Cost of Congestion to the Trucking Industry
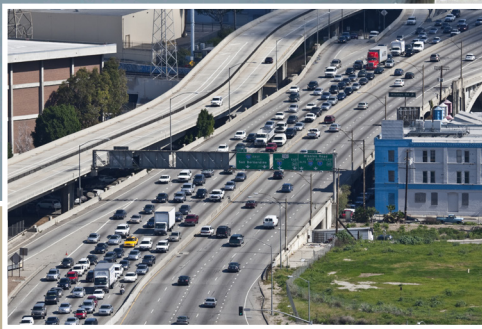
April 2016

Prepared by the American Transportation Research Institute

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Estimating the Cost of Congestion to the Trucking Industry

April 2016

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INTRODUCTION

Trucks transported nearly 10 billion tons of freight representing over two-thirds (68.8 percent) of total domestic tonnage shipped[1], and traveled more than 279 billion miles on the nation's roadway network in 2014.[2] Due to the critical role of safe and reliable truck movements in sustainable economic growth, it is essential to continually monitor and evaluate the efficiency of the national roadway system. A key impediment to nimble supply chains is the level of traffic congestion experienced on U.S. roadways, and the subsequent costs that are incurred due to this congestion.

In 2014 the American Transportation Research Institute (ATRI) conducted research quantifying the amount of delay experienced by the trucking industry on the U.S. Interstate Highway System (IHS) in 2012 and 2013.[3] In an effort to continually monitor and quantify congestion, ATRI has now implemented a number of standardization procedures to enable the comparison of these figures on a year-over-year basis including:

- Utilizing publicly available highway usage figures for the year studied;
- Utilizing the national trucking industry cost of operation figure specific to the year studied;
- Establishing a standardized methodology for quantifying the amount of delay; and
- Establishing a standardized methodology for estimating truck volumes.

Incorporating these new procedures will allow this 2014 report to become a benchmark of comparison for future study years, as well as allow future year-over-year comparisons. Additionally, the ever-growing nature of ATRI's truck Global Positioning System (GPS) and truck financial data allows the research team to expand the analysis beyond the IHS. While the National Highway System (NHS) is the primary focus of the analysis as its usage is more consistent, a high-level analysis of local road congestion was also conducted and is described later in this report. Finally, it is important to note that due to the changes utilized in standardizing the methodology for future studies, the figures presented in this report are not directly comparable to those of the previous Cost of Congestion study.

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[1] *American Trucking Trends 2015*. American Trucking Associations. Arlington, Virginia.
[2] *Table VM-1: Annual Vehicle Distance Traveled in Miles and Related Data by Highway Category and Vehicle Type – 2014.* Highway Statistics Series 2014. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information. December 2015. Available online: https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm1.cfm
[3] Pierce, Dave and Dan Murray. *Cost of Congestion to the Trucking Industry*. American Transportation Research Institute. Arlington, Virginia. April 2014.

METHODOLOGY

Four data sources were used in this analysis to quantify the impact of traffic congestion on the trucking industry:

(1) Commercial truck travel times from the Federal Highway Administration (FHWA) National Performance Management Research Data Set (NPMRDS);
(2) Commercial truck volumes from FHWA's Freight Analysis Framework (FAF);
(3) Commercial truck GPS data from ATRI's Freight Performance Measures (FPM) database; and
(4) Industry financial data from ATRI's annual *An Analysis of the Operational Costs of Trucking* publication.

Roadway Network

The NPMRDS network, published as a shape file in each monthly iteration of the NPMRDS, was utilized as the foundational network in this analysis. The network is made up of over 308,000 bi-directional roadway segments, the bulk of which are located in the U.S. (with some segments falling in Canada, Mexico, and Puerto Rico). Each roadway segment is identified by a unique traffic management channel (TMC) code, and each TMC contains information on various jurisdiction levels (country, state, county), the length in miles of the segment, the road name, the road direction, the route type, and the latitude and longitude of the center of the segment.

The first step in defining the roadway network was to extract only those TMCs corresponding to roads located within the 48 contiguous states as well as Alaska and Hawaii. This resulted in the network depicted in Figure 1.

Figure 1: United States NPMRDS Roadway Network
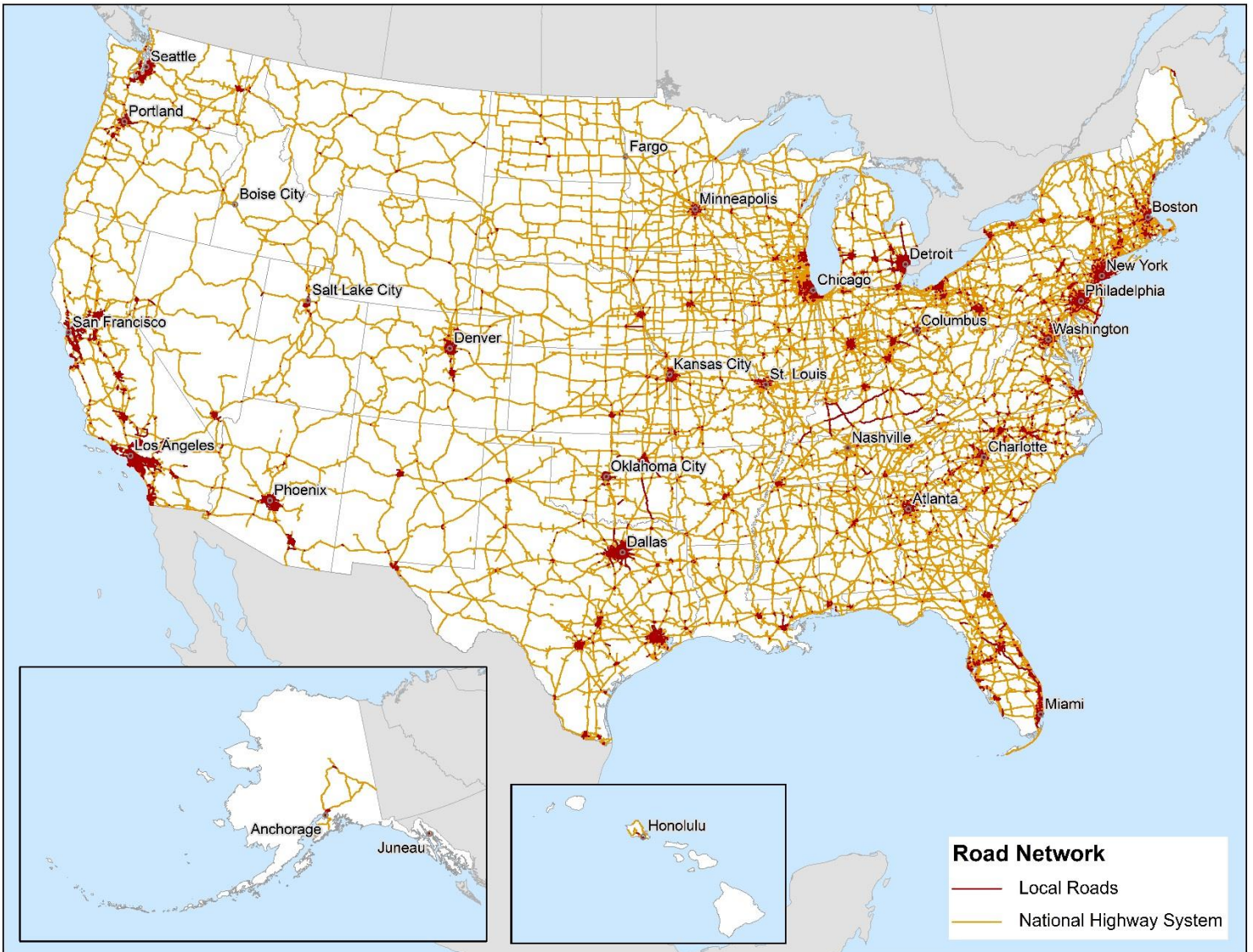
Next, using a combination of the route type indicator and the road name, the NHS was defined and extracted from the full U.S. network for use in this analysis. This network consists of numbered interstate, federal, state, and county highways. Detailed in Table 1, this generated just under 182,000 roadway segments, totaling over 444,000 bi-directional miles.

Table 1: NHS Roadway Network Statistics

NHS Road Network Profile	
Total Segment Miles	444,343
Total Network Length (miles)[4]	222,171
Total Number of Segments	181,909
Longest segment (miles)	86.1
Shortest segment (miles)	0.002
Average segment (miles)	2.4
Median segment (miles)	1.4

As noted, local roads were also examined in this analysis. These are roads with conventional street names and are predominantly found in urban areas. Highlighted in Table 2, this network accounted for approximately 80,000 additional segments and approximately 57,000 additional bi-directional miles.

Table 2: Local Roadway Network Statistics

Local Road Network Profile	
Total Segment Miles	56,934
Total Roadway Length (miles)	28,467
Total Number of Segments	78,990
Longest segment (miles)	37.0
Shortest segment (miles)	0.003
Average segment (miles)	0.721
Median segment (miles)	0.518

Finally, the entirety of the network was spatially joined using ArcGIS software to reflect a variety of features including metropolitan area[5], county, and time zone for use in subsequent steps in this analysis.

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[4] Total network length in miles is estimated by dividing the total segment miles figure in half.
[5] Core Based Statistical Areas (CBSAs). United States Department of Commerce, United States Census Bureau. Available online: https://www.census.gov/geo/maps-data/data/cbf/cbf_msa.html. For the purposes of this report micropolitan areas are referred to as metropolitan.

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Marginal Truck Travel Time Delay

Truck Speeds

New iterations of the NPMRDS are published each month and contain travel times in seconds for both passenger and commercial vehicles for each TMC across 288 five-minute epochs which correspond to a certain time of day on a particular day of the month. For example the average travel time for the 12:00-12:05 AM period corresponds to epoch 0. For the purposes of this analysis, the truck travel times were extracted from the full data set.

Next, weekdays were extracted from the truck travel time dataset as the majority of truck traffic occurs during the week, and therefore are the days most impacted by congestion. Due to the nature of the NPMRDS, the five-minute travel times were aggregated into one-hour time periods yielding 24 average travel times in seconds for each roadway segment. The intent of this task is to reduce the impact of outliers and missing data. These average travel times were then converted from seconds to hours, and subsequently converted to speeds in miles-per-hour (MPH) using the distance corresponding to each TMC as follows:

$$\overline{travTime}_{t,h,m} = \frac{\frac{1}{n} * \sum_{i=0}^{n} travTime_{t,i,m}}{3600}$$

$$\overline{speed}_{t,h,m} = \frac{distance_t}{\overline{travTime}_{t,h,m}}$$

Where:
- t is TMC;
- h is hour of the day;
- m is month of the year;
- i is epoch;
- n is the number of observations in an hour bin;
- $\overline{travTime}_{t,h,m}$ is the calculated mean travel time in hours on TMC t in hour bin h for month m;
- $travTime_{t,i,m}$ is the travel time for TMC t in epoch i for month m;
- $\overline{speed}_{t,h,m}$ is the calculated mean speed in MPH on TMC t in hour bin h for month m; and
- $distance_t$ is the distance of TMC t in miles.

Free-flow Speed

To facilitate the congestion level calculation, a free-flow speed was established for each roadway segment. While the posted speed limit of a particular segment can be used as

free-flow speed, issues can arise with varying degrees of speed limit enforcement and truck speed governor usage. As such, the empirical speeds found by the above process were used in the establishment of a free-flow speed for each segment.

First, a maximum speed of 80 MPH was set to further reduce the impact of outlier speeds. The fastest hourly speed was then found for each segment of each month resulting in 12 fastest speeds for each segment. Finally, the median of these 12 fastest speeds was set as the free-flow speed for the segment:

$$freeflow_t = \max \widetilde{speed_{t,m}}$$

Where:
- $freeflow_t$ is the calculated free flow speed for TMC t; and
- $\max \widetilde{speed_{t,m}}$ is the median of the maximum average speeds for TMC t in month m.

Congestion Threshold

Shown in Figure 2 below, a congestion threshold was calculated to flag instances of congestion. The congestion threshold was set at 90 percent of the identified free-flow speed as the trucking industry is generally flexible enough to adjust to minor congestion in daily operations. By using a more conservative threshold in calculating marginal delay, the results of the analysis provide a more accurate assessment of congestion that is having a noticeable impact on industry operations:

$$thresh_t = freeflow_t * .90$$

Where:
- $thresh_t$ is the calculated congestion threshold for TMC t in MPH.

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Figure 2: Example Segment - Establishing Congested Conditions
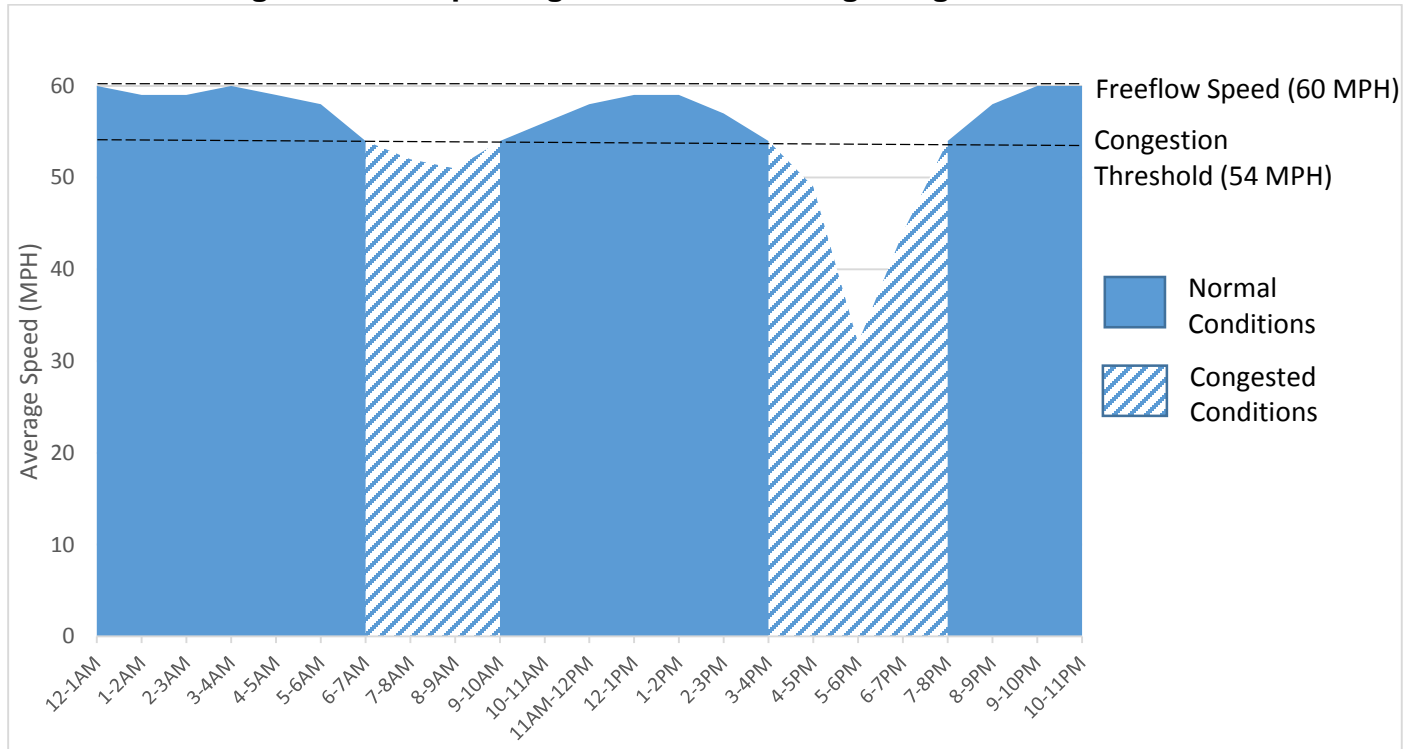
Travel Time Delay

To quantify travel time delay, the observed speeds and congestion threshold speeds were first converted back to travel times in hours:

$$\overline{travTime}_{t,h,m} = \frac{distance_t}{speed_{t,h,m}}$$

$$thresh'_t = \frac{distance_t}{thresh_t}$$

Where:

- $thresh'_t$ is the calculated congestion threshold travel time for TMC t in hours.

The observed travel times were then compared to the congestion threshold to identify when congestion was present. In instances where congestion was present, the actual travel time was subtracted from the congestion threshold travel time to establish a marginal delay value (Figure 3):

$$cong_{t,h,m} = \overline{travTime}_{t,h,m} - thresh'_t \leftrightarrow \overline{travTime}_{t,h,m} > thresh'_t$$

Where:

- $cong_{t,h,m}$ is the calculated travel time delay in hours for TMC t in hour bin h for month m.

This resulted in 24 marginal delay values for each segment in each month of 2014. If no delay was present at a particular time of a month, that hour bin received a delay value of zero.

Figure 3: Example Segment - Establishing Marginal Delay Values
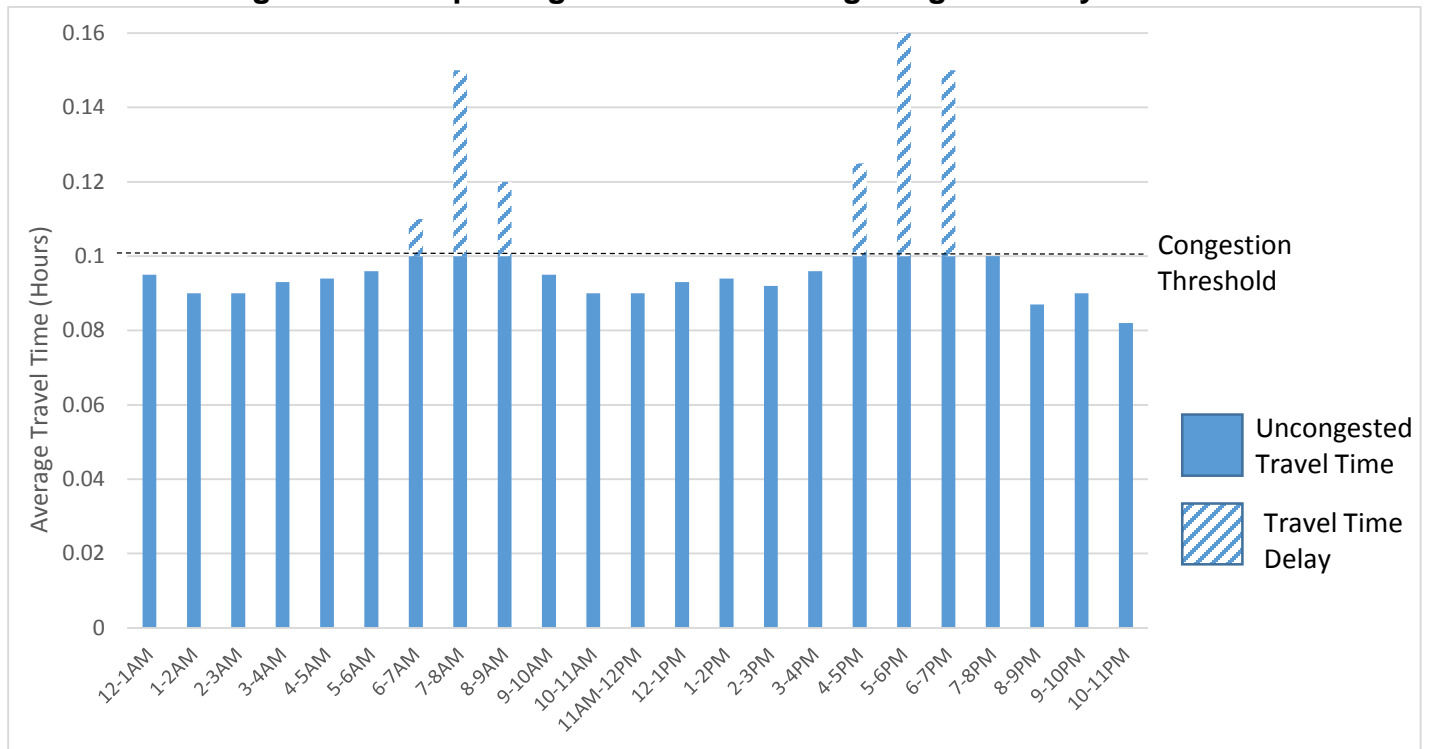
Estimating Truck Volumes

Marginal delay values can tell a very important story about the severity of congestion at a certain place and time, however truck volume data is needed in order to quantify the impact on the industry as a whole. This allows the analysis to account for the fact that two segments may have the same amount of marginal delay, but one segment is more heavily traveled by trucks than the other and therefore would result in a greater congestion impact on the industry.

Linking the FAF and NPMRDS Networks

One of the most commonly used government sources of truck volume estimates is contained in FHWA's FAF network shape file. The FAF data provides volume estimates, or average annual daily truck traffic (AADTT), for large trucks with a gross vehicle weight rating greater than 10,000 pounds on approximately 204,000 U.S. roadway segments. However, due to FAF roadway segments differing in many ways from those found in the NPMRDS, it was necessary to spatially join the two networks. This resulted in each NPMRDS roadway segment with a TMC code receiving an AADTT value from the FAF network.

Adjusting FAF Volume Estimates

Due to the nature of the FAF volume estimates associated with the NPMRDS network through this research process, a number of adjustments were needed to produce accurate hourly volume estimates for 2014. First, the AADTT estimates needed to be adjusted to 2014 values as the base-year FAF estimates in the most recent publication are for 2007. This was done by using truck vehicle miles traveled (VMT) figures produced by FHWA for urban and rural roadways[6] to calculate an adjustment factor as follows:

$$\Delta VMT_r = \frac{VMT_{r,14} - VMT_{r,07}}{VMT_{r,07}} + 1$$

Where:
- r is the roadway type; urban or rural;
- ΔVMT_r is the calculated adjustment factor for roadway type r;
- $VMT_{r,14}$ is the total VMT for roadway type r in 2014; and
- $VMT_{r,07}$ is the total VMT for roadway type r in 2007.

The FAF estimates were further adjusted by a factor of two to account for the FAF roadway segments being one-directional and the NPMRDS segments being bi-directional. While more nuanced methodologies could have been developed, constraints due to the national scope of this analysis as well as the lack of non-proprietary national VMT data by direction led to the following calculation for determining AADTT for 2014 for each TMC:

$$AADTT_{t,r,14} = \frac{AADTT_{t,r,07} * \Delta VMT_r}{2}$$

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[6] *Table VM-1: Annual Vehicle Distance Traveled in Miles and Related Data by Highway Category and Vehicle Type – 2014.* Highway Statistics Series 2014. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information. December 2015. Available online: https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm1.cfm

Where:

- t is TMC segment;
- $AADTT_{t,r,14}$ is the calculated AADTT for TMC t with roadway type r for 2014; and
- $AADTT_{t,r,07}$ is AADTT for TMC t with roadway type r in 2007.

To account for seasonality, FHWA's national volume statistics[7] were used to estimate how total volume fluctuates seasonally. A monthly utilization factor was calculated for each month for urban and rural roadways by:

$$util_{m,r} = \frac{VMT_{m,r,14}}{VMT_{r,14}} * 12$$

Where:

- m is month of the year;
- $util_{m,r}$ is the calculated monthly utility factor for month m and roadway type r;
- $VMT_{m,r,14}$ is VMT for month m and roadway type r in 2014; and
- $VMT_{r,14}$ is the total VMT for roadway type r in 2014.

Due to the granularity of the NPMRDS, AADTT estimates needed to be distributed across the hours of the day for each month of the year. To perform this, ATRI's proprietary truck GPS database was utilized. A five weekday sample of GPS data was extracted from each month of 2014. Each truck ping data point contains a unique truck identification code, a date/time stamp recorded in Greenwich Mean Time (GMT), a latitude/longitude location, a heading, and a spot speed; the total data sample used equated to approximately 1.1 billion truck GPS points.

The NPMRDS network was then spatially joined with a U.S. time zone shape file[8] resulting in each TMC receiving a time zone identifier. The truck GPS data was joined to this network which resulted in each GPS point receiving a TMC code and a time zone identifier. The date/time stamp of the GPS data was then converted from GMT to the time zone in which the point fell, and binned hourly. Finally, the hourly volume distribution for each TMC per month was found by (Figure 4):

$$dist_{t,h,m} = \frac{trucks_{t,h,m}}{trucks_{t,m}}$$

Where:

- h is hour of the day;
- $dist_{t,h,m}$ is the calculated volume distribution for TMC t in hour bin h for month m;

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[7] *Traffic Volume Trends.* Table – 1. Estimated Individual Monthly Motor Vehicle Travel in the United States. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information. December 2015. Available online: http://www.fhwa.dot.gov/policyinformation/travel_monitoring/14dectvt/14dectvt.pdf
[8] Muller, Eric. A Shapefile of the TZ Timezones of the United States Version 2016b. Last data update: 5 July 2013. Available online: http://efele.net/maps/tz/us/

- $trucks_{t,h,m}$ is the number of trucks on TMC t in hour bin h for month m; and
- $trucks_{t,m}$ is the total number of trucks on TMC t for month m.

Figure 4: Example Segment - Hourly Truck Distribution
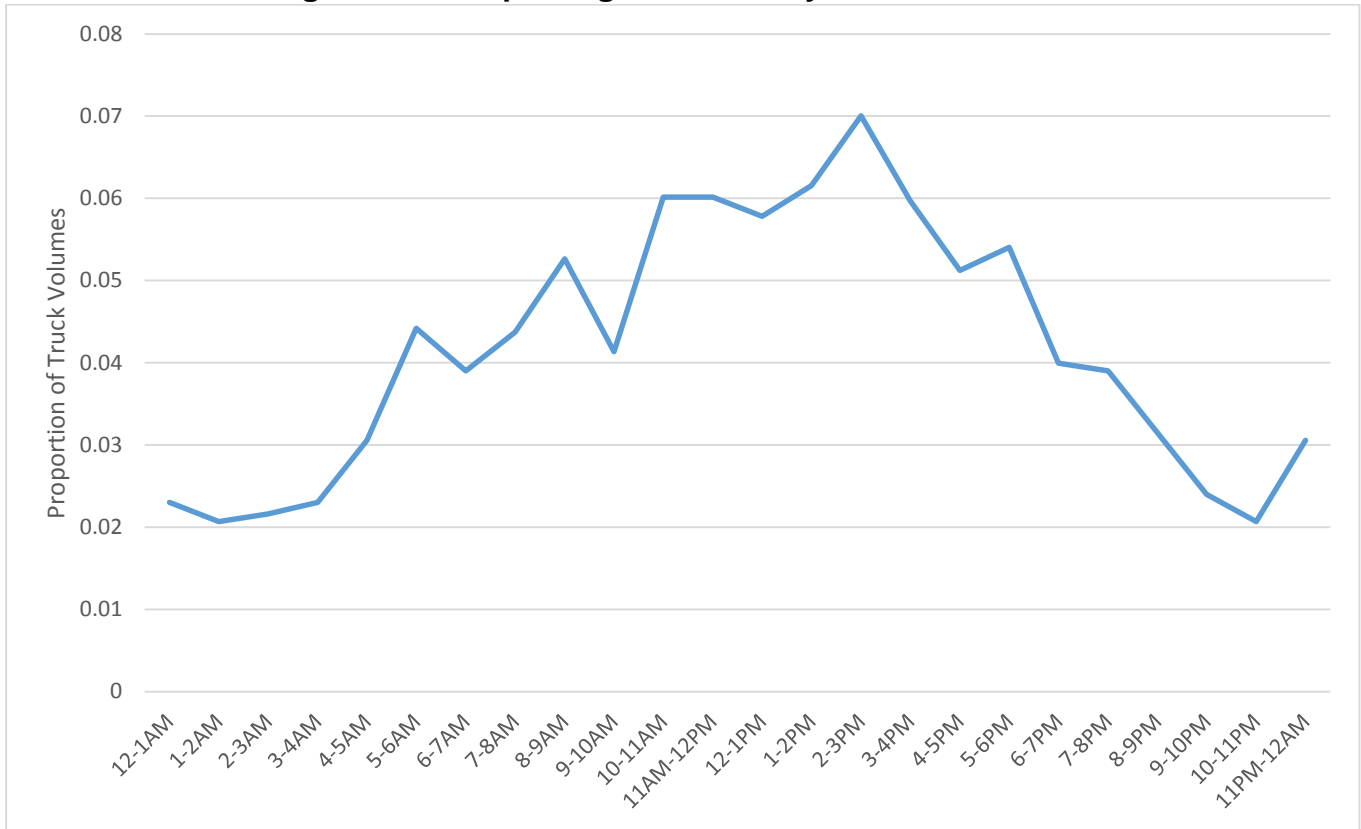
The volume estimates were then multiplied by a factor equal to the number of weekdays in a month given that this analysis focuses on weekday congestion. Incorporating this factor, the final volume estimates are calculated as:

$$vol_{t,h,m,r} = AADTT_{t,r,14} * util_{m,r} * dist_{t,h,m} * days_m$$

Where:
- $vol_{t,h,m,r}$ is the calculated volume estimate for TMC t in hour bin h for month m with road type r;
- $AADTT_{t,r,14}$ is the calculated AADTT for TMC t with roadway type r for 2014;
- $util_{m,r}$ is the calculated monthly utility factor for month m and roadway type r;
- $dist_{t,h,m}$ is the calculated volume distribution for TMC t in hour bin h for month m; and
- $days_m$ is the number of weekdays in month m.

Calculating Total Delay and Cost

With both marginal delay and volume estimates calculated for each TMC segment per hour of the day and month of the year, the total delay calculation simply becomes:

$$delay_{t,h,m} = cong_{t,h,m} * vol_{t,h,m,r}$$

Where:
- $delay_{t,h,m}$ is the calculated total delay on TMC t in hour bin h for month m;
- $cong_{t,h,m}$ is the calculated travel time delay in hours for TMC t in hour bin h for month m; and
- $vol_{t,h,m,r}$ is the calculated volume estimate for TMC t in hour bin h for month m with road type r.

The final step of the analysis was to apply a monetary equivalent to the total delay figures. ATRI annually produces a national average operating cost figure which is derived from financial data obtained directly from representative motor carriers throughout the country.[9] Applying this national per-hour cost of operation to the calculated hours of delay yields the total cost of delay incurred on the trucking industry by traffic congestion:

$$cost_{t,h,m} = delay_{t,h,m} * CPH$$

Where:
- $cost_{t,h,m}$ is the calculated cost of delay on TMC t in hour bin h for month m;
- $delay_{t,h,m}$ is the calculated total delay on TMC t in hour bin h for month m; and
- CPH is the national average cost per hour of operation.

These delay and cost figures were then aggregated across hours and months for each TMC segment to produce the total delay and cost experienced on a particular segment for the entire year. As presented in the next section of this report, further aggregation can produce national delay and cost figures which can then be stratified at the state, metropolitan area, and county level.

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[9] Torrey IV, W. Ford and Dan Murray. *An Analysis of the Operational Cost of Trucking: A 2015 Update.* American Transportation Research Institute. Arlington, VA. September 2015.

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RESULTS

National Highway System (NHS) Analysis

The first section of the results focuses on the U.S. NHS as this roadway network is the most vital for freight truck movements throughout the country. The results are presented as total cost, normalized cost-per-mile, and share of total cost figures where applicable, and are stratified across four jurisdiction levels: national, state, metropolitan area, and county.

National Level

Delay associated with weekday traffic congestion on the NHS totaled over 728 million hours in 2014. This amount of delay is the equivalent of 264,781 commercial truck drivers sitting idle for an entire working year.[10] Applying the 2014 national average operational cost per hour of $68.09[11] equated to just over $49.6 billion in increased operational costs to the trucking industry. Spreading this cost evenly across the 10.9 million registered large trucks in the U.S.[12] results in an increased average cost per truck of $4,546. However, the actual cost for any one truck is dependent on a variety of factors such as location of operation, number of miles driven, and operating sector. Using the 2014 total truck VMT figure[13] it is possible to extrapolate how much congestion delays impacted a truck based of the number of miles the truck traveled in 2014.[14] Depicted in Figure 5 below, the impact of congestion varied greatly depending an individual truck's VMT for the year. For example, a truck that traveled 25,000 in 2014 incurred an increased cost of $4,438 while a truck that traveled 150,000 miles had an average increased cost of $26,625.

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[10] A working year is defined as driving 11 hours a day, 5 days a week, for 50 weeks per year

[11] Torrey IV, W. Ford and Dan Murray. *An Analysis of the Operational Cost of Trucking: A 2015 Update.* American Transportation Research Institute. Arlington, VA. September 2015.

[12] *Table VM-1: Annual Vehicle Distance Traveled in Miles and Related Data by Highway Category and Vehicle Type – 2014.* Highway Statistics Series 2014. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information. December 2015. Available online: https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm1.cfm

[13] *Table VM-1: Annual Vehicle Distance Traveled in Miles and Related Data by Highway Category and Vehicle Type – 2014.* Highway Statistics Series 2014. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information. December 2015. Available online: https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm1.cfm

[14] $\frac{2014\ Total\ Cost}{2014\ Truck\ VMT} = Average\ Cost\ per\ VMT$

Figure 5: Average Cost per Truck Based on Miles Driven
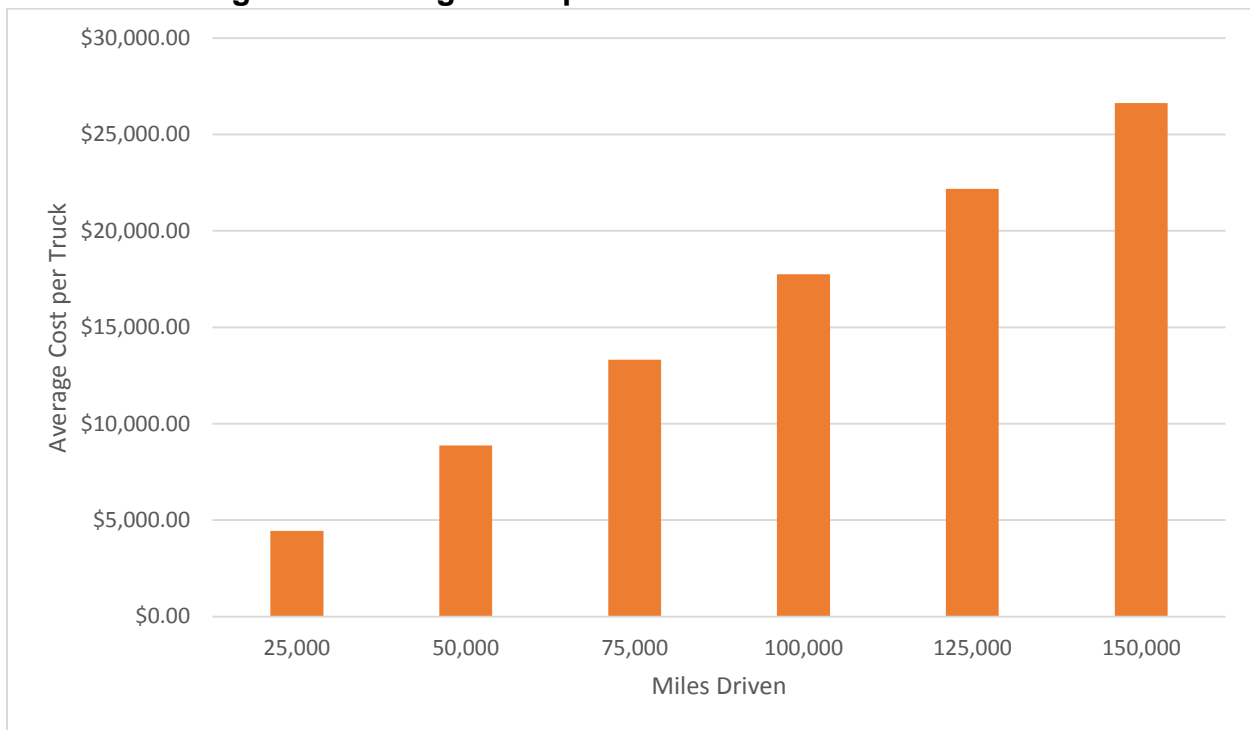
In addition, costs varied by the month of year. The first quarter of the year saw the lowest relative level of congestion, while the third quarter saw the highest (Figure 6). This is likely due to a number of factors including a decrease in U.S. Gross Domestic Product (GDP) growth in the first quarter of 2014, and high growth in the second and third quarters.[15]

Additionally, national VMT are generally higher in the second and third quarters of the year compared to the first and fourth[16] suggesting a greater number of vehicles on the road and therefore more opportunity for congestion.

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[15] *Table 1.1.1 Percent Change from Preceding Period in Real Gross Domestic Product.* National Income and Product Accounts Tables. Bureau of Economic Analysis. U.S. Department of Commerce. Last Revised 26 February 2016. Available online: http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=1&isuri=1&903=1
[16] *Traffic Volume Trends.* Table – 1. Estimated Individual Monthly Motor Vehicle Travel in the United States. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information. December 2015. Available online: U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information. December 2014. Available online: http://www.fhwa.dot.gov/policyinformation/travel_monitoring/14dectvt/14dectvt.pdf

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Figure 6: Cost of Congestion by Month of the Year
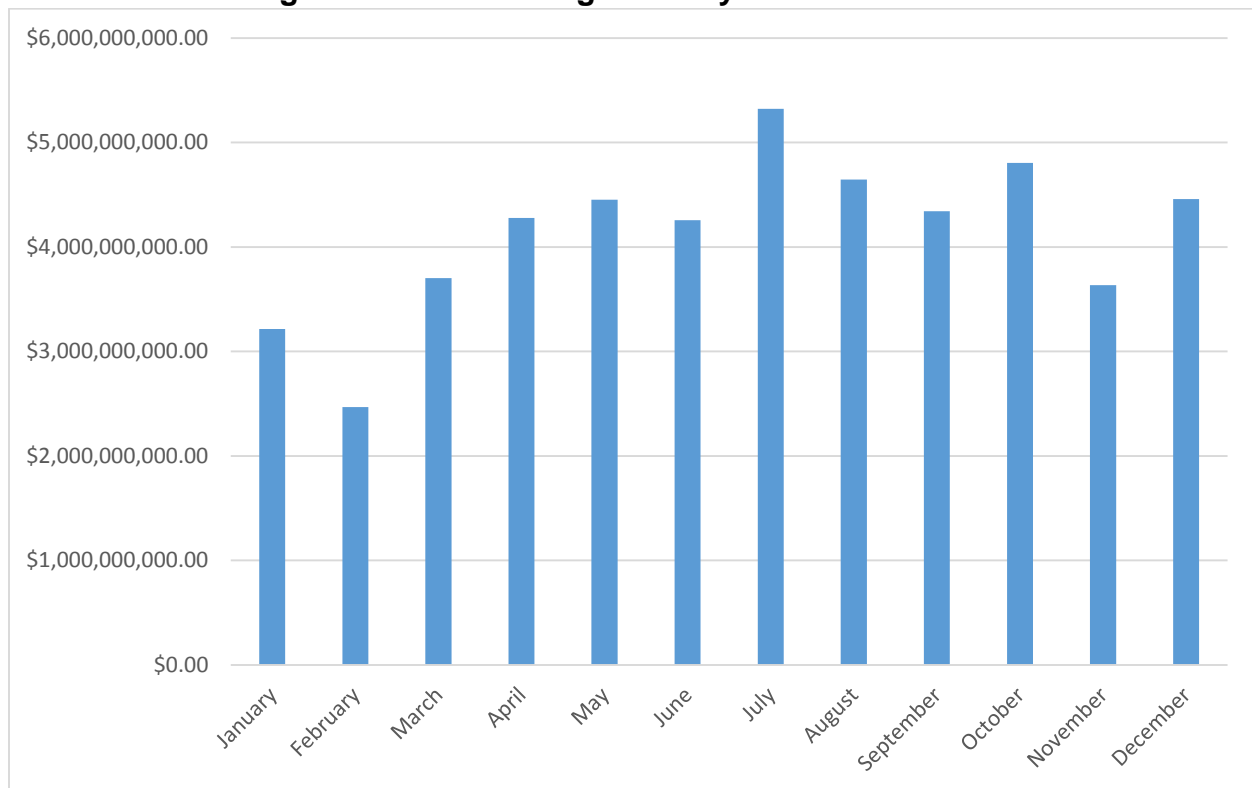
Further, the congestion impacts were not uniform across the NHS network, and were mainly concentrated in urban areas. While the total congestion costs spread across the NHS network averaged $111,578 per mile, relatively few segments met or exceeded this national average suggesting congestion was concentrated on a comparatively small portion of the network. Shown in Figure 7, a large majority of roadway segments (64.3 percent) experienced little to no congestion impacts, while those segments experiencing the highest impacts were in fact a small portion of the NHS network (17.6 percent); 88.1 percent of the congestion found in the analysis occurred on this portion of the network.

Figure 7: Cost and Mileage by Segment Network Intensity
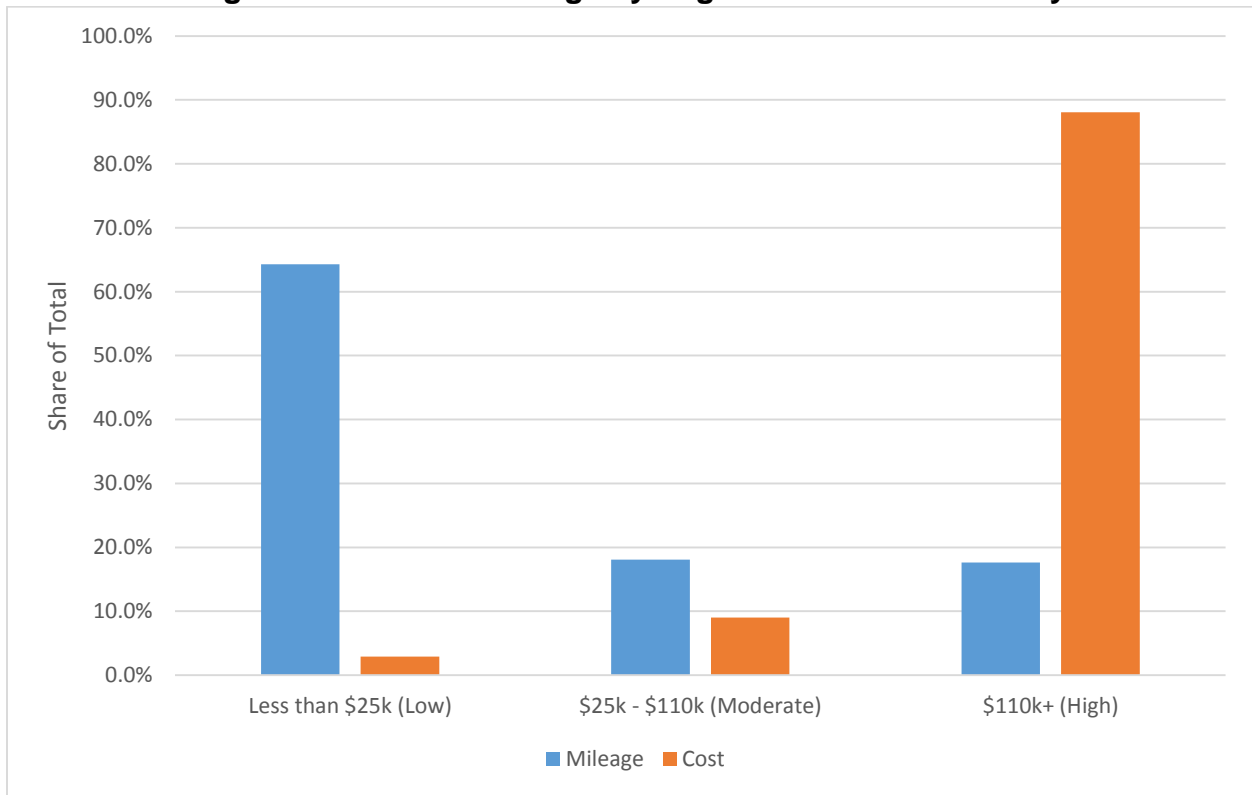
This concentration of congestion can be best visualized by examining a national map of the NHS network with congestion levels presented on each roadway segment. Figure 8 displays the cost of congestion on a per-mile basis for all of the nearly 182,000 roadway segments used in the NHS network analysis. This documents that congestion in 2014 was concentrated in major urban areas, namely New York, Chicago, and Philadelphia.

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Figure 8: Cost of Congestion on a Per Mile Basis
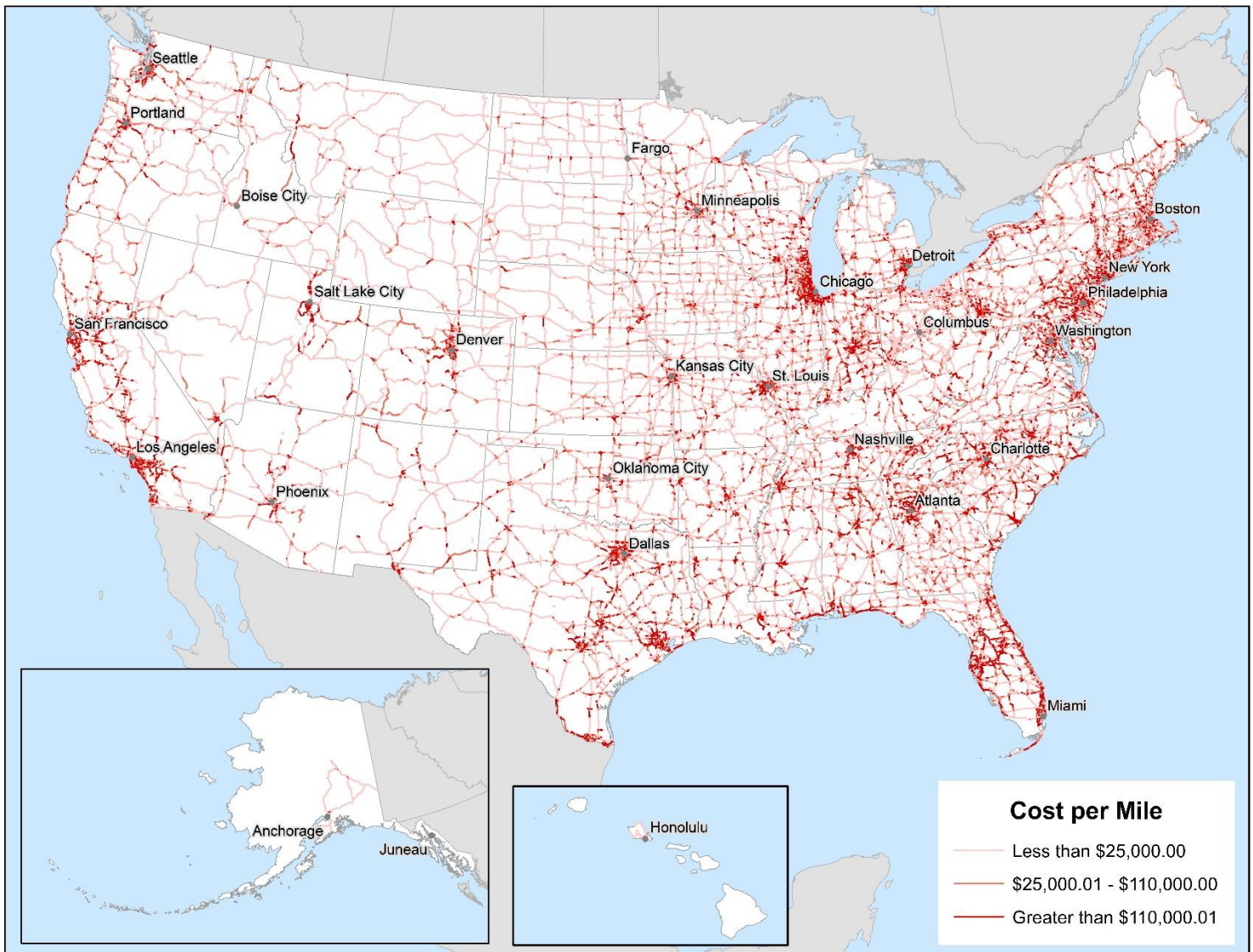
State Level

Stratification of total congestion costs by state[17] shows that the states with the highest costs are also generally the states with the highest population. As shown in Table 3, eight of the top ten states with the highest costs of congestion are also in the top ten most populated states. The two remaining states (New Jersey, Wisconsin), contain heavily traveled port areas in close vicinity to neighboring high-population states, which likely contributes to their top ten placement. The top two states by total cost of

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[17] All 50 states as well as Washington, DC are included in the state analysis. It is worth noting that no congestion was found in Hawaii using the above described methodology.

congestion, Florida and Texas, both totaled over $4 billion in total cost, and together accounted for 17.6 percent of the national cost of congestion value (Figure 9).

Table 3: Top Ten States by Total Cost of Congestion

Rank	State	Total Cost	Share of Total Cost
1	Florida	$4,632,938,425	9.3%
2	Texas	$4,119,079,262	8.3%
3	California	$3,268,924,598	6.6%
4	New Jersey	$2,995,602,210	6.0%
5	New York	$2,507,749,879	5.1%
6	Illinois	$2,406,760,528	4.9%
7	Pennsylvania	$2,161,880,916	4.4%
8	North Carolina	$2,039,569,226	4.1%
9	Georgia	$1,791,108,802	3.6%
10	Wisconsin	$1,526,754,282	3.1%

Figure 9: State Share of Total Cost of Congestion
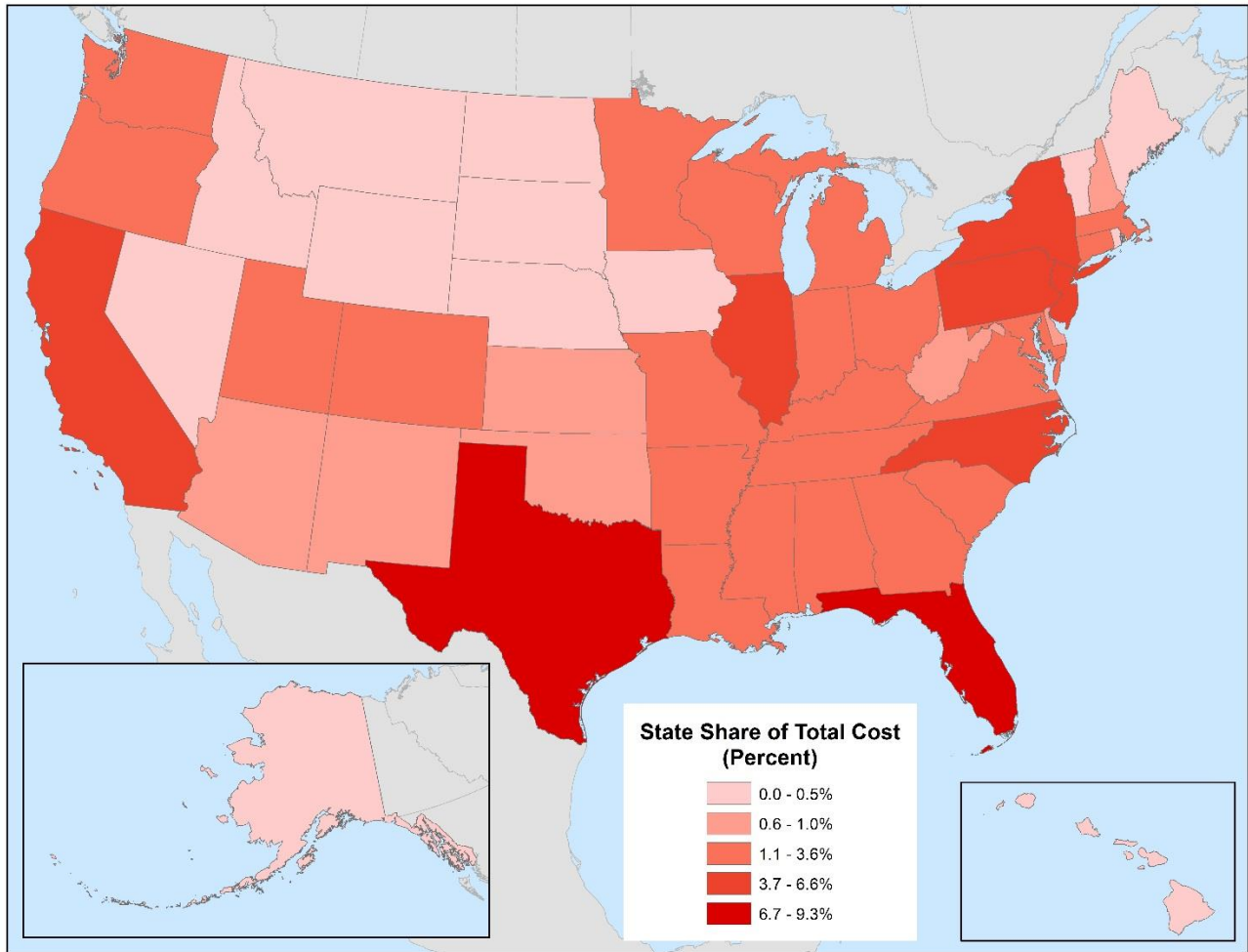
When normalizing costs on NHS miles contained within the state, the top ten list looks very different. The District of Columbia had the highest cost of congestion on a per-mile basis due to the high levels of congestion experienced on a very small number of NHS segment miles. Additionally, many of the smaller Northeastern states appear on the list as well for the same reason. Contrary to this trend, Florida and California remain on this top ten list despite having the second and third highest NHS segment miles, respectively (Table 4).

Table 4: Top Ten States Based on Cost per NHS Segment Mile

Rank	State	Miles of NHS Segments	Cost per Mile
1	District of Columbia	60	$1,045,978
2	New Jersey	5,692	$526,323
3	Delaware	1,001	$323,713
4	Maryland	4,762	$310,985
5	Florida	17,329	$267,354
6	Connecticut	3,462	$234,061
7	Massachusetts	5,616	$209,938
8	Utah	5,815	$188,915
9	New York	15,278	$164,140
10	California	20,013	$163,337

The full state congestion table, listed alphabetically, can be found in Appendix A of this report.

Metropolitan Level

When costs are analyzed at the metropolitan level, similar trends emerge that were prevalent at the state-level analysis, in that densely populated metropolitan areas experienced the highest instances of delays, and subsequently the highest cost of those delays. However, this level of analysis can offer deeper insight into the magnitude of congestion in urban areas. For instance, the metropolitan area with the highest total cost, New York-Newark-Jersey City, NY-NJ-PA, accounted for over half (53 percent) of the combined total cost of the three states in which it is encompassed (Table 5). Another notable example is the Atlanta-Sandy Springs-Roswell, GA metropolitan area accounting for over 55 percent of the total cost found in the entire state. From a national perspective, 95 percent of the total congestion cost occurred in metropolitan areas, with just over $2.5 billion occurring outside of metropolitan areas.

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Table 5: Top Ten Metropolitan Areas by Total Cost of Congestion

Rank	Metropolitan Area	Total Cost
1	New York-Newark-Jersey City, NY-NJ-PA	$4,060,571,449
2	Chicago-Naperville-Elgin, IL-IN-WI	$1,915,070,975
3	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	$1,539,185,875
4	Washington-Arlington-Alexandria, DC-VA-MD-WV	$1,508,625,815
5	Miami-Fort Lauderdale-West Palm Beach, FL	$1,331,032,562
6	Dallas-Fort Worth-Arlington, TX	$1,001,066,579
7	Atlanta-Sandy Springs-Roswell, GA	$991,678,664
8	Houston-The Woodlands-Sugar Land, TX	$917,681,071
9	Los Angeles-Long Beach-Anaheim, CA	$896,918,309
10	Boston-Cambridge-Newton, MA-NH	$875,940,026

Despite having the most NHS segment miles of all of the metropolitan areas analyzed, the New York-Newark-Jersey City, NY-NJ-PA metropolitan area also topped the list when normalizing the total segment mile costs (Table 6). Similar to the state analysis, smaller metropolitan areas appeared on the list due to high congestion intensity on a relatively small number of NHS segment miles, despite having comparatively small populations. Figure 10 below shows the national picture of urban congestion on a per mile basis.

Table 6: Top Ten Metropolitan Areas Based on Cost per NHS Segment Mile

Rank	Metropolitan Area	Miles of NHS Segments	Cost per Mile
1	New York-Newark-Jersey City, NY-NJ-PA	6,728	$603,552
2	Miami-Fort Lauderdale-West Palm Beach, FL	2,549	$522,080
3	Orlando-Kissimmee-Sanford, FL	1,393	$511,406
4	Ogden-Clearfield, UT	631	$497,400
5	Bridgeport-Stamford-Norwalk, CT	559	$471,535
6	San Francisco-Oakland-Hayward, CA	1,022	$468,075
7	Burlington, NC	103	$460,687
8	Washington-Arlington-Alexandria, DC-VA-MD-WV	3,294	$457,994
9	Los Angeles-Long Beach-Anaheim, CA	1,964	$456,715
10	Provo-Orem, UT	834	$395,268

Figure 10: Metropolitan Area Cost of Congestion on a per-Mile Basis
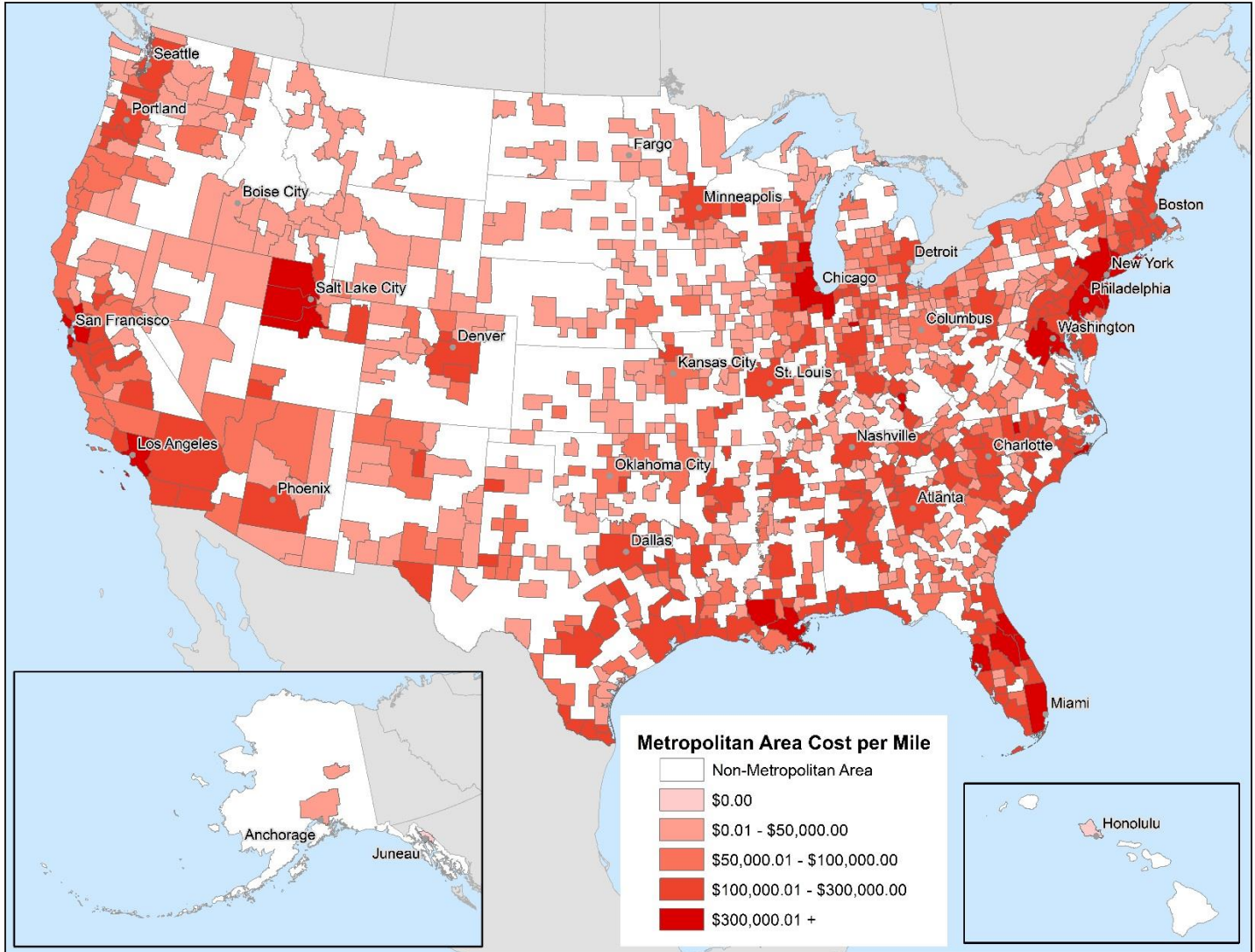
Due to the large number of metropolitan areas examined in this analysis, the congestion figures for individual areas are not included in this report and instead are available upon request.

County Level

This was the smallest jurisdiction level analyzed in this study. While the counties with the highest cost of congestion are generally those within major metropolitan areas, the county-level analysis can offer a greater level of granularity in understanding urban congestion. For example, only two counties in the large New York-Newark-Jersey City, NY-NJ-PA metropolitan area are on the "top ten by total cost" county list. From the

opposite perspective, two Florida counties not encompassed by the Miami-Fort Lauderdale-West Palm Beach, FL metropolitan area (the only Florida metropolitan area in the top ten by total cost) appeared on the top ten by total cost county list indicating congestion is concentrated in pockets of Florida cities. Contrary to this, none of the counties making up the Atlanta-Sandy Springs-Roswell, GA metropolitan area are on the list indicating that congestion is spread across the metro Atlanta area rather than concentrated in particular cities (Table 7).

Table 7: Top Ten Counties by Total Cost of Congestion

Rank	County	Total Cost
1	Cook, IL	$932,964,272
2	Los Angeles, CA	$648,233,355
3	Miami-Dade, FL	$594,263,128
4	Harris, TX	$536,631,381
5	Broward, FL	$441,008,444
6	Middlesex, NJ	$439,632,366
7	Orange, FL	$428,164,000
8	Bergen, NJ	$426,655,399
9	Middlesex, MA	$423,534,517
10	Hillsborough, FL	$406,166,107

When examining costs at the county level on a cost-per-NHS mile basis, the congestion intensity of the New York-Newark-Jersey City, NY-NJ-PA metropolitan area becomes very apparent. Four of the top five, and six of the top ten counties with the highest level of congestion on a per-mile basis fall within this metropolitan area (Table 8). Examining a national map of counties by per-mile cost of congestion creates a clear picture of how severe congestion tends to be fairly concentrated (Figure 11).

Table 8: Top Ten Counties Based on Cost per NHS Segment Mile

Rank	County	Miles of NHS Segments	Cost per Mile
1	Kings, NY	42	$2,347,681
2	Queens, NY	143	$2,058,403
3	Alexandria, VA	42	$1,915,548
4	Hudson, NJ	137	$1,747,312
5	Union, NJ	217	$1,746,424
6	Stafford, VA	74	$1,459,775
7	New York, NY	38	$1,136,971
8	District of Columbia, DC	60	$1,045,979
9	Weber, UT	175	$980,930
10	Bronx, NY	85	$980,928

Figure 11: County Cost of Congestion on a Per Mile Basis
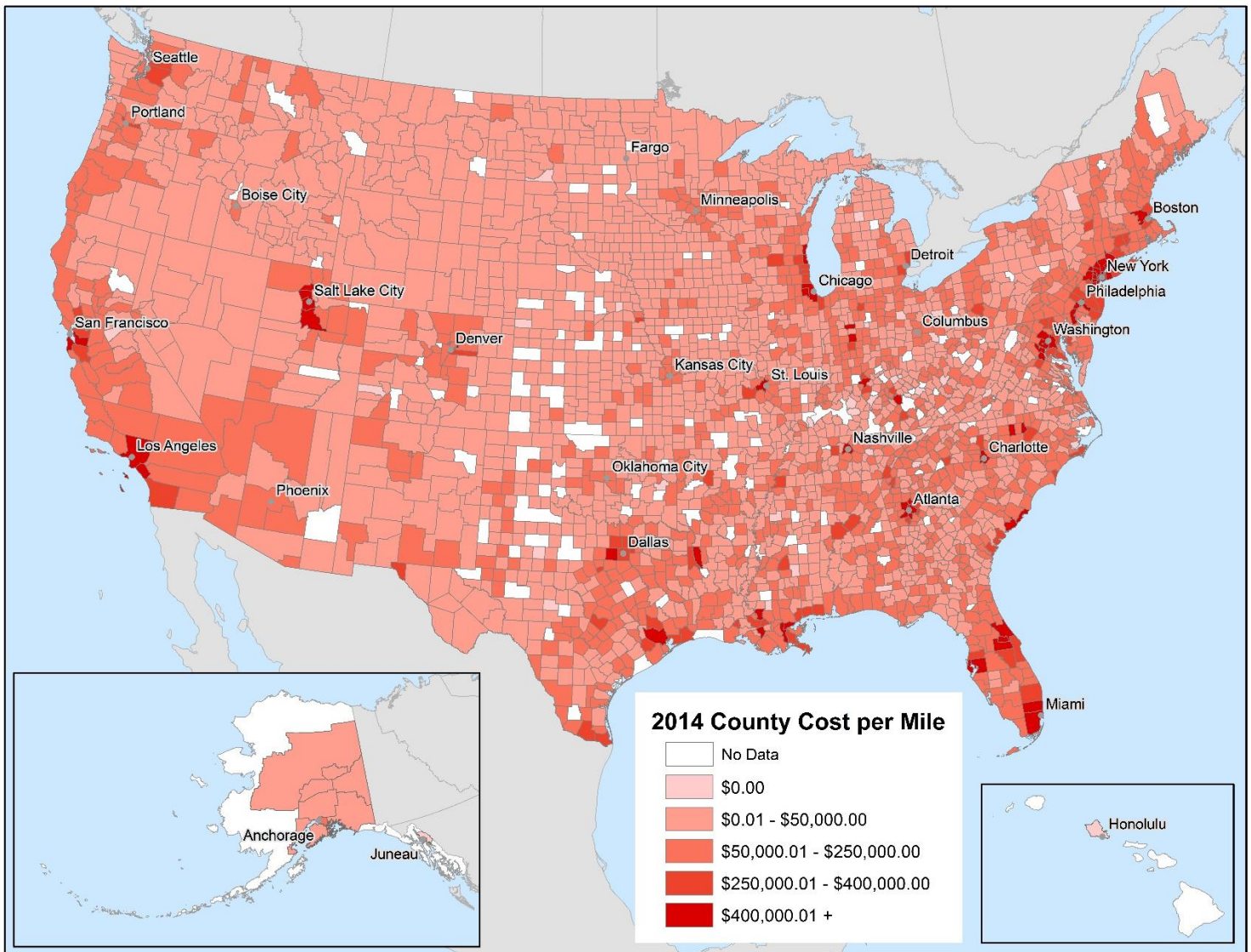
Due to the large number of counties examined in this analysis, the congestion figures for individual counties are not included in this report and instead are available upon request.

Local Roads Analysis

As previously noted, congestion on the NHS network was the primary focus of this analysis, and will continue to be so in future iterations of this study. This is due to the limited coverage of local roads in the NPMRDS network, as depicted in Figure 1, making it difficult to standardize congestion on these roads for the purposes of year-over-year comparisons. Additionally, much of the congestion that was calculated on these roads using this report's methodology could be due to activities such as local

pick-up and delivery operations, or city repairs and maintenance using heavy duty equipment. As such, cost figures on local roads covered by the network will be presented at a high level as supplemental information in this and future reports, and should be interpreted with caution.

Given these caveats, the cost of congestion information relating to these roads elucidates the challenges involved in urban freight movements. The local roadway network is predominantly made up of relatively short roadway segments in downtown urban areas, with only one-quarter of the segments having a length of over one mile long. These roads account for only 11 percent of the miles included in the entirety of the NPMRDS network yet over 483 million hours of delay were accumulated on these roads based on the methodology described earlier in this report. This is the equivalent of an additional 174,369 commercial truck drivers sitting idle for a working year on these roads, and resulted in increased costs of over $32.8 billion.

Due to the characteristics of this network, essentially the entirety of this cost occurred in urban areas with only 0.13 percent of the cost existing in rural areas. The Los Angeles-Long Beach-Anaheim, CA metropolitan area saw the highest total cost on local roads of over $5.3 billion with more than $4 billion of that occurring in Los Angeles County – the top county by this measure.

CONCLUSION

In an effort to benchmark the impact that traffic congestion has on the trucking industry, this report utilized a variety of data resources, and established a standardized methodology to quantify the amount of delay and monetary equivalent of that delay in 2014. Additionally, the analysis was expanded to include the entire NHS network.

Delay on the NHS was calculated to be over 728 million hours equating to approximately $49.6 billion in increased congestion-related costs to the trucking industry. This congestion was heavily concentrated in urban areas, with 88.1 percent of the total cost occurring on only 17.6 percent of the NHS network. This congestion in urban areas has been extensively documented by ATRI's annual list of the nation's top truck freight significant bottlenecks.[18]

This lost productivity is equivalent to 264,781 commercial truck drivers sitting idle for an entire working year. Additionally, the average truck experienced an increased cost of $4,546 due to congestion, with this figure varying widely depending on the number of miles a particular truck traveled in a particular area.

Finally, as a direct result of this analysis, ATRI has a unique opportunity to be a valuable source of congestion information to planners at every jurisdiction level. Utilizing the output of this analysis, a congestion cost database has been built with the intent of providing granular cost information. This information includes hours of delay and the cost of those hours by major jurisdiction type and road level, and presents data both yearly and on a month-by-month basis. Table 9 presents an example of the type of information that can be extracted from the database for use by planning officials.

Table 9: Sample Cost of Congestion Database Information - Interstates in Fulton County, Georgia

Road	Hours of Delay	Total Cost	Miles of NHS	Cost per Mile
I-20	254,694	$17,341,946	23	$750,721
I-285	190,594	$12,977,411	43	$303,570
I-75	613,302	$41,759,378	35	$1,185,400
I-85	418,625	$28,503,939	45	$636,385

To request congestion information please contact ATRI at ATRI@trucking.org.

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[18] Short, Jeff and Dan Murray. *Congestion Impacts Analysis of Freight Significant Highway Locations – 2015.* American Transportation Research Institute. Arlington, Virginia. November 2015. Available online: http://atri-online.org/2015/11/18/congestion-impact-analysis-of-freight-significant-highway-locations-2015/

APPENDIX A: STATE CONGESTION TABLE

State	Total Cost	Share of Total Cost	Miles of NHS Segments	Cost per Mile
Alabama	$983,139,939	2.0%	10,079	$97,545
Alaska	$29,438,498	0.1%	2,686	$10,962
Arizona	$463,002,645	0.9%	6,527	$70,937
Arkansas	$572,399,617	1.2%	7,931	$72,175
California	$3,268,924,598	6.6%	20,013	$163,337
Colorado	$694,152,939	1.4%	9,824	$70,658
Connecticut	$810,435,099	1.6%	3,462	$234,061
Delaware	$324,085,044	0.7%	1,001	$323,713
District of Columbia	$62,455,752	0.1%	60	$1,045,978
Florida	$4,632,938,425	9.3%	17,329	$267,354
Georgia	$1,791,108,802	3.6%	15,149	$118,231
Hawaii	$0	0.0%	129	$0
Idaho	$124,476,989	0.3%	5,119	$24,316
Illinois	$2,406,760,528	4.9%	16,482	$146,022
Indiana	$1,133,095,429	2.3%	10,384	$109,117
Iowa	$247,125,834	0.5%	10,564	$23,392
Kansas	$265,813,733	0.5%	10,014	$26,545
Kentucky	$520,344,743	1.0%	6,014	$86,520
Louisiana	$1,084,754,304	2.2%	6,833	$158,756
Maine	$191,936,913	0.4%	3,228	$59,452
Maryland	$1,480,934,307	3.0%	4,762	$310,985
Massachusetts	$1,178,981,930	2.4%	5,616	$209,938
Michigan	$644,587,441	1.3%	10,235	$62,982
Minnesota	$521,630,260	1.1%	12,127	$43,014
Mississippi	$607,308,902	1.2%	7,657	$79,309
Missouri	$1,103,811,575	2.2%	13,257	$83,261
Montana	$124,866,712	0.3%	8,470	$14,742
Nebraska	$206,566,006	0.4%	8,072	$25,589
Nevada	$136,738,939	0.3%	4,766	$28,691
New Hampshire	$250,318,794	0.5%	2,410	$103,866
New Jersey	$2,995,602,210	6.0%	5,692	$526,323
New Mexico	$284,166,056	0.6%	6,268	$45,337
New York	$2,507,749,879	5.1%	15,278	$164,140
North Carolina	$2,039,569,226	4.1%	13,632	$149,616
North Dakota	$97,978,827	0.2%	7,474	$13,109
Ohio	$920,086,079	1.9%	14,407	$63,865
Oklahoma	$407,191,879	0.8%	8,866	$45,929

State	Total Cost	Share of Total Cost	Miles of NHS Segments	Cost per Mile
Oregon	$578,553,721	1.2%	8,723	$66,327
Pennsylvania	$2,161,880,916	4.4%	14,629	$147,782
Rhode Island	$146,901,988	0.3%	1,064	$138,072
South Carolina	$991,880,431	2.0%	8,528	$116,303
South Dakota	$88,683,344	0.2%	7,615	$11,647
Tennessee	$1,380,222,796	2.8%	10,960	$125,929
Texas	$4,119,079,262	8.3%	33,835	$121,739
Utah	$1,098,591,882	2.2%	5,815	$188,915
Vermont	$93,835,564	0.2%	1,810	$51,829
Virginia	$1,189,866,723	2.4%	9,358	$127,156
Washington	$674,667,309	1.4%	7,519	$89,729
West Virginia	$316,877,468	0.6%	3,988	$79,449
Wisconsin	$1,526,754,282	3.1%	12,451	$122,623
Wyoming	$96,882,596	0.2%	6,230	$15,551

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