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2015 URBAN MOBILITY Scorecard

Texas A&M
Transportation
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INRIX

2015 URBAN MOBILITY SCORECARD

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Table of Contents

Page

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2015 Urban Mobility Scorecard

The national congestion recession is over. Urban areas of all sizes are experiencing the challenges seen in the early 2000s – population, jobs and therefore congestion are increasing. The U.S. economy has regained nearly all of the 9 million jobs lost during the recession and the total congestion problem is larger than the pre-recession levels. For the report and congestion data on your city, see: http://mobility.tamu.edu/ums.

The data from 1982 to 2014 (see Exhibit 1) show that, short of major economic problems, congestion will continue to increase if projects, programs and policies are not expanded.

- The problem is very large. In 2014, congestion caused urban Americans to travel an extra 6.9 billion hours and purchase an extra 3.1 billion gallons of fuel for a congestion cost of $160 billion. Trucks account for $28 billion (17 percent) of that cost, much more than their 7 percent of traffic.
- From 2013 to 2014, 95 of America's 100 largest metro areas saw increased traffic congestion, from 2012 to 2013 only 61 cities experienced increases.
- In order to reliably arrive on time for important freeway trips, travelers had to allow 48 minutes to make a trip that takes 20 minutes in light traffic.
- Employment was up by more than 500,000 jobs from 2013 to 2014 (*1*); if transportation investment continues to lag, congestion will get worse. Exhibit 2 shows the historical national congestion trend.
- More detailed speed data on more roads and more hours of the day from INRIX (*2*) a leading private sector provider of travel time information for travelers and shippers, have caused congestion estimates in most urban areas to be higher than in previous *Urban Mobility Scorecards*.

The best mobility improvement programs involve a mix of strategies – adding capacity of all kinds, operating the system to get the 'best bang for the buck,' travel and work schedule options and encouraging homes and jobs to be closer. This involves everyone - agencies, businesses, manufacturers, commuters and travelers. Each region should use the **combination of strategies that match its goals and vision**. The recovery from economic recession has proven that the problem will not solve itself.

Exhibit 1. Major Findings of the *2015 Urban Mobility Scorecard* (471 U.S. Urban Areas)

(Note: See page 2 for description of changes since the 2012 report)

Measures of…	**1982**	**2000**	**2010**	**2013**	**2014**
… Individual Congestion					
Yearly delay per auto commuter (hours)	18	37	40	42	42
Travel Time Index	1.09	1.19	1.20	1.21	1.22
Planning Time Index (Freeway only)	--	--	--	--	2.41
"Wasted" fuel per auto commuter (gallons)	4	15	15	19	19
Congestion cost per auto commuter (2014 $)	$400	$810	$930	$950	$960
… The Nation's Congestion Problem					
Travel delay (billion hours)	1.8	5.2	6.4	6.8	6.9
"Wasted" fuel (billion gallons)	0.5	2.1	2.5	3.1	3.1
Truck congestion cost (billions of 2014 dollars)	--	-	--	--	$28
Congestion cost (billions of 2014 dollars)	$42	$114	$149	$156	$160

Yearly delay per auto commuter – The extra time spent during the year 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.

Planning Time Index (PTI) – The ratio of travel time on the worst day of the month to travel time in free-flow conditions.

Wasted fuel – Extra fuel consumed during congested travel.

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

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Truck congestion cost - The yearly value of operating time and wasted fuel for commercial trucks.

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Exhibit 2. National Congestion Measures, 1982 to 2014

Year	Travel Time Index	Delay Per Commuter (Hours)	Total Delay (Billion Hours)	Fuel Wasted (Billion Gallons)	Total Cost (Billions of 2014 Dollars)
2014	1.22	42	6.9	3.1	$160
2013	1.21	42	6.8	3.1	$156
2012	1.21	41	6.7	3.0	$154
2011	1.21	41	6.6	2.5	$152
2010	1.20	40	6.4	2.5	$149
2009	1.20	40	6.3	2.4	$147
2008	1.21	42	6.6	2.4	$152
2007	1.21	42	6.6	2.8	$154
2006	1.21	42	6.4	2.8	$149
2005	1.21	41	6.3	2.7	$143
2004	1.21	41	6.1	2.6	$136
2003	1.20	40	5.9	2.4	$128
2002	1.20	39	5.6	2.3	$124
2001	1.19	38	5.3	2.2	$119
2000	1.19	37	5.2	2.1	$114
1999	1.18	36	4.9	2.0	$106
1998	1.18	35	4.7	1.8	$101
1997	1.17	34	4.5	1.7	$97
1996	1.17	32	4.2	1.6	$93
1995	1.16	31	4.0	1.5	$87
1994	1.15	30	3.8	1.4	$82
1993	1.15	29	3.6	1.4	$77
1992	1.14	28	3.4	1.3	$73
1991	1.14	27	3.2	1.2	$69
1990	1.13	26	3.0	1.2	$65
1989	1.13	25	2.8	1.1	$62
1988	1.12	24	2.7	1.0	$58
1987	1.12	23	2.5	0.9	$55
1986	1.11	22	2.4	0.8	$52
1985	1.11	21	2.3	0.7	$51
1984	1.10	20	2.1	0.6	$48
1983	1.10	19	2.0	0.5	$45
1982	1.09	18	1.8	0.5	$42

Notes:
See Exhibit 1 for explanation of measures.
For more congestion information and for congestion information on your city, see Tables 1 to 3 and http://mobility.tamu.edu/ums.

Turning Congestion Data Into Insight

(And the New Data Providing a More Accurate View)

The *2015 Urban Mobility Scorecard* is the 4th that TTI and INRIX (*2*) have prepared. The data behind the *2015 Urban Mobility Scorecard* 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 of the week. For the congestion analyst, this means 900 million speeds on 1.3 million miles of U.S. streets and highways – 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.

Key aspects of the *2015 Urban Mobility Scorecard* are summarized below.

- Congestion estimates are presented for each of the 471 U.S. urban areas. Improvements in the INRIX traffic speed data and the data provided by the states to the Federal Highway Administration (*3*) means that for the first time the *Urban Mobility Scorecard* can provide an estimate of the congestion effects on residents of every urban area.
- Speeds collected by INRIX every 15 minutes from a variety of sources every day of the year on almost every major road are used in the study. The data for all 96 15-minute periods of the day makes it possible to track congestion problems for the midday, overnight and weekend time periods. For more information about INRIX, go to www.inrix.com.
- This data improvement created significant difference in congestion estimates compared with past *Reports/Scorecards* – more congestion overall, a higher percentage of congestion on streets and different congestion estimates for many urban areas. As has been our practice, past measure values were revised to provide our best estimate of congestion trends.
- More detail is provided on truck travel and congestion. Estimates of truck volume during the day were developed (in past reports, trucks were assumed to have the same patterns as cars travel). This changed delay and fuel estimates in different ways for several cities.
- The measure of the variation in travel time from day-to-day now uses a more representative trip-based process (*4*) rather than the old dataset that used individual road links. The Planning Time Index (PTI) is based on the idea that travelers want to be on-time for an important trip 19 out of 20 times; so one would be late to work only one day per month (on-time for 19 out of 20 work days each month). For example, a PTI value of 1.80 indicates that a traveler should allow 36 minutes to make an important trip that takes 20 minutes in low traffic volumes. The new values are lower, and closer to real-world experience.
- Many of the slow speeds that were formerly considered ‘too slow to be a valid observation’ are now being retained in the INRIX dataset. Experience and increased travel speed sample sizes have increased the confidence in the data.
- Where speed estimates are required, the estimation process is benefitting from the increased number of speeds in the dataset. The methodology is described on the mobility study website (*5*).

More information on the performance measures and data can be found at:
http://mobility.tamu.edu/methodology/

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One Page of Congestion Problems

In the biggest regions and most congested corridors, traffic jams can occur at any hour, weekdays or weekends. The problems that travelers and shippers face include extra travel time, extra cost from wasted fuel and lost productivity and increasing unreliability where bad weather, roadwork, a malfunctioning traffic signal, a local event or a small accident or stalled vehicle can result in major delays. Some key measures 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 the 471 U.S. urban areas was (all values in constant 2014 dollars):

- In 2014 – $160 billion
- In 2000 – $114 billion
- In 1982 – $42 billion

Congestion wastes a massive amount of time, fuel and money. In 2014:

- 6.9 billion hours of extra time (more than the time it would take to drive to Pluto and back, if there was a road).
- 3.1 billion gallons of wasted fuel (more than 90 minutes worth of flow in the Missouri River).
- …and if all that isn't bad enough, folks making important trips had to plan for nearly 2 ½ 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 type of tax

- $160 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) (equivalent to the lost productivity, clinic visit and medication costs for 53 million cases of poison ivy).
- 18 percent ($28 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 auto commuter was $960 in 2014 compared to an inflation-adjusted $400 in 1982.

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

- Spent an extra 42 hours traveling in 2014 up from 18 hours in 1982.
- Wasted 19 gallons of fuel in 2014 – a week's worth of fuel for the average U.S. driver – up from 4 gallons in 1982.
- In areas with over one million persons, 2014 auto commuters experienced:
    - an average of 63 hours of extra travel time
    - a road network that was congested for 6 hours of the average weekday
    - had a congestion tax of $1,440

Congestion is also a problem at other hours.

- Approximately 41 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.

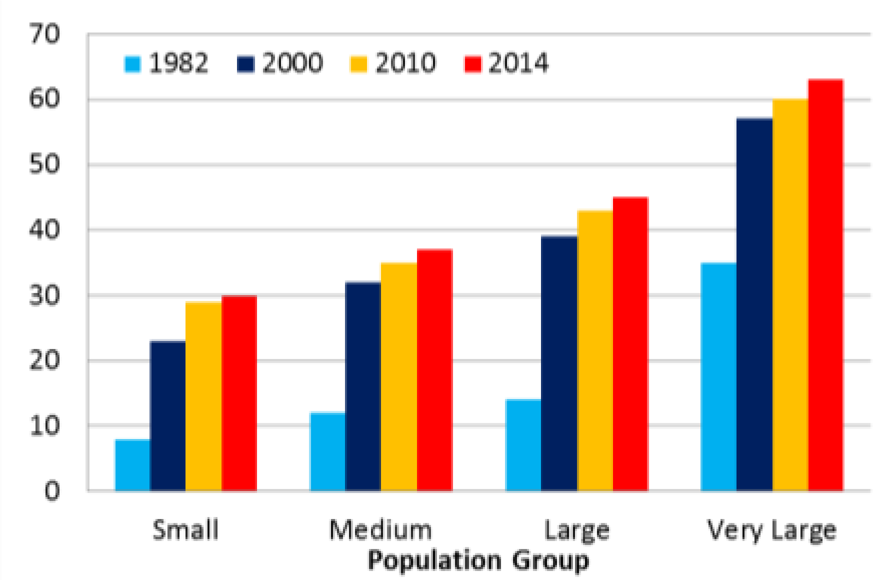
More Detail About Congestion Problems

Congestion, by every measure, has increased substantially over the 33 years covered in this report. And almost every area has "recovered" from the economic recession; almost all regions have worse congestion than before the 2008 crash. Traffic problems as measured by per-commuter measures are about the same as a decade ago, but because there are so many more commuters, and more congestion during off-peak hours, total delay has increased by almost one billion hours. The total congestion cost has also risen with more wasted hours, greater fuel consumption and more trucks stuck in stop-and-go traffic.

Immediate solutions and long-term plans are needed to reduce undesirable congestion. The recession reduced construction costs, or at least slowed their growth. Urban areas and states can still take advantage of this situation – but each area must craft a set of programs, policies and projects that are supported by their communities. This mix will be different in every city, but all of them can be informed by data and trend information.

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 have congestion problems – every economy is different and smaller regions often count on good mobility as a quality-of-life aspect that allows them to compete with larger, more economically diverse regions. As the national economy improves, it is important to develop the consensus on action steps -- major projects, programs and funding efforts take 10 to 15 years to develop.

Exhibit 3. Congestion Growth Trend – Hours of Delay per Auto Commuter



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

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Congestion Patterns

- **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 during any daylight hour (Exhibit 5).
- **Midday hours** comprise a significant share of the congestion problem.

Exhibit 4. Percent of Delay for Each Day

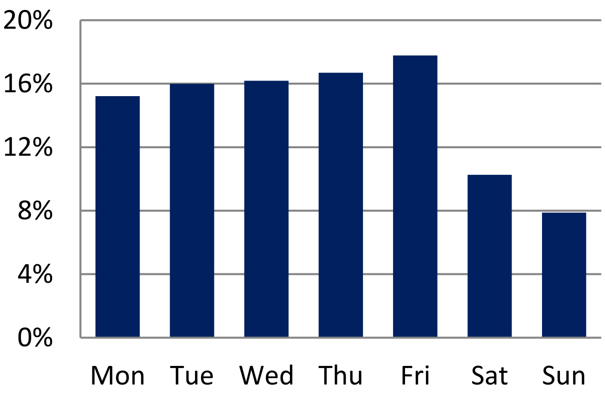
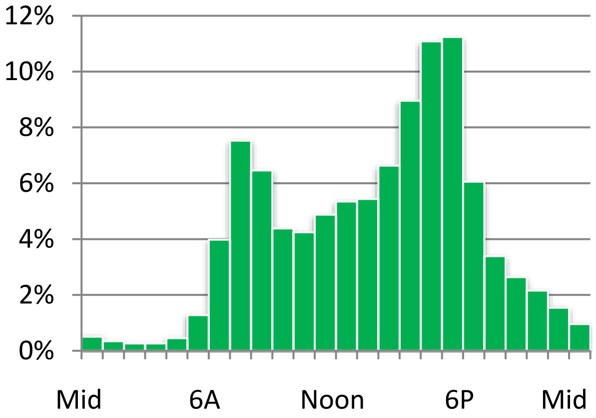


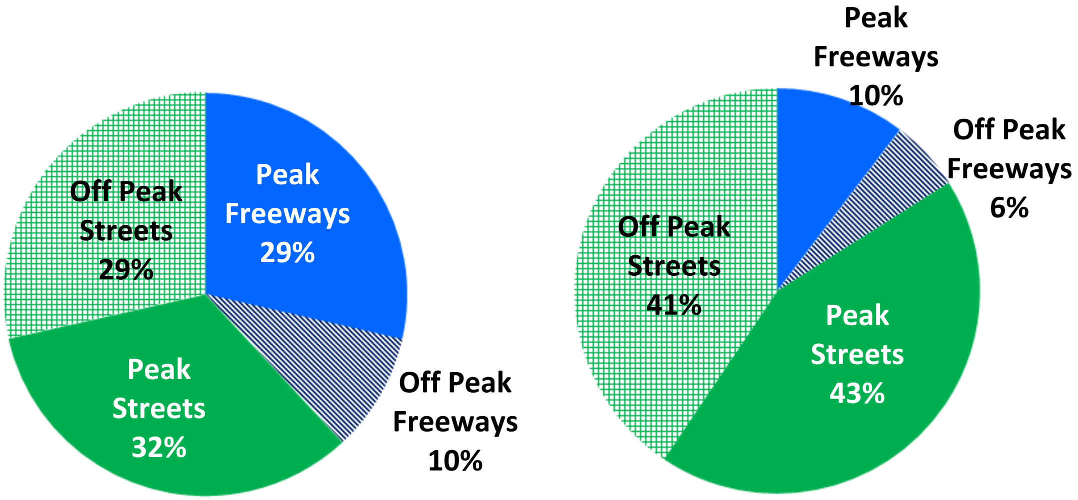
Exhibit 5. Percent of Delay for Hours of Day



Congestion on Freeways and Streets

- Streets have **more delay** than freeways, but there are also many more miles of streets (Exhibit 6).
- Approximately 40 percent of delay occurs in **off-peak hours**.
- Freeway delay is **much less** of the problem in areas under 1 million population.

Exhibit 6. Percent of Delay for Road Types



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Urban Areas Over 1M Population

Urban Areas Under 1M Population

Rush Hour

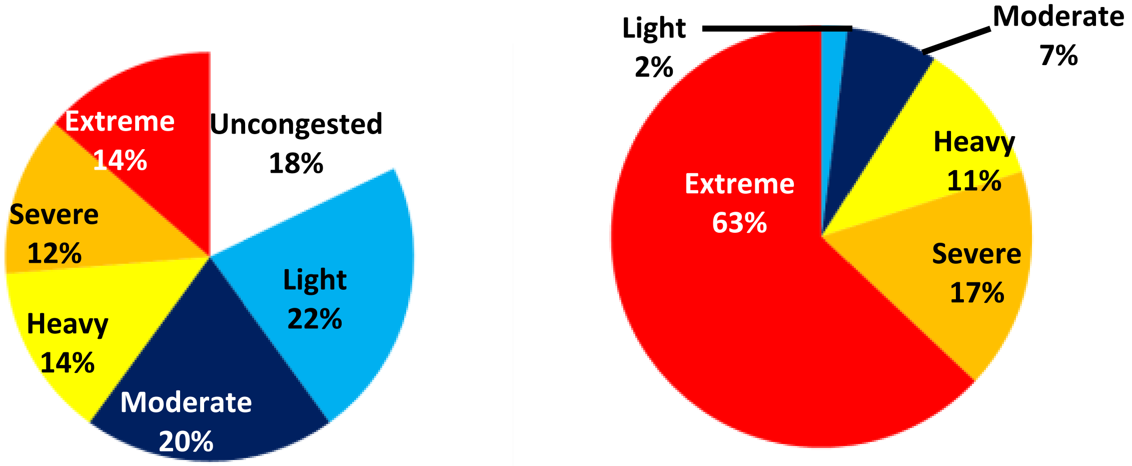
Congestion

- Severe and extreme congestion levels affected only **1 in 9 trips in 1982, but 1 in 4 trips in 2014**.
- The most congested sections of road account for **80% of peak period delays**, but only have 26% of the travel (Exhibit 7).

Exhibit 7. Peak Period Congestion in 2014

About 26% of trips are in severe congestion…..

rst trips
f the extra
travel time.



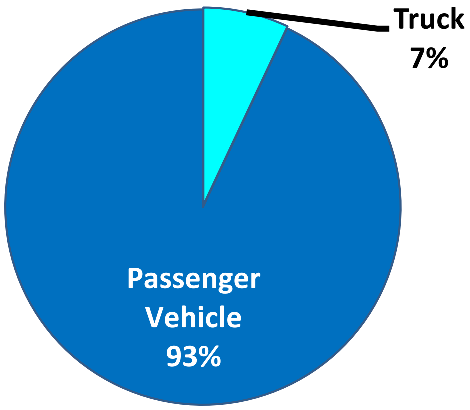
Truck Congestion

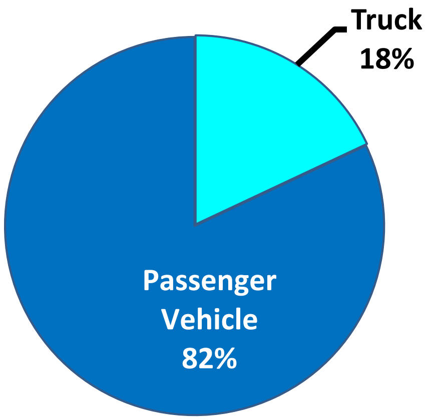
- Trucks account for 18 percent of the urban “congestion invoice” although they only represent 7 percent of urban travel (Exhibit 9).
- The costs in Exhibit 9 do not include the extra costs borne by private companies who build additional distribution centers, buy more trucks and build more satellite office centers to allow them to overcome the problems caused by a congested and inefficient transportation network.

Exhibit 9. 2014 Congestion Cost for Urban Passenger and Freight Vehicles

Travel by Vehicle Type

Congestion Cost by Vehicle Type





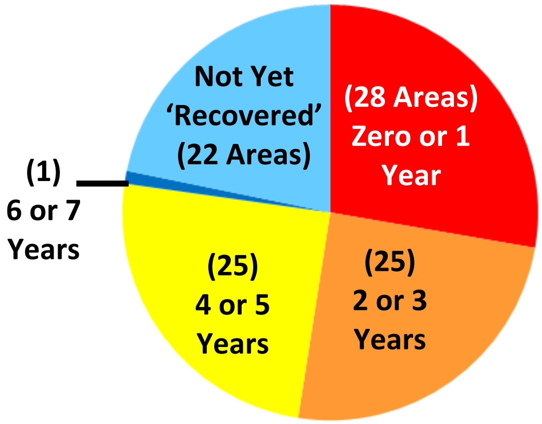
Since the Congestion Decline During the Recession ….

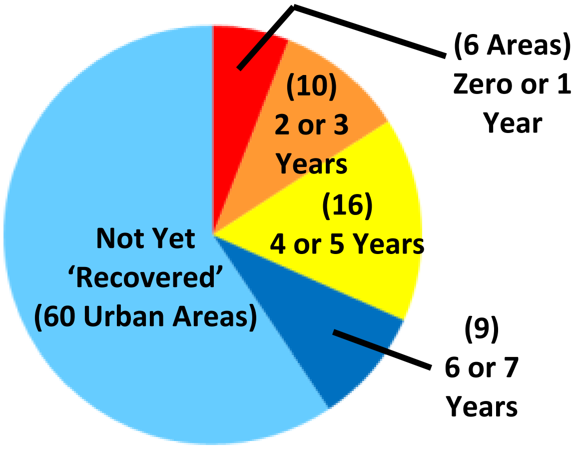
- American motorists are enduring about 5 percent more delay than the pre-recession peak in 2007. (Exhibit 2)
- While this is associated with a “good thing” -- economic and population growth in our major metro areas – it is also clear this growth is outpacing the investment in infrastructure and programs to address the increased demand on the network.
- Cities with employment and population growth faster than the national averages also experienced some of the biggest increases in traffic congestion.
- Cities that showed little to no change in traffic congestion were also those where employment and population growth was slower than the national average
- 53 of the 101 urban areas saw the total urban area delay exceed the pre-recession levels within 3 years; an immediate ‘snapback’ was seen in more than one-quarter of the studied regions.
- 22 areas still have lower total annual delay than in 2007/8. (Exhibit 8)
- In contrast to total delay, average auto commuter delay is still less than pre-recession levels in 60 areas
- 16 areas have higher hours per commuter exceeded the 2007/8 values in only 16 areas. (Exhibit 8)

Exhibit 8. Number of Years Before Congestion Returned to Pre-Recession Levels

Total Urban Area Delay **Delay Per Urban Auto Commuter**

CAUTION: See https://mobility.tamu.edu/umr/ for improved performance measures and updated data.





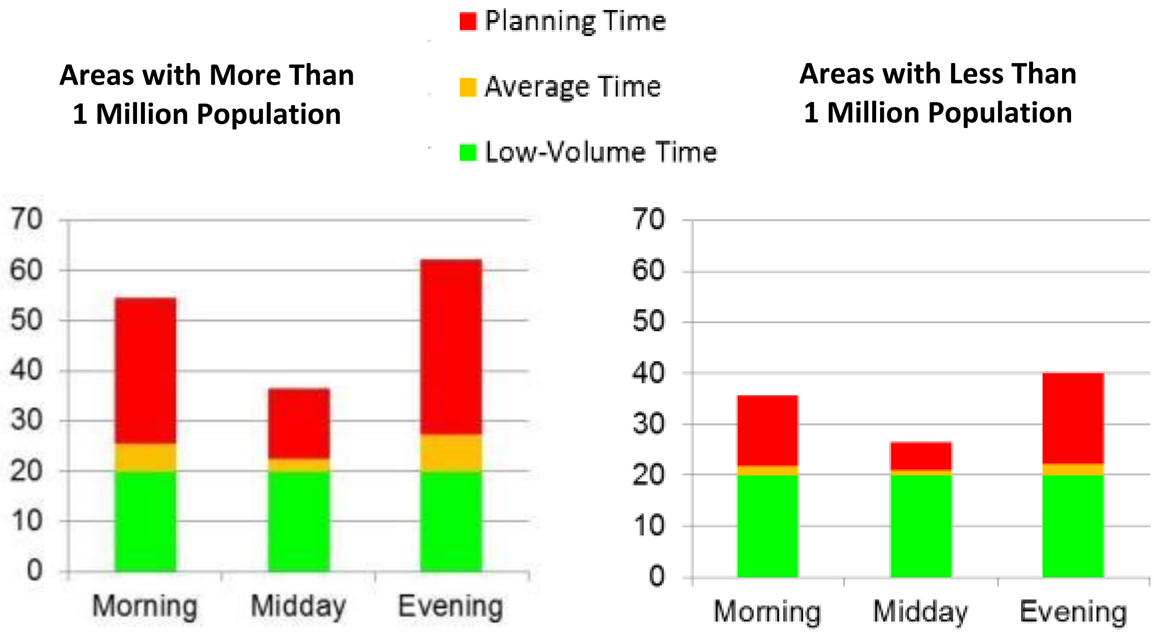
The Trouble With Planning Your Trip

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." The need to add extra time 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., we might still be inclined to add a little extra time, and the data indicate that our intuition is correct.

Exhibit 10 illustrates this problem. 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. Your trip usually takes 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 10 – in 2014 the average big city auto commute was 25 minutes in the morning and 27 minutes in the evening peak.

Now, if you have to make a very important trip during any of these time periods there is additional "planning time" you must allow to reliably arrive on-time. And, as shown in Exhibit 10 (red bar), it isn't just a "rush hour" problem – it can happen any time of the day and amounts to an extra 29 minutes in the morning, 35 minutes in the evening and even 14 minutes for your 20-minute trip in the midday. The news isn't much better for those planning trips in areas with fewer than 1 million people – 14 and 18 minutes longer in the morning and evening peaks. Data for individual urban areas is presented in Table 3 (in the back of the report).

Exhibit 10. Extra Time to Make Important Trips



The Future of Congestion

Before the economic recession, congestion was increasing at between 2 and 4 percent every year – which meant that extra travel time for the average commuter increased slightly less than 1 hour every year. The economic recession set back that trend a few years, but the trend in the last few years indicates congestion is rising again. Congestion is the result of an imbalance between travel demand and the supply of transportation capacity – whether that is freeway lanes, bus seats or rail cars. As the number of residents or jobs goes up in an improving economy, or the miles or trips that those people make increases, the road and transit systems also need to, in some combination, either expand or operate more efficiently. As the rising congestion levels in this report demonstrate, however, this is an infrequent occurrence. Travelers are not only paying the price for this inadequate response, but traffic congestion can also become a drain on further economic growth.

As one estimate of congestion in the near future, this report uses the expected population growth and congestion trends from the period of sustained economic growth between 2000 and 2005 to get an idea of what the next five years might hold. The basic input and analysis features:

- 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.
- The period before the economic recession (from 2000 to 2005) 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 the best indicator of the future level of investment in solutions and the resulting increase in congestion for each urban area.

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 did not capture these variations. Using this simplified approach the following offers an idea of the national congestion problem in 2020.

- The national congestion cost will grow from $160 billion to $192 billion in 2020 (in 2014 dollars).
- Delay will grow to 8.3 billion hours in 2020.
- Wasted fuel will increase to 3.8 billion gallons in 2020.
- The average commuter’s congestion cost will grow to $1,100 in 2020 (in 2014 dollars).
- The average commuter will waste 47 hours and 21 gallons in 2020.

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. 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 technology to promote and facilitate travel options, operational improvements, or land use redevelopment. In all cases, the solutions need to work together to provide an interconnected network of smart transportation services as well as improve the quality-of-life.

Better data can play a valuable role in all of the analyses. Advancements in volume collection, travel speed data and origin to destination travel paths for people and freight allow transportation agencies at all government levels and the private sector to better identify existing chokepoints, possible alternatives and growth patterns. The solution begins with better understanding of the challenges, problems, possibilities and opportunities – where, when, how and how often mobility problems occur – and moves into similar questions about solutions – where, when, how can mobility be improved. These data will allow travelers to capitalize on new transportation services, identify novel programs, have better travel time reliability and improve their access to information.

More information on the possible solutions, places they have been implemented and the effects estimated in this report can be found on the website http://mobility.tamu.edu/solutions None of these ideas are the whole mobility solution, but they can all play a role.

- **Get as much service as possible from what we have** – Many low-cost improvements have broad public support and can be rapidly deployed. These operations programs require innovation, new monitoring technologies and staffing plans, 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, and improving road and intersection designs are relatively simple actions. More complex changes such as traffic signals that rapidly adapt to different traffic patterns, systems that smooth traffic flow and reduce traffic collisions and communication technologies that assist travelers (in all modes) and the transportation network in achieving goals are also a part of the 'get the best bang for the buck' approach.
- **Add capacity in critical corridors** – Handling more freight or person travel on freeways, streets, rail lines, buses or intermodal facilities often requires "more." Important corridors or growing regions can benefit from more street and highway lanes, new or expanded public transportation facilities, and larger bus and rail fleets. Some of the "more" will also be in the form of advancements in connected and autonomous vehicles – cars, trucks, buses and trains that communicate with each other and with the transportation network – that will reduce crashes and congestion.
- **Provide choices** – This might involve different travel routes, travel modes or lanes that involve a toll for high-speed and reliable service. These options allow travelers and shippers to customize their travel plans. There is much more transportation information available on websites, smartphones and apps, radio, TV and in their car or at their transit stop; the information involves displays of existing travel times, locations of roadwork or crashes, transit ridership and arrival information and a variety of trip planner resources. They allow travelers to make real-time decisions about when to

depart on a trip, what route or mode to take, whether they are interested in paying a toll in order to guarantee an arrival time or perhaps just sleep in for a while and telecommute on a particularly bad day. In the past, this information was more difficult to find, tough to understand or was not updated very frequently. Today's commuters have much better information, delivered when and where its needed in a format they can use to make decisions

- **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. These are not typically agency-led or agency-directed strategies – they are workers and managers getting together to identify virtuous combinations of work hours, commute modes, office space arrangements and electronic communication mechanisms. Companies have seen productivity increase when workers are able to adjust their hours and commute trips to meet family or other obligations. Those companies also save on parking space and office requirements and see less staff turnover and, therefore, lower recruiting and training costs.
- **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 congestion in each of these sub-regions appears to be part, but not all, of the mobility solution. Analytical advancements in fields of transportation, land development, education and other information sources mean that home purchasers have much more information about their commute options and the expectations they should have. A range of home types, locations and prices when matched with more information about, for example, historic travel times, elementary and secondary education quality, entertainment and cultural sites provides the type of information that consumers want.
- **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. Identifying solutions and funding sources that meet a variety of community goals is challenging enough without attempting to eliminate congestion in all locations at all times. Congestion does not have to be an all-day event, and in many cases improving travel time awareness and predictability can be a positive first step towards improving urban mobility.

Case studies, analytical methods and data are available to support development of these strategies and monitor the effectiveness of deployments. There are also many good state and regional mobility reports that provide ideas for communicating the findings of the data analysis.

Analysis Using the Best Congestion Data & Analysis Methodologies

The base data for the *2015 Urban Mobility Scorecard* came from INRIX, the U.S. Department of Transportation and the states (2*, 3*). Several analytical processes were used to develop the final measures, but the biggest improvement in the last two decades is provided by the INRIX data. The speed data covering most travel on 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 technical report (*5*) that is 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 Historical Profile database. Commercial vehicles, smart phones and connected cars with location devices feed time and location data points to INRIX.
- 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 15-minute average speeds for each link of major roadway covered in the Historical Profile database (approximately 1.3 million miles in 2014).
- Traffic volume estimates 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 15-minute volumes using a national traffic count dataset (*6*).
- The 15-minute INRIX speeds were matched to the 15-minute volume estimates for each road section on the FHWA maps.
- An estimation procedure was also developed for the sections of road that did not have INRIX data. As described in the methodology website, the road sections were ranked according to volume per lane and then matched with a similar list of sections with INRIX and volume per lane data (as developed from the FHWA dataset) (*5*).

National Performance Measurement

"What Gets Measured, Gets Done"

Many of us have heard this saying, and it is very appropriate when discussing transportation system performance measurement. Performance measurement at the national level is gaining momentum. Many state and local transportation agencies are implementing performance measurement activities to operate their systems as efficiently as possible with limited resources.

The Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law on July 6, 2012 to fund surface transportation. Among other aspects, MAP-21 establishes performance-based planning and programming to improve transportation decision-making and increase the accountability and transparency of the Federal highway funding program (*7*).

As part of the transition to a performance and outcome-based Federal highway funding program, MAP-21 establishes national performance goals in the following areas *(7)*:

- Safety
- Infrastructure condition
- Congestion reduction
- System reliability
- Freight movement and economic vitality
- Environmental sustainability
- Reduced project delivery delays

MAP-21 requirements provide the opportunity to improve agency operations. While transportation professionals calculate required MAP-21 performance measures, there is an opportunity to also develop processes and measures to better understand their systems. The requirements of MAP-21 are specified through a Rulemaking process. At the time of this writing, the Notice of Proposed Rulemaking (NPRM) for system performance measures (congestion, reliability) has not been released by the United States Department of Transportation (USDOT).

While the specific requirements of MAP-21 related to system performance measures are not yet known, the data, measures, and methods in the *Urban Mobility Scorecard* provide transportation professionals with a 33-year trend of foundational knowledge to inform performance measurement and target setting at the urban area level. The measures and techniques have stood the test of time to communicate mobility conditions and potential solutions.

"Don't Let Perfect be the Enemy of Good"

Occasionally there is reluctance at transportation agencies to dive in and begin performance measurement activities because there is a concern that the data or methods are just not good enough. Over the years, the *Urban Mobility Report* (and now the *Scorecard*) has taken advantage of data improvements – and associated changes in analysis methods – and the use of more powerful computational methods (for example, geographic information systems). Such adaptations are typical when conducting on-going performance reporting. As the successful 33-year data trend of *UMR/UMS* suggests, changes can be made as improvements become available. The key is to get started!

Concluding Thoughts

The national economy has improved since the last *Urban Mobility Scorecard*, and unfortunately congestion has gotten worse. This has been the case in the past, and it appears that the economy-congestion linkage is as dependable as gravity. Some analysts had touted the decline in driving per capita and dip in congestion levels as a sign that traffic congestion would, in essence, fix itself. That is not happening.

The other seemingly dependable trend – not enough of any solution being deployed – also appears to be holding in most growing regions. That is really the lesson from this series of reports. The **mix of solutions** that are used is relatively less important than the **amount of solution** being implemented. All of the potential congestion-reducing strategies should be considered, and there is a role and location for most of the strategies.

- 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 work schedules, traveling times and travel modes to avoid the peak periods, use less vehicle travel and increase the amount of electronic "travel."
- In growth corridors, there also may be a role for additional capacity to move people and freight more rapidly and reliably.
- Some areas are seeing renewed interest in higher density living in neighborhoods with a mix of residential, office, shopping and other developments. These places can promote shorter trips that are more amenable to walking, cycling or public transportation modes.

The *2015 Urban Mobility Scorecard* points to national measures of the congestion problem for the 471 urban areas in 2014:

- $160 billion of wasted time and fuel
- Including $28 billion of extra truck operating time and fuel
- An extra 6.9 billion hours of travel and 3.1 billion gallons of fuel consumed

The average urban commuter in 2014:

- spent an extra 42 hours of travel time on roads than if the travel was done in low-volume conditions
- used 19 extra gallons of fuel
- which amounted to an average value of $960 per commuter

Traffic congestion has grown since the low point in 2009 during the economic recession. An additional 600 million hours and 700 million gallons of fuel were consumed in 2014 than in 2009. Congestion, in terms of average extra hours and gallons of fuel consumed by the average commuter, has not returned to pre-recession levels in 60 of the 101 urban areas that were intensively studied. But there have been increases in the extra hours of travel time and gallons those commuters suffer showing that the economic recession has not been a permanent cure for traffic congestion problems.

States and cities have been addressing the congestion problems they face with a variety of strategies and more detailed data analysis. Some of the solution lies in identifying congestion that is undesirable – that which significantly diminishes the quality of life and economic productivity – and some lies in using

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the smart data systems and range of technologies, projects and programs to achieve results and communicate the effects to assure the public that their project dollars are being spent wisely.

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National Congestion Tables

Table 1. What Congestion Means to You, 2014

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)	**63**		**1.32**		**27**		**1,433**	
Washington DC-VA-MD	82	1	1.34	8	35	1	1,834	1
Los Angeles-Long Beach-Anaheim CA	80	2	1.43	1	25	11	1,711	3
San Francisco-Oakland CA	78	3	1.41	2	33	3	1,675	4
New York-Newark NY-NJ-CT	74	4	1.34	8	35	1	1,739	2
Boston MA-NH-RI	64	6	1.29	17	30	4	1,388	9
Seattle WA	63	7	1.38	3	28	8	1,491	5
Chicago IL-IN	61	8	1.31	14	29	5	1,445	7
Houston TX	61	8	1.33	10	29	5	1,490	6
Dallas-Fort Worth-Arlington TX	53	11	1.27	19	22	23	1,185	14
Atlanta GA	52	12	1.24	25	20	44	1,130	22
Detroit MI	52	12	1.24	25	25	11	1,183	15
Miami FL	52	12	1.29	17	24	15	1,169	17
Phoenix-Mesa AZ	51	17	1.27	19	25	11	1,201	13
Philadelphia PA-NJ-DE-MD	48	22	1.24	25	23	18	1,112	26
San Diego CA	42	43	1.24	25	11	92	887	61

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 $17.67 per hour of person travel and $94.04 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. The best congestion comparisons are made between similar urban areas.

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Table 1. What Congestion Means to You, 2014, Continued

Urban Area	Yearly Delay per Auto Commuter		Travel Time Index		Excess Fuel per Auto Commuter		Congestion Cost per Auto Commuter	
	Hours	Rank	Value	Rank	Gallons	Rank	Dollars	Rank
Large Average (31 areas)	**45**		**1.23**		**21**		**$1,045**	
San Jose CA	67	5	1.38	3	28	8	1,422	8
Riverside-San Bernardino CA	59	10	1.33	10	18	62	1,316	10
Austin TX	52	12	1.33	10	22	23	1,159	20
Portland OR-WA	52	12	1.35	7	29	5	1,273	11
Denver-Aurora CO	49	19	1.30	16	24	15	1,101	28
Oklahoma City OK	49	19	1.19	42	23	18	1,110	27
Baltimore MD	47	23	1.26	21	21	32	1,115	25
Minneapolis-St. Paul MN	47	23	1.26	21	18	62	1,035	36
Las Vegas-Henderson NV	46	27	1.26	21	21	32	984	42
Orlando FL	46	27	1.21	34	21	32	1,044	34
Nashville-Davidson TN	45	29	1.21	34	22	23	1,168	18
Virginia Beach VA	45	29	1.19	42	19	51	953	46
San Antonio TX	44	33	1.25	24	20	44	1,002	38
Charlotte NC-SC	43	35	1.23	29	17	70	963	44
Indianapolis IN	43	35	1.18	46	23	18	1,060	30
Louisville-Jefferson County KY-IN	43	35	1.20	37	22	23	1,048	32
Memphis TN-MS-AR	43	35	1.19	42	21	32	1,080	29
Providence RI-MA	43	35	1.20	37	21	32	951	47
Sacramento CA	43	35	1.23	29	19	51	958	45
St. Louis MO-IL	43	35	1.16	65	21	32	1,020	37
San Juan PR	43	35	1.31	14	24	15	1,150	21
Cincinnati OH-KY-IN	41	45	1.18	46	21	32	989	40
Columbus OH	41	45	1.18	46	20	44	933	49
Tampa-St. Petersburg FL	41	45	1.21	34	18	62	907	57
Kansas City MO-KS	39	51	1.15	76	18	62	933	49
Pittsburgh PA	39	51	1.19	42	21	32	889	59
Cleveland OH	38	55	1.15	76	22	23	887	61
Jacksonville FL	38	55	1.18	46	15	78	842	72
Milwaukee WI	38	55	1.17	54	22	23	987	41
Salt Lake City-West Valley City UT	37	66	1.18	46	22	23	1,059	31
Richmond VA	34	77	1.13	88	14	84	729	82

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

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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. The best congestion comparisons are made between similar urban areas.

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Table 1. What Congestion Means to You, 2014, 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)	**37**		**1.18**		**18**		**$870**	
Honolulu HI	50	18	1.37	5	26	10	1,125	24
Bridgeport-Stamford CT-NY	49	19	1.36	6	22	23	1,174	16
Baton Rouge LA	47	23	1.22	32	25	11	1,262	12
Tucson AZ	47	23	1.22	32	23	18	1,128	23
Hartford CT	45	29	1.20	37	21	32	1,038	35
New Orleans LA	45	29	1.32	13	22	23	1,161	19
Tulsa OK	44	33	1.17	54	20	44	984	42
Albany NY	42	43	1.17	54	21	32	991	39
Charleston-North Charleston SC	41	45	1.23	29	20	44	1,047	33
Buffalo NY	40	49	1.17	54	21	32	918	53
New Haven CT	40	49	1.16	65	19	51	932	51
Grand Rapids MI	39	51	1.17	54	19	51	854	68
Rochester NY	39	51	1.16	65	20	44	889	59
Columbia SC	38	55	1.15	76	19	51	951	47
Springfield MA-CT	38	55	1.14	81	19	51	831	75
Toledo OH-MI	38	55	1.18	46	20	44	920	52
Albuquerque NM	36	70	1.16	65	19	51	886	63
Colorado Springs CO	35	72	1.16	65	17	70	772	78
Knoxville TN	35	72	1.14	81	17	70	849	70
Wichita KS	35	72	1.17	54	18	62	837	73
Birmingham AL	34	77	1.14	81	16	75	891	58
Raleigh NC	34	77	1.17	54	13	86	734	81
El Paso TX-NM	33	81	1.16	65	16	75	760	79
Omaha NE-IA	32	83	1.16	65	17	70	707	84
Allentown PA-NJ	30	86	1.17	54	15	78	694	87
Cape Coral FL	30	86	1.17	54	13	86	669	88
McAllen TX	30	86	1.15	76	13	86	649	89
Akron OH	27	89	1.12	91	15	78	634	90
Sarasota-Bradenton FL	26	90	1.16	65	12	91	589	92
Dayton OH	25	91	1.12	91	13	86	590	91
Fresno CA	23	92	1.11	97	11	92	495	96
Provo-Orem UT	21	94	1.12	91	15	78	708	83
Bakersfield CA	19	96	1.12	91	9	96	512	94

Medium Urban Areas—over 500,000 and less than 1 million 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—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 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. The best congestion comparisons are made between similar urban areas.

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Table 1. What Congestion Means to You, 2014, Continued

Urban Area	Yearly Delay per Auto Commuter		Travel Time Index		Excess Fuel per Auto Commuter		Congestion Cost per Auto Commuter	
	Hours	Rank	Value	Rank	Gallons	Rank	Dollars	Rank
Small Average (22 areas)	**30**		**1.14**		**14**		**$705**	
Jackson MS	38	55	1.13	88	15	78	878	64
Little Rock AR	38	55	1.14	81	13	86	853	69
Pensacola FL-AL	38	55	1.17	54	18	62	849	70
Spokane WA	38	55	1.17	54	23	18	911	55
Worcester MA-CT	38	55	1.12	91	18	62	865	67
Anchorage AK	37	66	1.20	37	19	51	913	54
Boise City ID	37	66	1.16	65	18	62	833	74
Poughkeepsie-Newburgh NY-NJ	37	66	1.12	91	17	70	867	66
Madison WI	36	70	1.18	46	19	51	911	55
Boulder CO	35	72	1.20	37	19	51	752	80
Salem OR	35	72	1.16	65	21	32	876	65
Beaumont TX	34	77	1.15	76	15	78	800	77
Eugene OR	33	81	1.18	46	19	51	804	76
Greensboro NC	32	83	1.10	99	14	84	703	85
Corpus Christi TX	31	85	1.13	88	16	75	697	86
Oxnard CA	23	92	1.14	81	8	97	494	97
Brownsville TX	21	94	1.14	81	11	92	494	97
Winston-Salem NC	19	96	1.11	97	7	98	415	99
Laredo TX	18	98	1.16	65	10	95	496	95
Stockton CA	18	98	1.14	81	7	98	516	93
Lancaster-Palmdale CA	17	100	1.10	99	5	100	349	100
Indio-Cathedral City CA	6	101	1.05	101	2	101	149	101
101 Area Average	**52**		**1.26**		**23**		**$1,190**	
Remaining Areas Average	**16**		**1.09**		**7**		**$370**	
All 471 Area Average	**42**		**1.22**		**19**		**$960**	

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 $17.67 per hour of person travel and $94.04 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. The best congestion comparisons are made between similar urban areas.

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Table 2. What Congestion Means to Your Town, 2014

Urban Area	Travel Delay (1,000 Hours)	Rank	Excess Fuel Consumed (1,000 Gallons)	Rank	Truck Congestion Cost ($ million)	Rank	Total Congestion Cost ($ million)	Rank
Very Large Average (15 areas)	**231,970**		**99,490**		**$885**		**$5,260**	
New York-Newark NY-NJ-CT	628,241	1	296,701	1	2,779	1	14,712	1
Los Angeles-Long Beach-Anaheim CA	622,509	2	195,491	2	1,721	2	13,318	2
Chicago IL-IN	302,609	3	147,031	3	1,482	3	7,222	3
Washington DC-VA-MD	204,375	4	88,130	6	710	6	4,560	5
Houston TX	203,173	5	94,300	4	1,118	4	4,924	4
Miami FL	195,946	6	90,320	5	736	5	4,444	6
Dallas-Fort Worth-Arlington TX	186,535	7	79,392	7	702	7	4,202	7
Philadelphia PA-NJ-DE-MD	157,183	8	77,456	8	683	9	3,669	8
Phoenix-Mesa AZ	155,730	9	75,938	9	692	8	3,641	9
Detroit MI	155,358	10	73,645	10	567	11	3,514	10
Boston MA-NH-RI	153,994	11	71,602	11	426	15	3,363	11
Atlanta GA	148,666	12	57,113	14	434	13	3,214	13
San Francisco-Oakland CA	146,013	13	62,320	12	360	18	3,143	14
Seattle WA	139,842	14	62,136	13	645	10	3,294	12
San Diego CA	79,412	20	20,742	36	192	35	1,658	21

Very Large Urban Areas—over 3 million population.
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Small Urban Areas—less than 500,000 population.

Travel Delay—Extra travel time during the year.

Excess Fuel Consumed—Value of increased fuel consumption due to travel in congested conditions rather than free-flow conditions (using state average cost per gallon).

Truck Congestion Cost—Value of increased travel time and other operating costs of large trucks (estimated at $94.04 per hour of truck time) and the extra diesel consumed (using state average cost per gallon).

Congestion Cost—Value of delay and fuel cost (estimated at $17.67 per hour of person travel, $94.04 per hour of truck time and state average fuel 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. The best congestion comparisons are made between similar urban areas.

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Table 2. What Congestion Means to Your Town, 2014, Continued

Urban Area	Travel Delay (1,000 Hours)	Rank	Excess Fuel Consumed (1,000 Gallons)	Rank	Truck Congestion Cost ($ million)	Rank	Total Congestion Cost ($ million)	Rank
Large Average (31 areas)	**55,390**		**25,690**		**$235**		**$1,280**	
San Jose CA	104,559	15	43,972	16	240	28	2,230	15
Minneapolis-St. Paul MN	99,710	16	38,542	19	327	20	2,196	17
Riverside-San Bernardino CA	99,058	17	30,732	23	361	17	2,201	16
Denver-Aurora CO	91,479	18	44,922	15	319	21	2,061	19
Baltimore MD	87,620	19	38,661	18	427	14	2,075	18
Portland OR-WA	72,341	21	39,611	17	375	16	1,763	20
Tampa-St. Petersburg FL	71,628	22	31,654	22	237	30	1,589	24
St. Louis MO-IL	69,350	23	32,991	21	328	19	1,637	22
San Antonio TX	64,328	24	28,809	25	251	27	1,462	25
Las Vegas-Henderson NV	63,693	25	30,001	24	158	45	1,375	26
San Juan PR	60,301	26	33,418	20	437	12	1,605	23
Sacramento CA	60,220	27	26,289	26	189	36	1,334	27
Orlando FL	52,723	28	23,938	31	212	33	1,207	28
Austin TX	51,116	29	21,654	33	182	39	1,140	31
Cincinnati OH-KY-IN	48,485	30	25,086	28	238	29	1,159	29
Virginia Beach VA	48,274	31	20,085	37	112	52	1,020	36
Indianapolis IN	46,435	32	25,066	29	259	26	1,142	30
Oklahoma City OK	45,652	33	21,027	35	166	43	1,030	34
Kansas City MO-KS	45,570	34	21,349	34	226	32	1,085	32
Cleveland OH	45,051	35	25,547	27	182	39	1,046	33
Pittsburgh PA	44,758	36	24,107	30	171	42	1,030	34
Columbus OH	40,025	37	19,870	38	162	44	921	41
Nashville-Davidson TN	38,977	39	19,093	39	285	22	1,013	38
Memphis TN-MS-AR	37,824	40	18,440	42	229	31	939	40
Providence RI-MA	37,809	41	18,853	41	121	49	846	45
Milwaukee WI	37,659	42	21,957	32	266	25	984	39
Louisville-Jefferson County KY-IN	35,622	45	17,841	43	186	38	860	43
Charlotte NC-SC	34,153	46	13,760	50	131	47	770	47
Jacksonville FL	29,680	48	12,063	53	101	57	659	49
Salt Lake City-West Valley City UT	26,925	51	16,304	46	267	24	779	46
Richmond VA	26,104	53	10,802	55	68	69	558	54

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

Travel Delay—Extra travel time during the year.

Excess Fuel Consumed—Value of increased fuel consumption due to travel in congested conditions rather than free-flow conditions (using state average cost per gallon).

Truck Congestion Cost—Value of increased travel time and other operating costs of large trucks (estimated at $94.04 per hour of truck time) and the extra diesel consumed (using state average cost per gallon).

Congestion Cost—Value of delay and fuel cost (estimated at $17.67 per hour of person travel, $94.04 per hour of truck time and state average fuel cost).

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Table 2. What Congestion Means to Your Town, 2014, 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)	**20,000**		**9,815**		**$94**		**$475**	
New Orleans LA	39,159	38	18,895	40	281	23	1,014	37
Bridgeport-Stamford CT-NY	37,119	43	16,586	45	194	34	898	42
Tucson AZ	35,993	44	17,477	44	176	41	856	44
Tulsa OK	30,341	47	14,128	47	107	54	682	48
Hartford CT	28,296	49	13,406	51	115	50	656	50
Honolulu HI	27,672	50	14,118	48	74	63	616	53
Buffalo NY	26,851	52	14,053	49	103	56	620	52
Baton Rouge LA	23,163	54	12,104	52	189	36	623	51
Raleigh NC	23,128	55	9,159	62	71	66	504	55
Grand Rapids MI	21,536	56	10,552	56	58	74	470	59
Rochester NY	20,582	57	10,550	57	73	64	469	61
Albuquerque NM	20,452	58	10,961	54	112	52	501	56
Albany NY	20,409	59	10,164	58	88	58	479	58
Birmingham AL	19,385	60	9,105	63	139	46	501	56
El Paso TX-NM	19,127	61	9,360	60	77	62	439	62
Springfield MA-CT	18,431	62	9,335	61	54	77	408	64
Charleston-North Charleston SC	18,422	63	9,024	64	126	48	470	59
Omaha NE-IA	18,224	64	9,535	59	57	75	407	65
Allentown PA-NJ	17,114	65	8,743	65	66	70	393	67
Wichita KS	16,860	66	8,594	66	88	58	407	65
New Haven CT	16,430	67	7,949	69	69	67	384	68
Columbia SC	16,315	68	8,018	68	104	55	409	63
McAllen TX	16,226	69	7,336	73	49	83	355	72
Colorado Springs CO	16,058	70	7,700	71	50	81	356	71
Toledo OH-MI	15,905	71	8,451	67	79	61	381	69
Knoxville TN	14,946	72	7,180	74	87	60	367	70
Dayton OH	14,604	74	7,434	72	69	67	346	73
Sarasota-Bradenton FL	14,053	75	6,574	76	46	84	312	75
Cape Coral FL	12,959	78	5,637	83	44	85	288	79
Akron OH	12,283	81	6,586	75	50	81	284	80
Fresno CA	11,823	83	5,682	80	23	95	251	85
Provo-Orem UT	8,178	86	5,677	81	115	50	270	83
Bakersfield CA	8,001	89	3,743	90	65	71	215	87

Travel Delay—Extra travel time during the year.
Excess Fuel Consumed—Value of increased fuel consumption due to travel in congested conditions rather than free-flow conditions (using state average cost per gallon).
Truck Congestion Cost—Value of increased travel time and other operating costs of large trucks (estimated at $94.04 per hour of truck time) and the extra diesel consumed (using state average cost per gallon).
Congestion Cost—Value of delay and fuel cost (estimated at $17.67 per hour of person travel, $94.04 per hour of truck time and state average fuel 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. The best congestion comparisons are made between similar urban areas.

CAUTION: See https://mobility.tamu.edu/umr/ for improved performance measures and updated data.

Table 2. What Congestion Means to Your Town, 2014, Continued

Urban Area	Travel Delay (1,000 Hours)	Rank	Excess Fuel Consumed (1,000 Gallons)	Rank	Truck Congestion Cost ($ million)	Rank	Total Congestion Cost ($ million)	Rank
Small Average (22 areas)	**8,170**		**3,850**		**36**		**190**	
Little Rock AR	14,799	73	5,262	84	61	72	336	74
Worcester MA-CT	13,143	76	6,432	77	52	80	302	77
Spokane WA	13,004	77	7,928	70	59	73	312	75
Poughkeepsie-Newburgh NY-NJ	12,843	79	5,723	79	55	76	299	78
Jackson MS	12,287	80	4,897	86	53	78	282	82
Boise City ID	11,963	82	5,673	82	40	87	269	84
Madison WI	11,159	84	5,773	78	72	65	283	81
Pensacola FL-AL	11,017	85	5,120	85	38	89	247	86
Beaumont TX	8,028	87	3,629	92	40	87	190	88
Corpus Christi TX	8,012	88	4,110	88	26	94	179	90
Greensboro NC	7,887	90	3,534	93	27	93	176	91
Anchorage AK	7,371	91	3,847	89	38	89	181	89
Salem OR	6,948	92	4,254	87	41	86	175	92
Eugene OR	6,354	93	3,728	91	32	92	155	93
Oxnard CA	6,282	94	2,241	95	16	97	134	96
Winston-Salem NC	6,111	95	2,400	94	21	96	135	95
Stockton CA	5,115	96	2,102	98	53	78	148	94
Lancaster-Palmdale CA	4,181	97	1,228	100	10	99	88	99
Boulder CO	4,080	98	2,204	96	10	99	89	98
Laredo TX	3,919	99	2,130	97	34	91	107	97
Brownsville TX	3,511	100	1,866	99	14	98	81	100
Indio-Cathedral City CA	1,685	101	660	101	9	101	40	101
101 Area Total	**6,036,500**		**2,697,300**		**24,360**		**138,400**	
101 Area Average	**59,800**		**26,700**		**240**		**1,370**	
Remaining Area Total	**906,200**		**424,200**		**4,040**		**21,170**	
Remaining Area Average	**2,400**		**1,140**		**11**		**57**	
All 471 Area Total	**6,942,700**		**3,121,500**		**28,400**		**159,600**	
All 471 Area Average	**14,710**		**6,610**		**60**		**340**	

Very Large Urban Areas—over 3 million population.

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

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

Small Urban Areas—less than 500,000 population.

Travel Delay—Extra travel time during the year.

Excess Fuel Consumed—Value of increased fuel consumption due to travel in congested conditions rather than free-flow conditions (using state average cost per gallon).

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Table 3. How Reliable is Freeway Travel in Your Town, 2014

Urban Area	Freeway Planning Time Index		Freeway Travel Time Index		Freeway Commuter Stress Index	
	Value	Rank	Value	Rank	Value	Rank
Very Large Average (15 areas)	**3.06**		**1.37**		**1.44**	
Los Angeles-Long Beach-Anaheim CA	3.75	1	1.57	1	1.63	2
Washington DC-VA-MD	3.48	2	1.40	10	1.52	7
Seattle WA	3.41	4	1.47	5	1.59	4
San Francisco-Oakland CA	3.30	6	1.49	4	1.64	1
Chicago IL-IN	3.16	10	1.39	11	1.45	17
New York-Newark NY-NJ-CT	3.15	11	1.38	13	1.44	18
Houston TX	3.13	12	1.43	7	1.47	13
Miami FL	2.85	15	1.28	21	1.30	78
Boston MA-NH-RI	2.81	17	1.38	13	1.47	13
Detroit MI	2.80	18	1.26	23	1.28	80
Phoenix-Mesa AZ	2.66	21	1.24	28	1.34	64
San Diego CA	2.66	21	1.25	26	1.32	75
Dallas-Fort Worth-Arlington TX	2.65	23	1.34	18	1.38	49
Atlanta GA	2.48	30	1.25	26	1.34	64
Philadelphia PA-NJ-DE-MD	2.41	33	1.19	32	1.25	84

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.

Freeway Planning Time Index—A travel time reliability measure that represents the total travel time that should be planned for a trip to be late for only 1 work trip per month. A PTI of 2.00 means that 40 minutes should be planned for a 20-minute trip in light traffic (20 minutes x 2.00 = 40 minutes).

Freeway Travel Time Index—The ratio of travel time in the peak period to the travel time at low volume 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.

Freeway Commuter Stress Index – The travel time index calculated for only the peak direction in each peak period (a measure of the extra travel time for a commuter).

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 3. How Reliable is Freeway Travel in Your Town, 2014, Continued

Urban Area	Freeway Planning Time Index		Freeway Travel Time Index		Freeway Commuter Stress Index	
	Value	Rank	Value	Rank	Value	Rank
Large Average (31 areas)	**2.46**		**1.23**		**1.37**	
Portland OR-WA	3.27	7	1.42	9	1.48	12
San Jose CA	3.24	8	1.43	7	1.52	7
Riverside-San Bernardino CA	3.21	9	1.36	16	1.54	6
Denver-Aurora CO	2.97	13	1.35	17	1.42	23
San Juan PR	2.93	14	1.38	13	1.44	18
Baltimore MD	2.85	15	1.26	23	1.34	64
Minneapolis-St. Paul MN	2.72	20	1.32	20	1.37	53
Charlotte NC-SC	2.61	24	1.21	30	1.29	79
Austin TX	2.58	25	1.50	3	1.59	4
Sacramento CA	2.58	25	1.19	32	1.24	85
Virginia Beach VA	2.52	29	1.17	37	1.23	88
Louisville-Jefferson County KY-IN	2.42	32	1.15	45	1.44	18
Tampa-St. Petersburg FL	2.39	34	1.19	32	1.24	85
Cincinnati OH-KY-IN	2.37	35	1.15	45	1.19	92
Nashville-Davidson TN	2.36	36	1.18	35	1.26	81
Orlando FL	2.34	37	1.16	40	1.22	89
Jacksonville FL	2.27	39	1.14	50	1.18	96
Providence RI-MA	2.25	42	1.18	35	1.21	90
Columbus OH	2.21	44	1.12	58	1.42	23
Las Vegas-Henderson NV	2.18	46	1.15	45	1.51	9
St. Louis MO-IL	2.16	47	1.13	54	1.40	34
Salt Lake City-West Valley City UT	2.13	49	1.11	62	1.42	23
Indianapolis IN	2.12	51	1.11	62	1.41	27
San Antonio TX	2.12	51	1.33	19	1.36	55
Memphis TN-MS-AR	2.08	55	1.14	50	1.42	23
Oklahoma City OK	2.08	55	1.15	45	1.43	21
Kansas City MO-KS	1.99	59	1.11	62	1.38	49
Milwaukee WI	1.97	60	1.17	37	1.19	92
Cleveland OH	1.96	62	1.10	69	1.38	49
Pittsburgh PA	1.80	77	1.14	50	1.43	21
Richmond VA	1.76	80	1.07	79	1.35	61

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Freeway Planning Time Index—A travel time reliability measure that represents the total travel time that should be planned for a trip to be late for only 1 work trip per month. A PTI of 2.00 means that 40 minutes should be planned for a 20-minute trip in light traffic (20 minutes x 2.00 = 40 minutes).

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Table 3. How Reliable is Freeway Travel in Your Town, 2014, Continued

Urban Area	Freeway Planning Time Index		Freeway Travel Time Index		Freeway Commuter Stress Index	
	Value	Rank	Value	Rank	Value	Rank
Medium Average (33 areas)	**2.08**		**1.14**		**1.38**	
New Orleans LA	3.46	3	1.45	6	1.49	11
Bridgeport-Stamford CT-NY	3.32	5	1.39	11	1.50	10
Baton Rouge LA	2.80	18	1.21	30	1.24	85
Honolulu HI	2.58	25	1.51	2	1.62	3
Charleston-North Charleston SC	2.54	28	1.16	40	1.47	13
Hartford CT	2.30	38	1.16	40	1.20	91
Colorado Springs CO	2.21	44	1.13	54	1.39	46
Buffalo NY	2.13	49	1.12	58	1.41	27
Raleigh NC	2.11	53	1.12	58	1.40	34
Tucson AZ	2.11	53	1.14	50	1.47	13
Toledo OH-MI	2.07	57	1.07	79	1.41	27
New Haven CT	2.05	58	1.12	58	1.40	34
Albany NY	1.97	60	1.11	62	1.40	34
Birmingham AL	1.96	62	1.08	75	1.36	55
Bakersfield CA	1.95	64	1.07	79	1.34	64
Wichita KS	1.93	65	1.11	62	1.40	34
Grand Rapids MI	1.89	67	1.06	86	1.41	27
Columbia SC	1.88	68	1.08	75	1.38	49
Albuquerque NM	1.87	69	1.08	75	1.39	46
Rochester NY	1.83	72	1.09	72	1.40	34
Sarasota-Bradenton FL	1.83	72	1.03	96	1.40	34
Akron OH	1.82	74	1.06	86	1.34	64
Knoxville TN	1.82	74	1.07	79	1.36	55
Allentown PA-NJ	1.78	78	1.09	72	1.40	34
El Paso TX-NM	1.73	81	1.17	37	1.16	97
Tulsa OK	1.73	81	1.08	75	1.40	34
Fresno CA	1.72	84	1.06	86	1.33	73
Cape Coral FL	1.70	87	1.04	95	1.40	34
Dayton OH	1.68	88	1.05	92	1.34	64
Omaha NE-IA	1.65	90	1.10	69	1.39	46
Springfield MA-CT	1.65	90	1.05	92	1.36	55
McAllen TX	1.62	92	1.16	40	1.34	64
Provo-Orem UT	1.53	94	1.03	96	1.34	64

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

Freeway Planning Time Index—A PTI of 2.00 means that 40 minutes should be planned for a 20-minute trip in light traffic (20 minutes x 2.00 = 40 minutes).

Freeway Travel Time Index—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).

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Table 3. How Reliable is Freeway Travel in Your Town, 2014, Continued

Urban Area	Freeway Planning Time Index		Freeway Travel Time Index		Freeway Commuter Stress Index	
	Value	Rank	Value	Rank	Value	Rank
Small Average (22 areas)	**1.76**		**1.09**		**1.30**	
Boulder CO	2.48	30	1.27	22	1.26	81
Stockton CA	2.27	39	1.13	54	1.15	99
Anchorage AK	2.26	41	1.26	23	1.19	92
Boise City ID	2.23	43	1.15	45	1.14	101
Oxnard CA	2.15	48	1.11	62	1.36	55
Madison WI	1.92	66	1.13	54	1.41	27
Little Rock AR	1.85	70	1.11	62	1.15	99
Spokane WA	1.84	71	1.07	79	1.41	27
Winston-Salem NC	1.81	76	1.06	86	1.33	73
Jackson MS	1.78	78	1.07	79	1.36	55
Eugene OR	1.73	81	1.09	72	1.41	27
Poughkeepsie-Newburgh NY-NJ	1.72	84	1.05	92	1.35	61
Worcester MA-CT	1.71	86	1.06	86	1.34	64
Beaumont TX	1.68	88	1.16	40	1.16	97
Salem OR	1.62	92	1.06	86	1.40	34
Corpus Christi TX	1.47	95	1.10	69	1.35	61
Pensacola FL-AL	1.47	95	1.02	99	1.40	34
Greensboro NC	1.44	97	1.03	96	1.32	75
Laredo TX	1.44	97	1.23	29	1.19	92
Lancaster-Palmdale CA	1.41	99	1.02	99	1.32	75
Brownsville TX	1.35	100	1.07	79	1.37	53
Indio-Cathedral City CA	1.32	101	1.01	101	1.26	81
101 Area Average	**2.66**		**1.28**		**1.40**	
Remaining Area Average	**1.74**		**1.08**		**1.21**	
All 471 Area Average	**2.41**		**1.23**		**1.35**	

Very Large Urban Areas—over 3 million population.
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Freeway Planning Time Index—A travel time reliability measure that represents the total travel time that should be planned for a trip to be late for only 1 work trip per month. A PTI of 2.00 means that 40 minutes should be planned for a 20-minute trip in light traffic (20 minutes x 2.00 = 40 minutes).

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Freeway Commuter Stress Index – The travel time index calculated for only the peak direction in each peak period (a measure of the extra travel time for a commuter).

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Table 4. Key Congestion Measures for 370 Urban Areas, 2014

	Annual Hours of Delay		Annual Congestion Cost	
Urban Area	Total (000)	Per Auto Commuter	Total (Million $)	$ per Auto Commuter
Aberdeen-Bel Air S-Bel Air N MD	4,533	20	112	489
Abilene TX	1,039	9	24	201
Aguadilla-Isabela-San Sebastian PR	4,840	16	130	424
Albany GA	1,342	13	31	301
Alexandria LA	1,376	15	34	368
Altoona PA	1,095	13	24	291
Amarillo TX	3,087	14	72	322
Ames IA	452	4	9	82
Anderson IN	1,317	14	31	329
Anderson SC	1,057	13	27	323
Ann Arbor MI	8,658	28	194	621
Anniston AL	987	11	23	260
Antioch CA	4,448	15	100	347
Appleton WI	2,896	12	73	307
Arecibo PR	1,931	13	51	354
Asheville NC	7,849	26	178	590
Athens-Clarke County GA	2,340	17	52	371
Atlantic City NJ	6,514	24	152	561
Auburn AL	1,272	15	30	356
Augusta-Richmond County GA-SC	12,338	30	282	689
Avondale-Goodyear AZ	2,893	13	70	310
Bangor ME	822	14	19	322
Barnstable Town MA	7,520	29	163	627
Battle Creek MI	1,128	13	25	291
Bay City MI	957	13	23	320
Bellingham WA	1,460	12	33	278
Beloit WI-IL	420	6	11	160
Bend OR	1,164	12	31	329
Benton Harbor-St. Joseph-Fair Plain MI	774	15	18	355
Billings MT	1,595	12	35	268
Binghamton NY-PA	2,679	16	64	382
Bismarck ND	969	10	21	220
Blacksburg VA	695	7	15	149
Bloomington IN	1,036	9	24	204
Bloomington-Normal IL	1,495	10	33	233
Bonita Springs FL	6,731	19	148	424
Bowling Green KY	1,219	14	29	325
Bremerton WA	3,265	16	77	379
Bristol TN-VA	923	12	22	289
Brunswick GA	888	11	20	252
Burlington NC	1,176	9	26	192
Burlington VT	1,983	17	46	382
Camarillo CA	1,229	17	27	368
Canton OH	4,761	16	107	367
Cape Girardeau MO-IL	676	10	15	214
Carbondale IL	855	11	20	264
Carson City NV	681	7	15	149
Cartersville GA	858	13	20	301
Casa Grande AZ	537	6	14	163

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Table 4. Key Congestion Measures for 370 Urban Areas, 2014 (continued)

Urban Area	Annual Hours of Delay Total (000)	Annual Hours of Delay Per Auto Commuter	Annual Congestion Cost Total (Million $)	Annual Congestion Cost $ per Auto Commuter
Casper WY	792	10	21	265
Cedar Rapids IA	1,479	7	31	153
Champaign IL	1,966	13	46	291
Charleston WV	3,399	21	78	481
Charlottesville VA	1,349	13	29	275
Chattanooga TN-GA	11,261	28	294	730
Cheyenne WY	914	11	24	295
Chico CA	829	8	19	179
Clarksville TN-KY	2,051	12	52	298
Cleveland TN	983	13	22	294
Coeur d'Alene ID	1,850	17	41	385
College Station-Bryan TX	2,588	14	63	344
Columbia MO	1,884	14	42	304
Columbus GA-AL	4,190	15	93	325
Columbus IN	681	8	16	191
Concord CA	21,712	35	466	752
Concord NC	2,562	12	59	269
Conroe-The Woodlands TX	3,744	14	83	307
Conway AR	770	10	17	229
Corvallis OR	608	6	15	149
Cumberland MD-WV-PA	908	14	23	345
Dalton GA	1,171	13	26	291
Danbury CT-NY	2,937	16	68	382
Danville IL	539	9	13	207
Danville VA-NC	734	9	16	202
Davenport IA-IL	5,335	18	120	402
Davis CA	553	7	13	169
Daytona Beach-Port Orange FL	4,944	23	114	524
Decatur AL	753	10	17	237
Decatur IL	1,119	11	27	266
DeKalb IL	641	8	14	187
Deltona FL	2,561	13	59	296
Denton-Lewisville TX	11,039	29	263	683
Des Moines IA	6,142	12	129	260
Dothan AL	1,236	15	30	370
Dover DE	1,332	11	31	249
Dover-Rochester NH-ME	906	10	20	219
Dubuque IA-IL	768	11	16	221
Duluth MN-WI	2,462	20	56	451
Durham NC	9,575	26	206	558
Eau Claire WI	1,145	10	30	275
El Centro-Calexico CA	439	4	10	87
El Paso de Robles-Atascadero CA	314	4	8	106
Elkhart IN-MI	2,107	14	52	337
Elmira NY	762	11	18	250
Erie PA	3,445	17	87	419
Evansville IN-KY	3,742	16	89	370
Fairbanks AK	635	9	15	212
Fairfield CA	1,980	14	42	303
Fajardo PR	547	6	15	151
Fargo ND-MN	5,255	26	110	551

Farmington NM	1,046	12	28	336

Table 4. Key Congestion Measures for 370 Urban Areas, 2014 (continued)

Urban Area	Annual Hours of Delay Total (000)	Annual Hours of Delay Per Auto Commuter	Annual Congestion Cost Total (Million $)	Annual Congestion Cost $ per Auto Commuter
Fayetteville NC	6,163	18	131	393
Fayetteville-Springdale-Rogers AR-MO	7,564	24	167	520
Flagstaff AZ	872	10	28	335
Flint MI	9,342	25	214	570
Florence AL	1,232	14	28	326
Florence SC	1,104	11	28	272
Florida-Imbrey-Barceloneta PR	892	12	24	310
Fond du Lac WI	498	6	13	160
Fort Collins CO	5,606	19	122	425
Fort Smith AR-OK	2,062	16	46	358
Fort Walton Beach-Navarre-Wright FL	4,897	23	107	494
Fort Wayne IN	9,252	28	212	641
Frederick MD	2,405	16	59	394
Fredericksburg VA	4,004	25	95	607
Gadsden AL	962	14	23	342
Gainesville FL	3,404	17	75	369
Gainesville GA	2,137	15	49	343
Galveston TX	505	6	11	122
Gastonia NC-SC	2,656	15	60	339
Gilroy-Morgan Hill CA	1,474	14	33	311
Glens Falls NY	1,222	17	29	391
Goldsboro NC	705	11	16	244
Grand Forks ND-MN	714	7	16	164
Grand Junction CO	1,363	10	30	212
Great Falls MT	776	11	17	234
Greeley CO	1,596	13	36	285
Green Bay WI	3,728	17	95	431
Greenville NC	1,525	11	34	255
Greenville SC	10,389	24	260	602
Guayama PR	1,193	14	32	383
Gulfport MS	4,463	19	98	411
Hagerstown MD-WV-PA	3,223	16	80	392
Hammond LA	757	10	19	239
Hanford CA	106	1	4	37
Harlingen TX	1,530	10	34	228
Harrisburg PA	10,342	23	254	562
Harrisonburg VA	815	10	18	237
Hattiesburg MS	1,159	13	26	298
Hazleton PA	656	13	15	283
Hemet CA	495	3	11	62
Hickory NC	4,423	19	98	427
High Point NC	2,866	16	63	345
Hinesville GA	462	7	10	169
Holland MI	1,688	15	37	341
Hot Springs AR	732	11	15	232
Houma LA	2,424	16	60	397
Huntington WV-KY-OH	3,280	16	77	362
Huntsville AL	7,253	23	159	510
Idaho Falls ID	621	6	14	135
Iowa City IA	740	6	16	125

Ithaca NY	867	16	20	370
Jackson MI	1,182	13	26	280

Table 4. Key Congestion Measures for 370 Urban Areas, 2014 (continued)

Urban Area	Annual Hours of Delay		Annual Congestion Cost	
	Total (000)	Per Auto Commuter	Total (Million $)	$ per Auto Commuter
Jackson TN	1,024	13	28	367
Jacksonville NC	1,428	13	31	284
Janesville WI	611	8	16	209
Jefferson City MO	607	8	14	172
Johnson City TN	1,594	12	37	272
Johnstown PA	711	10	16	235
Jonesboro AR	1,089	15	24	338
Joplin MO	1,252	15	29	335
Juana Diaz PR	907	11	24	296
Kailua (Honolulu County)-Kaneohe HI	1,254	10	29	227
Kalamazoo MI	5,136	23	115	515
Kankakee IL	873	10	22	244
Kennewick-Richland WA	2,780	12	67	281
Kenosha WI	1,133	8	30	219
Killeen TX	2,533	11	58	254
Kingsport TN-VA	1,665	15	40	357
Kingston NY	1,482	17	34	394
Kissimmee FL	7,814	22	185	517
Kokomo IN	1,174	12	27	264
La Crosse WI-MN	1,350	12	35	323
Lady Lake-The Villages FL	606	5	14	111
Lafayette IN	2,473	15	59	363
Lafayette LA	7,047	26	194	715
Lafayette-Louisville-Erie CO	1,083	12	23	264
Lake Charles LA	2,352	15	64	414
Lake Havasu City AZ	358	4	11	114
Lake Jackson-Angleton TX	694	9	16	205
Lakeland FL	4,022	14	96	331
Lancaster PA	7,807	18	187	441
Lansing MI	7,742	24	168	513
Las Cruces NM	1,126	8	32	220
Lawrence KS	1,430	13	34	310
Lawton OK	838	8	19	187
Lebanon PA	580	7	14	166
Leesburg-Eustis-Tavares FL	1,279	9	31	203
Leominster-Fitchburg MA	1,546	13	34	283
Lewiston ID-WA	579	9	14	200
Lewiston ME	722	11	18	273
Lexington Park-Cal-Ches Ranch Est MD	743	15	16	329
Lexington-Fayette KY	8,250	27	199	656
Lima OH	938	12	25	325
Lincoln NE	5,544	19	124	428
Livermore CA	1,395	16	31	358
Lodi CA	571	8	13	179
Logan UT	793	8	25	234
Lompoc CA	440	6	10	126
Longmont CO	1,238	12	27	266
Longview TX	1,512	15	35	342
Longview WA-OR	985	15	24	367

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Lorain-Elyria OH	2,550	14	58	308
Lubbock TX	2,933	12	67	269
Lynchburg VA	2,328	18	50	387

Table 4. Key Congestion Measures for 370 Urban Areas, 2014 (continued)

	Annual Hours of Delay		Annual Congestion Cost	
Urban Area	**Total (000)**	**Per Auto Commuter**	**Total (Million $)**	**$ per Auto Commuter**
Macon GA	2,271	15	51	337
Madera CA	360	4	8	87
Manchester NH	2,302	13	53	311
Mandeville-Covington LA	1,753	18	45	470
Manhattan KS	478	5	11	109
Mankato MN	602	8	13	182
Mansfield OH	838	10	19	232
Manteca CA	623	7	16	177
Marysville WA	2,630	16	62	389
Mauldin-Simpsonville SC	886	7	22	169
Mayaguez PR	1,468	13	39	353
McKinney TX	1,811	9	43	215
Medford OR	1,989	11	47	267
Merced CA	1,317	9	33	218
Michigan City-La Porte IN-MI	844	12	21	297
Middletown OH	850	8	20	182
Midland MI	735	10	18	238
Midland TX	972	7	25	188
Mission Viejo-Lk Forest-San Clemente CA	17,389	28	361	590
Missoula MT	1,443	15	32	334
Mobile AL	10,396	30	236	670
Modesto CA	6,656	18	159	421
Monessen-California PA	563	8	13	183
Monroe LA	1,820	14	45	356
Monroe MI	829	9	19	201
Montgomery AL	6,494	24	149	553
Morgantown WV	1,065	14	24	311
Morristown TN	1,001	19	24	458
Mount Vernon WA	857	15	21	367
Muncie IN	1,063	11	25	247
Murrieta-Temecula-Menifee CA	3,084	7	72	162
Muskegon MI	2,697	16	59	348
Myrtle Beach-Socastee SC-NC	7,452	30	188	754
Nampa ID	2,109	13	47	283
Napa CA	1,178	13	26	290
Nashua NH-MA	3,372	14	78	324
New Bedford MA	1,563	10	34	219
Newark OH	621	7	14	167
North Port-Port Charlotte FL	1,806	10	41	216
Norwich-New London CT-RI	3,017	20	69	451
Ocala FL	1,994	12	47	276
Odessa TX	1,605	13	39	330
Ogden-Layton UT	10,408	18	339	581
Olympia-Lacey WA	3,929	20	94	481
Oshkosh WI	513	6	13	155
Owensboro KY	1,010	13	27	335
Palm Coast-Daytona Bch-Port Orange FL	9,849	20	230	471
Panama City FL	3,395	21	77	485

Parkersburg WV-OH	965	14	22	317
Pascagoula MS	778	14	18	323
Peoria IL	4,743	17	110	391
Petaluma CA	634	9	15	201

Table 4. Key Congestion Measures for 370 Urban Areas, 2014 (continued)

Urban Area	Annual Hours of Delay		Annual Congestion Cost	
	Total (000)	Per Auto Commuter	Total (Million $)	$ per Auto Commuter
Pine Bluff AR	626	7	14	160
Pittsfield MA	556	7	12	150
Pocatello ID	656	9	15	199
Ponce PR	1,862	13	50	336
Port Huron MI	1,209	13	28	297
Port St. Lucie FL	8,123	19	189	448
Porterville CA	228	3	6	73
Portland ME	2,973	14	70	332
Portsmouth NH-ME	1,479	15	33	349
Pottstown PA	948	9	22	199
Prescott Valley-Prescott AZ	1,156	12	27	285
Pueblo CO	1,690	11	38	250
Racine WI	1,412	10	37	256
Radcliff-Elizabethtown KY	918	10	21	221
Rapid City SD	1,153	12	27	281
Reading PA	5,183	19	125	465
Redding CA	2,093	16	46	345
Reno NV	8,300	20	179	428
Roanoke VA	4,585	20	105	465
Rochester MN	1,581	13	34	282
Rock Hill SC	1,355	12	35	311
Rockford IL	7,221	23	173	558
Rocky Mount NC	714	11	15	228
Rome GA	1,029	16	24	361
Round Lk Bch-McHenry-Grayslake IL-WI	402	1	10	34
Saginaw MI	2,082	17	46	364
Salinas CA	2,037	10	47	233
Salisbury MD-DE	1,164	11	27	258
San Angelo TX	899	8	20	188
San German-Cabo Rojo-Sabana Grnd PR	749	6	20	159
San Luis Obispo CA	822	10	18	218
Santa Barbara CA	3,993	20	89	434
Santa Clarita CA	3,703	15	86	341
Santa Cruz CA	3,806	21	82	444
Santa Fe NM	1,790	19	42	437
Santa Maria CA	1,890	13	43	299
Santa Rosa CA	5,915	19	128	407
Saratoga Springs NY	843	11	20	267
Savannah GA	8,013	28	179	619
Scranton PA	8,297	21	188	473
Seaside-Monterey CA	1,606	13	35	287
Sheboygan WI	523	7	13	177
Sherman TX	735	9	19	228
Shreveport LA	8,412	27	222	713
Sierra Vista AZ	565	7	13	156
Simi Valley CA	690	5	14	110
Sioux City IA-NE-SD	598	5	14	127

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Sioux Falls SD	2,743	15	66	368
Slidell LA	791	8	21	212
South Bend IN-MI	5,205	18	125	425
South Lyon-Howell MI	2,376	18	65	505
Spartanburg SC	3,250	16	82	406

Table 4. Key Congestion Measures for 370 Urban Areas, 2014 (continued)

	Annual Hours of Delay		Annual Congestion Cost	
	Total	Per Auto	Total	$ per Auto
Urban Area	(000)	Commuter	(Million $)	Commuter
Springfield IL	2,222	13	51	287
Springfield MO	7,403	25	166	556
Springfield OH	796	9	18	195
St. Augustine FL	1,055	13	23	275
St. Cloud MN	2,190	19	51	438
St. George UT	1,146	10	32	281
St. Joseph MO-KS	936	10	24	263
State College PA	516	5	11	116
Sumter SC	927	12	24	308
Syracuse NY	9,443	22	224	530
Tallahassee FL	5,846	28	130	621
Temple TX	1,014	11	26	267
Terre Haute IN	1,812	19	43	452
Texarkana TX-AR	1,014	12	25	294
Texas City TX	1,917	16	42	349
Thousand Oaks CA	5,486	25	116	527
Titusville FL	542	7	13	159
Topeka KS	2,533	16	62	388
Tracy CA	126	1	3	38
Trenton NJ	6,970	24	157	532
Turlock CA	111	1	3	31
Tuscaloosa AL	2,563	17	61	403
Twin Rivers-Highstown NJ	1,178	17	26	384
Tyler TX	2,028	14	53	379
Uniontown-Connellsville PA	453	9	10	200
Utica NY	2,288	19	53	433
Vacaville CA	665	7	14	143
Valdosta GA	1,246	15	29	351
Vallejo CA	3,828	21	83	456
Vero Beach-Sebastian FL	1,475	18	35	418
Victoria TX	1,014	14	24	336
Victorville-Hesperia CA	4,286	12	102	292
Villas NJ	800	12	19	286
Vineland NJ	1,150	11	26	262
Visalia CA	1,980	8	46	190
Waco TX	2,039	11	52	276
Waldorf MD	1,713	14	41	326
Walla Walla-WA-OR	258	4	7	118
Warner Robins GA	1,646	11	36	247
Waterbury CT	3,851	20	90	458
Waterloo IA	532	4	11	88
Watsonville CA	1,118	14	25	315
Wausau WI	868	11	22	283
Weirton-Steubenville WV-OH-PA	742	10	18	239
Wenatchee WA	772	10	19	251
West Bend WI	658	9	17	229

Westminster-Eldersburg MD	1,101	14	27	354
Wheeling WV-OH	954	11	24	275
Wichita Falls TX	1,031	10	25	239
Williamsport PA	1,045	20	23	434
Wilmington NC	4,905	20	106	435
Winchester VA	977	13	22	293

Table 4. Key Congestion Measures for 370 Urban Areas, 2014 (continued)

Urban Area	Annual Hours of Delay Total (000)	Annual Hours of Delay Per Auto Commuter	Annual Congestion Cost Total (Million $)	Annual Congestion Cost $ per Auto Commuter
Winter Haven FL	2,888	13	71	329
Yakima WA	2,187	15	52	368
Yauco PR	443	5	12	121
York PA	3,801	15	90	368
Youngstown OH-PA	7,744	20	181	466
Yuba City CA	1,212	9	30	227
Yuma AZ-CA	1,531	11	41	292
Zephyrhills FL	602	12	14	274

CAUTION: See https://mobility.tamu.edu/umr/ for improved performance measures and updated data.

References

1. *Current Employment Statistics,* U.S. Bureau of Labor Statistics, U.S. Department of Labor, Washington D.C., http://www.bls.gov/ces/home.htm

2. *National Average Speed Database*, 2009 to 2014. INRIX. Kirkland, WA. www.inrix.com

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

4. *SHRP2 Project C11, Chapter 3. Reliability Analysis Tool: Technical Documentation and User's Guide* Prepared by: Cambridge Systematics, Inc. and Weris, Inc. Prepared for: Transportation Research Board July 2013. *Available*: *http://www.tpics.us/tools/documents/SHRP-C11-Reliability-Tech-Doc-and-User-Guide.pdf*

5. *Urban Mobility Scorecard Methodology. Texas A&M Transportation Institute, College Station, Texas. 2015. Available: http://mobility.tamu.edu/ums/methodology*

6. *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

7. *Moving Ahead for Progress in the 21st Century Act (MAP-21): A Summary of Highway Provisions.* United States Department of Transportation, Federal Highway Administration, Office of Policy and Governmental Affairs, July 17, 2012. Available: http://www.fhwa.dot.gov/map21/summaryinfo.cfm.

CAUTION: See https://mobility.tamu.edu/umr/ for improved performance measures and updated data.

Appendix A
Methodology for the *2015 Urban Mobility Scorecard*

The procedures used in the *2015 Urban Mobility Scorecard* have been developed by the Texas A&M 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 *2015 Urban Mobility Scorecard*. This methodology incorporates private sector traffic speed data from INRIX for calendar year 2014 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 for the *2015 UMS*

There are several changes to the *UMS* methodology for the *2015 Urban Mobility Scorecard*. The largest changes have to do with the reliability measure (Planning Time Index), estimates of daily truck volumes, and the ever-increasing INRIX speed data set size. These changes are documented in more detail in the following sections of the Methodology. Here are brief summaries of what has changed:

- Estimates of hourly truck volume were developed and incorporated. In past reports, trucks were assumed to have the same patterns as car travel.
- The measure of the variation in travel time from day-to-day now uses a more representative trip-based process rather than the old dataset that used individual road links. The Planning Time Index (PTI) is based on the ideas that travelers want to be on-time for an important trip 19 out of 20 times; so one would be late to work only one day per month (on-time for 19 out of the 20 work days each month). For example, a PTI value of 1.80 indicates that a traveler should allow 36 minutes to make an important trip that takes 20 minutes in low traffic volumes.
- Speeds supplied by INRIX are collected every 15-minutes from a variety of sources every day of the year on most major roads. Many of the slow speeds formerly considered “too slow to be a valid observation” are now being retained in the INRIX dataset. Experience and increased travel speed sample sizes have increased the confidence in the data.

Summary

The *Urban Mobility Scorecard (UMS)* 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.

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 2014 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 INRIX 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 2014 INRIX traffic speed data provide a better data source for the first two inputs, actual and free-flow travel time. The *UMS* 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 INRIX 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 15-minute time intervals for each day of the week to match with the time aggregation of the speed data.

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

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

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

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

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

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

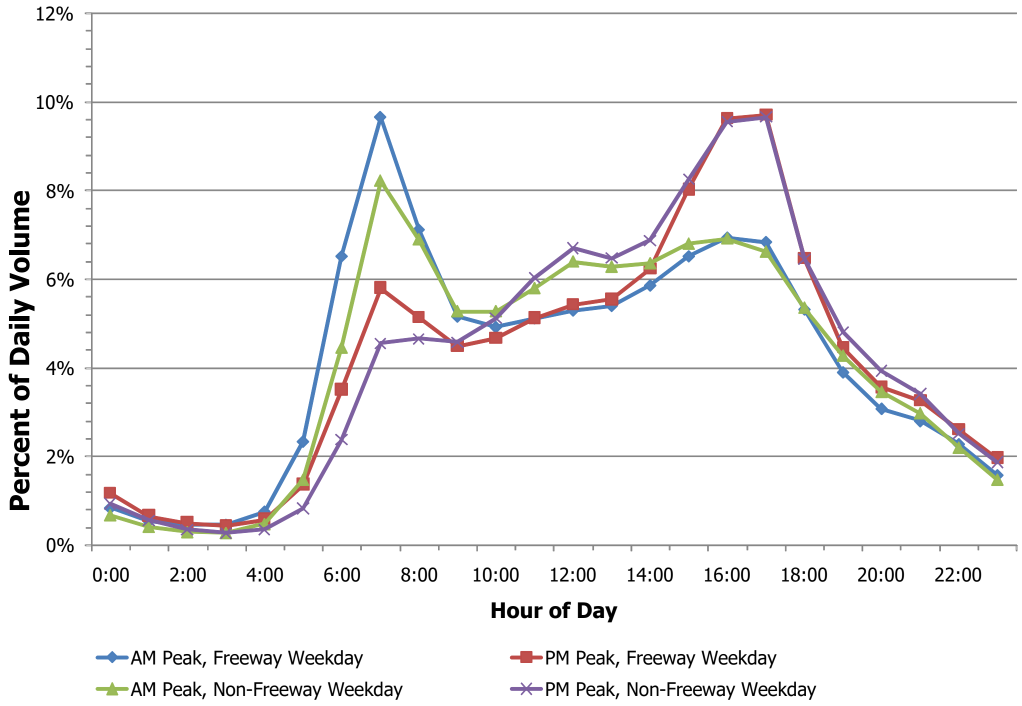


Exhibit A-3. Weekday Traffic Distribution Profile for Moderate Congestion

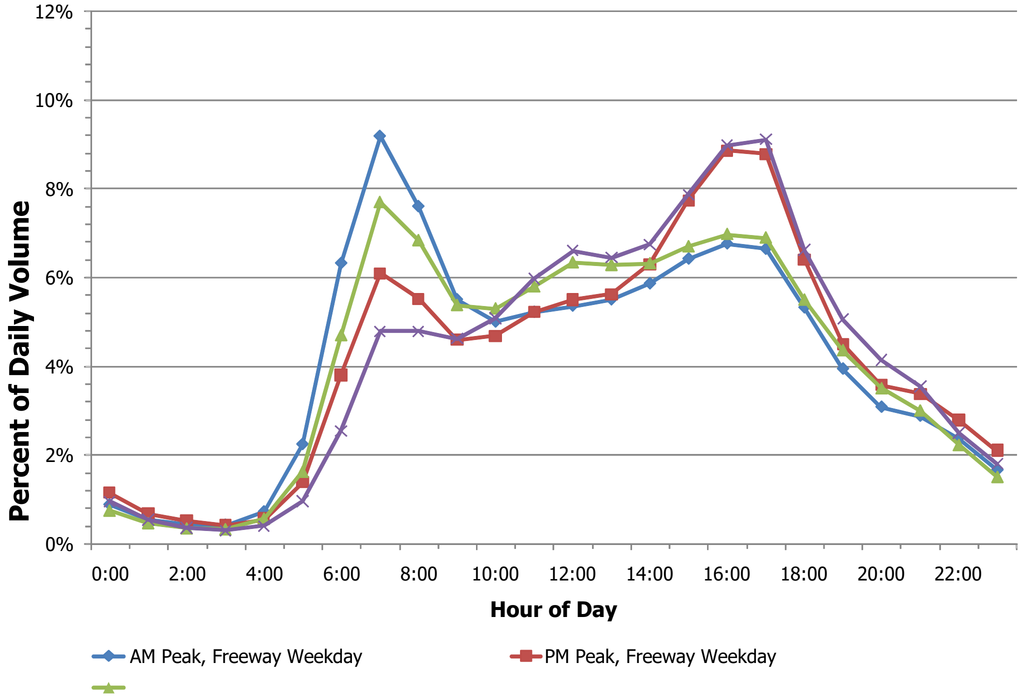


Exhibit A-4. Weekday Traffic Distribution Profile for Severe Congestion

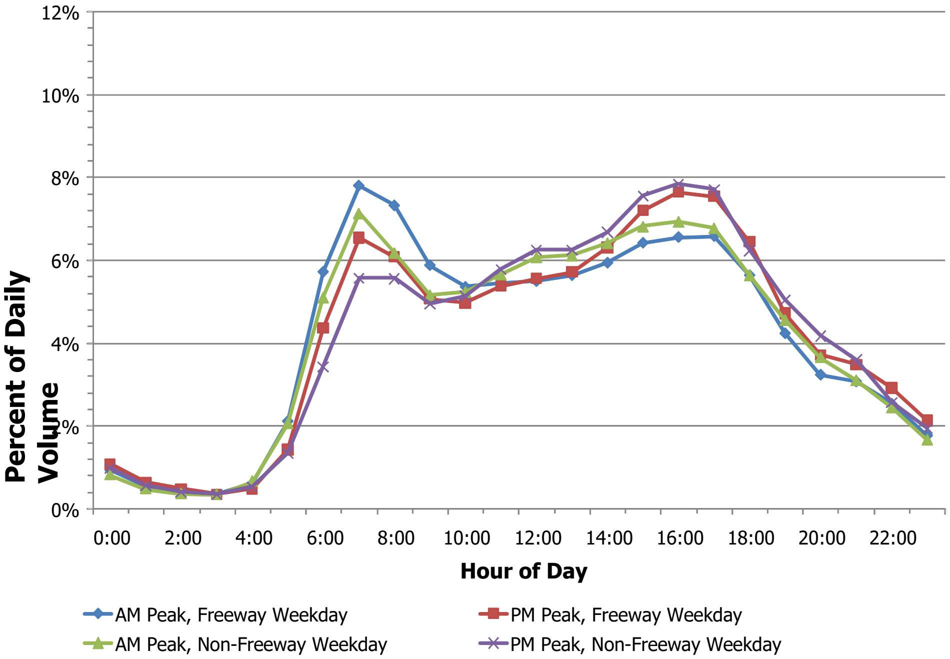


Exhibit A-5. Weekend Traffic Distribution Profile

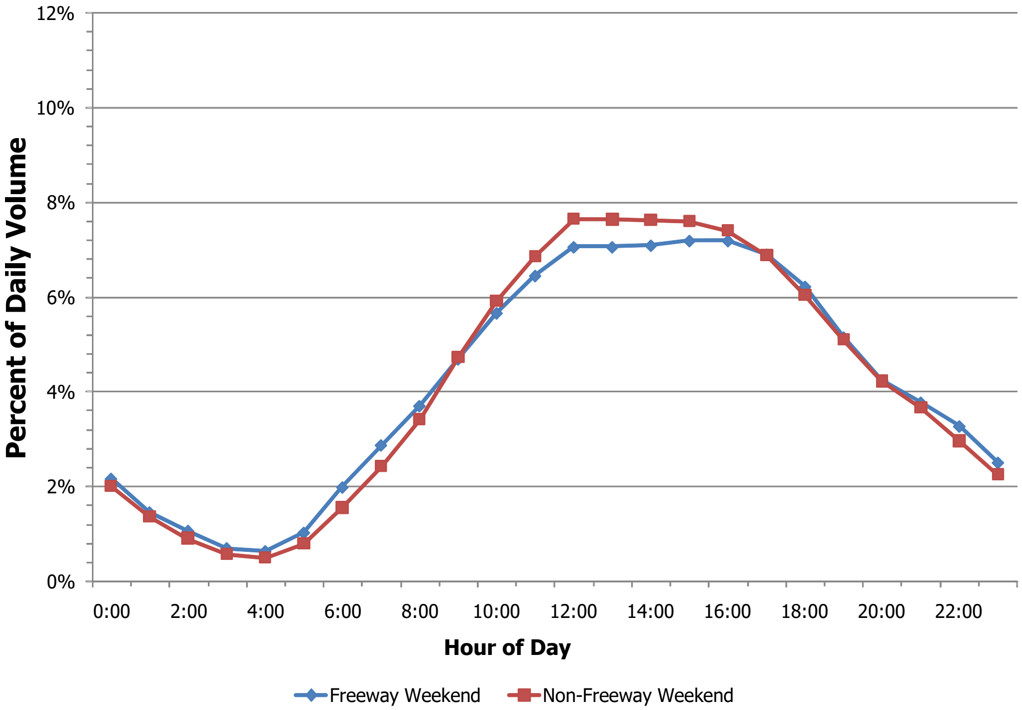
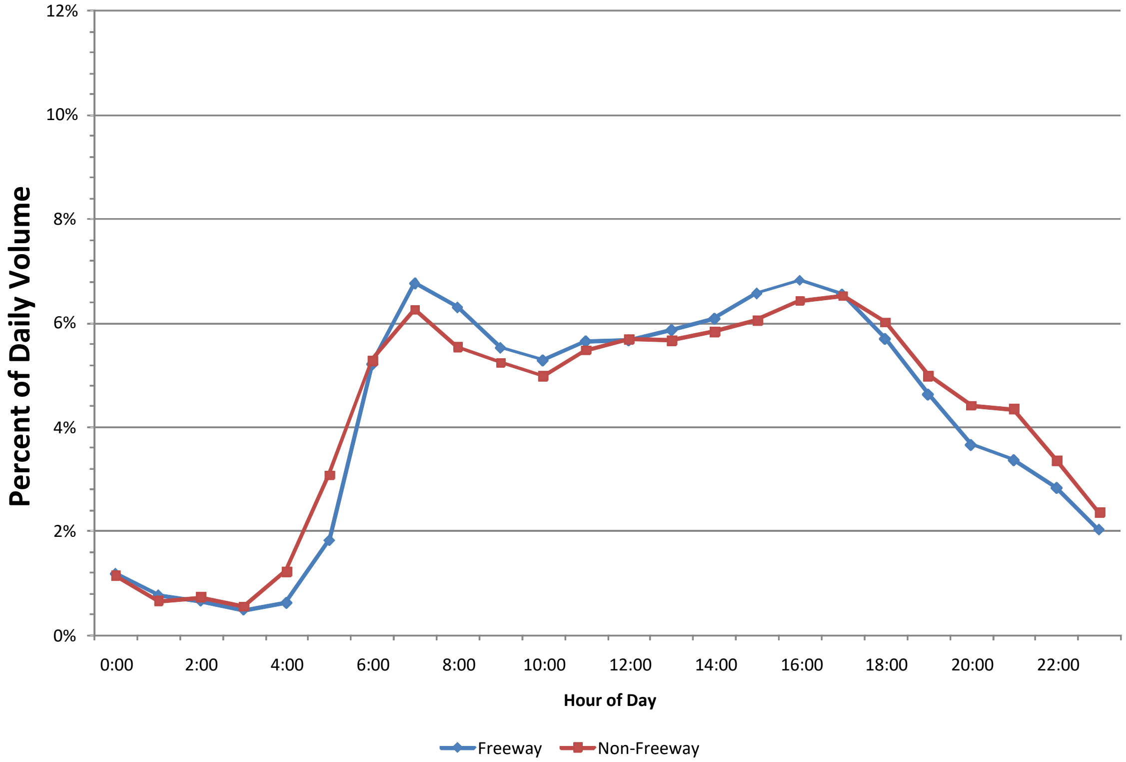


Exhibit A-6. Weekday Traffic Distribution Profile for Severe Congestion and Similar Speeds in Each Peak Period



The next step in the traffic flow assignment process is to determine which of the 16 traffic distribution profiles should be assigned to each XD Network roadway link ("XD Network" is the "geography" used by INRIX to define the roadways), 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 XD Network path using speed data from 6 a.m. to 10 a.m. (morning peak period) and 3 p.m. to 7 p.m. (evening peak period).

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

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

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

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.

Truck-Only Volume Profiles

New to the *2015 Urban Mobility Scorecard* is the use of truck-only volume curves. The mixed-vehicle process is repeated to create 15-minute truck volumes from daily truck volumes. However, much of the necessary information (e.g., facility type, day type, and time of day peaking) have already been determined in the mixed-vehicle volume process. The eight truck-only profiles used to create the 15-minute truck volumes are shown in Exhibits A-7 through A-9. The truck-only profiles are identical for all congestion levels.

Exhibit A-7. Weekday Freeway Truck-Traffic Distribution Profiles

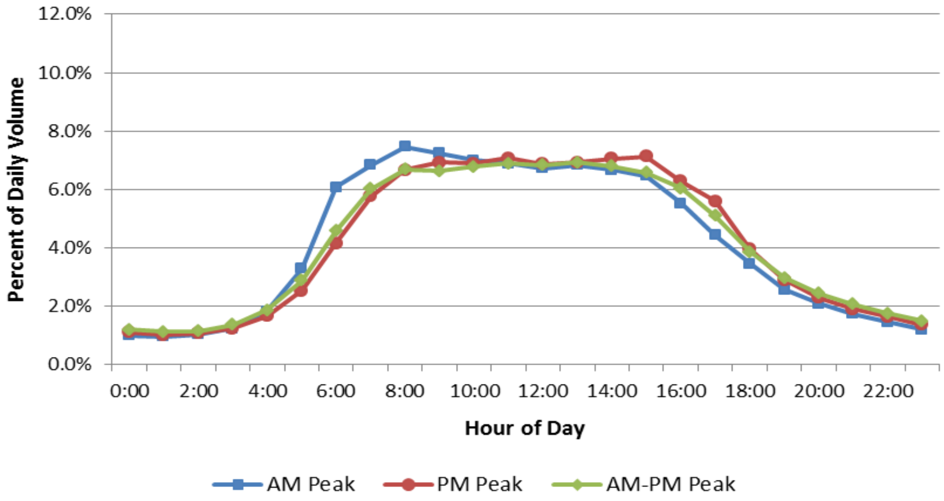


Exhibit A-8. Weekday Non-Freeway Truck-Traffic Distribution Profiles

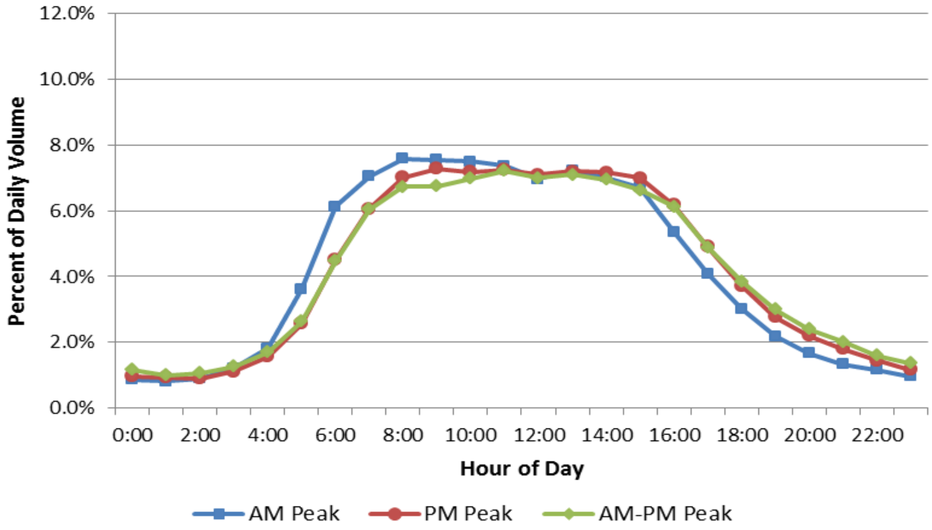
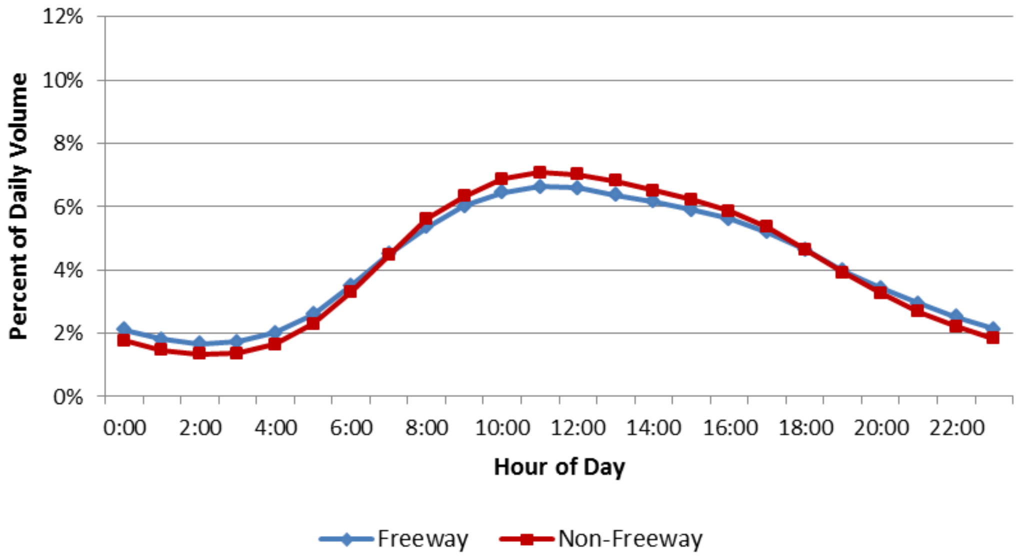


Exhibit A-9. Weekend Truck-Traffic Distribution Profiles



Step 4. Calculate Travel Time

The hourly speed and volume data were combined to calculate the total travel time for each 15-minute time period. The 15-minute 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 UMS methodology, the data were 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 15-minute 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 UMS 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 eventually be added to the GIS roadway shapefiles by the state DOTs as mandated by FHWA). A technique for handling the unmatched sections of roadway was used in the 2015 UMS. The percentage of arterial streets that had INRIX speed data is approximately 75 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 free-flow 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 were 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.

Calculation of the Congestion Measures

This section summarizes the methodology utilized to calculate many of the statistics shown in the *Urban Mobility Scorecard* 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. Not all of the measures are reported in the *2015 Urban Mobility Scorecard*. In some cases, the measures below were last reported in the *2012 Urban Mobility Report (UMR)*; this is noted in the pages that follow.

1. **National Constants**
2. **Urban Area Constants and Inventory Values**
3. **Variable and Performance Measure Calculation Descriptions**
    1) Travel Delay
    2) Annual Person Delay
    3) Annual Delay per Auto Commuter
    4) Total Peak Period Travel Time (last reported in *2012 UMR*)
    5) Travel Time Index
    6) Commuter Stress Index
    7) Planning Time Index
    8) Carbon Dioxide (CO_2) Production and Wasted Fuel (CO_2 last reported in *2012 UMR*)
    9) Total Congestion Cost and Truck Congestion Cost
    10) Truck Commodity Value (last reported in *2012 UMR*)
    11) Number of Rush Hours
    12) Percent of Daily and Peak Travel in Congested Conditions
    13) 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-10 as national constants—values used in all urban areas to estimate the effect of congestion.

Exhibit A-10. National Congestion Constants for *2015 Urban Mobility Scorecard*

Constant	Value
Vehicle Occupancy	1.25 persons per vehicle
Average Cost of Time ($2014) (*2*)	$17.67 per person hour[1]
Commercial Vehicle Operating Cost ($2014) (*3*)	$94.04 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 2014 value of person time used in the report is $17.67 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 $94.04 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 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 (e.g.,high tourism areas) may not represent all of the transportation users on an average day. The same NHTS data were also used to estimate the 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 Delay

Most of the basic performance measures presented in the *2015 Urban Mobility Scorecard* 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.

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

Annual Person Delay

This calculation is performed to expand the daily vehicle-hours of delay estimates for freeways and arterial streets to a yearly estimate in each study area. To calculate the annual person-hours of delay, multiply each day-of-the-week delay estimate by the average vehicle occupancy (1.25 persons per vehicle) and by 52 weeks per year (Equation A-3).

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

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 Scorecard* 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.

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

Total Peak Period Travel Time (Last reported in the 2012 UMR)

Total travel time is the sum of travel delay and free-flow travel time. 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.

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

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.

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

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).

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

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

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) was new beginning with the *2012 Urban Mobility Report*. Results are shown in Table 3 of the *2015 Urban Mobility Scorecard*. The PTI is based on the idea that travelers want to be on-time for an important trip 19 out of 20 times; so one would be late to work only one day per month (on-time for 19 out of 20 work days each month). For example, a PTI value of 1.80 indicates that a traveler should allow 36 minutes to make an important trip that takes 20 minutes in low traffic volumes. The PTI values in Table 3 are for freeways only.

The PTI is the 95th percentile travel time relative to the free-flow travel time as shown in Equation A-10. The *2015 Urban Mobility Scorecard* estimates the PTI for trips using average link (XD Network link) freeway PTI values. Researchers compute these trip PTI estimates using Equation A-11, which is from the Strategic Highway Research Program, 2 (SHRP2) *Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies* (*8*).

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

$$PTI_{trip} = (PTI_{link})^{0.8014} \qquad \text{(Eq. A-11)}$$

Where:

PTI_{trip} = PTI for a trip (reported for freeways in Table 3 of the *2015 UMS*); and

PTI_{link} = Average of PTIs for all the XD Network links weighted by VMT in the urban area.

Exhibit A-11 illustrates a distribution of travel times for a morning commute. Travel times can vary over a calendar year; the extreme cases usually have identifiable causes. 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.

Carbon Dioxide (CO_2) Production and Wasted Fuel (CO_2 was last reported in 2012 UMR)

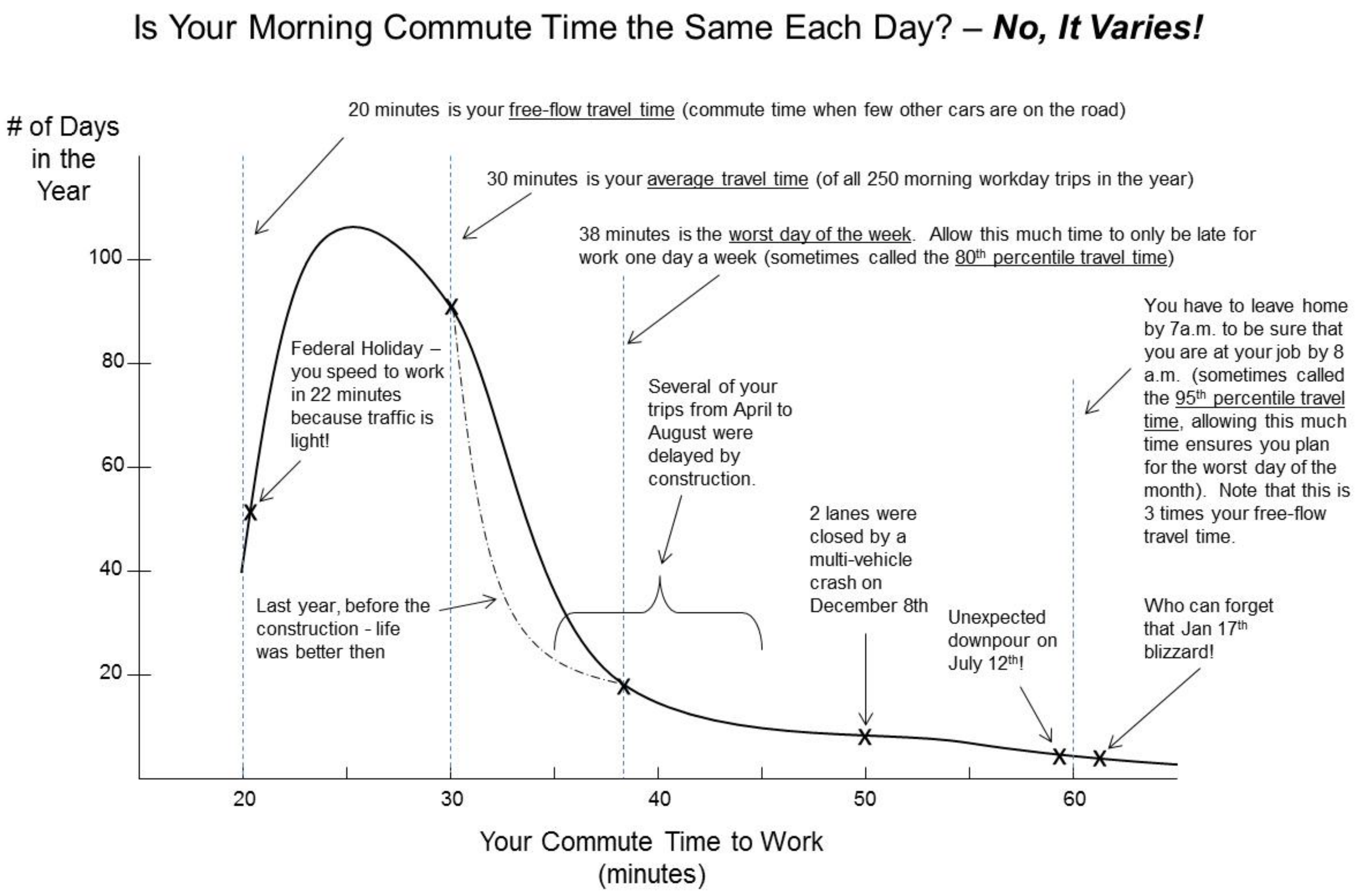
This methodology uses data from the United States Environmental Protection Agency's (EPA) MOtor Vehicle Emission Simulator (MOVES) model. MOVES is a model developed by the EPA to estimate emissions from mobile sources. Researchers primarily used MOVES to obtain vehicle emission rates, climate data, and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

CAUTION: See https://mobility.tamu.edu/umr/ for improved performance measures and updated data.

Exhibit A-11. Example of Morning Commute Travel Time Distribution



Is Your Morning Commute Time the Same Each Day? – ***No, It Varies!***

20 minutes is your free-flow travel time (commute time when few other cars are on the road)

30 minutes is your average travel time (of all 250 morning workday trips in the year)

38 minutes is the worst day of the week. Allow this much time to only be late for work one day a week (sometimes called the 80th percentile travel time)

You have to leave home by 7a.m. to be sure that you are at your job by 8 a.m. (sometimes called the 95th percentile travel time, allowing this much time ensures you plan for the worst day of the month). Note that this is 3 times your free-flow travel time.

Federal Holiday – you speed to work in 22 minutes because traffic is light!

Several of your trips from April to August were delayed by construction.

Last year, before the construction - life was better then

2 lanes were closed by a multi-vehicle crash on December 8th

Unexpected downpour on July 12th!

Who can forget that Jan 17th blizzard!

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."

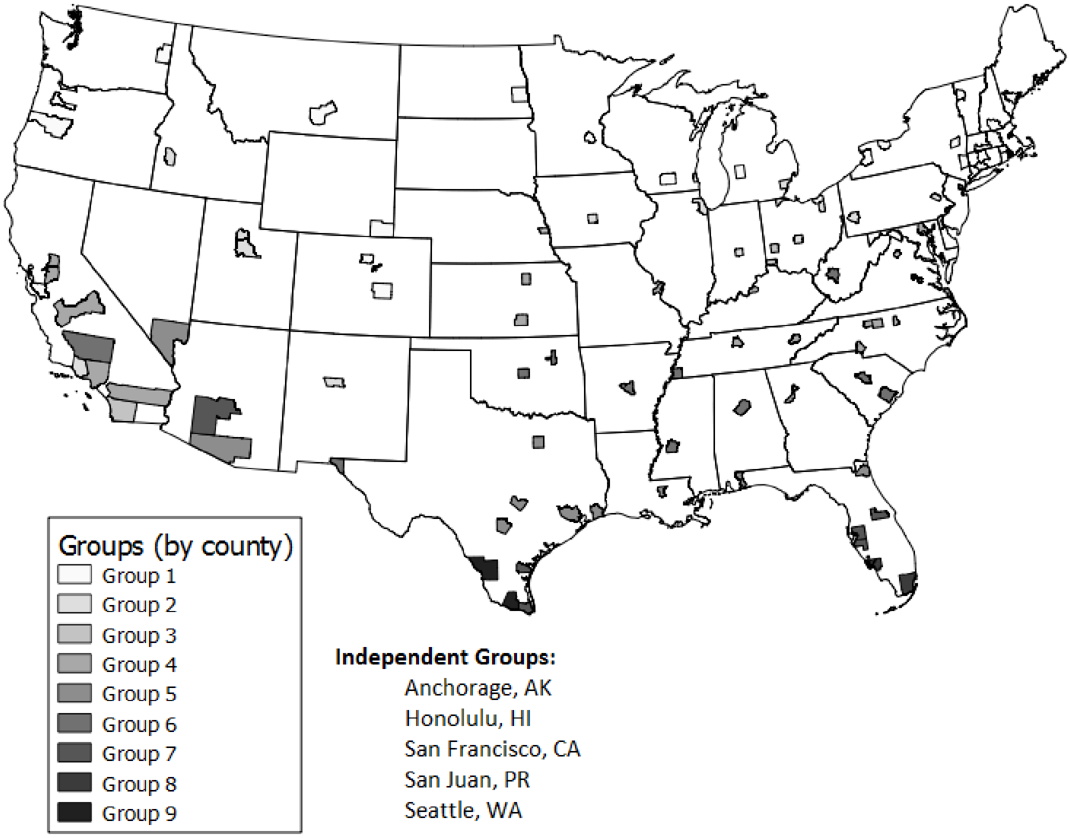
Because ACF is a factor of temperature and relative humidity, researchers collected hourly temperature and relative humidity data for a county within each urban area included in TTI's *UMR* from the MOVES database. Researchers collected the climate data by county, rather than urban area (or city), because 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-12 shows the groupings of urban areas.

Exhibit A-12. 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.

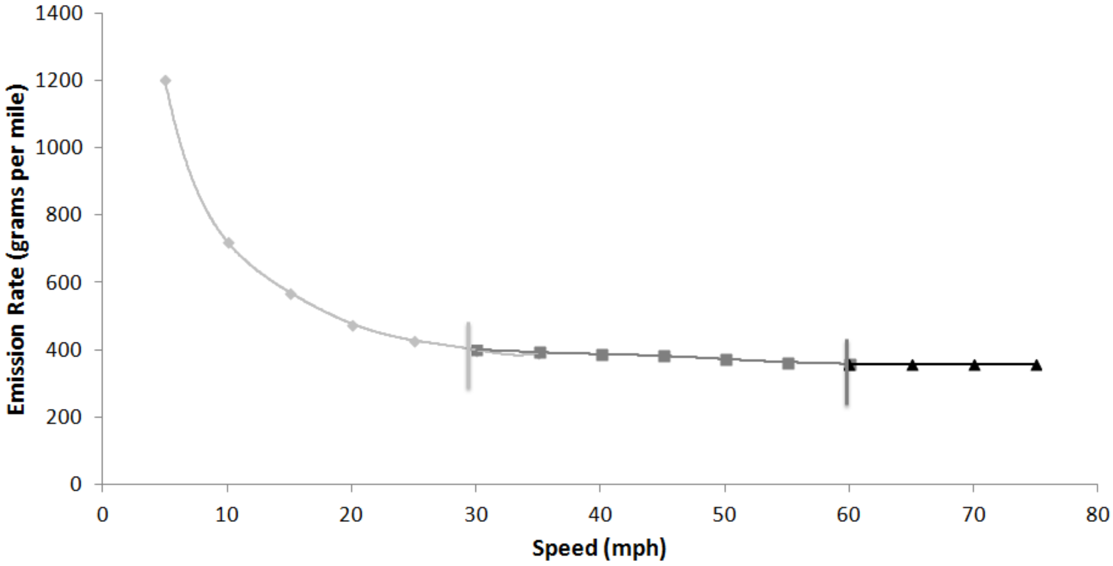
TTI researchers ran MOVES for the appropriate vehicle types, fuel types, and road types to obtain emission rates in grams per mile.

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-13 example). Researchers compared emission rates generated with the polynomial spline to the underlying MOVES-generated emission rates.

Exhibit A-13. 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 speeds when few cars are on the road to estimate free-flow emissions and fuel consumption. To estimate the CO_2 emissions from congestion, researchers subtracted the free-flow condition 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).

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

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

A Word about Assumptions in the CO_2 and Fuel Methodology

Table 4 of the main *2012 Urban Mobility 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 each urban area. More detailed and localized inputs and analyses are conducted by local or state agencies; those are better estimates of CO_2 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 *UMS* 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 all urban areas.

Total Congestion Cost and Truck Fuel 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.

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

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.

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

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.

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

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 (Last reported in 2012 UMR)

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.

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

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

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

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).

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

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

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

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

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*.

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

Number of “Rush Hours” (Congested Hours), Congested Lane-Miles, and Congested VMT

The number of “rush hours” (congested hours) is computed with a new method in the *2015 Urban Mobility Scorecard*. For each XD Network directional roadway link the 15-minute average speeds during the peak eight hours are evaluated for all five weekdays. If any 15-minute speed is less than 90 percent of the uncongested speed on a freeway, or less than 75 percent of the uncongested speed on an arterial, the section of road is marked as “congested” for that 15-minute period (*9*). If 30 percent of the urban area freeway system is congested, the 15-minute period is considered congested. Similarly, if 50 percent of the arterial road sections across the urban area are congested, the associated 15-minute period is considered congested. The number of congested 15-minute periods across the urban area (freeway or arterial) are summed to determine the urban area congested hours (“rush hours”) (*10*).

Congested lane-miles are similarly identified; speed below congestion threshold (90 percent/75 percent of uncongested speed on freeways/arterials). These lane-miles are summed for those time periods across the urban area separately for freeways and arterials. Congested vehicle-miles of travel is also summed for each 15-minute period for urban area freeways and arterial streets. These summations of peak period vehicle-miles of travel and lane-miles are compared with the peak-period totals to determine the percent that is congested.

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2015 URBAN MOBILITY Scorecard

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