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University Transportation Center for Mobility

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Real-Timing the 2010 Urban Mobility Report

Final Report

Tim Lomax, David Schrank, Shawn Turner, Lauren Geng, Yingfeng Li, and Nick Koncz

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16. Abstract

The Texas Transportation Institute is a national leader in providing congestion and mobility information. The *Urban Mobility Report (UMR)* is the most widely quoted report on urban congestion and its associated costs in the nation. The report measures system delay, wasted fuel, and the annual cost of congestion in all U.S. urban areas. The data that are available to analyze transportation performance are evolving, however, and the *UMR* procedures need to adopt the new data sources to provide the best possible estimate of mobility conditions. Private-sector companies advertising the availability of nationwide average speed data on many highways in the United States compete with the *UMR* for congestion coverage. Through this research, TTI has developed a partnership with one of the private-sector speed companies, INRIX. The TTI and INRIX databases were matched and used to re-compute the *UMR* statistics based on actual speed data for all days and all major urban roads. This research has improved the estimates of congestion and its costs, and has improved the timeliness of U.S. traffic congestion estimates.

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Real-Timing the 2010 Urban Mobility Report

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DISCLAIMER

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Executive Summary

Introduction

The Texas Transportation Institute (TTI) is a national leader in providing congestion and mobility information. TTI's mobility information is provided mostly through the annual *Urban Mobility Report* (http://mobility.tamu.edu/ums), but several other national, state, and regional activities also disseminate mobility information. The *Urban Mobility Report* is recognized internationally as the most comprehensive and authoritative analysis of traffic congestion in the United States. The report has evolved over the years, with several methodology and data changes, but with a consistent focus on providing technical information in an easily understood format.

The transportation industry is constantly evolving, with much technological advancement affecting the travel on roadways and the traffic data that are collected. TTI needs to ensure that one of its premier publications, the *Urban Mobility Report* (*UMR*), keeps pace with current trends and evolves to include the best data sources and most accurate information analytics.

The primary objective of this research project was to incorporate the historical speed data from INRIX, a private-sector speed company, into the methodology that generates the statistics in the *UMR,* and to produce the *2010 UMR*. These improvements and enhancements fall into the following three specific areas:

1. conflate the Highway Performance Monitoring System (HPMS) roadway inventory and INRIX speed networks,
2. modify the methodology and calculate measures, and
3. produce the *2010 UMR*.

Task 1: Conflate the Roadway Inventory and Speed Networks

This task built upon previous University Transportation Center for Mobility (UTCM)-sponsored research project 476090-38 to conflate, or match, the HPMS roadway inventory shapefile with the INRIX historical speed shapefile.

Task 2: Modify the Methodology and Calculate Measures

Task 2 also used some of the findings from previous UTCM-sponsored research project 476090-38 to develop the methodology to make use of the new INRIX speed data. The key difference between previous methodologies and the new INRIX-based methodology is that speed data are no longer estimated by TTI based on traffic volumes but are supplied by INRIX. The speed data provided by INRIX now include 24 hourly average speeds for each of the seven days of the week. Thus, it is now possible to analyze the data by day of the week, time of day, weekday versus weekend, and many more criteria.

The main objectives of this task were to:

1. estimate traffic volumes from average daily traffic (ADT) for each hourly interval using typical traffic distribution profiles,
2. create a means of estimating speeds for HPMS roadway sections that did not have an INRIX speed match, and
3. generate traditional *UMR* statistics as well as new statistics, such as the Commuter Stress Index, which were made possible by the addition of the INRIX speed data.

The methodology description that accompanies the *2010 Urban Mobility Report* is included in Appendix B of this research report.

Task 3: Produce the *2010 UMR*

The *2010 UMR* required additional information to explain the new methodology and how it differed from previous reports. It also required more detailed descriptions of the new findings, which were very different in some cases from previous *UMR* reports. Since the changes in some of the statistics were substantial, it was important to develop explanations for the differences between previous methodologies and the new speed-based methodology in order to maintain the credibility and allow readers and sponsors to be comfortable with the new statistics. The *2010 Urban Mobility Report* is included as Appendix A of this research report.

Introduction

TTI is a national leader in providing congestion and mobility information. TTI's mobility information is provided mostly through the annual *Urban Mobility Report* (http://mobility.tamu.edu/ums), but several other national, state, and regional activities also disseminate mobility information. The *Urban Mobility Report* is recognized internationally as the most comprehensive and authoritative analysis of traffic congestion in the United States. The *Urban Mobility Report* provides key stakeholders in transportation across the government, business, and public sectors with an unrivaled source of information on congestion problems and trends for the nation's roadways. The report has evolved over the years, with several methodology and data changes, but with a consistent focus on providing technical information in an easily understood format.

Problem Statement

The transportation industry is constantly evolving, with much technological advancement affecting the travel on roadways and the traffic data that are collected. TTI needs to ensure that one of its premier publications, the *Urban Mobility Report*, keeps pace with current trends and evolves to include the best data sources and most accurate information analytics.

Research Objectives

The primary objective of this research project was to develop several procedures that could be used to improve and enhance information currently provided in the *Urban Mobility Report*. These improvements and enhancements fall into the following three specific areas:

1. conflate the roadway inventory datasets from state departments of transportation (DOTs) with the INRIX speed datasets for the entire United States,
2. create new methodology to utilize the INRIX measured speed data, and
3. produce and communicate the *2010 Urban Mobility Report* with the new methodology.

Overview of This Report

This report is structured around four areas and is organized as follows:

- *Introduction*—provides a brief overview of the relevant issues and project objectives.
- *Conflation of Volume and Speed Networks*—summarizes the process for joining the roadway inventory data and private-sector historical speed data geographical information system (GIS) shapefiles.
- *Appendix A—The 2010 Urban Mobility Report*—provides a national analysis of long-term congestion trends, the most recent congestion comparisons, and a description of many congestion improvement strategies.
- *Appendix B—Methodology for the 2010 Urban Mobility Report*—analyzes the effects of long-term fuel price trends on vehicle-miles traveled (as measured by monthly fuel consumption data).

Conflation of Volume and Speed Networks

Previous UTCM research project 476090-38 demonstrated the possibility of conflating a public-sector roadway inventory network such as the HPMS with a private-sector speed network such as INRIX. The project's report went into detail about how the process works. There were more than 200,000 miles of roadway in the private-sector speed database to match with the public-sector network for the *2010 UMR*. This task required a significant amount of project resources to complete but is not a task that is easy to demonstrate results for.

About two-thirds of the urban vehicle travel in the 101 urban areas analyzed extensively in the *UMR* was located on conflated or "matched" roadways where both traffic volumes and speeds were available. The remaining vehicle travel occurred on "unmatched" roadways. There were several reasons why roadways did not conflate based on the two networks:

- There was no section in the speed network that matched the roadway inventory network.
- The roadway inventory network was incomplete. (This was especially true with the surface-street data for the minor arterial streets that were not included in the network shapefile because many of these roadways are not maintained by state DOTs but by local agencies.)
- The speed data for a roadway section were incomplete.

The methodology described in the next section of this report discusses the procedures used to handle roadway sections where conflation did not occur.

Appendix A—The 2010 Urban Mobility Report

TTI's 2010 URBAN MOBILITY REPORT
Powered by INRIX Traffic Data

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American Road & Transportation Builders Association – Transportation Development Foundation
American Public Transportation Association
Texas Transportation Institute

2010 Urban Mobility Report

This summary report describes the scope of the mobility problem and some of the improvement strategies. For the complete report and congestion data on your city, see: http://mobility.tamu.edu/ums.

Congestion is still a problem in America's 439 urban areas. The economic recession and slow recovery of the last three years, however, have slowed the seemingly inexorable decline in mobility. Readers and policy makers might be tempted to view this as a change in trend, a new beginning or a sign that congestion has been "solved." However, the data do not support that conclusion.

- First, the problem is very large. In 2009, congestion caused urban Americans to travel 4.8 billion hours more and to purchase an extra 3.9 billion gallons of fuel for a congestion cost of $115 billion.
- Second, 2008 appears to be the best year for congestion in recent times; congestion worsened in 2009.
- Third, there is only a short-term cause for celebration. Prior to the economy slowing, just 3 years ago, congestion levels were much higher than a decade ago; these conditions will return with a strengthening economy.

There are many ways to address congestion problems; the data show that these are not being pursued aggressively enough. The most effective strategy is one where agency actions are **complemented** by efforts of businesses, manufacturers, commuters and travelers. There is no **rigid prescription** for the "best way"—**each region** must identify the projects, programs and policies that achieve goals, solve problems and capitalize on opportunities.

Exhibit 1. Major Findings of the 2010 Urban Mobility Report (439 U.S. Urban Areas)

(Note: See page 2 for description of changes since the 2009 Report)

Measures of…	1982	1999	2007	2008	2009
… Individual Congestion					
Yearly delay per auto commuter (hours)	14	35	38	34	34
Travel Time Index	1.09	1.21	1.24	1.20	1.20
Commuter Stress Index	--	--	1.36	1.29	1.29
"Wasted" fuel per auto commuter (gallons)	12	28	31	27	28
Congestion cost per auto commuter (2009 dollars)	$351	$784	$919	$817	$808
… The Nation's Congestion Problem					
Travel delay (billion hours)	1.0	3.8	5.2	4.6	4.8
"Wasted" fuel (billion gallons)	0.7	3.0	4.1	3.8	3.9
Truck congestion cost (billions of 2009 dollars)			$36	$32	$33
Congestion cost (billions of 2009 dollars)	$24	$85	$126	$113	$115
… The Effect of Some Solutions					
Yearly travel delay saved by:					
Operational treatments (million hours)	--	--	363	312	321
Public transportation (million hours)	--	--	889	802	783
Yearly congestion costs saved by:					
Operational treatments (billions of 2009$)	--	--	$8.7	$7.6	$7.6
Public transportation (billions of 2009$)	--	--	$22	$20	$19

Yearly delay per auto commuter – The extra time spent traveling at congested speeds rather than free-flow speeds by private vehicle drivers and passengers who typically travel in the peak periods.

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 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak period.

Commuter Stress Index – The ratio of travel time for the peak direction to travel time at free-flow conditions. A TTI calculation for only the most congested direction in both peak periods.

Wasted fuel – Extra fuel consumed during congested travel.

Congestion cost – The yearly value of delay time and wasted fuel.

The Congestion Trends

(And the New Data Providing a More Accurate View)

This *Urban Mobility Report* begins an exciting new era for comprehensive national congestion measurement. Traffic speed data from INRIX, a leading private sector provider of travel time information for travelers and shippers, is combined with the traffic volume data from the states to provide a much better and more detailed picture of the problems facing urban travelers. Previous reports in this series have included more than a dozen significant methodology improvements. This year's report is the most remarkable "game changer;" the new data address the biggest shortcoming of previous reports.

INRIX (*1*) anonymously collects traffic speed data from personal trips, commercial delivery vehicle fleets and a range of other agencies and companies and compiles them into an average speed profile for most major roads. The data show conditions for every day of the year and include the effect of weather problems, traffic crashes, special events, holidays, work zones and the other congestion causing (and reducing) elements of today's traffic problems. TTI combined these speeds with detailed traffic volume data (*2*) to present an unprecedented estimate of the scale, scope and patterns of the congestion problem in urban America.

The new data and analysis changes the way the mobility information can be presented and how the problems are evaluated. The changes for the 2010 report are summarized below.

- Hour-by-hour speeds collected from a variety of sources on every day of the year on most major roads are used in the 101 detailed study areas and the 338 other urban areas. For more information about INRIX, go to www.inrix.com.
- An improved speed estimation process was built from the new data for major roads without detailed speed data. (See the methodology descriptions on the Report website – mobility.tamu.edu).
- The data for all 24 hours makes it possible to track congestion problems for the midday, overnight and weekend time periods.
- A revised congestion trend has been constructed for each urban region from 1982 to 2009 using the new data as the benchmark. Many values from previous reports have been changed to provide a more accurate picture of the likely patterns (Exhibit 2).
- Did we say 101 areas? Yes, 11 new urban regions have been added, including San Juan, Puerto Rico. All of the urban areas with populations above 500,000 persons are included in the detailed area analysis of the *2010 Urban Mobility Report*.
- Three new measures of congestion are calculated for the 2010 report from the TTI-INRIX dataset. These are possible because we have a much better estimate about when and where delay occurs.
    - Delay per auto commuter – the extra travel time faced each year by drivers and passengers of private vehicles who typically travel in the peak periods.
    - Delay per non-peak traveler – the extra travel time experienced each year by those who travel in the midday, overnight or on weekends.
    - Commuter Stress Index (CSI) – similar to the Travel Time Index, but calculated for the worst direction in each peak period to show the time penalty to those who travel in the peak directions.
- Truck freight congestion is explored in more detail thanks to research funding from the National Center for Freight and Infrastructure Research and Education (CFIRE) at the University of Wisconsin (http://www.wistrans.org/cfire/).

Exhibit 2. National Congestion Measures, 1982 to 2009

						Hours Saved (million hours)		Gallons Saved (million gallons)		Dollars Saved (billions of 2009$)	
Year	Travel Time Index	Delay per Commuter (hours)	Total Delay (billion hours)	Total Fuel Wasted (billion gallons)	Total Cost (2009$ 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	14.4	0.99	0.73	24.0	--	--	--	--	--	--
1983	1.09	15.7	1.09	0.80	26.0	--	--	--	--	--	--
1984	1.10	16.9	1.19	0.88	28.3	--	--	--	--	--	--
1985	1.11	19.0	1.38	1.03	32.6	--	--	--	--	--	--
1986	1.12	21.1	1.59	1.20	36.2	--	--	--	--	--	--
1987	1.13	23.2	1.76	1.35	40.2	--	--	--	--	--	--
1988	1.14	25.3	2.03	1.56	46.1	--	--	--	--	--	--
1989	1.16	27.4	2.22	1.73	50.8	--	--	--	--	--	--
1990	1.16	28.5	2.35	1.84	53.8	--	--	--	--	--	--
1991	1.16	28.5	2.41	1.90	54.9	--	--	--	--	--	--
1992	1.16	28.5	2.57	2.01	58.5						
1993	1.17	29.6	2.71	2.11	61.3						
1994	1.17	30.6	2.82	2.19	63.9						
1995	1.18	31.7	3.02	2.37	68.8						
1996	1.19	32.7	3.22	2.53	73.5	--	--	--	--	--	--
1997	1.19	33.8	3.40	2.68	77.2	--	--	--	--	--	--
1998	1.20	33.8	3.54	2.81	79.2	--	--	--	--	--	--
1999	1.21	34.8	3.80	3.01	84.9	--	--	--	--	--	--
2000	1.21	34.8	3.97	3.15	90.9	190	720	153	569	3.5	13.8
2001	1.22	35.9	4.16	3.31	94.7	215	749	173	593	4.2	14.8
2002	1.23	36.9	4.39	3.51	99.8	239	758	195	606	4.8	15.1
2003	1.23	36.9	4.66	3.72	105.6	276	757	222	600	5.5	15.2
2004	1.24	39.1	4.96	3.95	114.5	299	798	244	637	6.3	16.9
2005	1.25	39.1	5.22	4.15	123.3	325	809	260	646	7.2	18.1
2006	1.24	39.1	5.25	4.19	125.5	359	845	288	680	8.2	19.7
2007	1.24	38.4	5.19	4.14	125.7	363	889	290	709	8.7	21.5
2008	1.20	33.7	4.62	3.77	113.4	312	802	254	655	7.6	19.7
2009	1.20	34.0	4.80	3.93	114.8	321	783	263	641	7.6	18.8

The new analysis procedures were not applied to the older portions of the Report data series for these performance measures.

Note: For more congestion information see Tables 1 to 9 and http://mobility.tamu.edu/ums.

One Page of Congestion Problems

Travelers and freight shippers must plan around traffic jams for more of their trips, in more hours of the day and in more cities, towns and rural areas than in 1982. It extends far into the suburbs and includes weekends, holidays and special events. Mobility problems have lessened in the last couple of years, but there is no reason to expect them to continue declining, based on almost three decades of data. See data for your city at mobility.tamu.edu/ums/congestion_data.

Congestion costs are increasing. The congestion “invoice” for the cost of extra time and fuel in 439 urban areas was (all values in constant 2009 dollars):

- In 2009 – $115 billion
- In 2000 – $85 billion
- In 1982 – $24 billion

Congestion wastes a massive amount of time, fuel and money. In 2009:

- 3.9 billion gallons of wasted fuel (equivalent to 130 days of flow in the Alaska Pipeline).
- 4.8 billion hours of extra time (equivalent to the time Americans spend relaxing and thinking in 10 weeks).
- $115 billion of delay and fuel cost (the negative effect of uncertain or longer delivery times, missed meetings, business relocations and other congestion-related effects are not included).
- $33 billion of the delay cost was the effect of congestion on truck operations; this does not include any value for the goods being transported in the trucks.
- The cost to the average commuter was $808 in 2009 compared to an inflation-adjusted $351 in 1982.

Congestion affects people who make trips during the peak period.

- Yearly peak period delay for the average commuter was 34 hours in 2009, up from 14 hours in 1982.
- Those commuters wasted 28 gallons of fuel in the peak periods in 2009 – 2 weeks worth of fuel for the average U.S. driver – up from 12 gallons in 1982.
- Congestion effects were even larger in areas with over one million persons – 43 hours and 35 gallons in 2009.
- “Rush hour” – possibly the most misnamed period ever – lasted 6 hours in 2009.
- Fridays are the worst days to travel. The combination of work, school, leisure and other trips mean that urban residents earn their weekend after suffering one-fifth of weekly delay.
- 61 million Americans suffered more than 30 hours of delay in 2009.

Congestion is also a problem at other hours.

- Approximately half of total delay occurs in the midday and overnight (outside of the peak hours of 6 to 10 a.m. and 3 to 7 p.m.) times of day when travelers and shippers expect free-flow travel.
- Midday congestion is not as severe, but can cause problems, especially for time sensitive meetings or freight delivery shipments. Freight movement has attempted to move away from the peak periods to avoid congestion when possible. But this accommodation has limits as congestion extends into the midday and overnight periods; manufacturing processes and human resources are difficult to significantly reschedule.

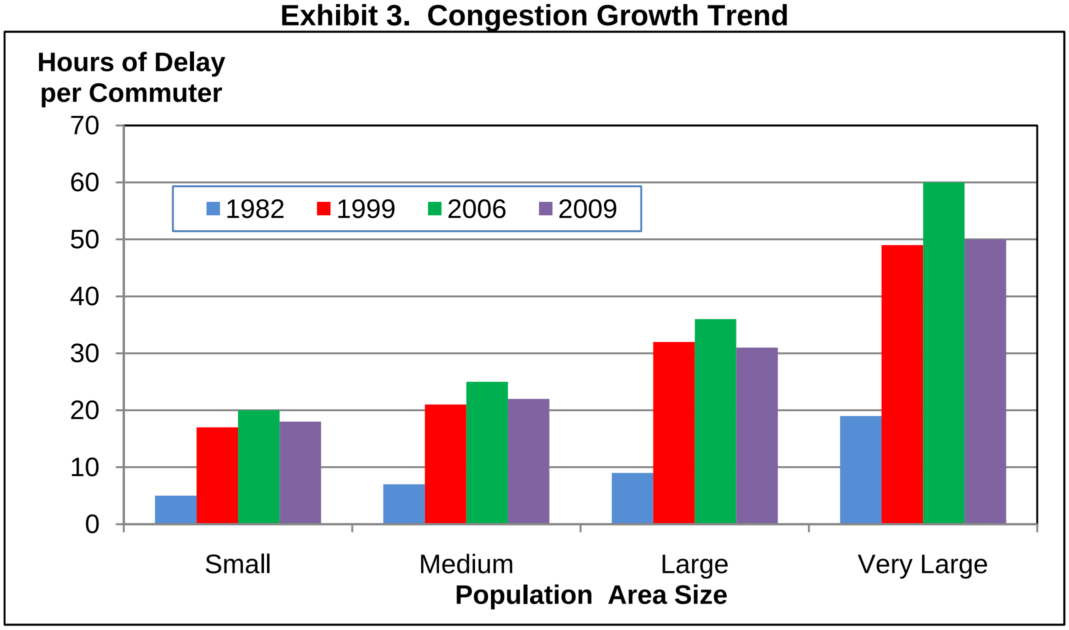
More Detail About Congestion Problems

Congestion, by every measure, has increased substantially over the 28 years covered in this report. The most recent four years of the report, however, have seen a decline in congestion in most urban regions. This is consistent with the pattern seen in some metropolitan regions in the 1980s and 1990s; economic recessions cause fewer goods to be purchased, job losses mean fewer people on the road in rush hours and tight family budgets mean different travel decisions are made. Delay per auto commuter – the number of hours of extra travel time – was 5 hours lower in 2009 than 2006. This change would be more hopeful if it was more widely associated with something other than rising fuel prices and a slowing economy.

The decline means the total congestion problem is near the levels recorded in 2004. This "reset" in the congestion trend, and the low prices for construction, should be used as a time to promote congestion reduction programs, policies and projects. If the history associated with every other recovery is followed in this case, congestion problems will return when the economy begins to grow.

Congestion is worse in areas of every size – it is not just a big city problem. The growing delays also hit residents of smaller cities (Exhibit 3). Regions of all sizes have problems implementing enough projects, programs and policies to meet the demand of growing population and jobs. Major projects, programs and funding efforts take 10 to 15 years to develop.

Exhibit 3. Congestion Growth Trend



Small = less than 500,000 | Large = 1 million to 3 million
Medium = 500,000 to 1 million | Very Large = more than 3 million

Think of what else could be done with the 34 hours of extra time suffered by the average urban auto commuter in 2009:

- 4 vacation days
- Almost 500 shopping trips on Amazon.com (*3*)
- Watch all the interesting parts of every reality show on television with enough time left over to take 100 power naps.

Congestion builds through the week from Monday to Friday. Weekends have less delay than any weekday (Exhibit 4). Congestion is worse in the evening but it can be a problem all day (Exhibit 5). Midday hours comprise a significant share of the congestion problem.

Exhibit 4. Percent of Delay for Each Day

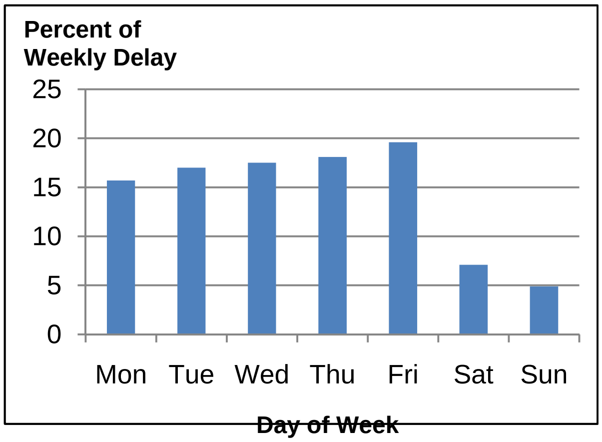
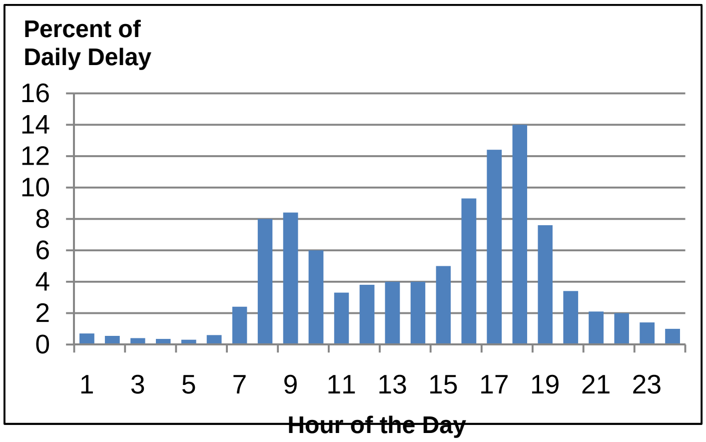
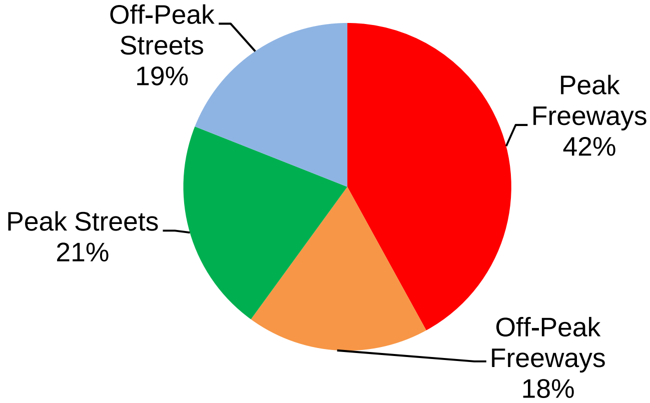


Exhibit 5. Percent of Delay by Time of Day



Freeways have more delay than streets, but not as much as you might think (Exhibit 6).

Exhibit 6. Percent of Delay for Road Types



The "surprising" congestion levels have logical explanations in some regions.

The urban area congestion level rankings shown in Tables 1 through 9 may surprise some readers. The areas listed below are examples of the reasons for higher than expected congestion levels.

- *Work zones* – Baton Rouge, Las Vegas. Construction, even when it occurs in the off-peak, can increase traffic congestion.
- *Smaller urban areas with a major interstate highway* – Austin, Bridgeport, Colorado Springs, Salem. High volume highways running through smaller urban areas generate more traffic congestion than the local economy causes by itself.
- *Tourism* – Orlando, Las Vegas. The traffic congestion measures in these areas are divided by the local population numbers causing the per-commuter values to be higher than normal.

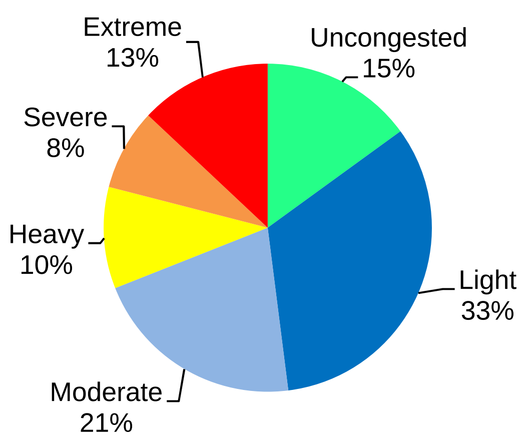
- *Geographic constraints* – Honolulu, Pittsburgh, Seattle. Water features, hills and other geographic elements cause more traffic congestion than regions with several alternative routes.

Travelers and shippers must plan around congestion more often.

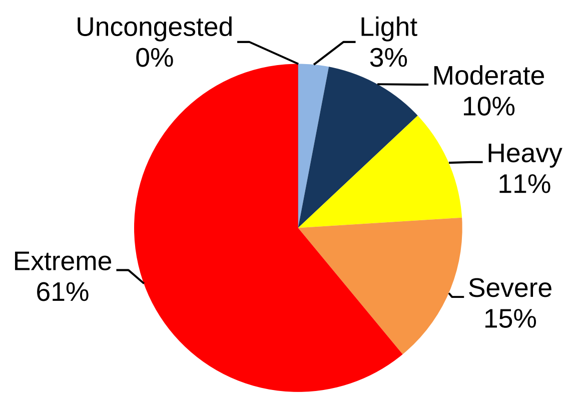
- In all 439 urban areas, the worst congestion levels affected only 1 in 9 trips in 1982, but almost 1 in 4 trips in 2009 (Exhibit 7).
- The most congested sections of road account for 76% of peak period delays, with only 21% of the travel (Exhibit 7).
- Delay has grown about five times larger overall since 1982.

Exhibit 7. Peak Period Congestion and Congested Travel in 2009

Vehicle travel in congestion ranges



Travel delay in congestion ranges



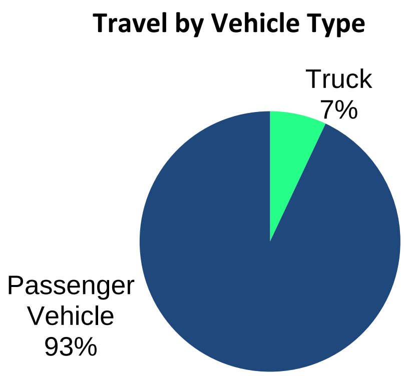
The Jam Clock (Exhibit 8) depicts the times of day when travelers are most likely to hit congestion.

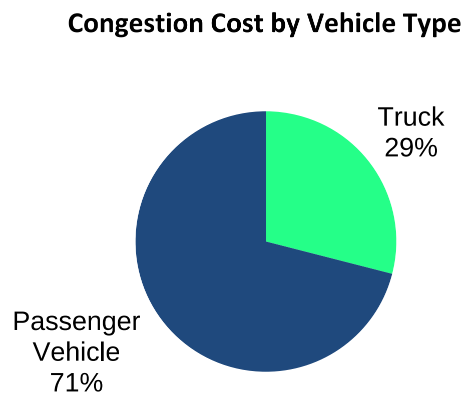
Exhibit 8. The Jam Clock Shows That Congestion is Widespread for Several Hours of the Day

Note: The *2010 Urban Mobility Report* examined all 24 hours of each day of the week with the INRIX National Average Speed dataset. Shading indicates regional congestion problems; some roads in regions may have congestion during the "gray" periods.

While trucks only account for 7 percent of the miles traveled in urban areas, they are almost 30 percent of the urban "congestion invoice." In addition, the cost in Exhibit 9 only includes the cost to operate the truck in heavy traffic; the extra cost of the commodities is not included.

Exhibit 9. 2009 Congestion Cost for Passenger and Freight Vehicles





Congestion Solutions – An Overview of the Portfolio

We recommend a ***balanced and diversified approach*** to reduce congestion – one that focuses on more of everything. It is clear that our current investment levels have not kept pace with the problems. Population growth will require more systems, better operations and an increased number of travel alternatives. And most urban regions have big problems now – more congestion, poorer pavement and bridge conditions and less public transportation service than they would like. There will be a different mix of solutions in metro regions, cities, neighborhoods, job centers and shopping areas. Some areas might be more amenable to construction solutions, other areas might use more travel options, productivity improvements, diversified land use patterns or redevelopment solutions. In all cases, the solutions need to work together to provide an interconnected network of transportation services.

More information on the possible solutions, places they have been implemented, the effects estimated in this report and the methodology used to capture those benefits can be found on the website http://mobility.tamu.edu/solutions.

- **Get as much service as possible from what we have** – Many low-cost improvements have broad public support and can be rapidly deployed. These management programs require innovation, constant attention and adjustment, but they pay dividends in faster, safer and more reliable travel. Rapidly removing crashed vehicles, timing the traffic signals so that more vehicles see green lights, improving road and intersection designs, or adding a short section of roadway are relatively simple actions.
- **Add capacity in critical corridors** – Handling greater freight or person travel on freeways, streets, rail lines, buses or intermodal facilities often requires "more." Important corridors or growth regions can benefit from more road lanes, new streets and highways, new or expanded public transportation facilities, and larger bus and rail fleets.
- **Change the usage patterns** – There are solutions that involve changes in the way employers and travelers conduct business to avoid traveling in the traditional "rush hours." Flexible work hours, internet connections or phones allow employees to choose work schedules that meet family needs and the needs of their jobs.
- **Provide choices** – This might involve different routes, travel modes or lanes that involve a toll for high-speed and reliable service—a greater number of options that allow travelers and shippers to customize their travel plans.
- **Diversify the development patterns** – These typically involve denser developments with a mix of jobs, shops and homes, so that more people can walk, bike or take transit to more, and closer, destinations. 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 at all times.

Congestion Solutions – The Effects

The *2010 Urban Mobility Report* database includes the effect of several widely implemented congestion solutions. These provide more efficient and reliable operation of roads and public transportation using a combination of information, technology, design changes, operating practices and construction programs.

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 had been discontinued and the riders traveled in private vehicles in 2009, the 439 urban areas would have suffered an additional 785 million hours of delay and consumed 640 million more gallons of fuel (Exhibit 10). The value of the additional travel delay and fuel that would have been consumed if there were no public transportation service would be an additional $18.8 billion, a 16% increase over current congestion costs in the 439 urban areas.

There were approximately 55 billion passenger-miles of travel on public transportation systems in the 439 urban areas in 2009 (*4*). The benefits from public transportation vary by the amount of travel and the road congestion levels (Exhibit 10). More information on the effects for each urban area is included in Table 3.

Exhibit 10. Delay Increase in 2009 if Public Transportation Service Were Eliminated – 439 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 (15)	41,761	671	24	16,060
Large (31)	5,561	68	7	1,620
Medium (33)	1,684	12	4	276
Small (22)	421	3	3	69
Other (338)	5,970	30	5	735
National Urban Total	55,397	784	16	$18,760

Note: Additional fuel consumption – 640 million gallons (included in Dollars Saved calculation).
Source: Reference (*4*) and Review by Texas Transportation Institute

Better Traffic Flow

Improving transportation systems is about more than just adding road lanes, transit routes, sidewalks and bike lanes. It is also about operating those systems efficiently. Not only does congestion cause slow speeds, it also decreases the traffic volume that can use the roadway; stop-and-go roads only carry half to two-thirds of the vehicles as a smoothly flowing road. This is why simple volume-to-capacity measures are not good indicators; actual traffic volumes are low in stop-and-go conditions, so a volume/capacity measure says there is no congestion problem. Several types of improvements have been widely deployed to improve traffic flow on existing roadways.

Five prominent types of operational treatments are estimated to relieve a total of 321 million hours of delay (6.7% of the total) with a value of $7.6 billion in 2009 (Exhibit 11). If the treatments were deployed on all major freeways and streets, the benefit would expand to almost 700 million hours of delay (14% of delay) and more than $16 billion would be saved. These are significant benefits, especially since these techniques can be enacted more quickly than significant roadway or public transportation system expansions can occur. The operational treatments, however, are not large enough to replace the need for those expansions.

Exhibit 11. Operational Improvement Summary for All 439 Urban Areas

Population Group and Number of Areas	Delay Reduction from Current Projects		Delay Reduction if In Place on All Roads (Million Hours)
	Hours Saved (Million)	Dollars Saved ($ Million)	
Very Large (15)	231	5,461	570
Large (31)	59	1,383	80
Medium (33)	12	297	30
Small (22)	3	79	7
Other (338)	16	395	35
TOTAL	321	$7,615	722

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 (*2,5*).

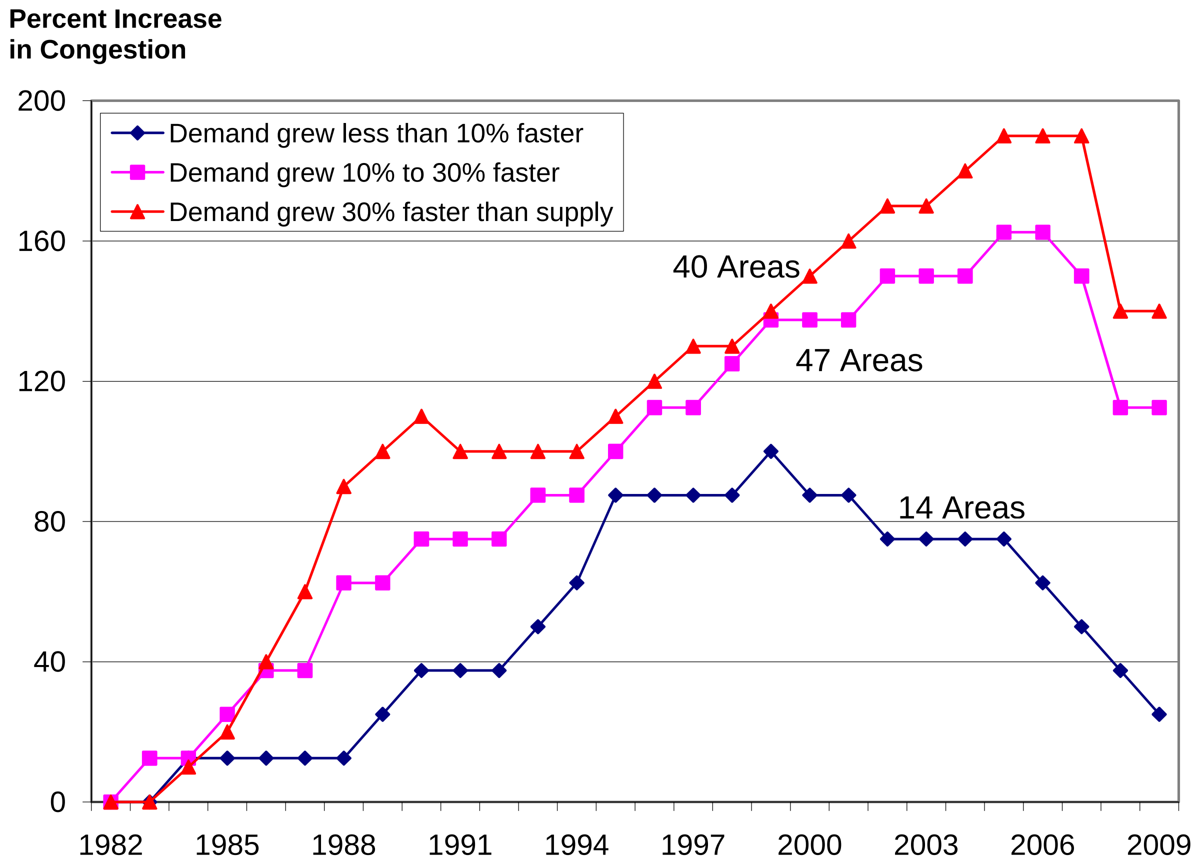
More information about the specific treatments and examples of regions and corridors where they have been implemented can be found at the website http://mobility.tamu.edu/resources/

More Capacity

Projects that provide more road lanes and more public transportation service are part of the congestion solution package in most growing urban regions. 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.

Additional roadways reduce the rate of congestion increase. This is clear from comparisons between 1982 and 2009 (Exhibit 12). Urban areas where capacity increases matched the demand increase saw congestion grow much more slowly than regions where capacity lagged behind demand growth. It is also clear, however, that if only 14 areas were able to accomplish that rate, there must be a broader and larger set of solutions applied to the problem. Most of these 14 regions (listed in Table 9) were not in locations of high economic growth, suggesting their challenges were not as great as in regions with booming job markets.

Exhibit 12. Road Growth and Mobility Level



Source: Texas Transportation Institute analysis, see Table 9 and
http://mobility.tamu.edu/ums/report/methodology.stm

Freight Congestion and Commodity Value

Trucks carry goods to suppliers, manufacturers and markets. They travel long and short distances in peak periods, middle of the day and overnight. Many of the trips conflict with commute trips, but many are also to warehouses, ports, industrial plants and other locations that are not on traditional suburb to office routes. Trucks are a key element in the just-in-time (or lean) manufacturing process; these business models use efficient delivery timing of components to reduce the amount of inventory warehouse space. As a consequence, however, trucks become a mobile warehouse and if their arrival times are missed, production lines can be stopped, at a cost of many times the value of the truck delay times.

Congestion, then, affects truck productivity and delivery times and can also be caused by high volumes of trucks, just as with high car volumes. One difference between car and truck congestion costs is important; a significant share of the $33 billion in truck congestion costs in 2009 was passed on to consumers in the form of higher prices. The congestion effects extend far beyond the region where the congestion occurs.

The 2010 Urban Mobility Report, with funding from the National Center for Freight and Infrastructure Research and Education (CFIRE) at the University of Wisconsin and data from USDOT's Freight Analysis Framework (*6*), developed an estimate of the value of commodities being shipped by truck to and through urban areas and in rural regions. The commodity values were matched with truck delay estimates to identify regions where high values of commodities move on congested roadway networks.

Table 5 points to a correlation between commodity value and truck delay—higher commodity values are associated with more people; more people are associated with more traffic congestion. Bigger cities consume more goods, which means a higher value of freight movement. While there are many cities with large differences in commodity and delay ranks, only 15 urban areas are ranked with commodity values much higher than their delay ranking.

The Table also illustrates the role of long corridors with important roles in freight movement. Some of the smaller urban areas along major interstate highways along the east and west coast and through the central and Midwestern U.S., for example, have commodity value ranks much higher than their delay ranking. High commodity values and lower delay might sound advantageous—lower congestion levels with higher commodity values means there is less chance of congestion getting in the way of freight movement. At the areawide level, this reading of the data would be correct, but in the real world the problem often exists at the road or even intersection level—and solutions should be deployed in the same variety of ways.

Possible Solutions

Urban and rural corridors, ports, intermodal terminals, warehouse districts and manufacturing plants are all locations where truck congestion is a particular problem. Some of the solutions to these problems look like those deployed for person travel—new roads and rail lines, new lanes on existing roads, lanes dedicated to trucks, additional lanes and docking facilities at warehouses and distribution centers. New capacity to handle freight movement might be an even larger need in coming years than passenger travel capacity. Goods are delivered to retail and commercial stores by trucks that are affected by congestion. But "upstream" of the store shelves, many manufacturing operations use just-in-time processes that rely on the ability of trucks to maintain a reliable schedule. Traffic congestion at any time of day causes potentially costly disruptions. The solutions might be implemented in a broad scale to address freight traffic growth or targeted to road sections that cause freight bottlenecks.

Other strategies may consist of regulatory changes, operating practices or changes in the operating hours of freight facilities, delivery schedules or manufacturing plants. Addressing customs, immigration and security issues will reduce congestion at border ports-of-entry. These technology, operating and policy changes can be accomplished with attention to the needs of all stakeholders and, like the operational strategies examined in Exhibit 11, can get as much from the current systems and investments as possible.

The Next Generation of Freight Measures

The dataset used for Table 5 provides origin and destination information, but not routing paths. The *2010 Urban Mobility Report* developed an estimate of the value of commodities in each urban area, but better estimates of value will be possible when new freight models are examined. Those can be matched with the detailed speed data from INRIX to investigate individual congested freight corridors and their value to the economy.

Methodology – The New World of Congestion Data

The base data for the *2010 Urban Mobility Report* come from INRIX, the U.S. Department of Transportation and the states (*1,2,4*). Several analytical processes are used to develop the final measures, but the biggest improvement in the last two decades is provided by INRIX data. The speed data covering most major roads in U.S. urban regions eliminates the difficult process of estimating speeds.

The methodology is described in a series of technical reports (*7,8,9,10*) that are posted on the mobility report website: http://mobility.tamu.edu/ums/report/methodology.stm.

- The INRIX traffic speeds are collected from a variety of sources and compiled in their National Average Speed (NAS) database. Agreements with fleet operators who have location devices on their vehicles feed time and location data points to INRIX. Individuals who have downloaded the INRIX application to their smart phones also contribute time/location data. The proprietary process filters inappropriate data (e.g., pedestrians walking next to a street) and compiles a dataset of average speeds for each road segment. TTI was provided a dataset of hourly average speeds for each link of major roadway covered in the NAS database for 2007, 2008 and 2009 (400,000 centerline miles in 2009).
- Hourly travel volume statistics were developed with a set of procedures developed from computer models and studies of real-world travel time and volume data. The congestion methodology uses daily traffic volume converted to average hourly volumes using a set of estimation curves developed from a national traffic count dataset (*11*).
- The hourly INRIX speeds were matched to the hourly volume data for each road section on the FHWA maps.
- An estimation procedure was also developed for the INRIX data that was not matched with an FHWA road section. The INRIX sections were ranked according to congestion level (using the Travel Time Index); those sections were matched with a similar list of most to least congested sections according to volume per lane (as developed from the FHWA data) (*2*). Delay was calculated by combining the lists of volume and speed.
- The effect of operational treatments and public transportation services were estimated using methods similar to previous Urban Mobility Reports.

Future Changes

There will be other changes in the report methodology over the next few years. There is more information available every year from freeways, streets and public transportation systems that provides more descriptive travel time and volume data. In addition to the travel speed information from INRIX, some advanced transit operating systems monitor passenger volume, travel time and schedule information. These data can be used to more accurately describe congestion problems on public transportation and roadway systems.

Concluding Thoughts

Congestion has gotten worse in many ways since 1982:

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

The *2010 Urban Mobility Report* points to a $115 billion congestion cost, $33 billion of which is due to truck congestion—and that is only the value of wasted time, fuel and truck operating costs. Congestion causes the average urban resident to spend an extra 34 hours of travel time and use 28 gallons of fuel, which amounts to an average cost of $808 per commuter. The report includes a comprehensive picture of congestion in all 439 U.S. urban areas and provides an indication of how the problem affects travel choices, arrival times, shipment routes, manufacturing processes and location decisions.

The economic slowdown points to one of the basic rules of traffic congestion—if fewer people are traveling, there will be less congestion. Not exactly rocket surgery-type findings. Before everyone gets too excited about the decline in congestion, consider these points:

- The decline in driving after more than a doubling in the price of fuel was the equivalent of about 1 mile per day for the person traveling the average 12,000 annual miles.
- Previous recessions in the 1980s and 1990s saw congestion declines that were reversed as soon as the economy began to grow again. And we think 2008 was the best year for mobility in the last several; congestion worsened in 2009.

Anyone who thinks the congestion problem has gone away should check the past.

Solutions and Performance Measurement

There are solutions that work. There are significant benefits from aggressively attacking congestion problems—whether they are large or small, in big metropolitan regions or smaller urban areas and no matter the cause. Performance measures and detailed data like those used in the *2010 Urban Mobility Report* can guide those investments, identify operating changes that should be made and provide the public with the assurance that their dollars are being spent wisely. Decision-makers and project planners alike should use the comprehensive congestion data to describe the problems and solutions in ways that resonate with traveler experiences and frustrations.

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 or to use less vehicle travel and more electronic “travel.” In many corridors, however, there is a need for additional capacity to move people and freight more rapidly and reliably.

The good news from the *2010 Urban Mobility Report* is that the data can improve decisions and the methods used to communicate the effects of actions. The information can be used to study congestion problems in detail and decide how to fund and implement projects, programs and policies to attack the problems. And because the data relate to everyone’s travel experiences, the measures are relatively easy to understand and use to develop solutions that satisfy the transportation needs of a range of travelers, freight shippers, manufacturers and others.

National Congestion Tables

Table 1. What Congestion Means to You, 2009

Urban Area	Yearly Delay per Auto Commuter		Travel Time Index		Excess Fuel per Auto Commuter		Congestion Cost per Auto Commuter	
	Hours	Rank	Value	Rank	Gallons	Rank	Dollars	Rank
Very Large Average (15 areas)	**50**		**1.26**		**39**		**1,166**	
Chicago IL-IN	70	1	1.25	7	52	2	1,738	1
Washington DC-VA-MD	70	1	1.30	2	57	1	1,555	2
Los Angeles-Long Beach-Santa Ana CA	63	3	1.38	1	50	4	1,464	3
Houston TX	58	4	1.25	7	52	2	1,322	4
San Francisco-Oakland CA	49	6	1.27	4	39	6	1,112	6
Dallas-Fort Worth-Arlington TX	48	7	1.22	16	38	7	1,077	8
Boston MA-NH-RI	48	7	1.20	20	36	10	1,112	6
Atlanta GA	44	10	1.22	16	35	11	1,046	11
Seattle WA	44	10	1.24	11	35	11	1,056	10
New York-Newark NY-NJ-CT	42	13	1.27	4	32	14	999	13
Miami FL	39	15	1.23	13	31	18	892	18
Philadelphia PA-NJ-DE-MD	39	15	1.19	23	30	21	919	17
San Diego CA	37	18	1.18	25	31	18	848	20
Phoenix AZ	36	20	1.20	20	31	18	972	14
Detroit MI	33	26	1.15	36	24	36	761	30

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
Medium Urban Areas—over 500,000 and less than 1 million population.
Small Urban Areas—less than 500,000 population.
Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
Travel Time Index—The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak period.
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 $16 per hour of person travel and $106 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon).
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.

Table 1. What Congestion Means to You, 2009, Continued

Urban Area	Yearly Delay per Auto Commuter		Travel Time Index		Excess Fuel per Auto Commuter		Congestion Cost per Auto Commuter	
	Hours	Rank	Value	Rank	Gallons	Rank	Dollars	Rank
Large Average (31 areas)	**31**		**1.17**		**26**		**726**	
Baltimore MD	50	5	1.17	29	43	5	1,218	5
Denver-Aurora CO	47	9	1.22	16	38	7	1,057	9
Minneapolis-St. Paul MN	43	12	1.21	19	37	9	970	15
Orlando FL	41	14	1.20	20	32	14	963	16
Austin TX	39	15	1.28	3	32	14	882	19
Portland OR-WA	36	20	1.23	13	30	21	830	23
San Jose CA	35	22	1.23	13	30	21	774	26
Nashville-Davidson TN	35	22	1.15	36	28	25	831	22
Tampa-St. Petersburg FL	34	25	1.16	32	27	27	764	29
Pittsburgh PA	33	26	1.17	29	27	27	778	25
San Juan PR	33	26	1.25	7	33	13	787	24
Virginia Beach VA	32	29	1.19	23	25	33	695	34
Las Vegas NV	32	29	1.26	6	26	30	708	33
St. Louis MO-IL	31	31	1.12	50	27	27	772	27
New Orleans LA	31	31	1.15	36	23	39	772	27
Riverside-San Bernardino CA	30	35	1.16	32	25	33	741	31
San Antonio TX	30	35	1.16	32	28	25	663	38
Charlotte NC-SC	26	41	1.17	29	22	41	651	40
Jacksonville FL	26	41	1.12	50	22	41	601	47
Indianapolis IN	25	44	1.18	25	19	56	615	45
Raleigh-Durham NC	25	44	1.13	44	22	41	620	44
Milwaukee WI	25	44	1.16	32	21	45	588	48
Memphis TN-MS-AR	24	49	1.13	44	21	45	571	51
Sacramento CA	24	49	1.18	25	21	45	550	54
Louisville KY-IN	22	56	1.10	61	19	56	521	57
Kansas City MO-KS	21	58	1.10	61	20	53	498	61
Cincinnati OH-KY-IN	19	66	1.12	50	15	74	451	63
Cleveland OH	19	66	1.10	61	16	68	423	71
Providence RI-MA	19	66	1.14	42	15	74	406	77
Buffalo NY	17	78	1.10	61	16	68	417	72
Columbus OH	17	78	1.11	58	15	74	388	79

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Table 1. What Congestion Means to You, 2009, Continued

Urban Area	Yearly Delay per Auto Commuter		Travel Time Index		Excess Fuel per Auto Commuter		Congestion Cost per Auto Commuter	
	Hours	Rank	Value	Rank	Gallons	Rank	Dollars	Rank
Medium Average (33 areas)	**22**		**1.11**		**18**		**508**	
Baton Rouge LA	37	18	1.24	11	30	21	1,030	12
Bridgeport-Stamford CT-NY	35	22	1.25	7	32	14	847	21
Colorado Springs CO	31	31	1.12	50	25	33	684	35
Honolulu HI	31	31	1.18	25	26	30	709	32
New Haven CT	29	37	1.15	36	26	30	678	36
Birmingham AL	28	38	1.14	42	23	39	662	39
Salt Lake City UT	28	38	1.12	50	22	41	607	46
Charleston-North Charleston SC	27	40	1.15	36	24	36	646	41
Albuquerque NM	26	41	1.13	44	21	45	677	37
Oklahoma City OK	25	44	1.09	70	21	45	575	50
Hartford CT	24	49	1.13	44	21	45	541	55
Tucson AZ	23	54	1.11	58	18	63	628	42
Allentown-Bethlehem PA-NJ	22	56	1.08	74	19	56	522	56
El Paso TX-NM	21	58	1.15	36	19	56	501	59
Omaha NE-IA	20	63	1.08	74	16	68	413	74
Wichita KS	20	63	1.08	74	21	45	451	63
Richmond VA	19	66	1.06	88	16	68	411	75
Grand Rapids MI	19	66	1.06	88	18	63	440	68
Oxnard-Ventura CA	19	66	1.12	50	19	56	443	67
Springfield MA-CT	19	66	1.09	70	14	78	417	72
Albany-Schenectady NY	18	75	1.10	61	15	74	446	66
Lancaster-Palmdale CA	18	75	1.11	58	13	82	382	81
Tulsa OK	18	75	1.07	79	17	67	407	76
Sarasota-Bradenton FL	17	78	1.10	61	14	78	391	78
Akron OH	16	81	1.05	95	12	86	349	85
Dayton OH	15	84	1.06	88	12	86	331	88
Fresno CA	14	87	1.07	79	13	82	345	86
Indio-Cathedral City-Palm Springs CA	14	87	1.13	44	11	92	337	87
Toledo OH-MI	12	92	1.05	95	9	98	276	95
Rochester NY	12	92	1.07	79	11	92	273	96
Bakersfield CA	11	95	1.08	74	11	92	310	92
Poughkeepsie-Newburgh NY	11	95	1.04	99	10	97	261	97
McAllen TX	7	101	1.09	70	6	101	147	101

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Table 1. What Congestion Means to You, 2009, Continued

Urban Area	Yearly Delay per Auto Commuter		Travel Time Index		Excess Fuel per Auto Commuter		Congestion Cost per Auto Commuter	
	Hours	Rank	Value	Rank	Gallons	Rank	Dollars	Rank
Small Average (22 areas)	**18**		**1.08**		**16**		**436**	
Columbia SC	25	44	1.09	70	20	53	622	43
Salem OR	24	49	1.10	61	20	53	567	52
Little Rock AR	24	49	1.10	61	24	36	581	49
Cape Coral FL	23	54	1.12	50	19	56	558	53
Beaumont TX	21	58	1.08	74	21	45	501	59
Knoxville TN	21	58	1.06	88	18	63	486	62
Boise ID	21	58	1.12	50	18	63	449	65
Worcester MA	20	63	1.07	79	16	68	429	69
Jackson MS	19	66	1.07	79	19	56	515	58
Pensacola FL-AL	19	66	1.07	79	16	68	427	70
Spokane WA	16	81	1.10	61	11	92	385	80
Winston-Salem NC	16	81	1.06	88	14	78	380	82
Boulder CO	15	84	1.13	44	12	86	320	90
Greensboro NC	15	84	1.05	95	13	82	377	83
Anchorage AK	14	87	1.05	95	12	86	329	89
Brownsville TX	14	87	1.04	99	12	86	350	84
Provo UT	14	87	1.06	88	12	86	306	93
Laredo TX	12	92	1.07	79	14	78	318	91
Madison WI	11	95	1.06	88	11	92	287	94
Corpus Christi TX	10	98	1.07	79	13	82	245	98
Stockton CA	9	99	1.02	101	9	98	240	99
Eugene OR	9	99	1.07	79	8	100	216	100
101 Area Average	**39**		**1.20**		**32**		**911**	
Remaining Areas	**18**		**1.09**		**16**		**445**	
All 439 Urban Areas	**34**		**1.20**		**28**		**808**	

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
Medium Urban Areas—over 500,000 and less than 1 million population.
Small Urban Areas—less than 500,000 population.
Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
Travel Time Index—The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak period.
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 $16 per hour of person travel and $106 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon).
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.

Table 2. What Congestion Means to Your Town, 2009

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Truck Congestion Cost ($ million)	Rank	Total Congestion Cost ($ million)	Rank
Very Large Average (15 areas)	**185,503**		**145,959**		**1,273**		**4,414**	
Los Angeles-Long Beach-Santa Ana CA	514,955	1	406,587	1	3,200	2	11,997	1
New York-Newark NY-NJ-CT	454,443	2	348,326	2	3,133	3	10,878	2
Chicago IL-IN	372,755	3	276,883	3	3,349	1	9,476	3
Washington DC-VA-MD	180,976	4	148,212	4	945	6	4,066	4
Dallas-Fort Worth-Arlington TX	159,654	5	126,112	6	948	5	3,649	5
Houston TX	144,302	6	129,627	5	940	7	3,403	6
Philadelphia PA-NJ-DE-MD	136,429	8	106,000	8	967	4	3,274	7
Miami FL	140,972	7	109,281	7	883	8	3,272	8
San Francisco-Oakland CA	121,117	9	94,924	9	718	11	2,791	9
Atlanta GA	112,262	11	90,645	10	852	9	2,727	10
Boston MA-NH-RI	118,707	10	89,928	11	660	12	2,691	11
Phoenix AZ	80,390	15	69,214	13	839	10	2,161	12
Seattle WA	86,549	13	68,703	14	659	13	2,119	13
Detroit MI	87,996	12	64,892	15	551	15	2,032	14
San Diego CA	71,034	18	60,057	18	450	16	1,672	18

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
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Small Urban Areas—less than 500,000 population.
Travel Delay—Value of extra travel time during the year (estimated at $16 per hour of person travel).
Excess Fuel Consumed—Value of increased fuel consumption due to travel in congested conditions rather than free-flow conditions (estimated using state average cost per gallon).
Truck Congestion Cost—Value of increased travel time, fuel and other operating costs of large trucks (estimated at $106 per hour of truck time).
Congestion Cost—Value of delay, fuel and truck congestion cost.
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.

Table 2. What Congestion Means to Your Town, 2009, Continued

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Truck Congestion Cost ($ million)	Rank	Total Congestion Cost ($ million)	Rank
Large Average (31 areas)	**32,953**		**27,926**		**216**		**780**	
Baltimore MD	82,836	14	70,912	12	620	14	2,024	15
Denver-Aurora CO	75,196	16	60,441	17	431	18	1,711	16
Minneapolis-St. Paul MN	74,070	17	64,765	16	409	19	1,689	17
Tampa-St. Petersburg FL	54,130	19	42,644	20	315	21	1,239	19
St. Louis MO-IL	48,777	21	42,474	21	432	17	1,238	20
San Juan PR	49,526	20	49,808	19	252	25	1,190	21
Riverside-San Bernardino CA	39,008	26	33,110	25	317	20	976	22
Pittsburgh PA	39,718	24	33,424	24	288	23	965	23
Orlando FL	39,185	25	31,189	26	306	22	962	24
Portland OR-WA	40,554	23	33,938	23	265	24	958	25
San Jose CA	42,313	22	35,422	22	197	27	937	26
Virginia Beach VA	33,469	27	26,612	28	135	42	714	27
Austin TX	30,272	28	25,631	29	174	30	691	28
Las Vegas NV	30,077	29	25,157	30	153	37	673	29
Sacramento CA	28,461	31	25,119	31	178	29	671	30
San Antonio TX	29,446	30	27,249	27	153	37	664	31
Nashville-Davidson TN	25,443	32	20,309	33	201	26	624	32
Milwaukee WI	24,113	33	19,736	34	162	33	570	33
Kansas City MO-KS	22,172	34	21,036	32	162	33	538	34
Cincinnati OH-KY-IN	21,391	36	17,528	37	166	32	525	35
New Orleans LA	19,867	39	14,772	43	188	28	511	36
Indianapolis IN	20,164	38	15,642	40	169	31	503	38
Cleveland OH	21,859	35	18,077	36	111	46	489	39
Raleigh-Durham NC	18,541	41	16,126	38	162	33	472	40
Jacksonville FL	18,481	42	16,029	39	130	44	445	41
Charlotte NC-SC	17,207	44	14,296	44	151	39	437	42
Memphis TN-MS-AR	17,639	43	15,483	41	133	43	430	43
Louisville KY-IN	16,019	47	13,672	45	120	45	389	45
Providence RI-MA	15,679	48	12,330	48	70	57	343	49
Columbus OH	14,282	50	12,054	49	77	51	323	51
Buffalo NY	11,660	56	10,716	55	76	52	280	56

Very Large Urban Areas—over 3 million population.
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Congestion Cost—Value of delay, fuel and truck congestion cost.
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.

Table 2. What Congestion Means to Your Town, 2009, Continued

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Truck Congestion Cost ($ million)	Rank	Total Congestion Cost ($ million)	Rank
Medium Average (33 areas)	**9,841**		**8,379**		**64**		**233**	
Bridgeport-Stamford CT-NY	20,972	37	18,730	35	142	40	507	37
Salt Lake City UT	18,789	40	15,063	42	91	50	415	44
Baton Rouge LA	14,017	52	11,523	52	162	33	387	46
Birmingham AL	16,227	46	13,344	46	105	48	380	47
Oklahoma City OK	16,335	45	13,269	47	101	49	376	48
Honolulu HI	14,394	49	12,018	50	60	61	326	50
Hartford CT	14,072	51	11,991	51	74	54	321	52
Tucson AZ	11,282	57	8,724	59	137	41	317	53
Albuquerque NM	10,798	58	8,563	60	110	47	286	54
New Haven CT	11,956	55	10,716	54	76	52	285	55
Richmond VA	12,895	53	11,188	53	54	66	279	57
Colorado Springs CO	12,074	54	9,667	56	58	62	266	58
El Paso TX-NM	10,020	59	8,725	58	72	56	242	59
Allentown-Bethlehem PA-NJ	9,998	60	8,438	61	65	60	237	60
Charleston-North Charleston SC	9,189	61	8,313	63	73	55	227	61
Oxnard-Ventura CA	8,921	62	9,333	57	58	62	216	62
Tulsa OK	8,621	64	8,434	62	54	66	202	63
Sarasota-Bradenton FL	8,563	65	6,953	68	52	68	198	65
Grand Rapids MI	8,131	68	8,020	64	52	68	193	66
Albany-Schenectady NY	7,844	69	6,517	69	55	65	190	67
Omaha NE-IA	8,737	63	7,223	67	32	82	184	68
Springfield MA-CT	8,264	66	6,210	73	40	76	183	69
Dayton OH	7,479	70	6,005	74	42	75	170	72
Fresno CA	6,669	77	6,280	71	50	71	165	74
Lancaster-Palmdale CA	7,300	74	5,454	78	35	78	161	75
Wichita KS	7,178	75	7,326	65	33	79	160	77
Akron OH	6,713	76	5,063	79	33	79	148	78
Indio-Cathedral City-Palm Springs CA	5,703	80	4,293	81	44	74	140	79
Rochester NY	6,124	78	5,658	76	31	84	140	79
Bakersfield CA	4,191	88	3,971	83	50	71	119	82
Poughkeepsie-Newburgh NY	4,373	85	4,147	82	31	84	107	84
Toledo OH-MI	4,427	84	3,276	91	28	88	102	86
McAllen TX	2,494	97	2,077	98	14	99	56	97

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Table 2. What Congestion Means to Your Town, 2009, Continued

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Truck Congestion Cost ($ million)	Rank	Total Congestion Cost ($ million)	Rank
Small Average (22 areas)	**4,262**		**3,754**		**31**		**104**	
Columbia SC	8,232	67	6,318	70	66	59	202	63
Cape Coral FL	7,465	71	5,932	75	58	62	183	69
Little Rock AR	7,424	72	7,247	66	51	70	179	71
Knoxville TN	7,338	73	6,270	72	45	73	170	72
Jackson MS	5,607	81	5,571	77	70	57	161	75
Worcester MA	6,051	79	4,997	80	29	87	135	81
Pensacola FL-AL	4,715	82	3,910	85	26	90	108	83
Spokane WA	4,247	86	2,837	94	36	77	106	85
Provo UT	4,652	83	3,915	84	21	93	102	86
Winston-Salem NC	4,163	89	3,786	86	32	82	102	86
Salem OR	4,119	90	3,409	89	30	86	100	89
Greensboro NC	3,560	91	3,311	90	33	79	93	90
Boise ID	4,236	87	3,546	87	16	98	91	91
Beaumont TX	3,536	92	3,529	88	25	91	86	92
Madison WI	3,118	93	3,073	93	25	91	79	93
Stockton CA	2,716	95	2,572	95	28	88	73	94
Anchorage AK	2,969	94	2,487	96	19	95	72	95
Corpus Christi TX	2,499	96	3,229	92	19	95	63	96
Laredo TX	2,001	99	2,270	97	20	94	54	98
Brownsville TX	2,005	98	1,686	99	19	95	52	99
Eugene OR	1,568	100	1,476	100	12	100	39	100
Boulder CO	1,547	101	1,225	101	5	101	32	101
101 Area Total	**4,222,614**		**3,414,200**		**28,596**		**100,356**	
101 Area Average	**41,808**		**33,804**		**283**		**994**	
Remaining Area Total	**575,407**		**511,894**		**4,657**		**14,403**	
Remaining Area Average	**1,702**		**1,514**		**14**		**43**	
All 439 Areas Total	**4,798,019**		**3,926,093**		**33,253**		**114,759**	
All 439 Areas Average	**10,929**		**8,943**		**76**		**262**	

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Excess Fuel Consumed—Value of increased fuel consumption due to travel in congested conditions rather than free-flow conditions (estimated using state average cost per gallon).
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Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

Table 3. Solutions to Congestion Problems, 2009

Urban Area	Operational Treatment Savings				Public Transportation Savings		
	Treatments	Delay (1000 Hours)	Rank	Cost ($ Million)	Delay (1000 Hours)	Rank	Cost ($ Million)
Very Large Average (15 areas)		**15,397**		**$364**	**44,732**		**$1,071**
Los Angeles-Long Beach-Santa Ana CA	r,i,s,a,h	62,859	1	1,464	33,187	4	773.2
New York-Newark NY-NJ-CT	r,i,s,a,h	45,089	2	1,079	368,062	1	8,810.3
Chicago IL-IN	r,i,s,a	16,064	3	408	92,507	2	2,351.7
Houston TX	r,i,s,a,h	14,954	4	353	6,663	12	157.1
San Francisco-Oakland CA	r,i,s,a,h	14,798	5	341	28,660	6	660.4
Washington DC-VA-MD	r,i,s,a,h	14,315	6	322	34,120	3	766.6
Miami FL	i,s,a,h	12,169	7	282	9,356	10	217.2
Dallas-Fort Worth-Arlington TX	r,i,s,a,h	10,085	8	231	5,989	14	136.9
Philadelphia PA-NJ-DE-MD	r,i,s,a,h	8,951	9	215	26,378	7	633.0
Seattle WA	r,i,s,a,h	7,296	10	179	14,153	8	346.5
San Diego CA	r,i,s,a	6,169	12	145	6,286	13	148.0
Atlanta GA	r,i,s,a,h	5,424	13	132	8,315	11	202.0
Boston MA-NH-RI	i,s,a	5,051	14	115	32,885	5	745.5
Phoenix AZ	r,i,s,a,h	4,538	15	122	2,474	22	66.5
Detroit MI	r,i,s,a	3,185	22	74	1,947	24	45.0

Very Large Urban Areas—over 3 million population.
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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.

Congestion Cost Savings—Value of delay, fuel and truck congestion cost.

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) 6^{th} and 12^{th}. 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.

Table 3. Solutions to Congestion Problems, 2009, Continued

Urban Area	Operational Treatment Savings: Treatments	Operational Treatment Savings: Delay (1000 Hours)	Operational Treatment Savings: Rank	Operational Treatment Savings: Cost ($ Million)	Public Transportation Savings: Delay (1000 Hours)	Public Transportation Savings: Rank	Public Transportation Savings: Cost ($ Million)
Large Average (31 areas)		**1,896**		**$45**	**2200**		**$52**
Minneapolis-St. Paul MN	r,i,s,a,h	7,166	11	163.4	5,059	18	115.4
Baltimore MD	i,s,a	4,412	16	107.8	13,227	9	323.2
Denver-Aurora CO	r,i,s,a,h	4,391	17	99.9	5,931	15	135.0
Tampa-St. Petersburg FL	i,s,a	3,952	18	90.5	1,041	36	23.8
Portland OR-WA	r,i,s,a,h	3,596	19	84.9	5,422	17	128.1
Riverside-San Bernardino CA	r,i,s,a,h	3,470	20	86.8	1,088	35	27.2
San Jose CA	r,i,s,a	3,458	21	76.6	1,872	26	41.5
Virginia Beach VA	i,s,a,h	2,690	23	57.4	1,191	33	25.4
Sacramento CA	r,i,s,a,h	2,644	24	62.3	1,314	32	31.0
Orlando FL	i,s,a	2,308	25	56.7	1,432	30	35.2
St. Louis MO-IL	i,s,a	2,048	26	52.0	2,909	21	73.8
Milwaukee WI	r,i,s,a	1,836	27	43.4	1,670	28	39.5
Las Vegas NV	i,s,a	1,676	28	37.5	1,447	29	32.4
Austin TX	i,s,a	1,503	29	34.3	1,893	25	43.2
Pittsburgh PA	i,s,a	1,433	30	34.8	4,890	19	118.8
New Orleans LA	i,s,a	1,237	31	31.8	1,815	27	46.7
San Juan PR	s,a	1,200	32	28.8	5,717	16	137.4
Jacksonville FL	i,s,a	1,083	33	26.1	409	48	9.8
San Antonio TX	i,s,a	1,068	34	24.1	1,331	31	30.0
Kansas City MO-KS	i,s,a	1,050	35	25.5	405	49	9.8
Nashville-Davidson TN	i,s,a	1,000	36	24.5	489	45	12.0
Charlotte NC-SC	i,s,a	780	39	19.8	645	42	16.4
Raleigh-Durham NC	i,s,a	767	41	19.5	660	41	16.8
Cleveland OH	i,s,a	745	43	16.7	2,145	23	48.0
Memphis TN-MS-AR	i,s,a	679	46	16.6	424	47	10.3
Cincinnati OH-KY-IN	r,i,s,a	657	48	16.1	1,152	34	28.3
Columbus OH	r,i,s,a	460	55	10.4	302	57	6.8
Indianapolis IN	i,s,a	433	56	10.8	349	54	8.7
Louisville KY-IN	i,s,a	422	58	10.2	401	50	9.7
Providence RI-MA	i,s,a	327	62	7.2	754	39	16.5
Buffalo NY	i,s,a	292	65	7.0	819	38	19.7

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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.
Congestion Cost Savings—Value of delay, fuel and truck congestion cost.
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.

Table 3. Solutions to Congestion Problems, 2009, Continued

Urban Area	Operational Treatment Savings				Public Transportation Savings		
	Treatments	Delay (1000 Hours)	Rank	Cost ($ Million)	Delay (1000 Hours)	Rank	Cost ($ Million)
Medium Average (33 areas)		**375**		**$9.0**	**361**		**$8.4**
Bridgeport-Stamford CT-NY	i,s,a	876	37	21.2	303	56	7.3
Baton Rouge LA	i,s,a	838	38	23.1	135	82	3.7
Salt Lake City UT	r,i,s,a	777	40	17.2	3,325	20	73.4
Birmingham AL	i,s,a	763	42	17.9	203	73	4.8
Honolulu HI	i,s,a	734	44	16.6	443	46	10.0
Albuquerque NM	i,s,a	727	45	19.3	218	65	5.8
Tucson AZ	i,s,a	665	47	18.7	358	53	10.1
Omaha NE-IA	i,s,a	646	49	13.6	143	81	3.0
El Paso TX-NM	i,s,a	632	50	15.3	732	40	17.7
Hartford CT	i,s,a	584	51	13.3	893	37	20.4
Sarasota-Bradenton FL	i,s,a	544	52	12.6	124	84	2.9
Richmond VA	i,s,a	509	53	11.0	533	44	11.5
Fresno CA	r,i,s,a	476	54	11.8	205	72	5.1
Colorado Springs CO	i,s,a	417	59	9.2	395	52	8.7
New Haven CT	i,s,a	395	60	9.4	276	58	6.6
Charleston-North Charleston SC	i,s,a	298	64	7.4	106	86	2.6
Wichita KS	i,s,a	241	66	5.4	221	64	4.9
Allentown-Bethlehem PA-NJ	r,i,s,a	240	67	5.7	260	59	6.2
Oxnard-Ventura CA	i,s,a	237	68	5.7	154	79	3.7
Albany-Schenectady NY	i,s,a	221	69	5.4	340	55	8.2
Indio-Cathedral City-Palm Springs CA	i,s,a	195	72	4.8	159	77	3.9
Oklahoma City OK	i,s,a	178	76	4.1	110	85	2.5
Grand Rapids MI	s,a	168	78	4.0	258	60	6.1
Bakersfield CA	i,s,a	165	79	4.7	210	69	6.0
Dayton OH	s,a	165	79	3.8	209	71	4.8
Rochester NY	i,s,a	160	81	3.7	212	67	4.8
Lancaster-Palmdale CA	s,a	156	82	3.4	604	43	13.3
Springfield MA-CT	i,s,a	153	83	3.4	238	62	5.3
Poughkeepsie-Newburgh NY	s,a	55	93	1.3	177	75	4.3
Tulsa OK	i,s,a	55	93	1.3	41	96	1.0
Toledo OH-MI	i,s,a	51	95	1.2	153	80	3.5
Akron OH	i,s,a	47	96	1.0	155	78	3.4
McAllen TX	s,a	16	101	0.4	24	100	0.5

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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.
Congestion Cost Savings—Value of delay, fuel and truck congestion cost.
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.

Table 3. Solutions to Congestion Problems, 2009, Continued

Urban Area	Operational Treatment Savings				Public Transportation Savings		
	Treatments	Delay (1000 Hours)	Rank	Cost ($ Million)	Delay (1000 Hours)	Rank	Cost ($ Million)
Small Average (22 areas)		**148**		**$3.6**	**126**		**$3.1**
Little Rock AR	i,s,a	433	56	10.4	21	101	0.5
Cape Coral FL	i,s,a	375	61	9.2	129	83	3.2
Knoxville TN	i,s,a	310	63	7.2	49	93	1.1
Winston-Salem NC	i,s,a	208	70	5.1	40	98	1.0
Provo UT	i,s,a	207	71	4.5	45	94	1.0
Jackson MS	s,a	193	73	5.5	54	92	1.6
Worcester MA	s,a	192	74	4.3	58	91	1.3
Spokane WA	i,s,a	190	75	4.7	400	51	10.0
Greensboro NC	i,s,a	178	76	4.7	103	87	2.7
Columbia SC	i,s,a	150	84	3.7	245	61	6.0
Stockton CA	i,s,a	123	85	3.3	183	74	4.9
Salem OR	s,a	95	86	2.3	214	66	5.2
Eugene OR	i,s,a	84	87	2.1	234	63	5.8
Anchorage AK	s,a	83	88	2.0	211	68	5.1
Beaumont TX	s,a	83	88	2.0	34	99	0.8
Boise ID	i,s,a	75	90	1.6	41	96	0.9
Pensacola FL-AL	s,a	74	91	1.7	45	94	1.0
Madison WI	s,a	65	92	1.6	210	69	5.3
Laredo TX	i,s,a	39	97	1.1	100	88	2.7
Brownsville TX	s,a	37	98	1.0	172	76	4.5
Boulder CO	s,a	35	99	0.7	80	90	1.7
Corpus Christi TX	s,a	23	100	0.6	96	89	2.4
101 Area Total		**305,370**		**7,220**	**753,870**		**18,025**
101 Area Average		**3,023**		**71**	**7,464**		**178**
All Urban Areas Total		**321,132**		**7,615**	**783,185**		**18,758**
All Urban Areas Average		**732**		**17**	**1,784**		**43**

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
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.
Congestion Cost Savings—Value of delay, fuel and truck congestion cost.
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.

Table 4. Other Congestion Measures, 2009

Urban Area	Delay Per Auto Commuter		Delay per Non-Peak Traveler		Commuter Stress Index	
	Hours	Rank	Hours	Rank	Value	Rank
Very Large Area (15 areas)	**50**		**13**		**1.37**	
Washington DC-VA-MD	70	1	16	2	1.43	2
Chicago IL-IN	70	1	19	1	1.36	7
Los Angeles-Long Beach-Santa Ana CA	63	3	16	2	1.54	1
Houston TX	58	4	13	6	1.37	6
San Francisco-Oakland CA	49	6	13	6	1.39	3
Boston MA-NH-RI	48	7	11	14	1.29	21
Dallas-Fort Worth-Arlington TX	48	7	13	6	1.33	15
Atlanta GA	44	10	11	14	1.31	17
Seattle WA	44	10	11	14	1.35	9
New York-Newark NY-NJ-CT	42	13	11	14	1.38	4
Miami FL	39	15	12	11	1.32	16
Philadelphia PA-NJ-DE-MD	39	15	12	11	1.26	23
San Diego CA	37	18	11	14	1.25	25
Phoenix AZ	36	20	10	23	1.30	18
Detroit MI	33	26	12	11	1.19	43

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
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Small Urban Areas—less than 500,000 population.
Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
Yearly Delay per Non-Peak Traveler—Extra travel time during midday, evening and weekends divided by the number of private vehicle travelers who do not typically travel in the peak periods.
Commuter Stress Index—The ratio of travel time in the peak period to the travel time at free-flow conditions for the peak directions of travel in both peak periods. A value of 1.40 indicates a 20-minute free-flow trip takes 28 minutes in the most congested directions of the peak periods.
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.

Table 4. Other Congestion Measures, 2009, Continued

Urban Area	Delay Per Auto Commuter		Delay per Non-Peak Traveler		Commuter Stress Index	
	Hours	Rank	Hours	Rank	Value	Rank
Large Area Average (31 areas)	**31**		**9**		**1.24**	
Baltimore MD	50	5	14	4	1.25	25
Denver-Aurora CO	47	9	14	4	1.30	18
Minneapolis-St. Paul MN	43	12	11	14	1.30	18
Orlando FL	41	14	13	6	1.25	25
Austin TX	39	15	8	44	1.38	4
Portland OR-WA	36	20	9	30	1.34	12
San Jose CA	35	22	11	14	1.35	9
Nashville-Davidson TN	35	22	10	23	1.22	36
Tampa-St. Petersburg FL	34	25	11	14	1.21	37
San Juan PR	33	26	9	30	1.34	12
Pittsburgh PA	33	26	11	14	1.23	33
Las Vegas NV	32	29	10	23	1.36	7
Virginia Beach VA	32	29	10	23	1.29	21
New Orleans LA	31	31	9	30	1.21	37
St. Louis MO-IL	31	31	10	23	1.16	54
San Antonio TX	30	36	8	44	1.25	25
Riverside-San Bernardino CA	30	36	10	23	1.25	25
Charlotte NC-SC	26	42	7	61	1.24	31
Jacksonville FL	26	42	8	44	1.17	53
Milwaukee WI	25	45	7	61	1.24	31
Indianapolis IN	25	45	8	44	1.21	37
Raleigh-Durham NC	25	45	8	44	1.18	46
Sacramento CA	24	50	7	61	1.26	23
Memphis TN-MS-AR	24	50	9	30	1.18	46
Louisville KY-IN	22	57	8	44	1.14	62
Kansas City MO-KS	21	59	7	61	1.15	58
Cincinnati OH-KY-IN	19	68	6	76	1.19	43
Cleveland OH	19	68	6	76	1.14	62
Providence RI-MA	19	68	6	76	1.20	42
Columbus OH	17	80	5	89	1.18	46
Buffalo NY	17	80	6	76	1.14	62

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Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
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Table 4. Other Congestion Measures, 2009, Continued

Urban Area	Delay Per Auto Commuter		Delay per Non-Peak Traveler		Commuter Stress Index	
	Hours	Rank	Hours	Rank	Value	Rank
Medium Area Average (33 areas)	**22**		**7**		**1.15**	
Baton Rouge LA	37	18	9	30	1.34	12
Bridgeport-Stamford CT-NY	35	22	9	30	1.35	9
Honolulu HI	31	31	8	44	1.25	25
Colorado Springs CO	31	31	13	6	1.16	54
New Haven CT	29	38	9	30	1.23	33
Birmingham AL	28	39	9	30	1.21	37
Salt Lake City UT	28	39	9	30	1.18	46
Charleston-North Charleston SC	27	41	9	30	1.21	37
Albuquerque NM	26	42	8	44	1.19	43
Oklahoma City OK	25	45	8	44	1.14	62
Hartford CT	24	50	7	61	1.18	46
Tucson AZ	23	55	9	30	1.15	58
Allentown-Bethlehem PA-NJ	22	57	9	30	1.11	72
El Paso TX-NM	21	59	6	76	1.23	33
Wichita KS	20	65	8	44	1.09	83
Omaha NE-IA	20	65	7	61	1.11	72
Oxnard-Ventura CA	19	68	7	61	1.16	54
Richmond VA	19	68	8	44	1.08	90
Springfield MA-CT	19	68	7	61	1.12	68
Grand Rapids MI	19	68	8	44	1.08	90
Albany-Schenectady NY	18	77	7	61	1.13	66
Lancaster-Palmdale CA	18	77	6	76	1.13	66
Tulsa OK	18	77	7	61	1.10	79
Sarasota-Bradenton FL	17	80	7	61	1.11	72
Akron OH	16	84	5	89	1.07	94
Dayton OH	15	87	5	89	1.09	83
Fresno CA	14	90	5	89	1.09	83
Indio-Cathedral City-Palm Springs CA	14	90	6	76	1.18	46
Rochester NY	12	95	4	99	1.10	79
Toledo OH-MI	12	95	5	89	1.07	94
Bakersfield CA	11	98	4	99	1.11	72
Poughkeepsie-Newburgh NY	11	98	5	89	1.05	99
McAllen TX	7	104	2	104	1.11	72

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Large Urban Areas—over 1 million and less than 3 million population.
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Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
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Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

Table 4. Other Congestion Measures, 2009, Continued

Urban Area	Delay Per Auto Commuter		Delay per Non-Peak Traveler		Commuter Stress Index	
	Hours	Rank	Hours	Rank	Value	Rank
Small Area Average (22 areas)	**18**		**7**		**1.10**	
Columbia SC	25	45	9	30	1.12	68
Little Rock AR	24	50	8	44	1.15	58
Salem OR	24	50	10	23	1.12	68
Cape Coral FL	23	55	8	44	1.15	58
Boise ID	21	59	6	76	1.18	46
Knoxville TN	21	59	8	44	1.09	83
Beaumont TX	21	59	8	44	1.11	72
Worcester MA	20	65	7	61	1.10	79
Pensacola FL-AL	19	68	7	61	1.09	83
Jackson MS	19	68	8	44	1.09	83
Winston-Salem NC	16	84	6	76	1.07	94
Spokane WA	16	84	6	76	1.12	68
Boulder CO	15	87	5	89	1.16	54
Greensboro NC	15	87	6	76	1.07	94
Brownsville TX	14	90	5	89	1.05	99
Anchorage AK	14	90	6	76	1.06	98
Provo UT	14	90	6	76	1.08	90
Laredo TX	12	95	5	89	1.08	90
Madison WI	11	98	4	99	1.09	83
Corpus Christi TX	10	101	5	89	1.10	79
Eugene OR	9	102	3	103	1.11	72
Stockton CA	9	102	4	99	1.03	101
101 Area Average	**39**		**11**		**1.29**	
Remaining Area Average	**18**		**7**		**1.13**	
All 439 Area Average	**34**		**10**		**1.29**	

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
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Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
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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.

Table 5. Truck Commodity Value and Truck Delay, 2009

Urban Area	Total Delay		Truck Delay			Truck Commodity Value	
	(1000 Hours)	Rank	(1000 Hours)	Rank	Congestion Cost ($ million)	($ million)	Rank
Very Large Average (15 areas)	**185,503**		**12,046**		**1,273**	**169,837**	
Chicago IL-IN	372,755	3	31,695	1	3,349	428,790	1
Los Angeles-Long Beach-Santa Ana CA	514,955	1	30,285	2	3,200	294,112	3
New York-Newark NY-NJ-CT	454,443	2	29,645	3	3,133	314,936	2
Philadelphia PA-NJ-DE-MD	136,429	8	9,149	4	967	117,097	9
Dallas-Fort Worth-Arlington TX	159,654	5	8,967	5	948	170,030	5
Washington DC-VA-MD	180,976	4	8,947	6	945	99,477	14
Houston TX	144,302	6	8,896	7	940	210,975	4
Miami FL	140,972	7	8,351	8	883	120,837	8
Atlanta GA	112,262	11	8,060	9	852	153,549	7
Phoenix AZ	80,390	15	7,942	10	839	99,567	13
San Francisco-Oakland CA	121,117	9	6,798	11	718	101,772	12
Boston MA-NH-RI	118,707	10	6,248	12	660	103,423	11
Seattle WA	86,549	13	6,240	13	659	110,369	10
Detroit MI	87,996	12	5,219	15	551	161,319	6
San Diego CA	71,034	18	4,255	16	450	61,303	26

Very Large Urban Areas—over 3 million population.
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Travel Delay—Travel time above that needed to complete a trip at free-flow speeds for all vehicles.
Truck Delay—Travel time above that needed to complete a trip at free-flow speeds for large trucks.
Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the urban area.
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.
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Table 5. Truck Commodity Value and Truck Delay, 2009, Continued

Urban Area	Total Delay (1000 Hours)	Total Delay Rank	Truck Delay (1000 Hours)	Truck Delay Rank	Truck Delay Congestion Cost ($ million)	Truck Commodity Value ($ million)	Truck Commodity Value Rank
Large Average (31 areas)	**32,953**		**2,046**		**216**	**52,938**	
Baltimore MD	82,836	14	5,871	14	620	69,724	21
St. Louis MO-IL	48,777	21	4,092	17	432	91,101	16
Denver-Aurora CO	75,196	16	4,080	18	431	64,915	24
Minneapolis-St. Paul MN	74,070	17	3,867	19	409	91,617	15
Riverside-San Bernardino CA	39,008	26	3,001	20	317	78,214	17
Tampa-St. Petersburg FL	54,130	19	2,985	21	315	61,111	27
Orlando FL	39,185	25	2,895	22	306	56,464	32
Pittsburgh PA	39,718	24	2,724	23	288	54,008	33
Portland OR-WA	40,554	23	2,506	24	265	57,608	31
San Juan PR	49,526	20	2,383	25	252	29,316	48
Nashville-Davidson TN	25,443	32	1,905	26	201	61,558	25
San Jose CA	42,313	22	1,869	27	197	40,506	40
New Orleans LA	19,867	39	1,782	28	188	23,074	52
Sacramento CA	28,461	31	1,689	29	178	47,397	36
Austin TX	30,272	28	1,644	30	174	33,185	46
Indianapolis IN	20,164	38	1,600	31	169	67,586	22
Cincinnati OH-KY-IN	21,391	36	1,570	32	166	60,194	28
Raleigh-Durham NC	18,541	41	1,532	33	162	41,299	38
Milwaukee WI	24,113	33	1,532	34	162	70,301	20
Kansas City MO-KS	22,172	34	1,529	35	162	73,291	18
Las Vegas NV	30,077	29	1,447	37	153	28,730	49
San Antonio TX	29,446	30	1,444	38	153	42,175	37
Charlotte NC-SC	17,207	44	1,432	39	151	59,720	30
Virginia Beach VA	33,469	27	1,273	42	135	31,092	47
Memphis TN-MS-AR	17,639	43	1,256	43	133	59,962	29
Jacksonville FL	18,481	42	1,228	44	130	12,751	64
Louisville KY-IN	16,019	47	1,131	45	120	51,724	34
Cleveland OH	21,859	35	1,055	46	111	71,825	19
Columbus OH	14,282	50	728	51	77	65,159	23
Buffalo NY	11,660	56	717	53	76	24,299	51
Providence RI-MA	15,679	48	665	57	70	21,180	53

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Table 5. Truck Commodity Value and Truck Delay, 2009, Continued

Urban Area	Total Delay		Truck Delay			Truck Commodity Value	
	(1000 Hours)	Rank	(1000 Hours)	Rank	Congestion Cost ($ million)	($ million)	Rank
Medium Average (33 areas)	**9,841**		**606**		**64**	**15,983**	
Baton Rouge LA	14,017	52	1,529	36	162	14,891	59
Bridgeport-Stamford CT-NY	20,972	37	1,344	40	142	14,228	60
Tucson AZ	11,282	57	1,300	41	137	20,340	54
Albuquerque NM	10,798	58	1,042	47	110	12,505	66
Birmingham AL	16,227	46	996	48	105	36,399	45
Oklahoma City OK	16,335	45	959	49	101	38,963	42
Salt Lake City UT	18,789	40	861	50	91	49,502	35
New Haven CT	11,956	55	720	52	76	10,509	69
Hartford CT	14,072	51	698	54	74	15,782	56
Charleston-North Charleston SC	9,189	61	689	55	73	10,338	70
El Paso TX-NM	10,020	59	684	56	72	9,460	73
Allentown-Bethlehem PA-NJ	9,998	60	612	60	65	13,582	62
Honolulu HI	14,394	49	569	61	60	7,372	82
Colorado Springs CO	12,074	54	552	62	58	5,979	89
Oxnard-Ventura CA	8,921	62	551	63	58	7,370	83
Albany-Schenectady NY	7,844	69	520	65	55	18,600	55
Tulsa OK	8,621	64	513	66	54	37,508	44
Richmond VA	12,895	53	510	67	54	39,879	41
Sarasota-Bradenton FL	8,563	65	489	68	52	7,122	85
Grand Rapids MI	8,131	68	489	69	52	38,254	43
Bakersfield CA	4,191	88	471	71	50	8,695	77
Fresno CA	6,669	77	469	72	50	7,601	79
Indio-Cathedral City-Palm Springs CA	5,703	80	418	74	44	4,376	93
Dayton OH	7,479	70	394	75	42	25,634	50
Springfield MA-CT	8,264	66	383	76	40	12,606	65
Lancaster-Palmdale CA	7,300	74	333	78	35	2,188	98
Wichita KS	7,178	75	317	79	33	6,492	88
Akron OH	6,713	76	315	80	33	9,020	75
Omaha NE-IA	8,737	63	304	82	32	7,441	81
Poughkeepsie-Newburgh NY	4,373	85	291	84	31	9,048	74
Rochester NY	6,124	78	291	85	31	8,858	76
Toledo OH-MI	4,427	84	261	89	28	10,057	72
McAllen TX	2,494	97	131	99	14	6,828	87

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Table 5. Truck Commodity Value and Truck Delay, 2009, Continued

Urban Area	Total Delay (1000 Hours)	Total Delay Rank	Truck Delay (1000 Hours)	Truck Delay Rank	Truck Delay Congestion Cost ($ million)	Truck Commodity Value ($ million)	Truck Commodity Value Rank
Small Average (22 areas)	**4,262**		**296**		**31**	**9,004**	
Jackson MS	5,607	81	663	58	70	15,008	58
Columbia SC	8,232	67	627	59	66	12,153	67
Cape Coral FL	7,465	71	545	64	58	7,480	80
Little Rock AR	7,424	72	486	70	51	13,438	63
Knoxville TN	7,338	73	426	73	45	10,205	71
Spokane WA	4,247	86	340	77	36	5,534	91
Greensboro NC	3,560	91	314	81	33	40,939	39
Winston-Salem NC	4,163	89	298	83	32	7,364	84
Salem OR	4,119	90	284	86	30	3,278	96
Worcester MA	6,051	79	278	87	29	13,986	61
Stockton CA	2,716	95	264	88	28	8,234	78
Pensacola FL-AL	4,715	82	250	90	26	5,946	90
Madison WI	3,118	93	238	91	25	15,753	57
Beaumont TX	3,536	92	238	92	25	7,033	86
Provo UT	4,652	83	200	93	21	10,902	68
Laredo TX	2,001	99	193	94	20	2,117	99
Corpus Christi TX	2,499	96	181	95	19	3,824	95
Anchorage AK	2,969	94	180	96	19	3,934	94
Brownsville TX	2,005	98	177	97	19	2,117	100
Boise ID	4,236	87	155	98	16	5,051	92
Eugene OR	1,568	100	117	100	12	3,103	97
Boulder CO	1,547	101	47	101	5	749	101
101 Area Average	**41,808**		**2,680**		**283**	**48,655**	
Remaining Area Average	**1,702**		**130**		**14**	**6,787**	
All 439 Area Average	**10,929**		**717**		**76**	**16,420**	

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
Medium Urban Areas—over 500,000 and less than 1 million population.
Small Urban Areas—less than 500,000 population.
Travel Delay—Travel time above that needed to complete a trip at free-flow speeds for all vehicles.
Truck Delay—Travel time above that needed to complete a trip at free-flow speeds for large trucks.
Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the urban area.
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.

Table 6. State Truck Commodity Value, 2009

State	Total Truck Commodity Value ($ million)	Rural Truck Commodity Value ($ million)	Urban Truck Commodity Value ($ million)
Alabama	189,260	67,453	121,807
Alaska	15,471	4,798	10,673
Arizona	207,824	125,037	82,787
Arkansas	141,300	26,140	115,159
California	943,732	706,912	236,820
Colorado	136,145	79,433	56,712
Connecticut	83,544	73,900	9,644
Delaware	32,489	20,991	11,498
Florida	494,555	211,689	282,866
Georgia	339,330	190,707	148,623
Hawaii	12,893	6,787	6,106
Idaho	61,369	11,612	49,757
Illinois	637,415	448,507	188,908
Indiana	333,141	145,834	187,306
Iowa	127,378	21,299	106,079
Kansas	119,642	37,410	82,232
Kentucky	220,204	72,049	148,155
Louisiana	165,536	76,729	88,808
Maine	37,646	7,202	30,444
Maryland	171,727	130,530	41,198
Massachusetts	155,744	142,166	13,578
Michigan	342,428	246,781	95,647
Minnesota	171,729	97,683	74,046
Mississippi	137,690	30,264	107,425
Missouri	234,124	132,038	102,086
Montana	35,583	1,865	33,718
Nebraska	83,543	10,067	73,476
Nevada	68,588	34,267	34,321
New Hampshire	35,583	13,850	21,734
New Jersey	206,282	184,447	21,835
New Mexico	99,012	17,962	81,050
New York	296,011	222,436	73,575
North Carolina	320,249	196,210	124,039
North Dakota	34,036	3,172	30,864

Total Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the state.
Rural Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the rural areas of the state.
Urban Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the urban areas of the state.

Table 6. State Truck Commodity Value, 2009, Continued

State	Total Truck Commodity Value ($ million)	Urban Truck Commodity Value ($ million)	Rural Truck Commodity Value ($ million)
Ohio	416,171	253,053	163,118
Oklahoma	207,825	77,273	130,552
Oregon	133,050	63,347	69,704
Pennsylvania	364,083	200,786	163,297
Rhode Island	18,565	15,240	3,325
South Carolina	174,307	55,599	118,708
South Dakota	40,224	4,332	35,892
Tennessee	278,993	145,569	133,424
Texas	934,959	554,818	380,141
Utah	124,282	72,571	51,711
Vermont	20,628	2,143	18,485
Virginia	227,424	129,949	97,475
Washington	204,216	133,913	70,303
West Virginia	72,712	20,112	52,600
Wisconsin	306,323	133,733	172,589
Wyoming	40,739	2,123	38,616
District of Columbia	9,283	9,283	--
Puerto Rico	48,991	44,563	4,429

Total Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the state.
Rural Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the rural areas of the state.
Urban Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the urban areas of the state.

Table 7. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2009)

Urban Area	Yearly Hours of Delay per Auto Commuter				Long-Term Change 1982 to 2009	
	2009	2008	1999	1982	Hours	Rank
Very Large Average (15 areas)	**50**	**50**	**49**	**19**	**31**	
Chicago IL-IN	70	64	55	18	52	1
Washington DC-VA-MD	70	70	70	20	50	2
Dallas-Fort Worth-Arlington TX	48	49	39	7	41	3
Boston MA-NH-RI	48	50	41	13	35	6
Houston TX	58	63	42	24	34	8
Seattle WA	44	47	52	10	34	8
New York-Newark NY-NJ-CT	42	42	36	10	32	10
Atlanta GA	44	45	49	13	31	11
San Francisco-Oakland CA	49	50	54	20	29	14
Miami FL	39	35	33	10	29	14
San Diego CA	37	41	33	8	29	14
Philadelphia PA-NJ-DE-MD	39	38	31	12	27	19
Los Angeles-Long Beach-Santa Ana CA	63	60	76	39	24	25
Detroit MI	33	37	36	14	19	37
Phoenix AZ	36	37	32	24	12	78

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
Medium Urban Areas—over 500,000 and less than 1 million population.
Small Urban Areas—less than 500,000 population.
Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
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.

Table 7. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2009), Continued

Urban Area	Yearly Hours of Delay per Auto Commuter				Long-Term Change 1982 to 2009	
	2009	2008	1999	1982	Hours	Rank
Large Average (31 areas)	**31**	**32**	**32**	**9**	**22**	
Baltimore MD	50	48	37	11	39	4
Minneapolis-St. Paul MN	43	50	47	6	37	5
Denver-Aurora CO	47	48	45	12	35	6
Orlando FL	41	37	46	11	30	12
Austin TX	39	41	35	9	30	12
San Juan PR	33	30	23	5	28	17
Las Vegas NV	32	27	24	5	27	19
Riverside-San Bernardino CA	30	30	22	3	27	19
San Antonio TX	30	28	25	4	26	22
Portland OR-WA	36	36	37	11	25	23
Charlotte NC-SC	26	26	17	5	21	29
Tampa-St. Petersburg FL	34	35	27	14	20	32
St. Louis MO-IL	31	33	44	11	20	32
Raleigh-Durham NC	25	25	25	5	20	32
Memphis TN-MS-AR	24	21	22	5	19	37
Nashville-Davidson TN	35	33	34	17	18	42
San Jose CA	35	38	49	17	18	42
Virginia Beach VA	32	35	43	14	18	42
Kansas City MO-KS	21	22	36	4	17	46
Providence RI-MA	19	20	18	2	17	46
Jacksonville FL	26	28	26	10	16	53
Milwaukee WI	25	27	32	9	16	53
Cleveland OH	19	20	20	3	16	53
Pittsburgh PA	33	31	37	18	15	59
Indianapolis IN	25	25	30	10	15	59
Sacramento CA	24	24	26	9	15	59
Cincinnati OH-KY	19	21	27	4	15	59
Columbus OH	17	19	16	2	15	59
New Orleans LA	31	28	26	17	14	70
Louisville KY-IN	22	21	25	9	13	73
Buffalo NY	17	16	14	4	13	73

Very Large Urban Areas—over 3 million population.
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Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
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Table 7. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2009), Continued

Urban Area	Yearly Hours of Delay per Auto Commuter				Long-Term Change 1982 to 2009	
	2009	2008	1999	1982	Hours	Rank
Medium Average (33 areas)	**22**	**21**	**21**	**7**	**15**	
Baton Rouge LA	37	37	31	9	28	17
Colorado Springs CO	31	31	39	6	25	23
Bridgeport-Stamford CT-NY	35	39	41	11	24	25
New Haven CT	29	28	34	7	22	27
Salt Lake City UT	28	24	24	6	22	27
Birmingham AL	28	26	29	7	21	29
Oklahoma City OK	25	26	25	5	20	32
Hartford CT	24	24	25	5	19	37
El Paso TX-NM	21	25	17	3	18	42
Honolulu HI	31	31	27	14	17	46
Charleston-North Charleston SC	27	24	25	10	17	46
Albuquerque NM	26	29	34	9	17	46
Omaha NE-IA	20	21	14	3	17	46
Oxnard-Ventura CA	19	18	15	2	17	46
Allentown-Bethlehem PA-NJ	22	22	23	7	15	59
Grand Rapids MI	19	17	19	4	15	59
Richmond VA	19	16	15	4	15	59
Albany-Schenectady NY	18	17	13	3	15	59
Wichita KS	20	20	19	6	14	70
Tulsa OK	18	16	14	4	14	70
Akron OH	16	16	23	3	13	73
Tucson AZ	23	21	17	11	12	78
Springfield MA-CT	19	17	18	9	10	83
Toledo OH-MI	12	10	18	2	10	83
Bakersfield CA	11	9	4	1	10	83
Rochester NY	12	13	12	3	9	87
Sarasota-Bradenton FL	17	13	19	9	8	89
Dayton OH	15	15	20	7	8	89
Fresno CA	14	12	17	7	7	91
Poughkeepsie-Newburgh NY	11	9	8	5	6	93
McAllen TX	7	6	5	1	6	93
Lancaster-Palmdale CA	18	16	11	19	-1	99
Indio-Cathedral City-Palm Springs CA	14	14	16	22	-8	101

Very Large Urban Areas—over 3 million population.
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Small Urban Areas—less than 500,000 population.
Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
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.

Table 7. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2009), Continued

Urban Area	Yearly Hours of Delay per Auto Commuter				Long-Term Change 1982 to 2009	
	2009	2008	1999	1982	Hours	Rank
Small Average (22 areas)	**18**	**18**	**17**	**5**	**13**	
Columbia SC	25	24	15	4	21	29
Salem OR	24	22	28	4	20	32
Little Rock AR	24	22	19	5	19	37
Boise ID	21	18	19	2	19	37
Beaumont TX	21	23	16	5	16	53
Jackson MS	19	19	12	3	16	53
Pensacola FL-AL	19	18	15	3	16	53
Cape Coral FL	23	23	24	8	15	59
Knoxville TN	21	22	28	6	15	59
Worcester MA	20	21	21	7	13	73
Brownsville TX	14	13	6	1	13	73
Winston-Salem NC	16	15	13	4	12	78
Greensboro NC	15	14	23	6	10	83
Laredo TX	12	4	1	0	12	78
Spokane WA	16	18	23	6	10	83
Provo UT	14	13	11	5	9	87
Stockton CA	9	9	7	2	7	91
Boulder CO	15	22	27	9	6	93
Madison WI	11	9	6	5	6	93
Corpus Christi TX	10	10	9	5	5	97
Eugene OR	9	10	12	5	4	98
Anchorage AK	14	16	20	16	-2	100
101 Area Average	**39**	**39**	**39**	**14**	**25**	
Remaining Area Average	**18**	**18**	**19**	**10**	**8**	
All 439 Area Average	**34**	**34**	**35**	**14**	**20**	

Very Large Urban Areas—over 3 million population.
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Small Urban Areas—less than 500,000 population.
Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.
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.

Table 8. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2009)

Urban Area	Travel Time Index				Point Change in Peak-Period Time Penalty 1982 to 2009	
	2009	2008	1999	1982	Points	Rank
Very Large Average (15 areas)	**1.26**	**1.26**	**1.27**	**1.12**	**14**	
Washington DC-VA-MD	1.30	1.29	1.31	1.11	19	3
Chicago IL-IN	1.25	1.26	1.21	1.08	17	6
Dallas-Fort Worth-Arlington TX	1.22	1.23	1.19	1.05	17	6
Los Angeles-Long Beach-Santa Ana CA	1.38	1.35	1.39	1.21	17	6
New York-Newark NY-NJ-CT	1.27	1.27	1.28	1.10	17	6
Seattle WA	1.24	1.26	1.34	1.09	15	13
Atlanta GA	1.22	1.23	1.23	1.08	14	16
Miami FL	1.23	1.26	1.24	1.09	14	16
San Diego CA	1.18	1.20	1.19	1.04	14	16
San Francisco-Oakland CA	1.27	1.28	1.30	1.13	14	16
Boston MA-NH-RI	1.20	1.21	1.25	1.09	11	26
Philadelphia PA-NJ-DE-MD	1.19	1.19	1.18	1.09	10	32
Phoenix AZ	1.20	1.17	1.17	1.10	10	32
Houston TX	1.25	1.28	1.25	1.18	7	49
Detroit MI	1.15	1.18	1.21	1.09	6	58

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
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 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak period.
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.

Table 8. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2009), Continued

Urban Area	Travel Time Index				Point Change in Peak-Period Time Penalty 1982 to 2009	
	2009	2008	1999	1982	Points	Rank
Large Average (31 areas)	**1.17**	**1.17**	**1.19**	**1.07**	**10**	
Austin TX	1.28	1.27	1.23	1.08	20	1
Las Vegas NV	1.26	1.27	1.24	1.06	20	1
Portland OR-WA	1.23	1.23	1.25	1.06	17	6
San Juan PR	1.25	1.22	1.19	1.07	18	4
Minneapolis-St. Paul MN	1.21	1.24	1.30	1.05	16	12
Denver-Aurora CO	1.22	1.21	1.25	1.07	15	13
Riverside-San Bernardino CA	1.16	1.16	1.12	1.01	15	13
Orlando FL	1.20	1.19	1.23	1.07	13	20
Sacramento CA	1.18	1.19	1.18	1.05	13	20
San Antonio TX	1.16	1.16	1.16	1.03	13	20
Baltimore MD	1.17	1.16	1.13	1.05	12	23
Indianapolis IN	1.18	1.18	1.15	1.06	12	23
Charlotte NC-SC	1.17	1.19	1.16	1.06	11	26
Providence RI-MA	1.14	1.15	1.15	1.03	11	26
San Jose CA	1.23	1.26	1.26	1.12	11	26
Milwaukee WI	1.16	1.17	1.18	1.06	10	32
Virginia Beach VA	1.19	1.19	1.24	1.09	10	32
Cincinnati OH-KY-IN	1.12	1.13	1.14	1.03	9	38
Columbus OH	1.11	1.08	1.09	1.02	9	38
Raleigh-Durham NC	1.13	1.13	1.12	1.04	9	38
Memphis TN-MS-AR	1.13	1.13	1.16	1.05	8	43
Cleveland OH	1.10	1.09	1.16	1.03	7	49
Buffalo NY	1.10	1.09	1.09	1.04	6	58
Jacksonville FL	1.12	1.13	1.13	1.06	6	58
Kansas City MO-KS	1.10	1.11	1.19	1.04	6	58
Louisville KY-IN	1.10	1.08	1.11	1.06	4	72
Nashville-Davidson TN	1.15	1.14	1.17	1.11	4	72
St. Louis MO-IL	1.12	1.12	1.21	1.08	4	72
Tampa-St. Petersburg FL	1.16	1.16	1.16	1.13	3	89
Pittsburgh PA	1.17	1.20	1.23	1.15	2	93
New Orleans LA	1.15	1.18	1.20	1.14	1	97

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
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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 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak period.
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.

Table 8. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2009), Continued

Urban Area	Travel Time Index				Point Change in Peak-Period Time Penalty 1982 to 2009	
	2009	2008	1999	1982	Points	Rank
Medium Average (33 areas)	**1.11**	**1.10**	**1.11**	**1.04**	**7**	
Bridgeport-Stamford CT-NY	1.25	1.23	1.23	1.07	18	4
Baton Rouge LA	1.24	1.23	1.20	1.07	17	6
El Paso TX-NM	1.15	1.15	1.14	1.03	12	23
New Haven CT	1.15	1.13	1.15	1.04	11	26
Oxnard-Ventura CA	1.12	1.11	1.08	1.01	11	26
Birmingham AL	1.14	1.14	1.12	1.04	10	32
Colorado Springs CO	1.12	1.14	1.16	1.03	9	38
Honolulu HI	1.18	1.19	1.15	1.09	9	38
Albuquerque NM	1.13	1.15	1.19	1.05	8	43
Hartford CT	1.13	1.15	1.17	1.05	8	43
McAllen TX	1.09	1.07	1.06	1.01	8	43
Albany-Schenectady NY	1.10	1.09	1.06	1.03	7	49
Bakersfield CA	1.08	1.07	1.04	1.01	7	49
Indio-Cathedral City-Palm Springs CA	1.13	1.09	1.09	1.06	7	49
Oklahoma City OK	1.09	1.09	1.08	1.02	7	49
Salt Lake City UT	1.12	1.11	1.17	1.05	7	49
Charleston-North Charleston SC	1.15	1.15	1.16	1.09	6	58
Omaha NE-IA	1.08	1.11	1.08	1.02	6	58
Tulsa OK	1.07	1.05	1.06	1.02	5	66
Wichita KS	1.08	1.06	1.06	1.03	5	66
Allentown-Bethlehem PA-NJ	1.08	1.08	1.08	1.04	4	72
Fresno CA	1.07	1.06	1.09	1.03	4	72
Grand Rapids MI	1.06	1.05	1.06	1.02	4	72
Lancaster-Palmdale CA	1.11	1.06	1.07	1.07	4	72
Rochester NY	1.07	1.07	1.06	1.03	4	72
Sarasota-Bradenton FL	1.10	1.09	1.11	1.06	4	72
Springfield MA-CT	1.09	1.07	1.09	1.05	4	72
Toledo OH-MI	1.05	1.04	1.08	1.01	4	72
Tucson AZ	1.11	1.12	1.11	1.07	4	72
Akron OH	1.05	1.05	1.09	1.02	3	89
Richmond VA	1.06	1.06	1.06	1.03	3	89
Dayton OH	1.06	1.06	1.09	1.05	1	97
Poughkeepsie-Newburgh NY	1.04	1.04	1.04	1.03	1	97

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

Table 8. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2009), Continued

Urban Area	Travel Time Index				Point Change in Peak-Period Time Penalty 1982 to 2009	
	2009	2008	1999	1982	Points	Rank
Small Average (22 areas)	**1.08**	**1.08**	**1.08**	**1.03**	**5**	
Boise ID	1.12	1.14	1.11	1.02	10	32
Boulder CO	1.13	1.12	1.15	1.05	8	43
Little Rock AR	1.10	1.08	1.07	1.02	8	43
Columbia SC	1.09	1.08	1.06	1.02	7	49
Salem OR	1.10	1.10	1.11	1.03	7	49
Beaumont TX	1.08	1.08	1.04	1.02	6	58
Laredo TX	1.07	1.06	1.05	1.01	6	58
Cape Coral FL	1.12	1.13	1.10	1.07	5	66
Jackson MS	1.07	1.08	1.06	1.02	5	66
Spokane WA	1.10	1.09	1.14	1.05	5	66
Winston-Salem NC	1.06	1.06	1.05	1.01	5	66
Corpus Christi TX	1.07	1.06	1.06	1.03	4	72
Greensboro NC	1.05	1.05	1.08	1.01	4	72
Pensacola FL-AL	1.07	1.08	1.09	1.03	4	72
Provo UT	1.06	1.03	1.04	1.02	4	72
Worcester MA	1.07	1.08	1.09	1.03	4	72
Madison WI	1.06	1.05	1.05	1.03	3	89
Brownsville TX	1.04	1.05	1.06	1.02	2	93
Eugene OR	1.07	1.08	1.11	1.05	2	93
Knoxville TN	1.06	1.07	1.10	1.04	2	93
Stockton CA	1.02	1.02	1.03	1.01	1	97
Anchorage AK	1.05	1.07	1.05	1.05	0	101
101 Area Average	**1.20**	**1.20**	**1.22**	**1.09**	**11**	
Remaining Areas	**1.09**	**1.09**	**1.10**	**1.04**	**5**	
All 439 Urban Areas	**1.20**	**1.20**	**1.20**	**1.08**	**12**	

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
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 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak period.
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.

Table 9. Urban Area Demand and Roadway Growth Trends

Less Than 10% Faster (14)	10% to 30% Faster (47)	10% to 30% Faster (cont.)	More Than 30% Faster (40)	More Than 30% Faster (cont.)
Anchorage AK	Allentown-Bethlehem PA-NJ	Memphis TN-MS-AR	Akron OH	New Haven CT
Boulder CO	Baton Rouge LA	Milwaukee WI	Albany-Schenectady NY	New York-Newark NY-NJ-CT
Cleveland OH	Beaumont TX	Nashville-Davidson TN	Albuquerque NM	Omaha NE-IA
Dayton OH	Boston MA-NH-RI	Oklahoma City OK	Atlanta GA	Orlando FL
Greensboro NC	Brownsville TX	Pensacola FL-AL	Austin TX	Oxnard-Ventura CA
Indio-Cath City-P Springs CA	Buffalo NY	Philadelphia PA-NJ-DE-MD	Bakersfield CA	Providence RI-MA
Lancaster-Palmdale CA	Cape Coral FL	Phoenix AZ	Baltimore MD	Raleigh-Durham NC
Madison WI	Charleston-N Charleston SC	Portland OR-WA	Birmingham AL	Riverside-S Bernardino CA
New Orleans LA	Charlotte NC-SC	Richmond VA	Boise ID	Sacramento CA
Pittsburgh PA	Corpus Christi TX	Rochester NY	Bridgeport-Stamford CT-NY	San Antonio TX
Poughkeepsie-Newburgh NY	Denver-Aurora CO	Salem OR	Chicago IL-IN	San Diego CA
Provo UT	Detroit MI	Salt Lake City UT	Cincinnati OH-KY-IN	San Francisco-Oakland CA
St. Louis MO-IL	El Paso TX-NM	San Jose CA	Colorado Springs CO	San Juan PR
Wichita KS	Eugene OR	Seattle WA	Columbia SC	Sarasota-Bradenton FL
	Fresno CA	Spokane WA	Columbus OH	Stockton CA
	Grand Rapids MI	Springfield MA-CT	Dallas-Ft Worth-Arlington TX	Washington DC-VA-MD
	Honolulu HI	Tampa-St. Petersburg FL	Hartford CT	
	Houston TX	Toledo OH-MI	Jacksonville FL	
	Indianapolis IN	Tucson AZ	Laredo TX	
	Jackson MS	Tulsa OK	Las Vegas NV	
	Kansas City MO-KS	Virginia Beach VA	Little Rock AR	
	Knoxville TN	Winston-Salem NC	Los Angeles-L Bch-S Ana CA	
	Louisville KY-IN	Worcester MA	Miami FL	
	McAllen TX		Minneapolis-St. Paul MN	

Note: See Exhibit 12 for comparison of growth in demand, road supply and congestion.

References

1 *National Average Speed Database*, 2007, 2008 and 2009. INRIX. Bellevue, WA. www.inrix.com

2 *Highway Performance Monitoring System*. 1982 to 2008 Data. Federal Highway Administration. Washington D.C. November 2009.

3 *Time Management Company Calculates Time You Spend Online…* Techuncover. June 4, 2010. http://techuncover.com/?tag=amazon

4 *National Transit Database*. Federal Transit Administration. 2008. Available: http://www.ntdprogram.gov/ntdprogram/

5 *ITS Deployment Statistics Database*. U.S. Department of Transportation. 2008. Available: http://www.itsdeployment.its.dot.gov/

6 *Freight Analysis Framework (FAF) Version 2.2, User Guide – Commodity Origin-Destination Database 2002 to 2035.* Federal Highway Administration. Washington D.C. November 2006.

7 *Urban Mobility Report Methodology*. Prepared by Texas Transportation Institute For University Transportation Center for Mobility, College Station, Texas. 2009. Available: http://mobility.tamu.edu/ums/report/methodology.stm

8 *An Early Look at the 2010 Urban Mobility Report: "Change" is Improving the Information.* Prepared by Texas Transportation Institute For University Transportation Center for Mobility, College Station, TX. September 2010. http://mobility.tamu.edu/ums/resources/umr2010_preview.pdf

9 *Developing a Total Travel Time Performance Measure: A Concept Paper.* Prepared by Texas Transportation Institute For Mobility Measurement in Urban Transportation Pooled Fund Study. College Station, TX. August 2010. http://mobility.tamu.edu/resources/ttt_measure_2010.pdf

10 *Incorporating Sustainability Factors Into The Urban Mobility Report: A Draft Concept Paper.* Prepared by Texas Transportation Institute For Mobility Measurement in Urban Transportation Pooled Fund Study. College Station, TX. August 2010. http://mobility.tamu.edu/resources/sustainability_factors.pdf

11 *Development of Diurnal Traffic Distribution and Daily, Peak and Off-Peak Vehicle Speed Estimation Procedures for Air Quality Planning.* Final Report, Work Order B-94-06, Prepared for Federal Highway Administration, April 1996.

Appendix B—Methodology for the 2010 Urban Mobility Report

Methodology for the 2010 Urban Mobility Report

The procedures used in the 2010 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. All the measures and many of the input variables for each year and every city are provided in a spreadsheet that can be downloaded at http://mobility.tamu.edu/ums/congestion_data/.

This memo documents the analysis conducted for the new methodology utilized in preparing the 2010 Urban Mobility Report. This revision incorporates private sector traffic speed data from INRIX for calendar year 2009 into the calculation of the mobility performance measures presented in the initial calculations. The roadway inventory data source for most of the calculations is the Highway Performance Monitoring System from the Federal Highway Administration (*1*). A detailed description of that dataset can be found at: http://www.fhwa.dot.gov/policy/ohpi/hpms/index.htm.

Summary

The Urban Mobility Report (UMR) procedures provide estimates of mobility at the areawide level. The approach that is used describes congestion in consistent ways allowing for comparisons across urban areas or groups of urban areas. As with the last several editions of the UMR, this report includes the effect of several operational treatments and to public transportation. The goal is to include all improvements, but good data is necessary to accomplish this.

The previous UMR methodology used a set of estimation procedures and data provided by state DOT's and regional planning agencies to develop a set of mobility measures. This memo describes a new congestion calculation procedure that uses a dataset of traffic speeds from INRIX, a private company that provides travel time information to a variety of customers. INRIX's 2009 data is an annual average of traffic speed for each section of road for every hour of each day for a total of 168 day/time period cells (24 hours x 7 days).

The travel speed data addresses the biggest shortcoming of previous editions of the UMR – the speed estimation process. INRIX's speed data improves the freeway and arterial street congestion measures in the following ways:

- "Real" rush hour speeds used to estimate a range of congestion measures; *speeds are measured not estimated.*
- Overnight speeds were used to identify the free-flow speeds that are used as a comparison standard; *low-volume speeds on each road section were used as the comparison standard.*
- The volume and roadway inventory data from FHWA's Highway Performance Monitoring System (HPMS) files were used with the speeds to calculate travel delay statistics; *the best speed data is combined with the best volume information to produce high-quality congestion measures.*

The Congestion Measure Calculation with Speed and Volume Datasets

The following steps were used to calculate the congestion performance measures for each urban roadway section.

1. Obtain HPMS traffic volume data by road section
2. Match the HPMS road network sections with the traffic speed dataset road sections
3. Estimate traffic volumes for each hour time interval from the daily volume data
4. Calculate average travel speed and total delay for each hour interval
5. Establish free-flow (i.e., low volume) travel speed
6. Calculate congestion performance measures
7. Additional steps when volume data had no speed data match

The mobility measures require four data inputs:

- Actual travel speed
- Free-flow travel speed
- Vehicle volume
- Vehicle occupancy (persons per vehicle) to calculate person-hours of travel delay

The 2009 private sector traffic speed data provided a better data source for the first two inputs, actual and free-flow travel time. The UMR analysis required vehicle and person volume estimates for the delay calculations; these were obtained from FHWA's HPMS dataset. The geographic referencing systems are different for the speed and volume datasets, a geographic matching process was performed to assign traffic speed data to each HPMS road section for the purposes of calculating the performance measures. When INRIX traffic speed data was not available for sections of road or times of day in urban areas, the speeds were estimated. This estimation process is described in more detail in Step 7.

Step 1. Identify Traffic Volume Data

The HPMS dataset from FHWA provided the source for traffic volume data, although the geographic designations in the HPMS dataset are not identical to the private sector speed data. The daily traffic volume data must be divided into the same time interval as the traffic speed data (hour intervals). While there are some detailed traffic counts on major roads, the most widespread and consistent traffic counts available are average daily traffic (ADT) counts. The hourly traffic volumes for each section, therefore, were estimated from these ADT counts using typical time-of-day traffic volume profiles developed from continuous count locations or other data sources. The section "Estimation of Hourly Traffic Volumes" shows the average hourly volume profiles used in the measure calculations.

Volume estimates for each day of the week (to match the speed database) were created from the average volume data using the factors in Exhibit B-1. Automated traffic recorders from around the country were reviewed and the factors in Exhibit B-1 are a "best-fit" average for both freeways and major streets. Creating an hourly volume to be used with the traffic speed values, then, is a process of multiplying the annual average by the daily factor and by the hourly factor.

Exhibit B-1. Day of Week Volume Conversion Factors

Day of Week	Adjustment Factor (to convert average annual volume into day of week volume)
Monday to Thursday	+5%
Friday	+10%
Saturday	-10%
Sunday	-20%

Step 2. Combine the Road Networks for Traffic Volume and Speed Data

The second step was to combine the road networks for the traffic volume and speed data sources, such that an estimate of traffic speed and traffic volume was available for each roadway segment in each urban area. The combination (also known as conflation) of the traffic volume and traffic speed networks was accomplished using Geographic Information Systems (GIS) tools. The INRIX speed network was chosen as the base network; an ADT count from the HPMS network was applied to each segment of roadway in the speed network. The traffic count and speed data for each roadway segment were then combined into areawide performance measures.

Step 3. Estimate Traffic Volumes for Shorter Time Intervals

The third step was to estimate traffic volumes for one-hour time intervals for each day of the week. Typical time-of-day traffic distribution profiles are needed to estimate hourly traffic flows from average daily traffic volumes. Previous analytical efforts[1,2] have developed typical traffic profiles at the hourly level (the roadway traffic and inventory databases are used for a variety of traffic and economic studies). These traffic distribution profiles were developed for the following different scenarios (resulting in 16 unique profiles):

- Functional class: freeway and non-freeway
- Day type: weekday and weekend
- Traffic congestion level: percentage reduction in speed from free-flow (varies for freeways and streets)
- Directionality: peak traffic in the morning (AM), peak traffic in the evening (PM), approximately equal traffic in each peak

The 16 traffic distribution profiles shown in Exhibits A-2 through A-6 are considered to be very comprehensive, as they were developed based upon 713 continuous traffic monitoring locations in urban areas of 37 states.

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[1] *Roadway Usage Patterns: Urban Case Studies*. Prepared for Volpe National Transportation Systems Center and Federal Highway Administration, July 22, 1994.

[2] *Development of Diurnal Traffic Distribution and Daily, Peak and Off-peak Vehicle Speed Estimation Procedures for Air Quality Planning*. Final Report, Work Order B-94-06, Prepared for Federal Highway Administration, April 1996.

Exhibit B-2. Weekday Traffic Distribution Profile for No to Low Congestion

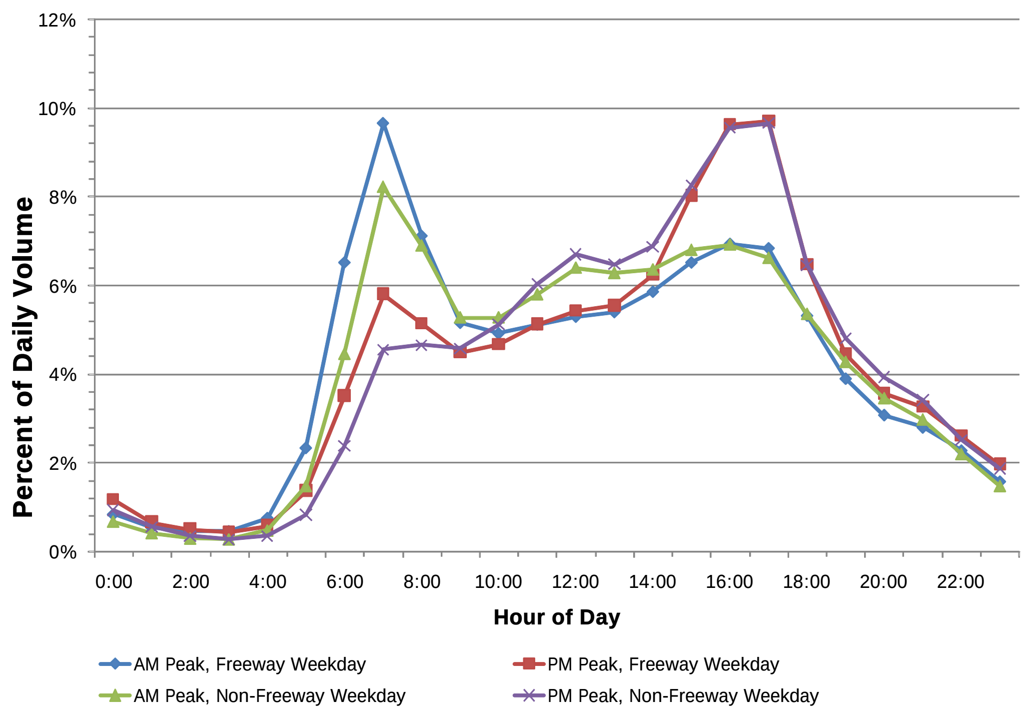


Exhibit B-3. Weekday Traffic Distribution Profile for Moderate Congestion

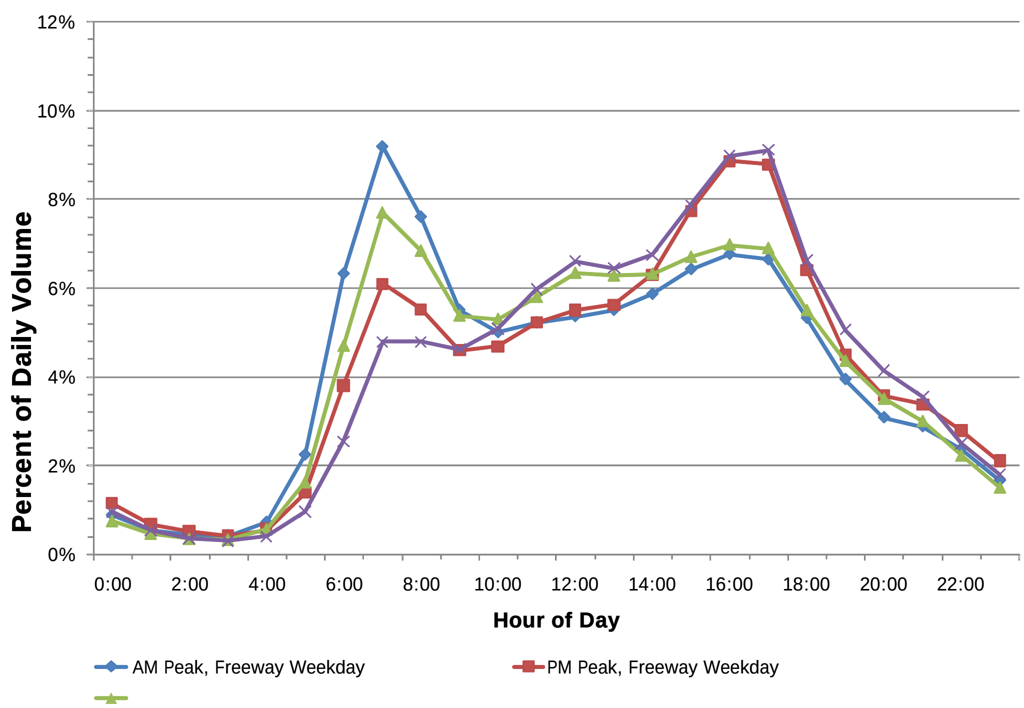


Exhibit B-4. Weekday Traffic Distribution Profile for Severe Congestion

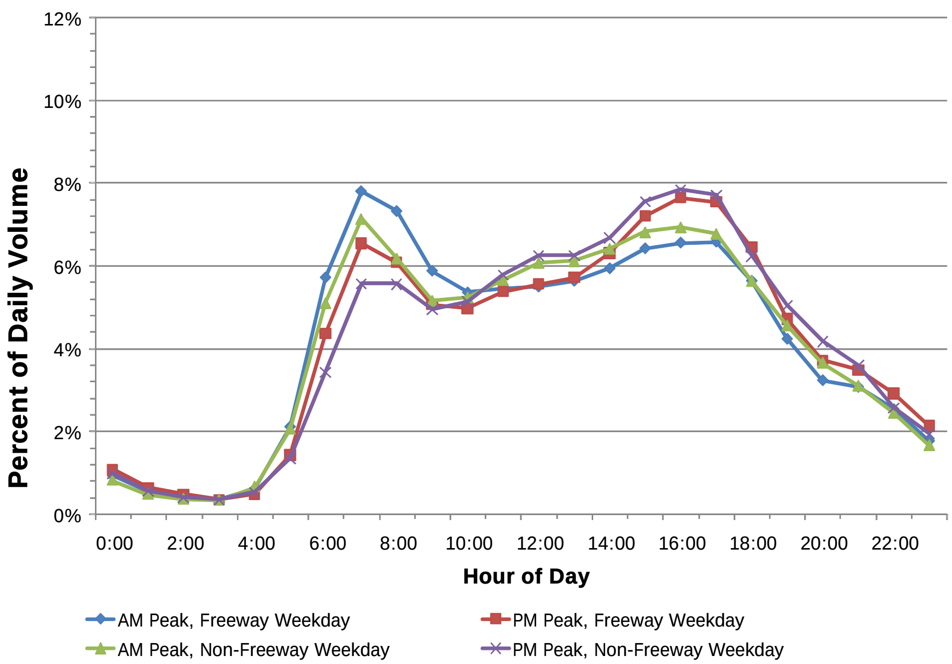


Exhibit B-5. Weekend Traffic Distribution Profile

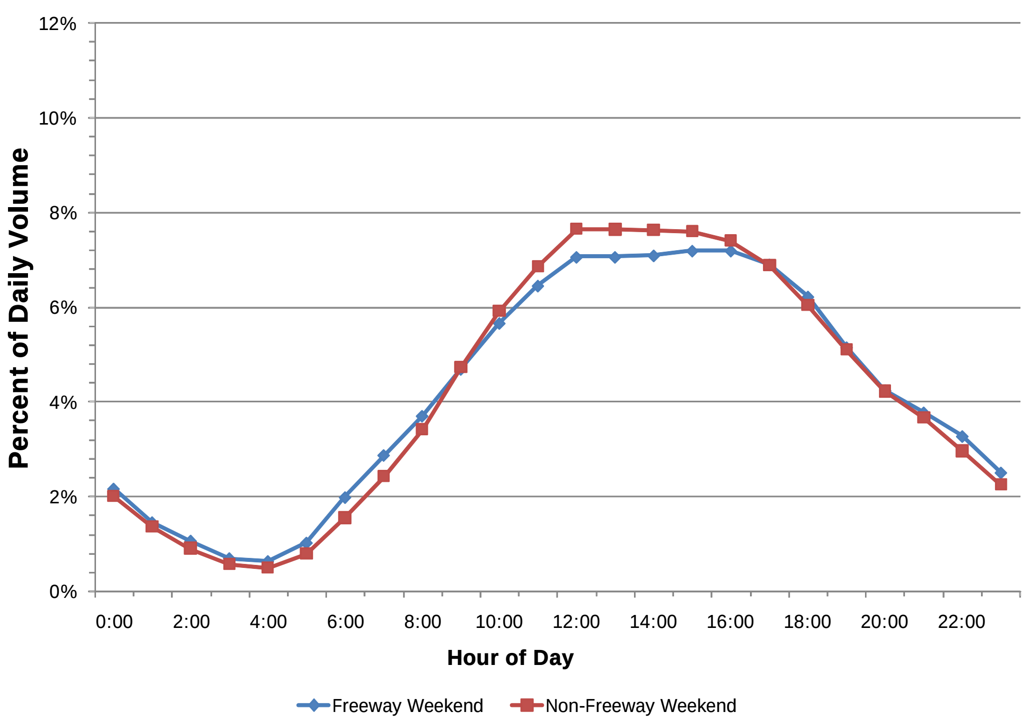
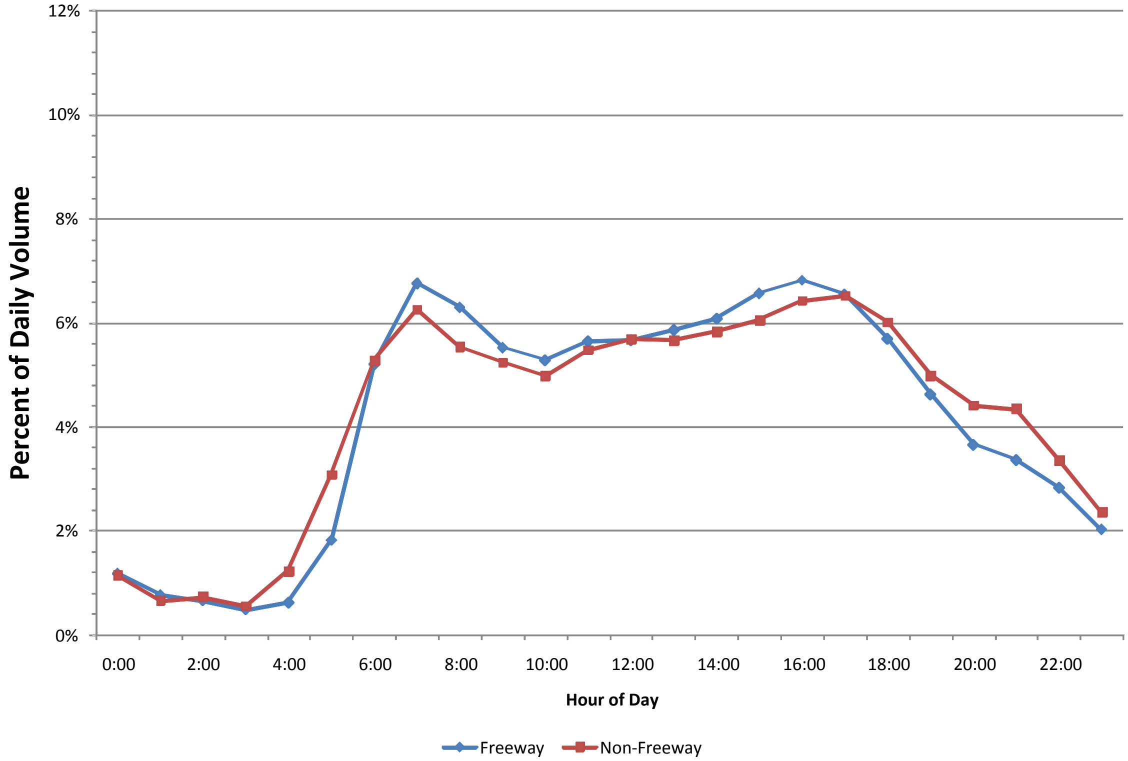


Exhibit B-6. Weekday Traffic Distribution Profile for Severe Congestion and Similar Speeds in Each Peak Period



The next step in the traffic flow assignment process is to determine which of the 16 traffic distribution profiles should be assigned to each Traffic Message Channel (TMC) path (the "geography" used by the private sector data providers), such that the hourly traffic flows can be calculated from traffic count data supplied by HPMS. The assignment should be as follows:

- Functional class: assign based on HPMS functional road class
    - Freeway – access-controlled highways
    - Non-freeway – all other major roads and streets

- Day type: assign volume profile based on each day
    - Weekday (Monday through Friday)
    - Weekend (Saturday and Sunday)

- Traffic congestion level: assign based on the peak period speed reduction percentage calculated from the private sector speed data. The peak period speed reduction is calculated as follows: 1) Calculate a simple average peak period speed (add up all the morning and evening peak period speeds and divide the total by the 8 periods in the eight peak hours) for each TMC path using speed data from 6 a.m. to 10 a.m. (morning peak period) and 3 p.m. to 7 p.m. (evening peak period).

2) Calculate a free-flow speed during the light traffic hours (e.g., 10 p.m. to 5 a.m.) to be used as the baseline for congestion calculations.

3) Calculate the peak period speed reduction by dividing the average combined peak period speed by the free-flow speed.

$$\begin{array}{c}\text{Speed} \\ \text{Reduction Factor}\end{array} = \frac{\begin{array}{c}\text{Average Peak} \\ \text{Period Speed}\end{array}}{\begin{array}{c}\text{Free-Flow Speed} \\ \text{(10 p.m. to 5 a.m.)}\end{array}} \qquad \text{(Eq. B-1)}$$

For Freeways:

- speed reduction factor ranging from 90% to 100% (no to low congestion)
- speed reduction factor ranging from 75% to 90% (moderate congestion)
- speed reduction factor less than 75% (severe congestion)

For Non-Freeways:

- speed reduction factor ranging from 80% to 100% (no to low congestion)
- speed reduction factor ranging from 65% to 80% (moderate congestion)
- speed reduction factor less than 65% (severe congestion)

- Directionality: Assign this factor based on peak period speed differentials in the private sector speed dataset. The peak period speed differential is calculated as follows:

  1) Calculate the average morning peak period speed (6 a.m. to 10 a.m.) and the average evening peak period speed (3 p.m. to 7 p.m.)

  2) Assign the peak period volume curve based on the speed differential. The lowest speed determines the peak direction. Any section where the difference in the morning and evening peak period speeds is 6 mph or less will be assigned the even volume distribution.

Step 4. Calculate Travel and Time

The hourly speed and volume data was combined to calculate the total travel time for each one hour time period. The one hour volume for each segment was multiplied by the corresponding travel time to get a quantity of vehicle-hours; these were summed across the entire urban area.

Step 5. Establish Free-Flow Travel Speed and Time

The calculation of congestion measures required establishing a congestion threshold, such that delay was accumulated for any time period once the speeds are lower than the congestion threshold. There has been considerable debate about the appropriate congestion thresholds, but for the purpose of the UMR methodology, the data was used to identify the speed at low volume conditions (for example, 10 p.m. to 5 a.m.). This speed is relatively high, but varies according to the roadway design characteristics. An upper limit of 65 mph was placed on the freeway free-flow speed to maintain a reasonable estimate of delay; no limit was placed on the arterial street free-flow speeds.

Step 6. Calculate Congestion Performance Measures

The mobility performance measures were calculated using the equations shown in the next section of this methodology once the one-hour dataset of actual speeds, free-flow travel speeds and traffic volumes was prepared.

Step 7. Estimate Speed Data Where Volume Data Had No Matched Speed Data

The UMR methodology analyzes travel on all freeways and arterial streets in each urban area. In many cases, the arterial streets are not maintained by the state DOT's so they are not included in the roadway network GIS shapefile that is reported in HPMS (all roadway classes will be added to the GIS roadway shapefiles within the next few years by the state DOTs as mandated by FHWA). A technique for handling the unmatched sections of roadway was developed for the 2010 UMR. The percentage of arterial streets that had INRIX speed data match ranged from about 20 to 40 percent across the U.S. while the freeway match percentages ranged from about 80 to 100 percent.

After the original conflation of the volume and speed networks in each urban area was completed, there were unmatched volume sections of roadway and unmatched INRIX speed sections of roadway. After reviewing how much speed data was unmatched in each urban area, it was decided that unmatched data would be handled differently in urban areas over under one million in population versus areas over one million in population.

Areas Under One Million Population

The HPMS volume data for each urban area that was unmatched was separated into freeway and arterial street sections. The HPMS sections of road were divided by each county in which the urban area was located. If an urban area was located in two counties, the unmatched traffic volume data from each county would be analyzed separately. The volume data was then aggregated such that it was treated like one large traffic count for freeways and another for street sections.

The unmatched speed data was separated by county also. All of the speed data and freeflow speed data was then averaged together to create a speed profile to represent the unmatched freeway sections and unmatched street sections.

The volume data and the speed data were combined and Steps 1 through 6 were repeated for the unmatched data in these smaller urban areas.

Areas Over One Million Population

In urban areas with populations over one million, the unmatched data was handled in one or two steps depending on the area. The core counties of these urban areas (these include the counties with at least 15 to 20 percent of the entire urban area's VMT) were treated differently because they tended to have more unmatched speed data available than some of the more suburban counties.

In the suburban counties (non-core), where less than 15 or 20 percent of the area's VMT was in a particular county, the volume and speed data from those counties were treated the same as the data in smaller urban areas with populations below one million discussed earlier. Steps 1 through 6 were repeated for the non-core counties of these urban areas.

In each of the core counties, all of the unmatched HPMS sections were gathered and ranked in order of highest traffic density (VMT per lane-mile) down to lowest for both freeways and arterial streets. These sections of roadway were divided into three groups. The top 25 percent of the lane-miles, with highest traffic density, were grouped together into the first set. The next 25 percent were grouped into a second set and the remaining lane-miles were grouped into a third set.

Similar groupings were made with the unmatched speed data for each core county for both functional classes of roadway. The roadway sections of unmatched speed data were ordered from most congested to least congested based on their Travel Time Index value. Since the lane-miles of roadway for these sections were not available with the INRIX speed data, the listing was divided into the same splits as the traffic volume data (25/25/50 percent). (The Travel Time Index was used instead of speed because the TTI includes both free-flow and actual speed).

The volume data from each of the 3 groups was matched with the corresponding group of speed data and steps 1 through 6 were repeated for the unmatched data in the core counties.

Calculation of the Congestion Measures

This section summarizes the methodology utilized to calculate many of the statistics shown in the Urban Mobility Report and 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) Travel Speed
    2) Travel Delay
    3) Annual Person Delay
    4) Annual Delay per Auto Commuter
    5) Annual Peak Period Travel Time
    6) Travel Time Index
    7) Commuter Stress Index
    8) Wasted Fuel
    9) Total Congestion Cost and Truck Congestion Cost
    10) Truck Commodity Value
    11) Roadway Congestion Index
    12) Number of Rush Hours
    13) Percent of Daily and Peak Travel in Congested Conditions
    14) Percent of Congested Travel

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 B-7 as national constants—values used in all urban areas to estimate the effect of congestion.

Exhibit B-7. National Congestion Constants for 2010 Urban Mobility Report

Constant	Value
Vehicle Occupancy	1.25 persons per vehicle
Average Cost of Time ($2009)*	$16.01 per person hour[1]
Commercial Vehicle Operating Cost ($2009)	$105.67 per vehicle hour[1, 2]
Working Days (5x50)	250 days
Total Travel Days (7x52)	364 days

[1] Adjusted annually using the Consumer Price Index.

[2] Adjusted periodically using industry cost and logistics data.

*Source: (Reference *7,8*)

Vehicle Occupancy

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

Working Days and Weeks

With the addition of the INRIX speed data in the 2010 UMR, the calculations are based on a full year of data that includes all days of the week rather than just the working days. The delay from each day of the week is multiplied by 50 work weeks to annualize the delay. The weekend days are multiplied by 57 to help account for the lighter traffic days on holidays. Total delay for the year is based on 364 total travel days in the year.

Average Cost of Time

The 2009 value of person time used in the report is $16.01 per hour based on the value of time, rather than the average or prevailing wage rate (*7*).

Commercial Vehicle Operating Cost

Truck travel time is valued at $105.67 per hour (*8*).

Urban Area Variables

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.

Population, Peak Travelers and Commuters

Population data were obtained from a combination of U.S. Census Bureau estimates and the Federal Highway Administration's Highway Performance Monitoring System (HPMS) (*1,9*). Estimates of peak period travelers are derived from the National Household Travel Survey (NHTS) (*10*) 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 cities 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. These same data from NHTS was also used to calculate an estimate of commuters who were traveling during the peak periods by private vehicle—a subset of the peak period travelers.

Fuel Costs

Statewide average fuel cost estimates were obtained from daily fuel price data published by the American Automobile Association (AAA) (*11*). Values for different fuel types used in motor vehicles, i.e., diesel and gasoline, did not vary enough to be reported separately.

Truck Percentage

The percentage of passenger cars and trucks for each urban area was estimated from the Highway Performance Monitoring System dataset (*1*). The values are used to estimate congestion costs and are not used to adjust the roadway capacity.

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 this methodology.

Travel Speed

The peak period average travel speeds from INRIX are shown in Exhibit B-8 for the freeways and arterial streets. Also shown are the freeflow travel speeds used to calculate the delay-based measures in the report. These speeds are based on the "matched" traffic volume/speeds datasets as well as the "unmatched" traffic volume/speed datasets described in Step 7 of the "Process" description.

Exhibit B-8. 2009 Traffic Speed Data

	Freeway		Arterial Streets	
Urban Area	Peak Speed	Freeflow Speed	Peak Speed	Freeflow Speed
Very Large Areas				
Atlanta GA	56.9	63.7	28.6	35.2
Boston MA-NH-RI	55.8	62.6	25.8	31.2
Chicago IL-IN	49.2	58.5	24.4	30.6
Dallas-Fort Worth-Arlington TX	53.2	61.5	26.9	32.0
Detroit MI	57.8	61.9	28.4	33.3
Houston TX	51.8	61.9	31.1	37.0
Los Angeles-Long Beach-Santa Ana CA	47.5	61.3	28.0	34.3
Miami FL	60.9	64.3	29.7	33.9
New York-Newark NY-NJ-CT	51.5	60.7	28.5	35.8
Philadelphia PA-NJ-DE-MD	57.9	62.6	30.2	35.5
Phoenix AZ	59.4	63.5	33.0	37.2
San Diego CA	56.7	63.0	31.2	36.7
San Francisco-Oakland CA	52.2	61.5	26.7	32.6
Seattle WA	48.7	59.3	27.6	32.6
Washington DC-VA-MD	50.3	61.5	30.5	36.8
Large Areas				
Austin TX	48.9	61.1	35.8	43.2
Baltimore MD	55.6	61.3	31.0	36.4
Buffalo NY	55.0	59.0	34.2	38.5
Charlotte NC-SC	57.1	62.5	31.7	37.8
Cincinnati OH-KY-IN	55.8	59.6	36.8	40.2
Cleveland OH	56.2	59.6	36.2	40.6
Columbus OH	57.3	59.6	41.5	46.2
Denver-Aurora CO	52.1	60.9	28.0	32.8
Indianapolis IN	47.0	55.4	29.5	34.9
Jacksonville FL	58.3	61.9	35.5	40.8
Kansas City MO-KS	58.0	61.8	33.2	37.0
Las Vegas NV	51.9	61.9	32.0	37.2
Louisville KY-IN	56.9	60.7	33.6	38.8
Memphis TN-MS-AR	55.9	60.4	37.2	42.1
Milwaukee WI	55.2	60.7	36.0	39.8
Large Areas				
Minneapolis-St. Paul MN	51.8	60.3	28.9	34.3
Nashville-Davidson TN	58.1	62.2	36.6	42.1
New Orleans LA	52.2	60.9	29.1	35.3
Orlando FL	57.5	62.7	29.0	36.3
Pittsburgh PA	52.8	58.3	39.1	44.2
Portland OR-WA	49.1	56.9	34.1	40.2
Providence RI-MA	56.0	60.5	32.3	36.2
Raleigh-Durham NC	60.2	63.6	35.9	41.3
Riverside-San Bernardino CA	55.3	60.8	31.4	35.9
Sacramento CA	54.0	60.9	29.1	34.1
San Antonio TX	56.3	62.5	34.3	40.8
San Jose CA	53.9	62.7	34.8	40.7
San Juan PR	55.0	61.7	35.8	39.1
St. Louis MO-IL	56.7	60.4	30.6	35.8
Tampa-St. Petersburg FL	60.3	64.0	30.5	35.3
Virginia Beach VA	54.3	60.0	34.4	39.7

Exhibit B-8. 2009 Traffic Speed Data, continued

Urban Area	Freeway Peak Speed	Freeway Freeflow Speed	Arterial Streets Peak Speed	Arterial Streets Freeflow Speed	Urban Area	Freeway Peak Speed	Freeway Freeflow Speed	Arterial Streets Peak Speed	Arterial Streets Freeflow Speed
Medium Areas					Small Areas				
Akron OH	57.5	58.5	34.9	38.8	Anchorage AK	59.7	62.9	32.9	39.1
Albany-Schenectady NY	59.1	61.7	29.9	35.0	Baton Rouge LA	53.6	62.2	38.1	44.0
Albuquerque NM	56.3	61.2	38.4	43.6	Beaumont TX	60.7	63.7	41.7	44.9
Allentown-Bethlehem PA-NJ	60.1	61.5	38.5	42.3	Boise ID	57.0	61.0	29.8	34.3
Bakersfield CA	56.8	59.4	28.9	34.7	Boulder CO	42.9	52.7	28.9	32.5
Birmingham AL	58.7	62.8	32.3	40.3	Brownsville TX	62.3	63.2	33.1	37.9
Bridgeport-Stamford CT-NY	52.7	62.6	25.5	30.7	Cape Coral FL	66.2	65.0	35.6	42.2
Charleston-North Charleston SC	57.0	61.7	36.1	42.3	Columbia SC	61.2	63.3	30.1	34.8
Colorado Springs CO	54.3	59.2	32.2	36.0	Corpus Christi TX	63.1	64.0	42.6	43.3
Dayton OH	58.5	59.1	45.3	47.8	Eugene OR	54.1	56.5	39.3	42.9
El Paso TX-NM	54.1	60.2	49.1	52.1	Greensboro NC	60.0	61.6	34.8	39.6
Fresno CA	57.3	60.0	33.3	37.4	Jackson MS	62.3	63.6	42.1	48.2
Grand Rapids MI	59.6	61.7	40.3	45.5	Knoxville TN	58.4	59.8	42.2	45.9
Hartford CT	57.7	62.5	35.4	40.3	Laredo TX	58.0	60.8	37.7	40.9
Honolulu HI	51.1	60.0	34.1	41.9	Little Rock AR	59.8	63.6	30.7	35.4
Indio-Cathedral City-Palm Springs CA	58.7	60.2	31.3	33.7	Madison WI	61.3	62.8	40.6	44.9
Lancaster-Palmdale CA	60.1	63.4	39.3	44.5	Pensacola FL-AL	63.2	62.6	34.7	39.1
McAllen TX	59.8	63.1	41.7	44.8	Provo UT	61.8	64.7	32.3	37.3
New Haven CT	58.8	63.2	38.4	44.9	Salem OR	54.6	56.9	36.4	40.4
Oklahoma City OK	58.4	62.1	37.7	42.2	Spokane WA	56.9	60.0	25.1	27.9
Omaha NE-IA	57.3	59.3	30.9	34.5	Stockton CA	58.3	59.3	48.3	51.0
Oxnard-Ventura CA	56.9	62.5	45.5	48.8	Winston-Salem NC	59.5	61.6	35.1	40.2
Poughkeepsie-Newburgh NY	61.1	62.4	43.8	47.3	Worcester MA	61.3	62.9	34.8	39.1
Richmond VA	61.3	62.6	35.3	40.1					
Rochester NY	58.1	60.8	33.3	38.4					
Salt Lake City UT	58.1	62.9	45.3	50.8					
Sarasota-Bradenton FL	67.8	65.0	36.2	41.5					
Springfield MA-CT	60.1	62.7	30.8	35.1					
Toledo OH-MI	58.9	59.8	35.4	38.8					
Tucson AZ	57.2	59.3	32.6	37.0					
Tulsa OK	59.6	62.7	48.1	51.5					
Wichita KS	57.7	61.0	42.5	47.0					

Travel Delay

Most of the basic performance measures presented in the Urban Mobility Report are developed in the process of calculating travel delay—the amount of extra time spent traveling due to congestion. The travel delay calculations have been greatly simplified with the addition of the INRIX speed data. This speed data reflects the effects of both recurring delay (or usual) and incident delay (crashes, vehicle breakdowns, etc.). The delay calculations are performed at the individual roadway section level and for each hour of the week. Depending on the application, the delay can be aggregated into summaries such as weekday peak period, weekend, weekday off-peak period, etc.

$$\begin{matrix}\text{Daily Vehicle-Hours}\\ \text{of Delay}\end{matrix} = \left(\frac{\begin{matrix}\text{DailyVehicle-Miles}\\ \text{of Travel}\end{matrix}}{\text{Speed}}\right) - \left(\frac{\begin{matrix}\text{DailyVehicle-Miles}\\ \text{of Travel}\end{matrix}}{\text{Free-Flow Speed}}\right) \qquad \text{(Eq. B-2)}$$

Annual Person Delay

This calculation is performed to expand the daily vehicle-hours of delay estimates for freeways and arterial streets to a yearly estimate in each study area. To calculate the annual person-hours of delay, multiply each day-of-the-week delay estimate by the average vehicle occupancy (1.25 persons per vehicle) and by 50 working weeks per year (Equation B-3).

$$\begin{matrix}\text{Annual}\\ \text{Persons-Hours}\\ \text{of Delay}\end{matrix} = \begin{matrix}\text{Daily Vehicle-Hours}\\ \text{of Delay on}\\ \text{Frwys and Arterial Streets}\end{matrix} \times \begin{matrix}\text{Annual Conversion}\\ \text{Factor}\end{matrix} \times \begin{matrix}\text{1.25 Persons}\\ \text{per Vehicle}\end{matrix} \qquad \text{(Eq. B-3)}$$

Annual Delay per Auto Commuter

Annual delay per auto commuter is a measure of the extra travel time endured throughout the year by auto commuters who make trips during the peak period. The procedure used in the Urban Mobility Report applies estimates of the number of people and trip departure times during the morning and evening peak periods from the National Household Travel Survey (10) to the urban area population estimate to derive the average number of auto commuters and number of travelers during the peak periods (*15*).

The delay calculated for each commuter comes from delay during peak commute times and delay that occurs during other times of the day. All of the delay that occurs during the peak hours of the day (6:00 a.m. to 10:00 a.m. and 3:00 p.m. to 7:00 p.m.) is assigned to the pool of commuters. In addition to this, the delay that occurs outside of the peak period is assigned to the entire population of the urban area. Equation B-4 shows how the delay per auto commuter is calculated. The reason that the off-peak delay is also assigned to the commuters is that their trips are not limited to just peak driving times but they also contribute to the delay that occurs during other times of the weekdays and the weekends.

$$\begin{array}{c}\text{Delay per}\\\text{Auto Commuter}\end{array} = \left(\frac{\text{Peak Period Delay}}{\text{Auto Commuters}}\right) + \left(\frac{\text{Remaining Delay}}{\text{Population}}\right) \qquad \text{(Eq. B-4)}$$

Annual Peak Period Major Road Travel Time

Total travel time can be used as both a performance measure and as a component in other calculations. The 2010 Urban Mobility Report used travel time as a component; future reports will incorporate other information and expand on the use of total travel time as a performance measure.

Total travel time is the sum of travel delay and free-flow travel time. Both of the quantities are only calculated for freeways and arterial streets. Free-flow travel time is the amount of time needed to travel the roadway section length at the free-flow speeds (provided by INRIX for each roadway section) (Equation B-5).

$$\begin{array}{c}\text{Annual Free-Flow}\\\text{Travel Time}\\\text{(Vehicle-Hours)}\end{array} = \frac{1}{\begin{array}{c}\text{Free-Flow}\\\text{Travel Speed}\end{array}} \times \begin{array}{c}\text{Daily}\\\text{Vehicle-Miles}\\\text{of Travel}\end{array} \times \begin{array}{c}\text{Annual}\\\text{Conversion}\\\text{Factor}\end{array} \qquad \text{(Eq. B-5)}$$

$$\begin{array}{c}\text{Annual}\\\text{Travel Time}\end{array} = \underbrace{\left(\begin{array}{c}\text{Freeway}\\\text{Delay}\end{array} + \begin{array}{c}\text{Arterial}\\\text{Street Delay}\end{array}\right)}_{\text{(Eq. A–3)}} + \underbrace{\left(\begin{array}{c}\text{Freeway}\\\text{Free-Flow}\\\text{Travel Time}\end{array} + \begin{array}{c}\text{Arterial}\\\text{Free-Flow}\\\text{Travel Time}\end{array}\right)}_{\text{(Eq. A–5)}} \qquad \text{(Eq. B-6)}$$

Travel Time Index

The Travel Time Index (TTI) compares 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 B-5 illustrates the ratio used to calculate the TTI. The ratio has units of 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.

The free-flow travel time for each functional class is subtracted from the average travel time to estimate delay. The Travel Time Index is calculated by comparing total travel time to the free-flow travel time (Equations B-7 and B-8).

$$\text{Travel Time Index} = \frac{\text{Peak Travel Time}}{\text{Free-Flow Travel Time}} \qquad \text{(Eq. B-7)}$$

$$\text{Travel Time Index} = \frac{\text{Delay Time} + \text{Free-Flow Travel Time}}{\text{Free-Flow Travel Time}} \qquad \text{(Eq. B-8)}$$

Commuter Stress Index

The Commuter Stress Index (CSI) is the same as the TTI except that it includes only the travel in the peak directions during the peak periods; the TTI includes travel in all directions during the peak period. Thus, the CSI is more indicative of the work trip experienced by each commuter on a daily basis.

Wasted Fuel

The average fuel economy calculation is used to estimate the difference in fuel consumption of the vehicles operating in congested and uncongested conditions. Equation B-9 is a linear regression applied to a modified version of fuel consumption reported by Raus (*16*).

$$\begin{matrix}\text{Average Fuel}\\ \text{Economy}\end{matrix} = 8.8 + 0.25\begin{pmatrix}\text{Average}\\ \text{Hourly}\\ \text{Speed}\end{pmatrix} \qquad \text{(Eq. B-9)}$$

The Urban Mobility Report calculates the wasted fuel due to vehicles moving at speeds slower than free-flow throughout the day. Equation B-10 calculates the fuel wasted in delay conditions from Equation B-3, the average hourly speed, and the average fuel economy associated with the hourly speed (Equation B-9).

$$\begin{matrix}\text{Annual}\\ \text{Fuel Wasted}\end{matrix} = \begin{matrix}\text{Travel Time}\\ \text{(vehicle hours)}\\ \text{(Eq. A–5)}\end{matrix} \times \begin{matrix}\text{Average Hourly}\\ \text{Speed}\\ \text{(Eq. A–2)}\end{matrix} \div \begin{matrix}\text{Average Fuel}\\ \text{Economy}\\ \text{(Eq. A–9)}\end{matrix} \times \begin{matrix}\text{Annual}\\ \text{Conversion Factor}\end{matrix} \qquad \text{(Eq. B-10)}$$

Equation B-11 incorporates the same factors 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 B-10).

$$\text{Annual Fuel Consumed in Free-Flow Conditions} = \text{Travel Time (Eq. A-5)} \times \text{Free-Flow Speed from INRIX Data} \div \text{Average Fuel Economy for Free-Flow Speeds (Eq. B–9)} \times \text{Annual Conversion Factor} \quad \text{(Eq. B-11)}$$

$$\text{Annual Fuel Wasted in Congestion} = \text{Annual Fuel Consumed in Congestion} - \text{Annual Fuel That Would be Consumed in Free-flow Conditions} \quad \text{(Eq. B-12)}$$

Total Congestion Cost and Truck 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 B-13 through B-15 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 B-13 shows how to calculate the passenger vehicle delay costs that result from lost time.

$$\text{Annual Psgr-Veh Delay Cost} = \text{Daily Psgr Vehicle Hours of Delay (Eq. A-4)} \times \text{Value of Person Time (\$ / hour)} \times \text{Vehicle Occupancy (pers/vehicle)} \times \text{Annual Conversion Factor} \quad \text{(Eq. B-13)}$$

Passenger Vehicle Fuel Cost. Fuel cost due to congestion is calculated for passenger vehicles in Equation B-14. This is done by associating the wasted fuel, the percentage of the vehicle mix that is passenger, and the fuel costs.

$$\text{Annual Fuel Cost} = \text{Daily Fuel Wasted (Eq. A–12)} \times \text{Percent of Passenger Vehicles} \times \text{Fuel Cost} \times \text{Annual Conversion Factor} \quad \text{(Eq. B-14)}$$

Truck or Commercial Vehicle Cost. The cost of both wasted time and fuel are included in the value of commercial vehicle time ($105.67 in 2009). Thus, there is not a separate value for wasted time and fuel. The equation to calculate commercial vehicle cost is shown in Equation B-15.

$$\begin{matrix}\text{Annual}\\ \text{Commercial}\\ \text{Cost}\end{matrix} = \begin{matrix}\text{Daily Vehicle}\\ \text{Hours of Delay}\\ \text{(Eq. A–4)}\end{matrix} \times \begin{matrix}\text{Percent of}\\ \text{Commercial}\\ \text{Vehicles}\end{matrix} \times \begin{matrix}\text{Value of}\\ \text{Comm. Vehicle}\\ \text{Time (\$/hour)}\end{matrix} \times \begin{matrix}\text{Annual}\\ \text{Conversion Factor}\end{matrix} \qquad \text{(Eq. B-15)}$$

Total Congestion Cost. Equation A-16 combines the cost due to travel delay and wasted fuel to determine the annual cost due to congestion resulting from incident and recurring delay.

$$\begin{matrix}\text{Annual Cost}\\ \text{Due to}\\ \text{Congestion}\end{matrix} = \left(\begin{matrix}\text{Annual Passenger}\\ \text{Vehicle Delay Cost}\\ \text{(Eq. B–13)}\end{matrix} + \begin{matrix}\text{Annual Passenger}\\ \text{Fuel Cost}\\ \text{(Eq. B–14)}\end{matrix}\right) + \begin{matrix}\text{Annual}\\ \text{Commerical Cost}\\ \text{(Eq. B–15)}\end{matrix} \qquad \text{(Eq. B-16)}$$

Truck Commodity Value

The data for this performance measure came from the Freight Analysis Framework (FAF) and the Highway Performance Monitoring System (HPMS) from the Federal Highway Administration. The basis of this measure is the integration of the commodity value supplied by FAF and the truck vehicle-miles of travel (VMT) calculated from the HPMS roadway inventory database.

There are 5 steps involved in calculating the truck commodity value for each urban area.

1. Calculate the national commodity value for all truck movements
2. Calculate the HPMS truck VMT percentages for states, urban areas and rural roadways
3. Estimate the state and urban commodity values using the HPMS truck VMT percentages
4. Calculate the truck commodity value of origins and destinations for each urban area
5. Average the VMT-based commodity value with the origin/destination-based commodity value for each urban area.

Step 1 - National Truck Commodity Value. The FAF (version 2) database has truck commodity values that originate and end in 114 regions of the U.S. The database contains a 114 by 114 matrix of truck goods movements (tons and dollars) between these regions. Using just the value of the commodities that originate within the 114 regions, the value of the commodities moving within the 114 regions is determined (if the value of the commodities destined for the 114 regions was included also, the commodity values would be double-counted). The FAF database has commodity value estimates for different years. The base year for FAF-2 is 2002 with estimates of commodity values in 2010 through 2035 in 5-year increments. The 2009 commodity value was estimated using a constant percentage growth trend between the 2002 and 2010 values. FAF (version 3) is now available but was released too late to be used in preparing the 2010 UMR.

Step 2 – Truck VMT Percentages. The HPMS state truck VMT percentages are calculated in Equation B-17 using each state's estimated truck VMT and the national truck VMT. This percentage will be used to approximate total commodity value at the state level.

$$\begin{matrix}\text{State Truck} \\ \text{VMT Percentage}\end{matrix} = \left(\frac{\text{State Truck VMT}}{\text{U. S. Truck VMT}}\right) \times 100\% \qquad \text{(Eq. B-17)}$$

The urban percentages within each state are calculated similarly, but with respect to the state VMT. The equation used for the urban percentage is given in Equation B-18. The rural truck VMT percentage for each state is shown in Equation B-19.

$$\begin{matrix}\text{State Urban} \\ \text{Truck VMT Percentage}\end{matrix} = \left(\frac{\begin{matrix}\text{State Urban} \\ \text{Truck VMT}\end{matrix}}{\begin{matrix}\text{State Truck} \\ \text{VMT}\end{matrix}}\right) \times 100\% \qquad \text{(Eq. B-18)}$$

$$\begin{matrix}\text{State Rural Truck} \\ \text{VMT Percentage}\end{matrix} = 100\% - \begin{matrix}\text{State Urban Truck} \\ \text{VMT Percentage}\end{matrix} \qquad \text{(Eq . B-19)}$$

The urban area truck VMT percentage is used in the final calculation. The truck VMT in each urban area in a given state is divided by all of the urban truck VMT for the state (Equation B-20).

$$\begin{matrix}\text{Urban Area Truck} \\ \text{VMT Percentage}\end{matrix} = \left(\frac{\begin{matrix}\text{Urban Area} \\ \text{Truck VMT}\end{matrix}}{\begin{matrix}\text{State Urban} \\ \text{Truck VMT}\end{matrix}}\right) \qquad \text{(Eq. B-20)}$$

Step 3 – Estimate State and Urban Area VMT from Truck VMT percentages. The national estimate of truck commodity value from Step 1 is used with the percentages calculated in Step 2 to assign a VMT-based commodity value to the urban and rural roadways within each state and to each urban area.

$$\begin{matrix}\text{State Urban Truck} \\ \text{VMT-Based} \\ \text{Commodity Value}\end{matrix} = \begin{matrix}\text{U. S. Truck} \\ \text{Commodity Value}\end{matrix} \times \begin{matrix}\text{State Urban} \\ \text{Truck Percentage}\end{matrix} \qquad \text{(Eq. B-21)}$$

$$\begin{matrix}\text{State Rural Truck} \\ \text{VMT-Based} \\ \text{Commodity Value}\end{matrix} = \begin{matrix}\text{U. S. Truck} \\ \text{Commodity Value}\end{matrix} \times \begin{matrix}\text{State Rural} \\ \text{Truck Percentage}\end{matrix} \qquad \text{(Eq. B-22)}$$

$$\begin{matrix}\text{Urban Area Truck} \\ \text{VMT-Based} \\ \text{Commodity Value}\end{matrix} = \begin{matrix}\text{State Urban} \\ \text{Truck VMT-Based} \\ \text{Commodity Value}\end{matrix} \times \begin{matrix}\text{Urban Area} \\ \text{Truck VMT Percentage}\end{matrix} \qquad \text{(Eq. B-23)}$$

Step 4 – Calculate Origin/Destination-Based Commodity Value. The results in Step 3 show the commodity values for the U.S. distributed based on the truck VMT flowing through states in both rural portions and urban areas. The Step 3 results place equal weighting on a truck mile in a rural area and a truck mile in an urban area. Step 4 redistributes the truck commodity values with more emphasis placed on the urban regions where the majority of the truck trips were originating or ending.

The value of commodities with trips that began or ended in each of the 114 FAF regions was calculated and the results were combined to get a total for the U.S. The percentage of the total U.S. origin/destination-based commodity values corresponding to each of the FAF regions, shown in Equations B-24 and B-25, was calculated and these percentages were used to redistribute the national freight commodity value estimated in Step 1 that were based only on the origin-based commodities. Equation B-26 shows that this redistribution was first done at the state level by summing the FAF regions within each state. After the new state commodity values were calculated, the commodity values were assigned to each urban area within each state based on the new percentages calculated from the origin/destination-based commodity data. Urban areas not included in a FAF region were assigned a commodity value based on their truck VMT relative to all the truck VMT which remained unassigned to a FAF region (Equation B-27).

$$\begin{matrix}\text{FAF Region} \\ \text{O/D-Based Commodity Value \%}\end{matrix} = \left(\frac{\begin{matrix}\text{FAF Region} \\ \text{O/D-Based Commodity Value}\end{matrix}}{\begin{matrix}\text{U.S. O/D-Based} \\ \text{Commodity Value}\end{matrix}} \right) \times 100\% \qquad \text{(Eq. B-24)}$$

$$\begin{matrix}\text{FAF Region O/D-Based} \\ \text{Commodity Value}\end{matrix} = \begin{matrix}\text{FAF Region O/D-Based} \\ \text{Commodity Value \%}\end{matrix} \times \begin{matrix}\text{U.S. O/D-Based} \\ \text{Commodity Value}\end{matrix} \qquad \text{(Eq. B-25)}$$

$$\begin{matrix}\text{O/D-Based} \\ \text{Commodity Value for State 1}\end{matrix} = \begin{matrix}\text{FAF Region 1} \\ \text{Value from State 1}\end{matrix} + \begin{matrix}\text{FAF Region 2} \\ \text{Value from State 1}\end{matrix} \qquad \text{(Eq. B-26)}$$

$$\begin{matrix}\text{Non-FAF Region} \\ \text{Urban Area O/D-Based} \\ \text{Commodity Value from State 1}\end{matrix} = \begin{matrix}\text{Remaining Unassigned} \\ \text{State 1 FAF O/D-Based} \\ \text{Commodity Value}\end{matrix} \times \left(\frac{\begin{matrix}\text{Non-FAF Urban Area Truck} \\ \text{VMT Percentage}\end{matrix}}{\begin{matrix}\text{Remaining Unassigned State 1} \\ \text{Truck VMT Percentage}\end{matrix}} \right) \qquad \text{(Eq. B-27)}$$

Step 5 – Final Commodity Value for Each Urban Area. The VMT-based commodity value and the O/D-based commodity value were averaged for each urban area to create the final commodity value to be presented in the Urban Mobility Report.

$$\begin{array}{c}\text{Final Commodity}\\ \text{Value for}\\ \text{Urban Area}\end{array} = \left(\begin{array}{c}\text{Urban Area}\\ \text{VMT-Based}\\ \text{Commodity Value}\end{array} + \begin{array}{c}\text{Urban Area}\\ \text{O/D-Based}\\ \text{Commodity Value}\end{array}\right) \div 2 \qquad \text{(Eq. B-28)}$$

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 a useful performance measure in some applications. The RCI measures the density of traffic across the urban area using generally available data. 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 according to the amount of travel on each type of road (Eq. A-27). 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 the index value is greater than or equal to 1.0.

The traffic density ratio (VMT per lane-mile) is divided by a value 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.

$$\begin{array}{c}\text{Roadway}\\ \text{Congestion}\\ \text{Index}\end{array} = \frac{\begin{array}{c}\text{Freeway}\\ \text{VMT/Ln. Mi.}\end{array} \times \begin{array}{c}\text{Freeway}\\ \text{VMT}\end{array} + \begin{array}{c}\text{Prin Art Str}\\ \text{VMT/Ln. Mi.}\end{array} \times \begin{array}{c}\text{Prin Art Str}\\ \text{VMT}\end{array}}{14{,}000 \times \begin{array}{c}\text{Freeway}\\ \text{VMT}\end{array} + 5{,}000 \times \begin{array}{c}\text{Prin Art Str}\\ \text{VMT}\end{array}} \qquad \text{(Eq. B-29)}$$

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 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 1 1/2 to 2 hours during each peak-period.
- Wait through one or two red lights at heavily traveled intersections.
- The RCI includes the effect of 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 over a short section of road (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.

Number of "Rush Hours"

The length of time each day that the roadway system contains congestion is presented as the number of "rush hours" of traffic. This measure is calculated differently than under previous methodologies. The average Travel Time Index is calculated for each urban area for each hour of the average weekday. The TTI for each hour of the day and the population of the urban area determ*ine the number of "rush hours".*

For each hour of the average weekday in each urban area, the TTI values are analyzed with the criteria in Exhibit B-9. For example, if the TTI value meets the highest criteria, the entire hour is considered congested. The TTI values in these calculations are based on areawide statistics. In order to be considered a "rush hour" the amount of congestion has to meet a certain level of congestion to be considered areawide. In the case of Very Large urban areas, the minimum TTI value for a portion of an hour to be considered congested is 1.12.

Exhibit B-9. Estimation of Rush Hours

Population Group	TTI Range	Number of Hours of Congestion
Very Large	Over 1.22	1.00
	1.17-1.22	0.50
	1.12-1.17	0.25
	Under 1.12	0.00
Large	Over 1.20	1.00
	1.15-1.20	0.50
	1.10-1.15	0.25
	Under 1.10	0.00
Medium/Small	Over 1.17	1.00
	1.12-1.17	0.50
	1.07-1.12	0.25
	Under 1.07	0.00

The following two measures are not based on the INRIX speeds and the new methodology. Due to some low match rates in some of the urban areas between the INRIX speed network and the HPMS roadway inventory data and because we currently use hourly speed and volume data instead of 15-minute, these measures are based on the previous methodology with estimated speeds. In the future as the match rate improves, these measures will be based on the new methodology with measured speeds.

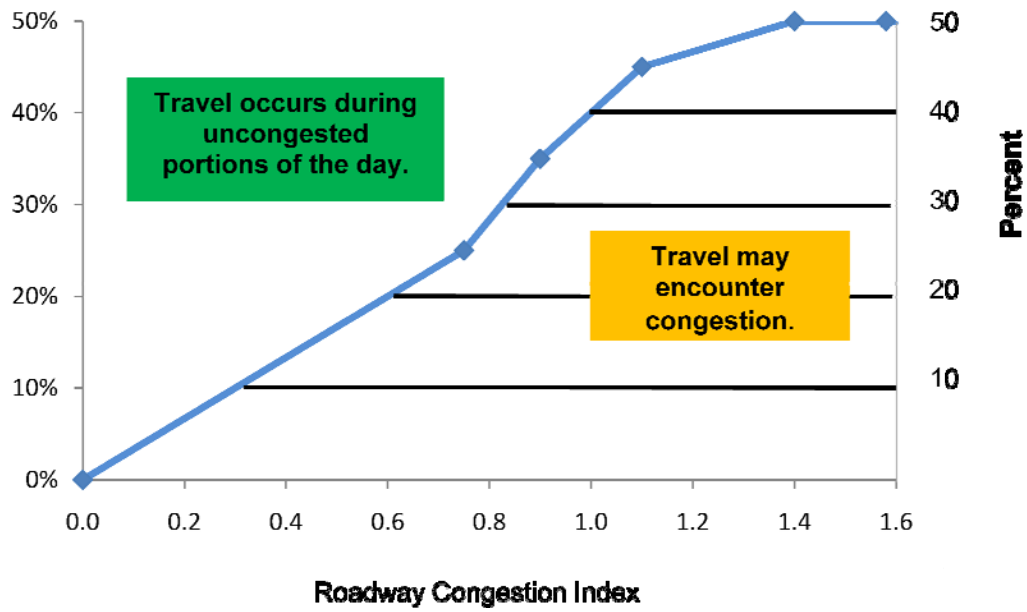
Percent of Daily and Peak Travel in Congested Conditions

Traditional 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. 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 UMR.

These percentages have been estimated again for the 2010 UMR. The historical measured speed data will make it possible in future reports to calculate the travel that occurs at a speed that is under a certain congestion threshold speed. However, in this report, the travel percentages were estimated using the process described below as changes to the methodology were not incorporated prior to this release.

Exhibit B-10 illustrates the estimation procedure used for all urban areas. The UMR 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 B-10 illustrates the process used to estimate the amount of the day (and the amount of travel) when travelers might encounter congestion. Travel during the peak period, but outside these possibly congested times, is considered uncongested and is assigned a free-flow speed. The maximum percentage of daily travel that can be in congestion is 50 percent which is also the maximum amount of travel that can occur in the peak periods of the day. The percentage of peak period travel that is congested comes from the 50 percent of travel that is assigned to the peak periods.

Exhibit B-10. Percent of Daily Travel in Congested Conditions



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 congested periods (Equations B-30 and B-31), 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 B-32), the factor in the denominator is the daily miles of travel.

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