2003 Urban Mobility Report: Volume 2

Five Congestion Reduction Strategies and Their

Effects on Mobility

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LIST OF EXHIBITS

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SUMMARY

The Urban Mobility Study (UMS) (1) Report procedures provide estimates of mobility at the areawide level. The approach that is used describes congestion in consistent ways using generally available data allowing for comparisons across urban areas or groups of urban areas. Past procedures only looked at projects that added lanes or reduced demand and overlooked many other types of projects that affected the demand characteristics. This report extends the procedures to several other treatments and even to public transportation. The goal is to include all improvements, but good data is necessary to accomplish this.

This report describes a framework for incorporating additional treatments and shows effects of those treatments. These two pieces should be viewed separately. This is a “first attempt” at showing the benefits of such projects and programs at an areawide level. The methodology for analyzing the treatments is developing just as transportation systems are also in a constant growth and development cycle. The results from the analysis could easily change as the research proceeds in this area.

The effect of operational treatments can be viewed as proportional to:

- the area of coverage
- the density of that coverage
- the mobility improvement provided by the treatment.

The traditional UMS procedures used to estimate travel delay can be modified by these factors to estimate new values that more accurately reflect the mobility contributions of the treatments. High-occupancy vehicle lanes and public transportation service have not been included in previous mobility estimates, and the operating and ridership statistics can be added to the database for each area.

The area and density factors have be estimated from federal, state and local databases and some confirmation of this information has been obtained by local reviews. The delay reduction effect of the treatments described below has been tailored as much as possible to the local implementation of the treatment, but typically varies with congestion level.

1. **Ramp Metering –** Improves the ability of the freeway to maintain relatively high speeds under conditions of high demand and postpones the onset of congestion.
   - **Inputs** to the delay reduction calculations range from 0 to about a 12 percent reduction.
   - **Results** show that ramp metering reduced freeway delay by about 4 percent in the 26 areas with metering in use.

2. **Traffic Signal Coordination—**Traffic signal coordination programs reduce delay by allowing more vehicles to maintain a smooth flow—particularly in the peak direction.
   - **Inputs** to the delay reduction calculations ranged from less than 1 percent to about a 6 percent reduction.
   - **Results** show that signal coordination reduced arterial delay by about 1.5 percent in the 75 areas studied.

3. **Incident Management Programs—**Quickly detecting and removing crashes and vehicle breakdowns reduces delay by returning traffic capacity to normal levels.
   - **Inputs** to the delay reduction calculations ranged from 0 to about a 40 percent reduction of incident delay.
   - **Results** show that incident management reduced freeway delay by just over 5 percent in the 56 areas that had some form of incident management implemented.

4. **HOV Lanes—**Providing reliable high-speed travel improves mobility levels in the corridors where HOV service is available. The HOV travel volume and speed statistics have been added to the current roadway system database for each area to produce an areawide reduction effect on the Travel Time Index.
   - **Inputs** to the delay reduction calculation for HOV lanes included 8 urban areas with HOV data with an average daily ridership of about 830,000 daily passenger-miles of travel.
   - **Results** of the HOV analysis showed that the Travel Time Index dropped by almost one-half point, on average, in each of the 8 areas with HOV lanes.

5. **Public Transportation Service—**Including public transportation service in a mobility measure will be accomplished with one of two methods. One method is to include the percentage of on-time transit riders in the uncongested roadway travel categories. The other approach would be to transfer transit riders into private automobiles and recalculate the mobility measures to estimate the increased congestion levels.
   - **Inputs** to the delay reduction calculation for public transportation included data for all 75 urban areas with an average annual ridership of approximately 581 million passenger-miles of travel.
   - **Results** using the first method (all transit riders are placed in uncongested auto trips) showed the Travel Time Index, on average, was reduced by approximately 4 points in the 75 urban areas studied.
   - **Results** using the second method (transit riders are placed in autos and mixed in with existing traffic) showed that transit riders added a total of 1,062 million hours of delay in the 75 urban areas in 2001. This additional delay could be viewed as the delay savings associated with the existence of transit in these areas.

BASIC DATA SOURCES

The Urban Mobility Study speed, delay and performance measure estimation methodology consists of two elements – use of **directly collected data** to study specific issues in depth where possible and **estimation processes** for other studies based on several national sources and analysis products:

- ITS Deployment Tracking Survey (IDTS)—This database provides access to information on the deployment and integration of ITS technology gathered through a series of nationwide surveys, beginning in 1996 and continuing to 2002
- ITS Deployment Analysis System (IDAS)—IDAS is a modeling tool that enables the user to conduct systematic assessments and quantitative evaluations of the relative benefits and costs of more than 60 types of ITS investments, in combination or in isolation
- Highway Performance Monitoring System (HPMS)—HPMS is a national level highway information system that includes data on the extent, condition, performance, use, and operating characteristics of the Nation's highways.
- Highway Economic Requirements System (HERS)—HERS is an engineering/economic analysis (EEA) tool that uses engineering standards to identify highway deficiencies, and then applies economic criteria to select the most cost-effective mix of improvements for system-wide implementation.
- Public Transportation Operation Statistics (APTA)—The American Public Transportation Association produces an annual report detailing transit usage by the various transit agencies within each urban areas across the U.S.
- Other data sources

ALTERNATIVES TO ESTIMATION PROCEDURES

In a perfect world, there would be no need for estimates of the effects of mobility enhancing projects as the data could be directly collected from the transportation system itself. However, the data collection for such projects is often cumbersome and expensive to collect and for these reasons—often goes uncollected.

Often, before/after studies or corridor analyses are performed to analyze the effects of an improvement by comparing characteristics before and after implementation. At other times, simulation models are used to calculate the benefits. Many of these types of analyses do exist for operational treatments but are typically performed over small areas such as a few miles of a road or perhaps an entire corridor.

Since this research effort focuses on regional transportation systems, some estimation is necessary as most areas do not perform system-wide studies. The information gained from the directly collected data and other detailed studies can be used to generate the necessary estimating parameters, but the data that will be available in most areas are the inventory and use statistics.

INCLUDING DIRECTLY COLLECTED DATA

The Mobility Monitoring Program (7) funded by FHWA has allowed the Texas Transportation Institute and Cambridge Systematics to identify and help create several data archives for the freeways that are monitored in 21 cities for 2000 and 2001. The data can be used to study the effects of a variety of treatments, as well as examine congestion and reliability levels and trends over several years when those data are available.

Other sources of directly collected data might include special project-focused studies or periodic speed or travel time studies. These studies support the estimation processes and studies of particular elements of the transportation system, and that may continue to be their role. Additional information will be gathered concerning the before and after conditions and the level of congestion in the area of the treatment (because some treatments have more effect in congested areas) to extend the usefulness of this data.

The directly collected data used in the Urban Mobility Study will include archived data information from the urban traffic operations centers or statewide data efforts such as California's Performance Measurement System (PeMS) (8). The information will also include studies of individual projects such as HOV lanes, ramp meters, incident management programs where that information is collected with sufficient level of detail and attention to isolating the before/after effects.

CONCEPT DESCRIPTION

The effect of operational treatments is proportional to the area of coverage, the density of that coverage and the mobility improvement provided by the treatment. The procedures used to estimate travel delay can be modified by these factors to estimate new values that more accurately reflect the mobility contributions of the treatments. High-occupancy vehicle lanes and public transportation service have not been included in previous mobility estimates, and the operating and ridership statistics from those elements can be added to the database for each area.

Three factors are key to estimating the mobility effects of operational treatments:

1. Area covered by the treatment—how much of the system has the treatment?
2. Density of the treatment within the covered area (particularly as it applies to service patrol programs)—how often is the area patrolled, updated or viewed?
3. Delay reduction effect—how much effect does the treatment have?

The area and density factors can be estimated from HPMS and IDTS databases and confirmed by local reviews. The delay reduction effect will be tailored as much as possible to the local area implementation of the treatment. State and local transportation staff can review the delay reduction factors to ensure reasonableness.

The ITS Deployment Tracking Survey (IDTS) database will be used when specific project effect information is not available or may be used to supplement specific project information. The general method used in these cases is described for each treatment type in that particular section.

The ITS Deployment Analysis System (IDAS) contains the tracking information and methods used by the U.S. Department of Transportation to evaluate ITS systems nationally.

FREEWAY ENTRANCE RAMP METERING

What Does Ramp Metering Do?

Ramp meters are modified traffic signals placed on the entrance ramps of urban freeways. They may operate on a pre-timed cycle or be responsive to conditions on the freeway mainlanes. Ramp meters typically release one vehicle per cycle from the ramp. The goal of these signals is to smooth out the flow of vehicles entering the freeway. Groups of vehicles entering a freeway that is approaching capacity can cause the freeway demand to exceed capacity. Stop and go traffic, reduced volume, and increased accident potential are associated with traffic demand exceeding capacity. If vehicles enter the freeway at a uniform rate, however, the smooth flow of traffic on the freeway can be preserved longer. Ramp meters will not eliminate congestion in most cases, but may delay stop-and-go conditions for 15 to 30 minutes having significant benefits.

Estimating the Delay Reduction Effect

Freeway entrance ramp metering improves the ability of the freeway mainlanes to maintain relatively high speeds under conditions of high demand. Postponing the onset of congestion can significantly improve the average travel speeds over the peak period. If the waiting time on the entrance ramps is factored into the estimates, the travel time savings are reduced, but not eliminated. Also included in the savings is the delay that can be reduced from a lower accident rate.

The IDTS includes information on the miles of system that were metered in 1999. The information from the HERS Operations Preprocessor (9) incorporates results from the Minnesota Ramp Metering Study (10). The Twin Cities study concluded that there was a 3 percent reduction in recurring delay reported for freeway, entrance ramp and street system and a 7 percent reduction reported for freeways-only. The recurring delay benefits will translate into some reduction in incident delay based on the current UMS methodology that factors incident delay from recurring delay. Exhibit 1 identifies the total delay reduction effect by freeway congestion category.

Exhibit 1. Ramp Metering Benefits in Delay Reduction (HPMS and Deployment Tracking)

Ramp Meter Strategy	Congestion Level				
	Uncongested	Moderate[1]	Heavy[1]	Severe[1]	Extreme[1]
No ramp meters	0	0	0	0	0
Isolated , pre-timed, centrally controlled or traffic responsive (recurring/incident)	0	peak=0 off-peak=0	peak=5.6 off-pk=0	peak=11.0 off-peak=7.3	peak=12.4 off-peak=11.6

[1] Derived from an equation relating speed to delay reduction for each congestion level.
Source: HERS Operations Preprocessor (9), Minnesota Ramp Metering Study (10), and TTI Analysis

Urban Mobility Report Procedures

Several steps are applied to the HPMS Universe sections for each urban area (the section of the database with volume and number of lanes for each section of the road system in the U.S.). The congestion level is determined for each section of roadway using the ADT per lane. The directional factor is applied to estimate the peak and off-peak traffic volume. The section of roadway is labeled as metered or unmetered based on the HPMS data. The average delay savings are calculated using the delay reduction percentages shown in Exhibit 1 for each congestion level. These percentages are based on the relationship in Exhibit 2 that is derived from the HERS model.

As an example of how the delay reduction factor relates to changes in average speed, Exhibit 3 shows the two freeway speed curves for peak and off-peak directions under the base UMS methodology, and the speed curves associated with ramp metering for both peak and off-peak travel. The delay reduction effects of ramp metering are more significant at the onset of congestion. Moving the congested time period back by only 15 to 30 minutes can have significant benefits. Ramp metering was found to be less effective after the onset of congestion, and the revised Minnesota metering scheme illustrates this.

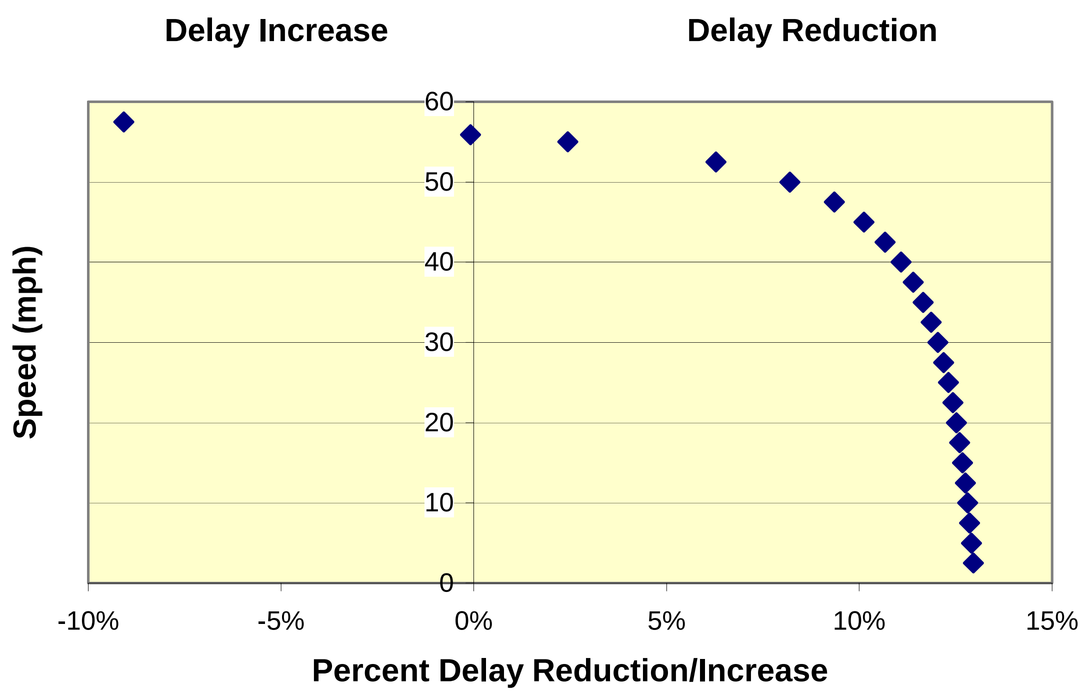

Exhibit 2. Ramp Metering Effects – Speed versus Delay Savings

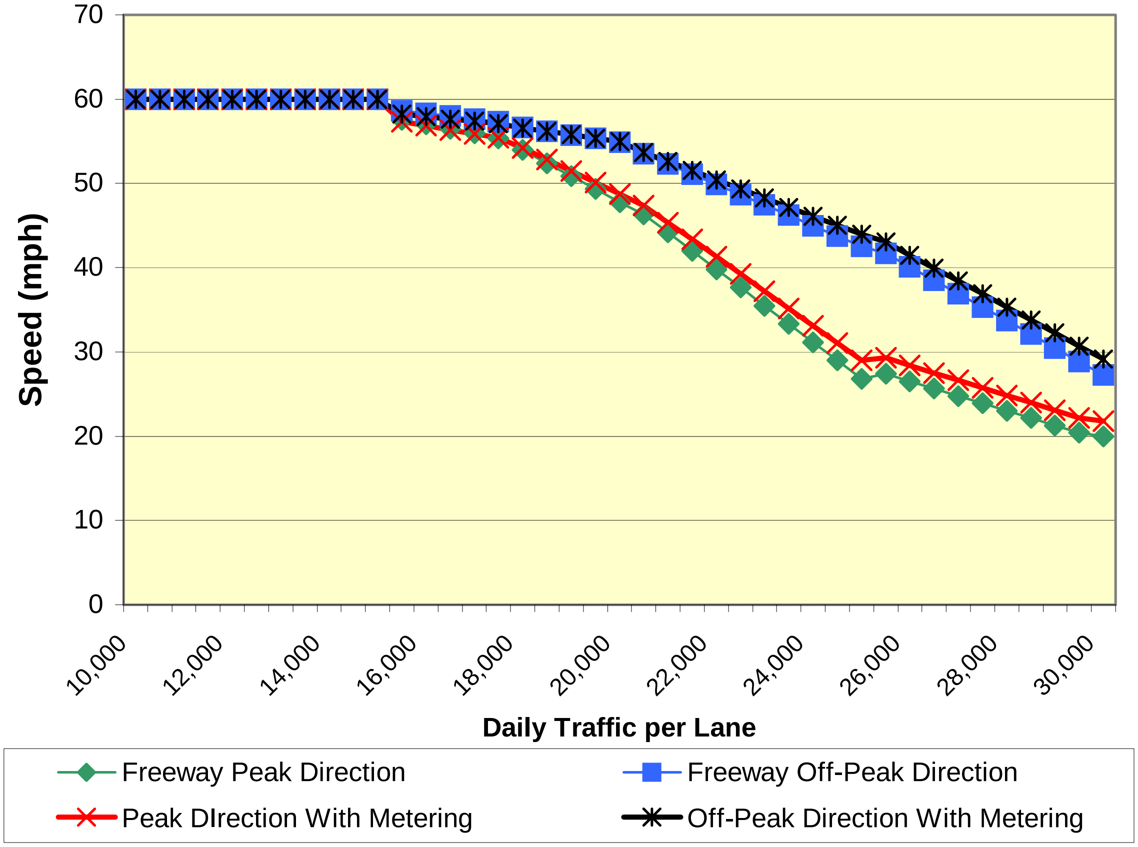

Exhibit 3. Freeway Speed Curves

Estimated Delay Reduction

Effect of Ramp Metering in 26 Areas Where Implemented

Exhibit 4 displays the amount of travel and the miles of freeway that are covered by ramp metering in the 26 urban areas that had ramp metering. There were no Small urban areas with ramp metering.

Exhibit 4. Freeway Ramp Metering Inventory—26 Areas

Population Group	Average Covered Freeway Travel		Average Covered Freeway Centerline-miles	
	Daily VMT (000)	Percentage	Miles	Percentage
Very Large (9)	11,450	20	80	16
Large (12)	9,620	47	105	40
Medium (5)	925	16	30	11
Small (0)	--	--	--	--
26 Area Average	8,580	28	80	23
26 Area Total	223,130	28	2,115	23

Source: HPMS (4), IDTS (2), and TIT Analysis

The effects of ramp metering in the 26 urban areas are shown in Exhibit 5. In the these areas, over 223 million daily vehicle-miles of travel (28 percent of all freeway travel in the 26 areas) occurred on 2,115 miles of freeway (23 percent of all freeway miles in the 26 areas) containing ramp metering. Some of the effects include:

- Overall, ramp metering lowered the freeway TTI by 0.016 (3.0 percent) and reduced the total freeway delay by 73 million hours (3.8 percent) in the 26 urban areas having ramp metering.
- The largest point and percentage reductions in freeway TTI and delay occurred in the Large urban areas with a 0.019 point reduction (4.7 percent) in the TTI and a 26.7 million hour reduction (6.3 percent) in total hours of delay.
- There was no ramp metering reported in the Small urban areas.

Exhibit 5. Freeway Ramp Metering Effects—26 Areas

Population Group	Freeway Travel Time Index			Freeway Hours of Delay (million)		
	Base	With Ramp Metering	Reduction	Base	With Ramp Metering	Reduction
Very Large (9)	1.613	1.598	.015	1,484.1	1,438.4	45.7
Large (12)	1.401	1.382	.019	423.8	397.1	26.7
Medium (5)	1.164	1.161	.003	20.0	19.3	0.7
Small (0)	--	--	--	--	--	--
26 Area Average	1.531	1.515	.016	1,927.8	1,854.8	73.0

Source: TTI Analysis

Effects of Ramp Metering in All 75 Areas

This section of analysis looks at the effects of ramp metering as it relates to all 75 of the areas in the UMS report. Exhibit 6 displays the amount of travel and the miles of freeway that are covered by ramp metering in the 75 urban areas.

Exhibit 6. Freeway Ramp Metering Inventory—75 Areas

Population Group	Average Covered Freeway Travel		Average Covered Freeway Centerline-miles	
	Daily VMT (000)	Percentage	Miles	Percentage
Very Large (10)	10,305	19	70	15
Large (30)	3,850	24	40	20
Medium (21)	220	3	5	2
Small (14)	--	--	--	--
75 Area Average	2,975	19	30	15
75 Area Total	223,130	19	2,115	15

Source: HPMS (4), IDTS (2), and TIT Analysis

The effects of ramp metering in the 75 urban areas are shown in Exhibit 7. In the these areas, over 223 million daily vehicle-miles of travel (19 percent of all freeway travel in the 75 areas) occurred on 2,115 miles of freeway (15 percent of all freeway miles in the 75 areas) containing ramp metering. Some of the effects include:

- Overall, ramp metering lowered the freeway TTI by 0.011 (2.6 percent) and reduced the total freeway delay by 73 million hours (3.1 percent) in the 75 urban areas.
- The largest point reduction in freeway TTI occurred in the Very Large urban areas with a 0.015 point reduction (2.5 percent). The delay was reduced by 45.6 million hours (3.0 percent) in the 75 areas.
- The greatest percentage reduction in freeway TTI occurred in the Large urban areas with a 0.010 reduction (3.1 percent). Delay was reduced by 3.8 percent (26.6 million hours).
- There was no ramp metering reported in the Small urban areas.

Exhibit 7. Freeway Ramp Metering Effects—75 Areas

Population Group	Freeway Travel Time Index			Freeway Hours of Delay (million)		
	Base	With Ramp Metering	Reduction	Base	With Ramp Metering	Reduction
Very Large (10)	1.609	1.594	.015	1,536.5	1,490.9	45.6
Large (30)	1.323	1.313	.010	709.8	683.2	26.6
Medium (21)	1.155	1.154	.001	107.8	107.3	0.5
Small (14)	1.053	1.053	.000	5.5	5.5	0.0
75 Area Average	1.428	1.417	.011	2,359.7	2,286.8	73.0

Source: TTI Analysis

TRAFFIC SIGNAL COORDINATION

What Does Traffic Signal Coordination Do?

Traffic signals can provide for the orderly movement of traffic, increase the capacity of intersections, and reduce the frequency of accidents. Making improvements to traffic signals can be one of the most cost-effective tools to increase mobility on arterials. In many cases, traffic signal equipment can be updated to more modern equipment to allow for greater flexibility of timing plans, including coordination with other nearby signals for progression. In some cases, existing equipment may be adequate, however, due to changing traffic patterns, timing plan improvements may be needed to more efficiently handle current traffic flows.

Estimating the Delay Reduction Effect

Traffic signal coordination programs reduce delay on arterial streets by allowing more vehicles to maintain a smooth flow—particularly in the peak direction. The IDTS dataset includes information about the total number of traffic signals managed by the reporting agency and the number of signals controlled from a central location. The HERS model estimates a maximum delay effect of about 9% reduction in recurring delay, based on the set of speed curves in IDAS for improvements in technology. These range from reductions of 3% for actuated signal control, 9% for centrally controlled systems and closed-loop systems and 20% for real-time adaptive signal controls. It might not be reasonable, however, to assume both directions at major crossing streets get a 9% benefit, and the values in Exhibit 8 have been reduced for network relationships.

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improved performance measures and updated data.

Exhibit 8. Signal Coordination Benefits in Delay Reduction

Signal Strategy	Signal Density (signals per mile)	Congestion Level				
		Uncongested	Moderate	Heavy	Severe	Extreme
No coordination	- -	0	0	0	0	0
Traffic Actuated	Less than 3 per mile	0	0.5	0.5	0.5	0.3
	3 to 6 per mile	0	2.2	2.1	1.9	1.5
	More than 6 per mile	0	2.1	2.1	1.5	1.1
Progressive (centralized or real-time)	Less than 3 per mile	0	1.0	1.0	0.9	0.7
	3 to 6 per mile	0	5.0	4.8	4.5	3.6
	More than 6 per mile	0	6.1	6.0	4.6	3.1

Source: HERS (9) and TTI Analysis

Urban Mobility Report Procedures

Several steps are applied to the HPMS sample sections for each urban area. The congestion level for each section is determined by using the ADT per lane for each section. Directional factors are applied to separate the traffic into peak and off-peak volumes. The signal density and type of signals are determined for each of the sections of roadway. The average speed for each congestion level is calculated once all of the sections of roadway are assigned (Exhibit 9). Finally, the average delay savings are calculated using the delay reduction percentages shown in Exhibit 6. This is accomplished by applying the appropriate reduction percentage for each congestion level, signal strategy and signal density to the delay that was calculated for each of those combinations in the preceding step.

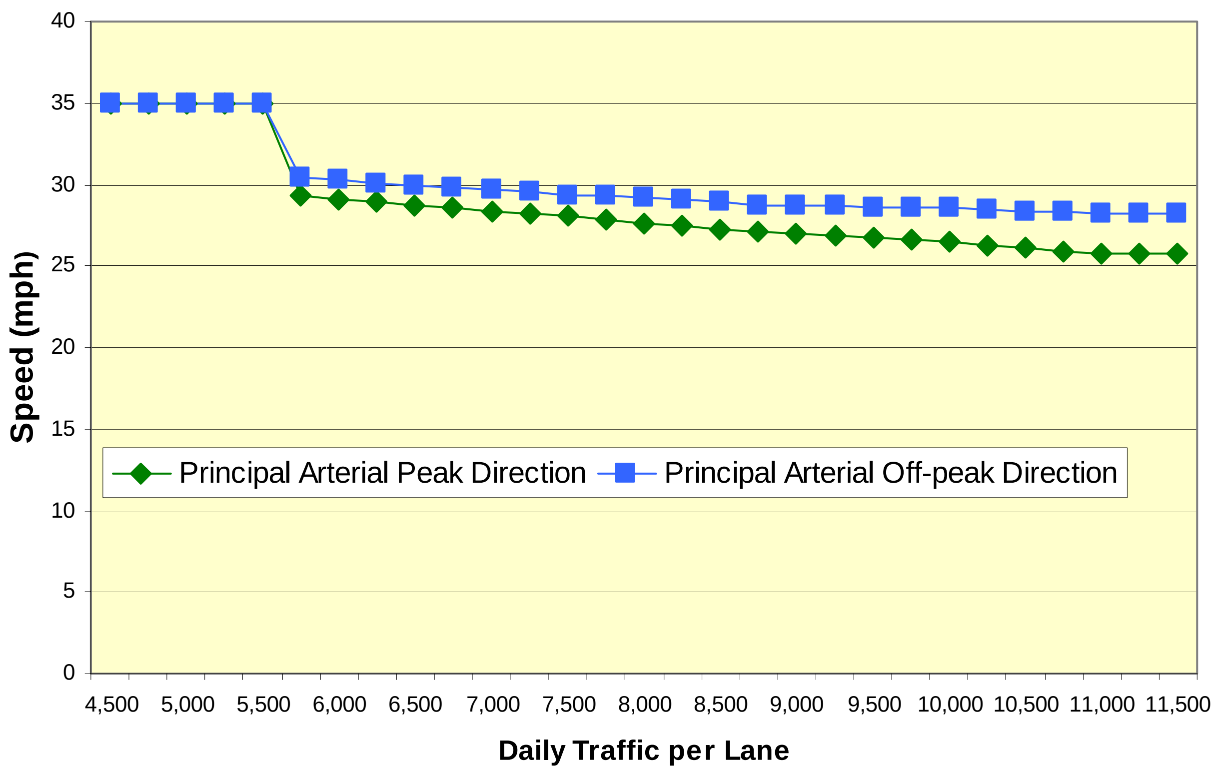

Exhibit 9. Principal Arterial Speed Estimation

Estimated Delay Reduction

Effects of Signal Coordination in All 75 Areas

All 75 urban areas had signal systems in place so there are not two analyses of the inventory and effects of signal systems. Exhibit 10 displays the vehicle-miles of travel and miles of principal arterial streets that had either actuated or progressive signal systems. In the 75 urban areas studied, over 702 million daily vehicle-miles of travel (59 percent) occurred on about 13,345 miles of principal arterial streets (54 percent) that have either actuated or progressive signals in place.

Exhibit 10. Principal Arterial Signal Coordination Inventory

Population Group	Average Covered P.A.S. Travel		Average Covered P.A.S. Centerline-miles	
	Daily VMT (000)	Percentage	Miles	Percentage
Very Large (10)	31,990	58	625	53
Large (30)	9,235	61	165	57
Medium (21)	3,905	57	80	53
Small (14)	1,675	55	35	47
75 Area Average	9,365	59	180	54
75 Area Total	702,405		13,345	54

Source: HPMS (4), IDTS (2), and TTI Analysis

Overall, principal arterial signal coordination reduced the arterial TTI by 0.005 (1.9 percent) and reduced the arterial hours of delay by 16.2 million hours (1.4 percent). Some of the results of signal coordination include (Exhibit 11):

- The greatest point reduction in the arterial TTI occurred in both the Very Large and Large urban areas with a 0.006 reduction. This equated to a 1.6 percent reduction in the Very Large urban areas and a 2.0 percent reduction in the Large areas.
- The largest savings in delay occurred in the Very Large urban areas with 7.3 million hours of delay (1.2 percent). The Large urban areas experienced a delay savings of 7.2 million hours (1.6 percent reduction).
- The smallest reduction occurred in the Small urban areas with a 0.003 reduction (1.9 percent) in the TTI and 0.3 million hours of delay savings (1.4 percent).

Exhibit 11. Principal Arterial Signal Coordination Effects

Population Group	Principal Arterial Travel Time Index			Principal Arterial Hours of Delay (million)		
	Base	with Signal Coordination	Reduction	Base	With Signal Coordination	Reduction
Very Large (10)	1.369	1.363	0.006	606.6	599.3	7.3
Large (30)	1.308	1.302	0.006	447.4	440.3	7.2
Medium (21)	1.251	1.247	0.004	111.3	109.9	1.4
Small (14)	1.158	1.155	0.003	21.4	21.1	0.3
75 Area Average	1.324	1.319	0.005	1,186.8	1,170.6	16.2

Source: TTI Analysis

INCIDENT MANAGEMENT PROGRAMS

What does Incident Management do?

Approximately half of the delay experienced by travelers in the United States is due to causes other than simple high volume of traffic. This nonrecurring congestion occurs as the result of traffic accidents, stalled vehicles, spilled loads, maintenance/construction activities, special events, and weather. The California DOT estimates that for each minute an incident blocks a lane, approximately five minutes are added to the total time the freeway will be congested. The actual capacity reduction of an incident blocking a lane is greater than the physical reduction in capacity due to motorist "rubbernecking" – slowing down to look at the incident – often on both roadway directions. Although a one-lane blockage out of three lanes translates to a 33 percent reduction in physical capacity, studies have shown an incident blocking a single lane out of three lanes results in a capacity reduction of up to 48 percent. Similarly, a two-lane blockage can reduce the capacity of a three-lane section by as much as 79 percent (1).
One method of combating congestion from nonrecurring incidents is to implement an incident management system. Incident management is a coordinated and planned approach for restoring freeway capacity as quickly as possible after an incident has occurred. The major elements of an incident management system are: detection and verification, response, clearance, and motorist notification.

Estimating the Delay Reduction Effect

Quickly identifying and removing crashes and vehicle breakdowns reduces delay by returning traffic capacity to normal levels. This analysis seeks to estimate where the freeway is monitored or patrolled and how frequently a service vehicle might patrol past the scene of a crash or breakdown. These factors have been studied in some projects, but the most comprehensive estimates of the effects are from the HERS applications. The results from the HERS and other studies are difficult to compare.

The IDTS database lists the amount of roadway covered by detection algorithms, cameras or service patrol vehicles and the number of vehicles used in the motorist assistance efforts. The effects are combined – the detection algorithms allow quicker identification of a problem, the cameras verify the problem and allow for more appropriate and quicker response, and the service patrols respond and remove the incident. The IDTS does not, however, identify specific sections of treatment.

The HPMS database identifies the specific sections (and miles) covered by each technique. Cambridge Systematics has merged these two elements for the HERS analysis and applied any "remaining miles" in the Deployment estimate to the most congested, but uncovered sections in the HPMS database. The algorithm and camera coverage is coded for the sections of treated road. A density level of 1 service patrol vehicle for every 10 or fewer miles identifies the standard for cities that should get a 100% density factor in the delay reduction estimates.

The delay reduction percentages, however, are not as easily translated from the HERS model to the Urban Mobility Study methodology. HERS estimates the effect of service patrols as a 25% reduction in incident duration which, when modeled at the section level with HPMS data resulted in a 65% reduction in incident delay. The camera systems contributed an additional four to five percent reduction in incident duration. When both treatments are combined, this would suggest a 30% reduction in incident duration and an 70 to 75 percent reduction in incident delay. This is too high to use for an areawide average, judging from the Buffer Time Index values in the 2001 and 2002 Mobility Monitoring Project reports and the incident management programs in the study cities. The net reduction in delay would seem to be less than the 65% value estimated in the model. The study will continue to compare the two analytical techniques (MMP and HERS). For methodology purposes, the UMS database was examined with a 15% reduction in duration and a 40% reduction in delay if both components are present (see Exhibits 12 and 13).

Exhibit 12. Incident Delay Reduction Benefits of Freeway Service Patrols (HPMS and Deployment Tracking)

System Coverage	Patrol Cycle (miles each vehicle covers)	Congestion Level				
		Uncongested	Moderate	Heavy	Severe	Extreme
No patrols		0	0	0	0	0
If 100% of the system is covered	More than 10 miles	0	18	21	24	28
	Less than 10 miles	0	25	28	31	35

Source: HERS (9) and TTI Analysis

Exhibit 13. Incident Delay Reduction Benefits of Surveillance Cameras (HPMS and Deployment Tracking)

System Coverage	Congestion Level				
	Uncongested	Moderate	Heavy	Severe	Extreme
No cameras	0	0	0	0	0
Coverage amount					
25%	0	2.5	3.0	3.5	3.5
50%	0	2.5	3.0	3.5	4.0
75%	0	3.0	3.5	4.0	4.5
100%	0	3.0	3.5	4.0	5.0

Source: HERS (9) and TTI Analysis

Urban Mobility Report Procedures

Several steps are applied to the HPMS universe sections for each urban area. The congestion level for each section is determined by using the ADT per lane for each section. Directional factors are applied to separate the traffic into peak and off-peak volumes. The existence of freeway service patrols and camera surveillance on each section is determined. The average delay is calculated for each congestion level and the corresponding savings are calculated using the delay reduction percentages shown in Exhibits 12 and 13. This is accomplished by applying the appropriate reduction percentage for each congestion level and treatment type to the delay that was calculated for each of those combinations.

Estimated Delay Reduction

Effects of Incident Management in 56 Areas Where Implemented

Incident Management programs were in place in 56 of the 75 urban areas. Exhibit 14 shows that over 307 million daily vehicle-miles of travel (32 percent) occurred on 3,110 miles of roadway (27 percent) that were monitored with some form of camera surveillance in 45 of the urban areas studied. Over twice this amount (644 million daily vehicle-miles of travel, 60 percent) traveled on 7,210 miles of freeway (54 percent) that had active service patrols in place in 53 of the urban areas.

Exhibit 14. Freeway Incident Management Inventory – 56 Areas

Population Group	Average Covered Freeway Travel		Average Covered Freeway Centerline-miles	
	Daily VMT (000)	Percentage	Miles	Percentage
Surveillance Cameras				
Very Large (9)	17,915	33	165	28
Large (22)	5,245	30	50	24
Medium (12)	2,360	35	35	29
Small (2)	1,070	44	20	38
45 Area Average	6,825	32	70	27
45 Area Total	307,165	32	3,110	27
Service Patrols				
Very Large (10)	30,275	56	305	51
Large (26)	10,350	63	125	58
Medium (15)	4,755	67	60	58
Small (2)	575	24	10	25
53 Area Average	12,155	60	135	54
53 Area Total	644,335	60	7,210	54

Source: HPMS (4), IDTS (2), and TTI Analysis

The effects of incident management programs are shown in Exhibit 15. Fifty-six of the urban areas had either camera surveillance, freeway service patrols, or both. Overall, the benefits of incidents management were a reduction in the TTI of 0.012 (2.7 percent) and a reduction in freeway hours of delay of 116.8 million hours (5.1 percent). Some of the other findings include:

- The greatest reduction in the TTI occurred in the Very Large areas with a reduction of 0.016 (2.6 percent). The Very Large areas also had the greatest delay reduction of 79 million hours (5.1 percent).
- The largest percentage reduction in the TTI occurred in the Small urban areas with a 3.8 percent reduction in the TTI (0.002 points). The Small urban areas also showed the largest percentage reduction in delay with a 10 percent savings (100,000 hours).

Exhibit 15. Freeway Incident Management Program Effects – 56 Areas

Population Group	Freeway Travel Time Index			Freeway Hours of Delay (million)		
	Base	With Incident Management	Reduction	Base	With Incident Management	Reduction
Very Large (10)	1.609	1.593	0.016	1,536.5	1,457.5	79.0
Large (28)	1.322	1.311	0.011	666.8	634.1	32.7
Medium (16)	1.163	1.157	0.006	89.8	84.8	5.0
Small (2)	1.053	1.051	0.002	1.0	0.9	0.1
56 Area Average	1.442	1.430	0.012	2,294.1	2,177.3	116.8

Source: TTI Analysis

Effects of Incident Management in All 75 Areas

This section shows the effects of incident management as it relates to all 75 urban areas studied. Exhibit 16 shows that over 307 million daily vehicle-miles of travel (26 percent) occurred on 3,110 miles of roadway (22 percent) that were monitored with some form of camera surveillance in all 75 of the urban areas. Over twice this amount (644 million daily vehicle-miles of travel, 54 percent) traveled on 7,210 miles of freeway (49 percent) that had active service patrols in place in the 75 urban areas.

Exhibit 16. Freeway Incident Management Inventory – 75 Areas

Population Group	Average Covered Freeway Travel		Average Covered Freeway Centerline-miles	
	Daily VMT (000)	Percentage	Miles	Percentage
Surveillance Cameras				
Very Large (10)	16,125	30	150	25
Large (30)	3,850	24	40	20
Medium (21)	1,350	20	20	16
Small (14)	155	11	5	9
75 Area Average	4,095	26	40	22
75 Area Total	307,165	26	3,110	22
Service Patrols				
Very Large (10)	30,275	56	305	51
Large (30)	8,970	55	110	51
Medium (21)	3,400	51	45	44
Small (14)	80	6	5	6
75 Area Average	8,590	54	95	49
75 Area Total	644,335	54	7,210	49

Source: HPMS (4), IDTS (2), and TTI Analysis

The effects of incident management programs are shown in Exhibit 17. Fifty-six of the urban areas had either camera surveillance, freeway service patrols, or both. Overall, the benefits of incidents management were a reduction in the TTI of 0.012 (2.8 percent) and a reduction in freeway hours of delay of 116.8 million hours (5.0 percent). Some of the other findings include:

- The greatest reduction in the TTI occurred in the Very Large areas with a reduction of 0.016 (2.6 percent). The Very Large areas also had the greatest delay reduction of 79 million hours (5.1 percent).
- The largest percentage reduction in the TTI occurred in the Large urban areas with a 3.4 percent reduction in the TTI (0.011 points). The Very Large urban areas showed the largest percentage reduction in delay with a 5.1 percent savings (79 million hours).

Exhibit 17. Freeway Incident Management Program Effects – 75 Areas

Population Group	Freeway Travel Time Index			Freeway Hours of Delay (million)		
	Base	With Incident Management	Reduction	Base	With Incident Management	Reduction
Very Large (10)	1.609	1.593	0.016	1,536.5	1,457.5	79.0
Large (30)	1.323	1.312	0.011	709.8	677.1	32.7
Medium (21)	1.155	1.150	0.005	107.8	102.9	4.9
Small (14)	1.053	1.052	0.001	5.5	5.5	0.0
75 Area Average	1.428	1.416	0.012	2,359.7	2,242.9	116.8

Source: TTI Analysis

HOV LANES

What Are HOV Lanes?

HOV lanes are exclusive roadways or lanes designated for high occupancy vehicles, such as buses, vanpools, and carpools. The facilities may operate as HOV lanes full time or only during the peak periods. HOV lanes typically require minimum vehicle occupancy of two or more persons. However, in some locations, occupancy requirements have been raised to preserve the high speeds on the facility. Support facilities such as park and ride lots and transit centers with direct access to the HOV lane are important system elements to increase facility use. HOV lanes may also be used to provide bypass lanes on entrance ramps with ramp meter signals.
Several common types of HOV lanes are barrier separated, concurrent flow, and contra flow lanes.

- Barrier-separated lanes are typically constructed in the center of the freeway and physically separated from the general-purpose lanes with concrete barriers. Single lane facilities operate as reversible lanes, flowing in one direction during the morning period and the other direction in the evening period. Multiple lane facilities may either be operated as two-way facilities or reversible facilities.
- Concurrent flow HOV lanes (commonly the inside lane) operate in the same direction of flow as the general-purpose lanes and are usually separated from the general-purpose lanes by a small buffer and wide paint stripe.
- Contra flow lanes make use of the inside off-peak direction general-purpose lane during the peak period. Movable concrete barriers are used on several facilities around the U.S..

Estimating the Delay Reduction Effect

Providing reliable and high-speed travel improves corridor mobility levels where HOV service is available. We will use evaluations or operating statistics of individual lanes that have reliable speed and person travel volume information. The HOV travel statistics will be added to the current freeway and principal arterial street system information for each area to produce an areawide effect on the Travel Time Index.

Urban Mobility Report Procedures

An HOV Travel Time Index is calculated for each city with HOV data. This HOV TTI is combined with the traditional UMS freeway TTI by weighting the freeway passenger-miles of travel with the HOV passenger-miles of travel. The difference between the combination and the traditional UMS freeway TTI displays the effects. Similarly, the amount of delay that is saved by having persons in the HOV lane and not the freeway mainlanes is calculated as well.

Estimated Delay Reduction

Effects of HOV Lanes in 8 Areas Where Implemented

High-occupancy vehicle data has been included from eight urban areas in the U.S. (Exhibit 18). This does not include information from all of the existing HOV lanes in the country, but only those where readily available statistics were available. Five of these areas are Very Large and 3 are Large. No Medium or Small areas have HOV information included. The average passenger-miles of travel (PMT) in the five Very Large areas is over 1.1 million miles a day while the average PMT for the Large areas is about 350,000 miles a day. There were approximately 6.6 million passenger-miles of travel on the HOV lanes in these areas.

Exhibit 18. Freeway High-Occupancy Vehicle Lane Inventory – 8 Areas

Population Group	HOV Lane Daily Passenger-miles of Travel (000)
Very Large (5)	1,115
Large (3)	352
Medium	--
Small	--
8 Area Average	829
8 Area Total	6,631

Source: Local agencies and TTI Review

Exhibit 19 displays the effects generated by HOV lanes. The HOV lane ridership included in the analysis lowered the freeway TTI by 0.009 (1.5 percent) and the freeway hours of delay by 11 million hours (0.9 percent) in these eight urban areas. Some additional statistics include:

- The HOV lanes lowered the freeway Travel Time Index values by 0.010 in the Very Large and 0.007 in the Large urban areas.
- There were approximately 9.7 million hours of delay saved per year by passengers using the HOV lanes in the Very Large urban areas and 1.3 million hours saved in the Large areas.

Exhibit 19. Freeway HOV Lane Effects – 8 Areas

Population Group	Freeway Travel Time Index			Freeway Hours of Delay (million)		
	Base	With HOV	Reduction	Base	Reduction due to HOV	Percent of Base Delay
Very Large (5)	1.661	1.651	0.010	1,121.2	9.7	0.9
Large (3)	1.457	1.450	0.007	140.2	1.3	0.9
Medium (0)	--	--	--	--	--	--
Small (0)	--	--	--	--	--	--
8 Area Average	1.629	1.620	0.009	1,261.4	11.0	0.9

Source: TTI Analysis

Effects of HOV Lanes in All 75 Areas

This portion of the analysis will show the effects that HOV lanes in 8 areas have on the 75 urban areas studied. High-occupancy vehicle data has been included from eight urban areas in the U.S. (Exhibit 20). This does not include information from all of the existing HOV lanes in the country, but only those where readily available statistics were available. Five of these areas are Very Large and 3 are Large. No Medium or Small areas have HOV information included. The average passenger-miles of travel (PMT) in the five Very Large areas is just over a half million miles a day while the average PMT for the Large areas is about 35,000 miles a day. There were approximately 6.6 million daily passenger-miles of travel on the HOV lanes in these areas.

Exhibit 20. Freeway High-Occupancy Vehicle Lane Inventory – 75 Areas

Population Group	HOV Lane Daily Passenger-miles of Travel (000)
Very Large (10)	557
Large (30)	35
Medium (21)	--
Small (14)	--
75 Area Average	88
75 Area Total	6,631

Source: Local agencies and TTI Review

Exhibit 21 displays the effects generated by HOV lanes. The HOV lane ridership included in the analysis lowered the freeway TTI by 0.004 (0.9 percent) and the freeway hours of delay by 11 million hours (0.5 percent) in these eight urban areas. Some additional statistics include:

- The HOV lanes lowered the freeway Travel Time Index values by 0.007 in the Very Large and 0.001 in the Large urban areas.
- There were approximately 9.7 million hours of delay saved per year by passengers using the HOV lanes in the Very Large urban areas and 1.3 million hours saved in the Large areas.

Exhibit 21. Freeway HOV Lane Effects – 75 Areas

Population Group	Freeway Travel Time Index			Freeway Hours of Delay (million)		
	Base	With HOV	Reduction	Base	Reduction due to HOV	Percent of Base Delay
Very Large (10)	1.609	1.602	0.007	1,536.5	9.7	0.6
Large (30)	1.323	1.322	0.001	709.8	1.3	0.2
Medium (21)	1.155	1.155	0.000	107.8	--	--
Small (14)	1.053	1.053	0.000	5.5	--	--
75 Area Average	1.428	1.424	0.004	2,359.7	11.0	0.5

Source: TTI Analysis

PUBLIC TRANSPORTATION

What is Public Transportation?

The buses and trains that comprise the majority of public transportation carry a significant amount of trips in many large areas and provide some important benefits in smaller areas. Peak period public transportation service during congested hours can improve the transportation capacity, provide options for travel mode and allows those without a vehicle to gain access to jobs, school, medical facilities or other destinations. In the case of public transportation lines that do not intersect roads, the service can be particularly reliable as they are not affected by the collisions and vehicle breakdowns that plague the roadway system, and are not as affected by weather, road work and other unreliability producing events. This section provides an estimate of the benefits of general public transportation service and high-occupancy vehicle lane operations.

Estimating the Delay Reduction Effect

The process of including transit service in a mobility measure must recognize that there are differences between estimates of mobility on roads and the concept of mobility in transit service. There are some similarities that can provide a basis for comparison, but an evolutionary approach to including public transportation service seems to make sense. This has proven useful on the roadway measures research efforts where the data, procedures and measures have changed as different needs were identified or new data became available. Using the best available data and models to produce estimates of the performance measures and improving the estimates and measures over the next few years as the needs are better understood and the knowledge is enhanced appears to be a reasonable course.

The available data sources do not readily lend themselves to estimates of peak period travel speed and person travel on transit. There may be ways to estimate these factors from a combination of nationally consistent databases and local studies or databases, but it is important to have a theoretical basis for the assumptions made in the analyses. The best time comparison would seem to use the peak period, and person travel appear to be the best way to capture the mobility provided by public transportation.

A significant potential source of confusion is in translating the roadway mobility concept of congestion into urban transit operations. There are several differences between what constitutes congestion and free-flow travel on roads and the same concepts on transit, but there also appears to be a common ground in the concept of what travel conditions are desirable. It is reasonable to assume that transit riders plan their trip based on the schedules and operating headways of the transit service. The expected performance, then, is for the train or bus to arrive on schedule. This would be equivalent to the roadway concept of free-flow travel. In this relationship, "on-time transit" would be equivalent to "uncongested roadway."

At first glance, it might appear overly generous to evaluate transit operations without an estimate of the travel speed. But, the service characteristics and expectation are very different. Local bus routes typically travel slower than the private vehicles on the same street because they stop to allow riders to enter and exit the bus. Rail routes may be faster or slower depending on the amount of interference with general vehicle traffic and station spacing. Transit routes can gain speed by decreasing stops, but at the risk of losing ridership. This relationship between speed and convenience is constantly adjusted by transit agencies seeking to increase transit service and ridership.

This approach to defining a "free-flow" speed for transit routes would result in a slower speed relative to the adjacent vehicle traffic on the same roadway. This might appear inconsistent, but two factors appear relevant.

- There is already a different speed threshold for streets and freeways. Vehicle travel on streets is graded against a free-flow speed of 35 mph compared to the freeway speed of 60 mph.
- Bus riders use the schedule speed to make their travel mode decisions. In doing this, the riders understand that travel might be slower or faster than adjacent street or freeway traffic. The "penalty" or "reward" for public transportation in this mobility estimate comes from gain or loss in ridership. If the route travel times become unreasonably long, ridership will decline, and the amount of "uncongested" passenger-miles contributed by public transportation will also decline. The beneficial effects of faster route times, better access or improved service from interconnected networks or high-speed bus or rail links would result in higher ridership values, which would increase the amount of "uncongested" travel in the mobility measure calculations.

Extending the concept of different "desirable" speeds to transit service analysis will provide a good measure of mobility, as well as simplifying the data requirements to the elements that might be available or estimated.

Urban Mobility Report Procedures

The passenger miles of travel from public transportation are included into the daily passenger-miles of travel on the roadways in order to calculate the TTI and delay savings. All transit PMT is included as uncongested travel to calculate the TTI, and the transit PMT is added to the existing mix on the roadways to calculate delay savings.

Estimated Delay Reduction

Effects in All 75 Areas

In the 75 urban areas studied, Exhibit 22 shows that there were approximately 44 billion passenger-miles of travel on public transportation systems in 2001. The annual ridership ranged from about 19 million in the Small urban areas to about 3.4 billion in the Very Large areas.

Exhibit 22. Public Transportation Inventory – 75 Areas

Population Group	Public Transportation Annual Passenger-miles of Travel (million)
Very Large (10)	3,403
Large (30)	257
Medium (21)	74
Small (14)	19
75 Area Average	581
75 Area Total	43,557

Source: APTA Operating Statistics (6) and TTI Review

Exhibit 23 shows the effects of public transportation in the 75 areas studied. Overall, public transportation lowered the TTI by 0.04 (10.2 percent) and accounted for a reduction in roadway delay of about 1.06 billion hours or 29.9 percent of total delay. Some additional effects include:

- The largest reduction in the TTI occurred in the Very Large areas with a reduction of 0.070 (13.7 percent). The Very Large areas experienced a reduction in delay of almost 849 million hours per year (almost 40 percent of total delay).
- The Large urban areas experienced the second largest reduction in the TTI and delay with a reduction of 0.014 points (4.4 percent) to the TTI and almost 189.2 million hours of delay per year (16.4 percent of total delay).

Exhibit 23. Effects of Public Transportation – 75 Areas

Population Group	System Travel Time Index			System Hours of Delay (million)		
	Base	with Public Transportation	Reduction	Base	Reduction due to Transit	Percent of Base Delay
Very Large (10)	1.513	1.443	0.070	2,143.1	848.5	39.6
Large (30)	1.318	1.304	0.014	1,157.3	189.2	16.4
Medium (21)	1.190	1.184	0.006	219.1	22.6	10.3
Small (14)	1.109	1.106	0.003	27.0	1.7	6.3
75 Area Average	1.392	1.352	0.040	3,546.5	1,061.9	29.9

Source: TTI Analysis

Future Improvements to Public Transportation Analysis

A longer-term approach will be to develop links with the public transportation operations databases that some agencies have. These include travel time, speed and passenger volume data automatically collected by transit vehicle monitoring systems. Linking this data with the roadway performance data in public transportation corridors would be the logical extension of the archived roadway data inclusion efforts being funded by the Federal Highway Administration. An alternative to the real-time data would be to estimate public transportation vehicle travel time and speed information from route schedules, and combine them with the passenger loading information collected by the public transportation systems. While these data are not reported in nationally consistent formats, most public transportation systems have this type of information.

Sensitivity Analysis of Operational Treatments

Sensitivity Analysis on Treatment Delay Reduction Factors

A sensitivity analysis was performed on the delay reduction factors associated with ramp metering, incident management, and traffic signal coordination. The factors were both increased and decreased by 20 percent to show just how sensitive the results were to changes in the inputs. Exhibit 24 shows the results of this analysis on both the Travel Time Index and annual hours of delay.

For ramp metering, the analysis revealed that a 20 percent decline in the delay reduction factors would lower the change in the TTI from a 3.0 percent to a 2.3 percent improvement and would lower the delay reduction from 4.0 percent down to 3.0 percent. A 20 percent increase in the delay reduction factors would increase the percent change in the TTI from 3.0 percent to 3.6 percent and would increase the percentage of delay reduced from 4.0 percent up to 4.5 percent.

The sensitivity analysis on the delay reduction factors for signal coordination revealed that increasing the delay reduction factors would not make much of a difference on the results while decreasing the factors would have some effects. This might be due where the progressive and actuated signals were located in the road networks in the cities and the fact that more of a difference would be made if the uncoordinated signal systems were upgraded in each of the cities. A 20 percent reduction in the delay reduction factors would reduce the TTI reduction from 1.9 percent to 1.5 percent and lower the delay reduction benefit from 1.4 to 1.1 percent. A 20 percent increase in the delay reduction factors would not show much of an increase the percentage reduction in the TTI and would increase the reduction in annual delay only slightly from 1.4 to 1.6 percent.

The sensitivity analysis for freeway incident management showed that a 20 percent drop in the delay reduction factors would lower the TTI reduction from 2.7 percent to 2.3 percent and would lower the reduction in delay from 5.1 to 4.1 percent. An increase of 20 percent to the delay reduction factors would increase the TTI reduction from 2.7 to 3.4 percent and would increase the delay reduction from 5.1 to 6.1 percent.

Exhibit 24. Sensitivity Analysis on Reduction Factors

	TTI				Total Annual Delay (million hours)			
	Base	With treatment	20% Reduction	20% Increase	Base	With treatment	20% Reduction	20% Increase
Freeway Statistics								
Ramp Metering								
Very Large (9)	1.613	1.598	1.601	1.595	1,484	1,438	1,449	1,430
Large (12)	1.401	1.382	1.386	1.378	424	397	403	392
Medium (5)	1.164	1.161	1.162	1.160	200	19	20	19
Small (0)	—	—	—	—	—	—	—	—
26 Areas	1.531	1.515	1.519	1.512	1,928	1,855	1,871	1,841
Incident Management								
Very Large	1.609	1.593	1.596	1.589	1,537	1,458	1,473	1,442
Large	1.322	1.311	1.313	1.309	667	634	641	628
Medium	1.163	1.157	1.158	1.156	90	85	86	84
Small	1.053	1.051	1.051	1.051	1.0	0.9	0.9	0.9
56 Areas	1.442	1.430	1.432	1.427	2,294	2,177	2,201	2,154
Principal Arterial Statistics								
Signal Coordination								
Very Large (10)	1.369	1.363	1.364	1.362	607	599	601	598
Large (12)	1.308	1.302	1.303	1.301	447	440	442	439
Medium (5)	1.251	1.247	1.247	1.246	111	110	110	110
Small (0)	1.158	1.155	1.156	1.155	21	21	21	21
75 Areas	1.324	1.318	1.319	1.318	1,187	1,171	1,174	1,167

Source: TTI Analysis

Full Implementation of Operational Treatments

What if the 75 Urban Areas had Full Implementation?

What sort of impact would the treatments make if all 75 urban areas had them implemented on 100 percent of their roadway system? An analysis was performed to answer this question. Full implementation of all three treatments would lower the Travel Time Index by 0.025 points resulting in an annual delay savings of almost 518 million hours. This level of implementation would save each person in the 75 areas over three hours per year, an amount equal to four or five years of growth.

Exhibit 25 shows that with 100 percent implementation of ramp metering, the TTI could be lowered by 0.035 points to 1.393 in the 75 urban areas. This equates to almost 269 million hours of delay that would be saved, an average of about one hour per year for every person living in the 75 areas. Approximately two-thirds of the delay savings would occur in the Very Large areas. Ramp meter delay reduction benefits would be a combination of recurring and incident delay.

The incident management program would also show significant benefits from full implementation with a reduction of 0.025 points to 1.403 in the 75 urban areas. This reduction equals over 215 million hours of delay that would be eliminated. On average, every person living in the 75 urban areas would see an annual delay reduction of about 2 hours per year. This value is a product of reducing the incident delay only and does not include the improved reliability that would result from reducing the long duration collision scenes.

If 100 percent of the signal systems were progressive, the amount of delay reduction in the 75 urban areas would approximately double. The TTI would be reduced by 0.01 points. The annual delay savings associated with full implementation would equal about 34 million hours. Every person in the 75 urban areas would experience an annual delay reduction of about 12 minutes.

The largest delay reduction improvements would occur in the Very Large and Large areas where the most travel and delay occurs, but the efficiency improvements in areas of all sizes are important aspects of achieving the most productivity from the available capacity.

Exhibit 25. Full Implementation of Operational Treatments

	TTI		Total Annual Delay (million hours)		Annual Delay per Capita (hours)	
	Base	100% full implementation	Base	100% full implementation	Base	100% full implementation
Freeway Statistics						
Ramp Metering						
Very Large (10)	1.609	1.558	1537	1356	24	21
Large (30)	1.323	1.297	710	631	14	12
Medium (21)	1.155	1.147	108	99	7	6.6
Small (14)	1.053	1.051	6	5	1	1.3
75 Areas	1.428	1.393	2360	2091	17	16
Incident Management						
Very Large (10)	1.609	1.575	1536.5	1395	24	22
Large (30)	1.323	1.304	710	648	14	13
Medium (21)	1.155	1.144	108	96	7.1	6.4
Small (14)	1.053	1.048	6	4.8	1.4	1.2
75 Areas	1.428	1.403	2360	2144	18	16
Principal Arterial Statistics						
Signal Coordination						
Very Large (10)	1.369	1.358	607	590	9.4	9.1
Large (30)	1.308	1.299	447	435	8.8	8.5
Medium (21)	1.251	1.244	111	108	7.4	7.2
Small (14)	1.158	1.154	21	21	5.5	5.3
75 Areas	1.324	1.314	1187	1153	8.8	8.6
Three Operational Treatment Statistics						
Very Large (10)	1.513	1.478	2143	1804	33	28
Large (30)	1.318	1.298	1157	1004	23	20
Medium (21)	1.190	1.181	219	196	15	13
Small (14)	1.109	1.105	27	25	6.9	6.5
75 Areas	1.392	1.367	3547	3029	26	23

Source: TTI Analysis

CONCLUSIONS

The purpose of this analysis is not to draw comparisons between strategies to determine which one is providing the most benefit. The purpose is simply to estimate the benefits at an urban area level using a consistent methodology. Each of the urban areas in the study has different characteristics that might make one strategy more viable than another and each area implements the strategies in different ways. Thus, analyzing the effects across urban areas may not provide a valid comparison. Technologies, operating practices, programs and strategies provide methods to get the most efficiency out of the road and transit capacity that is built, sometimes for modest costs and low environmental effects. In some cases, the operational improvements are some of the few strategies that can be approved, funded and implemented, and all of the strategies analyzed in the report have been shown to be very cost effective at the individual project level.

For years, the statistics in the Annual Mobility Report have shown that traffic congestion continues to increase. The report has also stated that cities need to use a diverse set of solutions to deal with the mobility problem. This analysis shows that some of the possible solutions to the problem are making a difference in the struggle with congestion. Obviously, more strategies are needed and greater implementation of these solutions is needed in many areas to keep up with the growing demand on the transportation system.

REFERENCES

1. Annual Urban Mobility Report website: http://mobility.tamu.edu/ums

2. ITS Deployment Tracking Survey (IDTS): itsdeployment2.ed.ornl.gov/its2002/default.asp.

3. ITS Deployment Analysis System (IDAS): www.camsys.com/tod/idas/index/html.

4. Highway Performance Monitoring system (HPMS): www.fhwa.dod.gov/policy/ohpi/hpms/index.htm.

5. Highway Economic Requirements System (HERS): www.fhwa.dot/gov//////infrastructure/csstmgmt/hersprep.htm.

6. American Public Transportation Association. Public Transportation Operation and Financial Statistics. America Public Transportation Association, Washington, D.C. (www.apta.com) Series 1982 to 2001.

7. Lomax, Tim, Shawn Turner and Richard Margiotta. Texas Transportation Institute and Cambridge Systematics, Inc. "Monitoring Urban Roadways in 2001: Using Archived Operations Data for Reliability and Mobility Measurement." June 2003.

8. California Department of Transportation. Performance Measurement System (PeMS). (www.dot.ca.gov).

9. Federal Highway Administration. *Highway Economic Requirement System Technical Report: Operations Pre-processor*. FHWA PL-00-028. December 2000.

10. Cambridge Systematics. Twin Cities Ramp Meter Evaluation-Final Report. February 2001.