2012 URBAN MOBILITY REPORT

DECEMBER 2012

Texas A&M Transportation Institute

POWERED BY INRIX TRAFFIC

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER

TTI's 2012 URBAN MOBILITY REPORT
Powered by INRIX Traffic Data

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

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2012 Urban Mobility Report

Congestion levels in large and small urban areas were buffeted by several trends in 2011. Some caused congestion increases and others decreased stop-and-go traffic. For the complete report and congestion data on your city, see: http://mobility.tamu.edu/ums.

The 2011 data are consistent with one past trend, congestion will not go away by itself – action is needed! (see Exhibit 1)

- The problem is very large. In 2011, congestion caused urban Americans to travel 5.5 billion hours more and to purchase an extra 2.9 billion gallons of fuel for a congestion cost of $121 billion.
- Second, in order to arrive on time for important trips, travelers had to allow for 60 minutes to make a trip that takes 20 minutes in light traffic.
- Third, while congestion is below its peak in 2005, there is only a short-term cause for celebration. Prior to the economy slowing, just 5 years ago, congestion levels were much higher than a decade ago; these conditions will return as the economy improves.

The data show that congestion solutions are not being pursued aggressively enough. The most effective congestion reduction strategy, however, 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 2012 Urban Mobility Report (498 U.S. Urban Areas)
(Note: See page 2 for description of changes since the 2011 Report)

Measures of…	1982	2000	2005	2010	2011
… Individual Congestion					
Yearly delay per auto commuter (hours)	16	39	43	38	38
Travel Time Index	1.07	1.19	1.23	1.18	1.18
Planning Time Index (Freeway only)	--	--	--	--	3.09
"Wasted" fuel per auto commuter (gallons)	8	19	23	19	19
CO_2 per auto commuter during congestion (lbs)	160	388	451	376	380
Congestion cost per auto commuter (2011 dollars)	$342	$795	$924	$810	$818
… The Nation's Congestion Problem					
Travel delay (billion hours)	1.1	4.5	5.9	5.5	5.5
"Wasted" fuel (billion gallons)	0.5	2.4	3.2	2.9	2.9
CO_2 produced during congestion (billions of lbs)	10	47	62	56	56
Truck congestion cost (billions of 2011 dollars)	--	--	--	$27	$27
Congestion cost (billions of 2011 dollars)	$24	$94	$128	$120	$121
… The Effect of Some Solutions					
Yearly travel delay saved by:					
Operational treatments (million hours)	9	215	368	370	374
Public transportation (million hours)	409	774	869	856	865
Yearly congestion costs saved by:					
Operational treatments (billions of 2011$)	$0.2	$3.6	$7.3	$8.3	$8.5
Public transportation (billions of 2011$)	$8.0	$14.0	$18.5	$20.2	$20.8

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.
Planning Time Index (PTI) – The ratio of travel time on the worst day of the month to travel time at free-flow conditions. A Planning Time Index of 1.80 indicates a traveler should plan for 36 minutes for a trip that takes 20 minutes in free-flow conditions (20 minutes x 1.80 = 36 minutes). The Planning Time Index is only computed for freeways only; it does not include arterials.
Wasted fuel – Extra fuel consumed during congested travel.
CO_2 per auto commuter during congestion –The extra CO_2 emitted at congested speeds rather than free-flow speed by private vehicle drivers and passenger who typically travel in the peak periods.
Congestion cost – The yearly value of delay time and wasted fuel.

Turning Congestion Data Into Knowledge
(And the New Data Providing a More Accurate View)

The *2012 Urban Mobility Report* is the 3rd prepared in partnership with INRIX (*1*), a leading private sector provider of travel time information for travelers and shippers. The data behind the *2012 Urban Mobility Report* are hundreds of speed data points on almost every mile of major road in urban America for almost every 15-minute period of the average day. For the congestion analyst, this means 600 million speeds on 875,000 thousand miles across the U.S. – an awesome amount of information. For the policy analyst and transportation planner, this means congestion problems can be described in detail and solutions can be targeted with much greater specificity and accuracy. Exhibit 2 shows historical national congestion trend measures.

Key aspects of the *2012 UMR* are summarized below.

- Speeds collected every 15-minutes from a variety of sources every day of the year on most major roads are used in the study. For more information about INRIX, go to www.inrix.com.
- The data for all 24 hours makes it possible to track congestion problems for the midday, overnight and weekend time periods.
- A measure of the variation in travel time from day-to-day is introduced. The Planning Time Index (PTI) is based on the idea that travelers would want to be on-time for an important trip 19 out of 20 times; so one would be late only one day per month (on-time for 19 out of 20 work days each month). A PTI value of 3.00 indicates that a traveler should allow 60 minutes to make an important trip that takes 20 minutes in uncongested traffic. In essence, the 19th worst commute is affected by crashes, weather, special events, and other causes of unreliable travel and can be improved by a range of transportation improvement strategies.
- 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/).
- Additional carbon dioxide (CO_2) greenhouse gas emissions due to congestion are included for the first time thanks to research funding from CFIRE and collaboration with researchers at the Energy Institute at the University of Wisconsin-Madison. The procedure is based on the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) modeling procedure.
- Wasted fuel is estimated using the additional carbon dioxide greenhouse gas emissions due to congestion for each urban area. For the first time, this method allows for consideration of urban area climate in emissions and fuel consumption calculations.
- More information on these new measures and data can be found at: http://mobility.tamu.edu/resources/

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

Exhibit 2. National Congestion Measures, 1982 to 2011

Year	Travel Time Index	Delay per Commuter (hours)	Total Delay (billion hours)	Fuel Wasted (billion gallons)	Total Cost (2011$ billion)	Hours Saved (million hours) Operational Treatments & HOV Lanes	Hours Saved (million hours) Public Transp	Gallons Saved (million gallons) Operational Treatments & HOV Lanes	Gallons Saved (million gallons) Public Transp	Dollars Saved (billions of 2011$) Operational Treatments & HOV Lanes	Dollars Saved (billions of 2011$) Public Transp
1982	1.07	15.5	1.12	0.53	24.4	9	409	1	204	0.2	8.0
1983	1.07	17.7	1.23	0.58	26.5	11	418	4	208	0.2	8.3
1984	1.08	18.8	1.34	0.65	28.9	16	433	7	219	0.3	8.5
1985	1.09	21.0	1.56	0.75	33.3	21	459	9	235	0.3	8.8
1986	1.10	23.2	1.79	0.88	37.0	28	434	12	229	0.5	8.1
1987	1.11	25.4	1.99	1.00	41.2	36	447	16	236	0.7	8.4
1988	1.12	27.6	2.29	1.15	47.3	48	546	21	289	0.8	10.2
1989	1.14	29.8	2.51	1.28	52.1	58	585	25	314	0.9	11.1
1990	1.14	32.0	2.66	1.36	55.2	66	583	29	317	1.0	10.9
1991	1.14	32.0	2.73	1.41	56.4	69	576	31	317	1.2	10.8
1992	1.14	32.0	2.90	1.50	60.1	78	566	35	310	1.3	10.6
1993	1.15	33.1	3.06	1.57	63.1	87	559	40	305	1.4	10.5
1994	1.15	34.2	3.19	1.64	65.8	97	581	44	318	1.6	10.9
1995	1.16	35.4	3.42	1.78	71.0	114	612	51	340	2.0	11.5
1996	1.17	36.5	3.64	1.90	75.9	131	633	59	354	2.2	12.0
1997	1.17	37.6	3.85	2.02	79.7	149	652	67	365	2.6	12.3
1998	1.18	37.6	4.00	2.12	81.9	170	692	76	392	2.8	12.8
1999	1.19	38.7	4.30	2.28	87.9	196	734	87	418	3.3	13.6
2000	1.19	38.7	4.50	2.39	94.2	215	774	116	431	3.6	14.0
2001	1.20	39.8	4.70	2.51	98.2	243	805	131	450	4.3	15.0
2002	1.21	40.9	4.97	2.67	103.7	270	815	148	461	4.9	15.4
2003	1.21	40.9	5.27	2.83	109.8	312	814	169	456	5.6	15.5
2004	1.22	43.1	5.61	3.02	119.1	338	858	186	486	6.4	17.2
2005	1.23	43.1	5.91	3.17	128.5	368	869	198	493	7.3	18.5
2006	1.22	43.1	5.94	3.20	130.8	406	908	220	519	8.4	20.1
2007	1.22	42.0	5.88	3.23	131.2	411	955	223	546	8.8	22.0
2008	1.18	37.6	5.23	2.76	115.3	353	862	185	478	7.6	19.7
2009	1.18	37.6	5.43	2.81	120.0	363	842	188	459	7.8	19.2
2010	1.18	37.6	5.46	2.85	120.0	370	856	192	445	8.3	20.2
2011	1.18	38.0	5.52	2.88	121.2	374	865	194	450	8.5	20.8

Note: For more congestion information see Tables 1 to 10 and http://mobility.tamu.edu/ums.

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One Page of Congestion Problems

In many regions, traffic jams can occur at any daylight hour, many nighttime hours and on weekends. The problems that travelers and shippers face include extra travel time, unreliable travel time and a system that is vulnerable to a variety of irregular congestion-producing occurrences. Some key descriptions are listed below. See data for your city at http://mobility.tamu.edu/ums/congestion_data.

Congestion costs are increasing. The congestion "invoice" for the cost of extra time and fuel in 498 urban areas was (all values in constant 2011 dollars):

- In 2011 – $121 billion
- In 2000 – $94 billion
- In 1982 – $24 billion

Congestion wastes a massive amount of time, fuel and money. In 2011:

- 5.5 billion hours of extra time (equivalent to the time businesses and individuals spend a year filing their taxes).
- 2.9 billion gallons of wasted fuel (enough to fill four New Orleans Superdomes).
- $121 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) ($121 billion is equivalent to the lost productivity and direct medical expenses of 12 average flu seasons).
- 56 billion pounds of additional carbon dioxide (CO_2) greenhouse gas released into the atmosphere during urban congested conditions (equivalent to the liftoff weight of over 12,400 Space Shuttles with all fuel tanks full).
- 22% ($27 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 $818 in 2011 compared to an inflation-adjusted $342 in 1982.

Congestion affects people who travel during the peak period. The average commuter:

- Spent an extra 38 hours traveling in 2011, up from 16 hours in 1982.
- Wasted 19 gallons of fuel in 2011 – a week's worth of fuel for the average U.S. driver – up from 8 gallons in 1982.
- In areas with over three million persons, commuters experienced an average of 52 hours of delay in 2011.
- Suffered 6 hours of congested road conditions on the average weekday in areas over 3 million population.
- 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 over 20 percent more delay hours than on Mondays.
- And if all that isn't bad enough, folks making important trips had to plan for approximately three times as much travel time as in light traffic conditions in order to account for the effects of unexpected crashes, bad weather, special events and other irregular congestion causes.

Congestion is also a problem at other hours.

- Approximately 37 percent of total delay occurs in the midday and overnight (outside of the peak hours) times of day when travelers and shippers expect free-flow travel. Many manufacturing processes depend on a free-flow trip for efficient production and congested networks interfere with those operations.

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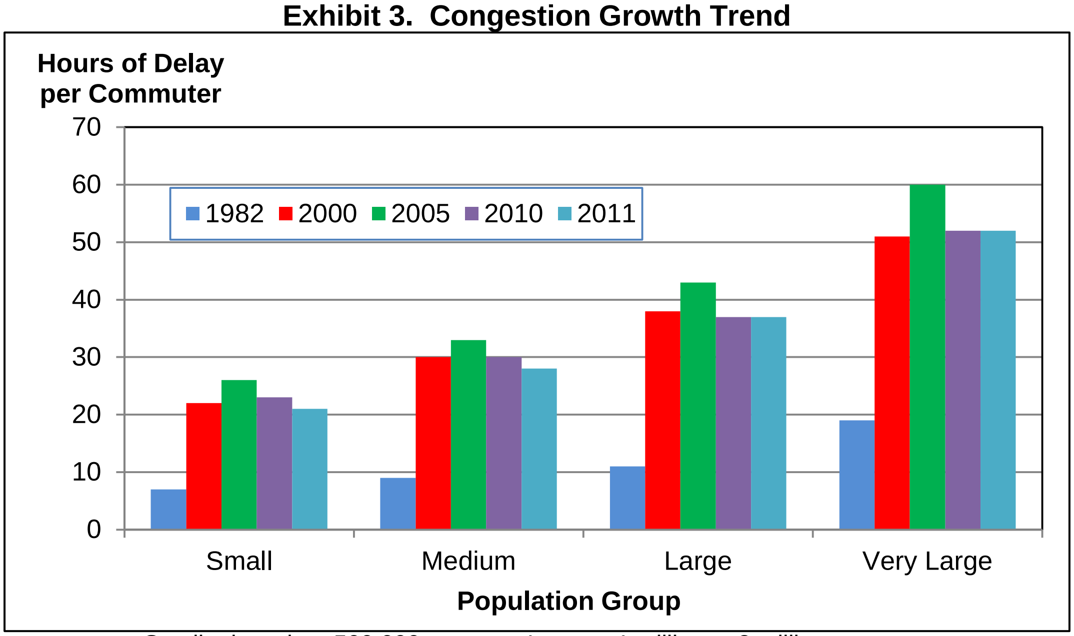
More Detail About Congestion Problems

Congestion, by every measure, has increased substantially over the 30 years covered in this report. And congestion is "recovering" from the improvements seen during the economic recession; many regions have seen congestion get worse as the economy gets better. As in past regional recessions (see California's dot com bubble in the early 2000s) when the economy recovers, so does traffic congestion and when unemployment lines shrank, lines of bumper-to-bumper traffic grew.

Recent trends show traffic congestion for commuters is relatively stable over the last few years after a decline at the start of the economic recession. The total congestion cost has risen as more commuters and freight shippers use the system. This trend is similar to past regional recessions and fuel price increases. Travel patterns change initially, and then travelers return to previous habits and congestion increases return to their previous pattern. There is still time to use this "reset" in the congestion trend, as well as the low prices for construction, to promote congestion reduction programs, policies and projects. But time is probably running out on the lower-cost construction period.

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). Big towns and small cities alike cannot implement enough projects, programs and policies to meet the demands 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 38 hours of extra time suffered by the average urban auto commuter in 2011:

- Almost 5 vacation days
- Equivalent to over one and a half times what Americans spend online shopping every year.
- Equivalent to the amount of time Americans spend over the winter holidays gift shopping, attending holiday parties and traveling to holiday parties.

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Congestion builds through the week from Monday to Friday. The two weekend days 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

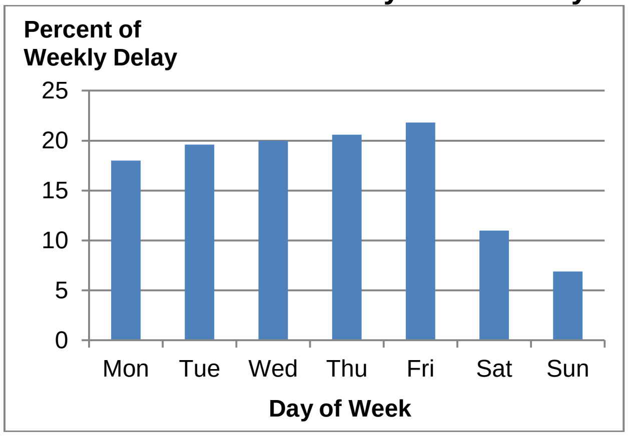
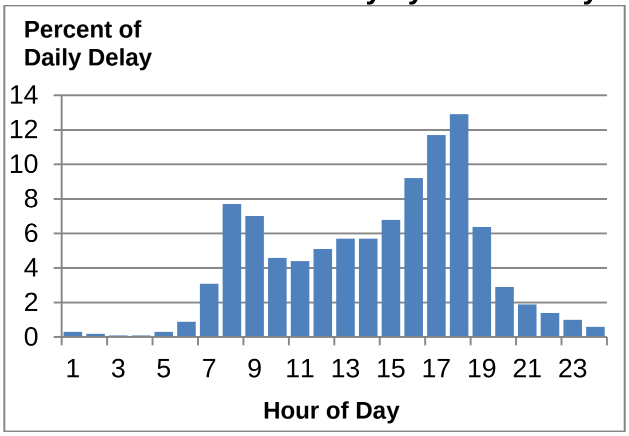
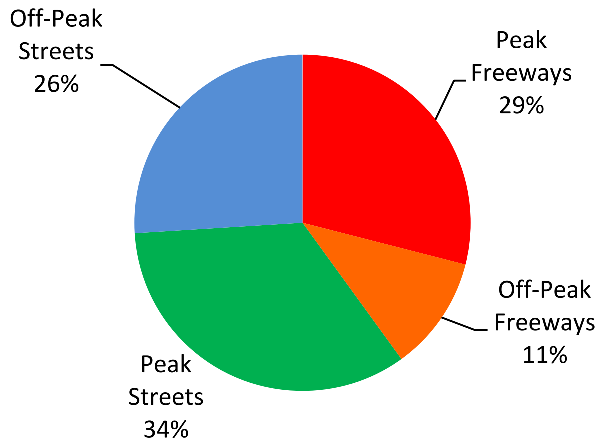


Exhibit 5. Percent of Delay by Time of Day



Streets have more delay than freeways (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 10 (pgs. 24-61) may surprise some readers. The areas listed below are examples of the reasons for higher than expected congestion levels.

- *Work zones* – Baton Rouge. Construction, even when it occurs in the off-peak, can increase traffic congestion.
- *Smaller urban areas with a major interstate highway* – Austin, Bridgeport, 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.

The Trouble With Planning Your Trip

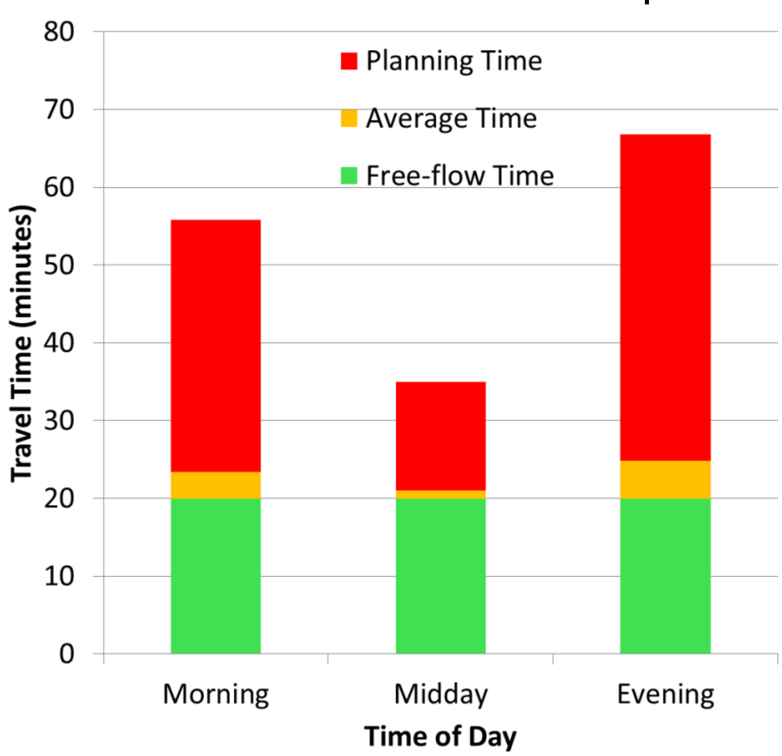
We've all made urgent trips—catching an airplane, getting to a medical appointment, or picking up a child at daycare on time. We know we need to leave a little early to make sure we are not late for these important trips, and we understand that these trips will take longer during the "rush hour." We are conditioned to add some extra time to these trips to make sure we make it, just in case there is an event that causes some unexpected congestion.

The need to add extra times isn't just a "rush hour" consideration. Trips during the off-peak can also take longer than expected. If we have to catch an airplane at 1 p.m. in the afternoon, we might still be inclined to add a little extra time, and the data indicate that our intuition is correct.

Exhibit 7 illustrates this idea. Say your typical trip takes 20 minutes when there are few other cars on the road. That is represented by the green bar across the morning, midday, and evening. Now imagine that your trip takes just a little longer, on average, whether that trip is in the morning, midday, or evening. This "average trip time" is shown in the solid yellow bar in Exhibit 7. Now consider that you have a very important trip to make during any of these time periods – there is additional "planning time" you must provide to ensure you make that trip on-time. And, as shown in Exhibit 7 (red bar), it isn't just a "rush hour" problem – it can happen any time of the day.

The analysis shown in the report (Table 3) indicates that folks making important trips on freeways during the peak periods had to plan for approximately three (3) times as much travel time as in light traffic conditions in order to account for the effects of unexpected crashes, bad weather, and other irregular congestion causes. Page 10 describes trip reliability in more detail.

Exhibit 7. Extra Time to Make Important Trips.



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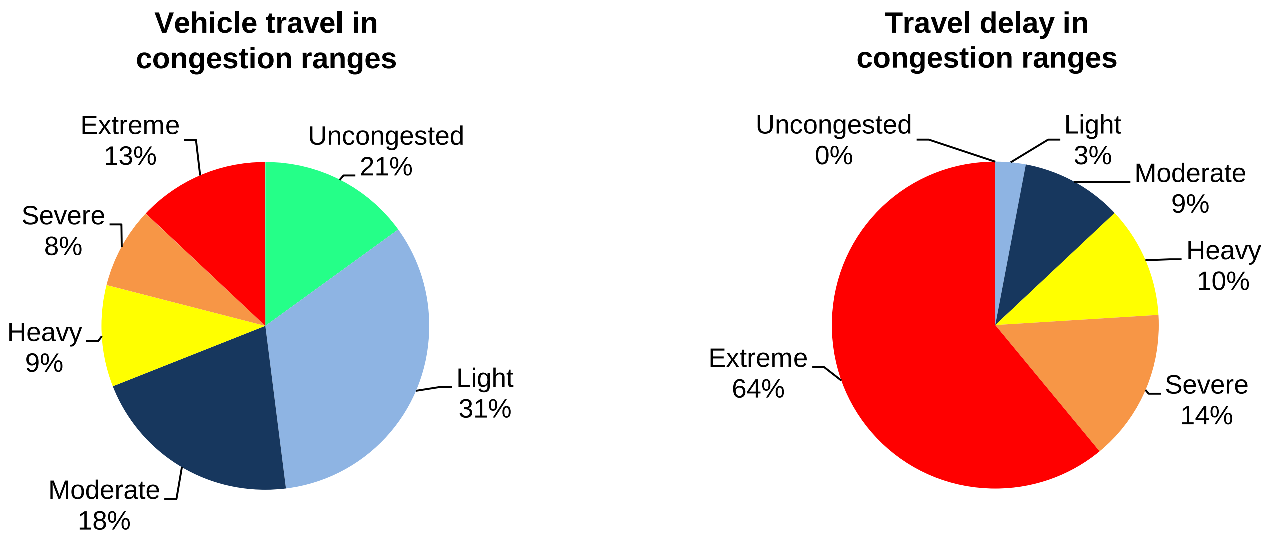
Travelers and shippers must plan around congestion more often.

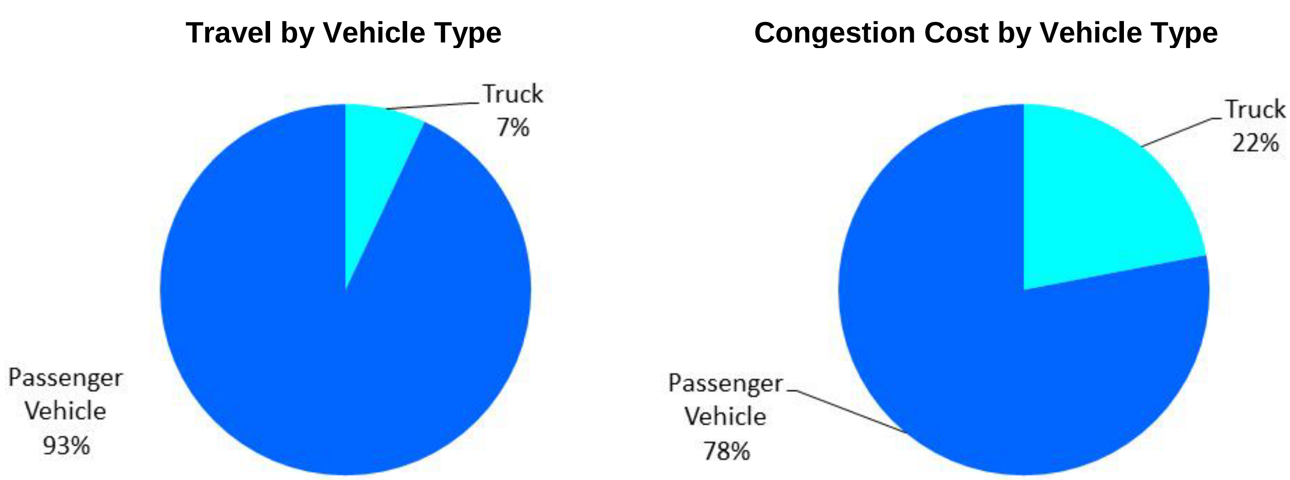
- In all 498 urban areas, the worst congestion levels affected only 1 in 9 trips in 1982, but almost 1 in 4 trips in 2011 (Exhibit 8).
- The most congested sections of road account for 78% of peak period delays, with only 21% of the travel (Exhibit 8).
- Delay has grown about five times larger overall since 1982 (Exhibit 2).

Exhibit 8. Peak Period Congestion and Congested Travel in 2011



While **trucks** only account for about 7 percent of the miles traveled in urban areas, they are **almost 23 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. 2011 Congestion Cost for Urban Passenger and Freight Vehicles



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The Future of Congestion

A few years ago, a congestion forecast of "more" would not be unusual. With the economic recession reducing congestion over the last few years, such predictions are more difficult. The 2012 Urban Mobility Report, however, uses expected population growth figures to provide some estimates to illustrate the near-future congestion problem. Congestion is the result of an imbalance between travel demand and the supply of transportation capacity; so if the number of people or jobs goes up, or the miles or trips that those people make increases, the road and transit systems also need to expand. As this report demonstrates, however, this is an infrequent occurrence, and travelers are paying the price for this inadequate response.

- Population and employment growth—two primary factors in rush hour travel demand—are projected to grow slightly slower from 2012 to 2020 than in the previous ten years.
- The combined role of the government and private sector will yield approximately the same rate of transportation system expansion (both roadway and public transportation). The analysis assumes that policies and funding levels will remain about the same.
- The growth in usage of any of the alternatives (biking, walking, work or shop at home) will continue at the same rate.
- Decisions as to the priorities and level of effort in solving transportation problems will continue as in the recent past.
- The period before the economic recession was used as the indicator of the effect of growth. These years had generally steady economic growth in most U.S. urban regions; these years are assumed to be a good indicator of the future level of investment in solutions and the resulting increase in congestion.

If this "status quo" benchmark is applied to the next five to ten years, a rough estimate of future congestion can be developed. The congestion estimate for any single region will be affected by the funding, project selections and operational strategies; the simplified estimation procedure used in this report will not capture these variations. Combining all the regions into one value for each population group, however, may result in a balance between estimates that are too high and those that are too low.

- The national congestion cost will grow from $121 billion to $199 billion in 2020 (in 2011 dollars).
- Delay will grow to 8.4 billion hours in 2020. Wasted fuel will increase to 4.5 billion gallons in 2020.
- The average commuter will see their cost grow to $1,010 in 2020 (in 2011 dollars). They will waste 45 hours and 25 gallons in 2020.
- If the price of gasoline grows to $5 per gallon, the congestion-related fuel cost would grow from about $10 billion in 2011 to approximately $22 billion in 2020 (in 2011 dollars).

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Unreliable Travel Times

The Annoying Issue of not Knowing How Long Your Trip Will Take

Trips take longer in rush hour, we all "get" that. But when you really need to be somewhere at a specific time - whether it's a family dinner, a meeting, an airplane departure or a health care appointment - you have to plan for the possibility of an even longer trip. As bad as traffic jams are, it's even more frustrating that you can't depend on how bad the traffic will be.

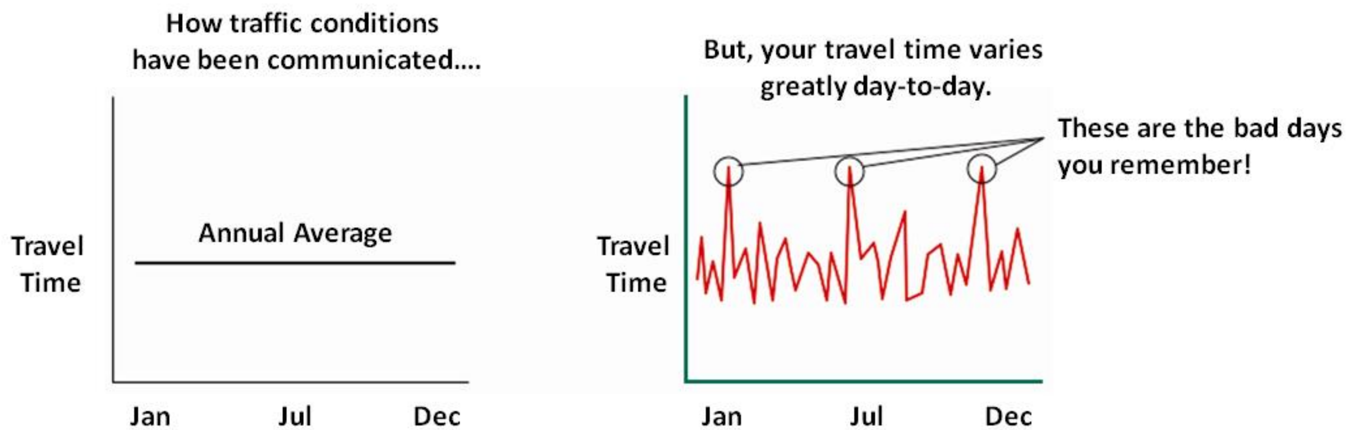
For the first time, the *Urban Mobility Report* includes a measure of this frustrating "extra" extra travel time – the amount of time you have to allow above the regular travel time. The INRIX dataset catalogs many trips taken on each road section; these have been analyzed to identify the longest trip times and present them in a measure similar to the Travel Time Index. The Planning Time Index (PTI) identifies the extra time that should be allowed to arrive on-time for a trip 19 times out of 20. Statistically, this is the 95^{th} percentile and it speaks to the effects of a variety of events that make travel time unpredictable.

Exhibit 10 shows how traffic conditions have historically been communicated – with averages. As shown in Exhibit 10, we all know that traffic isn't "average" everyday, it varies greatly. When your travel time is very high due to a large crash, special event, bad weather, or unexpected construction, your trip can take much longer. This variability in traffic is what the PTI helps you understand. If the PTI for your trip is 3.00, that tells you to plan 60 minutes for a trip that takes 20 minutes when there are few other cars on the road (20 minutes x 3.00 = 60 minutes) to ensure you are on-time for a trip 19 out of 20 times. Here's another way to think about it – suppose your boss tells you that it is ok to be late for work only 1 day out of the 20 workdays per month, the PTI would help you understand how much time to allow to satisfy your boss' requirement.

In addition to PTI, Table 3 (pgs. 32-35) also includes a reliability performance measure designed for transportation agency evaluation. PTI_{80} shows the "worst trip of the week" – the extra time to ensure timely arrival for 4 out of 5 trips. The worst trip of the week is frequently caused by a crash; rapid removal of these can improve $PTI_{80.}$ Bad weather that causes several of the worst travel times must be planned for, but it's difficult to grade an agency on weather conditions.

The methodology in the appendix provides further discussion and explanation of PTI and $PTI_{80.}$

Exhibit 10. Your Trip Can Vary Greatly



Source: Federal Highway Administration (2)

Air Quality Impacts of Congestion

According to the Environmental Protection Agency (EPA), transportation is the second largest emitting sector of carbon dioxide (CO_2) greenhouse gases behind electricity generation (*3*). There is increasing interest in the impact of transportation on air quality. For the first time, the *2012 Urban Mobility Report* includes measures of the additional CO_2 emissions as a result of congestion.

With funding from the Center for Freight and Infrastructure Research and Education (CFIRE) at the University of Wisconsin-Madison, TTI researchers teamed with researchers at the Energy Institute at the University of Wisconsin to develop a methodology to include CO_2 emissions in the *UMR*.

The methodology uses data from three primary sources, 1) HPMS, 2) INRIX traffic speeds, and 3) the EPA's MObile Vehicle Emission Simulator (MOVES) model. MOVES provides emissions estimates for mobile sources. Researchers used MOVES extensively to develop CO_2 emission rates, which were used to calculate CO_2 emissions and subsequently wasted fuel estimates. More details regarding the methodology are shown in the appendix.

Table 4 (pgs. 36-39) shows additional CO_2 production due to congestion by urban area size. Additional CO_2 production due to congestion in pounds per auto commuter and in total pounds for each urban area is shown. The 498 urban area total CO_2 produced by congestion is 56 billion pounds (equivalent to the takeoff weight of 12,400 space shuttles at liftoff with full fuel tanks). Note that this is only the additional CO_2 production due to congestion – it does not include CO_2 production from auto commuters traveling when roadways are uncongested.

A number of assumptions are in the model based upon available national-level data as inputs. These assumptions allow for a relatively simple and replicable method for 498 urban areas. More detailed and localized inputs should be used where available to improve local estimates of CO_2 production.

Estimation of the additional CO_2 emissions due to congestion provides another important element to characterize the urban congestion problem. It provides useful information for decision-making and policy makers, and it points to the importance of implementing transportation improvements to mitigate congestion. Researchers plan to incorporate other air quality pollutants into future editions of the *UMR*.

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; it is intuitive that some of the $27 billion in truck congestion costs in 2011was passed on to consumers in the form of higher prices. The congestion effects extend far beyond the region where the congestion occurs.

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 (*4*), a methodology was developed to estimate 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 (pgs. 40-43) 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 23 urban areas are ranked with commodity values much higher than their delay ranking.

Table 5 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 can produce 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 *2012 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.

Congestion Relief – An Overview of the Strategies

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 or on the following websites below.

- **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.
  - http://mobility.tamu.edu/mip/strategies.php#traffic
- **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.
  - http://mobility.tamu.edu/mip/strategies.php#additional
- **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.
  - http://mobility.tamu.edu/mip/strategies.php#options
- **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.
  - http://mobility.tamu.edu/mip/strategies.php#additional
- **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 appears to be part, but not all, of the solution.
  - http://mobility.tamu.edu/mip/strategies.php#options
- **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.
  - http://mobility.tamu.edu/mip/strategies.php#public

Congestion Solutions – The Effects

The *2012 Urban Mobility Report* database includes the effect of several widely implemented congestion solutions. These strategies provide faster and more reliable travel and make the most of the roads and public transportation systems that have been built. These solutions use a combination of information, technology, design changes, operating practices and construction programs to create value for travelers and shippers. There is a double benefit to efficient operations-travelers benefit from better conditions and the public sees that their tax dollars are being used wisely. The estimates described in the next few pages are a reflection of the benefits from these types of roadway operating strategies and public transportation systems.

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 2011, the 498 urban areas would have suffered an additional 865 million hours of delay and consumed 450 million more gallons of fuel (Exhibit 11). 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 $20.8 billion, a 15% increase over current congestion costs in the 498 urban areas.

There were approximately 56 billion passenger-miles of travel on public transportation systems in the 498 urban areas in 2011 (*5*). The benefits from public transportation vary by the amount of travel and the road congestion levels (Exhibit 11). More information on the effects for each urban area is included in Table 8 (pgs. 50-53).

Exhibit 11. Delay Increase in 2011 if Public Transportation Service Were Eliminated – 498 Areas

Population Group and Number of Areas	Average Annual Passenger-Miles of Travel (Million)	Reduction Due to Public Transportation			
		Hours of Delay Saved (Million)	Percent of Base Delay	Gallons of Fuel (Million)	Dollars Saved ($ Million)
Very Large (15)	43,203	721	24	398	17,415
Large (32)	6,407	80	5	34	1,939
Medium (33)	1,598	12	3	2	279
Small (21)	445	3	3	1	91
Other (397)	4,357	49	6	15	1,060
National Urban Total	56,010	865	15	450	$20,784

Source: Reference (*5*) and Review by Texas A&M 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 374 million hours of delay (7% of the total) with a value of $8.5 billion in 2011 (Exhibit 12). If the treatments were deployed on all major freeways and streets, the benefit would expand to almost 842 million hours of delay (15% of delay) and more than $19 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 12. Operational Improvement Summary for All 498 Urban Areas

Population Group and Number of Areas	Reduction Due to Current Projects			Delay Reduction if In Place on All Roads (Million Hours)
	Hours of Delay Saved (Million)	Gallons of Fuel Saved (Million)	Dollars Saved ($ Million)	
Very Large (15)	250	151	5,670	619
Large (33)	71	30	1,617	97
Medium (32)	16	4	358	42
Small (21)	4	1	89	9
Other (338)	33	8	750	75
TOTAL	374	194	$8,484	842

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 (*6,7*).

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/

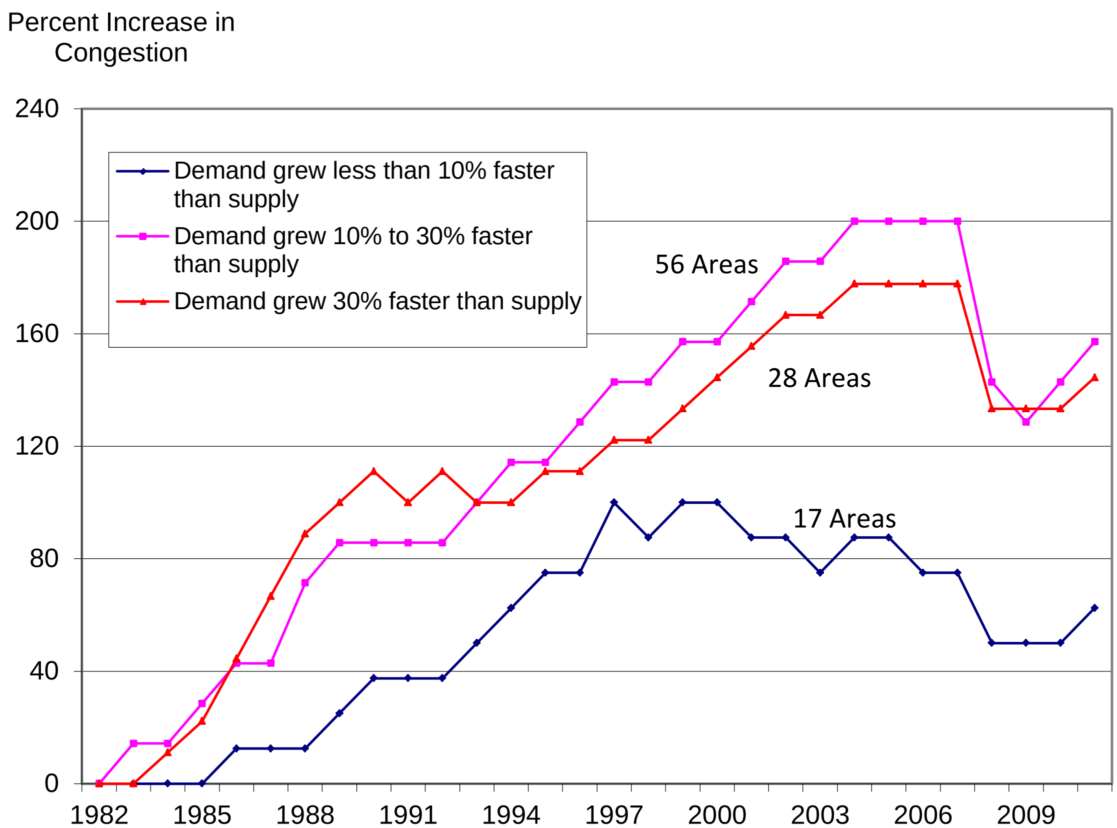
More Capacity

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.

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

Additional roadways reduce the rate of congestion increase. This is clear from comparisons between 1982 and 2011 (Exhibit 13). 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 areas were able to accomplish that rate, there must be a broader and larger set of solutions applied to the problem. Most of these regions (listed in Table 11 on page 97) were not in locations of high economic growth, suggesting their challenges were not as great as in regions with booming job markets.

Exhibit 13. Road Growth and Mobility Level



Source: Texas A&M Transportation Institute analysis, see and http://mobility.tamu.edu/ums/methodology/

Total Peak Period Travel Time

Another approach to measuring some aspects of congestion is the total time spent traveling during the peak periods. The measure can be used with other *Urban Mobility Report* statistics in a balanced transportation and land use pattern evaluation program. As with any measure, the analyst must understand the components of the measure and the implications of its use. In the *Urban Mobility Report* context where trends are important, values for cities of similar size and/or congestion levels can be used as comparisons. Year-to-year changes for an area can also be used to help an evaluation of long-term policies. The total peak period travel time measure is particularly well-suited for long-range scenario planning as it shows the effect of the combination of different transportation investments and land use arrangements.

Some have used total travel time to suggest that it shows urban residents are making poor home and job location decisions or are not correctly evaluating their travel options. There are several factors that should be considered when examining values of total travel time.

- Travel delay – The extra travel time due to congestion
- Type of road network – The mix of high-speed freeways and slower streets
- Development patterns – The physical arrangement of living, working, shopping, medical, school and other activities
- Home and job location – Distance from home to work is a significant portion of commuting time
- Decisions and priorities – It is clear that congestion is not the only important factor in the location and travel decisions made by families

Individuals and families frequently trade one or two long daily commutes for other desirable features such as good schools, medical facilities, large homes or a myriad of other factors.

Total peak period travel time (see Table 7 on pgs. 46-49) can provide additional explanatory power to a set of mobility performance measures. It provides some of the desirable aspects of accessibility measures, while at the same time being a travel time quantity that can be developed from actual travel speeds. Regions that are developed in a relatively compact urban form will also score well, which is why the measure may be particularly well-suited to public discussions about regional plans and how transportation and land use investments can support the attainment of community goals.

Calculation Methods

The *2012 Urban Mobility Report* combines several datasets not traditionally used together to generate procedures and base data that produce a total travel time measure. Challenges clearly exist in creating a broader use for the data; additional development and refinement will address specific issues. For example, smaller cities ranking highly in Table 7 and larger cities ranking lower will require further clarification. This report measures total travel time in minutes of peak-period road travel per auto commuter. Though capable of being a door-to-door metric in the future, values in Table 7 represent all travel only in automobiles and may appear to be less than average trip to work times reported by the US Census Bureau's American Community Survey (ACS) (*7*). The measure distinctly differs from the ACS by using real speed data instead of perceived travel times to generate a value for each urban area. The measure now includes delay and speeds (reference and congested) for local streets in its calculation. Other methodological refinements and a preliminary process for accounting for through trips have also been added. Researchers will continue to refine estimates of commuters, through trips, and local street travel as well as include other transportation modes.

More information about the total peak period travel time measure can be found at: http://mobility.tamu.edu/resources/

Using the Best Congestion Data & Analysis Methodologies

The base data for the *2012 Urban Mobility Report* come from INRIX, the U.S. Department of Transportation and the states (*1, 2, 6*). 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 and dramatically improves the accuracy and level of understanding about the congestion problems facing US travelers.

The methodology is described in a series of technical reports (*9, 10, 11, 12*) that are posted on the mobility report website: http://mobility.tamu.edu/ums/methodology/.

- 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 2011 (approximately 875,000 directional miles in 2011).
- 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 15-minute volumes using a set of estimation curves developed from a national traffic count dataset (*13*).
- The 15-minute INRIX speeds were matched to the 15-minute 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. Congested corridor data and travel time reliability statistics are two examples of how the improved data and analysis procedures can be used. 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:

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

The *2012 Urban Mobility Report* points to a $121 billion congestion cost, $27 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 38 hours of travel time and use 19 extra gallons of fuel, which amounts to an average cost of $818 per commuter. The report includes a comprehensive picture of congestion in all 498 U.S. urban areas and provides an indication of how the problem affects travel choices, arrival times, shipment routes, manufacturing processes and location decisions.

Recent trends show traffic congestion for commuters is relatively stable over the last few years after a decline at the start of the economic recession. The total congestion cost has risen, as more commuters and freight shippers use the system. This trend is similar to past regional recessions and fuel price increases. Travel patterns change initially, and then travelers return to previous habits and congestion increases return to their previous pattern.

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 *2012 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 *2012 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.

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

National Congestion Tables

Table 1. What Congestion Means to You, 2011

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)	**52**		**1.27**		**24**		**1,128**	
Washington DC-VA-MD	67	1	1.32	4	32	1	1,398	1
Los Angeles-Long Beach-Santa Ana CA	61	2	1.37	1	27	3	1,300	2
San Francisco-Oakland CA	61	2	1.22	23	25	6	1,266	4
New York-Newark NY-NJ-CT	59	4	1.33	3	28	2	1,281	3
Boston MA-NH-RI	53	5	1.28	6	26	4	1,147	6
Houston TX	52	6	1.26	10	23	12	1,090	8
Atlanta GA	51	7	1.24	17	23	12	1,120	7
Chicago IL-IN	51	7	1.25	14	24	8	1,153	5
Philadelphia PA-NJ-DE-MD	48	9	1.26	10	23	12	1,018	12
Seattle WA	48	9	1.26	10	22	15	1,050	10
Miami FL	47	11	1.25	14	25	6	993	13
Dallas-Fort Worth-Arlington TX	45	13	1.26	10	20	19	957	15
Detroit MI	40	25	1.18	37	18	30	859	27
San Diego CA	37	37	1.18	37	15	48	774	41
Phoenix-Mesa AZ	35	40	1.18	37	20	19	837	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 $8 per hour of person travel and $88 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon for gasoline and diesel).
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

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

Table 1. What Congestion Means to You, 2011, 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 (32 areas)	**37**		**1.20**		**17**		**780**	
Nashville-Davidson TN	47	11	1.23	20	24	8	1,034	11
Denver-Aurora CO	45	13	1.27	8	20	19	937	16
Orlando FL	45	13	1.20	27	22	15	984	14
Austin TX	44	17	1.32	4	20	19	930	18
Las Vegas NV	44	17	1.20	27	21	17	906	23
Portland OR-WA	44	17	1.28	6	21	17	937	16
Virginia Beach VA	43	20	1.20	27	19	24	877	26
Baltimore MD	41	23	1.23	20	19	24	908	22
Indianapolis IN	41	23	1.17	47	19	24	930	18
Charlotte NC-SC	40	25	1.20	27	20	19	898	25
Columbus OH	40	25	1.18	37	18	30	847	29
Pittsburgh PA	39	28	1.24	17	18	30	826	32
San Jose CA	39	28	1.24	17	17	40	800	35
Memphis TN-MS-AR	38	30	1.18	37	19	24	833	31
Riverside-San Bernardino CA	38	30	1.23	20	16	43	854	28
San Antonio TX	38	30	1.19	35	16	43	787	38
Tampa-St. Petersburg FL	38	30	1.20	27	18	30	791	37
Cincinnati OH-KY-IN	37	37	1.20	27	18	30	814	33
Louisville KY-IN	35	40	1.18	37	17	40	776	40
Minneapolis-St. Paul MN	34	44	1.21	25	12	69	695	45
Buffalo NY	33	45	1.17	47	18	30	718	43
Sacramento CA	32	47	1.20	27	13	60	669	50
Cleveland OH	31	50	1.16	51	15	48	642	57
St. Louis MO-IL	31	50	1.14	61	13	60	686	47
Jacksonville FL	30	53	1.14	61	13	60	635	58
Providence RI-MA	30	53	1.16	51	15	48	611	62
Salt Lake City UT	30	53	1.14	61	13	60	620	61
San Juan PR	29	60	1.25	14	15	48	625	60
Milwaukee WI	28	63	1.15	57	12	69	585	67
New Orleans LA	28	63	1.20	27	13	60	629	59
Kansas City MO-KS	27	68	1.13	68	12	69	584	68
Raleigh-Durham NC	23	83	1.14	61	11	80	502	82

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 $88 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon for gasoline and diesel).
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

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

Table 1. What Congestion Means to You, 2011, 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)	**29**		**1.15**		**14**		**628**	
Honolulu HI	45	13	1.36	2	24	8	928	20
Baton Rouge LA	42	21	1.22	23	26	4	1,052	9
Bridgeport-Stamford CT-NY	42	21	1.27	8	19	24	902	24
Hartford CT	38	30	1.18	37	18	30	781	39
Oklahoma City OK	38	30	1.15	57	18	30	803	34
Tucson AZ	38	30	1.16	51	24	8	921	21
Knoxville TN	37	37	1.16	51	18	30	792	36
Birmingham AL	35	40	1.19	35	18	30	773	42
New Haven CT	35	40	1.17	47	16	43	717	44
El Paso TX-NM	32	47	1.21	25	17	40	688	46
Tulsa OK	32	47	1.12	74	15	48	668	51
Albany NY	31	50	1.16	51	19	24	682	48
Allentown-Bethlehem PA-NJ	30	53	1.17	47	14	57	656	54
Charleston-North Charleston SC	30	53	1.15	57	14	57	647	55
Albuquerque NM	29	60	1.10	87	15	48	658	53
Richmond VA	29	60	1.11	79	12	69	581	69
McAllen TX	28	63	1.16	51	16	43	599	63
Rochester NY	28	63	1.13	68	13	60	590	65
Springfield MA-CT	28	63	1.13	68	15	48	575	71
Colorado Springs CO	26	71	1.13	68	11	80	530	78
Oxnard CA	26	71	1.10	87	10	86	543	75
Toledo OH-MI	26	71	1.13	68	12	69	555	73
Poughkeepsie-Newburgh NY	25	75	1.12	74	13	60	531	76
Dayton OH	24	80	1.11	79	12	69	507	81
Grand Rapids MI	24	80	1.09	93	11	80	501	83
Omaha NE-IA	24	80	1.11	79	11	80	494	84
Akron OH	23	83	1.12	74	10	86	483	85
Sarasota-Bradenton FL	21	88	1.12	74	11	80	444	87
Wichita KS	20	89	1.09	93	8	91	405	92
Fresno CA	15	95	1.08	95	7	95	337	94
Indio-Cathedral City-Palm Springs CA	15	95	1.08	95	7	95	331	96
Lancaster-Palmdale CA	15	95	1.08	95	6	97	317	97
Bakersfield CA	12	100	1.11	79	6	97	298	98

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 $88 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon for gasoline and diesel).
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

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Table 1. What Congestion Means to You, 2011, 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 (21 areas)	**23**		**1.11**		**11**		**497**	
Worcester MA-CT	33	45	1.13	68	16	43	677	49
Cape Coral FL	30	53	1.15	57	15	48	645	56
Columbia SC	30	53	1.11	79	14	57	663	52
Greensboro NC	27	68	1.10	87	12	69	588	66
Salem OR	27	68	1.14	61	12	69	580	70
Little Rock AR	26	71	1.07	99	12	69	545	74
Beaumont TX	25	75	1.10	87	12	69	531	76
Brownsville TX	25	75	1.18	37	15	48	565	72
Jackson MS	25	75	1.10	87	13	60	594	64
Provo-Orem UT	25	75	1.14	61	10	86	514	80
Spokane WA-ID	23	83	1.12	74	13	60	518	79
Boulder CO	22	86	1.18	37	12	69	436	88
Pensacola FL-AL	22	86	1.11	79	11	80	463	86
Madison WI	20	89	1.11	79	10	86	436	88
Winston-Salem NC	20	89	1.11	79	9	90	435	90
Laredo TX	19	92	1.14	61	8	91	418	91
Anchorage AK	17	93	1.18	37	8	91	367	93
Boise ID	16	94	1.06	100	8	91	334	95
Corpus Christi TX	14	98	1.04	101	6	97	287	100
Eugene OR	13	99	1.08	95	6	97	284	101
Stockton CA	12	100	1.10	87	5	101	293	99
101 Area Average	**43**		**1.23**		**20**		**922**	
Remaining Areas Average	**21**		**1.10**		**18**		**486**	
All 498 Area Average	**38**		**1.18**		**19**		**818**	

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.
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 $88 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon for gasoline and diesel).
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

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Table 2. What Congestion Means to Your Town, 2011

Urban Area	*Travel Delay*		*Excess Fuel Consumed*		*Truck Congestion Cost*		*Total Congestion Cost*	
	(1,000 Hours)	Rank	(1,000 Gallons)	Rank	($ million)	Rank	($ million)	Rank
Very Large Average (15 areas)	**195,831**		**90,936**		**933**		**4,253**	
New York-Newark NY-NJ-CT	544,063	1	255,798	1	2,541	1	11,837	1
Los Angeles-Long Beach-Santa Ana CA	501,881	2	219,710	2	2,290	2	10,785	2
Chicago IL-IN	271,718	3	127,016	3	1,716	3	6,214	3
Washington DC-VA-MD	179,331	4	85,103	5	656	8	3,771	4
Miami FL	174,612	5	93,863	4	739	5	3,749	5
Dallas-Fort Worth-Arlington TX	167,718	6	74,806	7	734	6	3,578	6
Philadelphia PA-NJ-DE-MD	156,027	7	75,558	6	730	7	3,387	7
San Francisco-Oakland CA	155,157	8	64,509	10	643	10	3,279	8
Houston TX	145,832	9	65,852	9	646	9	3,120	10
Atlanta GA	142,041	10	63,521	11	775	4	3,135	9
Boston MA-NH-RI	136,966	11	66,615	8	561	12	2,922	11
Detroit MI	106,434	12	48,705	12	475	14	2,287	12
Seattle WA	100,802	13	47,156	13	546	13	2,241	13
Phoenix-Mesa AZ	82,554	14	46,166	14	627	11	1,969	14
San Diego CA	72,331	16	29,666	18	314	17	1,537	17

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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 and other operating costs of large trucks (estimated at $88 per hour of truck time) and the extra diesel consumed (estimated using state average cost per gallon).
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.

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Table 2. What Congestion Means to Your Town, 2011, Continued

Urban Area	Travel Delay		Excess Fuel Consumed		Truck Congestion Cost		Total Congestion Cost	
	(1,000 Hours)	Rank	(1,000 Gallons)	Rank	($ million)	Rank	($ million)	Rank
Large Average (32 areas)	**39,747**		**18,265**		**182**		**856**	
Denver-Aurora CO	76,154	15	34,510	15	316	16	1,612	15
Baltimore MD	70,263	17	33,060	16	379	15	1,557	16
Tampa-St. Petersburg FL	62,876	18	30,539	17	246	21	1,325	18
Minneapolis-St. Paul MN	60,788	19	22,100	22	232	24	1,260	19
Portland OR-WA	51,987	20	24,949	19	244	22	1,130	21
Riverside-San Bernardino CA	51,195	21	21,243	26	310	18	1,152	20
St. Louis MO-IL	49,605	22	21,572	23	300	19	1,116	22
San Jose CA	47,385	23	20,028	28	153	33	971	26
Pittsburgh PA	46,725	24	21,443	25	213	26	1,007	24
Orlando FL	46,607	25	23,336	21	248	20	1,031	23
Virginia Beach VA	46,172	26	19,633	29	131	41	932	28
San Juan PR	45,991	27	24,095	20	176	28	980	25
Las Vegas NV	45,419	28	21,491	24	137	40	931	29
Cincinnati OH-KY-IN	42,785	29	20,783	27	230	25	947	27
San Antonio TX	39,998	30	16,776	33	139	39	825	31
Sacramento CA	39,138	31	16,384	35	172	29	834	30
Austin TX	38,307	32	17,075	32	157	31	810	33
Nashville-Davidson TN	35,781	33	18,652	30	199	27	801	34
Columbus OH	35,689	34	15,494	36	145	37	753	35
Indianapolis IN	35,186	35	16,748	34	241	23	817	32
Cleveland OH	34,980	36	17,481	31	130	43	736	36
Kansas City MO-KS	29,448	37	12,660	39	148	35	640	38
Charlotte NC-SC	28,974	38	14,599	37	168	30	653	37
Memphis TN-MS-AR	28,700	39	14,440	38	153	33	636	39
Milwaukee WI	27,755	40	11,797	45	131	41	599	40
Louisville KY-IN	26,253	42	12,507	40	145	37	584	41
Providence RI-MA	24,618	44	12,148	42	69	55	503	44
Jacksonville FL	22,629	46	10,300	50	103	48	486	45
Salt Lake City UT	21,903	47	9,266	53	71	54	449	50
Buffalo NY	21,545	48	11,611	46	102	49	474	47
New Orleans LA	19,125	52	9,353	52	127	44	441	51
Raleigh-Durham NC	17,923	54	8,407	55	96	50	396	55

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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 and other operating costs of large trucks (estimated at $88 per hour of truck time) and the extra diesel consumed (estimated using state average cost per gallon).
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.
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Table 2. What Congestion Means to Your Town, 2011, Continued

Urban Area	Travel Delay		Excess Fuel Consumed		Truck Congestion Cost		Total Congestion Cost	
	(1,000 Hours)	Rank	(1,000 Gallons)	Rank	($ million)	Rank	($ million)	Rank
Medium Average (33 areas)	**13,516**		**6,634**		**62**		**293**	
Bridgeport-Stamford CT-NY	26,503	41	12,226	41	111	46	566	42
Oklahoma City OK	25,182	43	12,035	44	115	45	543	43
Hartford CT	22,995	45	11,299	47	75	53	479	46
Birmingham AL	20,903	49	10,304	49	107	47	458	49
Honolulu HI	20,873	50	11,298	48	53	65	427	52
Richmond VA	19,499	51	7,944	57	62	61	398	54
Tucson AZ	19,078	53	12,125	43	155	32	466	48
Baton Rouge LA	17,122	55	10,201	51	148	35	424	53
El Paso TX-NM	15,990	56	8,500	54	81	52	353	56
Tulsa OK	15,500	57	7,242	58	67	57	331	57
Rochester NY	14,850	58	6,719	60	51	68	309	58
New Haven CT	14,560	59	6,966	59	50	69	304	59
Allentown-Bethlehem PA-NJ	13,247	60	6,339	64	69	55	292	61
Knoxville TN	13,247	60	6,339	64	63	59	287	63
Albany NY	13,092	62	8,032	56	64	58	293	60
Albuquerque NM	12,488	63	6,408	62	82	51	288	62
Oxnard CA	12,445	64	5,029	71	55	64	265	64
Dayton OH	12,442	65	6,106	66	52	67	265	64
Springfield MA-CT	12,084	66	6,403	63	40	78	253	66
McAllen TX	11,469	67	6,487	61	44	71	245	67
Charleston-North Charleston SC	10,885	68	5,108	70	58	62	240	68
Omaha NE-IA	10,721	69	4,737	74	32	86	219	72
Sarasota-Bradenton FL	10,523	70	5,301	67	41	75	222	70
Grand Rapids MI	10,016	73	4,572	75	44	71	215	73
Colorado Springs CO	9,941	75	4,128	78	36	81	205	77
Akron OH	9,789	76	4,147	77	44	71	209	76
Poughkeepsie-Newburgh NY	9,787	77	4,965	72	42	74	212	74
Toledo OH-MI	9,195	78	4,176	76	48	70	202	78
Fresno CA	7,376	82	3,124	83	41	75	164	82
Wichita KS	6,906	83	2,887	85	25	90	143	84
Lancaster-Palmdale CA	6,541	85	2,744	88	24	91	136	87
Indio-Cathedral City-Palm Springs CA	6,036	87	2,781	86	37	80	138	86
Bakersfield CA	4,752	91	2,240	92	41	75	117	91

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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 and other operating costs of large trucks (estimated at $88 per hour of truck time) and the extra diesel consumed (estimated using state average cost per gallon).
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Table 2. What Congestion Means to Your Town, 2011, Continued

Urban Area	Travel Delay		Excess Fuel Consumed		Truck Congestion Cost		Total Congestion Cost	
	(1,000 Hours)	Rank	(1,000 Gallons)	Rank	($ million)	Rank	($ million)	Rank
Small Average (21 areas)	**5,586**		**2,702**		**29**		**123**	
Worcester MA-CT	10,139	71	5,117	69	35	82	212	74
Columbia SC	10,081	72	4,850	73	58	62	225	69
Cape Coral FL	9,964	74	5,118	68	53	65	220	71
Provo-Orem UT	8,312	79	3,459	81	30	87	172	80
Little Rock AR	8,132	80	3,591	80	33	85	171	81
Jackson MS	7,535	81	4,024	79	63	59	183	79
Greensboro NC	6,625	84	3,005	84	35	82	146	83
Spokane WA-ID	6,107	86	3,457	82	38	79	141	85
Pensacola FL-AL	5,655	88	2,755	87	22	94	119	88
Winston-Salem NC	5,385	89	2,456	90	29	88	119	88
Madison WI	5,349	90	2,609	89	29	88	119	88
Salem OR	4,593	92	2,106	93	24	91	101	92
Beaumont TX	4,205	93	2,089	94	19	96	91	93
Brownsville TX	3,697	94	2,292	91	23	93	85	95
Boise ID	3,636	95	1,662	96	10	100	74	97
Anchorage AK	3,627	96	1,770	95	16	97	78	96
Stockton CA	3,519	97	1,415	98	35	82	90	94
Corpus Christi TX	3,160	98	1,340	99	14	98	67	99
Laredo TX	3,074	99	1,423	97	20	95	71	98
Eugene OR	2,271	100	1,002	101	14	98	51	100
Boulder CO	2,237	101	1,193	100	5	101	45	101
101 Area Total	**4,772,711**		**2,224,165**		**22,460**		**103,405**	
101 Area Average	**47,255**		**22,021**		**222**		**1,024**	
Remaining Area Total	**747,494**		**660,020**		**4,580**		**17,781**	
Remaining Area Average	**1,883**		**1,663**		**12**		**45**	
All 498 Area Total	**5,520,205**		**2,884,185**		**27,042**		**121,188**	
All 498 Area Average	**11,085**		**5,792**		**54**		**243**	

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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 and other operating costs of large trucks (estimated at $88 per hour of truck time) and the extra diesel consumed (estimated using state average cost per gallon)..
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.

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Table 3. How Reliable is Freeway Travel in Your Town, 2011

Urban Area	Freeway Planning Time Index				Freeway Travel Time Index	
	PTI		PTI_{80}		TTI	
	Value	Rank	Value	Rank	Value	Rank
Very Large Average (15 areas)	**4.08**		**2.03**		**1.31**	
Washington DC-VA-MD	5.72	1	2.56	1	1.38	4
Los Angeles-Long Beach-Santa Ana CA	4.95	2	2.50	2	1.54	1
New York-Newark NY-NJ-CT	4.44	3	2.13	6	1.32	6
Boston MA-NH-RI	4.25	8	2.02	8	1.29	10
Dallas-Fort Worth-Arlington TX	4.00	11	1.94	14	1.29	10
Seattle WA	3.99	12	2.02	8	1.31	8
Chicago IL-IN	3.95	13	2.02	8	1.30	9
San Francisco-Oakland CA	3.74	17	2.00	12	1.28	14
Atlanta GA	3.71	19	1.79	21	1.23	24
Houston TX	3.67	21	1.84	19	1.28	14
Miami FL	3.60	23	1.72	28	1.20	28
Philadelphia PA-NJ-DE-MD	3.46	24	1.75	27	1.22	26
Detroit MI	3.22	30	1.63	36	1.17	35
Phoenix-Mesa AZ	3.19	33	1.63	36	1.18	33
San Diego CA	2.90	48	1.66	31	1.20	28

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Planning Time Index—A travel time reliability measure that represents the total travel time that should be planned for a trip. Computed with the 95th percentile travel time, it represents the amount of time that should be planned for a trip to be late for only 1 day a month. Computed with the 80th percentile travel time (PTI_{80}), it represents the amount of time that should be planned for a trip to be late for only 1 day a week. A PTI of 3.00 means that for a 20-minute trip in light traffic, 60 minutes should be planned (20 minutes x 3.00 = 60 minutes).

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 (20 minutes x 1.30 = 26 minutes). Note that the TTI reported in Table 3 is only for freeway facilities to compare to the freeway-only PTI values in Table 3. Note that the TTI value in Table 1 includes both arterial and freeway roads.

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. Note that only 1 year of PTI values are available at this time.

Table 3. How Reliable is Freeway Travel in Your Town, 2011, Continued

Urban Area	Freeway Planning Time Index				Freeway Travel Time Index	
	PTI		PTI_{80}		TTI	
	Value	Rank	Value	Rank	Value	Rank
Large Average (32 areas)	**3.12**		**1.66**		**1.20**	
Austin TX	4.26	6	2.15	4	1.40	3
Portland OR-WA	4.26	6	2.15	4	1.34	5
Denver-Aurora CO	4.08	9	2.01	11	1.32	6
San Juan PR	4.06	10	1.96	13	1.29	10
Baltimore MD	3.81	15	1.88	16	1.23	24
New Orleans LA	3.80	16	1.88	16	1.25	19
Nashville-Davidson TN	3.63	22	1.79	21	1.20	28
San Jose CA	3.45	25	1.93	15	1.29	10
Virginia Beach VA	3.41	26	1.65	33	1.17	35
Riverside-San Bernardino CA	3.31	28	1.81	20	1.27	17
Charlotte NC-SC	3.20	31	1.61	39	1.15	42
Cincinnati OH-KY-IN	3.20	31	1.65	33	1.19	31
Milwaukee WI	3.15	34	1.66	31	1.18	33
Las Vegas NV	3.14	35	1.63	36	1.17	35
Minneapolis-St. Paul MN	3.14	35	1.79	21	1.27	17
Pittsburgh PA	3.14	35	1.77	26	1.24	21
Louisville KY-IN	3.09	38	1.64	35	1.16	39
Sacramento CA	3.01	41	1.68	30	1.24	21
Memphis TN-MS-AR	3.00	43	1.53	46	1.16	39
San Antonio TX	2.91	47	1.60	40	1.19	31
Tampa-St. Petersburg FL	2.90	48	1.54	44	1.15	42
Columbus OH	2.86	50	1.51	50	1.14	47
Providence RI-MA	2.86	50	1.55	43	1.15	42
Buffalo NY	2.79	52	1.48	52	1.15	42
Kansas City MO-KS	2.64	55	1.44	57	1.12	63
St. Louis MO-IL	2.64	55	1.44	57	1.13	56
Orlando FL	2.58	59	1.42	60	1.13	56
Indianapolis IN	2.50	62	1.41	61	1.16	39
Cleveland OH	2.49	63	1.48	52	1.14	47
Jacksonville FL	2.45	65	1.35	67	1.10	68
Raleigh-Durham NC	2.34	68	1.33	68	1.07	80
Salt Lake City UT	2.02	84	1.30	76	1.08	76

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Planning Time Index—A travel time reliability measure that represents the total travel time that should be planned for a trip. Computed with the 95th percentile travel time, it represents the amount of time that should be planned for a trip to be late for only 1 day a month. Computed with the 80th percentile travel time (PTI_{80}), it represents the amount of time that should be planned for a trip to be late for only 1 day a week. A PTI of 3.00 means that for a 20-minute trip in light traffic, 60 minutes should be planned (20 minutes x 3.00 = 60 minutes).

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 (20 minutes x 1.30 = 26 minutes). Note that the TTI reported in Table 3 is only for freeway facilities to compare to the freeway-only PTI values in Table 3. Note that the TTI value in Table 1 includes both arterial and freeway roads.

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Table 3. How Reliable is Freeway Travel in Your Town, 2011, Continued

Urban Area	Freeway Planning Time Index				Freeway Travel Time Index	
	PTI		PTI_{80}		TTI	
	Value	Rank	Value	Rank	Value	Rank
Medium Average (33 areas)	**2.66**		**1.47**		**1.13**	
Bridgeport-Stamford CT-NY	4.40	4	2.05	7	1.28	14
Honolulu HI	3.92	14	2.25	3	1.41	2
Baton Rouge LA	3.74	17	1.87	18	1.25	19
El Paso TX-NM	3.37	27	1.70	29	1.24	21
Charleston-North Charleston SC	3.24	29	1.56	41	1.13	56
Colorado Springs CO	3.06	39	1.47	55	1.13	56
New Haven CT	3.02	40	1.56	41	1.13	56
McAllen TX	3.01	41	1.44	57	1.14	47
Birmingham AL	2.97	44	1.52	48	1.14	47
Hartford CT	2.79	52	1.53	46	1.13	56
Albuquerque NM	2.70	54	1.52	48	1.04	95
Toledo OH-MI	2.64	55	1.37	66	1.10	68
Allentown-Bethlehem PA-NJ	2.61	58	1.39	64	1.14	47
Albany NY	2.57	60	1.40	63	1.10	68
Wichita KS	2.57	60	1.31	73	1.08	76
Oklahoma City OK	2.48	64	1.46	56	1.14	47
Oxnard CA	2.44	66	1.48	52	1.14	47
Dayton OH	2.37	67	1.31	73	1.07	80
Bakersfield CA	2.28	70	1.33	68	1.14	47
Akron OH	2.23	71	1.33	68	1.10	68
Richmond VA	2.22	72	1.28	80	1.07	80
Springfield MA-CT	2.16	76	1.27	82	1.06	89
Omaha NE-IA	2.15	77	1.29	78	1.08	76
Poughkeepsie-Newburgh NY	2.13	79	1.21	91	1.05	92
Tulsa OK	2.07	81	1.31	73	1.09	73
Tucson AZ	2.06	83	1.24	88	1.07	80
Knoxville TN	2.02	84	1.33	68	1.13	56
Grand Rapids MI	1.99	86	1.26	84	1.05	92
Rochester NY	1.96	87	1.28	80	1.08	76
Indio-Cathedral City-Palm Springs CA	1.88	90	1.21	91	1.10	68
Fresno CA	1.79	92	1.23	89	1.09	73
Sarasota-Bradenton FL	1.49	97	1.05	101	1.01	101
Lancaster-Palmdale CA	1.48	98	1.18	94	1.07	80

Very Large Urban Areas—over 3 million population.
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Table 3. How Reliable is Freeway Travel in Your Town, 2011, Continued

Urban Area	Freeway Planning Time Index				Freeway Travel Time Index	
	PTI		PTI_{80}		TTI	
	Value	Rank	Value	Rank	Value	Rank
Small Average (21 areas)	**2.09**		**1.27**		**1.07**	
Provo-Orem UT	4.39	5	1.54	44	1.11	64
Boulder CO	3.68	20	1.79	21	1.17	35
Spokane WA-ID	2.95	45	1.51	50	1.15	42
Anchorage AK	2.93	46	1.79	21	1.22	26
Madison WI	2.30	69	1.38	65	1.09	73
Worcester MA-CT	2.21	73	1.30	76	1.07	80
Jackson MS	2.20	74	1.27	82	1.06	89
Little Rock AR	2.20	74	1.33	68	1.05	92
Salem OR	2.15	77	1.29	78	1.11	64
Winston-Salem NC	2.09	80	1.25	86	1.07	80
Laredo TX	2.07	81	1.41	61	1.14	47
Columbia SC	1.95	88	1.21	91	1.06	89
Beaumont TX	1.90	89	1.22	90	1.07	80
Cape Coral FL	1.86	91	1.13	98	1.02	98
Stockton CA	1.74	93	1.25	86	1.11	64
Eugene OR	1.73	94	1.26	84	1.11	64
Boise ID	1.67	95	1.17	96	1.03	96
Greensboro NC	1.59	96	1.14	97	1.03	96
Brownsville TX	1.46	99	1.18	94	1.07	80
Corpus Christi TX	1.44	100	1.10	99	1.02	98
Pensacola FL-AL	1.31	101	1.09	100	1.02	98
101 Area Average	**3.54**		**1.82**		**1.25**	
Remaining Area Average	**2.09**		**1.27**		**1.07**	
All 498 Area Average	**3.09**		**1.65**		**1.19**	

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Table 4. Annual Urban Area CO_2 Production on Freeways and Arterial Streets, 2011

Urban Area	Pounds per Auto Commuter (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Free-flow)	Rank	Percent of CO_2 Production During Congestion Relative to Free-Flow
Very Large Average (15 areas)	**464**		**1,747**		**38,692**		**4.5**
Washington DC-VA-MD	631	1	1,703	5	29,916	9	5.7
New York-Newark NY-NJ-CT	557	2	5,146	1	76,858	2	6.7
Boston MA-NH-RI	526	3	1,338	8	26,161	12	5.1
San Francisco-Oakland CA	503	5	1,298	10	44,642	4	2.9
Miami FL	498	6	1,885	4	33,583	8	5.6
Houston TX	463	10	1,324	9	34,175	7	3.9
Atlanta GA	462	11	1,284	11	34,442	6	3.7
Philadelphia PA-NJ-DE-MD	458	12	1,520	6	28,549	10	5.3
Seattle WA	447	14	955	13	21,696	14	4.4
Los Angeles-Long Beach-Santa Ana CA	436	15	3,578	2	84,264	1	4.2
Chicago IL-IN	434	16	2,320	3	53,395	3	4.3
Dallas-Fort Worth-Arlington TX	405	20	1,505	7	39,098	5	3.8
Phoenix-Mesa AZ	401	22	944	14	25,668	13	3.7
Detroit MI	370	30	982	12	28,024	11	3.5
San Diego CA	218	76	427	25	19,905	15	2.1

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.

A number of assumptions are in the model using national-level data as inputs. This allows for a relatively simple and replicable methodology for 498 urban areas. More detailed and localized inputs should be used where available to improve local estimates of CO_2 production.

See the CO_2 emissions estimation methodology in the appendix for further details.

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.

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Table 4. Annual Additional CO_2 Production due to Roadway Congestion, 2011, continued

Urban Area	Pounds per Auto Commuter (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Free-flow)	Rank	Percent of CO_2 Production During Congestion Relative to Free-Flow
Large Average (32 areas)	**329**		**359**		**10,537**		**3.4**
Nashville-Davidson TN	491	7	377	28	10,638	29	3.5
Orlando FL	450	13	471	20	10,968	28	4.3
Las Vegas NV	417	17	429	24	9,358	34	4.6
Portland OR-WA	415	18	503	18	10,346	31	4.9
Charlotte NC-SC	412	19	296	36	9,012	38	3.3
Denver-Aurora CO	403	21	695	15	14,835	20	4.7
Austin TX	398	23	343	30	8,308	41	4.1
Indianapolis IN	393	24	340	31	11,314	25	3.0
Baltimore MD	392	25	667	16	16,029	18	4.2
Memphis TN-MS-AR	384	27	291	37	7,996	42	3.6
Virginia Beach VA	373	29	392	27	10,382	30	3.8
Tampa-St. Petersburg FL	366	32	613	17	14,924	19	4.1
Cincinnati OH-KY-IN	364	33	421	26	12,549	22	3.4
Buffalo NY	357	35	234	46	5,683	54	4.1
Pittsburgh PA	355	37	431	23	9,100	35	4.7
Columbus OH	353	39	311	34	10,153	32	3.1
Louisville KY-IN	340	40	253	40	8,311	40	3.0
San Antonio TX	323	44	336	33	11,637	24	2.9
Cleveland OH	308	46	350	29	11,079	27	3.2
San Juan PR	306	48	486	19	9,078	36	5.4
Providence RI-MA	293	51	242	43	7,506	45	3.2
St. Louis MO-IL	272	56	437	22	19,243	16	2.3
Jacksonville FL	271	57	207	51	7,777	43	2.7
New Orleans LA	270	58	190	52	4,980	57	3.8
Riverside-San Bernardino CA	257	60	339	32	13,471	21	2.5
Salt Lake City UT	257	60	185	53	5,534	55	3.3
Minneapolis-St. Paul MN	249	65	444	21	18,031	17	2.5
San Jose CA	249	65	302	35	11,113	26	2.7
Kansas City MO-KS	235	70	256	38	11,951	23	2.1
Milwaukee WI	232	74	237	45	9,046	37	2.6
Raleigh-Durham NC	217	77	170	55	6,779	47	2.5
Sacramento CA	207	84	254	39	10,047	33	2.5

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Table 4. Annual Additional CO2 Production due to Roadway Congestion, 2011, continued

Urban Area	Pounds per Auto Commuter (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Free-flow)	Rank	Percent of CO_2 Production During Congestion Relative to Free-Flow
Medium Average (33 areas)	**278**		**129**		**4,533**		**2.8**
Baton Rouge LA	526	3	210	49	5,791	52	3.6
Tucson AZ	491	7	248	41	6,053	50	4.1
Honolulu HI	485	9	225	48	3,254	79	6.9
Bridgeport-Stamford CT-NY	392	25	246	42	5,879	51	4.2
Albany NY	379	28	162	56	4,399	61	3.7
Hartford CT	368	31	226	47	6,620	49	3.4
Oklahoma City OK	362	34	242	43	8,642	39	2.8
Birmingham AL	356	36	208	50	6,775	48	3.1
Knoxville TN	355	37	128	62	4,356	62	2.9
El Paso TX-NM	335	41	171	54	4,341	63	3.9
New Haven CT	327	43	139	59	4,191	67	3.3
McAllen TX	320	45	130	61	3,359	76	3.9
Tulsa OK	298	50	145	58	5,765	53	2.5
Springfield MA-CT	292	52	128	62	4,023	69	3.2
Allentown-Bethlehem PA-NJ	289	54	128	62	4,020	70	3.2
Charleston-North Charleston SC	280	55	103	67	3,690	72	2.8
Rochester NY	257	60	134	60	4,252	66	3.2
Poughkeepsie-Newburgh NY	251	64	100	70	3,628	74	2.8
Dayton OH	235	70	123	65	5,291	56	2.3
Richmond VA	234	72	159	57	7,670	44	2.1
Toledo OH-MI	234	72	84	75	3,263	78	2.6
Omaha NE-IA	217	77	95	72	4,164	68	2.3
Grand Rapids MI	216	79	92	73	4,775	60	1.9
Colorado Springs CO	214	81	83	76	3,315	77	2.5
Sarasota-Bradenton FL	212	82	107	66	3,195	81	3.3
Akron OH	195	85	83	76	3,865	71	2.1
Oxnard CA	182	88	87	74	6,891	46	1.3
Albuquerque NM	170	90	74	79	4,826	59	1.5
Wichita KS	166	91	58	83	3,253	80	1.8
Bakersfield CA	118	95	45	89	2,684	84	1.7
Fresno CA	85	97	40	92	3,684	73	1.1
Indio-Cathedral City-Palm Springs CA	61	99	25	96	2,025	93	1.2
Lancaster-Palmdale CA	50	100	21	98	1,658	95	1.3

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Table 4. Annual Additional CO_2 Production due to Roadway Congestion, 2011, continued

Urban Area	Pounds per Auto Commuter (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Congestion Only)	Rank	Pounds (millions) (CO_2 Produced During Free-flow)	Rank	Percent of CO_2 Production During Congestion Relative to Free-Flow
Small Average (21 areas)	**209**		**51**		**2,355**		**2.2**
Worcester MA-CT	329	42	103	67	3,504	75	2.9
Brownsville TX	308	46	46	88	919	99	5.0
Cape Coral FL	302	49	103	67	2,815	83	3.7
Columbia SC	291	53	98	71	4,289	64	2.3
Jackson MS	269	59	83	76	4,254	65	2.0
Spokane WA-ID	257	60	70	80	2,448	86	2.9
Beaumont TX	248	67	42	90	2,374	89	1.8
Greensboro NC	245	68	60	82	2,995	82	2.0
Salem OR	244	69	42	90	1,365	96	3.1
Boulder CO	229	75	24	97	563	101	4.3
Pensacola FL-AL	215	80	55	84	2,285	91	2.4
Provo-Orem UT	208	83	69	81	2,395	88	2.9
Madison WI	194	86	53	85	2,310	90	2.3
Winston-Salem NC	183	87	50	86	2,437	87	2.1
Laredo TX	171	89	29	94	1,005	98	2.9
Little Rock AR	158	92	49	87	4,877	58	1.0
Anchorage AK	144	93	31	93	732	100	4.2
Boise ID	120	94	26	95	1,953	94	1.3
Eugene OR	114	96	20	99	1,324	97	1.5
Stockton CA	67	98	19	100	2,549	85	0.7
Corpus Christi TX	39	101	9	101	2,059	92	0.4
101 Area Total			**43,043**		**1,116,603**		**3.9**
101 Area Average	**385**		**426**		**11,055**		
Remaining Area Total			**13,352**		**641,134**		**2.1**
Remaining Area Average	**366**		**34**		**1,614**		
All 498 Area Total			**56,396**		**1,757,737**		**3.2**
All 498 Area Average	**380**		**113**		**3,529**		

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Table 5. Truck Commodity Value and Truck Delay, 2011

Urban Area	Total Annual Delay (1,000 Hours)	Total Annual Delay Rank	Annual Truck Delay (1,000 Hours)	Annual Truck Delay Rank	Congestion Cost ($ million)	Truck Commodity Value ($ million)	Truck Commodity Value Rank
Very Large Average (15 areas)	**195,831**		**12,292**		**933**	**208,893**	
New York-Newark NY-NJ-CT	544,063	1	33,433	1	2,541	481,177	1
Los Angeles-Long Beach-S. Ana CA	501,881	2	29,936	2	2,290	412,152	2
Chicago IL-IN	271,718	3	22,818	3	1,716	362,328	3
Atlanta GA	142,041	10	10,326	4	775	191,563	6
Dallas-Fort Worth-Arlington TX	167,718	6	9,750	5	734	230,466	5
Miami FL	174,612	5	9,682	6	739	155,425	9
Philadelphia PA-NJ-DE-MD	156,027	7	9,637	7	730	175,393	7
Washington DC-VA-MD	179,331	4	8,628	8	656	97,285	18
Houston TX	145,832	9	8,599	9	646	233,723	4
San Francisco-Oakland CA	155,157	8	8,442	10	643	132,539	11
Phoenix-Mesa AZ	82,554	14	8,213	11	627	131,234	12
Boston MA-NH-RI	136,966	11	7,372	12	561	129,308	13
Seattle WA	100,802	13	7,154	13	546	152,596	10
Detroit MI	106,434	12	6,266	14	475	161,391	8
San Diego CA	72,331	16	4,123	18	314	86,817	20

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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, 2011, continued

Urban Area	Total Annual Delay		Annual Truck Delay			Truck Commodity Value	
	(1,000 Hours)	Rank	(1,000 Hours)	Rank	Congestion Cost ($million)	($ million)	Rank
Large Average (32 areas)	**39,747**		**2,402**		**182**	**63,077**	
Baltimore MD	70,263	17	5,017	15	379	96,445	19
Denver-Aurora CO	76,154	15	4,162	16	316	76,748	22
Riverside-San Bernardino CA	51,195	21	4,124	17	310	109,604	14
St. Louis MO-IL	49,605	22	4,028	19	300	107,500	15
Orlando FL	46,607	25	3,265	20	248	63,858	32
Tampa-St. Petersburg FL	62,876	18	3,223	21	246	62,643	33
Indianapolis IN	35,186	35	3,222	22	241	85,407	21
Portland OR-WA	51,987	20	3,178	23	244	65,610	30
Minneapolis-St. Paul MN	60,788	19	3,110	24	232	97,828	17
Cincinnati OH-KY-IN	42,785	29	3,039	25	230	65,182	31
Pittsburgh PA	46,725	24	2,833	26	213	70,352	25
Nashville-Davidson TN	35,781	33	2,635	27	199	66,124	29
Sacramento CA	39,138	31	2,268	28	172	52,561	37
Charlotte NC-SC	28,974	38	2,222	29	168	69,136	26
San Juan PR	45,991	27	2,213	30	176	23,406	60
Austin TX	38,307	32	2,083	31	157	33,256	52
Memphis TN-MS-AR	28,700	39	2,027	32	153	99,459	16
San Jose CA	47,385	23	1,990	34	153	52,751	36
Kansas City MO-KS	29,448	37	1,974	35	148	72,882	23
Columbus OH	35,689	34	1,944	36	145	70,584	24
Louisville KY-IN	26,253	42	1,930	38	145	55,941	35
San Antonio TX	39,998	30	1,865	39	139	51,263	39
Las Vegas NV	45,419	28	1,806	40	137	36,032	49
Milwaukee WI	27,755	40	1,746	41	131	67,328	28
Virginia Beach VA	46,172	26	1,741	42	131	43,521	42
Cleveland OH	34,980	36	1,729	43	130	68,720	27
New Orleans LA	19,125	52	1,690	44	127	34,397	50
Jacksonville FL	22,629	46	1,366	48	103	42,002	44
Buffalo NY	21,545	48	1,315	49	102	48,933	41
Raleigh-Durham NC	17,923	54	1,268	50	96	50,194	40
Salt Lake City UT	21,903	47	949	54	71	56,934	34
Providence RI-MA	24,618	44	893	56	69	21,863	61

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Table 5. Truck Commodity Value and Truck Delay, 2011, continued

Urban Area	Total Annual Delay		Annual Truck Delay			Truck Commodity Value	
	(1,000 Hours)	Rank	(1,000 Hours)	Rank	Congestion Cost ($ million)	($ million)	Rank
Medium Average (33 areas)	**13,516**		**822**		**62**	**18,666**	
Tucson AZ	19,078	53	2,014	33	155	28,934	58
Baton Rouge LA	17,122	55	1,940	37	148	32,671	54
Oklahoma City OK	25,182	43	1,531	45	115	38,161	46
Bridgeport-Stamford CT-NY	26,503	41	1,465	46	111	11,199	73
Birmingham AL	20,903	49	1,415	47	107	38,716	45
Albuquerque NM	12,488	63	1,083	51	82	14,125	67
El Paso TX-NM	15,990	56	1,071	52	81	32,105	55
Hartford CT	22,995	45	983	53	75	42,754	43
Allentown-Bethlehem PA-NJ	13,247	60	912	55	69	16,118	65
Tulsa OK	15,500	57	888	57	67	29,127	57
Richmond VA	19,499	51	839	58	62	38,036	47
Knoxville TN	13,247	60	831	59	63	12,104	72
Albany NY	13,092	62	820	60	64	33,017	53
Charleston-North Charleston SC	10,885	68	774	62	58	10,677	76
Oxnard CA	12,445	64	723	64	55	9,320	82
Dayton OH	12,442	65	686	66	52	34,109	51
Honolulu HI	20,873	50	668	67	53	10,246	78
Rochester NY	14,850	58	667	68	51	26,369	59
New Haven CT	14,560	59	660	69	50	8,271	86
Toledo OH-MI	9,195	78	648	70	48	11,123	74
Akron OH	9,789	76	590	71	44	9,983	80
Grand Rapids MI	10,016	73	578	72	44	38,029	48
McAllen TX	11,469	67	578	72	44	7,788	88
Bakersfield CA	4,752	91	553	74	41	10,995	75
Poughkeepsie-Newburgh NY	9,787	77	551	75	42	13,850	68
Fresno CA	7,376	82	547	76	41	9,612	81
Sarasota-Bradenton FL	10,523	70	532	77	41	7,682	89
Springfield MA-CT	12,084	66	525	78	40	9,279	83
Indio-Cathedral City-Palm Springs CA	6,036	87	504	79	37	5,534	94
Colorado Springs CO	9,941	75	473	82	36	6,588	91
Omaha NE-IA	10,721	69	424	86	32	8,764	85
Wichita KS	6,906	83	330	90	25	7,918	87
Lancaster-Palmdale CA	6,541	85	312	92	24	2,767	99

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Table 5. Truck Commodity Value and Truck Delay, 2011, continued

Urban Area	Total Annual Delay (1,000 Hours)	Total Annual Delay Rank	Annual Truck Delay (1,000 Hours)	Annual Truck Delay Rank	Congestion Cost ($ million)	Truck Commodity Value ($ million)	Truck Commodity Value Rank
Small Average (21 areas)	**5,586**		**381**		**29**	**12,424**	
Jackson MS	7,535	81	820	60	63	17,253	64
Columbia SC	10,081	72	771	63	58	12,552	70
Cape Coral FL	9,964	74	688	65	53	6,033	93
Spokane WA-ID	6,107	86	494	80	38	7,292	90
Stockton CA	3,519	97	483	81	35	10,413	77
Greensboro NC	6,625	84	472	83	35	51,616	38
Worcester MA-CT	10,139	71	449	84	35	10,171	79
Little Rock AR	8,132	80	442	85	33	15,286	66
Provo-Orem UT	8,312	79	403	87	30	12,905	69
Winston-Salem NC	5,385	89	390	88	29	8,821	84
Madison WI	5,349	90	381	89	29	17,534	63
Salem OR	4,593	92	320	91	24	3,889	97
Brownsville TX	3,697	94	299	93	23	2,414	100
Pensacola FL-AL	5,655	88	292	94	22	6,415	92
Laredo TX	3,074	99	276	95	20	31,171	56
Beaumont TX	4,205	93	249	96	19	20,767	62
Anchorage AK	3,627	96	206	97	16	4,507	96
Corpus Christi TX	3,160	98	188	98	14	12,484	71
Eugene OR	2,271	100	182	99	14	3,682	98
Boise ID	3,636	95	139	100	10	4,879	95
Boulder CO	2,237	101	66	101	5	825	101
101 Area Average	**47,255**		**2,934**		**222**	**59,691**	
Remaining Area Average	**1,883**		**143**		**12**	**3,630**	
All 498 Area Average	**11,085**		**709**		**54**	**15,000**	

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Table 6. State Truck Commodity Value, 2011

State	Total Truck Commodity Value ($ million)	Urban Truck Commodity Value ($ million)	Rural Truck Commodity Value ($ million)
California	1,251,857	952,443	299,414
Texas	1,165,544	718,052	447,492
Florida	559,204	419,084	140,119
Illinois	554,964	378,263	176,701
New York	487,148	374,481	112,667
Ohio	454,118	273,551	180,567
Pennsylvania	451,679	252,392	199,286
Georgia	422,273	237,712	184,561
North Carolina	379,497	230,935	148,562
Indiana	375,891	172,466	203,425
Michigan	353,232	250,252	102,980
Tennessee	352,661	194,384	158,277
Wisconsin	330,022	137,929	192,093
New Jersey	299,452	286,397	13,055
Missouri	297,020	146,741	150,278
Washington	276,259	183,618	92,641
Arizona	269,498	166,548	102,950
Virginia	255,461	143,931	111,531
Alabama	226,777	85,686	141,091
Kentucky	225,535	76,833	148,702
Louisiana	216,348	115,854	100,494
Maryland	209,652	157,472	52,180
Oklahoma	207,180	68,143	139,037
Minnesota	194,957	105,183	89,774
South Carolina	194,942	96,013	98,929
Massachusetts	166,223	155,732	10,492
Arkansas	160,733	29,736	130,997
Mississippi	158,288	34,792	123,496
Iowa	158,272	26,466	131,807
Colorado	155,221	92,744	62,478
Oregon	154,598	71,916	82,683
Utah	145,454	84,242	61,212
Kansas	143,009	42,725	100,285
New Mexico	111,841	19,852	91,989

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.

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Table 6. State Truck Commodity Value, 2011, Continued

State	Total Truck Commodity Value ($ million)	Urban Truck Commodity Value ($ million)	Rural Truck Commodity Value ($ million)
Connecticut	111,220	103,646	7,574
Nebraska	97,163	11,709	85,454
West Virginia	86,172	23,835	62,337
Nevada	80,061	42,149	37,911
Idaho	59,276	11,216	48,060
Wyoming	49,503	2,579	46,924
North Dakota	48,281	4,500	43,781
Maine	45,225	8,652	36,574
South Dakota	44,614	4,805	39,809
Montana	42,781	2,242	40,539
Puerto Rico	39,114	35,578	3,536
New Hampshire	39,110	15,520	23,589
Delaware	35,447	22,902	12,545
Vermont	24,446	2,540	21,906
Rhode Island	21,390	17,559	3,831
Alaska	17,366	5,140	12,226
Hawaii	16,501	10,842	5,659
District Of Columbia	9,167	9,167	-

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.

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Table 7. Other Congestion Measures, 2011

Urban Area	Rank of Delay per Auto Commuter (See Table 1)	Total Peak Period Travel Time		Commuter Stress Index		Delay per Non-Peak Traveler	
		Minutes	Rank	Value	Rank	Hours	Rank
Very Large Average (15 areas)		**46**		**1.32**		**15**	
Washington DC-VA-MD	1	53	1	1.39	3	17	2
San Francisco-Oakland CA	2	47	9	1.22	37	18	1
Los Angeles-Long Beach-S Ana CA	2	48	6	1.34	9	15	5
New York-Newark NY-NJ-CT	4	50	3	1.40	2	15	5
Boston MA-NH-RI	5	48	6	1.35	5	14	15
Houston TX	6	44	24	1.35	5	15	5
Atlanta GA	7	50	3	1.33	13	15	5
Chicago IL-IN	7	44	24	1.31	16	15	5
Philadelphia PA-NJ-DE-MD	9	45	18	1.34	9	14	15
Seattle WA	9	44	24	1.33	13	13	21
Miami FL	11	45	18	1.35	5	15	5
Dallas-Fort Worth-Arlington TX	13	42	35	1.33	13	14	15
Detroit MI	25	48	6	1.22	37	13	21
San Diego CA	37	41	40	1.27	24	10	52
Phoenix-Mesa AZ	40	43	30	1.27	24	10	52

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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.
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Table 7. Other Congestion Measures, 2011, Continued

Urban Area	Rank of Delay per Auto Commuter (See Table 1)	Total Peak Period Travel Time		Commuter Stress Index		Delay per Non-Peak Traveler	
		Minutes	Rank	Value	Rank	Hours	Rank
Large Average (32 areas)		**39**		**1.25**		**12**	
Nashville-Davidson TN	11	45	18	1.28	20	14	15
Orlando FL	13	48	6	1.27	24	16	4
Denver-Aurora CO	13	40	47	1.34	9	15	5
Las Vegas NV	17	39	52	1.28	20	17	2
Austin TX	17	35	72	1.38	4	11	39
Portland OR-WA	17	37	62	1.35	5	11	39
Virginia Beach VA	20	41	40	1.28	20	15	5
Indianapolis IN	23	47	9	1.22	37	15	5
Baltimore MD	23	37	62	1.29	18	13	21
Columbus OH	25	36	68	1.22	37	13	21
Charlotte NC-SC	25	45	18	1.26	28	12	30
Pittsburgh PA	28	34	75	1.30	17	13	21
San Jose CA	28	36	68	1.24	31	11	39
Memphis TN-MS-AR	30	41	40	1.23	32	15	5
Tampa-St. Petersburg FL	30	43	30	1.28	20	13	21
Riverside-San Bernardino CA	30	38	58	1.23	32	12	30
San Antonio TX	30	40	47	1.26	28	11	39
Cincinnati OH-KY-IN	37	39	52	1.23	32	12	30
Louisville KY-IN	40	38	58	1.22	37	12	30
Minneapolis-St. Paul MN	44	44	24	1.29	18	9	66
Buffalo NY	45	39	52	1.19	54	11	39
Sacramento CA	47	36	68	1.22	37	10	52
Cleveland OH	50	39	52	1.20	50	10	52
St. Louis MO-IL	50	46	13	1.17	62	10	52
Jacksonville FL	53	43	30	1.19	54	11	39
Salt Lake City UT	53	33	80	1.17	62	11	39
Providence RI-MA	53	36	68	1.19	54	9	66
San Juan PR	60	27	92	1.34	9	9	66
Milwaukee WI	63	38	58	1.19	54	9	66
New Orleans LA	63	37	62	1.22	37	9	66
Kansas City MO-KS	68	43	30	1.15	73	9	66
Raleigh-Durham NC	83	43	30	1.21	45	8	81

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Table 7. Other Congestion Measures, 2011, Continued

Urban Area	Rank of Delay per Auto Commuter (See Table 1)	Total Peak Period Travel Time		Commuter Stress Index		Delay per Non-Peak Traveler	
		Minutes	Rank	Value	Rank	Hours	Rank
Medium Average (33 areas)		**36**		**1.17**		**10**	
Honolulu HI	13	31	86	1.51	1	11	39
Baton Rouge LA	21	40	47	1.26	28	13	21
Bridgeport-Stamford CT-NY	21	41	40	1.27	24	13	21
Tucson AZ	30	47	9	1.21	45	14	15
Oklahoma City OK	30	45	18	1.18	60	13	21
Hartford CT	30	41	40	1.21	45	12	30
Knoxville TN	37	43	30	1.19	54	14	15
Birmingham AL	40	45	18	1.23	32	12	30
New Haven CT	40	34	75	1.20	50	12	30
El Paso TX-NM	47	30	88	1.22	37	11	39
Tulsa OK	47	39	52	1.16	68	11	39
Albany NY	50	33	80	1.21	45	11	39
Allentown-Bethlehem PA-NJ	53	34	75	1.21	45	11	39
Charleston-North Charleston SC	53	38	58	1.18	60	10	52
Richmond VA	60	41	40	1.14	78	11	39
Albuquerque NM	60	36	68	1.06	101	10	52
McAllen TX	63	26	94	1.20	50	10	52
Rochester NY	63	34	75	1.17	62	10	52
Springfield MA-CT	63	39	52	1.17	62	10	52
Colorado Springs CO	71	36	68	1.16	68	9	66
Oxnard CA	71	32	83	1.11	93	9	66
Toledo OH-MI	71	36	68	1.16	68	9	66
Poughkeepsie-Newburgh NY	75	30	88	1.15	73	10	52
Dayton OH	80	38	58	1.13	81	9	66
Grand Rapids MI	80	40	47	1.12	88	8	81
Omaha NE-IA	80	41	40	1.13	81	8	81
Akron OH	83	29	90	1.13	81	8	81
Sarasota-Bradenton FL	88	31	86	1.17	62	9	66
Wichita KS	89	36	68	1.12	88	7	88
Fresno CA	95	34	75	1.08	99	6	92
Lancaster-Palmdale CA	95	29	90	1.11	93	6	92
Indio-Cathedral City-Palm Springs CA	95	23	99	1.11	93	5	97
Bakersfield CA	100	25	96	1.09	97	5	97

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Table 7. Other Congestion Measures, 2011, Continued

Urban Area	Rank of Delay per Auto Commuter (See Table 1)	Total Peak Period Travel Time		Commuter Stress Index		Delay per Non-Peak Traveler	
		Minutes	Rank	Value	Rank	Hours	Rank
Small Average (21 areas)		**35**		**1.13**		**8**	
Worcester MA-CT	45	44	24	1.15	73	12	30
Cape Coral FL	53	42	35	1.20	50	12	30
Columbia SC	53	46	13	1.14	78	10	52
Greensboro NC	68	43	30	1.13	81	10	52
Salem OR	68	29	90	1.17	62	10	52
Little Rock AR	71	46	13	1.07	100	8	81
Beaumont TX	75	41	40	1.13	81	9	66
Brownsville TX	75	25	96	1.19	54	9	66
Jackson MS	75	44	24	1.12	88	9	66
Provo-Orem UT	75	32	83	1.15	73	9	66
Spokane WA-ID	83	41	40	1.13	81	8	81
Pensacola FL-AL	86	46	13	1.16	68	8	81
Boulder CO	86	23	99	1.16	68	7	88
Winston-Salem NC	89	39	52	1.14	78	7	88
Madison WI	89	33	80	1.12	88	6	92
Laredo TX	92	25	96	1.15	73	7	88
Anchorage AK	93	22	101	1.23	32	6	92
Boise ID	94	32	83	1.12	88	6	92
Corpus Christi TX	98	33	80	1.11	93	5	97
Eugene OR	99	26	94	1.09	97	5	97
Stockton CA	100	23	99	1.13	81	5	97
101 Area Average		**39**		**1.33**		**13**	
Remaining Area Average		**34**		**1.18**		**8**	
All 498 Area Average		**38**		**1.29**		**12**	

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Table 8. Solutions to Congestion Problems, 2011

Urban Area	Operational Treatment Savings				Public Transportation Savings		
	Treatments	Delay (1,000 Hours)	Rank	Cost ($ Million)	Delay (1,000 Hours)	Rank	Cost ($ Million)
Very Large Average (15 areas)		**16,473**		**$356.3**	**49,465**		**1,076.5**
Los Angeles-Long Beach-Santa Ana CA	r,i,s,a,h	61,264	1	1,316.4	32,345	6	695.0
New York-Newark NY-NJ-CT	r,i,s,a,h	53,981	2	1,174.4	440,647	1	9,586.8
San Francisco-Oakland CA	r,i,s,a,h	18,956	3	400.6	36,714	4	775.9
Houston TX	r,i,s,a,h	15,113	4	323.4	6,733	13	144.1
Miami FL	i,s,a,h	15,073	5	323.6	11,589	9	248.8
Washington DC-VA-MD	r,i,s,a,h	14,185	6	298.3	33,810	5	711.0
Chicago IL-IN	r,i,s,a	11,710	7	267.8	67,432	2	1,542.1
Dallas-Fort Worth-Arlington TX	r,i,s,a,h	10,595	8	226.0	6,292	15	134.2
Philadelphia PA-NJ-DE-MD	r,i,s,a,h	10,237	9	222.2	30,167	7	654.9
Seattle WA	r,i,s,a,h	8,497	10	188.9	16,483	8	366.5
Atlanta GA	r,i,s,a,h	6,863	11	151.5	10,520	11	232.2
San Diego CA	r,i,s,a	6,282	12	133.5	6,401	14	136.0
Boston MA-NH-RI	i,s,a	5,827	14	124.3	37,943	3	809.4
Phoenix-Mesa AZ	r,i,s,a,h	4,660	15	111.2	2,541	23	60.6
Detroit MI	r,i,s,a	3,853	21	82.8	2,355	25	50.6

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.

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Table 8. Solutions to Congestion Problems, 2011, Continued

Urban Area	Operational Treatment Savings				Public Transportation Savings		
	Treatments	Delay (1,000 Hours)	Rank	Cost ($ Million)	Delay (1,000 Hours)	Rank	Cost ($ Million)
Large Average (32 areas)		**2,194**		**$47.1**	**2,524**		**54.3**
Minneapolis-St. Paul MN	r,i,s,a,h	5,881	13	121.9	4,152	19	86.1
Portland OR-WA	r,i,s,a,h	4,610	16	100.2	6,951	12	151.1
Tampa-St. Petersburg FL	i,s,a	4,591	17	96.8	1,210	38	25.5
Riverside-San Bernardino CA	r,i,s,a,h	4,554	18	102.5	1,428	37	32.1
Denver-Aurora CO	r,i,s,a,h	4,447	19	94.1	6,007	16	127.1
San Jose CA	r,i,s,a	3,872	20	79.3	2,097	28	42.9
Baltimore MD	i,s,a	3,742	22	82.9	11,219	10	248.6
Virginia Beach VA	r,i,s,a,h	3,710	23	74.9	1,643	34	33.2
Sacramento CA	i,s,a	3,636	24	77.5	1,807	31	38.5
Orlando FL	i,s,a	2,746	25	60.8	1,704	33	37.7
Las Vegas NV	r,i,s,a	2,531	26	51.9	2,184	27	44.7
Milwaukee WI	i,s,a	2,113	27	45.6	1,922	29	41.5
St. Louis MO-IL	i,s,a	2,083	28	46.9	2,958	22	66.5
Austin TX	r,i,s,a,h	1,902	29	40.2	2,395	24	50.6
Pittsburgh PA	i,s,a	1,686	30	36.3	5,753	17	124.0
San Antonio TX	i,s,a	1,450	31	29.9	1,808	30	37.3
Nashville-Davidson TN	i,s,a	1,406	32	31.5	688	45	15.4
Kansas City MO-KS	i,s,a	1,395	33	30.3	538	54	11.7
Jacksonville FL	i,s,a	1,326	34	28.5	501	56	10.8
Charlotte NC-SC	i,s,a	1,313	35	29.6	1,087	41	24.5
Cincinnati OH-KY-IN	r,i,s,a	1,313	35	29.1	2,305	26	51.0
Cleveland OH	i,s,a	1,193	37	25.1	3,432	21	72.3
New Orleans LA	i,s,a	1,191	38	27.4	1,748	32	40.3
Columbus OH	r,i,s,a	1,150	39	24.3	755	43	15.9
San Juan PR	s,a	1,115	41	23.7	5,309	18	113.1
Memphis TN-MS-AR	i,s,a	1,104	43	24.5	690	44	15.3
Salt Lake City UT	r,i,s,a	905	49	18.6	3,877	20	79.6
Indianapolis IN	i,s,a	756	53	17.6	609	49	14.1
Raleigh-Durham NC	i,s,a	742	54	16.4	638	48	14.1
Louisville KY-IN	i,s,a	691	55	15.4	657	46	14.6
Buffalo NY	i,s,a	539	58	11.9	1,513	35	33.3
Providence RI-MA	i,s,a	513	60	10.5	1,184	39	24.2

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).
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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.

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Table 8. Solutions to Congestion Problems, 2011, Continued

Urban Area	Operational Treatment Savings				Public Transportation Savings		
	Treatments	Delay (1,000 Hours)	Rank	Cost ($ Million)	Delay (1,000 Hours)	Rank	Cost ($ Million)
Medium Average (33 areas)		**492**		**$10.7**	**372**		**8.0**
Tucson AZ	i,s,a	1,125	40	27.5	606	50	14.8
Bridgeport-Stamford CT-NY	i,s,a	1,107	42	23.7	382	58	8.2
Honolulu HI	i,s,a	1,065	44	21.8	643	47	13.1
Baton Rouge LA	i,s,a	1,024	45	25.3	165	85	4.1
El Paso TX-NM	i,s,a	1,009	46	22.3	1,169	40	25.8
Birmingham AL	i,s,a	983	47	21.5	261	70	5.7
Hartford CT	i,s,a	954	48	19.9	1,460	36	30.4
Albuquerque NM	i,s,a	841	50	19.4	252	72	5.8
Omaha NE-IA	i,s,a	792	51	16.2	175	81	3.6
Richmond VA	i,s,a	769	52	15.7	806	42	16.5
Sarasota-Bradenton FL	i,s,a	668	56	14.1	152	87	3.2
Knoxville TN	i,s,a	560	57	12.1	89	93	1.9
Fresno CA	r,i,s,a	527	59	11.7	227	76	5.0
New Haven CT	i,s,a	481	62	10.1	336	64	7.0
Rochester NY	i,s,a	388	64	8.0	514	55	10.7
Albany NY	i,s,a	369	65	8.3	567	52	12.7
Charleston-North Charleston SC	i,s,a	354	67	7.8	126	88	2.8
Colorado Springs CO	i,s,a	343	68	7.1	325	65	6.7
Oxnard CA	i,s,a	330	70	7.0	215	78	4.6
Allentown-Bethlehem PA-NJ	r,i,s,a	318	72	7.0	344	62	7.6
Dayton OH	s,a	275	73	5.9	347	61	7.4
Oklahoma City OK	i,s,a	274	74	5.9	170	83	3.7
Wichita KS	i,s,a	232	78	4.8	213	79	4.4
Springfield MA-CT	i,s,a	224	79	4.7	349	60	7.3
Grand Rapids MI	s,a	207	80	4.5	318	66	6.8
Indio-Cathedral City-Palm Springs CA	i,s,a	206	81	4.7	168	84	3.8
Bakersfield CA	i,s,a	187	82	4.6	238	74	5.9
Lancaster-Palmdale CA	s,a	140	85	2.9	541	53	11.3
Poughkeepsie-Newburgh NY	s,a	124	86	2.7	395	57	8.6
Toledo OH-MI	i,s,a	106	89	2.3	318	66	7.0
Tulsa OK	i,s,a	100	92	2.1	75	95	1.6
McAllen TX	s,a	73	95	1.6	110	91	2.4
Akron OH	i,s,a	68	97	1.4	226	77	4.8

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.

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Table 8. Solutions to Congestion Problems, 2011, Continued

		Operational Treatment Savings			Public Transportation Savings		
Urban Area	Treatments	Delay (1,000 Hours)	Rank	Cost ($ Million)	Delay (1,000 Hours)	Rank	Cost ($ Million)
Small Average (21 areas)		**193**		**$4.3**	**183**		**4.1**
Cape Coral FL	i,s,a	501	61	11.1	173	82	3.8
Little Rock AR	i,s,a	474	63	10.0	23	101	0.5
Provo-Orem UT	i,s,a	369	65	7.7	80	94	1.7
Greensboro NC	i,s,a	331	69	7.3	191	80	4.2
Worcester MA-CT	s,a	322	71	6.7	98	92	2.0
Spokane WA-ID	i,s,a	274	74	6.4	576	51	13.4
Winston-Salem NC	i,s,a	269	76	6.0	52	98	1.1
Jackson MS	s,a	260	77	6.3	72	96	1.8
Columbia SC	i,s,a	184	83	4.1	301	69	6.7
Stockton CA	i,s,a	160	84	4.1	237	75	6.1
Eugene OR	i,s,a	122	87	2.7	339	63	7.6
Madison WI	s,a	112	88	2.5	360	59	8.0
Salem OR	s,a	106	89	2.3	239	73	5.2
Anchorage AK	s,a	101	91	2.2	258	71	5.5
Beaumont TX	s,a	99	93	2.1	40	99	0.9
Pensacola FL-AL	s,a	89	94	1.9	54	97	1.2
Brownsville TX	s,a	69	96	1.6	316	68	7.3
Boise ID	i,s,a	64	98	1.3	35	100	0.7
Laredo TX	i,s,a	60	99	1.4	154	86	3.5
Boulder CO	s,a	50	100	1.0	116	90	2.4
Corpus Christi TX	s,a	30	101	0.6	122	89	2.6
101 Area Total		**337,571**		**7,294.9**	**838,859**		**18,237.1**
101 Area Average		**3,342**		**72.2**	**8,306**		**180.6**
All Urban Areas Total		**374,000**		**8,484.0**	**865,000**		**20,784.0**
All Urban Areas Average		**751**		**17.0**	**1,737**		**41.7**

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).
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Table 9. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2011)

Urban Area	Yearly Hours of Delay per Auto Commuter					Long-Term Change 1982 to 2011	
	2011	2010	2005	2000	1982	Hours	Rank
Very Large Average (15 areas)	**52**	**52**	**60**	**51**	**19**	**33**	
Washington DC-VA-MD	67	66	74	65	18	49	1
New York-Newark NY-NJ-CT	59	59	55	38	11	48	2
Boston MA-NH-RI	53	53	64	49	15	38	3
Chicago IL-IN	51	51	55	39	13	38	3
Dallas-Fort Worth-Arlington TX	45	44	50	39	7	38	3
San Francisco-Oakland CA	61	60	89	72	24	37	6
Seattle WA	48	47	55	53	11	37	6
Atlanta GA	51	50	68	61	15	36	8
Miami FL	47	46	55	46	12	35	11
Philadelphia PA-NJ-DE-MD	48	48	48	36	14	34	12
Houston TX	52	51	49	40	22	30	23
San Diego CA	37	37	44	34	8	29	28
Los Angeles-Long Beach-Santa Ana CA	61	61	78	72	37	24	43
Detroit MI	40	40	50	44	17	23	47
Phoenix-Mesa AZ	35	35	43	34	24	11	91

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.

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Table 9. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2011), Continued

Urban Area	Yearly Hours of Delay per Auto Commuter					Long-Term Change 1982 to 2011	
	2011	2010	2005	2000	1982	Hours	Rank
Large Average (32 areas)	**37**	**37**	**43**	**38**	**11**	**26**	
Las Vegas NV	44	44	50	37	8	36	8
Columbus OH	40	40	42	33	4	36	8
Denver-Aurora CO	45	44	48	42	11	34	12
Austin TX	44	43	58	40	10	34	12
Riverside-San Bernardino CA	38	37	45	29	4	34	12
San Antonio TX	38	37	41	37	5	33	16
Orlando FL	45	44	51	55	13	32	17
Baltimore MD	41	41	45	32	9	32	17
Charlotte NC-SC	40	39	39	30	8	32	17
Portland OR-WA	44	43	49	45	13	31	21
Memphis TN-MS-AR	38	38	46	39	8	30	23
Cincinnati OH-KY-IN	37	37	49	51	7	30	23
Minneapolis-St. Paul MN	34	34	40	36	4	30	23
Providence RI-MA	30	30	41	30	3	27	31
Cleveland OH	31	31	26	31	5	26	33
Virginia Beach VA	43	43	52	47	18	25	38
Buffalo NY	33	33	41	31	8	25	38
San Juan PR	29	29	30	23	4	25	38
Nashville-Davidson TN	47	46	57	48	23	24	43
Indianapolis IN	41	41	51	52	17	24	43
Salt Lake City UT	30	30	27	30	7	23	47
Tampa-St. Petersburg FL	38	38	39	31	16	22	52
Kansas City MO-KS	27	27	35	38	5	22	52
San Jose CA	39	38	56	55	18	21	58
Louisville KY-IN	35	35	38	38	14	21	58
Sacramento CA	32	32	44	34	11	21	58
St. Louis MO-IL	31	31	39	45	11	20	65
Milwaukee WI	28	28	32	33	9	19	70
Jacksonville FL	30	30	37	31	12	18	74
Raleigh-Durham NC	23	23	28	23	5	18	74
Pittsburgh PA	39	39	46	44	23	16	80
New Orleans LA	28	28	21	20	13	15	82

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.
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Table 9. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2011), Continued

Urban Area	Yearly Hours of Delay per Auto Commuter					Long-Term Change 1982 to 2011	
	2011	2010	2005	2000	1982	Hours	Rank
Medium Average (33 areas)	**28**	**30**	**33**	**30**	**9**	**19**	
Baton Rouge LA	42	42	43	36	10	32	17
Hartford CT	38	38	39	38	7	31	21
Oklahoma City OK	38	37	36	36	8	30	23
Bridgeport-Stamford CT-NY	42	42	54	51	13	29	28
El Paso TX-NM	32	31	42	30	4	28	30
Knoxville TN	37	37	40	45	10	27	31
Honolulu HI	45	45	43	34	19	26	33
Birmingham AL	35	35	40	39	9	26	33
New Haven CT	35	35	43	43	9	26	33
Albany NY	31	31	35	25	5	26	33
Tulsa OK	32	32	28	26	7	25	38
McAllen TX	28	27	27	23	4	24	43
Richmond VA	29	29	24	19	6	23	47
Oxnard CA	26	26	31	22	3	23	47
Rochester NY	28	28	28	26	6	22	52
Toledo OH-MI	26	26	37	41	4	22	52
Colorado Springs CO	26	26	44	37	5	21	58
Omaha NE-IA	24	24	20	18	3	21	58
Tucson AZ	38	38	46	31	18	20	65
Allentown-Bethlehem PA-NJ	30	30	33	33	10	20	65
Albuquerque NM	29	29	38	35	10	19	70
Grand Rapids MI	24	24	24	23	5	19	70
Charleston-North Charleston SC	30	29	33	29	12	18	74
Akron OH	23	23	29	34	5	18	74
Springfield MA-CT	28	28	30	28	14	14	84
Wichita KS	20	20	19	19	6	14	84
Poughkeepsie-Newburgh NY	25	25	25	20	12	13	88
Dayton OH	24	24	26	32	12	12	89
Bakersfield CA	12	12	8	5	1	11	91
Sarasota-Bradenton FL	21	21	26	25	12	9	93
Fresno CA	15	15	18	21	8	7	96
Lancaster-Palmdale CA	15	15	16	11	18	-3	100
Indio-Cathedral City-Palm Springs CA	15	15	21	16	23	-8	101

Very Large Urban Areas—over 3 million population. Medium Urban Areas—over 500,000 and less than 1 million population.
Large Urban Areas—over 1 million and less than 3 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.
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Table 9. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2011), Continued

Urban Area	Yearly Hours of Delay per Auto Commuter					Long-Term Change 1982 to 2011	
	2011	2010	2005	2000	1982	Hours	Rank
Small Average (15 areas)	**21**	**23**	**26**	**22**	**7**	**14**	
Columbia SC	30	30	24	20	5	25	38
Brownsville TX	25	25	16	13	2	23	47
Greensboro NC	27	27	32	40	5	22	52
Salem OR	27	27	39	37	5	22	52
Little Rock AR	26	26	25	18	5	21	58
Jackson MS	25	25	26	16	4	21	58
Worcester MA-CT	33	33	40	40	13	20	65
Cape Coral FL	30	29	36	29	10	20	65
Beaumont TX	25	25	29	20	6	19	70
Pensacola FL-AL	22	22	25	19	4	18	74
Laredo TX	19	19	12	11	2	17	79
Provo-Orem UT	25	25	25	19	9	16	80
Winston-Salem NC	20	20	26	17	5	15	82
Spokane WA-ID	23	23	24	31	9	14	84
Boise ID	16	16	20	17	2	14	84
Madison WI	20	20	12	10	8	12	89
Boulder CO	22	22	41	41	13	9	93
Stockton CA	12	12	13	9	3	9	93
Corpus Christi TX	14	14	15	12	7	7	96
Eugene OR	13	13	23	24	8	5	98
Anchorage AK	17	17	25	24	19	-2	99
101 Area Average	**43**	**43**	**50**	**43**	**15**	**28**	
Remaining Area Average	**21**	**21**	**24**	**21**	**6**	**15**	
All 498 Area Average	**38**	**38**	**46**	**39**	**13**	**25**	

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.
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 10. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2011)

Urban Area	Travel Time Index					Point Change in Peak-Period Time Penalty 1982 to 2011	
	2011	2010	2005	2000	1982	Points	Rank
Very Large Average (15 areas)	**1.27**	**1.28**	**1.33**	**1.28**	**1.12**	**15**	
Washington DC-VA-MD	1.32	1.31	1.33	1.30	1.10	22	2
New York-Newark NY-NJ-CT	1.33	1.33	1.43	1.33	1.12	21	4
Dallas-Fort Worth-Arlington TX	1.26	1.25	1.30	1.22	1.06	20	6
Seattle WA	1.26	1.26	1.31	1.29	1.08	18	10
Los Angeles-Long Beach-Santa Ana CA	1.37	1.37	1.41	1.38	1.20	17	12
Chicago IL-IN	1.25	1.25	1.30	1.22	1.08	17	13
Boston MA-NH-RI	1.28	1.28	1.42	1.34	1.12	16	16
Atlanta GA	1.24	1.24	1.29	1.26	1.08	16	16
Miami FL	1.25	1.25	1.33	1.29	1.10	15	24
Philadelphia PA-NJ-DE-MD	1.26	1.26	1.27	1.22	1.11	15	25
San Diego CA	1.18	1.18	1.23	1.19	1.04	14	28
San Francisco-Oakland CA	1.22	1.22	1.31	1.26	1.10	12	36
Phoenix-Mesa AZ	1.18	1.18	1.18	1.15	1.08	10	46
Houston TX	1.26	1.26	1.31	1.25	1.17	9	57

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.
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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.

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Table 10. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2011), Continued

Urban Area	Travel Time Index					Point Change in Peak-Period Time Penalty 1982 to 2011	
	2011	2010	2005	2000	1982	Points	Rank
Large Average (32 areas)	**1.20**	**1.20**	**1.24**	**1.23**	**1.08**	**12**	
Austin TX	1.32	1.31	1.35	1.26	1.09	23	1
Riverside-San Bernardino CA	1.23	1.23	1.24	1.16	1.01	22	2
Portland OR-WA	1.28	1.28	1.30	1.29	1.07	21	4
Denver-Aurora CO	1.27	1.27	1.31	1.29	1.08	19	8
San Juan PR	1.25	1.25	1.24	1.21	1.07	18	10
Baltimore MD	1.23	1.23	1.23	1.17	1.06	17	13
Minneapolis-St. Paul MN	1.21	1.21	1.30	1.28	1.05	16	16
San Antonio TX	1.19	1.19	1.22	1.19	1.03	16	20
Cincinnati OH-KY-IN	1.20	1.20	1.21	1.23	1.05	15	21
Las Vegas NV	1.20	1.20	1.24	1.21	1.05	15	21
Sacramento CA	1.20	1.20	1.27	1.21	1.05	15	21
Columbus OH	1.18	1.18	1.18	1.15	1.03	15	25
San Jose CA	1.24	1.24	1.29	1.28	1.11	13	30
Charlotte NC-SC	1.20	1.20	1.23	1.22	1.07	13	30
Orlando FL	1.20	1.20	1.24	1.25	1.08	12	32
Providence RI-MA	1.16	1.16	1.24	1.20	1.04	12	32
Cleveland OH	1.16	1.16	1.19	1.24	1.05	11	40
Indianapolis IN	1.17	1.17	1.15	1.15	1.06	11	41
Memphis TN-MS-AR	1.18	1.18	1.27	1.27	1.07	11	42
Virginia Beach VA	1.20	1.20	1.27	1.23	1.10	10	44
Buffalo NY	1.17	1.17	1.22	1.19	1.07	10	46
Milwaukee WI	1.15	1.15	1.14	1.15	1.05	10	46
Raleigh-Durham NC	1.14	1.14	1.17	1.13	1.04	10	46
Nashville-Davidson TN	1.23	1.23	1.25	1.23	1.14	9	52
Kansas City MO-KS	1.13	1.13	1.18	1.21	1.05	8	64
Salt Lake City UT	1.14	1.14	1.20	1.23	1.06	8	65
Louisville KY-IN	1.18	1.18	1.21	1.20	1.11	7	73
Jacksonville FL	1.14	1.14	1.26	1.20	1.09	5	85
Pittsburgh PA	1.24	1.24	1.29	1.29	1.20	4	90
New Orleans LA	1.20	1.20	1.22	1.22	1.16	4	90
Tampa-St. Petersburg FL	1.20	1.20	1.22	1.19	1.16	4	90
St. Louis MO-IL	1.14	1.14	1.24	1.29	1.11	3	96

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Table 10. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2011), Continued

Urban Area	Travel Time Index					Point Change in Peak-Period Time Penalty 1982 to 2011	
	2011	2010	2005	2000	1982	Points	Rank
Medium Average (33 areas)	**1.15**	**1.15**	**1.16**	**1.15**	**1.06**	**9**	
Bridgeport-Stamford CT-NY	1.27	1.27	1.26	1.24	1.07	20	6
Honolulu HI	1.36	1.36	1.36	1.30	1.18	18	9
El Paso TX-NM	1.21	1.21	1.23	1.21	1.04	17	13
Baton Rouge LA	1.22	1.22	1.18	1.17	1.06	16	19
McAllen TX	1.16	1.16	1.13	1.11	1.02	14	27
Birmingham AL	1.19	1.19	1.19	1.15	1.05	14	28
New Haven CT	1.17	1.17	1.20	1.20	1.05	12	32
Oklahoma City OK	1.15	1.15	1.10	1.10	1.03	12	32
Hartford CT	1.18	1.18	1.20	1.22	1.06	12	36
Albany NY	1.16	1.16	1.20	1.14	1.06	10	44
Colorado Springs CO	1.13	1.13	1.18	1.18	1.03	10	46
Toledo OH-MI	1.13	1.13	1.18	1.21	1.03	10	46
Bakersfield CA	1.11	1.11	1.12	1.08	1.02	9	53
Omaha NE-IA	1.11	1.11	1.12	1.10	1.02	9	53
Tulsa OK	1.12	1.12	1.07	1.09	1.03	9	57
Oxnard CA	1.10	1.10	1.10	1.07	1.01	9	57
Akron OH	1.12	1.12	1.19	1.22	1.05	7	68
Allentown-Bethlehem PA-NJ	1.17	1.17	1.19	1.22	1.10	7	70
Charleston-North Charleston SC	1.15	1.15	1.16	1.15	1.08	7	70
Richmond VA	1.11	1.11	1.13	1.11	1.05	6	74
Tucson AZ	1.16	1.16	1.22	1.17	1.10	6	78
Albuquerque NM	1.10	1.10	1.16	1.17	1.05	5	79
Fresno CA	1.08	1.08	1.09	1.11	1.03	5	79
Grand Rapids MI	1.09	1.09	1.09	1.11	1.04	5	83
Wichita KS	1.09	1.09	1.08	1.08	1.04	5	83
Knoxville TN	1.16	1.16	1.24	1.26	1.11	5	85
Rochester NY	1.13	1.13	1.18	1.16	1.08	5	85
Springfield MA-CT	1.13	1.13	1.15	1.15	1.08	5	85
Sarasota-Bradenton FL	1.12	1.12	1.15	1.15	1.08	4	90
Indio-Cathedral City-Palm Springs CA	1.08	1.08	1.09	1.06	1.04	4	90
Poughkeepsie-Newburgh NY	1.12	1.12	1.15	1.12	1.09	3	95
Dayton OH	1.11	1.11	1.13	1.15	1.09	2	97
Lancaster-Palmdale CA	1.08	1.08	1.08	1.06	1.06	2	98

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Table 10 Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2011), Continued

Urban Area	Travel Time Index					Point Change in Peak-Period Time Penalty 1982 to 2011	
	2011	2010	2005	2000	1982	Points	Rank
Small Average (21 areas)	**1.11**	**1.11**	**1.13**	**1.12**	**1.04**	**7**	
Boulder CO	1.18	1.18	1.18	1.19	1.06	12	36
Laredo TX	1.14	1.14	1.12	1.10	1.02	12	36
Provo-Orem UT	1.14	1.14	1.09	1.07	1.03	11	42
Columbia SC	1.11	1.11	1.08	1.07	1.02	9	53
Winston-Salem NC	1.11	1.11	1.13	1.09	1.02	9	53
Brownsville TX	1.18	1.18	1.31	1.31	1.09	9	60
Salem OR	1.14	1.14	1.19	1.19	1.05	9	60
Beaumont TX	1.10	1.10	1.07	1.06	1.02	8	62
Greensboro NC	1.10	1.10	1.12	1.13	1.02	8	62
Pensacola FL-AL	1.11	1.11	1.14	1.12	1.04	7	67
Jackson MS	1.10	1.10	1.15	1.10	1.03	7	68
Worcester MA-CT	1.13	1.13	1.19	1.19	1.06	7	70
Madison WI	1.11	1.11	1.09	1.09	1.05	6	74
Spokane WA-ID	1.12	1.12	1.12	1.17	1.06	6	76
Little Rock AR	1.07	1.07	1.06	1.05	1.01	6	76
Stockton CA	1.10	1.10	1.25	1.15	1.05	5	79
Boise ID	1.06	1.06	1.09	1.07	1.01	5	79
Cape Coral FL	1.15	1.15	1.18	1.15	1.10	5	85
Corpus Christi TX	1.04	1.04	1.04	1.03	1.02	2	98
Eugene OR	1.08	1.08	1.17	1.17	1.07	1	100
Anchorage AK	1.18	1.18	1.21	1.18	1.18	0	101
101 Area Average	**1.23**	**1.23**	**1.27**	**1.24**	**1.10**	**13**	
Remaining Area Average	**1.10**	**1.10**	**1.12**	**1.09**	**1.03**	**7**	
All 498 Area Average	**1.18**	**1.18**	**1.24**	**1.20**	**1.08**	**10**	

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Table 11. Urban Area Demand and Roadway Growth Trends

Less Than 10% Faster (17)	10% to 30%Faster(cont.)	10% to 30% Faster (cont.)	More Than 30% Faster (28)	More Than 30% Faster (cont.)
Anchorage AK	Boulder CO	Memphis TN-MS-AR	Akron OH	Sarasota-Bradenton FL
Cleveland OH	Bridgeport-Stamford CT-NY	Milwaukee WI	Albany-Schenectady NY	Stockton CA
Dayton OH	Brownsville TX	Nashville-Davidson TN	Albuquerque NM	Washington DC-VA-MD
Eugene OR	Buffalo NY	New Haven CT	Atlanta GA	
Greensboro NC	Cape Coral FL	New York-Newark NY-NJ-CT	Baltimore MD	
Lancaster-Palmdale CA	Charleston-N Charleston SC	Oklahoma City OK	Birmingham AL	
Madison WI	Charlotte NC-SC	Omaha NE-IA	Boise ID	
New Orleans LA	Colorado Springs CO	Orlando FL	Chicago IL-IN	
Phoenix AZ	Corpus Christi TX	Pensacola FL-AL	Cincinnati OH-KY-IN	
Pittsburgh PA	Denver-Aurora CO	Philadelphia PA-NJ-DE-MD	Columbia SC	
Poughkeepsie-Newburgh NY	Detroit MI	Portland OR-WA	Columbus OH	
Provo UT	El Paso TX-NM	Providence RI-MA	Dallas-Ft Worth-Arlington TX	
St. Louis MO-IL	Fresno CA	Raleigh-Durham NC	Laredo TX	
Tulsa OK	Grand Rapids MI	Richmond VA	Las Vegas NV	
Wichita KS	Hartford CT	Rochester NY	Los Angeles-L Beach-S Ana CA	
Winston-Salem NC	Honolulu HI	Salem OR	McAllen TX	
Worcester MA	Houston TX	Salt Lake City UT	Miami FL	
	Indianapolis IN	San Jose CA	Minneapolis-St. Paul MN	
10% to 30% Faster (56)	Indio-Palm Springs CA	Seattle WA	Oxnard-Ventura CA	
Allentown-Bethlehem PA-NJ	Jackson MS	Spokane WA	Riverside-San Bernardino CA	
Austin TX	Jacksonville FL	Springfield MA-CT	Sacramento CA	
Bakersfield CA	Kansas City MO-KS	Tampa-St. Petersburg FL	San Antonio TX	
Baton Rouge LA	Knoxville TN	Toledo OH-MI	San Diego CA	
Beaumont TX	Little Rock AR	Tucson AZ	San Francisco-Oakland CA	
Boston MA-NH-RI	Louisville KY-IN	Virginia Beach VA	San Juan PR	

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

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1 *National Average Speed Database*, 2007, 2008, 2009, 2010, 2011. INRIX. Bellevue, WA. www.inrix.com

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3 United States Environmental Protection Agency. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010.* Report EPA 430-R-12-001. Washington, D.C. April 2012. Available: http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Main-Text.pdf.

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9 *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/methodology/

10 *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://tti.tamu.edu/documents/TTI-2010-9.pdf

11 *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://tti.tamu.edu/documents/TTI-2010-7.pdf

12 *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://tti.tamu.edu/documents/TTI-2010-8.pdf

13 *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.

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Appendix A
Methodology for the 2012 Urban Mobility Report

The procedures used in the 2012 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 appendix documents the analysis conducted for the methodology utilized in preparing the 2012 Urban Mobility Report. This methodology incorporates private sector traffic speed data from INRIX for calendar year 2011 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.

Methodology Changes to the 2012 UMR

There are several changes to the UMR methodology for the 2012 report. The largest changes have to do with estimates of CO_2 emissions for the first time, updated methods for computing wasted fuel based upon the CO_2 emissions, the addition of the Planning Time Index reliability measure, and INRIX data being reported in 15-minute time intervals. These changes are documented in more detail in the following sections of the Methodology. Here are brief summaries of what has changed:

- Additional carbon dioxide (CO_2) greenhouse gas emissions due to congestion are included for the first time. The procedure is based on the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) modeling procedure.
- Wasted fuel is estimated using the additional carbon dioxide greenhouse gas emissions due to congestion for each urban area. For the first time, this method allows for consideration of urban area climate in emissions and fuel consumption calculations.
- A measure of the variation in travel time from day-to-day is introduced. The Planning Time Index (PTI) is based on the idea that travelers would want to be on-time for an important trip 19 out of 20 times; so one would be late only one day per month (on-time for 19 out of 20 work days each month). A PTI value of 3.00 indicates that a traveler should allow 60 minutes to make an important trip that takes 20 minutes in uncongested traffic. In essence,

the 19th worst commute is affected by crashes, weather, special events, and other causes of unreliable travel and can be improved by a range of transportation improvement strategies.

- Speeds supplied by INRIX are collected every 15-minutes from a variety of sources every day of the year on most major roads.

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 are necessary to accomplish this.

Calculation procedures use a dataset of traffic speeds from INRIX, a private company that provides travel time information to a variety of customers. INRIX's 2011 data is an annual average of traffic speed for each section of road for every 15 minutes of each day for a total of 672 day/time period cells (24 hours x 7 days x 4 periods per hour).

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 2011 private sector traffic speed data provide a better data source for the first two inputs, actual and free-flow travel time. The UMR analysis requires 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 were 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 A-1. Automated traffic recorders from around the country were reviewed and the factors in Exhibit A-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 A-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)

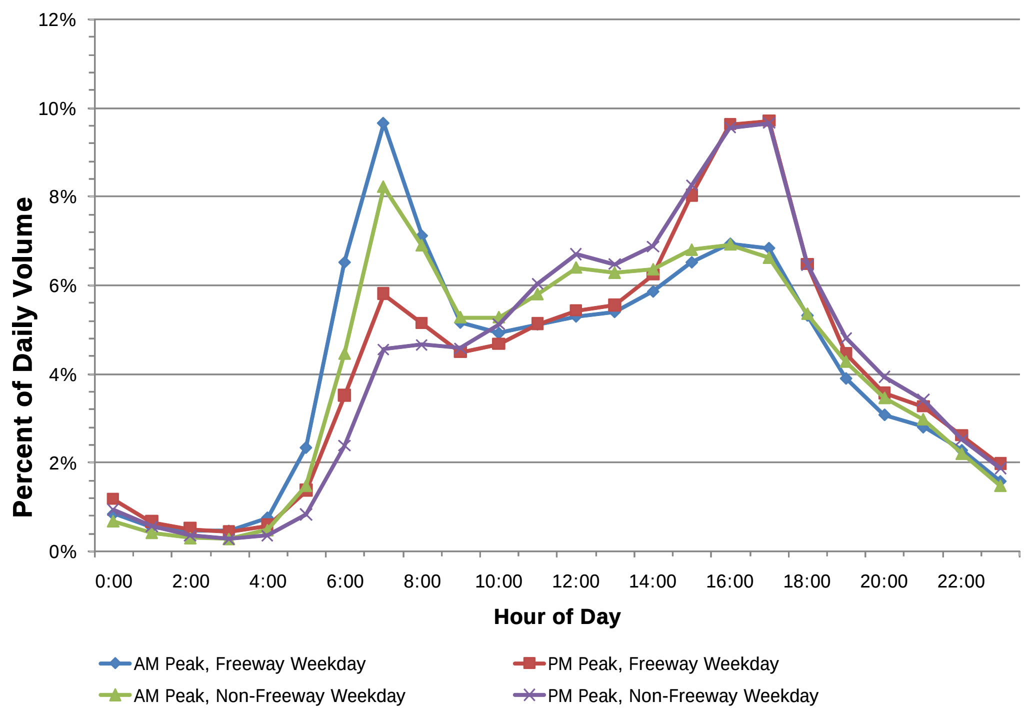
[1] *Roadway Usage Patterns: Urban Case Studies*. Prepared for Volpe National Transportation Systems Center and Federal Highway Administration, July 22, 1994.

[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.

- 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.

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



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

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

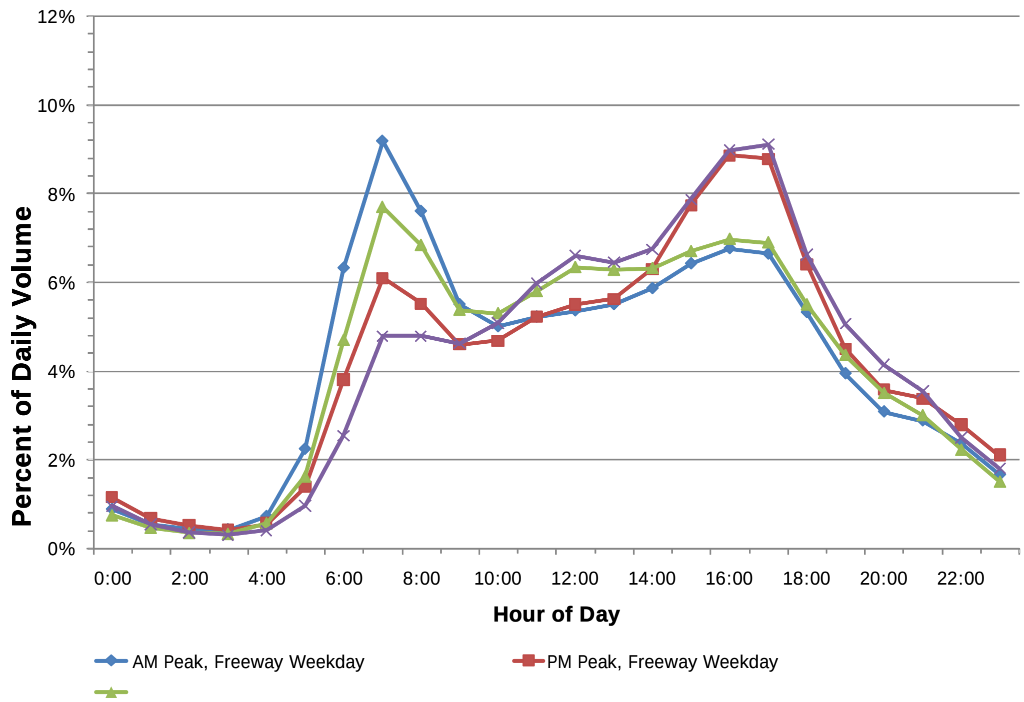
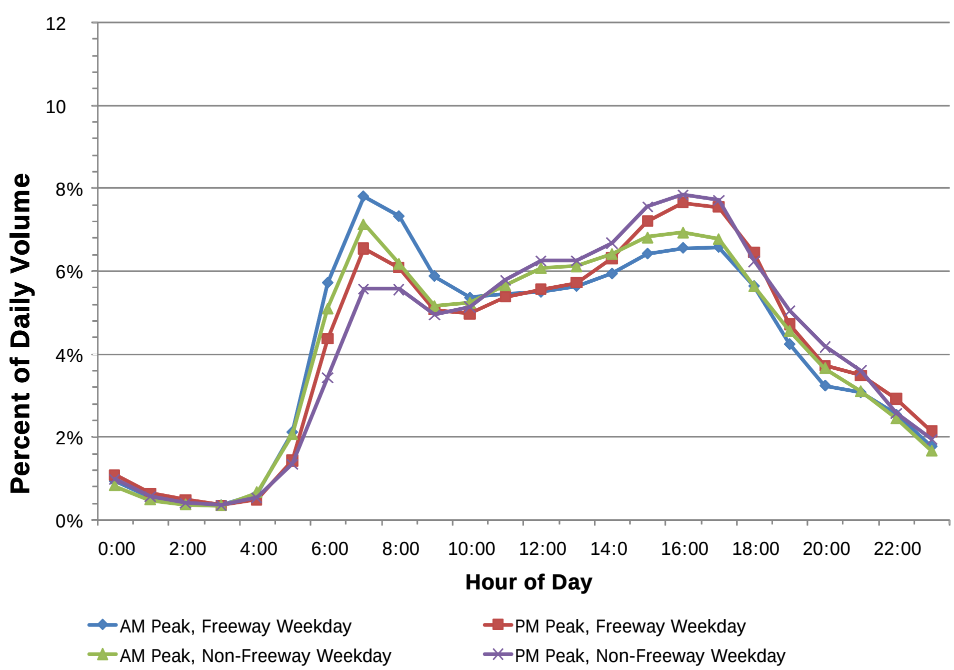


Exhibit A-4. Weekday Traffic Distribution Profile for Severe Congestion



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

Exhibit A-5. Weekend Traffic Distribution Profile

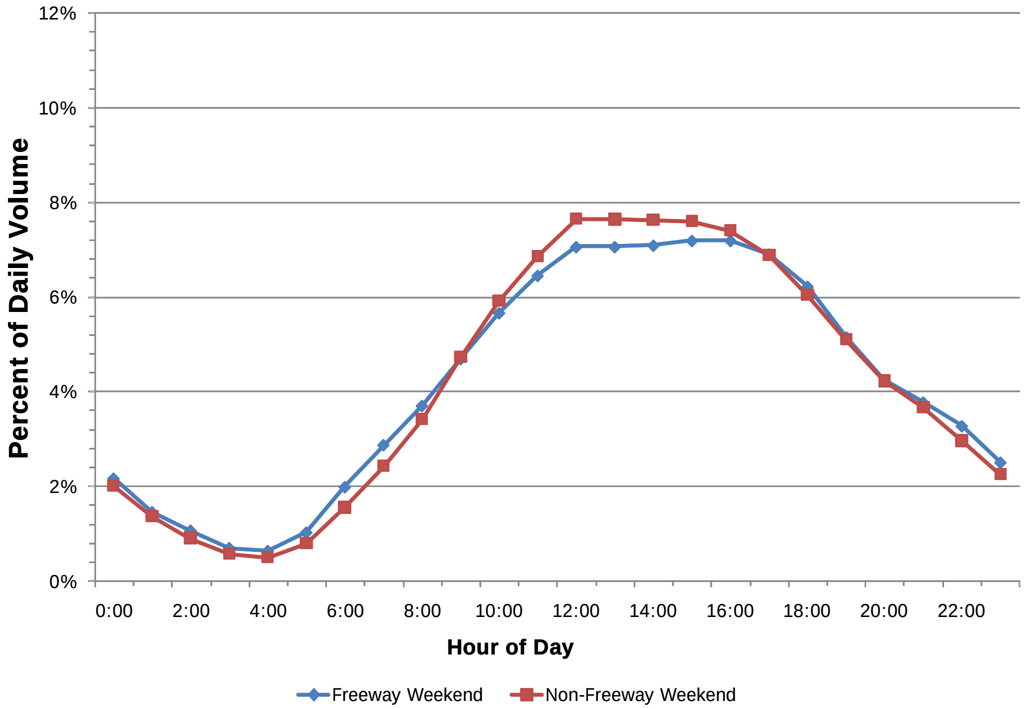
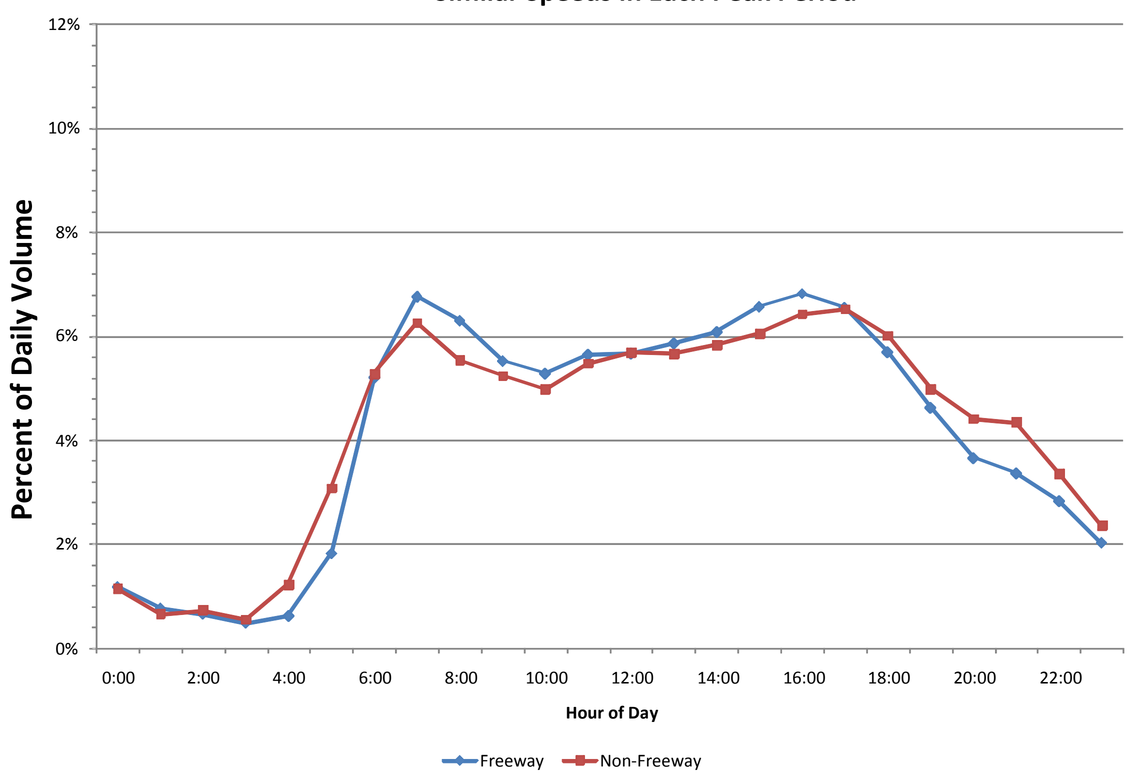


Exhibit A-6. Weekday Traffic Distribution Profile for Severe Congestion and Similar Speeds in Each Peak Period



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.

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

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 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 for all 24 hours 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 2011 UMR. The percentage of arterial streets that had INRIX speed data is approximately 65 percent across the U.S. while the freeway match percentage is approximately 90 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 were then aggregated such that it was treated like one large traffic count for freeways and another for street sections.

The unmatched speed data were separated by county also. All of the speed data and freeflow speed data were 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 were matched with the corresponding group of speed data and steps 1 through 6 were repeated for the unmatched data in the core counties.

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

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) Total Peak Period Travel Time
    6) Travel Time Index
    7) Commuter Stress Index
    8) Planning Time Index
    9) Carbon Dioxide (CO_2) Production and Wasted Fuel
    10) Total Congestion Cost and Truck Congestion Cost
    11) Truck Commodity Value
    12) Roadway Congestion Index
    13) Number of Rush Hours
    14) Percent of Daily and Peak Travel in Congested Conditions
    15) 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 A-7 as national constants—values used in all urban areas to estimate the effect of congestion.

Exhibit A-7. National Congestion Constants for 2012 Urban Mobility Report

Constant	Value
Vehicle Occupancy	1.25 persons per vehicle
Average Cost of Time ($2011) (*2*)	$16.79 per person hour[1]
Commercial Vehicle Operating Cost ($2011) (*3*)	$86.81 per vehicle hour[1]
Total Travel Days (7x52)	364 days

[1] Adjusted annually using the Consumer Price Index.

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 2011 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 52 work weeks to annualize the delay. Total delay for the year is based on 364 total travel days in the year.

Average Cost of Time

The 2011 value of person time used in the report is $16.79 per hour based on the value of time, rather than the average or prevailing wage rate (*2*).

Commercial Vehicle Operating Cost

Truck travel time and operating costs (excluding diesel costs) are valued at $86.81 per hour (*3*).

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) (*1,4*). Estimates of peak period travelers are derived from the National Household Travel Survey (NHTS) (*5*) 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 were 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) (*6*). Values for gasoline and diesel are 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 A-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.

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. Any observed speed faster than the free-flow speed is changed to the free-flow speed so that delay is zero, rather than providing a 'delay credit' (negative delay value) to the calculation.

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

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

Exhibit A-8. 2011 Traffic Speed Data

Urban Area	Freeway		Arterial Streets	
	Peak Speed	Freeflow Speed	Peak Speed	Freeflow Speed
Very Large Areas				
Atlanta GA	56.5	64.7	36.3	44.1
Boston MA-NH-RI	54.2	63.4	29.5	36.0
Chicago IL-IN	53.0	63.1	34.3	40.2
Dallas-Fort Worth-Arlington TX	54.0	64.1	33.1	39.1
Detroit MI	57.0	64.3	33.4	38.7
Houston TX	54.2	63.9	33.9	40.2
Los Angeles-Long Beach-Santa Ana CA	48.6	64.6	37.4	43.7
Miami FL	56.7	64.0	31.7	39.2
New York-Newark NY-NJ-CT	52.0	62.2	31.9	40.5
Philadelphia PA-NJ-DE-MD	55.5	63.6	31.8	39.2
Phoenix AZ	57.4	64.2	34.7	40.1
San Diego CA	56.8	64.5	37.6	43.7
San Francisco-Oakland CA	54.0	64.1	37.8	44.0
Seattle WA	51.2	62.0	30.4	35.2
Washington DC-VA-MD	49.4	62.0	32.9	40.1
Large Areas				
Austin TX	52.9	62.6	36.2	42.9
Baltimore MD	53.3	62.7	31.8	38.6
Buffalo NY	55.2	62.0	33.4	38.6
Charlotte NC-SC	58.0	62.9	34.0	41.4
Cincinnati OH-KY-IN	56.3	63.7	32.5	38.2
Cleveland OH	56.8	62.8	29.6	34.6
Columbus OH	57.6	64.1	31.1	37.3
Denver-Aurora CO	50.9	62.3	32.1	38.0
Indianapolis IN	55.4	63.0	34.6	40.1
Jacksonville FL	58.9	63.4	37.4	43.3
Kansas City MO-KS	57.6	62.7	33.9	37.5
Las Vegas NV	57.4	64.6	33.7	39.8
Louisville KY-IN	57.0	63.7	34.0	39.9
Memphis TN-MS-AR	56.9	64.0	36.1	42.5
Milwaukee WI	55.6	62.5	35.7	39.3
Large Areas				
Minneapolis-St. Paul MN	54.3	63.8	39.6	43.1
Nashville-Davidson TN	57.2	64.1	34.2	41.9
New Orleans LA	54.9	63.2	39.6	43.7
Orlando FL	58.8	64.3	34.9	42.8
Pittsburgh PA	55.2	62.6	33.3	40.1
Portland OR-WA	49.2	60.3	31.1	36.5
Providence RI-MA	56.1	61.9	30.9	35.0
Raleigh-Durham NC	61.3	64.1	39.1	45.4
Riverside-San Bernardino CA	54.4	64.7	37.5	43.1
Sacramento CA	55.2	64.7	37.4	43.5
San Antonio TX	57.2	62.9	35.0	39.4
Salt Lake UT	60.3	64.4	33.6	39.2
San Jose CA	57.1	64.0	34.6	40.4
San Juan PR	54.5	64.7	39.5	46.1
St. Louis MO-IL	44.4	56.0	29.8	34.9
Tampa-St. Petersburg FL	59.1	64.2	37.2	44.2
Virginia Beach VA	56.1	62.9	35.1	41.5

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

Exhibit A-8. 2011 Traffic Speed Data, continued

Urban Area	Freeway Peak Speed	Freeway Freeflow Speed	Arterial Streets Peak Speed	Arterial Streets Freeflow Speed
Medium Areas				
Akron OH	58.5	63.6	32.5	36.2
Albany-Schenectady NY	58.2	62.8	32.1	38.4
Albuquerque NM	62.8	63.1	38.7	41.5
Allentown-Bethlehem PA-NJ	57.5	63.6	35.6	41.5
Bakersfield CA	57.0	64.2	38.3	41.5
Baton Rouge LA	56.6	64.3	40.1	45.8
Birmingham AL	58.3	64.2	36.3	43.5
Bridgeport-Stamford CT-NY	53.2	63.6	29.6	35.8
Charleston-North Charleston SC	58.5	63.1	37.3	42.5
Colorado Springs CO	54.8	60.3	34.4	37.8
Dayton OH	60.1	63.3	33.4	38.0
El Paso TX-NM	53.8	62.7	34.1	39.6
Fresno CA	59.2	63.9	38.2	41.0
Grand Rapids MI	61.1	63.9	36.3	39.8
Hartford CT	58.1	63.3	30.6	37.2
Honolulu HI	44.7	57.2	28.5	34.8
Indio-Cathedral City-Palm Springs CA	58.6	64.0	38.5	41.3
Knoxville TN	57.8	64.4	38.8	44.7
Lancaster-Palmdale CA	60.7	64.9	40.0	42.9
McAllen TX	58.6	63.8	34.8	39.5
New Haven CT	58.8	63.7	30.3	36.8
Oklahoma City OK	58.4	64.6	33.5	37.7
Omaha NE-IA	57.2	61.2	34.4	38.1
Oxnard-Ventura CA	58.0	64.4	42.0	45.1
Poughkeepsie-Newburgh NY	61.1	63.7	35.5	41.9
Richmond VA	60.1	63.5	35.8	40.7
Rochester NY	58.1	61.2	33.7	38.9
Sarasota-Bradenton FL	64.1	64.2	37.7	43.5
Springfield MA-CT	60.3	63.4	31.4	36.4
Medium Areas				
Toledo OH-MI	58.6	63.7	33.9	38.7
Tucson AZ	60.3	63.7	34.8	40.4
Tulsa OK	59.8	64.2	33.9	37.8
Wichita KS	57.6	60.9	34.2	36.4
	58.6	63.7	33.9	38.7
Small Areas				
Anchorage AK	51.6	59.3	33.6	38.2
Beaumont TX	61.2	64.2	37.8	41.4
Boise ID	60.5	62.9	39.0	42.1
Boulder CO	50.3	56.5	32.2	37.0
Brownsville TX	60.3	64.0	32.2	37.7
Cape Coral FL	62.4	62.6	38.4	44.6
Columbia SC	61.3	64.1	35.1	40.2
Corpus Christi TX	62.0	58.1	39.3	41.2
Eugene OR	55.0	60.3	34.9	36.8
Greensboro NC	61.2	62.3	35.7	41.4
Jackson MS	61.4	64.6	44.7	49.6
Laredo TX	58.6	64.3	38.3	42.9
Little Rock AR	61.4	63.6	37.5	40.5
Madison WI	58.7	62.3	36.4	40.6
Pensacola FL-AL	63.4	64.6	39.0	43.8
Provo UT	58.8	64.4	35.6	40.7
Salem OR	56.4	62.0	31.2	35.6
Spokane WA	54.8	61.5	32.5	34.6
Stockton CA	58.3	64.4	39.9	42.7
Winston-Salem NC	59.4	62.8	36.3	42.3
Worcester MA	60.6	63.9	33.7	39.3

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 an nual person-hours of delay, multiply each day-of-the-week delay estimate by the average vehicle occupancy (1.25 persons per vehicle) and by 52 weeks per year (Equation A-3).

$$\begin{matrix}\text{Annual}\\\text{Persons-Hours}\\\text{of Delay}\end{matrix} = \begin{matrix}\text{Daily Vehicle-Hours}\\\text{of Delay on}\\\text{Frwys and Arterial Streets}\end{matrix} \times 52\text{ Weeks} \times \begin{matrix}\text{1.25 Persons}\\\text{per Vehicle}\end{matrix} \qquad \text{(Eq. A-3)}$$

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 (*5*) to the urban area population estimate to derive the average number of auto commuters and number of travelers during the peak periods (*7*).

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 A-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.

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

Total Peak Period Travel Time

This and future reports will expand on the use of total peak period travel time as a performance measure using supplemental information. In this report, travel time is reported during the peak period by commuters in minutes.

Total travel time is the sum of travel delay and free-flow travel time. Beginning in the 2012 Urban Mobility Report, both quantities are calculated for freeways, arterial, collector, and local streets. Previously, peak period travel time excluded collector and local streets because data were largely unavailable and incomplete. Though still sparse, these data elements have been included this year, offering a refinement to previous efforts. As data become more available, so will the measure's refinement.

For this report, the four roadway classifications have been grouped into two primary categories: primary roads (freeways and arterials) and minor roads (collectors and local streets).

Total peak period daily delay is the amount of extra time spent traveling during the morning peak hours of 6:00 a.m. and 10:00 a.m. and the evening peak hours of 3:00 p.m. and 7:00 p.m. due to congestion. Equation A-5 is modeled after Equation A-2 but includes factors to convert daily delay into peak period delay and vehicle-hours into a person hours.

$$\begin{matrix}\text{Peak Period}\\\text{Daily Delay}\\\text{(Person-Hours)}\end{matrix} = \left(\left[\frac{\text{Daily Vehicle-Miles of Travel}}{\text{Speed}}\right] - \left[\frac{\text{Daily Vehicle-Miles of Travel}}{\text{Free-Flow Speed}}\right]\right) \times \begin{matrix}\text{Percent of Vehicle}\\\text{Miles of Travel}\\\text{During the Peak}\end{matrix} \times \begin{matrix}\text{1.25 Persons}\\\text{per Vehicle}\end{matrix} \qquad \text{(Eq. A-5)}$$

Total peak period 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) during the day's peak hours (Equation A-6). Equation A-6 converts vehicle hours to person hours.

$$\begin{matrix}\text{Peak Free-Flow}\\\text{Travel Time}\\\text{(Person-Hours)}\end{matrix} = \frac{1}{\begin{matrix}\text{Free-Flow}\\\text{Travel Speed}\end{matrix}} \times \begin{matrix}\text{Daily}\\\text{Vehicle-Miles}\\\text{of Travel}\end{matrix} \times \begin{matrix}\text{Percent of Vehicle}\\\text{Miles of Travel}\\\text{During the Peak}\end{matrix} \times \begin{matrix}\text{1.25 Persons}\\\text{per Vehicle}\end{matrix} \qquad \text{(Eq. A-6)}$$

Peak period travel time is the sum of peak period delay and free-flow travel time for each roadway type (both primary and minor roads) (Equation A-7). The metric considers commuters rather than the total population to reflect actual travel time for those experiencing the worst congestion.

$$\text{Total Daily Peak Period Travel Time (Minutes per Commuter)} = \left(\frac{\begin{bmatrix}\text{Primary Road}\\ \text{Peak Delay}\end{bmatrix} + \begin{bmatrix}\text{Minor Road}\\ \text{Peak Delay}\end{bmatrix} + \begin{bmatrix}\text{Primary Road Peak Free-Flow Travel Time} + \text{Minor Road Peak Free-Flow Travel Time}\end{bmatrix}}{\text{Auto Commuters}} \right) \times \text{60 Minutes} \quad \text{(Eq. A-7)}$$

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 A85 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 A-8 and A-9).

$$\text{Travel Time Index} = \frac{\text{Peak Travel Time}}{\text{Free-Flow Travel Time}} \quad \text{(Eq. A-8)}$$

$$\text{Travel Time Index} = \frac{\text{Delay Time} + \text{Free-Flow Travel Time}}{\text{Free-Flow Travel Time}} \quad \text{(Eq. A-9)}$$

The change in Travel Time Index values is computed by subtracting 1.0 from all the TTI values so that the resulting values represent the change in extra travel time rather than the change in the numerical TTI values. For example, the increase in extra travel time from a TTI of 1.25 to 1.50 is 100 percent (extra travel time of 50 percent compared to 25 percent).

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.

Planning Time Index (Freeway Only)

The Planning Time Index (PTI) is new to the 2012 Urban Mobility Report. Results are shown in Table 3. The PTI values in Table 3 are for freeways only. On pages 7 and 10 of the report, researchers discuss unreliable travel in more detail. Appendix B also has discussion of the PTI and unreliable travel.

The PTI is computed as the 95th percentile travel time relative to the free-flow travel time as shown in Equation A-10. The PTI_{80} shown in Equation A-11 is computed as the 80th percentile travel time relative to the free-flow travel time. Both the PTI and PTI_{80} computations are performed with the 15-minute data and aggregated up to the urban area by weighting by passenger-miles of travel (PMT).

$$\text{Planning Time Index (PTI)} = \frac{\text{95th Percentile Travel Time (minutes)}}{\text{Free-Flow Travel Time (minutes)}} \qquad \text{(Eq. A-10)}$$

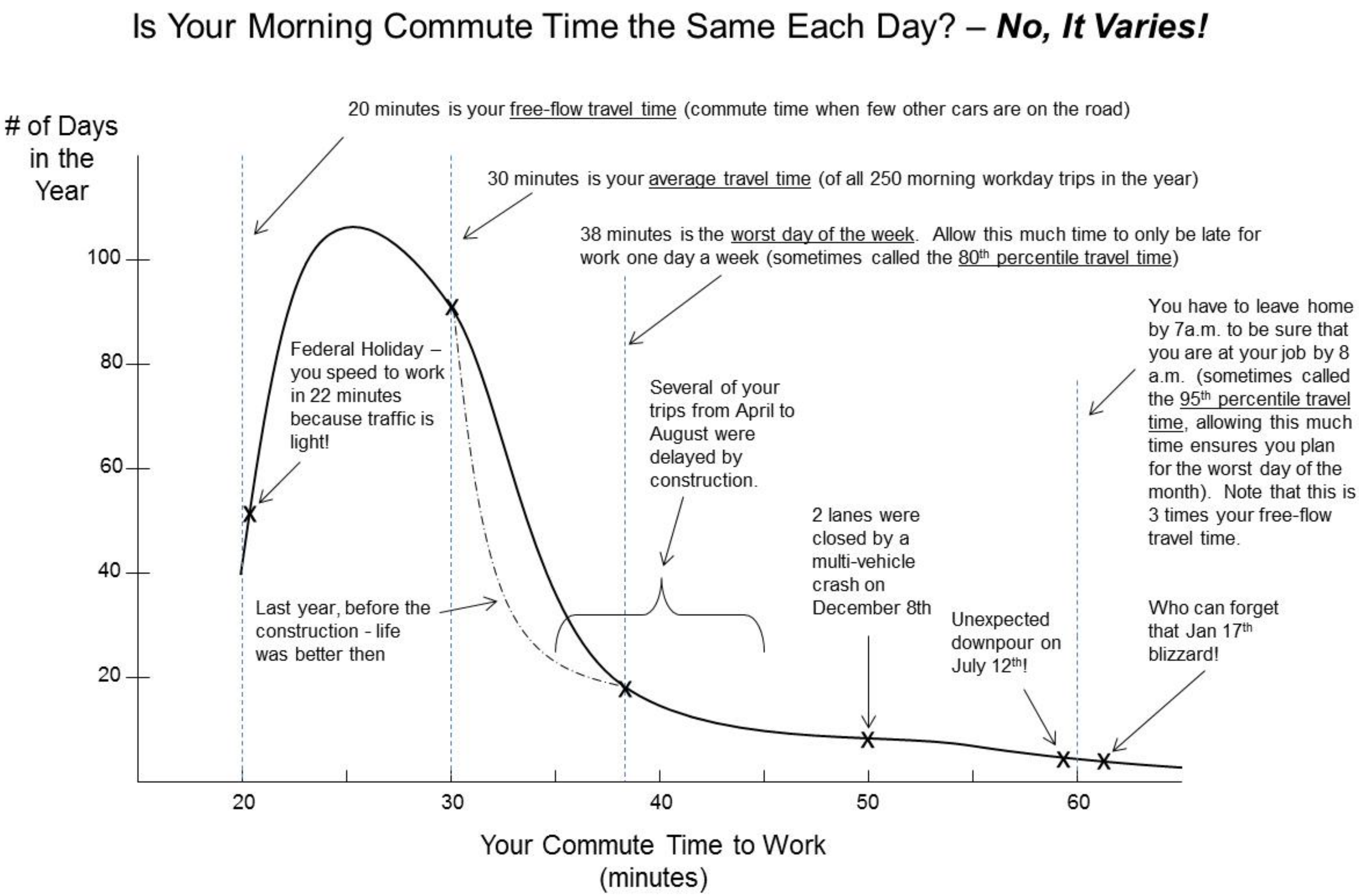
$$PTI_{80} = \frac{\text{80th Percentile Travel Time (minutes)}}{\text{Free-Flow Travel Time (minutes)}} \qquad \text{(Eq. A-11)}$$

The PTI value represents the "worst trip of the month" and the PTI_{80} value represents the "worst trip of the week." The authors of the UMR present both because the PTI is the preferred measure for individual commuters or truck drivers delivering goods – they need to allow more times for urgent trips. However, the PTI_{80} value is also presented because bad weather is often the cause for the longest travel times, and it really is not fair to measure an agency on these situations they have no impact upon. Therefore, the PTI_{80} measure is introduced, and transportation improvements can impact this measure.

Exhibit A-9 shows an illustration of a distribution of travel times for a morning commute. It illustrates over a calendar year how travel times can vary and their typical causes in extreme cases. It also quantifies and illustrates the relationship between the free-flow travel time, average travel time, 80th percentile travel time, and 95th percentile travel time.

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

Exhibit A-9. Example of Morning Commute Travel Time Distribution



Carbon Dioxide (CO_2) Production and Wasted Fuel

This methodology uses data from the United States Environmental Protection Agency's (EPA) MOtor Vehicle Emission Simulator (MOVES) model. MOVES is a model developed by the EPA to estimate emissions from mobile sources. Researchers primarily used MOVES to obtain vehicle emission rates, climate data, and vehicle fleet composition data.

The methodology uses data from three primary data sources: 1) the FHWA's HPMS, 2) INRIX traffic speed data, and 3) EPA's MOVES model. Five steps are implemented in the methodology:

1. Group Similar Urban Areas – considers seasonal variations and the percentage of travel that occurs with the air conditioner "on," which impacts CO_2 production.
2. Obtain CO_2 Emission Rates for Urban Area Group – emission rates (in grams per mile) were created for each of the 14 groups from Step #1.
3. Fit Curves to CO_2 Emission Rates – curves were created relating speed and emission rates from Step #2.
4. Calculate CO_2 Emissions and Fuel Consumption During Congested Conditions – combine speed, volume and emission rates to calculate emissions during congested conditions. Estimate fuel consumption using factors that relate the amount of gas (or diesel for trucks) produced for the CO_2 emissions produced.
5. Estimate the CO_2 Emissions and Fuel Consumption During Free-flow Conditions, and Estimate Wasted Fuel and CO_2 Due to Congestion – repeat the calculations from Step #4 using the free-flow speeds when few cars are on the road. Free-flow results are subtracted from congested-conditions results to obtain CO_2 emissions and fuel wasted due to congestion.

Step 1. Group Similar Urban Areas

For some pollutants, the influence of weather conditions causes vehicle tail-pipe emissions to vary considerably by location. Tail-pipe CO_2 emissions, however, are not directly influenced by weather conditions, although they still vary by location because they are influenced by air conditioning use. Traveling with the air conditioner turned "on" lowers fuel efficiency and increases CO_2 emission rates.

Thus, locations with warmer climates typically have higher emission rates because more travel occurs with the air conditioner turned "on."

It was not feasible to use emission rates for every county in the United States, so researchers instead created representative climate-type groups to account for the impact of climate on CO_2 emission rates. To create these groups, TTI researchers grouped the UMR urban areas based on similar seasonal "AConFraction" (ACF) values – a term used in MOVES to indicate the fraction of travel that occurs with the air conditioner turned "on." For example, a vehicle traveling 100 miles with an ACF of 11 percent would travel 11 of those 100 miles with the air conditioner turned "on."

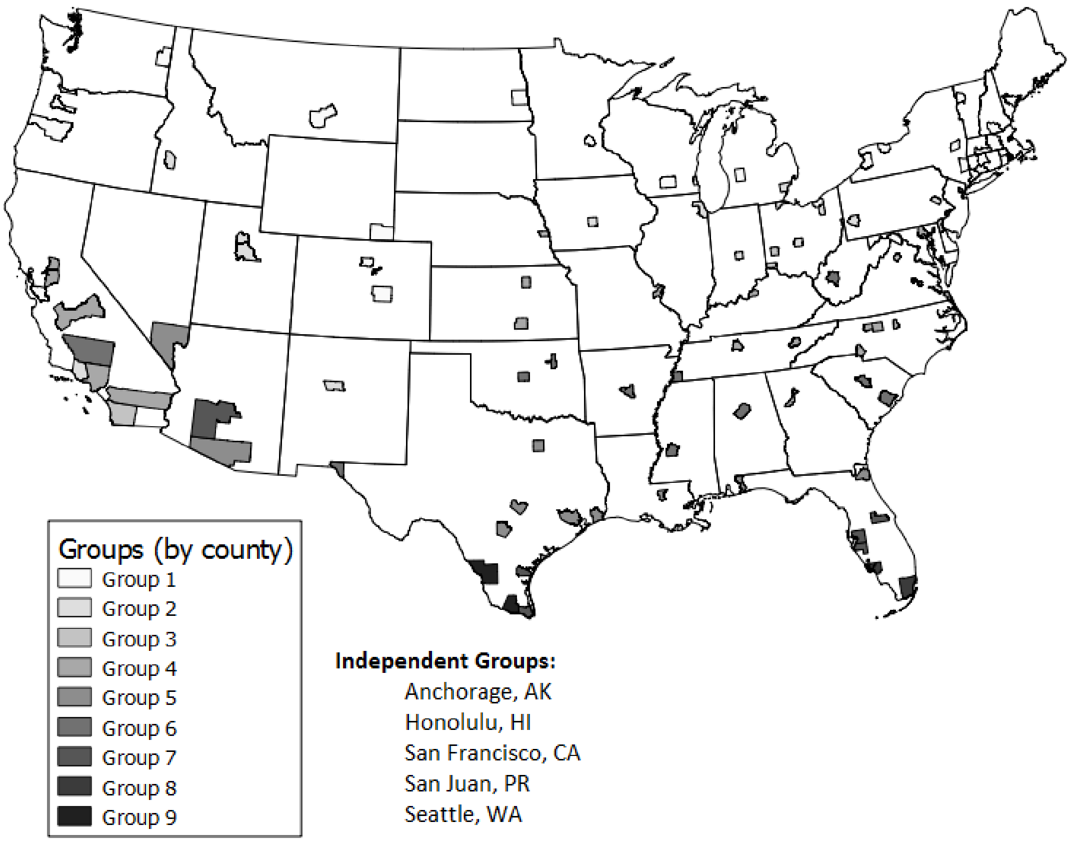
Because ACF is a factor of temperature and relative humidity, researchers collected hourly temperature and relative humidity data for a county within each urban area included in TTI's *UMR* from the MOVES database. Researchers collected the climate data by county, rather than urban area (or city), because the MOVES database only has climate data available by county.

For simplicity, one county per urban area (or city) was selected because the climate differences between adjacent counties were not significant.

TTI researchers used methods similar to those used in MOVES to calculate the seasonal "AConFraction" (ACF) for each county. Researchers developed seasonal ACFs based on hourly temperature and relative humidity data from MOVES. They used this hourly data to calculate hourly ACFs, which they then weighted by hourly traffic volume data from MOVES and averaged for each month. To produce the weighted seasonal ACFs, researchers averaged these weighted monthly ACFs over three-month periods for the seasons defined by MOVES.

To group the counties (or urban areas) based on similar seasonal climates, researchers used temperature and relative humidity scatter plots to visually identify which counties had similar climates. To refine the tentative groups, researchers previewed each group's average seasonal ACF values and removed any counties that differed from the group averages. The standard to which researchers allowed a county to vary from the average was approximately 5 to 10 percent or less. Researchers determined this margin for error during the grouping process based on the need to create a manageable number of groups without sacrificing accuracy. Several counties did not share similar seasonal ACF values with any group, so they retained their original values and would be calculated individually. Exhibit A-10 shows the groupings of urban areas.

Exhibit A-10. The Continental United States with Each County Shaded by Group



Step 2. Obtain CO_2 Emission Rates for Urban Area Group

TTI researchers used MOVES to produce emission rates for different vehicle types and locations. Researchers used these emission rates by combining them with volume and speed data to incorporate CO_2 emissions as described in Step 4. Researchers produced emission rates for every ACF value assigned to the groups in Step 1. For each ACF value, researchers produced emission rates for each vehicle type, fuel type, and road type used in the *UMR*.

MOVES has many different vehicle classifications, but TTI's *UMR* has just three broad categories: light-duty vehicles, medium-duty trucks, and heavy-duty trucks. To obtain emission rates, researchers selected MOVES vehicle types that were most similar to the vehicle types of the *UMR*.

Multiple "SourceTypes" from MOVES meet the description of each vehicle type used in TTI's *UMR* (light-duty vehicles, medium-duty trucks, and heavy-duty trucks). For example, both the combination short-haul and combination long-haul trucks qualify as heavy-duty trucks. Rather than weighting the emission rates of every "SourceType," researchers selected a single "SourceType" to supply emission rates for each *UMR* vehicle type because many "SourceTypes" have similar emission rates (light-duty vehicles are an exception, however). To determine which "SourceType" would supply the emission rates for a vehicle type, researchers chose the "SourceType" with the highest percentage of vehicle-miles of travel (VMT) within each *UMR* vehicle type.

TTI researchers used a different method for light-duty vehicles because not all "SourceTypes" within this classification have similar emission rates. The light-duty vehicle classification consists of passenger cars, passenger trucks, and light commercial trucks. Passenger trucks and light commercial trucks have similar emission rates, but passenger car emission rates are substantially different. To create one set of emission rates for this vehicle type (light-duty vehicles), researchers combined and weighted the emission rates of two different "SourceTypes" – passenger cars (59%) and passenger trucks (41%). Researchers used only the passenger truck "SourceType" to supply the emission rates for both passenger trucks and light commercial trucks because they have similar emission rates, and because passenger trucks account for more VMT.

Emission rates also differ for specific fuel types, and TTI researchers selected a fuel type for each vehicle type based on fuel usage data in MOVES. Given that light commercial trucks account for a small portion of the light-duty vehicle population, researchers used the gasoline emission rates to represent all fuel usage for light-duty vehicles when calculating emissions. Researchers used the diesel emission rates to represent all fuel usage for medium-duty trucks and heavy-duty trucks.

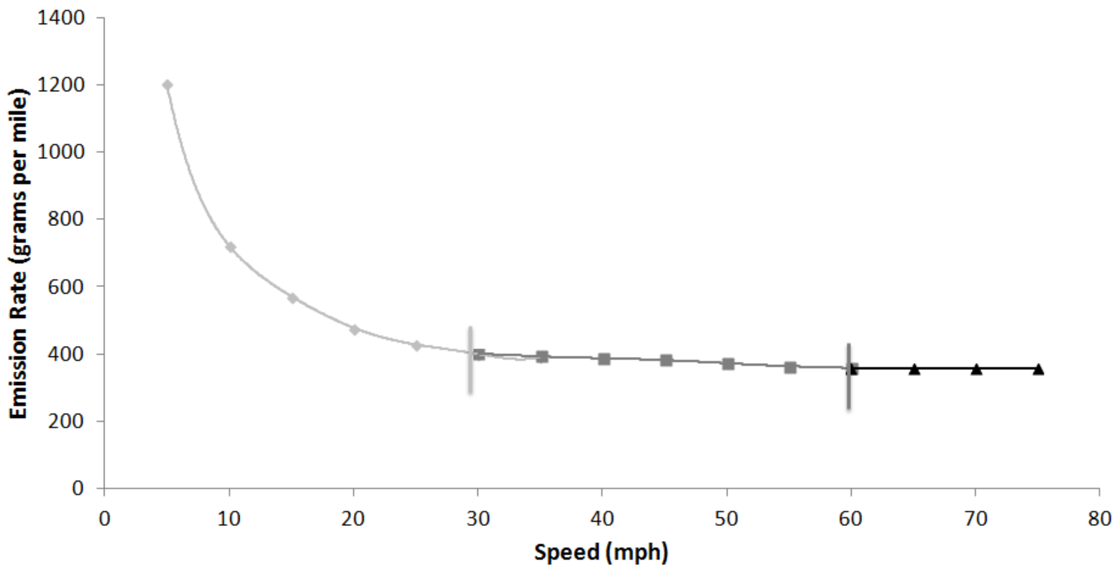
TTI researchers ran MOVES for the appropriate vehicle types, fuel types, and road types to obtain emission rates in grams per mile.

Step 3. Fit Curves to CO_2 Emission Rates

TTI researchers developed curves to calculate emission rates for a given speed. Researchers later used the equations for each curve to calculate emissions.

MOVES produces emission rates for speeds of 2.5 to 75 mph in increments of five (except for 2.5 mph). Using Microsoft Excel®, researchers initially constructed speed-dependent emission factor curves by fitting one to three polynomial curves (spline) to the emission rate data from MOVES (see Exhibit A-11 example). Researchers compared emission rates generated with the polynomial spline to the underlying MOVES-generated emission rates.

Exhibit A-11. Example Light-duty Vehicle Emission Rate Curve-set Showing Three Emission Rate Curves



The polynomial spline that was deemed sufficiently accurate by researchers was a two-segment spline using one 6th-order polynomial for the 0 – 30 mph segment and another 6th-order polynomial for the 30 – 60 mph segment. Speeds over 60 used the emission rates of the 30 – 60 mph polynomial at 60 mph. Note that these speeds are averages, and variability with speed (slope) is negligable for speeds greater than 60 mph. Lower average speeds have higher speed fluctations (or more stop-and-go), which causes higher emission rates. From a CO_2 perspective, these slower speeds are of great concern. Because there are fewer speed fluctuations at higher speeds, which results in a more efficient system operation, it is desirable for urban areas to operate during the relatively free-flow conditions as much as possible. Thus, the authors capped emissions generation at approximately 60 mph.

Step 4. Calculate CO_2 Emissions and Fuel Consumption During Congested Conditions

To calculate emissions, researchers combined the emission rates with hourly speed data supplied by INRIX and hourly volume data supplied by Highway Performance Monitoring System (HPMS).

Researchers used SAS® to automate the process of calculating emissions. This process involves selecting the appropriate emission rate equations (or curves), using the speed data to calculate emission rates, and combining the volume data with the emission rates to calculate emissions.

The volume and speed data are structured for each 15-minutes for each day of the week. This means there will be a separate speed and volume value for light-duty vehicles, medium-duty trucks, and heavy-duty trucks for each 15-minutes of each day of the week. To account for the seasonal climate changes, researchers calculated a separate emission rate for each season.

After calculating the emission rates, researchers combined these emission rates with the volume data to calculate emissions for each season. Lastly, researchers sum the emissions of each season, vehicle type, and day of the week to produce the annual emission estimates.

Researchers produced the annual emission estimates for congested conditions, which includes free-flow. Researchers used factors that relate CO_2 emissions from a gallon of gasoline (8,887 grams CO_2/gallon) and diesel (10,180 grams CO_2/gallon), in relation with the vehicle types and associated fuel type used, to estimate fuel consumption during congestion conditions, which includes free-flow.

Step 5. Estimate the CO_2 Emissions and Fuel Consumption During Free-flow Conditions and Estimate Wasted Fuel and CO_2 Due to Congestion

Researchers repeated the calculations in Step #4 using the free-flow speeds when few cars are on the road to estimate free-flow emissions and fuel consumption. To estimate the CO_2 emissions Due to congestion, researchers subtracted the free-flow conditions emissions estimates from the congested-conditions emissions estimate from Step #4. This is shown in Equation A-12. To estimate wasted fuel due to congestion, researchers subtracted the fuel consumed during free-flow from the fuel used during congested conditions (Equation A-13).

$$\begin{matrix}\text{Annual Additional } CO_2 \\ \text{Because of} \\ \text{Congestion}\end{matrix} = \begin{matrix}\text{Annual } CO_2 \\ \text{Emissions Produced} \\ \text{in Congestion}\end{matrix} - \begin{matrix}\text{Annual } CO_2 \\ \text{Emissions Produced} \\ \text{in Free-Flow Conditions}\end{matrix} \qquad \text{(Eq. A-12)}$$

$$\begin{matrix}\text{Annual Fuel} \\ \text{Wasted in Congestion}\end{matrix} = \begin{matrix}\text{Annual Fuel} \\ \text{Consumed in} \\ \text{Congestion}\end{matrix} - \begin{matrix}\text{Annual Fuel That} \\ \text{Would be Consumed} \\ \text{in Free-Flow Conditions}\end{matrix} \qquad \text{(Eq. A-13)}$$

A word about Assumptions in the CO_2 and Fuel Methodology

Table 4 of the main report presents the results of the steps above. Table 4 reports the total millions of pounds of CO_2 emissions that occur during free-flow in each urban area, which is a result of Step 5. The additional results of Step 5 (additional emissions because of congestion) are reported in Table 4 in pounds per auto commuter and millions of pounds for each urban area. As shown in Table 4, the emissions produced during congestion are only about 3 percent (from all 498 urban areas) of emissions produced during free-flow.

A number of national-level assumptions are used as model inputs (e.g., volume, speed, vehicle composition, fuel types). This analysis also only includes freeways and principal arterial streets. The assumptions allow for a relatively simple and replicable methodology for 498 urban areas. More detailed and localized inputs and analyses are conducted by local or state agencies; those are better estimates of CO2 production.

The analysis is based upon the urban area boundaries which are a function of state and local agency updates. Localized CO_2 inventory analyses will likely include other/all roadways (including collectors and local streets) and will likely have a different area boundary (e.g., often based upon metropolitan statistical area).

Finally, Step 5 uses the difference between actual congested-condition CO_2 emissions **and** free-flow CO_2 emissions and fuel consumption. According to the methodology, this difference is the “wasted” fuel and "additional" CO_2 produced due to congestion. Some may note that if the congestion were not present, speeds would be higher, throughput would increase, and this would generally result in lower fuel consumption and CO_2 emissions – thus the methodology could be seen as overestimating the wasted fuel and additional CO_2 produced due to congestion. Similarly, if there is substantial induced demand due to the lack of congestion, it is possible that more CO_2 could be present than during congested conditions because of more cars traveling at free-flow. While these are notable considerations and may be true for specific corridors, the UMR analysis is at the areawide level for all principal arterials and freeways and the assumption is that overestimating and underestimating will approximately balance out over the urban area. Therefore, the methodology provides a credible method for consistent and replicable analysis across 498 urban areas.

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 A-14 through A-16 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 in congestion. Equation A-14 shows how to calculate the passenger vehicle delay costs that result from lost time.

$$\begin{matrix}\text{Annual Psgr-Veh} \\ \text{Delay Cost}\end{matrix} = \begin{matrix}\text{Daily Psgr Vehicle} \\ \text{Hours of Delay} \\ \text{(Eq. A-4)}\end{matrix} \times \begin{matrix}\text{Value of} \\ \text{Person Time} \\ \text{(\$ / hour)}\end{matrix} \times \begin{matrix}\text{Vehicle} \\ \text{Occupancy} \\ \text{(pers/vehicle)}\end{matrix} \times \begin{matrix}\text{Annual} \\ \text{Conversion} \\ \text{Factor}\end{matrix} \qquad \text{(Eq. A-14)}$$

Passenger Vehicle Fuel Cost. Fuel cost due to congestion is calculated for passenger vehicles in Equation A-15. This is done by associating the wasted fuel, the percentage of the vehicle mix that is passenger, and the fuel costs.

$$\begin{matrix}\text{Annual} \\ \text{Fuel Cost}\end{matrix} = \begin{matrix}\text{Daily Fuel} \\ \text{Wasted} \\ \text{(Eq. A–13)}\end{matrix} \times \begin{matrix}\text{Percent of} \\ \text{Passenger} \\ \text{Vehicles}\end{matrix} \times \begin{matrix}\text{Gasoline} \\ \text{Cost}\end{matrix} \times \begin{matrix}\text{Annual} \\ \text{Conversion Factor}\end{matrix} \qquad \text{(Eq. A-15)}$$

Truck or Commercial Vehicle Delay Cost. The delay cost is an estimate of the value of lost time in commercial vehicles and the increased operating costs of commercial vehicles in congestion. Equation A-16 shows how to calculate the passenger vehicle delay costs that result from lost time.

$$\begin{matrix}\text{Annual Comm-Veh} \\ \text{Delay Cost}\end{matrix} = \begin{matrix}\text{Daily Comm Vehicle} \\ \text{Hours of Delay} \\ \text{(Eq. A-4)}\end{matrix} \times \begin{matrix}\text{Value of} \\ \text{Comm Vehicle Time} \\ \text{(\$ / hour)}\end{matrix} \times \begin{matrix}\text{Annual} \\ \text{Conversion} \\ \text{Factor}\end{matrix} \qquad \text{(Eq. A-16)}$$

Truck or Commercial Vehicle Fuel Cost. Fuel cost due to congestion is calculated for commercial vehicles in Equation A-16. This is done by associating the wasted fuel, the percentage of the vehicle mix that is commercial, and the fuel costs.

$$\begin{matrix}\text{Annual} \\ \text{Fuel Cost}\end{matrix} = \begin{matrix}\text{Daily Fuel} \\ \text{Wasted} \\ \text{(Eq. A–13)}\end{matrix} \times \begin{matrix}\text{Percent of} \\ \text{Commercial} \\ \text{Vehicles}\end{matrix} \times \begin{matrix}\text{Diesel} \\ \text{Cost}\end{matrix} \times \begin{matrix}\text{Annual} \\ \text{Conversion Factor}\end{matrix} \qquad \text{(Eq. A-17)}$$

Total Congestion Cost. Equation A-18 combines the cost due to travel delay and wasted fuel to determine the annual cost due to congestion resulting from incident and recurring delay.

$$\begin{matrix}\text{Annual Cost} \\ \text{Due to} \\ \text{Congestion}\end{matrix} = \left(\begin{matrix}\text{Annual Passenger} \\ \text{Vehicle Delay Cost} \\ \text{(Eq. A-14)}\end{matrix} + \begin{matrix}\text{Annual Passenger} \\ \text{Fuel Cost} \\ \text{(Eq. A-15)}\end{matrix}\right) + \begin{matrix}\text{Annual Comm} \\ \text{Veh Delay Cost} \\ \text{(Eq. A-16)}\end{matrix} + \begin{matrix}\text{Annual Comm} \\ \text{Veh Fuel Cost} \\ \text{(Eq A-17)}\end{matrix} \qquad \text{(Eq. A-18)}$$

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 3) database has truck commodity values that originate and end in 131 regions of the U.S. The database contains a 131 by 131 matrix of truck goods movements (tons and dollars) between these regions. Using just the value of the commodities that originate within the 131 regions, the value of the commodities moving within the 131 regions is determined (if the value of the commodities destined for the 131 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-3 is 2007 with estimates of commodity values in 2010 through 2040 in 5-year increments.

Step 2 – Truck VMT Percentages. The HPMS state truck VMT percentages are calculated in Equation A-19 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.

$$\begin{matrix}\text{State Truck}\\ \text{VMT Percentage}\end{matrix} = \left(\frac{\text{State Truck VMT}}{\text{U.S. Truck VMT}}\right) \times 100\% \qquad \text{(Eq. A-19)}$$

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 A-20. The rural truck VMT percentage for each state is shown in Equation A-21.

$$\begin{matrix}\text{State Urban}\\ \text{Truck VMT Percentage}\end{matrix} = \left(\frac{\begin{matrix}\text{State Urban}\\ \text{Truck VMT}\end{matrix}}{\begin{matrix}\text{State Truck}\\ \text{VMT}\end{matrix}}\right) \times 100\% \qquad \text{(Eq. A-20)}$$

$$\begin{matrix}\text{State Rural Truck}\\ \text{VMT Percentage}\end{matrix} = 100\% - \begin{matrix}\text{State Urban Truck}\\ \text{VMT Percentage}\end{matrix} \qquad \text{(Eq. A-21)}$$

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 A-20).

$$\begin{matrix}\text{Urban Area Truck}\\ \text{VMT Percentage}\end{matrix} = \left(\frac{\begin{matrix}\text{Urban Area}\\ \text{Truck VMT}\end{matrix}}{\begin{matrix}\text{State Urban}\\ \text{Truck VMT}\end{matrix}}\right) \qquad \text{(Eq. A-22)}$$

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.

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

$$\begin{matrix}\text{State Rural Truck}\\ \text{VMT-Based}\\ \text{Commodity Value}\end{matrix} = \begin{matrix}\text{U.S. Truck}\\ \text{Commodity Value}\end{matrix} \times \begin{matrix}\text{State Rural}\\ \text{Truck Percentage}\end{matrix} \qquad \text{(Eq. A-24)}$$

$$\text{Urban Area Truck VMT-Based Commodity Value} = \text{State Urban Truck VMT-Based Commodity Value} \times \text{Urban Area Truck VMT Percentage} \qquad \text{(Eq. A-25)}$$

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 131 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 A-26 and A-27, 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 A-28 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 A-29).

$$\text{FAF Region O/D-Based Commodity Value \%} = \left(\frac{\text{FAF Region O/D-Based Commodity Value}}{\text{U.S. O/D-Based Commodity Value}} \right) \times 100\% \qquad \text{(Eq. A-26)}$$

$$\text{FAF Region O/D-Based Commodity Value} = \text{FAF Region O/D-Based Commodity Value \%} \times \text{U.S. O/D-Based Commodity Value} \qquad \text{(Eq. A-27)}$$

$$\text{O/D-Based Commodity Value for State 1} = \text{FAF Region 1 Value from State 1} + \text{FAF Region 2 Value from State 1} \qquad \text{(Eq. A-28)}$$

$$\text{Non-FAF Region Urban Area O/D-Based Commodity Value from State 1} = \text{Remaining Unassigned State 1 FAF O/D-Based Commodity Value} \times \left(\frac{\text{Non-FAF Urban Area Truck VMT Percentage}}{\text{Remaining Unassigned State 1 Truck VMT Percentage}} \right) \qquad \text{(Eq. A-29)}$$

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.

$$\begin{matrix}\text{Final Commodity}\\ \text{Value for}\\ \text{Urban Area}\end{matrix} = \left(\begin{matrix}\text{Urban Area}\\ \text{VMT-Based}\\ \text{Commodity Value}\end{matrix} + \begin{matrix}\text{Urban Area}\\ \text{O/D-Based}\\ \text{Commodity Value}\end{matrix}\right) \div 2 \qquad \text{(Eq. A-30)}$$

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-31). 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.

$$\begin{matrix}\text{Roadway}\\ \text{Congestion}\\ \text{Index}\end{matrix} = \frac{\begin{matrix}\text{Freeway}\\ \text{VMT/Ln. Mi.}\end{matrix} \times \begin{matrix}\text{Freeway}\\ \text{VMT}\end{matrix} + \begin{matrix}\text{Prin Art Str}\\ \text{VMT/Ln. Mi.}\end{matrix} \times \begin{matrix}\text{Prin Art Str}\\ \text{VMT}\end{matrix}}{14{,}000 \times \begin{matrix}\text{Freeway}\\ \text{VMT}\end{matrix} + 5{,}000 \times \begin{matrix}\text{Prin Art Str}\\ \text{VMT}\end{matrix}} \qquad \text{(Eq. A-31)}$$

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 A-12. 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 A-12. 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.

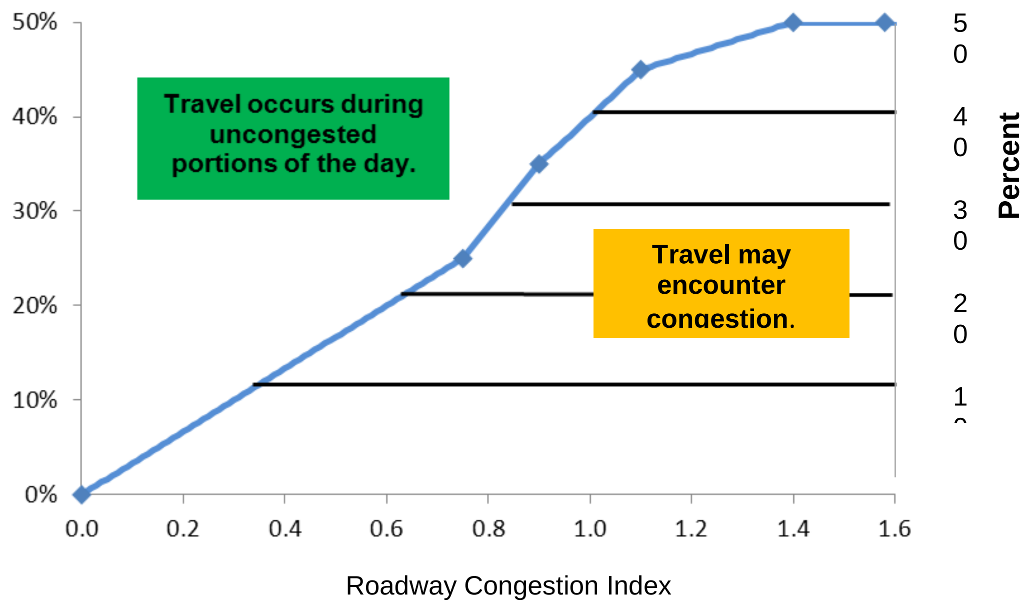
Percent of Daily and Peak Travel in Congested Conditions

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 2012 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 A-13 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 A-13 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 A-13. 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 A-32 and A-33), the amount of travel used is half of the daily total since the assumption is made that only 50 percent of daily travel occurs in the peak driving times. For the daily percentage (Equation A-34), the factor in the denominator is the daily miles of travel.

$$\begin{matrix}\text{Peak Period}\\\text{Congested Travel}\end{matrix} = \begin{matrix}\text{Percent of Congested}\\\text{Peak Period Travel}\end{matrix} \times \begin{matrix}\text{VMT for}\\\text{Roadway Type}\end{matrix} \qquad \text{(Eq. A-32)}$$

$$\begin{matrix}\text{Percent Congested}\\\text{Peak Period Travel}\end{matrix} = \begin{matrix}\text{Percent Congested}\\\text{Daily Travel}\end{matrix} \div 50 \text{ percent} \qquad \text{(Eq. A-33)}$$

$$\begin{matrix}\text{Percent Congested}\\\text{Daily Travel}\end{matrix} = \frac{\begin{matrix}\text{Freeway}\\\text{Congested Travel}\end{matrix} + \begin{matrix}\text{Arterial}\\\text{Congested Travel}\end{matrix}}{\text{Daily Travel}} \qquad \text{(Eq. A-34)}$$

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1 Federal Highway Administration. "Highway Performance Monitoring System," 1982 to 2010 Data. November 2012. Available: http://www.fhwa.dot.gov/policyinformation/hpms.cfm.

2 McFarland, W.F. M. Chui. "The Value of Travel Time: New Estimates Developed Using a Speed Choice Model." Transportation Research Record N. 1116, Transportation Research Board, Washington, D.C., 1987.

3 Ellis, David, "Cost Per Hour and Value of Time Calculations for Passenger Vehicles and Commercial Trucks for Use in the Urban Mobility Report." Texas Transportation Institute, 2009.

4 Populations Estimates. U.S. Census Bureau. Available: www.census.gov

5 2009 National Household Travel Survey, Summary of Travel Trends. Available: http://nhts.ornl.gov/index.shtml

6 American Automobile Association, Fuel Gauge Report. 2011. Available: www.fuelgaugereport.com

7 Means of Transportation to Work. American Community Survey 2009. Available: www.census.gov/acs/www

Appendix B

INCORPORATING THE EFFECT OF OPERATIONAL TREATMENTS – 101 URBAN AREAS

Many state and local transportation agencies, as well as the federal transportation program, have invested substantial funding in operational treatments and the future will include more of these programs in more cities. Technologies, operating practices, programs and strategies provide methods to get the most efficiency out of the road or transit capacity that is built, typically for relatively modest costs and low environmental effects. In some cases, the operational improvements are some of the few strategies that can be approved, funded and implemented.

For the Urban Mobility Report database, the operational treatments were assessed for the delay reduction that results from the strategy as implemented in the urban area. A separate report, *Six Congestion Reduction Strategies and Their Effects on Mobility*, describes the process of estimating the delay reduction in more detail. The ITS deployment analysis system (*1*) model was used as the basis for the estimates of the effect of the operational treatments. The ITS deployment database (*2*) and the Highway Performance Monitoring System (*3*) include data on the deployment of several operational improvements. These two databases provide the most comprehensive and consistent picture of where and what has been implemented on freeways and streets in urban areas.

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

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

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

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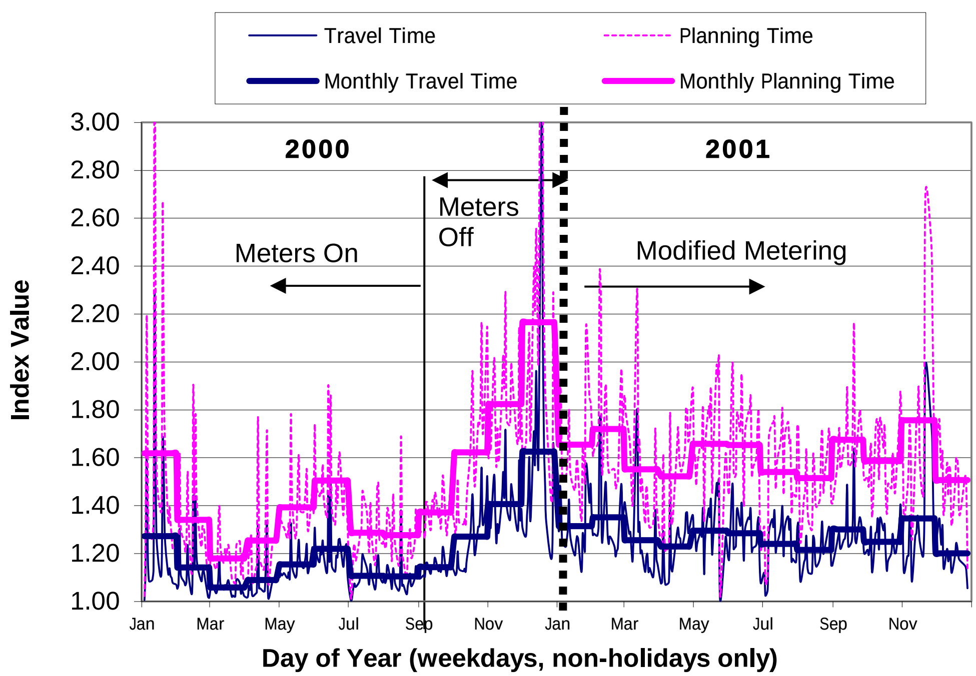
Freeway Entrance Ramp Metering

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

The effect of ramp metering was tested in Minneapolis-St. Paul in October 2000 when the extensive metering system was turned off and the freeway operated as it does in most other cities. The basic system was relatively aggressive in that ramp wait times of five minutes were not uncommon. The results of this systemwide experiment are clearly visible in the peak period data in Exhibit B-1. The Travel Time Index (average travel time) and the Planning Time Index (travel time that includes 19 out of every 20 trips) are plotted with each monthly average highlighted. Except for snowstorms, the highest values are during the shut-off experiment period. The metering experiment report produced by Cambridge Systematics (*4*) refers to a 22 percent increase in freeway travel time and the freeway system travel time becoming twice as unpredictable without the ramp meters. Congestion reductions are seen in January 2001 when a modified, less aggressive metering program was implemented. It might be interpreted that turning off the ramp meter system had the effect of a small snowstorm.

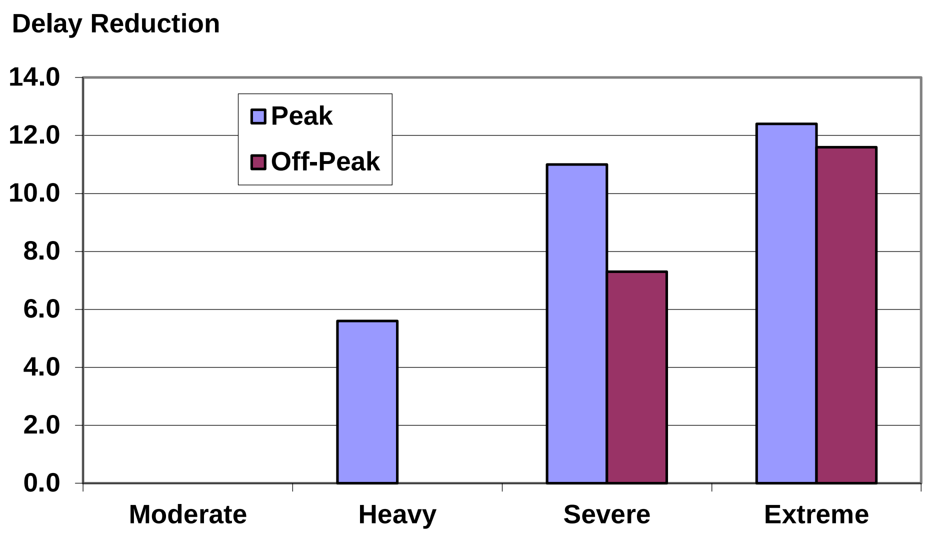
Exhibit B-1. Minneapolis-St. Paul Freeway System Congestion Levels



Delay Reduction Effects

The results of the Minneapolis experiment and simulation modeling performed for the Intelligent Transportation System Deployment Analysis System (IDAS) (*1*) have been combined into a relatively simple delay reduction estimation procedure for use in the Urban Mobility Report. Exhibit B-2 illustrates the delay reduction percentage for each of the four congestion ranges. More delay is subtracted from the more congested sections because there is more effect, particularly if the metering program can delay the beginning of stop-and-go conditions for some period of time.

Exhibit B-2. Ramp Metering Delay Reduction



Twenty-eight of the urban areas reported ramp metering on some portion of their freeway system in 2011 (*2*,*3*). The average metered distance was about one-quarter. The effect was to reduce delay by 39 million person hours (Exhibit B-3). This value is combined in the operational effects summary at the end of this section.

- Los Angeles has the largest delay reduction estimate in the Very Large group.
- Minneapolis-St. Paul has the most extensive metering benefits in the Large group.
- Of the 55 areas studied with under one million population, only two reported any metering.

Exhibit B-3. Freeway Ramp Metering Delay Reduction Benefits – 2011

Population Group	Percentage of Covered Freeway Lane-miles	Freeway Hours of Delay (million) Reduction
Very Large (15)	35	33.3
Large (32)	20	6.0
Medium (33)	2	0.2
Small (21)	0	0
101 Area Average	25	0.4
101 Area Total	25	39.4

Source: HPMS, IDAS, and TTI Analysis

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

Freeway Incident Management Programs

Freeway Service Patrol, Highway Angel, Highway Helper, The Minutemen and Motorists Assistance Patrol are all names that have been applied to the operations that attempt to remove crashed and disabled vehicles from the freeway lanes and shoulders. They work in conjunction with surveillance cameras, cell phone reported incident call-in programs and other elements to remove these disruptions and decrease delay and improve the reliability of the system. The benefits of these programs can be significant. Benefit/cost ratios from the reduction in delay between 3:1 and 10:1 are common for freeway service patrols (*5*). An incident management program can also reduce "secondary" crashes—collisions within the stop-and-go traffic caused by the initial incident. The range of benefits is related to traffic flow characteristics as well as to the aggressiveness and timeliness of the service.

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

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

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

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

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

Delay Reduction Effects

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

The results of incident management program evaluations conducted in several cities and simulation modeling performed for the Intelligent Transportation System Deployment Analysis System (IDAS) (*1*) have been used to develop a delay reduction estimation procedure. The process estimates benefits for monitoring cameras and service patrol vehicles (Exhibits B-4 and B-5) with the cameras receiving less benefit from the identification and verification actions they assist with than the removal efforts of the service patrol. As with the ramp metering programs, more delay is subtracted from the more congested sections because there is more effect.

Exhibit B-4. Benefits of Freeway Service Patrols

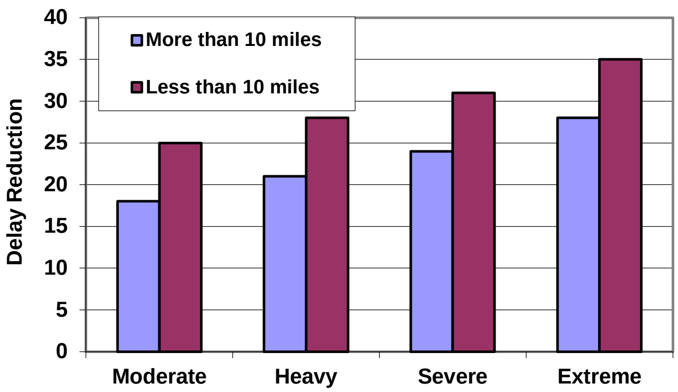
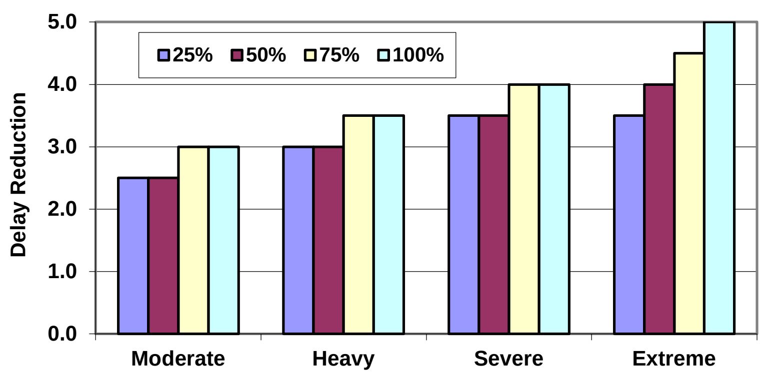


Exhibit B-5. Benefits of Freeway Surveillance Cameras



More than 85 areas reported one or both treatments in 2011, with the coverage representing from one-third to two-thirds of the freeway miles in the cities (*2,3*). The effect was to reduce delay by 150 million person hours (Exhibit B-6). This value is combined in the operational effects summary at the end of this section.

Incident Management

- The New York City and Los Angeles regions are estimated to derive the most benefit from incident management.
- Minneapolis-St. Paul and Baltimore are estimated to have the most benefit in the Large group.
- Bridgeport is the area within the Medium group with the highest delay reduction benefit.

Exhibit B-6. Freeway Incident Management Delay Reduction Benefits

Population Group	Percentage of Miles Covered Freeway Lane-miles	Freeway Hours of Delay (million) Delay Reduction
Surveillance Cameras		
Very Large (15)	60	Delay Reduction Included Below
Large (32)	52	
Medium (33)	30	
Small (21)	40	
101 Area Average	53	
101 Area Total	53	
Service Patrols		
Very Large (15)	82	110.3
Large (32)	68	32.5
Medium (33)	36	5.3
Small (21)	48	1.4
101 Area Average	70	1.5
101 Area Total	70	149.5

Source: HPMS, IDAS, and TTI Analysis

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

Traffic Signal Coordination Programs

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

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

Delay Reduction Estimates

Some of the delay reduction from signal coordination efforts that have been undertaken in the U.S. is the attention that is given to setting the signal timing to correspond to the current volume patterns and levels and to recalibrate the equipment. It is often difficult to identify how much of the benefit is due to this "maintenance" function and how much is due to the coordination program itself. The Urban Mobility Report methodology draws on the evaluations and simulation modeling performed for the Intelligent Transportation System Deployment Analysis System (IDAS) (*1*) to develop the delay reduction estimation procedure shown in Exhibits B-7 and B-8. There is less benefit for the more heavily congested sections of the street system due to the conflicting traffic flows and vehicle queues. The benefits of an actuated system (where the signals respond to demand) are about one-third of the benefits of a centrally controlled system that monitors and adapts the signals to changes in demand.

All 101 areas reported some level of traffic signal coordination in 2011, with the coverage representing slightly over half of the street miles in the cities (*2*,*3*). Signal coordination projects, because the technology has been proven, the cost is relatively low and the government institutions are familiar with the implementation methods, have the highest percentage of cities and road miles with a program. The evolution of programs is also evident in the lower percentage of advanced progressive systems. These systems require more planning, infrastructure, and agency coordination.

Exhibit B-7. Signal Coordination Benefits (actuated)

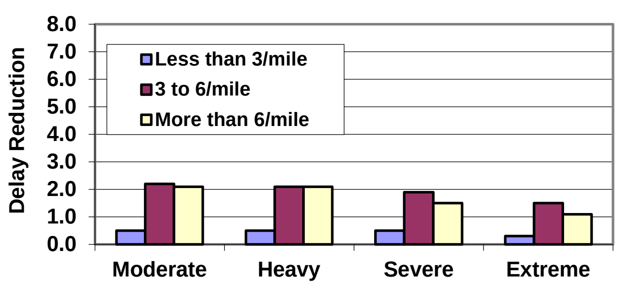
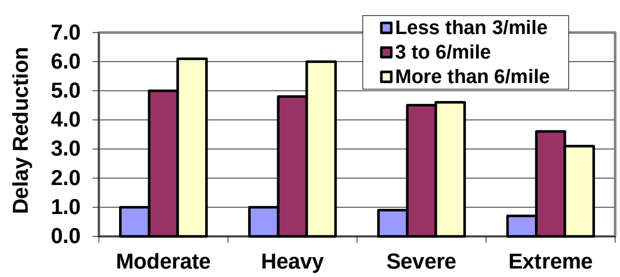


Exhibit B-8. Signal Coordination Benefits (progressive)



The effect of the signal coordination projects was to reduce delay by 24.7 million person hours, approximately one percent of the street delay (Exhibit B-9). This value is combined in the operational effects summary at the end of this section.

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

- Los Angeles and New York are the Very large areas with the highest benefits.
- Denver and Baltimore are the Large areas with the most hours of delay benefit from signal coordination in areas between one and three million population.
- Honolulu and Richmond in the Medium areas and Cape Coral in the Small areas lead their population group.

Exhibit B-9. Principal Arterial Street Traffic Signal Coordination Delay Reduction Benefits - 2011

Population Group	Percentage of Mileage Covered Lane-miles	Principal Arterial Hours of Delay (million) Reduction
Very Large (15)	67	14.7
Large (32)	58	6.2
Medium (33)	54	3.1
Small (21)	53	0.7
101 Area Average	62	0.2
101 Area Total	62	24.7

Source: HPMS, IDAS, and TTI Analysis

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

Arterial Street Access Management Programs

Providing smooth traffic flow and reducing collisions are the goal of a variety of individual treatments that make up a statewide or municipal access management program. Typical treatments include consolidating driveways to minimize the disruptions to traffic flow, median turn lanes or turn restrictions, acceleration and deceleration lanes and other approaches to reduce the potential collision and conflict points. Such programs are a combination of design standards, public sector regulations and private sector development actions. The benefits of access management treatments are well documented in National Cooperative Highway Research Program (NCHRP) Report 420 (*6*).

Delay Reduction Estimates

NCHRP Report 395 analyzed the impacts of going from a TWLTL to a raised median for various access point densities and traffic volumes (*7*). Tables produced in NCHRP Report 395 were used in the Urban Mobility Report methodology to obtain delay factors for both recurring and incident delay.

There is an increase in recurring delay for through and left-turning traffic when going from a TWLTL to a raised median. This increase is primarily due to the storage limitations of select turn bay locations with the raised median treatments. As the turn bays become full, traffic spills out into the through lanes and increases the delay of through vehicles. This situation worsens with increased congestion levels and increased signal density (*8*). The percent increase factors shown in Exhibit B-10 are applied to the recurring delay on the principal arterial streets to account for this increased delay.

Raised medians can increase roadway safety by reducing the number of conflict points and managing the location of the conflict points. The reduction in conflict points equates to a reduction in crashes. This benefit of the raised medians was included in the methodology. The delay factors were generated for roadways going from a TWLTL to a raised median. Exhibit B-11 shows the percent reduction factors that range from 12 percent at low signal density (≤ signals/mile) and the lowest congestion level to 22 percent at high signal density (>3 signals/mile) and the highest congestion level (*7*). These percent reduction values are applied to the incident delay on the principal arterial streets in the methodology.

All 101 areas reported some level of access management in 2011, with the coverage representing about 33 percent of the street miles in the cities (*3,9*). The effect of access management was to reduce delay by 85 million person hours (Exhibit B-24). The percent reduction drops as the size of the urban area gets smaller.

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

Exhibit B-10. Access Management Recurring Delay Effects

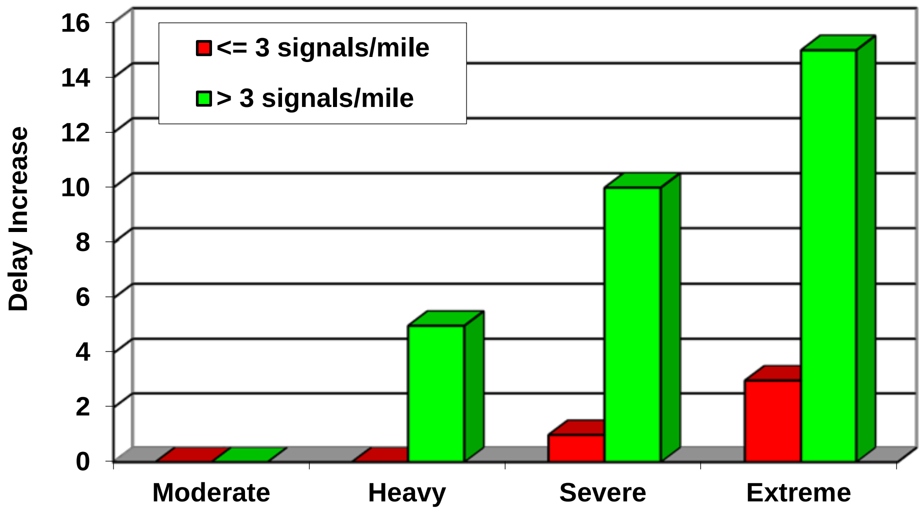
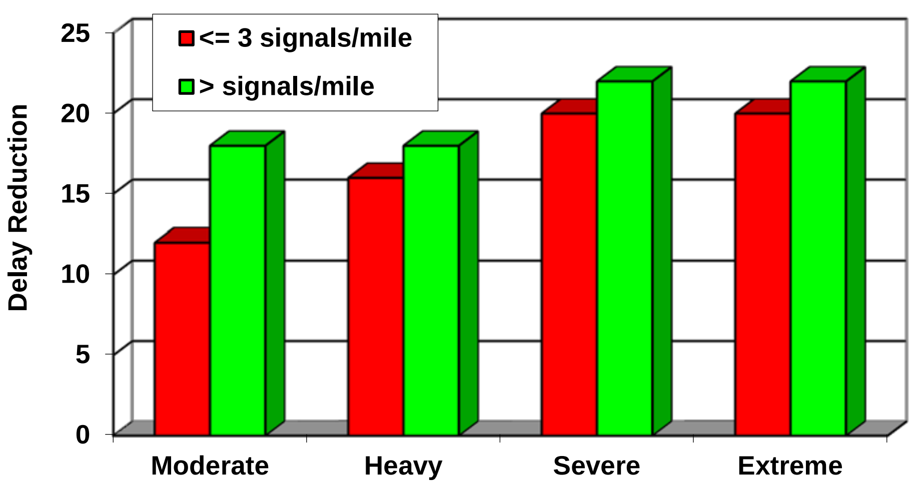


Exhibit B-11. Access Management Incident Delay Effects



Source: (*7*) and Texas A&M Transportation Institute Analysis

Exhibit B-12. Principal Arterial Street Access Management Delay Reduction Benefits

Population Group	Percentage of Mileage Covered Lane-miles	Principal Arterial Hours of Delay (million) Reduction
Very Large (15)	37	52.1
Large (32)	32	22.8
Medium (33)	26	7.7
Small (21)	19	2.0
101 Area Average	33	0.8
101 Area Total	33	84.7

Source: HPMS and TTI Analysis

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

Combined Effect of Operational Treatments

The delay reduction benefits of four operational treatments analyzed in this edition of the Urban Mobility Report are combined into an estimate of the total effect of the deployed projects in the 101 urban areas. The inventory of all projects is identified in Exhibit B-13 by the percentage of miles on freeways and streets that have one of the programs or projects implemented.
Exhibit B-13 shows the relatively low percentage of not only cities that have some treatments but also the low percentage of roads that have any treatment.

The total effect of the delay reduction programs represents about 6 percent of the delay in the 101 cities. Again, the value seems low but when the low percentage of implementation is factored in, the benefit estimates are reasonable. The programs are also important in that the benefits are on facilities that have been constructed. The operating improvements represent important efficiencies from significant expenditures that have already been made.

Exhibit B-13. Total Operational Improvement Delay Reduction

Operations Treatment	Number of Cities	Percent of System Covered	Delay Reduction Hours (millions)
Ramp Metering	28	25	39
Incident Management	85	53-70	150
Signal Coordination	101	62	25
Access Management	101	33	85

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

MOBILITY BENEFITS FROM PUBLIC TRANSPORTATION SERVICE

Buses and trains carry a significant number of trips in many large areas, and provide important benefits in many smaller ones. Peak period public transportation service during congested hours can improve the transportation capacity, provide options for travel mode and allow those without a vehicle to gain access to jobs, school, medical facilities, and other destinations. In the case of public transportation lines that do not intersect roads, the service can be particularly reliable as they are not affected by the collisions and vehicle breakdowns that plague the roadway system and are not as affected by weather, road work, and other unreliability-producing events. Early versions of the Urban Mobility Report included examples of the amount of public transportation improvements needed to address congestion. Later versions included public transportation service in the general measures and analysis. This paper provides an estimate of the mobility benefits associated with general public transportation service.

Public Transportation Service

The Urban Mobility Report methodology for roadways uses person volume and speed as the two main elements of the measurement analysis (*10*). While this is consistent with the goals of the public transportation service, there are differences between several aspects of road and transit operations. Regular route bus transit service stops frequently to allow riders to enter and leave the vehicles. Train service in many cases also makes more than one stop per mile. The goal of the service is to provide access to the area near the stops as well as move passengers to other destinations. A comparison with road transportation systems, therefore, cannot use the same standards or comparison methods.

The data sources for this type of analysis are a combination of locally collected and nationally consistent information. The nationally consistent public transportation data is supplied by the American Public Transportation Association (APTA) and includes ridership, passenger miles of travel, service mileage and hours (*11*). Consistent roadway data, in the form of the Highway Performance Monitoring System (HPMS) from Federal Highway Administration (FHWA) is available for similar statistics, but the relationship between volume and speed on the roadway side is more studied and more easily estimated than for the transit service (*3*). Some simplifying assumptions have been made to initiate the analysis. There is an ongoing effort to improve the data and statistics in order to reduce the number of assumptions that are needed, as well as improving the estimates that are made.

The Mobility Measures

Travel Delay Savings

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

Travel Time Index

The method used in this analysis to estimate a revised Travel Time Index focuses on "similar expectations". Transit service is operated according to a schedule. When buses and trains stop to pick up and discharge passengers, their average speed is generally slower than vehicles on the road. Riders and potential riders evaluate the service and make choices according to either the departure and arrival times or in the case of operations that run very frequently, the travel time to the destination with the expectation that the departure time will be relatively soon after arrival in the station. In transit operations this can be thought of as similar to an uncongested roadway trip. Public transportation service that operates on-time according to the schedule, then, would be classified by the patrons as uncongested roadway travel.

It may seem odd to disregard travel speed in this sense, but the service differences are important. Attempting to estimate the slower speeds on transit routes and incorporating them into the analysis would, in essence, double penalize the service. Many travelers already use the longer travel times to make their decision to not use transit and the longer times are one of the reasons ridership is relatively low during off-peak hours. Transit routes could gain speed by decreasing stops, but at the risk of losing ridership. This relationship between speed and convenience is constantly adjusted by transit agencies seeking to increase transit performance and ridership. Our approach to defining a different standard for transit routes is similar to the different speed threshold used for surface streets and freeways.

The "reward" for public transportation in this revised Travel Time Index estimate comes from gain in ridership and on-time operation. If the route travel times become unreasonably long, ridership will decline, and the amount of "uncongested" passenger-miles contributed by public transportation will also decline. The beneficial effects of faster route times, better access or improved service from interconnected networks or high-speed bus or rail links would result in higher ridership values, which would increase the amount of "uncongested" travel in the mobility measure calculations.

Revisions to Public Transportation Methodology

Since the release of the *2003 Urban Mobility Report* (UMR) the Texas Transportation Institute (TTI) has included several statistics that show the estimated reduction in traffic congestion attributed to public transportation. Following the release of the *2007 Urban Mobility Report*, the decision was made to take an in-depth look at the public transportation methodology to determine if any improvements could be made to the statistics produced in the analysis. The American Public Transportation Association (APTA) provided financial resources and industry contacts to this effort in addition to the transit statistics necessary to produce the congestion estimates. Three key items were identified for improvement.

- Incorporate transit modal share—determine the percentage of transit travel associated with bus, light rail, heavy rail, and commuter rail in each urban area.
- Transit ridership in the peak periods—determine the amount of daily transit travel occurring in the peak commuting periods.
- Account for location of transit routes on the roadway network—determine how to account for the fact that transit routes often operate in congested roadway corridors.

Incorporate Transit Modal Share

The purpose for this addition to the methodology is to allow the ridership from the different public transportation modes to be assigned to specific roadway functional classes based on the type of service provided by the mode. The modal share information is obtained from the public transportation operating statistics (*11*) supplied annually by APTA for inclusion into the Urban Mobility Report analysis. The passenger-miles of travel for each urban area are classified as light rail, heavy rail, commuter rail, or bus. No differentiation is made between service that is owned by the company and service that is purchased. Any other mode is placed in the bus category. These other modes include service such as vanpools and taxis. The reason for placing these into the bus category is that the service uses the surface streets and provides a similar type of service as buses.

- The transit vehicle-miles of travel from commuter rail are assigned to freeways because commuter rail typically travels longer distances into centrally located activity centers similar to freeway commuting. Arterial streets tend to handle shorter commutes than the freeway system, therefore, none of the commuter rail travel is assigned to the arterial streets.
- Travel from the remainder of the modes—light rail, heavy rail, and bus—is assigned to the roadway system in the same proportions that already exist on the roadway. For example, if 60 percent of the roadway travel in a city occurs on the freeway system, then 60 percent of the light rail, heavy rail, and bus travel is added to the freeway system and 40 percent of the transit travel is assigned to the arterial streets.

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

Public Transportation Ridership in the Peak Periods

The peak period transit ridership statistics were obtained from APTA who conducted a survey of the transit companies operating in approximately twenty urban areas across the U.S. APTA surveyed the majority of the Very Large urban areas—those with populations over 3 million—because the transit companies in these larger regions comprise a significant percentage of the public transportation usage in the U.S. Surveys were only sent to a sample of transit companies in the smaller urban area population groups to create a representative set of statistics that can be applied to all urban areas of similar size. Exhibit B-14 shows the results of the survey.

In some cases, an incomplete survey was returned to APTA by a transit agency. The transit agency may have reported a peak period modal share for one or two rail modes operating in their area but not all of the rail modes. In some areas, the survey was not returned by all transit operators. When this occurred, the urban area was assigned the average response for the modes from returned surveys. An area was assigned the population group average when no information was submitted.

Exhibit B-14. Peak Period Ridership Percentages by Mode

Urban Area	Percentage of Daily Modal Ridership in Peak Period			
	Bus	Commuter Rail	Heavy Rail	Light Rail
Very Large Area Average	60	75	65	60
	58	--	59	--
Atlanta	63	75	61	63
Boston	59	83	67	--
Chicago	60	74	--	68
Dallas-Fort Worth	65	--	63	63
Los Angeles	56	65	73	--
New York	70	--	68	--
Philadelphia	62	68	81	58
San Francisco-Oakland	63	75	--	60
Seattle	--	--	59	--
Washington DC				
Large Area Average	55	75	65	60
Denver	55	--	--	60
San Jose	55	--	--	55
Medium and Small Area Average	55	75	65	55
Charleston	54	--	--	--
Colorado Springs	54	--	--	--
Grand Rapids	55	--	--	--

Notes: -- denotes data are unavailable
Very Large Areas have populations over 3 million
Large Areas have populations between 1 and 3 million
Medium and Small Areas have populations under 1 million

Location of Public Transportation Routes

Many of the public transportation routes either utilize or run parallel to congested roadway corridors. In the prior version of the methodology, transit travel was assigned to all roadways throughout the urban area rather than being placed onto more congested corridors. Areas of a city that had little or no transit service were assigned some of the transit travel from portions of the city which had significant transit service. In reality, if transit service were eliminated, some traffic would shift to other corridors but much of it would continue to use the same corridor because of proximity to homes and jobs. In order to account for the location of transit routes along these congested corridors, researchers used two steps to alter the approach from "spread the transit travel like the road travel" to "peak period travel is more concentrated on highly traveled and congested corridors to major job centers."

Transit Travel on Congested Roads

Exhibit B-15 shows how the additional travel is added in urban areas with a range of congested roadways. For example, Urban Area 2 has roadway travel in the moderate, heavy, and severe congestion levels. The additional transit travel would be added only in the heavy and severe congestion levels to replicate the heavier congestion levels on transit routes. The percentage of transit travel assigned to uncongested roadways would be the same as with existing road travel. Thus, the same amount of transit travel is assigned to the roadway network as the previous methodology, but now it is applied to some of the more congested roadways.

Exhibit B-15. Accounting for Location of Transit Service on Roadway Network

Example Urban Area	Existing Roadway Travel by Congestion Level				Roadway Travel Following Addition of Transit Travel by Congestion Level			
	Moderate	Heavy	Severe	Extreme	Moderate	Heavy	Severe	Extreme
Area 1	X	X	X	X	X	X + T	X + T	X + T
Area 2	X	X	X		X	X + T	X + T	
Area 3	X	X			X	X + T		
Area 4	X				X + T			

Note: 'X' denotes existing roadway travel, 'T' denotes transit travel that is added to roadway system

Effect of Transit Travel

Another change to the previous methodology was to adjust the way the transit travel is added to roadways in the various congestion levels. Exhibit B-16 shows the traffic densities associated with the five congestion levels—uncongested, moderate, heavy, severe, and extreme—for both the freeways and arterial streets. If the additional transit travel assigned to a level causes the traffic density to surpass the highest traffic density allowed in that level, the amount of the travel above the highest allowable traffic density is allowed to "spill over" into the next more congested level. For example, if the average VMT per lane-mile in the freeway heavy congestion level is 19,970 and the additional transit travel assigned to the heavy level increases this average to 20,050, the 50 VMT per lane-mile "spills" into the severe level to lower the heavy level average to 20,000 (the ceiling for the heavy freeway level). The effect of this "spillage" is that the travel that shifts into the severe bin would be subjected to lower speeds (more delay) than the travel in the heavy level.

Exhibit B-16. Congestion Level Bins and Traffic Density

Functional Class and Traffic Density (VMT/Lane-mile)	Traffic Density by Congestion Level				
	Uncongested	Moderate	Heavy	Severe	Extreme
Freeways	under 15,000	15,000 to 17,499	17,500 to 19,999	20,000 to 24,999	over 25,000
Arterial Streets	under 5,500	5,501 to 6,999	7,000 to 8,499	8,500 to 9,999	over 10,000

In a perfect world, the transit travel would be assigned to the corridors where the transit service was provided and the traffic volumes on the roadway would be adjusted accordingly. The methodology used to produce the Urban Mobility Report, however, does not function at such a microscopic level. The two changes that deal with location of transit service provide a first step at emulating where much of the transit travel occurs and what would happen if the additional travel was added to roadways that are already congested.

Summary of Changes

Exhibit B-17 shows the steps for calculating the traffic delay reduction provided by public transportation. The Urban Mobility Report methodology has the following features for calculating the delay reduction effects of public transportation.

- Public transportation ridership is assigned to the roadway system based on the travel in each of the existing transit modes.
- The percentage of the daily public transportation ridership that occurs in the peak periods is used in the roadway delay calculations.
- Public transportation ridership is assigned to more congested roadways to estimate the effect of public transportation routes that utilize congested roadway corridors.

Exhibit B-17. Changes to the Urban Mobility Report Methodology

Computation Step	2012 Urban Mobility Report
1. Convert annual transit passenger-miles of travel (PMT) to daily vehicle-miles of travel (VMT)	Passenger miles / 300 days / 1.25 persons per auto = transit daily VMT
2. Assign VMT from Step 1 to transit mode	Using mode splits in APTA transit ridership report, assign VMT to commuter rail, heavy rail, light rail, or bus
3. Assign VMT to roadway facility	Assign modal VMT from Step 2 to freeways and arterials. Commuter Rail VMT is assigned entirely to freeways. The other 3 modes are assigned to freeways and arterials based on existing VMT proportions.
4. Re-calculate percentage of travel occurring in peak periods	Re-calculate with additional transit travel added to roadways (Unchanged)
5. Calculate amount of transit VMT added to existing roadway VMT	Use results from survey of transit companies by APTA to determine percentage of ridership by mode occurring in peak periods
6. Assign transit VMT to congestion levels (buckets)	Assign transit travel for moderate congestion category to more congested categories unless moderate is only current roadway congestion level.
7. Add peak period transit VMT to existing roadway VMT	Add transit VMT to road VMT based on results of Step 6 and allow for travel to spill over into more congested levels.
8. Re-calculate peak period operating speeds	Use combined volumes from Steps 6 and 7
9. Re-calculate delay	Use combined volumes and new speeds to calculate delay

Summary of the Mobility Effects of Public Transportation

The mobility effects from public transportation are shown for the key performance measure—travel delay. The travel delay shows an estimate of the amount of additional delay that would occur if public transportation did not exist and the transit riders were added onto the roadways.

Travel Delay

Exhibit B-18 shows that in the 498 urban areas studied, there were approximately 56 billion passenger-miles of travel on public transportation systems in 2011. The annual average ridership ranged from about 21 million passenger-miles in the Small urban areas to about 2.9 billion in the Very Large areas. Overall, if these riders were not handled on public transportation systems they would contribute an additional roadway delay of almost 865 million hours or about a 15 percent increase in the total delay. Some additional effects include:

- The range of benefits derived from public transportation in the 101 intensely studied urban areas ranged from about 24 percent in the Very Large Urban Areas down to about 3 percent in the Small Areas.
- Of the 865 million hours of potential extra delay, 816 million are in the 101 urban areas studied in detail.

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

Exhibit B-18. Delay Increase if Public Transportation Service Were Eliminated – 498 Areas

Population Group and Number of Areas	Population Group Average Annual Passenger-miles of Travel (million)	Delay Reduction Due to Public Transportation	
		Hours of Delay (million)	Percent of Base Delay
Very Large (15)	2,880	721	24
Large (32)	200	80	5
Medium (33)	48	12	3
Small (21)	21	3	3
101 Area Total	51,653	816	20
Other Areas (338)	4,357	49	6
All Areas	56,010	865	15

Source: (*11*) and TTI Analysis

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