilities and equipment.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Principal Arterial Interstate	Urban	Recurring un-predictable	All Day
	Principal Arterial Expressway	Metropolitan	Non-recurring un-predictable	
	Principal Arterial Other	Rural		
	Minor Arterial			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Emergency Response	Accident rates	Traffic counts
Improve Safety	Average duration of incident	
Increase Safety for Response Personnel	Delay	
	Number of accidents involving hazardous waste	

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety	Reduce delay	Improve air quality
	Improve safety	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # 53 Hazardous Material Incident Response

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy requires training of personnel and procurement of special equipment. Implementation may also require interagency coordination and communication.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 54 Incident Clearance

ORIENTATION Supply

CATEGORY Incident Management

DESCRIPTION

The purpose of incident clearance is to restore capacity and operations of the roadway to pre-incident conditions. Incident clearance is facilitated through physical means as well as through the adoption of policies. Incident clearance time can be improved by use of a policy requiring fast vehicle removal, requirements for drivers to stay with incapacitated vehicles, accident investigation sites, peak period motorcycle patrols, dedicated freeway service patrol, push bumpers, procurement of special equipment, inflatable air bag systems, responsive traffic control systems, variable lane closure, ordinances governing shoulder travel, emergency vehicle access, alternative route planning, identification of fire hydrant locations, incident response teams, personnel training programs, incident response manual, hazardous materials manual, administrative traffic management teams, improved interagency radio communication, identification arm bands, properly defined traffic control techniques, properly defined parking for response vehicles, flashing lights policy, central information processing and control site, command posts, public education programs, and total station surveying equipment. Effective incident clearance plans will remove incidents more quickly and safely.

Incident management is typically applied to expressways, primarily interstates and toll roads, but can also be applied to other high-volume corridors that can be dramatically affected by an incident. This strategy involves the cooperation between several agencies and the coordination of resources and personnel. Incident clearance is just one step of a successful incident management program.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	Principal Arterial Interstate	Urban	All congestion types	Peak Hour
	Principal Arterial Expressway	Metropolitan		Weekend
		Rural		All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Average duration of incident	Incident duration
Improve Vehicular Travel Times	Average speed	Moving car runs
Reduce Delay	Incident detection time	Real time speed
Reduce Secondary Incidents	Occurrence of secondary incidents	Real time traffic volume
	Response time to accidents	

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce delay	Reduce delay	Reduce the probability of secondary accidents
Reduce the probability of secondary accide	Reduce travel time	
Reduce transit travel time		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # **54** Incident Clearance

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Incident clearance represents one phase of an incident management program; other phases, (detection & verification, response, and information & routing) are also critical to the overall success of a regional incident management program. Incident clearance as a component of Incident Management requires cooperation and coordination of numerous inter-agency and intra-agency parties.

Success of Incident Management requires involvement by each stakeholder, achievement of consensus, and thorough understanding of roles and responsibilities by all participants. This approach requires recognizing and addressing the differences between stakeholders, as big differences may characterize what each can afford, staff, or justify. Partnerships between the public and private sectors require a clear understanding of the motivations and capabilities of each side, and of how to best leverage what each partner brings to the bargaining table.

WARRANTS

No definite warrant

EXAMPLES

A. Charlotte, NC: (1990 pop – 1,162,140); Federal and state; $500,000 annually; primary services not available; 28 IM freeway miles.
B. Portland, OR: (1990 pop – 1,515,452); Federal and state; $750,000 in start-up cost and $1,500,000 annually; primary services include traffic monitoring with surveillance equipment, variable message signs, radio, traffic signal and ramp meter changes; 81 IM freeway miles.
C. Seattle, WA: (1990 pop – 2,033,128); State; $17,900,000 start-up; primary services include cable television, variable message sign, highway advisory radio, Internet; 240 IM freeway miles.

STRATEGY #	55	Incident Detection/Verification	ORIENTATION	Supply
CATEGORY	Incident Management			

DESCRIPTION

Incident detection and verification is the first step in an incident management program. Incident detection and verification is defined as the activity required to determine or identify that an incident of some nature has occurred. Locating incidents and confirming that they have taken place can expedite the next steps of incident response and incident clearance and also save unnecessary deployment of personnel and resources. Once identified, incident information can be relayed back to a central location to allow communication, optimization, and deployment of incident response teams. Incident detection and verification can be performed by peak period motorcycle patrols, freeway service patrols, incident phone lines, motorist cellular call-ins, CB radio call-ins, commercial traffic reporters, police patrols, transit/taxi companies, aircraft patrol, call boxes, automated incident detection from surveillance cameras and electronic loop detection, and input to toll operators by motorists along toll facilities.

Incident management is typically applied to expressways, primarily interstates and toll roads, but can also be applied to other high-volume corridors that can be dramatically affected by an incident. This strategy involves the cooperation between several agencies and the coordination of resources and personnel. Incident detection and verification is just one step of a successful incident management program.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	Principal Arterial Interstate	Urban	All congestion types	Peak Hour
	Principal Arterial Expressway	Metropolitan		Weekend
		Rural		All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Emergency Response	Average duration of incident	Incident duration
Improve Safety	Average speed	Moving car runs
Improve Vehicular Travel Times	Incident detection time	Real time speed
Reduce Delay	Occurrence of secondary incidents	Real time traffic volume
Reduce Secondary Incidents	Response time to accidents	

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce delay	Reduce delay	Reduce the probability of secondary accidents
	Reduce travel time	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

The benefits of improved incident detection are derived through a reduction in the total time the incident block traffic or is left on the shoulder of the roadway. This, in turn, reduces traffic delay and reduces the potential for secondary accidents. Past research estimates that, under heavy traffic conditions, for every additional minute of delay in responding to and clearing an incident, from four to eight additional minutes of delay per vehicle in the queue may be expected.

STRATEGY # **55** Incident Detection/Verification

RELATIVE COST NOTES

DISADVANTAGES

False detection of incidents results in wasted resources. Consequently, many incident management measures, such as ITS applications, are aimed at improving the methods for detecting incidents. Methods for improving incident detection include, traffic detector loops, closed circuit television cameras, wireless phones, and visual observation.

INSTITUTIONAL FACTORS

Incident detection and verification as an element of Incident Management often cross jurisdictional boundaries and involved many agencies, even within a single jurisdiction. Success in this environment requires involvement by each stakeholder, achievement of consensus, and thorough understanding of roles and responsibilities by all participants. This approach requires recognizing and addressing the differences between stakeholders, as big differences may characterize what each can afford, staff, or justify. Partnerships between the public and private sectors require a clear understanding of the motivations and capabilities of each side, and of how to best leverage what each partner brings to the bargaining table.

WARRANTS

No definite warrant

EXAMPLES

A. Charlotte, NC: (1990 pop – 1,162,140); Federal and state; $500,000 annually; primary services not available; 28 IM freeway miles.
B. Portland, OR: (1990 pop – 1,515,452); Federal and state; $750,000 in start-up cost and $1,500,000 annually; primary services include traffic monitoring with surveillance equipment, variable message signs, radio, traffic signal and ramp meter changes; 81 IM freeway miles.
C. Seattle, WA: (1990 pop – 2,033,128); State; $17,900,000 start-up; primary services include cable television, variable message sign, highway advisory radio, Internet; 240 IM freeway miles.

STRATEGY # 56 Incident Information/Routing

ORIENTATION Supply

CATEGORY Incident Management

DESCRIPTION

Incident information and routing is the effective direction of vehicles around an incident and the transmission of information to motorists regarding incident location, duration, and route alternatives. Incident information and routing strives to maximize the use of available capacity within the transportation network. Information intended to inform, direct, and re-route motorists can be conveyed via highway advisory radio, dynamic message signs, commercial radio, static "flip-down" signs. Incident information can be improved through better media ties, development of highway advisory radio, strategic placement of variable message signs, radio data systems, and externally linked route guidance systems. The development of alternative route plans can facilitate the re-routing of vehicles to utilize available capacity and reduce delays.

Incident management is typically applied to expressways, primarily interstates and toll roads, but can also be applied to other high-volume corridors that can be dramatically affected by an incident. This strategy involves the cooperation between several agencies and the coordination of resources and personnel. Incident information and routing is just one step of a successful incident management program. A closely related strategy is regional multimodal traveler information.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES
- Improve Efficiency
- Improve Safety
- Increase Safety for Response Personnel
- Reduce Delay
- Reduce Secondary Incidents

PERFORMANCE MEASURES
- Amount/proportion of traffic diverted
- Average speed

DATA REQUIREMENTS
- Moving car runs
- Real time speed
- Real time traffic volume
- Traffic volume - mainline, ramps, and arterials

EFFECTS EVALUATION

SYSTEM BENEFITS
- Diversion of traffic
- Improve system efficiency

USER BENEFITS
- Reduce delay
- Reduce travel time

OTHER BENEFITS
- Improve safety
- Reduce the probability of secondary accidents

RELATIVE BENEFITS: Medium

RELATIVE COST: High

EASE OF DEPLOYMENT: Difficult

RELATIVE BENEFIT NOTES

Benefits associated with incident information/routing activities include: minimizing vehicle delay in and around the incident area; reducing the potential for secondary incidents; and providing safety for incident response personnel. Incident information may be used by motorists to adjust their trip time or route. Incident information/routing measures will result in a significant lessening of potential delay and safety impacts in the incident area.

STRATEGY # **56** Incident Information/Routing

RELATIVE COST NOTES

DISADVANTAGES

Transportation-related impacts (delays, accidents) may result along the diversion routes.

INSTITUTIONAL FACTORS

The existing incident management systems include a variety of activities to provide information to the traveling public. Congestion information produced by the ADOT Freeway Management System is broadcast over a highway advisory radio system, as well as over commercial radio stations. The surveillance system automatically indicates the location and extent of congestion on various parts of the network. The Traffic Operations Center (TOC) plays an important role in gathering and distributing the relevant information. Variable message signs have been installed in key locations to provide additional information.

Incident information/routing as a component of Incident Management requires cooperation and coordination of numerous inter-agency and intra-agency parties.

WARRANTS

No definite warrant

EXAMPLES

A. Charlotte, NC: (1990 pop – 1,162,140); Federal and state; $500,000 annually; primary services not available; 28 IM freeway miles.
B. Portland, OR: (1990 pop – 1,515,452); Federal and state; $750,000 in start-up cost and $1,500,000 annually; primary services include traffic monitoring with surveillance equipment, variable message signs, radio, traffic signal and ramp meter changes; 81 IM freeway miles.
C. Seattle, WA: (1990 pop – 2,033,128); State; $17,900,000 start-up; primary services include cable television, variable message sign, highway advisory radio, Internet; 240 IM freeway miles.
D. Tucson, AZ: The City of Tucson provides maps and information on incidents affecting city-wide corridors. The map is available at: http://tdotmaps.transview.org/Accidents/

STRATEGY #	57	Incident Response	ORIENTATION	Supply
CATEGORY	Incident Management			

DESCRIPTION

Incident response is the pre-planned deployment of personnel and resources to assist with incidents. Incident response is the second step following incident detection and verification in an incident management program. Incident response can be improved by: use of freeway service patrols, peak period motorcycle patrols, development of incident response plans, personnel training programs, development of personnel and equipment resource lists, tow truck/removal crane contracts, automation of response needs at the same time, computer-aided dispatch system, centrally locating information processing and control site, AVL systems to monitor emergency and equipment vehicles, GIS technology to organize available resources, improvement of interagency radio communication, establishment of ordinances governing travel on shoulders, provision of emergency vehicle access, closely spaced milepost markers, alternate route planning, equipment storage site location, administrative traffic management teams, implementation of emergency vehicle signal priority, and public education programs.

Incident management is typically applied to expressways, primarily interstates and toll roads, but can also be applied to other high-volume corridors that can be dramatically affected by an incident. This strategy involves the cooperation between several agencies and the coordination of resources and personnel. Incident response is just one step of a successful incident management program.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	Principal Arterial Interstate	Urban	All congestion types	Peak Hour
	Principal Arterial Expressway	Metropolitan		Weekend
		Rural		All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Average duration of incident	Incident duration
Improve Vehicular Travel Times	Average speed	Moving car runs
Reduce Delay	Incident detection time	Real time speed
Reduce Secondary Incidents	Occurrence of secondary incidents	Real time traffic volume
	Response time to accidents	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce delay	Reduce delay	Reduce the probability of secondary accidents
Reduce the probability of secondary accide	Reduce travel time	
Reduce transit travel time		

EFFECTS EVALUATION

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

STRATEGY # **57** Incident Response

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Incident Response as a component of Incident Management requires cooperation and coordination of numerous inter-agency and intra-agency parties.

Success of Incident Management requires involvement by each stakeholder, achievement of consensus, and thorough understanding of roles and responsibilities by all participants. This approach requires recognizing and addressing the differences between stakeholders, as big differences may characterize what each can afford, staff, or justify. Partnerships between the public and private sectors require a clear understanding of the motivations and capabilities of each side, and of how to best leverage what each partner brings to the bargaining table.

WARRANTS

No definite warrant

EXAMPLES

A. Charlotte, NC: (1990 pop – 1,162,140); Federal and state; $500,000 annually; primary services not available; 28 IM freeway miles.

B. Portland, OR: (1990 pop – 1,515,452); Federal and state; $750,000 in start-up cost and $1,500,000 annually; primary services include traffic monitoring with surveillance equipment, variable message signs, radio, traffic signal and ramp meter changes; 81 IM freeway miles.

C. Seattle, WA: (1990 pop – 2,033,128); State; $17,900,000 start-up; primary services include cable television, variable message sign, highway advisory radio, Internet; 240 IM freeway miles.

D. ADOT has ALERT Incident Response Teams.

E. Maricopa County DOT has REACT teams that respond to county incidents and assist a couple of the cities' enforcement departments.

STRATEGY #	58	Compact Development	ORIENTATION	Demand
CATEGORY	Land Use/Zoning and Growth Management			

DESCRIPTION

Low density residential development results in higher commute distances and longer travel times contributing to congestion in a region. Compact development promotes development and redevelopment with higher densities than is typical for the region. Through innovative design techniques, this strategy can be implemented in such a way that it blends with the setting and is unnoticeable to the average viewer. Compact development is performed through local zoning ordinances and through the developmental approval process. Successful integration of this strategy requires regional cooperation.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	Urban Metropolitan	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Other Environmental/Socioecono Increase HOV Trips Increase Non-Auto Trips Reduce Length of Trip Reduce Total Vehicle Trips Reduce VMT	Average trip length Mode share/shift Person trips Vehicle miles traveled (VMT) by congestion level	Long term traffic volume trends Origin-destination surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Increase transit use Reduce vehicular trips Reduce VMT	Shorten trip lengths	Increase transit ridership

EFFECTS EVALUATION

A primary method for analyzing the impact of land use strategies on the performance of the transportation network is to use the regional transportation model, combined with regional land use models.

Because land use changes take a long time, the ability to evaluate such changes is limited. Many other factors also influence travel over that period.

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

RELATIVE BENEFIT NOTES

More compact development can reduce travel distances, thus reducing VMT and increasing the potential for walk or bicycle travel. It can also be more effectively served by public transit, leading to increased transit use and further reductions in vehicle trips and VMT. A San Francisco Bay Area study has shown that doubling residential density from a suburban level to a level equal to that of the city of San Francisco neighborhoods reduces per capita VMT by 25 to 30 percent.

STRATEGY # **58** Compact Development

RELATIVE COST NOTES

DISADVANTAGES

Land use changes can take a long time, and the ability to evaluate such changes is limited.

INSTITUTIONAL FACTORS

Implementation involves adoption of plans which contain policies and specific action recommendations for the study of developing and redeveloping at higher densities through the use of "Diversified Regional Centers".

Growth management strategies can be very controversial and require public information and outreach. This strategy needs to involve developers and the business community.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	59	Corridor Land Use and Transportation Coordination	ORIENTATION	Demand
CATEGORY	Land Use/Zoning and Growth Management			

DESCRIPTION

Corridor land use and transportation coordination is the promotion of transportation and land use resolutions by cooperating agencies to help achieve congestion management goals. Examples include joint planning by communities that share a corridor and corridor-wide assessment of growth and development related impact. Coordination is facilitated through formal intergovernmental agreements that spell out the goals and procedures for planning and program implementation.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Other Environmental/Socioecono Manage Traffic Demand Manage Traffic Flow	Average trip length Mode share/shift Person trips Travel time Vehicle miles traveled (VMT) by congestion level	Link length Long term traffic volume trends Mode shift Traffic counts Travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow	Improve safety	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

EFFECTS EVALUATION

Because land use changes take a long time, the ability to evaluate such changes is limited. Many other facotrs also influence travel over that period.

RELATIVE BENEFIT NOTES

This tool can be helpful when congestion management projects call for a regional or subregional approach such as access management, corridor-wide land use design practices, transit access, or jobs/housing balance. Through these processes, it has been found that the cumulative effects of plans in a corridor, if pursued independently, will exceed adopted growth forecasts by a factor of five. This coordinated intergovernmental process allows for the examination and implementation of land use and transportation solutions to realistic growth forecasts and to avoid unwanted consequences of growth, such as congestion.

STRATEGY # 59 Corridor Land Use and Transportation Coordination

RELATIVE COST NOTES

DISADVANTAGES

Land use changes can take a long time, and the ability to evaluate such changes is limited.

INSTITUTIONAL FACTORS

This strategy can be implemented by adoption of plans which contain policies and specific action recommendations in support of coordinated, corridor-wide, intergovernmental planning for any new roadway or rail project. Model intergovernmental agreements can be made available for the formation of corridor planning councils.

Growth management strategies can be very controversial and require public information and outreach. This strategy needs to involve developers and the business community.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 60 Jobs/Housing Balance

ORIENTATION Demand

CATEGORY Land Use/Zoning and Growth Management

DESCRIPTION

Jobs-housing balance is a strategy that attempts to balance the number of jobs with the number of households within a sub-area. This strategy not only tries to balance the numbers of homes and jobs, but also attempts to balance the style and cost of housing with the wage level of jobs. The idea behind this strategy is to make it possible for people to live and work in the same area, and thereby remove the need for trips outside the sub-area for commuting. Jobs-housing balance is implemented through local zoning ordinances and through the developmental approval process. Region-wide cooperation is required to effectively address congestion issues related to a jobs-housing imbalance. The best method is supporting balance within a sub-region rather than for a particular development. A suggested area of three to five miles is a good area to strive for jobs and housing balance.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Other Environmental/Socioecono Reduce Length of Trip Reduce VMT	Average trip length Mode share/shift Percentage of employment sites with in x miles of major Percentage of population within x minutes of y percentag Person trips Vehicle miles traveled (VMT) by congestion level	Long term traffic volume trends Origin-destination surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce VMT	Reduce costs for personal vehicle maintenance and care Reduce travel time Shorten trip lengths	Improve air quality Reduce emissions

EFFECTS EVALUATION

A primary method for analyzing the impact of land use strategies on the performance of the transportation network is to use the regional transportation model, combined with regional land use models. The Census Transportation Planning Package contains subarea information on employment, household, and commuting patterns that can be used to identify areas with jobs/housing imbalances.

Because land use changes take a long time, the ability to evaluate such changes is limited. Many other factors also influence travel over that period.

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

RELATIVE BENEFIT NOTES

Any development that helps bring jobs and housing into better balance has the potential of reducing average commute lengths, thereby reducing VMT. This strategy may also eliminate much of the traffic congestion imposed by commuters traversing other communities on their way to work.

STRATEGY # 60 Jobs/Housing Balance

RELATIVE COST NOTES

DISADVANTAGES

Land use changes can take a long time, and the ability to evaluate such changes is limited.

INSTITUTIONAL FACTORS

Implementation involves adoption of plans which contain policies and specific action recommendations in support of balanced employment and housing development.

Growth management strategies can be very controversial and require public information and outreach. This strategy needs to involve developers and the business community.

WARRANTS

No definite warrant

EXAMPLES

The Southern California Association of Governments has adopted a policy of shifting 12 percent of new jobs away from areas of job surplus and shifting six percent of new housing away from areas of housing surplus. This policy was adopted as an alternative to adding roadway capacity because the region faces a large projected increase in congestion.

STRATEGY #	61	Mixed Use Development	ORIENTATION	Demand
CATEGORY	Land Use/Zoning and Growth Management			

DESCRIPTION

Mixed use development is the incorporation of multiple land uses into a single development, usually with multiple uses sharing a structure. Examples include housing overtop retail or office atop retail. Mixed use development provides housing, shopping, recreation, or work within the same development in order to minimize trips. A mixed use development can provide retail and services within traditional employment areas, or provide employment and retail in traditional residential areas. Mixed use developments are ideal at transit stations and transit centers, downtown areas, or satellite community centers.

Mixed use developments are implemented through local zoning ordinances and through the developmental approval process. Applications of mixed use developments are not allowed under many traditional zoning regulations. These challenges can be surmounted through innovative methods such as Planned Unit Developments.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	Urban Metropolitan Activity Centers	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Other Environmental/Socioecono Increase Non-Auto Trips Reduce VMT	Average trip length Mode share/shift Person trips Vehicle miles traveled (VMT) by congestion level	Long term traffic volume trends Origin-destination surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Increase transit use Reduce VMT	Shorten trip lengths	None

EFFECTS EVALUATION

A primary method for analyzing the impact of land use strategies on the performance of the transportation network is to use the regional transportation model, combined with regional land use models.

Because land use changes take a long time, the ability to evaluate such changes is limited. Many other factors also influence travel over that period.

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

RELATIVE BENEFIT NOTES

The advantage of mixed use development is the ability to shift and shorten some trips that would otherwise end up on regional roads, and to encourage walking and bicycling to destinations. Studies have shown that commercial centers with even a narrow range of uses can eliminate 25 percent of the trips consumers would have made going to separate destinations. At business parks, on-site services and shopping can eliminate 20 percent of the VMT by office workers. Hillsborough County, Florida has established minimum requirements for clustering on-site jobs and shopping for some new residential developments that can effectively keep up to 24 percent of all trips on-site.

STRATEGY # | **61** | Mixed Use Development

RELATIVE COST NOTES

DISADVANTAGES

Land use changes can take a long time, and the ability to evaluate such changes is limited.

INSTITUTIONAL FACTORS

Implementation involves adoption of plans which contain policies and specific action recommendations in support of mixed use development.

Growth management strategies can be very controversial and require public information and outreach. This strategy needs to involve developers and the business community.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	62	Transit-Oriented Development	ORIENTATION	Demand
CATEGORY	Land Use/Zoning and Growth Management			

DESCRIPTION

Transit-oriented development involves the support of land development patterns that allow efficient integration of transit systems. This strategy encourages mixed land uses, centrally located cores with compact development, a well-connected grid roadway network, and easy access for bicyclists and pedestrians. With these types of land use characteristics, transit providers are able to develop transit systems that serve the community efficiently and effectively. This strategy is implemented through local zoning ordinances and through the developmental approval process, and can be promoted at the regional level. Coordination between transportation and urban design planners, city personnel, developers, and the community is required to ensure success. Supporting strategies include TDM strategies, bicycle/pedestrian improvements, and other land use/zoning and growth management strategies.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	Urban Metropolitan	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Air Quality Improve Other Environmental/Socioecono Increase HOV Trips Increase Non-Auto Trips Reduce VMT	Average trip length Mode share/shift Person trips Vehicle miles traveled (VMT) by congestion level	Long term traffic volume trends Origin-destination surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Increase transit use Reduce VMT	Improve transit convenience	Improve air quality

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

RELATIVE BENEFIT NOTES

The goal of transit-oriented development is to take advantage of rail stations by locating high density residential developments near the stations allowing pedestrians easy access, or by locating employment or retail near a station so that rail riders can have easy access to those destinations. It promotes transit usage and eliminates the need to travel by automobile. This in turn reduces auto emissions and the resulting air pollution.

EFFECTS EVALUATION

Analysis of transit-oriented design standards can best be accomplished through case studies. Before-and-after analysis techniques have been applied to actual projects encompassing a variety of site design and related measures. Studies have shown that these techniques can have considerable positive impacts reducing VMT and reducing air pollutants. At a more localized level, a sketch planning methodology may be applied. Bases on the empirical results from the case studies, analysts may reduce the vehicle trip generation rates and boost transit and HOV rates proportionally for zones or developments where design standards are in force.

Because land use changes take a long time, the ability to evaluate such changes is limited. Many other factors also influence travel over that period.

STRATEGY # 62 Transit-Oriented Development

RELATIVE COST NOTES

DISADVANTAGES

Land use changes can take a long time, and the ability to evaluate such changes is limited.

INSTITUTIONAL FACTORS

Regional polices can offer support for transit-oriented development strategies. In addition, planning studies can be conducted for facilities with the objective to coordinate and encourage transit-oriented development and design with system improvement. This strategy requires close coordination between transit agencies, municipalities, and the development community.

WARRANTS

No definite warrant

EXAMPLES

A study has shown that, for two new apartment buildings near a commuter rail station, nearly 500,000 vehicle miles traveled were saved by the transit-oriented development. This translated into a reduction of about 2,000 pounds of hydrocarbons annually.

STRATEGY #	63	Bike Lanes	ORIENTATION	Demand
CATEGORY	Non-Motorized Measures			

DESCRIPTION

As defined by the Manual on Uniform Traffic Control Devices, a bikeway is a generic term for any road, street, path, or way that in some manner is specifically designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes. The Manual on Uniform Traffic Control Devices defines a bike lane as a portion of a roadway that has been designated by signs and pavement markings for preferential or exclusive use by bicyclists. Bike lanes are one component of a network of facilities designed to serve bicyclists and pedestrians.

Bike lanes are best implemented on low to moderate traffic volume streets. Bike lanes can be applied to areas with no off-street right-of-way availability. Existing bicycle activity can indicate good locations for bicycle facilities. Bike lanes can and should be used to tie bicycle networks together, linking shared-use paths, bike routes, and sidewalks to residential, employment, and destination centers. Other factors that help determine implementation of bikeways include: terrain, climate, recreation opportunities, activity density, mixed uses, and presence of a transit center or station. Implementation of any bikeway can promote bicycle and pedestrian travel. Change from vehicular travel to bicycle and pedestrian travel typically only occurs if the bicycle-pedestrian system is convenient, safe, and pleasurable. The Manual on Uniform Traffic Control Devices gives guidance for signing and marking of bicycle facilities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Other	All locations	All congestion types	All Day
Facility Expansion Feasibility	Minor Arterial			All Year
	Major Collector			
	Minor Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase Non-Auto Trips	Pedestrian volumes	Bike/ped counts at representative locations
Reduce Demand	Volume of cyclists	
Reduce Total Vehicle Trips		
Reduce VMT		

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips	Improve safety	Reduce emissions
Reduce demand		Decrease accident rates
Reduce vehicular trips		
Reduce VMT		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

Bicycle and pedestrian improvements increase the potential for non-motorized trips to replace motorized trips. This reduces vehicle trip demand and traffic congestion, albeit marginally in most situations. The impact is generally measured as a reduction in vehicle person-trips, but may also be expressed in vehicle miles traveled.

EFFECTS EVALUATION

Analysis of pedestrian and bicycle facilities is usually conducted at the level of individual trips, because the likelihood of a bicycle or pedestrian trip is directly dependent upon the origin, destination, and length of each trip. A fraction of the trips along a corridor or facility can be expected to bicycle or walk; the percentage depends upon factors such as the availability of bicycle and pedestrian facilities, trip length, trip purpose, weather, and socioeconomic characteristics of the travelers. A mode choice model (either a formal model or sketch-level analysis) is appropriate for this type of analysis.

Taking counts is relatively simple. Gauging impact on congestion will be impractical, for the most part.

STRATEGY # 63 Bike Lanes

RELATIVE COST NOTES

Bicycle infrastructure is less expensive and takes less time to build than roadway facilities. Bike lanes can be implemented through marking and signing of existing roadways.

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy can be supported by agencies at many levels.

WARRANTS

No definite warrant

EXAMPLES

Currently, only 2% of Americans commute to work by bicycle. A 1990 poll reported that respondents would bicycle to work if facilities that made it fun, safe, and convenient were in place. The most desired facility was a bicycle lane.

A. Davis, CA: (1990 pop –46,332); Bicycle Program; City of Davis, State of California, and local developers; cost not available; primary services include 45 miles of bike lane and 48 miles of bike path; effects of this system are quite impressive. Of all trips made in Davis, 20% to 25% of them are by bicycle.
B. Minneapolis, MN: (1990 pop –368,383); The Cedar Lake Trail; $1,100,000 cost; Cedar Lake Park Association, Minneapolis Department of Public Works, Minneapolis Park and Recreation Board, and the Hennepin County Regional Railroad Authority; primary services include The 3.5 mile Cedar Lake Bicycle Highway, 35 miles of lanes, 56 miles of paths, and parking facilities (46 bike racks and 14 bike lockers).
C. St. Louis, MO: (1990 pop –396,685); Regional Bicycle and Pedestrian Advisory Committee; cost not available; primary services include advise, coordinate, promote, and implement bicycle and pedestrian service plans; Council oversees 12 counties and approves funding for bicycle and pedestrian projects submitted by cities within their region.
D. Austin, TX: (1990 pop –472,020); Bicycle and Pedestrian Program; $750,000 in grants; Austin Transportation Study, Texas DOT, City of Austin Department of Public Works and Transportation; primary services are bicycle lanes, wide curb lanes, traisl, sidewalks, and crosswalks; solicits grants for specific projects and promotes guidelines and bicycle use.
E. Madison, WI: (1990 pop –190,766); Madison Bicycle and Pedestrian Division; cost not available; Wisconsin DOT, the Governor’s Bicycle Advisory Council, and the City of Madison, Traffic Engineering Division; primary services include 13 miles of bike lanes, 20 miles of bike paths, 59 miles of mixed traffic routes, and 7 sidewalks as of 1990.

STRATEGY #	64	Bike Route Marking/Signing	ORIENTATION	Demand
CATEGORY	Non-Motorized Measures			

DESCRIPTION

According to the Manual on Uniform Traffic Control Devices, a designated bicycle route is a system of bikeways designated by the jurisdiction having authority with appropriate directional and informational route markers, with or without specific bicycle route numbers. Bike routes are one component of a network of facilities designed to serve bicyclists and pedestrians.

Bike routes are best implemented on low to moderate traffic volume streets. Bike routes can be applied to areas with no off-street right-of-way and limited on-street right-of-way availability. Existing bicycle activity can indicate good locations for bicycle facilities. Bike routes can and should be used to tie bicycle networks together, linking shared-use paths, bike lanes, and sidewalks to residential, employment, and destination centers. Other factors that help determine implementation of bikeways include: terrain, climate, recreation opportunities, activity density, mixed uses, and presence of a transit center or station. Implementation of any bikeway can promote bicycle and pedestrian travel. Change from vehicular travel to bicycle and pedestrian travel typically only occurs if the bicycle-pedestrian system is convenient, safe, and pleasurable. The Manual on Uniform Traffic Control Devices gives guidance for signing and marking of bicycle facilities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Environment	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase Non-Auto Trips Reduce Demand Reduce Total Vehicle Trips Reduce VMT	Pedestrian volumes Volume of cyclists	Bike/ped counts at representative locations

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Reduce demand Reduce vehicular trips Reduce VMT	Improve safety	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

Bicycle and pedestrian improvements increase the potential for non-motorized trips to replace motorized trips. This reduces vehicle trip demand and traffic congestion, albeit marginally in most situations. The impact is generally measured as a reduction in vehicle person-trips, but may also be expressed in vehicle miles traveled.

EFFECTS EVALUATION

Analysis of pedestrian and bicycle facilities is usually conducted at the level of individual trips, because the likelihood of a bicycle or pedestrian trip is directly dependent upon the origin, destination, and length of each trip. A fraction of the trips along a corridor or facility can be expected to bicycle or walk; the percentage depends upon factors such as the availability of bicycle and pedestrian facilities, trip length, trip purpose, weather, and socioeconomic characteristics of the travelers. A mode choice model (either a formal model or sketch-level analysis) is appropriate for this type of analysis.

Taking counts is relatively simple. Gauging impact on congestion will be impractical, for the most part.

STRATEGY # 64 Bike Route Marking/Signing

DISADVANTAGES

RELATIVE COST NOTES

Bicycle infrastructure is less expensive and takes less time to build than roadway facilities. Bike routes can be implemented through signing of existing roadways.

INSTITUTIONAL FACTORS

This strategy can be supported by agencies at many levels.

WARRANTS

No definite warrant

EXAMPLES

A. Davis, CA: (1990 pop –46,332); Bicycle Program; City of Davis, State of California, and local developers; cost not available; primary services include 45 miles of bike lane and 48 miles of bike path; effects of this system are quite impressive. Of all trips made in Davis, 20% to 25% of them are by bicycle.
B. Minneapolis, MN: (1990 pop –368,383); The Cedar Lake Trail; $1,100,000 cost; Cedar Lake Park Association, Minneapolis Department of Public Works, Minneapolis Park and Recreation Board, and the Hennepin County Regional Railroad Authority; primary services include The 3.5 mile Cedar Lake Bicycle Highway, 35 miles of lanes, 56 miles of paths, and parking facilities (46 bike racks and 14 bike lockers).
C. St. Louis, MO: (1990 pop –396,685); Regional Bicycle and Pedestrian Advisory Committee; cost not available; primary services include advise, coordinate, promote, and implement bicycle and pedestrian service plans; Council oversees 12 counties and approves funding for bicycle and pedestrian projects submitted by cities within their region.
D. Austin, TX: (1990 pop –472,020); Bicycle and Pedestrian Program; $750,000 in grants; Austin Transportation Study, Texas DOT, City of Austin Department of Public Works and Transportation; primary services are bicycle lanes, wide curb lanes, traisl, sidewalks, and crosswalks; solicits grants for specific projects and promotes guidelines and bicycle use.
E. Madison, WI: (1990 pop –190,766); Madison Bicycle and Pedestrian Division; cost not available; Wisconsin DOT, the Governor's Bicycle Advisory Council, and the City of Madison, Traffic Engineering Division; primary services include 13 miles of bike lanes, 20 miles of bike paths, 59 miles of mixed traffic routes, and 7 sidewalks as of 1990.

STRATEGY #	65	Bike/Pedestrian Support Services	ORIENTATION	Demand
CATEGORY	Non-Motorized Measures			

DESCRIPTION

Bicycle/pedestrian support services are implemented to increase bicycle/pedestrian facility safety, convenience, and user satisfaction. Examples include: public bicycle storage lockers, bicycle racks on transit vehicles, lighting, security cameras, employer-provided bicycles, shower facilities, bicycle parking, monetary incentives, bike route maps, promotion campaigns highlighting health, environmental, convenience, and recreation benefits.

Support services should be implemented region-wide along existing bicycle-pedestrian facilities and incorporated into new projects. Support services provide enhancements to bicycle networks which are composed of shared-use paths, bike paths, bike routes, and sidewalks linking residential, employment, and destination centers. Implementation of support services can promote bicycle and pedestrian travel.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase Non-Auto Trips Reduce Demand Reduce Total Vehicle Trips Reduce VMT	Facility usage Mode share/shift	Facility usage counts Usage/customer satisfaction surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Reduce demand Reduce vehicular trips Reduce VMT	Improve safety Customer satisfaction	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

RELATIVE BENEFIT NOTES

Bicycle and pedestrian support services are only effective in conjunction with bicylce and pedestrian facilities, but are important to insure or improve the benefits described for bike/ped infrastructure improvements. These support services will make a difference to some travelers in choosing a non-motorized mode, and will be reflected in the number of motorized person-trips and VMT.

EFFECTS EVALUATION

Supporting strategies should be analyzed in terms of their support for the bicycle and pedestrian facilities, and specifically in terms of the number of people who use these modes. Supporting strategies are typically analyzed at a sketch planning level.

Usage of support services/facilities can often be easily counted, but recording is not usually done routinely.

STRATEGY # | **65** | Bike/Pedestrian Support Services

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Support for this strategy is reflected by numerous actions and efforts undertaken by agencies at various levels including: installation of bike racks, bike rack programs, designated staff responsible for bicycle and pedestrian planning, bicycle maps and brochures on commuting and safety, and CMAQ program support of bike and pedestrian improvement.

WARRANTS

This strategy is warranted in locations with high pedestrian and bicycle activity.

EXAMPLES

Valley Metro invites riders to "Rack 'n' Roll!" by providing bike racks on all buses. The agency provides the rack which accomodates two bikes free of charge. The proposed light rail will also allow riders to bring bicycles on board.

A. Minneapolis, MN: (1990 pop –368,383); The Cedar Lake Trail; $1,100,000 cost; Cedar Lake Park Association, Minneapolis Department of Public Works, Minneapolis Park and Recreation Board, and the Hennepin County Regional Railroad Authority; primary services include The 3.5 mile Cedar Lake Bicycle Highway, 35 miles of lanes, 56 miles of paths, and parking facilities (46 bike racks and 14 bike lockers).
B. St. Louis, MO: (1990 pop –396,685); Regional Bicycle and Pedestrian Advisory Committee; cost not available; primary services include advise, coordinate, promote, and implement bicycle and pedestrian service plans; Council oversees 12 counties and approves funding for bicycle and pedestrian projects submitted by cities within their region.
C. Austin, TX: (1990 pop –472,020); Bicycle and Pedestrian Program; $750,000 in grants; Austin Transportation Study, Texas DOT, City of Austin Department of Public Works and Transportation; primary services are bicycle lanes, wide curb lanes, trails, sidewalks, and crosswalks; solicits grants for specific projects and promotes guidelines and bicycle use.

STRATEGY #	66	Pedestrian Overpass/Underpass	ORIENTATION	Demand
CATEGORY	Non-Motorized Measures			

DESCRIPTION

A pedestrian overpass/underpass is a grade separated pedestrian link under or over a roadway. The overpass/underpass separates pedestrian movement from the vehicular flow thereby removing conflicts between pedestrians and vehicles. Pedestrian overpasses and underpasses can also be built to accommodate bicycle users.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Adjacent Development	Principal Arterial Interstate Principal Arterial Expressway Principal Arterial Other Minor Arterial Major Collector	Urban Metropolitan Activity Centers	Recurring predictable Recurring un-predictable	All Day

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Customer perception of safety Facility usage Pedestrian volumes Pedestrian-bicycle accidents Traffic volumes	Accident rates Bike/ped counts at representative locations Facility usage counts Traffic counts

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce conflicts	Improve safety	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	High	Medium

RELATIVE BENEFIT NOTES

STRATEGY # | **66** | Pedestrian Overpass/Underpass

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

WARRANTS

Requires sufficient levels of pedestrian activity, as well as high traffic volumes. Safety could also be an overriding factor.

EXAMPLES

The City of Tucson recently completed construction of the Broadway Boulevard Bicycle/Pedestrian Overpass. The bridge structure connects the Broadway-Arroyo Chico multi-use path and the Park-Euclid bike path along Barraza-Aviation Parkway. Work involved the construction of a two-span cast-in-place concrete post-tensioned box girder bridge, retaining walls, sidewalk, traffic control, lighting and painting, landscaping and related work. The overpass looks like a Diamondback rattlesnake and will become a landmark in Tucson. The project was scheduled to be completed in April 2002 at a construction cost of $1,500,000.

STRATEGY # 67 Shared-Use Paths

ORIENTATION Demand

CATEGORY Non-Motorized Measures

DESCRIPTION

A shared-use path is defined in the Manual on Uniform Traffic Control Devices as a bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent alignment. Shared-use paths might also be used by pedestrians, skaters, wheelchair users, joggers, and other non-motorized users. Shared-use paths are one component of a network of facilities designed to serve bicyclists and pedestrians.

Shared-use paths can be applied to areas with available off-street right-of-way. Existing bicycle activity can indicate good locations for bicycle and pedestrian facilities. Shared-use paths can and should be used to tie bicycle and pedestrian networks together, linking bike lanes, bike routes, and sidewalks to residential, employment, and destination centers. Other factors that help determine implementation of bikeways include: terrain, climate, recreation opportunities, activity density, mixed uses, and presence of a transit center or station. Implementation of any bikeway can promote bicycle and pedestrian travel. Change from vehicular travel to bicycle and pedestrian travel typically only occurs if the bicycle-pedestrian system is convenient, safe, and pleasurable. The Manual on Uniform Traffic Control Devices gives guidance for signing and marking of bicycle facilities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	Not Class Specific	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase Non-Auto Trips Reduce Demand Reduce Total Vehicle Trips Reduce VMT	Percentage of trips in peak hour Pedestrian volumes Volume of cyclists	Bike/ped counts at representative locations

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Reduce demand Reduce vehicular trips Reduce VMT	Improve safety	Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Medium	Medium

RELATIVE BENEFIT NOTES

Bicycle and pedestrian improvements increase the potential for non-motorized trips to replace motorized trips. This reduces vehicle trip demand and traffic congestion, albeit marginally in most situations. The impact is generally measured as a reduction in vehicle person-trips, but may also be expressed in vehicle miles traveled.

EFFECTS EVALUATION

Analysis of pedestrian and bicycle facilities is usually conducted at the level of individual trips, because the likelihood of a bicycle or pedestrian trip is directly dependent upon the origin, destination, and length of each trip. A fraction of the trips along a corridor or facility can be expected to bicycle or walk; the percentage depends upon factors such as the availability of bicycle and pedestrian facilities, trip length, trip purpose, weather, and socioeconomic characteristics of the travelers. A mode choice model (either a formal model or sketch-level analysis) is appropriate for this type of analysis.

Taking counts is relatively simple. Gauging impact on congestion will be impractical, for the most part.

STRATEGY # | **67** | Shared-Use Paths

RELATIVE COST NOTES

Bicycle infrastructure is less expensive and takes less time to build than roadway facilities.

DISADVANTAGES

May require acquisition of right-of-way.

INSTITUTIONAL FACTORS

Shared-use paths may involve multiple jurisdictions and thereby require coordination in determining alignment and providing maintenance.

WARRANTS

No definite warrant

EXAMPLES

Currently, only 2% of Americans commute to work by bicycle. A 1990 poll reported that respondents would bicycle to work if facilities that made it fun, safe, and convenient were in place. The most desired facility was a bicycle lane.

A. Davis, CA: (1990 pop –46,332); Bicycle Program; City of Davis, State of California, and local developers; cost not available; primary services include 45 miles of bike lane and 48 miles of bike path; effects of this system are quite impressive. Of all trips made in Davis, 20% to 25% of them are by bicycle.
B. Minneapolis, MN: (1990 pop –368,383); The Cedar Lake Trail; $1,100,000 cost; Cedar Lake Park Association, Minneapolis Department of Public Works, Minneapolis Park and Recreation Board, and the Hennepin County Regional Railroad Authority; primary services include The 3.5 mile Cedar Lake Bicycle Highway, 35 miles of lanes, 56 miles of paths, and parking facilities (46 bike racks and 14 bike lockers).
C. St. Louis, MO: (1990 pop –396,685); Regional Bicycle and Pedestrian Advisory Committee; cost not available; primary services include advise, coordinate, promote, and implement bicycle and pedestrian service plans; Council oversees 12 counties and approves funding for bicycle and pedestrian projects submitted by cities within their region.
D. Austin, TX: (1990 pop –472,020); Bicycle and Pedestrian Program; $750,000 in grants; Austin Transportation Study, Texas DOT, City of Austin Department of Public Works and Transportation; primary services are bicycle lanes, wide curb lanes, trails, sidewalks, and crosswalks; solicits grants for specific projects and promotes guidelines and bicycle use.
E. Madison, WI: (1990 pop –190,766); Madison Bicycle and Pedestrian Division; cost not available; Wisconsin DOT, the Governor’s Bicycle Advisory Council, and the City of Madison, Traffic Engineering Division; primary services include 13 miles of bike lanes, 20 miles of bike paths, 59 miles of mixed traffic routes, and 7 sidewalks as of 1990.

STRATEGY #	68	Sidewalks
CATEGORY	Non-Motorized Measures	

ORIENTATION: Demand

DESCRIPTION

Sidewalks are facilities designed for pedestrians, usually adjacent to roadways. Sidewalks can be aligned directly next to roadways or be separated from roadways by a park strip. Sidewalks are one component of a network of facilities designed to serve bicyclists and pedestrians. Sidewalks can be applied along existing roadways or in any areas with existing pedestrian activity. Some important steps that can be taken to develop better network characteristics for pedestrian movement include the provision of continuous and connected sidewalks. Shared-use paths can and should be used to tie bicycle and pedestrian networks together, linking shared-use paths, bike lanes, and bike routes to residential, employment, and destination centers. Other factors that help determine implementation of bikeways include: terrain, climate, recreation opportunities, activity density, mixed uses, and presence of a transit center or station. Implementation of any bikeway or sidewalk can promote bicycle and pedestrian travel. Change from vehicular travel to bicycle and pedestrian travel typically only occurs if the bicycle-pedestrian system is convenient, safe, and pleasurable.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Adjacent Development	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase Non-Auto Trips Reduce Demand Reduce Total Vehicle Trips Reduce VMT	Pedestrian volumes Volume of cyclists	Bike/ped counts at representative locations

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Reduce demand Reduce vehicular trips Reduce VMT	Improve safety	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Medium	Medium

RELATIVE BENEFIT NOTES

Bicycle and pedestrian improvements increase the potential for non-motorized trips to replace motorized trips. This reduces vehicle trip demand and traffic congestion, albeit marginally in most situations. The impact is generally measured as a reduction in vehicle person-trips, but may also be expressed in vehicle miles traveled.

EFFECTS EVALUATION

Analysis of pedestrian and bicycle facilities is usually conducted at the level of individual trips, because the likelihood of a bicycle or pedestrian trip is directly dependent upon the origin, destination, and length of each trip. A fraction of the trips along a corridor or facility can be expected to bicycle or walk; the percentage depends upon factors such as the availability of bicycle and pedestrian facilities, trip length, trip purpose, weather, and socioeconomic characteristics of the travelers. A mode choice model (either a formal model or sketch-level analysis) is appropriate for this type of analysis.

Taking counts is relatively simple. Gauging impact on congestion will be impractical, for the most part.

STRATEGY # **68** Sidewalks

RELATIVE COST NOTES

Pedestrian infrastructure is less expensive and takes less time to build than roadway facilities.

DISADVANTAGES

INSTITUTIONAL FACTORS

This strategy can be supported by agencies at many levels.

WARRANTS

No definite warrant

EXAMPLES

A. St. Louis, MO: (1990 pop –396,685); Regional Bicycle and Pedestrian Advisory Committee; cost not available; primary services include advise, coordinate, promote, and implement bicycle and pedestrian service plans; Council oversees 12 counties and approves funding for bicycle and pedestrian projects submitted by cities within their region.
B. Austin, TX: (1990 pop –472,020); Bicycle and Pedestrian Program; $750,000 in grants; Austin Transportation Study, Texas DOT, City of Austin Department of Public Works and Transportation; primary services are bicycle lanes, wide curb lanes, trails, sidewalks, and crosswalks; solicits grants for specific projects and promotes guidelines and bicycle use.
C. Madison, WI: (1990 pop –190,766); Madison Bicycle and Pedestrian Division; cost not available; Wisconsin DOT, the Governor's Bicycle Advisory Council, and the City of Madison, Traffic Engineering Division; primary services include 13 miles of bike lanes, 20 miles of bike paths, 59 miles of mixed traffic routes, and 7 sidewalks as of 1990.
D. Tucson, AZ: Wakefield Phase 3: Ninth Avenue Pedestrian Improvements. This Back to Basics project consisted of installing new sidewalk access ramps, driveway aprons, concrete pavers between curb and sidewalk, and tree planting on 9th Avenue between 44th Street and Hollinger Elementary School. Neighbors have stepped in to provide irrigation. This project was completed at the beginning of July 2002 at a cost of $149,000.
E. Tucson, AZ: Wilmot Road, Broadway Boulevard to Golf Links Road District Lighting and Sidewalk Improvements. This work consists of installing street lighting and a fiber optics system and constructing sidewalks and modifying existing driveways as necessary on Wilmot Road between Broadway Boulevard and Golf Links Road. The lighting system will consist of conduit, wire, pull boxes, poles, luminaires, lamps, pole foundations and all other items required. This project will also provide for street lighting improvements to 28th Street between Swan Road and Belvedere Avenue. Work is complete as of April 2002 at a cost of $932,000.

STRATEGY #	69	Parking Fees	ORIENTATION	Demand
CATEGORY	Road Pricing			

DESCRIPTION

Parking fees are implemented to encourage use of alternate modes by requiring private vehicles to pay for parking. Parking fees can be assessed through on-street parking meters or through surcharges or taxes on off-street parking. Parking rates can be fixed or adjusted by demand or by time of day. Employers can also impose parking fees. Related strategies include parking/site management, as well as transit and HOV strategies.

Parking fees attempt to address the environment and congestion and can be applied at a single location, throughout a sub-area, or on a regional level. Typically, parking fees are assessed at activity centers and regional coordination is implemented to prevent employment and retail from moving to locations where parking fees are not imposed. Parking fees are most successful in heavily congested areas where few other alternatives can still be implemented.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	Urban Metropolitan	All congestion types	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase HOV Trips Increase Non-Auto Trips Reduce Total Vehicle Trips Reduce VMT	Mode share/shift Parking utilization Vehicle miles traveled (VMT) by congestion level	Mode shift Parking occupancy counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase non-auto trips Increase transit use Reduce vehicular trips Reduce VMT Defer addition of capacity Provide "correct pricing signals" Better resource utilization	Disbenefits to commuters	Reduce emissions Reduce energy consumption

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Low	Medium

RELATIVE BENEFIT NOTES

The impacts of parking fees will depend upon the scale of implementation, but they will generally result in changes in overall trip making, time of day for travel, and mode choice (use of high-occupancy modes and bicycle/pedestrian access). Appropriate measures for the success of parking pricing techniques include changes in VMT and mode choice.

EFFECTS EVALUATION

Strategy impacts can be estimated directly through the regional travel demand model, by modifying the cost of parking as one element of the out-of-pocket costs for travel. The mode choice model itself within the regional travel demand model can be used directly to report changes in travel mode. As an alternative, a sketch-planning approach may be used. This approach involves the use of price elasticity assumptions to determine how many trips are eliminated; how many are shifted to other modes; and how many travelers shifted onto parallel facilities. One study of parking fees cited a range of elasticities from -0.08 to -0.23, for an average of -0.15. If information is available about the cross-elasticities of other modes, it may be possible to determine mode shift, trip elimination, and diversion impacts.

Parking occupancy counts tell only a partial story (parking locations may have shifted). Surveys of mode choice in the work place are usually the most direct approach.

STRATEGY # 69 Parking Fees

RELATIVE COST NOTES

DISADVANTAGES

The political issues surrounding market-based measures may make parking pricing difficult to implement.

INSTITUTIONAL FACTORS

The political issues surrounding market-based measures may make parking pricing difficult to implement. One technique to make this strategy more palatable is the decision about how parking revenues would be used. Public support for transportation user fees is generally greatest when funds generated by the charges are devoted explicitly to transportation improvements. To the extent that parking fees, surcharges or taxes are dedicated to projects which have the potential to reduce congestion, the fees themselves are more palatable. This factor is an important consideration in the overall design of any market-based measure.

Implementation of parking fees are the domain of individual jurisdictions. Many jurisdictions have implemented metered parking in downtown areas and activity centers. Parking rates are largely established by private operators and market forces. Some operators currently vary rates by time of day, but not for congestion relief purposes.

WARRANTS

No definite warrant

EXAMPLES

A) US West, Bellevue, Washington

When US West, a communications firm consolidated its regional operations at a new Bellevue location, it faced a restriction on parking (by city regulation) and a requirement to implement a TDM program. US West implemented the following program: limited on-site parking (408 spaces for 1,150 employees), parking charge of $60 per month for drive-alone, $45 for 2-person carpools, and no charge for pools of 3 or more, reserved parking for HOV's, flexible work hours, and an on-site transportation coordinator. As a result, only 26% of US West's employees drive alone and the company generates 47% fewer trips than other downtown Bellevue employers.

B) Bellevue City Hall, Bellevue, Washington

Bellevue City Hall employs approximately 600 people in a small business complex outside the Bellevue downtown. Transit service at the site is limited, making access dependent on private vehicles. To encourage use of alternative modes, the City implemented the following strategies: employees who drive alone pay aparking charge of $30 per month, those who carpool/vanpool at least 60% of the time park free and are given priority parking. Employees who use commute alternatives at least 80% of the time are given an additional subsidy of $15 to $25 per month. As a result of the program, nearly 50% of City Hall employees use transit, carpools, vanpools, or other alternative modes, representing 26% fewer vehicle trips than other sites in the region. Further, as parking fees are used to subsidize alternative modes, the net cost of the program to the City is zero.

STRATEGY # 70 — Road User Fees

ORIENTATION Demand

CATEGORY Road Pricing

DESCRIPTION

Road user fees are implemented to reallocate or remove trips. Road user fees include congestion pricing where fees are imposed on users at rates that differ by time of day and location depending on the level of congestion. Road user fees also include charges for use of toll roads, toll lanes, bridges or tunnels; as well as charges for access to city centers, airport ground systems, or other activity centers. Additional applications include higher fuel taxes, auto parts taxes, excise taxes, and registration fees. Another alternative is a VMT fee, where users are charged fees that are based on the amount of miles traveled by type of vehicle class.

Road user fees applied to facilities are appropriate if the facility has significant access control and if there are few or no alternate routes available. Higher taxes and fees are best if applied area-wide. Complementary measures include good transit and bicycle/pedestrian facilities and associated strategies.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	Urban	All congestion types	All Day
	Principal Arterial Expressway	Metropolitan		All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase HOV Trips	Level of service	Mode shift
Increase Non-Auto Trips	Mode share/shift	Traffic counts
Manage Traffic Demand		
Manage Traffic Flow		
Reduce Total Vehicle Trips		
Reduce VMT		
Shift Trip Time		

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Change in trip timing	Disbenefits to commuters	Increase transit ridership
Increase non-auto trips		
Increase transit use		
Redistribution of trips		
Reduce vehicular trips		
Reduce VMT		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Difficult

RELATIVE BENEFIT NOTES

Road user fees have several different potential impacts, depending upon the approach selected. Fees associated with a particular facility, in addition to providing a consistent revenue stream, can result in diversion from that facility to parallel routes on which no fee is charged. Alternatively, time-of-day fees can result in shifting demand into different time periods. Finally, if a fee is charged for non-HOV vehicles to use the excess capacity on an HOV facility, the result may be more economic use of capacity while maintaining relatively high levels of service. Area pricing schemes can result in mode shifts, as travelers to an activity center choose to park at the periphery, or make their entire trip by an alternative mode, rather than pay an access fee.

Any of these approaches can result in reduced environmental impacts, resulting from lower VMT and fewer vehicular trips. However, it is crucial that mobility alternatives exist which will provide access for those who choose not to pay the road fees.

EFFECTS EVALUATION

In general, travel demand models perform well in assessing potential impacts from road user fees. Some sketch planning approaches are available to model the impacts of areawide access fees for smaller activity centers.

The changes induced by pricing mechanisms can be complex and difficult to track. A full evaluation would need to track diversions among modes, routes, and time periods.

STRATEGY # | **70** | Road User Fees

RELATIVE COST NOTES

Road user fees through higher fuel taxes, auto parts (e.g., tires) taxes, excise taxes, or registration fees can be done at a low cost. Toll facilities require toll collection infrastructure to be built which can be a high cost initially.

DISADVANTAGES

INSTITUTIONAL FACTORS

It is difficult to apply road user fees to existing facilities. Also, imposition of fees can cause questions of equity between low income drivers who have difficulty paying and high income drivers who can easily pay. This strategy requires an extensive education campaign.

WARRANTS

No definite warrant

EXAMPLES

Value pricing is underway on:
SR-91 in Orange County, CA
I-15 in San Diego, CA
Lee County bridges in Fort Myers, FL
I-10 (Katy) Freeway high-occupancy vehicle lane in Houston, TX

STRATEGY # 71 Acceleration/Deceleration Lanes

ORIENTATION Supply

CATEGORY Roadway Geometric Improvements

DESCRIPTION

The provision of acceleration lanes allows vehicles entering a roadway time to reach the speed of other vehicles already on the roadway. Deceleration lanes provide a place for vehicles exiting the roadway to slow down without impeding other vehicles on the roadway. Acceleration/deceleration lanes improve safety by reducing conflicts due to speed differences.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	Principal Arterial Other	All locations	All congestion types	All Day
Terrain	Minor Arterial			All Year
Vehicle Mix	Major Collector			
Vertical and Horizontal Geometry	Minor Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Accident rates	Accident rates
Improve Safety	Average speed	Delay
Improve Traffic Flow	Delay per vehicle	Level of service analysis
Increase Capacity	Intersection level of service	Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Reduce vehicle conflict	Improve safety
Improve traffic flow		
Increase capacity		
Reduce conflicts		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Medium	Medium

RELATIVE BENEFIT NOTES

These strategies are designed to improve traffic flow by increasing the effective capacity of the affected intersection or roadway segment. This is achieved primarily by providing separate lanes for various maneuvers (e.g., turning, passing, merging). In doing so, geometric improvement strategies may also provide significant safety benefits.

Geometric improvements typically are low-cost and highly cost-effective, require minimal right-of-way, and can be implemented in a relatively short timeframe, although these characteristics may vary.

EFFECTS EVALUATION

Field inspections by a qualified traffic engineer can often determine where this type of strategy is appropriate. The operating impacts of these strategies can be assessed using the methodologies described in the Highway Capacity Manual and related software package. Most other level of service analysis and simulation packages (e.g., TRANSYT, NETSIM, FREQ) can also be used. Turning movement counts, current geometrics and signal timing are necessary for a thorough analysis. Future traffic volumes should also be considered.

Delay (intersection) and speed (arterial) are the best measures of actual effect. Traffic volume should be measured to gauge diversion effect (i.e. more vehicles taking advantage of improved operation).

STRATEGY # 71 Acceleration/Deceleration Lanes

RELATIVE COST NOTES

DISADVANTAGES

Social and environmental impacts are generally minimal, but may include land acquisition, reduced sidewalk widths, and bringing traffic lanes closer to property lines and buildings.

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Intersection improvements should follow engineering principles.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	72	Bus Turnouts	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

Bus turnouts are extensions of pavement that allow transit vehicles to pull out of the travel lane. They are typically provided on the far side of intersections. Bus turnouts prevent blockage of the travel lane to other vehicles thereby improving traffic flow. Bus turnouts can improve safety by preventing rear-end collisions and uncertainty to drivers. Bus turnouts are appropriate along major bus routes and should be implemented in consultation with the appropriate transit provider.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Safety Improve Traffic Flow Increase Capacity	Accident rates Average speed Delay per vehicle Intersection level of service	Accident rates Delay Level of service analysis Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow Increase capacity	Reduce delay Improve safety	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

RELATIVE BENEFIT NOTES

These strategies are designed to improve traffic flow by increasing the effective capacity of the affected intersection or roadway segment. This is achieved primarily by providing separate lanes for various maneuvers (e.g., turning, passing, merging). In doing so, geometric improvement strategies may also provide significant safety benefits.

Geometric improvements typically are low-cost and highly cost-effective, require minimal right-of-way, and can be implemented in a relatively short timeframe, although these characteristics may vary.

EFFECTS EVALUATION

Field inspections by a qualified traffic engineer can often determine where this type of strategy is appropriate. The operating impacts of these strategies can be assessed using the methodologies described in the Highway Capacity Manual and related software package. Most other level of service analysis and simulation packages (e.g., TRANSYT, NETSIM, FREQ) can also be used. Turning movement counts, current geometrics and signal timing are necessary for a thorough analysis. Future traffic volumes should also be considered.

Delay (intersection) and speed (arterial) are the best measures of actual effect. Traffic volume should be measured to gauge diversion effect (i.e. more vehicles taking advantage of improved operation).

STRATEGY # **72** Bus Turnouts

RELATIVE COST NOTES

DISADVANTAGES

Social and environmental impacts are generally minimal, but may include land acquisition, reduced sidewalk widths, and bringing traffic lanes closer to property lines and buildings. Bus turnouts may also cause additional delay for transit vehicles trying to reenter the through travel lane.

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Roadway improvements should follow engineering principles.

WARRANTS

Warrant based on ADT. For example, the facility would benefit more from the installation of bus turnouts on busy roads than on less traveled roadways.

EXAMPLES

Bus turnouts are implemented throughout metro Phoenix usually on the far-side of intersections.

STRATEGY #	73	Channelization	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

Channelization is the addition of markings, and signs, and the provision of separate lanes for different turning movements. Channelization is effective in reducing driver uncertainty and improving safety.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes Vertical and Horizontal Geometry	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Safety Improve Traffic Flow Increase Capacity	Accident rates Average speed Delay per vehicle Intersection level of service	Accident rates Delay Level of service analysis Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow Increase capacity	Reduce delay Improve safety	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Medium

RELATIVE BENEFIT NOTES

These strategies are designed to improve traffic flow by increasing the effective capacity of the affected intersection or roadway segment. This is achieved primarily by providing separate lanes for various maneuvers (e.g., turning, passing, merging). In doing so, geometric improvement strategies may also provide significant safety benefits.

Geometric improvements typically are low-cost and highly cost-effective, require minimal right-of-way, and can be implemented in a relatively short timeframe, although these characteristics may vary.

EFFECTS EVALUATION

Field inspections by a qualified traffic engineer can often determine where this type of strategy is appropriate. The operating impacts of these strategies can be assessed using the methodologies described in the Highway Capacity Manual and related software package. Most other level of service analysis and simulation packages (e.g., TRANSYT, NETSIM, FREQ) can also be used. Turning movement counts, current geometrics and signal timing are necessary for a thorough analysis. Future traffic volumes should also be considered.

Delay (intersection) and speed (arterial) are the best measures of actual effect. Traffic volume should be measured to gauge diversion effect (i.e. more vehicles taking advantage of improved operation).

STRATEGY # 73 Channelization

RELATIVE COST NOTES

Channelized roadway and intersections - $200-$500 per block

DISADVANTAGES

Social and environmental impacts are generally minimal, but may include land acquisition, reduced sidewalk widths, and bringing traffic lanes closer to property lines and buildings.

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Intersection improvements should follow engineering principles.

WARRANTS

No definite warrant

EXAMPLES

A. Amarillo, TX: (1990 pop – 157,571); Public Works Division; cost not available; Texas DOT; primary service includes right turn channelization; no records available on effects.

B. Corpus Christi, TX: (1990 pop – 257,453); Metropolitan Planning Organization; $200,000 to $250,000 annually; City of Corpus Christi; primary services include right turn channelization and left turn channelization; City reports improvements have increased traffic volumes greatly and accidents at one sampled intersection has reduced.

C. Vancouver, WA: (1990 pop – 463,634); Public Works, Transportation Agency; double left turn lanes ($400,000), signal intersection improvements ($135,000-$550,000), signal modifications and provisions of dual left-turn lane ($146,000); U.S. DOT and Washington DOT; primary services for this single intersection included right turn channels (most with a raised median), left turn pockets, and islands for traffic signals; reported that traffic accidents reduced at this intersection.

STRATEGY #	74	Climbing Lanes	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

A climbing lane is an additional lane designed for use by slow moving vehicles. The main purpose is to reduce the adverse impact of heavily loaded vehicle traffic on grades of sufficient length to result in speeds that could impede following vehicles. Climbing lanes are found to reduce delay and the number of serious crashes occurring on grades.

Climbing lanes are generally applied to two-lane highways, but less prevalent on freeways and multilane highways. Climbing lanes are generally not as easily justified on multilane facilities because multilane facilities more frequently have sufficient capacity to handle traffic demands, besides having lanes that allow passing slow moving vehicles.

A separate climbing lane exclusively for slow moving vehicles is preferred to the addition of an extra lane carrying mixed traffic. Climbing lanes are designed for each direction independently of the other. Depending on the alignment and profile conditions, they may or may not overlap.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	Principal Arterial Interstate	Urban	All congestion types	All Day
Terrain	Principal Arterial Other	Rural		All Year
Vehicle Mix	Minor Arterial			
Vertical and Horizontal Geometry				

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Delay	Peak hour factor
Reduce Delay	Number of accidents per VMT	Directional distribution factor
		Design hour volume
		Truck flow rate
		Number of trucks in the upgrade direction
		Percentage of trucks in the upgrade direction

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety	Reduce delay	Reduce frequency of highway accidents
Improve traffic flow	Improve safety	
Reduce delay		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Medium

RELATIVE BENEFIT NOTES

STRATEGY # | **74** | Climbing Lanes

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Roadway improvements should follow engineering principles.

DISADVANTAGES

WARRANTS

From the AASHTO (2001, p. 248), the following three criteria that reflect economic considerations should be satisfied to justify a climbing lane:

1. Upgrade traffic flow rate in excess of 200 vehicles per hour.
2. Upgrade truck flow rate in excess of 20 vehicles per hour.
3. One of the following conditions exist:
   * A 10 mph or greater speed reduction is expected for a typical heavy truck.
   * Level-of-service E or F exists on the grade.
   * A reduction of two or more levels of service is experienced when moving from the approach segment to the grade.

In addition, safety considerations may justify the addition of a climbing lane regardless of grade or traffic volumes.

EXAMPLES

Commonly applied strategy.

STRATEGY #	75	Grade Separation	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

Grade separation is the addition of an overpass or underpass to physically separate one of the through movements at an intersection. An example of grade separation is the construction of an interchange along a freeway corridor. The conversion of existing interchanges to single point urban interchanges can also improve traffic flow.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Adjacent Development	Principal Arterial Other	All locations	Recurring predictable	All Day
Vertical and Horizontal Geometry	Minor Arterial		Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Accident rates	Accident rates
Improve Safety	Average speed	Delay
Improve Traffic Flow	Delay per vehicle	Level of service analysis
Increase Capacity	Intersection level of service	Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Improve travel speeds	Improve safety
Improve traffic flow	Improve safety	
Increase capacity		
Reduce conflicts		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

These strategies are designed to improve traffic flow by increasing the effective capacity of the affected intersection or roadway segment. This is achieved primarily by providing separate lanes for various maneuvers (e.g., turning, passing, merging). In doing so, geometric improvement strategies may also provide significant safety benefits.

Geometric improvements typically are low-cost and highly cost-effective, require minimal right-of-way, and can be implemented in a relatively short timeframe, although these characteristics may vary.

EFFECTS EVALUATION

Field inspections by a qualified traffic engineer can often determine where this type of strategy is appropriate. The operating impacts of these strategies can be assessed using the methodologies described in the Highway Capacity Manual and related software package. Most other level of service analysis and simulation packages (e.g., TRANSYT, NETSIM, FREQ) can also be used. Turning movement counts, current geometrics and signal timing are necessary for a thorough analysis. Future traffic volumes should also be considered.

Delay (intersection) and speed (arterial) are the best measures of actual effect. Traffic volume should be measured to gauge diversion effect (i.e. more vehicles taking advantage of improved operation).

STRATEGY # | **75** | Grade Separation

RELATIVE COST NOTES

DISADVANTAGES

Social and environmental impacts can be high, and include: land acquisition, reduced sidewalk widths, and bringing traffic lanes closer to property lines and buildings.

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Intersection improvements should follow engineering principles.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 76 Improve Shoulders

ORIENTATION Supply

CATEGORY Roadway Geometric Improvements

DESCRIPTION

Improved traffic operations can be facilitated by adding or widening shoulders. Wider shoulders allow more separation for disabled vehicles and provide more space for emergency access. Shoulders along surface streets can be used as defacto turn lanes. Improving the shoulders along existing freeways and surface streets can help improve traffic operations, minimize accidents, create a more suitable location for disabled vehicles to pull off the roadway, and expedite emergency response by providing more space for emergency access.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Adjacent Development	All Functional Classes	All locations	Recurring predictable	All Day
Terrain			Recurring un-predictable	All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Emergency Response	Accident rates	Accident rates
Improve Safety	Delay	Delay
Improve Vehicular Travel Times	Travel time	Number of access points
Increase Capacity		Traffic counts
Reduce Conflicts		Travel time
Reduce Delay		

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity	Reduce delay	Improve safety
Reduce conflicts	Reduce travel time	
Reduce lane closures	Reduce waiting time	
Improve emergency vehicle access		
Improve incident response time		
Improve incident clearance time		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	High	Medium

RELATIVE BENEFIT NOTES

Increased safety by physically separating conflicting modes.
Increased safety and throughput for incidents that can be relocated to the shoulder.

STRATEGY # **76** Improve Shoulders

RELATIVE COST NOTES

DISADVANTAGES

Requires sufficient right-of-way and clearance to adjacent development.
Adjacent development impact.

INSTITUTIONAL FACTORS

Involve coordination with adjacent development. Roadway improvements should follow engineering principles.

WARRANTS

Access point density, accident frequency, parking on roadway frequency.

EXAMPLES

Commonly applied strategy.

STRATEGY #	**77**	Lane Widening	**ORIENTATION**	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

Lane widening provides additional separation between vehicles in opposing or side by side travel lanes. The extra lane width can improve the safety of the facility.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control Adjacent Development Number of Lanes	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Safety Improve Traffic Flow Increase Capacity	Accident rates Average speed Delay per vehicle Intersection level of service	Accident rates Delay Level of service analysis Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow Increase capacity Reduce conflicts	Reduce vehicle conflict	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Medium

RELATIVE BENEFIT NOTES

These strategies are designed to improve traffic flow by increasing the effective capacity of the affected intersection or roadway segment. This is achieved primarily by providing separate lanes for various maneuvers (e.g., turning, passing, merging). In doing so, geometric improvement strategies may also provide significant safety benefits.

Geometric improvements typically are low-cost and highly cost-effective, require minimal right-of-way, and can be implemented in a relatively short timeframe, although these characteristics may vary.

EFFECTS EVALUATION

Field inspections by a qualified traffic engineer can often determine where this type of strategy is appropriate. The operating impacts of these strategies can be assessed using the methodologies described in the Highway Capacity Manual and related software package. Most other level of service analysis and simulation packages (e.g., TRANSYT, NETSIM, FREQ) can also be used. Turning movement counts, current geometrics and signal timing are necessary for a thorough analysis. Future traffic volumes should also be considered.

Delay (intersection) and speed (arterial) are the best measures of actual effect. Traffic volume should be measured to gauge diversion effect (i.e. more vehicles taking advantage of improved operation).

STRATEGY # | **77** | Lane Widening

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Roadway improvements should follow engineering principles.

DISADVANTAGES

Social and environmental impacts are generally minimal, but may include land acquisition, reduced sidewalk widths, and bringing traffic lanes closer to property lines and buildings.

WARRANTS

Warrant based on level of service.

EXAMPLES

Commonly applied strategy.

STRATEGY #	78	One-way Couplets	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

The conversion of two-way streets into one-way streets can potentially improve traffic flow and vehicle throughput. Converted streets allow simpler signal timing plans than two-way streets. Conversion to one-way couplets should be considered in high volume, high conflict areas with closely spaced intersections, such as downtown central business districts. Newly developed activity centers can also incorporate one-way couplet networks.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	Principal Arterial Other	Urban	All congestion types	All Day
	Minor Arterial	Metropolitan		All Year
	Major Collector			
	Minor Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Accident rates	Accident rates
Improve Safety	Average speed	Delay
Improve Traffic Flow	Delay per vehicle	Level of service analysis
Increase Capacity	Intersection level of service	Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Reduce delay	Improve safety
Improve traffic flow		
Increase capacity		
Redistribution of trips		
Allow turns from more than one lane		
Simplify traffic signal timing		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Medium	Overcome Institutional Hurdles

RELATIVE BENEFIT NOTES

These strategies are designed to improve traffic flow by increasing the effective capacity of the affected intersection or roadway segment. This is achieved primarily by providing separate lanes for various maneuvers (e.g., turning, passing, merging). In doing so, geometric improvement strategies may also provide significant safety benefits (prevent pedestrian entrapment, Improve driver's field of vision).

Geometric improvements typically are low-cost and highly cost-effective, require minimal right-of-way, and can be implemented in a relatively short timeframe, although these characteristics may vary.

EFFECTS EVALUATION

Field inspections by a qualified traffic engineer can often determine where this type of strategy is appropriate. The operating impacts of these strategies can be assessed using the methodologies described in the Highway Capacity Manual and related software package. Most other level of service analysis and simulation packages (e.g., TRANSYT, NETSIM, FREQ) can also be used. Turning movement counts, current geometrics and signal timing are necessary for a thorough analysis. Future traffic volumes should also be considered.

Delay (intersection) and speed (arterial) are the best measures of actual effect. Traffic volume should be measured to gauge diversion effect (i.e. more vehicles taking advantage of improved operation).

STRATEGY # 78 One-way Couplets

RELATIVE COST NOTES

Converting two-way streets to one-way - $500-$2,000 per block

DISADVANTAGES

Social and environmental impacts are generally minimal, but may include land acquisition, reduced sidewalk widths, and bringing traffic lanes closer to property lines and buildings.

This strategy can potentially decrease safety (due to higher speeds, and wider pedestrian crossings), and cause adverse impact on businesses.

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Roadway improvements should follow engineering principles. Implementation requires public outreach.

WARRANTS

One-way couplets are warranted in high density, high conflict areas.

EXAMPLES

A) One-way streets are implemented in downtown Phoenix.

B) Downtown Scottsdale also has one-way couplets.

STRATEGY #	79	Passing Lanes	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

Passing lanes are added lanes which can be provided in one or both directions of travel to improve traffic operations in sections of lower capacity. The purpose is to at least achieve the same quality of service as adjacent road sections. Passing lanes can also be provided to improve overall traffic operations on two-lane highways by reducing delays caused by inadequate passing opportunities over significant length of highways, typically 6 to 60 miles. They are frequently provided systematically at regular intervals.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	All Functional Classes	Rural	Recurring predictable	All Day
Terrain			Recurring un-predictable	All Year
Vehicle Mix				
Vertical and Horizontal Geometry				

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency	Delay	Delay
Improve Traffic Flow	Travel time	Traffic counts
Improve Vehicular Travel Times		
Reduce Delay		

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Reduce delay	Improve safety
Improve traffic flow	Reduce travel time	Reduce frequency of highway accidents
	Reduce driver frustration	

EFFECTS EVALUATION

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Medium

RELATIVE BENEFIT NOTES

STRATEGY # **79** Passing Lanes

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Roadway improvements should follow engineering principles.

WARRANTS

Passing lanes should be considered where climbing lanes are not warranted and where the extent and frequency of passing sections are too few.

EXAMPLES

Commonly applied strategy.

STRATEGY #	80	Providing Additional Lanes without Widening	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

This strategy is accomplished through restriping. This process of adding lanes increases the carrying capacity and traffic flow of a roadway. Restriping can be done by removing parking spaces along the curb, the conversion of shoulders to travel lanes, or narrowing lanes so as to allow more space for an additional travel lane.

The use of freeway shoulders as travel lanes has been done since the late 1960s. Many of these shoulder conversions have been for HOV use. Freeway shoulder modifications include using one or more shoulder as a travel lane and reduction in lane widths to provide additional lanes within the existing roadway. This strategy is applicable only in locations where excess pavement width is available to accommodate additional lanes.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control Number of Lanes	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Vehicular Travel Times Increase Capacity Reduce Delay	Average speed Delay Level of service Traffic volumes	Link volume Number of lanes Traffic counts Travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity Reduce localized traffic congestion	Improve travel speeds Reduce travel time	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Low	Easy

RELATIVE BENEFIT NOTES

EFFECTS EVALUATION

The urban-scale benefits of lane additions can be difficult to assess, but this is best done using the regional travel demand model. Corridor-scale benefits and impacts of these strategies can be assessed using procedures described in the Highway Capacity Manual and simulation analysis packages such as TRANSYT, PASSER, SYNCHRO, NETFLO and NETSIM.

Full evaluation should include evaluation of parallel routes, as well as impact on transit ridership.

STRATEGY # **80** Providing Additional Lanes without Widening

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

This strategy requires a joint effort with enforcement agencies. Public education is also required. Roadway improvements should follow engineering principles.

DISADVANTAGES

Providing additional capacity may induce traffic. Air quality issues may prevent the addition of lanes or addition of capacity.

By adding travel lanes to the existing pavement width will potentially bring the traveling vehicles closer to pedestrians on adjoining sidewalks. The perceived widening with the lane addition may adversely impact pedestrian travel and traffic operations. Wide roadways are perceived by pedestrians as a barrier and will inhibit pedestrian travel. Wider arterials may also require multi-phase traffic signals which improve safety, but reduce efficiency due to longer clearance times between different conflicting turning movements.

In addition, restriping to accommodate additional travel lanes may result in the removal of bike lanes or on-street parking. A potential disbenefit is the economic impact to businesses related to reduced parking

WARRANTS

No definite warrant

EXAMPLES

An FHWA staff study found that in cities with populations over one million, almost 32 percent of the urban freeway mileage could experience reduced congestion through such low cost measures (as providing additional lanes without widening the freeway). Another study examined the northern Virginia I-95 use of shoulder lanes for the entire day (Chen 1995). This 8-mile/12.9~km section of Interstate has a left lane designated fro 3+ HOV vehicles, two general purpose lanes, and a right shoulder lane which is used as a conventional travel lane. The study concluded that the use of shoulder lanes increased freeway capacity significantly. Analysis indicated that removing the shoulder lanes from general purpose use would increase queue lengths by 140 percent and system delays by 929 percent. The HOV and shoulder lanes carried 47 percent of total vehicles and 63 percent of total travelers on the freeway. No adverse impacts on general traffic accident frequency was found. Fatality rates were lower than the "before" situation. Several modifications had been made to maintain operational and enforcement activities such as building and signing of emergency pullouts to allow for safe storage of disabled vehicles.

Amarillo, TX: (1990 pop – 157,571); S.W. 9th Avenue, Washington Street, Coulter Street., S.W. 45th Avenue, and Eastern Street; costs respectively are $2,000, not available, $493,928, $499,851, and $1,105,621; Craig Methodist Retirement Center and City of Amarillo; increased lanes via striping and/or reconstruction; inconclusive assessment suggests that restriping has had a beneficial effect on traffic flow and decreased the number of traffic collisions.

STRATEGY #	81	Reversible Lanes	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

A highway or street lane on which the direction of traffic flow can be changed to use maximum roadway capacity during peak periods.

Reversible lanes or changeable lane assignments takes advantage of differences in peak directional volumes which render capacity in one direction of travel being significantly under utilized. By reversing the direction of travel for the center lane for the morning peak period and then again in the afternoon peak period, an entire lane of capacity can be added for the peak direction of travel. Significant safety measures need to be in place to ensure that drivers utilizing the reversible lane are traveling in the correct direction. This can be accomplished by movable barriers or lane use control signals.

Reversible lanes may be considered on facilities with a significant peaking pattern; where the percentage of traffic in the peak direction is much greater than fifty percent in the peak period.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	Principal Arterial Other Minor Arterial	Urban Metropolitan	Recurring predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Traffic Flow Improve Vehicular Travel Times Increase Capacity Reduce Delay	Average speed Delay Level of service Traffic volumes	Link volume Number of lanes Travel time

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow Increase capacity	Reduce delay Reduce travel time	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Medium	Medium

RELATIVE BENEFIT NOTES

STRATEGY # **81** Reversible Lanes

RELATIVE COST NOTES

DISADVANTAGES

Disadvantages may include reduced capacity for minor flows, operational problems at termini, and the need for concentrated enforcement efforts to prevent violation of the lane-use regulations.

INSTITUTIONAL FACTORS

Arizona currently implements this strategy in the Phoenix metro area.

Roadway improvements should follow engineering principles. Planning and operations development should involve enforcement agencies.

WARRANTS

No definite warrant

EXAMPLES

One of the outstanding examples of multiple reversible lanes is the eight-lane Outer Drive in Chicago, which operates a 6-2 lane split during peak traffic periods. The system is particularly effective on bridges and in tunnels, where the cost to provide additional capacity would be high and perhaps impossible.

A stretch of 7th Street in Phoenix utilizes a peak hour reversible lane. Part of 7th Avenue also has a peak hour reversible lane.

STRATEGY #	82	Turn Lanes	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

Provision of turn lanes at intersections provides storage for vehicles making right or left turns and allows through moving vehicles to proceed unimpeded by turning vehicles. Turn lanes channelize vehicles making different movements thereby improving safety and ease of drivers.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Safety Improve Traffic Flow Increase Capacity	Accident rates Average speed Delay per vehicle Intersection level of service	Accident rates Delay Level of service analysis Moving car runs

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow Increase capacity Reduce conflicts	Reduce delay Reduce vehicle conflict	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Medium	Medium

RELATIVE BENEFIT NOTES

These strategies are designed to improve traffic flow by increasing the effective capacity of the affected intersection or roadway segment. This is achieved primarily by providing separate lanes for various maneuvers (e.g., turning, passing, merging). In doing so, geometric improvement strategies may also provide significant safety benefits.

Geometric improvements typically are low-cost and highly cost-effective, require minimal right-of-way, and can be implemented in a relatively short timeframe, although these characteristics may vary.

EFFECTS EVALUATION

Field inspections by a qualified traffic engineer can often determine where this type of strategy is appropriate. The operating impacts of these strategies can be assessed using the methodologies described in the Highway Capacity Manual and related software package. Most other level of service analysis and simulation packages (e.g., TRANSYT, NETSIM, FREQ) can also be used. Turning movement counts, current geometrics and signal timing are necessary for a thorough analysis. Future traffic volumes should also be considered.

Delay (intersection) and speed (arterial) are the best measures of actual effect. Traffic volume should be measured to gauge diversion effect (i.e. more vehicles taking advantage of improved operation).

STRATEGY # 82 Turn Lanes

RELATIVE COST NOTES

DISADVANTAGES

Social and environmental impacts are generally minimal, but may include land acquisition, reduced sidewalk widths, and bringing traffic lanes closer to property lines and buildings.

INSTITUTIONAL FACTORS

These types of strategies are commonly implemented throughout Arizona and the rest of the U.S. ADOT supports the implementation of these strategies where appropriate. Intersection improvements should follow engineering principles.

WARRANTS

No definite warrant

EXAMPLES

A. Albuquerque, NM: (1990 pop – 384,915); Public Works Department; cost not available; City of Albuquerque; primary services included left turn storage (or bays) and dual left turn lanes; when deciding if changes are to be implemented, the department takes into account available resources, traffic capacity public complaints, accidents, and side streets and intersections in the vicinity.

B. Vancouver, WA: (1990 pop – 463,634); Public Works, Transportation Agency; double left turn lanes ($400,000), signal intersection improvements ($135,000-$550,000), signal modifications and provisions of dual left-turn lane ($146,000); U.S. DOT and Washington DOT; primary services for this single intersection included right turn channels (most with a raised median), left turn pockets, and islands for traffic signals; reported that traffic accidents reduced at this intersection.

STRATEGY #	83	Vehicle Pullouts	ORIENTATION	Supply
CATEGORY	Roadway Geometric Improvements			

DESCRIPTION

Vehicle pullouts are areas along a two-lane highway where slower moving vehicles can pull off the roadway to allow trailing vehicles to pass. Vehicle pullouts can also be used to relocate disabled vehicles.

Vehicle pullouts can also be implemented along freeways to safely separate stopped trucks or vehicles from through traffic. These vehicle pullouts are typically in locations that are long distances from urban areas or services. Vehicle pullouts may also be ideal in unique terrain situations.

Vehicle pullouts can also be used along sections of urban freeway with limited shoulder availability. Provision of pullouts with associated signage at strategic locations allows disabled vehicles to be removed from traffic and prevents blockage to travel lanes.

Adequate sight distance, signage and acceleration to allow safe reentry of vehicles must be in place.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Number of Lanes Terrain Vehicle Mix	All Functional Classes	Urban Rural	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Traffic Flow Improve Vehicular Travel Times Reduce Delay	Delay Traffic volumes Travel time	Delay Number of lanes Traffic counts Travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency Improve traffic flow	Reduce delay Reduce travel time	Improve safety

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Medium	Medium

RELATIVE BENEFIT NOTES

EFFECTS EVALUATION

STRATEGY # **83** Vehicle Pullouts

RELATIVE COST NOTES

Vehicle pullouts are less expensive than construction of passing lanes or additional travel lanes, but may not be as effective.

DISADVANTAGES

Vehicles must reenter the traffic stream sometimes at lower speeds. If there is constant traffic, no benefit will be gained.

INSTITUTIONAL FACTORS

Roadway improvements should follow engineering principles.

WARRANTS

Vehicle pullouts are warranted along roadway sections with steep grade, and are often implemented at the crest of a hill before the downhill descent. Vehicle pullouts are also warranted along urban freeways with limited shoulder availability.

EXAMPLES

Northbound I-17 near Camp Verde has a vehicle pullout. There are many other examples throughout the state.

STRATEGY #	84	Parking Restrictions	ORIENTATION	Supply
CATEGORY	Time-of-Day Restrictions			

DESCRIPTION

Parking restrictions can remove conflicts due to on-street parking and allow improved vehicle throughput and improved safety. Parking restrictions are usually only applied during peak periods, but can be in effect all day near an intersection, along a section of roadway, or throughout a sub-area. Parking restrictions should only be applied at time periods or in areas where there is a congestion or accident problem and where alternate locations are available. Complementary strategies include the addition of off-street parking or parking/site management.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Adjacent Development	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Travel Speeds Reduce Delay	Accident rates Average speed Traffic volumes Travel time	Accident rates Speeds Traffic counts Travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Improve travel speeds Reduce delay	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

These restrictions are designed to maximize operational efficiency of the existing system by eliminating turning or parking conflicts, reducing the impacts of trucks, or freeing up roadway capacity. For example, parking restrictions during peak hours allow the curb lane to be used as an additional through or right turn lane. On roadways with no separate left run lanes, turn restrictions eliminate queues and conflicts thus reducing delays and improving travel speeds by eliminating conflicts. An important advantage of this strategy is that increased operational efficiency is achieved at a relatively low cost and without the need for construction or additional ROW.

EFFECTS EVALUATION

The application of time-of-day restrictions can be evaluated using the methodologies in the Highway Capacity Manual and/or arterial simulation packages like TRANSYT 7F. Data typically required for this analysis includes turning movement counts, lane configurations, signal phasing and timing, and travel speed. Because turn prohibitions force drivers to use alternative routes, consideration should be given to the additional VMT generated. Turn restrictions are not recommended if they force detours greater than 0.5 mile.

Noticeable changes in traffic patterns may occur for restrictions affecting significant volumes of traffic. Left turn restrictions may significantly improve speed.

STRATEGY # | **84** | Parking Restrictions

RELATIVE COST NOTES

DISADVANTAGES

A potential disbenefit of parking restrictions is the economic impact to businesses related to reduced parking.

INSTITUTIONAL FACTORS

Local government and businesses may oppose restrictions on parking.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY #	85	Truck Restrictions	ORIENTATION	Supply
CATEGORY	Time-of-Day Restrictions			

DESCRIPTION

Truck restrictions involve limiting access to a facility or prohibition of truck loading in congested areas. Truck restrictions can remove conflicts due to trucks and allow improved vehicle throughput and improved safety. Truck restrictions are usually only applied during peak periods, but can be effective all day at an intersection, along a section of roadway, or throughout a sub-area. Truck restrictions should only be applied at time periods or in areas where there is a congestion or accident problem and where alternate routes or locations are available. Truck restrictions may also be implemented on facilities with insufficient lane width or turning radii.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Vehicle Mix	Principal Arterial Other Minor Arterial Major Collector Minor Collector	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Efficiency Improve Travel Speeds Reduce Delay	Accident rates Average speed Traffic volumes Travel time	Accident rates Speeds Traffic counts Travel time

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve system efficiency	Improve travel speeds Reduce delay	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

These restrictions are designed to maximize operational efficiency of the existing system by eliminating turning or parking conflicts, reducing the impacts of trucks, or freeing up roadway capacity. For example, parking restrictions during peak hours allow the curb lane to be used as an additional through or right turn lane. On roadways with no separate left run lanes, turn restrictions eliminate queues and conflicts thus reducing delays and improving travel speeds by eliminating conflicts. An important advantage of this strategy is that increased operational efficiency is achieved at a relatively low cost and without the need for construction or additional ROW.

EFFECTS EVALUATION

The application of time-of-day restrictions can be evaluated using the methodologies in the Highway Capacity Manual and/or arterial simulation packages like TRANSYT 7F. Data typically required for this analysis includes turning movement counts, lane configurations, signal phasing and timing, and travel speed. Because turn prohibitions force drivers to use alternative routes, consideration should be given to the additional VMT generated. Turn restrictions are not recommended if they force detours greater than 0.5 mile.

Noticeable changes in traffic patterns may occur for restrictions affecting significant volumes of traffic. Left turn restrictions may significantly improve speed.

STRATEGY # 85 Truck Restrictions

RELATIVE COST NOTES

DISADVANTAGES

Restrictive measures may have negative economic impacts for truck operators and the shippers or receivers of goods.

INSTITUTIONAL FACTORS

Truck restrictions may face opposition by the trucking industry. Implementation of this strategy involves coordination with businesses and trucking companies.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 86 Turning Restrictions

ORIENTATION Supply

CATEGORY Time-of-Day Restrictions

DESCRIPTION

Turning restrictions can remove conflicts due to turning vehicles and allow improved vehicle throughput and improved safety. Turning restrictions are usually only applied during peak periods, but can be in effect all day at an intersection, along a section of roadway, or throughout a sub-area. Turning restrictions should only be applied at time periods or in areas where there is a congestion or accident problem and where alternate locations for making the restricted movement are available. Complementary strategies include the improvement of adjacent intersections.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Other	Urban	All congestion types	All Day
Adjacent Development	Minor Arterial	Metropolitan		All Year
	Major Collector	Activity Centers		
	Minor Collector	Special Venue		

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Traffic Flow	Accident rates	Accident rates
Reduce Conflicts	Average speed	Speeds
Reduce Delay	Traffic volumes	Traffic counts
Increase Intersection Efficiency	Travel time	Turning movement volumes
Reduce Accidents	Volume throughput	Alternate routes
		Lane configurations
		Signal phasing and timing

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve safety	Reduce delay	None
Improve system efficiency	Improve safety	
Improve traffic flow		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

These restrictions are designed to maximize operational efficiency of the existing system by eliminating turning or parking conflicts, reducing the impacts of trucks, or freeing up roadway capacity. For example, parking restrictions during peak hours allow the curb lane to be used as an additional through or right turn lane. On roadways with no separate left run lanes, turn restrictions eliminate queues and conflicts thus reducing delays and improving travel speeds by eliminating conflicts. An important advantage of this strategy is that increased operational efficiency is achieved at a relatively low cost and without the need for construction or additional ROW.

EFFECTS EVALUATION

The application of time-of-day restrictions can be evaluated using the methodologies in the Highway Capacity Manual and/or arterial simulation packages like TRANSYT 7F. Data typically required for this analysis includes turning movement counts, lane configurations, signal phasing and timing, and travel speed. Because turn prohibitions force drivers to use alternative routes, consideration should be given to the additional VMT generated. Turn restrictions are not recommended if they force detours greater than 0.5 mile.

Noticeable changes in traffic patterns may occur for restrictions affecting significant volumes of traffic. Left turn restrictions may significantly improve speed.

STRATEGY # 86 Turning Restrictions

RELATIVE COST NOTES

Two-way street left turn restrictions - $400 per intersection

DISADVANTAGES

For turn restrictions, a potential disbenefit is increased VMT as vehicles circumvent restricted areas or avoid prohibited movements.

Other critical issues associated with restricting turns is the economic impact on businesses that are now not as accessible as before.

INSTITUTIONAL FACTORS

A modest planning effort is required to identify the locations for possible application of turning prohibitions. A routine design and construction process is then implemented, using appropriate design standards. Implementation often requires outreach to abutting property owners.

WARRANTS

Turn prohibition studies should consider: 1) The amount of congestion and delay caused by turning movements. 2) The number of collisions involving vehicles making the turning movement. 3) The availability of suitable alternative travel paths if turns are restricted. 4) The possible impact of traffic diversion on congestion and accidents at intersections that would be required to accommodate the traffic diverted by the turning restriction. 5) Possible adverse environmental impacts caused by re-routed traffic. 6) The feasibility of alternative solutions, such as provision of separate storage lanes for the turning movements and, at signalized intersections, the use of special turn-movement phasing. 7) The exclusion of buses, taxis, and bicycles from the turn prohibition, depending on circumstances.

EXAMPLES

Data compiled in San Francisco indicated that accidents at four intersections with turn restrictions were reduced between 38 percent to 52 percent. All of the intersections were high volume intersections used by 30,000 to 50,000 motorists on an average day (Institute of Transportation Engineers, 1992).

STRATEGY # 87 Ramp Metering

ORIENTATION Supply

CATEGORY Traffic Operational Improvements

DESCRIPTION

Ramp metering is a strategy implemented to improve vehicle throughput on freeways. By regulating vehicles entering the freeway, mainline traffic operates more efficiently and mainline capacities are protected. Ramp metering is accomplished using a modified traffic signal placed at the end of a ramp or by use of changeable message signs or gates. The ramp meter allows vehicles to enter the freeway at or below demand rates at pre-timed intervals or as determined by ramp or mainline traffic. Demand responsive based ramp meter rates can prevent excessive ramp queues and can address changes in traffic volumes. Ramp metering can be implemented at ramps, freeway-to-freeway connections, and at gateways like bridges and tunnels. HOV bypass lanes at ramp meters provide incentives for carpooling and transit by eliminating delay for multiple occupant vehicles.

Ramp metering is most effective when the freeway is oversaturated for only a short time period. This strategy becomes less effective as oversaturation extends beyond the peak period or lasts several hours. Ramp metering is usually implemented in locations with long sections of freeway that are near capacity. Because this strategy is implemented to reduce the effect of merging vehicles, it is most often implemented at locations with high numbers of entering vehicles, or at locations where adjacent traffic signals result in platoons of vehicles entering at a time. Successful ramp metering often involves modification of ramps to provide adequate queue storage and adjustment of signal timings at adjacent intersections.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Interstate	Urban	All congestion types	Peak Hour
	Principal Arterial Expressway	Metropolitan		All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Average speed	Freeway ramp queues
Improve Traffic Flow	Freeway mainline/ramp accidents	Moving car runs
Improve Travel Speeds	Ramp queue lengths and delays	Real time speed
Increase Person Throughput	Traffic volumes	Real time traffic volume
Reduce Conflicts		Traffic counts

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow	Improve travel speeds	Decrease accident rates
Improve throughput		
Reduce conflicts		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

Ramp metering has proven to be one of the most cost-effective techniques for improving traffic flow on expressways. By spacing or limiting the number of vehicles entering the highway, merge conflicts are reduced and mainline speeds can be increased. In addition, increased volume throughput and reduced accident rates have been observed.

Allowing HOV vehicles to bypass ramp meter queues can encourage ridesharing and reduce person travel-time.

Increase traffic throughput, Discourage short-trip freeway use, Provide incentives to transit and carpool, Improve conditions at specific problem merge areas.

EFFECTS EVALUATION

Ramp metering is often analyzed using macro- or micro-simulation models; FREQ is the most commonly used tool. It is important to use techniques and data that support a fine level of analysis. While a difference of 50 vehicles per hour may be insignificant for expressway operations, a similar error on a ramp may be the difference between an effective strategy and an unsatisfactory queue spillback. For simple situations, spreadsheet analysis can be used.

Expressway surveillance systems can be used to gather data, but may not be available prior to turning metering on. This is a difficult strategy to evaluate.

STRATEGY # | **87** | Ramp Metering

RELATIVE COST NOTES

Costs will normally vary depending on the individual circumstances and the condition of the existing freeway, but in general, costs per mile will be $1.5 million for construction and engineering, and $12,000 per year for maintenance. Overall, low-cost improvements have the potential of returning a benefit/cost ratio of up to 7:1.

DISADVANTAGES

Potential disbenefits of metering include increased wait times on ramps, queue spillover onto local streets, and diversion to alternate routes. Local trips may be discouraged because of additional wait time at ramps.

Disbenefits can be mitigated by increasing ramp storage, creating an area wide system control of metering to distribute backups among many different ramps, and by installing a queue detector at the top of the ramp to increase the metering rate in order to clear out the vehicles in the queue.

INSTITUTIONAL FACTORS

Equity issues arise as long-distance trips may have improved travel times and local, shorter-distance trips have increased delay. Implementation requires a joint effort with enforcement agencies and public education in areas where drivers are not familiar with ramp metering.

WARRANTS

Ramp metering is warranted by ramp ADT.

EXAMPLES

Ramp metering has been used in many locations throughout Arizona. ADOT has 122 ramp meters in the Phoenix area with 85 in operation, 55 of which are tied to the Freeway Management System.

STRATEGY # 88 Traffic Signal Improvements

ORIENTATION Supply

CATEGORY Traffic Operational Improvements

DESCRIPTION

Traffic signal improvements include a variety of actions such as installing new signals, updating equipment, re-timing signals, adding signal phases, converting from fixed-time to actuated operation, improving coordination/synchronization, improving maintenance practices to reduce repair time, accommodating bus or emergency vehicle preemption, and implementing all-red clearances.

This strategy can be applied at individual intersections, along an entire corridor, or throughout an entire sub-area. Traffic signal improvements are applicable in areas that have experienced growth or changes in travel patterns. Accident rates can also be used to identify candidate intersections. Corridor or area-wide signal improvements are most applicable where signals are closely spaced. Traffic signal improvements can be incorporated into roadway construction projects.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Access Control	Principal Arterial Other	Urban	Recurring predictable	All Day
Number of Lanes	Minor Arterial	Metropolitan	Recurring un-predictable	All Year
Vehicle Mix	Major Collector	Activity Centers		
	Minor Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Air Quality	Average speed	Accident rates
Improve Efficiency	Delay per vehicle	Approach queue length
Improve Traffic Flow	Duration of queues	Cycle length
Improve Travel Speeds	Number of stops	Delay
Improve Vehicular Travel Times	Travel time	Signal density
Reduce Delay	Volume throughput	Speeds
Improve Throughput		Traffic counts
		Signal phasing and timing

EFFECTS EVALUATION

Potential impacts of traffic signal improvements are typically measured by assessing changes in travel times, speeds and delays. For isolated intersections and simple arterial segments, the Highway Capacity Manual methodology and related software package may be used. For more complex situations, a number of traffic simulation packages (e.g. SYNCHRO, CORSIM, PASSER II, and TRANSYT-7F) are available. These packages can provide local and network estimates of changes in total delay and travel time.

Automated travel time equipment provides a more cost-effective evaluation method to tabulate speed changes.

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Improve traffic flow	Improve schedule reliability	Improve air quality
Increase capacity	Improve travel speeds	Allow pedestrian crossing
Improve throughput	Reduce delay	
Defer addition of capacity	Reduce travel time	
	Improve safety	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Medium

RELATIVE BENEFIT NOTES

Traffic signal improvements are aimed at improving operations and vehicle flow. Most of these measures can be implemented within the existing right of way, cause minimal disruption to existing residents and businesses, and can be accomplished at a relatively low cost and in a short time. Improved traffic operations result in higher overall travel speeds, reduced delay, improved safety, and better air quality.

An Illinois DoT study, where projects implemented signal coordination and timing improvements revealed a 41% reduction in overall peak period delay. The duration of positive impacts from signal improvements is usually short term (5 yrs or less). The effectiveness of the system needs to be maintained and timing changes made to ensure benefits are realized.

STRATEGY # **88** Traffic Signal Improvements

RELATIVE COST NOTES

Typical costs associated with traffic signalization improvements include: (Environmental Protection Agency 1991) equipment or software updating at $2,000-$3,000 per signal; timing plan improvements at $300-$400 per signal; signal coordination and interconnection at $5,000-$13,000 per signal; and signal removal at $300-$400 per signal.

DISADVANTAGES

May increase rear-end collisions.

INSTITUTIONAL FACTORS

Multiple jurisdictional responsibility for signals requires collaborative effort.

WARRANTS

There are eight signal warrants as defined in the Manual on Uniform Traffic Control Devices, December 2000, pages 4C-1 to 4C-14. The eight warrants include: eight-hour vehicular volume, four-hour vehicular volume, peak hour, pedestrian volume, school crossing, coordinated signal system, crash experience, and roadway network.

EXAMPLES

Texas implemented a statewide signal synchronization program and concluded that after 26 projects, and $1.7 million in expenditure, there was a 19.4 percent reduction in delay, an 8.8 percent reduction in the number of stops, and a 13.3 percent reduction in fuel consumption (Fambro et al 1995). The overall benefit/cost ratio was 38:1. In Tucson, AZ a regional program to improve traffic signals resulted in reductions in average delay per signal cycle from between 14 to 29 seconds (City of Tucson 1991). A similar effort for northern Virginia resulted in benefit/cost ratios in the 20:1 range for signal improvements. The annual user benefits (in terms of travel time savings and fuel costs) were estimated to be just over $7 million (Virginia DOT 1991). An aggressive program of signal timing optimization in California indicated a benefit-cost ratio of 58 to 1. Applied to 3,172 signals in the state, the program resulted in over a 15 percent reduction in vehicular delays and a 16 percent reduction in stops over three years. Overall travel times through these systems dropped by 7.2 percent. The reduction in fuel expenditures (8.6 percent) alone produced savings almost 18 times the total cost of implementing the signal retime program.

A comprehensive signal interconnection effort in Denver resulted in travel time reduction on the arterial corridors ranging from 7 to 22 percent (Denver Council of Governments 1995). A similar program in Richmond, Virginia saw a reduction in travel time ranging from 9 percent on one corridor to 14 percent on another; a 14 percent to 30 percent reduction in total delay; and a 28 percent to 39 percent reduction in stops (Virginia DOT 1994).

A. San Francisco Bay Area, CA: (1990 pop –6,249,881); Regional Traffic Signalization and Operation Program; $18.0 million cost; Metropolitan Transportation Commission; primary services included retiming or replacement of existing regional traffic signals; benefits include 15% improvement in travel times, a $1.2 million fuel cost savings, and reduced auto emissions of approximately 110 tons per year.

B. Montgomery County, MD: (1990 pop –4,222,830); Transportation Management Center; $3.0 million annually; County of Montgomery, U.S. DOT, and Maryland DOT; primary services included traffic responsive signal system, inductance loops, microwave detection, machine vision, traffic video, camera system, and aerial traffic monitoring; benefits include 14$-20% increased rush hour travel speeds and 17$-37% decreases in delay.

C. Greater Detroit (Oakland County), MI: (1990 pop –4,266,654); FAST-TRAC; $7.0 million for FY 1998; The County of Oakland; primary services included upgrade, maintain, coordinate, and replace traffic signal systems; benefits include reports that communities within the county have experienced positive effects (such as reduced traffic accidents) as a result of the increased signalization.

D. Laredo, TX: (1990 pop –133,239); Traffic Signalization System; per year $200,000 to install 4 new signals plus $20,000 per year on upgrades and maintenance; Texas DOT; primary services include 63 traffic signals using a closed loop, on line NAZTEZ program; traffic relief benefits have caused DOT to see approval for additional upgrades.

E. Houston, TX: (1990 pop –3,321,926); TranStar; $13.454 million cost; City of Houston, Harris County, Metropolitan Transit Authority of Harris County, and Texas DOT; primary services included computerized traffic signals, computerized freeway management system, roadway sensors, and automatic vehicle location systems; this is one of the largest undertakings of an on-line, real-time, computerized

STRATEGY # 89 Exclusive Right-of-Way Facilities

ORIENTATION Supply

CATEGORY Transit Capital Improvements

DESCRIPTION

Commuter rail lines, light rail lines, busways, bus lanes, and bus bypass ramps are all examples of exclusive right-of-way facilities. These types of facilities allow transit vehicles to move unobstructed by other vehicles. Rail lines and busways usually have infrastructure that is separated from roadways. Bus lanes are roadway lanes dedicated for use only by transit vehicles. Bypass ramps allow buses to go around long queues and avoid delays at ramp meters. Improvements to exclusive right-of-way facilities include reconstruction, extension, or new construction. This strategy can be implemented to serve major activity centers and is typically applied along heavily traveled corridors or subareas.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Facility Expansion Feasibility	All Functional Classes	Urban Metropolitan	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Air Quality Improve Transit Travel Times Increase HOV Trips	Transit ridership Travel time	Mode shift Ridership Usage/customer satisfaction surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase transit use Defer addition of capacity	Reduce travel time Provide alternative to personal vehicle	Improve air quality

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
High	High	Difficult

RELATIVE BENEFIT NOTES

Free of roadway congestion and vehicular incidents, the primary advantage of exclusive right-of-way facilities is that they provide more consistent and lower transit travel times. As such, this strategy can result in significant transit ridership increases that, in turn, leads to reduced congestion and improved air quality. These benefits must be weighed against the ROW requirements and significant costs associated with these facilities.

EFFECTS EVALUATION

Rail and busway projects should be examined at the corridor or regional level. The guidelines for a Major Investment Study (MIS) should be consulted. The principal tools for conducting this analysis are the regional travel demand model and the transit travel demand model. The regional model can be used to estimate mode shifts and impacts on the roadway network. Various sketch planning techniques are also available for estimating potential ridership.

Bus lanes and bypass ramps may be analyzed through sketch planning techniques based on the HCM, although large-scale bus lane improvements may warrant use of the regional travel demand model. A simple process would be to assume a reduction in bus travel time equal to the average time spent in the queue for all other traffic. Simulation programs such as FRESIM may be adapted to model the operation of bus bypass treatments.

On-going monitoring programs normally provide ridership information on a regular basis.

STRATEGY # **89** Exclusive Right-of-Way Facilities

RELATIVE COST NOTES

DISADVANTAGES

This strategy involves significant ROW costs.

INSTITUTIONAL FACTORS

Agencies in the state have supported transit capital improvements.

Responsibility for paying high capital and operating costs and the securement of funding are issues. Another issue is potential low usage.

WARRANTS

No definite warrant

EXAMPLES

A. Ottawa-Carleton, Ontario, Canada: (1990 pop – 313,987); Bus-Transitway (Bus Roadway); $420 million; Federal, Regional operations and capital, Reserves, Passenger fares; 265,000 people ridership daily; elements include 21 mainline routes, 79 routes during peak hours only, 24 stations, fixed routes; in 1978 it was decided that a transitway would convince motorists that ther is a better way to commute rather than their personal automobiles and the system began was completed in 1996; without the transitway, the buses would be required to use the general purpose roadways, which are congested.

B. Pittsburgh, PA: (1990 pop – 2,394,811); Bus-East Roadway Extension; $326.8 million; Pittsburgh Turnpike Commission and City of Pittsburgh; 30,000 weekday ridership; elements include over 900 buses; the fixed guideway is exclusive for buses, but allowances are made for emergency vehicles and private bus companies. A significant amount of development has occurred around the busway.

C. Sacramento CA: (1990 pop – 1,418,220); Sacramento Regional Transit District; $350 million implementation and $13.95 million operating cost in 1995; City of Sacramento, Sacramento County, Sacramento Area Council of Governments, and the State of California; primary service includes 36 light rail cars and 18.3 miles of track; 27,500 riders per weekday.

D. San Diego, CA: (1990 pop – 2,498,016); San Diego Trolley Inc.; $552 million (as of 1998); Metropolitan Transit Development Board; primary service includes 123 vehicles and 40 miles of track; 70,000 riders per weekday.

E. St. Louis, MO: (1990 pop – 2,492,348); Metrolink; $420 million (as of 1998); Bi-State Development Agency; primary services includes 31 light rail cars, 17 miles of track and 18 stations; ridership not available.

F. Portland, OR: (1990 pop – 1,515,452); MAX light rail system; $1.6 billion; Federal Transit Authority; FHWA, Oregon DOT, the Cities of Beaverton, Hillsboro, and Portland, and the Counties of Multnomah and Washington; primary services include 33 miles of track, 46 stations, 72 light rail cars, and a bicycle and ride program; with the creation and expansion of the light rail system, the City of Portland has been able to avoid the expansion of any roads in the downtown area for 20 years; ridership unknown.

G. Dallas/Fort Worth, TX: (1990 pop – 4,037,282); Dallas Area Rapid Transit—Light and Commuter Rails; $928.5 million (construction), $27 million light rail operating for FY 1997, $5.0 million commuter rail operating cost for FY 1997; City of Dallas and 12 suburban cities; primary services includes 40 light rail cars traveling 20 miles of light rail track and 13 commuter rail cars traveling 10 miles of commuter track; 35,000 daily ridership for light rail.

STRATEGY #	90	Fleet Improvements	ORIENTATION	Supply
CATEGORY	Transit Capital Improvements			

DESCRIPTION

Fleet improvements include replacing and upgrading vehicles, as well as acquiring new vehicles. Addition of vehicles does not imply expanded service or increased frequency, which are components of the transit service improvements strategy. Replacement vehicles can just be newer or they can also have improvements such as increased capacity, efficiency, or comfort. This strategy should be applied when transit vehicles are outdated or broken down, when existing vehicles are operating at capacity, or when vehicles do not meet rider expectations. Related strategies include vehicle management systems, automated vehicle location systems, electronic fare payment, and other transit improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Air Quality Increase HOV Trips Reduce Total Vehicle Trips	Maintenance costs Number of breakdowns On-time arrivals Remaining service life Transit ridership Vehicle age distribution	Maintenance records Ridership Schedule adherence monitoring

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity Increase transit use Reduce vehicular trips Reduce maintenance and operation costs	Improve schedule reliability Improve passenger convenience	Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	High	Difficult

RELATIVE BENEFIT NOTES

Fleet improvements are intended to increase the attractiveness of transit service through a combination of improved comfort and convenience, improved reliability, and increased capacity. More attractive transit service can then lead to increased ridership resulting in reduced vehicle trips and congestion levels. Experience in New York City revealed that ridership increased on new or renovated vehicles.

Fleet improvements can also reduce maintenance costs, reduce emissions, and improve fuel efficiency. They can also help improve the fleet mix so that the appropriate size vehicle is being operated to accommodate ridership or the area served. Because this strategy does not directly involve the construction of new facilities, it does not require additional land nor create construction-related environmental impacts, but often requires considerable capital investment.

EFFECTS EVALUATION

While it is generally acknowledged that improvements in the reliability, attractiveness and comfort of transit services will have a positive impact on ridership, very little has been done to quantify those impacts. In the absence of a formal approach, empirical data from local experience supplemented by analysis of passenger surveys can be used to estimate the likely impacts of such improvements. Alternatively, available sketch planning techniques may be adapted for this purpose.

Some of this information is collected routinely. Route-based ridership and schedule adherence may require extra effort or can be monitored periodically.

STRATEGY # **90** Fleet Improvements

RELATIVE COST NOTES

DISADVANTAGES

This strategy often requires considerable capital investment.

INSTITUTIONAL FACTORS

There is a strong commitment within the state to the maintenance and upgrade of the transit fleet. The state's transit agencies are continuously undertaking programs to upgrade their current fleets. Transit agencies have expenditures for the rehabilitation of vehicles, the purchase of replacement vehicles, the purchase of new vanpool and paratransit vehicles, and the upgrading of fare control and communications systems.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 91 Transit Support Facilities

ORIENTATION Supply

CATEGORY Transit Capital Improvements

DESCRIPTION

Transit support facilities provide services or enhancements that encourage transit use. Support facilities can allow a transit program to be more convenient, safe or pleasurable for transit users. Examples of transit support facilities include: park-and-ride lots, rail stations, bus shelters or stops, security cameras, improved lighting, transit centers, and rail yards or maintenance facilities. Park-and-ride lots can be located in suburban or congested urban areas, and should be near major roads for easy access. A transit center is a transfer point at which various modes of travel converge, such as commuter rail, light rail, buses, and taxis. Transit centers are most effective in locations with high pedestrian traffic. Implementation of this strategy can involve new construction, extension and rebuilding of existing facilities, or enhancements to existing facilities.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase HOV Trips Reduce Length of Trip Reduce Total Vehicle Trips	Facility usage Transit ridership	Facility usage counts Mode shift Usage/customer satisfaction surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase transit use Reduce vehicular trip lengths Reduce vehicular trips	Reduce costs for personal vehicle maintenance and care No specific benefit to user	Reduce emissions

EFFECTS EVALUATION

The analysis techniques for evaluating the impacts of implementing transit support facilities vary by the type of facility or improvement. The evaluation of major mulitmodal centers or new rail stations will likely require use of the regional travel demand forecasting model. The implementation of park-and-ride lots and minor transit centers may be evaluated with sketch planning techniques.

These facilities may help boost ridership, but it is often difficult to make the connection between the facility and a change in ridership.

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Varies Widely	Medium

RELATIVE BENEFIT NOTES

The construction of new facilities directly increases the accessibility of transit services. Thus, new markets may be captured and transit ridership increased. Improvements to existing facilities make them and transit service more attractive by improving comfort, safety, or amenities. This, in turn, may induce more travelers to use transit. As a result, this strategy can reduce vehicular trips and/or trip lengths.

STRATEGY # **91** Transit Support Facilities

RELATIVE COST NOTES

INSTITUTIONAL FACTORS

Park-and-ride lots have been built throughout the state; future lots can be built at rapid transit and commuter rail stations.

Responsibility for paying capital and operating costs and the securement of funding are issues.

Services connecting at the transit center must be integrated or coordinated, but this integration should not be forced.

DISADVANTAGES

These facilities may require additional public property.

WARRANTS

A standard should be developed for shelters and benches so that they are placed at appropriate bus stops.

EXAMPLES

A. Baltimore, MD: (1990 pop – 2,382,172); Baltimore-Washington International (BWI) Amtrak Rail Station; $400,000 annual cost; Amtrak; primary services include Amtrak High Speed Rail, Maryland Rail Commuter (MARC), Maryland Aviation Administration Airport Shuttles, Baltimore Central Light Rail, Local Taxi and Limousine Service; 485,000 annual ridership on MARC to and from BWI Airport Station, 147,220 annual ridership on Amtrak, BWI airport serves 8.696 million passengers per year.

B. Battle Creek, MI: (1990 pop – 429,453); Battle Creek Transportation Center; $2.127 million for design and construction; Battle Creek Transit and the City of Battle Creek; primary services include Amtrak, Greyhound and Indian Trails Bus Service, Battle Creek Local Bus Service, Taxi and Parking; 51,542 annual ridership on Amtrak arriving and departing in 1993; project has helped revitalize the Battle Creek downtown area.

C. Meridian, MS: (1990 pop – 41,036); Union Station Multimodal Transportation Center; $5.016 million; City of Meridian and Federal Transit Authority; primary services include Meridian Transit System, Passenger and Commercial Rail, Inter-City bus, Paratransit Airline Shuttles, and Local Taxi Service; ridership not available; an estimated $8 million of private development has occurred around the center as a result of the renovated facility.

D. Gallup, NM: (1990 pop – 19,157); The Gallup Cultural Center; $2.0 million (construction); primary services include Amtrak, Local, Regional, and National Bus Service; ridership not available; a variety of services are provided within and outside the center.

E. Dallas, TX: (1990 pop – 2,676,248); Union Station; $1.2 million (annual operations); primary services include Amtrak, Dallas Area Rapid Transit (light and commuter rail, bus, and paratransit), and local taxi service; ridership not available.

F. Portland, OR: (1990 pop – 1,515,452); Portland Transit Mall; $15.8 million; Federal, state and local; ridership not available; elements include 32 shelter TV kiosks, 8 information kiosks, 13 drinking fountains, 209 historic street lamps, widened brick sidewalks, 11 works of art, 5 fountains, 287 London plane (Sycamore) trees (transit mall trademark), and 36 banner poles; the transit mall development removed 308 curbside parking spaces and compensated by building two public parking garages with 1,300 parking spaces; part of a $1.3 billion redevelopment of the downtown area with results that now 50% of people who work downtown take public transportation, buses or light rail.

STRATEGY #	92	Fare Incentives	ORIENTATION	Demand
CATEGORY	Transit Operational Improvements			

DESCRIPTION

Fare incentives are lowered transit user costs including fare reductions, special fare packages, or reduced rates of fare increase. Fare incentives are typically offered for off-peak time periods like summer or as prepaid tickets to specific user groups such as seniors and students. Transit/carpool incentives is a complementary strategy. Fare incentives are usually applied to an entire region, but can also be applicable to a subarea such as a downtown business area free fare zone or as a free downtown shuttle. This strategy is only feasible if extra capacity is available and where mandatory farebox recovery ratios are met if applicable.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Air Quality Increase HOV Trips Reduce Total Vehicle Trips Reduce VMT	Mode share/shift Revenue Transit ridership	Mode shift Ridership

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce vehicular trips Reduce VMT	Customer satisfaction Potential to reduce total travel cost	Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Medium	Easy

RELATIVE BENEFIT NOTES

The application of fare-related measures are intended to reduce the cost associated with transit travel, and provide the incentive for increased transit ridership. The increase in ridership will help reduce vehicle trips and VMT as a result of the diversion from auto to transit. In turn, congestion levels and vehicle emissions can be reduced.

EFFECTS EVALUATION

The impact of fare strategies on person-trips by mode may be estimated using the demand elasticity factor methodology. Generalized elasticity factors may be used; although it is preferable to develop local factors. Some transit agencies use a model to examine changes in fare prices and the fare mix. The regional travel demand model or transit travel demand model may also be used to estimate mode shifts related to transit fare incentives.

Regular ridership monitoring may capture system-wide changes. Special studies may be needed to target particular groups.

STRATEGY # **92** Fare Incentives

RELATIVE COST NOTES

DISADVANTAGES

The potential cost of this strategy is a loss of revenue from lower fares.

INSTITUTIONAL FACTORS

Agencies can implement a variety of programs and passes that introduce fare reductions.

Who is responsible to fund the incentives is an issue.

WARRANTS

No definite warrant

EXAMPLES

Valley Metro offers many different fare packages including monthly passes; semester passes; summer passes; and discount fares to youth, seniors, and disabled riders.

STRATEGY #	93	Traffic Operations for Transit	ORIENTATION	Demand
CATEGORY	Transit Operational Improvements			

DESCRIPTION

Transit buses produce significantly less air pollution per person and use roadway space and energy resources more efficiently than all other highway modes of travel. Operational or capital transit improvements can have significant impacts on transit ridership. Traffic operations for transit improvements can be applied at specific locations or along entire corridors. Specific applications include many strategies detailed elsewhere in this toolbox. Strategies to improve transit operations include bypass ramps and bus lanes, bus turnouts, off-street bus turnarounds, signal preemption, modification to the location and frequency of bus stops, and rail crossing coordination. Transit signal preemption, where green times are extended for transit vehicles, is most effective on roadways with bus lanes, but can also be applied to facilities with mixed traffic. Geometric improvements and traffic operational improvements for general-purpose traffic can also enhance transit operations.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Principal Arterial Other	Urban	Recurring predictable	Peak Hour
	Minor Arterial	Metropolitan		All Year
	Major Collector	Rural		
	Minor Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Average speed	Mode shift
Improve Schedule Reliability	Delay per vehicle	Ridership
Improve Transit Convenience	Level of service	Travel time
Improve Transit Travel Times	Mode share/shift	Usage/customer satisfaction surveys
Increase HOV Trips	Schedule reliability	
Reduce Total Vehicle Trips	Transit ridership	
Reduce VMT	Travel time	

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase transit use	Improve schedule reliability	Improve safety
Reduce vehicular trips	Improve transit convenience	
Reduce VMT	Reduce travel time	

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Varies Widely	Medium

RELATIVE BENEFIT NOTES

Generally, these measures are intended to reduce transit travel times or, at least, minimize the variability of these times, and improve schedule reliability. Individual measures may also improve transit convenience and safety. The result is an increase in transit ridership leading to a reduction in vehicle trips and VMT. Bus turnouts and turnarounds eliminate buses from occupying road space thus improving vehicle flows. Turnarounds also provide safer turn movements and can reduce operating costs. Costs include those for any physical modification or improvement to the roadway and signal systems.

EFFECTS EVALUATION

Evaluation of this strategy requires first that any travel time savings be determined. This may be done using the proposed priority plans or field measurements. Arterial analysis packages such as HCS or TRANSYT may be useful for this task. These savings may then be used to determine changes in ridership using sketch planning techniques or the regional travel demand model.

This analysis should also examine the impacts to mixed-flow traffic caused by the combination of a reduction in volume (reduced number of vehicles as travelers shift to transit) and reduced green times for certain movements (in the case of transit vehicle signal priority). The NETSIM model incorporates a bus priority feature and can analyze the impact of reductions in bus dwell time on arterial streets. Measures that primarily affect convenience and safety are more difficult to quantify.

Most of these changes would require special, route-specific data collection efforts. Signal priority would require not only bus-related travel time information, but also an assessment of impacts on other traffic.

STRATEGY # 93 Traffic Operations for Transit

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Most of these improvements are made by the city or agency with jurisdiction over the roadway and not by the transit agency. Coordination between the jurisdictional agency and the transit provider will ensure greater success for implementing this strategy.

WARRANTS

No definite warrant

EXAMPLES

A. Bremerton, WA: (1990 pop – 189,731); Public Bus-Preemption Signals; $4.5 million for start-up cost of entire preemption system; Federal and State; 14,114 passengers daily ridership; elements include 50-60 intersections with preemption and 40 fixed bus routes; integrated vehicle location system allows on-board computer to activate preemption at an intersection when the bus is running late; public's perception is changing regarding buses being slower than personal automobiles.

STRATEGY #	**94**	Transit Marketing/Information	**ORIENTATION**	Demand
CATEGORY	Transit Operational Improvements			

DESCRIPTION

Transit marketing and information is a strategy to improve public knowledge of the types of services available. Examples include marketing programs, service coordination, and information systems. Marketing programs detail what services are available and describe the benefits for using transit. Marketing can be facilitated by advertisements or special promotions. Information systems tell prospective riders how to use the transit service. Types of information programs can include transit route maps and schedules as well as advanced transit information systems. Agency coordination is the cooperation between different transit agencies in providing services. Examples of agency coordination include fare coordination, schedule coordination, coordinated customer information, and signage coordination.

This strategy can be applied to particular locations or subareas or to an entire region. An example is the application of marketing and information to an entire region, or only to areas with growth or with new or changed service. Signage coordination can be applied over the entire region, whereas schedule coordination need only be applied where different services overlap. Complementary strategies include transit service improvements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Transit Convenience Increase HOV Trips Reduce Total Vehicle Trips	Mode share/shift Transit ridership	Mode shift Ridership Usage/customer satisfaction surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase transit use Reduce vehicular trips	Improve transit convenience	Increase transit ridership

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Medium	Medium

RELATIVE BENEFIT NOTES

By increasing awareness and ease of use, transit marketing and information measures can attract new riders. The implementation of transit coordination measures will help improve service quality which in turn will increase transit ridership. These measures marginally reduce congestion levels by encouraging more travelers to use transit and reducing the number of vehicle trips.

Implementation of a "typical" package of marketing and information actions can result in a 0.50 percent increase in transit ridership, although comprehensive marketing programs combined with other actions such as route or schedule changes, fare reductions, and special fare programs, have been credited with ridership increases ranging from 20 to 25 percent. Impacts of these measures are limited to costs of implementation; there are no environmental impacts.

EFFECTS EVALUATION

As a rule, effects from marketing, enhanced information dissemination and coordination are too small to be effectively modeled, even with sketch planning techniques. However, these strategies offer synergistic effects that may enhance the effectiveness of other strategies. In these instances, it would be appropriate to rely on impact estimates that are in the high end of the range of potential effects.

Surveys should include questions regarding the knowledge of the system. Surveys should include the general public, not just existing transit riders.

STRATEGY # | **94** | Transit Marketing/Information

RELATIVE COST NOTES

DISADVANTAGES

INSTITUTIONAL FACTORS

Transit providers can have on-going marketing and information programs. These programs range from paid advertisements in various media to posters and signs on vehicles and in stations. Other services could include the provision of information on routes and schedules to callers via a toll-free number and ticket-by-mail programs.

WARRANTS

No definite warrant

EXAMPLES

Transit system booklets are available from Valley Metro. They can be ordered at: http://www.valleymetro.org/VM/Busops/order-bb.htm

Sun Tran has their system wide map available online at: http://suntran.com/trindex.htm

The City of Tucson Transportation Department provides an online map of their free Tucson Inner City Express Transit service. The map is at: http://dot.ci.tucson.az.us/parkwise/ticetmap/index.htm

STRATEGY #	**95**	Transit Service Improvements	**ORIENTATION**	Demand
CATEGORY	Transit Operational Improvements			

DESCRIPTION

Transit service improvements alter distribution and user serviceability. Transit service improvements include route modifications such as realignment, expansion, and new routes; schedule modifications like increased frequency, operation hour changes, schedule coordination, and timed transfers; and additional bus stops. Service improvements can also be changes in the type of service to or from fixed-route, express, and demand responsive. Other service improvements include enhanced security, comfort, reliability, and safety. Safety, frequency, ridership, schedule, potential transfers, and other current operating conditions may indicate where transit service improvements are needed. Related strategies include fleet improvements, transit support facilities, and transit marketing/information. Other complementary strategies include travel demand measures, transit/carpool incentives, HOV strategies, advanced public transportation strategies, regional multimodal traveler information systems, kiosks, growth management, and transit-oriented development.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	All Functional Classes	All locations	All congestion types	All Day

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Schedule Reliability	Customer satisfaction Frequency of transit service	Bus density

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase transit use Reduce vehicular trips	Improve transit convenience Reduce travel time	Improve air quality

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Varies Widely	Medium

RELATIVE BENEFIT NOTES

Transit service improvements can increase transit ridership by serving new markets or increasing access (route modification or expansion), reducing passenger travel times (increased frequency, express routes), or increasing attractiveness through improved comfort, reliability and safety (vehicle upgrades, security). Depending on the measure, cost impacts will vary. While route expansion will undoubtedly increase operating cost, route modification may result in no change or even a decrease. By increasing transit use and reducing vehicle trips, transit operational measures can have a positive environmental impact.

EFFECTS EVALUATION

There are a number of tools or techniques that can be used to evaluate the impacts of transit operational improvements. The appropriateness of specific techniques depends on the nature of the service improvement and the data that is available. If the proposed improvements are of a large scale, the regional travel demand model or transit travel demand model may be used. Additional models can be used for analyzing smaller-scale projects. GIS can be used to help identify service needs and analyze potential impacts. Several sketch planning techniques can also be used. The most common of these techniques involves the use of demand elasticity factors.

Special studies can be targeted toward specific routes that have undergone the most change. To detect changes in ridership, monitoring would typically need to occur over a period of time (e.g. one month before and one month after).

STRATEGY # **95** Transit Service Improvements

RELATIVE COST NOTES

DISADVANTAGES

Route expansion will undoubtedly increase operating cost.

INSTITUTIONAL FACTORS

Transit agencies are continuously identifying and implementing service improvements. A key consideration for these modifications is if there is a requirement that the service meet a minimum farebox recovery ratio. This requirement is used to assess the feasibility of proposed service expansions, as well as to identify the need for the modification or elimination of low-performing routes.

Responsibility for paying high capital and operating costs and the securement of funding are issues.

WARRANTS

No definite warrant

EXAMPLES

Commonly applied strategy.

STRATEGY # 96 Guaranteed Ride Home Programs

ORIENTATION Demand

CATEGORY Travel Demand Measures

DESCRIPTION

Guaranteed ride home programs provide transportation to individuals who would usually get home using carpool, vanpool, or transit, but were not able to use those means of transport due to special circumstances, such as working late. Guaranteed ride home programs support use of carpool, transit and other TDM strategies by giving ease to users, letting them know that in case of an emergency they have a way home and do not need a personal vehicle. Guaranteed ride home programs can be provided by an individual company or through an area wide program and can be facilitated through a company or agency owned vehicle or by providing taxi fare to users.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	Urban Metropolitan Activity Centers	All congestion types	All Day All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase HOV Trips	Mode share/shift Transit ridership Vehicle miles traveled (VMT) by congestion level	Employer records on rides given Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase HOV trips	Enhance security	None

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Medium

RELATIVE BENEFIT NOTES

The primary benefit of guaranteed ride home programs is that of adding to the sense of personal security for those people using non-SOV modes. The guaranteed ride home program provides assurance that a person can get home safely and quickly when needed. In turn, this strategy can help encourage the use of alternative modes. Research has suggested that a guaranteed ride home program can reduce SOV trips by 1-3% for employees of a company, when it is used in combination with other TDM measures.

EFFECTS EVALUATION

Guaranteed ride home programs should not be analyzed individually for trip reduction. The analysis techniques for other TDM measures can be adjusted slightly if guaranteed ride home programs are (or are not) available.

Effect is potentially much more significant than number of rides given. Surveys provide best data, but associating with the guaranteed ride home program may be difficult.

STRATEGY # **96** Guaranteed Ride Home Programs

RELATIVE COST NOTES

DISADVANTAGES

Cost to maintain a company, or transit agency vehicle.

INSTITUTIONAL FACTORS

Important issues include extent of coverage, flexibility of means, enforcement, and oversight.

WARRANTS

No definite warrant

EXAMPLES

Maricopa county has at least ten dial-a-ride programs sponsored by the county, city, or groups of cities. Contact information is available at: http://www.valleymetro.org/transit/dar.htm

A. Boulder, CO: (1990 pop - 225,339); Rideshare, Guaranteed Ride Home; Boulder Community Hospital, City of Boulder, and Community Transit Agency; cost not available; participation not available, primary services include financial incentives.

B. Denver, CO: (1990 pop. - 1,622,980); The Guaranteed Ride Home Program, RideArrangers/ECO Pass; Denver Regional Council of Governments and individual employers; cost not available, participation by 1,201 employers and 43,500 employees (1997); primary services include guaranteed taxi rides home and use of public transportation.

C. Austin, TX: (1990 pop. - 846,227); Ridefinders; Capital Metro; cost not available; participation by 33,000 (1998 average monthly ridership), 111 vans as of Aug. 1998; primary services include computerized ride matching, vanpool program, employer assistance, and guaranteed ride home.

D. Bremerton, WA: (1990 pop. - 189,731); Smart Commuter; Washington State; reimbursement of $16,577 to taxi companies who provided guaranteed rides home; participation by 882 guaranteed rides home since 1994; primary services include vanpools, guaranteed rides home, park-and-ride lots.

STRATEGY #	97	Parking/Site Management	ORIENTATION	Supply
CATEGORY	Travel Demand Measures			

DESCRIPTION

Parking and site management strategies are promoted to make the best use of limited resources, to give priority to particular users, and to restrict vehicular travel of certain types (e.g. restricting commuters, but not customers or residents). Specific measures may include parking supply limitation and preferential parking for HOVs and "Guaranteed Ride Home".

Measures that favor carpools and vanpools, include parking charges for drive-alone commuter parking, preferential parking for pool vehicles, and the elimination of free or low-cost, on-street parking employment areas. Lots may also be established in areas outside of the work site in combination with shuttle bus services to keep motor vehicles out of congested employment areas.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Adjacent Development	Not Class Specific	Urban	Recurring predictable	Peak Hour
		Metropolitan	Special event	All Year
		Special Venue		

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase HOV Trips	Mode split	Parking occupancy counts
Increase Non-Auto Trips	Parking utilization	Vehicle occupancy
Reduce Total Vehicle Trips	Vehicle miles traveled (VMT) by congestion level	Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase HOV trips	Ease of parking for customers and residents	Improve air quality
Increase non-auto trips		
Reduce vehicular trips		

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Medium	Low	Overcome Institutional Hurdles

RELATIVE BENEFIT NOTES

A limited parking supply in a region effectively reduces demand for SOV travel. The primary intent of parking management is to discourage driving by making it more difficult or more expensive to park. The higher cost and/or additional time needed to park may make alternate modes more attractive. Thus, this strategy will reduce vehicle trips and encourage the use of non-auto modes. The impact is typically greatest on peak period work trips, when parking supply is most critical. Preferential parking for HOVs will lead directly to increased HOV travel. This strategy may lead to reduced development costs due to reduced parking requirements.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips and/or shifts in mode choice. The FHWA TDM Model can be used for evaluating the potential of various TDM measures. In addition, a sketch-planning spreadsheet analysis can be performed to determine environmental impacts of a program. Elasticities can be used to estimate the impact of parking supply on pricing and the impact of parking pricing on mode choice, but the available data are somewhat limited. Another resource is the ITE Parking Generation manual which can be used to determine the number of parking spaces required for a particular development or mix of developments.

Surveys are the most direct measurement technique. Caution should be exercised on parking counts. Parkers may have merely moved to an alternative facility.

STRATEGY # 97 Parking/Site Management

RELATIVE COST NOTES

DISADVANTAGES

This strategy can be a disbenefit to commuters, particularly single occupant vehicles.

INSTITUTIONAL FACTORS

Implementation of this strategy can be difficult and requires regional/citywide coordination between private and publicly owned parking facilities.

This strategy is most often implemented on a local level (at specific sites or streets) but can also be effective across a larger area. Parking management measures may be applied in a variety of settings. Characteristics that contribute to the effectiveness of this strategy include the availability of alternative transportation options (such as public transit, non-motorized mode facilities, and rideshare services) and a high parking occupancy rate. It should be noted that it is generally recognized that most suburban areas oversupply parking, so reducing parking spaces in these areas may have minimal impact. Generally, parking management has its greatest impact in areas where parking is already in short supply, and support measures such as ridematching and preferential parking are provided by the employer.

WARRANTS

No definite warrant

EXAMPLES

A) Nuclear Regulatory Commission, North Bethesda, MD

The Nuclear Regulatory Commission has limited on-site parking (365 spaces on-site for 1,400 employees) and charges employees $60 per month for parking. Although the area is primarily auto-oriented, the site is half a block from a regional subway station and has reasonable public bus service. The agency provides guaranteed parking for carpools, offers on-site sales of subsidized transit passes (subsidy provided by the County, since as a federal government agency, NRC is not allowed to subsidize employee travel), and heavily promotes commute alternatives. This combination of measures has resulted in a mode split of 42% drive-alone, 27% carpool, and 28% transit. This is compared to a mode split for the sorrounding area of 90% drive-alone, 6% carpool, and 4% transit.

B) GEICO, Friendship Heights, MD

GEICO developed a TDM program when it consolicated 2,500 employees into a new headquarters in a medium density "suburban downtown". Parking is somewhat restricted, but the site is within a few blocks of a regional subway station. GEICO's TDM plan included: restricted on-site parking (1,020 spaces for 2,500 employees) and parking fees of $30 to $60 per month in a garage and $10 per month is a surface lot. Other measures included free parking and reserved spaces for carpools and vanpools, a subsidized vanpool program, and transit subsidies. Only 40% of GEICO's employees drive-alone, 20% rideshare, and 31% use transit. Compared to a nearby area with similar parking conditions and levels of transit service, GEICO produces 39% fewer vehicle trips.

C) Tucson, AZ

The City of Tucson Transportation Department provides periphery parking and a free Tucson Inner City Express Transit service to manage parking in downtown Tucson. Information is available at: http://dot.ci.tucson.az.us/parkwise/parkwise.htm

STRATEGY #	98	Ridesharing Programs	ORIENTATION	Demand
CATEGORY	Travel Demand Measures			

DESCRIPTION

Ridesharing is the cooperative effort between two or more people who travel together; usually to and from work. Carpools, vanpools and buspools are all examples of ridesharing. Ridesharing can include public transportation, such as buses, trains or subways, as well.

Measures to support ridesharing include promotion and marketing programs, ridematching services, and vanpool operation. Related strategies include transit/carpool incentives, preferential parking, and guaranteed ride home programs.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	All locations	Recurring predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Vehicular Travel Times Reduce Commute Cost Reduce Total Vehicle Trips Reduce VMT	Average vehicle occupancy Mode share/shift Number of carpoolers placed by program Park-and-ride-lot utilization Vehicle miles traveled (VMT) by congestion level	Parking counts at park-and-ride facilities Regional travel survey Work place surveys of mode choice

EFFECTS EVALUATION

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Reduce vehicular trips Reduce VMT	Reduce costs for personal vehicle maintenance and care Reduce travel time	Improve air quality Reduce emissions

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Easy

RELATIVE BENEFIT NOTES

Ridesharing can reduce congestion by reducing the number of vehicle trips, in turn leading to reductions in VMT, air pollution and energy consumption. For participants, ridesharing can reduce commute costs. For companies, the most visible benefit is the reduced need for parking and the associated cost savings. Like most TDM measures, the effectiveness of ridesharing programs is dependent on the location and type of program. Studies have shown that TDM programs can lead to parking reductions of up to 30%.

STRATEGY # 98 Ridesharing Programs

RELATIVE COST NOTES

DISADVANTAGES

Less flexibility for personal travel, possible late arrivals to work.

INSTITUTIONAL FACTORS

Strong employer or management support is critical to program success. Public agencies can offer Ridematching services to the general public and a variety of services to employers such as help in setting up local programs, promotional assistance, and coordinator training.

Important issues include extent of coverage, flexibility of means, enforcement, and oversight.

WARRANTS

Ridesharing programs traditionally warranted in areas with large employers. Ridesharing is warranted in large metropolitan areas.

EXAMPLES

Valley Metro has an online ridematching program at www.ShareTheRide.com. You can also call to request a ridematch or receive information about carpooling or vanpooling at the Valley Metro Rideshare Hotline number 602-262-RIDE (7433) or (TTY users: 602-495-0936). Or E-mail Valley Metro at: rideshare@valleymetro.org

Example cities include:
A. Boulder, CO: (1990 pop - 225,339); Rideshare, Guaranteed Ride Home; Boulder Community Hospital, City of Boulder, and Community Transit Agency; cost not available; participation not available, primary services include financial incentives.

B. Denver, CO: (1990 pop. - 1,622,980); The Guaranteed Ride Home Program, RideArrangers/ECO Pass; Denver Regional Council of Governments and individual employers; cost not available, participation by 1,201 employers and 43,500 employees (1997); primary services include guaranteed taxi rides home and use of public transportation.

C. Austin, TX: (1990 pop. - 846,227); Ridefinders; Capital Metro; cost not available; participation by 33,000 (1998 average monthly ridership), 111 vans as of Aug. 1998; primary services include computerized ride matching, vanpool program, employer assistance, and guaranteed ride home.

STRATEGY #	99	Transit/Carpool Incentives	ORIENTATION	Demand
CATEGORY	Travel Demand Measures			

DESCRIPTION

Subsidies or economic incentives for transit, vanpool, and carpool users can be implemented through employers or on a regional basis. Methods vary but include: providing free or subsidized vanpool service, providing free or reduced parking for carpools and vanpools, giving cash to those employees not using parking spaces, and providing employees with free or reduced-transit passes. Other incentives can include free gasoline, prizes and recognition, and paid time off. Tax advantages can also be given to employers who offer subsidies and programs that encourage use of transit or carpool. Programs like free ridematching and guaranteed ride home are also incentives to use alternative modes.

Most incentives are provided by individual employers, and often through large employers. Incentives are most effective in areas with underutilized transit service, where parking supply is limited, or where most of the employees commute long distances. Transit subsidies can be made available at the regional level as a promotion or for the goal to encourage transit use along a specific route. Complementary strategies are rideshare programs and transit enhancements.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Not Facility Specific	Not Class Specific	Urban Metropolitan	Recurring predictable	Peak Hour All Year

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Increase HOV Trips	Mode share/shift Number of trips being subsidized Vehicle miles traveled (VMT) by congestion level	Employer records of subsidies Vehicle occupancy Work place surveys

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase HOV trips	Reduce costs for personal vehicle maintenance and care	Reduce emissions Reduce energy consumption

RELATIVE BENEFITS	RELATIVE COST	EASE OF DEPLOYMENT
Low	Low	Overcome Institutional Hurdles

RELATIVE BENEFIT NOTES

Incentive-based measures generally encourage HOV (transit, carpool, vanpool) use by reducing the costs incurred by travelers. The overall impact may be measured through a reduction in SOV vehicle trips, and an increase in carpool or transit mode share. Experience in New York/New Jersey indicates that participants in a transit subsidy program were able to increase transit use by approximately 15%.

EFFECTS EVALUATION

The effect of this strategy is generally measured by the reduction in vehicle trips and/or shifts in employee mode choice. Travel models can be used for evaluating the potential of various TDM measures. In addition, a sketch-planning spreadsheet analysis can be performed to determine environmental impacts of a program.

The impact of these programs can also be estimated through peer group comparisons with other programs where information about transit and/or carpool participation (either increased transit utilization, carpool formation or better rideshare retention) is known. This information can then be used to calculate the potential increase in carpool share or transit utilization rates at the study location. After implementation, surveys of employees can be used to measure actual mode shifts.

Records of subsidies provide relatively easy methods to determine approximate effect. However, one must ensure that subsidies are being used as intended.

STRATEGY # **99** Transit/Carpool Incentives

RELATIVE COST NOTES

DISADVANTAGES

There are no real negative impacts for these programs, as long as there are employers willing to participate.

INSTITUTIONAL FACTORS

Who pays for the incentives can be a debated issue.

Important issues include extent of coverage, flexibility of means, enforcement, and oversight.

WARRANTS

No definite warrant

EXAMPLES

Valley Metro sponsors a Bus Card Plus Program that allows employers to distribute bus cards. The cards reduce administrative costs for buying and selling tickets, tokens, and passes and gives the employer the ability to track ridership by employees and clients. More information is available at: http://www.valleymetro.org/transit/employer.htm

A. Boulder, CO: (1990 pop - 225,339); Rideshare, Guaranteed Ride Home; Boulder Community Hospital, City of Boulder, and Community Transit Agency; cost not available; participation not available, primary services include financial incentives.

B. Denver, CO: (1990 pop. - 1,622,980); The Guaranteed Ride Home Program, RideArrangers/ECO Pass; Denver Regional Council of Governments and individual employers; cost not available, participation by 1,201 employers and 43,500 employees (1997); primary services include guaranteed taxi rides home and use of public transportation.

C. Montgomery County, MD: (1990 pop. - 4,222,830); Government Employee Transit Incentives, (Get-In) Program; Montgomery County; $35,000 for implementation; participation by over 100 county employees; primary service include monthly subsidy for not driving alone.

D. Austin, TX: (1990 pop. - 846,227); Ridefinders; Capital Metro; cost not available; participation by 33,000 (1998 average monthly ridership), 111 vans as of Aug. 1998; primary services include computerized ride matching, vanpool program, employer assistance, and guaranteed ride home.

E. Bremerton, WA: (1990 pop. - 189,731); Smart Commuter; Washington State; reimbursement of $16,577 to taxi companies who provided guaranteed rides home; participation by 882 guaranteed rides home since 1994; primary services include vanpools, guaranteed rides home, park-and-ride lots.

Notes - Supplemental Text: As mentioned earlier, some of the strategies include more information than can be printed in the format of this Appendix. The strategies with additional material are detailed below.

#12 Freeway Management – Institutional Factors

Arizona is a leader in ATMS, and regional policy supports continued growth in this area. The Phoenix metropolitan area's surveillance and control system is operated through the ADOT Freeway Management System's (FMS) Traffic Operations Center (TOC). The TOC has been in operation for 11 years. Fifty-five of ADOT's 85 operational ramp meters in the Phoenix area are tied to the FMS.

The TOC was built in 1991 for ADOT. It was originally proposed for the sole purpose of housing the FMS, but it was not long before the building's full potential was realized. In addition to FMS components the TOC is also home to several other ITS being used in Arizona. A statewide, simulcast radio system; the I-10 deck tunnel monitoring system including lighting, fans, fire detection and cameras; and elk alert sign control are several systems currently contained within the building. With the extensive computer network purchased for the FMS, however, the capability exists to bring more systems into the TOC at very little extra cost. Not only can systems be controlled directly from the TOC, but the network has the potential to be utilized by other agencies to simply collect and disseminate data to users at remote locations.

Implementation of a freeway management system involves a long timeframe and requires a multi-agency effort and public education.

#16 Dynamic Message Sign – Examples

A. Cleveland, OH: (1990 pop – 2,202,069); Federal and state; $34,000 per sign; one permanent and two portable signs.

B. Houston, TX: (1990 pop – 3,321,926); State; $75,000 to $100,000; 75 permanent signs.

C. Laredo, TX: (1990 pop – 133,239); State; $150-$200,000; 2 permanent and 2 portable flap signs.

D. Madison, WI: (1990 pop – 367,085); State; $32,000; signs with 12 flap/flip disk, solid matrix LED.

E. Cheyenne, WY: (1990 pop – 20,008); State; $30,000 per sign; 6 permanent overhead and 1 roadside signs.

F. Dane County Dynamic Message Sign Deployment (Wisconsin)

   Goals: To notify the traveling public of upcoming construction or maintenance. Approach: A DMS is deployed a few weeks prior to construction or road maintenance to notify roadway users to take an alternative route, for example. Or, if construction is in progress, it may advise motorists of lane restrictions. Location: Dane County, Wisconsin. Any location where traffic will be impacted, including construction and maintenance sites, special events, and emergencies. Current Status: As of January 2001, Dane County has four portable Dynamic Message Signs. Future Activities: The DMS are useful. Anecdotal feedback has been positive and use of the DMS will continue. The county would like to add more signs for a few permanent and semi permanent locations. Impacts: Travelers respond well to the advance notification of construction and maintenance activities. Phone calls from angry or distressed citizens regarding traffic delays have stopped. County officials appreciate having another form of communication available in times of crisis and/or emergency. Cost Information: Each DMS costs $25,000. Dane county is currently funding them through Capital Improvement funds and Federal grants. Participating Institutions: Dane County; FHWA

G. Colorado Incident Management Using Dynamic Message Signs (Colorado)

Goals: To enable corridor incident management using dynamic message signs. Approach: The Colorado Department of Transportation is installing 23 DMS on an interstate corridor. The signs are controlled from a central hub, with an on-screen visualization of the network being available to the operator. This corridor experiences heavy seasonal traffic and the objective is to place signs at interchanges where alternate routes can be taken to enable travelers to bypass congested areas and any incidents that occur. Location: The signs are located on the I-70 corridor between Utah and Vail Pass, Colorado. Current Status: The signs have been installed and are in use. Future Activities: The DOT is looking to link the signs to a central location using a planned fiber optic network. Impacts: No results are available at this time, but from previous experiments with dynamic message signs, it is shown that they can mitigate traffic flow during incidents. Cost Information: Mobile DMS units cost $25,000 each plus cellular telephone connection. Permanent installations cost $18,000 to $20,000, depending on the availability of communications infrastructure. DMS may also be rented or leased. There are also installation and integration costs, which may be thousands of dollars depending on the expense of the fiber optic network they plan to install for these signs. Participating Institutions: Colorado Department of Transportation.

#88 Traffic Signal Improvements – Examples

Texas implemented a statewide signal synchronization program and concluded that after 26 projects, and $1.7 million in expenditure, there was a 19.4 percent reduction in delay, an 8.8 percent reduction in the number of stops, and a 13.3 percent reduction in fuel consumption (Fambro et al 1995). The overall benefit/cost ratio was 38:1. In Tucson, AZ a regional program to improve traffic signals resulted in reductions in average delay per signal cycle from between 14 to 29 seconds (City of Tucson 1991). A similar effort for northern Virginia resulted in benefit/cost ratios in the 20:1 range for signal improvements. The annual user benefits (in terms of travel time savings and fuel costs) were estimated to be just over $7 million (Virginia DOT 1991). An aggressive program of signal timing optimization in California indicated a benefit-cost ratio of 58 to 1. Applied to 3,172 signals in the state, the program resulted in over a 15 percent reduction in vehicular delays and a 16 percent reduction in stops over three years. Overall travel times through these systems dropped by 7.2 percent. The reduction in fuel expenditures (8.6 percent) alone produced savings almost 18 times the total cost of implementing the signal retime program.

A comprehensive signal interconnection effort in Denver resulted in travel time reduction on the arterial corridors ranging from 7 to 22 percent (Denver Council of Governments 1995). A similar program in Richmond, Virginia saw a reduction in travel time ranging from 9 percent on one corridor to 14 percent on another; a 14 percent to 30 percent reduction in total delay; and a 28 percent to 39 percent reduction in stops (Virginia DOT 1994).

A. San Francisco Bay Area, CA: (1990 pop –6,249,881); Regional Traffic Signalization and Operation Program; $18.0 million cost; Metropolitan Transportation Commission; primary services included retiming or replacement of existing regional traffic signals; benefits include 15% improvement in travel times, a $1.2 million fuel cost savings, and reduced auto emissions of approximately 110 tons per year.

B. Montgomery County, MD: (1990 pop –4,222,830); Transportation Management Center; $3.0 million annually; County of Montgomery, U.S. DOT, and Maryland DOT; primary services included traffic responsive signal system, inductance loops, microwave detection, machine vision, traffic video, camera system, and aerial traffic monitoring; benefits include 14$-20% increased rush hour travel speeds and 17$-37% decreases in delay.

C. Greater Detroit (Oakland County), MI: (1990 pop –4,266,654); FAST-TRAC; $7.0 million for FY 1998; The County of Oakland; primary services included upgrade, maintain, coordinate, and replace traffic signal systems; benefits include reports that communities within the county have experienced positive effects (such as reduced traffic accidents) as a result of the increased signalization.

D. Laredo, TX: (1990 pop –133,239); Traffic Signalization System; per year $200,000 to install 4 new signals plus $20,000 per year on upgrades and maintenance; Texas DOT; primary services include 63 traffic signals using a closed loop, on line NAZTEZ program; traffic relief benefits have caused DOT to see approval for additional upgrades.

E. Houston, TX: (1990 pop –3,321,926); TranStar; $13.454 million cost; City of Houston, Harris County, Metropolitan Transit Authority of Harris County, and Texas DOT; primary services included computerized traffic signals, computerized freeway management system, roadway sensors, and automatic vehicle location systems; this is one of the largest undertakings of an on-line, real-time, computerized system that manages 3,000 intersections.

F. Vancouver, WA: (1990 pop – 463,634); Public Works, Transportation Agency; double left turn lanes ($400,000), signal intersection improvements ($135,000-$550,000), signal modifications and provisions of dual left-turn lane ($146,000); U.S. DOT and Washington DOT; primary services for this single intersection included right turn channels (most with a raised median), left turn pockets, and islands for traffic signals; reported that traffic accidents reduced at this intersection.

Of the approximate 240,000 urban signalized intersections in the United States, about 148,000 need upgrading of physical equipment and signal timing optimization, while another 30,000 are only in need of signal timing optimization (Federal Highway Administration, 1987).

APPENDIX G

USER GUIDE TO THE CONGESTION STRATEGIES DATABASE IN MS ACCESS ENVIRONMENT

CONGESTION MITIGATION STRATEGIES DATABASE

USER GUIDE

Research Project SPR 542 - TRACS No. R0542 14P

Prepared for

Arizona Department of Transportation
Arizona Transportation Research Center
206 S. 17th Avenue
Phoenix, Arizona 85007

Prepared by

Virginia A. Sapkota & Cody T. Christensen
Bucher, Willis & Ratliff Corporation
18001 North 79th Avenue, Glendale, Arizona 85308
7920 Ward Parkway Kansas City, Missouri 64114

October 2002

TABLE OF CONTENTS

1. INTRODUCTION 396
2. CONGESTION STRATEGIES IN THE DATABASE 397
3. TABLES, FIELDS AND RELATIONSHIPS 400
   3.1 TABLES 400
   3.2 FIELDS 404
   3.3 RELATIONSHIPS 412
4. FORMS, QUERIES AND REPORTS 414
   4.1 FORMS 414
   4.2 QUERIES 418
   4.3 REPORTS 420
5. USING ADOT'S TOOLBOX 428
   5.1 OPENING MS ACCESS FILE 428
   5.2 THE MAIN SWITCHBOARD 428
   5.3 VIEWING STRATEGIES 432
   5.4 EDITING STRATEGIES 445
   5.5 QUERYING RECORDS 448
   5.6 USING PREDEFINED REPORTS 455
   5.7 EXITING FROM THE DATABASE 455

LIST OF FIGURES

Figure 1	Relationships of Tables in the Congestion Strategies Toolbox	413
Figure 2	Main Viewing Form	416
Figure 3	Main Editing Form	417
Figure 4	Single Field Query Example	419
Figure 5	Multiple Field Query Example	421
Figure 6	Report from a Single Field Query in Figure 4: Performance Measure is Average Vehicle Occupancy	422
Figure 7	Report from a Single Field Query in Figure 4: Performance Measure is Percentage of Trips in Peak Hour	423
Figure 8	Report from a Multiple Field Query	425
Figure 9	Example of a One-Page Report Summary per Strategy	426
Figure 10	Listing of Strategy by Category (Two Categories Selected)	427
Figure 11	Main Switchboard	429
Figure 12	Predefined Query Switchboard	430
Figure 13	Print Reports Switchboard	431
Figure 14	Main Viewing Form: Driveway Management Strategy	433
Figure 15	Application Considerations: Driveway Management Strategy	434
Figure 16	Performance Objectives and Measures: Driveway Management Strategy	435
Figure 17	Data Requirements and Ease of Deployment: Driveway Management Strategy	436
Figure 18	Benefits/Cost: Driveway Management Strategy	437
Figure 19	Disadvantages: Driveway Management Strategy	438
Figure 20	Institutional Factors: Driveway Management Strategy	439
Figure 21	Warrants: Driveway Management Strategy	440
Figure 22	Examples: Driveway Management Strategy	441
Figure 23	Evaluation: Driveway Management Strategy	442
Figure 24	Use of Individual Form to View a Strategy Attribute: Example of “Passing Lanes” Performance Objectives	444
Figure 25	Examples and Evaluation of Effects Data Entry Form	446

LIST OF TABLES

Table 1 Recommended Strategies Listed by Category 397

Table 2 Tables, Fields and Data Types 401

Table 3 Fields with “Pick List” Items 405

Table 4 List of FORMS in the Database 414

Table 5 List of Predefined Queries 418

Table 6 List of Predefined Reports 420

1. INTRODUCTION

This document provides guidance to users of the congestion mitigation strategies toolbox developed for ADOT's State Highway System. There are four parts in this user guide. The first part provides a full list of the recommended strategies outlined in Section 5.4 (Table 5) of the main report. The second part outlines the details of the tables, the fields contained in each table, and the data types defined for each field in each table. The third part provides an overview of the database, while the fourth and last part is a brief guide on how the user can access the information in the database.

The recommended congestion mitigation strategies are stored in a relational database system using the MS Access 2002 version. An overview of the database in MS Access environment is described in Section 5 of this User Guide.

2. CONGESTION STRATEGIES IN THE DATABASE

The recommended strategies described in Section 5.4 of the main report are listed below in Table 1. There are 99 strategies listed by category. The categories are ordered alphabetically. Note that each strategy is assigned a unique Strategy ID number as indicated in Table 1.

Table 1 Recommended Strategies Listed by Category

Access Management

- #1 Driveway Management
- #2 Frontage Roads
- #3 Median Management

Advanced Public Transportation Systems

- #4 Automatic Vehicle Location System
- #5 Electronic Fare Payment
- #6 Vehicle Management Systems

Advanced Traffic Management Systems

- #7 Alternate Routing Information System
- #8 Automatic Anti-Icing System
- #9 Electronic Border Crossing
- #10 Electronic Toll Collection (ETC)
- #11 Emergency Management
- #12 Freeway Management
- #13 Highway-Rail Intersections Management
- #14 Smart Corridors
- #15 Special Event Plans

Advanced Traveler Information Systems

- #16 Dynamic Message Sign
- #17 Kiosk
- #18 Regional Multimodal Traveler Information
- #19 Road Weather Information Systems (RWIS)

Advanced Vehicle Control Systems

- #20 Collision Avoidance System
- #21 Vehicle Guidance System

Alternative Work Arrangements

- #22 Compressed Work Weeks
- #23 Flex-Time
- #24 Staggered Work Hours

Arterials and Collectors

- #25 Add Lanes to Existing Facilities
- #26 Construct New Facilities

Commercial Vehicle Improvements

- #27 Advanced Port Processing Plans
- #28 Commercial Vehicle Facilities
- #29 Geometric Improvements
- #30 Intermodal Facilities
- #31 Truck Routes

Commercial Vehicle Operations (CVO)

- #32 Electronic Credential Checking
- #33 Weigh-in-Motion System

Communication Substitution

- #34 Online Shopping
- #35 Telecommuting
- #36 Teleconferencing
- #37 Teleshopping

Construction Management

- #38 Advance Notice
- #39 Construction Management Plans
- #40 Detours
- #41 Lane Closures Management
- #42 Signing

Expressways

- #43 Add Lanes to Existing Facilities
- #44 Construct New Facilities

Freeways

- #45 Add Lanes to Freeways
- #46 Construct New Freeways
- #47 Freeway Auxiliary Lanes
- #48 Freeway Express Lanes
- #49 Freeway Ramp Lane Additions
- #50 Freeway to Freeway Connections

HOV Measures

- #51 HOV Priority Systems
- #52 HOV Support Services

Incident Management

- #53 Hazardous Material Incident Response
- #54 Incident Clearance
- #55 Incident Detection/Verification
- #56 Incident Information/Routing
- #57 Incident Response

Land Use/Zoning and Growth Management

- #58 Compact Development
- #59 Corridor Land Use and Transportation Coordination
- #60 Jobs/Housing Balance
- #61 Mixed Use Development
- #62 Transit-Oriented Development

Non-Motorized Measures

- #63 Bike Lanes
- #64 Bike Route Marking/Signing
- #65 Bike/Pedestrian Support Services
- #66 Pedestrian Overpass/Underpass
- #67 Shared-Use Paths
- #68 Sidewalks

Road Pricing

- #69 Parking Fees
- #70 Road User Fees

Roadway Geometric Improvements

- #71 Acceleration/Deceleration Lanes
- #72 Bus Turnouts
- #73 Channelization
- #74 Climbing Lanes
- #75 Grade Separation
- #76 Improve Shoulders
- #77 Lane Widening
- #78 One-way Couplets
- #79 Passing Lanes
- #80 Providing Additional Lanes without Widening
- #81 Reversible Lanes
- #82 Turn Lanes
- #83 Vehicle Pullouts

Time-of-Day Restrictions

- #84 Parking Restrictions
- #85 Truck Restrictions
- #86 Turning Restrictions

Traffic Operational Improvements

- #87 Ramp Metering
- #88 Traffic Signal Improvements

Transit Capital Improvements

#89 Exclusive Right-of-Way Facilities

#90 Fleet Improvements

#91 Transit Support Facilities

Transit Operational Improvements

#92 Fare Incentives

#93 Traffic Operations for Transit

#94 Transit Marketing/Information

#95 Transit Service Improvements

Travel Demand Measures

#96 Guaranteed Ride Home Programs

#97 Parking/Site Management

#98 Ridesharing Programs

#99 Transit/Carpool Incentives

3. TABLES, FIELDS AND RELATIONSHIPS

A relational database system organizes information by way of two-dimensional tables, i.e. with columns or fields of attributes pertinent to rows or records of data. Each table stores one topic or subject and is uniquely identified. Likewise each record in a table must be unique. Tables are logically linked to enable querying of meaningful information. The link is established by defining the relationships between two tables. The ability to link tables and dynamically query makes a relational database system efficient in extracting information from a diverse set of data.

3.1 Tables

As discussed in Section 6 of the main report, the database has 32 tables. Table 2 provides a complete list of the tables including the fields defined for each table, together with the data type defined for each field. An index below is provided for ease in navigating the tables.

INDEX

List of TABLES in the database

- Strategy
- Orientation
- Category
- Functional Class
- Functional Class Details
- Facility Characteristics
- Facility Characteristics Details
- Geographic Location
- Geographic Location Details
- Congestion Type
- Congestion Type Details
- Congestion Period
- Congestion Period Details
- Performance Objective
- Performance Objective Details
- Performance Measure
- Performance Measure Details
- Data Requirements
- Data Requirements Details
- System Benefit
- System Benefit Details
- User Benefit
- User Benefit Details
- Other Benefit
- Other Benefit Details
- Relative Benefits
- Relative Cost
- Ease of Deployment
- References
- References Details
- Glossary
- Switchboard Items

Table 2 Tables, Fields and Data Types

*Note: * denotes primary key in each table*

STRATEGY

Field Name	Data Type
StrategyID*	Number
CategoryID	Number
OrientationID	Number
StrategyName	Text
StrategyDescription	Memo
CostID	Number
RelativeCostNotes	Memo
RelativeBenefitID	Number
Disadvantages	Memo
InstitutionalFactors	Memo
Warrants	Memo
Examples	Memo
Evaluation	Memo

ORIENTATION

Field Name	Data Type
OrientationID*	Number
Orientation	Text

CATEGORY

Field Name	Data Type
CategoryID*	Number
CategoryName	Text
CategoryDescription	Memo

FUNCTIONAL CLASS

Field Name	Data Type
FunctionalClassificationID*	Number
FunctionalClassification	Text

FUNCTIONAL CLASS DETAILS

Field Name	Data Type
StrategyID*	Number
FunctionalClassificationID*	Number

FACILITY CHARACTERISTICS

Field Name	Data Type
FacilityCharacteristicsID*	Number
FacilityCharacteristics	Text

FACILITY CHARACTERISTICS DETAILS

Field Name	Data Type
StrategyID*	Number
FacilityCharacteristicsID*	Number

GEOGRAPHIC LOCATION

Field Name	Data Type
• GeographicLocationID*	• Number
• GeographicLocation	• Text

GEOGRAPHIC LOCATION DETAILS

Field Name	Data Type
• StrategyID*	• Number
• GeographicLocationID*	• Number

CONGESTION TYPE

Field Name	Data Type
• CongestionTypeID*	• Number
• CongestionType	• Text

CONGESTION TYPE DETAILS

Field Name	Data Type
• StrategyID*	• Number
• CongestionTypeID*	• Number

CONGESTION PERIOD

Field Name	Data Type
• CongestionPeriodID*	• Number
• CongestionPeriod	• Text

CONGESTION PERIOD DETAILS

Field Name	Data Type
• StrategyID*	• Number
• CongestionPeriodID*	• Number

PERFORMANCE OBJECTIVE

Field Name	Data Type
• PerformanceObjectiveID*	• Number
• PerformanceObjective	• Text

PERFORMANCE OBJECTIVE DETAILS

Field Name	Data Type
• StrategyID*	• Number
• PerformanceObjectiveID*	• Number

PERFORMANCE MEASURE

Field Name	Data Type
• PerformanceMeasureID*	• Number
• PerformanceMeasure	• Text

PERFORMANCE MEASURE DETAILS

Field Name	Data Type
• StrategyID*	• Number
• PerformanceMeasureID*	• Number

DATA REQUIREMENTS

Field Name	Data Type
• DataRequirementsID*	• Number
• DataRequirements	• Text

DATA REQUIREMENTS DETAILS

Field Name	Data Type
• StrategyID*	• Number
• DataRequirementsID*	• Number

SYSTEM BENEFIT

Field Name	Data Type
• SystemBenefitID*	• Number
• SystemBenefit	• Text

SYSTEM BENEFIT DETAILS

Field Name	Data Type
• StrategyID*	• Number
• CategoryID	• AutoNumber
• SystemBenefitID*	• Number

USER BENEFIT

Field Name	Data Type
• UserBenefitID*	• Number
• UserBenefit	• Text

USER BENEFIT DETAILS

Field Name	Data Type
• StrategyID*	• Number
• UserBenefitID*	• Number

OTHER BENEFIT

Field Name	Data Type
• OtherBenefitID*	• Number
• OtherBenefit	• Text

OTHER BENEFIT DETAILS

Field Name	Data Type
• StrategyID*	• Number
• OtherBenefitID*	• Number

RELATIVE BENEFITS

Field Name	Data Type
• RelativeBenefitID*	• Number
• RelativeBenefit	• Text

RELATIVE COST

Field Name	Data Type
• CostID*	• Number
• Cost	• Text

EASE OF DEPLOYMENT

Field Name	Data Type
DeploymentID*	Number
Deployment	Text

REFERENCES

Field Name	Data Type
SourceID*	Number
Source	Text

REFERENCES DETAILS

Field Name	Data Type
StrategyID*	Number
SourceID*	Number

GLOSSARY

Field Name	Data Type
GlossaryID*	AutoNumber
Term	Text
Definition	Memo

SWITCHBOARD ITEMS

Field Name	Data Type
SwitchboardID*	Number
ItemNumber	Number
ItemText	Text
Command	Number
Argument	Text

3.2 Fields

The fields defined for each strategy were presented in Section 5 (Figure 2) of the main report. Some of the fields have "pick list" items, allowing more than one attributes to be associated with a strategy. For example, two or more performance measures may be associated with a strategy. Similarly, a strategy may be applicable to more than one type of congestion. Table 3 provides a complete list of fields with "pull-down" or "pick lists". An index below is provided for ease in navigating the fields.

INDEX

List of FIELDS in the database with "pick list" item

Orientation Name
Category Name
Functional Class
Facility Characteristics
Geographic Location
Congestion Type
Congestion Period
Performance Objective
Performance Measure
Data Requirements
System Benefit
User Benefit
Ease of Deployment
Other Benefit
Relative Benefits
Relative Cost

Table 3 Fields with "Pick List" Items

ORIENTATION NAME

Demand
Supply

CATEGORY NAME

Access Management
Advanced Public Transportation Systems
Advanced Traffic Management Systems
Advanced Traveler Information Systems
Advanced Vehicle Control Systems
Alternative Work Arrangements
Arterials and Collectors
Car Sharing Program
Commercial Vehicle Improvements
Commercial Vehicle Operations (CVO)
Communication Substitution
Construction Management
Expressways
Freeways
HOV Measures
Incident Management
Land Use/Zoning and Growth Management
Non-Motorized Measures
Ridesharing Programs
Road Pricing
Roadway Geometric Improvements
Time-of-Day Restrictions
Traffic Management
Traffic Operational Improvements
Transit Capital Improvements
Transit Operational Improvements
Travel Demand Measures

FUNCTIONAL CLASS

Principal Arterial Interstate
Principal Arterial Expressway
Principal Arterial Other
Minor Arterial
Major Collector
Minor Collector
Local
All Functional Classes
Not Class Specific

FACILITY CHARACTERISTICS

Access Control
Adjacent Development
Environment
Facility Expansion Feasibility
Frequency of Access Points
Number of Lanes
Terrain
Vehicle Mix
Vertical and Horizontal Geometry
Not Facility Specific

GEOGRAPHIC LOCATION

Activity Centers
All locations
Metropolitan
Rural
Special Venue
Urban

CONGESTION TYPE

- Recurring predictable
- Recurring un-predictable
- Non-recurring predictable
- Non-recurring un-predictable
- Special event
- All congestion types
- Duration

CONGESTION PERIOD

- All Day
- All Year
- Off-Peak
- Peak Hour
- Seasonal
- Weekend

PERFORMANCE OBJECTIVE

- Allow Informed Decisions
- Improve Air Quality
- Improve Efficiency
- Improve Emergency Response
- Improve HOV Convenience
- Improve HOV Travel Times
- Improve Other Environmental/Socioeconomic Factor
- Improve Safety
- Improve Schedule Reliability
- Improve Traffic Flow
- Improve Transit Convenience
- Improve Transit Travel Times
- Improve Travel Speeds
- Improve Vehicular Travel Times
- Increase Capacity
- Increase HOV Trips
- Increase Non-Auto Trips
- Increase Person Throughput
- Increase Safety for Response Personnel
- Make Real-time Adjustments
- Manage Traffic Demand
- Manage Traffic Flow
- Provide Improved Knowledge of Maintenance Problems
- Provide Incident Conditions Information to Drivers
- Reduce Boarding Time
- Reduce Cash Management Costs
- Reduce Commute Cost
- Reduce Conflicts
- Reduce Delay
- Reduce Demand
- Reduce Frequency of Accidents
- Reduce Impacts of Accidents
- Reduce Length of Trip
- Reduce Secondary Incidents
- Reduce Total Vehicle Trips
- Reduce VMT
- Shift Trip Time
- Improve Throughput
- Increase Intersection Efficiency
- Reduce Accidents
- Savings on cost for tollbooths

PERFORMANCE MEASURE

Accessibility index
Accident rates
Accident rates for equipped vs. non-equipped vehicles
Accident Risk index
Accidents at major intermodal facilities(e.g., railroad crossings)
Accidents per VMT or PMT
Administrative efficiency improvements
Amount/proportion of traffic diverted
Average cost per lane-mile constructed
Average duration of incident
Average service times
Average speed
Average travel speed by heavy vehicles
Average travel time by heavy vehicles
Average travel time from origin to destination
Average trip length
Average vehicle occupancy
Cost for transportation system services
Cost per passenger
Cost per ton-mile
Cost savings
Cost-benefit measures
Customer perception of safety
Customer perception of urban quality
Customer perceptions on travel times
Customer satisfaction
Delay
Delay on minor street
Delay per ton-mile
Delay per vehicle
Delay reductions
Difference between change in urban household density and suburban household density
Duration of queues
Economic cost of crashes
Economic cost of lost time

Effects on business
Environmental factors
Facility usage
Freeway mainline/ramp accidents
Frequency of transit service
Fuel consumption per VMT or PMT
HOV lane travel speed
HOV lane travel time
HOV use
Incident detection time
Intersection delay
Intersection level of service
In-vehicle travel time
Jobs created or supported (directly and indirectly)
Level of service
Lost time due to congestion
Maintenance costs
Miles of congested roadway
Miles/intersection with access control
Mode share/shift
Mode split
Number of accidents involving hazardous waste
Number of accidents per capita
Number of accidents per ton-mile
Number of accidents per VMT
Number of accidents per year
Number of breakdowns
Number of carpoolers placed by program
Number of construction-related fatalities
Number of days in air quality noncompliance
Number of high accident locations
Number of people working at home
Number of stops
Number of trips being subsidized
Numbers of bridges with vertical clearance less that x feet
Occurrence of secondary incidents
On-time arrivals
Origin-destination of travel times

Overall mode split by facility or route
Park-and-ride-lot utilization
Parking utilization
Passenger trips per household
Peak load factor
Pedestrian volumes
Pedestrian-bicycle accidents
Percent walking or using bike by trip type
Percentage of employment sites with in X miles of major highway
Percentage of on time transit
Percentage of population/employment served
Percentage of population exposed to noise above certain threshold
Percentage of population within x minutes of y percentage of employment sites
Percentage of projects rated good to excellent
Percentage of region's mobility impaired who can reach specific activities by public transportation
Percentage of roads and bridges below standard condition
Percentage of trips in the peak hour
Percentage of VMT on roads with deficient ride quality
Person hours traveled or PHT
Person miles traveled or PMT
Person throughput
Person trips
Ramp queue lengths and delays
Remaining service life
Response time to accidents
Revenue
Roughness index for pavement
Savings in vehicle hours per weekday or year
Schedule reliability
Service miles between road calls for transit vehicles
Throughput
Tons of pollution
Traffic volume on segments used for diversion
Traffic volumes
Transfer time
Transit ridership

Travel time
Vehicle age distribution
Vehicle hours traveled or VHT
Vehicle miles traveled (VMT) by congestion level
Volume of cyclists
Volume throughput
Volume-to-capacity ratios
Wait time

DATA REQUIREMENTS

Accident rates
Accidents rates for heavy vehicles
Alternate routes
Approach queue length
Average trip length
Bike/pedestrian counts at representative locations
Bus density
Counts of carpoolers
Current percentage volumes by link type
Cycle length
Delay
Delay at weigh stations/border crossings
Design hour volume
Development density
Directional distribution factor
Distance between access points
Driveway volumes
Employer records of subsidies
Employer records of telecommuting
Employer records on rides given
Facility usage counts
Freeway ramp queues
Incident duration
Labor expended
Lane configurations
Lane occupancy
Length of queue
Level of service analysis
Link capacity
Link length
Link volume
Long term traffic volume trends
Maintenance and operation costs
Maintenance records
Mode shift
Moving car runs
Number of access points
Number of incidents
Number of lanes
Number of trucks in the upgrade direction
Origin-destination surveys
Parking counts at park-and-ride facilities
Parking occupancy counts
Peak hour factor
Percentage of trucks in the upgrade direction
Percentage volumes with electronic tolls
Real time speed
Real time traffic volume
Regional travel survey
Ridership
Schedule adherence monitoring
Signal density
Signal phasing and timing
Speeds
Stopped delay
Surveys of program participants
Total average weekday daily volume through toll plaza
Total average weekend daily volume through toll plaza
Total number of train-miles
Traffic counts
Traffic counts at site
Traffic volume - mainline, ramps, and arterials
Transfer time surveys
Transit in-vehicle travel time
Travel time
Trip logs
Truck flow rate
Truck tracking (e.g. GPS)
Truck travel time
Turning movement volumes
Usage/customer satisfaction surveys
Vehicle occupancy
Volume counts by vehicle class
Work place surveys
Work place surveys of mode choice

SYSTEM BENEFIT

- Allow real-time adjustments
- Allow turns from more than one lane
- Allows monitoring of transit system
- Better resource utilization
- Change in trip timing
- Defer addition of capacity
- Diversion of traffic
- Efficient use of available capacity
- Facilitate intermodal transfer
- Improve emergency vehicle access
- Improve HOV convenience
- Improve incident clearance time
- Improve incident response time
- Improve safety
- Improve system efficiency
- Improve throughput
- Improve traffic flow
- Improve incident management
- Increase capacity
- Increase HOV trips
- Increase non-auto trips
- Increase person throughput
- Increase transit operations
- Increase transit use
- Provide "correct pricing signals"
- Redistribute traffic
- Redistribution of trips
- Reduce administrative costs
- Reduce boarding times
- Reduce cash management and theft problems
- Reduce conflicts
- Reduce delay
- Reduce delay for trucks
- Reduce demand
- Reduce impact of highway accidents
- Reduce lane closures
- Reduce local congestion
- Reduce localized traffic congestion
- Reduce maintenance and operation costs
- Reduce SOV trips
- Reduce the probability of secondary accidents
- Reduce transit travel time
- Reduce vehicular trip lengths
- Reduce vehicular trips
- Reduce VMT
- Reduced peak period travel
- Save operating costs at toll plazas
- Simplify traffic signal timing

USER BENEFIT

Allow informed decisions
Customer satisfaction
Disbenefits to commuters
Ease of parking for customers and residents
Eliminate time for making trip
Enhance security
Enhance vehicle operations
Improve passenger convenience
Improve safety
Improve schedule reliability
Improve transit convenience
Improve travel speeds
Improve user efficiency
No specific benefit to user
Potential to reduce total travel cost
Provide alternative to personal vehicle
Reduce costs for personal vehicle maintenance and care
Reduce delay
Reduce driver frustration
Reduce stressful driving
Reduce travel time
Reduce vehicle conflict
Reduce waiting time
Reduced boarding times
Shorten trip lengths
Time flexibility

EASE OF DEPLOYMENT

Easy
Difficult
Overcome Institutional Hurdles
Medium

OTHER BENEFIT

Allow pedestrian crossing
Decrease accident rates
Expedite response to maintenance and security problems
Improve air quality
Improve safety
Improved interagency coordination and decision-making
Improved knowledge of maintenance problems
Increase transit ridership
None
Reduce administrative costs
Reduce emissions
Reduce energy consumption
Reduce frequency of highway accidents
Reduce noise impact
Reduce the probability of secondary accidents
Reduces cash management costs and theft problems

RELATIVE BENEFITS

Low
Medium
High
Varies Widely
Difficult to Quantify

RELATIVE COST

Low
Medium
High
Varies Widely

3.3 Relationships

Except for the Glossary table, the 32 tables listed in Table 2 are linked in the relationships shown in Figure 1. The **Strategy** table is the main table where the other tables relate to, and forms one-to-many relationships. The database is fully relational, and therefore can be queried more efficiently.

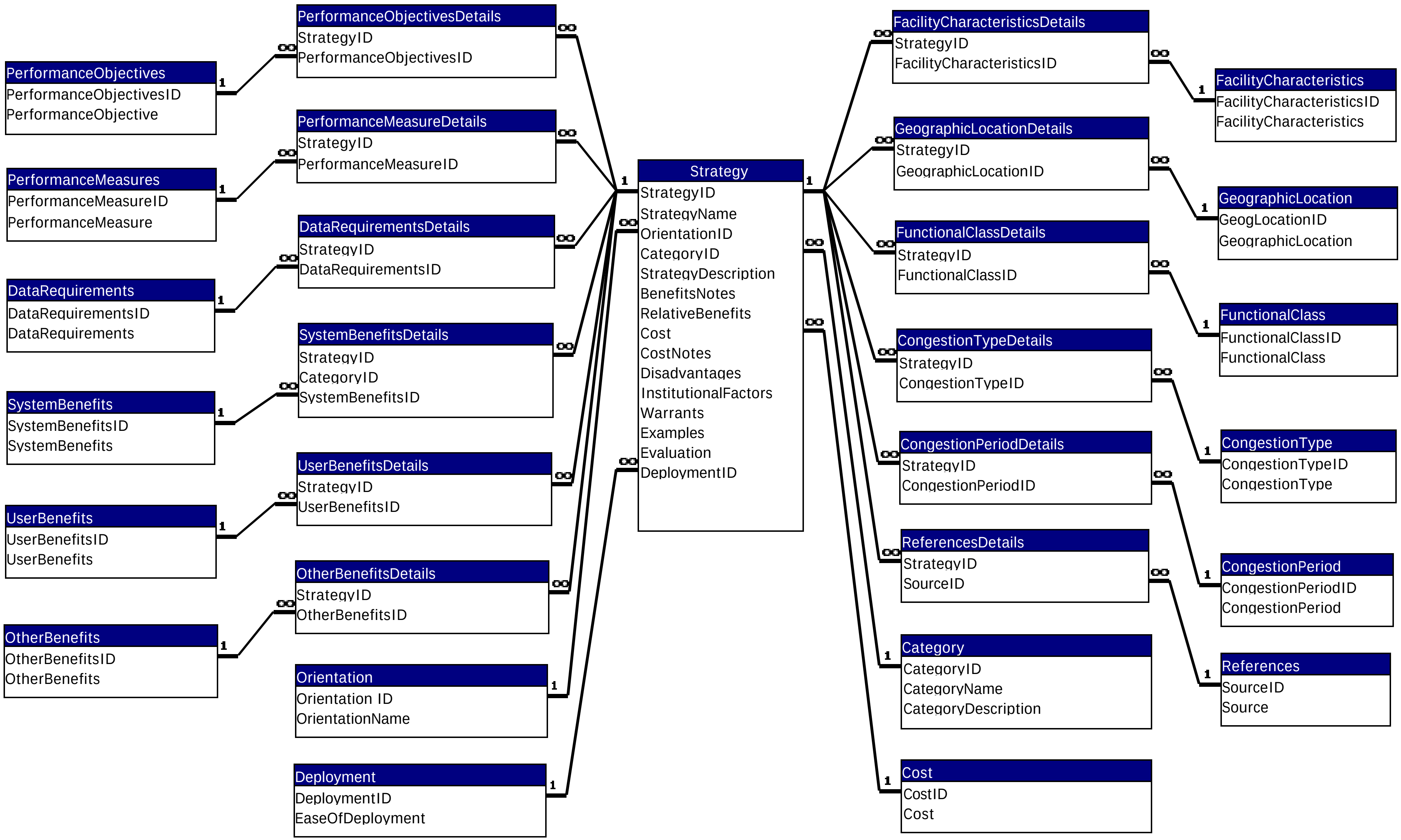


Figure 1 Relationships of Tables in the Congestion Strategies Toolbox

4. FORMS, QUERIES AND REPORTS

This section of the user guide describes the forms, queries and reports created in the database to facilitate extraction of information. Instructions and examples on how to use these forms, queries and reports are given in subsequent sections.

4.1 Forms

Forms beginning with "frm" are associated with pre-defined queries described in the next section.

Various forms are created in the database to facilitate viewing and editing of information (refer Table 4). Two of these forms are designed to show pertinent information for each strategy. Figure 2 shows the main form for viewing each strategy. This form does not allow the user to edit or modify any information. This restriction protects the database from inadvertent changes. Figure 3 on the other hand, allows viewing of information for each strategy and at the same time allows editing of information.

Both viewing and editing forms are available from the main switchboard of the database. The main switchboard is described in the next section.

Table 4 List of FORMS in the Database

1	Application Considerations
2	Application Considerations Data Entry Form1
3	Benefits Cost
4	BenefitsCost DataEntryForm
5	Category
6	Congestion Period
7	Congestion Period Details Print Subform
8	Congestion Period Details Subform
9	Congestion Type
10	Congestion Type Details Print Subform
11	Congestion Type Details Subform
12	Cost Range Explanation
13	Data Requirements
14	Data Requirements Deployment Data Entry Form
15	Data Requirements Details Print Subform
16	Data Requirements Details Subform
17	Disadvantages
18	Evaluation
19	Examples
20	Examples Evaluation
21	Facility Characteristics
22	Facility Characteristics Details Print Subform
23	Facility Characteristics Details Subform
24	frmConPeriod
25	frmConType
26	frmDataRequirements
27	frmDeployment
28	frmDeploymentAndCost
29	frmFacilityCharacteristics

30	frmFunctionalClass
31	frmLocationAndClass
32	frmLocationAndClassAndCost
33	frmLocationAndConPeriod
34	frmLocationAndConType
35	frmLocationAndCost
36	frmLocationType
37	frmLocClassConTypeSysBenefitCost
38	frmOtherBenefits
39	frmPerfMeasures
40	frmPerfObjectives
41	frmRelativeCosts
42	frmRunSuperQuery
43	frmSystemBenefits
44	frmUserBenefits
45	Functional Class
46	Functional Class Details Print Subform
47	Functional Class Details Subform
48	Geographic Location
49	Geographic Location Details Print Subform
50	Geographic Location Details Subform
51	Glossary
52	Institutional Factors
53	Main Data Entry Form
54	One-Page Print Form by Strategy
55	Other Benefits
56	Other Benefits Details Print Subform
57	Other Benefits Details Subform
58	Performance Measures
59	Performance Measure Details Print Subform
60	Performance Measure Details Subform
61	Performance Measures Data Entry Form
62	Performance Objectives
63	Performance Objectives Details Print Subform
64	Performance Objectives Details Subform
65	References
66	References Details Subform
67	Strategy Main Form
68	Switchboard
69	System Benefits
70	System Benefits Details Print Subform1
71	System Benefits Details Subform
72	System Benefits Details Subform1
73	Two-Page Print Form by Strategy
74	User Benefits
75	User Benefits Details Print Subform
76	User Benefits Details Subform
77	Warrants

4.1.1 Viewing Form

Figure 2 shows the Main Form for viewing the information in the database. More details are discussed in Section 5.

4.1.2 Editing Form

Every record in each table can be edited. The "Main Data Entry Form" shown in Figure 3 is designed to facilitate editing of information.

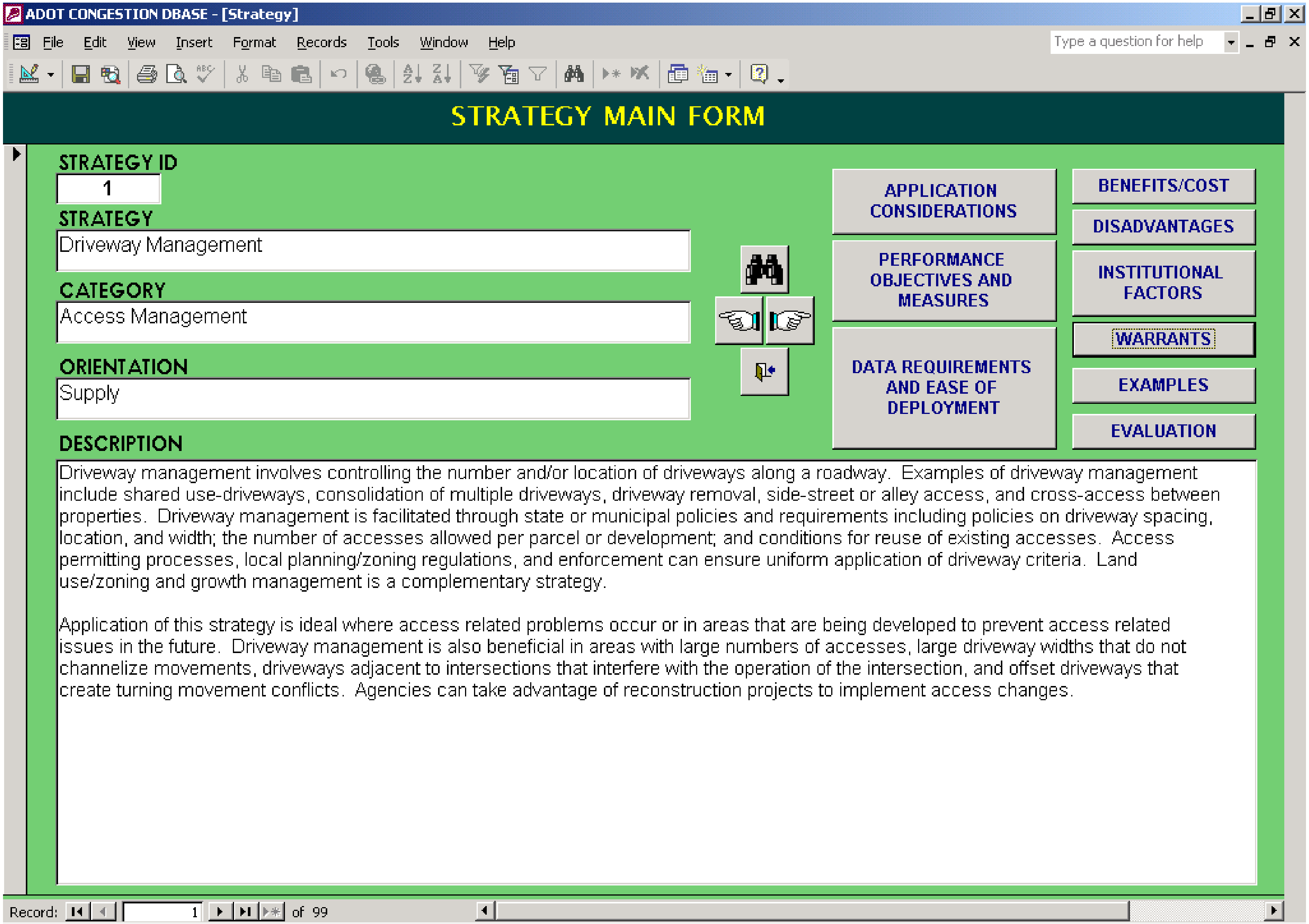


Figure 2 Main Viewing Form

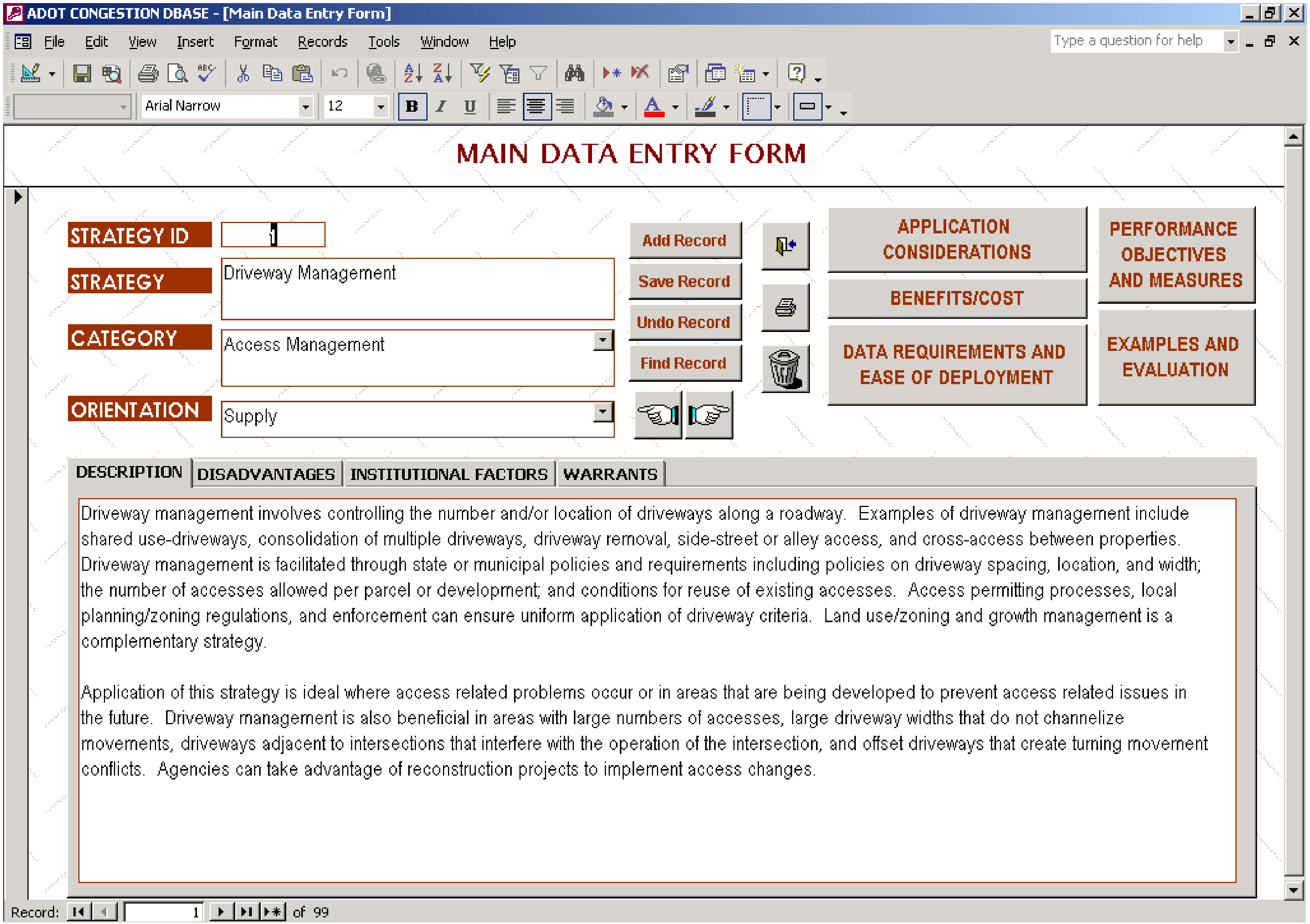


Figure 3 Main Editing Form

4.2 Queries

Predefined queries are set up to facilitate extraction of information from the database. Table 5 provides a list of the user-friendly queries. Fourteen of these queries are based on a single field, five queries on two fields, one query on three fields, and one query on five fields. There is also a query called a "Super Query". The super query considers all of the fields in the database, with all possible permutations. It generates close to two million records. Consequently, it takes a few minutes to run; therefore it should not be used unless the user requires permutations of all the data in the database.

4.2.1 Single Field Query

The predefined queries are called user-friendly because they allow the users to simply select the item from the "pull-down" list. For the single field query, the user may select one or more items from the list. Figure 4 shows an example of a single field query, where the selected field is the "performance measures". In the example, two items are chosen from the list. Clicking on the "Preview Query Results" would open a predefined report which displays the results of the query.

Table 5 List of Predefined Queries

1	Other Benefit Query
2	Query By Congestion Period
3	Query By Congestion Type
4	Query By Data Requirements
5	Query By Deployment
6	Query By Deployment and Cost
7	Query By Facility Characteristics
8	Query By Functional Class
9	Query By Location Type
10	Query By LocationClassConTypeSystemBenefitCost
11	Query By Location Type and Functional Class
12	Query By Location Type and Class and Cost
13	Query By Location Type and ConPeriod
14	Query By Location Type and ConType
15	Query By Location Type and Cost
16	Query By Other Benefits
17	Query By Performance Measures
18	Query By Performance Objectives
19	Query By Relative Benefits
20	Query By Relative Costs
21	Query By System Benefits
22	Query by User Benefits
23	Strategies
24	Strategy By Category
25	Strategy Performance Query
26	SUPER QUERY

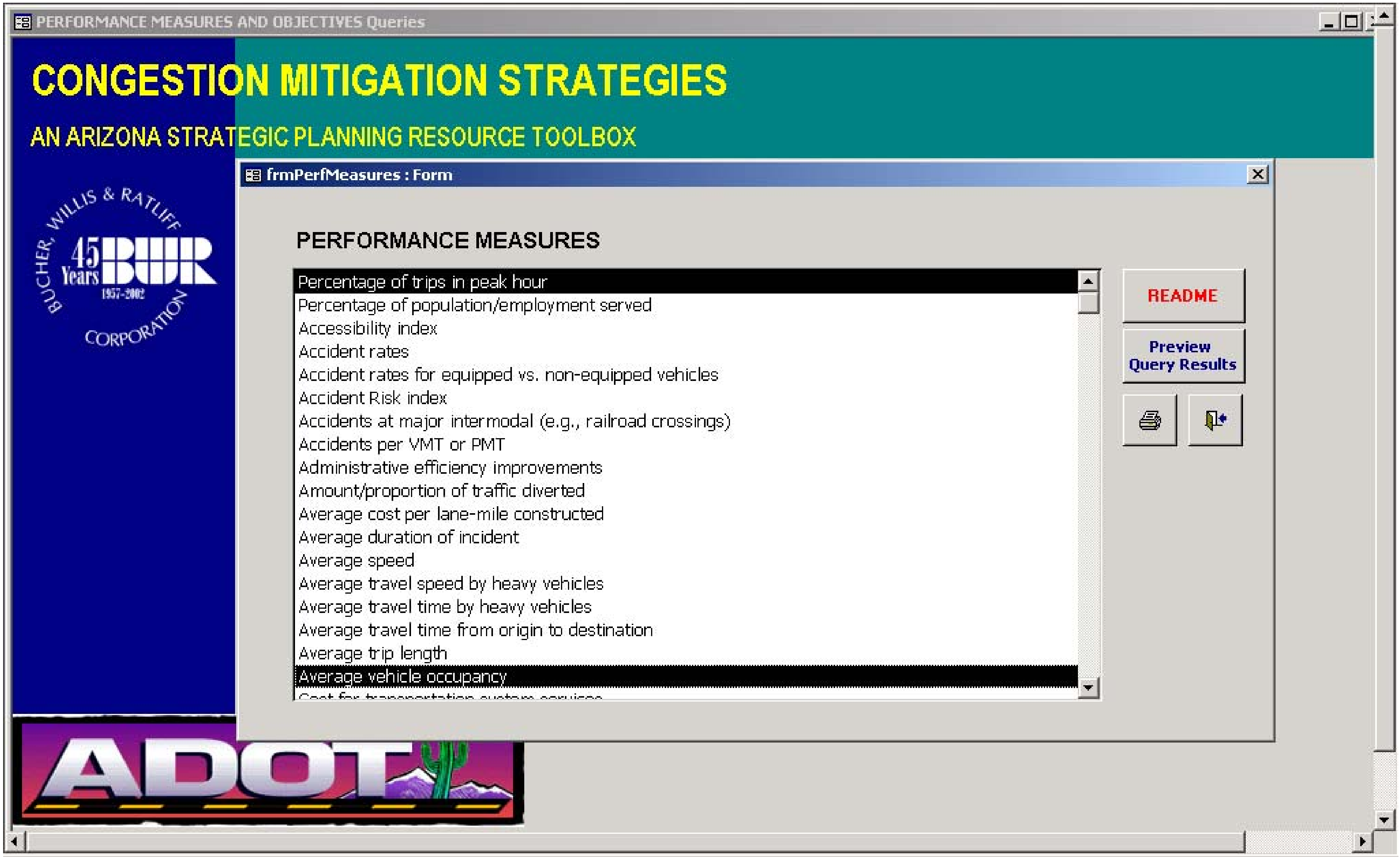


Figure 4 Single Field Query Example

4.2.2 Multiple Field Query

From the list of queries in Table 5, query number 6 and 10 to 15 are multiple field queries. An example of a multiple field query is shown in Figure 5, which uses five fields: location type, congestion type, functional class, relative cost and system benefits. The user would simply click on the item in each field. Note that only one item from the "pull-down" or "drop-down" list can be selected for the multi-field query. The query is an "and" type, therefore if any of the field returns a "null" result, then the multi-field query will return an empty report.

Examples of reports for the queries in Figures 4 and 5 are presented in the following section.

4.3 Reports

There are 25 predefined reports that can be readily sent for printing. See Table 6 for a complete list. Twenty one of these reports show the results from the 21 predefined queries.

4.3.1 Report of Strategy Based on Queries

<u>Report for the Single Field Query Example</u>

The single field query example in Figure 4, with two performance measures chosen from the "drop-down" list, generates the results shown in Figures 6 and 7. For the performance measure "Percent of trips in peak hour", there are 8 strategies meeting this query while only 3 strategies meet the performance measure of "average vehicle occupancy". The predefined reports in Figures 6 and 7 can be sent directly for printing.

Table 6 List of Predefined Reports

1	Glossary
2	One-Page PrintForm By Strategy
3	Two-Page PrintForm By Strategy
4	Print Strategy By Category
5	Print Strategy By Congestion Period
6	Print Strategy By Congestion Type
7	Print Strategy By Data Requirements
8	Print Strategy By Ease of Deployment
9	Print Strategy By Ease of Deployment and Cost
10	Print Strategy By Facility Characteristics
11	Print Strategy By Functional Class
12	Print Strategy By Location Class ConType System Benefit Cost
13	Print Strategy By Location Type
14	Print Strategy By Location Type and Class
15	Print Strategy By Location Type and Class and Cost
16	Print Strategy By Location Type and Congestion Period
17	Print Strategy By Location Type and Congestion Type
18	Print Strategy By Location Type and Cost
19	Print Strategy By Other Benefits
20	Print Strategy By Performance Measures
21	Print Strategy By Performance Objectives
22	Print Strategy By Relative Benefits
23	Print Strategy By Relative Costs
24	Print Strategy By System Benefits
25	Print Strategy By User Benefits

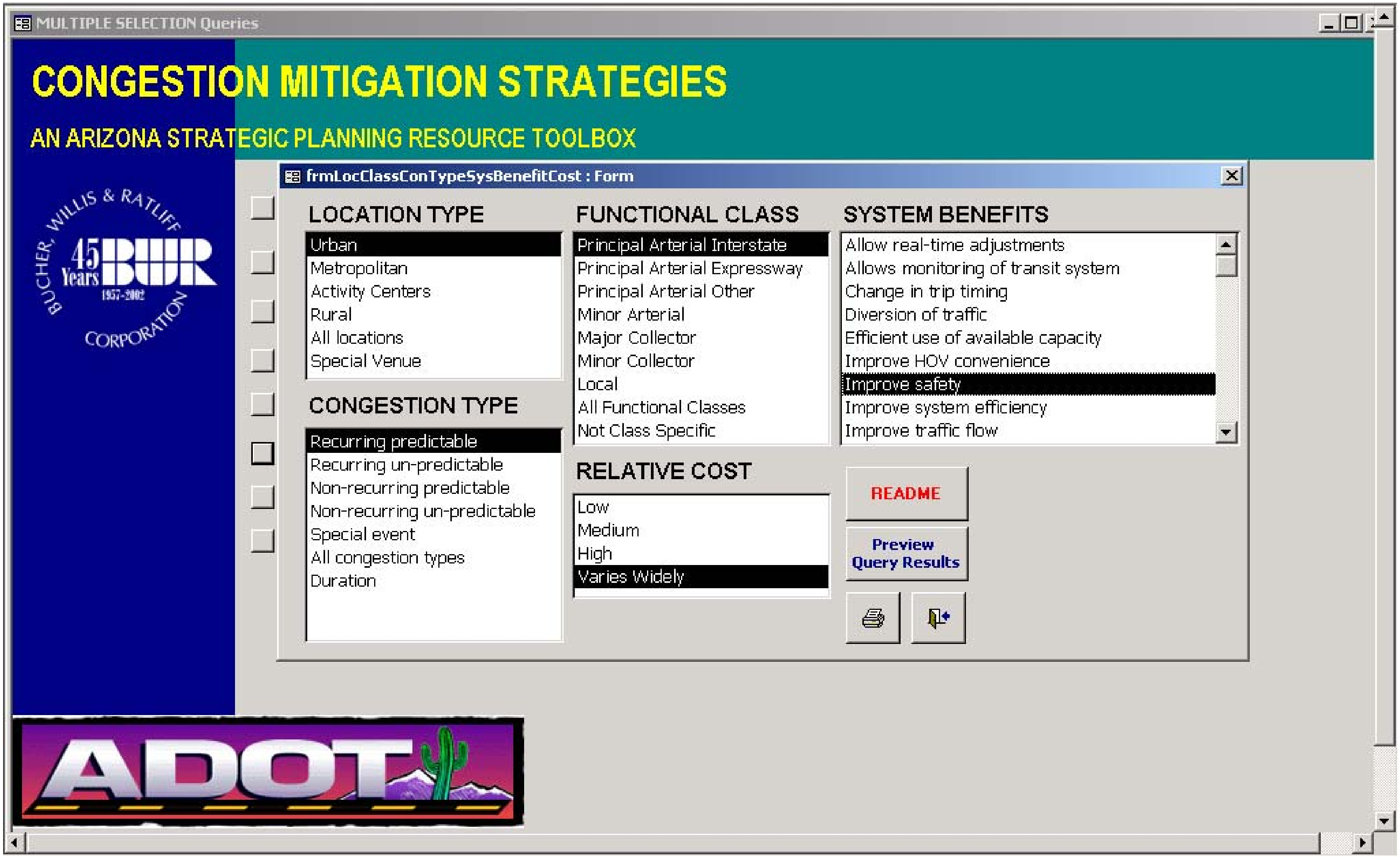


Figure 5 Multiple Field Query Example

STRATEGY BY PERFORMANCE MEASURES

PERFORMANCE MEASURES | **Average vehicle occupancy**

ORIENTATION	CATEGORY	STRATEGY	STRATEGY ID
Demand			
	HOV Measures	HOV Priority Systems	51
	Travel Demand Measures	Ridesharing Programs	98
Supply			
	HOV Measures	HOV Support Services	52

Page: 1

Figure 6 Report from a Single Field Query in Figure 4: Performance Measure is Average Vehicle Occupancy

PERFORMANCE MEASURES | **Percentage of trips in peak hour**

ORIENTATION	CATEGORY	STRATEGY	STRATEGY ID
Demand			
	Alternative Work Arrangements	Compressed Work Weeks	22
	Alternative Work Arrangements	Flex-Time	23
	Alternative Work Arrangements	Staggered Work Hours	24
	Communication Substitution	Online Shopping	34
	Communication Substitution	Telecommuting	35
	Communication Substitution	Teleconferencing	36
	Communication Substitution	Teleshopping	37
	Non-Motorized Measures	Shared-Use Paths	67

Page: 2

Figure 7 Report from a Single Field Query in Figure 4: Performance Measure is Percentage of Trips in Peak Hour

Report for the Multiple Field Query Example

The multi-field example in Figure 5 would result in only one strategy meeting all five fields as shown in Figure 8.

4.3.2 Report by Strategy

There are two predefined reports that provide a summary for each strategy. The one-page summary presents most of the pertinent fields relating to each strategy while the two-page summary shows all the fields associated to each strategy. Figure 9 shows a one-page print-out of the strategy "Median Management." Two-page summary reports for each of the 99 strategies in the database are given in Appendix F.

Using the predefined strategy report summary, the user can select the strategy to print by simply selecting the desired strategy.

4.3.3 Report Strategy by Category

A predefined report that gives the full list of strategies in the database grouped into categories is also available. The list is sorted in alphabetical order by Category. Figure 10 shows a report of strategies grouped by category for two selected categories: Access Management and Advanced Public Transportation Systems.

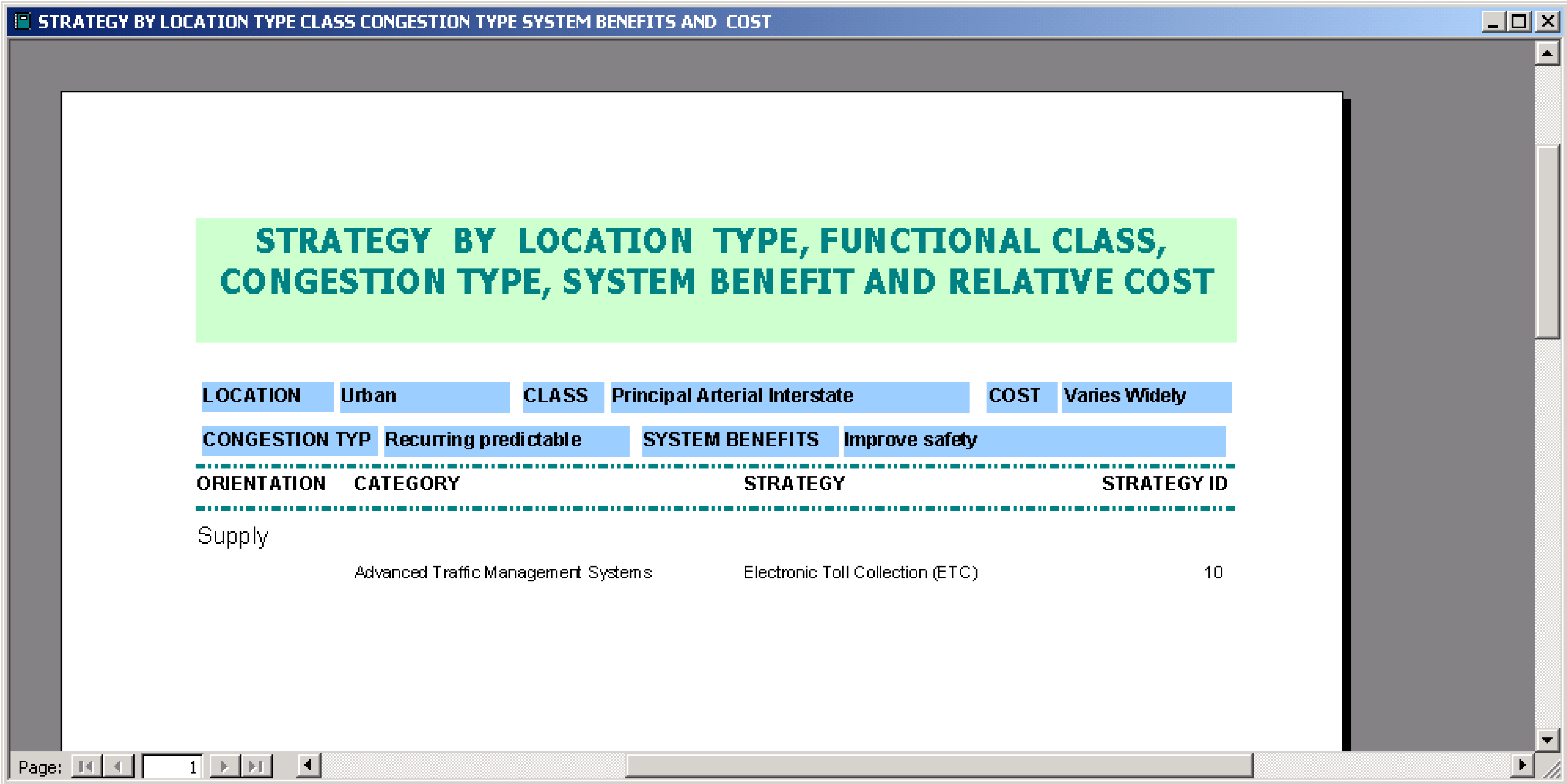


Figure 8 Report from a Multiple Field Query

STRATEGY #	3	Median Management	ORIENTATION	Supply
CATEGORY	Access Management			

DESCRIPTION

Median management involves the installation of center medians within a roadway that limit left turning movements as well as cross movements. The removal of left turns and cross traffic increases capacity and improves vehicle throughput and safety along the major roadway. Median management also involves the establishment of median breaks where left turn and through movements are allowed. Bi-directional left turn lanes can also be installed to allow left-turns from the major roadway while restricting through and left-turns from the cross street. Median management is typically facilitated through state or municipal regulatory policies and requirements that are applied to one or more functional classes of roadway. The regulatory requirements detail policies on median placement, median break locations, and median break spacing. Land use/zoning and growth management is a complementary strategy.

Application of this strategy is ideal where access related problems occur or in areas that are being developed to prevent access related issues in the future. Median management is also beneficial in areas with large numbers of accesses that create turning movement conflicts, at roadway sections with too many median breaks, when median breaks adjacent to intersections interfere with the operation of the intersection, at bi-directional turn lanes that are near capacity, and at locations that do not currently have bi-directional turn lanes. Uncontrolled strip development often leads to the need for median management and other access management strategies to restore

INSTITUTIONAL FACTORS

The implementation of median management measures is the responsibility of the agency with jurisdiction over the affected roadway. An agency may have a long standing policy of median management, but may not make significant changes in median configuration unless in conjunction with a roadway improvement. In limited circumstances, businesses have successfully petitioned an agency for reestablishing a median cut, citing adverse conditions and access.

FACILITY CHARACTERISTICS	FUNCTIONAL CLASS	GEOGRAPHIC LOCATION	CONGESTION TYPE	CONGESTION PERIOD
Frequency of Access Points	Principal Arterial Other	All locations	All congestion types	All Day
Number of Lanes	Minor Arterial			All Year
	Major Collector			

PERFORMANCE OBJECTIVES	PERFORMANCE MEASURES	DATA REQUIREMENTS
Improve Safety	Accident rates	Accident rates
Improve Travel Speeds	Average speed	Moving car runs
Increase Capacity	Delay on minor street	Traffic counts
Reduce Conflicts	Effects on business	
Reduce Delay	Miles of congested roadway	

DISADVANTAGES

Turning vehicles may experience increased travel distances and times if alternative routing is necessary. The possibility of reduced accessibility to adjacent properties is also a concern.

SYSTEM BENEFITS	USER BENEFITS	OTHER BENEFITS
Increase capacity	Improve travel speeds	Improve safety
Reduce conflicts	Reduce delay	

RELATIVE BENEFITS

Medium

RELATIVE COST

Medium

EASE OF DEPLOYMENT

Medium

EXAMPLES

A study in Wichita, Kansas, reported that prohibition of turns between intersections by use of a median reduced accidents between intersections by amounts ranging from 43 percent to 69 percent during the first three years after the median was installed. During the same period, accidents at intersections where turns were not prohibited increased by amounts ranging from 12 percent to 38 percent. However, because accidents between intersections originally represented more than 60 percent of the total accidents on the street section affected by the construction, the median construction resulted in a net accident reduction ranging from 12 percent to 38 percent (see section on Arterial Access Management).

Figure 9 Sample Database Form Showing Strategy Attributes

STRATEGY LISTING BY CATEGORY

CATEGORY **Access Management**

STRATEGY #	STRATEGY
1	Driveway Management
2	Frontage Roads
3	Median Management

CATEGORY **Advanced Public Transportation Systems**

STRATEGY #	STRATEGY
4	Automatic Vehicle Location System
5	Electronic Fare Payment
6	Vehicle Management Systems

Figure 10 Listing of Strategy by Category (Two Categories Selected)

5. USING ADOT'S TOOLBOX

The first three sections have provided an overview of the contents of the congestion mitigation strategies database, including the tables, forms, queries and reports that were created in MS Access 2002. This section gives a quick tour on how to use ADOT's strategies toolbox.

This user guide is written with the assumption that the user has some level of understanding of using the MS Access program. Therefore, instructions on how to use MS Access and its objects: tables, forms, queries and reports are not included.

5.1 Opening MS Access File

The database is stored in MS Access 2002 format. The MS Access database file is "ADOT Congestion Toolbox.mdb".

To open the database, simply double-click on the file "ADOT Congestion Toolbox.mdb". The database opens to its default switchboard, which is described below.

5.2 The Main Switchboard

When the database is opened, it defaults to a switchboard shown in Figure 11. The purpose of the switchboard is to facilitate viewing, editing and querying of information in the database by allowing users to make their selection. When the database is opened, the default view is the main switchboard.

The main switchboard has six options; two options open up other switchboards.

1. VIEW STRATEGIES— clicking on "View Strategies" selection opens up the form shown in Figure 2 and in Figure 14.

2. EDIT STRATEGIES— selecting "Edit Strategies" opens up the form in Figure 3.

3. VIEW PREDEFINED QUERIES— clicking on this option will open up another switchboard as shown in Figure 12.

4. PRINT REPORTS— this option will open another switchboard as shown in Figure 13.

5. VIEW GLOSSARY— selecting this option will open the Glossary.

6. EXIT MS ACCESS— clicking on this option will exit the MS Access program.

The user can simply close the main switchboard and go to the different database objects: tables, forms, queries and reports.

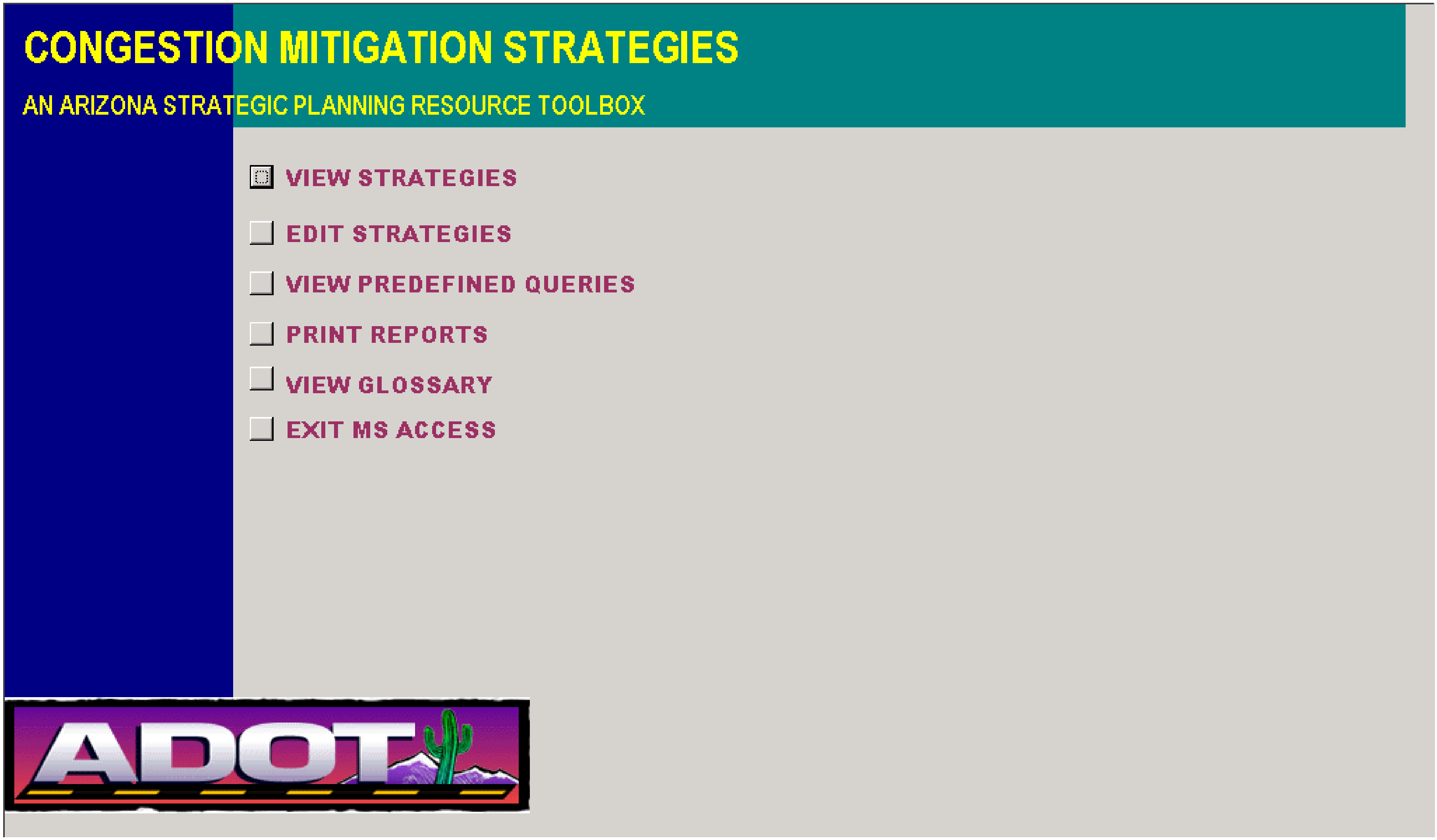


Figure 11 Main Switchboard

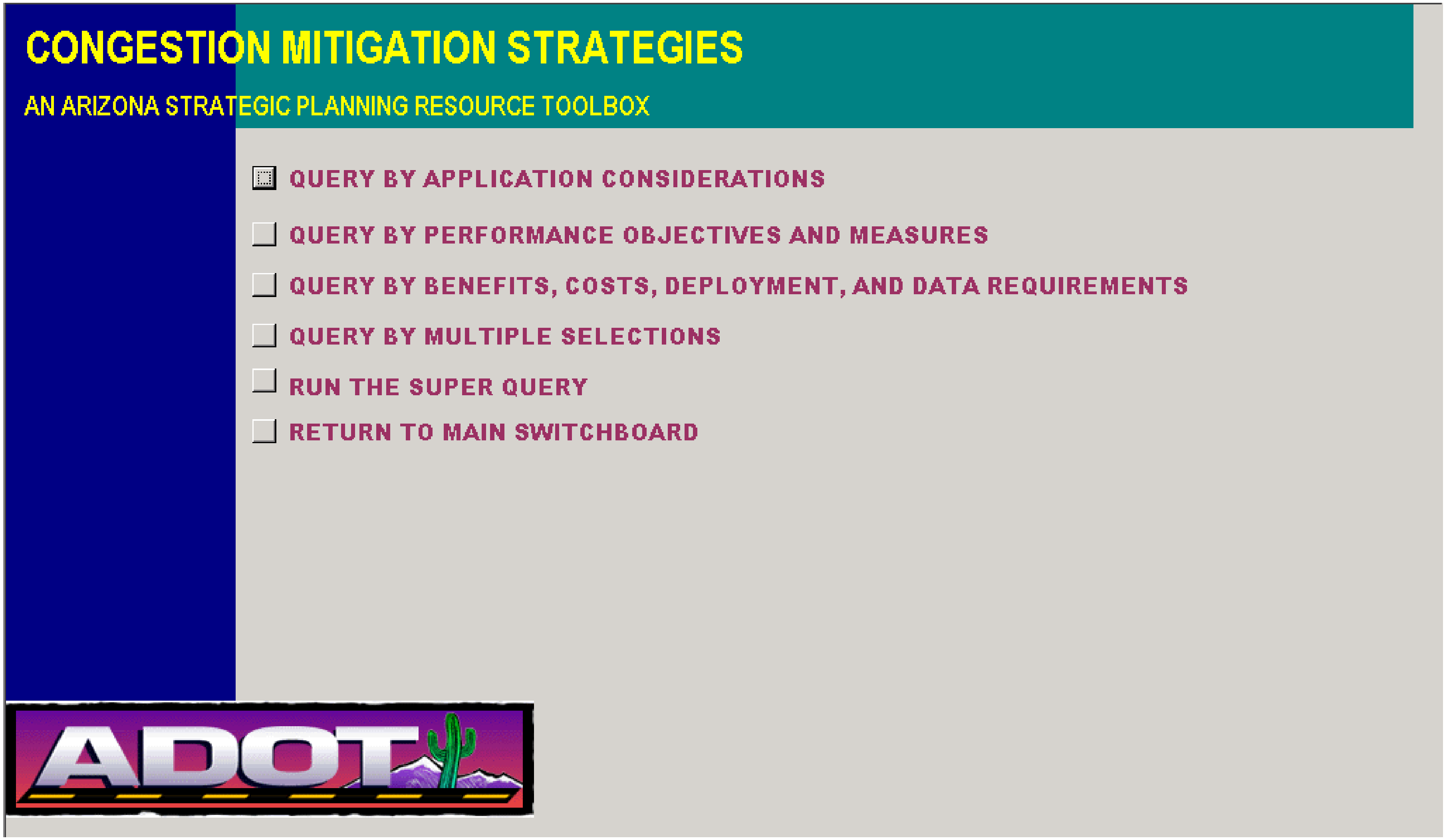


Figure 12 Predefined Query Switchboard

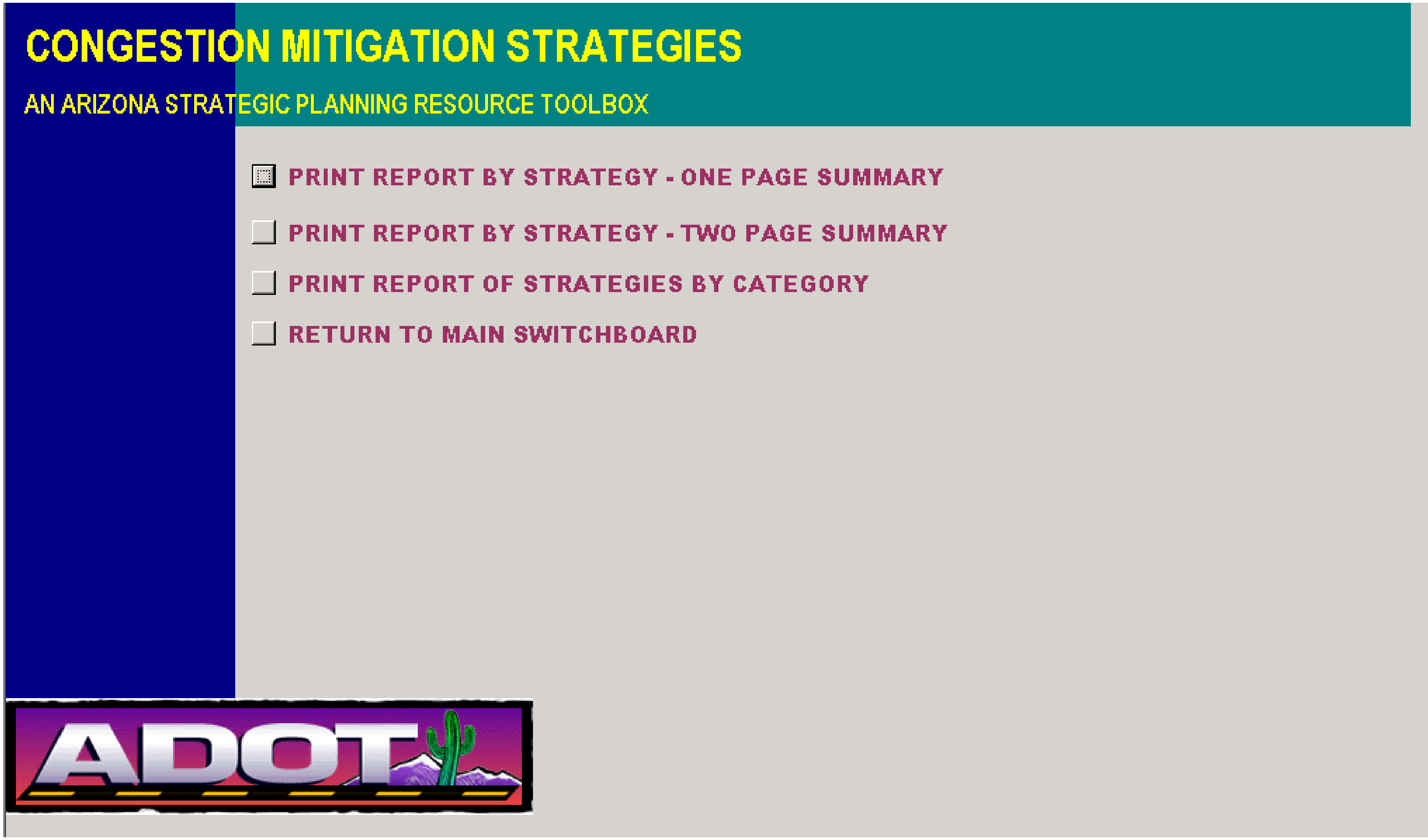


Figure 13 Print Reports Switchboard

5.3 Viewing Strategies

As mentioned in Section 4, a "view" only form is created that allows users to browse the database. This form is protected against any modification of records, thus prevents inadvertent changes to the database contents.

Figure 14 is the main form for viewing, also as "STRATEGY MAIN FORM." This can be accessed via the Main Switchboard or by simply going into the FORMS object in MS Access. The STRATEGY MAIN FORM has nine other forms that display the different attributes associated with each strategy. The following Figures 15 to 23 show an example of the "Driveway Management" strategy.

1. Application Considerations— this form displays Location Type, Functional Class, Facility Characteristics, Congestion Type and Congestion Period. Figure 15 shows the "Application Considerations" viewing form.

2. Performance Objectives and Measures— this form displays the associated performance objectives and measures for each strategy. Figure 16 shows the viewing form named "PerformanceMeasures".

3. Data Requirements and Ease of Deployment— the viewing form is named "DataRequirements" and is shown in Figure 17.

4. Benefits/Cost— the viewing form is named "OpenBenefits" and is shown in Figure 18.

5. Disadvantages— the viewing form is named "Disadvantages" and is shown in Figure 19.

6. Institutional Factors— the viewing form is named "InstitutionalFactors" and is shown in Figure 20.

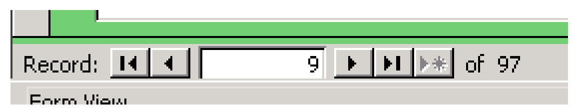
7. Warrants— the viewing form is named "Warrants" and is shown in Figure 21.

8. Examples— the viewing form is named "Examples" and is shown in Figure 22.

9. Evaluation— the viewing form is named "Evaluation" and is shown in Figure 23.

5.3.1 Record Selector

From the MAIN STRATEGY FORM, the user can browse or select the strategy using the record selector as shown in the Figure.



The record selector is found at the bottom left hand corner of the form. The right and left arrows are used to navigate through the records in the database. The number displayed in the box indicates the record number of the strategy that is displayed. Note that the record number does not necessarily correspond to the Strategy ID number. Thus, if the user wants a particular strategy number, he/she should use the search button and do the search for the Strategy ID.

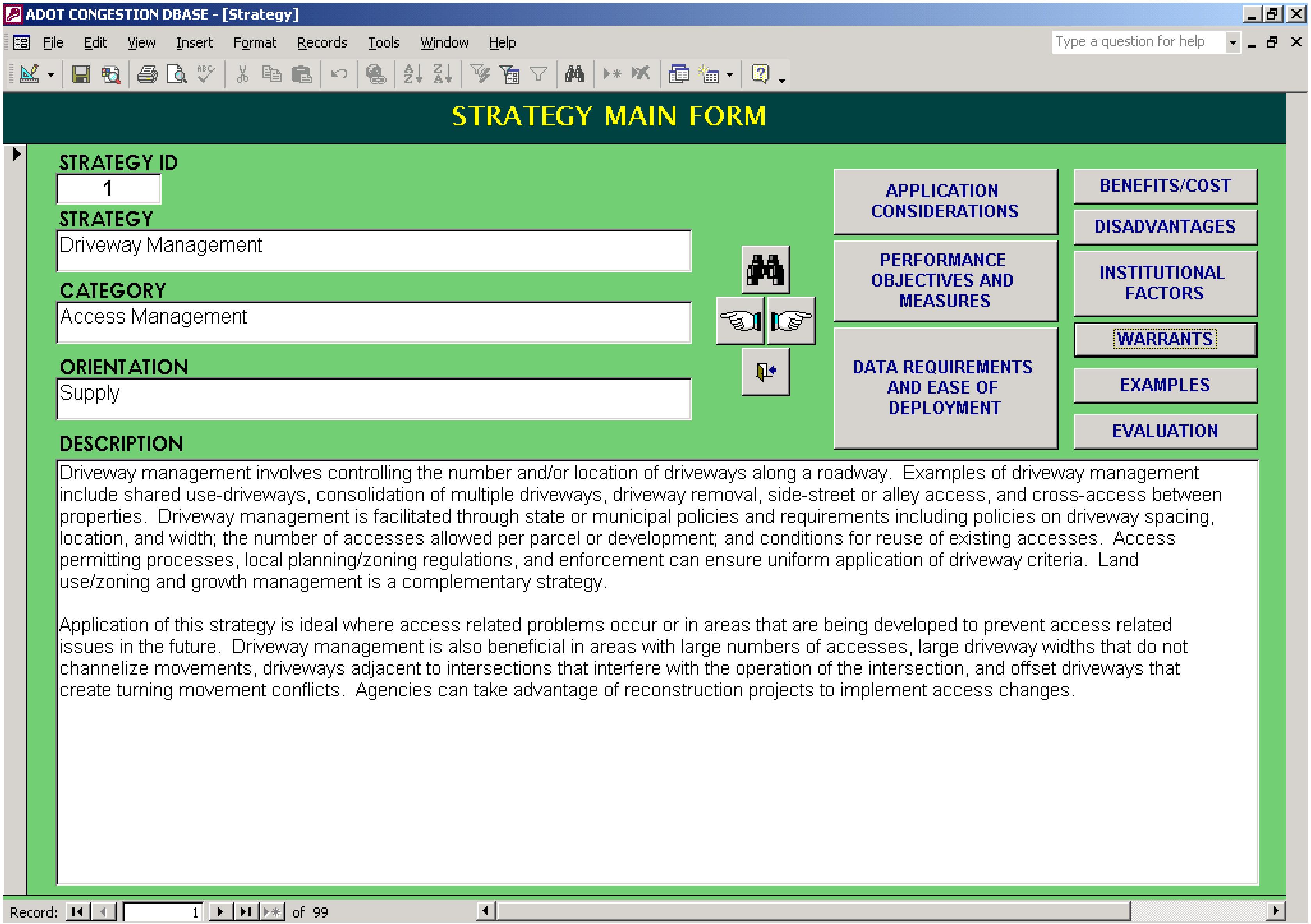


Figure 14 Main Viewing Form: Driveway Management Strategy

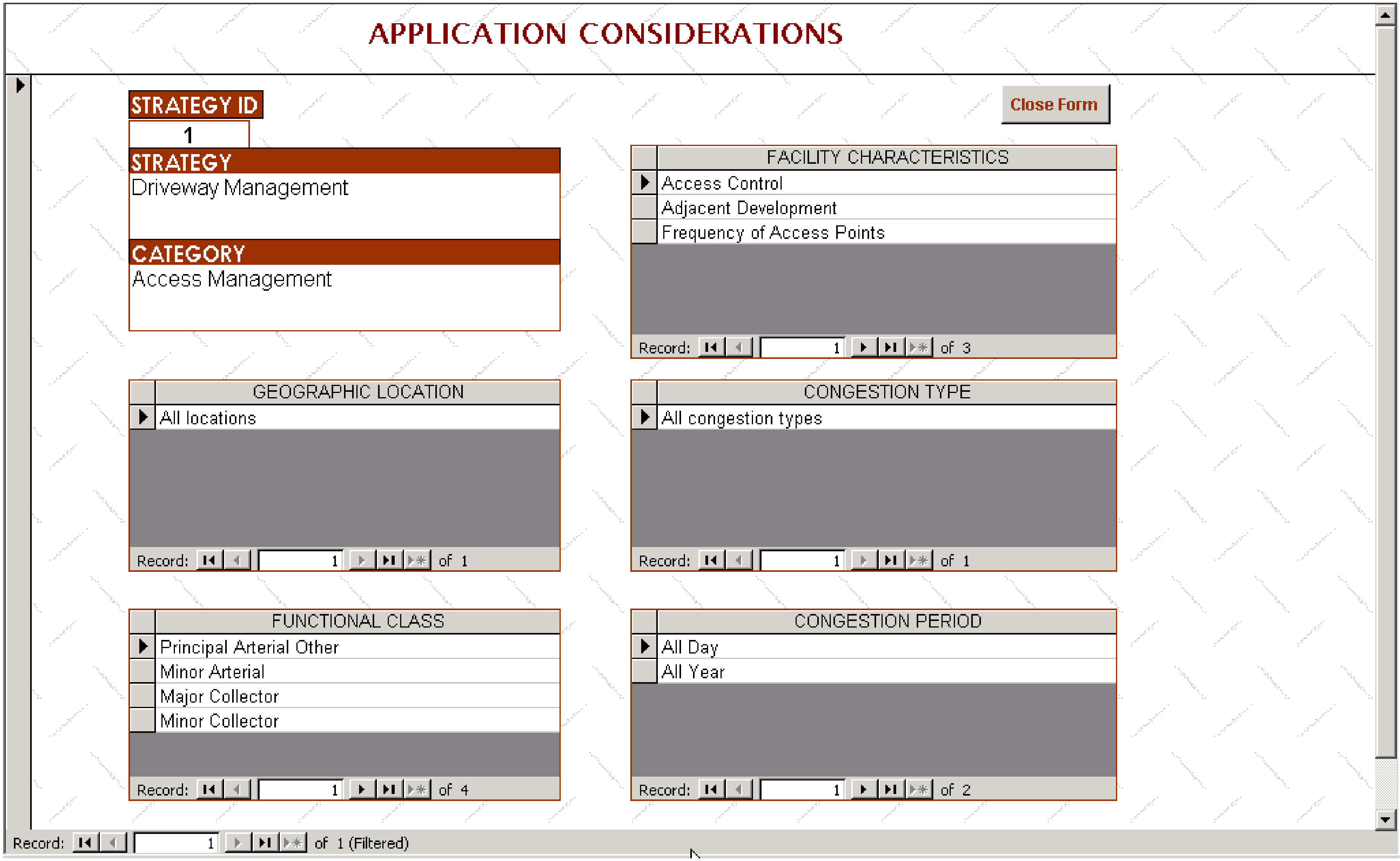


Figure 15 Application Considerations: Driveway Management Strategy

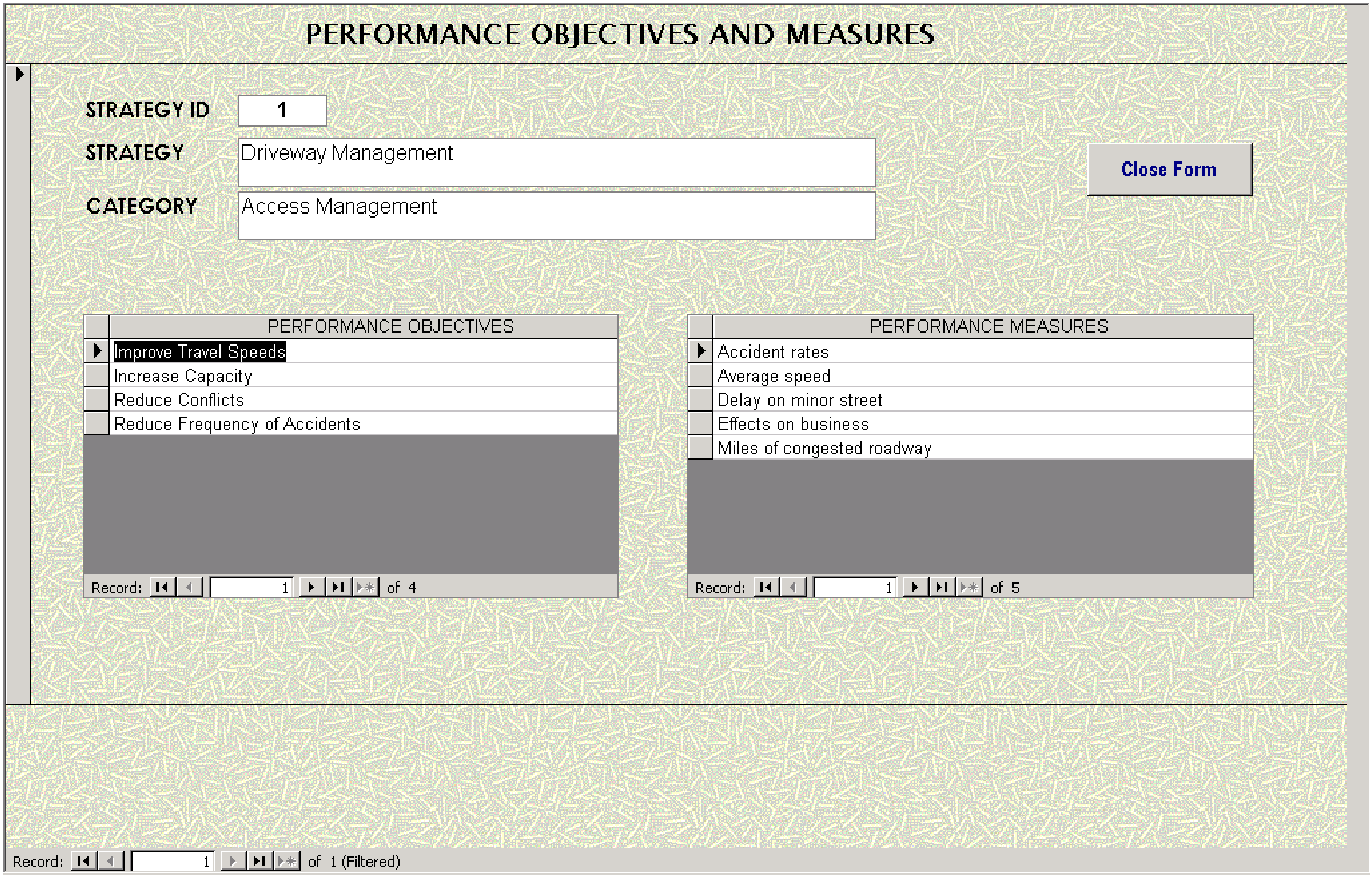
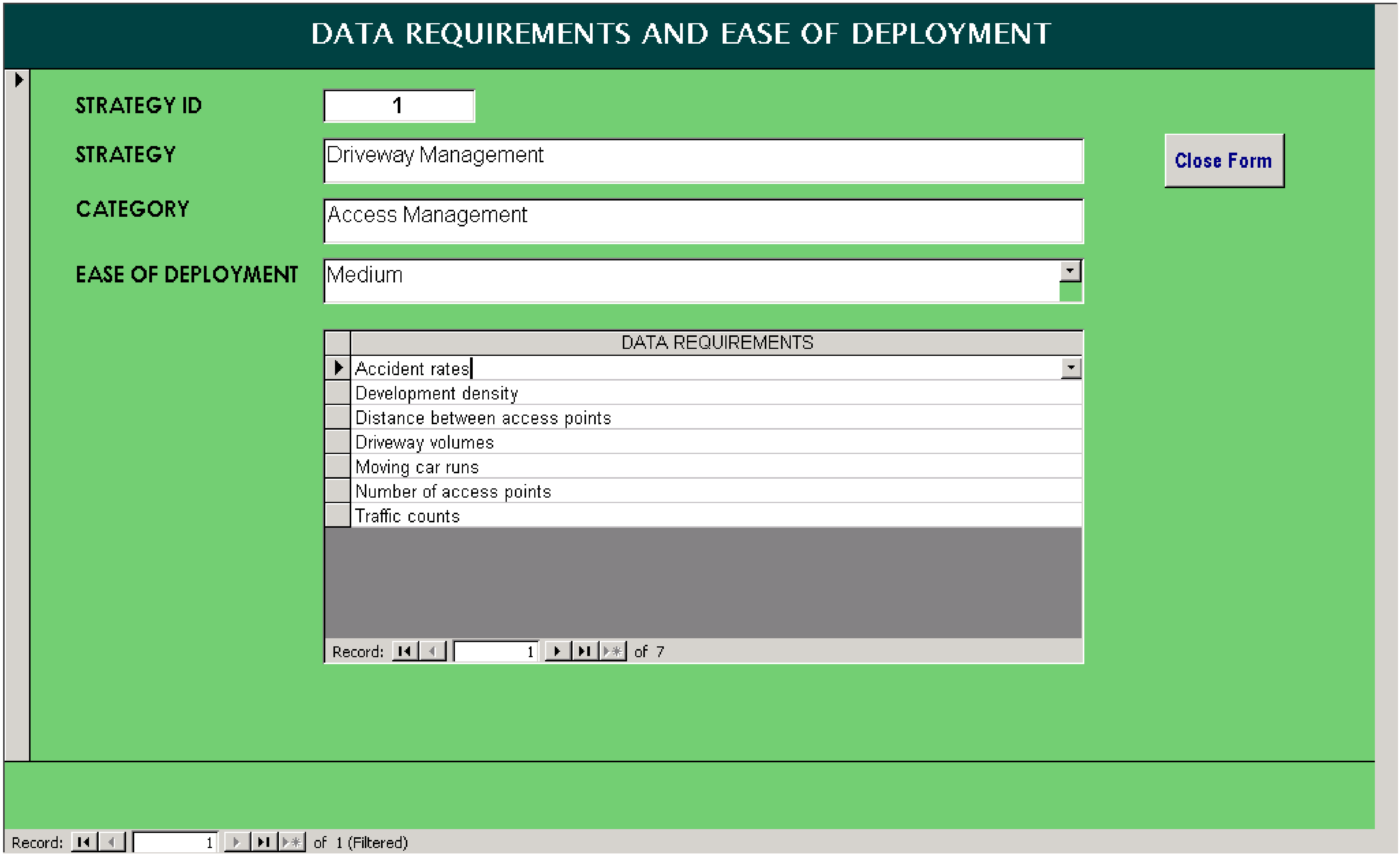


Figure 16 Performance Objectives and Measures: Driveway Management Strategy



DATA REQUIREMENTS AND EASE OF DEPLOYMENT

STRATEGY ID: 1

STRATEGY: Driveway Management

CATEGORY: Access Management

EASE OF DEPLOYMENT: Medium

Close Form

DATA REQUIREMENTS
Accident rates
Development density
Distance between access points
Driveway volumes
Moving car runs
Number of access points
Traffic counts

Record: 1 of 7

Record: 1 of 1 (Filtered)

Figure 17 Data Requirements and Ease of Deployment: Driveway Management Strategy

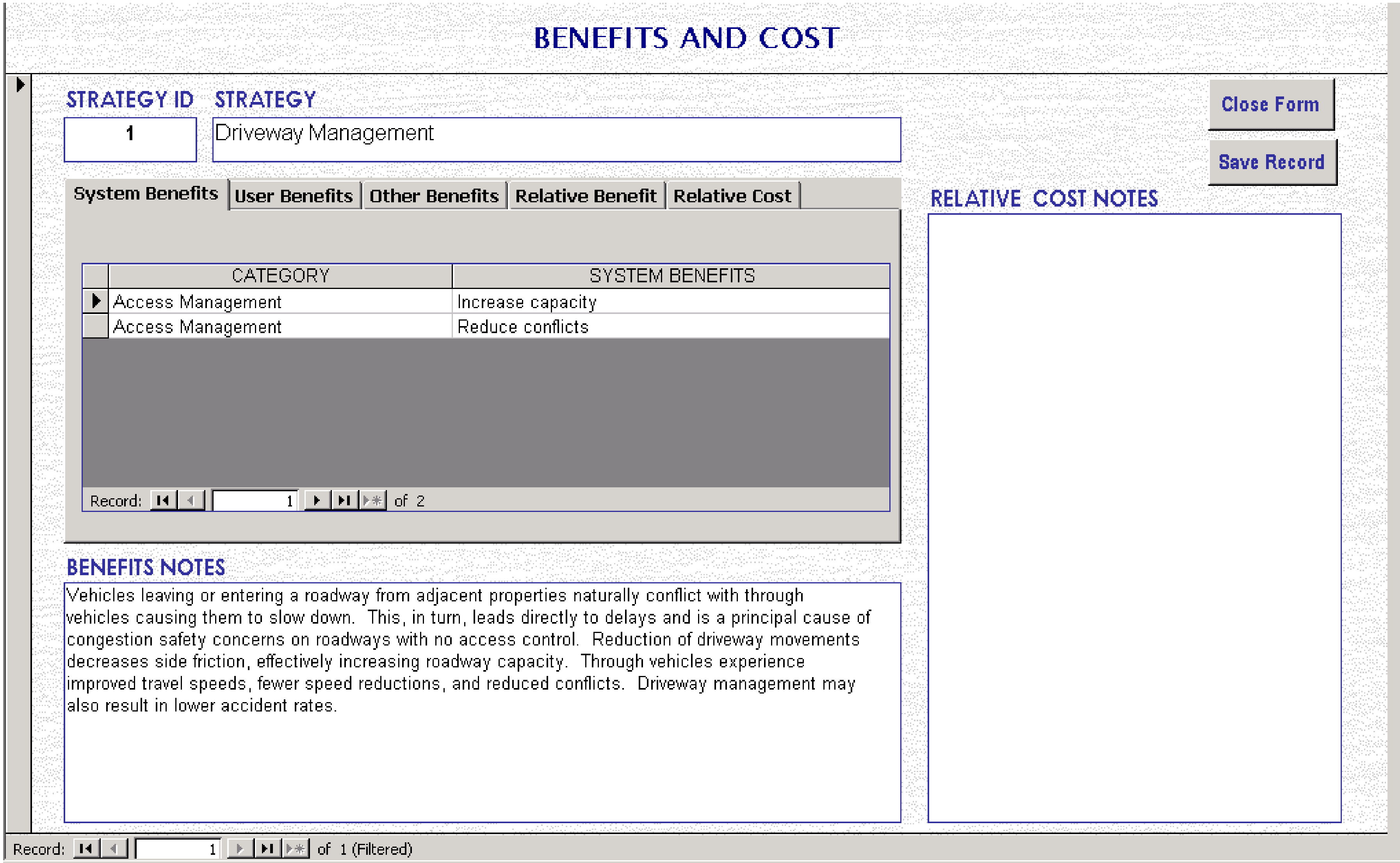


Figure 18 Benefits/Cost: Driveway Management Strategy

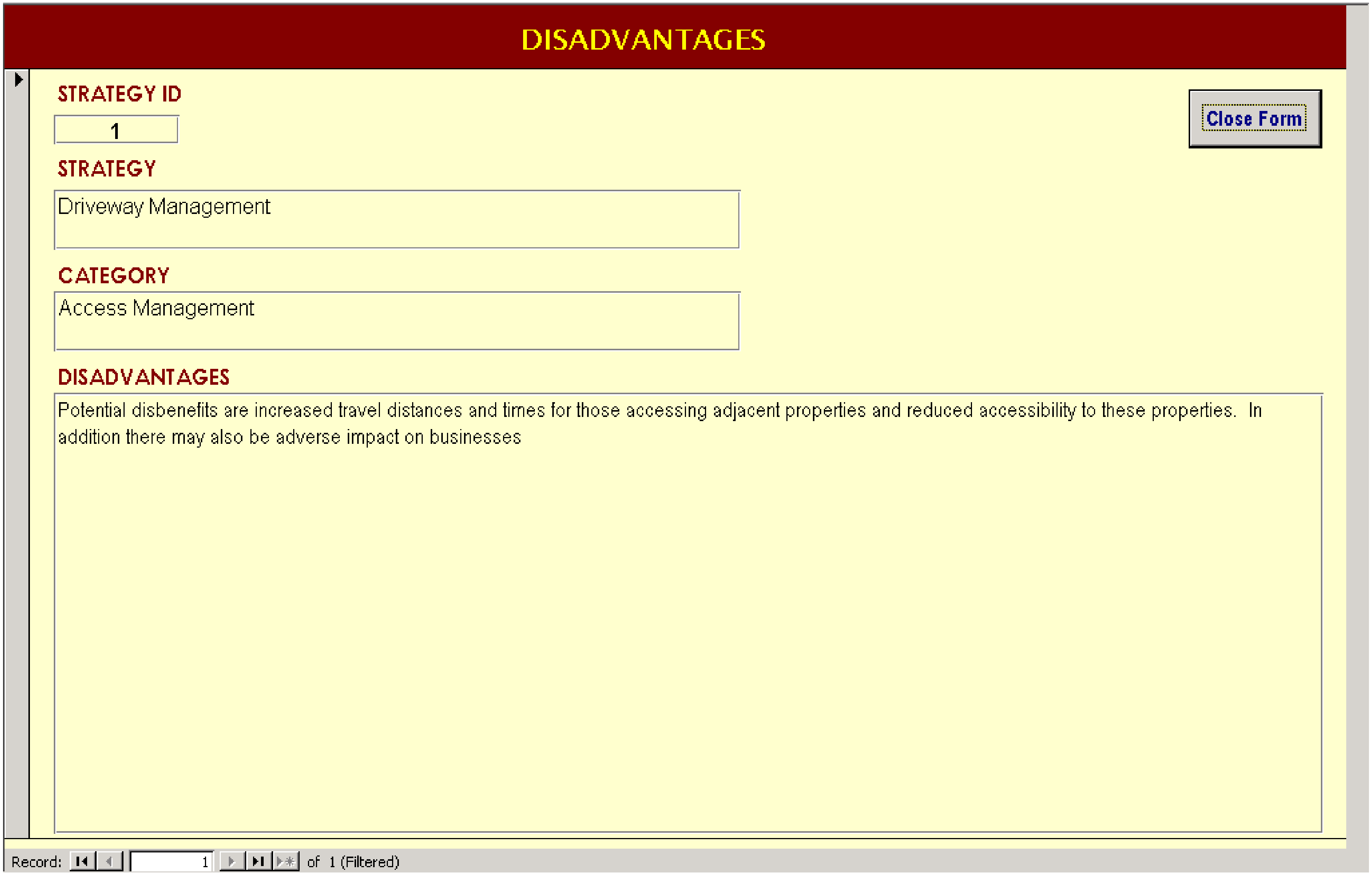
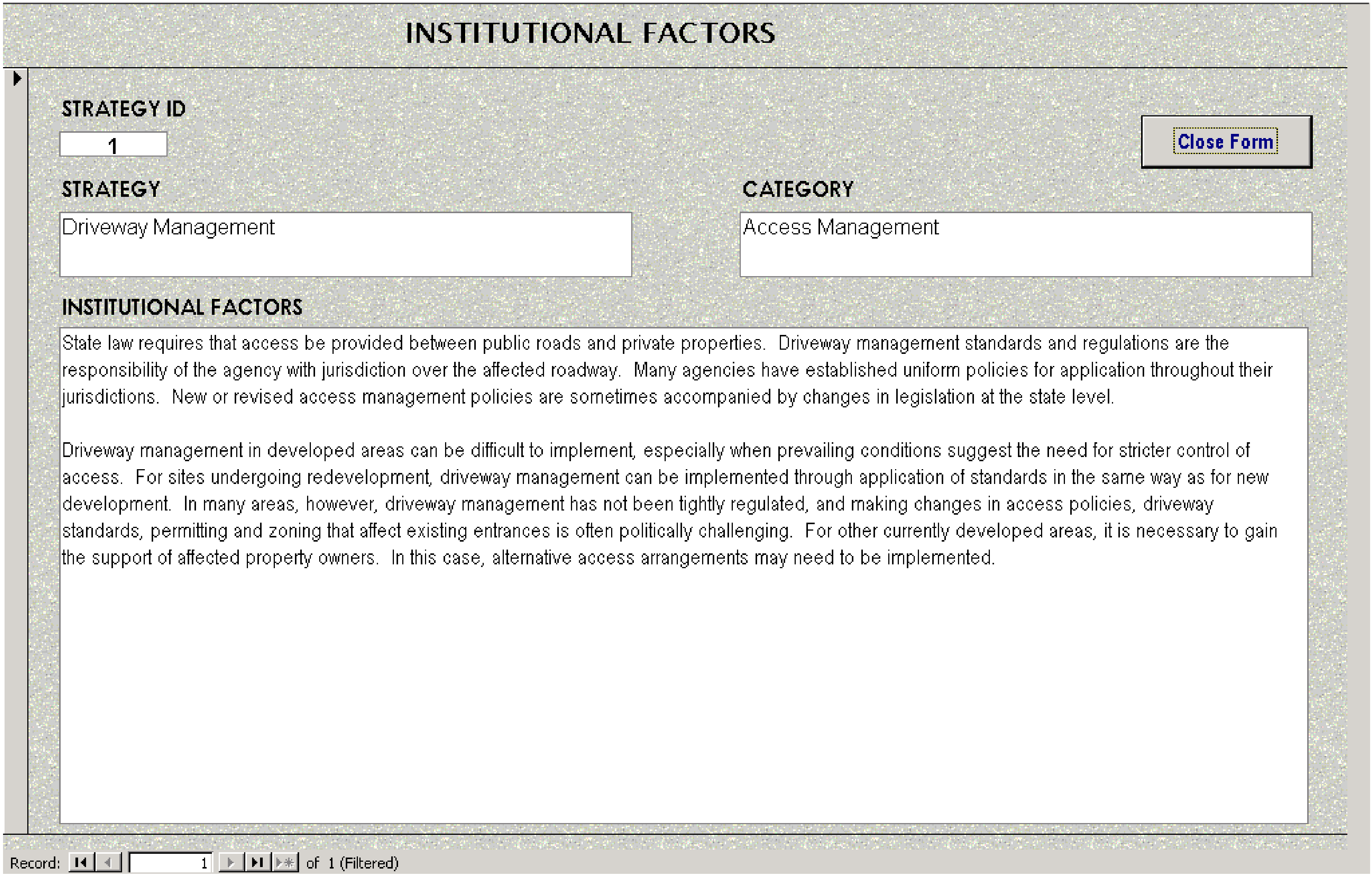


Figure 19 Disadvantages: Driveway Management Strategy



INSTITUTIONAL FACTORS

STRATEGY ID

1

Close Form

STRATEGY

Driveway Management

CATEGORY

Access Management

INSTITUTIONAL FACTORS

State law requires that access be provided between public roads and private properties. Driveway management standards and regulations are the responsibility of the agency with jurisdiction over the affected roadway. Many agencies have established uniform policies for application throughout their jurisdictions. New or revised access management policies are sometimes accompanied by changes in legislation at the state level.

Driveway management in developed areas can be difficult to implement, especially when prevailing conditions suggest the need for stricter control of access. For sites undergoing redevelopment, driveway management can be implemented through application of standards in the same way as for new development. In many areas, however, driveway management has not been tightly regulated, and making changes in access policies, driveway standards, permitting and zoning that affect existing entrances is often politically challenging. For other currently developed areas, it is necessary to gain the support of affected property owners. In this case, alternative access arrangements may need to be implemented.

Record: 1 of 1 (Filtered)

Figure 20 Institutional Factors: Driveway Management Strategy

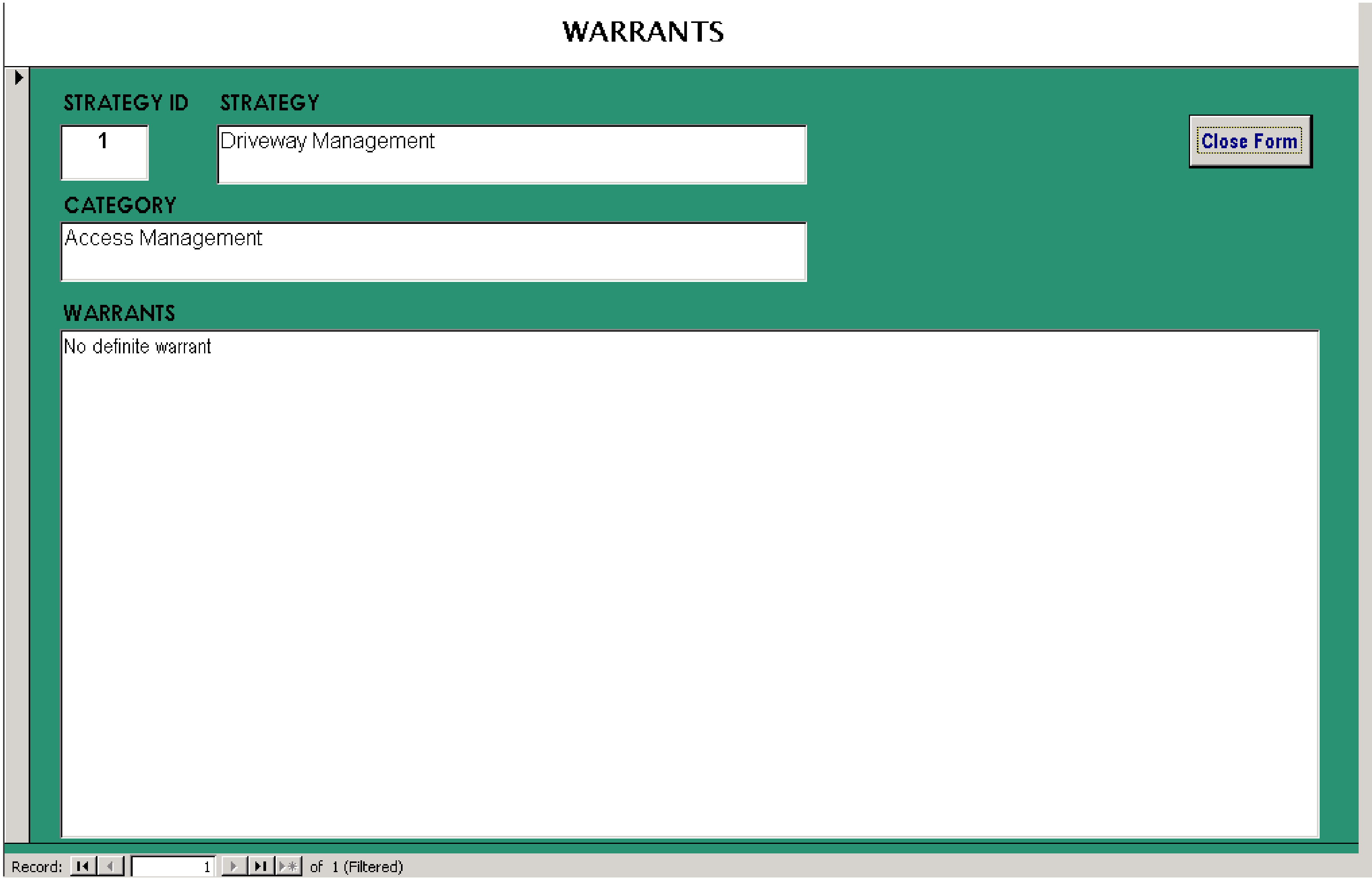


Figure 21 Warrants: Driveway Management Strategy

EXAMPLES

STRATEGY ID

1

Close Form

STRATEGY

Driveway Management

CATEGORY

Access Management

EXAMPLES

Fifty-two percent of all accidents in Colorado were access-related; 32 percent of all fatalities. In Oklahoma, 57 percent of the accidents are access-related; in Michigan 55 percent.

A. Irvine, CA: (1990 pop –110,330); Alton Parkway; City of Irvine; cost not available; 8.5 mile, four-lane, raised median roadway; two-lane roadway converted to a four-lane roadway with a raised median; access management is a major component in land planning and development in this "young" community, incorporated in 1971.
B. Melbourne Area, FL: (1990 pop –60,034); New Haven Avenue; Florida DOT; $4,230,000 cost; 5.1 mile four-lane divided arterial; 16 median openings were closed and 42 full openings were modified to directional median openings; traffic volumes increased dramatically and travel speeds increased.
C. Atlanta, GA: (1990 pop –393,929); Memorial Drive (State Route 10); $3,919,876 cost; Georgia DOT; 4.34 mile section replaced two-way left turn lane with raised median; 7 large intersections were not provided with median openings.
D. Overland Park, KS: (1990 pop –111,790); 135th Street (Kansas State Highway 150); Cities of Overland Park, Leawood, and Olathe; cost not available; study produced concept of 9 mile multi-lane arterial with median, and limited right-turn-only access; median openings every half-mile, right-turn-only access, and reverse frontage roads (along the back sides of properties) every quarter-mile in areas of intensive development; concept applied as uniformly as possible with exceptions handled on a case-by-case basis.
E. Plano, TX: (1990 pop –127,885); Access Management / Custer Road; $6,326,992 cost; City of Plano; 6-lane roadway with 24-foot median; design follows Thoroughfare Standards Rules and Regulations Manual, which outlines City's policies concerning access management.

Record: 1 of 1 (Filtered)

Figure 22 Examples: Driveway Management Strategy

EVALUATION OF EFFECTS

Close Form

STRATEGY ID

1

STRATEGY

Driveway Management

CATEGORY

Access Management

EVALUATION

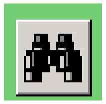
Criteria for the application of driveway management measures include the number of conflict points, their proximity to each other and intersections, traffic volumes, driveway volume and development density. Utilizing basic highway capacity concepts and/or simulation models like CORSIM, the planner can generate analytical justification for implementing driveway management measures. For a long corridor or in a regional setting, impacts can be estimated using a regional model.

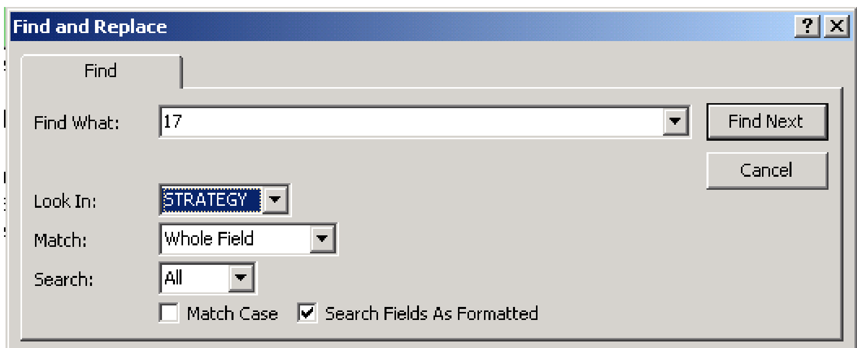
Businesses often fear a major impact from access restrictions. Data may be needed to support a finding that impacts were minimal. Most difficult part of traffic analysis is gauging effect on side street delay or ease of access.

Record: 1 of 1 (Filtered)

Figure 23 Evaluation: Driveway Management Strategy

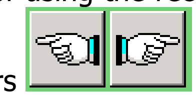
5.3.2 Record Search

The "binocular" picture  indicates a search function. Each field in the form can be searched for any string. For example, in the STRATEGY MAIN FORM each of the fields "Strategy ID", "Strategy", "Category", "Orientation", and "Description" can be searched. To activate the search, simply place the cursor at the field where the search is desired, then click on the binocular. The following pop up menu will appear.



In this example, the search is for a "Strategy" field. In the **Match** field, the user has three options: Any Part of Field, Whole Field, and Start of Field. It is preferable to select Any Part of Field rather than Whole Field to reduce the typing required as some Strategy names are quite long. In the field **Find What,** the user enters the word or words, e.g. the user may type **signal** to search for strategy or strategies that involve signal improvements.

5.3.3 Record Navigator

Instead of using the record selector, the user may use the record navigators  in the form. It is more convenient to use these record navigators than the record selectors because of their location in the form.

5.3.4 Viewing Individual Forms

The forms listed in Table 4 can be viewed individually, i.e., without having to go to the MAIN STRATEGY VIEWING form. For example, opening the form "PerformanceObjective" allows viewing of performance objectives associated with each strategy. The user can simply use the record selector to browse the performance objective/s associated with each strategy. Figure 24 shows an example.

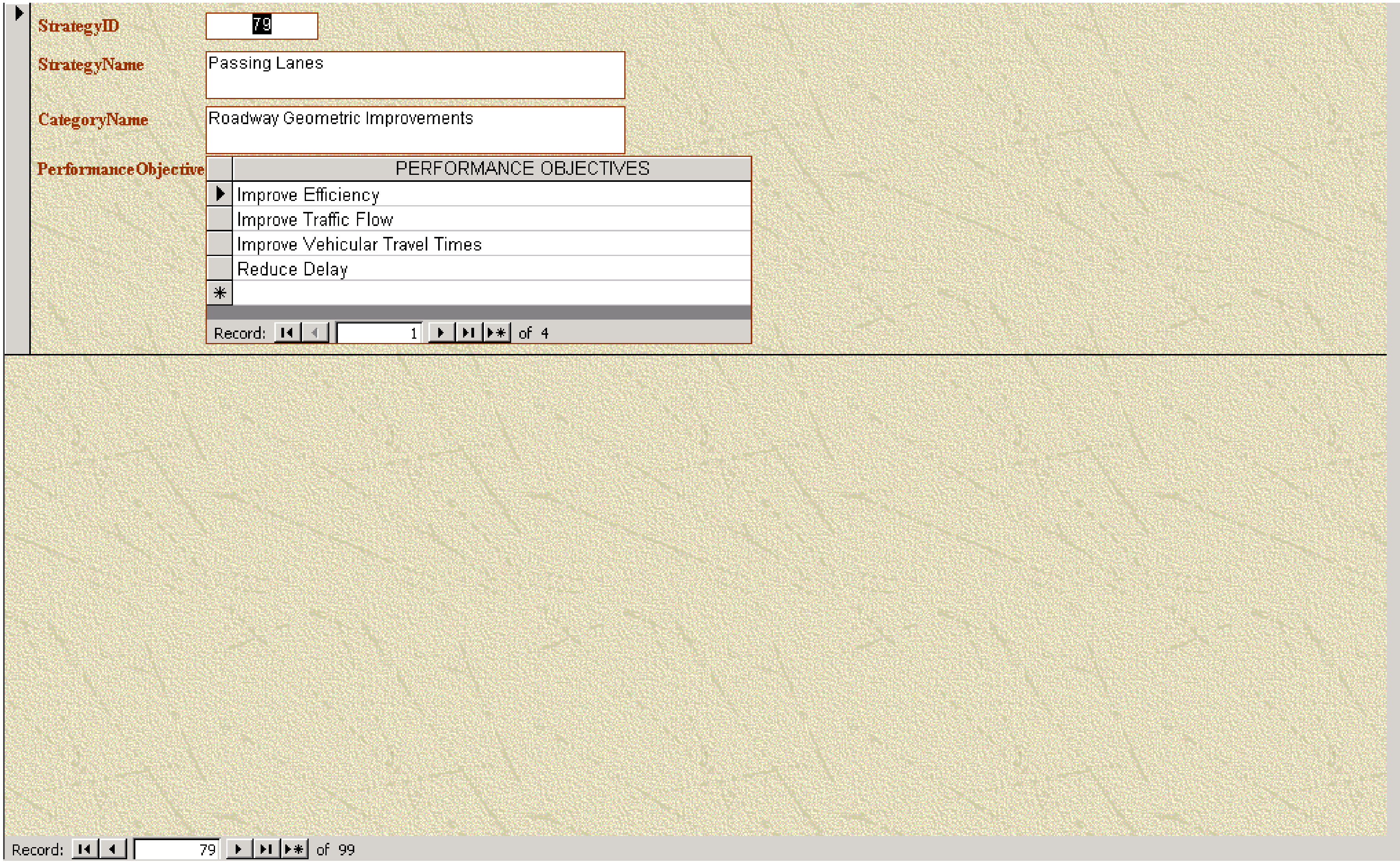


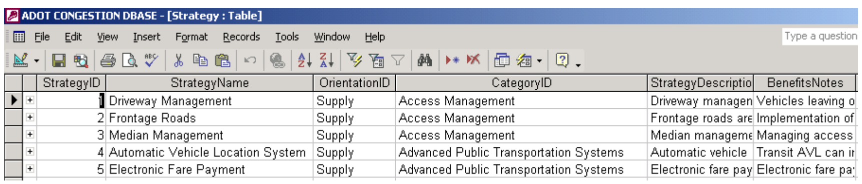
Figure 24 Use of Individual Form to View a Strategy Attribute: Example of "Passing Lanes" Performance Objectives

5.4 Editing Strategies

Every record in the strategies toolbox can be edited. MS Access allows different ways to edit records. These are outlined in the following sections.

5.4.1 Editing Records in Tables

Every record in each table can be edited. To edit record/s in a table, simply open the desired table. For example, to change the Category of a strategy, open the Strategy table. In the column "CategoryID", select the category from the "drop-down" list.



StrategyID	StrategyName	OrientationID	CategoryID	StrategyDescriptio	BenefitsNotes
1	Driveway Management	Supply	Access Management	Driveway managen	Vehicles leaving o
2	Frontage Roads	Supply	Access Management	Frontage roads are	Implementation of
3	Median Management	Supply	Access Management	Median manageme	Managing access
4	Automatic Vehicle Location System	Supply	Advanced Public Transportation Systems	Automatic vehicle	Transit AVL can ir
5	Electronic Fare Payment	Supply	Advanced Public Transportation Systems	Electronic fare pay	Electronic fare pa

5.4.2 Editing Records Using Forms and Queries

For smaller tables, such as Congestion Period, Congestion Type, etc, editing or adding records are straightforward as entries are very short. In some fields, like the Strategy Description, Benefits Notes, and Institutional Factors, it is desirable to use forms because of the lengthy contents in these fields.

Figure 3 shows the main form designed for editing records in the strategies toolbox. This form is named "MAIN DATA ENTRY FORM". It has a similar layout to the Viewing form shown in Figure 2 and in Figure 14. It has the following five subforms:

1. Application Considerations— this form is similar to Figure 15, but is not protected against editing. The form is named "ApplicationConsiderations DataEntry Form1".

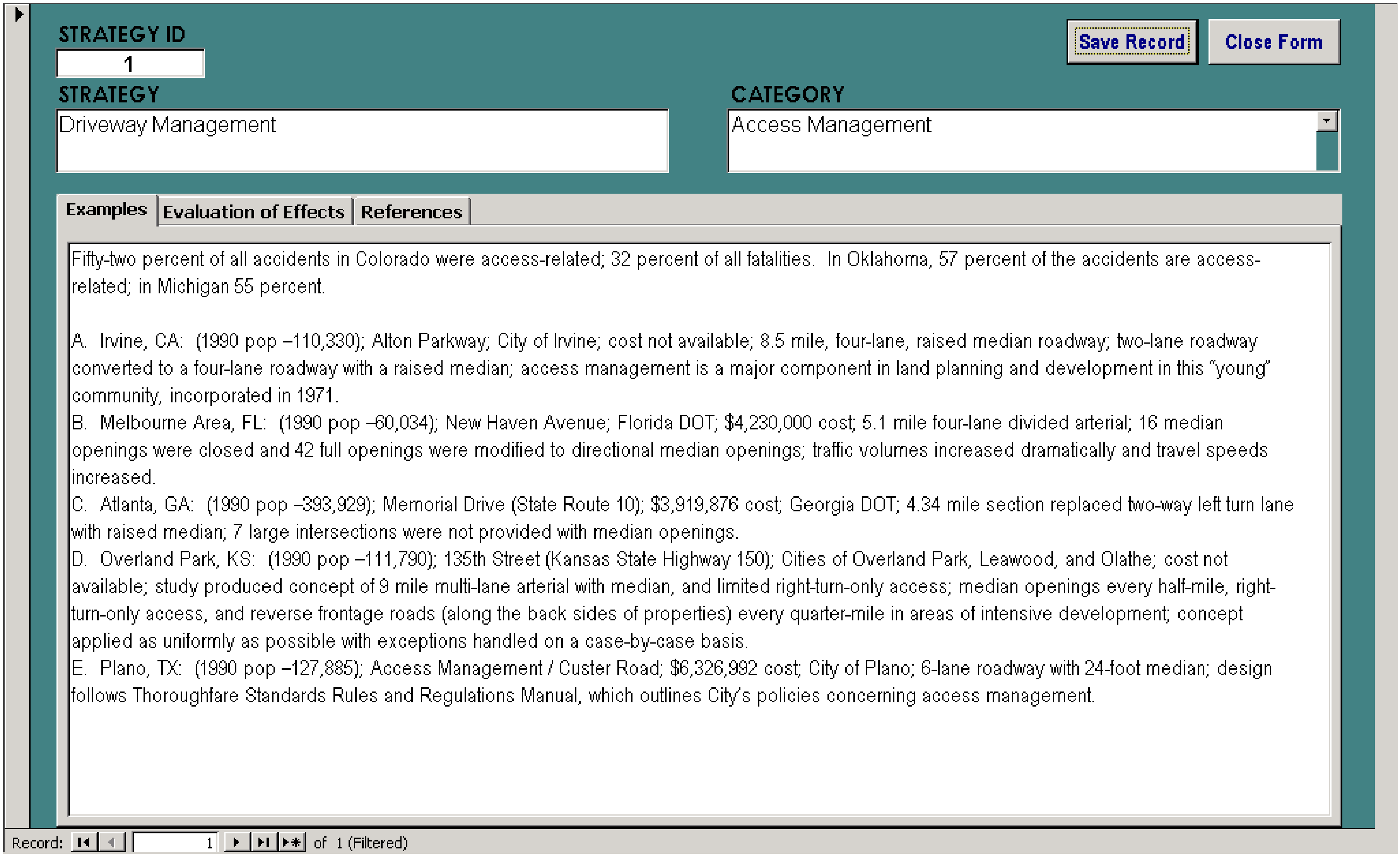
2. Performance Objectives and Measures — this form is similar to Figure 16, but is not protected against editing. The form is named "PerformanceMeasures DataEntry Form".

3. Data Requirements and Ease of Deployment— this form is similar to Figure 17, but is not protected against editing. The form is named "DataRequirementsDeployment DataEntry Form".

4. Benefits/Cost— this form is similar in layout to Figure 18, but is not protected against editing. The form is named "BenefitsCost DataEntry Form".

5. Examples and Evaluation — this form is different from the ones used for viewing. The form is called "ExamplesEvaluation", and is shown in Figure 25.

The records shown in each form are linked together using queries. Each query uses a dynaset, which updates the changes to the record in each respective or underlying table.



STRATEGY ID

1

STRATEGY

Driveway Management

CATEGORY

Access Management

Save Record

Close Form

Examples | Evaluation of Effects | References

Fifty-two percent of all accidents in Colorado were access-related; 32 percent of all fatalities. In Oklahoma, 57 percent of the accidents are access-related; in Michigan 55 percent.

A. Irvine, CA: (1990 pop –110,330); Alton Parkway; City of Irvine; cost not available; 8.5 mile, four-lane, raised median roadway; two-lane roadway converted to a four-lane roadway with a raised median; access management is a major component in land planning and development in this "young" community, incorporated in 1971.

B. Melbourne Area, FL: (1990 pop –60,034); New Haven Avenue; Florida DOT; $4,230,000 cost; 5.1 mile four-lane divided arterial; 16 median openings were closed and 42 full openings were modified to directional median openings; traffic volumes increased dramatically and travel speeds increased.

C. Atlanta, GA: (1990 pop –393,929); Memorial Drive (State Route 10); $3,919,876 cost; Georgia DOT; 4.34 mile section replaced two-way left turn lane with raised median; 7 large intersections were not provided with median openings.

D. Overland Park, KS: (1990 pop –111,790); 135th Street (Kansas State Highway 150); Cities of Overland Park, Leawood, and Olathe; cost not available; study produced concept of 9 mile multi-lane arterial with median, and limited right-turn-only access; median openings every half-mile, right-turn-only access, and reverse frontage roads (along the back sides of properties) every quarter-mile in areas of intensive development; concept applied as uniformly as possible with exceptions handled on a case-by-case basis.

E. Plano, TX: (1990 pop –127,885); Access Management / Custer Road; $6,326,992 cost; City of Plano; 6-lane roadway with 24-foot median; design follows Thoroughfare Standards Rules and Regulations Manual, which outlines City's policies concerning access management.

Record: 1 of 1 (Filtered)

Figure 25 Examples and Evaluation of Effects Data Entry Form

5.4.3 Deleting Records

While records in the database can be deleted, caution is always required to ensure inadvertent deletions. Some tables are linked in such a way that records cannot be deleted if relationships exist in other tables. For example, a record from the "Performance Objectives" table cannot be deleted if there is a strategy associated with it in the "Performance Objectives Details" table. The record or records in the associated "Performance Objectives Details" table must be deleted first, and then a performance objective in the "Performance Objectives" table can be deleted.

The user is reminded to look into the relationships whenever there is a problem in deleting records that is associated with related records.

5.4.4 Adding a New Strategy

To add a new strategy, follow these simple steps:

1. OPEN the "MAIN DATA ENTRY FORM".
2. Click on ADD RECORD.
3. Type the Strategy ID number. Make sure that the ID does not already exist in the database.
4. Type the name of the new Strategy.
5. Select the CATEGORY from the drop-down list.
6. Select the ORIENTATION from the drop-down list.
7. Fill in the information for DESCRIPTION, DISADVANTAGES, INSTITUTIONAL FACTORS and WARRANTS.
8. Click on SAVE RECORD.
9. Click on APPLICATION CONSIDERATIONS. A form will open that already contains the Strategy ID, Strategy Name and Category. Fill in the information for Location Type, Facility Characteristics, Functional Class, Congestion Type and Congestion Period. All these fields have drop-down lists. CLOSE the form after filling all the information.
10. Click on the BENEFITS/COST form to fill the information related to benefits and cost of the strategy.
11. Click on DATA REQUIREMENTS AND EASE OF DEPLOYMENT.
12. Click on PERFORMANCE OBJECTIVES AND MEASURES. Select from the drop-down list the relevant objective/s and measure/s.
13. Click on EXAMPLES AND EVALUATION.

It is important to note that information for a strategy can be entered in any order, i.e., it does not have to follow the sequence as described above. Benefits and Cost information can be entered first before filling in Description, etc.

The Strategy ID is the key of the Strategy table that is linked to the other related tables, and therefore must be supplied first. It is also suggested to assign the Category field as it is used as a key in the System Benefits Details table.

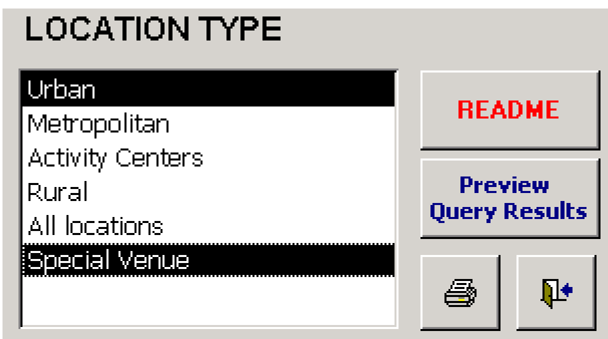
5.5 Querying Records

5.5.1 Using Predefined Queries

As described earlier in Section 5.2, there are predefined queries in the database. A switchboard shown in Figure 11 lists five other switchboards that contain different levels of queries, namely:

1. Query By Application Considerations— this query opens up a switchboard that allows listing of strategies by the following attributes: Geographic Location, Facility Characteristics, Functional Class, Congestion Type and Congestion Period. This single-field query allows multiple selections.

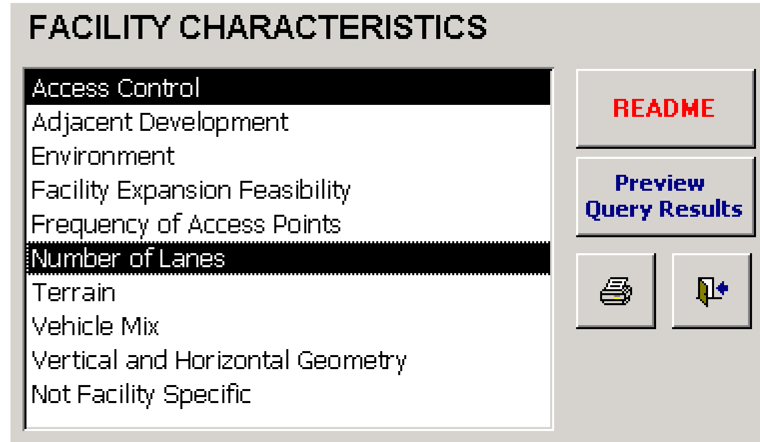
   For example, clicking on the Query By Geographic Location will open the form "frmLocationType", as shown in the figure.



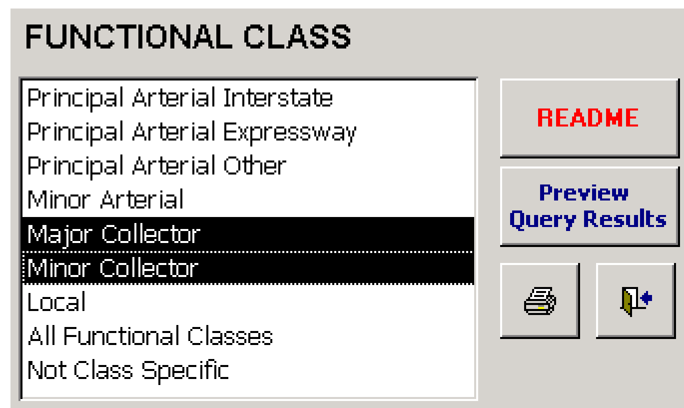
The user may choose one or more location types. As shown, both Urban and Special Venue are selected. To view the results, simply click on the "Preview Query Results".

Forms for the other queries are:

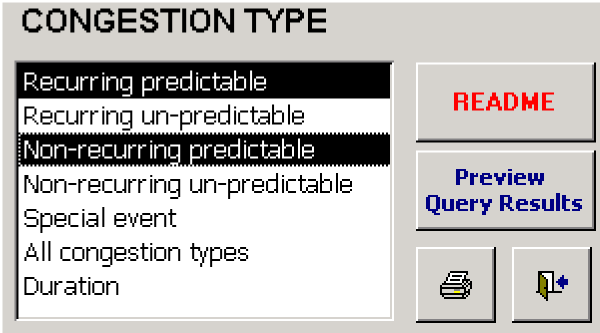
<u>Query By Facility Characteristics</u>



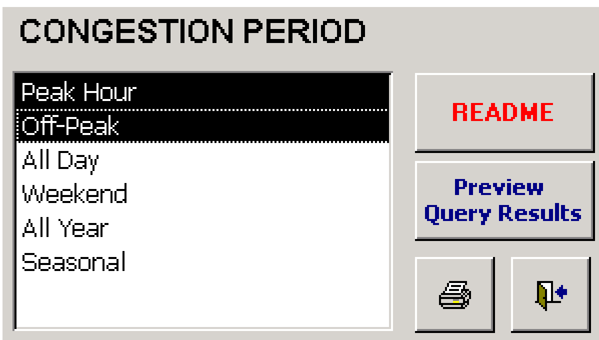
<u>Query By Functional Class</u>



Query By Congestion Type

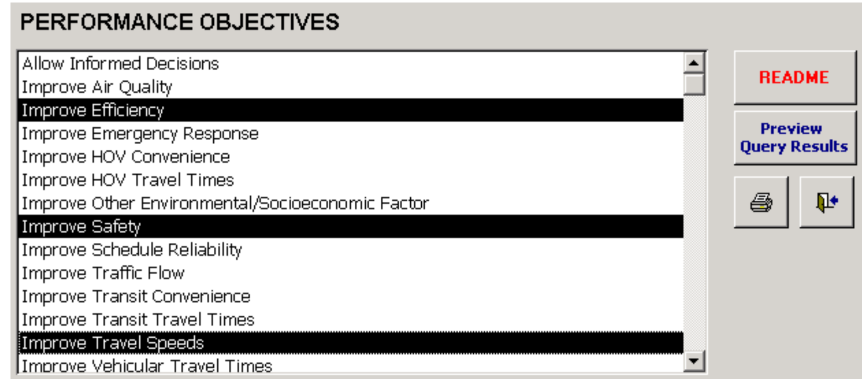


Query By Congestion Period

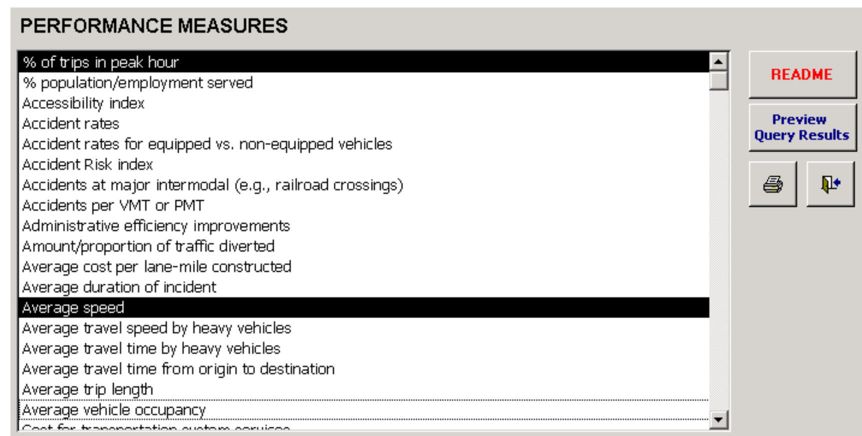


2. Query By Performance Objectives and Measures— this switchboard has two queries: Query By Performance Objectives and Query By Performance Measures.

Query By Performance Objectives

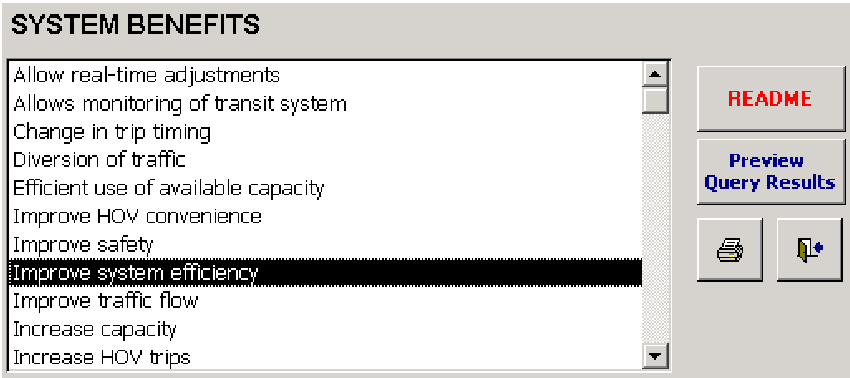


Query By Performance Measures

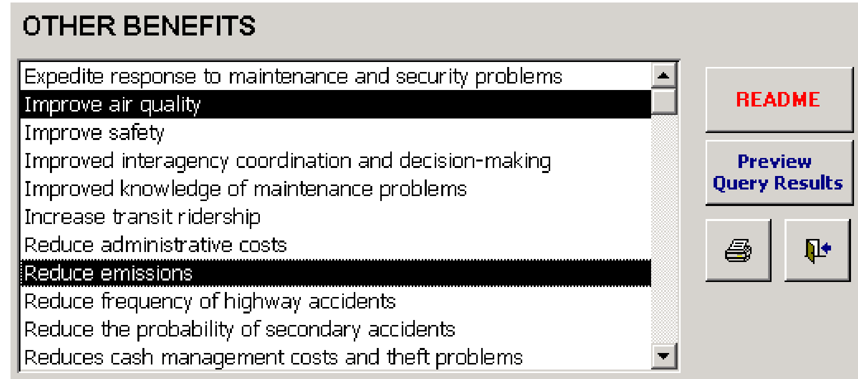


3. Query By Benefits, Costs, Data Requirements and Ease of Deployment— this switchboard has the following seven queries.

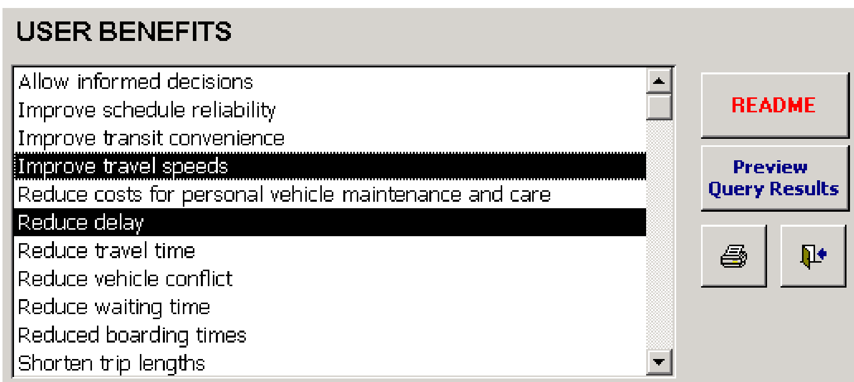
Query By System Benefits



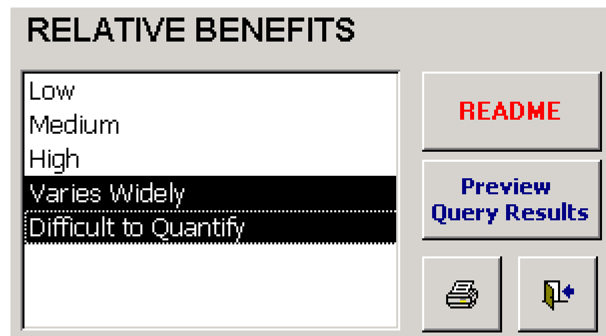
Query By Other Benefits



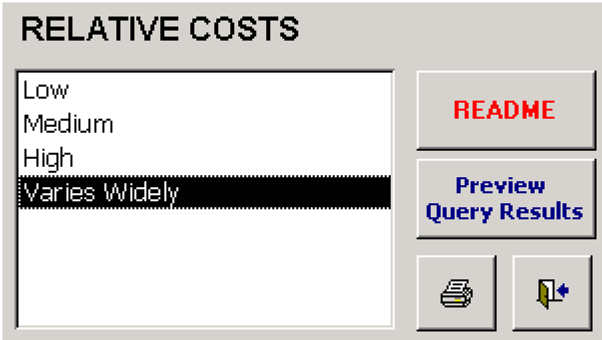
Query By User Benefits



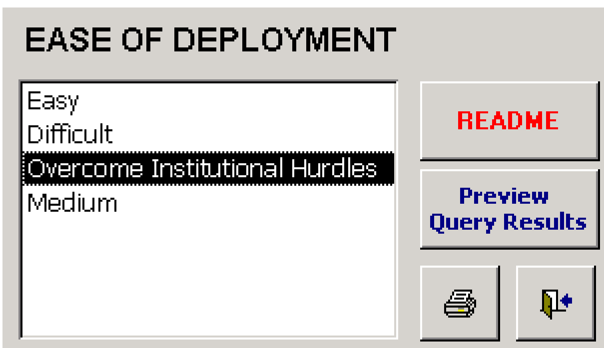
Query By Relative Benefits



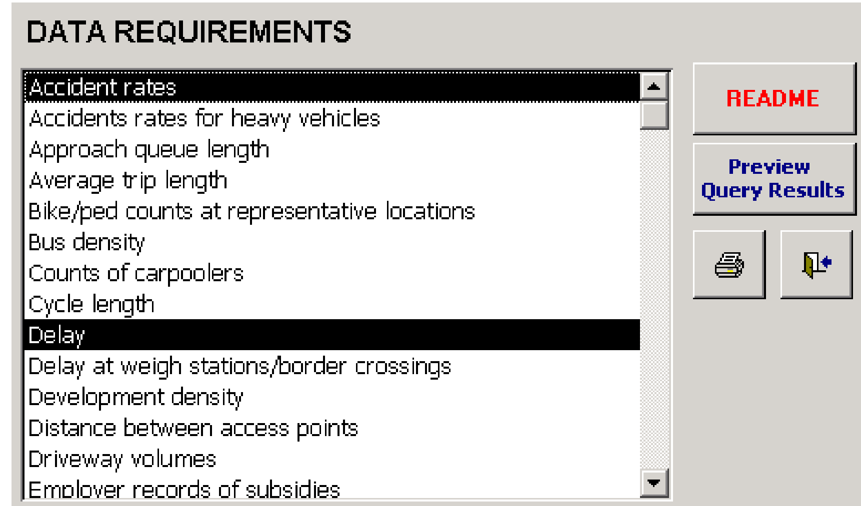
Query By Relative Costs



Query By Ease of Deployment

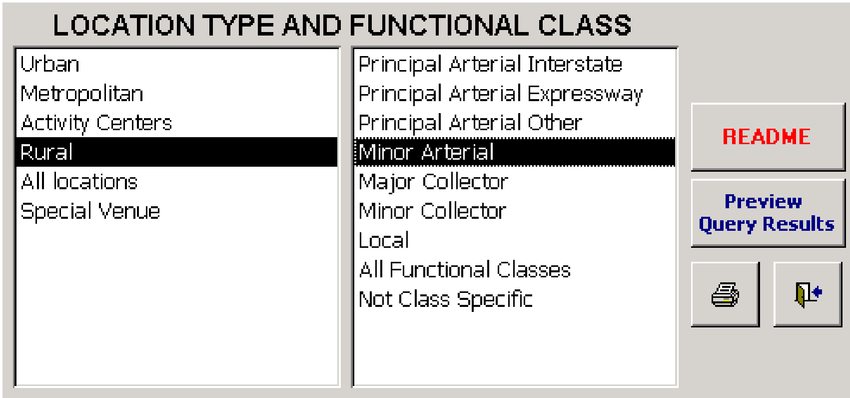


Query By Data Requirements

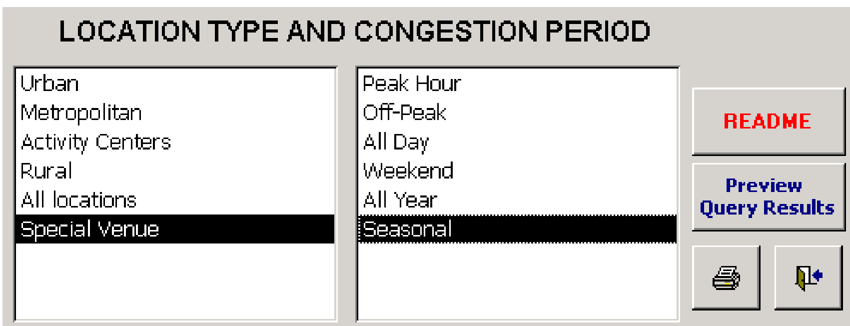


4. Query By Multiple Selections— this switchboard has the following seven queries. Five of these are based on two fields, one on three fields and one on five fields. Unlike the single-field queries described above, these multi-field queries allow only one selection per field.

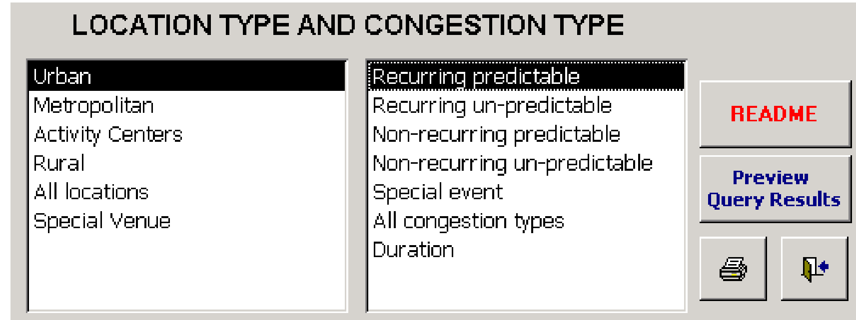
Query By Location Type and Functional Class



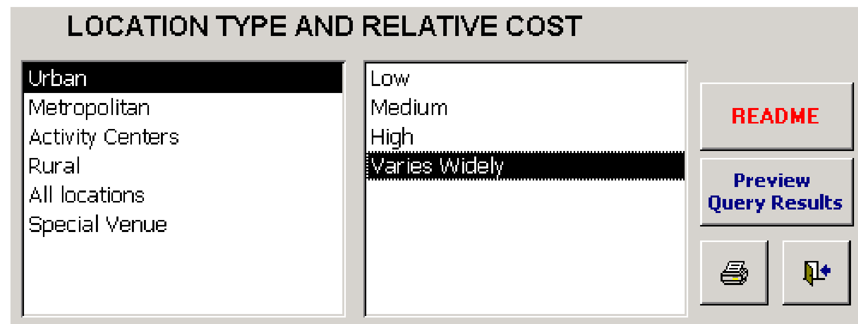
Query By Location Type and Congestion Period



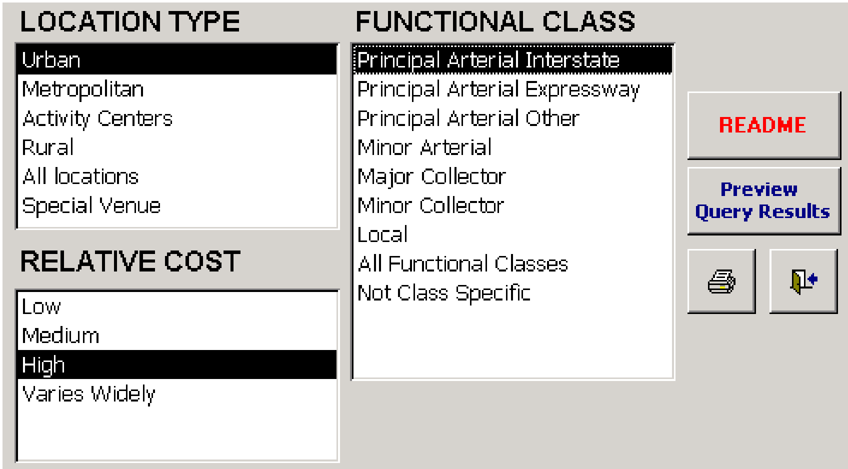
Query By Location Type and Congestion Type



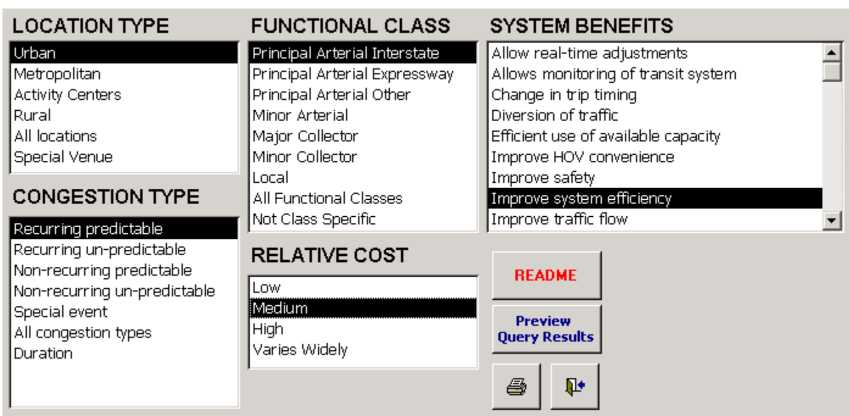
Query By Location Type and Relative Cost



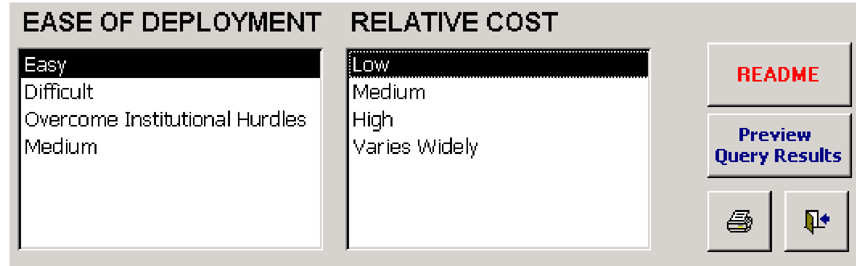
Query By Location Type, Functional Class and Relative Cost



Query By Location Type, Functional Class, Congestion Type, System Benefit and Relative Cost



Query By Ease of Deployment and Relative Cost



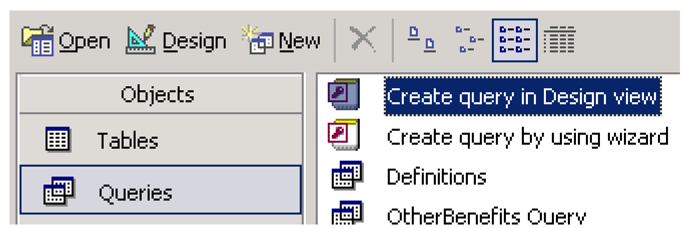
5. Super Query— this query allows the user to output all permutations of fields in the database. This takes several minutes to run, therefore it should not be used unless required.

5.5.2 Create New Query

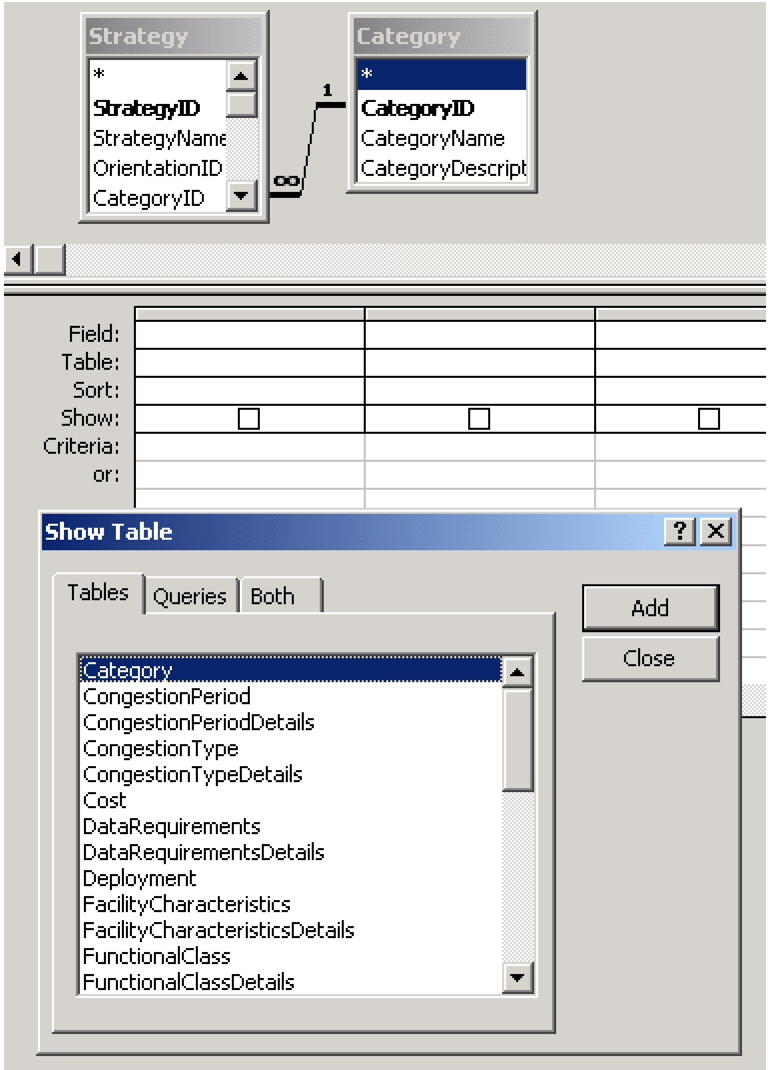
The user may create new queries. There are two ways to do this: create a query in design view or by using the wizard.

Create Query in Design View

1. Select the Queries object.



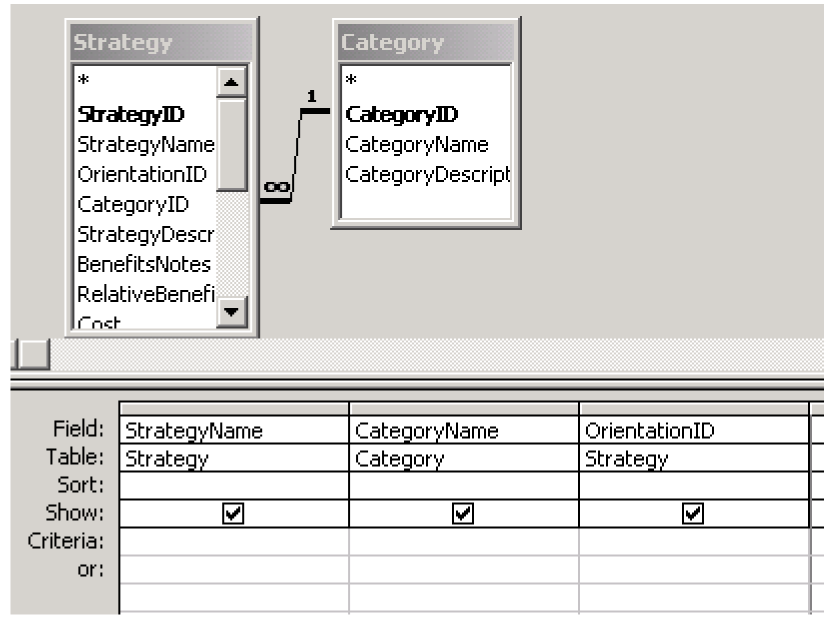
2. Double click on Create query in design view. A pop up menu will open together with the design grid as shown in the figure below.

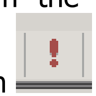


3. From the Show Table menu, double click to select on the Strategy and Category. After selecting the tables, they should display as shown.

4. Close the Show Table.

5. From each table, select the fields you want to display. For example, select StrategyName from the Strategy table, CategoryName from the Category table, and OrientationID from the Strategy table.



6. To run the query, simply click on the exclamation mark button  from the Main Menu.

Create Query via the Wizard

1. Select the Queries object, and double click on Create query by using wizard.

2. Simply follow the wizard's instructions.

5.6 Using Predefined Reports

There are 25 predefined reports available in the database. From the list in Table 6, predefined reports from numbers 5 to 25 are associated with the predefined queries discussed in the earlier section. Examples of predefined reports are shown in Section 4.3.1 and in Figures 6 and 7.

5.7 Exiting from the Database

There are two ways to exit from the strategies database. One is to exit from the main switchboard by simply clicking on the EXIT MS ACCESS. The other is to go the main menu and select Exit.

It is important to note that every change made in the database is automatically saved. Thus, the program will not ask to save the database when the program closes the file.