THE 2007 URBAN MOBILITY REPORT

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September 2007

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Acknowledgements

Pam Rowe—Report Preparation
Tobey Lindsey—Web Page Creation and Maintenance
Richard Cole, Rick Davenport, Bernie Fette and Michele Hoelscher—Media Relations
John Henry and Kim Miller—Cover Artwork
Dolores Hott and Nancy Pippin—Printing and Distribution
Rhonda Brinkmann—Editing

Support for this research was provided in part by a grant from the U.S. Department of Transportation, University Transportation Centers Program to the University Transportation Center for Mobility (DTRT06-G-0044).

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Texas Transportation Institute
UTCM University Transportation Center for Mobility Texas Transportation Institute
APTA American Public Transportation Association
ARTBA American Road & Transportation Builders Association

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2007 Urban Mobility Report

Congestion is a problem in America's 437 urban areas and it is getting worse in regions of all sizes. Congestion caused urban Americans to travel 4.2 billion hours more and to purchase an extra 2.9 billion gallons of fuel for a congestion cost of $78 billion (Exhibit 1). This was an increase of 220 million hours, 140 million gallons and $5 billion from 2004. **THE** solution to this problem is really to consider implementing **ALL** the solutions. One lesson from more than 20 years of mobility studies is that congestion relief is not just a matter of highway and transit agencies building big projects. Those are important. But so are actions by businesses, shippers, manufacturers and employers, as well as commuters, shoppers, and travelers for all reasons. Agencies, Businesses, Commuters—as simple as A-B-C.

For the complete report and congestion data on your city, see: http://mobility.tamu.edu/ums

Many Problems, Many Solutions

There is no "wonder" technology or policy to solve the congestion problem because there is not A congestion problem. There are several problems and therefore several solutions. The *2007 Urban Mobility Report* points out that the supply of solutions is not being implemented at a rate anywhere near the rate of travel demand growth. This report and the website data describe the scope of the problem and some of the improvement strategies.

Exhibit 1. Major Findings for 2007 –
The Important Numbers for The 437 U.S. Urban Areas
(Note: Improved methodology and more urban areas than 2005 Report)

Measures of…	1982	1995	2004	2005
… Individual Traveler Congestion				
Annual delay per peak traveler (hours)	14	31	37	38
Travel Time Index	1.09	1.19	1.25	1.26
"Wasted" fuel per peak traveler (gallons)	9	21	25	26
Congestion Cost (constant 2005 dollars)	$260	$570	$680	$710
Urban areas with 40+ hours of delay per peak traveler	1	11	28	28
… The Nation's Congestion Problem				
Travel delay (billion hours)	0.8	2.5	4.0	4.2
"Wasted" fuel (billion gallons)	0.5	1.7	2.7	2.9
Congestion cost (billions of 2005 dollars)	$14.9	$45.4	$73.1	$78.2
… Travel Needs Served				
Daily travel on major roads (billion vehicle-miles)	1.67	2.79	3.62	3.73
Annual public transportation travel (billion person-miles)	35.0	36.4	44.7	45.1
… Expansion Needed to Keep Today's Congestion Level				
Lane-miles of freeways and major streets added every year	19,233	17,254	15,677	16,203
Daily public transportation riders added every year (million)	14.5	14.9	16.0	16.5
… The Effect of Some Solutions				
Travel delay saved by				
Operational treatments (million hours)	N/A	N/A	270	292
Public transportation (million hours)	255	396	543	541
Congestion costs saved by				
Operational treatments (billions of 2005 dollars)	N/A	N/A	$5.0	$5.4
Public transportation (billions of 2005 dollars)	$4.9	$7.4	$10.1	$10.2

N/A – No Estimate Available Pre-2000 data do not include effect of operational strategies.
Travel Time Index (TTI) – The ratio of travel time in the peak period to travel time at free-flow conditions. A Travel Time Index of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak.
Delay per Peak Traveler – The extra time spent traveling at congested speeds rather than free-flow speeds divided by the number of persons making a trip during the peak period.
Wasted Fuel – Extra fuel consumed during congested travel.
Vehicle-miles – Total of all vehicle travel (10 vehicles traveling 9 miles is 90 vehicle-miles).
Expansion Needed – Either lane-miles or daily riders to keep pace with travel growth (and maintain congestion).

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Since You Asked, Here's Why the Numbers Are Different

Each year the *Urban Mobility Report* revises procedures and improves the processes and data used in the estimates. With sponsorship from the National Cooperative Highway Research Program of the Transportation Research Board (*1*), the methodology was significantly revised in 2006 and 2007 to take advantage of new studies and detailed data sources that have not been available in previous studies. Some key changes for this year and their general effects are summarized in Exhibit 2. All of the congestion statistics in the *2007 Urban Mobility Report* have been revised for all years from 1982 so that true trends can be identified (Exhibit 3).

- For almost all urban areas that were intensively studied, and for urban America as a whole, there was more delay, more wasted fuel and higher congestion cost in 2005 than in 2004. That is the conclusion of this report—congestion is worse in urban areas of all sizes.
- The revised methodology described below, however, shows that the estimated speeds on the most congested freeways are better in the 2007 Report than in the 2005 Report. But the year-to-year congestion trends are still "up."
- The 2007 report also estimates congestion problems in all urban areas, instead of only 85 regions. The 352 added regions were mostly small areas with relatively low congestion levels. Their addition reduces the average congestion values for each person traveling in the peak period (i.e., a little more delay and a lot more people), but it also increases the total congestion estimates (i.e., a lot more people that each have a small amount of delay).
- The benefits from operational treatments and public transportation likewise appear to decline compared to the 2005 report; the actual numbers increase if the same methods are used.

More information on the methodology is included on the website at:
http://mobility.tamu.edu/ums/report/methodology.stm

Exhibit 2. Summary – Changes to the *2007 Urban Mobility Report*

Change for 2007 Report	General Effect Compared to Previous Reports
Estimate of congestion in all 437 U.S. urban areas (individual urban area estimates were only developed for 85 urban areas)	Increase the total delay, fuel and cost of congestion values. Decrease the average "per traveler" congestion values.
Minor arterial street congestion estimate	Increase delay, fuel and cost values.
High-occupancy vehicle lane statistics	Better estimate of regional congestion
Improve freeway speed estimate	Reduce delay, fuel and cost values. Also caused lower benefits for operations treatments & public transportation service (lower initial delay results in lower delay benefits).
Improve population estimate in some regions	Better estimate of congestion effects on individuals
Use truck percentages for each road	Better estimate than previous 5 percent value for all regions
Use average of daily fuel prices for each state	Better estimate than previous sample of fuel prices
Seattle region moved to Very Large population group	All historical population group statistics revised to include Seattle in the Very Large group

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Exhibit 3. National Congestion Measures, 1982 to 2005

						Hours Saved (million hours)		Gallons Saved (million gallons)		Dollars Saved (billions of 2005$)	
Year	TTI	Delay per Traveler (hours)	Total Delay (billion hours)	Total Fuel Wasted (billion gallons)	Total Cost ($2005 billion)	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp
1982	1.09	14	0.8	0.5	16.2		255		151		4.9
1983	1.09	15	0.9	0.5	16.2		259		154		5.0
1984	1.10	16	1.0	0.6	17.7		266		160		5.0
1985	1.11	18	1.1	0.7	20.5		280		169		5.3
1986	1.13	21	1.3	0.8	23.1		268		167		5.0
1987	1.14	22	1.4	0.9	25.8		277		173		5.1
1988	1.16	25	1.7	1.1	29.7		342		212		6.3
1989	1.17	27	1.8	1.2	32.9		363		227		6.7
1990	1.18	27	1.9	1.3	35.5		367		232		6.9
1991	1.18	28	2.0	1.3	35.8		366		233		6.8
1992	1.18	29	2.1	1.4	38.0		367		233		6.8
1993	1.18	30	2.2	1.5	40.1		367		232		6.8
1994	1.18	30	2.3	1.5	41.9		381		240		7.0
1995	1.19	31	2.5	1.7	45.4		396		251		7.4
1996	1.20	33	2.7	1.8	48.5		403		258		7.5
1997	1.21	34	2.8	1.9	51.3		421		269		7.8
1998	1.22	34	3.0	2.0	53.2		447		285		8.2
1999	1.23	35	3.2	2.1	57.2		471		304		8.7
2000	1.22	34	3.2	2.2	57.6	175	497	92	311	3.2	9.1
2001	1.23	35	3.3	2.3	60.4	197	517	104	325	3.6	9.5
2002	1.24	35	3.5	2.4	63.9	220	520	116	326	4.0	9.5
2003	1.24	36	3.7	2.5	67.2	247	508	130	319	4.5	9.3
2004	1.25	37	4.0	2.7	73.1	270	543	140	340	5.0	10.1
2005	1.26	38	4.2	2.9	78.2	292	541	147	340	5.4	10.2

Note: For more congestion information see Table 1 to 8 and http://mobility.tamu.edu/ums

Change Highlights—Additions to Congestion Estimates

- National estimate of congestion and costs – The 352 areas that are not intensively studied were grouped together and congestion estimates were developed to describe the congestion problem in the nation's 437 urban areas (*2*). Adding these urban areas increased the total number of peak-period travelers included in the analysis from 82.1 million in the 85 urban areas to 110.5 million in the 437 urban areas. This change increases the total delay but, because the smaller areas are much less congested than the large regions, it reduces the average hours of delay per traveler.
- Minor arterial congestion – As major roads became congested, minor road traffic volumes have increased. The estimates of congestion are more complete with these streets included in the arterial category for the *2007 Urban Mobility Report*.
- HOV travel – Buses and carpools traveling in reserved lanes provide one solution that is successful in many urban corridors. In some cases these lanes can also be used by single travelers who pay a fee. The person volume and travel speed statistics from operational evaluations in 70 corridors have been included in the urban area congestion estimates.

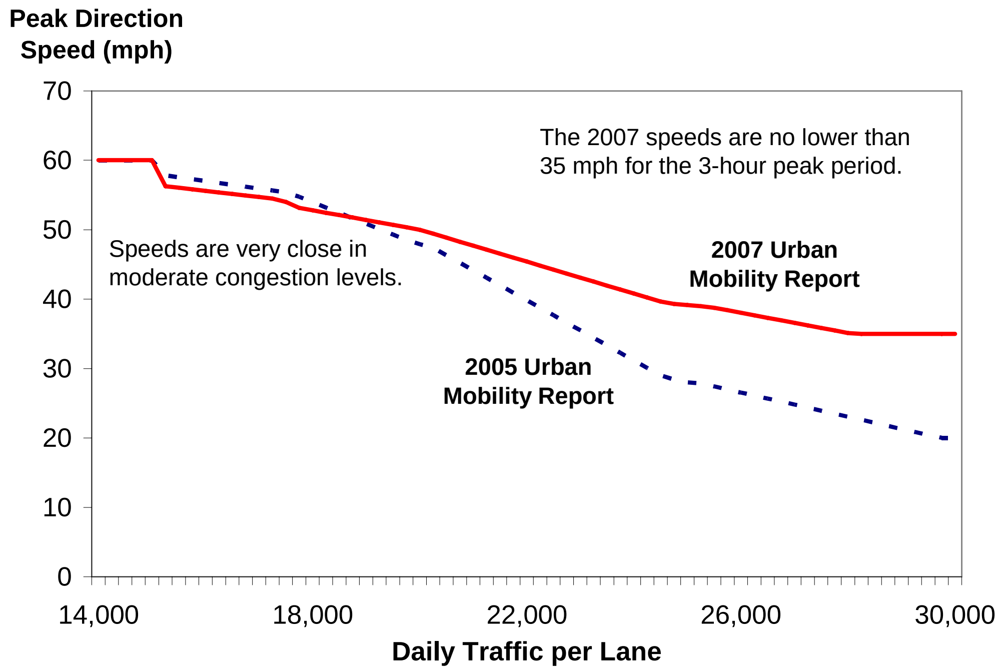
Change Highlights—Changes to Congestion Methodology

- Freeway speed estimate – Data from freeway operation centers have become available in many travel corridors over the last few years. While the data are not complete enough to use as a direct measure of congestion in all 85 areas, it was used to update the estimation procedures. In general, the very low speeds used in previous studies are not sustained for an entire peak period in most freeway corridors (Exhibit 4). The detailed data show that freeways carry more vehicles at higher speeds than models previously estimated. In addition, traffic growth in the faster flowing off-peak direction has been greater than growth in the slower speed peak direction. The average traffic speed for all lanes, therefore, has not declined as much as previous models predicted. The congestion estimates for all urban areas are lower because of this change, but in most cases the trends have not changed from previous studies.
- Population estimate – Urban area populations are not updated by all state departments of transportation (DOTs) every year in every region. As better estimates are prepared by local planners, they are incorporated into the Urban Mobility Report database, even if data from previous years must be changed.
- Truck percentages for each road – Freight congestion has become a separate issue in some communities with its own set of solutions. Truck travel estimates included in the state and local datasets have improved over the years and have replaced the previous estimate of 5 percent trucks on all urban roads.
- Average of daily fuel price – The recent fluctuations in gas prices suggested a need to include more than a small sample of fuel prices. An average of daily prices in each study state has been developed.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

- Seattle region – Regions are grouped according to population. Seattle's population is now above 3 million and its statistics are now included in the Very Large group. As with similar past changes, the Large and Very Large averages for each statistic and every year have been recalculated with the new urban area groupings.

Exhibit 4. Freeway Speed – Volume Relationship



Source: Reference (*1*)

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What Causes Congestion?

In a word, "you." Most of the Mojave Desert is not congested. But the rural portions also support very few jobs, has hardly any schools and provides a very small contribution to the nation's economic production. The 100 largest metropolitan regions, on the other hand, contribute 70 percent of the gross domestic product and have 69 percent of the jobs (*3*). It is not surprising that congestion exists in large areas given the number of people and the amount of freight moving in many directions over the course of two peak periods of two or three hours each. *So the first cause—many people and lots of freight moving at the same time*.

The second cause is the slow growth in supply—both roads and public transportation—in the last 20 years. Congestion has increased even though there are more roads and more transit service. Travel by public transportation riders has increased 30 percent in the 85 urban areas studied in this report. The contribution of the road growth effect to the congestion problem is difficult to estimate. The data files used for the Urban Mobility Report include the growth in urban roadway and travel that results from job and population growth, transportation investments **and** expanding urbanized area boundaries. Roads in areas that were rural are re-designated as urban, causing the "urban" lane-miles to grow even if there are no roads constructed. But even given this shortcoming, the differences are dramatic— travel has increased 105 percent in big metro regions while road capacity on freeways and major streets has grown by only 45 percent. *Too many people, too many trips over too short of a time period on a system that is too small—not really a new observation* (*2*,*4*).

A third factor causes many trips to be delayed by events that are irregular, but frequent. Crashes, vehicle breakdowns, improperly timed traffic signals, special events and weather are factors that cause a variety of traffic congestion problems. The effect of these events are made worse by the increasing travel volumes. *The solutions to each of these problems are different and are usually a combination of policies, practices, equipment and facilities*.

The commuting *uber reference*, *Commuting in America III* (*5*) confirmed the lengthening commute times, with average travel time to work growing 2 minutes (to 25.5 minutes) from 1990 to 2000, following a 1.7 minute increase in the decade before. This two-decade trend in commuting time growth raises concerns when compared to the growth in commuter volume—23 million more solo drivers in the 80s, but only 13 million more single drivers in the 90s. A greater growth in travel time with substantially fewer additional trips suggests that the transportation capacity built in earlier decades is being "used up."

The proportion of commute trips going from one county to another and from one suburb to another has increased significantly. The long commutes—*Commuting in America III* labels a one-way trip over 1 hour as "extreme"—increased from 6 percent of commute trips to 8 percent. Over 12 percent of commuters in the largest metropolitan regions (over 5 million) had trips lengths beyond 60 minutes. With this as an alternative, it is not surprising that working at home and leaving for work before 6 a.m. also saw substantial increases.

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The Congestion Problems

Travelers and shippers must plan around traffic jams for more of their trips, in more hours of the day and in more parts of town than in 1982. In some locations, this includes weekends and rural areas. Mobility problems have increased at a relatively consistent rate during the more than two decades studied.

Congestion wastes a lot of time, fuel and money. In 2005,

- 2.9 billion gallons of wasted fuel (enough to fill 58 supertankers)
- 4.2 billion hours of extra time (enough to fill 260 million iPod Shuffles™ with music)
- $78 billion of delay and fuel cost (enough to buy $78 billion of something)

The effect of uncertain or longer delivery times, missed meetings, business relocations and other congestion results are not included.

Congestion costs are increasing. The congestion "invoice" for the cost of extra time and fuel in 437 urban areas (all values in constant 2005 dollars),

- In 2005 – $78 billion
- In 2004 – $73 billion
- In 1982 – $15 billion

Congestion affects the people who typically make trips during the peak period.

- Yearly delay for the peak-period traveler was 38 hours in 2005—almost one week of vacation—an increase from 14 hours in 1982 (Exhibit 5).
- That traveler wasted 26 gallons of fuel in 2005—three weeks worth of gasoline for the average U.S. resident—up from 9 gallons in 1982 (Exhibit 6).
- Congestion effects were even larger in areas over one million persons—48 hours and 34 gallons in 2005.

The value for the delay and wasted fuel was $710 per traveler in 2005 compared to an inflation-adjusted $260 in 1982.

Exhibit 5. Hours of Travel Delay per Peak-Period Traveler

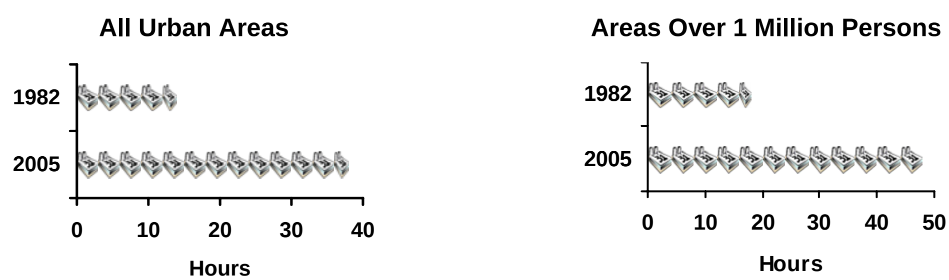
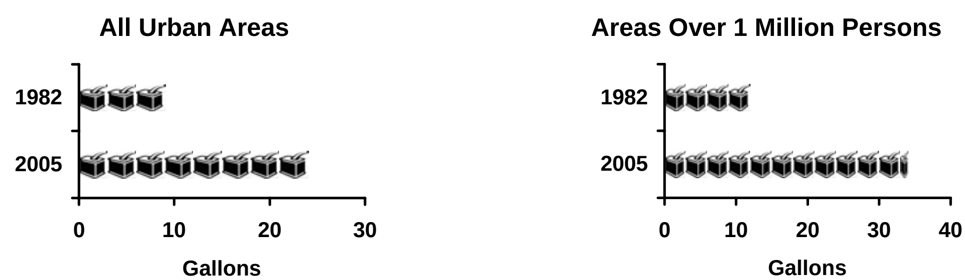


Exhibit 6. Gallons of Fuel Wasted per Peak-Period Traveler



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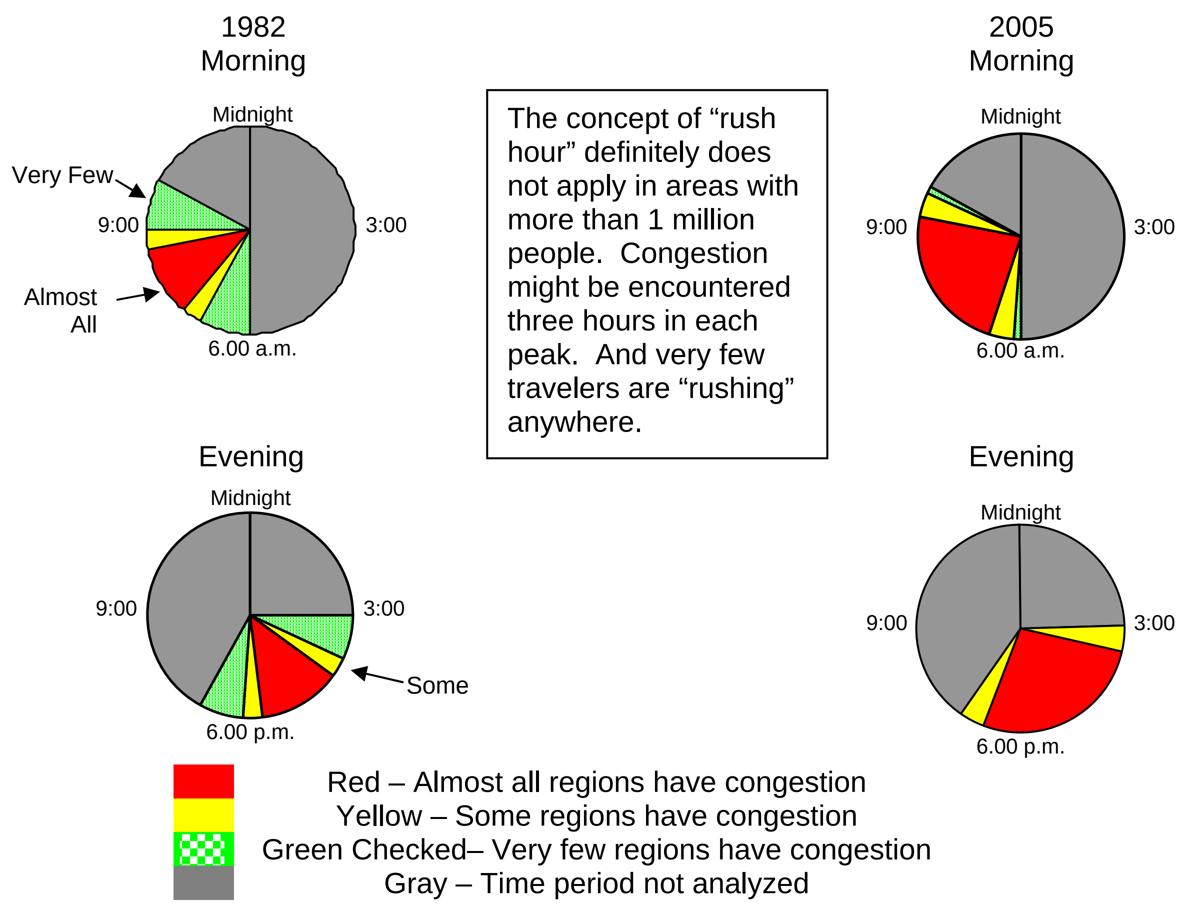
Think of what else could be done with the 38 hours of extra congestion suffered by the average urban traveler in 2005.

- Almost 5 vacation days
- Approximately 20 movies (but not including previews of other movies)
- More than 120 summer sunburns

The Jam Clock (Exhibit 7) depicts the growth of congested periods within the morning and evening "rush hours."

Exhibit 7. The Jam Clock

The Time of Day when Congestion Might Exist (in urban areas with more than 1 million people)



Note: The *2007 Urban Mobility Report* examined 6 to 10 a.m. and 3 to 7 p.m.

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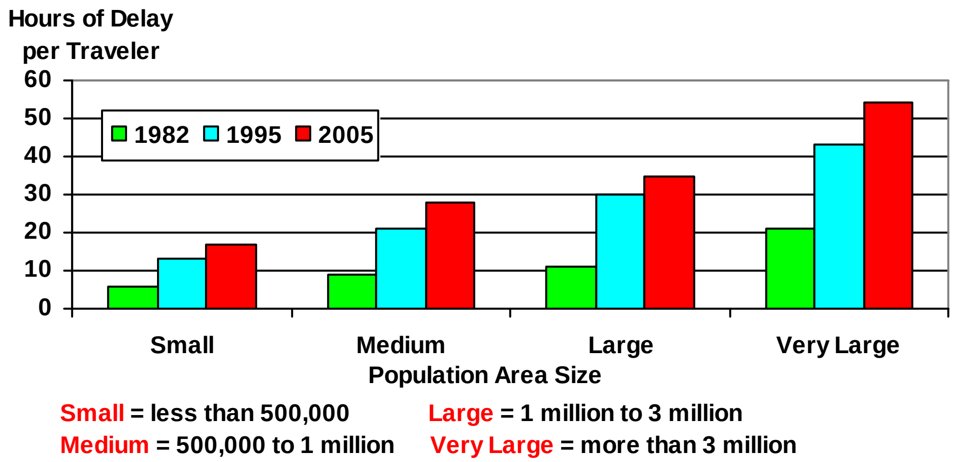
Congestion is worse in areas of every size (Exhibit 8)

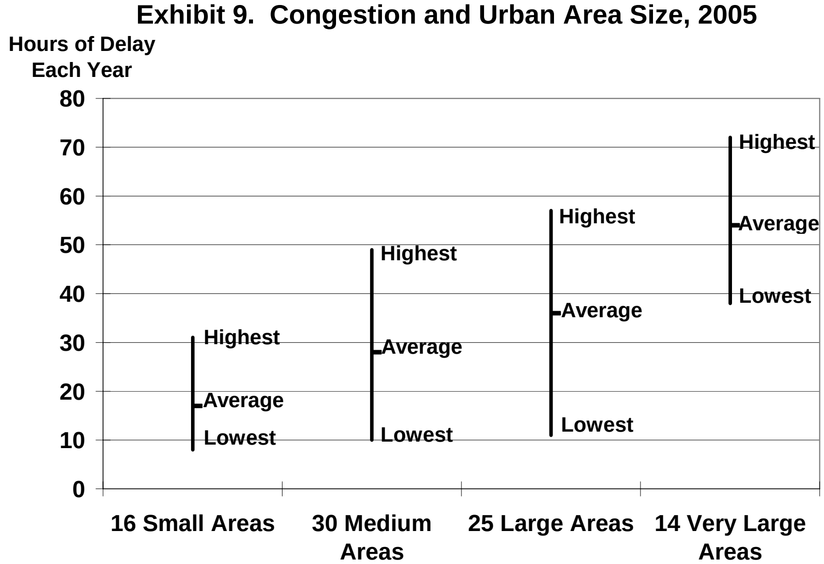
Exhibit 8. Congestion Growth Trend



The delay statistics in Exhibit 8 point to the importance of action. Major projects, programs and funding efforts take 10 to 15 years to develop. In that time, congestion endured by travelers and businesses grow to those of the next largest population group. So in ten years, cities with 500,000 to 1 million people will have the traffic problems that areas over 1 million people have now, if actions are not taken to change the trends.

Congestion levels vary in cities of the same size. Exhibit 9 shows the wide range in congestion problems in each of the four urban size groups. In the three largest groups, there is a difference of at least 30 hours of delay per traveler between the most and least congested regions. Certainly there is some natural variation due to geographic, economic and weather conditions.

Exhibit 9. Congestion and Urban Area Size, 2005



Some of the differences are also the result of decisions by the public about transportation funding levels, mobility goals and what type of projects, programs and policies they support to address congestion problems. The answer is not to grade every city, every project and every hour of delay on the same scale, but rather to identify the community goals, benefits and costs and decide how to reach the mobility targets.

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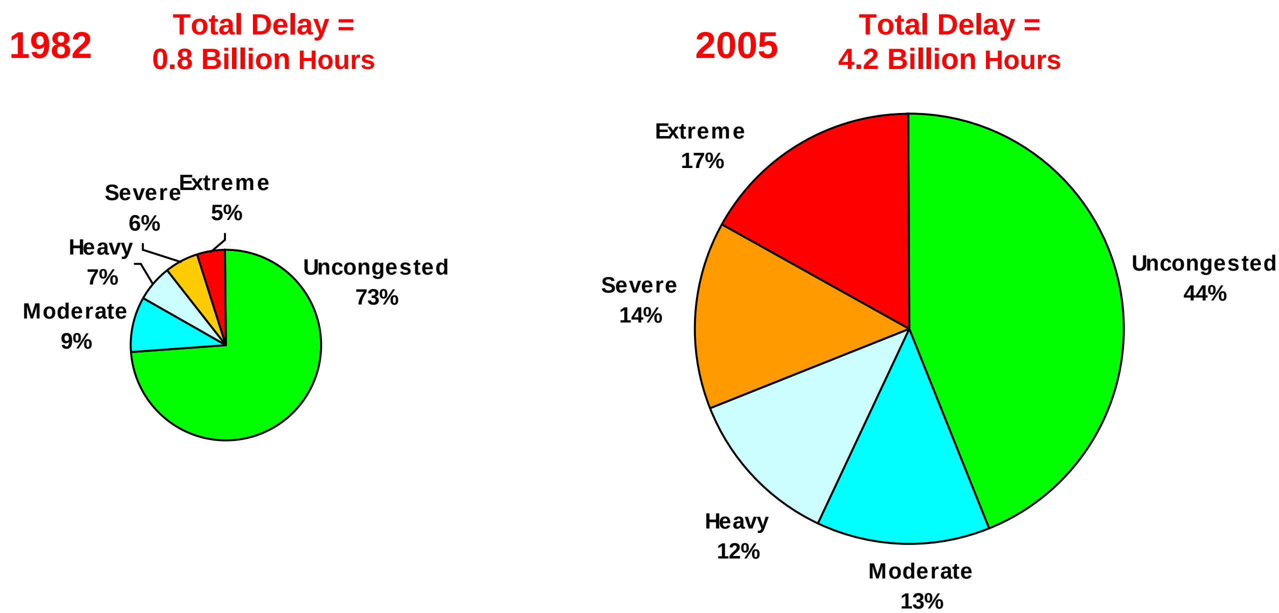
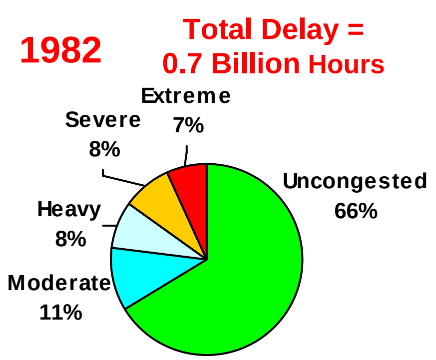
Travelers and shippers must plan around congestion more often.

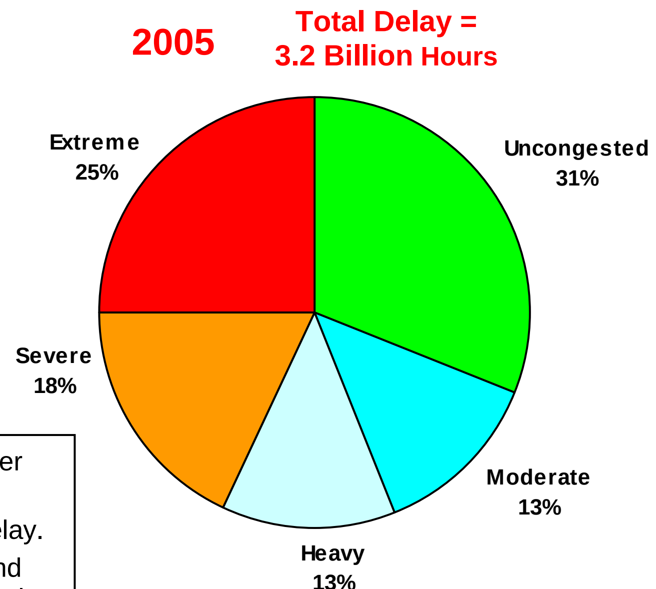
- In all 437 urban areas, the worst congestion levels affected (Exhibit 10) only 1 in 9 trips in 1982, but 1 in 3 trips in 2005.
- Free-flowing traffic is seen less than one-third of the time in urban areas over 1 million population.
- Delay is five times larger overall and is six times higher in regions with fewer than 1 million people.

Exhibit 10. Congestion Growth – 1982 to 2005



Urban Areas Over 1 Million Population





But the problem could be even worse in the regions over 1 million population.

- Operational treatments save 259 million hours of delay.
- And if there were no public transportation service and travelers used their cars, there would be an additional 493 million hours of delay.

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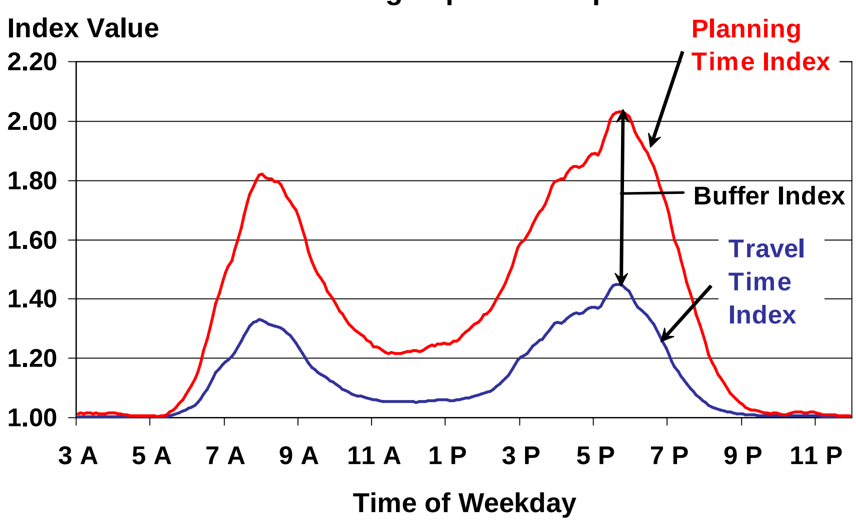
Unreliable Travel Times – One of the Congestion Problems

You have an important family event at home at 5:45 p.m. Your normal commute time is 30 to 35 minutes. But you also know that your travel time varies. The problem is that crashes, vehicle breakdowns, road work, weather and variations in daily traffic volume all change the commute from day to day. In order to arrive before the event starts, you must plan for extra travel time. This extra time, or "buffer time," is part of the congestion problem—unreliability.

The Planning Time Index is similar to the Travel Time Index except that the PTI indicates the travel time needed to make your destination on time 19 days out of 20—essentially the worst weekday of the month (*6*). An Index value of 2.0, for example, would mean that you should allow twice as much time for an important trip as your travel time in uncongested conditions. The difference between the average time and the planning time is a reliability measure termed the "Buffer Index." (Exhibit 11) In general, the Buffer Index goes up in the peak periods, indicating reliability problems and congestion occur at the same time and explaining why so much extra travel time has to be planned.

Exhibit 11. The Extra "Buffer" Time Needed When Planning Important Trips



Source: Reference (*7*)

According to data from some of the freeways in 19 metropolitan regions (Exhibit 12), travelers and freight shippers should plan on twice as much extra travel time if they have an important trip as they would allow in average conditions. For example, in Phoenix a 20-minute free-flow trip takes an average of almost 28 minutes. On one weekday out of 20 (essentially the worst travel day of the month) that trip will take 36 minutes. The frustrating and economically damaging part of this doubling of the extra travel time (16 minutes vs. 8 minutes more than the free-flow travel time of 20 minutes) is that we cannot know which day that is and how it might affect important trips or deliveries.

This distinction between "average" and "important" is crucial to understanding the role of the solutions described in the next few pages. Some strategies reduce congestion for all travelers and at all times on every day. Other strategies provide options that some travelers, manufacturers or freight shippers might choose for time-sensitive travel. Some solutions target congestion problems that occur every day and others address irregular events such as vehicle crashes that cause some of the longest delays and greatest frustrations.

Exhibit 12. You Should Plan for Much Longer Travel Times if You Wish to Arrive On-Schedule, 2007 Data

Region	Multiply the free-flow travel time by this factor to estimate the time to reach your destination:	
	In Average Conditions (Travel Time Index)	For an Important Trip (Planning Time Index)
Chicago, IL	1.48	2.07
Detroit, MI	1.24	1.65
Houston, TX	1.43	2.01
Los Angeles, CA	1.47	1.92
Minneapolis-St. Paul, MN	1.29	1.70
Orange County, CA	1.40	1.77
Philadelphia, PA	1.29	1.76
Phoenix, AZ	1.38	1.80
Pittsburgh, PA	1.28	1.70
Portland, OR	1.34	1.87
Providence, RI	1.14	1.43
Riverside-San Bernardino, CA	1.34	1.77
Sacramento, CA	1.26	1.61
Salt Lake City, UT	1.16	1.52
San Antonio, TX	1.22	1.61
San Diego, CA	1.31	1.66
San Francisco, CA	1.25	1.51
Seattle, WA	1.44	2.06
Tampa, FL	1.23	1.55

Source: Reference (*7*)

Note: Index values are a ratio of travel time in the peak to free-flow travel time. A Travel Time Index of 1.40 indicates a 20-minute off-peak trip takes 28 minutes on average. A Planning Time Index of 1.80 indicates the 20-minute off-peak trip might take 36 minutes one day each month.

Note: In most regions only a few freeways are included in this dataset. This difference in coverage and differences in the data collection devices make comparisons between the regional values in Exhibit 12 impossible. These 2007 data are only for freeways and, thus, not comparable with the areawide data included in other tables in the *2007 Urban Mobility Report.*

Congestion Solution Portfolio – An Overview

The problem has grown too rapidly and is too complex for only one technology or service to be "the solution" in most regions. The increasing trends also indicate the urgency of the improvement need. Major improvements can take 10 to 15 years and smaller efforts may not satisfy all the needs.

So we recommend a ***balanced and diversified approach*** to reduce congestion. The solutions will be different depending on the state or city where they are implemented. There will also be a different mix of solutions in various parts of town depending on the type of development, the level of activity and policy or geographic constraints in particular sub-regions, neighborhoods and activity centers. Portions of a city might be more amenable to construction solutions, other areas might use more demand management, productivity improvements, diversified land use patterns or redevelopment solutions.

- **Get as much service as possible from what we have** – The billions of dollars invested in roads and public transportation systems provide a good starting place, but only a start. If those systems are not managed to serve person trips and freight shipments with safe, fast and reliable service, the return on the investment is not maximized. Many of these are low-cost improvements that typically have broad public support, like programs that rapidly remove crashed or stalled vehicles. Timing the traffic signals so that more vehicles see green lights is another relatively simple action, but one that requires periodic attention.

- **Add capacity in critical corridors** – This may be to handle freight or person travel; it could be a freeway or street, rail line, more buses or travel options; an intermodal transfer facility for freight or people; or other types of public transportation facility. More regions are also considering tolling one or more lanes as a way to pay for construction and provide high-speed and reliable trips to the public and freight shippers. The capacity expansions for people and freight might also include internet or computer systems, additional rail service, containers or other modes.

- **Relieve chokepoints in road and transit systems** – There are congested areas that may be quickly fixed by relatively small changes to designs or operating practices. Short sections of freeway, streets or public transportation systems may cause long back-ups. The solutions may be costly—such as rebuilding a freeway interchange—or they may be relatively inexpensive—adding a short section of freeway lane between an entrance and exit ramp or retiming a traffic signal to provide more time for a high-volume street.

- **Change the usage patterns** – There are many 8 to 5 or 9 to 5 jobs. School classes meet from 8:00 to 3:00 or 3:30. Combine those trips with trips to the doctor, shops and other locations and there is an easy way to understand the congestion problem—many trips trying to use the system at the same time. There are solutions that involve employers and travelers changing the time they travel. Flexible work hours allow employees to choose work schedules that meet family needs and the needs of their jobs. Using the phone, computer and internet to work from home for a few hours, or a few days each month also moves trips to off-peak hours while providing productivity benefits and lower turnover to employers and travel time benefits, stress reduction and job satisfaction improvements to employees.

- **Provide choices** – This might involve different routes, travel modes or lanes that involve a toll for high-speed and reliable service. As congestion has grown, the effect of collisions and vehicle breakdowns has become more severe because there are fewer alternative travel paths. Allowing travelers and shippers to satisfy their travel needs in ways that allow them to say, “this trip is very important and I need to get there on time” also provides an element of choice that is often lacking in current travel plans.

- **Diversify the development patterns** – Suburbs, downtowns, urban and rural areas are characterized by different arrangements of shops, offices and residential developments. The vehicle transportation requirements to serve these areas can be lessened using a variety of techniques. These typically involve denser developments with a mix of jobs, shops and homes, so that more people can walk to more destinations. They also frequently involve design elements like sidewalks, shade trees, medians, porches and parking garages or parking lots behind buildings. Shorter trips and denser developments are also conducive to using public transportation services. Sustaining the “quality of life” and gaining economic development without the typical increment of mobility decline in each of these sub-regions appear to be part, but not all, of the solution.

- **Realistic expectations** are also part of the solution. Large urban areas will be congested. Some locations near key activity centers in smaller urban areas will also be congested. But congestion does not have to be an all-day event. Identifying solutions and funding sources that meet a variety of community goals is challenging enough without attempting to eliminate congestion in all locations.

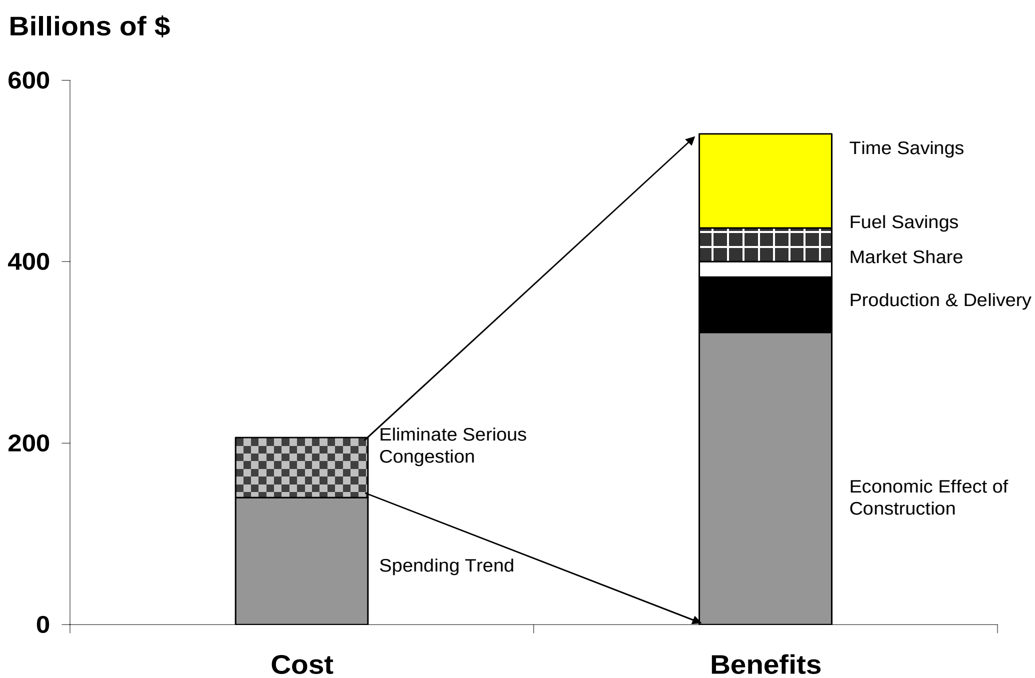
All types of programs, projects and policies should be considered. Without a detailed analysis it is impossible to say which action or set of actions will best meet the corridor or community needs. But, it is important to recognize that actions can make a difference. It is possible to at least slow the growth and in the right circumstances, such as slow or no growth in population and jobs and appropriate investment levels, reduce congestion.

The Benefits of Action

Addressing the congestion problems can provide substantial benefits and provide improvements in many sectors of society and the economy. The costs involved in eliminating serious congestion problems are large and the projects, programs and policies that are implemented will require the cooperation of the public, agencies at all levels of government and, in many states, the private sector as well.

A study conducted for the Texas Governor's Business Council (*8*) estimated that solving the serious congestion problems in the state's eight largest metropolitan regions would generate $540 billion in economic benefits—including $37 billion in reduced fuel consumption and $104 billion in travel time savings (Exhibit 13). The analysis estimated almost $80 billion in business efficiencies and operating savings would result from lower congestion levels. More than $320 billion in construction effects, which include more than 110,000 jobs that would be created, were also identified.

Exhibit 13. 25-Year Costs and Benefits of Implementing Texas Metropolitan Mobility Plan



Source: Reference (*8*)

The results suggest that the congestion costs included in the *Urban Mobility Report* series are on the low side of those actually experienced. The cost of eliminating all the serious congestion in the eight regions was estimated at between $65 billion and $70 billion by a joint committee of Texas Department of Transportation and the Metropolitan Planning Organizations in each region (*9*). The combination of specific projects was left to each urban region to identify over the coming years, and the end result would not be "no congestion" but rather congestion that would only last for one hour in each commute period, rather than three or four hours.

Similar mobility planning efforts have been conducted in Atlanta, where the transportation agencies have adopted a long-term mobility goal and increased the importance of congestion relief in their project selection process (*10*). Projections of 2030 congestion levels twice the current levels are similar to many major metro regions. The selection and funding of projects will be the subject of much discussion and the type of mobility improvement strategies that will be pursued will depend on the size, character and location of the problem within the metro region.

When these types of improvement packages and mobility goals are offered by agencies that are perceived to be doing a good job with the funding and options they have, approval rates are generally high. The Washington State Legislature has approved two funding increases in the last four years for a variety of operational and infrastructure improvement programs proposed by the Washington State Department of Transportation (*11*). A transportation investment package consisting of $19.9 billion in new bond financing was approved by California voters in November 2006 (*12*). Included in both programs were a range of solutions and a commitment to transparent reporting of results and accountability to decision-makers and taxpayers for timely reporting and project completion. Both programs have mobility and other performance goals.

The purpose of a mobility planning effort is to establish a process where vision, needs and accountability drive the process of transportation improvement. Current procedures follow a process determined by the expected available funds that dictate the amount of transportation improvement projects and programs. The more aggressive mobility planning approaches address "how can we fulfill our mobility vision?" or "how can we reduce congestion?" or "how can we improve service reliability?" rather than simply "what does the funding allow?"

Improve Productivity

More efficient operation of roads and public transportation can provide more productivity from the existing system at relatively low cost. Some of these can be accelerated by information technology, some are the result of design changes and some are the result of more aggressive operating practices.

This report presents information on the effect of four prominent operational treatments which are estimated to relieve a total of 257 million hours of delay (6 percent of the total) in 2005 (Exhibit 14) with a value of $5.1 billion. If the treatments were deployed on all major freeways and streets, the benefit would expand to about 565 million hours of delay (13 percent of delay) and more than $10.5 billion would be saved. These are significant benefits, especially since these techniques can be enacted much quicker than significant roadway or public transportation system expansions can occur. But the operational treatments do not replace the need for those expansions (*13*,*14*,*15*).

Exhibit 14. Operational Improvement Summary for All 437 Urban Areas

Operations Treatment	Delay Reduction from Current Projects		Possible Delay Reduction if Implemented on All Roads (Million Hours)
	Hours Saved (Million)	Dollars Saved ($ Million)	
Ramp Metering (25)	38.6	733	106.2
Incident Management (272)	129.5	2,493	222.6
Signal Coordination (437)	21.0	451	55.5
Access Management (437)	68.2	1,376	180.2
TOTAL	257	5,053	565

Note: This analysis uses nationally consistent data and relatively simple estimation procedures. Local or more detailed evaluations should be used where available. These estimates should be considered preliminary pending more extensive review and revision of information obtained from source databases.

Note: This operational treatment benefit summary does not include high-occupancy vehicle lanes.

The Washington State DOT has implemented several of the productivity improvement programs and is acknowledged as a leader in the use of operations strategies—both at a technical and policy level. The incident management program is a combination of transportation, enforcement and emergency responder personnel who have common goals and shared responsibilities. The ramp metering system provides an ability to accommodate more vehicles, people and freight on the freeway system with fewer collisions and greater reliability. The transportation network has been examined to identify bottlenecks (chokepoints)—locations where congestion begins before the rest of the network is overloaded. Investments in solving these problem locations will allow more travelers to get through the bottlenecks before systemwide congestion becomes a problem. And as an agency, WSDOT has improved the ability to control the traffic flow to maximize safety and reliability by a variety of methods and with a variety of partnering agencies (*16*).

Freeway Entrance Ramp Metering

Entrance ramp meters regulate the flow of traffic on freeway ramps using traffic signals similar to those at street intersections. They are designed to create more space between entering vehicles so those vehicles do not collide or disrupt the mainlane traffic flow. The signals allow one vehicle to enter the freeway at some interval (for example, every two to five seconds). They also reduce the number of entering vehicles due to the short distance trips that are encouraged to use the parallel streets to avoid the ramp wait time (*17*).

The Minnesota DOT conducted an experiment that consisted of turning off the 430 ramp meters in the Minneapolis-St. Paul region for seven weeks in 2000. The results showed that there are travel time savings from operating the ramp meters, but the most dramatic change was the 26 percent increase in crashes when the meters were de-activated. There was also a 14 percent increase in the volume handled by the freeway with the meters on—the productivity improvement that operations programs seek to attain. Reducing collisions, increasing volume and improving the reliability of service on the freeway mainlanes maximizes the return from the freeway investment (*17*).

Freeway Incident Management Programs

Freeway Service Patrol, Highway Angel, Highway Helper, The Minutemen and Motorists Assistance Program are all names that have been applied to the operations that remove crashed and disabled vehicles from the freeway lanes and shoulders. They work in conjunction with surveillance cameras, cell phone incident call-in programs and other elements to remove these disruptions, decrease delay and fuel consumption and improve the reliability of the system.

The benefits of these programs can be significant. Benefit/cost ratios from the reduction in delay between 3:1 and 10:1 are common for freeway service patrols (*18*). These are achieved by a combination of additional personnel, technology and equipment deployment and interagency cooperation. The mix of agencies and jurisdictions that must work together are sometimes problematic and incident management programs cause a re-evaluation of the procedures used. Evaluations of the Maryland Coordinated Highways Action Response Team (CHART) show that the incident clearance times were reduced in patrolled areas (which is logical), but also reduced in areas without CHART patrols due to improvements in operating efficiency by all agencies (*19*).

An incident management program can also reduce "secondary" crashes—collisions within the stop-and-go traffic caused by the initial incident. Perhaps the most aggressive program in the U.S.—Houston's SAFEclear—consists of tow trucks that respond within six minutes of notification. Quick removal of stalled vehicles and crashes, combined with the Motorist Assistance Program, has reduced collisions by more than 10 percent in the first two years of operation, saving $70 million in collision costs (*20*).

Traffic Signal Coordination Programs

Traffic signal timing can be a significant source of delay on the major street system. Much of this delay is the result of managing the flow of intersecting traffic, but some of the delay can be reduced if the traffic arrives at the intersection when the signal is green instead of red. This is difficult in a complex urban environment, and when traffic volumes are very high coordinating the signals does not work as well due to the long lines of cars already waiting to get through the intersection in both directions.

The 85 intensively studied urban areas reported some level of traffic signal coordination in 2005, with the coverage representing slightly over half of the street miles in the urban areas (*2*,*15*). Signal coordination projects have the highest percentage treatment within the urban areas studied because the technology has been proven, the cost is relatively low and the government institutions are familiar with the implementation methods.

The effect of the signal coordination projects was to reduce delay by 17 million person hours, approximately 1 percent of the street delay (*13*). While the total effect is relatively modest, the cost is relatively low and the benefits decline as the system becomes more congested. The modest effect does not indicate that the treatment should not be implemented—why should a driver encounter a red light if it is not necessary? As the National Traffic Signal Report Card (*21*) found in 2005, many cities should put more effort into maximizing the benefits from signal coordination.

Arterial Street Access Management Programs

Providing smooth traffic flow and reducing collisions are the goals of a variety of individual treatments that make up a statewide or municipal access management program. Typical treatments include:

- Combining driveways to minimize the disruptions to street traffic flow
- Increasing the spacing between intersections
- Median turn lanes or turn restrictions
- Acceleration and deceleration lanes
- Development regulations that help reduce the potential collision and conflict points

Such programs are a combination of design standards, public sector regulations and private sector development actions. Colorado and Florida have been particularly aggressive in adopting access management practices (*22*).

Access management treatments have been shown to reduce collisions, increase the number of vehicles that can use a street, reduce fuel consumption and decrease travel times by regulating the flow of traffic and reducing the number of challenging situations for drivers. The benefits estimated in the *2007 Urban Mobility Report* are for a moderate mix of these treatments and only include the reduction in travel delay and wasted fuel. In surveys of business owners affected by the medians and turn lanes, most report no reduction in customers and some see an increase in property values (*23*).

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

More Capacity

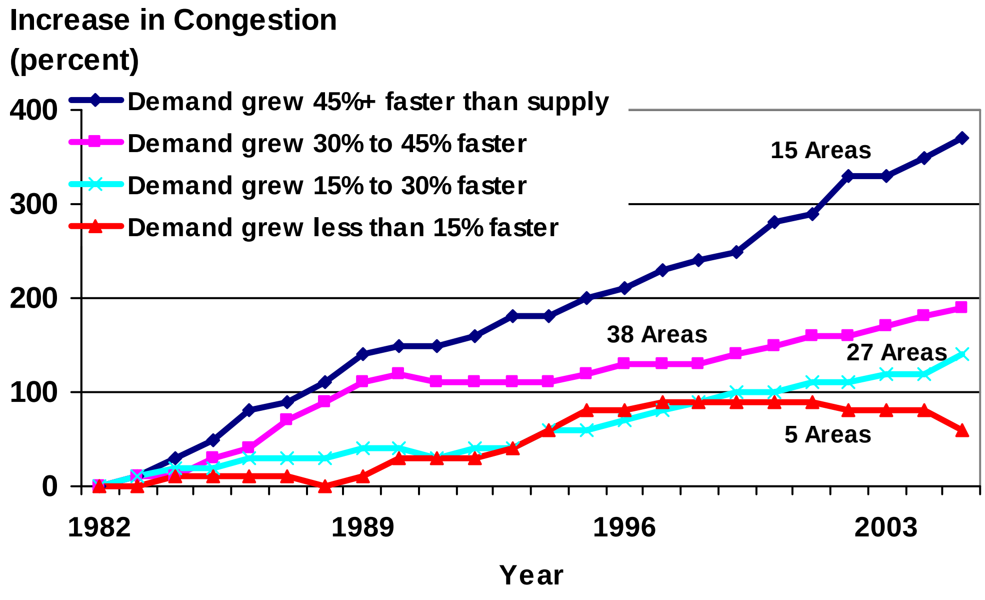
More road and public transportation improvement projects are part of the equation. New streets and urban freeways will be needed to serve new developments; public transportation improvements are particularly important in congested corridors and to serve major activity centers; and, toll highways and toll lanes are being used more frequently in urban corridors. Capacity expansions are also important additions for freeway-to-freeway interchanges and connections to ports, rail yards, intermodal terminals and other major activity centers for people and freight transportation.

Benefits of Roadway Capacity Increases

Urban areas can slow the growth of congestion by building roads. Regions where road capacity has grown at about the same rate as travel demand have seen less delay growth than areas where travel has increased much more rapidly than road supply. The change in miles traveled was compared to the change in lane-miles for each of the 85 urban areas between 1982 and 2005 (Exhibit 15 and Table 7). Four groups of urban regions were identified based on the ratio of growth in demand and roads. The increase in congestion from 1982 to 2005 was plotted for each group.

- **Significant mismatch** – Traffic growth was more than 45 percent faster than the growth in road capacity for the 15 urban areas in this group.
- **Moderate mismatch** – Traffic growth was between 30 and 45 percent greater than road growth. There were 38 urban areas in this group.
- **Closer match** – Traffic growth was between 15 percent and 30 percent more than road growth. There were 27 urban areas in this group.
- **Narrow gap** – Road growth was within 15 percent of traffic growth for the 5 urban areas in this group.

Exhibit 15. Road Growth and Mobility Level



Additional roadways reduce the rate of increase in congestion. It appears that the growth in facilities has to be at a rate slightly greater than travel growth in order to maintain constant travel times, if additional roads are the only solution used to address mobility concerns. It is also clear, however, that if only five of the 85 areas studied were able to accomplish that rate, ***there must be a broader set of solutions*** applied to the problem, as well as more of each solution.

Constructing transportation projects quickly and with as little extra delay as possible requires a mix of strategies, just as the regional approach to congestion relief. The Katy Freeway (I-10 West in Houston) expansion project includes additional mainlanes and high-occupancy toll lanes, in addition to reconstructed pavement, noise walls and landscaping. The regional toll authority purchased the right to operate the toll lanes using funds generated over almost two decades of successful toll operation in other corridors. The accelerated cash flow enabled the Texas DOT to decrease the construction time from 12 years to six years. The increased cost of the 24-hour construction schedule was partially offset by savings in construction cost inflation that would have occurred. The estimated $2.8 billion in benefits that resulted from six years of improvements in delay, lower fuel consumption and improved business environment more than offset the estimated $300 million in extra costs (*8*).

The recent reconstruction of the MacArthur Maze Interchange in Oakland, near the Bay Bridge, illustrates the kind of rapid response to the destruction of critical transportation links that the public and business leaders expect. A contracting process that emphasized cooperation between construction companies, suppliers and state and local agencies and which included incentives for rapid completion led to the interchange be fully re-opened in 26 days, 35 days ahead of the deadline. The $5 million completion bonus was accounted for in the contractor's bid. A project without the completion bonus would have resulted in a higher construction bid, and no incentive to rapidly finish repairing an interchange estimated to have a $6 million daily economic effect on the region (*24*,*25*).

Benefits of Public Transportation Service

Regular route public transportation service on buses and trains provides a significant amount of peak-period travel in the most congested corridors and urban areas in the U.S. If public transportation service was discontinued and the riders traveled in private vehicles, the 437 urban areas would have suffered an additional 541 million hours of delay and consumed 340 million more gallons of fuel in 2005 (Exhibit 16), one-third more than a decade ago (*4*). The value of the delay and fuel that would be consumed if there were no public transportation service would be an additional $10.2 billion congestion cost, a 13 percent increase over current levels in the 437 urban areas.

This total is less than previous estimates because there is lower freeway delay due to the methodology improvements. There is an estimated delay savings contribution of 31 million hours and $574 million from public transportation services in the 352 urban areas that were not individually studied. Delay is lower in the most congested regions with the new calculation procedure than with the old; these are also the regions that have the highest public transportation ridership. The new method comes to the same conclusion—substantial and increasing benefits.

Public transportation service provides many other benefits in the corridors and areas it serves. Access to jobs, shops, medical, school and other destinations for those who do not have private transportation may provide societal benefits and the reliable service provided by underground and overhead rail lines that are not affected by traffic congestion are not quantified. Typically, in contrast to roads, the ridership is concentrated in a relatively small portion of the urban area. That is often the most congested area and the locations where additional road capacity is difficult to construct. Downtowns and other large employment centers in major urban regions would look much different without public transportation service.

There were approximately 51 billion passenger-miles of travel on public transportation systems in the 437 urban areas in 2005 (*4*). The annual travel ranges from an average of 18 million miles per year in Small urban areas to about 2.7 billion miles in Very Large areas. More information on the effects for each urban area is included in Table 3.

- The Very Large areas would experience an increase in delay of about 430 million hours per year (17 percent of total delay) if there were no public transportation service. Most of the urban areas over 3 million population have significant public transportation ridership, extensive rail systems and very large bus systems.

- The Large urban areas would experience the second largest increase in delay with about 64 million additional hours of delay per year (7 percent of today delay) if public transportation service were not available. Public transportation plays an important role in providing travel options in these communities. As corridors become more congested, the role of public transportation in providing travel capacity to major activity centers in these regions will grow.

Exhibit 16. Delay Increase if Public Transportation Service Were Eliminated – 437 Areas

Population Group and Number of Areas	Average Annual Passenger-Miles of Travel (Million)	Delay Reduction Due to Public Transportation		
		Hours of Delay (Million)	Percent of Base Delay	Dollars Saved ($ Million)
Very Large (14)	37,691	430	17	8,091
Large (25)	5,459	64	7	1,193
Medium (30)	1,665	15	4	270
Small (16)	287	1	3	26
Other (352)	6,324	31	5	574
National Urban Total	51,426	541	13	10,154

Source: Reference (*4*) and TTI Review

A longer-term approach to estimating mobility benefits from public transportation will be to develop links with transit agency operations databases. These include travel time, speed and passenger volume data automatically collected by transit vehicle monitoring systems. Linking these 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 (*7*). 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 some of this information; the challenge is to develop comparable datasets.

The Metropolitan Transportation Authority (MTA) and the Long Island Rail Road (LIRR) are proposing to construct a new direct 3.5-mile commuter rail extension from Long Island and Queens to Grand Central Terminal (GCT) on Manhattan's East Side. The current highway system and East River crossings are at capacity and subject to severe congestion and long delays. The LIRR operates at capacity in this area with peak service of 37 trains per hour into its only Manhattan terminal at Penn Station. Nearly half of LIRR's 106,000 existing daily riders, however, have destinations on Manhattan's East Side and currently spend approximately 20 minutes "doubling back" from Penn Station on the island's West Side. The project will connect to the currently unused lower level of the 63rd Street Tunnel beneath the East River. At Grand Central Terminal, the project would provide new tracks, platforms, entrances, waiting areas, ticket windows and other services (*26*).

Relieve Chokepoints

Congestion does not come in one size or shape and neither do solutions. Some congestion problems start as just a few too many cars trying to get through an intersection or onto a freeway. The slowdowns that begin there penalize travelers and shippers in at least two ways. First, the trips take longer because traffic is moving slower. Secondly, a stop-and-go system is inefficient and fewer travelers can get through the constriction. This double penalty was depicted by Washington State DOT as rice flowing (or not) through a funnel—pour slowly and the rice tumbles through; pour quickly and the constriction point is overwhelmed and rice clogs the funnel (*27*).

Eliminating these problem locations could have huge benefits. A 2004 study of the largest highway bottlenecks by the American Highway Users Alliance (*28*) estimated that there were more than 210 congested locations in 33 states with more than one million hours of travel delay. The top 24 most congested freeway bottlenecks each accounted for more than 10 million hours of delay; these were located in 13 different metropolitan regions. The study noted that progress had been made in the five years since the previous study with seven of the top 20 locations dropping off the worst bottlenecks list through construction improvements.

Similar studies focusing on freight bottlenecks were conducted for the Ohio DOT and expanded to national examinations of freight travel and congestion problems (*29,30,31*). Several metropolitan regions have also conducted analyses of public transportation service bottlenecks. All the conclusions have been similar—there are significant returns on investment from addressing the locations of most severe congestion. The solutions range from the simple, quick and cheap to the complex, lengthy and expensive. For example, about 250 miles of freeway shoulder in Minneapolis are used to allow buses to bypass stop-and-go traffic, thereby saving time and providing a much more reliable time schedule for public transportation riders. The routes that use the shoulders had a 9.2 percent ridership increase over a two-year period when the overall system ridership decreased 6.5 percent, illustrating the favorable passenger reaction to improved speed and reliability attributes (*32*).

Change the Usage Pattern

The way that travelers use the transportation network can be modified to accommodate more demand and reduce congestion. Using the telephone or internet for certain trips, traveling in off-peak hours and using public transportation and carpools are examples. Projects that use tolls or pricing incentives can be tailored to meet transportation needs and also address social and economic equity concerns.

Any of these changes will affect the way that travelers, employers and shippers conduct their lives and business; these may not be inconsequential effects. The key will be to provide better conditions and more travel options primarily for work commutes, but there are also opportunities to change trips for shopping, school, health care and a variety of other activities.

Although comprising slightly less than 20 percent of all vehicular trips in the average urban area, commute trips generally cluster around the most congested peak periods and are from the same origin to the same destination at the same time of day. These factors make commute trips by carpooling, vanpooling, public transit, bicycling and walking more likely. Furthermore, alternative work arrangements—including flexible work hours, compressed work weeks and teleworking—provide another means of shifting trips out of the peak periods. This “triple divergence”—moving away from congested roads—is described in much more detail by Anthony Downs in his book, “Still Stuck in Traffic” (*33*).

The goal of all of these programs is to move trips to uncongested times, routes or modes so that there is less congestion during peak hours and so that more trips can be handled on the current system. Carrying more trips can be thought of in the same way as increasing production in a manufacturing plant. If the current buses, cars and trains can carry more people to the places they want to go, there are benefits to society and the economy.

The role of phones, computers and the internet cannot be overlooked as the future role of commute options are examined. New technologies are being used along with changes in business practices to encourage employers to allow jobs to be done from home or remote locations—and these might allow workers to avoid their commute a few days each month, or travel to their jobsites after a few hours of work at home in the morning.

Atlanta’s “Cash for Commuters” program is a one example of the newer, more aggressive commute option programs. Built around a Clean Air Campaign, the program involved payment of cash incentives to driver-only commuters who switched to another mode. Participants earned up to $60 per month (for three months) by choosing and using an eligible alternative mode of transportation. During the program, participants used alternative modes an average of more than four days each week compared to less than one day per week before. A year and one-half after the program, participants still used a commute alternative an average of 2.4 days per week. Overall, program participants decreased their single-occupant commute modes from 84 percent to 53 percent. This type of change has benefits in less vehicle travel and fewer parking spaces needed and participants have reported lower frustration levels and better on-time arrival. Decreasing each commuter’s peak-period personal vehicle trips by one per week could have substantial congestion benefits, if employers and employees choose these options (*34*).

Provide Travel Options

Lanes that provide high-speed reliable service for bus, carpool, vanpool, and toll-paying travelers are being operated in at least three dozen metropolitan regions (*35*). In addition, they are becoming an important element in regions that wish to add road capacity. The ability to move more people in fewer cars, and the possibility of providing a high-speed, reliable operation are increasingly viewed as a desired element in the congestion reduction checklist (even when a toll is charged). The lanes are most used during the peak travel periods when congestion is worst and the time savings compared to the general travel lanes are the most significant. In addition to saving time on an average trip, the buses, carpools, and other users experience more reliable service because they are less affected by collisions or vehicle breakdowns.

The 70 congested corridors with data on the person volume and travel time for high-occupancy vehicle lanes or high-occupancy toll lanes in 15 metropolitan regions showed an annual delay reduction of 33 million hours, with a value of $620 million per year. These HOV and high-occupancy toll (HOT) lanes carry about one-third of the peak-direction passenger load on the freeways, providing significant passenger movement at much higher speeds and with more reliable travel times than the congested mainlanes. (See Supporting Information section of the report at http://mobility.tamu.edu/ums/report).

High-occupancy toll lanes appear to be the way that the concept of value (or congestion) pricing will be initially implemented in many regions. Offering a high-speed and reliable trip in exchange for a price allows travelers and freight shippers to react to situations where a trip is more important than at other times. While there are only a few corridors with such lanes—SR 91 and I-15 in Southern California, I-394 in Minneapolis, I-10 and US 290 in Houston, I-25 in Denver and I-15 in Salt Lake City—there are several others being considered as part of corridor improvement projects. The focus on providing a different type of service is the attraction of the concept. The experience to date indicates that the typical high-occupancy toll lane user places a higher value on quickly completing the trip than most mainlane users. This may be repair workers attempting to make one more service call, parents picking up kids at day care or making a trip to see a performance or business travelers getting to a meeting or the airport. The many types of trip purposes and levels of tolerance for delay are a part of the diverse peak-period travel population, not unlike the many different congestion problems that have several solutions.

Pricing is also involved in an innovative freight improvement program that has been implemented at the ports of Los Angeles/Long Beach and Oakland. Container fees are reduced for overnight loading or unloading and raised during the peak daylight hours. The higher peak fees are used to fund the overtime pay rates and other overnight operating charges. Approximately one-third of containers have shifted to the off-peak hours in less than two years of program operation (*36*).

Congestion Solutions - Conclusions

Most large city transportation agencies are pursuing all of these strategies as well as others. The mix of programs, policies and projects may be different in each city and the pace of implementation varies according to overall funding, commitment, location of problems, public support and other factors. Addressing the range of different problems with an overall strategy that chooses solutions with the greatest benefit for the least cost recognizes the diversity of the problems and opportunities in each region.

Policy-makers and big city residents have learned to expect congestion for 1 or 2 hours in the morning and in the evening. However, agencies should be able to improve the performance and reliability of the service at other hours. But they have not been able to combine the leadership, technical and financial support to expand the system, improve operations and change travel patterns to keep congestion levels from growing.

The involvement of business leaders in crafting a set of locally supported solutions would seem to be a very important element in the future. At the strategic end, business leader actions take the form of information development and communication with the public and decision makers to emphasize the role of transportation in the state and regional economy. Leaders in Atlanta, Oregon and Texas have documented the costs of congestion to businesses and the benefits from pursuing vision-oriented efforts that offer concepts and funding solutions (*8*,*10*,*36,37*,*38*).

At the tactical end, a group of business leaders in Miami have formed a group named "Meeting Our Vehicular Needs" (MOV'N) to push for a mix of strategies from relatively small, focused operations or design changes to areawide education efforts aimed at improving congestion and safety. Actions requiring modest effort on the part of individuals—moving minor crashes off the road or staying out of intersections when the road ahead is filled—are relatively minor individually, but as regional actions, these can improve travel times and travel time reliability (*39*).

But, as we started the discussion of problems with "you" as the problem, so there are roles for "you" in the solution. Trying a carpool, vanpool or public transportation, flexible work hours, telecommuting and the simple act of checking the travel information websites before starting a trip are immediate actions that may improve your travel.

All of the options are appropriate for congested corridors. In some cases, one or two improvement types will satisfy the community mobility goals. The improvements can also build on the services and qualities provided by the others. The Ohio Department of Transportation, for example, found that the safety problems and congested locations were very similar and solutions to one problem usually improved the other condition as well (*40*).

It bears repeating that regions where the agencies are seen as aggressively operating the current system to get as much service as possible with existing resources have built an expectation and level of trust that allows them to engage the public in a discussion about the benefits of additional transportation investments. The public and decision makers do not always support increased funding or new strategies, but the debate is typically over whether the benefits are worth the cost, rather than if there is a need.

Methodology

The base data for the *2007 Urban Mobility Report* come from the states and the US Department of Transportation (*2*,*15*). The travel and road inventory statistics are analyzed with a set of procedures developed from computer models and empirical studies. The new travel time and speed estimation process is described in a technical memorandum (*1*) and a website: http://mobility.tamu.edu/ums/report/methodology.stm

The methodology creates a set of "base" statistics developed from traffic density values. The density data—daily traffic volume per lane of roadway—is converted to average peak-period speed using a set of estimation curves based on relatively ideal travel conditions—no crashes, breakdowns or weather problems for the years 1982 to 2005.

The "base" estimates, however, do not include the effect of many transportation improvements. The 2007 report addresses this estimation deficiency with methodologies designed to identify the effect of operational treatments and public transportation services. The delay, cost and index measures for 2000 through 2005 include these treatments and identify them as "with strategies." The effects of public transportation, however, are shown for every year since 1982.

The calculation details for estimating the effect of operational treatments and public transportation service are described in a separate report (*13*) available at http://mobility.tamu.edu/ums/report/methodology.stm

Future Changes

There will be changes in the methodology used in this report series over the next few years. There is more information every year from freeways, streets and public transportation systems that provide more descriptive travel time data. Travel time information is being collected from travelers and shippers on the road network by a variety of public and private data collection sources. Some advanced transit operating systems monitor passenger volume, travel time and schedule information and share data with traffic signal systems. Traffic signals can be retimed immediately by the computers to reduce person congestion (not just vehicle congestion). These data can also be used to more accurately describe congestion problems on public transportation and roadway systems.

Combining Performance Measures

Table 6 illustrates an approach to understanding several of the key measures. The value for each statistic is rated according to the relationship to the average value for the population group. The terms "higher" and "lower" than average congestion are used to characterize the 2005 values and trends from 1982 to 2005. These descriptions do not indicate any judgment about the extent of mobility problems. Urban areas that have better than average rankings may have congestion problems that residents consider significant. What Table 6 does, however, is provide the reader with some context for the mobility discussion.

Concluding Thoughts

Congestion is getting worse in many ways.

- Trips take longer.
- Congestion affects more of the day.
- Congestion affects weekend travel and rural areas.
- It affects more personal trips and freight shipments.
- Trip travel times are unreliable.

The *2007 Urban Mobility Report* points to a $78 billion congestion cost—and that is only the value of wasted time and fuel. Congestion causes the average peak-period traveler to spend an extra 38 hours of travel time, 26 gallons of fuel consumption and amounts to a cost of $710 per traveler. The report includes a more comprehensive picture of congestion in all 437 U.S. urban areas and uses an improved methodology to identify congestion effects. The report also describes the problems presented by irregular events—crashes, stalled vehicles, work zones, weather problems, special events and other causes—that result in an unreliable transportation network that causes late arrivals, shipments that miss the delivery time and inefficient manufacturing processes.

There is a cost to reducing congestion, but the benefits are enormous. According to one study, eliminating serious congestion returns eight dollars for every one spent. The benefits range from less travel time and fuel consumed, to faster and more reliable delivery times, expanded service regions and market areas; the benefit estimates do not include others such as safety and air quality that have also been shown to result.

The good news is that there are solutions that work. There are significant benefits from solving congestion problems—whether they are large or small, in big metropolitan regions or smaller urban areas and no matter the cause. There are performance measures that provide accountability to the public and decision makers and improve operational effectiveness. Detailed travel time data from freeways, streets and public transportation systems illustrate many of the traveler frustrations. Mobility reports in coming years will use more comprehensive datasets and improved analysis tools to capture traveler experience.

All of the potential congestion-reducing strategies are needed. Getting more productivity out of the existing road and public transportation systems is vital to reducing congestion and improving travel time reliability. Businesses and employees can use a variety of strategies to modify their times and modes of travel to avoid the peak periods. In many corridors, however, there is a need for additional capacity to move people and freight more rapidly and reliably. Future program decisions should focus on how to use each project, program or strategy to attack the problems, and how much transportation improvement to pursue.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

National Congestion Tables

Table 1. Key Mobility Measures, 2005

Urban Area	Annual Delay per Traveler		Travel Time Index		Wasted Fuel per Traveler	
	Hours	Rank	Value	Rank	Gallons	Rank
Very Large Average (14 areas)	54		1.38		38	
Los Angeles-LBch-Santa Ana, CA	72	1	1.50	1	57	1
San Francisco-Oakland, CA	60	2	1.41	3	47	2
Washington, DC-VA-MD	60	2	1.37	7	43	5
Atlanta, GA	60	2	1.34	11	44	3
Dallas-Fort Worth-Arlington, TX	58	5	1.35	9	40	7
Houston, TX	56	7	1.36	8	42	6
Detroit, MI	54	8	1.29	21	35	10
Miami, FL	50	11	1.38	6	35	10
Phoenix, AZ	48	15	1.31	15	34	13
Chicago, IL-IN	46	16	1.47	2	32	17
New York-Newark, NY-NJ-CT	46	16	1.39	5	29	23
Boston, MA-NH-RI	46	16	1.27	25	31	19
Seattle, WA	45	19	1.30	17	34	13
Philadelphia, PA-NJ-DE-MD	38	33	1.28	23	24	34
Large Average (25 areas)	37		1.24		25	
San Diego, CA	57	6	1.40	4	44	3
San Jose, CA	54	8	1.34	11	38	9
Orlando, FL	54	8	1.30	17	35	10
Denver-Aurora, CO	50	11	1.33	13	33	15
Riverside-San Bernardino, CA	49	13	1.35	9	40	7
Tampa-St. Petersburg, FL	45	20	1.28	23	28	25
Baltimore, MD	44	22	1.30	17	32	17
Minneapolis-St. Paul, MN	43	23	1.26	26	30	21
Indianapolis, IN	43	23	1.22	32	28	25
Sacramento, CA	41	27	1.32	14	30	21
Las Vegas, NV	39	29	1.30	18	27	27
San Antonio, TX	39	29	1.23	28	27	27
Portland, OR-WA	38	33	1.29	21	27	27
Columbus, OH	33	36	1.19	36	24	34
St. Louis, MO-IL	33	36	1.16	46	20	40
Virginia Beach, VA	30	42	1.18	39	20	40
Memphis, TN-MS-AR	30	42	1.13	53	16	46
Providence, RI-MA	29	44	1.16	46	17	45
Cincinnati, OH-KY-IN	27	45	1.18	39	19	42
Milwaukee, WI	19	59	1.13	53	14	52
New Orleans, LA	18	63	1.15	49	11	62
Kansas City, MO-KS	17	64	1.08	73	10	66
Pittsburgh, PA	16	67	1.09	64	9	69
Cleveland, OH	13	75	1.09	64	9	69
Buffalo, NY	11	77	1.08	73	7	76
85 Area Average	**44**		**1.30**		**31**	
Remaining Areas						
51 Urban Areas Over 250,000 Popn	22		1.15		15	
301 Urban Areas Under 250,000 Popn	20		1.12		11	
All 437 Urban Areas	**38**		**1.26**		**26**	

Very Large Urban Areas—over 3 million population. Large Urban Areas—over 1 million and less than 3 million population.

Annual Delay per Traveler – Extra travel time for peak-period travel during the year divided by the number of travelers who begin a trip during the peak period (6 to 9 a.m. and 4 to 7 p.m.). Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.

Travel Time Index – The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak

2005 values include the effects of operational treatments.

Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.

Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 1. Key Mobility Measures, 2005, Continued

Urban Area	Annual Delay per Traveler Hours	Annual Delay per Traveler Rank	Travel Time Index Value	Travel Time Index Rank	Wasted Fuel per Traveler Gallons	Wasted Fuel per Traveler Rank
Medium Average (30 areas)	28		1.16		18	
Austin, TX	49	13	1.31	15	33	15
Charlotte, NC-SC	45	20	1.23	28	31	19
Louisville, KY-IN	42	25	1.23	28	29	23
Tucson, AZ	42	25	1.23	28	26	31
Nashville-Davidson, TN	40	28	1.17	42	25	33
Oxnard-Ventura, CA	39	29	1.24	27	27	27
Jacksonville, FL	39	29	1.21	35	26	31
Raleigh-Durham, NC	35	35	1.18	39	23	37
Albuquerque, NM	33	36	1.17	42	21	39
Birmingham, AL	33	36	1.15	49	22	38
Bridgeport-Stamford, CT-NY	31	40	1.22	32	24	34
Salt Lake City, UT	27	45	1.19	36	18	44
Sarasota-Bradenton, FL	25	48	1.19	36	15	50
Omaha, NE-IA	25	48	1.16	46	15	50
Honolulu, HI	24	51	1.22	32	16	46
El Paso, TX-NM	24	51	1.17	42	16	46
Grand Rapids, MI	24	51	1.10	60	14	52
Allentown-Bethlehem, PA-NJ	22	55	1.14	51	14	52
Oklahoma City, OK	21	56	1.09	64	13	59
Fresno, CA	20	57	1.12	55	12	61
Richmond, VA	20	57	1.09	64	13	59
Hartford, CT	19	59	1.11	57	14	52
New Haven, CT	19	59	1.11	57	14	52
Tulsa, OK	19	59	1.09	64	11	62
Dayton, OH	17	64	1.10	60	11	62
Albany-Schenectady, NY	16	67	1.08	73	10	66
Toledo, OH-MI	15	71	1.09	64	9	69
Springfield, MA-CT	11	77	1.06	81	7	76
Akron, OH	10	80	1.07	76	7	76
Rochester, NY	10	80	1.07	76	7	76
Small Average (16 areas)	17		1.09		10	
Charleston-North Charleston, SC	31	40	1.17	42	19	42
Colorado Springs, CO	27	45	1.14	51	16	46
Pensacola, FL-AL	25	48	1.11	57	14	52
Cape Coral, FL	24	51	1.12	55	14	52
Little Rock, AR	17	64	1.07	76	11	62
Boulder, CO	16	67	1.10	60	9	69
Columbia, SC	16	67	1.07	76	10	66
Eugene, OR	14	72	1.10	60	8	73
Bakersfield, CA	14	72	1.09	64	8	73
Salem, OR	14	72	1.09	64	8	73
Laredo, TX	12	76	1.09	64	6	81
Beaumont, TX	11	77	1.05	84	7	76
Anchorage, AK	10	80	1.07	76	5	83
Corpus Christi, TX	10	80	1.06	81	6	81
Brownsville, TX	8	84	1.06	81	4	85
Spokane, WA	8	84	1.04	85	5	83
85 Area Average	**44**		**1.30**		**31**	
Remaining Areas						
51 Urban Areas Over 250,000 Popn	22		1.15		15	
301 Urban Areas Under 250,000 Popn	20		1.12		11	
All 437 Urban Areas	**38**		**1.26**		**26**	

Medium Urban Areas—over 500,000 and less than 1 million population. Small Urban Areas—less than 500,000 population.

Annual Delay per Traveler – Extra travel time for peak-period travel during the year divided by the number of travelers who begin a trip during the peak period (6 to 9 a.m. and 4 to 7 p.m.). Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.

Travel Time Index – The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak.

2005 values include the effects of operational treatments.

Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.

Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 2. Components of the Congestion Problem, 2005 Urban Area Totals

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Congestion Cost ($ Million)	Rank
Very Large Average (14 areas)	169,278		120,127		3,205	
Los Angeles-LBch-Santa Ana, CA	490,552	1	383,674	1	9,325	1
New York-Newark, NY-NJ-CT	384,046	2	241,976	2	7,383	2
Chicago, IL-IN	202,835	3	141,612	3	3,968	3
Dallas-Fort Worth-Arlington, TX	152,129	4	106,207	4	2,747	4
Miami, FL	150,146	5	105,181	5	2,730	5
Atlanta, GA	132,296	6	96,066	7	2,581	6
San Francisco-Oakland, CA	129,919	7	100,525	6	2,414	7
Washington, DC-VA-MD	127,394	8	90,861	9	2,331	8
Houston, TX	124,131	9	92,559	8	2,225	9
Detroit, MI	115,547	10	76,062	10	2,174	10
Philadelphia, PA-NJ-DE-MD	111,704	11	70,902	12	2,076	11
Boston, MA-NH-RI	93,374	12	62,521	13	1,820	12
Phoenix, AZ	81,727	14	58,922	14	1,687	14
Seattle, WA	74,098	15	54,707	15	1,413	15
Large Average (25 areas)	33,809		23,366		628	
San Diego, CA	90,711	13	71,123	11	1,708	13
Denver-Aurora, CO	64,997	16	42,519	16	1,176	16
Minneapolis-St. Paul, MN	59,746	17	41,820	17	1,099	18
Baltimore, MD	56,769	18	40,814	18	1,126	17
Tampa-St. Petersburg, FL	56,203	19	35,281	20	1,005	19
San Jose, CA	50,038	20	34,710	21	899	21
Riverside-San Bernardino, CA	48,266	21	39,627	19	955	20
Orlando, FL	40,595	22	26,049	23	738	22
Sacramento, CA	39,577	23	29,244	22	729	23
St. Louis, MO-IL	37,772	24	23,342	25	711	24
Portland, OR-WA	33,660	25	24,007	24	625	25
Las Vegas, NV	29,493	26	20,023	27	543	26
San Antonio, TX	29,380	27	20,425	26	530	27
Virginia Beach, VA	25,602	28	17,102	29	467	29
Cincinnati, OH-KY-IN	24,378	29	17,447	28	459	30
Indianapolis, IN	24,318	30	16,098	30	478	28
Columbus, OH	21,958	32	15,513	31	409	32
Providence, RI-MA	19,482	37	11,660	38	343	38
Memphis TN-MS-AR	17,129	39	9,234	43	317	40
Pittsburgh, PA	16,159	41	9,215	44	285	41
Milwaukee, WI	15,402	42	10,815	40	282	42
Kansas City, MO-KS	13,737	45	8,637	46	256	44
Cleveland, OH	13,162	46	8,840	45	236	46
New Orleans, LA	10,837	49	6,917	49	207	49
Buffalo, NY	5,852	65	3,685	66	112	65
Remaining Areas						
51 Areas Over 250,000 – Total	244,210		157,741		4,601	
51 Areas Over 250,000 - Average	4,788		3,093		90	
301 Areas Under 250,000 - Total	348,023		171,546		5,896	
301 Areas Under 250,000 - Average	1,156		570		20	
All 437 Areas – Total	4,188,716		2,869,070		78,136	
All 437 Areas - Average	9,585		6,565		179	

Very Large Urban Areas—over 3 million population. Large Urban Areas—over 1 million and less than 3 million population.
Travel Delay – Travel time above that needed to complete a trip at free-flow speeds.
Excess Fuel Consumed – Increased fuel consumption due to travel in congested conditions rather than free-flow conditions.
Congestion Cost – Value of travel time delay (estimated at $14.60 per hour of person travel and $77.10 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon).
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Table 2. Components of the Congestion Problem, 2005 Urban Area Totals, Continued

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Congestion Cost ($ Million)	Rank
Medium Average (30 areas)	11,087		7,307		206	
Austin, TX	22,580	31	15,505	32	422	31
Nashville-Davidson, TN	21,707	33	13,505	36	404	34
Charlotte, NC-SC	21,204	34	14,340	34	409	32
Jacksonville, FL	20,779	35	13,997	35	376	36
Louisville, KY-IN	20,558	36	14,415	33	395	35
Raleigh-Durham, NC	18,234	38	11,700	37	346	37
Tucson, AZ	17,011	40	10,483	41	338	39
Bridgeport-Stamford, CT-NY	14,510	43	11,500	39	280	43
Salt Lake City, UT	14,236	44	9,327	42	250	45
Birmingham, AL	12,416	47	8,210	48	234	47
Oxnard-Ventura, CA	12,184	48	8,350	47	229	48
Albuquerque, NM	10,407	50	6,644	50	200	50
Richmond, VA	10,081	51	6,388	52	181	51
Oklahoma City, OK	9,468	52	6,179	54	171	52
Honolulu, HI	9,342	53	6,255	53	166	53
Hartford, CT	9,252	54	6,526	51	166	53
Sarasota-Bradenton, FL	8,840	55	5,293	57	156	56
Omaha, NE-IA	8,784	56	5,344	56	154	57
El Paso, TX-NM	8,675	57	5,745	55	159	55
Tulsa, OK	8,453	58	4,796	59	149	58
Grand Rapids, MI	7,593	60	4,404	62	138	60
Allentown-Bethlehem, PA-NJ	7,483	61	4,650	60	137	61
Dayton, OH	6,863	63	4,621	61	127	63
Fresno, CA	6,625	64	4,151	65	127	63
New Haven, CT	5,706	66	4,227	64	104	66
Albany-Schenectady, NY	4,574	69	2,848	68	86	68
Toledo, OH-MI	4,170	70	2,632	70	78	70
Springfield, MA-CT	4,053	71	2,475	71	71	72
Rochester, NY	3,527	73	2,351	73	64	74
Akron, OH	3,293	76	2,340	74	62	75
Small Average (16 areas)	3,047		1,832		56	
Charleston-North Charleston, SC	8,041	59	4,922	58	148	59
Colorado Springs, CO	7,332	62	4,377	63	131	62
Cape Coral, FL	5,322	67	3,074	67	98	67
Pensacola, FL-AL	4,773	68	2,680	69	84	69
Columbia, SC	3,730	72	2,364	72	73	71
Bakersfield, CA	3,482	74	2,113	76	66	73
Little Rock, AR	3,416	75	2,323	75	62	75
Corpus Christi, TX	1,784	77	1,088	78	32	77
Salem, OR	1,773	78	1,042	79	31	79
Eugene, OR	1,766	79	1,095	77	32	77
Spokane, WA	1,523	80	918	80	28	80
Anchorage, AK	1,496	81	838	81	27	81
Beaumont, TX	1,377	82	830	82	25	82
Laredo, TX	1,262	83	693	83	23	83
Boulder, CO	996	84	576	84	17	84
Brownsville, TX	680	85	383	85	12	85
Remaining Areas						
51 Areas Over 250,000 – Total	244,210		157,741		4,601	
51 Areas Over 250,000 - Average	4,788		3,093		90	
301 Areas Under 250,000 - Total	348,023		171,546		5,896	
301 Areas Under 250,000 - Average	1,156		570		20	
All 437 Areas - Total	4,188,716		2,869,070		78,136	
All 437 Areas - Average	9,585		6,565		179	

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Excess Fuel Consumed – Increased fuel consumption due to travel in congested conditions rather than free-flow conditions.
Congestion Cost – Value of travel time delay (estimated at $14.60 per hour of person travel and $77.10 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon).
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Table 3. 2005 Effect of Mobility Improvements

	Operational Treatment Savings				Public Transportation Savings		
Urban Area	Treatments	Delay (1000 Hours)	Rank	Cost ($ Million)	Delay (1000 Hours)	Rank	Cost ($ Million)
Very Large Average (14 areas)		14,779		276.8	30,681		577.9
Los Angeles-LBch-Santa Ana, CA	r,i,s,a,h	56,611	1	1,067.8	28,494	3	458.7
New York-Newark, NY-NJ-CT	r,i,s,a,h	41,215	2	781.9	216,431	1	4,177.6
San Francisco-Oakland, CA	r,i,s,a,h	16,705	3	305.8	26,263	4	487.2
Houston, TX	r,i,s,a,h	13,617	4	240.8	5,959	14	96.1
Miami, FL	i,s,a,h	12,911	5	232.1	9,748	11	170.3
Dallas-Fort Worth-Arlington, TX	r,i,s,a,h	12,193	6	215.5	5,642	15	102.2
Washington, DC-VA-MD	r,i,s,a,h	8,942	7	162.8	25,655	5	456.4
Atlanta, GA	r,i,s,a,h	8,647	8	172.1	12,542	9	245.2
Chicago, IL-IN	r,i,s,a	8,384	9	163.6	39,554	2	779.4
Seattle, WA	r,i,s,a,h	7,019	11	133.5	12,661	8	225.3
Philadelphia, PA-NJ-DE-MD	r,i,s,a	6,393	12	120.1	19,155	7	359.7
Phoenix, AZ	r,i,s,a,h	5,805	13	116.7	2,720	19	55.6
Boston, MA-NH-RI	i,s,a	4,643	16	89.5	21,441	6	416.1
Detroit, MI	r,i,s,a	3,824	18	73.0	3,276	18	61.3
Large Average (25 areas)		2,143		39.6	2,558		47.7
San Diego, CA	r,i,s,a	7,949	10	146.4	8,922	12	164.6
Minneapolis-St. Paul, MN	r,i,s,a,h	5,367	14	95.6	5,337	16	95.9
Riverside-San Bernardino, CA	r,i,s,a,h	5,213	15	102.2	2,165	24	40.0
San Jose, CA	r,i,s,a	4,165	17	73.9	2,592	21	46.2
Denver-Aurora, CO	r,i,s,a,h	3,528	19	63.5	4,464	17	81.2
Tampa-St. Petersburg, FL	i,s,a	3,522	20	62.5	1,282	33	22.8
Sacramento, CA	r,i,s,a,h	3,482	21	65.2	2,089	26	37.6
Baltimore, MD	i,s,a	2,843	22	56.2	9,923	10	199.7
Portland, OR-WA	r,i,s,a,h	2,653	23	50.0	6,676	13	124.1
Virginia Beach, VA	i,s,a,h	2,165	24	39.3	1,214	35	22.4
Orlando, FL	i,s,a	1,929	25	34.9	1,909	27	34.5
Las Vegas, NV	i,s,a	1,309	26	23.4	2,439	22	46.6
San Antonio, TX	i,s,a	1,213	27	21.9	1,774	30	32.2
Milwaukee, WI	r,i,s,a	1,174	28	21.4	1,274	34	23.4
Columbus, OH	r,i,s,a	1,130	29	21.7	616	43	11.8
St. Louis, MO-IL	i,s,a	998	32	18.9	2,293	23	43.6
Memphis, TN-MS-AR	i,s,a	910	34	17.8	634	41	12.0
Cincinnati, OH-KY-IN	r,i,s,a	790	36	15.0	1,909	27	36.2
Indianapolis, IN	i,s,a	697	39	13.8	308	49	6.0
Kansas City, MO-KS	i,s,a	602	45	11.1	308	49	5.7
New Orleans, LA	i,s,a	586	46	11.1	1,070	36	20.8
Cleveland, OH	i,s,a	487	48	9.0	1,503	32	27.4
Pittsburgh, PA	i,s,a	390	52	7.0	1,882	29	33.8
Providence, RI-MA	i,s,a	295	55	5.4	976	37	17.3
Buffalo, NY	i,s,a	181	63	3.5	382	47	7.4
Remaining Areas							
51 Areas Over 250,000 – Total		7,314		136.2	4,539		83.1
51 Areas Over 250,000 - Average		143		2.7	89		1.6
301 Areas Under 250,000 - Total		10,211		171.5	26,789		490.6
301 Areas Under 250,000 - Average		34		0.6	89		1.6
All 437 Areas - Total		292,168		5,438.7	540,878		10,153.9
All 437 Areas - Average		669		12.4	1,238		23.2

Very Large Urban Areas—over 3 million population. Large Urban Areas—over 1 million and less than 3 million population.

Operational Treatments – Freeway incident management (i), freeway ramp metering (r), arterial street signal coordination (s), arterial street access management (a) and high-occupancy vehicle lanes (h).

Public Transportation – Regular route service from all public transportation providers in an urban area.

Delay savings are affected by the amount of treatment or service in each area, as well as the amount of congestion and the urban area population.

Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.

Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 3. 2005 Effect of Mobility Improvements, Continued

Urban Area	Operational Treatment Savings: Treatments	Delay (1000 Hours)	Rank	Cost ($ Million)	Public Transportation Savings: Delay (1000 Hours)	Rank	Cost ($ Million)
Medium Average (30 areas)		426		8.0	488		9.0
Austin, TX	i,s,a	1,079	30	20.3	1,709	31	32.2
Jacksonville, FL	i,s,a	1,008	31	18.4	498	46	9.1
Nashville-Davidson, TN	i,s,a	955	33	18.3	231	56	4.3
Tucson, AZ	i,s,a	896	35	17.6	567	44	11.3
Louisville, KY-IN	i,s,a	790	36	15.4	558	45	10.9
Charlotte, NC-SC	i,s,a	718	38	13.8	973	38	18.6
Omaha, NE-IA	i,s,a	674	40	11.8	188	61	3.3
El Paso, TX-NM	i,s,a	654	41	11.7	636	40	11.5
Albuquerque, NM	i,s,a	650	42	12.2	122	67	2.3
Salt Lake City, UT	r,i,s,a	611	43	11.0	2,152	25	38.3
Bridgeport-Stamford, CT-NY	i,s,a	604	44	11.8	323	48	6.4
Sarasota-Bradenton, FL	i,s,a	506	47	8.9	82	74	1.4
Birmingham, AL	i,s,a	484	49	9.8	242	55	4.7
Fresno, CA	r,i,s,a	464	50	8.9	259	53	4.9
Raleigh-Durham, NC	i,s,a	437	51	8.5	742	39	14.1
Hartford, CT	i,s,a	379	53	6.9	619	42	11.3
Richmond, VA	i,s,a	313	54	5.6	196	60	3.5
Honolulu, HI	i,s,a	241	58	4.3	2,711	20	47.6
Oxnard-Ventura, CA	i,s,a	235	59	4.3	265	52	4.9
New Haven, CT	i,s,a	211	60	3.8	158	64	2.9
Allentown-Bethlehem, PA-NJ	r,i,s,a	185	62	3.5	119	68	2.2
Dayton, OH	s,a	135	64	2.3	244	54	4.6
Rochester, NY	i,s,a	124	65	2.2	283	51	5.1
Grand Rapids, MI	s,a	123	66	2.2	85	71	1.5
Albany-Schenectady, NY	i,s,a	101	68	2.0	231	56	4.4
Springfield, MA-CT	i,s,a	56	74	1.0	173	63	3.0
Oklahoma City, OK	i,s,a	55	75	1.1	2	84	0.0
Tulsa, OK	i,s,a	50	77	1.0	-2	85	0.0
Toledo, OH-MI	s,a	26	80	0.5	144	65	2.8
Akron, OH	s,a	12	84	0.2	133	66	2.5
Small Average (16 areas)		86		1.6	89		1.6
Cape Coral, FL	i,s,a	292	56	5.4	75	76	1.4
Colorado Springs, CO	i,s,a	243	57	4.2	226	58	4.0
Bakersfield, CA	i,s,a	203	61	3.7	202	59	3.9
Little Rock, AR	i,s,a	105	67	2.1	4	83	0.1
Pensacola, FL-AL	s,a	87	69	1.5	56	79	1.0
Charleston-North Charleston, SC	i,s,a	75	70	1.5	118	69	2.2
Eugene, OR	i,s,a	72	71	1.4	174	62	3.2
Anchorage, AK	s,a	60	72	1.1	77	75	1.4
Columbia, SC	i,s,a	59	73	1.3	59	78	1.2
Spokane, WA	i,s,a	51	76	1.0	83	73	1.5
Boulder, CO	s,a	34	78	0.6	35	81	0.6
Salem, OR	s,a	29	79	0.5	85	71	1.5
Laredo, TX	i,s,a	26	80	0.5	61	77	1.1
Beaumont ,TX	s,a	17	82	0.3	10	82	0.2
Corpus Christi, TX	s,a	17	82	0.3	107	70	1.9
Brownsville, TX	s	7	85	0.1	52	80	0.9
Remaining Areas							
51 Areas Over 250,000 – Total		7,314		136.2	4,539		83.1
51 Areas Over 250,000 - Average		143		2.7	89		1.6
301 Areas Under 250,000 - Total		10,211		171.5	26,789		490.6
301 Areas Under 250,000 - Average		34		0.6	89		1.6
All 437 Areas - Total		292,168		5,438.7	540,878		10,153.9
All 437 Areas - Average		669		12.4	1,238		23.2

Medium Urban Areas—over 500,000 and less than 1 million population. Small Urban Areas—less than 500,000 population.
Operational Treatments – Freeway incident management (i), freeway ramp metering (r) arterial street signal coordination (s), arterial street access management (a) and high-occupancy vehicle lanes (h).
Public Transportation – Regular route service from all public transportation providers in an urban area.
Delay savings are affected by the amount of treatment or service in each area, as well as the amount of congestion and the urban area population.
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 4. Trends—Annual Delay per Traveler, 1982 to 2005

Urban Area	Annual Hours of Delay per Traveler				Long-Term Change 1982 to 2005	
	2005	2004	1995	1982	Hours	Rank
Very Large Average (14 areas)	54	51	43	21	33	
Dallas-Fort Worth-Arlington, TX	58	51	34	10	48	1
Washington, DC-VA-MD	60	60	53	16	44	3
San Francisco-Oakland, CA	60	56	56	24	36	7
Atlanta, GA	60	63	70	26	34	10
Boston, MA-NH-RI	46	45	30	12	34	10
Miami, FL	50	49	35	16	34	10
New York-Newark, NY-NJ-CT	46	42	30	12	34	10
Seattle, WA	45	42	52	13	32	18
Chicago, IL-IN	46	44	33	15	31	19
Detroit, MI	54	56	51	25	29	21
Los Angeles-LBch-Santa Ana, CA	72	70	71	45	27	24
Houston, TX	56	52	32	30	26	27
Philadelphia, PA-NJ-DE-MD	38	37	27	16	22	36
Phoenix, AZ	48	42	33	35	13	57
Large Average (25 areas)	37	36	30	11	26	
San Diego, CA	57	59	35	12	45	2
Riverside-San Bernardino, CA	49	47	28	5	44	3
Minneapolis-St. Paul, MN	43	40	34	6	37	5
Orlando, FL	54	56	54	18	36	7
Denver-Aurora, CO	50	46	37	16	34	10
Baltimore, MD	44	43	33	11	33	15
San Antonio, TX	39	38	19	6	33	15
San Jose, CA	54	51	51	23	31	19
Columbus, OH	33	34	27	4	29	21
Las Vegas, NV	39	39	37	10	29	21
Sacramento, CA	41	40	35	14	27	24
Providence, RI-MA	29	29	12	3	26	27
Portland, OR-WA	38	37	33	13	25	29
Indianapolis, IN	43	46	53	19	24	31
Memphis TN-MS-AR	30	29	23	6	24	31
Cincinnati, OH-KY-IN	27	27	26	5	22	36
St. Louis, MO-IL	33	31	38	12	21	40
Tampa-St. Petersburg, FL	45	46	41	24	21	40
Virginia Beach, VA	30	30	27	14	16	49
Kansas City, MO-KS	17	16	17	3	14	54
Milwaukee, WI	19	20	22	7	12	62
Cleveland, OH	13	14	16	3	10	67
Buffalo, NY	11	11	6	3	8	72
Pittsburgh, PA	16	17	19	11	5	80
New Orleans, LA	18	18	20	16	2	84
85 Area Average	**44**	**42**	**36**	**16**	**28**	
Remaining Areas						
51 Urban Areas Over 250,000 Popn	22	25	18	6	16	
301 Urban Areas Under 250,000 Popn	20	19	16	5	15	
All 437 Urban Areas	**38**	**37**	**31**	**14**	**24**	

Very Large Urban Areas—over 3 million population. Large Urban Areas—over 1 million and less than 3 million population.

Annual Delay per Traveler – Extra travel time for peak-period travel during the year divided by the number of travelers who begin a trip during the peak period (6 to 9 a.m. and 4 to 7 p.m.). Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.

Data for years 2000 to 2005 include the effects of operational treatments.

Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.

Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 4. Trends—Annual Delay per Traveler, 1982 to 2005, Continued

Urban Area	Annual Hours of Delay per Traveler				Long-Term Change 1982 to 2005	
	2005	2004	1995	1982	Hours	Rank
Medium Average (30 areas)	28	27	21	9	19	
Austin, TX	49	44	32	12	37	5
Oxnard-Ventura, CA	39	35	21	4	35	9
Charlotte, NC-SC	45	47	23	12	33	15
Raleigh-Durham, NC	35	35	26	8	27	24
Birmingham, AL	33	33	21	8	25	29
Louisville, KY-IN	42	44	34	18	24	31
Jacksonville, FL	39	41	40	16	23	34
Albuquerque, NM	33	30	30	11	22	36
Bridgeport-Stamford, CT-NY	31	28	22	9	22	36
El Paso, TX-NM	24	22	10	3	21	40
Nashville-Davidson, TN	40	40	35	20	20	43
Omaha, NE-IA	25	26	19	5	20	43
Salt Lake City, UT	27	29	32	8	19	46
Grand Rapids, MI	24	24	19	6	18	47
Tucson, AZ	42	39	23	24	18	47
Oklahoma City, OK	20	22	17	5	15	51
Hartford, CT	19	19	13	4	15	51
New Haven, CT	19	18	13	5	14	54
Richmond, VA	20	20	22	6	14	54
Albany-Schenectady, NY	16	16	8	3	13	57
Allentown-Bethlehem, PA-NJ	22	22	21	9	13	57
Toledo, OH-MI	15	17	12	2	13	57
Tulsa, OK	19	19	14	8	11	65
Honolulu, HI	24	22	26	14	10	67
Sarasota-Bradenton, FL	25	26	19	15	10	67
Akron, OH	10	11	9	2	8	72
Fresno, CA	20	19	17	12	8	72
Dayton, OH	17	19	22	10	7	76
Rochester, NY	10	10	7	3	7	76
Springfield, MA-CT	11	10	10	7	4	83
Small Average (16 areas)	17	17	13	6	11	
Colorado Springs, CO	27	22	12	4	23	34
Pensacola, FL-AL	25	24	16	5	20	43
Charleston-North Charleston, SC	31	32	28	15	16	49
Cape Coral, FL	24	24	28	9	15	51
Little Rock, AR	17	17	10	4	13	57
Bakersfield, CA	14	12	7	2	12	62
Columbia, SC	16	16	11	4	12	62
Salem, OR	14	14	12	3	11	65
Laredo, TX	12	11	7	2	10	67
Boulder, CO	16	16	16	7	9	71
Eugene, OR	14	12	7	6	8	72
Beaumont, TX	11	11	6	4	7	76
Brownsville, TX	8	8	4	2	6	79
Corpus Christi, TX	10	10	7	5	5	80
Spokane, WA	8	8	10	3	5	80
Anchorage, AK	10	10	9	10	0	85
85 Area Average	**44**	**42**	**36**	**16**	**28**	
Remaining Areas						
51 Urban Areas Over 250,000 Popn	22	25	18	6	16	
301 Urban Areas Under 250,000 Popn	20	19	16	5	15	
All 437 Urban Areas	**38**	**37**	**31**	**14**	**24**	

Medium Urban Areas—over 500,000 and less than 1 million population. Small Urban Areas—less than 500,000 population.
Annual Delay per Traveler – Extra travel time for peak-period travel during the year divided by the number of travelers who begin a trip during the peak period (6 to 9 a.m. and 4 to 7 p.m.). Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.
Data for years 2000 to 2005 include the effects of operational treatments.
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 5. Trends—Travel Time Index, 1982 to 2005

Urban Area	Travel Time Index 2005	2004	1995	1982	Point Change in Peak-Period Time Penalty Points	Rank
Very Large Area Average (14 areas)	1.38	1.36	1.29	1.14	24	
Chicago, IL-IN	1.47	1.44	1.31	1.12	35	1
Dallas-Fort Worth-Arlington, TX	1.35	1.31	1.16	1.05	30	4
New York-Newark, NY-NJ-CT	1.39	1.36	1.24	1.10	29	5
Miami, FL	1.38	1.37	1.26	1.11	27	6
San Francisco-Oakland, CA	1.41	1.38	1.35	1.15	26	7
Los Angeles-LBch-Santa Ana, CA	1.50	1.48	1.44	1.25	25	9
Washington, DC-VA-MD	1.37	1.37	1.32	1.12	25	9
Atlanta, GA	1.34	1.32	1.25	1.10	24	11
Seattle, WA	1.30	1.28	1.30	1.07	23	15
Boston, MA-NH-RI	1.27	1.27	1.20	1.08	19	22
Houston, TX	1.36	1.32	1.19	1.19	17	24
Phoenix, AZ	1.31	1.27	1.17	1.15	16	25
Detroit, MI	1.29	1.30	1.26	1.13	16	25
Philadelphia, PA-NJ-DE-MD	1.28	1.27	1.18	1.12	16	25
Large Area Average (25 areas)	1.24	1.24	1.18	1.07	17	
San Diego, CA	1.40	1.41	1.22	1.07	33	2
Riverside-San Bernardino, CA	1.35	1.35	1.19	1.03	32	3
Sacramento, CA	1.32	1.32	1.21	1.06	26	7
Denver-Aurora, CO	1.33	1.30	1.22	1.09	24	11
Las Vegas, NV	1.30	1.31	1.25	1.06	24	11
Baltimore, MD	1.30	1.29	1.20	1.07	23	15
Portland, OR-WA	1.29	1.27	1.20	1.07	22	17
Minneapolis-St. Paul, MN	1.26	1.24	1.18	1.04	22	17
San Jose, CA	1.34	1.32	1.25	1.13	21	19
Orlando, FL	1.30	1.30	1.27	1.10	20	21
San Antonio, TX	1.23	1.23	1.10	1.04	19	22
Columbus, OH	1.19	1.20	1.15	1.03	16	25
Indianapolis, IN	1.22	1.23	1.24	1.08	14	32
Cincinnati, OH-KY-IN	1.18	1.18	1.16	1.04	14	32
Providence, RI-MA	1.16	1.17	1.08	1.03	13	37
Virginia Beach, VA	1.18	1.18	1.16	1.07	11	43
St. Louis, MO-IL	1.16	1.16	1.18	1.07	9	46
Memphis TN-MS-AR	1.13	1.14	1.11	1.04	9	46
Tampa-St. Petersburg, FL	1.28	1.29	1.30	1.20	8	50
Milwaukee, WI	1.13	1.13	1.13	1.05	8	50
Cleveland, OH	1.09	1.10	1.11	1.03	6	64
Kansas City, MO-KS	1.08	1.08	1.07	1.02	6	64
Buffalo, NY	1.08	1.08	1.04	1.03	5	70
New Orleans, LA	1.15	1.15	1.16	1.11	4	77
Pittsburgh, PA	1.09	1.10	1.10	1.06	3	79
85 Area Average	**1.30**	**1.29**	**1.22**	**1.11**	**19**	
Remaining Areas						
51 Urban Areas Over 250,000 Popn	1.15	1.16	1.10	1.05	10	
301 Urban Areas Under 250,000 Popn	1.12	1.11	1.09	1.03	9	
All 437 Urban Areas	**1.26**	**1.25**	**1.19**	**1.09**	**17**	

Very Large Urban Areas—over 3 million population. Large Urban Areas—over 1 million and less than 3 million population.
Travel Time Index – The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak. Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.
Data for years 2000 to 2005 include the effects of operational treatments.
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 5. Trends—Travel Time Index, 1982 to 2005, Continued

Urban Area	Travel Time Index				Point Change in Peak-Period Time Penalty	
	2005	2004	1995	1982	Points	Rank
Medium Area Average (30 areas)	1.16	1.16	1.12	1.05	11	
Austin, TX	1.31	1.29	1.18	1.07	24	11
Oxnard-Ventura, CA	1.24	1.22	1.12	1.03	21	19
Charlotte, NC-SC	1.23	1.25	1.13	1.07	16	25
Bridgeport-Stamford, CT-NY	1.22	1.21	1.16	1.06	16	25
El Paso, TX-NM	1.17	1.16	1.07	1.02	15	31
Jacksonville, FL	1.21	1.22	1.20	1.07	14	32
Salt Lake City, UT	1.19	1.21	1.19	1.05	14	32
Raleigh-Durham, NC	1.18	1.17	1.11	1.04	14	32
Tucson, AZ	1.23	1.22	1.13	1.10	13	37
Louisville, KY-IN	1.23	1.23	1.17	1.11	12	39
Albuquerque, NM	1.17	1.16	1.16	1.05	12	39
Omaha, NE-IA	1.16	1.16	1.11	1.04	12	39
Honolulu, HI	1.22	1.20	1.21	1.11	11	43
Birmingham, AL	1.15	1.15	1.09	1.04	11	43
Sarasota-Bradenton, FL	1.19	1.19	1.15	1.10	9	46
Nashville-Davidson, TN	1.17	1.17	1.13	1.09	8	50
Allentown-Bethlehem, PA-NJ	1.14	1.14	1.14	1.06	8	50
Hartford, CT	1.11	1.11	1.08	1.03	8	50
New Haven, CT	1.11	1.10	1.08	1.03	8	50
Fresno, CA	1.12	1.12	1.11	1.05	7	58
Grand Rapids, MI	1.10	1.11	1.09	1.03	7	58
Oklahoma City, OK	1.09	1.09	1.07	1.02	7	58
Toledo, OH-MI	1.09	1.10	1.07	1.02	7	58
Tulsa, OK	1.09	1.09	1.07	1.03	6	64
Albany-Schenectady, NY	1.08	1.08	1.04	1.02	6	64
Richmond, VA	1.09	1.09	1.09	1.04	5	70
Akron, OH	1.07	1.08	1.06	1.02	5	70
Rochester, NY	1.07	1.07	1.05	1.02	5	70
Dayton, OH	1.10	1.11	1.12	1.07	3	79
Springfield, MA-CT	1.06	1.06	1.06	1.04	2	83
Small Area Average (16 areas)	1.09	1.09	1.07	1.03	6	
Colorado Springs, CO	1.14	1.12	1.07	1.02	12	39
Charleston-North Charleston, SC	1.17	1.18	1.14	1.08	9	46
Pensacola, FL-AL	1.11	1.11	1.08	1.03	8	50
Bakersfield, CA	1.09	1.08	1.04	1.01	8	50
Laredo, TX	1.09	1.09	1.06	1.02	7	58
Salem, OR	1.09	1.09	1.07	1.02	7	58
Eugene, OR	1.10	1.08	1.04	1.04	6	64
Boulder, CO	1.10	1.09	1.09	1.04	6	64
Cape Coral, FL	1.12	1.12	1.15	1.07	5	70
Little Rock, AR	1.07	1.07	1.04	1.02	5	70
Columbia, SC	1.07	1.07	1.04	1.02	5	70
Brownsville, TX	1.06	1.07	1.04	1.02	4	77
Corpus Christi, TX	1.06	1.05	1.04	1.03	3	79
Beaumont, TX	1.05	1.05	1.03	1.02	3	79
Spokane, WA	1.04	1.05	1.05	1.02	2	83
Anchorage, AK	1.07	1.07	1.06	1.06	1	85
85 Area Average	**1.30**	**1.29**	**1.22**	**1.11**	**19**	
Remaining Areas						
51 Urban Areas Over 250,000 Popn	1.15	1.16	1.10	1.05	10	
301 Urban Areas Under 250,000 Popn	1.12	1.11	1.09	1.03	9	
All 437 Urban Areas	**1.26**	**1.25**	**1.19**	**1.09**	**17**	

Medium Urban Areas—over 500,000 and less than 1 million population. Small Urban Areas—less than 500,000 population.
Travel Time Index – The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak. Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.
Data for years 2000 to 2005 include the effects of operational treatments.
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

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Table 6. Summary of Congestion Measures and Trends

Urban Area	Congestion Levels in 2005			Congestion Increase 1982 to 2005	
	Delay per Traveler (Hours)	Travel Time Index	Total Delay (1000 Hours)	Delay per Traveler (Hours)	Total Delay (1000 Hours)
Very Large Average (14 areas)	**54**	**1.38**	**169,278**	**33**	**131,206**
New York-Newark, NY-NJ-CT	L	0	H+	0	F+
Los Angeles-LBch-Santa Ana, CA	H+	H+	H+	S	F+
Chicago, IL-IN	L	H+	H	0	F+
Miami, FL	L	0	L	0	0
Philadelphia, PA-NJ-DE-MD	L-	L-	L-	S-	S-
Dallas-Fort Worth-Arlington, TX	H	L	L	F+	F
Washington, DC-VA-MD	H	0	L	F+	S-
Atlanta, GA	H	L	L	0	S-
San Francisco-Oakland, CA	H	H	L	F	S-
Boston, MA-NH-RI	L	L-	L-	0	S-
Detroit, MI	0	L-	L-	S	S-
Houston, TX	H	0	L-	S	S-
Phoenix, AZ	L	L	L-	S-	S-
Seattle, WA	L-	L-	L-	0	S-
Large Average (25 areas)	**37**	**1.24**	**33,811**	**26**	**28,565**
San Diego, CA	H+	H+	H+	F+	F+
Minneapolis-St. Paul, MN	H	0	H+	F+	F+
Baltimore, MD	H+	H	H+	F	F+
Tampa-St. Petersburg, FL	H+	H	H+	S	F+
St. Louis, MO-IL	L	L-	H	S	0
Denver-Aurora, CO	H+	H+	H+	F+	F+
Pittsburgh, PA	L-	L-	L-	S-	S-
Riverside-San Bernardino, CA	H+	H+	H+	F+	F+
Cleveland, OH	L-	L-	L-	S-	S-
Sacramento, CA	H	H+	H	0	F+
Portland, OR-WA	0	H	0	0	0
San Jose, CA	H+	H+	H+	F	F+
Cincinnati, OH-KY-IN	L-	L	L	S	S-
Virginia Beach, VA	L	L	L	S-	S-
Kansas City, MO-KS	L-	L-	L-	S-	S-
Milwaukee, WI	L-	L-	L-	S-	S-
Las Vegas, NV	H	H	0	F	0
Orlando, FL	H+	H	H	F+	F+
San Antonio, TX	H	0	0	F	0
Providence, RI-MA	L	L-	L-	0	S-
Columbus, OH	L	L	L	F	S-
Buffalo, NY	L-	L-	L-	S-	S-
New Orleans, LA	L-	L-	L-	S-	S-
Indianapolis, IN	H	0	L	0	S-
Memphis, TN-MS-AR	L	L-	L-	0	S-
Interval Values – Very Large and Large	5 hours	5 index points	(5 hours x average popn. for group)	5 hours	(5 hours x average change in popn. for group)

0 – *Average congestion levels or average congestion growth (within 1 interval)*
(Note: Interval – If the difference in values is less than this, it may not indicate a difference in congestion level).

Between 1 and 2 intervals above or below the average
H *Higher congestion*; F *Faster congestion growth*;
L *Lower congestion*; S *Slower congestion growth*;

More than 2 intervals above or below the average
H+ *Much higher congestion*; F+ *Much faster growth*
L- *Much lower congestion*; S- *Much slower growth*

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 6. Summary of Congestion Measures and Trends, Continued

Urban Area	Congestion Levels in 2005: Delay per Traveler (Hours)	Congestion Levels in 2005: Travel Time Index	Congestion Levels in 2005: Total Delay (1000 Hours)	Congestion Increase 1982 to 2005: Delay per Traveler (Hours)	Congestion Increase 1982 to 2005: Total Delay (1000 Hours)
Medium Average (30 areas)	**28**	**1.16**	**11,087**	**19**	**9,129**
Jacksonville, FL	H+	H+	H+	F	F+
Nashville-Davidson, TN	H+	0	H+	0	F+
Salt Lake City, UT	0	H	H	0	F+
Raleigh-Durham, NC	H+	H	H+	F+	F+
Richmond, VA	L-	L-	0	S-	S
Louisville, KY-IN	H+	H+	H+	F+	F+
Hartford, CT	L-	L-	L	S	S-
Bridgeport-Stamford, CT-NY	H	H+	H+	F	F+
Charlotte, NC-SC	H+	H+	H+	F+	F+
Austin, TX	H+	H+	H+	F+	F+
Oklahoma City, OK	L-	L-	L-	S-	S-
Tulsa, OK	L-	L-	L	S-	S-
Tucson, AZ	H+	H+	H+	0	F+
Dayton, OH	L-	L-	L-	S-	S-
Honolulu, HI	L	H+	L	S-	S-
Birmingham, AL	H+	0	H	F+	F+
El Paso, TX-NM	L	0	L	F	S-
Rochester, NY	L-	L-	L-	S-	S-
Springfield, MA-CT	L-	L-	L-	S-	S-
Omaha, NE-IA	L	0	L	0	S-
Sarasota-Bradenton, FL	L	H	L	S-	S-
Allentown-Bethlehem, PA-NJ	L-	L	L-	S-	S-
Akron, OH	L-	L-	L-	S-	S-
Fresno, CA	L-	L	L-	S-	S-
Grand Rapids, MI	L	L-	L-	0	S-
Oxnard-Ventura, CA	H+	H+	0	F+	F+
Albuquerque, NM	H+	0	0	F	S
New Haven, CT	L-	L-	L-	S-	S-
Albany-Schenectady, NY	L-	L-	L-	S-	S-
Toledo, OH-MI	L-	L-	L-	S-	S-
Small Average (16 areas)	**17**	**1.09**	**3,047**	**11**	**2,540**
Colorado Springs, CO	H+	H+	H+	F+	F+
Charleston-North Charleston, SC	H+	H+	H+	F	F+
Bakersfield, CA	L	0	0	0	F+
Columbia, SC	0	L	H	0	F+
Cape Coral, FL	H+	H	H+	F	F+
Little Rock, AR	0	L	0	0	F
Spokane, WA	L-	L-	L-	S-	S-
Pensacola, FL-AL	H+	H	H+	F+	F+
Corpus Christi, TX	L-	L	L	S-	S-
Anchorage, AK	L-	L	L-	S-	S-
Eugene, OR	L	0	L	S-	S-
Beaumont, TX	L-	L	L-	S-	S-
Salem, OR	L	0	L	0	S-
Laredo, TX	L-	0	L-	S	S-
Brownsville, TX	L-	L	L-	S-	S-
Boulder, CO	0	0	L-	S	S-
Interval Values – Medium and Small	3 hours	3 index points	(3 hours x average popn. for group)	3 hours	(3 hours x average change in popn. for group)

0 – *Average congestion levels or average congestion growth (within 1 interval)*
(Note: Interval – If the difference in values is less than this, it may not indicate a difference in congestion level).

Between 1 and 2 intervals above or below the average
H *Higher congestion*; F *Faster congestion growth*;
L *Lower congestion*; S *Slower congestion growth*;

More than 2 intervals above or below the average
H+ *Much higher congestion*; F+ *Much faster growth*
L- *Much lower congestion*; S- *Much slower growth*

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Table 7. Urban Area Demand and Roadway Growth Trends

Less than 15% Faster (5)	30% to 40% Faster (38)	45% Faster (15)
Anchorage, AK	Akron, OH	Atlanta, GA
Dayton, OH	Albany-Schenectady, NY	Baltimore, MD
New Orleans, LA	Albuquerque, NM	Chicago, IL-IN
Pittsburgh, PA	Allentown-Bethlehem, PA-NJ	Columbus, OH
St. Louis, MO-IL	Austin, TX	Dallas-Fort Worth-Arlington, TX
	Bakersfield, CA	El Paso, TX-NM
15% to 30% Faster (27)	Birmingham, AL	Las Vegas, NV
Beaumont, TX	Boston, MA-NH-RI	Miami, FL
Boulder, CO	Bridgeport-Stamford, CT-NY	Minneapolis-St. Paul, MN
Brownsville, TX	Charlotte, NC-SC	Orlando, FL
Buffalo, NY	Cincinnati, OH-KY-IN	Riverside-San Bernardino, CA
Cape Coral, FL	Colorado Springs, CO	Sacramento, CA
Charleston-North Charleston, SC	Columbia, SC	San Diego, CA
Cleveland, OH	Denver-Aurora, CO	Sarasota-Bradenton, FL
Corpus Christi, TX	Detroit, MI	Washington, DC-VA-MD
Eugene, OR	Hartford, CT	
Fresno, CA	Indianapolis, IN	
Grand Rapids, MI	Jacksonville, FL	
Honolulu, HI	Laredo, TX	
Houston, TX	Little Rock, AR	
Kansas City, MO-KS	Los Angeles-LBch-Santa Ana, CA	
Memphis, TN-MS-AR	Louisville, KY-IN	
Milwaukee, WI	New Haven, CT	
Nashville-Davidson, TN	New York-Newark, NY-NJ-CT	
Oklahoma City, OK	Omaha, NE-IA	
Philadelphia, PA-NJ-DE-MD	Oxnard-Ventura, CA	
Phoenix, AZ	Pensacola, FL-AL	
Richmond, VA	Portland, OR-WA	
Spokane, WA	Providence, RI-MA	
Springfield, MA-CT	Raleigh-Durham, NC	
Tampa-St. Petersburg, FL	Rochester, NY	
Tucson, AZ	Salem, OR	
Tulsa, OK	Salt Lake City, UT	
Virginia Beach, VA	San Antonio, TX	
	San Francisco-Oakland, CA	
	San Jose, CA	
	Seattle, WA	
	Toledo, OH	

Note: See Exhibit 15 for comparison of growth in demand, road supply and congestion.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Congestion Data for Additional Years

The new calculation procedure for the *2007 Urban Mobility Report* has been used to calculate new values for all urban areas and all years to provide a consistent trend in congestion performance measures. As such, values in all previous reports are not valid for comparison. Because some readers are curious about how the numbers have changed, however, Table 8 presents the data for 2000, 2003 and 2005.

Several changes are described in the report section, "Since You Asked – Here's Why the Numbers are Different." More detailed data on every year for each of the 85 intensively studied urban areas can be found on the "Congestion Data for Your City" section of the Mobility Report website: http://mobility.tamu.edu/ums

Table 8. Additional Congestion Data: 85 Urban Areas
(Note: These data do not compare to the statistics in Exhibit 1; those measure congestion for the 437 U.S. urban areas)

Characteristic	2000 Value	2003 Value	2005 Value	Change 2000-2005	Change 2003-2005
Hours of Delay per Traveler					
Very Large (14 areas)	46	49	54	8	5
Large (25 areas)	34	35	37	3	2
Subtotal Very Large and Large Areas (39 areas)	42	44	48	6	4
Medium (30 areas)	25	26	28	3	2
Small (16 areas)	15	16	17	2	1
Subtotal Medium and Small Areas (46 areas)	23	25	26	3	1
Subtotal Identified Areas (85 areas)	39	41	44	5	3
New Other (352 areas)	17	19	21	4	2
Total All Areas (437 areas)	34	36	38	4	2
Wasted Fuel per Traveler (gallons)					
Very Large (14 areas)	32	35	38	6	3
Large (25 areas)	23	24	25	2	1
Subtotal Very Large and Large Areas (39 areas)	29	31	34	5	3
Medium (30 areas)	16	17	18	2	1
Small (16 areas)	9	10	10	1	0
Subtotal Medium and Small Areas (46 areas)	15	16	17	2	1
Subtotal Identified Areas (85 areas)	27	28	31	4	3
New Other (352 areas)	10	12	13	3	1
Total All Areas (437 areas)	23	24	26	3	1
Total Cost of Congestion (billions of 2005 $)					
Very Large (14 areas)	33.4	38.2	44.9	11.5	6.2
Large (25 areas)	12.4	14.1	15.7	3.3	1.6
Subtotal Very Large and Large Areas (39 areas)	45.9	52.6	60.6	14.7	8.0
Medium (30 areas)	4.8	5.6	6.2	1.4	0.6
Small (16 areas)	0.7	0.8	0.9	0.2	0.1
Subtotal Medium and Small Areas (46 areas)	5.5	6.4	7.1	1.6	0.7
Subtotal Identified Areas (85 areas)	51.4	59.0	67.7	16.3	8.7
New Other (352 areas)	6.2	8.3	10.5	4.3	2.2
Total All Areas (437 areas)	57.6	67.2	78.2	20.6	11.0

Table 8. Additional Congestion Data: 85 Urban Areas, Continued

Characteristic	2000 Value	2003 Value	2005 Value	Change 2000-2005	Change 2003-2005
Annual Hours of Delay (billions of hours)					
Very Large (14 areas)	1.81	2.10	2.37	1.19	0.27
Large (25 areas)	0.69	0.78	0.85	0.16	0.07
Subtotal Very Large and Large Areas (39 areas)	1.87	2.87	3.22	1.35	0.34
Medium (30 areas)	0.27	0.31	0.33	0.07	0.03
Small (16 areas)	0.04	0.04	0.05	0.01	0.01
Subtotal Medium and Small Areas (46 areas)	0.30	0.35	0.38	0.08	0.03
Subtotal Identified Areas (85 areas)	2.17	3.23	3.60	1.43	0.37
New Other (352 areas)	0.37	0.48	0.59	0.22	0.11
Total All Areas (437 areas)	3.17	3.70	4.19	1.65	0.49
Annual Wasted Fuel (billions of gallons)					
Very Large (14 areas)	1.28	1.49	1.68	0.41	0.19
Large (25 areas)	0.47	0.54	0.58	0.11	0.05
Subtotal Very Large and Large Areas (39 areas)	1.75	2.03	2.27	0.52	0.24
Medium (30 areas)	0.17	0.20	0.22	0.05	0.02
Small (16 areas)	0.02	0.03	0.03	0.01	0.00
Subtotal Medium and Small Areas (46 areas)	0.20	0.23	0.25	0.05	0.02
Subtotal Identified Areas (85 areas)	1.94	2.26	2.51	0.57	0.26
New Other (352 areas)	0.22	0.29	0.36	0.14	0.07
Total All Areas (437 areas)	2.16	2.54	2.87	0.71	0.33
Delay Savings due to Operational Treatments					
Very Large (14 areas)	119.5	174.0	206.9	87.4	32.9
Large (25 areas)	34.8	46.5	53.6	18.8	7.1
Subtotal Very Large and Large Areas (39 areas)	154.3	219.6	258.9	104.6	39.3
Medium (30 areas)	8.8	11.3	12.8	4.0	1.5
Small (16 areas)	0.9	1.1	1.4	0.5	0.3
Subtotal Medium and Small Areas (46 areas)	9.7	12.4	14.2	4.5	1.8
Subtotal Identified Areas (85 areas)	164.0	232.0	273.1	109.1	41.1
New Other (352 areas)	10.9	14.2	17.5	6.6	3.3
Total All Areas (437 areas)	174.9	247.1	292.2	117.3	45.1
Delay Savings due to Public Transportation (million hours)					
Very Large (14 areas)	396.4	404.2	429.5	33.1	25.3
Large (25 areas)	62.0	60.7	63.9	1.9	3.2
Subtotal Very Large and Large Areas (39 areas)	458.4	464.9	493.4	35.0	28.5
Medium (30 areas)	13.6	15.4	14.6	1.0	-0.8
Small (16 areas)	1.4	1.2	1.4	0.0	0.2
Subtotal Medium and Small Areas (46 areas)	15.0	16.6	16.0	1.0	-0.6
Subtotal Identified Areas (85 areas)	473.4	481.5	509.4	36.0	27.9
New Other (352 areas)	23.5	26.5	31.3	7.8	4.8
Total All Areas (437 areas)	496.9	508.0	540.7	43.8	32.7

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

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APPENDIX A
Methodology for 2007 Annual Report

The data source for most of the calculations is the Highway Performance Monitoring System from the Federal Highway Administration. A detailed description of that dataset can be found at: http://www.fhwa.dot.gov/policy/ohpi/hpms/index.htm. The procedures used in the 2007 Urban Mobility Report have been developed by the Texas Transportation Institute over several years and several research projects. The congestion estimates for all study years are recalculated every time the methodology is altered to provide a consistent data trend. The estimates and methodology from this report should be used in place of any other previous measures.

This appendix summarizes the methodology utilized to calculate many of the statistics shown in the Urban Mobility Report. The methodology is divided into three main sections containing information on the constant values, variables and calculation steps of the main performance measures of the mobility database.

1. **National Constants**
2. **Urban Area Constants and Inventory Values**
3. **Variable and Performance Measure Calculation Descriptions**
    1) Roadway Congestion Index
    2) Percent of Daily Travel in Congested Conditions
    3) Travel Speed
    4) Travel Delay
    5) Incident-Related Travel Delay
    6) Annual Person Delay
    7) Travel Time Index
    8) Fuel Economy
    9) Wasted Fuel
    10) Congestion Cost
    11) Percent of Congested Cost

Some of the sections refer to variables that are described in other sections. Generally, the sections are listed in the order that they will be needed to complete all calculations.

NATIONAL CONSTANTS

The congestion calculations utilize the values in Exhibit A-1 as national constants—values used in all urban areas to estimate the effect of congestion.

Exhibit A-1. National Congestion Constants for 2005 Annual Report

Constant	Value
Vehicle Occupancy	1.25 persons per vehicle
Working Days	250 days per year
Percent of Daily Travel in Peak Periods	50 percent
Average Cost of Time ($2005)*	$14.60 per person hour[1]
Commercial Vehicle Operating Cost ($2005)	$77.10 per vehicle hour

[1] Adjusted annually using the Consumer Price Index.

*Source: (Reference 1)

Vehicle Occupancy

The average number of persons in each vehicle during peak period travel is 1.25.

Working Days

Cost calculations were based on 250 working days per year.

Percent of Daily Travel in the Peak Period

The times of the day outside of the peak-period are typically uncongested. Even though some sections of road in larger areas can be congested for 10 to 12 hours of the day, the Mobility Report methodology only examines the peak-periods—estimated as 6:00 to 10:00 a.m. and 3:00 to 7:00 p.m. These time periods are estimated to include 50 percent of the daily vehicle travel. The rationale for eliminating the remainder of the day is that an area's mobility statistics should not be "credited" for having an uncongested system at 3:00 a.m.

Average Cost of Time

The 2005 value of person time used in the report is $14.60 per hour based on the value of time, rather than the average or prevailing wage rate (1).

Commercial Vehicle Operating Cost

Truck travel time is valued at $77.10 per hour for the purposes of estimating congestion cost.

URBAN AREA CONSTANTS AND INVENTORY VALUES

In addition to the national constants, four urbanized area or state specific values were identified and used in the congestion cost estimate calculations.

Daily Vehicle-Miles of Travel

The daily vehicle-miles of travel (DVMT) is the average daily traffic (ADT) of a section of roadway multiplied by the length (in miles) of that section of roadway. This allows the daily volume of all urban facilities to be presented in terms that can be utilized in cost calculations. DVMT was estimated for the freeways and principal arterial streets located in each urbanized study area. These estimates originate from the HPMS database and other local transportation data sources. The congestion data for each urban area includes vehicle travel data for freeways and arterial streets (2).

Population and Peak Travelers

Population data were obtained from a combination of U.S. Census Bureau estimates and population estimates reported in the Federal Highway Administration's Highway Performance Monitoring System (HPMS) (2,3). Estimates of peak period travelers are derived from the American Community Survey data on the time of day when trips begin. Any resident who begins a trip, by any mode, between 6 a.m. and 10 a.m. or 3 p.m. and 7 p.m. is counted as a peak-period traveler. Data are available for many of the major urban areas and a few of the smaller areas. Averages for areas of similar size are used in cases with no specific data. The traveler estimate for some regions, specifically high tourism areas, may not represent all of the transportation users on an average day. The congestion data for each urban area includes the population and peak traveler estimates.

Fuel Costs

Statewide average fuel cost estimates were obtained from daily fuel price data published by the American Automobile Association (AAA) (4). Values for different fuel types used in motor vehicles, i.e., diesel and gasoline, did not vary enough to be reported separately. Therefore, an average rate for all fuel types was used in cost estimate calculations. The congestion data for each urban area includes the per gallon fuel cost.

Truck Percentage

The percentage of passenger cars and trucks for each urban area was estimated from the Highway Performance Monitoring System dataset (2). The values are used to estimate congestion costs and are not used to adjust the capacity or vehicle speed estimating procedures.

VARIABLE AND PERFORMANCE MEASURE CALCULATION DESCRIPTIONS

The major calculation products are described in this section. In some cases the process requires the use of variables described elsewhere in Appendix A.

Roadway Congestion Index

Early versions of the Urban Mobility Report used the roadway congestion index as a primary measure. While other measures that define congestion in terms of travel time and delay have replaced the RCI, it is still used as part of the calculation of delay. The RCI measures the density of traffic across the urban area using generally available and not significantly detailed statistics. Urban area estimates of vehicle-miles of travel (VMT) and lane-miles of roadway (Ln-Mi) are combined in a ratio using the amount of travel on each portion of the system. The combined index measures conditions on the freeway and arterial street systems (Eq. A-1). This variable weighting factor allows comparisons between areas that carry different percentages of regional vehicle travel on arterial streets and freeways. The resulting ratio indicates an undesirable level of areawide congestion if a value greater than or equal to 1.0 is obtained.

The traffic density ratio is divided by a similar ratio that represents congestion for a system with the same mix of freeway and street volume. The RCI is, therefore, a measure of both intensity and duration of congestion. While it may appear that the travel volume factors (e.g., freeway VMT) on the top and bottom of the equation cancel each other, a sample calculation should satisfy the reader that this is not the case.

$$\text{Roadway Congestion Index} = \frac{\frac{\text{Freeway}}{\text{VMT/Ln.-Mi.}} \times \frac{\text{Freeway}}{\text{VMT}} + \frac{\text{Prin Art Str}}{\text{VMT/Ln-Mi.}} \times \frac{\text{Prin Art Str}}{\text{VMT}}}{14{,}000 \times \frac{\text{Freeway}}{\text{VMT}} + 5{,}000 \times \frac{\text{Prin Art Str}}{\text{VMT}}} \qquad \text{(Eq. A-1)}$$

An Illustration of Travel Conditions When an Urban Area RCI Equals 1.0

The congestion index is a macroscopic measure which does not account for local bottlenecks or variations in travel patterns that affect time of travel or origin-destination combinations. It also does not include the effect of improvements such as freeway entrance ramp signals, or treatments designed to give a travel speed advantage to transit and carpool riders. The urban area may see several of the following effects:

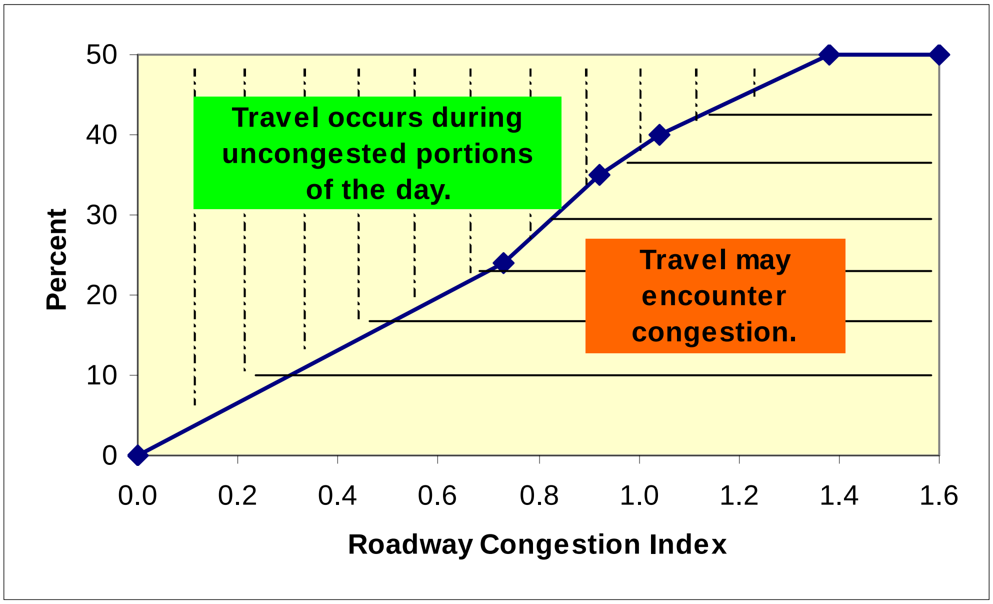
- Typical commute time not more than 25% longer than off-peak travel time.
- Slower moving traffic during the peak period on the freeways, but not sustained stop-and-go conditions.
- Moderate congestion for not more than 1 1/2 to 2 hours during each peak-period.
- Wait through one or two red lights at heavily traveled intersections, but not 3 or 4.
- The RCI includes roadway expansion, demand management, and vehicle travel reduction programs.
- The RCI does not include the effect of operations improvements (e.g., clearing accidents quickly, regional traffic signal coordination), person movement efficiencies (e.g., bus and carpool lanes) or transit improvements (e.g., priority at traffic signals).
- The RCI does not address situations where a traffic bottleneck means much less capacity than demand (e.g., a narrow bridge or tunnel crossing a harbor or river), or missing capacity due to a gap in the system.
- The urban area congestion index averages all the developments within an urban area; there will be locations where congestion is much worse or much better than average.

Percent of Daily Travel in Congested Conditions

Peak travel periods in urban areas are the morning and evening "rush hours" when slow speeds are most likely to occur. The length of the peak period is held constant—essentially the most traveled four hours in the morning and evening—but the amount of the peak period that may suffer congestion is estimated separately. The length of time when congestion may be encountered is different and generally longer in larger urban areas. Large urban areas have peak periods that are typically longer than smaller or less congested areas because not all of the demand can be handled by the transportation network during a single hour. The congested times of day have increased since the start of the Urban Mobility Report. The maximum value is 50% of daily travel.

Exhibit A-2 illustrates the estimation procedure used for all urban areas. The Urban Mobility Report procedure uses the roadway congestion index (RCI)—a ratio of daily traffic volume to the number of lane-miles of arterial street and freeway—to estimate the length of the peak period. In this application, the RCI acts as an indicator of the number of hours of the day that might be affected by congested conditions (a higher RCI value means more traffic during more hours of the day). Exhibit A-2 illustrates the process used to estimate the amount of the day (and the amount of travel) when travelers might encounter congestion. Exhibit A-3 presents the results of the 2005 data analysis. Travel during the peak period, but outside these possibly congested times, is considered uncongested and is assigned a free-flow speed.

Exhibit A-2. Percent of Daily Travel in Congested Conditions



CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Exhibit A-3. Percentage of Daily Travel Used in Delay Estimation Procedure for 2007 Annual Report

Urban Area	Roadway Congestion Index	% of Daily Travel in Congested Conditions	Urban Area	Roadway Congestion Index	% of Daily Travel in Congested Conditions
Very Large			Medium		
Atlanta, GA	1.34	48.9	Akron, OH	0.87	33.1
Boston, MA-NH-RI	1.11	45.1	Albany-Schenectady, NY	0.81	29.0
Chicago, IL-IN	1.28	48.0	Albuquerque, NM	0.99	39.5
Dallas-Fort Worth-Arlington, TX	1.26	47.6	Allentown-Bethlehem, PA-NJ	0.95	37.4
Detroit, MI	1.24	47.3	Austin, TX	1.16	46.0
Houston, TX	1.27	47.9	Birmingham, AL	1.00	40.1
Los Angeles-LBch-Santa Ana, CA	1.58	50.0	Bridgeport-Stamford, CT-NY	1.17	46.1
Miami, FL	1.39	49.8	Charlotte, NC-SC	1.11	45.2
New York-Newark, NY-NJ-CT	1.13	45.5	Dayton, OH	0.93	36.4
Philadelphia, PA-NJ-DE-MD	1.12	45.3	El Paso, TX-NM	1.07	43.7
Phoenix, AZ	1.32	48.7	Fresno, CA	0.94	36.9
San Francisco-Oakland, CA	1.40	49.9	Grand Rapids, MI	0.85	31.6
Seattle, WA	1.15	45.9	Hartford, CT	0.95	37.3
Washington, DC-VA-MD	1.35	49.1	Honolulu, HI	1.08	43.8
			Jacksonville, FL	1.10	45.1
Large			Louisville, KY-IN	1.14	45.7
Baltimore, MD	1.21	46.8	Nashville-Davidson, TN	1.01	40.4
Buffalo, NY	0.73	24.5	New Haven, CT	1.00	39.8
Cincinnati, OH-KY-IN	1.06	43.1	Oklahoma City, OK	0.89	34.5
Cleveland, OH	0.90	34.8	Omaha, NE-IA	0.93	36.6
Columbus, OH	1.09	44.6	Oxnard-Ventura, CA	1.26	47.7
Denver-Aurora, CO	1.18	46.3	Raleigh-Durham, NC	1.01	40.4
Indianapolis, IN	1.16	46.0	Richmond, VA	0.82	29.6
Kansas City, MO-KS	0.80	28.1	Rochester, NY	0.78	27.3
Las Vegas, NV	1.31	48.6	Salt Lake City, UT	1.06	43.1
Memphis, TN-MS-AR	0.95	37.6	Sarasota-Bradenton, FL	1.24	47.3
Milwaukee, WI	0.95	37.6	Springfield, MA-CT	0.84	30.9
Minneapolis-St. Paul, MN	1.17	46.1	Toledo, OH-MI	0.86	32.6
New Orleans, LA	0.96	37.8	Tucson, AZ	1.17	46.1
Orlando, FL	1.20	46.6	Tulsa, OK	0.81	29.1
Pittsburgh, PA	0.79	27.7		0.87	33.1
Portland, OR-WA	1.23	47.2	Small		
Providence, RI-MA	0.94	36.8	Anchorage, AK	0.76	25.5
Riverside-San Bernardino, CA	1.44	50.0	Bakersfield, CA	0.83	30.2
Sacramento, CA	1.36	49.3	Beaumont, TX	0.78	26.9
San Antonio, TX	1.10	44.8	Boulder, CO	0.90	35.0
San Diego, CA	1.41	50.0	Brownsville, TX	0.78	26.7
San Jose, CA	1.33	48.8	Cape Coral, FL	1.23	47.2
St. Louis, MO-IL	0.91	35.5	Charleston-No. Charleston, SC	1.08	44.2
Tampa-St. Petersburg, FL	1.27	47.8	Colorado Springs, CO	0.88	33.8
Virginia Beach, VA	1.02	41.0	Columbia, SC	0.90	34.7
			Corpus Christi, TX	0.75	25.0
			Eugene, OR	0.93	36.6
			Laredo, TX	0.76	25.7
			Little Rock, AR	0.88	33.8
			Pensacola, FL-AL	1.09	44.6
			Salem, OR	0.89	34.2
			Spokane, WA	0.70	23.2

Note: 2005 data used in 2007 Urban Mobility Report.

Travel Speed

The volume and speed data that is collected by freeway operations centers in many metropolitan regions and computer simulation modeling to adjust the Urban Mobility Report congestion estimation procedures. The speed functions used for the 2007 Urban Mobility Report are shown in Exhibits A-4 and A-5, along with the speed equations used in the 2005 Report and data points from freeways in more than two dozen U.S. metropolitan regions. More details on the supporting research are in a technical memorandum on the Urban Mobility Study website (5,6). The speed equations in Exhibit A-6 are linear within the congestion range and together the equations form a continuous line as shown in Exhibits A-4 and A-5.

Both the peak direction and off-peak direction speed functions were changed. Of particular significance, the slowest speeds in the peak and off-peak directions have been increased to reflect the data from the freeway traffic monitors. The peak direction speed function was changed for more congested road segments. A new slowest speed of 35 miles per hour (instead of the 20 mile per hour value in the 2005 methodology) was used for the 2007 Report. The off-peak direction speed function was changed in the Extreme congestion level with a new slow speed of 40 miles per hour instead of the 25 miles per hour that was used previously. There is also a small drop in estimated speeds that occurs at the initial congestion threshold of 15,000 daily vehicles per lane that matches the speeds below 60 mph at lower volume levels.

Exhibit A-4. 2007 Urban Mobility Report – Freeway Peak-Direction Speed Function

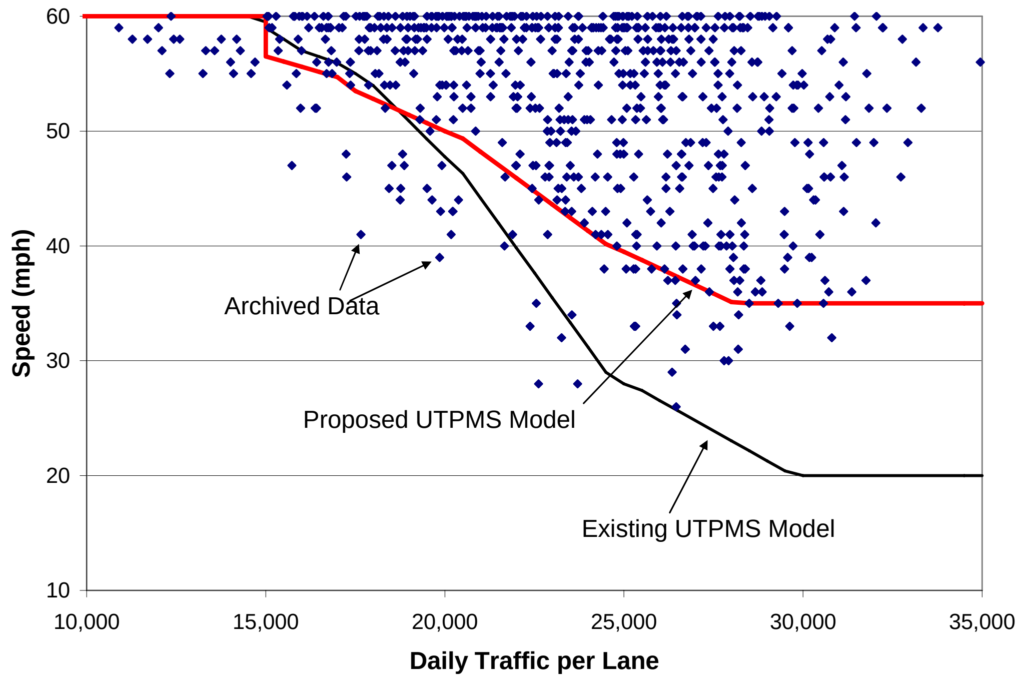


Exhibit A-5. 2007 Urban Mobility Report – Freeway Off-Peak Direction Speed Function

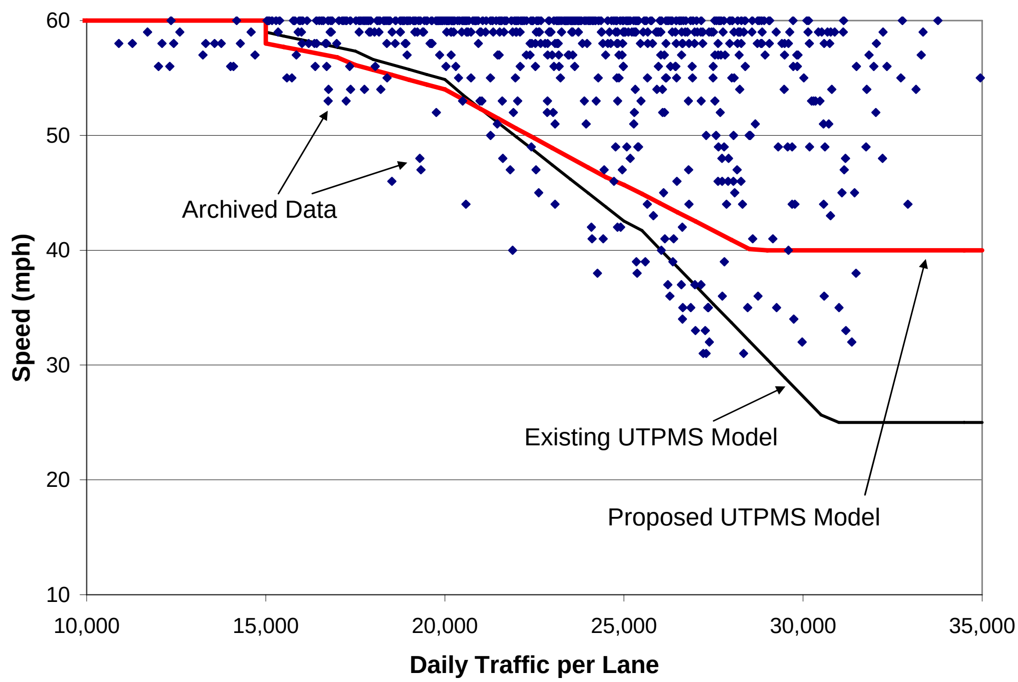


Exhibit A-6. Daily Traffic Volume per Lane and Speed Estimating Used in Delay Calculation

Facility and Congestion Level	Daily Traffic Volume per Lane	Speed Estimate Equation[1]	
		Peak Direction	Off-Peak Direction
Freeway			
Uncongested	Under 15,000	60	60
Medium	15,001-17,500	70-(0.9* ADT/Lane)	67-(0.6* ADT/Lane)
Heavy	17,501-20,000	78-(1.4* ADT/Lane)	71-(0.85* ADT/Lane)
Severe	20,001-25,000	96-(2.3* ADT/Lane)	88-(1.7* ADT/Lane)
Extreme	Over 25,000	76-(1.46* ADT/Lane)	85.7-(1.6* ADT/Lane)
		Lowest speed is 35 mph	Lowest speed is 40 mph
Arterial Street			
Uncongested	Under 5,500	35	35
Medium	5,501-7,000	33.58-(0.74 ADT/Lane)	33.82-(0.59 ADT/Lane)
Heavy	7,001-8,500	33.80-(0.77 ADT/Lane)	33.90-(0.59 ADT/Lane)
Severe	8,501-10,000	31.65-(0.51 ADT/Lane)	30.10 (0.15 ADT/Lane)
Extreme	Over 10,000	32.57-(0.62 ADT/Lane)	31.23-(0.27 ADT/Lane)
		Lowest speed is 20 mph	Lowest speed is 27 mph

Note: [1]ADT/Lane in thousands.

For a variety of reasons the speed equations are not plotted as a "best fit" line through the data points from the traffic monitoring centers. The report identified several reasons why the researchers believe the actual freeway delay values are somewhat higher than the monitoring systems indicate including:

- Delay on streets used as alternative routes during incidents is not included in the freeway data – The effect of freeway crashes is not fully captured when traffic uses streets to get around crashes, the freeway monitors do not count the delay.
- Delay due to trips that shift to other times is not included in the peak periods – Travelers in very congested corridors move to other times of the day to avoid congestion. Congestion in the midday and weekends is not included.
- Ramp delay is not included in the archived data – Ramp metering and high volume ramps often cause longer travel times. These delays are part of the commute trip but are not collected by the mainlane monitoring systems.
- Speed detectors are not always calibrated to estimate speeds precisely – Many systems are used to power operating systems and identify major road blockages. These systems must be accurate enough to distinguish 45 mph from 20 mph. The difference between 25 mph and 20 mph, however, is very important for congestion monitoring.

Each of the examples described above lead the researchers to be conservative with the adjustments to the 2005 Urban Mobility Report speed functions. The result of the research project is a procedure that will, in most cases, generate less delay than estimated with the available planning models and more delay than the archived datasets. Based on the results obtained in this study, the new Urban Mobility Report models appear to be more accurate and closer to archived field data than the previous models.

The amount of travel (measured in vehicle-miles for each roadway link) is summed for each congestion level and direction. The average daily traffic volume per lane for each group is determined by dividing the VMT by the sum of lane-miles for all the links in each congestion level and direction. The average speed for each roadway type is obtained by weighting the speed in each congestion level by the total amount of travel at that level. The uncongested category includes travel on the uncongested portions of roadway, as well as travel during portions of the day that are estimated to rarely have congestion. The uncongested portion of the day varies for each city. The total amount of travel included in the speed averaging procedure, however, is 50 percent of the average daily vehicle-miles of travel for all urban areas.

Equation A-2 shows the calculation for a weighted average of speed. The average speed for each element of the road system is multiplied by the amount of travel on that set of roads. Using the amount of travel as a weighting factor provides a way to get an average "system experience" of travelers based on the amount of travel that occurs within each portion of the road system. This fundamental concept is used elsewhere in the Urban Mobility Study methodology. The resulting freeway and arterial speeds are shown in Exhibit A-7.

$$\begin{matrix}\text{Average Speed}\\ \text{(mph)}\end{matrix} = \frac{\begin{matrix}\text{Average}\\ \text{Freeway Speed}\end{matrix}\begin{pmatrix}\text{Freeway}\\ \text{VMT}\end{pmatrix} + \begin{matrix}\text{Average Arterial}\\ \text{Street Speed}\end{matrix}\begin{pmatrix}\text{Arterial}\\ \text{VMT}\end{pmatrix}}{\begin{matrix}\text{Freeway}\\ \text{VMT}\end{matrix} + \begin{matrix}\text{Street}\\ \text{VMT}\end{matrix}} \quad \text{(Eq. A-2)}$$

Exhibit A-7. Traffic Speed Estimates

Urban Area	Freeway	Arterial Street	Urban Area	Freeway	Arterial Street
Very Large			Medium		
Atlanta, GA	42.5	26.8	Akron, OH	56.0	32.4
Boston, MA-NH-RI	45.6	28.3	Albany-Schenectady, NY	57.4	31.0
Chicago, IL-IN	39.1	24.3	Albuquerque, NM	49.9	30.0
Dallas-Fort Worth-Arlington, TX	40.5	28.3	Allentown-Bethlehem, PA-NJ	56.0	29.0
Detroit, MI	47.6	26.4	Austin, TX	45.1	26.6
Houston, TX	40.3	27.4	Birmingham, AL	53.7	29.1
Los Angeles-LBch-Santa Ana, CA	34.7	25.6	Bridgeport-Stamford, CT-NY	47.2	29.9
Miami, FL	42.1	24.9	Charlotte, NC-SC	49.7	27.4
New York-Newark, NY-NJ-CT	40.5	26.1	Dayton, OH	55.7	30.9
Philadelphia, PA-NJ-DE-MD	45.6	27.5	El Paso, TX-NM	49.5	30.3
Phoenix, AZ	42.0	27.9	Fresno, CA	55.7	30.1
San Francisco-Oakland, CA	39.4	25.5	Grand Rapids, MI	58.1	30.5
Seattle, WA	43.2	27.8	Hartford, CT	54.4	30.9
Washington, DC-VA-MD	43.1	25.0	Honolulu, HI	50.3	27.5
			Jacksonville, FL	53.1	26.3
Large			Louisville, KY-IN	48.6	28.1
Baltimore, MD	44.6	27.6	Nashville-Davidson, TN	52.6	28.8
Buffalo, NY	56.1	32.3	New Haven, CT	54.3	31.0
Cincinnati, OH-KY-IN	50.0	30.0	Oklahoma City, OK	56.2	31.5
Cleveland, OH	55.5	31.6	Omaha, NE-IA	53.0	29.4
Columbus, OH	50.2	28.8	Oxnard-Ventura, CA	48.5	28.2
Denver-Aurora, CO	44.1	26.4	Raleigh-Durham, NC	51.9	29.2
Indianapolis, IN	51.9	27.3	Richmond, VA	55.5	31.6
Kansas City, MO-KS	55.8	32.1	Rochester, NY	56.4	31.9
Las Vegas, NV	44.2	27.3	Salt Lake City, UT	52.4	28.0
Memphis, TN-MS-AR	52.2	31.2	Sarasota-Bradenton, FL	58.2	27.8
Milwaukee, WI	49.4	32.1	Springfield, MA-CT	58.1	31.9
Minneapolis-St. Paul, MN	44.7	28.9	Toledo, OH-MI	55.0	32.2
New Orleans, LA	53.3	29.5	Tucson, AZ	50.5	27.9
Orlando, FL	49.9	25.2	Tulsa, OK	58.2	31.1
Pittsburgh, PA	56.1	31.5			
Portland, OR-WA	44.1	27.9	Small		
Providence, RI-MA	52.0	29.9	Anchorage, AK	59.7	31.5
Riverside-San Bernardino, CA	40.6	28.7	Bakersfield, CA	55.3	31.9
Sacramento, CA	43.9	26.2	Beaumont, TX	58.2	33.0
San Antonio, TX	48.8	27.7	Boulder, CO	59.1	30.6
San Diego, CA	40.8	25.8	Brownsville, TX	59.7	32.0
San Jose, CA	43.5	25.7	Cape Coral, FL	58.2	30.0
St. Louis, MO-IL	52.4	29.1	Charleston-No. Charleston, SC	55.3	28.7
Tampa-St. Petersburg, FL	49.5	26.2	Colorado Springs, CO	52.3	30.6
Virginia Beach, VA	50.8	28.9	Columbia, SC	58.1	31.6
			Corpus Christi, TX	57.6	32.6
			Eugene, OR	57.5	30.6
			Laredo, TX	59.4	31.3
			Little Rock, AR	57.5	31.7
			Pensacola, FL-AL	58.9	30.8
			Salem, OR	58.6	30.7
			Spokane, WA	58.7	33.3

Note: 2005 data used in 2007 Urban Mobility Report.

Travel Delay

Most of the basic performance measures presented in the Urban Mobility Report are developed as part of calculating travel delay—the amount of extra time spent traveling due to congestion. An overview of the process is followed by more detailed descriptions of the individual steps.

Travel delay calculations are performed in two steps—recurring (or usual) delay and incident delay (due to crashes, vehicle breakdowns, etc.). Recurring delay estimates are developed using a process designed to identify peak period congestion due to traffic volume and capacity. Delay caused by other events is not included in the recurring delay estimate. Generally, these events can be categorized as one of the seven sources of unreliability (7).

- Traffic Incidents
- Work Zones
- Weather
- Fluctuation in Demand
- Special Events
- Traffic Control Devices
- Inadequate Base Capacity

The 2007 Urban Mobility Report methodology only includes estimates of travel delay from incidents, demand fluctuations and base capacity inadequacy.

Recurring Travel Delay - Summary Version

Travel delay is estimated from equations relating vehicle traffic volume per lane and traffic speed. The calculation proceeds through the following steps (displayed in Exhibit A-8):

- Estimate peak period travel miles.
- Estimate the amount of travel in times that might encounter congestion; place remainder of the travel in the uncongested group.
- Separate congested travel into peak and off-peak directions.
- Place each road section in a congestion group (one of four congestion levels for peak and off-peak or the uncongested group).
- Calculate a speed for each congestion group.
- Calculate average speed on each portion of road system.

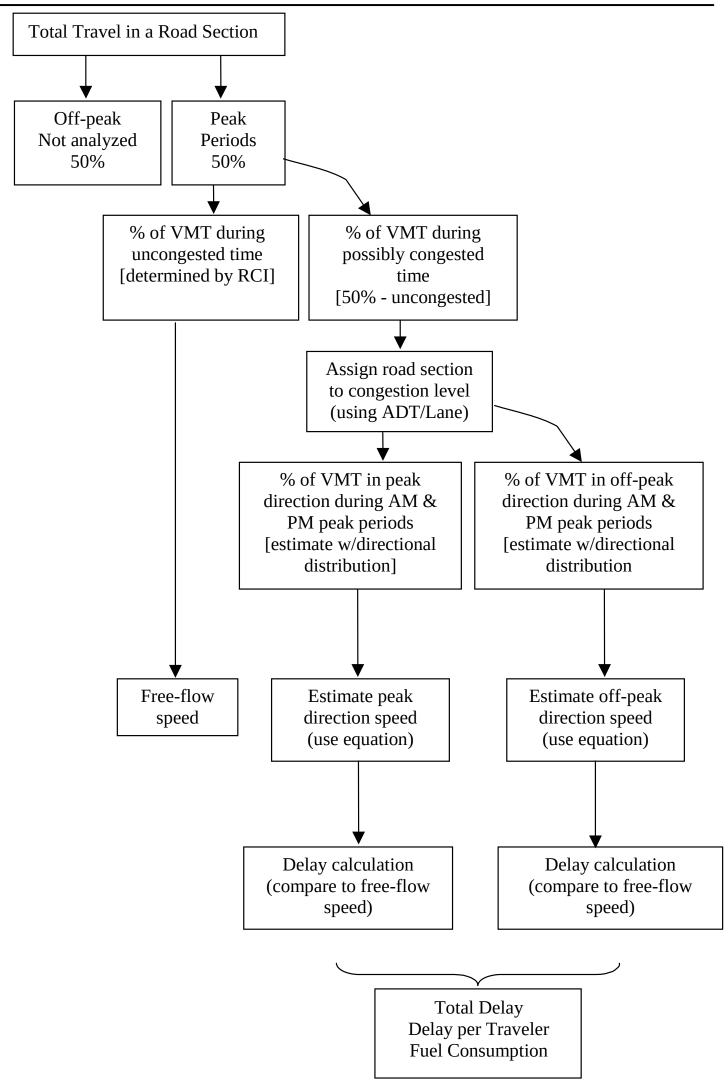
Collect Travel and Roadway Characteristics

Information for each section of roadway includes daily traffic volume, length and number of lanes.

Exhibit A-8. Overview of Speed and Delay Calculation Process

Step	Why? or What
Collect travel and roadway characteristics	Get data for an average day
Isolate peak-period travel	Remove off-peak, uncongested travel (50% of day)
Identify the usually congested time of day	Varies for each area; congestion usually lasts longer in larger areas
Identify congestion level of each section of roadway	Use daily traffic/lane and Exhibit A-6
Assign travel to peak/off-peak directions	Accumulate VMT by congestion level and direction, determine average VMT per lane-mile
Apply speed estimates to each congestion level and direction	Using speed curves, determine average speed for each direction and level
Calculate delay	Compare average speeds to free-flow speeds
Calculate other measures	Use VMT, speeds and remaining methodology to determine other measures

The 'Process'



Isolate Peak-Period and Congested Travel

Fifty percent of the daily vehicle travel occurs in the peak period and is used in the speed and delay estimates. The calculation procedure to estimate the congested portions of the peak (described previously) is used to initially distribute travel to the uncongested portions of the day and those that may be congested.

Separate Peak and Off-Peak Direction Travel Volume

The directional distribution factor in the Highway Performance Monitoring System database is used to divide the traffic on each link to the peak and off-peak directions. There is a different speed estimating equation for each direction (2). The delay reduction equation for arterial street traffic signal coordination is also different for the two directions.

Congestion Level of Each Section of Roadway

Each roadway link is assigned to one of five congestion levels—uncongested, moderate, heavy, severe or extreme, based on the daily traffic volume per lane. These assignments are used in the estimation of both the peak period travel speed and the delay reducing effects of the operational treatments.

Estimate Travel Speed in Each Congestion Group

Previous steps have separated the roadway links into freeway or arterial, congestion level, and peak or off-peak direction. The speed calculation is applied for each combination of congestion level/road type/direction for each group.

Estimate Travel Time

The travel time for each combination of road/direction/congestion level is calculated by dividing the miles traveled in each group by the average speed. The travel time at free-flow conditions is calculated by dividing the travel distance by the free-flow speed.

Estimate Travel Delay Using Speed and Travel Volume

The amount of delay incurred in the peak period is the difference in the time to travel at the average speed and the travel time at the free-flow speed, multiplied by the distance traveled in the peak period.

Estimate Travel Delay

The difference in the amount of time it takes to travel the peak-period vehicle-miles at the average speed and at free-flow speeds is termed delay.

Incident-Related Travel Delay

Another type of delay encountered by travelers is incident delay. This is the delay that results from a collision or disabled vehicle. Incident delay is related to the frequency of crashes or vehicle breakdowns and how easily those incidents are removed from the traffic lanes and shoulders. The basic procedure used to estimate incident delay in this study is to multiply the recurring delay by a ratio (Equation A-3).

$$\begin{array}{c}\text{Daily Arterial}\\ \text{Street Incident}\\ \text{Vehicle - Hours of Delay}\end{array} = \begin{array}{c}\text{Daily Arterial}\\ \text{Street Recurring}\\ \text{Vehicle - Hours of Delay}\end{array} \times \begin{array}{c}\text{Arterial Street}\\ \text{Recurring to Incident}\\ \text{Delay Factor}\end{array} \qquad \text{(Eq. A-3)}$$

The process used to develop the ratio is a detailed examination of the freeway characteristics and volumes. In addition, a methodology developed by FHWA is used to model the effect of incidents based on the design characteristics and estimated volume patterns (8). The procedure involves the random assignment of crashes to the roadway system based on the distribution of frequency and severity of collisions. Each type of collision has a different capacity reducing effect and depending on the traffic volume at the "time" of the collision, travel delay can increase by very little (for minor crashes during low volume conditions) to a large amount if the collision blocks a lane or lanes during high traffic volume periods. The resulting ratios are presented in Exhibit A-9.

Exhibit A-9. Incident Delay Ratios

Urban Area	Freeway Incident Delay Ratio	Arterial Street Incident Delay Ratio	Urban Area	Freeway Incident Delay Ratio	Arterial Street Incident Delay Ratio
Very Large			Medium		
Atlanta, GA	1.1	1.1	Akron, OH	1.3	1.1
Boston, MA-NH-RI	1.5	1.1	Albany-Schenectady, NY	2.2	1.1
Chicago, IL-IN	0.8	1.1	Albuquerque, NM	1.1	1.1
Dallas-Fort Worth-Arlington, TX	1.3	1.1	Allentown-Bethlehem, PA-NJ	1.5	1.1
Detroit, MI	1.2	1.1	Austin, TX	1.5	1.1
Houston, TX	0.9	1.1	Birmingham, AL	1.9	1.1
Los Angeles-LBch-Santa Ana, CA	0.7	1.1	Bridgeport-Stamford, CT-NY	1.4	1.1
Miami, FL	1.0	1.1	Charlotte, NC-SC	1.1	1.1
New York-Newark, NY-NJ-CT	2.5	1.1	Dayton, OH	1.4	1.1
Philadelphia, PA-NJ-DE-MD	2.2	1.1	El Paso, TX-NM	1.6	1.1
Phoenix, AZ	0.9	1.1	Fresno, CA	2.3	1.1
San Francisco-Oakland, CA	0.9	1.1	Grand Rapids, MI	2.1	1.1
Seattle, WA	1.2	1.1	Hartford, CT	2.1	1.1
Washington, DC-VA-MD	0.9	1.1	Honolulu, HI	1.2	1.1
			Jacksonville, FL	1.5	1.1
Large			Louisville, KY-IN	1.6	1.1
Baltimore, MD	1.3	1.1	Nashville-Davidson, TN	1.7	1.1
Buffalo, NY	2.1	1.1	New Haven, CT	1.4	1.1
Cincinnati, OH-KY-IN	1.3	1.1	Oklahoma City, OK	2.0	1.1
Cleveland, OH	1.5	1.1	Omaha, NE-IA	2.5	1.1
Columbus, OH	1.3	1.1	Oxnard-Ventura, CA	1.3	1.1
Denver-Aurora, CO	1.2	1.1	Raleigh-Durham, NC	1.5	1.1
Indianapolis, IN	1.0	1.1	Richmond, VA	2.2	1.1
Kansas City, MO-KS	2.5	1.1	Rochester, NY	2.3	1.1
Las Vegas, NV	1.1	1.1	Salt Lake City, UT	1.2	1.1
Memphis, TN-MS-AR	1.6	1.1	Sarasota-Bradenton, FL	2.5	1.1
Milwaukee, WI	1.0	1.1	Springfield, MA-CT	1.8	1.1
Minneapolis-St. Paul, MN	1.4	1.1	Toledo, OH-MI	2.1	1.1
New Orleans, LA	1.3	1.1	Tucson, AZ	1.5	1.1
Orlando, FL	1.3	1.1	Tulsa, OK	2.0	1.1
Pittsburgh, PA	2.5	1.1			
Portland, OR-WA	1.3	1.1	Small		
Providence, RI-MA	2.2	1.1	Anchorage, AK	2.5	1.1
Riverside-San Bernardino, CA	0.9	1.1	Bakersfield, CA	1.8	1.1
Sacramento, CA	1.0	1.1	Beaumont, TX	2.5	1.1
San Antonio, TX	1.1	1.1	Boulder, CO	2.5	1.1
San Diego, CA	0.8	1.1	Brownsville, TX	2.5	1.1
San Jose, CA	1.2	1.1	Cape Coral, FL	2.5	1.1
St. Louis, MO-IL	1.2	1.1	Charleston-No. Charleston, SC	2.0	1.1
Tampa-St. Petersburg, FL	1.5	1.1	Colorado Springs, CO	2.2	1.1
Virginia Beach, VA	2.2	1.1	Columbia, SC	1.8	1.1
			Corpus Christi, TX	2.4	1.1
			Eugene, OR	2.4	1.1
			Laredo, TX	2.5	1.1
			Little Rock, AR	1.5	1.1
			Pensacola, FL-AL	2.5	1.1
			Salem, OR	2.5	1.1
			Spokane, WA	2.4	1.1

Incident delay occurs in different ways on streets than freeways. While there are driveways that can be used to remove incidents, the crash rate is higher and the recurring delay is lower on streets. Arterial street designs are more consistent from city to city than freeway designs. For the purpose of this study, incident delay for arterial streets is estimated as 110 percent of arterial street recurring delay.

Annual Person Delay

This calculation is performed to expand the daily recurring and incident delay estimates for freeways and arterial streets to a yearly estimate in each study area. The daily vehicle-hours of delay is the sum of the delay resulting from recurring and incident delay in all four congestion levels on both types of facilities. To calculate the annual person-hours of delay, multiply the daily delay estimates by the average vehicle occupancy (1.25 persons per vehicle) and by 250 working days per year (Equation A-4).

$$\begin{matrix}\text{Annual}\\\text{Person-Hours}\\\text{of Delay}\end{matrix} = \begin{matrix}\text{Daily}\\\text{Vehicle-Hours of}\\\text{Incident and Recurring}\\\text{Delay on Frwys and}\\\text{Arterial Streets}\end{matrix} \times \begin{matrix}\text{250 Working Days}\\\text{per Year}\end{matrix} \times \begin{matrix}\text{1.25 Persons}\\\text{per Vehicle}\end{matrix} \qquad \text{(Eq. A-4)}$$

Annual delay per traveler is a measure of the extra travel time endured by persons who make trips during the peak period. The procedure used in the 2007 Urban Mobility Report applies estimates of the number of people and trip departure times during the morning and evening peak periods from the American Community Survey to the urban area population estimate to derive the average number of travelers during the peak periods (9). Total delay is divided by the number of travelers to get the annual delay per peak traveler.

Travel Time Index

The Travel Time Index (TTI) illustrates the comparison of peak period travel time to free-flow travel time. The Travel Time Index includes both recurring and incident conditions and is, therefore, an estimate of the conditions faced by urban travelers. Equation A-5 illustrates the ratio used to calculate the TTI. The ratio is time divided by time, and the Index, therefore, has no units. This “unitless” feature allows the Index to be used to compare trips of different lengths to estimate the travel time in excess of that experienced in free-flow conditions. Table 1 of the 2007 Urban Mobility Report contains the 2005 Travel Time Index values.

The index is calculated with a procedure consistent with the methods and data that will be used in the automated travel management centers. The free-flow travel time for each functional class is subtracted from the average travel time to estimate delay. The recurring delay is multiplied by the incident-to-recurring delay ratio to estimate incident delay. For each congestion level, the incident delay is added to the recurring delay to estimate total delay. The Travel Time Index is calculated by comparing total travel time to the freeflow travel time (Equations A-5 and A-6).

$$\text{Travel Time Index} = \frac{\text{Peak Travel Time}}{\text{Free-Flow Travel Time}} \qquad \text{(Eq. A-5)}$$

$$\text{Travel Time Index} = \frac{\text{Delay Time} + \text{Free-Flow Travel Time}}{\text{Free-Flow Travel Time}} \qquad \text{(Eq. A-6)}$$

Fuel Economy

The average fuel economy calculation is used to estimate the fuel consumption of the vehicles operating in congested and uncongested conditions. Equation A-7 is a linear regression applied to a modified version of fuel consumption reported by Raus (10).

$$\begin{matrix}\text{Average Fuel}\\ \text{Economy}\\ \text{in Congestion}\end{matrix} = 8.8 + 0.25 \begin{pmatrix}\text{Average Peak}\\ \text{Period Congested}\\ \text{System Speed}\end{pmatrix} \qquad \text{(Eq. A-7)}$$

Wasted Fuel

The Urban Mobility Report calculates the wasted fuel due to vehicles moving at speeds slower than free-flow during peak period travel. Equation A-8 calculates the fuel consumed in recurring and incident delay conditions (using delay estimate from Equation A-4), the average peak period speed (Equation A-2), and the average fuel economy associated with the peak speed (Equation A-7). Equation A-9 incorporates the same factors except free-flow speed is used to calculate fuel that would be consumed in free-flow conditions. The fuel that is deemed wasted due to congestion is the difference between the amount consumed at peak speeds and free-flow speeds (Equation A-10).

$$\text{Annual Fuel Consumed in Peak Conditions} = \text{Travel Delay (vehicle-hours) (Eq. A-4)} \times \text{Average Peak Period System "Congested" Speed (Eq. A-2)} \div \text{Average Fuel Economy (Eq. A-7)} \times \text{250 Working Days per Year} \quad \text{(Eq. A-8)}$$

$$\text{Annual Fuel that would be Consumed in Free-flow Conditions} = \text{Travel Delay} \times \text{Free-flow Speed (35 mph - arterial, 60 mph - freeway)} \div \text{Average Fuel Economy for Free-flow Speeds} \times \text{250 Working Days per Year} \quad \text{(Eq. A-9)}$$

$$\text{Annual Fuel Wasted in Congestion} = \text{Annual Fuel Consumed in Peak Conditions} - \text{Annual Fuel that would be Consumed in Free-flow Conditions} \quad \text{(Eq. A-10)}$$

Congestion Cost

Two cost components are associated with congestion: delay cost and fuel cost. These values are directly related to the travel speed calculations. The following sections and Equations A-11 through A-13 show how to calculate the cost of delay and fuel effects of congestion.

Passenger Vehicle Delay Cost

The delay cost is an estimate of the value of lost time in passenger vehicles and the increased operating costs of commercial vehicles in congestion. Equation A-11 shows how to calculate the passenger vehicle delay costs that result from lost time.

$$\text{Annual Passenger Vehicle Delay Cost} = \text{Daily Passenger Vehicle Hours of Delay (Eq. A-4)} \times \text{Value of Person Time (\$/hour)} \times \text{Vehicle Occupancy (persons/vehicle)} \times \text{Days} \quad \text{(Eq. A-11)}$$

Passenger Vehicle Fuel Cost

Fuel cost due to congestion is calculated for passenger vehicles in Equation A-12. This is done by associating the peak period congested speeds, the average fuel economy, and the fuel costs with the vehicle-hours of delay.

$$\text{Annual Fuel Cost} = \text{Daily Vehicle-Hours of Delay (Eq. A-4)} \times \text{Percent of Passenger Vehicles} \times \text{Average Peak Period Congested System Speed (Eq. A-2)} \div \text{Average Fuel Economy (Eq. A-7)} \times \text{Fuel Cost} \times \text{Days} \quad \text{(Eq. A-12)}$$

Commercial Vehicle Cost

The cost of both wasted time and fuel are included in the value of commercial vehicle time ($77.10 in 2005). Thus, there is not a separate value for wasted time and fuel. The equation to calculate commercial vehicle cost is shown in Equation A-13.

$$\begin{matrix}\text{Annual}\\ \text{Commercial}\\ \text{Cost}\end{matrix} = \begin{matrix}\text{Delay}\\ \text{Vehicle Hours}\\ \text{of Delay}\end{matrix} \times \begin{matrix}\text{Percent of}\\ \text{Commercial}\\ \text{Vehicles}\end{matrix} \times \begin{matrix}\text{Value of}\\ \text{Commercial}\\ \text{Vehicle Time}\end{matrix} \times \text{Days} \qquad \text{(Eq. A-13)}$$

Total Congestion Cost

Equation A-14 combines the cost due to travel delay and wasted fuel to determine the annual cost due to congestion resulting from incident and recurring delay. Table 2 in the 2007 Urban Mobility Report presents the congestion cost estimated with the new methodology.

$$\begin{matrix}\text{Annual Cost}\\ \text{Due to}\\ \text{Congestion}\end{matrix} = \begin{matrix}\text{Annual}\\ \text{Passenger}\\ \text{Vehicle}\\ \text{Delay Cost}\\ (\text{Eq. A-11})\end{matrix} + \begin{matrix}\text{Annual}\\ \text{Passenger}\\ \text{Fuel Cost}\\ (\text{Eq. A-12})\end{matrix} + \begin{matrix}\text{Annual}\\ \text{Commercial}\\ \text{Cost}\\ (\text{Eq. A-13})\end{matrix} \qquad \text{(Eq. A-14)}$$

Percent of Congested Travel

The percentage of travel in each urban area that is congested both for peak travel and daily travel can be calculated. The equations are very similar with the only difference being the amount of travel in the denominator. For calculations involving only the peak congested periods (Equations A-15 and A-16), the amount of travel used is half of the daily total since the assumption is made that only 50 percent of daily travel occurs in the peak driving times. For the daily percentage (Equation A-17), the factor in the denominator is the daily miles of travel. Exhibit A-10 shows the 2005 percent of congested travel values.

$$\begin{matrix}\text{Congested}\\ \text{Travel}\end{matrix} = \begin{matrix}\text{Percent of Congested}\\ \text{Peak Period Travel}\end{matrix} \times \begin{matrix}\text{VMT for}\\ \text{Roadway Type}\end{matrix} \qquad \text{(Eq. A-15)}$$

$$\begin{matrix}\text{Peak Congested}\\ \text{Peak Travel}\end{matrix} = \begin{matrix}\text{Percent Congested}\\ \text{Daily Travel}\end{matrix} \div 50 \text{ percent} \qquad \text{(Eq. A-16)}$$

$$\begin{matrix}\text{Percent Congested}\\ \text{Daily Travel}\end{matrix} = \frac{\begin{matrix}\text{Freeway}\\ \text{Congested Travel}\end{matrix} + \begin{matrix}\text{PAS}\\ \text{Congested Travel}\end{matrix}}{\text{Daily Travel}} \qquad \text{(Eq. A-17)}$$

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Exhibit A-10. Percentage of Congested Travel

Urban Area	Percent of Travel that is Congested in Peak Period	Percentage of Daily Travel that is Congested	Urban Area	Percent of Travel that is Congested in Peak Period	Percentage of Daily Travel that is Congested
Very Large			Medium		
Atlanta, GA	76	38	Akron, OH	29	14
Boston, MA-NH-RI	59	29	Albany-Schenectady, NY	25	12
Chicago, IL-IN	82	41	Albuquerque, NM	45	22
Dallas-Fort Worth-Arlington, TX	66	33	Allentown-Bethlehem, PA-NJ	38	19
Detroit, MI	71	35	Austin, TX	66	33
Houston, TX	73	36	Birmingham, AL	44	22
Los Angeles-LBch-Santa Ana, CA	86	43	Bridgeport-Stamford, CT-NY	61	30
Miami, FL	85	42	Charlotte, NC-SC	58	29
New York-Newark, NY-NJ-CT	68	34	Dayton, OH	36	18
Philadelphia, PA-NJ-DE-MD	63	32	El Paso, TX-NM	45	22
Phoenix, AZ	72	36	Fresno, CA	37	19
San Francisco-Oakland, CA	81	41	Grand Rapids, MI	30	15
Seattle, WA	70	35	Hartford, CT	37	19
Washington, DC-VA-MD	81	40	Honolulu, HI	53	26
			Jacksonville, FL	60	30
Large			Louisville, KY-IN	59	30
Baltimore, MD	66	33	Nashville-Davidson, TN	44	22
Buffalo, NY	22	11	New Haven, CT	38	19
Cincinnati, OH-KY-IN	51	25	Oklahoma City, OK	31	16
Cleveland, OH	29	15	Omaha, NE-IA	44	22
Columbus, OH	59	29	Oxnard-Ventura, CA	57	29
Denver-Aurora, CO	67	34	Raleigh-Durham, NC	47	23
Indianapolis, IN	62	31	Richmond, VA	28	14
Kansas City, MO-KS	22	11	Rochester, NY	24	12
Las Vegas, NV	69	35	Salt Lake City, UT	54	27
Memphis, TN-MS-AR	37	18	Sarasota-Bradenton, FL	48	24
Milwaukee, WI	38	19	Springfield, MA-CT	22	11
Minneapolis-St. Paul, MN	61	30	Toledo, OH-MI	26	13
New Orleans, LA	44	22	Tucson, AZ	57	28
Orlando, FL	69	35	Tulsa, OK	24	12
Pittsburgh, PA	26	13			
Portland, OR-WA	66	33	Small		
Providence, RI-MA	39	19	Anchorage, AK	19	10
Riverside-San Bernardino, CA	78	39	Bakersfield, CA	27	14
Sacramento, CA	79	40	Beaumont, TX	15	8
San Antonio, TX	61	31	Boulder, CO	27	14
San Diego, CA	85	42	Brownsville, TX	19	9
San Jose, CA	76	38	Cape Coral, FL	35	18
St. Louis, MO-IL	42	21	Charleston-No. Charleston, SC	45	22
Tampa-St. Petersburg, FL	69	34	Colorado Springs, CO	36	18
Virginia Beach, VA	51	26	Columbia, SC	24	12
			Corpus Christi, TX	16	8
			Eugene, OR	31	15
			Laredo, TX	25	13
			Little Rock, AR	28	14
			Pensacola, FL-AL	31	15
			Salem, OR	26	13
			Spokane, WA	15	7

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CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

APPENDIX B

WHAT IS THE SOURCE OF DATA FOR THIS REPORT?

This report uses data from federal, state, and local agencies to develop estimates of congestion and mobility within an urban area. The methodology developed by several previous research studies (1,2,3,4,5) yields a quantitative estimate of urbanized area mobility levels, utilizing generally available data, while minimizing the need for extensive data collection.

The methodology primarily uses the Federal Highway Administration's Highway Performance Monitoring System (HPMS) database, with supporting information from various state and local agencies (6). The HPMS database is used because of its relative consistency and comprehensive nature. State departments of transportation collect, review, and report the data annually. Since each state classifies roadways in a slightly different manner, TTI reviews and adjusts the data to make it comparable and then state and local agencies familiar with each urban area review the data.

The Urban Mobility Report procedures have been modified to take advantage of special issue studies that provide more detailed information, but the assumptions used in the Annual Mobility Report do not fully account for the effect of all operational improvements. Comparisons between cities are always difficult and the local and state studies are typically more detailed and relevant for specific areas. The Urban Mobility Report is more applicable for comparisons of trends for individual cities, rather than any value for a particular year.

Urban Area Boundary Effects

Urban boundaries are redrawn at different intervals in the study states. Official realignments and local agency boundary updates are sometimes made to reflect urban growth. These changes may significantly change the size of the urban area, which also causes a change in system length, travel and mobility estimates. The effect in the Urban Mobility Report database is that travel and roadways that previously existed in rural areas are added to the urban area statistics. It is important to recognize that newly constructed roads are only a portion of the "added" roads.

When the urban boundary is not altered every year in fast growth areas, the HPMS data items take on a "stair-step appearance." The Urban Annual Report process closely re-examines the most recent years to see if any of the trends or data should be altered (e.g., smoothing some of the stair steps into more continuous curves) to more closely reflect actual experience. This changes some data and measures for previous years. Any analysis should use the most recent report and data—they include the best estimates of the mobility statistics.

Why Is Free-Flow Travel Speed the Congestion Threshold?

The conditions in the middle of the day (or middle of the night) are the ones that travelers generally identify as desirable and use for comparison purposes. It is also relatively easy to understand that those conditions are not achievable during the peak travel periods without significant funding, environmental concerns and social effects. The decisions to make substantial improvements to achieve some desirable condition using investments in road, transit, operations, demand management or other strategies are products of detailed studies—studies that are not replicated in this report.

For the purposes of a national study, therefore, it is reasonable to set a congestion measurement baseline that everyone generally understands. Free-flow speed—which we estimate is 60 mph on freeways and 35 mph on major streets—is such a baseline. Speeds less than that will be an indication of delay. It is not intended to be the target for peak-hour conditions in urban corridors. The target setting exercise is discussed in more detail in a report section addressing "acceptable conditions" as targets.

Why Use Traffic Counts and Estimates Instead of "Real" Traffic Speeds?

Because there are not enough cities collecting enough high quality traffic speed data on enough roads, estimates are necessary. The Urban Mobility Report series seeks to understand congestion and mobility levels in many urban areas, and unfortunately, the best common database is one that has roadway design and traffic information. The estimation procedures are used to develop travel time and speed measures that can be used to communicate to a variety of audiences. This Annual Report also has some travel speed data from urban traffic operations centers, but until that information is more widely available, estimates will be required.

In the near future, these reports will also include estimates of the effects from several key improvements such as incident management, ramp metering, traffic signal coordination and high-occupancy vehicles lanes. The benefits of these projects are only indirectly included in the current methodology. When more cities and states conduct thorough evaluation studies and the comparison techniques are improved, the operations and demand management programs will be more completely characterized.

Detailed Speed Data and Reliability Information

The high quality speed data that are available were collected as part of the Mobility Monitoring Program (http://mobility.tamu.edu/mmp), a joint research effort of Texas Transportation Institute and Cambridge Systematics for the Federal Highway Administration (7). The MMP collected and analyzed detailed traffic volume and speed data for freeways in 29 cities for 2003. The data are prepared for 5-minute time intervals for sections of freeway between one-half and three miles in length. The base data sets were examined for quality and reasonable values and analyzed for a few key performance measures.

The continuous nature of this database provides a very good picture of the variation in conditions through the year—significantly better information than was available before. Variation or reliability in transportation conditions was studied with 2003 data. Some of that data is used in this report.

The detailed traffic operations center data also does not cover very much of the transportation system of the travel even in the most highly monitored cities. The percentage of the freeway system that was monitored during 2003 in the 29 Mobility Monitoring Program cities averaged around 50 percent. There was very little arterial street condition data. It is difficult to construct a set of city to city comparison measures or interpret the meaning of data under these conditions. While the data are very useful for examining issues, they are less useful for area or trend comparisons. Even the evaluation of incidents is hampered by the lack of arterial street data. Traffic that changes route from the freeway to a street experiences delay, but that delay is not counted because there is no monitoring equipment. So the "real" traffic data does not include all of the delay that occurs. Estimates are required to obtain a full picture of the congestion situation.

MEASURES AND RANKINGS WITHIN POPULATION GROUPS—WHICH MEASURE SHOULD BE USED?

We recommend that several measures, as well as the trend in the measures over several years, be considered before any "official rank" is determined. Just as the report indicates there is no single "solution" to the mobility problems in most areas, there is also no single "best" measure. The measures illustrate different aspects of the congestion problems and improvement strategies.

There is a temptation to choose one measure to make the interpretations and message easy. As a minimum two of the "intensity" measures and one "magnitude" measure should be used to assess the mobility situation at an areawide level. At the corridor level, where solutions are frequently implemented, more measures and more detailed analyses are needed to identify the most appropriate solution and evaluate the effects. The measures reflect travel time concerns and can be applied to a variety of evaluation cases. More information on these measures is available on the website: http://mobility.tamu.edu.

- Travel Time Index—the ratio of peak period travel time to free-flow travel time. The TTI expresses the average amount of extra time it takes to travel in the peak relative to free-flow travel. A TTI of 1.3, for example, indicates a 20-minute free-flow trip will take 26 minutes during the peak travel periods, a 6-minute (30 percent) travel time penalty. Free-flow travel speeds are used because they are an easy and familiar comparison standard, not because they should be the goal for urban transportation system improvements.
- Delay per Traveler—the hours of extra travel time divided by the number of urban area peak period travelers. This is an annual measure indicating the sum of all the extra travel time that would occur during the year for the average traveler. All urban travelers are used as the comparison device to better relate the delay statistics to those affected on the roadways.
- Cost of Congestion—the value of the extra time and fuel that is consumed during congested travel. The value of time for 2005 is estimated for passenger vehicles and trucks and the fuel costs are the per-gallon average price for each state. The value of a person's time is derived from the perspective of the individual's value of their time, rather than being based on the wage rate. Only the value of truck operating time is included; the value of the commodities is not. The value of time is the same for all urban areas.
- Change in Congestion—not a particular measure, but a concept used in many analyses. The trends in congestion are often more important than the absolute mobility levels, because they indicate if the right amount of improvement is being funded.

The mobility performance measures and the rankings based on them are useful for a variety of purposes. They are especially good at identifying multi-year trends and in comparing relative levels of congestion. As evidenced by the continual refinement of the measures, estimation procedures and data, however, this series of reports is still a "work-in-progress."

One element of this uncertainty is that the measure values have an element of variation in them. All estimation procedures have simplifying assumptions that are not correct for every situation. And traffic data reflects the day-to-day variation in activity that affects traveler experiences. There are also locations or corridors in each urban area, especially those over one million population, where mobility levels are much lower than any average value. Those who frequently travel in these places may get a biased view of the urban areawide mobility level.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

HOW CONGESTED ARE THE ROADS? ARE THEY GETTING WORSE?

Congestion levels and the trends in congestion growth are important aspects of the database. Where and when congestion occurs is important within an urban network, as well as for comparing urban areas to each other. Comparisons should include considerations such as, areawide congestion levels tend to be worse in the larger urban areas, but there are some isolated pockets of very bad traffic congestion in smaller urban areas that rival some locations in larger cities. Comparisons with areas of similar population are usually more informative than broader comparisons.

Conclusions

In general, traffic congestion is worse in the larger urban areas than in the smaller ones. Traffic congestion levels have increased in every area since 1982. Congestion extends to more time of the day, more roads, affects more of the travel and creates more extra travel time than in the past. And congestion levels have risen in all size categories, indicating that even the smaller areas are not able to keep pace with rising demand.

The need for attention to transportation projects is illustrated in these trends. Major projects or programs require a significant planning and development time—10 years is not an unrealistic timeframe to go from an idea to a completed project or to an accepted program. At recent growth rates, the urban area average congestion values will jump to the next highest classification—medium areas in 2015 will have congestion problems of large areas in 2005.

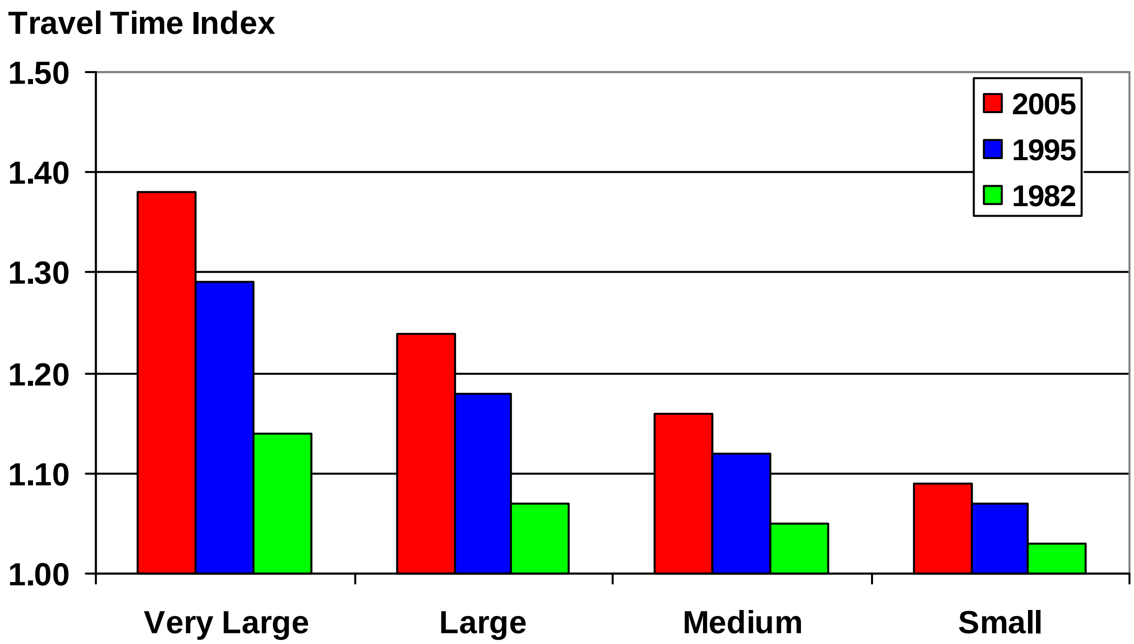
The Travel Time Index is one of two primary measures of extra travel time for travelers. (See Exhibit B-1). It measures the amount of additional time needed to make a trip during a typical peak travel period in comparison to traveling at free-flow speeds.

Travel delay per peak traveler is the other individual measure that provides estimates of the mobility levels (see Exhibit B-2). The extra travel time per year can be related to many other activities and may be more relevant for some discussions.

The extra travel time each year is a combination of the extra travel time for each trip (as measured by the TTI), the trip distance and the number of trips. The effect of this difference is relatively modest in most areas—that is, the TTI and delay per traveler tell basically the same story. The rankings are similar and the pattern of growth or decline are about the same. In some areas, however, the two values lead to different conclusions.

Portland is one area where the multiple performance measures help illustrate the effect of the transportation and land use policies that are being pursued to create a denser urban area that is better served by public transportation. The Travel Time Index and the delay per traveler values have both increased since 1982, indicating an increase in congestion. The Travel Time Index for Portland grew faster from 1982 to 2005 than it has for the majority of the other areas in the Large urban group. Delay per traveler, however, has grown at a rate closer to the Large area average, indicating that delay has not grown as rapidly as the per-minute travel time penalties have declined. Perhaps the urban growth and transportation policies are encouraging shorter trips and travel on light rail and other modes.

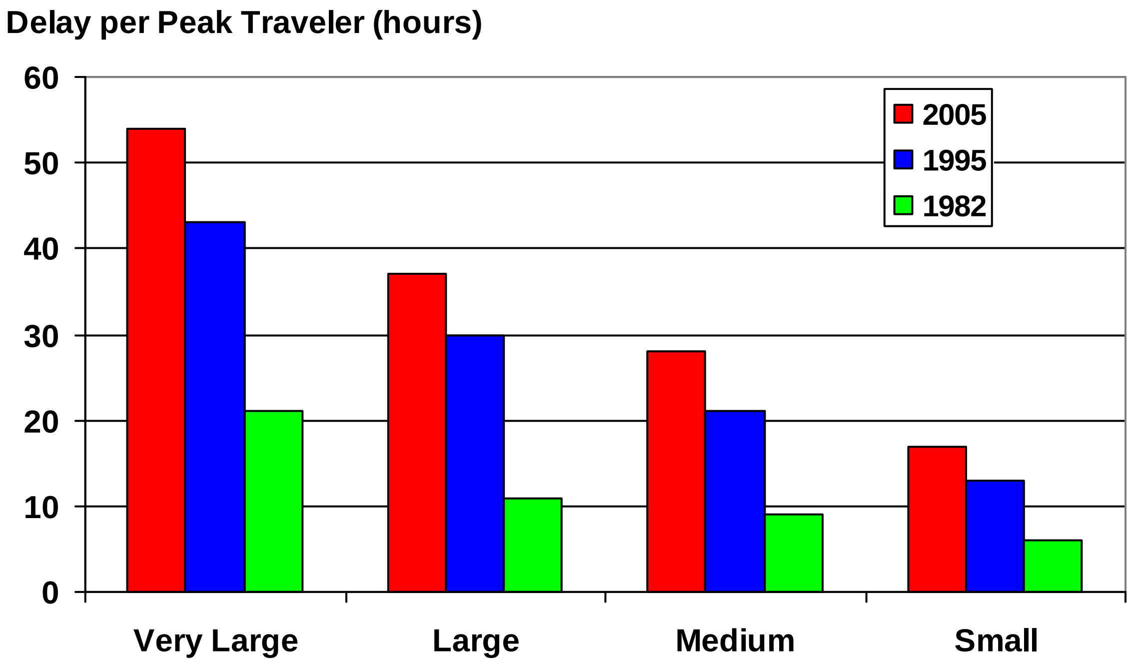
Exhibit B-1. Travel Time Index Trends



Note: The Travel Time Index is a ratio of average peak period to free-flow travel time. A value of 1.30 indicates a free-flow trip of 20 minutes takes 26 minutes in the peak due to heavy traffic demand and incidents.

- The average TTI for all 437 urban areas is 1.30. Thus, an average 20-minute off-peak trip takes almost 25 minutes to complete during the peak due to heavy traffic demand and incidents.
- Congestion problems tend to be more severe in larger cities. The average TTI for each individual population group ranges from 1.38 in the Very Large areas down to 1.09 in the Small urban areas.
- The average increase in the travel time penalty was 19 points (1.11 to 1.30) between 1982 and 2005. This gap ranges from 24 points in the Very Large group to 6 points in the Small population group.
- Twenty of the 437 urban areas have a TTI of at least 1.30. Nineteen of these urban areas are in the Very Large and Large population groups—they have populations greater than one million. Austin is the only area with fewer than one million people and a TTI more than 1.30.

Exhibit B-2. Delay per Peak Traveler Trends



- The average delay per peak traveler in the 437 urban areas is 38 hours.
- There are 12 urban areas with delay per peak traveler values in excess of 50 hours, showing the effect of the very large delays in the areas with populations larger than 3 million.
- The average delay per peak traveler in the Large population group is about the same as the average delay in the Very Large population group in 1992.
- The average delay per peak traveler in the Medium population group is about the same as the average delay in the Large group in 1994.

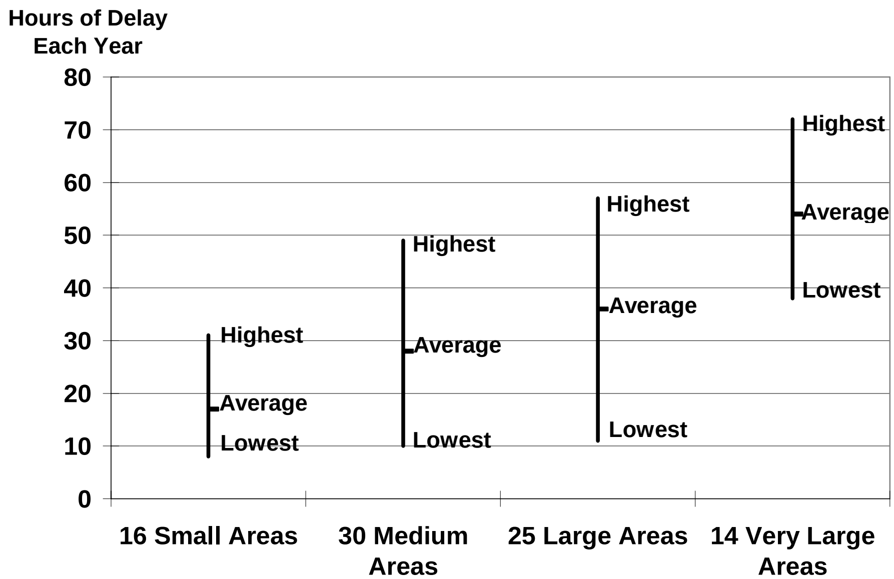
CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

WHAT CONGESTION LEVEL SHOULD WE EXPECT?

Congestion travel time penalties are related to size of the area, and Exhibit B-3 illustrates this. The Delay per Traveler decreases as population does, but there is a significant amount of variation within the groups. Areas that have seen high rates of growth in recent years are more likely to be near the top of their population group because demand will increase much faster than the roadway, public transportation service, operational treatments and land use patterns.

- Areas with populations over 3 million (Very Large) should expect a minimum delay per traveler of 38 hours.
- Areas over 1 million (Large and Very Large) should expect a delay per traveler of at least 11 hours with a more likely value of around 36 hours.
- Areas over one-half million (all except Small) should expect at least 10 hours with typical values being closer to 28 to 54 hours.
- Areas less than a half million (Small) should expect a delay per traveler of up to 31 hours.

Exhibit B-3. Congestion and Urban Area Size, 2005



CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

HOW FAR HAS CONGESTION SPREAD?

Traffic congestion affects a broader segment of the transportation system each year. Several dimensions are explored within this report. Congestion has spread to **more cities** to **more** of the **road system** and **trips** in cities to **more time** during the day and to **more days** of the week in some locations.

Conclusions

Congestion has spread significantly over the 20 years of the study. A few notable changes from 1982 to 2005 include:

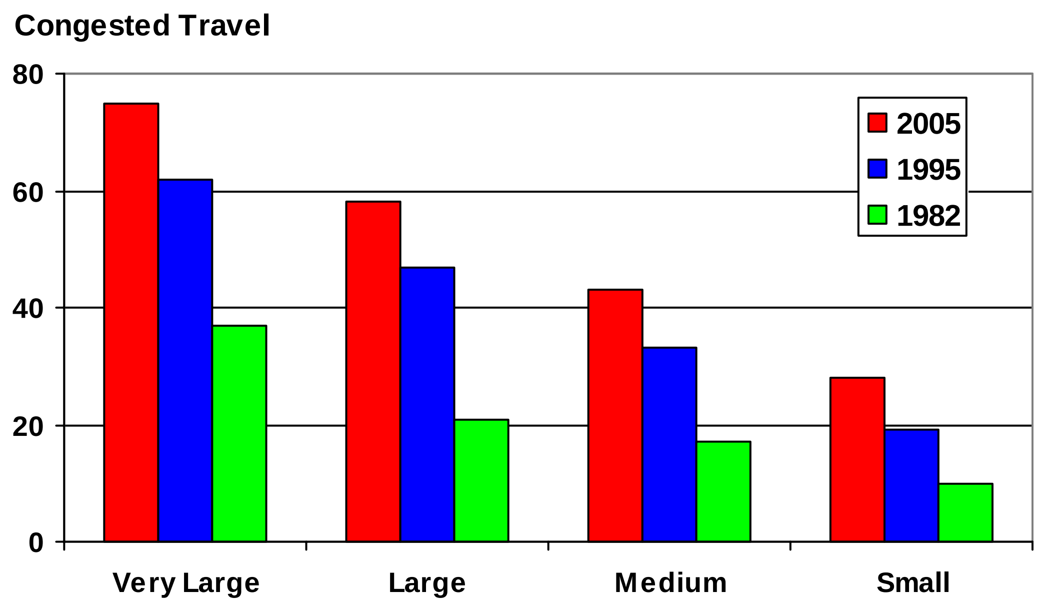
- Twenty urban areas have a Travel Time Index above 1.30 compared with one such area in 1982.
- Sixty-three percent of the peak period travel is congested compared to 29 percent in 1982.
- Forty-eight percent of the major road system is congested compared to 29 percent in 1982.
- The number of hours of the day when congestion might be encountered has grown from about 4.2 hours to about 7.0 hours.

Most of the trend information indicates that the 2005 average values for each population group are above the 1995 value for the next highest population group. This is also the case for the 1995 and 1982 comparison. This suggests that each group will attain congestion levels of the next highest approximately each decade if trends are not reversed.

Congested Travel

The amount of traffic experiencing congested conditions in the peak travel periods (three hours in the morning and three hours in the afternoon) has doubled in 20 years of the study from 29 percent in 1982 to 63 percent in 2005. This means that two of every three cars experience congestion in their morning or evening trip. Exhibit B-4 provides more information on this trend.

Exhibit B-4. Percent of Travel in Congested Conditions



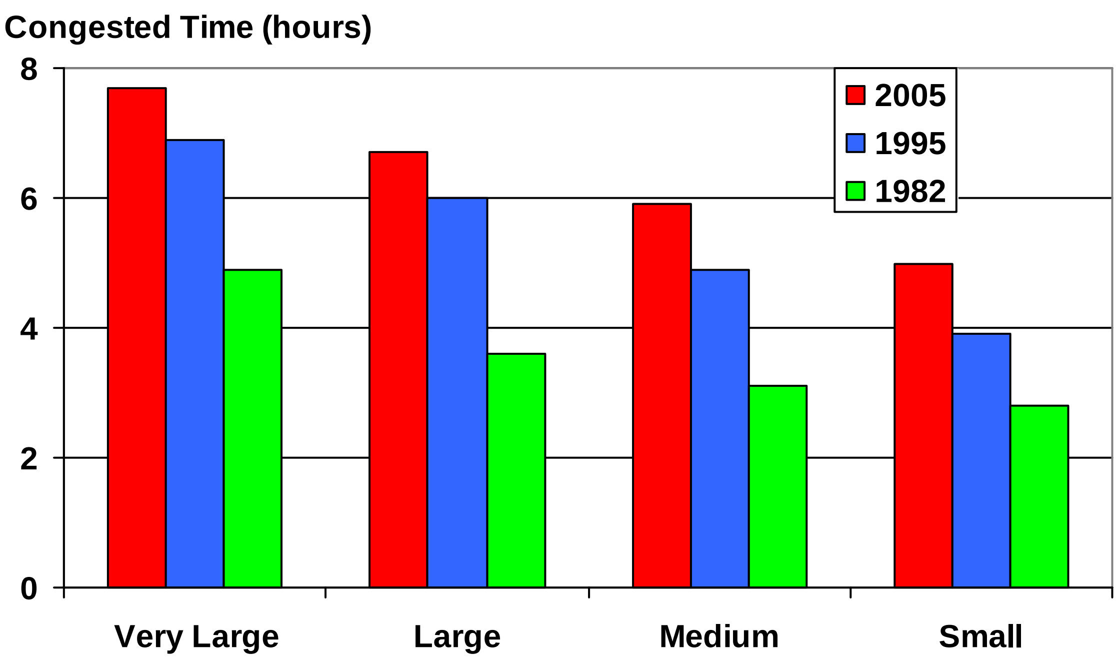
- The range of travel experiencing congestion grew from between 10 percent and 37 percent in 1982 to between 28 percent and 75 percent in 2005.
- The average percentage has increased to the next highest population group approximately each decade.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Congested Time

From the traffic database that is used for this study, it is uncertain exactly how long the congested periods last in each urban area. We can estimate, however, the amount of travel that occurs during times of the day when travelers **may** encounter congestion. This is not the amount of time when congestion occurs on a particular segment of road, but rather is the time when congestion occurs on some part of the road system. Exhibit B-5 shows the average length of the congested periods for each population group for 1982, 1995 and 2005.

Exhibit B-5. Hours of Day When Congestion May Occur

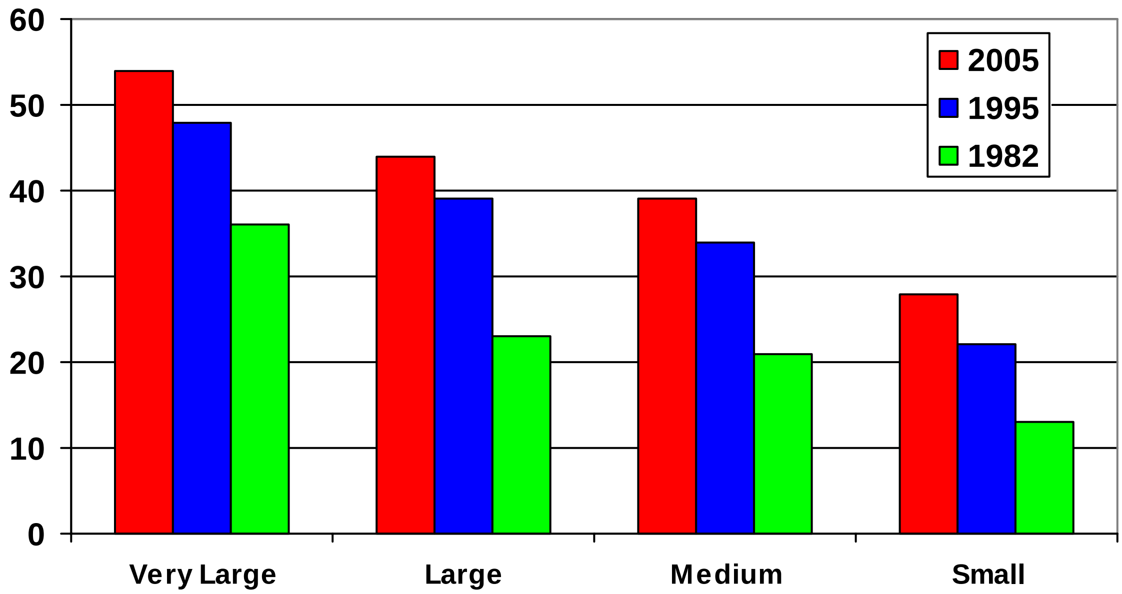


- The time when congestion might be encountered on major urban roads has grown in all population categories.
- The congested time in the morning and evening is near 3 hours in even the Small group—indicating that in many areas the term "rush hour" does not convey the length of time travelers may suffer slowdowns.
- Slow conditions might be encountered for 3 hours in each peak period in areas above 500,000. The amount of slowdown does not appear to be as great in the smaller areas.
- Three hours of congestion in each peak does not extend to the entire urban area, but some travelers must allow for extra time during a substantially longer portion of the day.

Congested Roads

The amount of roadways (freeways and principal arterial streets) that is congested during the peak period is shown in Exhibit B-6 for 1982, 1995 and 2005. The percentage of the major roadway system that is congested has risen from 29 percent in 1982 to 48 percent in 2005.

Exhibit B-6. Percentage of Roads that Experience Some Congestion During Peak Periods



- The percentage of roads where congestion might occur in the peak period has about doubled in the Small, and nearly doubled in the Medium and Large areas since 1982.
- The largest percentage point increase has occurred in the Large areas.
- Each of the population groups has a 2005 value close to the 1995 value for the next highest population group. This is similar to the condition in 1995 when compared to 1982 data.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Growth in Delay and Congested Travel

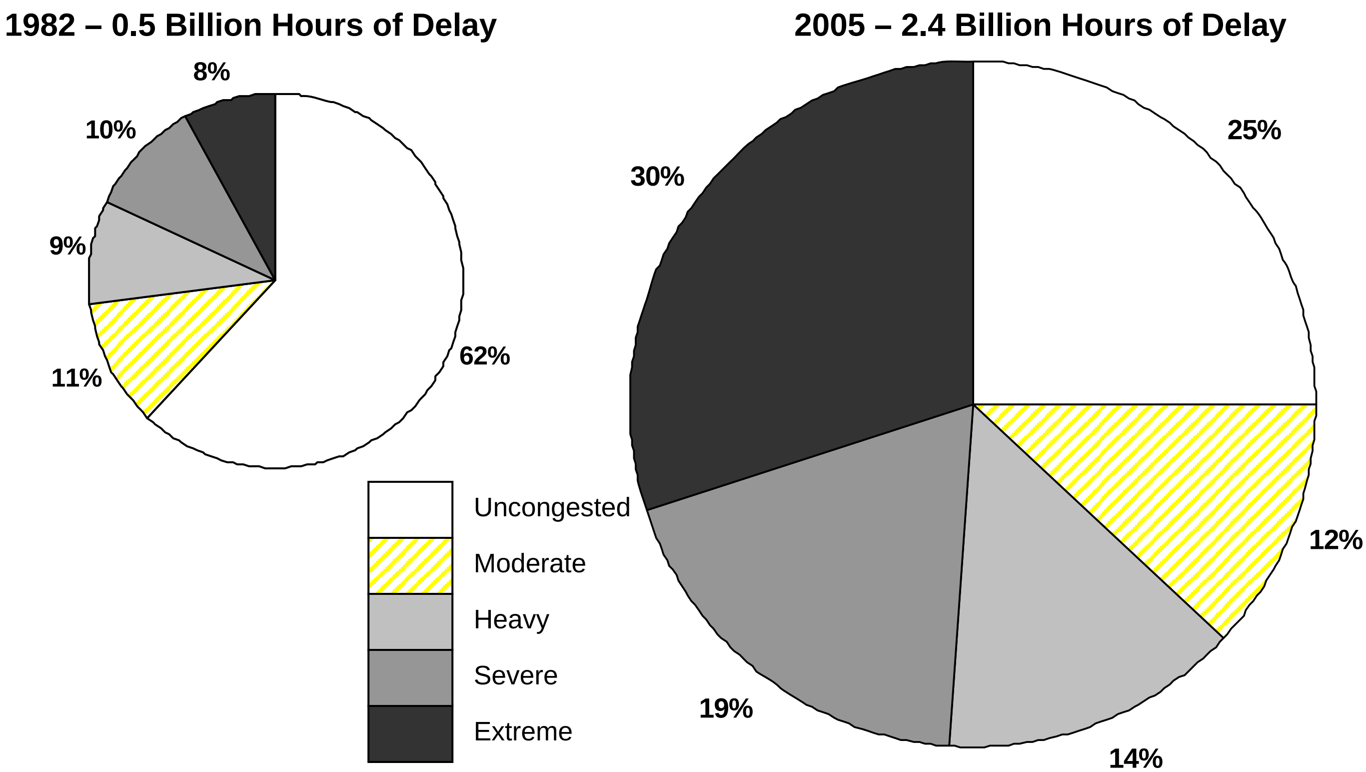
This section provides a graphical comparison for each of the four population groups in the Urban Mobility Report. There are two circles on each page representing conditions in 1982 and 2005.

- The growth in the area of the circle represents the growth in travel delay for all the cities in the group from 1982 to 2005.
- The amount of miles traveled during the peak period in each of five congestion levels is also displayed for each year to give a perspective on the change in conditions experienced by travelers.

Exhibits B-7 through B-10 illustrate conditions for the four population groups.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

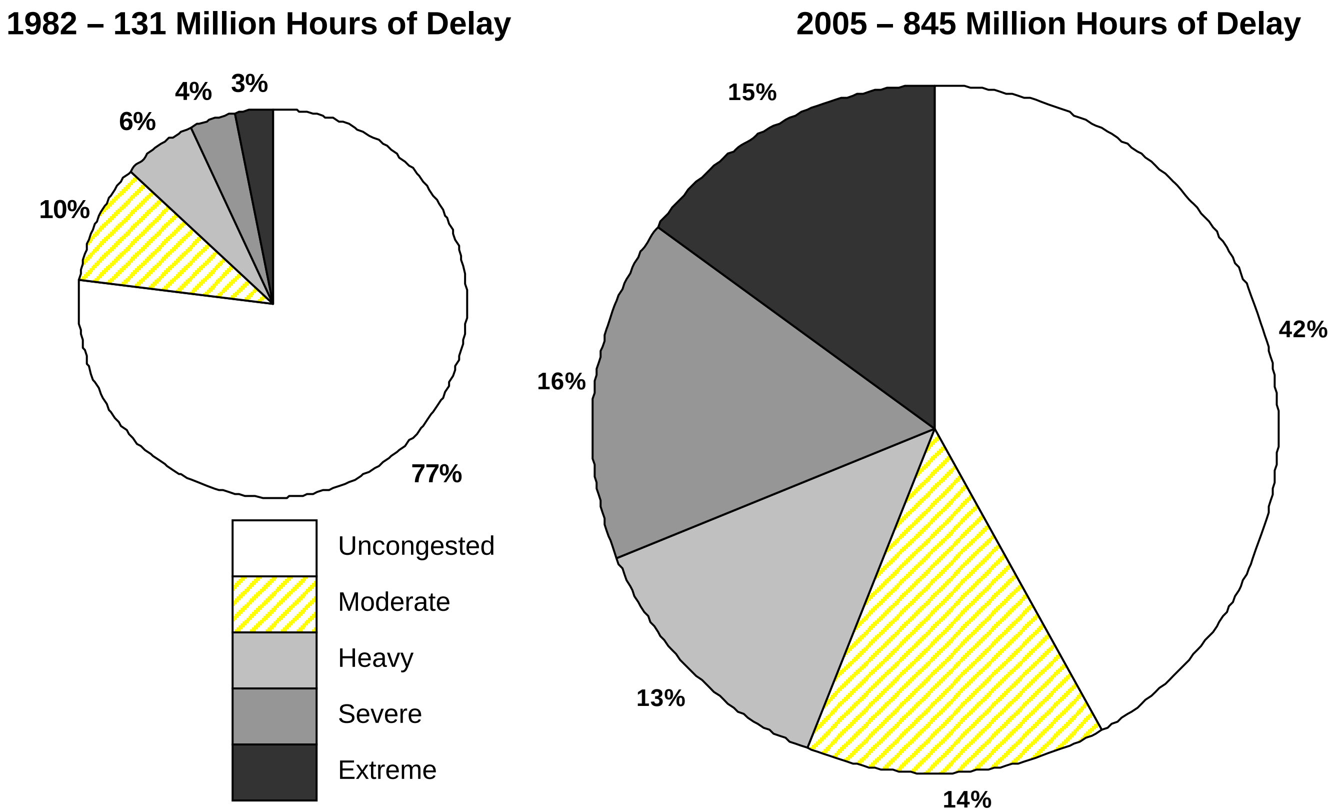
Exhibit B-7. Very Large Urban Area Travel Conditions



- Fourteen urban areas are included in this group representing 55 percent of the population and 66 percent of the travel delay in 2005.
- Delay grew approximately 350 percent from 1982 to 2005.
- There was significant growth in the severely and extremely congested volume ranges with travel increasing from about 18 percent to almost 50 percent.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

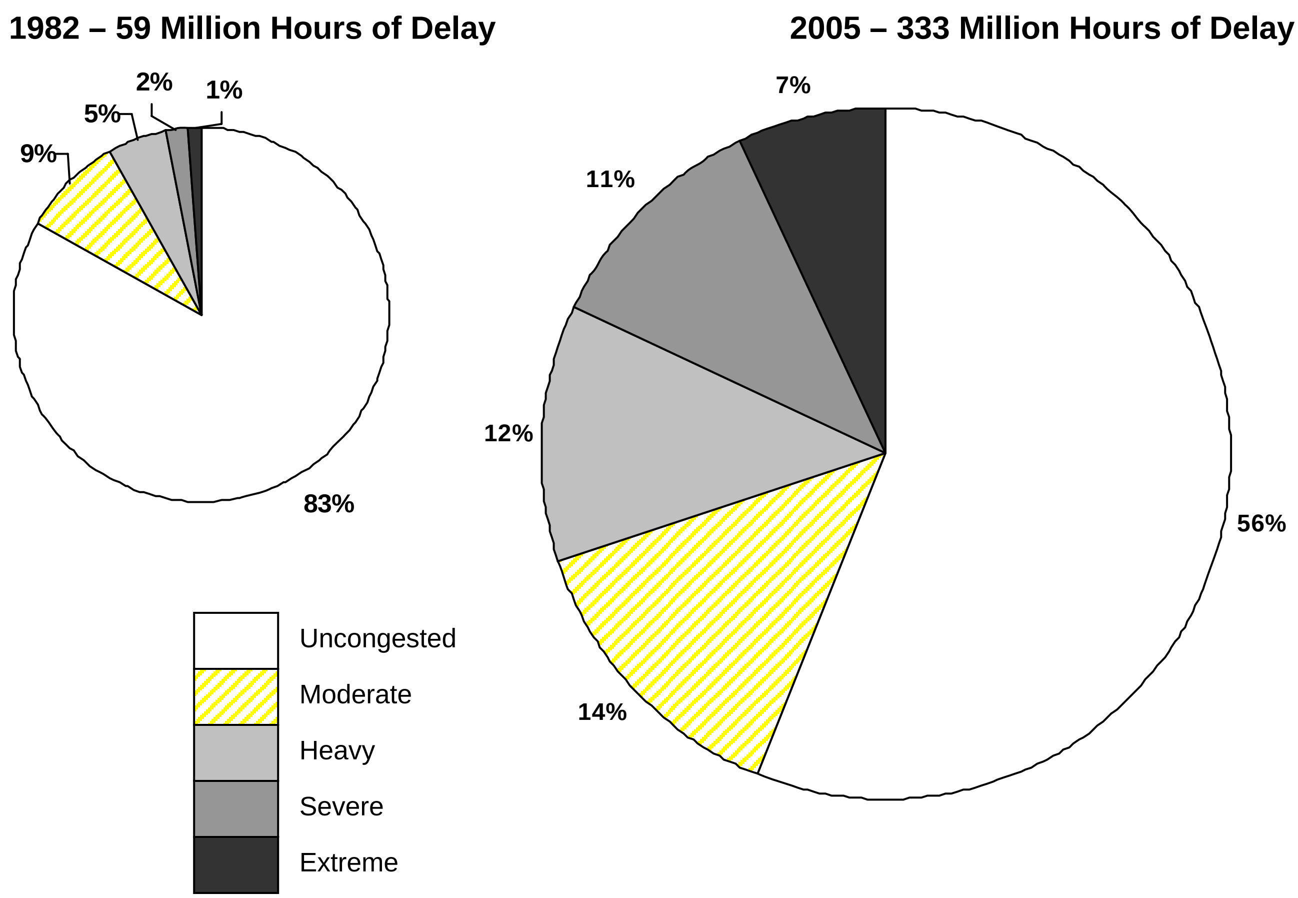
Exhibit B-8. Large Urban Area Travel Conditions



- Twenty-five urban areas are included in this group representing 27 percent of the population and 23 percent of the travel delay in 2005.
- Delay grew 545 percent from 1982 to 2005.
- There was almost no travel in the two most congested categories in 1982, while those ranges now account for almost 1/3 of peak travel.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

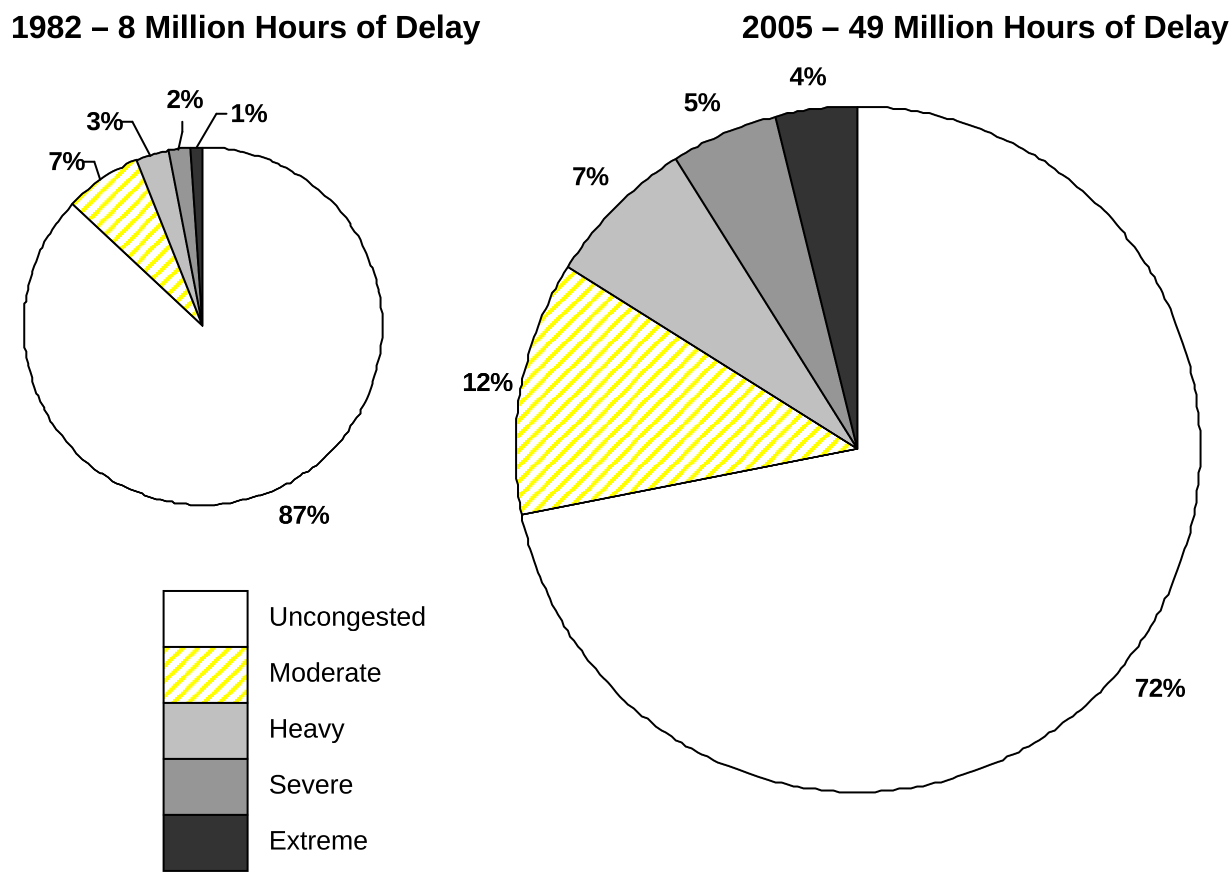
Exhibit B-9. Medium Urban Area Travel Conditions



- Thirty urban areas are included in this group representing 15 percent of the population and 9 percent of the travel delay in 2005.
- Delay grew 465 percent from 1982 to 2005.
- Travel in the congested regions now accounts for almost half of travel during the peak, compared to less than 20 percent in 1982.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Exhibit B-10. Small Urban Area Travel Conditions



- Sixteen urban areas are included in this group representing 3 percent of the population and 1 percent of the travel delay in 2005.
- Delay grew 500 percent from 1982 to 2005.
- Congestion, although not a significant problem for most peak period travel, has increased to about 30 percent of peak travel miles.

WHAT DOES CONGESTION COST US?

Congestion has several effects on travelers, businesses, agencies and cities. One significant element is the value of the additional time and wasted fuel. The top 14 urban areas include about two-thirds of the delay estimated for 2005, and the top 20 areas account for over 75 percent of annual delay. Some other highlights include:

- In 2005, congestion (based on wasted time and fuel) cost about $78.2 billion in the 437 urban areas, compared to $73.1 billion in 2004. (See Exhibit B-11).
- The average cost per traveler in the 437 urban areas was $707 in 2005, up from $680 in 2004 (using constant dollars). The cost ranged from $1,041 per traveler in Very Large urban areas down to $318 per traveler in the Small areas.
- Exhibits B-13 and B-14 show that 2.9 billion gallons of fuel were wasted in the 437 urban areas. This amount of fuel would fill 58 super-tankers or 290,000 gasoline tank trucks.
- The urban areas with populations greater than 3 million accounted for 1.7 billion gallons (about two-thirds) of wasted fuel.
- The amount of wasted fuel per traveler ranges from 38 gallons per year in the Very Large urban areas to 6 gallons per year in the Small areas.

Exhibit B-11. Congestion Effects on the Average Traveler – 2005

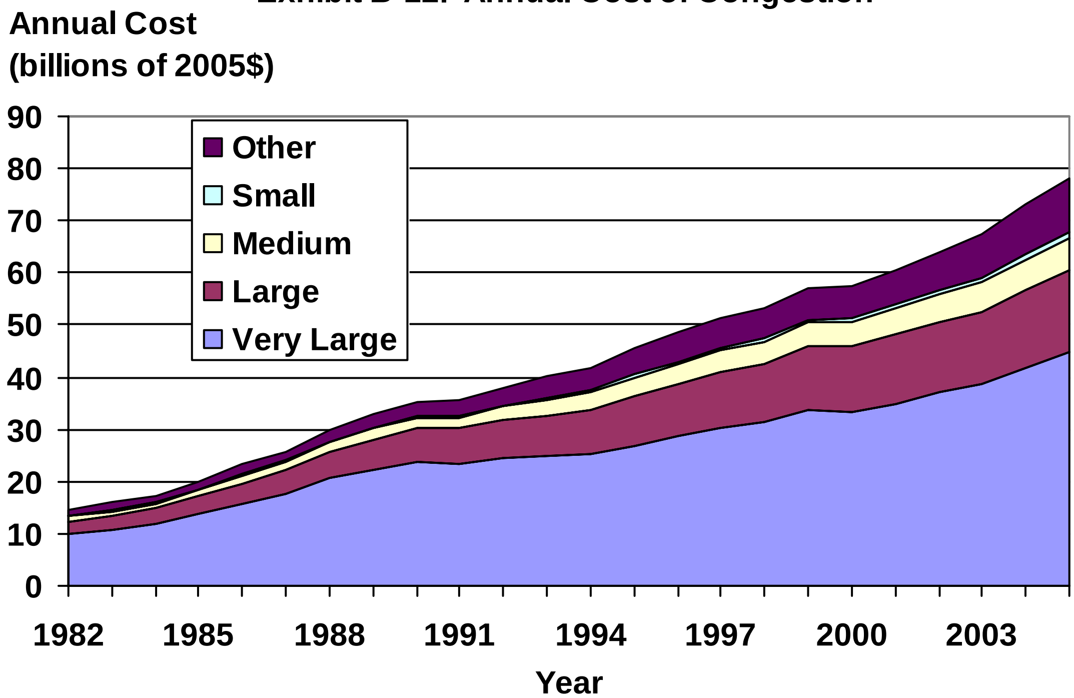
	Congestion Statistics per Traveler		
Population Group	**Average Cost ($)**	**Average Delay (hours)**	**Average Fuel (gallons)**
Very Large areas	1,014	54	38
Large areas	683	37	25
Medium areas	512	28	18
Small areas	318	17	10
Other Urban Areas	370	21	13
437 Area Average	707	40	26
437 Area Total	$78.2 billion	4.2 billion	2.9 billion

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

What is the Total Cost of Congestion?

The total cost of congestion for each population size group is shown in Exhibit B-12. This cost accounts for the amount of wasted time and fuel due to traffic congestion. The total cost of congestion in the urban areas is $78.2 billion in 2005 or an average of $707 per traveler.

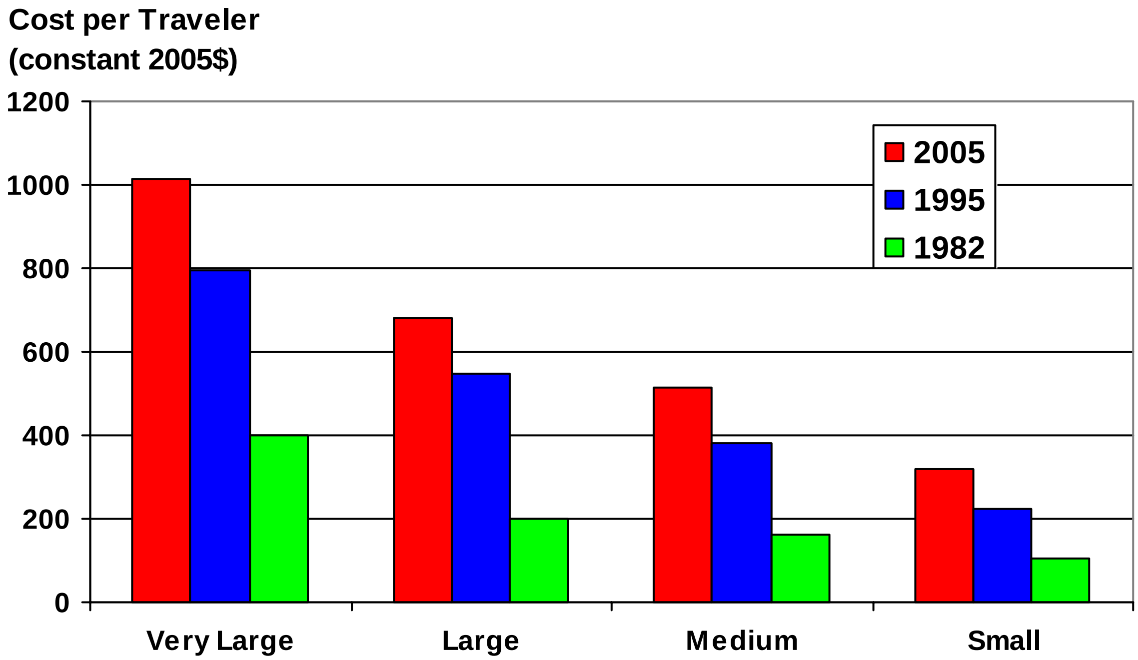
Exhibit B-12. Annual Cost of Congestion



- Nineteen urban areas had a total annual congestion cost of at least $1 billion each.
- The areas with populations over 3 million persons account for about 60 percent of the congestion cost.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Exhibit B-13. Annual Cost of Congestion per Traveler



What is the cost of congestion for me?

The total cost of congestion is divided by the number of peak period travelers to determine the effect of congestion on an individual (Exhibit B-13). The average annual cost to each of these travelers is about $707.

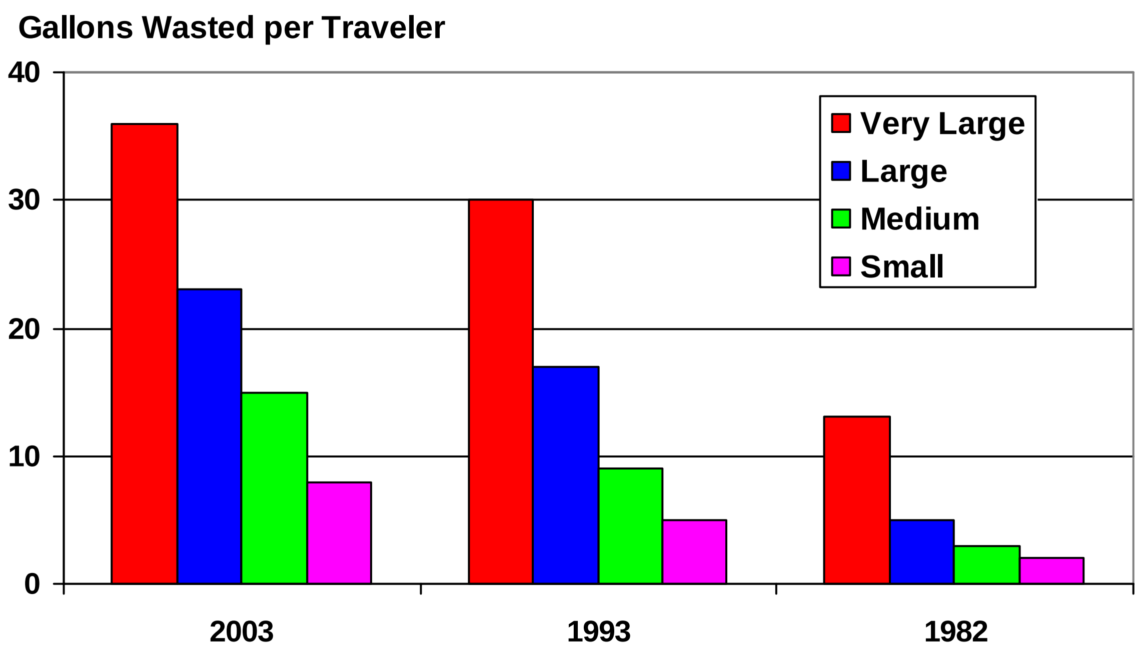
- Travelers of 74 areas are "paying" more than $1 per workday in congestion costs; 45 areas have a congestion value exceeding $2 per workday.
- The average cost of congestion per traveler ranged from $1,014 in the Very Large population group to $318 in the Small population group in 2005.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

How Much Fuel is Wasted in Congestion?

As with cost, the amount of fuel wasted in congestion is divided by the estimated number of persons in the urban area. This provides an estimate of the amount of fuel consumed for each individual because of congestion (Exhibit B-14), a quantity that can be compared to other per capita consumptions. More than 26 gallons are wasted per traveler in the 437 urban areas. (See Exhibit B-14 for more information).

Exhibit B-14. Wasted Fuel per Traveler



- The average amount of wasted fuel per traveler in 2005 in the 437 study areas was 26 gallons.
- The amount of wasted fuel per traveler ranged from 3 gallons in the Small population group to 38 gallons in the Very Large population group in 2005.
- The total amount of wasted fuel in the 437 urban areas was approximately 2.9 billion gallons in 2005.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

CAN MORE ROAD SPACE REDUCE CONGESTION GROWTH?

The analysis in this section (shown in Exhibit B-15) addresses the issue of whether or not roadway additions made significant differences in the delay experienced by drivers in urban areas between 1982 and 2005. These years saw a range of economic conditions but a relatively consistent pattern between demand or population growth and increase in congestion. Rapid population growth was usually accompanied by significant congestion growth, while slow growth saw less congestion growth. The length of time needed to plan and construct major transportation improvements, however, means that very few areas see a rapid increase in economic activity and population without a significant growth in congestion. It also reinforces the idea that congestion is not a problem that can be addressed and then ignored for a decade.

Two measures are used to answer this question.

1. The Travel Time Index (TTI) is a mobility measure that shows the additional time required to complete a trip during congested times versus other times of the day. The TTI accounts for both recurrent delay and delay caused by roadway incidents.
2. The difference between lane-mile increases and traffic growth compares the change in supply and demand. If roadway capacity has been added at the same rate as travel, the deficit will be zero. The two changes are expressed in percentage terms to make them easily comparable. The changes are oriented toward road supply because transportation agencies have more control over changes in roadway supply than over demand changes. In most cases in the Urban Mobility Report database, traffic volume grows faster than lane-miles.

Conclusions

The analysis shows that **changes** in roadway supply have an effect on the **change** in delay. Additional roadways reduce the rate of increase in the amount of time it takes travelers to make congested period trips. In general, as the lane-mile "deficit" gets smaller, meaning that urban areas come closer to matching capacity growth and travel growth, the travel time increase is smaller. It appears that the growth in facilities has to be at a rate slightly greater than travel growth in order to maintain constant travel times, if additional roads are the only solution used to address mobility concerns. It is clear that adding roadway at about the same rate as traffic grows will slow the growth of congestion.

It is equally clear, however, that only five of the 85 intensively studied urban areas were able to accomplish that rate. There must be a broader set of solutions applied to the problem, as well as more of each solution than has been implemented in the past, if more areas are to move into the "maintaining conditions or making progress on mobility" category.

Analyses that only examine comparisons such as travel growth vs. delay change or roadway growth vs. delay change are missing the point. The only comparison relevant to the question of road, traffic volume and congestion growth is the relationship between all three factors. Comparisons of only two of these elements will provide misleading answers.

Exhibit B-15 shows the ratio of changes in demand (miles traveled) and supply (roadway) and the resulting change in the mobility level measured by the Travel Time Index. If road growth is a useful strategy for reducing the growth of congestion, lane-mileage increases that are faster than the traffic growth should improve conditions. If adding roads is not an effective strategy, the relationship between added roads and added demand will not indicate lower congestion growth for a demand-supply balance.

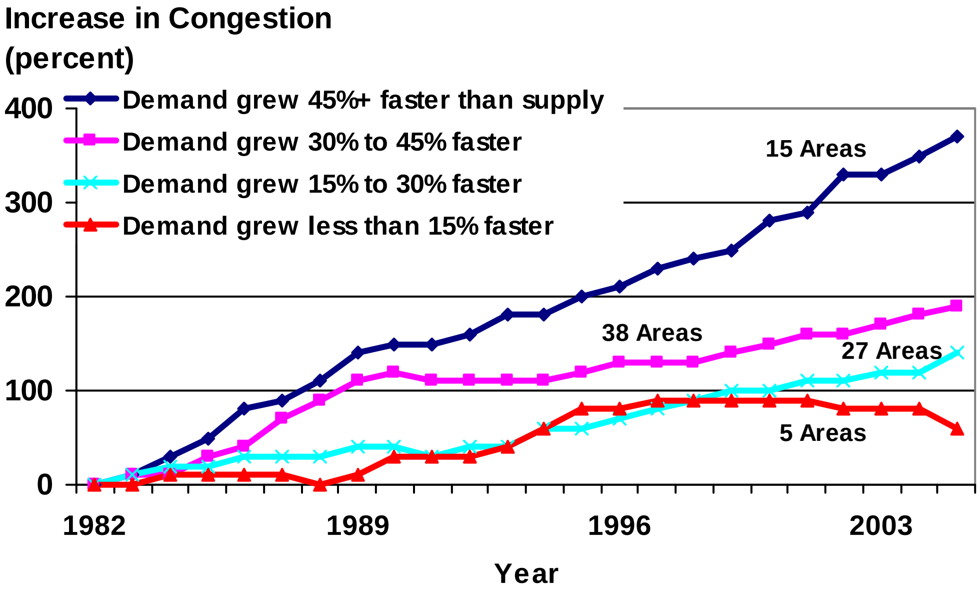
The 85 intensively studied urban areas were divided into three groups based on the differences between lane-mile growth and traffic growth. If an area's traffic volume grew relatively slowly, the road capacity would need to only grow slowly to maintain a balance. Faster traffic growth rates would require more road capacity growth. The key analysis point is to examine the **change** in demand, the **change** in supply and the **change** in congestion levels. This allows fast growth cities that have built roads in approximately the same rate that demand has grown to be judged against other areas where demand and supply changes have been balanced.

The four groups were arranged using data from 1982 to 2005:

- **Significant mismatch** – Traffic growth was more than 45 percent faster than the growth in road capacity for the 15 urban areas in this group.
- **Moderate mismatch** – Traffic growth was between 30 and 45 percent greater than road growth. There were 38 urban areas in this group.
- **Closer match** – Traffic growth was between 15 percent and 30 percent more than road growth. There were 27 urban areas in this group.
- **Narrow gap** – Road growth was within 15 percent of traffic growth for the 5 urban areas in this group.

The resulting growth in congestion is charted in Exhibit B-15, and the cities in each group are listed in Exhibit B-16. The 2005 Travel Time Index values were compared to the 1982 values to examine the growth in extra travel time (in a manner similar to the Consumer Price Index).

Exhibit B-15. Road Growth and Mobility Level



Note: Legend represents difference between traffic growth and road additions.

- A general trend appears to hold—the more that travel growth outpaced roadway expansion, the more the overall mobility level declined.
- The five urban areas with a demand-supply growth balance had their congestion levels increase at a much lower rate than those areas where travel increased at a much higher rate than capacity expansion. The demand increases in some of these areas was also relatively low compared to other areas in the study, which made it easier to add roads at the needed rate.
- The recession in California in the early 1990s and the combination of the economy and increased road construction efforts in Texas in the late 1980s and early 1990s affects the change in congestion levels during that time.
- The number of areas in each group is another significant finding. Only five urban areas were in the Narrow Gap group. Three of those, St. Louis, Pittsburgh and New Orleans, had populations greater than 1 million. Dayton, from the Medium population group, and Anchorage, from the Small group, were the other two. All of these areas had relatively low population growth rates from 1982 to 2005, indicating that the low demand growth may have been responsible for their inclusion in this group, rather than rapid road construction.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Exhibit B-16. Urban Area Demand and Roadway Growth Trends

Less than 15% Faster (5)
- Anchorage, AK
- Dayton, OH
- New Orleans, LA
- Pittsburgh, PA
- St. Louis, MO-IL

15% to 30% Faster (27)
- Beaumont, TX
- Boulder, CO
- Brownsville, TX
- Buffalo, NY
- Cape Coral, FL
- Charleston-North Charleston, SC
- Cleveland, OH
- Corpus Christi, TX
- Eugene, OR
- Fresno, CA
- Grand Rapids, MI
- Honolulu, HI
- Houston, TX
- Kansas City, MO-KS
- Memphis, TN-MS-AR
- Milwaukee, WI
- Nashville-Davidson, TN
- Oklahoma City, OK
- Philadelphia, PA-NJ-DE-MD
- Phoenix, AZ
- Richmond, VA
- Spokane, WA
- Springfield, MA-CT
- Tampa-St. Petersburg, FL
- Tucson, AZ
- Tulsa, OK
- Virginia Beach, VA

30% to 40% Faster (38)
- Akron, OH
- Albany-Schenectady, NY
- Albuquerque, NM
- Allentown-Bethlehem, PA-NJ
- Austin, TX
- Bakersfield, CA
- Birmingham, AL
- Boston, MA-NH-RI
- Bridgeport-Stamford, CT-NY
- Charlotte, NC-SC
- Cincinnati, OH-KY-IN
- Colorado Springs, CO
- Columbia, SC
- Denver-Aurora, CO
- Detroit, MI
- Hartford, CT
- Indianapolis, IN
- Jacksonville, FL
- Laredo, TX
- Little Rock, AR
- Los Angeles-LBch-Santa Ana, CA
- Louisville, KY-IN
- New Haven, CT
- New York-Newark, NY-NJ-CT
- Omaha, NE-IA
- Oxnard-Ventura, CA
- Pensacola, FL-AL
- Portland, OR-WA
- Providence, RI-MA
- Raleigh-Durham, NC
- Rochester, NY
- Salem, OR
- Salt Lake City, UT
- San Antonio, TX
- San Francisco-Oakland, CA
- San Jose, CA
- Seattle, WA
- Toledo, OH

45% Faster (15)
- Atlanta, GA
- Baltimore, MD
- Chicago, IL-IN
- Columbus, OH
- Dallas-Fort Worth-Arlington, TX
- El Paso, TX-NM
- Las Vegas, NV
- Miami, FL
- Minneapolis-St. Paul, MN
- Orlando, FL
- Riverside-San Bernardino, CA
- Sacramento, CA
- San Diego, CA
- Sarasota-Bradenton, FL
- Washington, DC-VA-MD

HOW MUCH MORE TRANSPORTATION CAPACITY WOULD BE NEEDED?

Road Construction

This is a difficult question to answer for at least two reasons.

- Most urban areas implement a wide variety of projects and programs to deal with traffic congestion. Each of these projects or programs can add to the overall mobility level for the area. Thus, isolating the effects of roadway construction is difficult because these other programs and projects are making a contribution at the same time.
- The relevancy of the analysis is questionable. Many areas focus on managing the growth of congestion, particularly in rapid growth areas. The analysis presented here is not intended to suggest that road construction is the best or only method to address congestion, but some readers will interpret it that way.

Conclusions

This analysis shows that it would be almost impossible to attempt to maintain a constant congestion level with road construction only. Over the past 2 decades, only about 50 percent of the needed mileage was actually added. This means that it would require at least twice the level of current-day road expansion funding to attempt this road construction strategy. An even larger problem would be to find suitable roads that can be widened, or areas where roads can be added, year after year. Most urban areas are pursuing a range of congestion management strategies, with road widening or construction being only one of them.

How Much Roadway has been Added?

Before we discuss the road growth issue, a word about our data. One answer to the question "How much roadway has been added?" is "not as much as our statistics indicate." The roadway growth in the Urban Mobility Report database includes the roads that were added because the urban boundary grew to include areas that previously were classified as rural. These existing, but newly urbanized, roads appear as additions to the urban databases, but do not have the same effect as new roadway. Even including these redesignated roads, however, the amount of added roadway is considerably less than that needed to match travel volume growth.

Examining Road Growth

This analysis uses the premise that enough road construction should take place so that the areawide congestion level is kept constant. For every percent increase in vehicle-miles of travel, it is assumed that there should be a similar percent increase in the lane-miles of roadway. Based on these assumptions, the percentage of the "Needed" roadway that has been "Added" can be calculated (Exhibit B-17). The 1982 to 2005 statistics show:

- Over the 24-year period, less than half of the roadway that was needed to maintain a constant congestion level was added. These percentages are actually higher than the amount that was "constructed" since they also include roadway mileage that was added through shifting urban boundaries and not just new construction.
- Exhibit B-18 also shows that the larger urban areas have done a little better, on average, at maintaining pace with the growth of travel.

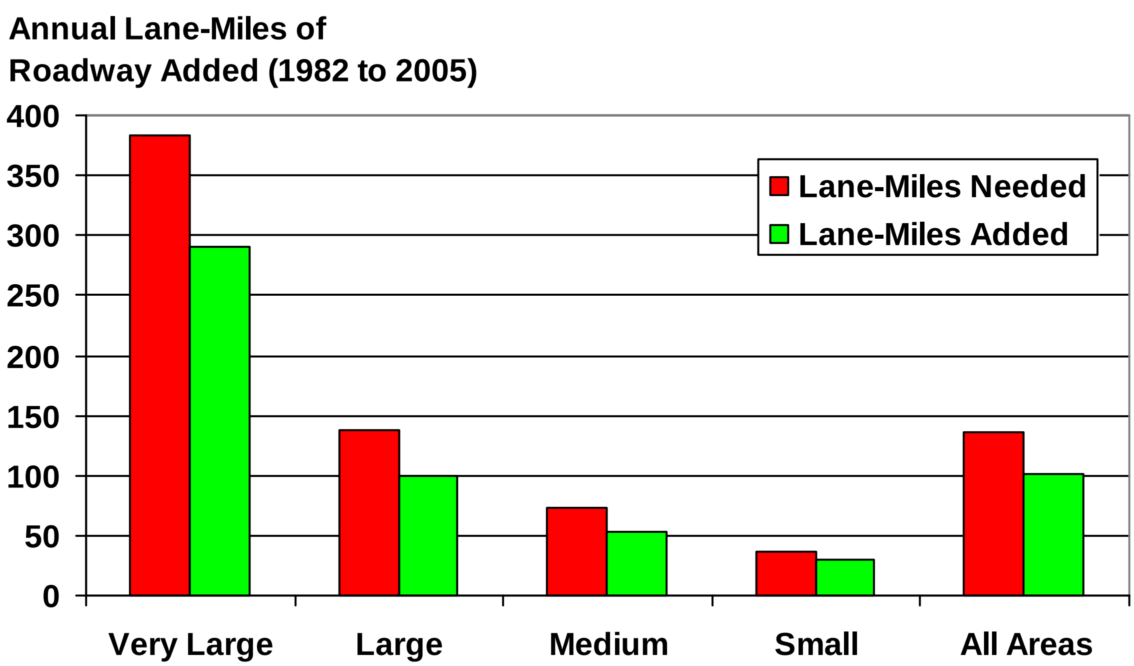
Exhibit B-17. Vehicle Travel and Roadway Additions

2005 Population Group Average	Avg. Annual Growth in Vehicle-Miles of Travel (1982 to 2005)	Percentage of Needed Roadway Added[1]
Very Large areas	3.1	41
Large areas	3.6	43
Medium areas	3.7	40
Small areas	4.0	42
85 area average	3.4	41

[1] Lane-miles added divided by lane-miles needed. "Lane-miles needed" are based on matching the VMT growth rate.

Note: Assumes that all added lane-miles are roadway system expansion. The database does not include data concerning the number of lane-miles added because of changing urban boundaries.

Exhibit B-18. Comparison of Roadway Added to Needed



- Over the 24-year period, less than half (41 percent) of the roadway that was needed to maintain a constant congestion level was actually added.
- There is very little difference between the roadway added percentage values for any of the population groups. Areas of all sizes are approximately equal in ability to add lane-miles.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

HOW MANY NEW CARPOOLS OR BUS RIDERS WOULD BE NEEDED IF THEY WERE THE ONLY SOLUTION?

Another method of examining the role and potential of public transportation is to examine the amount of service that would be required to address the growing delay problem if this were the only solution. Just as with the "roadway construction" only solution, this analysis will focus on the changes in occupancy level needed to accommodate travel growth. The results from this analysis show the increase in occupancy level in order to maintain existing congestion levels. But they are not intended to suggest that this is a realistic solution.

Conclusions

The 85 urban areas in the Urban Mobility Report added more than 52 million additional miles of daily person travel in 2005. To accomplish a goal of maintaining a constant congestion level in these areas by only adding transit riders of carpoolers, there would have to be a substantial growth in these modes. The growth would be equivalent to an additional 3 or 4 percent of all vehicles becoming carpools, or expanding transit systems by more than one-third of the current ridership each year.

It may be very difficult to convince this many persons to begin ridesharing or riding transit. As indicated elsewhere in this report, some success with this solution, in conjunction with other techniques may give an urban area the opportunity to slow the mobility decline.

Vehicle travel volume growth is estimated with the annual growth rate for the previous five years. Passenger-miles of travel are estimated using the standard 1.25 persons per vehicle value used elsewhere in the study. The growth in demand is estimated and the number of added passenger-miles of travel is divided by a simple national average trip length to estimate the number of additional trips that would have to be made by carpool or transit. Average trip lengths vary by metropolitan area. The length of a trip can have an effect on how much exposure a traveler has to congestion. For purposes of comparison, however, this report assumes one trip length for all areas.

- 5.6 million trips per day would have to be made as carpools or bus trips in the 85 urban areas to handle the 50 million additional person-miles of travel if congestion levels are to remain constant.
- On average, the occupancy of each vehicle in the 85 urban areas would have to rise by about 0.04 persons or, in other words, 4 out of every 100 vehicles would have to become a new 2-person carpool to handle one year's growth.

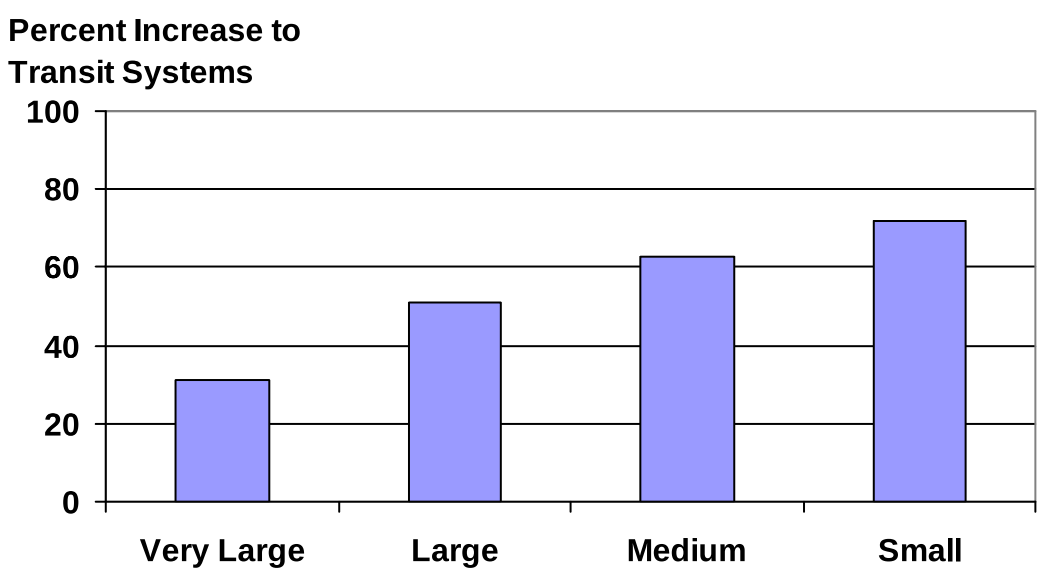
CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

How Many Trips Would be Needed on Transit?

Transit, like ridesharing, park-and-ride lots and high-occupancy vehicle lanes, typically have a greater effect on the congestion statistics in a corridor, rather than across a region. Transit and these other elements "compete" very well with the single-occupant vehicle in serving dense activity centers and congested travel corridors. But it is also useful to examine the data at the urban area level. Ridership statistics were gathered for the 85 intensively studied urban areas to determine how much more travel the systems would have to handle to offset congestion growth—again, if transit expansion was the only method to address travel growth. The additional passenger-miles of travel (or estimated trips) from the roadway were compared with the number of trips from existing transit service.

There are no other U.S. cities with ridership like New York City. Approximately one out of five U.S. transit trips are made in the New York area. Including these statistics would not present a useful comparison for typical cities over 3 million population; the New York data were removed from this comparison. The transit ridership increase that would be needed for each year in the remaining areas is shown in Exhibit B-19.

Exhibit B-19. Increase in Existing Transit System to Hold Congestion Constant



Note: The New York urban area statistics have been removed from the calculation.

- The Very Large urban areas would have to increase transit trips by over 30 percent to maintain a constant congestion level.
- The Large urban areas would have to add about half as many transit trips as they already have to maintain a constant congestion level.
- The Small and Medium urban areas would have to add at least two-thirds of their existing transit ridership to maintain their congestion level.

INCORPORATING THE EFFECT OF OPERATIONAL TREATMENTS

Many state and local transportation agencies, as well as the federal transportation program, have invested substantial funding in operational treatments and the future will include more of these programs in more cities. Technologies, operating practices, programs and strategies provide methods to get the most efficiency out of the road or transit capacity that is built, typically for relatively 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.

For the Urban Mobility Report database, the operational treatments were assessed for the delay reduction that results from the strategy as implemented in the urban area. A separate report, *Six Congestion Reduction Strategies and Their Effects on Mobility* (8), describes the process of estimating the delay reduction in more detail. The ITS deployment analysis system (9) model was used as the basis for the estimates of the effect of the operational treatments. The ITS deployment database (10) and the Highway Performance Monitoring System (6) include data on the deployment of several operational improvements. These two databases provide the most comprehensive and consistent picture of where and what has been implemented on freeways and streets in urban areas.

The delay reduction estimates are determined by a combination of factors:

- extent of the treatments
- congestion level of the location
- density of the treatment (if it applies)
- effect of the treatment

These factors are estimated from the databases, the inventory information found and applied within the existing Urban Mobility Report structure, and the delay reduction has been incorporated into several of measures calculated in the study.

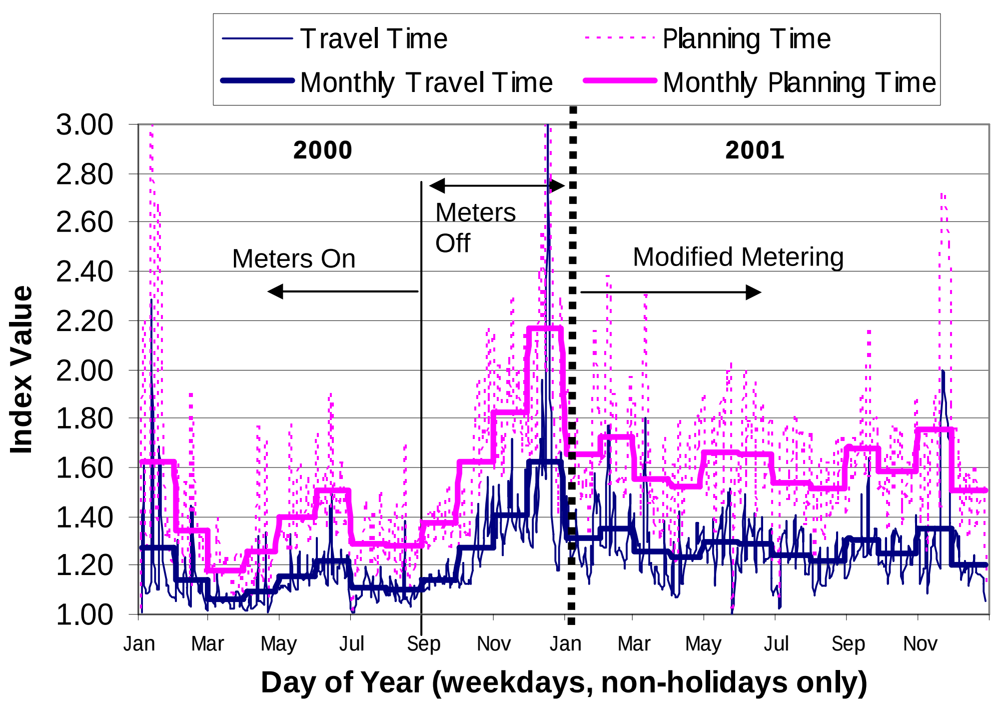
CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Freeway Entrance Ramp Metering

Entrance ramp meters regulate the flow of traffic on freeway entrance ramps. They are designed to create more space between entering vehicles so those vehicles do not disrupt the mainlane traffic flow. The signals, just as traffic signals at street intersections, allow one vehicle to enter the freeway at some interval (for example, every two to five seconds) They also somewhat reduce the number of entering vehicles due to the short distance trips that are encouraged to use the parallel streets to avoid the ramp wait time.

The effect of ramp metering was tested in Minneapolis-St. Paul in October 2000 when the extensive metering system was turned off and the freeway operated as it does in most other cities. The basic system was relatively aggressive in that ramp wait times of five minutes were not uncommon. The results of this systemwide experiment are clearly visible in the peak period data in Exhibit B-20. The Travel Time Index (average travel time) and the Planning Time Index (travel time that includes 19 out of every 20 trips) are plotted with each monthly average highlighted. Except for snowstorms, the highest values are during the shut-off experiment period. The metering experiment report produced by Cambridge Systematics (11) refers to a 22 percent increase in freeway travel time and the freeway system travel time becoming twice as unpredictable without the ramp meters. Congestion reductions are seen in January 2001 when a modified, less aggressive metering program was implemented. It might be interpreted that turning off the ramp meter system had the effect of a small snowstorm.

Exhibit B-20. Minneapolis-St. Paul Freeway System Congestion Levels

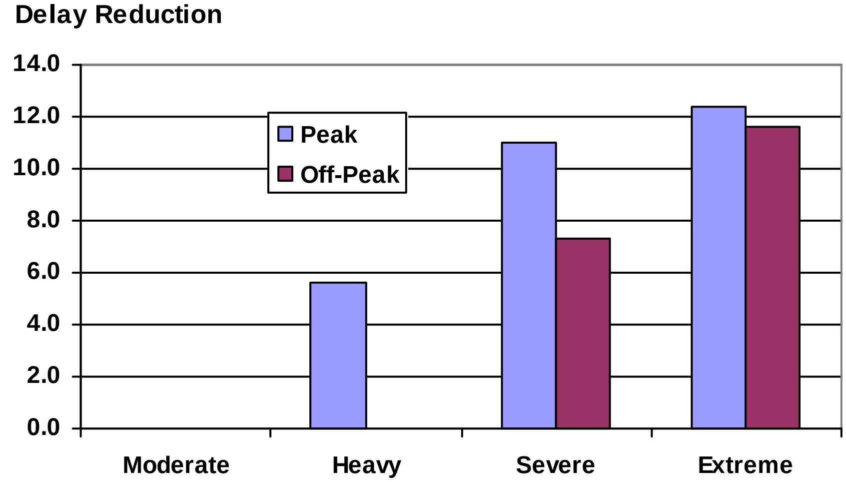


CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Delay Reduction Effects

The results of the Minneapolis experiment and simulation modeling performed for the Intelligent Transportation System Deployment Analysis System (IDAS) (9) have been combined into a relatively simple delay reduction estimation procedure for use in the Urban Mobility Report. Exhibit B-21 illustrates the delay reduction percentage for each of the four congestion ranges. More delay is subtracted from the more congested sections because there is more effect, particularly if the metering program can delay the beginning of stop-and-go conditions for some period of time.

Exhibit B-21. Ramp Metering Delay Reduction



Twenty-five of the urban areas reported ramp metering on some portion of their freeway system in 2005 (6,10). The average metered distance was 665 lane-miles which represents less than one-third of all the miles in the 25 cities. The effect was to reduce delay by 29.4 million person hours, approximately 2.4 percent of the freeway delay (Exhibit 22). This value is combined in the operational effects summary at the end of this section.

- Los Angeles has the largest delay reduction estimate in the Very Large group.
- Minneapolis-St. Paul, Riverside-San Bernardino and San Diego have the most extensive metering benefits in the Large group.
- Of the 46 areas studied with under one million population, only three reported any metering.

Exhibit B-22. Freeway Ramp Metering Delay Reduction Benefits - 2005

Population Group	Average Covered Freeway Lane-miles		Freeway Hours of Delay (million)
	Lane-miles	Percentage	Reduction
Very Large (12)	724	28	29.4
Large (10)	605	54	9.2
Medium (3)	151	36	0.8
Small (0)	0	0	0.0
25 Area Average	665	34	--
25 Area Total	16,637	34	38.6

Source: HPMS, IDAS, and TTI Analysis
Note: This analysis uses nationally consistent data and relatively simplistic estimation procedures. Local or more detailed evaluations should be used where available. These estimates should be considered preliminary pending more extensive review and revision of base inventory information obtained from source databases.

Freeway Incident Management Programs

Freeway Service Patrol, Highway Angel, Highway Helper, The Minutemen and Motorists Assistance Patrol are all names that have been applied to the operations that attempt to remove crashed and disabled vehicles from the freeway lanes and shoulders. They work in conjunction with surveillance cameras, cell phone reported incident call-in programs and other elements to remove these disruptions and decrease delay and improve the reliability of the system. The benefits of these programs can be significant. Benefit/cost ratios from the reduction in delay between 3:1 and 10:1 are common for freeway service patrols (12). An incident management program can also reduce "secondary" crashes—collisions within the stop-and-go traffic caused by the initial incident. The range of benefits is related to traffic flow characteristics as well as to the aggressiveness and timeliness of the service.

Addressing these problems requires a program of monitoring, evaluation and action.

- Monitoring—Motorists calling on their cell phones are often the way a stalled vehicle or a crash is reported, but closed circuit cameras enable the responses to be more effective and targeted. Shortening the time to detect a disabled vehicle can greatly reduce the total delay due to an incident.

- Evaluation—An experienced team of transportation and emergency response staff provide ways for the incident to be quickly and appropriately addressed. Cameras and on-scene personnel are key elements in this evaluation phase.

- Action—Freeway service patrols and tow trucks are two well-known response mechanisms that not only reduce the time of the blockage but can also remove the incident from the area and begin to return the traffic flow to normal. Even in states where a motorist can legally move a wrecked vehicle from the travel lanes, many drivers wait for enforcement personnel dramatically increasing the delay. Public information campaigns that are effective at changing motorists' behavior (that is, move vehicles from the travel lanes when allowed by law) are particularly important.

An active management program is a part of many cities comprehensive strategy to get as much productivity out of the system as possible. Removing incidents in the off-peak periods may also be important particularly in heavily traveled corridors or those with a high volume of freight movement. Commercial trucks generally try to avoid peak traffic hours, but the value of their time and commodities, as well as the effect on the manufacturing and service industries they supply can be much greater than simple additional minutes of travel time.

Delay Reduction Effects

The basic Urban Mobility Report methodology includes an estimate of the delay due to incidents. This estimate is based on roadway design characteristics and incident rates and durations from a few detailed studies. These give a broad overview, but an incomplete picture of the effect of the temporary roadway blockages. They also use the same incident duration patterns for all urban areas. Incidents are estimated to cause somewhere between 52 and 58 percent of total delay experienced by motorists in all urban area population groups. A more complete understanding of how incidents affect travelers will be possible as continuous travel speed and traffic count monitoring equipment is deployed on freeways and major streets in U.S. cities. Unfortunately, that equipment is in place and recording data in only a few cities. These can, however, give us a view of how travel speeds and volumes change during incidents.

The results of incident management program evaluations conducted in several cities and simulation modeling performed for the Intelligent Transportation System Deployment Analysis System (IDAS) (9) have been used to develop a delay reduction estimation procedure. The process estimates benefits for monitoring cameras and service patrol vehicles (Exhibits B-23 and B-24) with the cameras receiving less benefit from the identification and verification actions they assist with than the removal efforts of the service patrol. As with the ramp metering programs, more delay is subtracted from the more congested sections because there is more effect.

Exhibit B-23. Benefits of Freeway Service Patrols

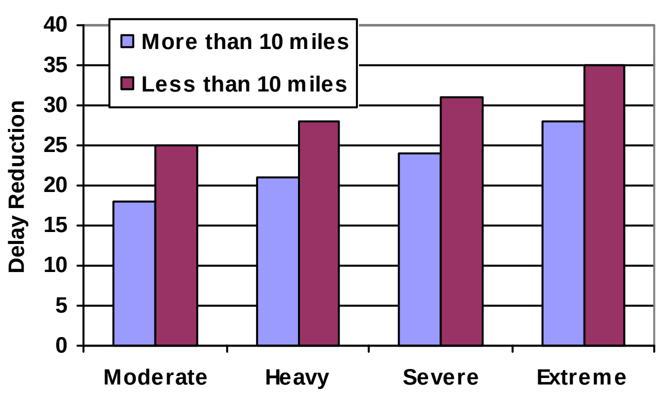
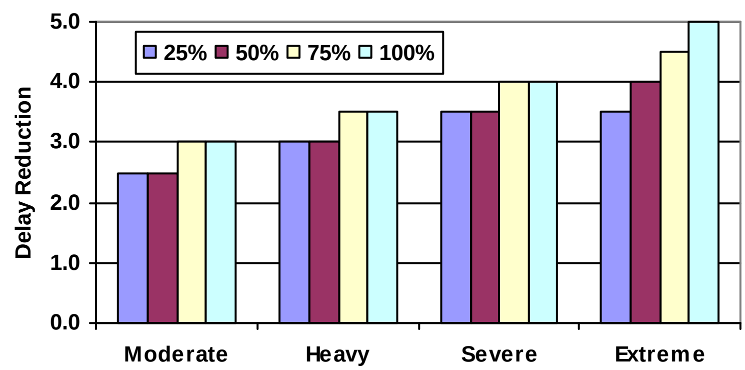


Exhibit B-24. Benefits of Freeway Surveillance Cameras



More than 74 areas reported one or both treatments in 2005, with the coverage representing from one-third to two-thirds of the freeway miles in the cities (7,11). The effect was to reduce delay by 127 million person hours, approximately seven percent of the freeway delay (Exhibit B-25). This value is combined in the operational effects summary at the end of this section.

Incident Management

- The New York City and Los Angeles regions are estimated to derive the most benefit from incident management.
- Minneapolis-St. Paul and San Diego are estimated to have the most benefit in the Large group.
- Austin, Nashville and Louisville are the areas within the Medium group with the highest delay reduction benefit.

Exhibit B-25. Freeway Incident Management Delay Reduction Benefits

Population Group	Average Covered Freeway Lane-miles		Freeway Hours of Delay (million)
	Lane-miles	Percentage	Delay Reduction
Surveillance Cameras			
Very Large (14)	1,460	50	Delay Reduction Included Below
Large (25)	436	37	
Medium (26)	202	35	
Small (9)	99	34	
67 Area Average	531	43	
67 Area Total	35,553	43	
Service Patrols			
Very Large (14)	2,208	76	96.5
Large (25)	668	62	24.1
Medium (26)	312	56	6.0
Small (9)	212	76	0.2
67 Area Average	832	68	–
67 Area Total	55,743	68	126.8

Source: HPMS, IDAS, and TTI Analysis

Note: This analysis uses nationally consistent data and relatively simplistic estimation procedures. Local or more detailed evaluations should be used where available. These estimates should be considered preliminary pending more extensive review and revision of base inventory information obtained from source databases.

Traffic Signal Coordination Programs

Traffic signal timing can be a significant source of delay on the major street system. Much of this delay is the result of the managing the flow of intersecting traffic, but some of the delay can be reduced if the streams arrive at the intersection when the traffic signal is green instead of red. This is difficult in a complex urban environment, and when traffic volumes are very high, coordinating the signals does not work as well due to the long lines of cars already waiting to get through the intersection.

There are different types of coordination programs and methods to determine the arrival of vehicles, but they all basically seek to keep moving the vehicles that approach intersections on the major roads, somewhat at the expense of the minor roads. On a system basis, then, the major road intersections are the potential bottlenecks.

Delay Reduction Estimates

Some of the delay reduction from signal coordination efforts that have been undertaken in the U.S. is the attention that is given to setting the signal timing to correspond to the current volume patterns and levels and to recalibrate the equipment. It is often difficult to identify how much of the benefit is due to this "maintenance" function and how much is due to the coordination program itself. The Urban Mobility Report methodology draws on the evaluations and simulation modeling performed for the Intelligent Transportation System Deployment Analysis System (IDAS) (9) to develop the delay reduction estimation procedure shown in Exhibits B-26 and B-27. There is less benefit for the more heavily congested sections of the street system due to the conflicting traffic flows and vehicle queues. The benefits of an actuated system (where the signals respond to demand) are about one-third of the benefits of a centrally controlled system that monitors and adapts the signals to changes in demand.

All 85 areas reported some level of traffic signal coordination in 2005, with the coverage representing slightly over half of the street miles in the cities (6,10). Signal coordination projects, because the technology has been proven, the cost is relatively low and the government institutions are familiar with the implementation methods, have the highest percentage of cities and road miles with a program. The evolution of programs is also evident in the lower percentage of advanced progressive systems. These systems require more planning, infrastructure, and agency coordination.

Exhibit B-26. Signal Coordination Benefits (actuated)

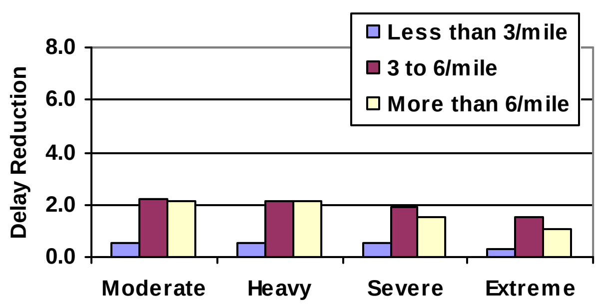
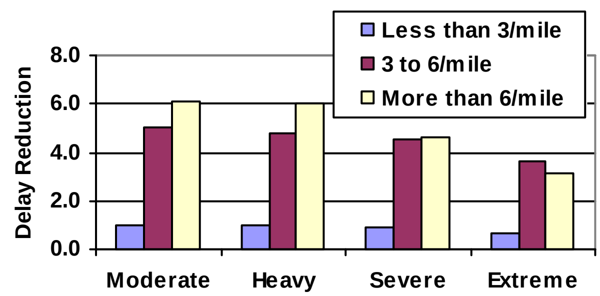


Exhibit B-27. Signal Coordination Benefits (progressive)



The effect of the signal coordination projects was to reduce delay by 16.7 million person hours, approximately one percent of the street delay (Exhibit B-28). The percentage is slightly higher in the Large population group where there is less congestion in the severely and extremely congested ranges. This value is combined in the operational effects summary at the end of this section.

While the total effect is relatively modest, the relatively low percentage of implementation should be recognized, as should the relatively low cost and the amount of benefit on any particular road section. The modest effect does not indicate that the treatment should not be implemented—why would a driver wish to encounter a red light if it were not necessary? The estimates do indicate that the benefits are not at the same level as a new travel lane, but neither are the costs or the implementation difficulties or time. It also demonstrates that if there are specific routes that should be favored—due to high bus ridership, an important freight route or parallel route road construction—there may be reasons to ignore the system or intersecting route effects.

- Los Angeles and New York are the Very large areas with the highest benefits.
- Denver and San Diego are the Large areas with the most hours of delay benefit from signal coordination in areas between one and three million population.
- Austin, Jacksonville and Omaha in the Medium areas and Colorado Springs in the Small areas lead their population group.

Exhibit B-28. Principal Arterial Street Traffic Signal Coordination Delay Reduction Benefits - 2005

Population Group	Average Covered Lane-miles		Principal Arterial Hours of Delay (million)
	Lane-miles	Percentage	Reduction
Very Large (14)	5,340	57	10.9
Large (25)	1,485	52	3.7
Medium (30)	651	45	1.8
Small (16)	354	48	0.3
85 Area Average	1,613	53	–
85 Area Total	137,098	53	16.7

Source: HPMS, IDAS, and TTI Analysis

Note: This analysis uses nationally consistent data and relatively simplistic estimation procedures. Local or more detailed evaluations should be used where available. These estimates should be considered preliminary pending more extensive review and revision of base inventory information obtained from source databases.

Arterial Street Access Management Programs

Providing smooth traffic flow and reducing collisions are the goal of a variety of individual treatments that make up a statewide or municipal access management program. Typical treatments include consolidating driveways to minimize the disruptions to traffic flow, median turn lanes or turn restrictions, acceleration and deceleration lanes and other approaches to reduce the potential collision and conflict points. Such programs are a combination of design standards, public sector regulations and private sector development actions. The benefits of access management treatments are well documented in National Cooperative Highway Research Program (NCHRP) Report 420 (13).

Delay Reduction Estimates

NCHRP Report 395 analyzed the impacts of going from a TWLTL to a raised median for various access point densities and traffic volumes (14). Tables produced in NCHRP Report 395 were used in the Urban Mobility Report methodology to obtain delay factors for both recurring and incident delay.

There is an increase in recurring delay for through and left-turning traffic when going from a TWLTL to a raised median. This increase is primarily due to the storage limitations of select turn bay locations with the raised median treatments. As the turn bays become full, traffic spills out into the through lanes and increases the delay of through vehicles. This situation worsens with increased congestion levels and increased signal density (17). The percent increase factors shown in Exhibit B-29 are applied to the recurring delay on the principal arterial streets to account for this increased delay.

Raised medians can increase roadway safety by reducing the number of conflict points and managing the location of the conflict points. The reduction in conflict points equates to a reduction in crashes. This benefit of the raised medians was included in the methodology. The delay factors were generated for roadways going from a TWLTL to a raised median. Exhibit B-30 shows the percent reduction factors that range from 12 percent at low signal density (≤ signals/mile) and the lowest congestion level to 22 percent at high signal density (>3 signals/mile) and the highest congestion level (14). These percent reduction values are applied to the incident delay on the principal arterial streets in the methodology.

All 85 areas reported some level of access management in 2005, with the coverage representing about 29 percent of the street miles in the cities (6,10). The effect of access management was to reduce delay by 58 million person hours, approximately 3 percent of the principal arterial street delay (Exhibit B-31). The percent reduction drops as the size of the urban area gets smaller.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Exhibit B-29. Access Management Recurring Delay Effects

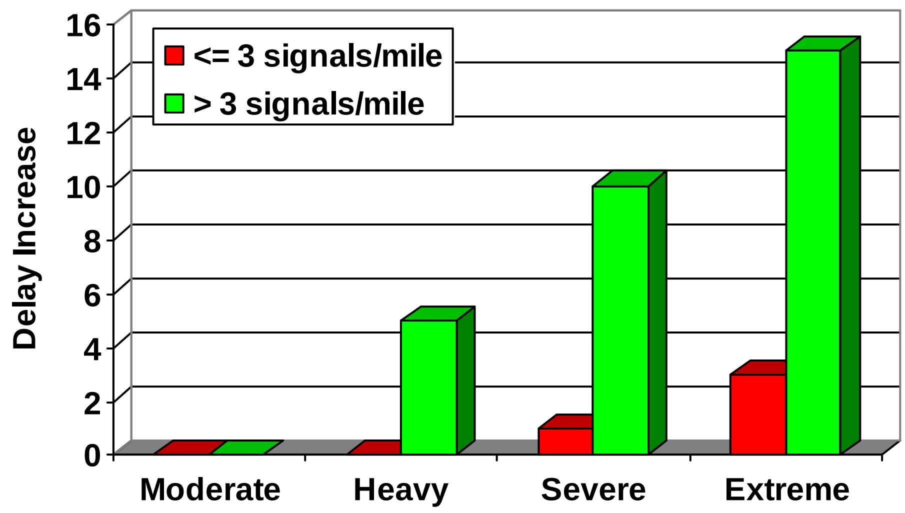
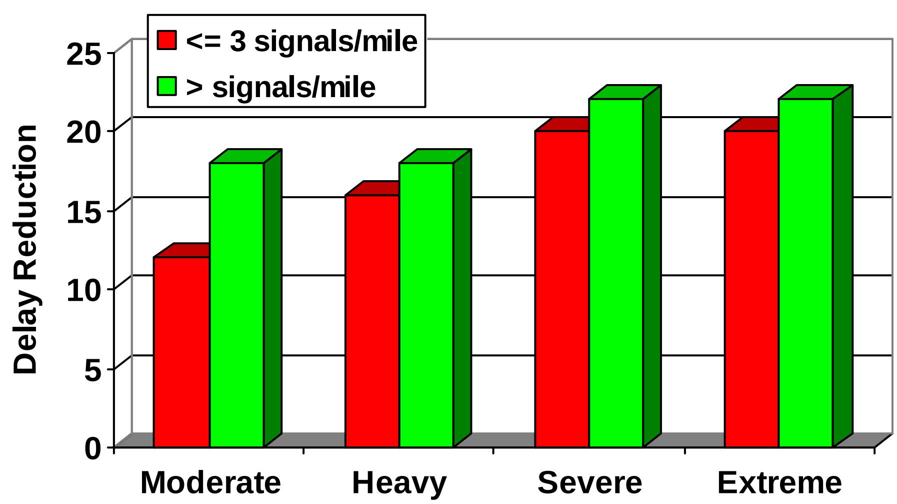


Exhibit B-30. Access Management Incident Delay Effects



Source: HPMS and TTI Analysis

Exhibit B-31. Principal Arterial Street Access Management Delay Reduction Benefits

Population Group	Average Covered Lane-miles		Principal Arterial Hours of Delay (million)
	Lane-miles	Percentage	Reduction
Very Large (14)	3,123	33	38.3
Large (25)	795	28	13.7
Medium (30)	303	21	4.9
Small (16)	140	19	0.8
85 Area Average	882	29	--
85 Area Total	74,928	29	57.7

Source: HPMS and TTI Analysis

Note: This analysis uses nationally consistent data and relatively simplistic estimation procedures. Local or more detailed evaluations should be used where available. These estimates should be considered preliminary pending more extensive review and revision of base inventory information obtained from source databases.

Combined Effect of Operational Treatments

The delay reduction benefits of four operational treatments analyzed in this edition of the Urban Mobility Report are combined into an estimate of the total effect of the deployed projects in the 85 urban areas. The inventory of all projects is identified in Exhibit B-32 by the percentage of miles on freeways and streets that have one of the programs or projects implemented. Exhibit B-32 shows the relatively low percentage of not only cities that have some treatments but also the low percentage of roads that have any treatment.

The total effect of the delay reduction programs represents 7.1 percent of the delay in the 85 cities. Again, the value seems low but when the low percentage of implementation is factored in, the benefit estimates are reasonable. The programs are also important in that the benefits are on facilities that have been constructed. The operating improvements represent important efficiencies from significant expenditures that have already been made.

Exhibit B-32. Total Operational Improvement Delay Reduction

Operations Treatment	Number of Cities	Percent of System Covered	Delay Reduction Hours (millions)
Ramp Metering	25	34	39
Incident Management	67	43-68	127
Signal Coordination	85	53	17
Access Management	85	29	58

Note: This analysis uses nationally consistent data and relatively simplistic estimation procedures. Local or more detailed evaluations should be used where available. These estimates should be considered preliminary pending more extensive review and revision of base inventory information obtained from source databases.

MOBILITY BENEFITS FROM PUBLIC TRANSPORTATION SERVICE

Previous Urban Mobility Reports have included examples of the amount of public transportation improvements needed to address congestion. The next step is the inclusion of public transportation service in the general measures and analysis. Buses and trains carry a significant amount of trips in many large areas, and provide 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.

Public Transportation Service

The mobility report methodology uses person volume and speed as the two main elements of the measurement analysis. While this is consistent with the goals of public transportation service, there are differences between several aspects of road and transit operations. Regular route bus transit service stops frequently to allow riders to enter and leave the vehicles. Train service in many cases also makes more than one stop per mile. The goal of the service is to provide access to the area near the stops as well as move passengers to other destinations. A useful comparison with road transportation systems, therefore, cannot use the same standards or same comparison methods.

The data sources for this type of analysis are a combination of locally collected and nationally consistent information. The nationally consistent data is available for ridership, passenger miles of travel, service mileage and hours. Consistent roadway data is available for similar statistics, but the relationship between volume and speed on the roadway side is more studied and more easily estimated than for transit service. Some simplifying assumptions, therefore, have been made to initiate the analysis. The next few years will see additional investigations of these statistics and the data that might be available with a goal of reducing the number of assumptions that are needed as well as improving the estimates that are made.

The method used in this analysis to estimate a revised Travel Time Index focused on similar expectations. Transit service, while the average speed may be slower, is operated according to a schedule. Riders and potential riders evaluate the service and make mode choices according to either the departure and arrival times or in the case of operations that run very frequently, the travel time to the destination with the expectation that the departure time will be relatively soon after arrival in the station. In transit operations this can be thought of as similar to an uncongested trip. Public transportation service that operates on-time according to the schedule, then, would be classified as uncongested travel.

It may seem odd to disregard travel speed in this sense, but the service differences are important. Attempting to estimate the slower speeds on transit routes and incorporating them into the analysis would, in essence, double penalize the service. Travelers already use the travel times to make their decisions and the longer times are the reason ridership is relatively low during off-peak hours. Transit routes could 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. And this approach to defining a different standard speed for transit routes is similar to the different threshold used for streets and freeways.

The “penalty” or “reward” for public transportation in this revised Travel Time Index 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.

The delay benefits were calculated using the “what if transit riders were in the general traffic flow” case. Additional traffic on already crowded road networks would affect all the other peak period travelers as well. This is an artificial case in the sense that the effects of a transit service shutdown would be much more significant and affect more than just the transit riders or roadway travelers. Public transportation patrons who rely on the service for their basic transportation needs would find travel much more difficult, making jobs, school, medical or other trip destinations much harder to achieve. And the businesses that count on the reliable service and access to consumers and workers that public transportation provides would suffer as well.

Delay Effect Estimate

In the 437 urban areas studied, Exhibit B-33 shows that there were approximately 51 billion passenger-miles of travel on public transportation systems in 2005 (15). The annual ridership ranged from about 18 million in the Small urban areas to about 2.7 billion in the Very Large areas. Overall, if these riders were not handled on public transportation systems they would contribute an additional roadway delay of over 541 million hours or 13 percent of total delay. Some additional effects include:

- The Very Large areas would experience an increase in delay of about 430 million hours per year (18 percent of total delay). This is the result of the significant public transportation ridership in these areas. Most of the urban areas over 3 million population have extensive rail systems and all have very large bus systems.
- The Large urban areas would experience the second largest increase in delay with 64 million additional hours of delay per year. While the average Large area transit system carried only 7 percent of the ridership of the Very Large area systems, the delay increase would represent 15 percent of the Very Large group because there are 25 Large areas.
- The New York urban area accounted for almost 40 percent of the delay increase estimated in the report.

- The Los Angeles, Chicago and San Francisco-Oakland systems are each estimated to provide almost 100 million hours of benefit each year.
- The largest benefits in the Large population group are in Baltimore and San Diego.
- Honolulu, Salt Lake City and Austin have the highest delay increase in the Medium group if public transportation service were eliminated.
- Colorado Springs, Bakersfield and Eugene-Springfield are estimated to have the most delay increase of the Small urban area group. Only 16 cities of that size were studied, however, which should be accounted for if a broad conclusion is required.

Exhibit B-33. Delay Increase if Public Transportation Service Were Eliminated – 85 Areas

Population Group & Number of Areas	Population Group Average Annual Passenger-Miles of Travel (million)	Delay Reduction Due to Public Transportation	
		Hours of Delay (million)	Percent of Base Delay
Very Large (14)	2,692	429.6	18.1
Large (25)	218	63.9	7.4
Medium (30)	56	14.6	4.4
Small (16)	18	1.4	2.9
85 Area Total	45,102	509.6	14.2
Other Areas (352	18	31.3	5.3
All Areas	51,426	540.8	12.9

Source: APTA Operating Statistics and TTI Review (15)

Future Improvements to Public Transportation Analysis

A longer-term approach will be to develop links with the system 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 (7). 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 some of this information; the challenge is to develop comparable datasets.

MOBILITY BENEFITS FROM HIGH-OCCUPANCY VEHICLE LANES

High-occupancy vehicle lanes (also known as diamond lanes, bus and carpool lanes, transitways) provide a high-speed travel option to buses and carpools as an incentive to share a vehicle and reduce the number of vehicle trips. The lanes are most used during the peak travel periods when congestion is worst and the time savings compared to the general travel lanes is most significant. In addition to saving time on an average trip, the HOV lanes also provide more reliable service as they are less affected by collisions or vehicle breakdowns.

The HOV lanes provide service similar to freeway mainlanes in that there are relatively few lanes that have stations on the route. The buses on the lanes can either pickup patrons on regular bus routes before entering the HOV lane, or they can provide service to a park-and-ride lot that allows patrons to drive their private vehicle to a parking lot and use a bus to their destination. The high-speed lanes are also open to use by carpools (although there are some bus-only lanes) which provide additional flexibility for use by travelers.

Another version of high-occupancy vehicle lane involves allowing single-occupant vehicles to use the lane for a fee. These have been labeled high-occupancy/toll lanes (HOT lanes) and, while fewer than ten of these projects exist, many more are being planned and studied. The advantages of high speed and reliable transportation service can be extended to another user group. If a variable tolling system is used to maintain high-speed operations (e.g., by charging a higher toll when the freeway mainlanes are congested) more vehicles can be allowed to use the lane without the possibility of speed decreases or congestion.

<u>Delay Reduction Estimate</u>

HOV lane service is similar to the general freeway operation, and because HOV lane data is not included in the regular freeway data, the operating statistics (e.g., speed, person volume and miles traveled) can be added to the freeway and street data. Exhibit B-34 is a summary of HOV lane operations in several urban corridors from the year 2005. While this is only a partial list of HOV projects, it provides a view of the usefulness of the data, as well as an idea of the mobility contribution provided by the facilities. The exhibit includes information about the typical peak period operating conditions (three hours in the morning and evening) on the HOV lane. The statistics from six peak hours of operation may appear to show relatively low ridership, but in some corridors the significant benefits may only be for one hour in each peak. Some other aspects of the corridor operations such as the variation in travel time and the effects of park-and-ride service or transit operations are also not fully explored in these statistics.

The data for freeway mainlanes and HOV lanes in a city or region can be combined to produce an improved Travel Time Index. This index and other statistics can provide a multimodal mobility estimate.

Exhibit B-34. Mobility Levels in HOV Corridors in 2005

		Peak Period Operations	
	Miles	Person Volume	Average Speed (mph)
Atlanta			
I-75	20.0	6,340	54
I-85	20.0	7,890	52
I-20	8.5	7,240	49
Dallas			
I-30 East	5.5	6,350	60
I-35 North	7.3	4,850	60
I-35 South	9.0	6,000	60
I-635 North	6.7	9,410	62
Denver			
I-25	7.0	9,700	57
Houston			
I-10 West	12.3	23,290	52
I-45 North	19.3	26,660	54
I-45 South	15.0	17,940	56
US 290	13.4	23,050	52
US 59 South	11.5	22,680	59
US 59 North	19.9	12,380	60
Los Angeles			
LA/Ventura Counties			
I-10	20.1	13,740	53
SR-14	35.9	9,880	66
SR-57	4.5	8,700	27
SR-60	7.5	8,770	54
SR-91	14.3	10,390	55
I-105	16.0	11,360	32
I-110	10.7	24,170	58
SR-118	11.4	9,510	69
SR-134	12.8	7,110	67
SR-170	6.1	6,770	42
I-210	27.2	22,930	39
I-405	16.7	20,700	35
I-605	20.7	11,500	59
Orange County♦			
I-5	35.3	N/A♦	53
SR-55	10.3	N/A♦	56
SR-57	12.1	N/A♦	50
SR-91	22.2	N/A♦	53
I-405	23.6	N/A♦	55
Miami			
I-95 North	31.4	4,450	57
I-95 South	22.7	5,600	52
Minneapolis-St. Paul			
I-394	10.4	9,920	65
I-35W	7.5	5,590	58
New York			
Long Island Expressway	40.0	3,150	60

♦Passenger-miles of travel estimated from Caltrans PEMS data.

Exhibit B-34. Mobility Levels in HOV Corridors in 2005, continued

	Miles	Peak Period Operations: Person Volume	Peak Period Operations: Average Speed (mph)
Phoenix			
I-10 West	21.0	4,000	60
I-10 East	5.0	4,000	60
SR-202	9.0	3,000	60
I-17	7.0	3,000	60
Portland			
I-5/I-405	6.7	7,700	34
Riverside-San Bernardino♦			
SR-60	13.3	N/A♦	58
SR-91	17.6	N/A♦	52
I-10	8.4	N/A♦	58
I-210	10.4	N/A♦	58
SR-71	7.7	N/A♦	57
Sacramento			
US-50	11.5	1,710	63
I-80	9.6	1,970	63
SR-99	14.3	3,070	47
San Francisco-Oakland			
I-80 (Alameda County)	5.3	16,760	53
I-84 (Alameda County)	2.0	4,900	60
SR-92 (Alameda County)	3.0	5,060	60
I-680 (Alameda County)	14.0	3,840	65
I-880 (Alameda County)	20.5	5,920	65
SR-4 (Contra Costa County)	7.0	4,930	65
I-80 (Contra Costa County)	9.9	10,670	48
I-680 (Contra Costa County)	12.9	6,080	65
US-101 (Marin County)	6.1	4,810	47
SR-85 (Santa Clara County)	23.8	3,750	65
US-101 (Santa Clara County)	34.8	3,790	64
Seattle			
I-5 South	16.5	51,880	55
I-5 North	18.4	77,330	54
I-405 South	12.9	42,260	55
I-405 North	15.9	60,890	57
I-90	7.4	30,010	60
SR-520	7.0	21,550	55
SR-167	9.2	51,960	59
Virginia Beach			
I-64	14.0	1,500	64
I-64 SS	9.0	3,620	64
I-264	9.0	3,070	59
Washington, DC			
I-395	28.4	26,010	63
I-66	27.9	14,010	40
I-270	18.4	5,920	49
VA 267	24.2	6,550	51
US 50	9.1	4,010	64

♦Passenger-miles of travel estimated from Caltrans PEMS data.

COMBINED EFFECT OF PUBLIC TRANSPORTATION AND OPERATIONAL IMPROVEMENTS

The analytical improvements will continue to be developed and incorporated into the Urban Mobility Report. The values and approach may change, but the goal is to include all the types of transportation improvements in a comprehensive areawide mobility assessment. The use of the information may also encourage local and state transportation officials to develop their own databases and procedures to maximize the flexibility and inclusiveness of corridor and sub-regional evaluations, as some agencies are doing now.

The expanded version of the methodology used in this report is available on the website (http://mobility.tamu.edu/ums). The summary statistics at the population group level for 2005 are illustrated in Exhibit B-35. Most of the delay in the 437 urban areas is in the 14 areas with populations above three million, so it should not be surprising that the majority of the operational treatment benefits are in those areas as well. Large areas not only have had large problems for longer, and thus more incentive to pursue a range of solutions, but the expertise needed to plan and implement innovative or complex programs are also more likely to be readily accessible.

Several of the areas with populations between one million and three million also have significant contributions from four or five of the six treatments identified in the report. Some of the delay reduction estimates are as large or larger than the above three million population areas. The medium group areas have relatively small overall contributions due to the low congestion level, but they are also implementing and refining techniques that will be more valuable as congestion grows.

The Travel Time Index change from the base value to the "inclusive" value follows the same pattern as the delay reduction—much more change in the Very Large group than in the others. The TTI values are presented with three decimal places to better illustrate the amount of change. The amount of change should be gauged against the base TTI value—small areas with less congestion that have implemented more operational treatments or a more extensive transit system may have larger changes as a percentage of the base value than larger areas that have not used these options.

Several other observations about this initial attempt to include a broader set of mobility treatments in the regular mobility data reporting are listed below.

- The significant investment in operations treatments in states that are widely judged to be among the leaders in these technologies is evident. California, Minnesota, Illinois, Arizona, Oregon and Washington have relatively large delay reductions, in several case for cities outside the "most congested" list.
- The delay reduction estimate for public transportation service should be considered as "delay avoided" because the calculation involves comparing current operations to conditions that might exist if the service were not in operation.
- Almost three-fourths of delay reduction from incident management and ramp meters is in the Very Large group.
- Although the percentage of "treated" streets and freeways is relatively low, the combined effects are equal to several years of growth in the Very Large group, and one or two years in the Large and some of the Medium group cities.

Exhibit B-35. Summary of Public Transportation and Operational Improvement Delay Reduction Effects - 2007

	Population Group – Annual Hours Saved (million)					
	Very Large	Large	Medium	Small	Intensively Studied	All 439
Number of Cities	14	29	31	16	90	439
Delay Reduction from						
Ramp Metering	30.7	9.0	0.1	0.0	39.8	39.8
Incident Management	102.7	29.5	4.3	0.6	137.1	143.3
Signal Coordination	10.3	4.1	1.6	0.3	16.3	19.4
Access Management	38.1	16.6	5.1	0.8	60.6	68.8
High-Occupancy Vehicles	33.8	3.2	0.0	0.0	37.0	37.0
Delay Savings from Public Transportation	557.6	58.8	12.8	1.5	630.1	645.9

Communicating Mobility and Reliability Issues

The transportation profession is adopting a distinction between mobility—the ease of getting to a destination—and reliability—the predictability of travel times for usual trips. Travelers, elected leaders, the media and decision-makers may question the relevance of this distinction since problems with both elements cause increases in travel times and costs. The two concepts are clearly related, but the difference is useful when discussing solutions. Most of the computerized simulation and planning tools are not equipped to fully handle this issue, and so a significant amount of the data on congestion relates to the average of fairly good conditions—midweek day, clear weather and pavement, no collisions or lane-blocking roadwork, etc.—rather than the conditions that travelers and shippers must allow for to arrive on-time for important trips.

There are some strategies that focus on improving "mobility"—improving travel time—by adding capacity, improving the operational efficiency or managing demand in such way as to reduce the peak load. But there are also transportation improvements that reduce average travel time by reducing the amount of irregular problems or the influence of them on travel time. Incident management is the most obvious of these, but others such as providing bus or road routing information, improving interagency or interjurisdictional cooperation and communication and partnerships with private companies can pay huge benefits in reduction of incident clearance times and travel time variations.

The ability to predict travel times is highly valued by travelers and businesses. It affects the starting time and route used by travelers on a day-to-day basis, and the decisions about travel mode for typical trips and for day-to-day variations in decisions. Reliability problems can be traced to seven sources of travel time variation in both road and transit operations. Some are more easily addressed than others and some, such as weather problems, might be addressed by communicating information, rather than by agency design or operations actions.

- Incidents—collisions and vehicle breakdowns causing lane blockages and driver distractions.
- Work Zones—construction and maintenance activity that can cause added travel time in locations and times where congestion is not normally present.
- Weather—reduced visibility, road surface problems and uncertain waiting conditions result in extra travel time and altered trip patterns.
- Demand Changes—traffic volume varies from hour-to-hour and day-to-day and this causes travel time, crowding and congestion patterns to disappear or to significantly worsen for no apparent reason in some locations.
- Special Events—an identifiable case of demand changes where the volume and pattern of the change can frequently be predicted or anticipated.
- Traffic Control Devices—poorly timed of inoperable traffic signals, drawbridges, railroad grade crossing signals or traveler information systems contribute to irregularities in travel time.

- Inadequate Road or Transit Capacity—actually the interaction of capacity problems with the other six sources causes travel time to expand much faster than demand.

The profession is only at the start of understanding the precise mechanisms by which these sources contribute to congestion problems. Both public and private sectors undoubtedly see a cost from unreliable travel times, but those values can be very different for many situations. It is clear that there are several strategies to reduce the problem. There are construction, operations, management, operational practices, education and information components to these strategies. As more research is performed, there will be more detail about the effectiveness of the solutions as well as an idea of how much of the problem has a "solution." If drivers insist on slowing down to look at a collision on the other direction, incident management techniques will be less effective. If road construction zones are allowed to close busy rural roads, there will be problems during holiday travel. There will always be trade-offs between operational efficiencies and the costs necessary to obtain them.

Measuring Reliability

If travelers assume each trip will take the average travel time, they will be late for half of their trips. It has not been determined what level of certainty should be used for trip planning purposes, but it seems reasonable to start with an assumption that a supervisor might allow an employee to be late one day per month. This translates into a need to be on time for approximately 19 out of 20 days, or 95 percent of the time.

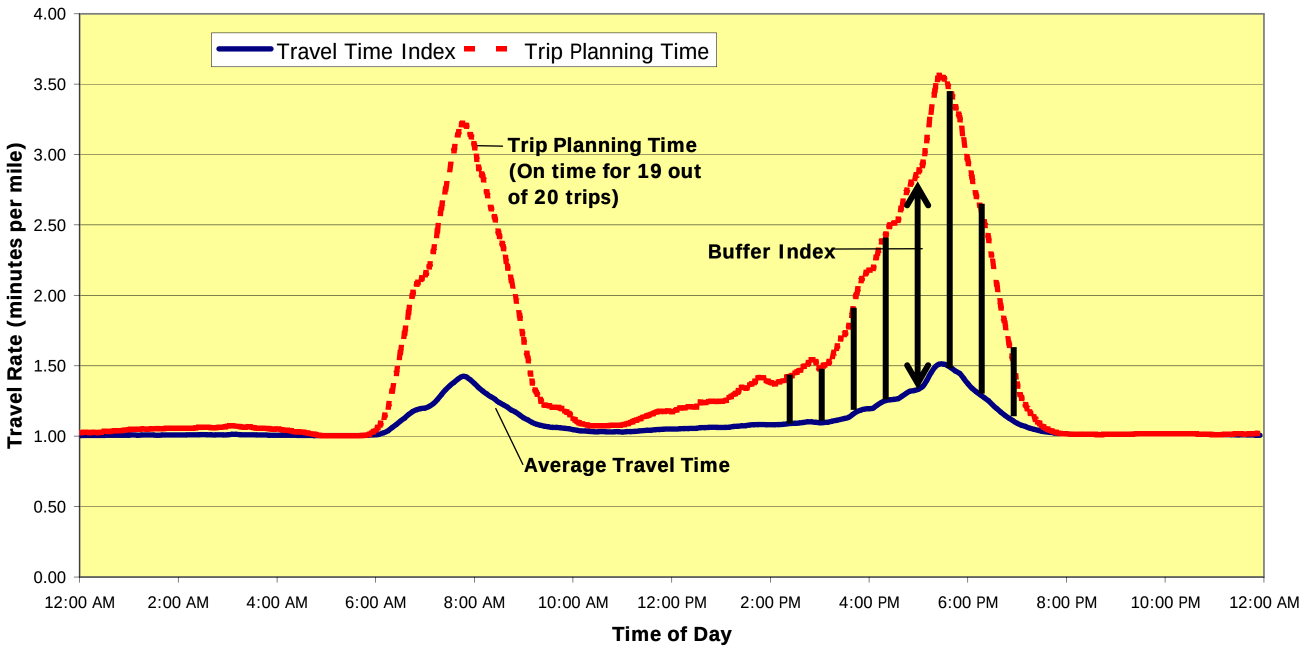
The difference between the average conditions and the 95th percentile conditions is the extra time that has to be budgeted, an illustration of the Buffer Time Index measure (Equation 1). In the middle of the peak in most cities studied in the Mobility Monitoring Program, the sources of travel time variation are more significant than in the midday.

$$\text{Buffer Time Index (BTI)} = \frac{\underset{\text{(in minutes per mile)}}{\text{95th percentile travel rate}} - \underset{\text{(in minutes per mile)}}{\text{Average travel rate}}}{\underset{\text{(in minutes per mile)}}{\text{Average travel rate}}} \times 100\% \qquad \text{Equation 1}$$

What does all this mean? If you are a commuter who travels between about 7:00 a.m. and 9:00 a.m., Exhibit B-36 indicates your trip takes an average of about 30 percent longer (that is, the TTI value is 1.3) than in the off peak. A 20-mile, 20-minute trip in the off-peak would take an average of 26 minutes in a typical home-to-work trip. The Buffer Time Index during this time is between 50 and 100 percent resulting in a Trip Planning Time of 2.1 minutes per mile. So if your boss wants you to begin work on time 95 percent of the days, you should plan on 42 minutes of travel time (20 miles times an average of 2.1 minutes per mile of trip for the peak period). But, to arrive by 8:00 a.m., you might have to leave your home around 7:00 a.m. because the system is even less reliable in the period between 7:30 a.m. and 8:00 a.m.

CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

Exhibit B-36. Houston Freeway System Average Time and Trip Planning Travel Times

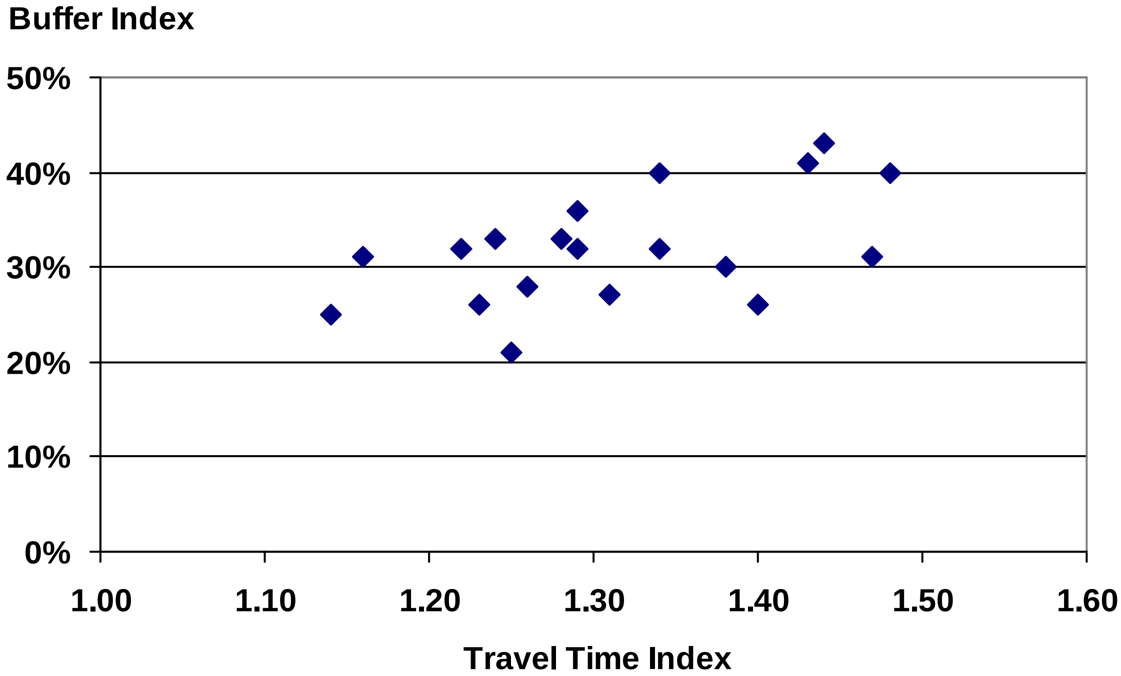


The mobility measure, the Travel Time Index, can be thought of as the time penalty for traveling in the peak period. The reliability measure, the Buffer Time Index, describes how much more time above the average should be budgeted to make an on-time trip. Reliability problems can be caused by simple variations in demand, as well as by vehicle crashes or breakdowns, weather, special events, construction, maintenance and other regular and irregular events. It can present difficulties for commuters and off-peak travelers, and for individuals and businesses (16).

With both of these measures one can tell how congested a transportation system is and how much variation there is in the congestion. This is particularly important when evaluating the wide range of improvement types that are being implemented. Traditional roadway and transit line construction and some operating improvements such as traffic signal system enhancements are oriented toward the typical, daily congestion levels. Others, such as crash and vehicle breakdown detection and removal programs, address the reliability issue. Most projects, programs and strategies have some benefits for each aspect of urban transportation problems.

Exhibit B-37 indicates that there is a general consistency between mobility and reliability measures. That is, at the urban area level, places that are congested are also relatively unreliable. The data are for some freeways in a few cities selected because their archived databases were relatively complete and readily accessible for year 2001 data. The statistics developed from this database should not be used to compare systems or cities to each other. But, the data are used in the next section to analyze some aspects of reliability. Future reports will explore the subject in greater depth. For more information about the reliability database, see: http://mobility.tamu.edu/mmp.

Exhibit B-37. Mobility and Reliability



CAUTION: See http://mobility.tamu.edu/ums for improved performance measures and updated data.

HOW SHOULD WE ADDRESS THE MOBILITY PROBLEM?

Just as congestion has a number of potential causes, there are several ways to address the problem. Generally, the approaches can be grouped under four main strategies—adding capacity, increasing the efficiency of the existing system, better management of construction and maintenance projects, and managing the demand. The benefits associated with these improvements include reduced delay, and more predictable and lower trip times. Emissions may be reduced due to the reduction in demand or congestion, improved efficiencies and the change in the way travelers use the system. The locations of congestion may also move over time due to the new development that occurs or is encouraged by the new transportation facilities.

More Travel Options

While not a specific improvement, providing more options for how a trip is made, the time of travel and the way that transportation service is paid for may be a useful mobility improvement framework for urban areas. For many trips and in many cities, the alternatives for a peak period trip are to travel earlier or later, avoid the trip or travel in congestion. Given the range of choices that Americans enjoy in many other aspects of daily life, these are relatively few and not entirely satisfying options.

The Internet has facilitated electronic "trips." There are a variety of time-shift methods that involve relationships between communication and transportation. Using a computer or phone to work at home for a day, or just one or two hours, can reduce the peak system demand levels without dramatically altering lifestyles.s

Using information and pricing options can improve the usefulness of road space as well as offering a service that some residents find very valuable. People who are late for a meeting, a family gathering or other important event could use a priced lane to show that importance on a few or many occasions—a choice that does not exist for most trips.

The diversity of transportation needs is not matched by the number of travel alternatives. The private auto offers flexibility in time of travel, route and comfort level. Transit can offer some advantages in avoiding congestion or unreliable travel conditions. But many of the mobility improvements below can be part of creating a broader set of options.

Add Capacity

Adding capacity is the best known, and probably most frequently used, improvement option. Pursuing an "add capacity" strategy can mean more traffic lanes, additional buses or new bus routes, new roadways or improved design components as well as a number of other options. Grade separations and better roadway intersection design, along with managed lanes and dedicated bus and carpool priority lanes, can also contribute to moving more traffic through a given spot in the same or less time. The addition of, or improvements to heavy rail, commuter rail, bus system, and improvement in the freight rail system all can assist in adding capacity to varying degrees. In growing areas, adding capacity of all types is essential to handle the growing demand and avoid rapidly rising congestion.

Manage the Demand

Demand management strategies include a variety of methods to move trips away from the peak travel periods. These are either a function of making it easier to combine trips via ridesharing or transit use, or providing methods to reduce vehicle trips via tele-travel or different development designs.

The fact is, transportation system demand and land use patterns are linked and influence each other. There is a variety of strategies that can be implemented to either change the way that travelers affect the system or the approaches used to plan and design the shops, offices, homes, schools, medical facilities and other land uses.

Relatively few neighborhoods, office parks, etc. will be developed for auto-free characteristics—that is not the goal of most of these treatments. The idea is that some characteristics can be incorporated into new developments so that new economic development does not generate the same amount of traffic volume as existing developments. Among the tools that can be employed are better management of arterial street access, incorporating bicycle and pedestrian elements, better parking strategies, assessing transportation impact before a development is approved for construction, and encouraging more diverse development patterns. These changes are not a congestion panacea, but they are part of a package of techniques that are being used to address "quality-of-life" concerns—congestion being only one of many.

Increase Efficiency of the System

Sometimes, the more traditional approach of simply adding more capacity is not possible or not desirable. However, improvements can still be made by increasing the efficiency of the existing system. These treatments are particularly effective in three ways. They are relatively low cost and high benefit which is efficient from a funding perspective. They can usually be implemented quickly and can be tailored to individual situations making them more useful because they are flexible. They are usually a distinct, visible change; it is obvious that the operating agencies are reacting to the situation and attempting improvements.

In many cases, the operations improvements also represent a "stretching" of the system to the point where the margin of error is relatively low. It is important to capitalize on the potential efficiencies – no one wants to sit through more traffic signal cycles or behind a disabled vehicle if it is not necessary – but the efficiency improvements also have limits. The basic transportation system—the roads, transit vehicles and facilities, sidewalks and more—is designed to accommodate a certain amount of use. Some locations, however, present bottlenecks, or constraints, to smooth flow. At other times, high volume congests the entire system, so strategies to improve system efficiency by improving peak hour mobility are in order. The community and travelers can benefit from reduced congestion and reduced emissions, as well as more efficiently utilizing the infrastructure already in place.

Among the strategies that fall into this category are tools that make improvements in intersections, traffic signals, freeway entrance ramps, special event management (e.g., managing traffic before and after large sporting or entertainment events) and incident management. In addition such strategies as one-way streets, electronic toll collection systems, and changeable lane assignments are often helpful.

Freeway entrance ramp metering (i.e., traffic signals that regulate the traffic flow entering the freeway) and incident management (i.e., finding and removing stalled or crashed vehicles) are two operations treatments highlighted in this report. When properly implemented, monitored and aggressively managed, they can decrease the average travel time and significantly improve the predictability of transportation service. Both can decrease vehicle crashes by smoothing traffic flow and reducing unexpected stop-and-go conditions. Both treatments can also enhance conditions for both private vehicles and transit.

Manage Construction and Maintenance Projects

When construction takes place to provide more lanes, new roadways, or improved intersections, or during maintenance of the existing road system, the effort to improve mobility can itself cause congestion. Better techniques in managing construction and maintenance programs can make a difference. Some of the strategies involve methods to improve the construction phase by shortening duration of construction, or moving the construction to periods where traffic volume is relatively low. Among the strategies that might be considered include providing contractor incentives for completing work ahead of schedule or penalties for missed construction milestones, adjustments in the contract working day, using design-build strategies, or maintenance of traffic strategies during construction to minimize delays.

Role of Pricing

Urban travelers pay for congestion by sitting in traffic or on crowded transit vehicles. Anthony Downs (17), among many, has suggested this is the price that Americans are willing to pay for the benefits that they derive from the land development and activity arrangements that cause the congestion. But for most Americans there is no mechanism that allows them to show that they place a higher value on certain trips. Finding a way to incorporate a pricing mechanism into some travel corridors could provide an important option for urban residents and freight shippers.

A fee has been charged on some transportation projects for a long time. Toll highways and transit routes are two familiar examples. An extension of this concept would treat transportation services like most other aspects of society. There would be a direct charge for using more important system elements. Price is used to regulate the use and demand patterns of telephones, movie seats, electricity, food and many other elements of the economy. In addition to direct charges, transportation facilities and operations are typically paid for by per-gallon fees, sales taxes or property taxes. One could also include the extra time spent in congestion as another way to pay for transportation.

Electronic tolling methods provide a way for travelers to pay for their travel without being penalized by stopping to pay a fee. Electronics can also be used to reduce the fee for travelers in certain social programs (e.g., welfare to work) or to vary the fee by time of day or congestion level. Implementing these special lanes as an addition to roads (rather than converting existing lanes) has been the most common method of instituting pricing options in a corridor. This offers a choice of a premium service for a fee, or lower speed, less reliable travel with no additional fee.

Importance of Evaluating Transportation Systems

Providing the public and decision-makers with a sufficient amount of understandable information can help "make the case" for transportation. Part of the implementation and operation of transportation projects and programs should be a commitment to collecting evaluation data. These statistics not only improve the effectiveness of individual projects, but they also provide the comparative data needed to balance transportation needs and opportunities with other societal imperatives whether those are other infrastructure assets or other programs.

HOW SHOULD THE MEASURES AND RANKINGS WITH THE IMPROVEMENT STRATEGIES BE INTERPRETED?

Most of the measures presented in the report address roadway systems. While the problems and solutions are not solely focused on roads, much of the data that are available relate to roads and vehicle travel. This year's report also includes operational improvement information and public transportation data at an areawide level. While this expands the scope of the data and measures, the effect of these strategies is often at a corridor or activity center area level where they are applied. So, while the road statistics may provide a picture of urban mobility levels, the addition of the public transportation data and operational treatment effects improve the usefulness of the comparisons.

On the "solution" side of the measures, the current database and methodology include roadway lanes, public transportation and traffic volumes for the database years, and statistics on a few operational improvements for 2000 through 2005. Most larger urban areas are expanding their use of these improvements and are also increasing the data and evaluation studies. The methodologies and more detailed description of estimating the mobility effect of the operational solutions and public transportation service is also investigated in a separate report also on the Urban Mobility Report website.

The estimates are not a replacement, a substitute or a better method of evaluating these strategies at the corridor or project level. The estimates included in this report are a way to understand the comparative mobility contributions of various strategies using a consistent methodology.

Another key manifestation of uncertainty is the ranking of the measures. Estimating the measures creates one set of variations—the "real" measure could be higher or lower—and the relatively close spacing of the measures mean that the rankings should be considered as an indication of the range within which the true measure lies. There are many instances where one or two hours of delay or one or two index points could move an urban area several ranking spots.

Rankings, whether with or without the operational improvements or public transportation service, should be examined by comparing the values for cities with similar population, density, geography or other key elements. The rankings of values with strategies are available for only the most recent year, and the performance measures are presented for mobility levels with and without the strategy contributions.

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