AMERICAN HIGHWAY USERS ALLIANCE

Unclogging America's Arteries 2015

Prescriptions for Healthier Highways

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CPCS

CPCS Transcom Inc. (CPCS) conducted this study and prepared the final report for the American Highway Users Alliance. CPCS is a management consulting firm specializing in transportation sector strategy, economic analysis, and policy. With more than 100 professionals in 15 global offices, CPCS has an established track record of providing clear, high quality advice to government and corporate clients.

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AMERICAN HIGHWAY USERS ALLIANCE

Since 1932, the American Highway Users Alliance has represented motorists, RV enthusiasts, truckers, bus companies, motorcyclists, and a broad cross-section of businesses that depend on safe and efficient highways to transport their families, customers, employees, and products. Highway Users members pay the fuel taxes and other user fees that fund the federal highway program. We advocate public policies that dedicate highway user revenue to improved safety and mobility.

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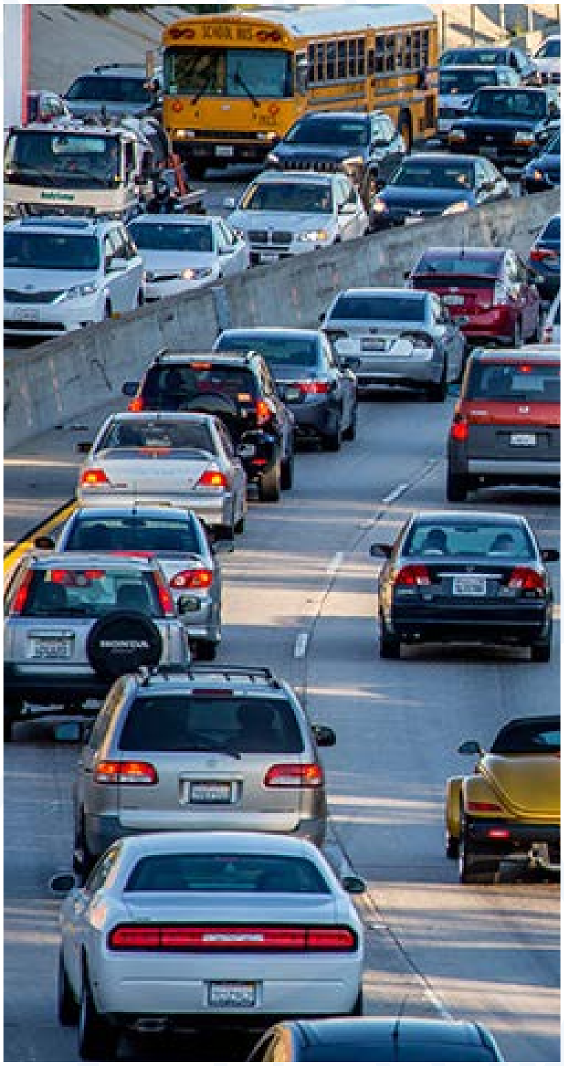
FOREWORD



WHAT IS *UNCLOGGING AMERICA'S ARTERIES 2015*?

Unclogging America's Arteries 2015 utilizes vehicle speed data to identify the 50 worst highway bottlenecks across the nation, highlighting the benefits of improving the top 30. Our nation's top bottlenecks bring passenger and freight traffic to a crawl on key Interstate and freeway facilities every day, across the country, and negatively affect U.S. economic competitiveness, the environment, and quality of life. For drivers of personal and commercial vehicles in affected regions these bottlenecks are very real and the impacts of constant and crushing delays have significant implications on their productivity and health.

Our nation's top bottlenecks bring passenger and freight traffic to a crawl and negatively affect U.S. economic competitiveness, the environment, and quality of life.

HOW DID WE IDENTIFY THE BOTTLENECKS?

To identify the bottlenecks, CPCS Transcom Inc. (CPCS), a management consulting firm specializing in transportation strategy and policy, utilized the latest observed vehicle speed data from the HERE/ATRI data set. This is the same data that is processed into the Federal Highway Administration's (FHWA) National Performance Management Research Data set (NPMRDS), which is then made available to state departments of transportation (DOTs) and metropolitan planning organizations (MPOs). The GPS probe-based data are collected from smartphones, personal navigation devices (PNDs) and vehicles. As part of the analysis, the American Highway Users Alliance and CPCS contacted state DOTs to validate the findings and better understand the nature and precise location of the nation's top bottlenecks.

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FOREWORD

WHAT DOES IT MEAN FOR U.S. ECONOMIC COMPETITIVENESS AND QUALITY OF LIFE?

Some of the bottlenecks stretch for miles, bringing traffic flow to a crawl for many hours of the day—even well outside traditional peak commuting hours. Others are shorter, yet persistently slow—frustrating travelers and adding significant costs to freight deliveries. This situation is untenable for the world's largest economy. To unclog America's arteries will require significant investments—not only in capacity but also in the form of improved operations and technologies to lessen impacts and get traffic moving. This report comes at a critical time: with the U.S. Congress poised to advance the first long-term highway bill since 2005, States will have a much greater ability to plan and implement major congestion relief projects. Reinvesting in our critical infrastructure advances national economic competitiveness, safety, the environment, and quality of life for millions of Americans.

With the U.S. Congress poised to advance the *first long-term highway bill since 2005,* States will have a much greater ability to plan and implement major congestion relief projects.

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EXECUTIVE SUMMARY

SEVERE CONGESTION continues to stymie passenger and freight movement on many of America's critical urban Interstates and freeways. This 2015 update to *Unclogging America's Arteries* identifies the 50 worst highway bottlenecks in the U.S. and demonstrates that the cost of doing nothing is too significant to ignore.[1]

$39 BILLION

Present value of time savings over 20 years if we fix the nation's worst 30 bottlenecks

BOTTLENECKS IMPOSE MASSIVE DELAYS AND COSTS ON U.S. DRIVERS AND BUSINESSES.

This study assessed congestion on urban Interstates and other access controlled highways using observed vehicle speed data from 2014. The top 30 metro-area bottlenecks each cause at least one million hours of delay per year, and three million on average.[2] **The worst bottleneck in Chicago, Illinois experiences nearly 17 million hours of delay per year.** We profile these hotspots in detail. Drivers stuck on these roads altogether experience delays of about 91 million hours every year, the equivalent of 45,500 person-work years.[3] The lost value of time to the economy from congestion in this handful of locations is upwards of $2.4 billion annually—or enough each year to fund several major transportation solutions to alleviate congestion.[4]

SEVERE LOCALIZED BOTTLENECKS STAND OUT.

The top bottlenecks are mostly concentrated in our largest cities. The nation's worst bottleneck is a 12-mile stretch of the Kennedy Expressway (I-90) in Chicago, between the "Circle" Interchange (with I-290) and the Edens Junction (at I-94). It was among the most severe even in 2004, and outranks the others in our 2015 list both in terms of total delays as well as queue length.[5] Eleven of the 30 most severe bottlenecks are in the Los Angeles region, six of them among the top 10. The New York metropolitan area is home to five bottlenecks in the top 30. The I-35 corridor running through downtown Austin, Texas is number 10 on the list with about 3 million hours of annual total delay.

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[1] See our 2004 report. See also Federal Highway Administration (FHWA), Texas A&M Transportation Institute (TTI), and American Transportation Research Institute (ATRI) for a series of relevant studies.

[2] Annual figures assume 260 travel weekdays hours per year. Weekends are not included in our study.

[3] Employed persons on average work 8 hours a day for about 250 days a year, according to the US Bureau of Labor Statistics Time of Use Survey (2014)

[4] Using the average value of a volunteer hour in each state, for 260 weekdays driven in a year. This is likely an underestimate even for this small number of locations.

[5] For ranking bottlenecks, we define our main congestion metric of Daily Total Delay as the cumulative delays experienced by all vehicles entering and leaving a congestion queue in all hours of a representative non-holiday weekday. This metric accounts for both length of the bottleneck (queue length) and expected volume through that bottleneck over a 24-hour period. See Appendix C: Methodology for more details.

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America's Top Bottlenecks in 2015

CONGESTION IS NOT JUST A METROPOLITAN PROBLEM.

Small growing cities and some rural areas also experience high-levels of delays and associated costs. We also identify other bottlenecks in many US states. These congestion zones impose significant costs on local drivers and the local economy.

ALLEVIATING CONGESTION UNLOCKS ECONOMIC, ENVIRONMENTAL, AND SAFETY BENEFITS.

In addition to freeing up drivers' valuable lost time for other productive work or leisure, reduced congestion saves fuel and curbs greenhouse gas emissions. Eliminating congestion in the nation's top 30 bottlenecks alone can save more than 35 million gallons of fuel every year and reduce by about 740 million pounds the CO_2 emitted from both trucks and passenger cars. These benefits roughly amount to 830 million gallons in fuel savings and 17 billion pounds in avoided CO_2 emissions over the next two decades. The present value of time that could be regained is $39 billion.

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EXECUTIVE SUMMARY

12 MILES

The estimated length of the country's worst congestion bottleneck, in Chicago on I-90 between the 'Circle' Interchange and Edens Junction.

TARGETED INVESTMENTS IN TECHNOLOGY AND CAPACITY CAN PROVIDE RELIEF ON THE MOST SEVERE SEGMENTS.

In its 2014 Cost of Congestion report, the American Transportation Research Institute (ATRI) determined that 89 percent of truck-related congestion costs were associated with only 12 percent of road miles traveled.[1] This suggests that efforts can be focused on the most problematic areas. Most of these solutions do not automatically imply large investments in highway capacity additions or mass transit projects. In fact, many solutions are designed to simply make existing capacity more efficient. Information and communications technologies have made it easier than ever before for drivers and system operators to make informed choices, with much of the infrastructure already in place. What is needed is cohesive, systematic thinking with the resolve to infuse resources in cost-effective, high-impact investments.

The available fuel savings for both trucks and passenger cars from eliminating the 30 worst bottlenecks.

35 MILLION GALLONS A YEAR

[1] ATRI (2014). Cost of Congestion to the Trucking Industry. Arlington, Virginia.

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RANKINGS

AMERICA'S TOP 50 BOTTLENECKS

Our study identified the nation's top 50 bottlenecks, listed below.

National Rank	State	Urban Area	Location	Queue Length (miles)	Annual Total Delay (hours)	Annual Lost Value Of Time (US $)	Annual Fuel Wasted / Potential Savings (gallons)
1	Illinois	Chicago	I90 between Roosevelt Rd and N Nagle Ave	12.0	16,900,000	$ 418,000,000	6,370,000
2	California	Los Angeles	I405 between SR22 and I605	4.1	7,100,000	$ 191,000,000	1,819,480
3	California	Los Angeles	I10 between Santa Fe Ave and Crenshaw Blvd	6.9	6,900,000	$ 187,000,000	2,231,840
4	California	Los Angeles	I405 between Venice Blvd and Wilshire Blvd	5.2	6,300,000	$ 169,000,000	1,961,960
5	California	Los Angeles	US101 between Franklin Ave and Glendale Blvd	4.4	5,400,000	$ 146,000,000	1,761,500
6	California	Los Angeles	I110 between Exposition Blvd and Stadium Way	4.3	5,400,000	$ 145,000,000	1,855,880
7	California	Los Angeles	US101 between Sepulveda Blvd and Laurel Canyon Blvd	3.8	3,600,000	$ 96,000,000	1,047,800
8	New York and New Jersey	New York	Lincoln Tunnel between 10th Ave and John F Kennedy Blvd	2.6	3,400,000	$ 87,000,000	1,730,300
9	New York	New York	I95 between I895 and Broadway	3.1	3,000,000	$ 82,000,000	1,545,700
10	Texas	Austin	I35 between East Riverside Dr and E Dean Keeton St	3.0	3,000,000	$ 73,000,000	1,776,320
11	California	Los Angeles	I5/I10 between N Mission Rd and US101	2.0	2,300,000	$ 62,000,000	966,680
12	California	San Francisco	I80 between US101 and Bay Bridge	1.9	2,200,000	$ 59,000,000	797,680
13	California	Los Angeles	I10 between La Brea Ave and National Blvd	2.2	2,100,000	$ 57,000,000	551,720
14	California	Los Angeles	I5 between S Eastern Ave and Euclid Ave	2.0	2,100,000	$ 56,000,000	992,160
15	Massachusetts	Boston	I93 between I90 and US1	1.9	2,100,000	$ 58,000,000	1,980,680
16	California	Oakland	I80 between I580 and Ashby Ave	2.0	1,900,000	$ 50,000,000	691,860
17	Washington	Seattle	I5 between Madison St. and Exit 168A	1.6	1,600,000	$ 45,000,000	619,840

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AMERICA'S TOP 50 BOTTLENECKS (CONTINUED)

National Rank	State	Urban Area	Location	Queue Length (miles)	Annual Total Delay (hours)	Annual Lost Value Of Time (US $)	Annual Fuel Wasted / Potential Savings (gallons)
18	New Jersey	New York	I95 between SR4 and Palisades Interstate Pkwy in Fort Lee	0.9	1,500,000	$ 38,000,000	810,680
19	New Jersey	New York	Pulaski Skyway between I95 and Central Ave in Newark	1.1	1,400,000	$ 36,000,000	856,960
20	Florida	Miami	Palmetto Expy between 41st St. and Dolphin Expy	1.7	1,400,000	$ 30,000,000	647,400
21	New York	New York	I678 between Queens Blvd and Liberty Ave	1.4	1,400,000	$ 37,000,000	512,980
22	Texas	Houston	I610 between Richmond Ave and Post Oak Blvd	1.3	1,300,000	$ 31,000,000	509,340
23	Illinois	Chicago	I90 Between I55 and W Pershing Rd	1.2	1,300,000	$ 31,000,000	678,600
24	Georgia	Atlanta	I75/I85 between Freedom Pkwy NE and North Ave NE	1.3	1,200,000	$ 27,000,000	392,600
25	Texas	Houston	I69/I59 between Hazard St and Buffalo Speedway	1.3	1,100,000	$ 28,000,000	613,080
26	Virginia	Washington, DC	I395 between Washington Blvd and George Washington Memorial Pkwy	1.1	1,100,000	$ 27,000,000	322,660
27	Texas	Dallas	Woodall Rodgers Freeway	1.1	1,100,000	$ 26,000,000	470,860
28	Massachusetts	Boston	I93 between Edge Hill Rd and West St	1.2	1,000,000	$ 28,000,000	362,700
29	California	Los Angeles	I405 between Burbank Blvd and Ventura Blvd	1.0	1,000,000	$ 26,000,000	339,820
30	California	Los Angeles	US101 between SR110 and Alameda St	1.0	1,000,000	$ 26,000,000	434,200
31	New Jersey	New York	US1&9 between Wilson Ave and I78	0.8	800,000	$ 21,000,000	291,720
32	Florida	Miami	Dolphin Expy between 72nd Ave and Palmetto Expy	0.5	800,000	$ 17,000,000	405,080
33	New York	New York	Brooklyn Bridge	0.9	800,000	$ 21,000,000	577,460
34	Texas	Houston	US290 between I610 and Mangum Rd	0.9	800,000	$ 19,000,000	405,860

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AMERICA'S TOP 50 BOTTLENECKS (CONTINUED)

National Rank	State	Urban Area	Location	Queue Length (miles)	Annual Total Delay (hours)	Annual Lost Value Of Time (US $)	Annual Fuel Wasted / Potential Savings (gallons)
35	Colorado	Denver	I25 between Santa Fe Dr and S Logan St	0.8	700,000	$ 18,000,000	356,980
36	Pennsylvania	Philadelphia	I76 at US1 between City Ave and Roosevelt Blvd	0.8	700,000	$ 16,000,000	263,120
37	New Jersey	New York	Pulaski Skyway between Tonnelle Ave and Broadway	0.7	600,000	$ 15,000,000	347,620
38	Virginia	Norfolk	US58 at Martin Luther King Fwy in Portsmouth	0.6	600,000	$ 16,000,000	210,600
39	Florida	Miami	Dolphin Expy between 17th Ave and 22nd Ave	0.6	500,000	$ 11,000,000	158,080
40	California	Los Angeles	I10 between I5 and US101	0.6	500,000	$ 13,000,000	240,240
41	Virginia	Washington, DC	I495 at the Dulles Toll Road	0.5	500,000	$ 12,000,000	146,900
42	New York	New York	Long Island Expressway (I495) near I-278 between 58th St and 48th St.	0.4	400,000	$ 10,000,000	117,260
43	Texas	Dallas	I30 between St. Paul St. and I45	0.4	400,000	$ 9,000,000	174,200
44	Virginia	Washington, DC	I395 from Duke St to halfway between Duke St and Edsall Rd	0.3	300,000	$ 8,000,000	83,720
45	Florida	Tampa	I4 between N 22nd St and N Nebraska Ave	0.4	300,000	$ 7,000,000	191,100
46	Illinois	Chicago	I94 between I90 interchange and N Elston Ave	0.3	300,000	$ 7,000,000	106,860
47	Pennsylvania	Philadelphia	I676 between I76 interchange and N 24th St	0.3	300,000	$ 6,000,000	112,580
48	Texas	Dallas	US75 between N Haskell Avenue and SR366	0.3	200,000	$ 6,000,000	127,920
49	Georgia	Atlanta	T. Harvey Mathis Pkwy between Johnson Ferry Rd NE and I285	0.3	200,000	$ 6,000,000	73,580
50	Massachusetts	Boston	I90 from Dorchester Ave to A St	0.3	200,000	$ 7,000,000	135,720

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ACRONYMS

AADTT	annual average daily truck traffic
AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AHUA	American Highway Users Alliance
ATRI	American Transportation Research Institute
CO_2	carbon dioxide
DMS	Dynamic Message Signs
DOT	Department of Transportation
FFS	free-flow speed
FHWA	Federal Highway Administration
GPS	global positioning system
HOT	high-occupancy toll
HOV	high-occupancy vehicle
HPMS	Highway Performance Monitoring System
ITS	Intelligent Transportation Systems
MPO	metropolitan planning organizations
MTS	maximum throughput speed
NAFTA	North American Free Trade Agreement
NPMRDS	National Performance Management Research Data Set
SR	State Route
TMC	traffic message channel
TTI	Texas A&M Transportation Institute
VMT	vehicle-miles traveled

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CHAPTER 1

Why Assess National Highway Bottlenecks?

- Severe congestion continues to stymie passenger and freight movement on many of America's critical urban Interstates and freeways.
- There is no single cause of traffic congestion and there is no silver bullet for addressing it, but severe congestion must be confronted and can be reduced.
- New empirical GPS probe-based data enables more accurate and precise identification of highway bottlenecks.
- Bottlenecks not only frustrate and anger drivers and diminish our quality of life, but also harm the environment, increase the costs of goods and services, and make roads more dangerous.

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CHAPTER 1

WHAT ARE HIGHWAY BOTTLENECKS AND HOW DO WE FIX THEM?

Bottlenecks are severe traffic chokepoints where demand far exceeds available highway capacity. According to the Federal Highway Administration, recurring bottlenecks account for the largest share of road delay in the nation (40%), far exceeding traffic incidents (25%), inclement weather (15%), construction (10%) or other causes.[1] Each of these scenarios calls for its own set of solutions: for example, prompt crash response is needed after a traffic accident, and proactive snow and ice removal programs (plowing and salting) help the snowbelt states stay safe and mobile during harsh winters. Recurring bottlenecks are the focus of this report.

Fixing bottlenecks requires addressing insufficient capacity. While new construction plays an important long-term role, limited resources and immediate demands often require solutions centered on maximizing the efficiency of existing infrastructure. Like traditional bottleneck removal projects, optimizing existing assets and implementing emerging technologies can also save fuel and time, reducing greenhouse gases and other emissions. Considering the high cost of regulations,[2] congestion reduction solutions may be more feasible, cost-effective, and accepted than some regulatory approaches designed to achieve environmental and energy-savings goals – see the two inset boxes in this chapter on "Optimizing Existing Assets" and "Emerging Technologies and Solutions".

Congestion reduction solutions may be more *feasible, cost-effective, and accepted* than some regulatory approaches designed to achieve environmental and energy-savings goals.

WHAT CAUSES HIGHWAY CONGESTION?

Congestion is a mismatch between capacity and demand on the nation's highways. In other words, congestion occurs when there are many more drivers attempting to drive a stretch of highway than the available capacity of that stretch. Under these conditions, drivers are forced to reduce speed to accommodate a larger number of vehicles. In addition to the number of vehicles, highway design features such as merging lanes, ramps, and reduced visibility around curves also contribute to congestion as they cause drivers to quickly decrease speed. Weather, visual distractions, accidents, construction and maintenance, and special events may further affect the smooth flow of vehicles. In most cases, these factors do not operate in isolation; a number of them interact to exacerbate congestion.[3]

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[1] Federal Highway Administration (FHWA). 2012 Urban Congestion Trends. Accessed Nov 12, 2015. http://www.ops.fhwa.dot.gov/publications/fhwahop13016/index.htm

[2] U.S. Chamber of Commerce, "Assessing the Impact of Potential New Carbon Regulations in the United States", May 2014, http://www.energyxxi.org/assessing-impact-proposed-new-carbon-regulations-united-states

[3] Federal Highway Administration (FHWA). Describing the Congestion Problem. Accessed Nov 8, 2015. https://www.fhwa.dot.gov/congestion/describing_problem.htm

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WHAT ARE THE EFFECTS OF CONGESTION?

Congestion increases the time it takes to get from point A to B, what we commonly refer to as "delays". The lost time impacts both quality of life for individuals and the overall economy. Drivers give up productive work hours, and precious personal and family time. When trucks are stuck in traffic, the goods they are moving become more costly to businesses and consumers. The lost productivity from delayed passenger trips and freight deliveries harms our regional and national economic competitiveness.

Along with delays, congestion increases fuel consumption and greenhouse gas emissions. Cars idling in traffic consume far more fuel than necessary. And vehicles emit more greenhouse gases in congested conditions.

WHY STUDY HIGHWAY CONGESTION...AGAIN?

Severe congestion continues to stymie passenger and freight movement on many of America's critical urban Interstates and freeways. The Federal Highway Administration (FHWA) of the US Department of Transportation (US DOT) estimates that hours of delay per traveler have more than doubled in cities of all sizes since 1982.[3] In its recent 2015 *Urban Mobility Scorecard,* the Texas A&M Transportation Institute (TTI) estimated that congestion caused Americans to spend an extra 6.9 billion hours on travel in 2014. In spite of the 2007 recession, recent economic growth has led to a resurgence in congestion.[4] FHWA forecasts that vehicle-miles traveled (VMT), an indicator of the demand for travel, by light-duty vehicles will grow at about 1% annually over the next two decades. Truck vehicle-miles traveled will grow at over 2% annually over the same 20-year period.[5] Growth in VMT will further exacerbate congestion in the absence of specific actions to mitigate it.

The collection of real-time probe data from smarphones, personal navigation devices (PNDs) and vehicles provides rich insights on highway speeds. Analyses of data collected year-round enable researchers to hone in on the stretches

The Federal Highway Administration (FHWA) estimates that hours of delay per traveler have *more than doubled* in cities of all sizes since 1982.

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[3] Federal Highway Administration (FHWA). Describing the Congestion Problem

[4] Texas A&M Transportation Institute and INRIX. 2015 Urban Mobility Scorecard. Accessed November 12 2015. http://mobility.tamu.edu/ums/media-information/press-release/

[5] Forecast of Vehicle-Miles Traveled. June 2015. https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.pdf

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of highway that routinely experience low speeds, leading to congestion. This empirical approach is a substantial improvement over previous analyses of congestion, including our own 2004 study, which relied heavily on mathematical models to estimate speeds. The new empirical GPS probe-based data enables more accurate and precise identification of highway bottlenecks.

In many parts of the country, transportation agencies have begun to rely on similar empirical data to identify localized bottlenecks. Our study does not intend to replace these local efforts; instead it makes visible the most severely congested stretches of the nation's highways—or the segments we identified that incur more than one million hours of annual delay. By focusing on the nation's most intensely congested segments, this report is intended to help direct resources to solutions that could add the most value in relieving congestion. This report also reinforces state-level efforts to address the most congested areas.

We identify the *top 50 bottlenecks* across the country that result in severe cumulative delays on the average commuting weekday, and present detailed validated profiles for the top 30 of these bottlenecks.

OBJECTIVE: IDENTIFYING THE NATION'S TOP BOTTLENECKS

Highway bottlenecks are stretches of highway that are routinely and consistently congested. The delays in these stretches are more than just a peak-period or rush hour problem. The large number of vehicles passing through bottlenecks experience severe delays, over the 24-hour course of a weekday. Even though bottlenecks are commonly associated with gridlocked conditions, there are many stretches of highway where even minor delays of a few minutes per vehicle add up across the many vehicles traveling those stretches. For example, in its 2014 Cost of Congestion report, the American Transportation Research Institute (ATRI) determined that 89 percent of truck-related congestion costs

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were associated with only 12 percent of the road miles. The case for passenger vehicles is analogous. As in our 2004 study, this 2015 update identifies the nation's worst urban area bottlenecks, but this study uses a new GPS probe methodology. Delay figures from the previous study cannot be directly compared to those in this report.

The following key questions drove our research and choice of methods:

1. **How should bottlenecks be identified and classified? What is an appropriate metric for ranking them nationally?**
2. **What are the main characteristics of the nation's top bottlenecks, including cost impacts as well as the potential benefits of eliminating them? How are these hotspots being addressed?**
3. **What are some important secondary bottlenecks that are worth highlighting?**
4. **What mechanisms and solutions could be deployed to mitigate congestion?**

METHOD

Our chosen method allows us to systematically compare and rank highway bottlenecks nationwide. We relied on vehicle speed data from the HERE/ATRI data set. With assistance from ATRI and HERE, we processed the data to develop weekday speed profiles for over 350,000 urban highway segments across the nation. Delay estimates were generated by comparing the observed speed profile for each highway segment to an ideal speed profile for the same segment. Delay estimates were then adjusted for the relative lengths of highway segments, as well as the estimated volume of vehicles (both cars and trucks) on those segments. The resulting delay metric is Daily Total Delay, measured in hours. Appendix C contains details of the steps we followed, and the mathematical formulations we used to develop our delay estimates for the national ranking. The mathematical relationships for cost impacts and benefits calculations were drawn from peer-reviewed and published materials, which we cite accordingly.

We sought *detailed feedback* from state DOTs and representative regional organizations to validate our own findings.

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We expected to see slight differences in the precise locations and estimated lengths of the top-ranking bottlenecks in our own analysis and the detailed congestion studies of state DOTs due to differences in data and methods. For this reason, we sought detailed feedback from state DOTs and representative regional organizations to validate our own findings. We leveraged local knowledge to prepare the profiles for the top 30 bottlenecks, shown in Chapter 2.

ORGANIZATION OF THIS REPORT

The rest of this study report is structured as follows. Chapter 2 presents the nation's top 30 bottlenecks. A national map depicts these visually, and profile pages summarize the characteristics of the individual bottlenecks including the associated costs of congestion. Chapter 3 presents details on the benefits available from alleviating congestion from the top 30 bottlenecks. Several "success stories" highlight the impact of critical highway investments over the last decade and show that these benefits are achievable. The report culminates with a discussion of solutions for congestion relief—including approaches and technologies to make better use of existing highway capacity. Finally, in a series of appendices we summarize the characteristics of the top 50 bottlenecks, secondary bottlenecks in a number of states, and a detailed description of our data and methodology.

Optimizing Existing Assets

Opportunities for improving the efficiency of our existing highway system range from communications (e.g., traffic advisories) to full-scale reconstruction projects (e.g., rebuilding a bridge or interchange). This spectrum also includes highly cost-effective access control devices, and complex traffic management strategies that are worthy of their own field of study.

Below are some key examples that have been successful across the country.

Information/communications: Congestion countermeasures in this category include the 511 traveler information system, as well as highway advisory radio stations and Dynamic Message Signs (DMS) that provide real-time travel information. Together, these systems manage congestion by maximizing the capacity available by highlighting alternate routes; reducing demand on the network by encouraging drivers with flexible schedules to delay travel until congestion clears; and alerting motorists driving towards bottlenecks of stopped vehicles, thereby reducing

> **... the 511 traveler information system, as well as highway advisory radio stations and Dynamic Message Signs (DMS) provide real-time travel information.**

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crashes. The Federal Communications Commission assigned 511 for this purpose in 2000, and the 511 Deployment Coalition – led by the US Department of Transportation (DOT), American Association of State Highway and Transportation Officials (AASHTO), American Public Transportation Association, and Intelligent Transportation Systems (ITS) Joint Program Office – has since been active to help spread its implementation.[1] Additionally, the Federal Highway Administration (FHWA) encourages the use of DMS to provide timely travel information, especially in areas that experience recurring bottlenecks.[2]

Navigation and Guidance: Access to turn-by-turn route guidance from in-vehicle, portable, and mobile navigation devices has had a dramatic impact on how we move. The enhancement of real-time traffic flow and incident data enables drivers to reroute around congestion and accidents in real-time. Navigation continues to improve with more predictive and personalized information enabling safer and more efficient journeys.[3]

Access to turn-by-turn route guidance from in-vehicle, portable, and mobile navigation devices has had a dramatic impact on how we move.

Access control: Ramp metering on freeways has been estimated to have a benefit-cost ratio of up to 15 to 1, given improved travel times and reductions in crashes and excess emissions.[4] These simple devices stagger merging traffic onto a freeway so that mainline vehicle flow doesn't collapse. Relatively simple systems alternate between red and green lights on on-ramps at set intervals; more complex setups can dynamically adjust timing based on conditions and detection of new vehicles.[3]

According to FHWA, properly-managed lanes are expected to save drivers 30 seconds per mile.

Managed lanes: This category can include any type of travel lane that is operated dynamically according to time-of-day or travel conditions, in order to increase capacity where and when it is needed. Examples include high occupancy vehicle (HOV) lanes that are only available to vehicles with multiple passengers during periods of peak traffic (generally inbound during the morning rush and outbound in the evening); high occupancy toll (HOT) lanes that drivers can elect to pay to use for reduced travel time; dynamic use of paved shoulders as travel lanes during peak travel or to add capacity around an incident; contra-flow lanes, and reversible express lanes. According to FHWA, properly-managed lanes are expected to save drivers 30 seconds per mile.[5]

continued ▶

[1] http://www.ops.fhwa.dot.gov/511/about511/history.htm

[2] http://www.ops.fhwa.dot.gov/travelinfo/resources/cms_rept/travtime.htm

[3] http://360.here.com/2015/04/08/jaguar-land-rover-here-auto/

[4] http://www.ops.fhwa.dot.gov/publications/fhwahop14020/sec1.htm

[5] http://www.ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/revision/jan2011/mgdlaneschp8/sec8.htm

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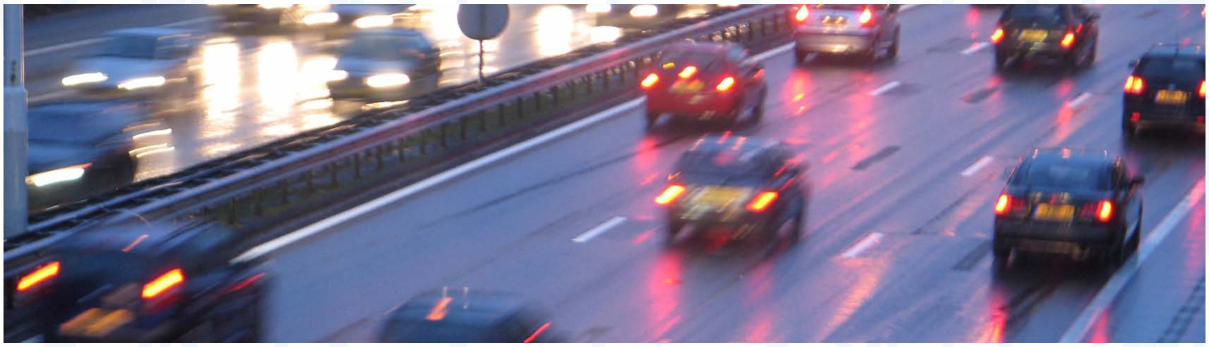
> **Adding capacity does not always involve building new roads or adding lane-miles to existing highways.**

Physical improvements: Adding capacity does not always involve building new roads or adding lane-miles to existing highways. Design standards are constantly evolving, and older roads – even some on the Interstate system – were built for lower volumes of slower vehicles. In some cases, capacity can be increased by upgrading design features, realigning tight curves or steep grades, improving visibility, repaving and restriping surfaces, reconfiguring merges and interchanges, or rebuilding common chokepoints like outdated bridges.

Emerging Technologies and Future Possibilities

Transportation researchers and policymakers are increasingly looking to new technologies and systems that have the potential to overhaul the efficiency of the nation's road network and provide lasting, long-term improvements. In fact, Intelligent Transportation Systems (ITS) technologies have emerged as a leading priority for research, evaluation, and implementation, with expected benefits ranging from dramatic safety gains to elimination of barriers to lifelong independent mobility for all.[6] ITS broadly refers to a range of technologies that allow for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications – together called "V2X."

Intelligent Transportation Systems (ITS) technologies have emerged as a *leading priority* for research, evaluation, and implementation.



V2V advancements, in which smarter vehicles are more "aware" of their , hold promise to increase highway capacity, improve safety and reduce greenhouse gas emissions. For example, the next generation of advanced, adaptive cruise control may allow vehicles to safely platoon, closer together, and at higher speeds. Similar technology could also lead to vehicles merging onto and off of freeways without braking — causing less traffic disruption and getting more efficiency through bottlenecks. Existing V2V technologies, such as active

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[6] Intelligent Transportation Systems Joint Program Office Strategic Plan, has not accessed Nov 12 http://www.its.dot.gov/strategicplan.pdf

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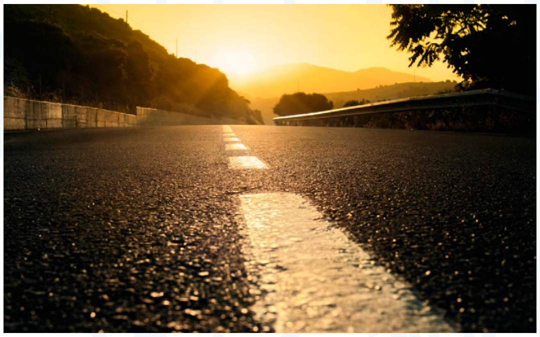
emergency braking and blind spot warning systems, are already preventing rear-end and side swipe collisions that traditionally cause hundreds, if not thousands, of daily traffic jams.

Overall, technological solutions that connect vehicles to each other, and to infrastructure, hold the promise of reducing congestion caused by accidents, relieving recurring bottlenecks, and sharply reducing the emissions associated with these delays. Due in part to lower gasoline prices, many vehicle manufacturers continue to report difficulty getting customers to buy the vehicles they need to sell to meet EPA greenhouse gas targets.[7] But the potential for emission-reducing V2X technologies could create another, more commercially successful path to fuel savings and greenhouse gas reductions.



The US DOT estimated that the societal benefits from a subset of seven existing ITS technologies – as measured by improvements in mobility, safety, emissions, and fuel consumption – *exceeded $2.3 billion.*

While ITS may conjure futuristic images of cities teeming with self-driving cars, many examples of V2I are already easily found. In fact, a 2010 study by the US DOT estimated that the societal benefits from a subset of seven existing ITS technologies – as measured by improvements in mobility, safety, emissions, and fuel consumption –exceeded $2.3 billion.[8] These technologies included electronic toll collection, which greatly speeds traffic through toll booths; ramp metering; traffic signal coordination, which has the potential to address the estimated 75% of U.S. traffic lights whose synchronization needs improvement;[9] and the traveler information systems that feed the previously-discussed DMS. Some truck fleets have implemented automatic transmission shifting in trucks using advanced maps and real-time data to reduce fuel consumption and emissions and to enhance truck safety.[10] In some instances, these and other technologies have enabled another emerging approach to bottleneck mitigation: congestion pricing. Essentially a demand-management strategy, congestion pricing relies on ITS technologies to assess travel conditions and adjust prices (e.g., of a HOT lane) dynamically. In the United States, public support for pricing has been strongest when used on new lanes, new roads, or underutilized HOV lanes. Proposals to price existing, untolled, general-purpose lanes have met with opposition and have generally not been successful in the U.S.[11] [12]

[7] Hybrid and Electric Vehicles Struggle to Maintain Owner Loyalty, Reports Edmunds.com, April 21, 2015 http://www.edmunds.com/about/press/hybrid-and-electric-vehicles-struggle-to-maintain-owner-loyalty-reports-edmundscom.html

[8] http://ntl.bts.gov/lib/34000/34900/34991/ITS_Deployment_Tracking_FINAL_508C_101210.pdf

[9] https://www.fhwa.dot.gov/congestion/toolbox/service.htm

[10] http://360.here.com/2014/12/10/continental-map-road-future-ces/

[11] The New York Times, April 8, 2008, http://www.nytimes.com/2008/04/08/nyregion/08congest.html?_r=0

[12] The Wilson Times, October 10, 2012. http://www.wilsontimes.com/News/Feature/Story/14297309 — THE-ROAD-WARRIORS

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CHAPTER 2

America's Top Bottlenecks

- Thirty of America's most severe urban bottlenecks impose about 91 million hours of delay on drivers each year, the equivalent to 45,500 person-work years.
- Most of the top 30 bottlenecks are located in the largest metropolitan areas in the U.S. The Los Angeles and New York City regions have the greatest concentration of top 30 bottlenecks while Chicago features the single most severe bottleneck in this ranking.
- The lost value of time to the economy from congestion in just this handful of locations is upwards of $2.4 billion annually.
- Major freight bottlenecks impose substantial costs on the freight and trucking industry, and place significant strains on truck drivers.

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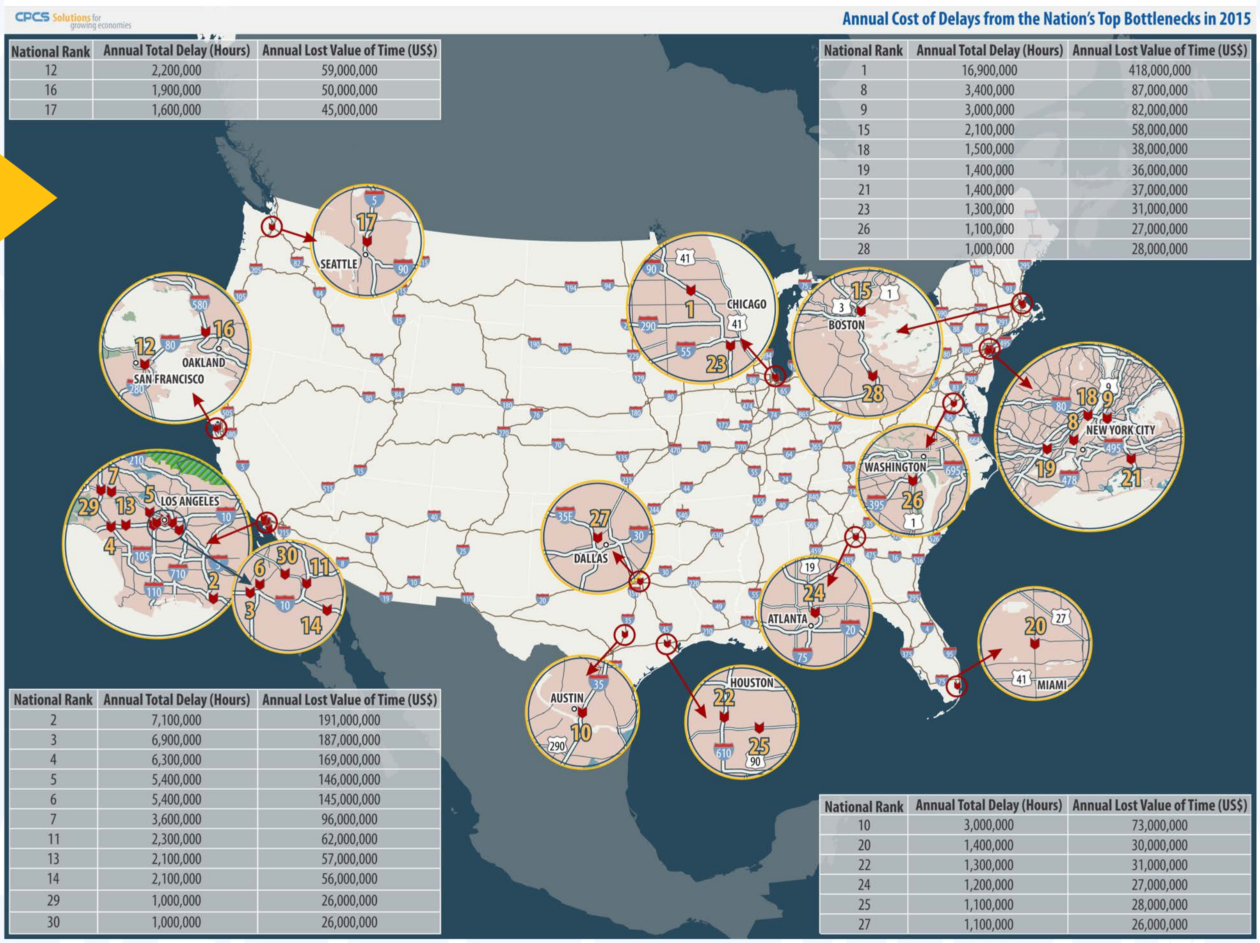
Our study identified the 50 most severe highway bottlenecks around the country. We highlight and profile the top 30 of these in this chapter. Appendix A of this report contains the full list of 50. We also include at the end of this chapter a separate list of major freight bottlenecks that impose substantial costs on the freight and trucking industry in particular. Many of these freight bottlenecks coincide with major bottlenecks on our top 30 list, which covers all vehicles classes.

The map of the Interstate Highway System shows the locations of the top 30 bottlenecks in magnified insets. Both the annual total delays (hours), based on the daily total delays metric we used for ranking, and the associated annual lost value of time (in US $) – for each bottleneck appear in the inset tables.

Annual Cost of Delays from the Nation's Top 30 Bottlenecks



National Rank	Annual Total Delay (Hours)	Annual Lost Value of Time (US$)
12	2,200,000	59,000,000
16	1,900,000	50,000,000
17	1,600,000	45,000,000

National Rank	Annual Total Delay (Hours)	Annual Lost Value of Time (US$)
1	16,900,000	418,000,000
8	3,400,000	87,000,000
9	3,000,000	82,000,000
15	2,100,000	58,000,000
18	1,500,000	38,000,000
19	1,400,000	36,000,000
21	1,400,000	37,000,000
23	1,300,000	31,000,000
26	1,100,000	27,000,000
28	1,000,000	28,000,000

National Rank	Annual Total Delay (Hours)	Annual Lost Value of Time (US$)
2	7,100,000	191,000,000
3	6,900,000	187,000,000
4	6,300,000	169,000,000
5	5,400,000	146,000,000
6	5,400,000	145,000,000
7	3,600,000	96,000,000
11	2,300,000	62,000,000
13	2,100,000	57,000,000
14	2,100,000	56,000,000
29	1,000,000	26,000,000
30	1,000,000	26,000,000

National Rank	Annual Total Delay (Hours)	Annual Lost Value of Time (US$)
10	3,000,000	73,000,000
20	1,400,000	30,000,000
22	1,300,000	31,000,000
24	1,200,000	27,000,000
25	1,100,000	28,000,000
27	1,100,000	26,000,000

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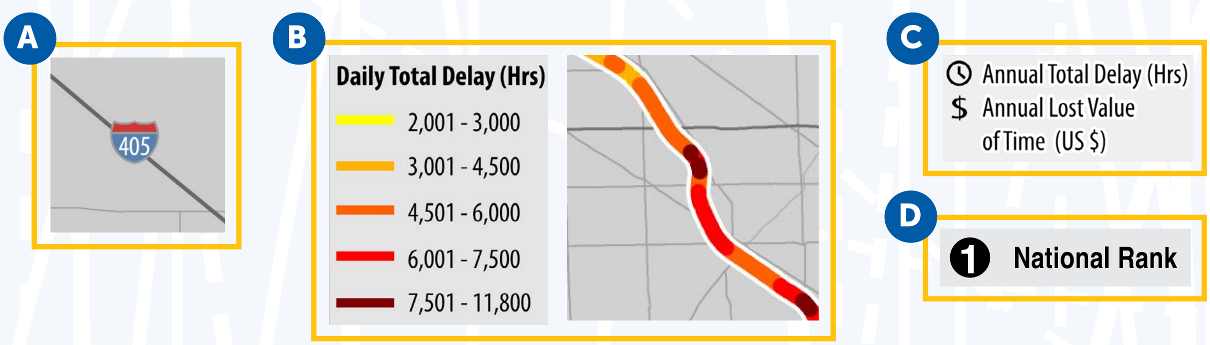
CHAPTER 2

The top 30 bottlenecks are each responsible for *more than one million hours of lost time annually.*

The top 30 bottlenecks are each responsible for more than one million hours of lost time *annually.* Drivers stuck on these roads experience total delays of about 91 million hours every year, the equivalent of 45,500 person-work years.[1] The lost value of time to the economy from congestion just in this handful of locations is upwards of $2.4 billion annually.[2]

Most of the top 30 bottlenecks are located in the largest metropolitan areas in the U.S. Los Angeles and New York City have the greatest concentration of top 30 bottlenecks while Chicago features the single most severe bottleneck in this ranking. Most of the country's largest cities are affected by at least one of the top bottlenecks. Fast-growing Austin, Texas, with a metropolitan population of 2 million, is the smallest city with a top bottleneck: I-35 near downtown Austin, which ranks 10th nationally.[3]

The top 30 bottlenecks are profiled in detail in this chapter, organized by metro area. Each map shows urban freeways using standard symbols such as the one for Interstate highways (**A**) on a gray or neutral background. Bottleneck queues or congestion corridors (**B**) are color coded according to the adjoining legend (**B**), with lighter colors for lower levels of Daily Total Delays (measured in hours of cumulative delay) and darker colors for the highest, most severe delays. For longer queues, multiple highway segments may be included, with their color code indicating the delays contributed by those specific sections (**B**). The total annual cost impact of each bottleneck, both in annual total delays (hours) and annual lost value of time (US $) (**C**), are indicated with the adjoining clock and $ symbols. Finally, the national rank (**D**) of a bottleneck is shown in a black circle, indicating its relative position among the national top 30.



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[1] Employed persons on average work 8 hours a day for about 250 days a year, according to the US Bureau of Labor Statistics Time of Use Survey (2014)

[2] Using the average value of a volunteer hour in each state, for 260 non-holiday weekdays driven in a year. This is likely an underestimate even for this small number of locations.

[3] U.S. Census Bureau 2014 Metropolitan and Micropolitan Statistical Areas Population Estimates

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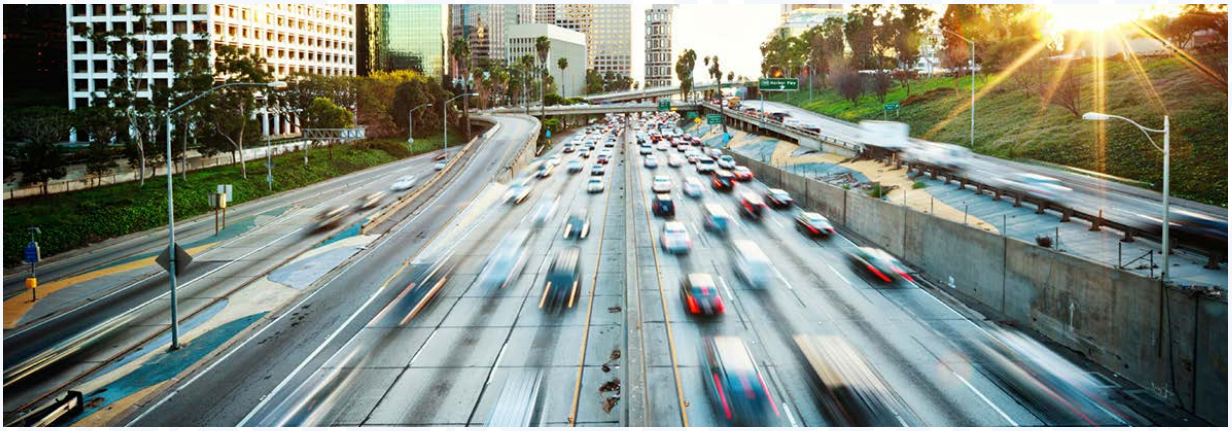

Drivers around the country who are intimately familiar with these bottlenecks will appreciate the costs of congestion not only measured in lost time (delays), but also the lost value of that time, and the value of wasted fuel.

Because we used a cumulative delay metric (see Appendix C) that accounts for both length of the highway segments as well as the number of vehicles that typically drive through the congested areas, our results may differ from those of other studies. Yet, through an extensive validation process we vetted our findings with state Departments of Transportation (DOTs) to conclude that the bottlenecks in this study consistently overlap with some of the most problematic areas identified by local transportation agencies. Drivers around the country who are intimately familiar with these bottlenecks will appreciate the costs of congestion not only measured in lost time (delays), but also the lost value of that time, and the value of wasted fuel.

CHICAGO (#1 AND #23)

America's most severe bottleneck is on the Kennedy Expressway (I-90), the main access route to the city of Chicago from its north and northwest suburbs. This is the stretch of I-90 between Roosevelt Road near the Jane Byrne / "Circle" Interchange (I-290) at one end[4] and Nagle Avenue beyond the Edens Junction (I-94) junction at the other. Congestion occurs throughout the day in both directions, causing daily total delays on this 12-mile stretch to add up to almost 17 million hours annually. The lost value of time across all drivers experiencing delays amounts to $418 million every year. Two reversible

The lost value of time across all drivers in the nation's worst bottleneck amounts to *$418 million every year.*

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[4] http://www.circleinterchange.org/

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highway lanes, the Blue subway line, and a Metra rail link servicing this corridor alleviate congestion marginally; however, this bottleneck remains the most severe nationally. This segment is currently being evaluated for the potential of congestion pricing, active lane management, and other various "smart highway" technologies in an effort to better address congestion and maximize existing capacity.

Chicago's other bottleneck in the top 30 occurs on the stretch of I-90 called the Dan Ryan Expressway between W Pershing Road and the Stevenson Expressway (I-55). Ranked #23, this bottleneck produces about 1.3 million hours of annual total delays and about $31 million in associated lost value of time. The nearby interchange connects these two major freeways entering Chicago from the south and southwest suburbs. A major $134 million bridge rehabilitation and replacement project between the Dan Ryan Expressway and Lake Shore Drive requires lane closures and causes delays.[5] This bridge rehabilitation project and another managed lane projects in the I-55 corridor are expected to relieve congestion in this zone in the future.

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[5] http://www.idot.illinois.gov/projects/I55-at-LSD

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LOS ANGELES (#2, #3, #4, #5, #6, #7, #11, #13, #14, #29, AND #30)

The Los Angeles metropolitan area is home to 11 of the nation's top 30 bottlenecks, and six of these are among the 10 worst. Ten of the 11 LA area bottlenecks are located in Los Angeles County, whereas the single most severe of the 11 (ranked at #2 nationally) is on I-405 in Seal Beach, Orange County. In sum, these 11 bottlenecks are responsible for about 44 million hours, or slightly less than 50% of the daily total delays of the entire top 30 list. The lost value of this time is $1.17 billion annually.

These eleven bottlenecks are responsible for about 44 million hours, or slightly less than 50% of the daily total delays of the entire top 30 list.

The Seal Beach area bottleneck, occupying the #2 spot on our list, extends along a four-mile stretch of the San Diego Freeway (I-405) between I-605 and the Garden Grove Freeway (SR 22). In 2014, this bottleneck resulted in about 7.1 million hours of delays valued at $191 million. A project to directly connect High Occupancy Vehicle (HOV) lanes before and after the I-405/I-605 interchange was completed recently. This alleviates congestion somewhat because it eliminates the need for vehicles to exit and re-enter HOV lanes around the interchange. The Orange County Transportation Authority (OCTA) has planned

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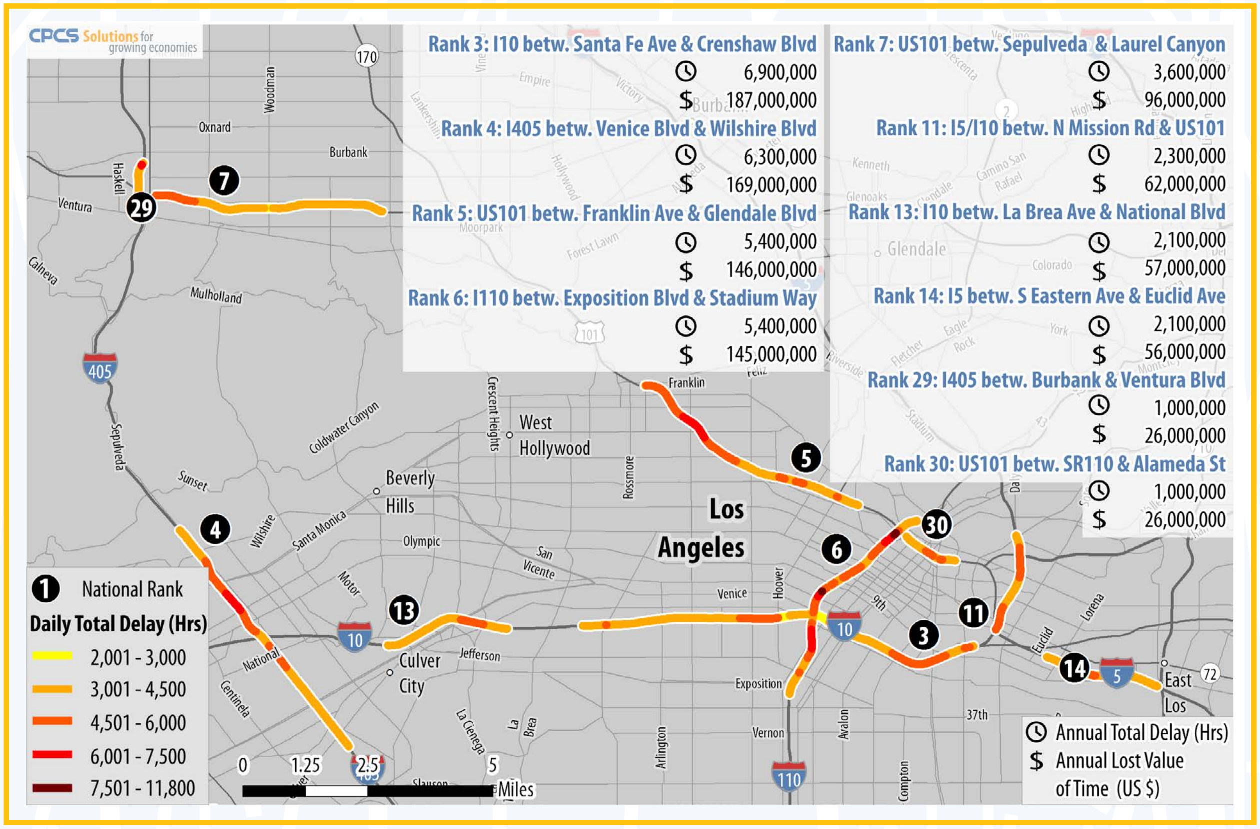
an extensive I-405 widening project, which will include additional general-purpose and managed toll lanes, further relieving congestion after it is completed.[6]

The ten bottlenecks in LA County range from queue lengths of about one to seven miles, and between one million to seven million hours of delays annually. They occur along the following stretches:

- I-10 (Santa Monica Freeway, #3) in downtown LA that provides access to the Convention Center, Staples Center and the downtown area; and between La Brea Ave and National Boulevard where there are many lane merges and divergences[7] (#13).
- I-405 in West LA between Venice and Wilshire Boulevards (#4) where the number of lanes drops from five to four with heavy merging and diverging traffic with I-10. The closely spaced ramps to Wilshire and Santa Monica Boulevards provide access to the nearby tourist attractions, state beaches and neighborhoods exacerbate the congestion. An HOV lane was recently added to reduce congestion in the general purpose lanes.



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[6] http://www.octa.net/Projects-and-Programs/All-Projects/Freeway-Projects/San-Diego-Freeway-%28I-405%29/I-405-%28SR-73-to-I-605%29/?frm=7135

[7] Lane divergences are the locations where lanes separate, for example at a fork or near a ramp. Reduced speeds could cause congestion, as drivers slow down to change lanes or transfer onto a ramp.

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- The Hollywood Freeway, US 101, between Franklin Avenue and Glendale Boulevard (#5), which serves adjacent residential and commercial areas. This zone has an active construction project near Universal Studios.
- The Harbor Freeway (I-110) in downtown LA between Exposition Boulevard and Stadium Way (#6). This three lane freeway runs through the heart of downtown, with some 12 on- and off-ramps in a two and a half mile stretch and two major interchanges.
- The US 101 Freeway between Sepulveda and Laurel Canyon (#7) leading up to the I-405 interchange. Two of six lanes in this stretch were lost to the I-405 connector.
- The merged I-5/I-10 section between US-101 and N. Mission Road (#11).
- The Golden State Freeway (I-5 between S. Eastern Avenue and Euclid Ave, #14), which connects to I-710, the main Long Beach Harbor truck route and commercial and industrial districts in the City of Commerce. Two lanes in this area were lost to the I-710 connector.
- The I-405 Freeway between Burbank and Ventura Boulevards (#29) in the Valley.
- The US 101 Freeway / Downtown Slot (#30) between SR-110 and Alameda Street, near a four-level interchange and many on- and off-ramps for the downtown area.

Caltrans, the department of transportation for the state of California, conducts its own detailed bottleneck studies using local sensor data from the Caltrans PeMS system. Their detailed analysis is published in a series or quarterly and annual Mobility Performance Reports.[8]

NEW YORK METRO AREA (#8, #9, #18, #19, #21)

The New York metropolitan area is home to five bottlenecks in the top 30, two of which are in the top 10. The Lincoln Tunnel, between 10th Avenue in Manhattan and Kennedy Boulevard in New Jersey ranks at #8. Drivers using the tunnel experience an annual total delay of 3.4 million hours, worth $87 million in lost time. At #9 is the Cross Manhattan Expressway ("under the apartments") and Cross Bronx Expressway, a three mile stretch of I-95 from Broadway to I-895 east of the George Washington Bridge. This segment also experiences about 3 million hours of delays and about $82 million in lost time annually.

continued ▶

[8] http://www.dot.ca.gov/hq/traffops/mpr/stats.html

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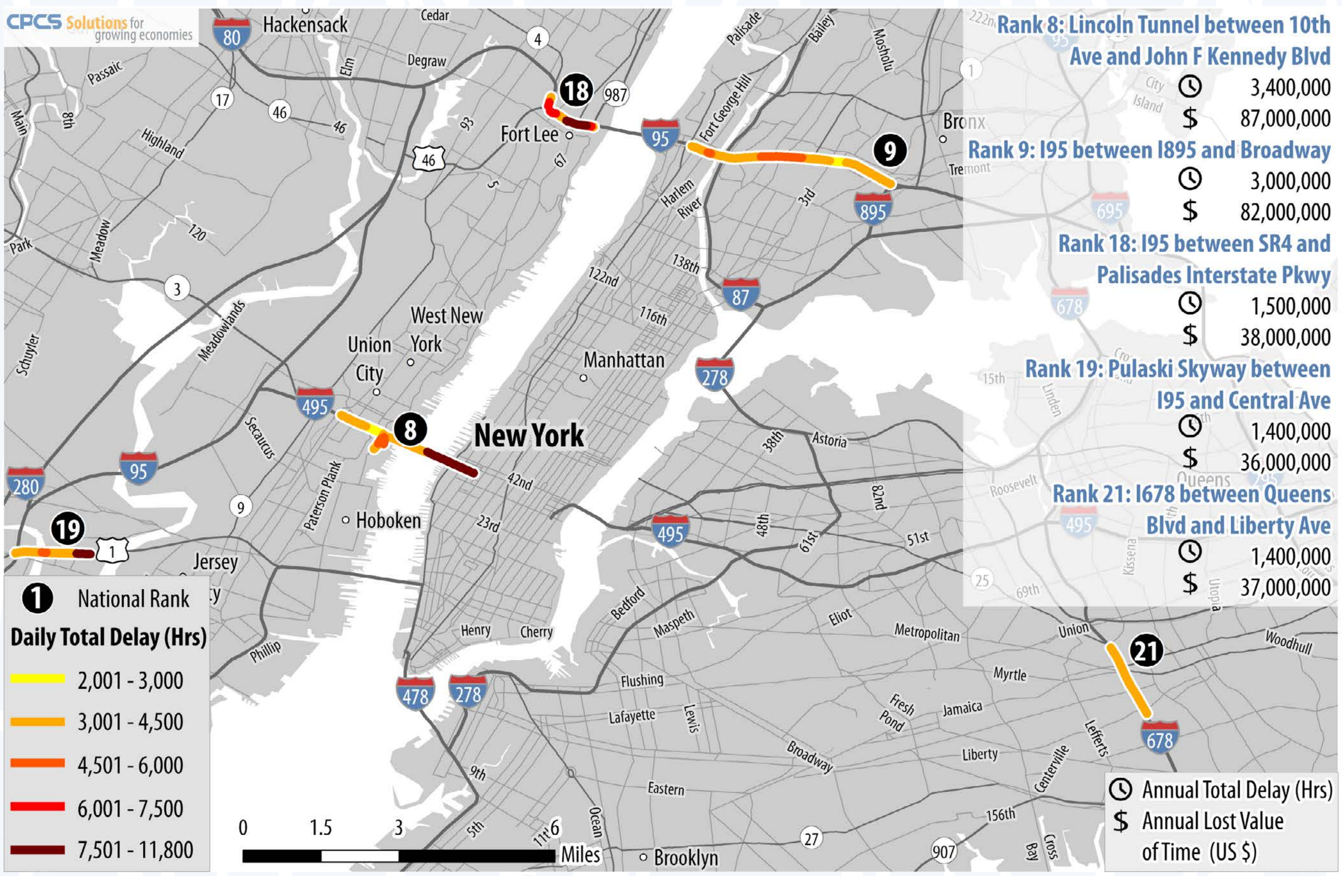
The other top-ranking bottlenecks in this area have around 1.4 to 1.5 million hours of delays, and between $36 million – $38 million in lost time:

- The mile-long section of I-95 west of the George Washington Bridge between the Palisades Parkway and SR-4 (#18), in New Jersey.
- The Pulaski Skyway in New Jersey between I-95 and Central Avenue, also about one mile long (#19).
- A mile-and-a-half section of the Van Wyck (I-678), between Queens Boulevard and Liberty Avenue.

The New York area Expressways have a high concentration of trucks, due to the lack of freight tunnels into Manhattan.

Other notable New York area bottlenecks that just miss the top 30 list include US1/US9 near I-78 in Newark (#31), the Brooklyn Bridge (#33), US 1/US 9 near I-78 in Jersey City (#37), and the Long Island Expressway I-495 / I-278 Brooklyn-Queens Expressway interchange in Queens (#42).



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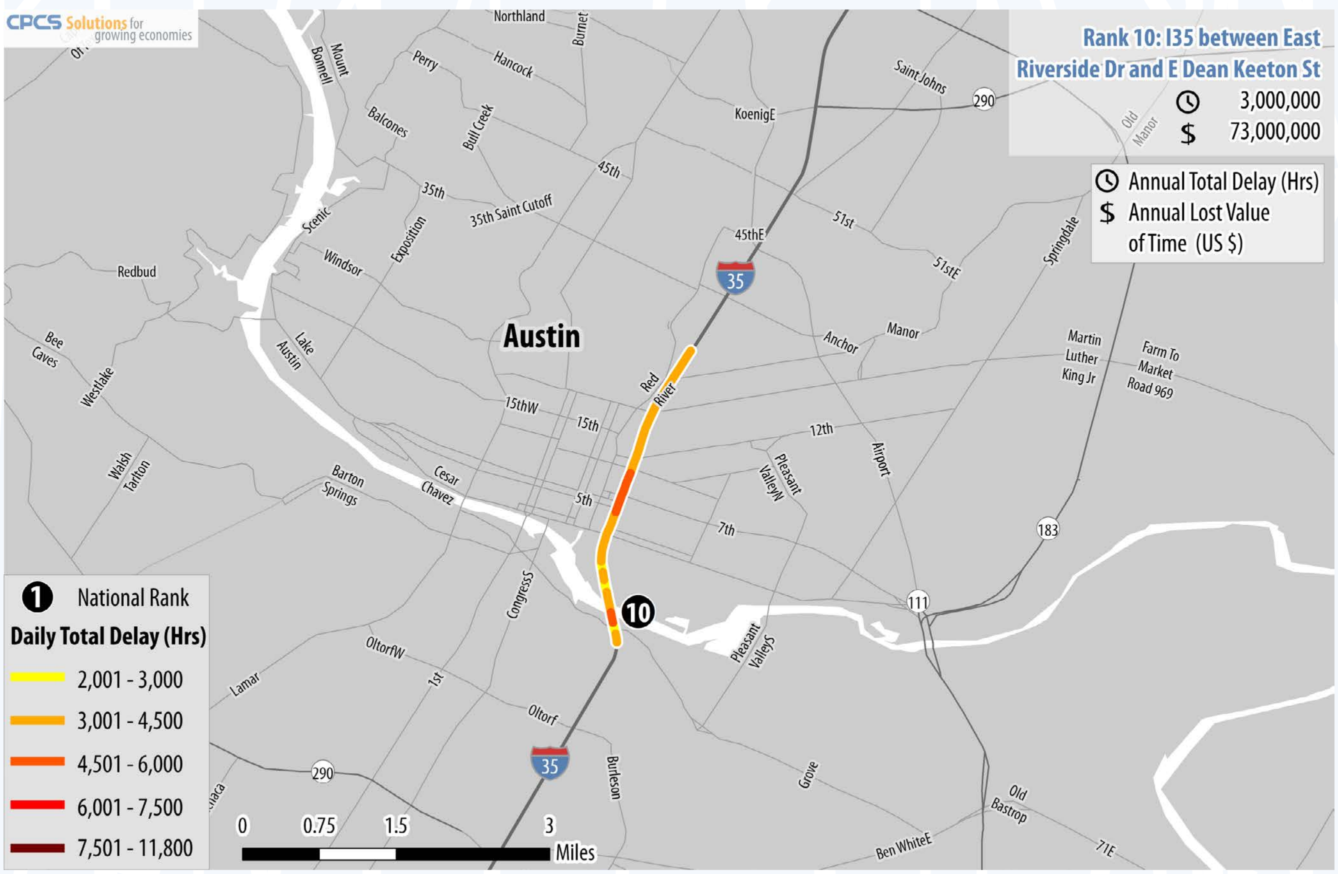
AUSTIN (#10)

The three-mile long section of I-35 in downtown Austin between East Dean Keeton and East Riverside Drive ranks at #10 on the list of top bottlenecks, higher than those in many metro areas around the country, including Texas' other big metros of Dallas and Houston. The I-35 corridor is vital to both passenger and freight traffic and carries the highest percentage of trucks (12 percent) of any of the top 30 bottlenecks.[9] Not only is this section critical to regional and international trade with Mexico under the North American Free Trade Agreement (NAFTA), it provides access to the University of Texas, the Texas Capitol, and the central business and entertainment districts. Annual total delays from this bottleneck amount to 3 million hours at a lost value of time of about $73 million a year.

The three-mile long section of I-35 in downtown Austin ranks at #10 on the list of top bottlenecks, higher than those in Texas' other big metros of Dallas and Houston.



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[9] http://opendata.arcgis.com/datasets/36073ad6180e4f5fb8e56ba36f639147_0
And http://www.txdot.gov/apps/statewide_mapping/StatewidePlanningMap.html

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SAN FRANCISCO BAY AREA (#12 AND #16)

The San Francisco Bay area is home to two major bottlenecks on the top 30 list. At #12 is a section of I-80 between US-101 and the western foot of the San Francisco-Oakland Bay Bridge. This section is about two miles long and produces about 2.2 million hours of annual total delay. The value of lost time is relatively high for this level of delay, at about $59 million annually, reflecting the high wages of commuters in this region. The other two-mile bottleneck, ranked #16, is at the other end of the Bay Bridge in Oakland. It stretches between the eastern foot of the Bay Bridge and Ashby Avenue on a section of I-80 that provides access to the town of Berkeley. This bottleneck's annual total delays are slightly lower at 1.9 million hours. Various components of the I-80 Integrated Corridor Mobility (ICM) SMART Corridor project are currently under construction in this area.[10]

The value of lost time is relatively high for this level of delay, at about *$59 million annually.*

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[10] http://80smartcorridor.org/

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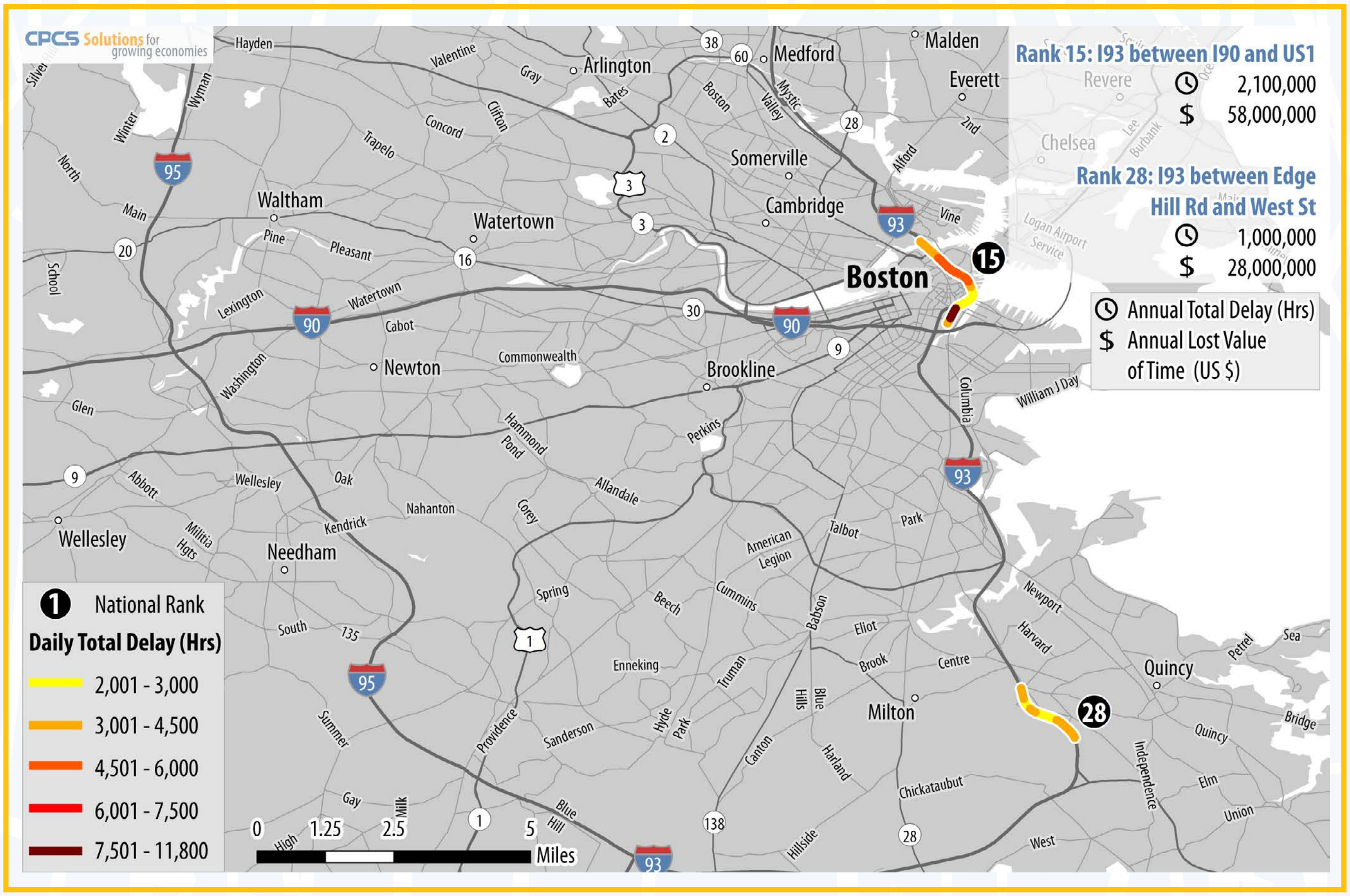
BOSTON (#15 AND #28)

Boston's two nationally ranked bottlenecks are both located on the I-93 corridor. The bottleneck on I-93 between I-90 and US-1 causes about 2.1 million hours of annual total delays, or a lost value of $58 million. This bottleneck is in the heart of Boston along the site of the previous Central Artery and Tunnel project (CA/T) between the Zakim Bunker Hill Bridge and the I-90 / I-93 interchange near South Station. The second bottleneck in this area, at #28 on the list, is between Edge Hill Road and West Street on I-93 before it intersects with the Pilgrim's Highway, which provides access to Boston from its southern coastal suburbs, or South Shore.

The bottleneck on I-93 between I-90 and US-1 causes about 2.1 million hours of annual total delays, or a *lost value of $58 million.*



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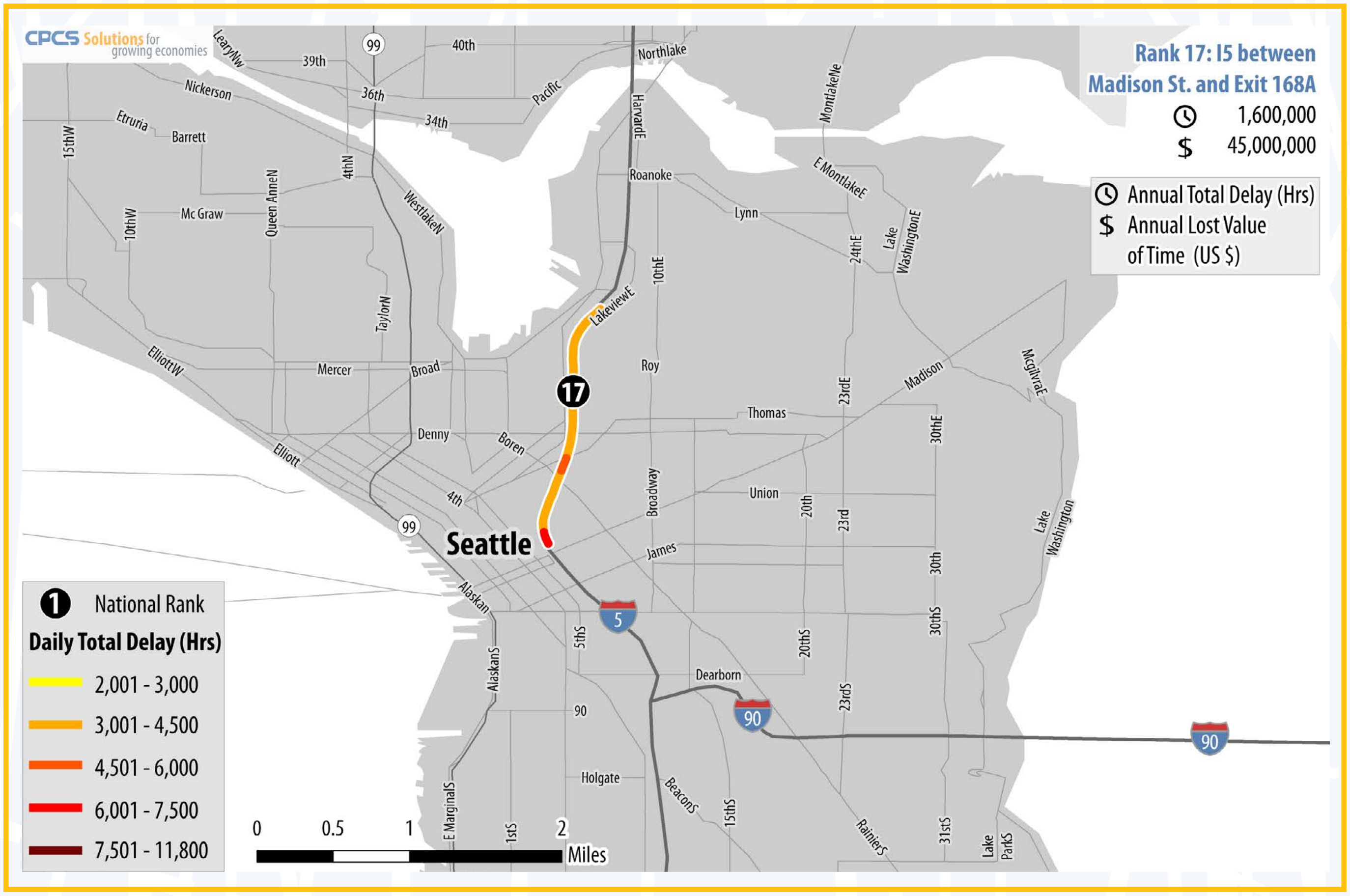
SEATTLE (#17)

The I-5 corridor through downtown Seattle is the major bottleneck in this city, ranked at #17. The many curves and reduced visibility in this 1.6 mile stretch along with off-and on-ramps for the downtown area exacerbate congestion. This bottleneck produces about 1.6 million hours of annual total delays. There have been no recent projects in this stretch.

The many curves and reduced visibility in this 1.6 mile stretch along with off-and on-ramps for the downtown area exacerbate congestion.

Washington State Department of Transportation (WSDOT) recently completed its own annual detailed congestion study - the 2015 Corridor Capacity Report - focused on peak hour bottlenecks.[11] That study also identified roughly the same stretch of the I-5 corridor as a congestion zone.



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[11] http://www.wsdot.wa.gov/Accountability/Congestion/2015.htm

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MIAMI (#20)

The most severe Miami area bottleneck is a 1.7-mile section on the Palmetto Expressway (SR 826) extending between 41st Street and the Dolphin Expressway (SR 836) near Miami International Airport. The delays add up to about 1.4 million hours annually. This costs the local economy approximately $30 million in lost time per year. Appendix A lists two other Dolphin Expressway bottlenecks that narrowly escape the Top 30 list, one between 72nd Ave and the Palmetto Expressway (#32) and the other between 17th Ave and 22nd Ave (#39).

The most severe Miami area bottleneck is a 1.7-mile section on the Palmetto Expressway.

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HOUSTON (#22 AND #25)

In Houston, two similarly sized bottlenecks of about 1.3 miles each made the top 30 list. One is part of the I-610 loop south of Memorial Park (#22) between Richmond Avenue and Post Oak Boulevard. The other is inside the I-610 loop on the Southwest Freeway (I-69) between Hazard Street and Buffalo Speedway (#25). The daily total delays for the two are almost 1.3 million and 1.1 million hours respectively. Both of these occur on the main access highways serving important commercial and residential districts of Houston including the Galleria and Bellaire area, and provide access to the downtown Houston area from its western suburbs. Another Houston bottleneck that narrowly escapes the top 30 list is US 290 between I-610 and Magnum Road (#34).

In Houston, two similarly sized bottlenecks of about 1.3 miles each made the top 30 list.

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ATLANTA (#24)

The most severe national bottleneck in Atlanta is located on the Downtown Connector (the joint stretch of I-75 and I-85) between North Avenue and the Freedom Parkway, in the northern part of the "Grady Curve". These freeways connect downtown Atlanta to major commercial districts and suburbs to the north. This section features two large interchanges and many closely spaced on-and off-ramps providing access to the Georgia Dome, Grady Hospital, State Capitol and the downtown business district. The estimated delays are about 1.2 million hours annually at a lost value of $27 million in this 1.3 mile long congested stretch. Missing the top 30 list is GA400 at I-285 (#49).

The estimated delays are about 1.2 million hours annually at a lost value of *$27 million in this 1.3 mile* long congested stretch.

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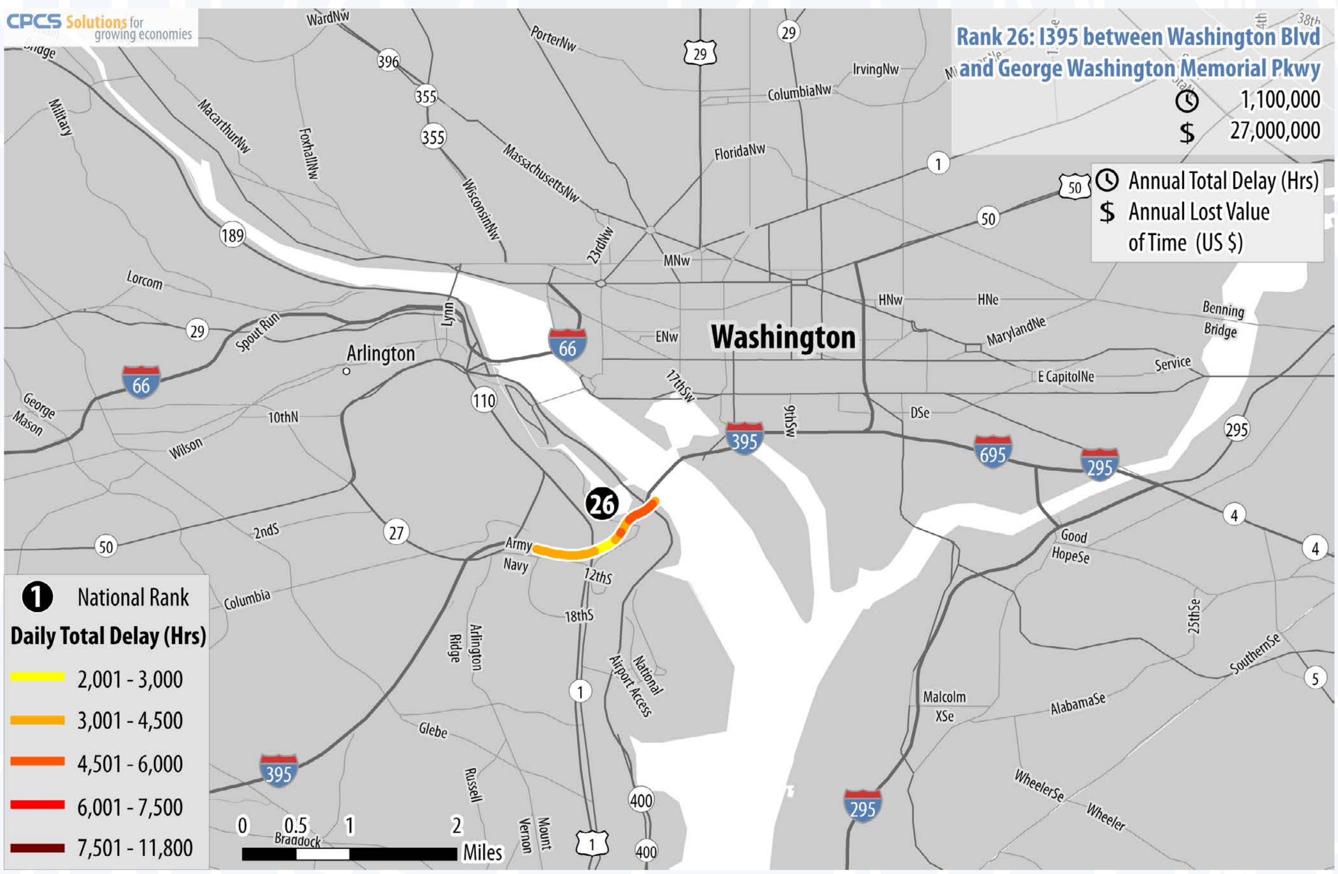
WASHINGTON, DC (#26)

> The nation's capital consistently ranks as one of the most congested regions in the country.

While the nation's capital consistently ranks as one of the most congested regions in the country, one bottleneck in particular stands out enough to rank nationally at #26. This segment is a 1.1-mile stretch on I-395 between the Pentagon and the 14th Street Bridge which provides access across the Potomac River into the Downtown Washington and the U.S. Capitol area from Virginia. The segment wraps around the Pentagon between the George Washington Memorial Parkway and Washington Boulevard with merges, divergences, and on- and off-ramps, and is just north of Reagan National Airport. The 1.1 million hours of annual total delay in this bottleneck are valued at about $27 million worth of lost time. The Capital Beltway (I-495) is the highway most commonly associated with area congestion, but the bottlenecks where express lanes end at the Springfield Interchange (#44) and near the Dulles Toll Road (#41) are just outside the top 30 list.



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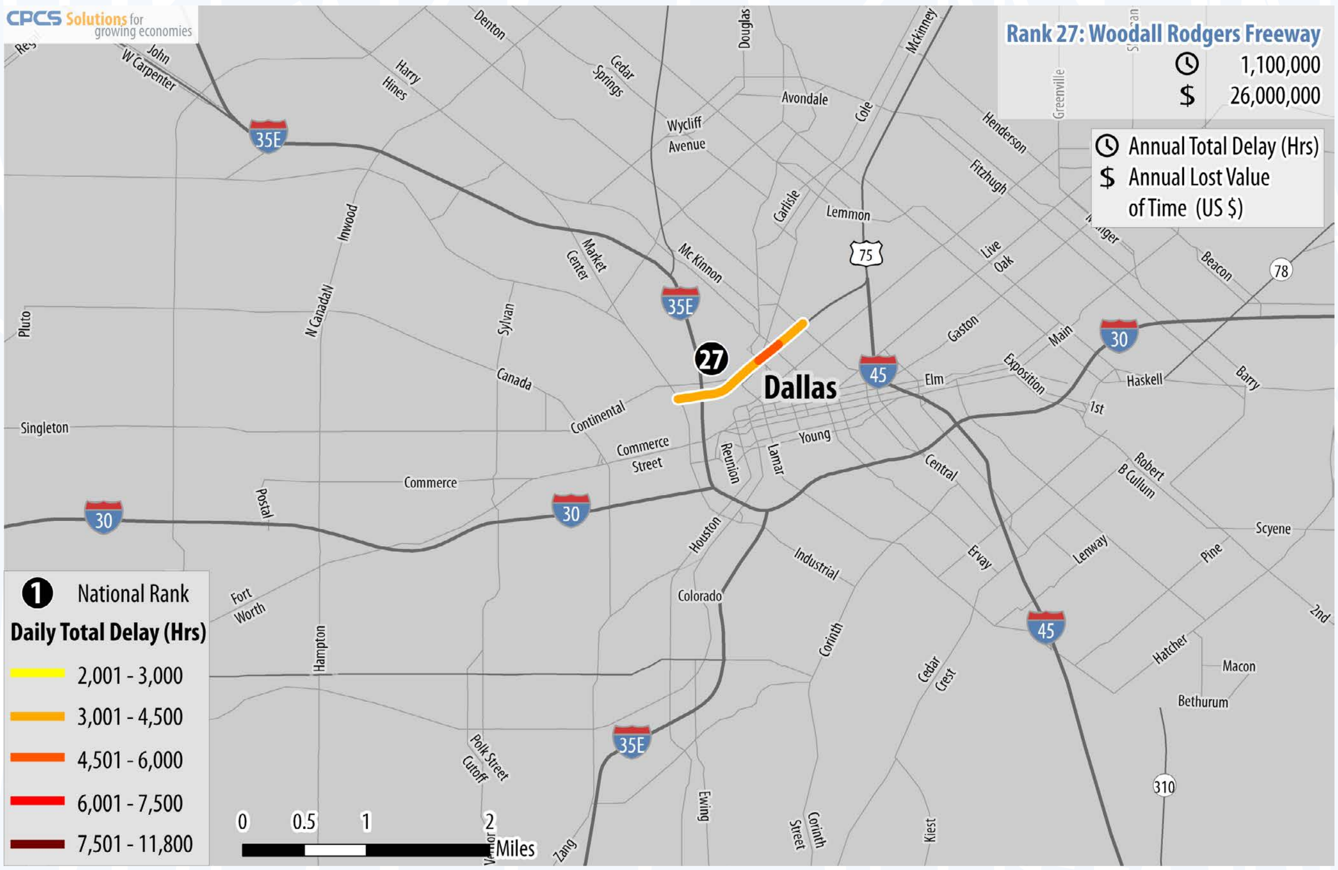
DALLAS (#27)

The Woodall Rogers Freeway in Dallas is the final Texas metro area bottleneck appearing on the list of top 30. At slightly over a million hours of delay and about $26 million of lost value, it is comparable to bottlenecks in Washington, DC, Atlanta, and Houston. A tight curve and merges from both north and south directions near I-35 East make this a congestion hotspot. No projects have recently been undertaken in this area. Missing the top 30 is I-30 between St. Paul Street and I-45 (#43) and US 75 between N. Haskell Avenue and the Woodall Rodgers Freeway (#48).

Missing the top 30 is I-30 between St. Paul Street and I-45 (#43) and US 75 between N. Haskell Avenue and the Woodall Rodgers Freeway (#48).



OTHER NOTABLE AREAS: DENVER, PHILADELPHIA, NORFOLK & TAMPA

Appendix A includes additional bottlenecks in urban areas that were not among the top 30 highlighted in this chapter. In addition to the areas discussed above, bottlenecks in and around Denver, Philadelphia, Norfolk, and Tampa are among those ranked between 31 and 50.

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TRUCK BOTTLENECKS: A DIFFERENT ANIMAL WITH DIFFERENT CONSEQUENCES

Consumer demand for faster, more reliable goods delivery continues to push freight onto trucks. In 2014, trucks moved more than 68.8 percent of all manufactured freight,[12] and economic firm Global Insight estimates the industry's share will increase to more than 71 percent in the next 10 years.[13] Reflecting this trend, recent FHWA estimates predict that truck VMT will increase by more than double the rate of passenger vehicles over the next 20 years.[14] With large trucks logging more than 275 billion miles in 2014,[15] the U.S. highway network is the lifeblood of the trucking industry.

As a result, it is no surprise that traffic congestion, infrastructure impediments and unexpected delays can create financial and safety concerns for motor carriers as well as several million large-truck drivers. These bottlenecks impact truck operations more severely, and in a different manner, than they do automobiles. The differences relate to vehicle configurations and acceleration/deceleration requirements, vehicle operating costs, alternative truck route restrictions, and shipper contracts that dictate on-time delivery requirements.

Recent FHWA estimates predict that truck VMT will increase by more than double the rate of passenger vehicles over the next 20 years.

These differences can also create safety hazards for both car drivers and truck drivers. Truck bottlenecks also have the secondary impact of increasing both emissions and fuel consumption.

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[12] ATA. U.S. Freight Transportation Forecast to 2025. Arlington, VA. (2014)

[13] Ibid

[14] Forecast of Vehicle-Miles Traveled. June 2015. https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.pdf

[15] ATA. American Trucking Trends: 2015. Arlington, VA. (2015)

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Finally, truck drivers experience personal economic harm from truck bottlenecks, as a large percentage of the drivers are paid by the miles they drive; immobile trucks are costly to everyone.

> **Truck drivers experience personal economic harm from truck bottlenecks … immobile trucks are *costly to everyone.***

Due to the stark differences that traffic congestion and bottlenecks have on cars and trucks, the American Transportation Research Institute (ATRI) has developed a customized methodology for identifying and assessing its annual ranking of "freight" bottlenecks:

- Identification of study population through extraction of relevant commercial truck data during all weekdays of the year 2014 at 250 specific locations using an extensive truck GPS database;
- Application of data quality tools and techniques;
- Application of a four-step analysis process that utilizes vehicle time, date and speed information;
- Calculation of total freight congestion values and ranking (congestion index); and
- Production of detailed congestion profiles for the 100 top ranked locations.

This resulted in the following 2015 Top Ten worst freight bottlenecks list:

RANK	LOCATION
1	Atlanta, GA: I-285 at I-85 (North)
2	Chicago, IL: I-290 at I-90/I-94
3	Fort Lee, NJ: I-95 at SR 4
4	Louisville, KY: I-65 at I-64/I-71
5	Houston, TX: I-610 at US 290
6	Houston, TX: I-10 at I-45
7	Cincinnati, OH: I-71 at I-75
8	Houston, TX: I-45 at US 59
9	Los Angeles, CA: SR 60 at SR 57
10	Houston, TX: I-10 at US 59

Using truck travel data from 2014, the top freight bottleneck was the Tom Moreland Interchange in Atlanta, GA, a five-level stack interchange at the intersection of I-285

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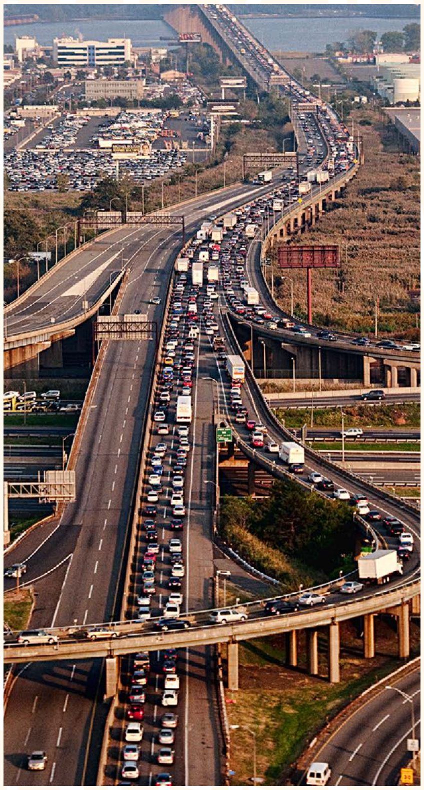
and I-85 northeast of the city. Known locally as Spaghetti Junction, it not only lies at the juncture of two highly traveled interstates, but also provides ramps to four additional adjoining roadways. Already notorious as a predictable freight bottleneck, the January 2014 Gulf Coast winter storm, which brought Atlanta traffic to a standstill for days, likely contributed to the location's rise from third place last year to the number one bottleneck in 2015.

The top freight bottleneck was the Tom Moreland Interchange in Atlanta, GA, a five-level stack interchange at the intersection of I-285 and I-85 northeast of the city … known locally as *Spaghetti Junction.*

The 'Circle' Interchange in Chicago, IL is the number two spot. In the midst of a $420 million reconstruction project, the newly named Jane Byrne Interchange at I-290 and I-90/I94 will continue to be a major freight bottleneck until the large-scale project is completed. As with any construction project ultimately aimed at alleviating congestion, traffic slowdowns at work zones may initially hurt a location's ranking, but are ultimately expected to improve both truck flows and its bottleneck ranking.



Another dramatic example of construction-induced congestion was seen at the George Washington Bridge, which connects New York and New Jersey. Due to new construction, three upper-level lanes –lanes that trucks are required to use – were closed for three months starting in the middle of June and ending in the middle of September.[14] Lane closures likely caused the George Washington Bridge to be in the top three freight bottlenecks.

In November 2015, ATRI released the 2015 Freight Bottleneck Report, which comprehensively documents more than 150 freight bottlenecks throughout the U.S., as well as other freight critical locations.

[14] http://pix11.com/2014/06/15/gwb-upper-lanes-to-close-for-12-weeks/

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CHAPTER 3

Benefits of Addressing Congestion

- Recent investments in major bottlenecks show that even complex congestion problems can be successfully tackled. The projects have provided significant benefits to passenger and freight users by improving speed, reliability, safety, and emissions on critical segments of our national highway system.
- By alleviating the top 30 bottlenecks, Americans would annually save:
  - – 91 million hours of time worth $2.4 billion
  - – 35 million gallons of fuel
  - – 740 million pounds of CO_2
  - – 9,800 accidents would be prevented
- Over twenty years, we estimate the following societal benefits:
  - – $39 billion saved in 2014 dollars
  - – 830 million gallons of fuel not wasted idling in traffic
  - – 17 billion pounds of CO_2 not emitted
  - – 211,000 accidents avoided

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CHAPTER 3

This chapter estimates the benefits of alleviating the top 30 bottlenecks identified in this report. The top 30 bottlenecks impose 91 million hours of delays annually worth $2.4 billion on drivers and freight (identified in Chapter 2). Other important benefits include more than 35 million gallons in fuel savings every year, 740 million pounds in reduced greenhouse gas emissions (CO_2), and the elimination of as many as 9,800 avoided accidents.

Over two decades these benefits translate to *$39 billion* (2014 dollars) of regained value of time.

Recent investments in major bottlenecks show that even complex congestion problems can be successfully tackled. The projects discussed in this chapter have provided significant and even life-changing benefits to passenger and freight users by improving speed, reliability, safety, and emissions on critical segments of our national highway system. This section highlights three success stories where partnerships between state DOTs and local stakeholders advanced innovation in design and operations to dramatically improve conditions at an overwhelmed bridge, an overcrowded corridor, and an aging and accident-prone interchange. These stories—from different corners of the country—highlight the enormous benefits of fixing bottlenecks.

The $2.4 billion lost in delays from just these top 30 bottlenecks—if reinvested in bottleneck solutions—could unleash *significant economic and personal productivity* in several metropolitan areas each year.

Benefits of Alleviating the Top 30 Bottlenecks

We estimated important benefits of eliminating the nation's top 30 bottlenecks, in addition to delays and lost value of time. We focused on the potential fuel savings (gallons), reduced greenhouse gas emissions (CO_2 in pounds), and avoided crashes. Figure 3.1 below lists the benefits for each of the top bottlenecks. In total, the potential fuel savings add up to 35 million gallons, which could reduce greenhouse gas emissions (CO_2) by about 740 million pounds annually. Eliminating these bottlenecks is also estimated to avoid about 9,800 vehicle crashes annually.

Although a long-term forecast of benefits requires many assumptions about the changing economy, technologies, and driver behavior, a simple 20-year projection using FHWA's own growth trends[1] suggests that the present value of lost time that could be regained by eliminating these 30 bottlenecks is about $39 billion (in 2014). The potential fuel savings

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[1] Forecast of Vehicle-Miles Traveled. June 2015
https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.pdf

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and avoided emissions over two decades is 830 million gallons of fuel and over 17 billion pounds of CO_2 respectively. Finally, about 211,000 vehicle crashes could be avoided.

Figure 3.1. Estimated annual benefits of alleviating the top 30 bottlenecks in 2014.

National Rank	State	Urban Area	Location	Potential Fuel Savings (gallons)	Potential Emissions Avoided (pounds)
1	Illinois	Chicago	I90 between Roosevelt Rd and N Nagle Ave	6,370,000	132,983,282
2	California	Los Angeles	I405 between SR22 and I605	1,819,480	36,685,043
3	California	Los Angeles	I10 between Santa Fe Ave and Crenshaw Blvd	2,231,840	47,002,712
4	California	Los Angeles	I405 between Venice Blvd and Wilshire Blvd	1,961,960	40,124,266
5	California	Los Angeles	US101 between Franklin Ave and Glendale Blvd	1,761,500	36,685,043
6	California	Los Angeles	I110 between Exposition Blvd and Stadium Way	1,855,880	37,831,451
7	California	Los Angeles	US101 between Sepulveda Blvd and Laurel Canyon Blvd	1,047,800	22,354,948
8	New York and New Jersey	New York	Lincoln Tunnel between 10th Ave and John F Kennedy Blvd	1,730,300	34,965,432
9	New York	New York	I95 between I895 and Broadway	1,545,700	31,526,209
10	Texas	Austin	I35 between East Riverside Dr and E Dean Keeton St	1,776,320	38,404,655
11	California	Los Angeles	I5/I10 between N Mission Rd and US101	966,680	20,635,337
12	California	San Francisco	I80 between US101 and Bay Bridge	797,680	16,049,706
13	California	Los Angeles	I10 between La Brea Ave and National Blvd	551,720	11,464,076
14	California	Los Angeles	I5 between S Eastern Ave and Euclid Ave	992,160	21,208,541
15	Massachusetts	Boston	I93 between I90 and US1	1,980,680	40,124,266
16	California	Oakland	I80 between I580 and Ashby Ave	691,860	14,330,095
17	Washington	Seattle	I5 between Madison St. and Exit 168A	619,840	13,183,687

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National Rank	State	Urban Area	Location	Potential Fuel Savings (gallons)	Potential Emissions Avoided (pounds)
18	New Jersey	New York	I95 between SR4 and Palisades Interstate Pkwy in Fort Lee	810,680	16,622,910
19	New Jersey	New York	Pulaski Skyway between I95 and Central Ave, in Newark and Kearny	856,960	17,196,114
20	Florida	Miami	Palmetto Expy between 41st St. and Dolphin Expy	647,400	13,756,891
21	New York	New York	I678 between Queens Blvd and Liberty Ave	512,980	10,317,668
22	Texas	Houston	I610 between Richmond Ave and Post Oak Blvd	509,340	10,890,872
23	Illinois	Chicago	I90 Between I55 and W Pershing Rd	678,600	14,903,299
24	Georgia	Atlanta	I75/I85 between Freedom Pkwy NE and North Ave NE	392,600	8,598,057
25	Texas	Houston	I-69/US59 between Hazard St and Buffalo Speedway	613,080	13,183,687
26	Virginia	Washington, DC	I395 between Washington Blvd and George Washington Memorial Pkwy	322,660	6,305,242
27	Texas	Dallas	Woodall Rodgers Freeway	470,860	9,744,465
28	Massachusetts	Boston	I93 between Edge Hill Rd and West St	362,700	7,451,649
29	California	Los Angeles	I405 between Burbank Blvd and Ventura Blvd	339,820	6,878,446
30	California	Los Angeles	US101 between SR110 and Alameda St	434,200	9,171,261

Success Story 1: Wilson Bridge Reconstruction (MD-VA-DC)

Before its reconstruction in 2008, the Woodrow Wilson Bridge on the Capital Beltway (I-95) was one of the most persistent bottlenecks on the I-95 corridor, constraining regional commuter traffic moving between the Maryland and Virginia suburbs of Washington, DC and long-distance truck traffic moving along the I-95 corridor. The old six-lane bridge was a chokepoint on the Capital Beltway and the lane drop on the bridge approach created a traffic jam that would extend for miles on either side of the structure.

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After years of careful planning, the Maryland State Highway Administration, Virginia DOT, and the District of Columbia DOT, in partnership with the Federal Highway Administration, embarked on a $2.5 billion project to replace the old bridge with new structures and to improve the adjacent 7.5 miles of the Capital Beltway including four reconstructed interchanges. The new span includes five general purpose lanes in each direction separated into local and express lanes. The bridge design includes one additional lane in each direction reserved for future transit use.

Since its opening in December 2008, regional commuters, local freight carriers, and long-haul truckers have benefited from improved travel times and greater reliability. Following project completion the Metropolitan Washington Council of Governments reported a dramatic change in speed over the segment:

> **"In the westbound direction during the morning peak, segments of the Capital Beltway on and near the Wilson Bridge that saw travel speeds frequently drop below 20 miles per hour in 2008 were found in 2011 to have free-flowing travel speeds of 55 to 65 miles per hour."[2]**

Figure 3.2 shows differences in congestion from aerial photography of the bottleneck before and after the project was completed.

Figure 3.2 Change in Wilson Bridge Westbound Morning Peak Congestion Maryland Approach

Source: MWCOG / Skycomp 2011

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[2] Metropolitan Washington Council of Governments (MWCOG) and Skycomp. Traffic Quality on the Metropolitan Washington Area Freeway System. 2011.

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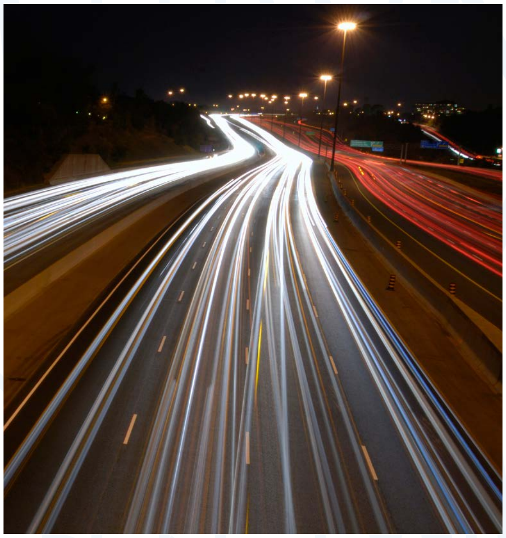
The Wilson Bridge project, along with the $676 million makeover of the nearby Springfield Mixing Bowl (junction of I-95, I-495, I-395), have provided significant mobility improvements to local and through travelers in Metropolitan Washington.

Success Story 2: Katy Freeway Reconstruction (Houston, Texas)

The Katy Freeway is the primary east-west Interstate highway in the Houston region. It connects downtown Houston with its suburbs and is the principal freight connection to San Antonio to the west and New Orleans to the east. Originally constructed in the 1960s and designed for 80,000 vehicles per day, growth in the Houston area overwhelmed the facility with nearly three times those volumes—a situation which produced up to 11 hours of daily congestion.[3]

To alleviate severe congestion on the Katy Freeway, TxDOT and the Harris County Toll Road Authority (HCTRA) undertook a $2.8 billion reconstruction of a 20-mile section from the Bend County Line to the I-10/I-610 interchange. The construction was completed over a nearly five-year period between 2003 and 2008 and widened the freeway from three lanes in each direction to six general purpose lanes in each direction and two variably priced high occupancy toll lanes. The project was funded with a combination of toll-backed debt and traditional grant funding.



The result of the investment is congestion relief—and faster commutes:

> **The Houston Chronicle reported in 2012 that morning commutes along the reconstructed corridor dropped from 33 minutes to 27 minutes during morning peak hour and from over 38 minutes to 28 minutes during evening peak.[4]**

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[3] Federal Highway Administration. Katy Freeway Reconstruction Profile. https://www.fhwa.dot.gov/ipd/project_profiles/tx_katyfreeway.aspx

[4] Freemantle, Tony. Expanded Katy Freeway shaves minutes from commute. Houston Chronicle. October 12, 2012. http://www.chron.com/news/houston-texas/article/Expanded-Katy-Freeway-shaves-minutes-from-commute-3941203.php

[5] Politifact analysis of WisDOT, Milwaukee County Sherriff's Accident Data. http://www.politifact.com/wisconsin/statements/2015/may/24/wisconsin-transportation-builders-association/accidents-cut-half-after-marquette-interchange-wor/

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Success Story 3: Marquette Interchange (I-94 / I-43 / I-794 Milwaukee)

The Marquette Interchange at the convergence of I-94, I-43, and I-794 near downtown Milwaukee was one of Wisconsin's most congested highway locations and was particularly accident-prone. Not only was there a high crash rate but traffic was also increasing at the interchange and the structures were at the end of their useful life. Beginning in 2004 and culminating in 2008, Wisconsin DOT made an $810 million investment to rebuild the Marquette.

The project achieved operations goals and reduced accidents by half—with a 45 percent decrease for total accidents and 55 percent decrease in injury accidents.

WisDOT attributes the improvements to the new design, especially improved sight lines for drivers.[5] Specifically telling was that the cumulative accident count from 1999-2003 was 3,416 versus the same count from 2009-2013 which was 1,890. Figure 3.3 shows the old and new Marquette Interchange and resulting traffic conditions.

The Marquette Interchange improvements serve as the anchor of a series of projects by WisDOT to modernize adjacent highway sections and interchanges (This includes the notorious Zoo Interchange of US 41 and I-94, which contributes to the bottleneck on US 41 between West Watertown Plank Road and West Bluemond Road — just north of the interchange as cited in Appendix B.).

Figure 3.3 Marquette Interchange (I-94 / I-43) Milwaukee Before and After Reconstruction

Before (construction started 2004)

After (construction completed 2008)

Source: Wisconsin DOT, Milwaukee Transportation Partners. Presentation by Mike Paddock to Marquette Interchange Peer Review http://www.dot.state.mn.us/pm/documents/peer-review/marquette-widot.pdf

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APPENDICES

APPENDIX A. AMERICA'S TOP 50 BOTTLENECKS

Our study identified the nation's top 50 bottlenecks, listed below. These zones of congestion were validated using feedback from local experts and state Departments of Transportation (DOTs). In Chapter 2 of this report, we present detailed profiles for the top 30. Many bottlenecks that narrowly missed the top 30 cut are in the same urban areas: Atlanta, Boston, Chicago, Dallas, Houston, Los Angeles, Miami, New York, and Washington, DC. Notable bottlenecks in areas not profiled in Chapter 2 are highlighted below. Denver, Norfolk (VA), and Tampa have a bottleneck each, and Philadelphia has two.

National Rank	State	Urban Area	Location	Queue Length (miles)	Annual Total Delay (hours)	Annual Lost Value Of Time (US $)	Annual Fuel Wasted / Potential Savings (gallons)
1	Illinois	Chicago	I90 between Roosevelt Rd and N Nagle Ave	12.0	16,900,000	$ 418,000,000	6,370,000
2	California	Los Angeles	I405 between SR22 and I605	4.1	7,100,000	$ 191,000,000	1,819,480
3	California	Los Angeles	I10 between Santa Fe Ave and Crenshaw Blvd	6.9	6,900,000	$ 187,000,000	2,231,840
4	California	Los Angeles	I405 between Venice Blvd and Wilshire Blvd	5.2	6,300,000	$ 169,000,000	1,961,960
5	California	Los Angeles	US101 between Franklin Ave and Glendale Blvd	4.4	5,400,000	$ 146,000,000	1,761,500
6	California	Los Angeles	I110 between Exposition Blvd and Stadium Way	4.3	5,400,000	$ 145,000,000	1,855,880
7	California	Los Angeles	US101 between Sepulveda Blvd and Laurel Canyon Blvd	3.8	3,600,000	$ 96,000,000	1,047,800
8	New York and New Jersey	New York	Lincoln Tunnel between 10th Ave and John F Kennedy Blvd	2.6	3,400,000	$ 87,000,000	1,730,300
9	New York	New York	I95 between I895 and Broadway	3.1	3,000,000	$ 82,000,000	1,545,700
10	Texas	Austin	I35 between East Riverside Dr and E Dean Keeton St	3.0	3,000,000	$ 73,000,000	1,776,320
11	California	Los Angeles	I5/I10 between N Mission Rd and US101	2.0	2,300,000	$ 62,000,000	966,680
12	California	San Francisco	I80 between US101 and Bay Bridge	1.9	2,200,000	$ 59,000,000	797,680
13	California	Los Angeles	I10 between La Brea Ave and National Blvd	2.2	2,100,000	$ 57,000,000	551,720
14	California	Los Angeles	I5 between S Eastern Ave and Euclid Ave	2.0	2,100,000	$ 56,000,000	992,160

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APPENDIX A. AMERICA'S TOP 50 BOTTLENECKS (CONTINUED)

National Rank	State	Urban Area	Location	Queue Length (miles)	Annual Total Delay (hours)	Annual Lost Value Of Time (US $)	Annual Fuel Wasted / Potential Savings (gallons)
15	Massachusetts	Boston	I93 between I90 and US1	1.9	2,100,000	$ 58,000,000	1,980,680
16	California	Oakland	I80 between I580 and Ashby Ave	2.0	1,900,000	$ 50,000,000	691,860
17	Washington	Seattle	I5 between Madison St. and Exit 168A	1.6	1,600,000	$ 45,000,000	619,840
18	New Jersey	New York	I95 between SR4 and Palisades Interstate Pkwy in Fort Lee	0.9	1,500,000	$ 38,000,000	810,680
19	New Jersey	New York	Pulaski Skyway between I95 and Central Ave in Newark	1.1	1,400,000	$ 36,000,000	856,960
20	Florida	Miami	Palmetto Expy between 41st St. and Dolphin Expy	1.7	1,400,000	$ 30,000,000	647,400
21	New York	New York	I678 between Queens Blvd and Liberty Ave	1.4	1,400,000	$ 37,000,000	512,980
22	Texas	Houston	I610 between Richmond Ave and Post Oak Blvd	1.3	1,300,000	$ 31,000,000	509,340
23	Illinois	Chicago	I90 Between I55 and W Pershing Rd	1.2	1,300,000	$ 31,000,000	678,600
24	Georgia	Atlanta	I75/I85 between Freedom Pkwy NE and North Ave NE	1.3	1,200,000	$ 27,000,000	392,600
25	Texas	Houston	I69/I59 between Hazard St and Buffalo Speedway	1.3	1,100,000	$ 28,000,000	613,080
26	Virginia	Washington, DC	I395 between Washington Blvd and George Washington Memorial Pkwy	1.1	1,100,000	$ 27,000,000	322,660
27	Texas	Dallas	Woodall Rodgers Freeway	1.1	1,100,000	$ 26,000,000	470,860
28	Massachusetts	Boston	I93 between Edge Hill Rd and West St	1.2	1,000,000	$ 28,000,000	362,700
29	California	Los Angeles	I405 between Burbank Blvd and Ventura Blvd	1.0	1,000,000	$ 26,000,000	339,820
30	California	Los Angeles	US101 between SR110 and Alameda St	1.0	1,000,000	$ 26,000,000	434,200
31	New Jersey	New York	US1&9 between Wilson Ave and I78	0.8	800,000	$ 21,000,000	291,720
32	Florida	Miami	Dolphin Expy between 72nd Ave and Palmetto Expy	0.5	800,000	$ 17,000,000	405,080

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APPENDIX A. AMERICA'S TOP 50 BOTTLENECKS (CONTINUED)

National Rank	State	Urban Area	Location	Queue Length (miles)	Annual Total Delay (hours)	Annual Lost Value Of Time (US $)	Annual Fuel Wasted / Potential Savings (gallons)
33	New York	New York	Brooklyn Bridge	0.9	800,000	$ 21,000,000	577,460
34	Texas	Houston	US290 between I610 and Mangum Rd	0.9	800,000	$ 19,000,000	405,860
35	Colorado	Denver	I25 between Santa Fe Dr and S Logan St	0.8	700,000	$ 18,000,000	356,980
36	Pennsylvania	Philadelphia	I76 at US1 between City Ave and Roosevelt Blvd	0.8	700,000	$ 16,000,000	263,120
37	New Jersey	New York	Pulaski Skyway between Tonnelle Ave and Broadway	0.7	600,000	$ 15,000,000	347,620
38	Virginia	Norfolk	US58 at Martin Luther King Fwy in Portsmouth	0.6	600,000	$ 16,000,000	210,600
39	Florida	Miami	Dolphin Expy between 17th Ave and 22nd Ave	0.6	500,000	$ 11,000,000	158,080
40	California	Los Angeles	I10 between I5 and US101	0.6	500,000	$ 13,000,000	240,240
41	Virginia	Washington, DC	I495 at the Dulles Toll Road	0.5	500,000	$ 12,000,000	146,900
42	New York	New York	Long Island Expressway (I495) near I-278 between 58th St and 48th St.	0.4	400,000	$ 10,000,000	117,260
43	Texas	Dallas	I30 between St. Paul St. and I45	0.4	400,000	$ 9,000,000	174,200
44	Virginia	Washington, DC	I395 from Duke St to halfway between Duke St and Edsall Rd	0.3	300,000	$ 8,000,000	83,720
45	Florida	Tampa	I4 between N 22nd St and N Nebraska Ave	0.4	300,000	$ 7,000,000	191,100
46	Illinois	Chicago	I94 between I90 interchange and N Elston Ave	0.3	300,000	$ 7,000,000	106,860
47	Pennsylvania	Philadelphia	I676 between I76 interchange and N 24th St	0.3	300,000	$ 6,000,000	112,580
48	Texas	Dallas	US75 between N Haskell Avenue and SR366	0.3	200,000	$ 6,000,000	127,920
49	Georgia	Atlanta	T. Harvey Mathis Pkwy between Johnson Ferry Rd NE and I285	0.3	200,000	$ 6,000,000	73,580
50	Massachusetts	Boston	I90 from Dorchester Ave to A St	0.3	200,000	$ 7,000,000	135,720

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APPENDIX B. OTHER ZONES OF CONGESTION IN US STATES

Our method used stringent criteria for identifying the national top 50 bottlenecks (see Appendix C). We also used an alternative method to identify additional congestion zones around the country. Although congested, the worst segments of highway do not have the same severe delays/mile (delay density) as the nationally ranking bottlenecks. In many cases, the areas below are the most congested in their respective states. The queue lengths and delay estimates on the list below use a different methodology than the list of top 50 discussed previously.

State	Area	Road name	Queue Length (Miles)	Annual Total Delay (hours)
Alabama	Birmingham	I20 between 23rd St N and 15th St N	0.8	135,200
Alabama	Birmingham	I65 between 6th Ave N and University Blvd.	1.1	190,060
Arizona	Phoenix	I10 between N 16th Street and N 7th Ave (North of downtown Phoenix)	1.9	600,080
Arizona	Phoenix	I17 through I10N near Phoenix Int'l Airport, between Sky Harbor Cir and S 24th Street	0.8	154,180
Arkansas	Little Rock	I630 between I430 and John Barrow Road	1.4	230,620
Connecticut	Hartford	I84 between Trumbull St and Park St	1.4	705,900
Connecticut	Stamford	I95 (Governor John Davis Lodge Turnpike) between Fairfield Ave and Elm St	1.3	494,000
Hawaii	Honolulu	IH1 between Ala Kapuna St and Exit 1D	0.7	607,100
Hawaii	Halawa	H201 at H3	0.1	78,260
Idaho	Boise	I84 between S Meridian Rd and SR55	1.8	119,080
Indiana	Indianapolis	I65 between W21st St and Central Ave	1.7	400,400
Indiana	Jeffersonville (Bordering Kentucky)	I65 from Indiana/Kentucky Border to Old Indiana 62	1.8	198,120
Iowa	Council Bluff (Bordering Nebraska)	I29 between Plaza View Dr and S Expressway St	2.3	117,520
Kansas	Wichita	US400 between Rock Rd and I35 (Kansas Turnpike)	2.6	375,180
Kentucky	Louisville	164 at 165 between N Preston St and N Clay Street (North of Louisville Slugger Field)	0.4	102,700
Kentucky	Louisville	I65 at US150	1.0	241,540
Louisiana	New Orleans	US90 between Loyola Ave and Convension Center Blvd	0.9	741,780
Louisiana	Baton Rouge	I10 between Louise St and S River Rd	1.0	334,880
Maryland	Bethesda	I495 between SR190 and I270	1.9	705,120
Maryland	Bethesda	I495 between I270 (near SR355) and Cedar Ln	0.8	296,660
Michigan	Detroit	I75 north of I696 between W Lincoln Ave and Twelve Mile Rd	1.2	569,920

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APPENDIX B. OTHER ZONES OF CONGESTION IN US STATES (CONTINUED)

State	Area	Road name	Queue Length (Miles)	Annual Total Delay (hours)
Michigan	Detroit	I94 between Rose Parks Blvd and Brush St (North of Wayne State University)	1.5	532,480
Minnesota	Minneapolis	I94 between W River Pkwy and 22nd Ave S	0.7	362,960
Minnesota	Edina	US169 between Crosstown Hwy and Valley View Rd	1.0	490,100
Mississippi	Jackson	I55 between Savanna St and I20	2.0	145,860
Missouri	St. Louis	I44 beween Eads Bridge and I70	1.1	417,560
Missouri	St. Louis	I64 between S 18th St and Historic US 66	0.7	225,852
Nebraska	Lincoln	I80 between US6 and Pinnacle Arena Dr (North of University of Nebraska - Lincoln)	0.7	118,300
Nebraska	Omaha	US6 between N 120th St and S 108th St (East of I680)	1.0	160,420
Nevada	Las Vegas	I15 between W Oakley Blvd and Exit 41 (Near Las Vegas North Premium Outlets)	0.9	258,180
Nevada	Las Vegas	US95 between Clarkway Dr and I15	0.7	172,640
New Hampshire	Epping	SR125 between SR101 and Water St	1.0	159,120
New Hampshire	Portsmouth	US4 between Woodbury Ave. and Nimble Hill Rd	0.9	128,440
New Mexico	Albuquerque	I25 between Osuna Rd NE and SR423	2.5	666,380
North Carolina	Raleigh	I440 between Exits 14 and 15	0.3	59,909
North Carolina	Charlotte	I485 between Exit 65 and 65B (Crossing South Blvd)	0.5	96,819
Ohio	Columbus	I670 between N 3th St and Exit 5 (east of I71)	1.7	293,280
Ohio	Cincinnati	I75 between Bank St and Ohio/Kentucky Border	2.6	433,160
Oklahoma	Oklahoma City	I235 at I44 between NW 59th St and NW 50th St	0.7	99,840
Rhode Island	Providence	I95 between Point St and O'Connel St	0.9	202,280
Rhode Island	Providence	I95 between US6 and SR146	0.6	142,480
Tennessee	Nashville	I40 at I65 between US ALT 31 and 12th Ave S	0.7	211,900
Tennessee	Nashville	I24 between I65 and Crutcher St	2.1	566,540
Utah	Salt Lake City	I15 between I215 and S Green St	0.9	101,400
Wisconsin	Milwaukee	US41 between W Watertown Plank Rd and W Bluemond Rd	0.8	245,960
Wisconsin	Milwaukee	I43 between W Canal St and SR145	1.1	267,280

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APPENDIX C. METHODOLOGICAL ANNEX

AHUA National Highway Bottlenecks (2015)

WHAT IS THE GEOGRAPHICAL SCOPE OF THIS STUDY?

This 2015 update to AHUA's 2004 study *Unclogging America's Arteries* focuses on the nation's top bottlenecks on America's urban freeways. Freeways include Interstate and other limited access highways, coded as Functional Class 1 and 2 in the Federal Highway Administration's Highway Performance Monitoring System (HPMS). The HPMS is a national level highway information system that includes data on the extent, condition, performance, use and operating characteristics of the nation's highways.

Figure 1: Focus on Functional Classes 1 and 2 of Freeways

FUNCTIONAL CLASS	DESCRIPTION
1	Interstate
2	Principal Arterial-Other Freeways & Expressways
3	Principal Arterial-Other
4	Minor Arterial
5	Major Collector
6	Minor Collector
7	Local

Our algorithms used a 10-mile buffer upstream and downstream of urban areas to ensure that the analysis retained these possibly congested stretches.

We used the US Census Bureau's definition of "Urbanized Areas" as areas with 50,000 or more people to identify urban freeways. Congestion-related traffic queues sometime extend well outside of demarcated urban areas, and also along important traffic corridors such as the one on I-35 between Dallas, Austin and San Antonio. Our algorithms used a 10-mile buffer upstream and downstream of urban areas to ensure that the analysis retained these possibly congested stretches.

WHAT DATA DO WE USE FOR ESTIMATING DELAYS?

This study uses spot speed data collected from GPS probes that are averaged for each five-minute interval. The organizations HERE North America, LLC (HERE) and American

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Transportation Research Institute (ATRI) collect these data for passenger and freight vehicles, respectively. These data are part of a large data set that feeds into the Federal Highway Administration's (FHWA) National Performance Management Research Data Set (NPMRDS). In these data sets, the GPS probe-based speeds are allocated to a road network layer called Traffic Message Channel (TMC). We combine this data with other information from the HPMS system through a process known as conflation, described below.

What time horizon does the data cover, and how is it processed for delay calculations?

To eventually develop estimates of delays for weekday travel, we first needed to understand the 24-hour weekday speed profile.

We used empirical GPS observations from the year 2014. To eventually develop estimates of delays for weekday travel, we first needed to understand the 24-hour weekday speed profile of different stretches of highway. The speed profile is the speed at which drivers would expect to drive on a stretch of highway in a particular hour on a weekday. The 5-minute speed data was averaged for every weekday hour (60 min / 5 min = 12 observations) for weekdays from eight weeks (5 weekdays/week x 8 weeks = 40 weekdays). Thus the average consists of 480 observations. Two weeks for each quarter of the year 2014 were chosen to account for seasonal choices in driving behavior, and to avoid statutory holidays. These weeks were:

- **Quarter 1, 2014:** **February 3 to 16**
- **Quarter 2, 2014:** **May 5 to 18**
- **Quarter 3, 2014:** **August 4 to 17**
- **Quarter 4, 2014:** **November 3 to 16**

The aggregate estimate of delay for a freeway segment needs not only the speed profile of vehicles driving that stretch but also the volume of vehicles that could potentially experience delays (Average Annual Daily Traffic (AADT) or Average Annual Daily Truck Traffic (AADTT)). The speed data for each section of freeway from the HERE/ATRI data set must be tied to the expected vehicle volumes (i.e. AADT) and number of lanes from the HPMS data for the same section. Network conflation is the process of combining these two separate spatial data sets.

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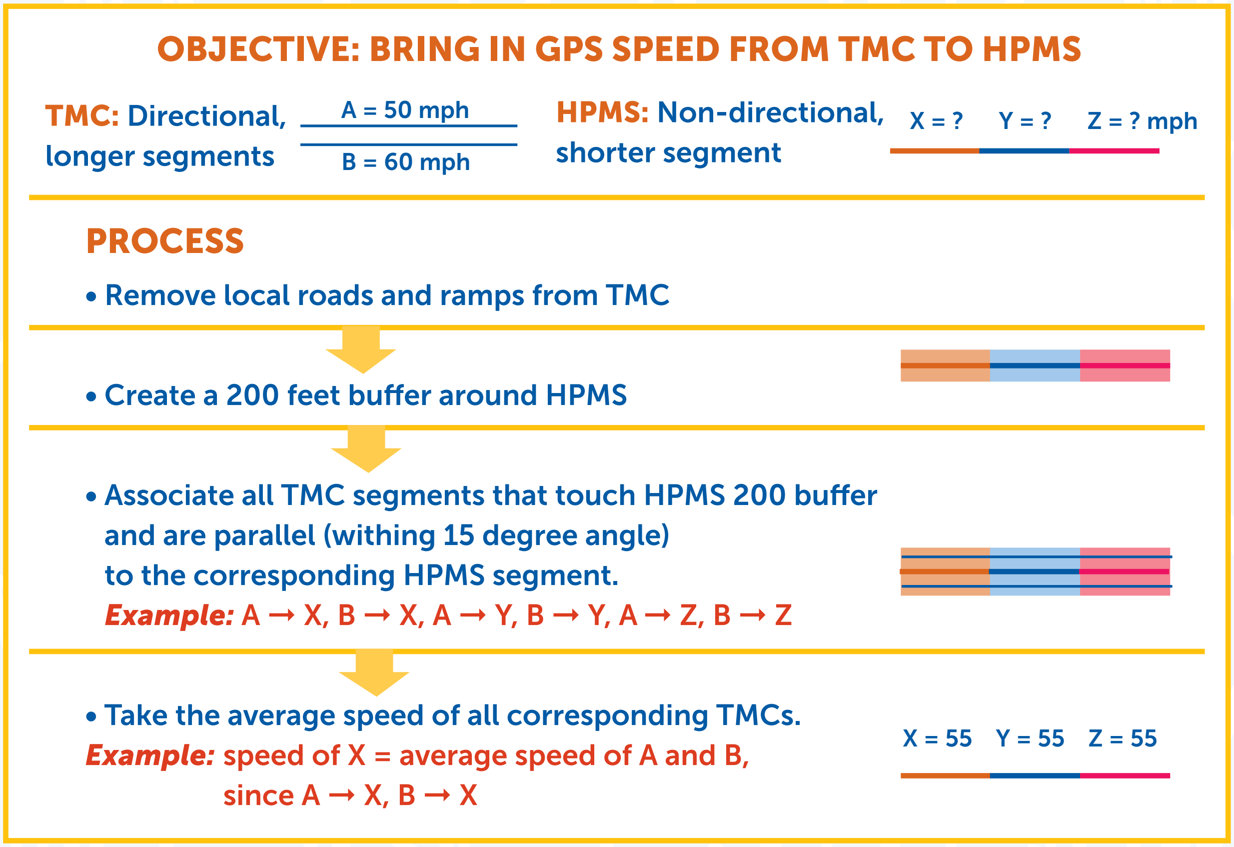
An important aspect of network conflation is to accurately match information from one data set to the corresponding geography in the other data set. We used Geographic Information System (GIS) models to accomplish the conflation. Figure 2 below summarizes the steps in the conflation process.

Figure 2: Network Conflation Process



The HPMS combines data in both directions while HERE/ATRI data set has separate directional flows, denoted by Traffic Messaging Channel (TMC) identifiers.[1] The two networks could be conflated either from HPMS (nondirectional) to TMC (directional), however this approach requires assumptions about the number of lanes in each direction for the road networks nationwide. We chose to conflate the directional networks in the other direction to avoid erroneous assumptions; we combined average observed speeds from the directional TMCs to the HPMS nondirectional vehicle volume and lane data. Another advantage

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[1] TMC is a road network (GIS shapefile) used for mapping GPS probe speeds or performance measures (e.g. delays) from the data set. The data set is structured by unique TMC IDs which is used to join speed data to the TMC network (which also has the same TMC IDs) for mapping purposes.

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of conflating to the HPMS data is that the resulting freeway segments are shorter, allowing us to more accurately pinpoint congested stretches.

Since the geographic focus of the study is on urban freeways, any local roads and ramps from the HERE/ATRI data set (TMC identifiers) were first removed so that the lower speeds on those nearby roads did not "contaminate" the freeway speed during network conflation.

Network conflation automatically sources average speeds of a TMC-identified freeway and matches nearby, corresponding HPMS segments. To make this automatic process more accurate, two conditions were set: the TMC segment should be within 200 feet[2] of a HPMS segment and both segments should be parallel[3] to each other.

In most cases, conflation correctly matched multiple TMC-identified segments to a HPMS freeway segment, and then averaged the speeds. Readings of 0 mph or higher than 85 mph were discarded as errors and possible outliers. Figure 3 (upper) shows an example of TMC-identified speeds from the data set before conflation, and average speeds on the HPMS network after conflation (lower) for the area near I-5 / I-10 interchange in Los Angeles.

How did we translate daily vehicle volumes to hourly volumes?

After network conflation, we used the Texas A&M Transportation Institute's published daily traffic distribution data to allocate Annual Average Daily Traffic (AADT) to each hour of the day in the weekday speed profile for each freeway segment.[4] The allocated volumes were checked and adjusted using empirical relationships, such as the one below:[5]

$$(804.17 + 90.4836 * Speed - 4.0648 * Speed^2 + 0.09212 * Speed^3 - 0.0007672 * Speed^4) * Number\ of\ Lanes$$

where,

Speed is the hourly weekday profile speed on a given freeway segment, as calculated above from the data, and

Number of Lanes is obtained from HPMS after network conflation

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[2] A series of buffer distances between 50 feet and 200 feet were tested iteratively. The chosen buffer of 200 feet captured more than 99.5% of all TMC segments. Further visual inspection showed that a larger buffer distance would lead the algorithm to incorrectly capture irrelevant segments, for example orthogonal roads at intersections.

[3] Once again to enhance the accuracy of conflation, a cut-off of 15° were chosen to avoid irrelevant segments at interchanges. Very small angles, on the other hand, left out relevant segments.

[4] Texas A&M Transportation Institute and INRIX. 2015 Urban Mobility Scorecard. Accessed November 12 2015.

[5] Sources: http://people.umass.edu/ndh/TFT/Ch05%20Equilibrium.pdf
http://ntl.bts.gov/lib/31000/31400/31419/14497_files/chap_2.htm

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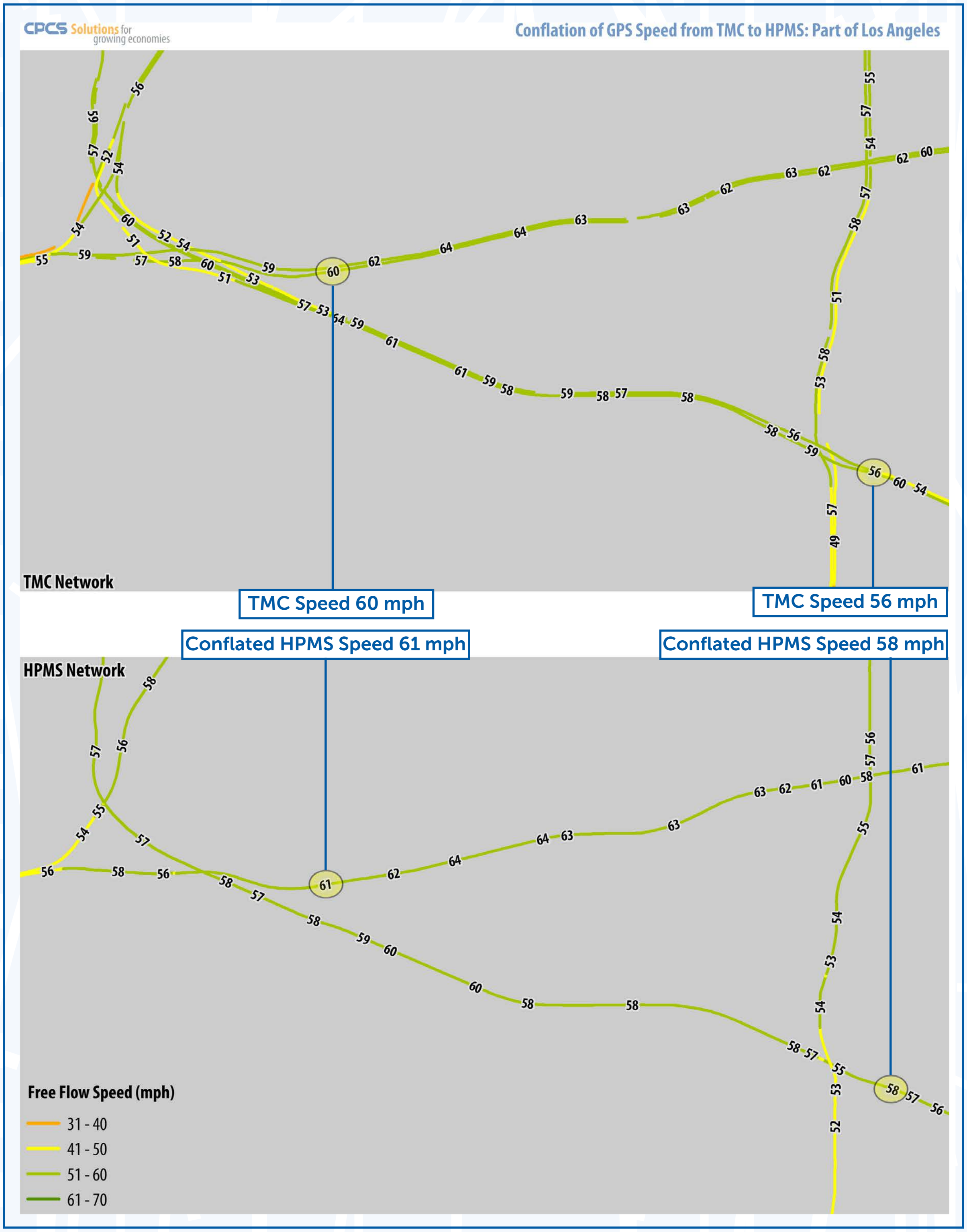
Figure 3: Network Conflation of Average Speeds: TMC to HPMS.

upper: before conflation ; lower: after conflation



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How did we calculate the normalized hour-indexed delay?

We calculated length-normalized hour-indexed delays (hours per mile) for every urban freeway segment *i* using this relationship:

$$\text{Delay } (d_{ji}) = \text{Vehicles per hour}_{ji} * \left(\frac{1}{\text{Observed Speed}_{ji}} - \frac{1}{\text{Baseline Speed}_{i}} \right)$$

Where,

Observed Speed is the weekday profile speed for every hour j in the day, as calculated above;

Baseline Speed is the Maximum Throughput Speed (MTS) for that freeway segment i, a counterfactual speed based on ideal travel conditions, developed using relationships published in the Transportation Research Board's (TRB) Highway Capacity Manual.[6]

Vehicles per hour is the hourly volume estimated as above.

NOTE: *The relationship above holds ONLY in weekday hours when the observed speed is lower than the Maximum Throughput Speed, i.e. drivers experience slow down due to congestion. The following explains the process of congestion build up in relation to the Maximum Throughput Speed. When observed speeds exceeds MTS, delays in those hours -> 0.*

The Maximum Throughput Speed is the speed corresponding to optimal vehicle volume flow, i.e. the speed at which a maximum number of vehicles can pass through a road segment. Imagine an empty stretch of highway with a few vehicles passing through at the Free Flow Speed (FFS), the posted speed limit for example. As more vehicles enter the stretch, the volume (number of vehicles passing through a road segment at a given time) increases and the speed decreases due to lane changes, fluctuating separation distance, and other behavioral and design factors. As more and more vehicles enter the freeway, the volume reaches a theoretical maximum throughput – the speed at this stage in the traffic flow process is the MTS. Additional vehicles beyond this level of throughput start to reduce the speed leading to slow downs and congestion. Even though drivers experience slowdowns, this may still be far from "sitting in traffic" or jam conditions.

Although the MTS baseline is lower than the FFS, it represents a better use of available freeway capacity and is therefore an improved reference point for estimating delays due to congestion. Assuming a constant volume of vehicles in this range of speeds, using the

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[6] Highway Capacity Manual, 2010, http://hcm.trb.org/vol2?qr=1

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MTS as a baseline also gives us a more conservative estimate of congestion. In other words, we most likely underestimate hourly delays.[7]

$$MTS_i = 39 + 0.2 \ \ FFS_i$$

Where,
FFS is the free flow speed as estimated by 95th percentile of calculated weekday hourly speeds.

Figure 4 shows the histogram (table) of resulting MTS speeds (mph) for the 350,000 + urban freeway segments we analyzed.

Figure 4: Distribution of MTS, Weekday Car

MAXIMUM THROUGHPUT SPEED (MPH)	NUMBER OF SEGMENTS
40	9
41	18
42	53
43	119
44	557
45	1,477
46	2,618
47	4,129
48	5,763
49	11,547
50	34,324
51	87,702
52	143,093
53	66,237

How did we calculate daily total delays and rank the nation's "top bottlenecks"?

We ranked bottlenecks by the metric Daily Total Delay (hours), defined as the sum of the estimated delays in all hours experienced by all vehicles entering and leaving a congestion queue on a representative non-holiday weekday.

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[7] MTS is in the denominator of the equation above, and since MTS < FFS it follows that 1/MTS > 1/FFS . The result (1/observed – 1/MTS) < (1/observed – 1/FFS)

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To go from the length-normalized hour-indexed delay (hours per mile, as above) to the Daily Total Delay (hours), we followed a four-step process:

1. ***Adjustment to Daily:*** We first calculated the length-normalized daily delay (hours /mile) for all urban freeway segments *i*

$$\text{Daily Delay}\ (D_i) = \sum_{(j=1)}^{24} \text{Delay}\ (d_{ji})$$

2. ***Adjacency Analysis:*** We then defined a bottleneck as a group of contiguous highway segments *i* that are each above a certain Daily Delay threshold. For national bottlenecks, a cut-off of 3,000 hours/mile of Daily Delay was chosen based on the *Di* distribution across all freeway segments with non-zero delays. In iterative analysis we found that a cut off of 2,500 hours did not change the list of bottlenecks, rather added some new adjacent segments to the existing list, thus 3,000 hours/mile appeared to be a natural break in the distribution. The chosen cut-off represents the 99.7th percentile, meaning the top 0.3% of congested freeway segments qualified for national bottlenecks. If two bottlenecks were located within 0.5 mile of each other, they, along with the segments in between were considered as being part of one corridor.

NOTE: *We did not apply this 0.5 mile for the bottlenecks located in two different freeways near an interchange.*

3. ***Length-weighting:*** The Daily *Total Delay* for each bottleneck was calculated as the sum-product of Daily Delay *(Di)* and length of individual segments *i* in a bottleneck.

$$\text{Daily Total Delay}_A = \sum_{i=1}^{n} \text{Daily Delay}_i \times \text{Length}_i$$

Where,

i represents a freeway segment that is part of bottleneck A, and

n is the number of segments in that bottleneck.

This resulting metric accounts for both length of the bottleneck and the expected volume of vehicles through that bottleneck over a 24-hour period.

The corresponding queue length (in miles) for bottleneck A is L_A, given by

$$\text{Queue Length}\ (L_A) = \sum^{n} \text{Length}_i$$

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4. ***National Ranking:*** In the final step, we rank ordered all the bottlenecks identified in the adjacency analysis in Step 2, using the Daily Total Delay (hours) calculated in Step 3. We identified 3,500 hours of Daily Total Delay (or about 900,000 hours annually) as a natural break in the distribution of top-ranked bottlenecks. The final output of this analysis is the curated list of top 30 bottlenecks shown in Chapter 2. A number of bottlenecks in the same urban areas and a few other notables (ranks 31 – 50 nationally) are listed in Appendix A.

It is worth noting that in the AHUA's 2004 study, a 5-mile queue length was assumed by default for each bottleneck, and the locations identified were central chokepoints within this radius. The current study does not make this assumption. We allow the length of bottlenecks to vary based on estimated delays and the adjacency analysis described above. Furthermore, the 2004 study is based on queuing simulation models that factor in information such as volume, capacity, and other characteristics to predict daily delays. We limit our scope to estimated delays based on observed traffic probe data. For this reason, we cannot readily compare our 2015 study results to the original 2004 study.

HOW DID WE ESTIMATE THE LOST VALUE OF TIME DUE TO DELAYS?

We valued each hour of delay using the state-specific estimate of the value of a volunteer hour (US $/hour). This value is a weighted average of employment wage rates across many labor and skill sectors, and based on data collected by the US Bureau of Labor Statistics

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(BLS). The organization Independent Sector summarizes the calculation process and presents a time trend of how the value of a volunteer hour has evolved over time in the US.[8] This approach most likely underestimates the lost value of time.

HOW DID WE ESTIMATE THE BENEFITS OF ALLEVIATING CONGESTION?

We estimated the fuel wasted due to congestion and potential fuel savings (gallons) using relationships between vehicle speed (miles per hour, mph) and fuel economy (miles per gallon, mpg) published by the Oak Ridge National Laboratory.[9] These relationships are based on lab tests as well as observed data from a large fleet of vehicles. Only the excess fuel used when vehicles are traveling at slow speeds during congested conditions are counted.

We then calculated the potential emissions avoided (pounds CO_2) using standard parameter values published by the US Environmental Protection Agency:[10]

CO_2 Emissions from a gallon of gasoline (for cars): 8,887 grams CO_2/ gallon

CO_2 Emissions from a gallon of diesel (for trucks): 10,180 grams CO_2/ gallon

To calculate the number of vehicle crashes that could possibly be avoided (number), we used the Transportation Research Board's analysis of accident data for the statistical relationships between total crashes and vehicle-miles traveled (VMT).[11]

[8] Independent Sector (2015). The Value of Volunteer Time. Accessed Nov 12, 2015. https://www.independentsector.org/volunteer_time

[9] Oak Ridge National Laboratory (September 2015). Transportation Energy Data Book. Chapters 4 and 5. Accessed Nov 12, 2015. http://cta.ornl.gov/data/index.shtml

[10] United States Environmental Protection Agency (EPA)(October 2014). *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2014.* EPA-420-R -14-023a

Office of Transportation and Air Quality. United States Environmental Protection Agency (EPA) (May 2014). *Greenhouse Gas Emissions from a Typical Passenger Vehicle,* EPA-420-F-14-040a

[11] Potts et al. (2015). *Further Development of the Safety and Congestion Relationship for Urban Freeways,* Strategic Highway Research Program 2, Report S2-L07-RR-3

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