UTCM

"Improving the Quality of Life
by Enhancing Mobility"

University Transportation Center for Mobility

DOT Grant No. DTRT06-G-0044

Improving Mobility Information with Better Data and Estimation Procedures

Final Report

Tim Lomax, Bruce Wang, David Schrank, William Eisele, Shawn Turner, David Ellis, Yingfeng Li, Nick Koncz, and Lauren Geng

Performing Organization
University Transportation Center for Mobility™
Texas Transportation Institute
The Texas A&M University System
College Station, TX

Sponsoring Agency
Department of Transportation
Research and Innovative Technology Administration
Washington, DC

Texas
Transportation
Institute

UTCM Project # 09-17-09
March 2010

Technical Report Documentation Page

1. Project No. UTCM 09-17-09	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Improving Mobility Information with Better Data and Estimation Procedures		5. Report Date March 2010
		6. Performing Organization Code Texas Transportation Institute
7. Author(s) Tim Lomax, Bruce Wang, David Schrank, William Eisele, Shawn Turner, David Ellis, Yingfeng Li, Nick Koncz, and Lauren Geng		8. Performing Organization Report No. UTCM 09-17-09
9. Performing Organization Name and Address University Transportation Center for Mobility™ Texas Transportation Institute The Texas A&M University System 3135 TAMU College Station, TX 77843-3135		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DTRT06-G-0044
12. Sponsoring Agency Name and Address Department of Transportation Research and Innovative Technology Administration 400 7th Street, SW Washington, DC 20590		13. Type of Report and Period Covered Final Report 01/01/2009 – 12/31/2009
		14. Sponsoring Agency Code
15. Supplementary Notes Supported by a grant from the US Department of Transportation, University Transportation Centers Program		

16. Abstract

The Texas Transportation Institute (TTI) continues to be a national leader in providing congestion and mobility information. The information produced by TTI is used to communicate the issues of urban mobility at all levels of government in the U.S. and by both industry and non-industry professionals when discussing mobility topics. The transportation field continues to evolve with more technological advancements affecting travel on the roadways and the data collected. This project incorporates the speed data from some of these new technologies into the Urban Mobility Report (UMR) to ensure that the report remains the preeminent source on the subject. The 2009 Urban Mobility Report will utilize the current speed estimation methodology, but future reports may be able to incorporate some archived speed information in place of the current estimated speeds. With the fuel price increases of the past few years, an updated analysis of the effects of fuel price fluctuations on travel demand and congestion are being included in the UMR. TTI has developed a methodology for estimating the commodities that are flowing in trucks and the associated traffic delay throughout our nation's cities. However, at this time, it is unclear how to utilize this information in decision-making. Some analysis is being performed to determine how to utilize this truck commodity flow information.

17. Key Word Mobility, Traffic Congestion, Traffic Delay, Traffic Estimation, Traffic Data, Travel Demand, Commodity Flow, Data Collection, Fuel Prices, Research Projects		18. Distribution Statement Public distribution	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 87	22. Price n/a

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Improving Mobility Information with Better Data and Estimation Procedures

Tim Lomax
Research Engineer
Texas Transportation Institute

Bruce Wang
Assistant Professor
Texas A&M University

David Schrank
Associate Research Scientist
Texas Transportation Institute

William Eisele
Research Engineer
Texas Transportation Institute

Shawn Turner
Senior Research Engineer
Texas Transportation Institute

David Ellis
Research Scientist
Texas Transportation Institute

Yingfeng Li
Assistant Research Scientist
Texas Transportation Institute

Nick Koncz
Assistant Research Scientist
Texas Transportation Institute

Lauren Geng
Systems Analyst I
Texas Transportation Institute

Final Report

Project #09-17-09
University Transportation Center for Mobility™

March 2010

DISCLAIMER

ACKNOWLEDGMENTS

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

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

Introduction

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

The transportation industry is constantly evolving with much technological advancement affecting the travel on roadways and the traffic data that is collected. There is a need to ensure that TTI's premier publication, the Urban Mobility Report, keeps pace with current trends and evolves to include the best data sources and most accurate information analytics.

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

1. feasibility of using private sector historical speed data,
2. policy implications of freight mobility commodity data, and
3. analysis of the effects of fuel price fluctuation on travel and congestion.

Task 1: Feasibility of Using Private Sector Historical Speed Data

The main objectives of this task were to:

1. Investigate the feasibility of conflating the private sector speed network to the HPMS volume and roadway inventory network, and
2. Develop a methodology to estimate hourly or 15-minute traffic volumes from annual average daily traffic (AADT) counts.

In this task, TTI researchers established procedures to integrate private sector speed data for nationwide mobility analyses: 1) conflating the private sector TMC network with the HPMS network so that both speeds and traffic volumes are available for each road segment; and 2) estimating average hourly traffic volumes from average daily counts to match hourly average speeds. These two steps will be integrated with other steps of the Urban Mobility Report's analytical process that have already been developed.

The following major steps will be used to calculate the mobility performance measures in forthcoming version of TTI's Urban Mobility Report:

1. **Obtain up-to-date HPMS road network** that includes traffic volumes by road segment.
2. **Conflate (or match) the HPMS network to the private TMC road network** that includes average speeds by hour or 15-minute intervals. The result of this step is a common road network (using TMC segmentation) that has AADT traffic values and hourly or 15-minute average speeds.
3. **Estimate traffic volumes for each hourly or 15-minute time interval** using the typical traffic distribution profiles.

4. **Establish free-flow travel time/speed** by using the average speed data during off-peak time periods.
5. **Calculate mobility performance measures** using standard formulas.

Task 2: Policy Implications of Using Freight Commodity Mobility Information for Decision-Making

An understanding of freight mobility is critical to roadway system performance evaluation and subsequent policy development. Specifically, freight transportation decision-makers depend on information about trip origin/destination patterns, congestion levels, and freight values (monetary and weight) on the transportation system.

Because more information is becoming available on freight mobility, it is necessary to determine just what this means for decision-makers and policy-makers. This task explored what is happening in the U.S. regarding policy decisions based on freight mobility information, and it provides some examples of existing freight mobility uses.

There are extensive policy implications involved with the freight mobility methodology and value data produced by TTI *(20).* Where to spend construction and operational funding is just one of many concerns. Another is whether to place greater value on freight corridors than corridors that primarily serve passenger vehicles. As discussed in this report, there are not too many existing uses of freight mobility data in the public sector. Most of the freight data deal with truck volumes and weights rather than travel times. There is a need for more freight mobility information to better understand the role the public sector can play in helping to move freight more efficiently on the roadway network.

The mobility data are important to the private sector also. While their operations tend to account for the traffic congestion and an unreliable transportation system, the private sector must react to any changes to the roadway network following adjustments made by the public sector to deal with congestion issues.

There are still many challenges that exist in trying to fully develop the commodity data, but the benefits of these data could be tremendous. Several existing uses of mobility-type data were discussed in this report. However, it is apparent that up to this point, there has not been much information developed in this area. The focus of this report was on the estimation of the value of commodity delay. The framework laid out in TTI's freight mobility work *(20)* should be valuable to future research in this area.

Task 3: Effects of Fuel Price on Travel and Congestion

There are two major conclusions that result from this research. First, the effect of gasoline price on consumption can varies significantly based on the time of year. Second, the price of gasoline during the summer months of June, July and August has a greater effect on gasoline consumption than other months. Third, given the funding pressures that transportation agencies face, it seems clear that revenue and cash flow forecasting could be enhanced with a better understanding of the gasoline price/gasoline consumption relationship.

INTRODUCTION

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

Problem Statement

The transportation industry is constantly evolving with much technological advancement affecting the travel on roadways and the traffic data that is collected. There is a need to ensure that TTI's premier publication, the Urban Mobility Report, keeps pace with current trends and evolves to include the best data sources and most accurate information analytics.

Research Objectives

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

1. feasibility of using private sector historical speed data,
2. analysis of the effects of fuel price fluctuation on travel and congestion, and
3. policy implications of freight mobility commodity data.

The other objective of this project was to develop and publish the 2009 Urban Mobility Report (see Appendix A).

Overview of this Report

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

- *Introduction* – provides a brief overview of the relevant issues and project objectives.
- *Private Sector Historical Speed Data* – summarizes the feasibility of using private sector historical speed data in national mobility analyses.
- *Effects of Fuel Price on Travel and Congestion* – analyzes the effects of long-term fuel price trends on vehicle-miles traveled (as measured by monthly fuel consumption data).
- *Policy Implications of Freight Commodity Data* – examines several policy considerations for using commodity information in freight mobility analyses.
- *2009 Urban Mobility Report* – national analysis of long-term congestion trends, the most recent congestion comparisons, and a description of many congestion improvement strategies.

PRIVATE SECTOR HISTORICAL SPEED DATA

Background

TTI's Urban Mobility Report currently includes several travel time and speed-based performance measures (e.g., travel time index, peak period delay per traveler). Because average travel times and speeds have not been routinely collected on a national basis, TTI has developed an analytical process that estimates travel time-based performance measures from traffic volume and roadway inventory data available through the Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS) database. In short, TTI's analytical process has used the best available data for the past 20 years.

Several companies now advertise the availability of nationwide average speed data on major U.S. roadways, primarily for the purposes of traveler information and route navigation. This private sector historical speed could be used to replace the speed estimates currently used to calculate delay in the Urban Mobility Report. In previous research, evaluations were performed to determine how well the private sector data compared to speed data from traditional public agency sources. The results of these comparisons have been positive and encouraging, in that private sector speed data appear consistent and compare favorably with existing data sources.

Problem Statement

Even if the private sector speed data are used for mobility measures, there is still a need for traffic volume and roadway inventory data from the HPMS database. Traffic volumes are necessary to calculate traveler delay (person or vehicle-hours of delay), as well as to calculate weighted averages when combining performance measures for all roads in an urban area. Therefore, there is a need to match the HPMS roadway network to the private sector speed network, such that directly measured average speeds, traffic volumes, and roadway inventory data could be available for all roadway links on a national basis. The primary difficulties of combining (or conflating) these two roadway networks are that they:

1. use different linear referencing systems,
2. are segmented differently, and
3. have different levels of coverage.

In addition to the disparate roadway networks, there is also a mismatch in the level of detail between the private sector traffic speeds and HPMS traffic volumes. The traffic speeds are available in average 15-minute or hourly time intervals, whereas the HPMS traffic volumes are only available as average annual traffic counts. Therefore, there is also a need to estimate traffic volumes at a sub-daily level, either hourly or in 15-minute intervals, for all those road segments on which private sector speed data are available.

Task Objectives

Given the issues stated above, the main objectives of this task were to:

1. investigate the feasibility of conflating the private sector speed network to the HPMS volume and roadway inventory network, and
2. develop a methodology to estimate hourly or 15-minute traffic volumes from annual average daily traffic (AADT) counts.

Methodology

This section is divided into the following two parts to document the project work in this task:

1. roadway network conflation and
2. sub-daily traffic volume estimation.

Roadway Network Conflation

There is a need to conflate (or combine) the following two different road networks for mobility performance measures:

1. FHWA's HPMS database, which contains traffic volume and roadway inventory data; and
2. private sector TMC (Traffic Messaging Channel) network, which contains average historical speed data.

The FHWA HPMS database has existed since 1978 and is the most comprehensive nationwide data system in use that shows the physical condition and usage of the Nation's highway infrastructure. Each state department of transportation (DOT) is responsible for reporting data on public roads within its jurisdiction. For our purposes, the relevant HPMS data includes traffic characteristics (e.g., AADT, peak hour factor, directional distribution) and roadway inventory information (e.g., number of lanes, capacity).

To date, HPMS data submittals by each state DOT have been in the format of fixed-column ASCII-text files. Recently, however, FHWA has encouraged states to submit their HPMS data in the form of a geographic information system (GIS) file. FHWA's intent is to eventually require all states to submit HPMS data as a GIS-compatible file that can be combined at the national level. For this study, FHWA provided a beta version of the HPMS national roadway network in a GIS format.

Nearly all commercial traffic information providers use the private sector TMC network for the purposes of traveler information, both real-time and historical. The TMC network is a de facto, consensus standard that is currently maintained by two major mapping companies, NAVTEQ and TeleAtlas. Like the HPMS network, the TMC network is also defined on a national basis. However, the TMC network is segmented into links and nodes for the sole purposes of consumer traffic information. Therefore, the segmentation of the TMC network typically does not align with the segmentation of the HPMS network (in most cases, the HPMS network segmentation is more disaggregate). Further, the coverage of the roadway networks can differ – the TMC network may include links not in the HPMS network and vice versa.

Roadway network conflation is a common function in GIS and several automated tools exist to combine different networks. For example, ESRI® ArcGIS™ has the functionality to combine the attributes of multiple feature classes through two options: spatial join and attribute join. The former allows users to join the attributes of a feature (*A*) to another feature (*B*) of a different layer based on certain spatial rules, such as *A* completely enclosing *B*, *A* intersecting with *B*, or *A* being closest to *B*. The latter is a table operation that joins two attribute tables based on a common feature identifier.

The resulting quality of automated conflation methods can vary widely depending upon several factors, such as the spatial relationship of the two datasets, existence of a common feature identifier, and spatial and attribute data quality of both roadway networks. A quick examination of the TMC and HPMS datasets showed that an attribute join was not possible. Both datasets use very different feature identifying mechanisms as well as the route naming conventions. In addition, the two datasets do not share any other common field that could be used as feature identifiers during a join. Therefore, a spatial join became necessary.

The first task that our research team undertook was to determine the cost-effective spatial join method as well as to determine how much additional quality control/assurance was necessary to clean up suspect matching results. The following are the major challenges for the spatial join approach used in this network conflation task.

1. Different feature representation mechanisms. One of the most basic issues is that, on most roads, the HPMS network represents both directions of traffic with a single line, whereas the TMC network represents each direction of traffic as a unique line. In addition, the HPMS network occasionally represents each traffic direction as a unique line for roads on which each traffic direction is a separate and distinct roadbed (e.g., rural divided interstate highway).

2. Different roadway segmentation (Figure 1). As discussed earlier, the TMC and HPMS networks were created for different purposes and to represent different attributes. The two datasets divide the same roadways using very different mechanisms, resulting in different numbers of segments that are different in length for the same roadway.

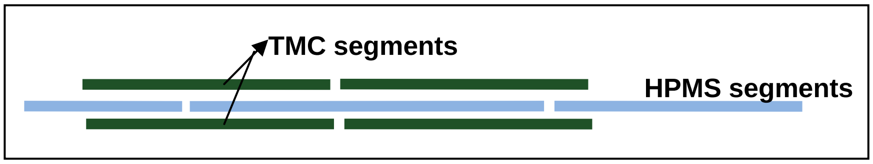


Figure 1. Different Roadway Segments

3. At-grade intersections (Figure 2). Spatial joins are primarily based on predefined spatial criteria between features that are to be joined. Two unrelated features from different layers could be spatially joined by mistake due to certain spatial relationship that is not ruled out by the predefined criteria. In the case of at-grade intersections, it is possible that a portion of the intersecting street (right at the junction) is incorrectly assigned to the main perpendicular roadway. The fact that the TMC dataset contains many lower-level roadways that are not included in the HPMS network further complicates this situation.

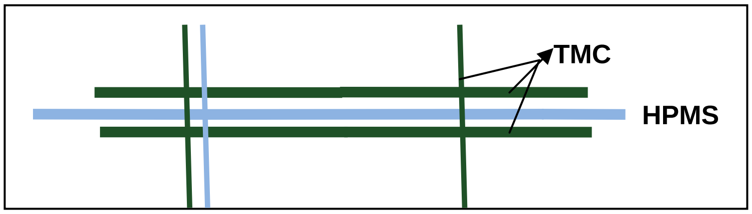


Figure 2. At-Grade Intersections

4. Complex highway interchange areas. One of the most difficult challenges is combining networks in complex highway interchange areas (Figure 3). In these areas, dense roadways are mixed with ramps, service roads, and occasionally high-occupancy or toll lanes (represented separately on the TMC network), which makes automatic spatial joins at these areas extremely difficult.

Figure 3. Complex Highway Interchange Areas

5. Frontage roads. Frontage roads are separate roadways that closely parallel the main highways (Figure 4). It is possible that the mainlane segment in the HPMS network could be matched to the frontage roads in the TMC network.

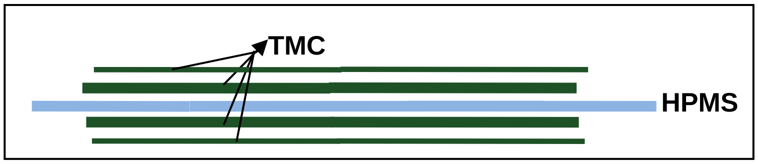


Figure 4. Frontage Roads in TMC Network

6. Other nearby roads. Nearby roads are another instance in which conflation errors could develop (Figure 5). In some cases, segments of these roadways can be very close to each other and therefore joined incorrectly.

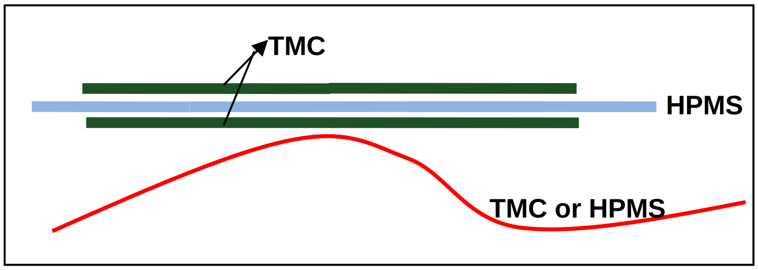


Figure 5. Nearby Parallel Roads (Other Than Frontage Roads) on the TMC Network

7. Multiple overlapping road segments with different traffic data. Another basic issue that had to be addressed was the quality and consistency of the HPMS network. Because the HPMS network was a beta version that was a compilation of 50 state DOT submittals, there were some data quality problems with certain states. For example, a common problem in a few states was multiple overlapping road segments with different traffic data (Figure 6). In cases like these, it will be necessary to manually review and correct the matching results based on engineering judgment.

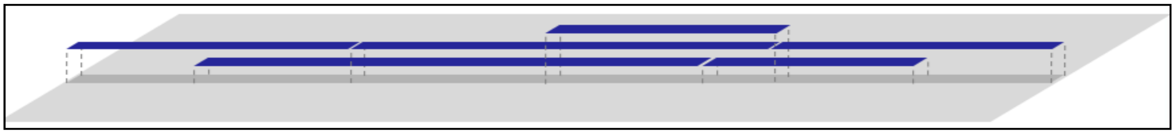


Figure 6. Overlapping Road Segments on HPMS Network

After several trial-and-error efforts, the research team developed a conflation procedure that spatially joins the attributes of the HPMS segments with those of the TMC segments. The idea was to first create a small buffer for each of the HPMS segments that would inherit the attributes of the HPMS segment and then pass them to the TMC segments it completely encloses. In reality, the procedure involved five major steps grouped into three stages (i.e., data preprocessing, data conflation, and final quality control) (Figure 7). The research team used several existing functions of ArcGIS desktop as well as tools of an ArcGIS extension known as XTools Pro.

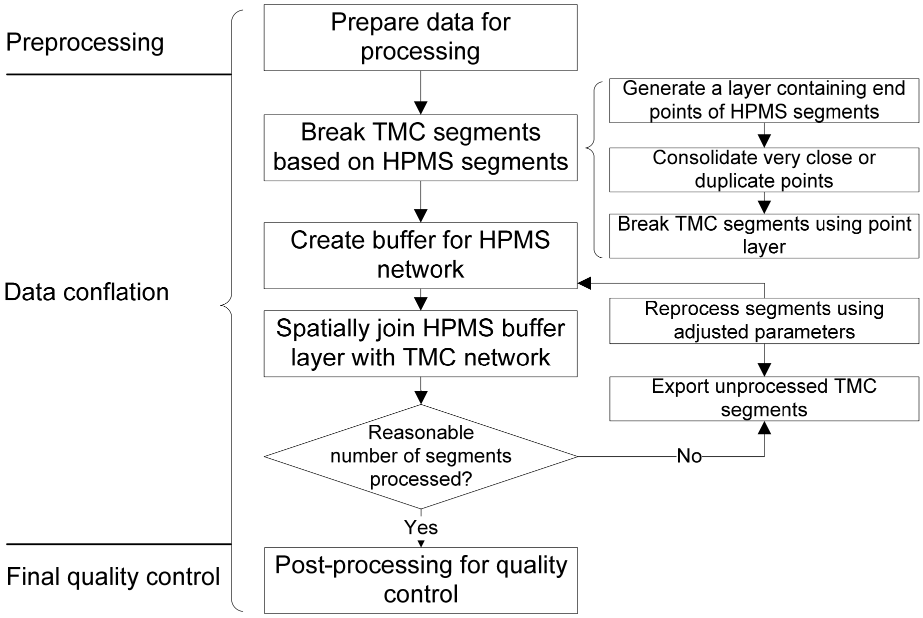


Figure 7. Roadway Conflation Procedure Developed for Combining HPMS Network Attributes onto the TMC Speed Network

Preprocessing. The research team first preprocessed both HPMS and TMC datasets in preparation for the data conflation. The team divided both networks into smaller regions to improve processing speed, avoid memory limit problems, and simplify final quality control. The HPMS data came in nine files, each representing a different region (Figure 8), while the TMC data were included in a single layer representing the nationwide network. The researchers divided the TMC network according to HPMS regions and projected both layers for each region into the same projection system. During this stage, it was also necessary to screen the HPMS data before conflation to delete those duplicate records that included evidently incorrect attribute values (e.g., zeros for the AADT field).

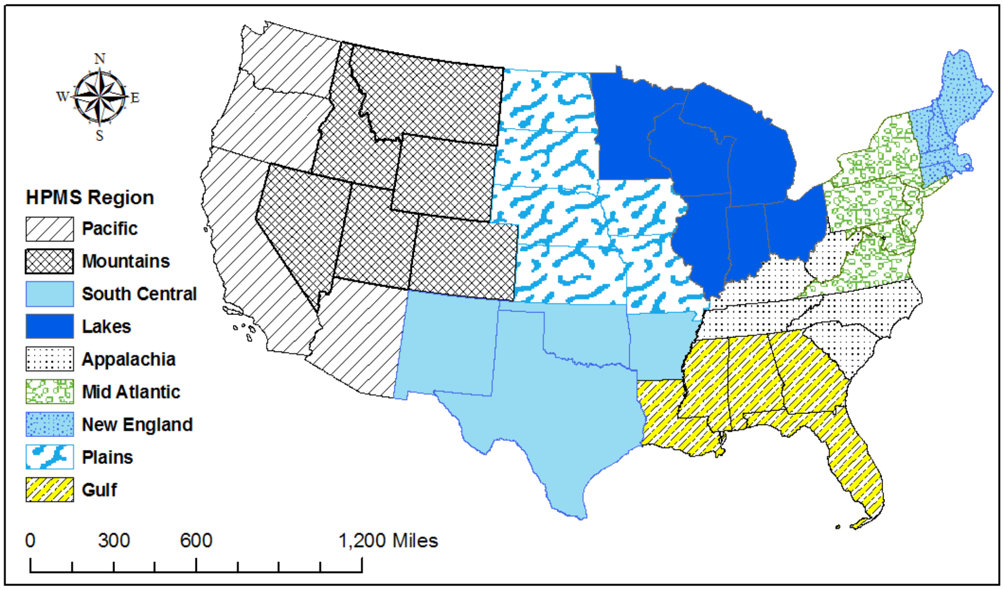


Figure 8. HPMS Regions Used during Data Conflation

Data conflation. The data conflation stage included three major steps:

1. Break TMC segments based on HPMS segments. As noted earlier, one of the major changes for a spatial join was that the two datasets had roadway segments of different lengths (Figure 1). To enable a relatively accurate spatial join, it was necessary to break the TMC segments according to the HPMS segments so that correct TMC segments could be spatially identified for each HPMS segment for conflation. As shown in Figure 9, this task was accomplished in several sub-steps. The start and end points of each HPMS segment were first identified and stored on a point layer (Figure 9a). The duplicates and very-close neighbors on the point layer were then consolidated to reduce unnecessary/incorrect breaks (Figure 9b). Finally, the TMC segments were broken into smaller segments using the point layer (Figure 9c).

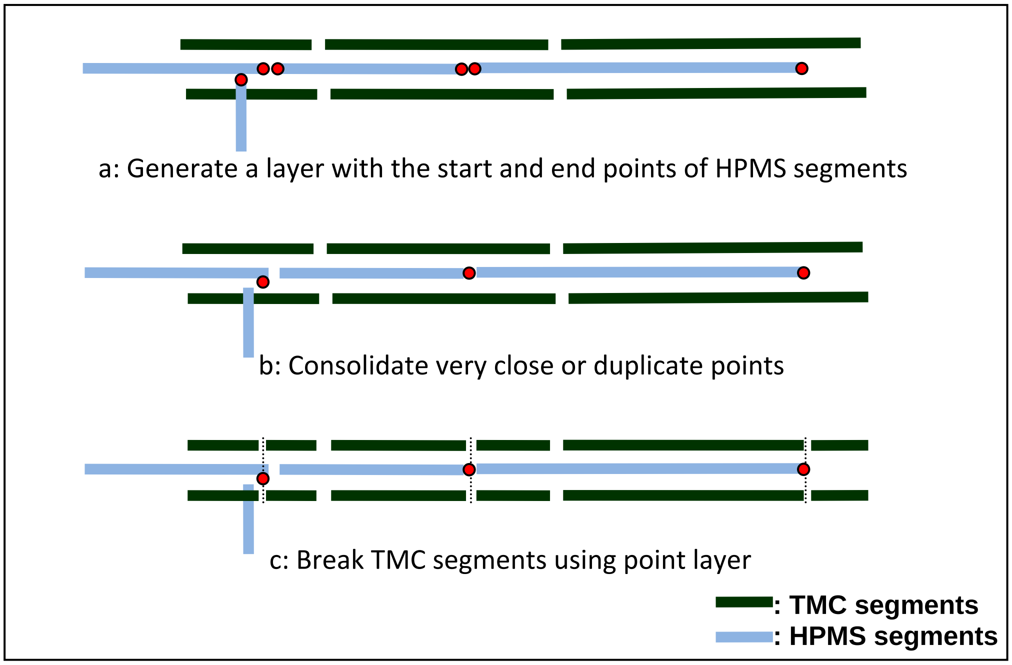


Figure 9. Break TMC Segments Based on HPMS Segments

2. Create buffers from the HPMS segments. To enable spatial joins, a small buffer was created around each HPMS segment (Figure 10). This buffer inherited the attributes from the HPMS segment that would be joined to the TMC segments that fell completely inside the buffer.

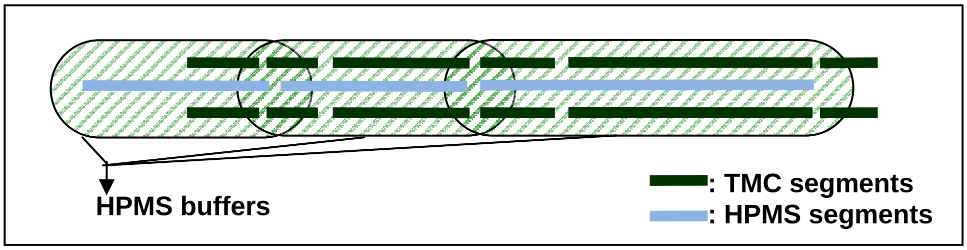


Figure 10. Create Buffers from HPMS Segments

3. Spatially join the attributes of HPMS buffers to TMC segments. During this step, the attributes of the buffers (which they inherited from their parent HPMS segments) were joined with those of the TMC segments that they completely enclosed, as shown in Figure 11.

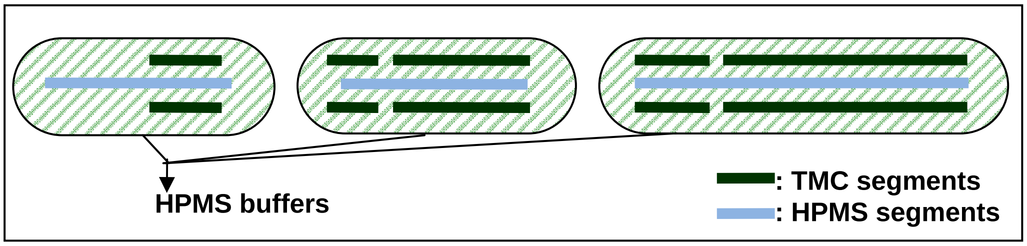


Figure 11. HPMS Attributes Passed to TMC Segments through HPMS Buffers

Readers should notice that, to improve accuracy, the researchers typically used a relatively small buffer radius during the first round of data conflation. Depending on positional consistency of the HPMS network compared with the TMC network, it was necessary to export the TMC segments that were not processed during this round and iterate the conflation method for one or two more rounds with an increased buffer radius.

Final quality control. Other than the original data errors, this conflation procedure could result in the following three types of errors due to the data issues discussed earlier:

- TMC segments that should have been conflated but left unprocessed due to large positional differences from corresponding HPMS segments;
- TMC segments that should not have been assigned with any HPMS attributes but were conflated due to their proximity to other roadways; and
- TMC segments that were assigned with attributes from wrong HPMS segments.

As such, it was necessary to conduct a final quality control to improve the accuracy overall as well as for the important areas (e.g., urban areas). The final quality control was done manually by visually checking through the error-prone roadways. Several techniques were used during the quality control to improve productivity, such as

- color coding TMC segments for easy identification of problematic ones,
- setting selectable layers and identifiable layers wisely,
- hiding unnecessary attributes to make tables smaller for easy viewing, and
- using table joins instead of entering values manually for each incorrect segment.

Hourly Traffic Volume Estimation

Private sector historical speed data are available in 15-minute and hourly time intervals; however, the traffic volume data available through HPMS are average annual daily volume totals (AADT). It is necessary to estimate traffic volumes for 15-minute or hourly time intervals.

In summary, a simple average of the hourly traffic speeds was used to identify which of the time-of-day volume pattern curves to apply. Congestion levels were the initial sorting factor as determined by the percentage difference between the average peak period speed and the free-flow speed. The peak time was then determined by the peak with the lower speeds; or if both peaks had approximately the same speed, another curve was used. The traffic volume profiles developed from Texas sites and the national continuous count locations are shown in later sections. These profiles are based on some of the following characteristics:

- Low, medium or high congestion levels – The general level of congestion is determined by the amount of speed decline from the off-peak speeds. Lower congestion levels typically have higher percentages of traffic volume in the peak, while higher congestion levels are usually associated with more volume in hours outside of the peak hour.
- Morning or evening peak; or approximately even peak speeds – The speed database has values for each direction of traffic. Most roadways have one peak direction; matching the volume pattern to the speed dataset greatly improves the delay estimate; the higher volume was assigned to the peak period with the lower speed. Roadways with approximately the same congested speed in the morning and evening have a separate volume pattern that was also associated with the relatively high volumes in the midday hours as well.

This section describes in more detail the derivation of hourly traffic volume percentages (15-minute traffic volumes can be similarly derived).

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); and
- Directionality: peak traffic in the morning (AM), peak traffic in the evening (PM), approximately equal traffic in each peak (AM+PM).

The 16 traffic distribution profiles shown in Figures 12 through 16 are considered to be very comprehensive, as they were developed based upon 713 urban continuous traffic monitoring locations in 37 states. TTI compared these reported traffic profiles with readily available, recent empirical traffic data in Houston, San Antonio, and Austin to confirm that these reported profiles remain valid.

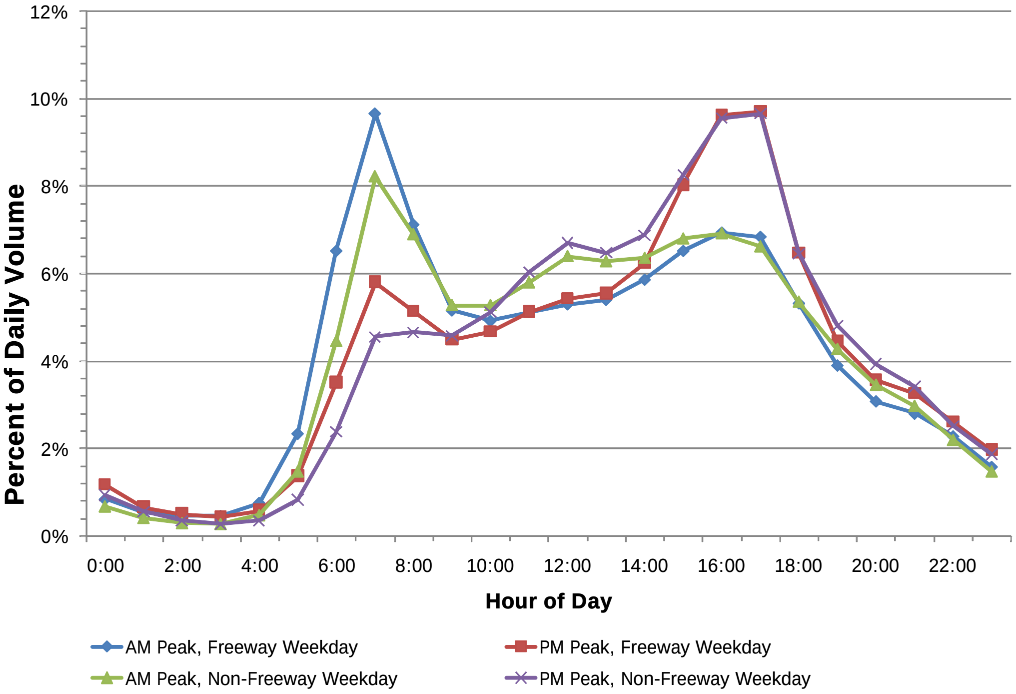


Figure 12. Weekday Traffic Distribution Profile for No to Low Congestion

---

[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.

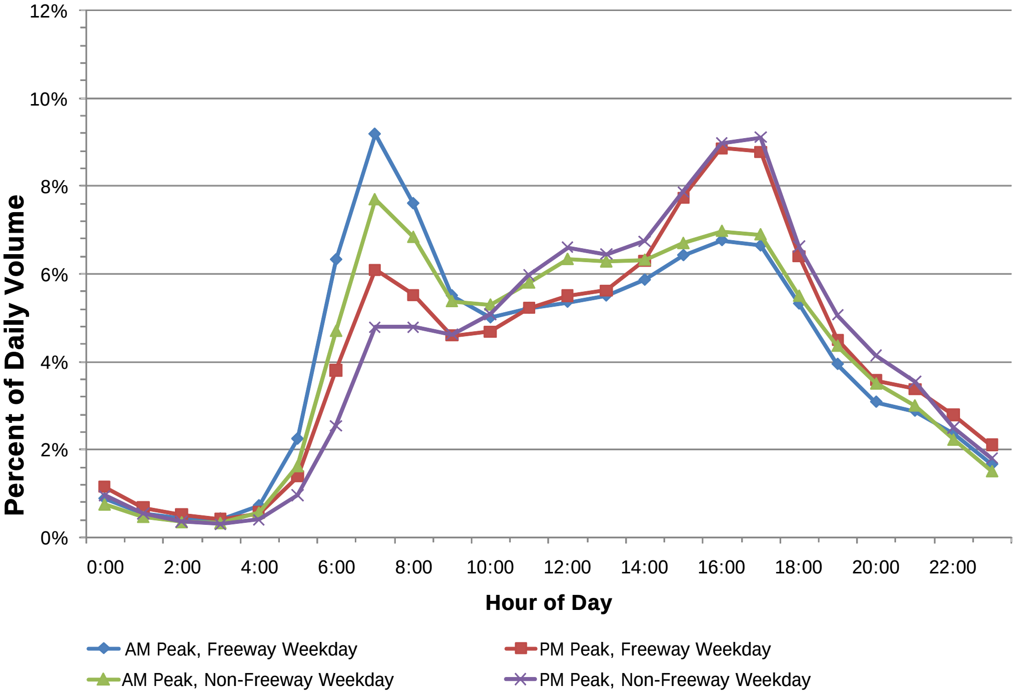


Figure 13. Weekday Traffic Distribution Profile for Moderate Congestion

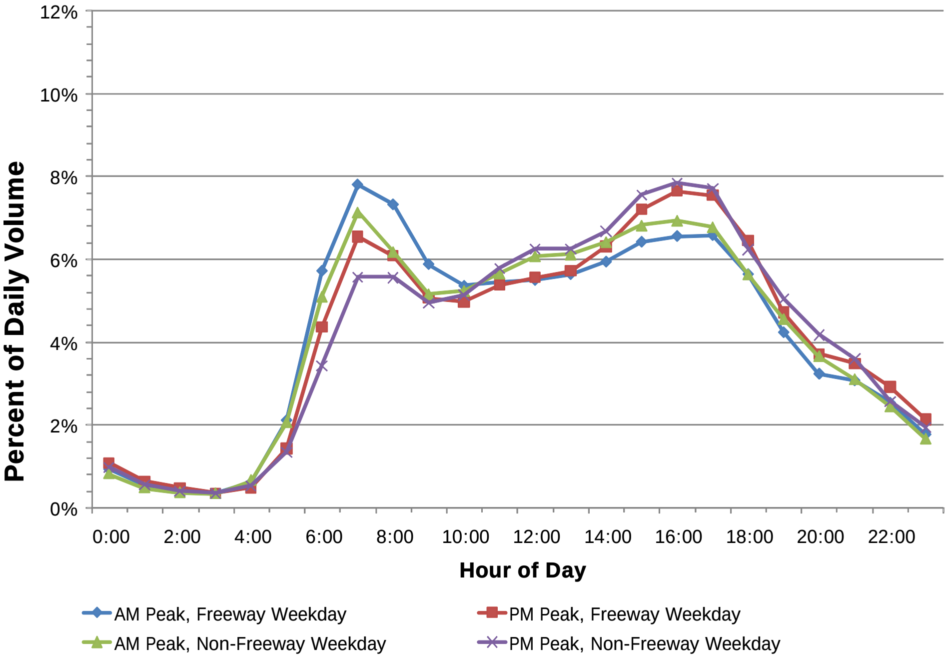


Figure 14. Weekday Traffic Distribution Profile for Severe Congestion

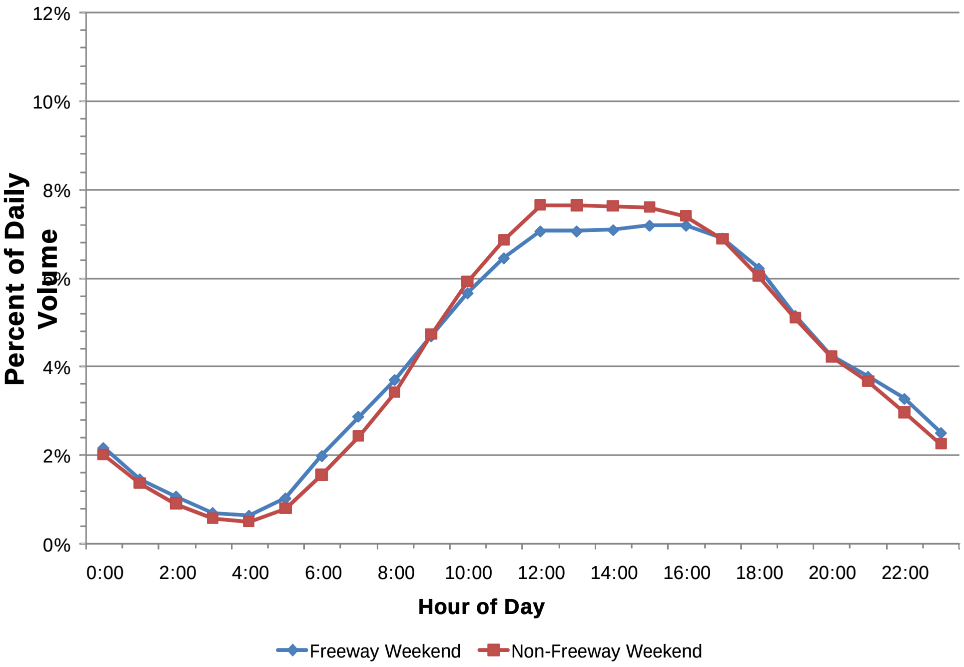


Figure 15. Weekend Traffic Distribution Profile

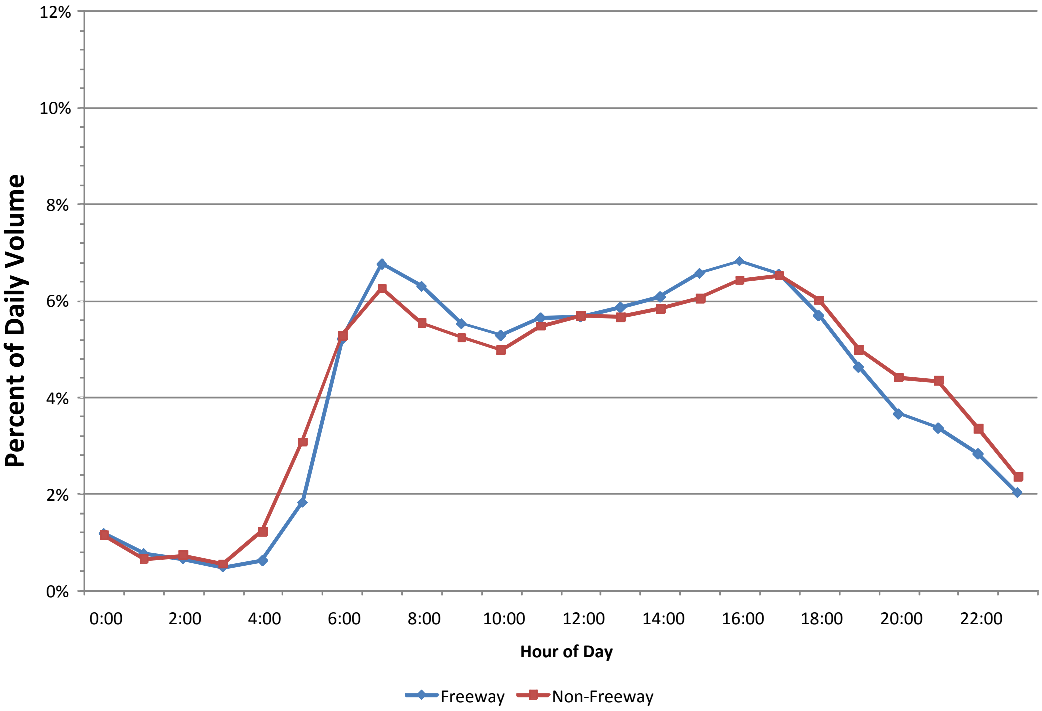


Figure 16. Weekday Traffic Distribution Profile for Severe Congestion and Similar Speeds in Each Peak Period

The next step in the traffic flow assignment process is to determine which of the 16 traffic distribution profiles to assign to each TMC path, such that the hourly traffic flows can be calculated from HPMS AADT values. 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 speeds and divide the total by the 24 15-minute periods in the six peak hours) for each TMC path using speed data from 6 a.m. to 9 a.m. (morning peak period) and 4 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.

  $$\text{Speed Reduction Factor} = \frac{\text{Average Peak Period Speed}}{\text{Free-flow Speed (10 p.m. to 5 a.m.)}}$$

  For Freeways (roads with a free-flow [baseline] speed more than 55 mph):
    - 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 (roads with a free-flow [baseline] speed less than 55 mph):
    - 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 9 a.m.) and the average evening peak period speed (4 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 to the even volume distribution.

Findings and Conclusions

This chapter of the report has briefly documented two critical steps in using private sector speed data for nationwide mobility analyses: 1) conflating the private sector TMC network with the HPMS network so that both speeds and traffic volumes are available for each road segment; and 2) estimating average hourly traffic volumes from average daily counts to match hourly average speeds. These two steps will be integrated with other steps of the analytical process that have already been developed. For the sake of completeness, all of the steps in this nationwide mobility analysis are summarized here.

The following major steps will be used to calculate the mobility performance measures in forthcoming version of TTI's Urban Mobility Report:

1. **Obtain up-to-date HPMS road network** that includes traffic volumes by road segment.

2. **Conflate (or match) the HPMS network to the private TMC road network** that includes average speeds by hour or 15-minute intervals. The result of this step is a common road network (using TMC segmentation) that has AADT traffic values and hourly or 15-minute average speeds.

3. **Estimate traffic volumes for each hourly or 15-minute time interval** using the typical traffic distribution profiles.

4. **Establish free-flow travel time/speed** by using the average speed data during off-peak time periods.

5. **Calculate mobility performance measures** using standard formulas.

POLICY IMPLICATIONS OF USING FREIGHT COMMODITY MOBILITY INFORMATION FOR DECISION-MAKING

Overview

An understanding of freight mobility is critical to roadway system performance evaluation and subsequent policy development. Specifically, freight transportation decision-makers depend on information about trip origin/destination patterns, congestion levels, and freight values (monetary and weight) on the transportation system.

Much of this information was previously lacking for several reasons. First, data collection resources are limited. It is a daunting task to get such data on the entire transportation network. Second, it takes time for information technologies to mature and identify effective application in freight decision-making. With the rapidly increasing use of new data collection technologies, more and more freight performance data are becoming available from many sources including both the public sector and private industry. Technologies are more capable than ever of generating travel speed information for passenger cars and commercial vehicles on the roadway system through the use of probe data sources (e.g., GPS devices, cellular phone tracking) and traditional sources (e.g., loop detectors, toll-tag readers).

Because more information is becoming available on freight mobility, it is necessary to determine just what this means for decision-makers and policy-makers. This report will discuss what is happening in the U.S. regarding policy decisions based on freight mobility information, and it provides some examples of existing freight mobility uses.

Freight Mobility Data in the U.S.

At the national level, there have been efforts to measure freight commodity flows such as the 2006 Commodity Flow Survey (CFS) *(1).* The CFS provides information on the flow of goods in the United States, specifically data on shipments originating from manufacturing, mining, wholesale, auxiliary warehouses, and selected retail establishments in the 50 states and the District of Columbia. The uses for the CFS data tend to be more at the macro-level such as analyzing trends in goods movement over time or conducting economic analyses at the state or regional level. Typically CFS data are used at the state or national levels, where it is most applicable. The CFS does not provide road section-specific commodity flow data, especially in regard to congestion and delay. The Freight Analysis Framework (FAF) is another national effort ongoing at the Federal Highway Administration that integrates data from a variety of sources including CFS to estimate commodity flows and freight activity within and between states, regions, and major international gateways *(2).* FAF includes values for current commodity movements and forecasts of commodity movements out to the year 2035 for 114 geographic regions within the U.S.

The Freight Performance Measures (FPM) project is another FHWA effort to measure speed and travel time on freight significant corridors as well as many border crossings using GPS technologies to track truck movement and generate travel times *(3).* Additionally, the FPM project creates tools that transportation agencies at all levels and the freight industry can use to satisfy a variety of data needs. Another ongoing research effort conducted by the Texas Transportation Institute on freight information architecture sponsored by the National Cooperative Freight Research Program (NCFRP) represents a step toward creating a national standard for compiling and disseminating freight data in the form of a clearinghouse *(4).* These efforts do not specifically address freight commodity mobility data; they do include many different freight data components.

There have been sporadic local efforts in developing and disseminating freight mobility information. Examples include the Seattle Freight Mobility Program, which publishes an informational map of freight corridors and disseminates the information to truckers *(5)*. The information provided to truckers includes restrictions, construction updates on freight improvement projects, on-line roadside camera pictures and many other items. In the Upper Midwest, the former Upper Midwest Freight Coalition (precursor of the Mississippi Valley Freight Coalition) coordinated by the University of Wisconsin Madison conducted a freight mobility study for the Midwest Region of the U.S. *(6)*. The study examined issues including information sharing and freight bottleneck management through cross-border collaborations between states in the Midwest.

Through the Mobility Measurement in Urban Transportation (MMUT) FHWA pooled fund research projects *(7)*, researchers at the Texas Transportation Institute have developed a “Freight Box Concept” *(8)*. The Freight Box Concept is a framework that visually incorporates the effects of geographic area, commodity type, and time period on freight mobility and reliability (shown in Figure 17). The Freight Box Concept is “scalable” to address any near-term limitations in data completeness, but provides a method to communicate congestion mobility and reliability as data availability improves. This framework was designed to help transportation professionals better communicate, visualize, understand, compute, and make planning level decisions based upon the factors that affect freight reliability and mobility. As part of this work, researchers demonstrated how delay by commodity information can be used to fully incorporate freight aspects into transportation system monitoring, system evaluation, and project selection.

In an extension of the “Freight Box” effort, researchers at TTI have undertaken an effort to develop freight commodity mobility information at the city level using FAF and HPMS data *(9).* They have developed a methodology to estimate the tons of commodities and their values that are contained inside the trucks moving on regional roadways. Using a methodology that has produced congestion statistics in the TTI *Urban Mobility Report*, the hours of travel delay associated with each commodity can be estimated as well *(10).* The research demonstrates how transportation officials and decision-makers could have a value for the delay and the commodities that are present along the various major roadway corridors in a region. During the transportation programming process, this freight mobility information can be used as one of the performance measures for each corridor where improvements are proposed.

Building on these efforts at TTI, the following sections attempt to clarify policy implications of using freight mobility data by answering questions such as:

- Who are the (potential) users of freight mobility information?
- How will they use it?
- What are the applications and ramifications of estimating the value of delay on commodities themselves?

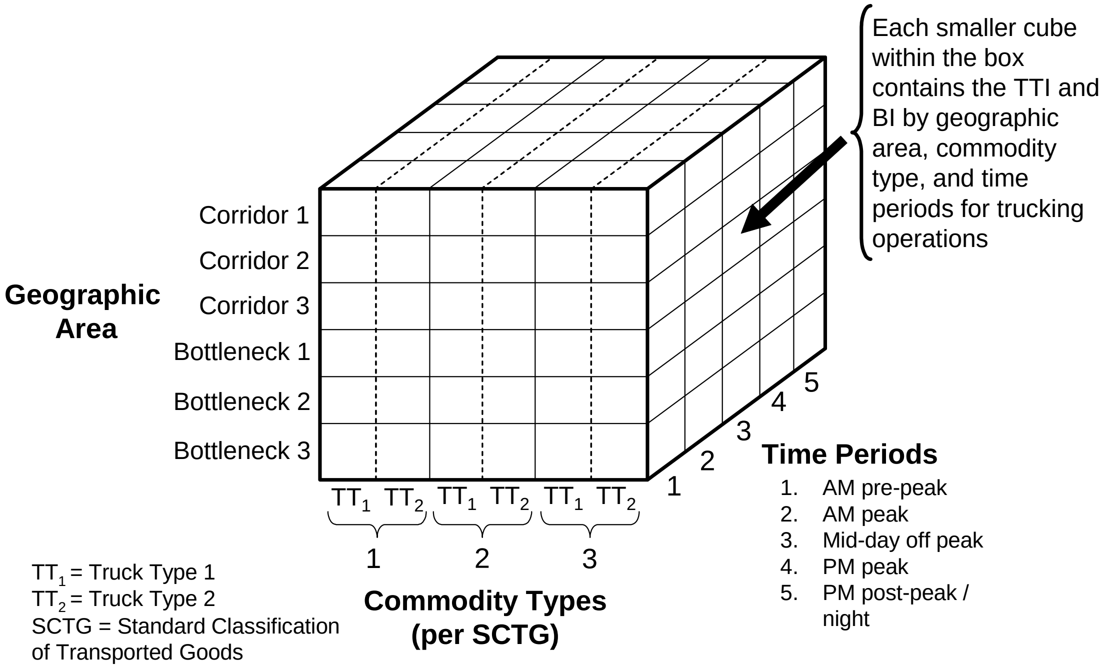


Figure 17. Freight Box Conceptual Framework Applied to Trucks (Adapted from Reference 8)

Who Will Use Freight Mobility Information and How?

The primary user of the freight information in the context discussed here is public agency decision-makers for freight infrastructure investment. The following sections describe some of the uses.

Freight Planners

With the freight mobility data, freight system planners can rank the benefits derived from congestion relief activities across multiple locations, including terminals and corridors. A simple example can illustrate this process. Given two corridors, each having a certain number of hours of delay for a certain volume of freight traffic, the total number of truck-hours of delay (or other equivalent measures) can be readily determined by commodity group. With the value of the actual commodities, the economic impact of the delay along the corridors becomes available (in terms of the value of goods affected). Freight system planners can then conduct a cost-benefit analysis using this value of delayed goods to maximize the use of public funds for congestion relief if the public policy deems it important to keep freight moving through the transportation system. The cost of the commodities could be considered a conservative estimate because there will be secondary costs associated with goods when they are delayed on the transportation system.

Another application for incorporating improved commodity information is for capacity analysis. On the surface street system, one traditional method of allocating capacity between conflicting traffic at intersections considers the volume of traffic in each approach with commercial vehicles being converted to passenger car equivalents. This conversion is traditionally done according to the commercial vehicle's mechanical dynamics compared with passenger cars (e.g., acceleration/deceleration/vehicle size). With detailed freight mobility data, and with the value of delay associated with particular commodity groups, freight vehicles could be converted into passenger car equivalents based on their value of time and potential delay instead of just based on physical characteristics of the vehicles themselves.

An example of how commodity flow and the associated value of the commodities affects traffic controls is shown in recent research sponsored by the Southwest Region University Transportation Center (SWUTC) *(11).* The optimal signal timing considering freight traffic delay cost has a very different setup than the traditional way, which does not consider freight traffic delay cost explicitly. At a simple intersection with two reasonable conflicting traffic streams, a conservative assumption is used that 5 percent of the traffic is commercial and this accounts for 20 percent more delay cost than passenger car delay. In this conservative scenario, the green time would increase by over 30 percent for the major traffic direction due to the delay implication on the freight traffic. As suggested, one may interject the impact of commodity flows along major freight corridors on the allocation of right-of-way if the commodity data and their value of delay are known.

One of the reasons that traffic control traditionally does not explicitly differentiate traffic is due to the lack of information about the traffic mix and detailed delay cost estimates. Valuing the type of vehicle by value of time has promise in the future to maximize the throughput at intersections and minimize the regional economic costs.

Private Freight Stakeholders

The value of commodity delay needs to be calibrated with data from the private sector. Although 80 percent of truckers and carriers deem freight delay and traffic congestion as their biggest problem, it is not clear how improved value data of commodities can be utilized by carriers and shippers *(12).* The private sector usually depends on local information such as time-of-day or day-of-week traffic delay information for making their routing decisions in shipping. The freight mobility data are generally at an aggregated and possibly even area-wide level. The private sector may not find as much use for these data as the public agencies in charge of the transportation system development. However, the private sector will want to monitor the results of the delay studies and resulting transportation programming decisions because any changes to the transportation system may result in necessary logistical changes by private sector companies.

In a report *(8)* by TTI for the Southwest Region University Transportation Center, a contrast was drawn between how the public and private sectors differ on their approaches to traffic congestion issues.

The Public Agency Perspective

Figure 18 illustrates how delay-causing urban roadway congestion affects both the public sector (public transportation agency) and the private sector (trucking company). The gray highlighted area on the left of the figure relates to the perspective of the public agency. First, the roadway congestion causes personnel from the public agency to ask questions that relate to the congestion itself (e.g., how bad is the congestion?). This is typically answered in terms of travel time and delay. When faced with congestion issues, public agencies also begin to ask questions about what roadway improvements may be needed, and how improvements will be programmed and funded.

Potential public agency changes include transportation system improvements. It is important to note that these public agency improvements can alter trucking company operations. The bottom dashed line in Figure 18 represents this influence. It is discussed in the next section.

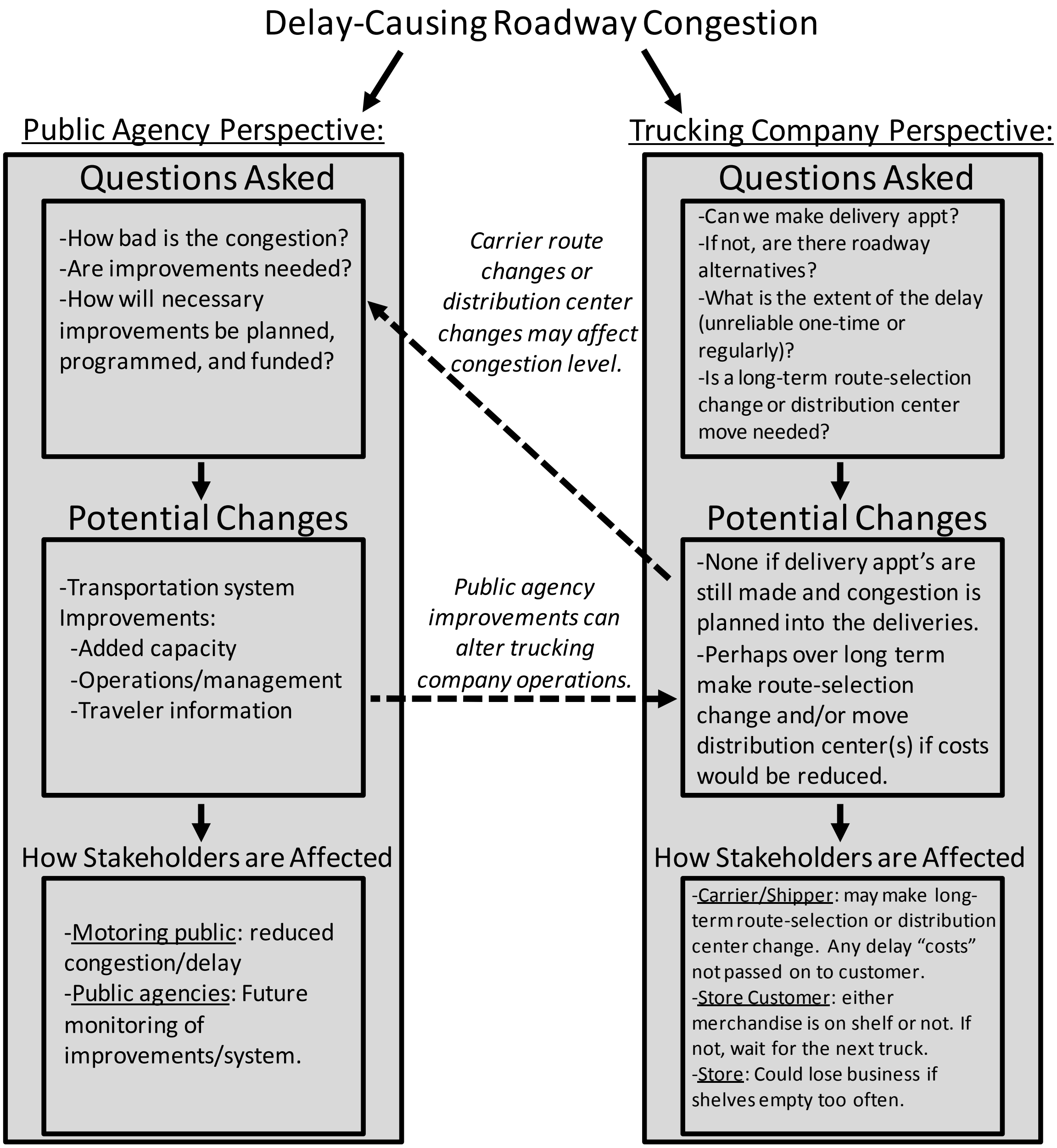
Following the arrows within the public agency perspective of Figure 18 ends with identifying how stakeholders are affected. Within the public sector realm described here, there are primarily two stakeholders—the motoring public and the public agencies themselves. Given these transportation improvements, the motoring public is impacted by reduced congestion and delay on the roadways of interest. The other stakeholders—public agencies—are affected in that they are responsible for continued mobility monitoring of the system, which now includes the additional transportation improvements provided in response to the initial congestion.

The Private Sector Perspective
Along the right side of Figure 18 is the trucking company perspective on the delay-causing roadway congestion. As alluded to previously in this section of the report, the trucking industry is concerned with making delivery appointments and minimizing costs. The first question asked from the public-sector perspective is whether that delivery appointment can still be made. If not, alternative roadways may be of interest. Distribution centers might also be moved if costs would be reduced. The effect of the delay on reliability is also important. There is an interest in knowing if the congestion is a "one-shot" problem or whether the road is consistently congested at the same time and place. If it is consistently problematic, there may be a long-term route-selection change needed.

From the trucking company perspective, there are no changes needed if the delivery appointments are still made, or if the current levels of congestion can be planned into the deliveries. Over the long-term, routes might be changed or distribution centers might be moved if it would result in lower costs (i.e., reduced fuel costs, reductions in other costs due to missed delivery appointments) relative to not changing but living with the congestion. Note that the public agency improvements can alter trucking company operations (bottom dashed line in Figure 18), and the trucking company could experience lower costs by altering trucking operations as a result of the public agency improvements.

Also note the top dashed line in Figure 18. It results because if carriers make route changes or distribution center changes, this may affect congestion levels. For example, moving a distribution center might improve congestion in one location that was near the old location of the distribution center, while congestion might get worse near the location of the new distribution center. As shown with the two dashed lines in Figure 18, the result is a "continuous loop" where infrastructure changes by the public agencies can alter trucking company operations, and carrier route changes or distribution center changes may affect congestion levels and, therefore, influence public agency infrastructure improvement planning.

Finally, consider how the final stakeholders are affected from the perspective of the trucking company (lower-right portion of Figure 18). The stakeholders here are the carrier/shipper, store customer, and the store itself. Carriers/shippers might make long-term route-selection or distribution center changes if costs are predictably and reliably higher along current routes than expected on an alternate route. However, any additional/unexpected "costs" incurred from congestion would not generally be passed along to the customer in the cost of the merchandise. The store customer can either find the desired merchandise on the store shelf, or not. If not, the customer would likely be informed when the next truck will arrive. From the perspective of the store's management, it is possible that the store could lose some business if they repeatedly did not have the desired merchandise in stock.



-How bad is the congestion?
-Are improvements needed?
-How will necessary improvements be planned, programmed, and funded?

-Transportation system Improvements:
-Added capacity
-Operations/management
-Traveler information

-Motoring public: reduced congestion/delay
-Public agencies: Future monitoring of improvements/system.

Carrier route changes or distribution center changes may affect congestion level.

Public agency improvements can alter trucking company operations.

-Can we make delivery appt?
-If not, are there roadway alternatives?
-What is the extent of the delay (unreliable one-time or regularly)?
-Is a long-term route-selection change or distribution center move needed?

-None if delivery appt's are still made and congestion is planned into the deliveries.
-Perhaps over long term make route-selection change and/or move distribution center(s) if costs would be reduced.

-Carrier/Shipper: may make long-term route-selection or distribution center change. Any delay "costs" not passed on to customer.
-Store Customer: either merchandise is on shelf or not. If not, wait for the next truck.
-Store: Could lose business if shelves empty too often.

Figure 18. Public Agency and Trucking Company Perspectives on Delay-Causing Roadway Congestion (Adapted from Reference 8)

What is the Cost of Delay on the Commodities Themselves and How can it be Measured?
There have been efforts to estimate the impacts of delay on the commodities themselves—not just the vehicle hauling the commodity. Freight transportation policy development, especially that concerning freight congestion relief, depends on adequate measurement of several major benefits: direct, indirect and induced *(13).* First, the direct benefits of congestion relief on the freight industry includes reduced labor and fuel cost. Second, the indirect benefits might include the increased productivity of shippers and warehousing operations due to the productivity gain of commercial vehicles from improved mobility. This benefit was estimated using an input/output model by correlating the 528 sectors of industry in a six-county region of Chicago, IL. Third, the induced benefit is due to such things as

increased purchasing power from improved productivity and additional employment, which generates more demand for new products. The induced benefit is a critical factor for freight planning; however, it is difficult to estimate accurately. The authors estimated in their study that a freight policy in the six-county area would yield about $11.5 million in direct benefit to the trucking industry, and an indirect benefit of more than $270 million to the region, as well as an additional $300 million of induced benefits.

To freight planners, the economic benefit, whether direct, indirect, or induced, is an important criterion for decision-making. Numerous projects have focused on measuring this economic benefit from improved freight mobility on the roadways and at major freight terminals. Traditionally, input/output models are used for regional impact analyses *(13-16).* Standard software packages for economic impact analysis of transportation projects are also available (e.g., StratBENCOST, MicroBENCOST). However, these input/output models can be very resource-intensive. Therefore, these models' applicability in major corridors of national importance, where the importance of the corridor traffic goes beyond the local scope, may be questionable due to the size of the area to be studied.

It has been a goal of state freight planners to be able to "extract and apply freight specific data in benchmarking freight projects" *(17).* The Freight Mobility Strategic Investment Board of Washington State deployed intelligent transportation systems technologies with a stated goal of collecting freight specific data. The freight indicators used therein include: daily truck trips along major corridors (I-5, I-90, Highway 395, and US 97); average monthly cross-border truck volume; and road segment rankings in terms of truck tonnage *(17).*

The amount of delay on individual commodities may be available in future freight mobility data, and it could provide the basic input to existing transportation planning models. For example, the current Highway Economic Requirements System-State Version (HERS-ST) uses a value of time table with auto and truck hourly costs to measure the economic impact for the purpose of transportation fund allocation *(18).* The value of time in that model shows $16.50 per hour in 1995 dollars for commercial vehicles. The value of time information in HERS-ST does not differentiate truck cost based on the commodity being hauled.

Having freight mobility information which includes commodity flows and their sector specific delays provides an opportunity to measure more accurately the impact of congestion on carriers and shippers, which the traditional input/output models do not address. With such commodity specific information a much simpler method can be developed to get the indirect benefit from delay reduction projects or programs. This is in contrast to input/output economic models that translate cost savings into new demand for production or consumption. They also represent the many interactions between the various industries.

Another consideration is delay cost. For example, one current FHWA figure to account for truck time is about $30 per hour as opposed to the almost $100 per hour used in TTI's Urban Mobility Report *(10).* TTI's truck cost value includes such costs as driver time, truck maintenance, fuel usage, and insurance. Congestion cost is comprised of many different factors beyond just the time lost by the driver; thus, FHWA's $30 per hour value of time to truckers may be underestimating the direct cost of congestion alone *(19).* Additionally, these hourly cost values for the truck average value do not account for different commodity flows. Some corridors carry high value products, while others may carry only bulk, lower value products. The overall costs of delay on these two corridors are different, and that difference can only be obtained by determining the commodities ("rolling value") on each corridor.

Traffic Management

In the area of traffic operations and control, traffic engineers will be able to better manage the roadways by explicitly considering the cost of delay to traffic that includes both a passenger and commercial mix. As previously mentioned, there is a different value of time for private automobiles and commercial vehicles. Within the commercial traffic, there can be a very different hourly cost for delay time for a given truck depending on the cargo and the particular commodities being hauled. Therefore, different traffic mixes can have very different delay costs. A potential value of delay by commodity type in the TTI freight mobility data will enable traffic management to make better use of the roadway system to minimize the local and regional economic impact by ensuring that freight can move on the roadway system.

Additional Policy Questions of Using Commodity Value Information

Collecting commodity value data represents a significant investment of time and resources. Several additional questions arise when considering this information.

Why are certain commodities on the roadways during congested times?

There are two possible reasons why trucks are on the roadway during peak congested times. The first reason is that although a roadway is congested during peak times, the major, congested roads still may represent the shortest path for certain commodities and these commodities have to be delivered during these time periods. Therefore trucks that operate during the normal workday have to utilize all of the roadways, irrespective of congestion level to make their deliveries and pickups. In this case, congestion relief will directly result in shipping time savings for commodities. The second reason is if shippers and carriers do not have information about congestion. Therefore, having freight mobility data available could possibly change their shipping decisions. This reason is probably the least likely of the two reasons for trucks being on the roadways during congestion.

A related question is whether these trucks can be shifted to the off-peak time to free up peak hour capacity. This implies another use of the freight mobility data. Obviously there is a need for shifting traffic from peak hours to the off-peak hours from the perspective of congestion management. Local municipal ordinances concerning allowable delivery times and shipper's delivery requirements both have an impact on truck operations. With the freight mobility data, policy implications can be analyzed. For example, a city ordinance banning early morning delivery might add some cost to shippers, but would also have a societal benefit from reduced congestion during the morning peak driving period. Since operating trucks in congestion is an expensive alternative, it is likely that any truck operations that could easily move out of peak congestion times have already been moved. Thus, most of the trucks that are still operating during peak congestion times probably have to be on the roadways and cannot be shifted from the peak periods.

Should the commodities in trucks traveling in off-peak times be included in the economic value placed on the corridor?

Many people tend to look at corridors from the perspective of congestion. In this case, if a corridor does not have congestion during a certain time period, it does not get attention. Consider the following questions: Where would the freight traffic go without the current corridor? Would the trucks experience delay and incur additional shipping time elsewhere without the current corridor? A what-if analysis would be helpful in answering these questions. However, how to include the commodities during the off-peak hours in corridor value remains a perplexing question. When focusing on traffic congestion, consideration is given to the negative attributes of a roadway. One roadway can move a lot of cars with little congestion but another roadway can move twice as many cars in a day but with heavy congestion. While the second roadway experiences a lot of delay, it also carries twice the volume and thus could have greater economic importance to the region. The same is true with freight traffic. The freight that moves outside of the peak congested times could have the same economic value as the freight moving during congested times; therefore, there is a need to focus on daily truck freight value in the corridor as opposed to just looking at the value of freight during peak times.

Methods to Measure the Value of Freight Delay

In the TTI freight mobility value-estimating methodology, the hours of delay associated with each commodity group can be translated into dollar cost if the value of delay information is available *(20).* Therefore, the value of delay is an important parameter and needs to be estimated.

General Framework of the Freight Delay Cost

Freight delay has cost to both carriers and shippers (e.g., distributors, retailers and manufacturers), respectively. The cost to carriers is comprised of two components. Direct cost to vehicles (idle time due to congestion, non-necessary energy consumption during idling, prolonged labor hours, etc.) may be obtained through a direct analysis *(20)*. Loss of productivity of the carrier fleet is another cost experienced due to congestion. Given a fleet size and market demand for shipping, reduced congestion allows carriers to serve more customer demand or be more efficient in serving the demand. The loss of productivity due to congestion (longer time as well as associated uncertainty) may be estimated through simulation using operational data.

In addition, there is a logistics cost associated with (1) increased inventory to account for longer travel times and, (2) arrangements for docking operation due to uncertain delivery. This logistics implication is very hard to quantify. A stated preference survey is a likely way to discover information about such logistical costs.

In terms of methodology to estimate the incurred cost to the freight community due to congestion, there are several factors that need to be considered including the commodity type and fleet type. The commodity type is linked to logistics and supply chain strategies. On the other hand, fleet type reflects operational implications to carriers. For large carriers, the effect due to delay of one vehicle may be offset by rearrangement of other vehicles. For self-operators, there is no such advantage. An estimate of delay cost according to commodity group and fleet size is desirable.

Delay of one hour at a location has much less negative impact on a shipment that takes several days of shipping time as opposed to one that only takes a few hours of shipping time. Therefore, shipping distance is an important factor to the value of delay. However, at this stage, it is uncertain whether explicit inclusion of shipping distance would introduce more errors in estimates and cause significant additional cost. This needs to be carefully examined in future efforts.

Public freight planners may use freight mobility data in the following way to estimate the freight congestion cost: $C = \sum_{i,j} c_{ij} v_{ij}$. Here c_{ij} will be an estimate of per truck cost of a fleet size in truck type *i* and commodity group *j*. v_{ij} is the volume of trucks in truck type *i* and of commodity group *j*. This commodity volume v_{ij} is the volume on a corridor or in an area of interest. *C* is the total delay cost therein. The mobility freight value methodology will address how to estimate v_{ij} in the future.
The following provides details on different aggregations (data clusters) of the freight data for analysis.

Commodity Groups

Four groups of commodities are recommended for analysis: bulk, low-value, mid-value, and high-value products. The four groups suggested are based on the 42 groups of commodities according to the Standard Classification of Transported Goods *(21)*. The bulk commodity group includes: agricultural products, fertilizer, coal and other minerals, oil products, sand, gravel, logs and rough wood, waste and scrap. Low-value manufactured products include wood products, paper print, paper board, textile products, base metal, and chemical products. Mid-value products include machinery, vehicles, office equipments, and mixed freight. High-value products include electronic equipments, precision instruments, and perishable products such as seafood, fashion items, and express mails. Commodity values also reflect characteristics of supply chain activities such as inventory policy and distribution strategies. The key is to find out the value of delay to each commodity or commodity type.

Carrier Groups

There are numerous carriers, and they can be stratified in many different ways. It is important to classify them in a way that their operations are consistent within the group. Some examples of stratifications are fleet size (based on the number of tractors), ownership (owner-operator versus company), general freight versus specialized such as tank trucks, household goods movers, etc. Classification based on fleet size is probably most desirable.

Additional Factors

There are two types of costs to consider: stakeholders' perceived cost and the actual cost (e.g., delay time, wasted fuel). Perceived cost deals with stakeholders' responsive behavior to public policies. The actual cost may be the criterion that public planners want to use in their decision-making. The two costs have different bases. For example, carriers' perceived cost might just consider their own productivity and efficiency, and might not consider the logistics implications upstream or downstream of the supply chain. However, the two costs are highly correlated. For example, a high actual cost is likely perceived high as well. The perceived cost is much easier to estimate through a survey. The actual cost is much harder to quantify.

Freight cost of congestion also has to do with geographic locations. Take freight bottlenecks as an example. The cost of congestion at a freight terminal is likely different from that at a general highway location such as a freeway interchange. The delay cost at a terminal, or maybe the reliability of time, has a larger logistics impact than at a general intersection or interchange. In a similar light, congestion cost at border crossings may be measured differently. In addition, short-haul and long-haul trips may also cause a different impact on logistics operations. Freight commodity mobility data can provide commodity mix and delay information, when coupled with location-specific information such as hauling distance mix and fleet size mix, will provide policy makers unbiased cost information that other sources cannot provide.

Note that estimation of benefits from congestion relief or bottleneck removal often assumes the eliminated congestion does not shift to other locations. In many cases, the congestion relief at one location is accompanied by increased congestion at an additional location on the roadway network. The freight mobility data show the effect of the current roadway network on freight. If the congestion bottlenecks shift across a region, a new assessment will have to be done to re-quantify the mobility levels.

Conclusions

There are extensive policy implications involved with the freight mobility methodology and value data produced by TTI *(20).* Where to spend construction and operational funding is just one of many concerns. Another is whether to place greater value on freight corridors than corridors that primarily serve passenger vehicles. As discussed in this report, there are not too many existing uses of freight mobility data in the public sector. Most of the freight data deal with truck volumes and weights rather than travel times. There is a need for more freight mobility information to better understand the role the public sector can play in helping to move freight more efficiently on the roadway network.

The mobility data are important to the private sector also. While their operations tend to account for the traffic congestion and an unreliable transportation system, the private sector must react to any changes to the roadway network following adjustments made by the public sector to deal with congestion issues.

There are still many challenges that exist in trying to fully develop the commodity data, but the benefits of these data could be tremendous. Several existing uses of mobility-type data were discussed in this report. However, it is apparent that up to this point, there has not been much information developed in this area. The focus of this report was on the estimation of the value of commodity delay. The framework laid out in TTI's freight mobility work *(20)* should be valuable to future research in this area.

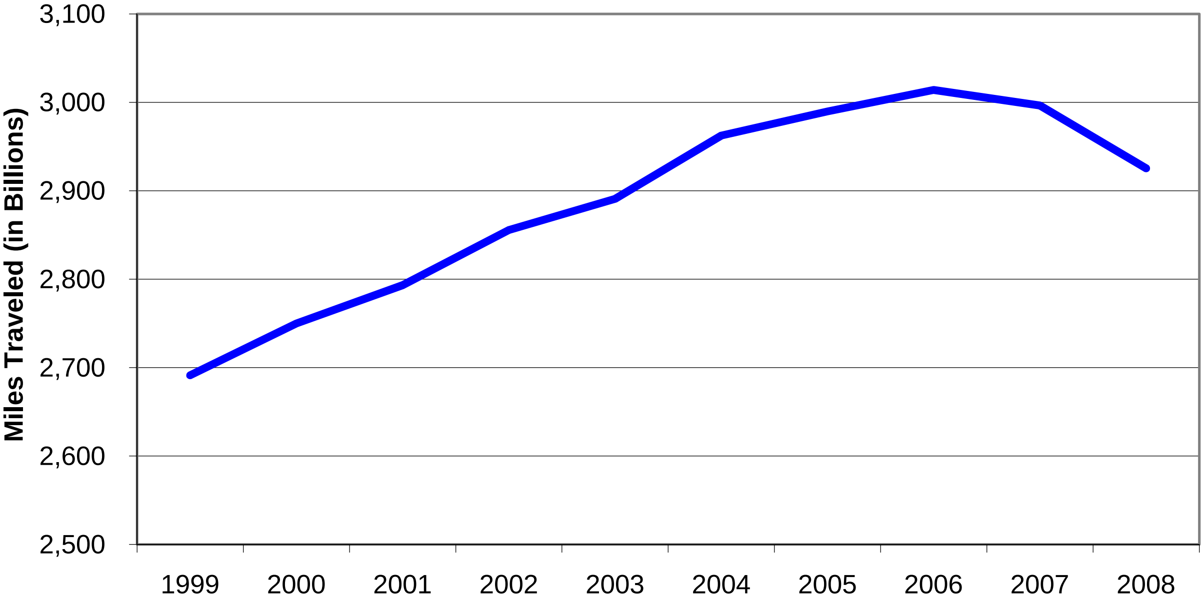
EFFECTS OF FUEL PRICE ON TRAVEL AND CONGESTION

> *"America is experiencing its longest and steepest drop in driving, signaling a permanent shift away from reliance on the car to other modes of transportation, according to a new Brookings Institution report released today. In the coming years, this shift will have far reaching implications for transportation, environmental, energy, and land-use planning." Brookings Institution Press Release, December 18, 2008.*

Background

In July 2008, when the price of gasoline in the United States had reached its peak of over $4.00 per gallon, as reflected in the quote above, many thought the end of the automobile-dominant transportation era would slowly, but surely, come to an end.

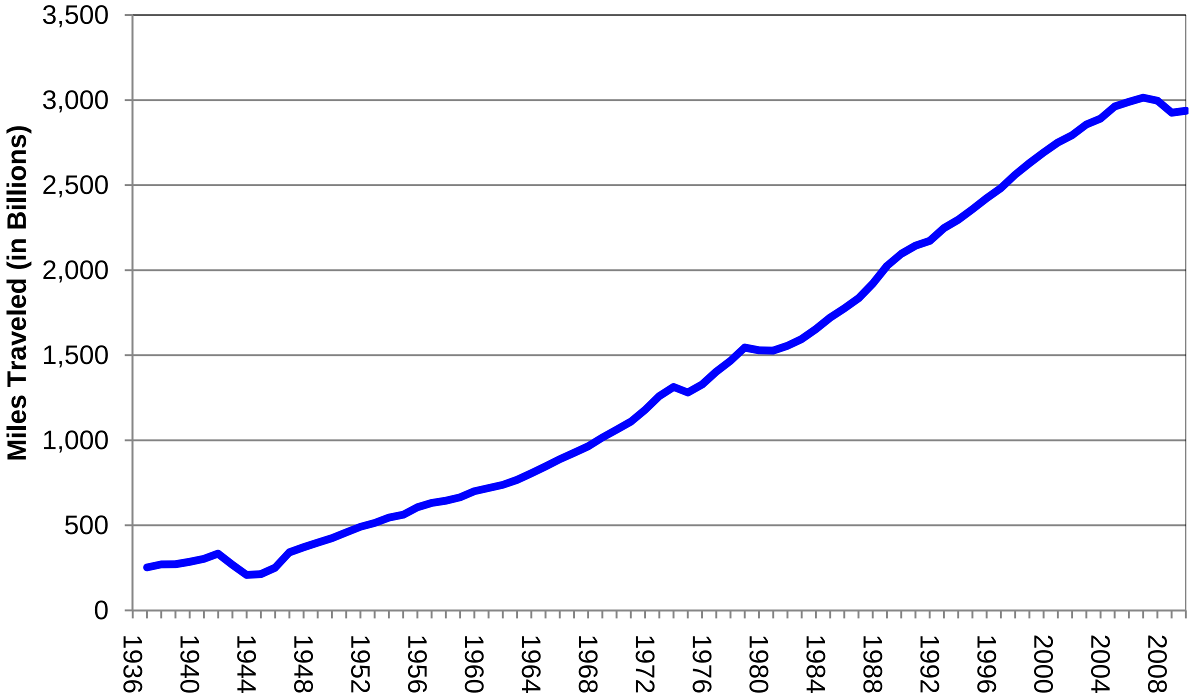
As indicated in Figure 19 below, in recent years vehicle miles traveled (VMT) reached its peak in 2006 and actually declined in both 2007 and 2008. However, just looking at a relatively short-term period might be misleading.



Source: *Traffic Volume Trends* (http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_stx_a.htm)

Figure 19: Vehicle Miles Traveled in the United State: 1999 through 2008.

If a more long-term historical new of VMT is taken as shown in Figure 20, it becomes apparent that the decrease in VMT experienced in 2006-2008 is, in fact, not unique. Indeed, the 2006-2008 decrease is the fourth such decrease in the last 70+ years.



Source: *Traffic Volume Trends* (http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_stx_a.htm)

Figure 20: Vehicle Miles Traveled in the United States: 1936 through 2009

The first decrease in VMT occurred, as might be expected, during the Second World War. During that time, not only were some 16 million American citizens in the armed forces, 75 percent of whom served overseas, but supplies of both gasoline and rubber were rationed as well.

The second decrease in VMT occurred in 1974 coincident with a major price increase resulting from a restriction in supply in crude oil. The "oil crisis" began in October 1973, as the Organization of Petroleum Exporting Countries (OPEC) announced a decision to raise the posted price of oil by 70 percent, to $5.11 a barrel. The following day, Arab oil ministers agreed to embargo all oil shipments to the United States, as well as a cut in production by five percent from the September 1974 output. They also announced their intention to continue to cut production over time in five percent increments in response to the U.S. decision to re-supply the Israeli military during the Yom Kippur War. Furthermore, they vowed to continue the embargo until their economic and political objectives were met. The embargo lasted until late Spring of 1974.

Also playing a major role in the decline of VMT was the stock market crash and recession that lasted from January 1973 to December 1974. During that period, the Dow Jones Industrial Average lost 45 percent of its value. In the two years from late 1972 to late 1974, the U.S. economy slowed from 7.2 percent real GDP growth to a -2.1 percent contraction, while inflation, as measured by the Consumer Price Index (CPI), jumped from 3.4 percent in 1972 to 12.3 percent in 1974.

The third decrease in VMT occurred in the 1979-1980 period. This period, again, saw dramatic increases in the price of crude oil, this time primarily as a result of declining production in Iran as a result of political instability, production decreases by Libya and Kuwait and successive 15 percent OPEC price increases.

The fourth decrease, which began in 2006, but accelerated in 2008, also coincided with price increases that, in this instance, resulted from a number of factors including supply disruptions in Nigeria, OPEC production cuts, hurricanes that significantly reduced production in the Gulf of Mexico, and general supply uncertainties exacerbated by oil futures market speculation. Also contributing to the decline in VMT was the U.S. recession that started in late 2007 and continues to this day.

Figure 21, below, shows these price spikes in a historical context adjusted to constant 2009 dollars.

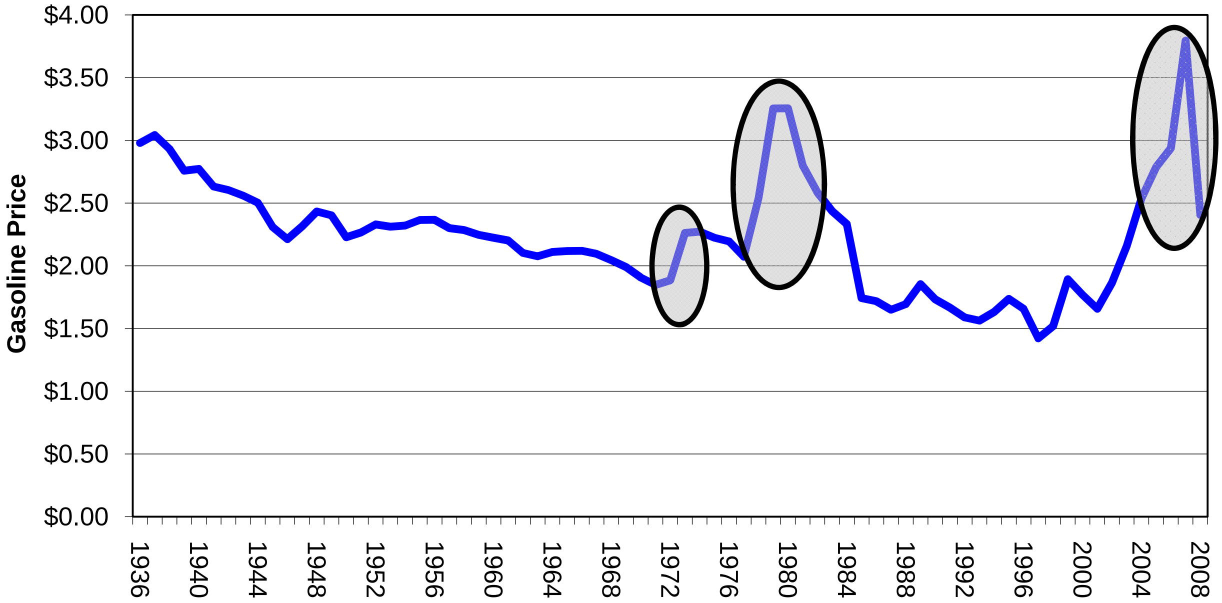


Figure 21: Average Annual Gasoline Price in the United States: 1936 through 2009 (in 2009 $)

Figure 22 brings these two concepts together by showing the year-over-year percent change in both VMT and the real price of gasoline. The three shaded areas show the 1974, 1979-1980 and 2008 period of high price increases and corresponding declines in VMT. (Note also the significant increase in VMT immediately following the Second World War as troops overseas came home and fuel rationing was lifted.)

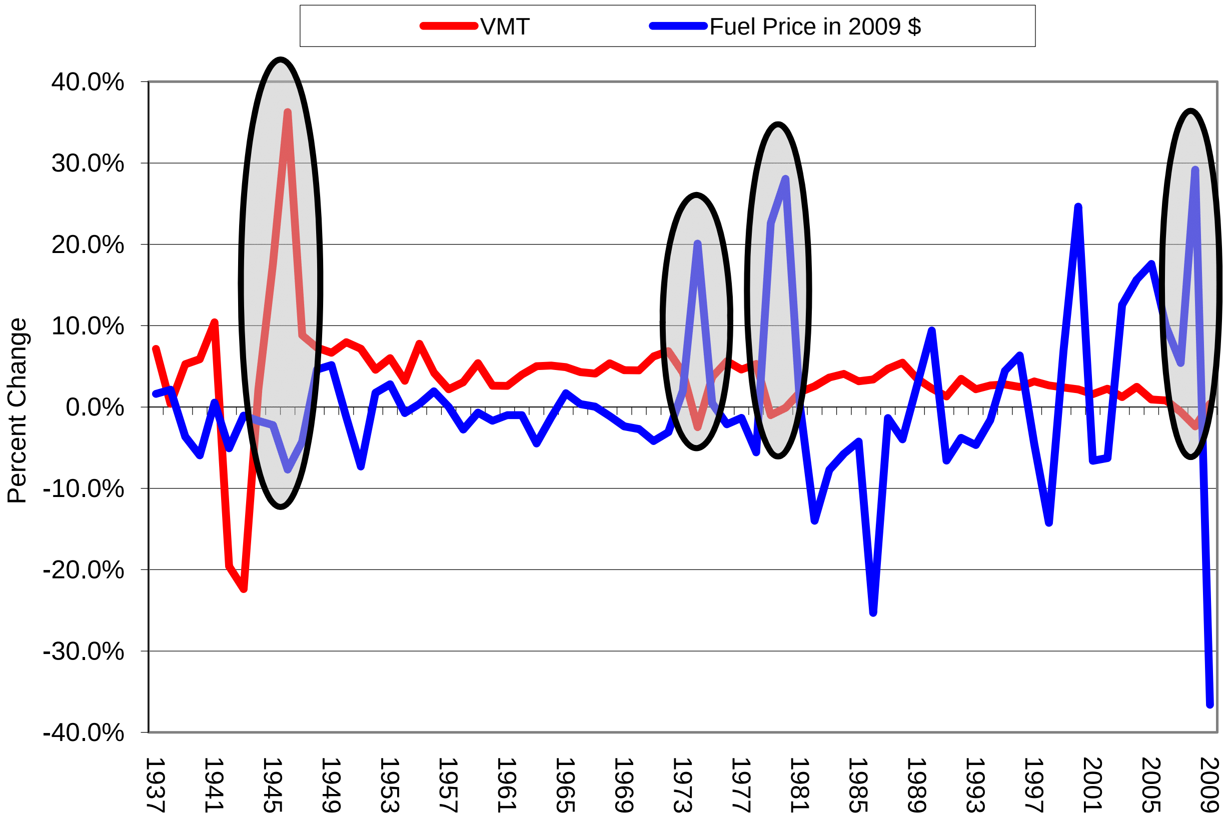


Figure 22: Year-to-Year Percent Change in VMT and Gasoline Price (in 2009 $)

All of these data, taken together, seem to indicate that there is, in fact, a relationship between gasoline price and vehicle miles traveled. But these data only track gasoline price and VMT at a gross (annual) level. Furthermore, the VMT included in this analysis is an estimate based on limited samples gathered by the states and submitted to the Federal Highway Administration's Office of Highway Policy Information for inclusion in the monthly *Traffic Volume Trends* publication (http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_stx_a.htm). Finally, the VMT reflected in the preceeding charts also includes miles attributable to commercial trucks, the overwhelming percentage of whom use diesel fuel rather than gasoline.

Taking a Closer Look at Texas

In order to take a more detailed look at the gasoline price and VMT relationship, Texas gasoline tax revenue data was obtained from the Texas Comptroller of Public Accouts for each month, from the beginning of the 1998 fiscal year forward (August 1997).

Since gasoline used on the public roads of Texas is taxed on a per-gallon basis and tax revenues are reported on a monthly basis, it is an easy task to convert gasoline tax revenues into gasoline consumption simply by dividing tax revenues by the tax rate. However, if this calculation was the only one performed, the level of consumption would be biased by both population growth and, to a lesser degree, by increased fuel efficiency. Figures 23 and 24 show this clearly. Exhibit 23 would indicate that gasoline use is trending upward – which it is. But Exhibit 24 shows that per capita use of is actually decreasing, primarily a function of population growth and fuel efficiency.

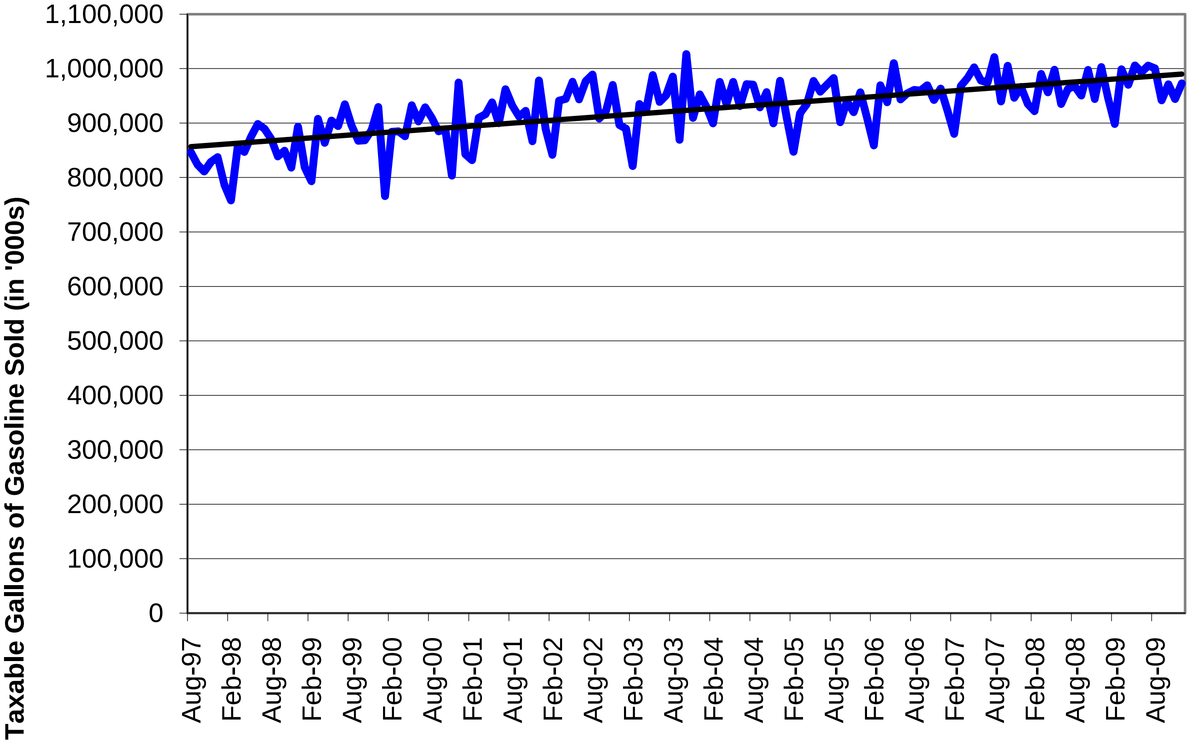


Figure 23: Taxable Gallons of Gasoline Sold (in thousands): August 1997 through December 2009

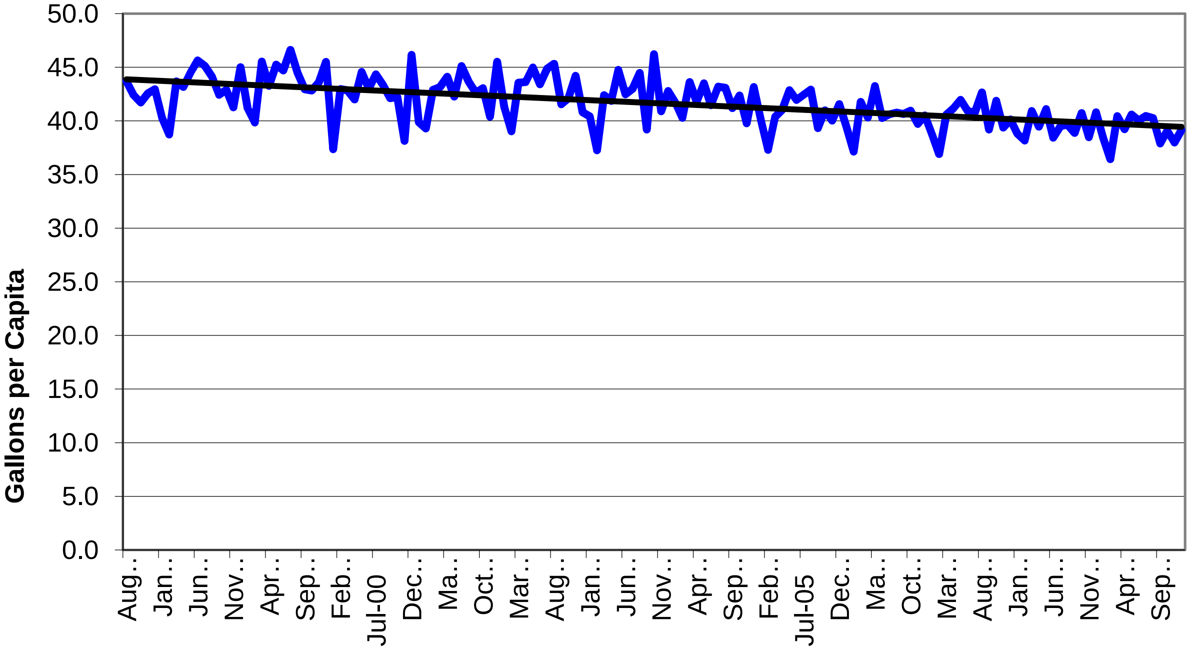


Figure 24: Taxable Gallons of Gasoline Sold Per Capita: August 1997 through December 2009

To better compare the amount of gasoline consumed at a specific level of price however, it is also necessary to adjust total gallons of gasoline consumed to a per capita basis and then adjust for changes in fuel efficiency. Gasoline price is adjusted by the rate of inflation as reflected by the CPI.

To adjust for population, total consumption, as mentioned above, is divided by total popuatlion to produce a per capita estimate. This is done using population estiamtes developed by the Texas State Data Center (http://txsdc.utsa.edu/). These data are produced on an annual basis and contain estimates of the total Texas population for the months of January and July. Population for months between the estimate dates are derived using interpolation.

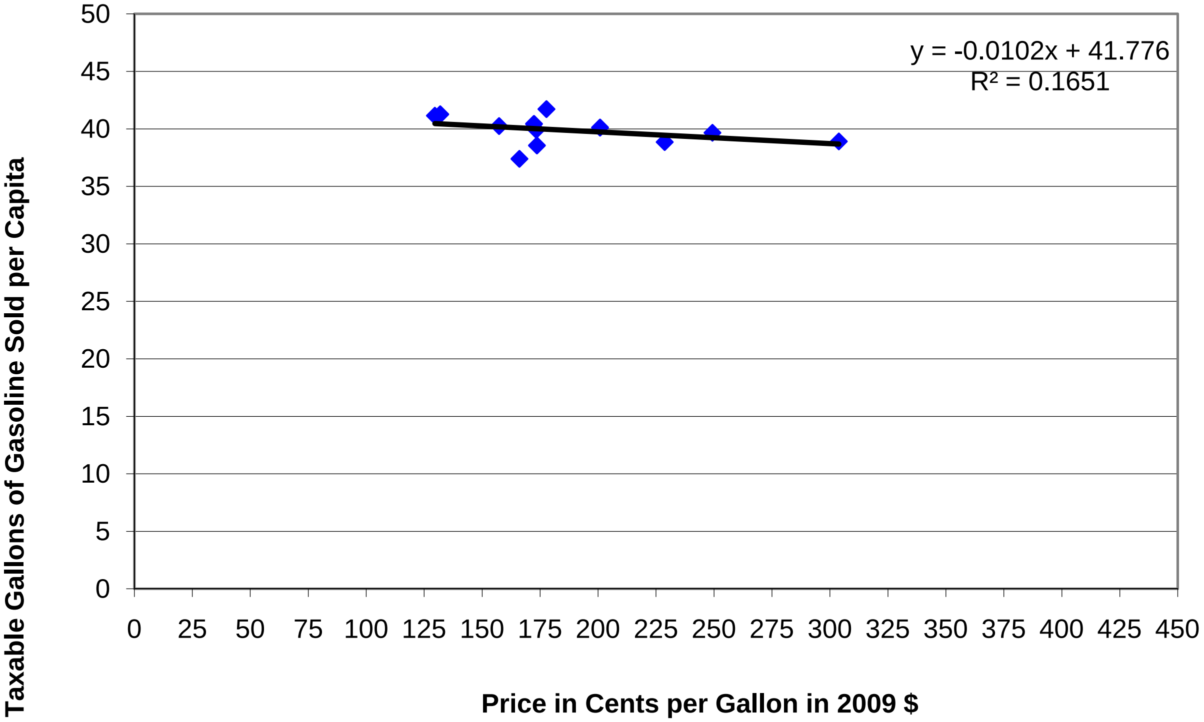
Estimates for fuel efficiency were developed by the Texas Transportation Institute as a part of the Transportation Revenue Estimator and Needs Determination System (TRENDS) Model (http://trends-tti.tamu.edu/). The fuel efficiency data used in the TRENDS Model development was, in turn, developed from national estimates of fuel efficiency produced by the Office of Energy Information's *Annual Energy Review* (http://www.eia.doe.gov/emeu/aer/pdf/aer.pdf). These national estimates were then adopted to fit the Texas vehicle fleet.

The retail price of gasoline in Texas is obtained by the Office of Energy Information's *Weekly Gasoline and Diesel Fuel Prices* (http://tonto.eia.doe.gov/dnav/pet/pet_gnd_dcus_stx_a.htm). These historical gasoline prices for Texas were then converted to 2009 dollars by the Consumer Price Index (All Urban Consumers [Current Series]) produced by the U.S. Department of Commerce's Bureau of Labor Statisitics (http://www.bls.gov/cpi/).

Consequently, at the conclusion of this adjustment process, we have gasoline consumption standardized both by population and fuel efficiency (serving as a surrogate for total VMT), while gasoline price is adjusted for inflation as adjusted by the CPI.

Next, the inflation-adjusted price of gasoline for each month was plotted with the fuel efficiency-adjusted per capita consumption for each month. The gasoline price-per capita fuel consumption points for like months of each year were then plotted and a least-squares linear regression analysis was performed with per capita fuel efficiency-adjusted consumption as the independent (*x*) variable and inflation-adjusted gasoline price as the dependent (*y*) variable.

Figures 25 and 26 show examples of the regression analysis performed for each month – in this case February and July. (Equations regression equations for remaining months are included in the Appendix.)



Figures 25: Gasoline Price and Gasoline Consumption in February in 2009 Dollars: 1997 through 2009.

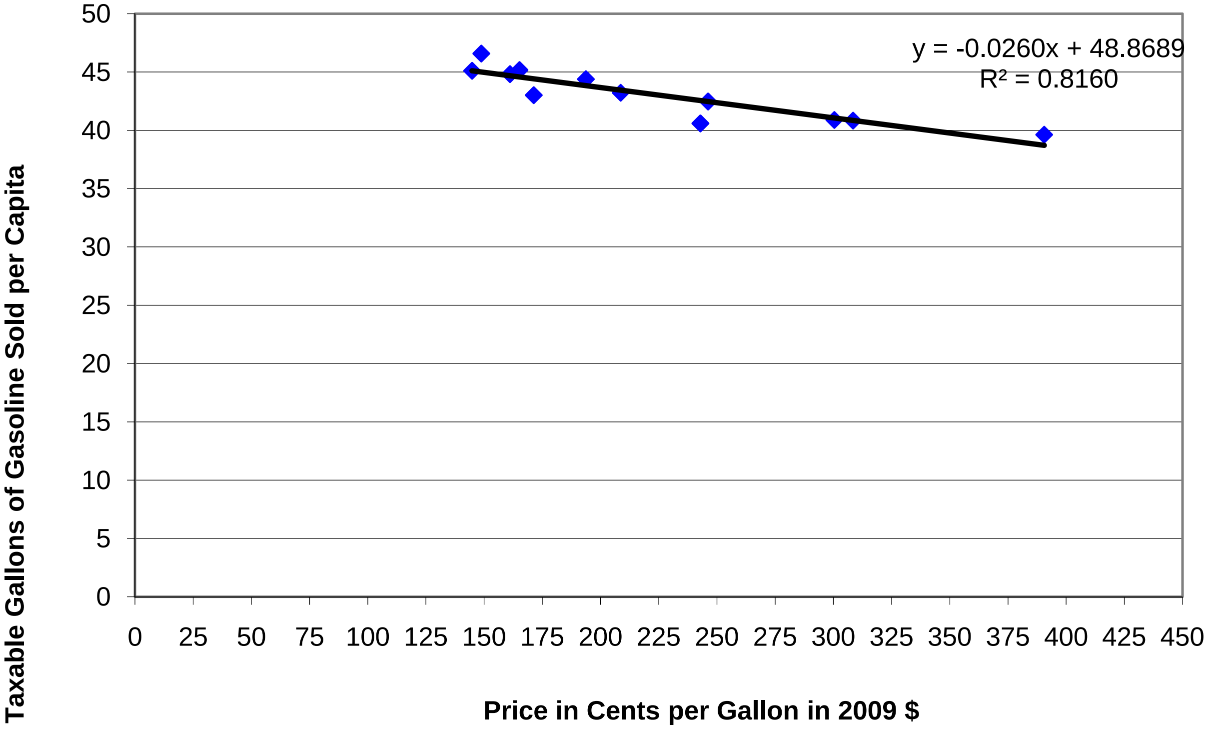


Figure 26: Gasoline Price and Gasoline Consumption in July in 2009 Dollars: 1997 through 2009.

Figure 27 shows the result of the 12 linear regression analyses of gasoline price and per capita gasoline consumption. The r-squared values plotted for each month represent the percentage of variation in the price of gasoline that can be explained by the variation in per capita consumption of gasoline.

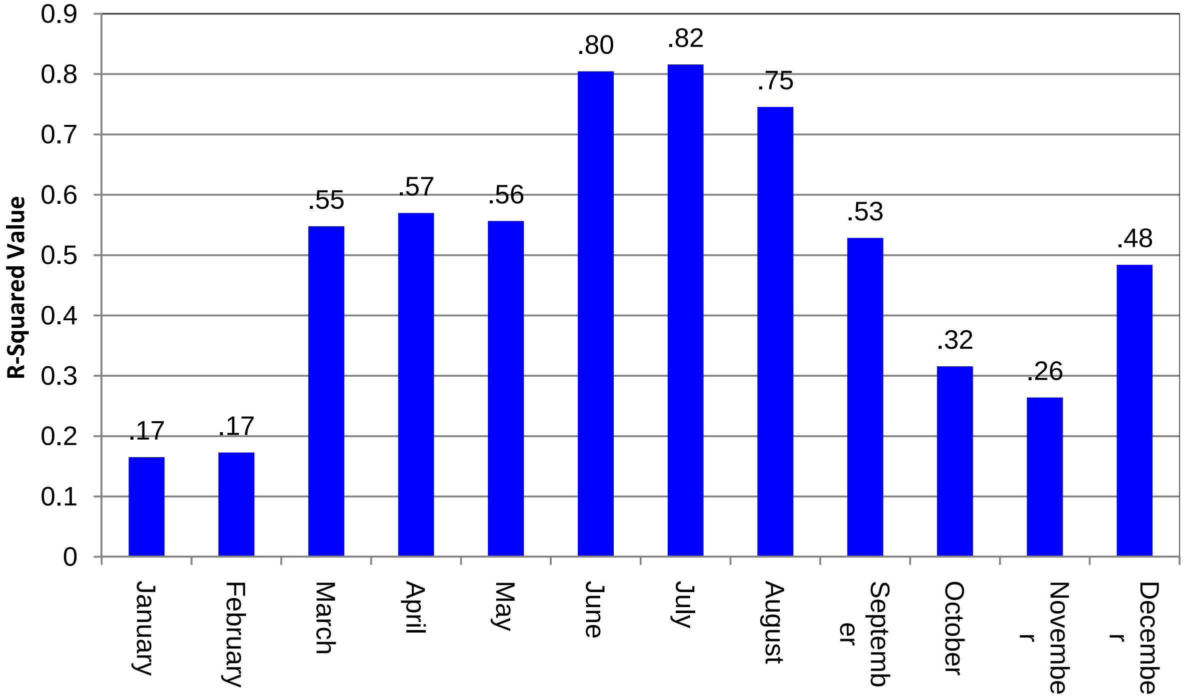


Figure 27: Price Elasticity of Demand for Gasoline: Comparative R-Squared Values by Month 1997 through 2009.

The results shown indicate less correlation between price and per capita consumption in January and February (r-squared values of .17), increased correlation March through May, and significant correlation during the summer months (with the price of gasoline explaining between 75 to 82 percent of the variation in the consumption of gasoline). The correlation between gasoline price and per capita consumption then decreases between September and November and increases once again in December.

These fluctuations tend to make sense. During the summer months, there is a higher percentage of VMT that is discretionary represented by traditional vacation driving. The length and number of these trips, since they are discretionary, can be influenced to a greater extent by the price of gasoline. The months of January, February, October and November tend to be months with smaller percentages discretionary driving and consequently there is less correlation between gasoline price and VMT. September and December tend to be months where there is a higher percentage of discretionary driving than non-summer months (due perhaps to the Labor Day and Christmas Holidays) but less than summer months.

Given the strengths of the relationship between price and consumption, **when** gasoline price increases occur can have a significant impact on VMT. As a result, this same timing in gasoline price increases can have a significant effect on tax revenues. Such has been in the case in Texas over the past four years. As shown in Figure 28 below, the most significant price increases in gasoline have predominately occurred during the time when gasoline price has the most effect on gasoline consumption – and consequently fuel tax revenues.

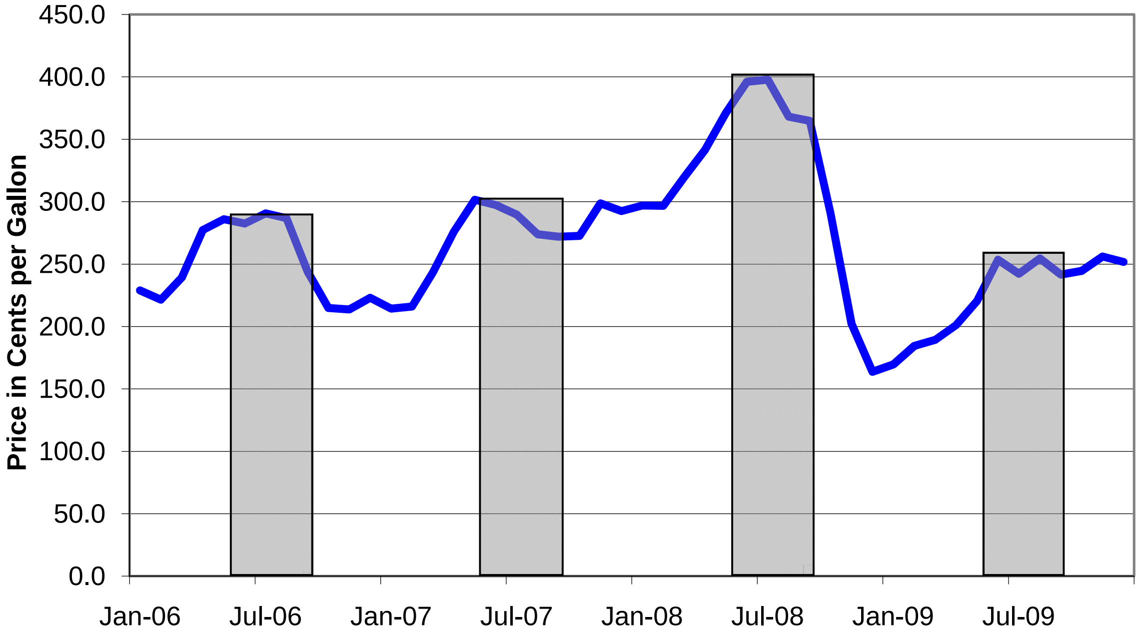


Figure 28: Gasoline Price in Texas: 2006 though 2009

To see the effect of gasoline price spikes on consumption in the summer months (and consequently, the effects on tax revenues), let us assume for the moment that the price peaks seen above in Figure 28 during the summer months had not occurred (shaded area). In the alternative, let's assume that the price of gasoline in January 2006 had gradually increased by the rate of increase in the CPI (in this case, from $2.38 per gallon in January 2006 to $2.49 in December 2009).

The change in price under this scenario is shown in Figures 29 and 30 below. (The CPI-adjusted price of gasoline is shown by the dashed line in Exhibit 30.)

Date	Actual Price	CPI-Adjusted Price
Jun-06	282.5	234.2
Jul-06	290.6	234.9
Aug-06	286.8	235.4
Jun-07	297.3	240.5
Jul-07	289.7	240.4
Aug-07	273.9	240.0
Jun-08	396.1	252.6
Jul-08	397.8	253.9
Aug-08	368.1	252.9
Jun-09	253.5	249.0
Jul-09	242.2	248.6
Aug-09	254.5	249.1

Figure 29: Actual Price of Gasoline in Texas versus Inflation-Adjusted Price (in cents per gallon)

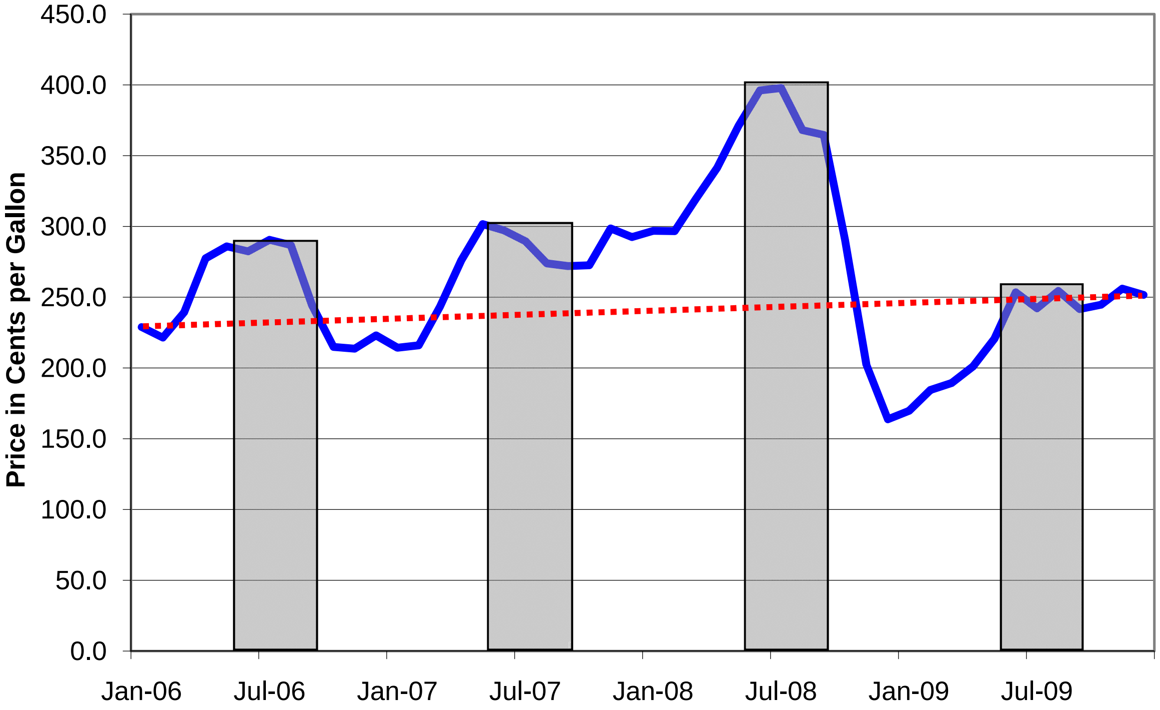


Figure 30: Actual Price of Gasoline in Texas versus Inflation-Adjusted Price

To calculate the expected versus actual per capita gasoline consumption for the summer of months of June, July and August, the following equations were employed:

June: $y = -0.0233x + 47.36$
July: $y = -0.0260x + 48.87$
August: $y = -0.0205x + 47.47$

Where: y = gallons of gasoline consumed per capita
x = price of gasoline

Based on the actual price and the hypothetical CPI-adjusted price of gasoline and using the appropriate equation shown above, it is possible to calculate the estimated per capita consumption of gasoline at the two alternative prices (See Figure 31.)

Date	Consumption Based on Actual Price	Consumption Based on CPI Price
Jun-06	40.78	41.90
Jul-06	41.31	42.76
Aug-06	40.30	41.59
Jun-07	40.43	41.76
Jul-07	41.34	42.62
Aug-07	40.62	41.47
Jun-08	38.13	41.48
Jul-08	38.53	42.27
Aug-08	38.27	41.15
Jun-09	41.45	41.56
Jul-09	42.57	42.41
Aug-09	41.11	41.24

Figure 31: Gasoline Consumption Per Capita in Texas Based on the Actual Price of Gasoline vs. the Price Based in Increase in the Consumer Price Index

When the per capita consumption data are then multiplied first by the estimated population for that corresponding month and then by the gasoline tax rate (20 cents per gallon), the resulting monthly revenue for the two alternative prices are determined.

Date	Fuel Tax Revenue Based on Actual Price	Fuel Tax Revenue Based on on CPI Price	Difference in Revenue
Jun-06	$191.1	$196.4	$5.3
Jul-06	$194.2	$201.1	$6.8
Aug-06	$189.9	$196.0	$6.1
Jun-07	$193.2	$199.5	$6.3
Jul-07	$197.6	$203.8	$6.1
Aug-07	$194.5	$198.5	$4.1
Jun-08	$185.5	$201.8	$16.3
Jul-08	$187.8	$206.0	$18.2
Aug-08	$186.8	$200.9	$14.1
Jun-09	$205.7	$206.2	$0.5
Jul-09	$211.6	$210.8	-$0.8
Aug-09	$204.3	$205.0	$0.7
TOTAL	$2,342.3	$2,425.9	$83.6

Figure 32: Revenues from Alternative Gasoline Price Levels in Texas during the Summer Months of 2006, 2007, 2008, and 2009.

As shown in Figure 32, the total effect of the gasoline price differential (See Exhibit 11.) for the summer months of 2006 through 2009 is estimated to be $83.6 million – a not insignificant amount, particularly in a time when transportation agencies are facing funding difficulties from a host of other reasons as well.

Conclusions

There are two major conclusions that result from this research. First, the effect of gasoline price on consumption can varies significantly based on the time of year. Second, the price of gasoline during the summer months of June, July and August has a greater effect on gasoline consumption than other months. Third, given the funding pressures that transportation agencies face, it seems clear that revenue and cash flow forecasting could be enhanced with a better understanding of the gasoline price/gasoline consumption relationship.

Regression Equations and Corresponding R-Squared Values for All Months

January:	y = -.0102x = 41.78	R-squared value = .1651
February:	y = -.0153x + 41.58	R-squared value = .1728
March:	y = -.0202x + 46.46	R-squared value = .5478
April:	y = -.0162x + 45.18	R-squared value = .5697
May:	y = -.0155x + 46.95	R-squared value = .5566
June:	y = -.0233x + 47.36	R-squared value = .8064
July:	y = -.0260x + 48.87	R-squared value = .8160
August:	y = -.0205x + 47.47	R-squared value = .7456
September:	y = -.0179x + 44.75	R-squared value = .5284
October:	y = -.0164x + 45.56	R-squared value = .3157
November:	y = -.0199x + 44.48	R-squared value = .2640
December:	y = -.0313x + 48.68	R-squared value = .4841

Where: *y* = gallons of gasoline consumed per capita
x = price of gasoline

REFERENCES

1. N. Zmud. 2006. Commodity Flow Survey: *Improving Methods to Enhance Data Quality and Usefulness.* Transportation Research E-Circular No. E-C088. Available TRIS online at http://onlinepubs.trb.org/onlinepubs/circulars/ec088.pdf. (Accessed August 2009)
2. Federal Highway Administration. Freight Analysis Framework. (http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm) (Accessed August 2009)
3. Federal Highway Administration. *Freight Performance Measures: Travel Time in Freight-Significant Corridors.* (http://ops.fhwa.dot.gov/freight/freight_analysis/perform_meas/fpmtraveltime/index.htm)
4. Quiroga, Cesar, Nicholas Koncz, et al. *Specifications for Freight Transportation Data Architecture (Draft)*. National Cooperative Freight Research Program. Project NCFRP 12. December 2009.
5. Seattle Freight Mobility Program. (http://www.cityofseattle.net/transportation/freight.htm) (Accessed August 2009)
6. Adams, T., Gordon, E., Wittwer, J., Gupta, P., Lindquist, M., Vonderembse, K., Kawamura,,and S. McNeil. Upper Midwest Freight Corridor Study. Work Report. Midwest Regional University Transportation Center. University of Wisconsin Madison. 2005.
7. Mobility Measurement in Urban Transportation. FHWA Pooled Fund Study. Texas Transportation Institute. (http://mobility.tamu.edu/ums/study_information/)
8. Winterich, David, William L. Eisele et al. Developing and Applying Mobility Performance Measures for Freight Transportation in Urban Areas. Southwest Region University Transportation Center. Texas Transportation Institute. Report Number SWUTC-09-476660-00014-1. November 2009.
9. Federal Highway Administration. “Highway Performance Monitoring System,” 1982 to 2008 Data. January 2010.
10. David L. Schrank and Timothy J. Lomax. *2009 Urban Mobility Report.* Texas Transportation Institute Work Report. The Texas A&M University System, College Station, Texas.
11. X. Wang and K. Yin. 2009. *Sustainable Intersection Control to Accommodate Urban Freight Mobility.* Texas Transportation Institute. Report Number SWUTC-08-476660-0007-1.
12. T. F. Golob and Amelia C. Regan. 2000. Freight Industry Attitudes towards Policies to Reduce Congestion. Transportation Research Part E: Logistics and Transportation Review 36 (1) 55-77.
13. A. Seetharaman, K. Kawamura, and S. Bhatta. 2003. Economic Benefits of Freight Policy Relating to Trucking Industry, Evaluation of Regional Transportation Plan Freight Policy for a Six-County Region, Chicago, Illinois. *Transportation Research Record 1833.* pp. 17-37.
14. Politano, A. L., and C. J. Roadifer. 1989. Regional Economic Impact Model for Highway Systems (REIMHS). *Transportation Research Record 1229,* pp. 43–52.
15. Hewitt, J., J. Stephens, K. Smith, and N. Menuez. Infrastructure and Economic Impacts of Changes in Truck Weight Regulations in Montana. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1653,* TRB, National Research Council, Washington, D.C., 1999, pp. 42–51.
16. Hewings, G, and J. Seo. *Economic Impact of the Transportation Sector on the Chicago Economy 1970–2021 and the Potential Impact of Freight Transportation Capacity Limitations on the*

Chicago, Illinois, and U.S. Economies. Regional Economics Applications Laboratory, University of Illinois, Urbana, 2001.

17. Srour, F. J., and D. Newton. Freight Specific Data Derived from Intelligent Transportation Systems: Potential Uses in Planning Freight Improvement Projects. *Transportation Research Record, No. 1957*. 2006. pp. 66-74.
18. Luskin, D. M., E. E. Mallard, and I. C. Victoria-Jaramillo. 2008. Potential Gains From More Efficient Spending on Texas Highways. *Annuals of Regional Science*. No. 42, pp. 565-590.
19. D. Brownstone, C. Kazimi, A. Ghosh, T. F. Golob, and D. vanAmelsfort. 2003. Drivers' Willingness-to-Pay to Reduce Travel Time: Evidence from the San Diego I-15 Congestion Pricing Project. *Transportation Research A*, 37, pp. 373-387.
20. Eisele, W. L., and David L. Schrank. Conceptual Framework and Trucking Application to Estimate the Impact of Congestion on Freight. Presented at the 89th Annual Meeting of the Transportation Research Board. Washington, D.C. January 2010.
21. U.S. Department of Transportation and U.S. Department of Commerce. *2007 Commodity Flow Survey Standard Classification of Transported Goods.* October 2006. (http://www.bts.gov/publications/commodity_flow_survey/survey_materials/pdf/sctg_booklet.pdf)

APPENDIX A – 2009 URBAN MOBILITY REPORT

Appendix A

2009 URBAN MOBILITY REPORT

David Schrank
Associate Research Scientist

and

Tim Lomax
Research Engineer

Texas Transportation Institute
The Texas A&M University System
http://mobility.tamu.edu

July 2009

Acknowledgements

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

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

Table of Contents

Sponsored by:

University Transportation Center for Mobility – Texas A&M University
American Road & Transportation Builders Association – Transportation Development Foundation
American Public Transportation Association
Texas Transportation Institute

2009 Urban Mobility Report

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

Congestion is a problem in America's 439 urban areas, and it has gotten worse in regions of all sizes. In 2007, congestion caused urban Americans to travel 4.2 billion hours more and to purchase an extra 2.8 billion gallons of fuel for a congestion cost of $87.2 billion – an increase of more than 50% over the previous decade (Exhibit 1). This was a decrease of 40 million hours and a decrease of 40 million gallons, but an increase of over $100 million from 2006 due to an increase in the cost of fuel and truck delay. Small traffic volume declines brought on by increases in fuel prices over the last half of 2007 caused a small reduction in congestion from 2006 to 2007.

There are many congestion problems but there are also many solutions. **The most effective strategy is one where agency actions are complemented by efforts of businesses, manufacturers, commuters and travelers. The best approach to selecting strategies is to identify projects, programs and policies that solve problems or capitalize on opportunities.** The strategies must address the issue that the problems are not the same in every region or on every day – the variation in travel time is often as frustrating and costly as the regular "daily slog" through traffic jams. The *2009 Urban Mobility Report* clearly demonstrates that all the solutions are not being implemented fast enough.

Exhibit 1. Major Findings for 2009 –
The Important Numbers for the 439 U.S. Urban Areas
(Note: See page 2 for description of changes since 2007 Report)

Measures of…	1982	1997	2006	2007
… Individual Traveler Congestion				
Annual delay per peak traveler (hours)	14	32	37	36
Travel Time Index	1.09	1.20	1.25	1.25
"Wasted" fuel per peak traveler (gallons)	9	21	25	24
Congestion Cost (constant 2007 dollars)	$290	$621	$758	$757
Urban areas with 40+ hours of delay per peak traveler	1	10	27	23
… The Nation's Congestion Problem				
Travel delay (billion hours)	0.79	2.72	4.20	4.16
"Wasted" fuel (billion gallons)	0.50	1.82	2.85	2.81
Congestion cost (billions of 2007 dollars)	$16.7	$53.6	$87.1	$87.2
… Travel Needs Served				
Daily travel on major roads (billion vehicle-miles)	1.68	2.93	3.79	3.82
Annual public transportation travel (billion person-miles)	38.8	42.6	53.4	55.8
… Expansion Needed to Keep Today's Congestion Level				
Lane-miles of freeways and major streets added every year	15,500	16,532	15,032	12,676
Public transportation riders added every year (million)	3,456	3,876	3,779	3,129
… The Effect of Some Solutions				
Travel delay saved by				
Operational treatments (million hours)	7	116	307	308
Public transportation (million hours)	290	455	622	646
Congestion costs saved by				
Operational treatments (billions of 2007 dollars)	$.02	$2.3	$6.4	$6.5
Public transportation (billions of 2007 dollars)	$6.3	$9.3	$13.1	$13.7

Travel Time Index (TTI) – The ratio of travel time in the peak period to travel time at free-flow conditions. A Travel Time Index of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak.
Delay per Peak Traveler – The extra time spent traveling at congested speeds rather than free-flow speeds divided by the number of persons making a trip during the peak period.
Wasted Fuel – Extra fuel consumed during congested travel.
Vehicle-miles – Total of all vehicle travel (10 vehicles traveling 9 miles is 90 vehicle-miles).
Expansion Needed – Either lane-miles or annual riders to keep pace with travel growth (and maintain congestion).

The Congestion Trends

(And Why A Few Numbers Are Different than Previous Reports)

Each *Urban Mobility Report* reviews procedures, processes, and data used to develop the best estimates of the costs and challenges of traffic congestion, improving them when possible. The methodology was revised in 2008/9 to improve the public transportation methodology. In addition, the benefits from operations treatments were estimated throughout the extent of the study database to improve the relevance of the long-term trends. This caused some numbers from previous reports to change. All of the congestion statistics in the *2009 Urban Mobility Report* have been revised using the new calculation procedures for all years from 1982 so that true trends can be identified (Exhibit 2).

Congestion, by every measure, has increased substantially over the 25 years covered in this report. The most recent two years of the report, however, have seen slower growth or even a decline in congestion. Delay per traveler – the number of hours of extra travel time that commuters spend during rush hours – was 1.3 hours lower in 2007 than 2005. This change would be more hopeful if it was associated with something other than rising fuel prices (which occurred for a short time in 2005 and 2006 before the sustained increase in 2007 and 2008) and a slowing economy. This same kind of slow growth/decline over a few years occurred in the early 1990s when spending and growth in the high-tech and defense sectors of the economy declined dramatically.

The decline means congestion is near the levels recorded in 2003, not exactly a year remembered for trouble-free commuting.

Changes to Congestion Methodology – Highlights

- Public transportation – An improved method for transferring riders back into the roadway network to simulate the effect of eliminating public transportation service resulted in larger delay reduction benefits in the 2009 report. The new methodology was reapplied for all previous years as well. Improvements include using the transit modes in each region to determine the peak travel mileage and alternative routes.
- Operations benefits - The 2009 report estimates the benefits from programs that reduce congestion without adding roadway lanes for every year since 1982. Previous reports included these programs only since 2000. There are fewer data for the pre-2000 period, but general trend information and project-specific reports were used to smooth out what had been a disruptive element in the urban area congestion trends.

The base data for this report are from the Federal Highway Administration's Highway Performance Monitoring System (*1*). More information on the methodology is included on the website at: http://mobility.tamu.edu/ums/report/methodology.stm

Exhibit 2. National Congestion Measures, 1982 to 2007

						Hours Saved (million hours)		Gallons Saved (million gallons)		Dollars Saved (billions of $2007)	
Year	Travel Time Index	Delay per Traveler (hours)	Total Delay (billion hours)	Total Fuel Wasted (billion gallons)	Total Cost ($2007 billion)	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp
1982	1.09	13.8	0.79	0.50	16.7	7	290	4	163	0.2	6.3
1983	1.09	14.7	0.87	0.54	18.0	9	296	5	167	0.2	6.4
1984	1.10	15.8	0.95	0.60	19.7	12	306	7	174	0.3	6.6
1985	1.11	12.0	1.10	0.70	22.6	17	324	9	187	0.3	6.9
1986	1.13	20.2	1.27	0.81	25.2	22	306	12	181	0.4	6.3
1987	1.14	21.6	1.41	0.92	27.9	28	315	16	186	0.6	6.5
1988	1.16	24.2	1.62	1.06	32.0	37	384	20	228	0.7	7.9
1989	1.17	25.9	1.78	1.17	35.3	45	411	24	246	0.9	8.5
1990	1.18	26.8	1.88	1.25	37.3	51	409	28	248	1.0	8.4
1991	1.18	26.5	1.93	1.29	38.1	54	404	30	247	1.1	8.3
1992	1.18	27.4	2.05	1.37	40.6	61	397	34	241	1.2	8.1
1993	1.18	28.5	2.17	1.43	42.6	68	391	38	237	1.3	8.0
1994	1.18	28.8	2.26	1.49	44.3	76	407	42	246	1.5	8.3
1995	1.19	30.0	2.42	1.61	47.8	89	427	49	262	1.8	8.8
1996	1.19	31.0	2.58	1.72	51.0	102	442	56	272	2.0	9.1
1997	1.20	31.7	2.73	1.82	53.6	116	455	64	280	2.3	9.3
1998	1.21	31.9	2.83	1.91	55.0	131	482	72	299	2.5	9.7
1999	1.22	33.3	3.04	2.05	58.9	151	511	82	319	2.9	10.3
2000	1.22	33.4	3.18	2.14	63.1	166	538	109	327	3.3	10.9
2001	1.23	34.2	3.33	2.25	65.7	187	559	123	341	3.7	11.3
2002	1.24	35.0	3.52	2.38	69.3	208	566	138	346	4.1	11.4
2003	1.24	35.4	3.73	2.53	73.3	238	558	156	341	4.7	11.2
2004	1.25	36.5	3.97	2.69	79.4	258	591	171	362	5.2	12.1
2005	1.25	37.4	4.18	2.82	85.6	278	595	182	365	5.7	12.4
2006	1.25	36.6	4.20	2.85	87.1	307	622	200	384	6.4	13.1
2007	1.25	36.1	4.16	2.81	87.2	308	646	202	398	6.5	13.7

Note: For more congestion information see Tables 1 to 7 and http://mobility.tamu.edu/ums

One Page of Congestion Problems

Travelers and freight shippers must plan around traffic jams for more of their trips, in more hours of the day and in more parts of town than in 1982. In some cases, this includes weekends and rural areas. Until 2007, mobility problems worsened at a relatively consistent rate during the more than two decades studied.

Congestion costs are increasing. The congestion "invoice" for the cost of extra time and fuel in 439 urban areas (all values in constant 2007 dollars):

- In 2007 – $87.2 billion
- In 2000 – $63.1 billion
- In 1982 – $16.7 billion

Congestion wastes a massive amount of time, fuel and money. In 2007:

- 2.8 billion gallons of wasted fuel (enough to fill 370,000 18-wheeler fuel delivery trucks – bumper-to-bumper from Houston to Boston to Los Angeles)
- 4.2 billion hours of extra time (enough to listen to *War and Peace* being read 160 million times through your car stereo)
- $87.2 billion of delay and fuel cost (The negative effect of uncertain or longer delivery times, missed meetings, business relocations and other congestion results are not included)

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

- Yearly delay for the average peak-period traveler was 36 hours in 2007 – almost one week of vacation – an increase from 14 hours in 1982 (Exhibit 3).
- That traveler wasted 24 gallons of fuel in 2007 – three weeks worth of fuel for the average U.S. resident – up from 9 gallons in 1982 (Exhibit 4).
- The value for the delay and wasted fuel was almost $760 per traveler in 2007 compared to an inflation-adjusted $290 in 1982.
- Congestion effects were even larger in areas over one million persons – 46 hours and 31 gallons in 2007.

Exhibit 3. Hours of Travel Delay per Peak-Period Traveler

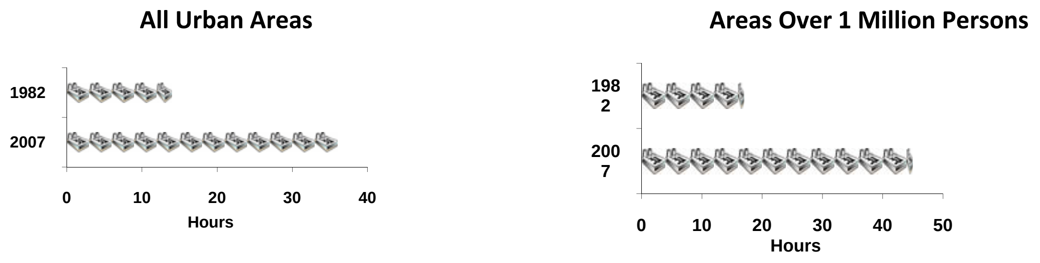
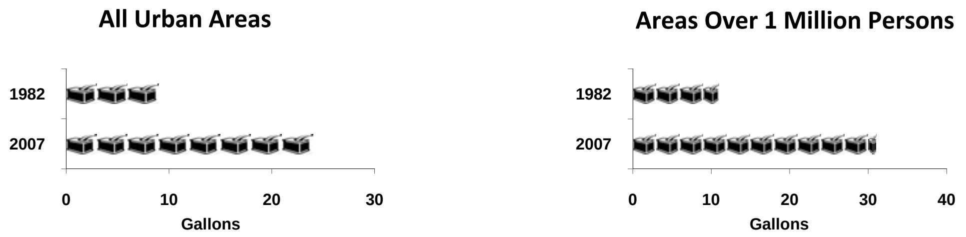


Exhibit 4. Gallons of Fuel Wasted per Peak-Period Traveler



Appendix A

Won't Higher Fuel Prices and the Economic Slowdown Help Solve Congestion Problems?

The *2009 Urban Mobility Report* suggests a tentative "yes" to the fuel price question above, if…
- By "higher" you mean very high – above $4 per gallon for more than a year
- By "solve" you mean slower growth or modest declines in congestion (don't expect to drive at the speed limit on your way to work)

The way most people understand congestion, then, the answer is "no, higher fuel prices are not the answer."

The economic solution, likewise, doesn't hold much hope for those wishing to find the easy answer. Travel may grow slower than in the past, but that will only mean "things get worse slower" – hardly a positive goal statement. The Urban Mobility Report database includes a few similar periods from regional recessions in the past (the northeastern states in the early-to-mid 1980s, Texas in the mid 1980s, California in the early-to-mid 1990s). In every case, when the economy rebounded, so did the congestion problem. An examination of recent fuel price, traffic volume, transit ridership and congestion trends shows (Exhibit 5):
- There is a cycle to traffic volume and fuel prices – they generally go up in the summer and down in the winter.
- There was a small but varying decline in traffic volume in 2008. The largest declines were in rural areas and on the weekends. The smallest declines were in the urban areas on weekdays – where most of the congestion exists.
- Traffic volume began to increase when prices declined in the Fall of 2008.
- Traffic volume and congestion trends during the economic downturn in the last half of 2008 were consistent with previous recessions – slow or no growth in areas with job losses.
- Public transportation ridership was up in early and mid-2008 when fuel prices were at their highest levels (*2*).

None of these events suggest that price increases which are modest and take a long time or price increases that are rapid but decline after a few months will cause any substantial change in travel behavior or cause a dramatic slowdown in congestion growth trends.

Data collected on freeways in 23 urban regions (see Exhibit 5) as part of a 2008 study for the Federal Highway Administration (*3*) found:
- Weekday traffic volumes were down between 2% and 4% from June to December 2008 compared to June to December 2007.
- Traffic congestion for these same time periods was down between 3% and 5%.
- Weekend traffic volumes were down between 4% and 7% between June and November 2008 and the same period in 2007.
- Weekend traffic volumes were down only 2% to 3% in December 2008 (with lower fuel prices).

These values show that dramatic fuel price increases and a falling job market will "solve" only part of the congestion problem.

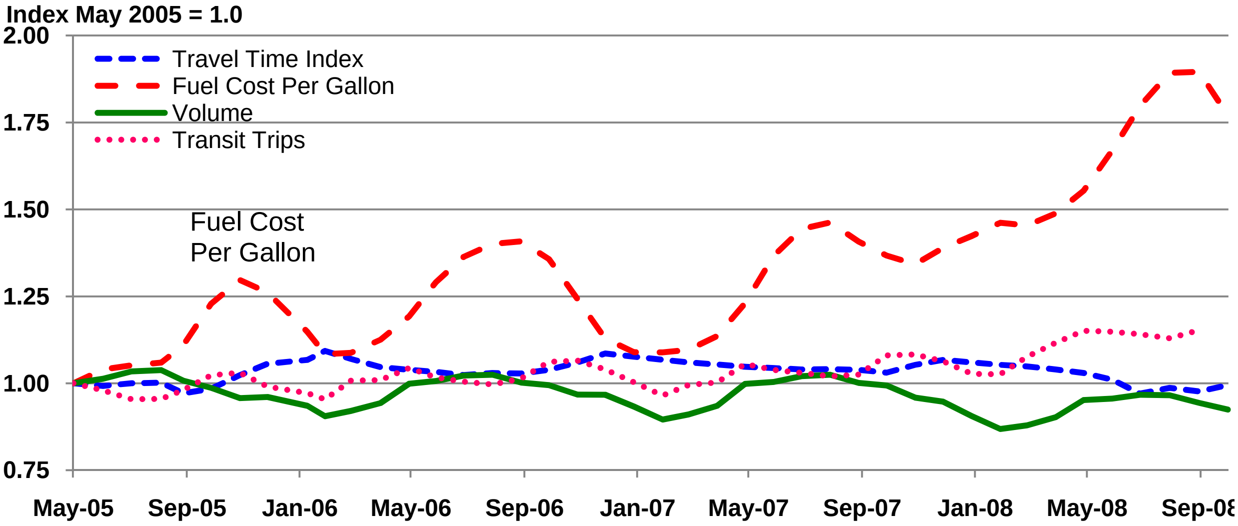
The reason why the travel decline was relatively small (in relation to the price increase) may have been due to the fact that people could adopt several coping strategies:

- Cut back spending in other areas to pay for fuel
- Reduce their percentage of drive-alone trips
- Combine trips, for example, stopping at the store on the way home from work
- Avoid optional trips in “rush hours” (but in many areas this time period was already congested – one would be hard pressed to find a lot of “joy-riding” in rush hour)

Over a relatively short time period, many people are “locked in” to many of their choices and cannot respond rapidly. Consider these factors that made it difficult for people to react to short-term fuel price increases in 2007 and 2008:

- Cannot sell a large car or SUV for the amount of the loan, because trade-in value was low
- Cannot ride public transportation for trips that are not served by transit systems
- Cannot change jobs – many employers were not hiring because the economy was expected to slow down
- Cannot move homes because prices had slipped and it was difficult to obtain a mortgage

Exhibit 5. Congestion, Traffic Volume, Transit Ridership and Fuel Cost – 2005 to 2008

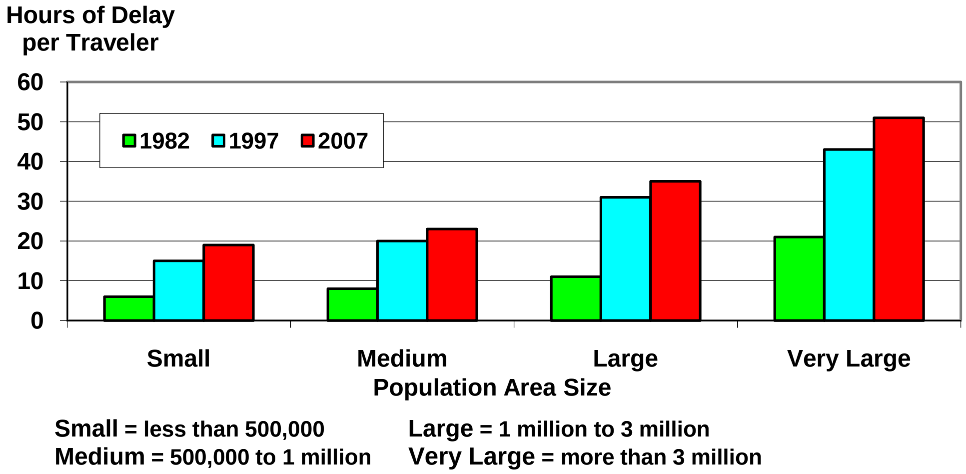


Note: Trends are based on 3-month running averages.

More Detail about Congestion Problems

Congestion is worse in areas of every size – it is not just a big city problem. The growing time delays hit residents of smaller cities as well (Exhibit 6). Regions of all sizes have problems implementing enough projects, programs and policies to meet the demand of growing population and jobs. Major projects, programs and funding efforts take 10 to 15 years to develop. In 2020, at this rate, congestion problems in cities with 500,000 to 1 million people will resemble today's traffic headaches for areas over 1 million people.

Exhibit 6. Congestion Growth Trend



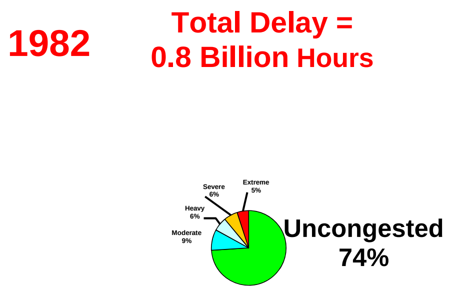
Think of what else could be done with the 36 hours of extra time suffered in congestion by the average urban traveler in 2007:

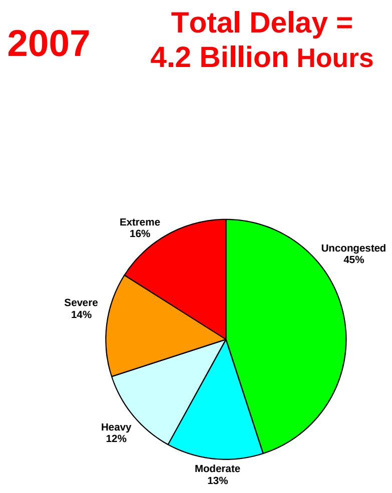
- Almost 5 vacation days
- Almost 13 big league baseball games
- More than 600 average online video clips

Travelers and shippers must plan around congestion more often.

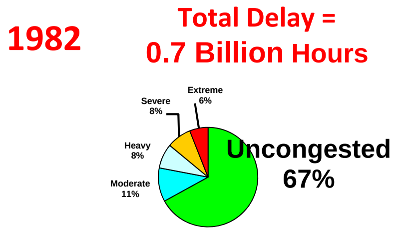
- In all 439 urban areas, the worst congestion levels affected only 1 in 9 trips in 1982, but almost 1 in 3 trips in 2007 (Exhibits 7 and 8).
- Free-flowing traffic is seen less than one-third of the time in urban areas over 1 million population.
- Delay has grown five times larger overall since 1982 and more than four times higher in regions with more than 1 million people.

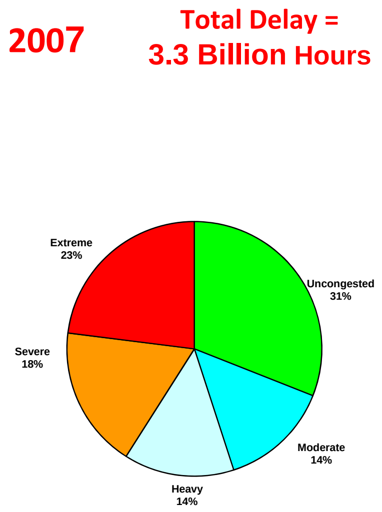
Exhibit 7. Congestion Growth – 1982 to 2007





Urban Areas Over 1 Million Population



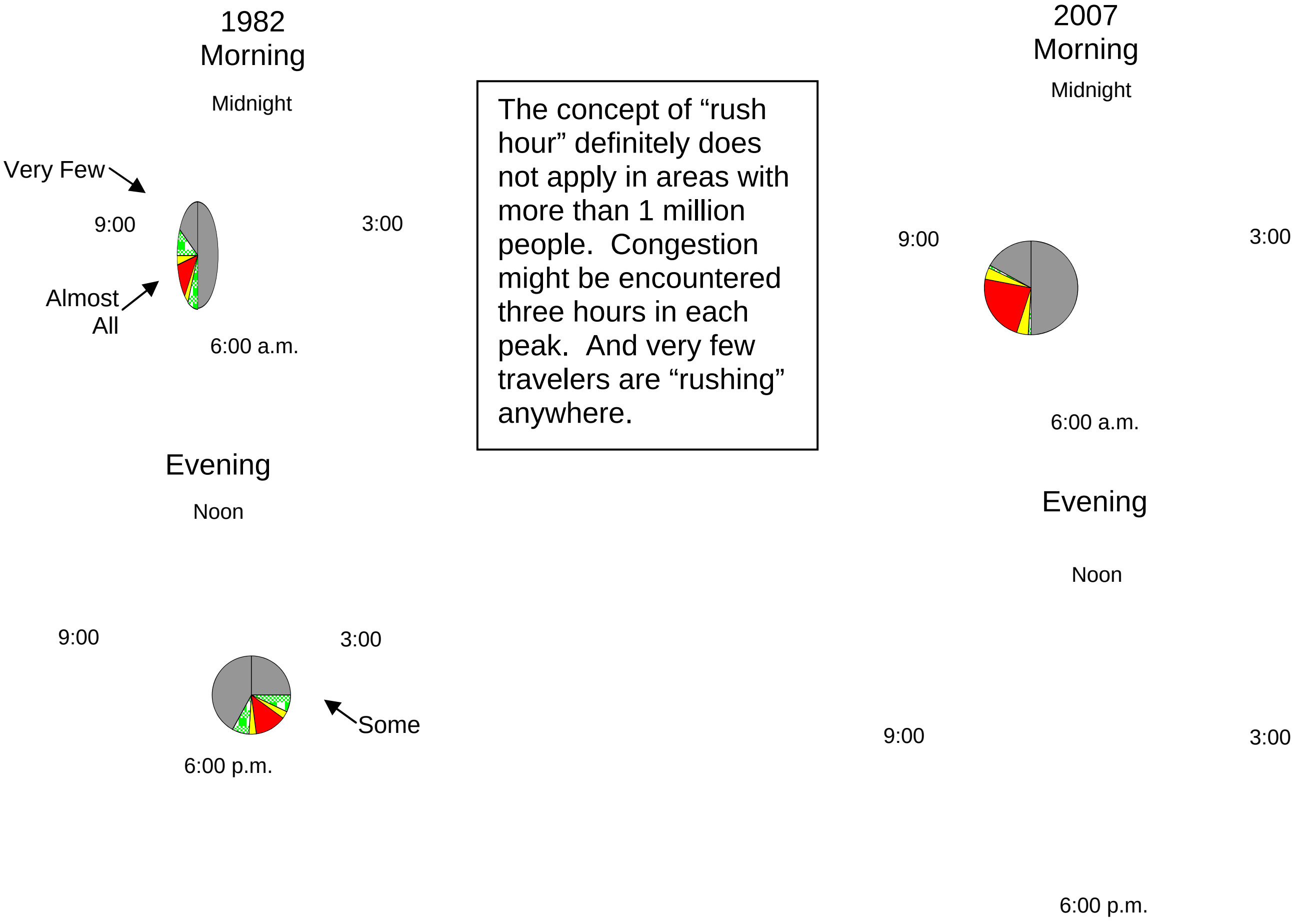


But the problem could be even worse in the regions over 1 million population.

- Operational treatments save 278 million hours of delay.
- And if there were no public transportation service and travelers used their cars, there would be an additional 616 million hours of delay.

The Jam Clock (Exhibit 8) depicts the growth of congested periods within the morning and evening “rush hours.”

Exhibit 8. The Jam Clock Shows That It Is Hard To Avoid Congestion in Urban Areas with More than 1 Million Persons



The concept of “rush hour” definitely does not apply in areas with more than 1 million people. Congestion might be encountered three hours in each peak. And very few travelers are “rushing” anywhere.

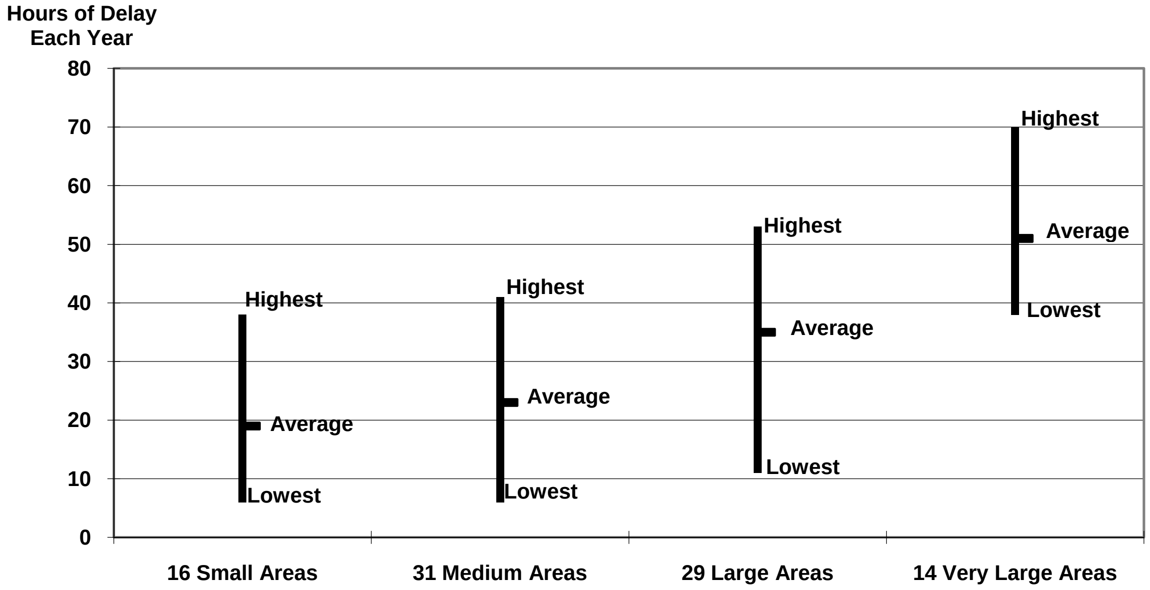
🟥 Red – Almost all regions have congestion
🟨 Yellow – Some regions have congestion
🟩 Green Checked– Very few regions have congestion
⬜ Gray – Time period not analyzed

Note: The *2009 Urban Mobility Report* examined 6 to 10 a.m. and 3 to 7 p.m.

Congestion levels vary in cities of the same size. Exhibit 9 shows the wide range in congestion problems in each of the four urban size groups. In all four groups, there is a difference of at least 30 hours of delay per traveler between the most and least congested regions. There are many causes for this range – some natural, some man-made. And some of the differences are the result of investment decisions.

The public and decision-makers at all levels should consider whether there is a match between transportation funding levels, mobility goals and the projects, programs and policies they support to address congestion problems. Every city is different, but the data suggest the current trends are not acceptable.

Exhibit 9. Congestion and Urban Area Size, 2007



Congestion Solutions – An Overview of the Portfolio

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

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

- **Get as much service as possible from what we have** – Many low-cost improvements have broad public support and can be rapidly deployed. These management programs require innovation, constant attention and adjustment, but they pay dividends in faster, safer and more reliable travel. Rapidly removing crashed vehicles, timing the traffic signals so that more vehicles see green lights, improving road and intersection designs, or adding a short section of roadway are relatively simple actions.
- **Add capacity in critical corridors** – Handling greater freight or person travel on freeways, streets, rail lines, buses or intermodal facilities often requires “more.” Important corridors or growth regions can benefit from more road lanes, new streets and highways, new or expanded public transportation facilities, and larger bus and rail fleets.
- **Change the usage patterns** –There are solutions that involve changes in the way employers and travelers conduct business to avoid traveling in the traditional “rush hours.” Flexible work hours, internet connections or phones allow employees to choose work schedules that meet family needs and the needs of their jobs.
- **Provide choices** – This might involve different routes, travel modes or lanes that involve a toll for high-speed and reliable service – a greater number of options that allow travelers and shippers to customize their travel plans.
- **Diversify the development patterns** – These typically involve denser developments with a mix of jobs, shops and homes, so that more people can walk, bike or take transit to more, and closer, destinations. Sustaining the “quality of life” and gaining economic development without the typical increment of mobility decline in each of these sub-regions appear to be part, but not all, of the solution.
- **Realistic expectations** are also part of the solution. Large urban areas will be congested. Some locations near key activity centers in smaller urban areas will also be congested. But congestion does not have to be an all-day event. Identifying solutions and funding sources that meet a variety of community goals is challenging enough without attempting to eliminate congestion in all locations at all times.

Appendix A

Congestion Solutions – The Effects

The *2009 Urban Mobility Report* database includes the effect of several widely implemented congestion solutions. These provide more efficient and reliable operation of roads and public transportation using a combination of information, technology, design changes, operating practices and construction programs.

Benefits of Public Transportation Service

Regular-route public transportation service on buses and trains provides a significant amount of peak-period travel in the most congested corridors and urban areas in the U.S. If public transportation service had been discontinued and the riders traveled in private vehicles in 2007, the 439 urban areas would have suffered an additional 646 million hours of delay and consumed 398 million more gallons of fuel (Exhibit 10), 40% more than a decade ago. The value of the additional travel delay and fuel that would have been consumed if there were no public transportation service would be an additional $13.7 billion, a 16% increase over current levels in the 439 urban areas.

There were approximately 55 billion passenger-miles of travel on public transportation systems in the 439 urban areas in 2007 (*2*). The benefits from public transportation vary by the amount of travel and the road congestion levels (Exhibit 10). More information on the effects for each urban area is included in Table 3.

Exhibit 10. Delay Increase in 2007 if Public Transportation Service Were Eliminated – 439 Areas

Population Group and Number of Areas	Average Annual Passenger-Miles of Travel (Million)	Delay Reduction Due to Public Transportation		
		Hours of Delay (Million)	Percent of Base Delay	Dollars Saved ($ Million)
Very Large (14)	41,602	557	18	11,874
Large (29)	6,180	59	6	1,226
Medium (31)	1,718	13	4	259
Small (16)	289	2	3	31
Other (349)	6,033	16	3	339
National Urban Total	55,822	646	16	$13,729

Source: Reference (*2*) and Review by Texas Transportation Institute

Better Operations

Five prominent types of operational treatments are estimated to relieve a total of 308 million hours of delay (7% of the total) with a value of $6.5 billion in 2007 (Exhibit 11). If the treatments were deployed on all major freeways and streets, the benefit would expand to about 504 million hours of delay (11% of delay) and more than $10.5 billion would be saved. These are significant benefits, especially since these techniques can be enacted much quicker than significant roadway or public transportation system expansions can occur. The operational treatments, however, do not replace the need for those expansions.

Exhibit 11. Operational Improvement Summary for All 439 Urban Areas

Operations Treatment (Number of Regions with Treatment)	**Delay Reduction from Current Projects**		**Delay Reduction if In Place on All Roads (Million Hours)**
	Hours Saved (Million)	**Dollars Saved ($ Million)**	
Ramp Metering (25)	39.8	851	98.5
Incident Management (272)	143.3	3,060	199.5
Signal Coordination (439)	19.6	404	45.8
Access Management (439)	68.7	1,370	159.7
High-Occupancy Vehicle Lanes (16)	37.0	779	Not Known
TOTAL	308	$6,464	504

Note: This analysis uses nationally consistent data and relatively simple estimation procedures. Local or more detailed evaluations should be used where available. These estimates should be considered preliminary pending more extensive review and revision of information obtained from source databases.(*1*,*4*)

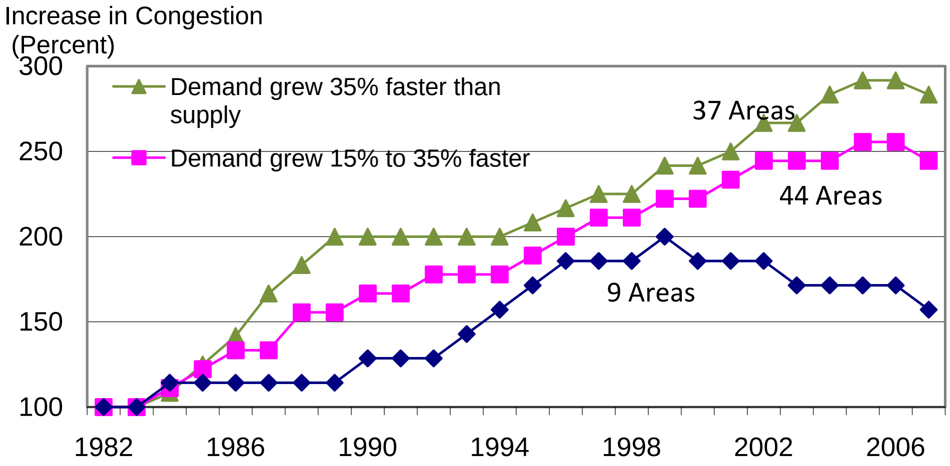
More information about the specific treatments and examples of regions and corridors where they have been implemented can be found at the website http://mobility.tamu.edu/resources/

More Capacity

Projects that provide more road lanes and more public transportation service are part of the congestion solution package in most growing urban regions. New streets and urban freeways will be needed to serve new developments, public transportation improvements are particularly important in congested corridors and to serve major activity centers, and toll highways and toll lanes are being used more frequently in urban corridors. Capacity expansions are also important additions for freeway-to-freeway interchanges and connections to ports, rail yards, intermodal terminals and other major activity centers for people and freight transportation.

Additional roadways reduce the rate of congestion increase. This is clear from comparisons between 1982 and 2007 (Exhibit 12). Urban areas where capacity increases matched the demand increase saw congestion grow much more slowly than regions where capacity lagged behind demand growth. It is also clear, however, that if only 9 areas were able to accomplish that rate, there must be a broader and larger set of solutions applied to the problem. Most of these 9 regions (listed in Table 7) were not in locations of high economic growth, suggesting their challenges were not as great as in regions with booming job markets.

Exhibit 12. Road Growth and Mobility Level



Source: Texas Transportation Institute analysis, see Table 7 and http://mobility.tamu.edu/ums/report/methodology.stm

Appendix A

All Congestion Solutions Are Needed

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

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

The involvement of business leaders in crafting a set of locally supported solutions would seem to be a very important element in the future. At the strategic end, business leader actions take the form of information development and communication with the public and decision-makers to emphasize the role of transportation in the state and regional economy. On the tactical end, business and community leaders can make the case for small-scale improvements that may not be evident to the operating agencies. And they can support individual workers who wish to choose carpooling, public transportation, flexible work hours, telecommuting or other route or mode options.

Addressing the congestion problems can provide substantial benefits and provide improvements in many sectors of society and the economy. A Texas study (*5*) estimated that solving the congestion problems in the state's urban regions would generate more than $6.50 in economic benefits for every $1.00 spent. Rebuilding transportation facilities to provide more capacity also addresses the need for roadway repair and infrastructure renewal.

Appendix A

Methodology

The base data for the *2009 Urban Mobility Report* come from the U.S. Department of Transportation and the states (*1,4*). Several analytical processes are used to develop the final measures. These are described in a series of technical reports (*6*) that are posted on the mobility report website: http://mobility.tamu.edu/ums/report/methodology.stm.

- The travel and road inventory statistics are analyzed with a set of procedures developed from computer models and studies of real-world travel time and traffic congestion data. The congestion methodology creates a set of base statistics developed from traffic density values. The density data (daily traffic volume per lane of roadway) are converted to average peak-period speeds using a set of estimation curves based on relatively ideal travel conditions – no crashes, breakdowns or weather problems – for the years 1982 to 2007.
- The base estimates, however, do not include the effect of many transportation improvements. The 2009 report addresses this estimation deficiency with methodologies designed to identify the effect of operational treatments and public transportation services. The delay, cost and index measures for all years include these treatments.
- The new estimation procedures for public transportation benefits include more detail than previous reports and provide additional information to analyze the effect of public transportation services.

Future Changes

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

Combining Performance Measures

Table 6 illustrates an approach to understanding several of the key measures. The value for each statistic is rated according to the relationship to the average value for the population group. The terms “higher” and “lower” than average congestion are used to characterize the 2007 values and trends from 1982 to 2007. These descriptions do not indicate any judgment about the extent of mobility problems. Urban areas that have better than average rankings may have congestion that residents consider a significant problem. What Table 6 does, however, is provide the reader with some context for the mobility discussion.

Appendix A

Concluding Thoughts

Congestion has gotten worse in many ways since 1982:

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

The *2009 Urban Mobility Report* points to an $87.2 billion congestion cost – and that is only the value of wasted time and fuel. Congestion causes the average peak-period traveler to spend an extra 36 hours of travel time and use 24 gallons of fuel consumption, which amounts to a cost of $760 per traveler. The report includes a comprehensive picture of congestion in all 439 U.S. urban areas and provides an indication of how the problem affects travel choices, arrival times, shipment routes, manufacturing processes and location decisions.

The recent rise and then fall in fuel prices and the economic slowdown has disrupted the steady climbing trend seen in the last few congestion reports. Before victory is declared on the congestion or imported fuel issues, however, a few points should be considered:

- The decline in driving after more than a doubling in the price of fuel was the equivalent of about 1 mile per day for the person traveling the average 12,000 annual miles.
- Previous recessions in the 1980s and 1990s saw congestion declines that were reversed as soon as the economy began to grow again.
- The "recovery" in miles traveled in Fall 2008 when fuel prices dropped before the economy turned down suggests historical patterns are still in place and congestion will grow again.

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

The good news is that there are solutions that work. There are significant benefits from solving congestion problems – whether they are large or small, in big metropolitan regions or smaller urban areas and no matter the cause. There are performance measures that provide accountability to the public and decision-makers and improve operational effectiveness. Mobility reports in coming years will use more comprehensive datasets and improved analysis tools to capture traveler experiences (and frustration).

All of the potential congestion-reducing strategies are needed. Getting more productivity out of the existing road and public transportation systems is vital to reducing congestion and improving travel time reliability. Businesses and employees can use a variety of strategies to modify their times and modes of travel to avoid the peak periods or to use less vehicle travel and more electronic "travel." In many corridors, however, there is a need for additional capacity to move people and freight more rapidly and reliably.

Future program decisions should focus on how to use each project, program or strategy to attack the problems, and how much transportation improvement to pursue. The solutions will require more funding – this report clearly describes the shortfall in projects, programs and policies. Focusing on the broad areas of agreement and consensus funding arrangements will provide a base of implementable strategies. Besides the congestion benefits, the construction projects also help rebuild infrastructure elements, a need noted in many analyses over the past decade. The U.S. should begin fixing these problems while crafting an all-encompassing long-term solution.

National Congestion Tables

Table 1. What Congestion Means to You, 2007

Urban Area	Annual Delay per Traveler		Travel Time Index		Wasted Fuel per Traveler	
	Hours	Rank	Value	Rank	Gallons	Rank
Very Large Average (14 areas)	**51**		**1.37**		**35**	
Los Angeles-Long Beach-Santa Ana CA	70	1	1.49	1	53	1
Washington DC-VA-MD	62	2	1.39	4	42	2
Atlanta GA	57	3	1.35	10	40	3
Houston TX	56	4	1.33	11	40	3
San Francisco-Oakland CA	55	5	1.42	3	40	3
Dallas-Fort Worth-Arlington TX	53	6	1.32	12	36	8
Detroit MI	52	9	1.29	20	34	11
Miami FL	47	11	1.37	5	33	12
New York-Newark NY-NJ-CT	44	14	1.37	5	28	20
Phoenix AZ	44	14	1.30	17	31	14
Seattle WA	43	19	1.29	20	30	15
Boston MA-NH-RI	43	19	1.26	25	29	19
Chicago IL-IN	41	21	1.43	2	28	20
Philadelphia PA-NJ-DE-MD	38	29	1.28	24	24	34
Large Average (29 areas)	**35**		**1.23**		**24**	
San Jose CA	53	6	1.36	8	37	7
Orlando FL	53	6	1.30	17	35	9
San Diego CA	52	9	1.37	5	40	3
Tampa-St. Petersburg FL	47	11	1.31	14	30	15
Denver-Aurora CO	45	13	1.31	14	30	15
Riverside-San Bernardino CA	44	14	1.36	8	35	9
Baltimore MD	44	14	1.31	14	32	13
Las Vegas NV	44	14	1.30	17	30	15
Charlotte NC-SC	40	23	1.25	26	27	23
Sacramento CA	39	24	1.32	12	28	20
Austin TX	39	24	1.29	20	27	23
Minneapolis-St. Paul MN	39	24	1.24	28	27	23
Jacksonville FL	39	24	1.23	32	27	23
Indianapolis IN	39	24	1.21	34	27	23
San Antonio TX	38	29	1.23	32	27	23
Portland OR-WA	37	34	1.29	20	26	31
Raleigh-Durham NC	34	36	1.17	43	22	37
Columbus OH	30	40	1.18	39	21	39
Virginia Beach VA	29	41	1.18	39	19	41
Providence RI-MA	29	41	1.17	43	18	42
St. Louis MO-IL	26	47	1.13	52	17	46
Cincinnati OH-KY-IN	25	51	1.18	39	18	42
Memphis TN-MS-AR	25	51	1.12	57	15	52
New Orleans LA	20	61	1.17	43	12	65
Milwaukee WI	18	67	1.13	52	13	60
Pittsburgh PA	15	70	1.09	70	9	71
Kansas City MO-KS	15	70	1.07	80	9	71
Cleveland OH	12	76	1.08	77	8	74
Buffalo NY	11	79	1.07	80	7	77
90 Area Average	**41**		**1.29**		**28**	
Remaining Areas						
48 Urban Areas Over 250,000 Popn	24		1.16		15	
301 Urban Areas Under 250,000 Popn	18		1.10		10	
All 439 Urban Areas	**36**		**1.25**		**24**	

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

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

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

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

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

Table 1. What Congestion Means to You, 2007, Continued

Urban Area	Annual Delay per Traveler		Travel Time Index		Wasted Fuel per Traveler	
	Hours	Rank	Value	Rank	Gallons	Rank
Medium Average (31 areas)	**23**		**1.14**		**15**	
Tucson AZ	41	21	1.24	28	26	31
Oxnard-Ventura CA	38	29	1.24	28	27	23
Louisville KY-IN	38	29	1.20	35	26	31
Nashville-Davidson TN	37	34	1.15	48	23	35
Albuquerque NM	34	36	1.18	39	22	37
Bridgeport-Stamford CT-NY	33	38	1.25	26	27	23
Birmingham AL	32	39	1.15	48	21	39
Salt Lake City UT	27	45	1.19	37	18	42
Oklahoma City OK	27	45	1.12	57	17	46
Honolulu HI	26	47	1.24	28	18	42
Omaha NE-IA	26	47	1.16	47	17	46
Sarasota-Bradenton FL	25	51	1.19	37	15	52
Colorado Springs CO	23	54	1.13	52	14	56
Allentown-Bethlehem PA-NJ	22	55	1.14	50	14	56
Grand Rapids MI	22	55	1.10	64	13	60
Tulsa OK	22	55	1.10	64	13	60
Hartford CT	21	60	1.12	57	15	52
Fresno CA	20	61	1.13	52	13	60
Richmond VA	20	61	1.09	70	13	60
El Paso TX-NM	19	64	1.12	57	12	65
New Haven CT	19	64	1.11	63	14	56
Albany-Schenectady NY	19	64	1.10	64	12	65
Poughkeepsie-Newburgh NY	17	68	1.09	70	10	68
Dayton OH	14	73	1.09	70	10	68
Toledo OH-MI	14	73	1.08	77	9	71
Indio-Cathedral City-Palm Springs CA	13	75	1.14	50	8	74
Bakersfield CA	12	76	1.09	70	7	77
Springfield MA-CT	11	79	1.06	85	7	77
Rochester NY	10	83	1.06	85	6	83
Akron OH	9	85	1.07	80	6	83
Lancaster-Palmdale CA	6	89	1.10	64	3	89
Small Average (16 areas)	**19**		**1.10**		**11**	
Charleston-North Charleston SC	38	29	1.20	35	23	35
Cape Coral FL	29	41	1.17	43	17	46
Pensacola FL-AL	28	44	1.13	52	16	50
Knoxville TN	26	47	1.12	57	16	50
Columbia SC	22	55	1.10	64	14	56
Little Rock AR	22	55	1.09	70	15	52
Salem OR	16	69	1.10	64	10	68
Laredo TX	15	70	1.12	57	8	74
Boulder CO	12	76	1.09	70	7	77
Eugene OR	11	79	1.08	77	7	77
Beaumont TX	11	79	1.05	87	7	77
Anchorage AK	10	83	1.07	80	6	83
Corpus Christi TX	9	85	1.05	87	5	86
Spokane WA	9	85	1.05	87	5	86
Brownsville TX	8	88	1.07	80	5	86
Wichita KS	6	89	1.02	90	3	89
90 Area Average	**41**		**1.29**		**28**	
Remaining Areas						
48 Urban Areas Over 250,000 Popn	24		1.16		15	
301 Urban Areas Under 250,000 Popn	18		1.10		10	
All 439 Urban Areas	**36**		**1.25**		**24**	

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

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

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

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

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

Table 2. What Congestion Means to Your Town, 2007 Urban Area Totals

Urban Area	Travel Delay		Excess Fuel Consumed		Congestion Cost	
	(1000 Hours)	Rank	(1000 Gallons)	Rank	($ million)	Rank
Very Large Average (14 areas)	**166,900**		**115,654**		**3,549**	
Los Angeles-Long Beach-Santa Ana CA	485,022	1	366,969	1	10,328	1
New York-Newark NY-NJ-CT	379,328	2	238,934	2	8,180	2
Chicago IL-IN	189,201	3	129,365	3	4,207	3
Atlanta GA	135,335	6	95,936	6	2,981	4
Miami FL	145,608	4	101,727	4	2,955	5
Dallas-Fort Worth-Arlington TX	140,744	5	96,477	5	2,849	6
Washington DC-VA-MD	133,862	7	90,801	8	2,762	7
San Francisco-Oakland CA	129,393	8	94,295	7	2,675	8
Houston TX	123,915	9	88,239	9	2,482	9
Detroit MI	116,981	10	76,425	10	2,472	10
Philadelphia PA-NJ-DE-MD	112,074	11	71,262	11	2,316	11
Boston MA-NH-RI	91,052	12	60,986	13	1,996	12
Phoenix AZ	80,456	14	57,200	14	1,891	13
Seattle WA	73,636	15	50,541	15	1,591	15
Large Average (29 areas)	**31,778**		**22,024**		**661**	
San Diego CA	85,392	13	65,734	12	1,786	14
Baltimore MD	56,964	18	41,777	16	1,276	16
Denver-Aurora CO	61,345	16	40,492	17	1,240	17
Tampa-St. Petersburg FL	61,018	17	39,612	18	1,205	18
Minneapolis-St. Paul MN	55,287	19	38,534	20	1,148	19
Riverside-San Bernardino CA	48,135	21	38,537	19	1,083	20
San Jose CA	51,070	20	35,630	21	1,013	21
Orlando FL	41,791	22	27,842	23	850	22
Sacramento CA	39,197	23	28,358	22	806	23
Portland OR-WA	34,418	25	23,969	24	712	24
Las Vegas NV	34,521	24	23,425	25	705	25
St. Louis MO-IL	32,863	26	20,660	27	697	26
San Antonio TX	31,026	27	21,973	26	621	27
Charlotte NC-SC	24,237	29	16,046	31	525	28
Indianapolis IN	23,505	31	16,135	30	522	29
Cincinnati OH-KY-IN	23,832	30	17,307	28	508	30
Virginia Beach VA	24,665	28	16,324	29	501	31
Austin TX	22,777	32	15,578	33	471	32
Jacksonville FL	22,491	33	15,711	32	457	33
Columbus OH	20,428	34	14,519	34	424	35
Raleigh-Durham NC	19,588	37	12,716	37	421	36
Providence RI-MA	19,937	36	12,114	39	386	39
Memphis TN-MS-AR	14,633	43	8,975	44	311	41
Milwaukee WI	14,860	42	10,651	41	307	42
Pittsburgh PA	15,334	41	8,753	45	304	43
Kansas City MO-KS	12,703	47	8,085	49	267	47
New Orleans LA	11,327	50	7,147	51	244	49
Cleveland OH	12,037	49	8,166	48	241	51
Buffalo NY	6,185	66	3,929	67	134	65
90 Area Total	**3,592,338**		**2,473,532**		**75,761**	
90 Areas Average	**39,915**		**27,484**		**842**	
Remaining Areas						
48 Areas Over 250,000 - Total	247,046		161,607		5,387	
48 Areas Over 250,000 - Average	5,147		3,367		112	
301 Areas Under 250,000 - Total	319,331		179,223		6,074	
301 Areas Under 250,000 - Average	1,061		595		20	
All 439 Areas Total	**4,158,715**		**2,814,363**		**87,222**	
All 439 Areas Average	**9,473**		**6,411**		**199**	

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

Travel Delay – Travel time above that needed to complete a trip at free-flow speeds.

Excess Fuel Consumed – Increased fuel consumption due to travel in congested conditions rather than free-flow conditions.

Congestion Cost – Value of travel time delay (estimated at $15.47 per hour of person travel and $102.12 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon).

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

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

Table 2. What Congestion Means to Your Town, 2007 Urban Area Totals, Continued

	Travel Delay		Excess Fuel Consumed		Congestion Cost	
Urban Area	**(1000 Hours)**	**Rank**	**(1000 Gallons)**	**Rank**	**($ million)**	**Rank**
Medium Average (31 areas)	**9,002**		**5,879**		**186**	
Nashville-Davidson TN	20,215	35	12,487	38	426	34
Louisville KY-IN	19,015	38	13,024	35	409	37
Tucson AZ	17,321	39	10,883	40	393	38
Bridgeport-Stamford CT-NY	16,077	40	12,759	36	350	40
Oxnard-Ventura CA	14,258	45	10,017	42	298	44
Salt Lake City UT	14,557	44	9,468	43	287	45
Birmingham AL	12,605	48	8,395	46	267	46
Oklahoma City OK	12,826	46	8,262	47	257	48
Albuquerque NM	11,095	51	7,070	52	244	49
Hartford CT	10,147	53	7,201	50	203	53
Richmond VA	10,212	52	6,557	54	202	54
Honolulu HI	10,076	54	7,051	53	199	55
Tulsa OK	9,826	56	5,589	57	192	56
Omaha NE-IA	9,298	57	5,864	56	184	57
Sarasota-Bradenton FL	9,030	58	5,418	58	176	58
Allentown-Bethlehem PA-NJ	7,571	59	4,664	60	154	59
Fresno CA	7,032	64	4,436	61	151	61
Grand Rapids MI	7,324	61	4,335	63	148	62
El Paso TX-NM	7,185	62	4,691	59	147	63
Albany-Schenectady NY	6,082	67	3,842	69	131	66
Colorado Springs CO	6,457	65	3,860	68	129	67
Dayton OH	5,800	68	4,000	66	120	69
New Haven CT	5,728	69	4,225	65	117	70
Poughkeepsie-Newburgh NY	4,739	72	2,886	73	95	73
Toledo OH-MI	3,916	77	2,480	74	83	74
Indio-Cathedral City-Palm Springs CA	4,049	74	2,338	77	82	75
Rochester NY	4,038	75	2,441	75	81	76
Springfield MA-CT	3,989	76	2,422	76	77	77
Bakersfield CA	3,359	78	2,091	79	73	78
Akron OH	3,031	79	2,172	78	63	79
Lancaster-Palmdale CA	2,208	80	1,314	80	44	80
Small Average (16 areas)	**3,444**		**2,090**		**71**	
Charleston-North Charleston SC	9,944	55	6,090	55	207	52
Cape Coral FL	7,451	60	4,347	62	152	60
Knoxville TN	7,166	63	4,295	64	147	64
Columbia SC	5,478	70	3,516	70	121	68
Pensacola FL-AL	5,469	71	3,122	72	106	71
Little Rock AR	4,652	73	3,298	71	97	72
Salem OR	2,069	81	1,224	81	41	81
Laredo TX	1,806	82	1,005	83	37	82
Spokane WA	1,714	83	1,056	82	36	83
Corpus Christi TX	1,629	84	970	84	32	84
Anchorage AK	1,616	85	903	85	32	85
Eugene OR	1,481	86	903	85	30	86
Beaumont TX	1,425	87	866	87	28	87
Wichita KS	1,404	88	793	88	27	88
Boulder CO	953	89	562	89	18	89
Brownsville TX	841	90	486	90	17	89
90 Area Total	**3,592,338**		**2,473,532**		**75,761**	
90 Areas Average	**39,915**		**27,484**		**842**	
Remaining Areas						
48 Areas Over 250,000 - Total	247,046		161,607		5,387	
48 Areas Over 250,000 - Average	5,147		3,367		112	
301 Areas Under 250,000 - Total	319,331		179,223		6,074	
301 Areas Under 250,000 - Average	1,061		595		20	
All 439 Areas Total	**4,158,715**		**2,814,363**		**87,222**	
All 439 Areas Average	**9,473**		**6,411**		**199**	

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

Travel Delay – Travel time above that needed to complete a trip at free-flow speeds.

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 $15.47 per hour of person travel and $102.12 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon).

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

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

Table 3. Solutions to Congestion Problems, 2007

	Operational Treatment Savings				Public Transportation Savings		
Urban Area	Treatments	Delay (1000 Hours)	Rank	Cost ($ Million)	Delay (1000 Hours)	Rank	Cost ($ Million)
Very Large Average (14 areas)		**15,413**		**324.6**	**39,784**		**848.2**
Los Angeles-Long Beach-Santa Ana CA	r,i,s,a,h	60,576	1	1,286.1	32,348	3	588.8
New York-Newark NY-NJ-CT	r,i,s,a,h	40,466	2	863.7	319,247	1	6,929.2
San Francisco-Oakland CA	r,i,s,a,h	17,675	3	360.8	31,835	4	658.9
Houston TX	r,i,s,a,h	15,201	4	300.8	5,902	13	103.0
Miami FL	i,s,a,h	13,443	5	269.2	10,026	10	191.1
Dallas-Fort Worth-Arlington TX	r,i,s,a,h	11,186	6	221.8	5,486	14	111.1
Washington DC-VA-MD	r,i,s,a,h	10,517	7	216.1	26,285	5	521.1
Atlanta GA	r,i,s,a,h	9,426	8	215.0	10,474	9	224.8
Chicago IL-IN	r,i,s,a	8,038	10	179.5	48,751	2	1,121.1
Philadelphia PA-NJ-DE-MD	r,i,s,a	7,856	11	165.1	22,538	7	472.6
Seattle WA	r,i,s,a,h	6,802	12	145.6	12,521	8	261.4
Phoenix AZ	r,i,s,a,h	5,359	15	121.4	2,566	21	59.8
Boston MA-NH-RI	i,s,a	4,929	16	106.7	26,266	6	573.8
Detroit MI	r,i,s,a	4,313	19	92.9	2,732	19	57.4
Large Average (29 areas)		**2,149**		**44.6**	**2,029**		**42.3**
San Diego CA	r,i,s,a	8,309	9	170.0	7,832	12	161.7
Riverside-San Bernardino CA	r,i,s,a,h	5,505	13	123.5	1,397	30	27.7
Minneapolis-St. Paul MN	r,i,s,a,h	5,457	14	109.6	3,900	17	79.4
San Jose CA	r,i,s,a	4,396	17	86.4	2,375	22	46.9
Tampa-St. Petersburg FL	i,s,a	4,378	18	86.5	1,250	32	24.3
Sacramento CA	r,i,s,a,h	3,877	20	80.7	1,865	25	37.0
Baltimore MD	i,s,a	3,568	21	79.8	9,474	11	216.0
Denver-Aurora CO	r,i,s,a,h	3,554	22	71.3	5,033	15	101.6
Portland OR-WA	r,i,s,a,h	2,922	23	61.6	4,771	16	98.0
Orlando FL	i,s,a	2,613	24	53.0	1,572	27	31.7
Virginia Beach VA	i,s,a,h	1,947	25	39.5	913	38	18.6
Las Vegas NV	i,s,a	1,661	26	33.0	1,723	26	35.4
Jacksonville FL	i,s,a	1,475	27	30.1	511	43	10.4
San Antonio TX	i,s,a	1,386	28	27.8	1,455	29	29.0
St. Louis MO-IL	i,s,a	1,323	29	27.9	2,031	23	43.2
Milwaukee WI	r,i,s,a	1,296	30	26.7	1,071	35	22.1
Austin TX	i,s,a	1,209	31	25.1	1,472	28	30.6
Columbus OH	r,i,s,a	1,002	32	21.8	451	45	9.5
Memphis TN-MS-AR	i,s,a	965	34	21.2	372	50	7.9
Charlotte NC-SC	i,s,a	910	35	19.8	946	37	20.4
Cincinnati OH-KY-IN	r,i,s,a	793	37	17.1	1,328	31	28.4
Indianapolis IN	i,s,a	697	42	15.5	431	48	9.5
New Orleans LA	i,s,a	675	44	14.6	1,075	34	23.4
Cleveland OH	i,s,a	505	49	10.3	1,227	33	24.6
Raleigh-Durham NC	i,s,a	491	50	10.9	723	39	15.5
Kansas City MO-KS	i,s,a	486	51	10.1	240	55	5.0
Pittsburgh PA	i,s,a	431	55	8.7	1,957	24	39.1
Providence RI-MA	i,s,a	324	57	6.5	989	36	19.1
Buffalo NY	i,s,a	160	65	3.6	451	45	9.8
90 Area Total		**290,824**		**6,105.3**	**630,149**		**13,390.7**
90 Area Average		**3,231**		**68.0**	**7,002**		**149.0**
Remaining Areas							
48 Areas Over 250,000 - Total		8,165		178.9	6,891		150.9
48 Areas Over 250,000 - Average		170		3.7	144		3.1
301 Areas Under 250,000 - Total		9,239		179.6	8,874		187.9
301 Areas Under 250,000 - Average		31		0.6	29		0.6
All 439 Areas Total		**308,319**		**6,463.8**	**645,914**		**13,729.5**
All 439 Areas Average		**702**		**14.7**	**1,471**		**31.3**

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

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

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

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

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

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

Table 3. Solutions to Congestion Problems, 2007, Continued

	Operational Treatment Savings				Public Transportation Savings		
Urban Area	Treatments	Delay (1000 Hours)	Rank	Cost ($ Million)	Delay (1000 Hours)	Rank	Cost ($ Million)
Medium Average (31 areas)		**354**		**7.4**	**414**		**8.4**
Tucson AZ	i,s,a	994	33	22.3	571	41	12.9
Nashville-Davidson TN	i,s,a	893	36	19.6	407	49	8.6
Omaha NE-IA	i,s,a	765	38	15.2	161	67	3.2
Bridgeport-Stamford CT-NY	i,s,a	744	39	16.4	248	53	5.4
Albuquerque NM	i,s,a	734	40	15.8	237	56	5.2
Birmingham AL	i,s,a	723	41	16.6	160	68	3.4
Louisville KY-IN	i,s,a	682	43	14.9	501	44	10.9
Sarasota-Bradenton FL	i,s,a	564	45	10.9	135	73	2.6
Fresno CA	r,i,s,a	529	46	11.3	224	58	4.7
El Paso TX-NM	i,s,a	515	47	10.3	546	42	11.1
Salt Lake City UT	r,i,s,a	513	48	10.5	2,672	20	52.9
Oxnard-Ventura CA	i,s,a	468	52	9.3	257	52	5.3
Hartford CT	i,s,a	440	54	8.9	670	40	13.4
Richmond VA	i,s,a	274	58	5.4	435	47	8.6
Honolulu HI	i,s,a	245	59	4.8	3,045	18	59.2
Allentown-Bethlehem PA-NJ	r,i,s,a	204	61	4.3	202	60	4.1
Colorado Springs CO	i,s,a	197	62	3.8	222	59	4.4
New Haven CT	i,s,a	197	62	4.0	138	71	2.8
Grand Rapids MI	s,a	188	64	3.7	245	54	5.0
Albany-Schenectady NY	i,s,a	145	66	3.2	271	51	5.8
Indio-Cathedral City-Palm Springs CA	i,s,a	145	66	3.0	118	76	2.4
Bakersfield CA	i,s,a	144	68	3.0	175	63	3.8
Oklahoma City OK	i,s,a	131	69	2.7	95	79	1.9
Rochester NY	i,s,a	113	72	2.3	146	69	2.9
Dayton OH	s,a	85	74	1.6	169	65	3.6
Poughkeepsie-Newburgh NY	s,a	82	75	1.6	199	61	4.0
Tulsa OK	i,s,a	78	76	1.6	51	86	1.0
Lancaster-Palmdale CA	s,a	64	78	1.3	190	62	3.7
Springfield MA-CT	i,s,a	64	78	1.3	119	75	2.3
Akron OH	i,s,a	24	86	0.5	73	82	1.5
Toledo OH-MI	i,s,a	23	87	0.5	141	70	3.0
Small Average (16 areas)		**110**		**2.3**	**95**		**2.0**
Cape Coral FL	i,s,a	456	53	9.3	137	72	2.8
Knoxville TN	i,s,a	373	56	8.0	48	87	1.0
Little Rock AR	i,s,a	213	60	4.7	12	90	0.2
Charleston-North Charleston SC	i,s,a	122	70	2.7	117	77	2.4
Pensacola FL-AL	s,a	114	71	2.2	57	84	1.2
Columbia SC	i,s,a	98	73	2.4	170	64	3.9
Spokane WA	i,s,a	75	77	1.6	168	66	3.6
Salem OR	s,a	54	80	1.0	111	78	2.3
Eugene OR	i,s,a	52	81	1.1	230	57	4.7
Anchorage AK	s,a	50	82	1.0	120	74	2.4
Laredo TX	i,s,a	36	83	0.8	94	80	1.9
Wichita KS	i,s,a	32	84	0.6	45	88	0.9
Boulder CO	s,a	26	85	0.5	52	85	1.0
Corpus Christi TX	s,a	23	87	0.5	65	83	1.3
Brownsville TX	s,a	18	89	0.4	75	81	1.5
Beaumont TX	s,a	13	90	0.2	15	89	0.3
90 Area Total		**290,824**		**6,105.3**	**630,149**		**13,390.7**
90 Area Average		**3,231**		**68.0**	**7,002**		**149.0**
Remaining Areas							
48 Areas Over 250,000 - Total		8,165		178.9	6,891		150.9
48 Areas Over 250,000 - Average		170		3.7	144		3.1
301 Areas Under 250,000 - Total		9,239		179.6	8,874		187.9
301 Areas Under 250,000 - Average		31		0.6	29		0.6
All 439 Areas Total		**308,319**		**6463.8**	**645,914**		**13,729.5**
All 439 Areas Average		**702**		**14.7**	**1,471**		**31.3**

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

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

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

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

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

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

Table 4. Congestion Trends – Wasted Hours (Annual Delay per Traveler, 1982 to 2007)

	Annual Hours of Delay per Traveler				Long-Term Change 1982 to 2007	
Urban Area	**2007**	**2006**	**1997**	**1982**	**Hours**	**Rank**
Very Large Average (14 areas)	**51**	**52**	**43**	**21**	**30**	
Washington DC-VA-MD	62	59	52	16	46	1
Dallas-Fort Worth-Arlington TX	53	55	34	10	43	2
Atlanta GA	57	59	56	19	38	5
Miami FL	47	48	35	15	32	11
New York-Newark NY-NJ-CT	44	45	32	12	32	11
San Francisco-Oakland CA	55	58	47	23	32	11
Boston MA-NH-RI	43	44	32	12	31	15
Seattle WA	43	45	52	12	31	15
Detroit MI	52	53	48	24	28	21
Houston TX	56	56	39	29	27	22
Chicago IL-IN	41	43	35	15	26	23
Los Angeles-Long Beach-Santa Ana CA	70	72	69	44	26	23
Philadelphia PA-NJ-DE-MD	38	38	28	16	22	36
Phoenix AZ	44	45	35	35	9	70
Large Average (29 areas)	**35**	**36**	**31**	**11**	**24**	
San Diego CA	52	54	36	12	40	3
Riverside-San Bernardino CA	44	45	26	5	39	4
Orlando FL	53	55	59	18	35	6
Las Vegas NV	44	43	34	10	34	7
Baltimore MD	44	44	32	11	33	9
Minneapolis-St. Paul MN	39	40	38	6	33	9
San Antonio TX	38	40	24	6	32	11
Charlotte NC-SC	40	39	25	10	30	17
San Jose CA	53	55	44	23	30	17
Austin TX	39	39	32	10	29	19
Denver-Aurora CO	45	48	41	16	29	19
Columbus OH	30	32	31	4	26	23
Providence RI-MA	29	26	15	3	26	23
Raleigh-Durham NC	34	32	31	8	26	23
Portland OR-WA	37	38	35	13	24	28
Sacramento CA	39	42	35	15	24	28
Tampa-St. Petersburg FL	47	48	37	24	23	32
Jacksonville FL	39	38	39	17	22	36
Cincinnati OH-KY-IN	25	26	29	5	20	40
Indianapolis IN	39	42	56	19	20	40
Memphis TN-MS-AR	25	28	23	6	19	44
Virginia Beach VA	29	30	31	14	15	56
St. Louis MO-IL	26	30	39	12	14	57
Kansas City MO-KS	15	17	19	3	12	64
Milwaukee WI	18	18	19	7	11	67
Cleveland OH	12	13	18	3	9	70
Buffalo NY	11	12	7	3	8	72
Pittsburgh PA	15	15	18	11	4	82
New Orleans LA	20	20	21	17	3	87
90 Area Average	**41**	**42**	**36**	**16**	**25**	
Remaining Areas						
48 Urban Areas Over 250,000 Popn	24	23	19	7	17	
301 Urban Areas Under 250,000 Popn	18	18	16	5	13	
All 439 Urban Areas	**36**	**37**	**32**	**14**	**22**	

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

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

Data for all years include effects of operational treatments.

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

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

Table 4. Congestion Trends – Wasted Hours (Annual Delay per Traveler, 1982 to 2007), Continued

	Annual Hours of Delay per Traveler				Long-Term Change 1982 to 2007	
Urban Area	2007	2006	1997	1982	Hours	Rank
Medium Average (31 areas)	**23**	**24**	**20**	**8**	**15**	
Oxnard-Ventura CA	38	36	21	4	34	7
Birmingham AL	32	33	24	8	24	28
Bridgeport-Stamford CT-NY	33	33	24	9	24	28
Albuquerque NM	34	33	33	11	23	32
Oklahoma City OK	27	24	20	5	22	36
Omaha NE-IA	26	28	19	5	21	39
Louisville KY-IN	38	40	39	18	20	40
Colorado Springs CO	23	26	16	4	19	44
Salt Lake City UT	27	26	28	8	19	44
Hartford CT	21	21	15	4	17	49
Nashville-Davidson TN	37	38	36	20	17	49
Tucson AZ	41	43	29	24	17	49
Albany-Schenectady NY	19	17	9	3	16	52
El Paso TX-NM	19	21	10	3	16	52
Grand Rapids MI	22	23	21	6	16	52
New Haven CT	19	19	15	5	14	57
Richmond VA	20	20	21	6	14	57
Tulsa OK	22	22	18	8	14	57
Allentown-Bethlehem PA-NJ	22	21	25	9	13	61
Honolulu HI	26	24	22	14	12	64
Toledo OH-MI	14	15	14	2	12	64
Sarasota-Bradenton FL	25	27	22	14	11	67
Bakersfield CA	12	13	7	2	10	69
Fresno CA	20	20	18	12	8	72
Akron OH	9	11	13	2	7	74
Poughkeepsie-Newburgh NY	17	18	14	10	7	74
Rochester NY	10	9	8	3	7	74
Dayton OH	14	17	22	10	4	82
Springfield MA-CT	11	12	10	7	4	82
Lancaster-Palmdale CA	6	5	6	12	-6	89
Indio-Cathedral City-Palm Springs CA	13	15	15	20	-7	90
Small Average (16 areas)	**19**	**18**	**15**	**6**	**13**	
Charleston-North Charleston SC	38	35	27	15	23	32
Pensacola FL-AL	28	28	22	5	23	32
Cape Coral FL	29	28	26	9	20	40
Columbia SC	22	19	12	4	18	47
Little Rock AR	22	19	10	4	18	47
Knoxville TN	26	25	39	10	16	52
Laredo TX	15	12	9	2	13	61
Salem OR	16	17	12	3	13	61
Beaumont TX	11	12	6	4	7	74
Boulder CO	12	14	14	6	6	78
Brownsville TX	8	7	4	2	6	78
Spokane WA	9	8	10	3	6	78
Eugene OR	11	11	9	6	5	81
Corpus Christi TX	9	8	7	5	4	82
Wichita KS	6	5	5	2	4	82
Anchorage AK	10	10	9	10	0	88
90 Area Average	**41**	**42**	**36**	**16**	**25**	
Remaining Areas						
48 Urban Areas Over 250,000 Popn	24	23	19	7	17	
301 Urban Areas Under 250,000 Popn	18	18	16	5	13	
All 439 Urban Areas	**36**	**37**	**32**	**14**	**22**	

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

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

Data for all years include effects of operational treatments.

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

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

Table 5. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2007)

	Travel Time Index				Point Change in Peak-Period Time Penalty	
Urban Area	**2007**	**2006**	**1997**	**1982**	**Points**	**Rank**
Very Large Average (14 areas)	**1.37**	**1.38**	**1.30**	**1.14**	**23**	
Chicago IL-IN	1.43	1.45	1.33	1.12	31	2
San Francisco-Oakland CA	1.42	1.44	1.30	1.14	28	4
Washington DC-VA-MD	1.39	1.37	1.32	1.11	28	4
New York-Newark NY-NJ-CT	1.37	1.38	1.26	1.10	27	6
Dallas-Fort Worth-Arlington TX	1.32	1.33	1.17	1.05	27	6
Miami FL	1.37	1.37	1.26	1.11	26	8
Los Angeles-Long Beach-Santa Ana CA	1.49	1.51	1.45	1.24	25	10
Atlanta GA	1.35	1.34	1.27	1.10	25	10
Seattle WA	1.29	1.30	1.31	1.07	22	15
Boston MA-NH-RI	1.26	1.27	1.20	1.08	18	24
Philadelphia PA-NJ-DE-MD	1.28	1.27	1.20	1.11	17	26
Detroit MI	1.29	1.29	1.27	1.13	16	27
Phoenix AZ	1.30	1.29	1.21	1.15	15	29
Houston TX	1.33	1.34	1.23	1.19	14	31
Large Average (29 areas)	**1.23**	**1.24**	**1.19**	**1.07**	**16**	
Riverside-San Bernardino CA	1.36	1.36	1.18	1.03	33	1
San Diego CA	1.37	1.38	1.23	1.07	30	3
Sacramento CA	1.32	1.33	1.21	1.06	26	8
Baltimore MD	1.31	1.31	1.20	1.07	24	12
Las Vegas NV	1.30	1.30	1.23	1.06	24	12
San Jose CA	1.36	1.37	1.23	1.13	23	14
Denver-Aurora CO	1.31	1.31	1.26	1.09	22	15
Austin TX	1.29	1.29	1.22	1.07	22	15
Portland OR-WA	1.29	1.29	1.24	1.07	22	15
Orlando FL	1.30	1.31	1.30	1.10	20	20
Minneapolis-St. Paul MN	1.24	1.25	1.21	1.04	20	20
San Antonio TX	1.23	1.23	1.13	1.04	19	22
Charlotte NC-SC	1.25	1.24	1.16	1.07	18	24
Jacksonville FL	1.23	1.22	1.18	1.07	16	27
Columbus OH	1.18	1.19	1.16	1.03	15	29
Cincinnati OH-KY-IN	1.18	1.18	1.18	1.04	14	31
Providence RI-MA	1.17	1.15	1.10	1.03	14	31
Indianapolis IN	1.21	1.21	1.25	1.08	13	36
Raleigh-Durham NC	1.17	1.16	1.12	1.04	13	36
Tampa-St. Petersburg FL	1.31	1.30	1.26	1.20	11	42
Virginia Beach VA	1.18	1.18	1.18	1.07	11	42
Milwaukee WI	1.13	1.12	1.12	1.05	8	54
Memphis TN-MS-AR	1.12	1.13	1.12	1.04	8	54
New Orleans LA	1.17	1.17	1.15	1.11	6	67
St. Louis MO-IL	1.13	1.16	1.19	1.07	6	67
Cleveland OH	1.08	1.09	1.13	1.03	5	72
Kansas City MO-KS	1.07	1.08	1.08	1.02	5	72
Buffalo NY	1.07	1.08	1.04	1.03	4	79
Pittsburgh PA	1.09	1.09	1.09	1.06	3	83
90 Area Average	**1.29**	**1.29**	**1.23**	**1.10**	**19**	
Remaining Areas						
48 Urban Areas Over 250,000 Popn	1.16	1.15	1.11	1.05	11	
301 Urban Areas Under 250,000 Popn	1.10	1.11	1.09	1.03	7	
All 439 Urban Areas	**1.25**	**1.25**	**1.20**	**1.09**	**16**	

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

Travel Time Index – The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak. Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.

Data for all years include the effects of operational treatments.

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

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

Table 5. Congestion Trends – Wasted Time (Travel Time Index, 1982 to 2007), Continued

	Travel Time Index				Point Change in Peak-Period Time Penalty	
Urban Area	2007	2006	1997	1982	Points	Rank
Medium Average (31 areas)	**1.14**	**1.14**	**1.11**	**1.05**	**9**	
Oxnard-Ventura CA	1.24	1.23	1.12	1.03	21	19
Bridgeport-Stamford CT-NY	1.25	1.25	1.17	1.06	19	22
Tucson AZ	1.24	1.25	1.16	1.10	14	31
Salt Lake City UT	1.19	1.18	1.18	1.05	14	31
Honolulu HI	1.24	1.23	1.19	1.11	13	36
Albuquerque NM	1.18	1.17	1.18	1.05	13	36
Omaha NE-IA	1.16	1.17	1.11	1.04	12	40
Birmingham AL	1.15	1.15	1.10	1.04	11	42
Colorado Springs CO	1.13	1.14	1.09	1.02	11	42
El Paso TX-NM	1.12	1.13	1.07	1.02	10	46
Oklahoma City OK	1.12	1.10	1.08	1.02	10	46
Louisville KY-IN	1.20	1.22	1.19	1.11	9	51
Sarasota-Bradenton FL	1.19	1.20	1.18	1.10	9	51
Hartford CT	1.12	1.12	1.09	1.03	9	51
Allentown-Bethlehem PA-NJ	1.14	1.13	1.16	1.06	8	54
Fresno CA	1.13	1.13	1.11	1.05	8	54
New Haven CT	1.11	1.11	1.09	1.03	8	54
Albany-Schenectady NY	1.10	1.09	1.04	1.02	8	54
Bakersfield CA	1.09	1.09	1.04	1.01	8	54
Tulsa OK	1.10	1.10	1.09	1.03	7	63
Grand Rapids MI	1.10	1.10	1.10	1.03	7	63
Nashville-Davidson TN	1.15	1.16	1.14	1.09	6	67
Indio-Cathedral City-Palm Springs CA	1.14	1.16	1.12	1.08	6	67
Toledo OH-MI	1.08	1.09	1.08	1.02	6	67
Richmond VA	1.09	1.09	1.08	1.04	5	72
Poughkeepsie-Newburgh NY	1.09	1.09	1.07	1.04	5	72
Akron OH	1.07	1.08	1.08	1.02	5	72
Lancaster-Palmdale CA	1.10	1.10	1.06	1.06	4	79
Rochester NY	1.06	1.07	1.06	1.02	4	79
Dayton OH	1.09	1.10	1.12	1.07	2	86
Springfield MA-CT	1.06	1.07	1.05	1.04	2	86
Small Average (16 areas)	**1.10**	**1.09**	**1.08**	**1.03**	**7**	
Charleston-North Charleston SC	1.20	1.18	1.14	1.08	12	40
Cape Coral FL	1.17	1.15	1.14	1.07	10	46
Pensacola FL-AL	1.13	1.13	1.10	1.03	10	46
Laredo TX	1.12	1.10	1.07	1.02	10	46
Salem OR	1.10	1.10	1.07	1.02	8	54
Columbia SC	1.10	1.08	1.05	1.02	8	54
Knoxville TN	1.12	1.11	1.14	1.05	7	63
Little Rock AR	1.09	1.08	1.04	1.02	7	63
Boulder CO	1.09	1.11	1.10	1.04	5	72
Brownsville TX	1.07	1.07	1.05	1.02	5	72
Eugene OR	1.08	1.08	1.05	1.04	4	79
Beaumont TX	1.05	1.05	1.03	1.02	3	83
Spokane WA	1.05	1.04	1.05	1.02	3	83
Corpus Christi TX	1.05	1.05	1.04	1.03	2	86
Anchorage AK	1.07	1.07	1.06	1.06	1	89
Wichita KS	1.02	1.02	1.02	1.01	1	89
90 Area Average	**1.29**	**1.29**	**1.23**	**1.10**	**19**	
Remaining Areas						
48 Urban Areas Over 250,000 Popn	1.16	1.15	1.11	1.05	11	
301 Urban Areas Under 250,000 Popn	1.10	1.11	1.09	1.03	7	
All 439 Urban Areas	**1.25**	**1.25**	**1.20**	**1.09**	**16**	

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

Travel Time Index – The ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak. Free-flow speeds (60 mph on freeways and 35 mph on principal arterials) are used as the comparison threshold.

Data for all years include the effects of operational treatments.

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

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

Table 6. Summary of Congestion Measures and Trends

	Congestion Levels in 2007			Congestion Increase 1982 to 2007	
Urban Area	**Delay per Traveler (Hours)**	**Travel Time Index**	**Total Delay (1000 Hours)**	**Delay per Traveler (Hours)**	**Total Delay (1000 Hours)**
Very Large Average (14 areas)	**51**	**1.37**	**166,900**	**30**	**129,322**
New York-Newark NY-NJ-CT	-	0	++	0	F+
Los Angeles-Long Beach-Santa Ana CA	++	++	++	S	F+
Chicago IL-IN	L-	+	+	S	F+
Miami FL	-	0	-	0	S
Philadelphia PA-NJ-DE-MD	--	--	--	S-	S-
San Francisco-Oakland CA	+	+	-	0	S-
Dallas-Fort Worth-Arlington TX	0	-	-	F+	0
Atlanta GA	+	0	-	F+	S
Washington DC-VA-MD	++	0	-	F+	S-
Boston MA-NH-RI	--	--	--	0	S-
Detroit MI	0	--	--	0	S-
Houston TX	+	-	-	S	S-
Phoenix AZ	-	-	--	S-	S-
Seattle WA	--	--	--	0	S-
Large Average (29 areas)	**35**	**1.23**	**31,778**	**24**	**26,944**
San Diego CA	++	++	++	F+	F+
Minneapolis-St. Paul MN	+	0	++	F+	F+
Baltimore MD	++	++	++	F+	F+
Tampa-St. Petersburg FL	++	++	++	0	F+
St. Louis MO-IL	--	--	0	S-	S
Denver-Aurora CO	++	++	++	F	F+
Riverside-San Bernardino CA	++	++	++	F+	F+
Sacramento CA	+	++	+	0	F+
Pittsburgh PA	--	--	--	S-	S-
Portland OR-WA	0	+	0	0	F
Cleveland OH	--	--	--	S-	S-
San Jose CA	++	++	++	F	F+
Cincinnati OH-KY-IN	--	-	-	S	S-
Virginia Beach VA	-	-	-	S-	S-
Kansas City MO-KS	--	--	--	S-	S-
Milwaukee WI	--	--	--	S-	S-
San Antonio TX	+	0	0	F+	F
Las Vegas NV	++	+	0	F+	F+
Orlando FL	++	+	+	F+	F+
Providence RI-MA	-	-	-	0	S-
Columbus OH	-	-	-	0	S-
Buffalo NY	--	--	--	S-	S-
New Orleans LA	--	-	--	S-	S-
Charlotte NC-SC	+	0	-	F	S-
Indianapolis IN	+	0	-	S	S-
Jacksonville FL	+	0	-	0	S-
Austin TX	+	+	-	F	S-
Memphis TN-MS-AR	--	--	--	S	S-
Raleigh-Durham NC	0	-	--	0	S-
Interval Values – Very Large and Large	5 hours	5 index points	(5 hours x average popn. for group)	5 hours	(5 hours x average popn. for group)

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

Between 1 and 2 intervals above or below the average	More than 2 intervals above or below the average
+ *Higher congestion*; F *Faster congestion growth*;	++ *Much higher congestion*; F+ *Much faster growth*
- *Lower congestion*; S *Slower congestion growth*;	-- *Much lower congestion*; S- *Much slower growth*

Table 6. Summary of Congestion Measures and Trends, Continued

	Congestion Levels in 2007			Congestion Increase 1982 to 2007	
Urban Area	**Delay per Traveler (Hours)**	**Travel Time Index**	**Total Delay (1000 Hours)**	**Delay per Traveler (Hours)**	**Total Delay (1000 Hours)**
Medium Average (31 areas)	**23**	**1.14**	**9,002**	**15**	**7,295**
Nashville-Davidson TN	++	0	++	F	F+
Salt Lake City UT	+	++	++	F	F+
Richmond VA	-	--	+	0	F+
Louisville KY-IN	++	++	++	F+	F+
Hartford CT	-	-	+	F	F+
Bridgeport-Stamford CT-NY	++	++	++	F+	F+
Oklahoma City OK	+	-	++	F+	F+
Tulsa OK	0	-	0	0	F
Tucson AZ	++	++	++	F	F+
Dayton OH	--	--	--	S-	S-
Rochester NY	--	--	--	S-	S-
Birmingham AL	++	0	++	F+	F+
Lancaster-Palmdale CA	--	-	--	S-	S-
Honolulu HI	+	++	+	S	S
El Paso TX-NM	-	-	-	0	S
Oxnard-Ventura CA	++	++	++	F+	F+
Sarasota-Bradenton FL	+	++	0	S-	0
Springfield MA-CT	--	--	--	S-	S-
Omaha NE-IA	+	+	0	F+	F
Fresno CA	-	0	-	S-	S-
Allentown-Bethlehem PA-NJ	0	0	-	S	S-
Akron OH	--	--	--	S-	S-
Grand Rapids MI	0	-	-	0	S
Albany-Schenectady NY	-	-	-	0	S-
Albuquerque NM	++	+	+	F+	F+
New Haven CT	-	-	--	0	S-
Indio-Cathedral City-Palm Springs CA	--	0	--	S-	S-
Toledo OH-MI	--	--	--	S	S-
Poughkeepsie-Newburgh NY	--	--	--	S-	S-
Bakersfield CA	--	--	--	S-	S-
Colorado Springs CO	0	0	-	F	S-
Small Average (16 areas)	**19**	**1.10**	**3,444**	**13**	**2,881**
Knoxville TN	++	+	++	F	F+
Charleston-North Charleston SC	++	++	++	F+	F+
Cape Coral FL	++	++	++	F+	F+
Columbia SC	+	0	++	F+	F+
Wichita KS	--	--	--	S-	S-
Little Rock AR	+	0	+	F+	F+
Spokane WA	--	--	--	S-	S-
Pensacola FL-AL	++	+	++	F+	F+
Corpus Christi TX	--	--	--	S-	S-
Anchorage AK	--	-	--	S-	S-
Eugene OR	--	-	--	S-	S-
Salem OR	-	0	-	0	S-
Beaumont TX	--	--	--	S-	S-
Laredo TX	-	+	--	0	S-
Brownsville TX	--	-	--	S-	S-
Boulder CO	--	0	--	S-	S-
Interval Values – Medium and Small	5 hours	5 index points	(5 hours x average popn. for group)	5 hours	(5 hours x average popn. for group)

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

Between 1 and 2 intervals above or below the average	More than 2 intervals above or below the average
+ *Higher congestion*; F *Faster congestion growth*;	++ *Much higher congestion*; F+ *Much faster growth*
- *Lower congestion*; S *Slower congestion growth*;	-- *Much lower congestion*; S- *Much slower growth*

Table 7. Urban Area Demand and Roadway Growth Trends

Less Than 15% Faster (9)	15% to 35% Faster (44)	More Than 35% Faster (37)
Anchorage AK	Allentown-Bethlehem PA-NJ	Akron OH
Dayton OH	Bakersfield CA	Albany-Schenectady NY
Indio-Cathedral City-Palm Springs CA	Beaumont TX	Albuquerque NM
Lancaster-Palmdale CA	Boulder, CO	Atlanta GA
New Orleans LA	Boston MA-NH-RI	Austin TX
Pittsburgh PA	Brownsville TX	Baltimore MD
Poughkeepsie-Newburgh NY	Buffalo NY	Birmingham AL
St. Louis MO-IL	Charleston-North Charleston SC	Bridgeport-Stamford CT-NY
Wichita KS	Charlotte NC-SC	Cape Coral, FL
	Cleveland OH	Chicago IL-IN
	Corpus Christi TX	Cincinnati OH-KY-IN
	Denver-Aurora CO	Colorado Springs CO
	Detroit MI	Columbia SC
	El Paso TX-NM	Columbus, OH
	Eugene OR	Dallas-Fort Worth-Arlington TX
	Fresno CA	Hartford CT
	Grand Rapids MI	Jacksonville FL
	Honolulu HI	Laredo TX
	Houston TX	Las Vegas NV
	Indianapolis IN	Little Rock AR
	Kansas City MO-KS	Los Angeles-L Bch-Santa Ana CA
	Knoxville TN	Miami FL
	Louisville KY-IN	Minneapolis-St. Paul MN
	Memphis TN-MS-AR	New Haven CT
	Milwaukee WI	New York-Newark NY-NJ-CT
	Nashville-Davidson TN	Orlando FL
	Oklahoma City OK	Oxnard-Ventura CA
	Omaha NE-IA	Pensacola FL-AL
	Philadelphia PA-NJ-DE-MD	Providence RI-MA
	Phoenix AZ	Raleigh-Durham NC
	Portland OR-WA	Riverside-San Bernardino CA
	Richmond VA	Sacramento CA
	Rochester NY	San Antonio TX
	Salem OR	San Diego CA
	Salt Lake City UT	San Francisco-Oakland CA
	San Jose CA	Sarasota-Bradenton FL
	Seattle WA	Washington DC-VA-MD
	Spokane WA	
	Springfield MA-CT	
	Tampa-St. Petersburg FL	
	Toledo OH-MI	
	Tucson AZ	
	Tulsa, OK	
	Virginia Beach VA	

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

References

1 Federal Highway Administration. “Highway Performance Monitoring System,” 1982 to 2007 Data. November 2008.

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

3 Urban Congestion Report: National Executive Summary. Federal Highway Administration. Unpublished monthly data, 2008.

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

5 *2030 Committee Texas Transportation Needs Report.* Texas 2030 Committee, Austin Texas. February 2009. Available: http://texas2030committee.tamu.edu/

6 Urban Mobility Report Methodology. Texas Transportation Institute, College Station, Texas. 2009. Available: http://mobility.tamu.edu/ums/report/methodology.stm

University Transportation Center for Mobility™
Texas Transportation Institute
The Texas A&M University System
College Station, TX 77843-3135
Tel: 979.845.2538   Fax: 979.845.9761
utcm.tamu.edu