US Traffic Hotspots

Measuring the impact of congestion in the United States

INRIX Research
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INRIX

ABOUT INRIX RESEARCH

Launched in 2016, INRIX Research uses proprietary INRIX big data and expertise to make the movement of people and goods more efficient, safer and convenient.

We achieve this by leveraging 500 Terabytes of INRIX data from 300 million different sources covering over five million miles of road, and combining it with our other data sources including global parking, origin and destination trip data, fuel, point of interest, public transport, and road weather information. Together, our data provide a rich and fertile picture of urban mobility that enable us to produce valuable and actionable insights for policy makers, transport professionals, automakers and drivers.

The INRIX Research team has researchers in Europe and North America and is comprised of economists, transportation policy specialists and data scientists with a mix of research backgrounds from academia, think tanks and commercial research and development groups. We have decades of experience in applying rigorous, cutting-edge methodologies to answer salient, real-world problems.

INRIX Research develops original, relevant and global research content to inform decision makers, transportation officials and the traveling public. In addition to our research outputs, INRIX Research is a valuable and free resource for journalists, researchers and policymakers. We assist with data, analysis and expert commentary on all aspects of urban mobility and smart cities. Spokespeople are available globally for interviews.

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1 EXECUTIVE SUMMARY

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1.1 INTRODUCTION

INRIX Roadway Analytics identified the worst traffic hotspots in America's 25 most-congested cities to learn more about the health of the road and transportation network. As public officials consider increasing transportation spending, strategically targeting investments will be crucial to unlocking maximum benefits.

INRIX Roadway Analytics is the first cloud-based, on-demand traffic analytics platform available in 47 countries across North America, Europe and the Middle East. It provides state and local transportation agencies with easy access to powerful road analysis and insights stemming from highly-granular INRIX XD™ segments. INRIX Roadway Analytics allows transportation planners and analysts to leverage big data to monitor changes in traffic patterns, target transportation improvements to maximize benefits and produce visualizations to convey important information to decision makers.

For this study, INRIX Research used the 25 most congested U.S. cities from the INRIX 2016 Global Traffic Scorecard.[1] Table 1 displays each city and their 2016 cost of congestion to drivers and households within them.[2] To understand the impact of congestion at the street level instead of the household level, INRIX Research leveraged the "bottleneck tool" in the INRIX Roadway Analytics platform.

INRIX Roadway Analytics captures the duration and maximum length of every traffic jam. Traffic jams that occur at the same locations along a stretch of road are called "traffic hotspots." INRIX Research then estimated the lost time, wasted fuel and carbon emitted at each traffic hotspot based on inflation-adjusted United States Department of Transportation (USDOT) values of time. Besides offering a digestible way to examine the severity of specific traffic hotspot, the cost of congestion also provides an economic value to gauge future investment.

At of the time of this writing, the Trump administration has signaled interest in spending one trillion dollars on infrastructure, a large portion of which would be geared toward surface transportation improvements. Though funding and financing questions remain, it will be important that any infrastructure package prioritize projects to generate the most benefit at the least cost.

1. *Since 18th ranked Tacoma, WA and 26th ranked Concord, CA fall within a Metropolitan Statistical Area covered in this study, 27th ranked Columbia, MD was included.*

2. *The cost per city in the INRIX 2016 Global Traffic Scorecard may not reflect similarly to the results of this study, as the costs in Scorecard are based on household data provided by the National Household Travel Survey. In addition, this study focuses on the Metropolitan Statistical Area as defined by the Census Bureau, not the INRIX Urban Area used in the Scorecard.*

Table 1: INRIX 2016 Global Traffic Scorecard

INRIX 2016 GLOBAL TRAFFIC SCORECARD							
RANK	CITY	PEAK HOURS SPENT IN CONGESTION	TOTAL COST OF CONGESTION	RANK	CITY	PEAK HOURS SPENT IN CONGESTION	TOTAL COST OF CONGESTION
1	Los Angeles, CA	104	$9.7b	14	San Diego, CA	46	$1.4b
2	New York, NY	89	$16.9b	15	Minneapolis, MN	40	$1.2b
3	San Francisco, CA	83	$2.5b	16	Stamford, CT	39	$67m
4	Atlanta, GA	71	$3.1b	17	Philadelphia, PA	38	$2.5b
5	Miami, FL	65	$3.6b	19	Phoenix, AZ	37	$1.5b
6	Washington, D.C.	61	$3.0b	20	Baton Rouge, LA	36	$271m
7	Dallas, TX	59	$2.9b	21	Denver, CO	36	$1.2b
8	Boston, MA	58	$2.9b	22	Santa Barbara, CA	36	$101m
9	Chicago, IL	57	$5.2b	23	Nashville, TN	34	$517m
10	Seattle, WA	55	$2.0b	24	Detroit, MI	33	$1.5b
11	Houston, TX	52	$2.5b	25	Pittsburgh, PA	33	$944m
12	Portland, OR	47	$1.0b	27	Columbia, MD	32	$42m
13	Austin, TX	47	$810m		**U.S. Total**		**$295b**


Ed Koch
Queensboro Bridge
LOWER RDWY
ONLY

1.2
KEY FINDINGS

Drivers in Los Angeles faced the greatest impact from traffic hotspots, followed by New York, Washington D.C., Atlanta and Dallas. Per capita, Angelenos were most affected by traffic jams but Stamford, San Francisco and San Diego had the most severe traffic jams, although fewer of them. Across all 25 cities, traffic hotspots are estimated to cost drivers $480 billion over the next ten years in lost time, wasted fuel and carbon emitted.

The U.S. Traffic Hotspot Study provides insight into the 25 cities most affected by traffic congestion as identified by the INRIX 2016 Global Traffic Scorecard. New York had more traffic hotspots than any other city analyzed (13,608), yet drivers in Los Angeles faced the highest economic burden of hotspots. More than 128,000 traffic jams occurred in L.A. between March and April 2017, resulting in an Impact Factor of 11.7 million. Based on Impact Factor, the economic cost of Los Angeles' hotspots are estimated at more than $90 billion over the next ten years if congestion levels remain constant.

New York ranked second, with an Impact Factor of 8.2 million, 30 percent lower than L.A., resulting in an estimated cost of $64 billion over the next decade. The Impact Factor and cost of hotspots in Los Angeles and New York combined surpassed the next five cities added together: Washington D.C. (IF: 3.8m; $29bn), Atlanta (IF: 3.7m; $29bn), Dallas (IF: 3.6m; $28bn), Chicago (IF: 3.6m; $28bn) and San Francisco (IF: 3.5m; $27bn).

The nation's worst single traffic hotspot identified was located on Interstate 95 Southbound at Exit 133A in the Washington D.C. region near Fredericksburg, VA. This traffic hotspot is comprised of 1,394 traffic jams over the two-month study period, with an average duration of 33 minutes stretching an average maximum length of 6.47 miles – leading to an Impact Factor of 297,633 (1,394 x 33 x 6.47). Based on Impact Factor, this hotspot is estimated to cost drivers $2.3 billion through 2026.

Stamford, CT had the second-highest Impact Factor per capita and the highest Impact Factor per traffic jam, suggesting that the area has a disproportionately-high level of congestion at traffic hotspots for its size, something not reflected in its 22nd overall ranking. The opposite was found in New York City - though ranked second, had the 17th-highest Impact Factor per capita.

In another example, San Francisco (ranked seventh) had nearly double the Impact Factor per traffic jam than Atlanta (ranked fourth), despite an Impact Factor just six percent lower than Atlanta. This suggests that traffic jams, when they occur, are more severe in the Bay Area than Atlanta.

2 METHODOLOGY

2.1 INRIX ROADWAY ANALYTICS: TRAFFIC HOTSPOTS

INRIX operates the most robust driver network in the world, gathering data from more than 300 million connected cars and devices, equating to nearly two billion data points per day. Its automotive-grade traffic services are available on over five million miles of road worldwide.

INRIX combines anonymous, real-time GPS probe data and hundreds of market-specific criteria that affect traffic – such as construction and road closures, real-time disruptions, sporting and entertainment events, weather forecasts and school schedules – to provide the most accurate picture of current and historical travel conditions.

This real-time traffic data is at the heart of the INRIX Roadway Analytics platform. A key feature of the platform is the bottleneck tool that identifies and evaluates every traffic jam within a customizable study area and time-period. The detection of a traffic jam is based on comparisons of travel speeds to reference speeds, which are the proxy of the free flow or uncongested speed. A potential traffic jam is detected when speeds on a segment drop to 65 percent of the reference speed, and is confirmed if speeds stay below 65 percent for more than two minutes. The congestion occurrence will only be cleared once speeds rise above 75 percent of the reference speed.

In other words, a "traffic jam" is an occurrence of congestion at a specific location on the road network. It may be caused by a physical bottleneck (e.g. where three lanes of traffic are reduced to two), an accident, construction, or by the volume of traffic relative to the available road space – common on urban freeways during the peak periods. The INRIX Roadway Analytics bottleneck tool is agnostic to the cause of the congestion, and is meant to be used as a planning and evaluation tool that allows users to prioritize investment spending, benchmark transportation facilities and maximize benefits for road users and public agencies. As traffic jams often form frequently at the same location, the bottleneck tool aggregates and summarizes these locations. In this report, the locations of these repeated traffic jams are called traffic hotspots.

The impact of the congestion caused by hotspots is calculated by multiplying the average duration in minutes, average maximum length in miles, and the number of traffic jams to generate the "Impact Factor" score (duration x length x number of traffic jams). This score allows traffic hotspots to be ranked in terms of severity.

WHAT IS A ROAD'S FRC?

FRC stands for Functional Road Classification and is how roads are classified into a hierarchy in the INRIX Roadway Analytics platform. By dividing roads into classes, transportation engineers and government agencies can benchmark and monitor by the specific purpose of a set of road segments.

FRC1 = Limited-access highways, like those encompassing the original Interstate Highway System. Prime examples include Interstate 95, Interstate 90 and Interstate 5.

FRC2 =Roads in this classification are considered freeways or expressways, with somewhat-limited access and similar functions to FRC1. Prominent examples include the Southern State Parkway / Belt Parkway in New York City and the Glenn Anderson Freeway (I-105) in Los Angeles.

FRC3 = These roads typically serve high traffic volumes and intra area travel between downtowns and residential areas. Compared to FRC1 and FRC2, multiple FRC3s typically surround an urban center, carrying people and goods through the region. Examples of FRC3 in urban areas include Broadway and 2nd Avenue in Manhattan.

FRC4 and FRC5 = Roads under the FRC4 classification typically connect to higher-level arterial streets. Folsom Street in San Francisco and New Hampshire Ave NW in Washington D.C. are examples of FRC4 streets.

For this study, INRIX Research analyzed two months of traffic data between March and April 2017 using the Roadway Analytics bottleneck tool. While the period chosen should accurately reflect traffic conditions on corridors with a large degree of confidence, local traffic conditions may generate some bias.

For example, on March 30, 2017, a portion of Interstate 85 in Atlanta collapsed due to a fire under the bridge. The new span opened to northbound and southbound traffic on May 15, 2017. Events like the I-85 collapse may generate traffic hotspots that would normally score lower or not be present, while at the same time de-emphasizing traffic hotspots occurring on I-85 in that specific area. Hence, local conditions – including highway and bridge construction, repairs, traffic incidents, road closures and other disruptions – need to be taken into consideration when analyzing the impact of traffic hotspots in this report.

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2.1.1 TRAFFIC HOTSPOT EXAMPLE: WORST IN AMERICA

Figure 1, the "Summary Table," provides a list of the 6,097 aggregated traffic hotspots across the Washington D.C. region and each traffic hotspot's characteristics, while Figure 2 provides a visualization of the traffic hotspot being studied. Though this study largely focused on the aggregated traffic hotspots instead of individual instances of traffic jams, INRIX Roadway Analytics also provides greater insights into traffic.

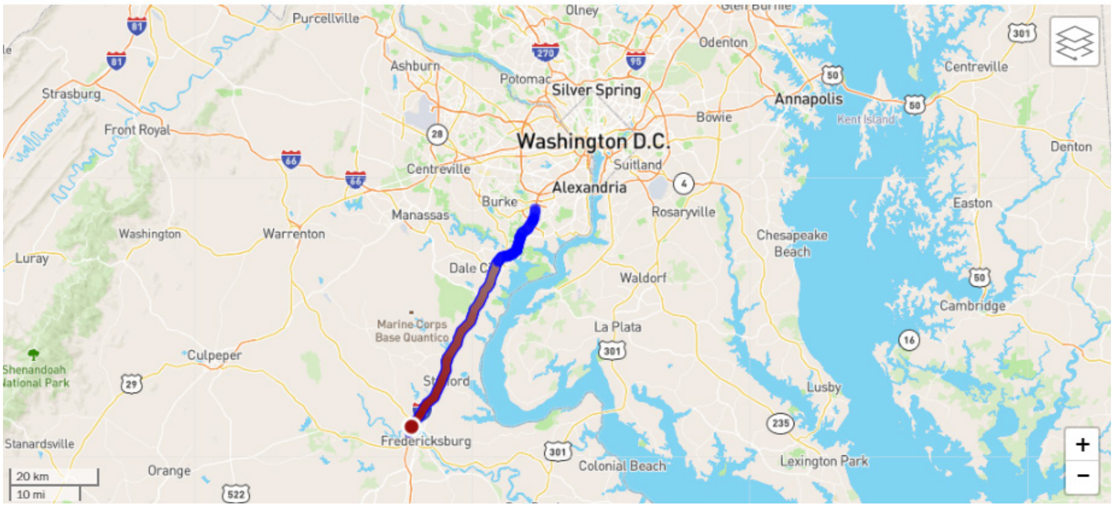
Figure 1: Bottleneck Results Summary Table

Summary Table

Road Name	Intersection	Direction	Occurrences	Avg Max Duration (min)	Average Max Length (miles)
I-95 S / Richmond Petersburg Tpke S	I-95	S	1394	33	6.47
I-95 N / Capital Beltway N / I-495 N	I-95	N	936	33	4.51
I-95 N / Capital Beltway N / I-495 N	I-95 Capital Beltway	N	684	39	5.08
I-95 N / Capital Beltway N / I-495 N	I-95 Exits 160,160A,160B / VA-123 Gordon Blvd / Annap...	N	200	86	4.68
I-66 E / Custis Memorial Pkwy E	I-66 Exit 71 / Fairfax Dr	E	193	97	3.24
I-95 S / Capital Beltway S / I-495 S / Capital Beltway N / I...	I-495 Capital Beltway Exit 38 / I-270 Spur	S	87	110	5.92
I-66 W / Custis Memorial Pkwy W	I-66	W	424	25	4.61
I-95 N / Capital Beltway N / I-495 N / Capital Beltway S / ...	I-495 Capital Beltway Exits 45,45A,45B / VA-267 Dulles A...	N	143	56	5.87
I-95 S / Capital Beltway S / I-495 S / Capital Beltway N / I...	I-495 Capital Beltway Exit 41 / Clara Barton Pkwy	S	86	128	4.21
I-95 N / Capital Beltway N / I-495 N / Capital Beltway S / ...	I-495 Capital Beltway	N	151	77	3.89
I-95 N / Capital Beltway N / I-495 N	I-95 Exit 167 / Backlick Rd	N	181	48	5.00
MD-295 S / Baltimore Washington Pkwy S	MD-295 Baltimore Washington Pkwy / Powder Mill Rd	S	181	48	4.90
I-66 W / Custis Memorial Pkwy W	I-66 Exits 57A,57B / US-50 Lee Jackson Memorial Hwy / ...	W	143	56	4.96
I-270 N / Washington National Pike N	I-270	N	244	33	4.94
I-295 S / I-695 S / Southwest Fwy N / I-395 N	I-95 Capital Beltway Exits 2A,2A-B,2B,3,3A / I-295 Exits 1...	S	49	143	5.62
I-95 S / Capital Beltway S / I-495 S / Capital Beltway N / I...	I-95 Capital Beltway Exit 13 / Ritchie Marlboro Rd	S	125	47	6.48

Figure 2: Mapping Hotspots

I-95 S / Richmond Petersburg Tpke S



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Interstate 95 Southbound at Exit 133A near our nation's capital was America's worst traffic hotspot. This hotspot was comprised of 1,394 traffic jams over two months, with an average duration of 33 minutes stretching an average maximum length of 6.47 miles – leading to an Impact Factor of 297,633 (1,394 x 33 x 6.47). Based on Impact Factor, this traffic hotspot is estimated to cost drivers $2.3 billion over the next 10 years in in lost time, wasted fuel and carbon emitted.

But Virginia Department of Transportation (VDOT) officials aren't just standing by. Their partnership with Transurban will add 2.2 miles of reversible lanes to extend the I-95 Express Lanes to the south to alleviate heavy congestion caused by weaving. Officials have also planned and funded other projects in the vicinity, like the I-95 Rappahannock River Crossing, a two-lane collector distributor road between the Route 17 and Route 3 interchanges to reduce congestion in the southbound direction.

Figure 3 reveals why these improvements are needed. Every traffic jam on I-95 Southbound during the study period is shown by time of day, duration and frequency.

Figure 3: Traffic Jams by Time of Day, Duration and Frequency

2.2 ECONOMIC COST OF CONGESTION

Traffic hotspots on the roadway lead to economic losses in time, fuel and carbon to drivers, bus riders and freight movers. Using the Impact Factor score, the economic cost of congestion at hotspots can be estimated, providing a measure transportation professionals and public officials to consider when evaluating strategic infrastructure investments.

Due to both the range of FRC roads and the number of roads contained in the study, simplifying the economic cost calculation requires consideration and assumption of three variables:

1. Average number of lanes of traffic in traffic hotspots

2. Average number of vehicles per mile of traffic hotspot

3. Average vehicle occupancy

In addition to the assumptions, a value of time must be established. A value of time allows transportation agencies and public officials to accurately gauge whether a project's costs outweigh the travel time benefits. For the purposes of this study, INRIX Research based value of time estimates from USDOT figures: $12.81 per hour commuting, $25.19 per hour for business travel and $9.51 per hour for all other travel purposes. Approximately 17 percent of person trips in the country are reported to be for commuting, while three percent is business-related. The reminder of trips – errands, school, social and recreational – are classified as other.[3]

Trip-specific vehicle occupancy values from the Federal Highway Administration, when applied to the USDOT value of time, along with a congestion factor, provided an average hourly value of time of $33.11. When wasted fuel and the value of carbon emitted were factored in, an hour in congested travel was estimated to cost $34.50, or $0.57 per minute.

Since hotspots varied in terms of FRC and number of available general purpose, auxiliary and merging lanes stretching a roadway, INRIX Research based estimates using a conservative two-lane road assumption. INRIX Research estimated the density of vehicles at 150 vehicles per lane-mile. While level of service F conditions state that unstable congestion happens at densities greater than 67, vehicle density can be much greater.

Multiplying these factors together provided a conversion factor of 172.50, which was applied to the Impact Factor produced in INRIX Roadway Analytics to generate the economic cost of traffic hotspots.

__3.__ "2009 National Household Travel Survey," Federal Highway Administration, Table 9, at http://nhts.ornl.gov/2009/pub/stt.pdf."

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For the purposes of this study, INRIX Research assumed the two-month period, multiplied by six, to be the annual total for estimating the cost of congestion. The present value of the cost of congestion over the next decade was estimated using the social discount rate of seven percent, as recommended by the Office of Management and Budget. A ten-year period was chosen as it can take as many years from project inception to completion, especially on complex highway projects through urban areas. A hotspot's cost should be measured alongside potential project benefits to determine if investment is warranted.

3 U.S. TRAFFIC HOTSPOTS

3.1 TOP 25 TRAFFIC HOTSPOTS

The 25 top-ranked U.S. cities in the INRIX 2016 Global Traffic Scorecard were analyzed further to pinpoint the locations of traffic hotspots. INRIX Roadway Analytics identified more than 800,000 traffic jams at nearly 108,000 traffic hotspots between March and April 2017. The top 25 hotspots are estimated to cost drivers over $25 billion over the next decade.

Table 2 presents the top 25 traffic hotspots out of the cities studied. With five of the top 10 hotspots, and 10 out of the top 25, drivers in Los Angeles were most affected by traffic hotspots. However, the single most severe traffic hotspot was on I-95 Southbound in Washington D.C. Traffic jams on I-95 stretched an averaged 6.47 miles with an average duration of 33 minutes, leading to $2.3 billion in lost time, wasted fuel and carbon emitted over the next decade.

The top 25 traffic hotspots represented a significant share of the total Impact Factor. Only 0.04 percent of hotspots were represented in the top 25, yet they made up over five percent of the total Impact Factor. This was especially evident in Washington D.C. and L.A. The three Washington D.C. hotspots in the top 25 were responsible for 15 percent of the city's total Impact Factor. In L.A., more than 11 percent of the city Impact Factor was concentrated in the top 25.

Just nine cities had a hotspot in the top 25. Twenty-four out of the top 25 traffic hotspots are limited access highways (FRC1). The only expressway (FRC2) in the top 25 was the Belt Parkway in New York.

Table 2: INRIX Roadway Analytics Top 25 Traffic Hotspots

RANK	CITY	TRAFFIC HOTSPOT	AVG. DURATION (MIN)	AVG. MAX LENGTH (MILES)	TRAFFIC JAMS	IMPACT FACTOR	2026 ECONOMIC COST
1	Washington, D.C.	I-95 S at Exit 133A to Fairfax County Parkway	33	6.47	1,394	297,633	$2.3bn
2	Los Angeles, CA	I-405 N at Exit 43 to Exit 21	23	5.12	2,032	239,288	$1.9bn
3	Los Angeles, CA	I-405 S at Exit 22 to Exit 45	24	4.98	1,403	167,687	$1.3bn
4	Los Angeles, CA	US-101 S at Exit 3B to CA-134/ CA-170	355	4.22	108	161,795	$1.3bn
5	Chicago, IL	I-90 W at 81A to Exit 56B	79	8.55	238	160,757	$1.3bn
6	Los Angeles, CA	I-405 N at Exit 53 to 38B	40	5.61	680	152,592	$1.2bn
7	Washington, D.C.	I-95 N at Exit 143B to SR-608	33	4.51	936	139,305	$1.1bn
8	Los Angeles, CA	US-101 S at Exit 13B to Exit 34	124	4.54	241	135,673	$1.1bn
9	Washington, D.C.	I-495 Beltway at Route 201 to Exit 4A	39	5.08	684	135,514	$1.1bn
10	San Diego, CA	I-15 N at Exit I-215 to Gopher Canyon Road	177	13.71	54	131,040	$1.0bn
11	New York, NY	Brooklyn Queens Expy E at Exit 28A to W Shore Expy	64	4.37	462	129,212	$1.0bn
12	Houston, TX	I-45 S Exit 46A to Exit 63	75	5	340	127,500	$992m
13	New York, NY	I-95 N / Cross Bronx Expy at Exit 4A to Route 46	155	3.35	243	126,178	$981m
14	San Francisco, CA	I-80 W at Emeryville to CA-4	53	4.35	504	116,197	$904m
15	Los Angeles, CA	I-5 S at I-10 to CA-170	76	7.41	201	113,195	$880m
16	Atlanta, GA	I-285 S at I-20 to Route 23	74	10.38	143	109,841	$854m
17	Atlanta, GA	I-75 N at Exit 271 to I-75/I-85	62	8.99	187	104,230	$811m
18	New York, NY	Belt Pkwy E at Crossbay Blvd to I-278	115	7.16	122	100,455	$781m
19	Los Angeles, CA	I-10 E at I-5/I-10 Exit 135C to Exit 1A Santa Monica	26	9.04	422	99,187	$771m
20	Seattle, WA	I-5 S at Pike St to 128th St/Exit 186	39	6.14	406	97,221	$756m
21	Los Angeles, CA	I-5 N Exit 146A to Exit 126B	86	6.13	184	97,001	$754m
22	Chicago, IL	I-90 E at Exit 50B to I-294	48	6.56	304	95,724	$744m
23	Los Angeles, CA	I-10 W at I-110 to Exit 19C	112	3.79	218	92,537	$720m
24	Los Angeles, CA	I-405 N at Exit 70 to I-105	22	12.03	349	92,366	$718m
25	New York, NY	I-95 S / Cross Bronx Expy at Alexander Hamilton Bridge to Exit 6A	155	3.76	158	92,082	$716m

3.2 TOP TRAFFIC HOTSPOT IN EACH CITY

Though just nine cities had hotspots in the top 25, traffic problems were present in every city studied. Table 3 shows the top traffic hotspot in each city, along with a traffic hotspot's start and end points, duration, length and number of traffic jams that occurred within the study period. Also provided is the present value of cost of congestion across the next decade, discounted at seven percent annually.

For example, the I-278 Eastbound traffic hotspot at Brooklyn Bridge Park was the number one rated traffic hotspot in New York City, but the 11th-ranked traffic hotspot in the country. This hotspot was estimated to cost drivers on that stretch of road more than one billion dollars over the next ten years.

Some traffic hotspots have long durations but happen two to three times per weekday on different sections of the road. Other traffic jams occur multiple times every weekday but break up and reform often. While the aggregated summary allows a high-level look into these top traffic hotspots, INRIX Roadway Analytics allows users to dive further into each traffic jam and their related incidents.

Table 3: INRIX Roadway Analytics Top Hotspots by City

RANK	CITY	TRAFFIC HOTSPOT	AVG. DURATION (MIN)	AVG. MAX LENGTH (MILES)	TRAFFIC JAMS	IMPACT FACTOR	2026 ECONOMIC COST
1	Washington, D.C.	I-95 S at Exit 133A to Fairfax County Parkway	33	6.47	1,394	297,633	$2.3bn
2	Los Angeles, CA	I-405 N at Exit 43 to Exit 21	23	5.12	2,032	239,288	$1.9bn
5	Chicago, IL	I-90 W at 81A to Exit 56B	79	8.55	238	160,757	$1.3bn
10	San Diego, CA	I-15 N at Exit I-215 to Gopher Canyon Road	177	13.71	54	131,040	$1.0bn
11	New York, NY	Brooklyn Queens Expy E at Exit 28A to W Shore Expy	64	4.37	462	129,212	$1.0bn
12	Houston, TX	I-45 S Exit 46A to Exit 63	75	5	340	127,500	$992m
14	San Francisco, CA	I-80 W at Emeryville to CA-4	53	4.35	504	116,197	$904m
16	Atlanta, GA	I-285 S at I-20 to Route 23	74	10.38	143	109,841	$854m
20	Seattle, WA	I-5 S at Pike St to 128th St/Exit 186	39	6.14	406	97,221	$756m
27	Boston, MA	Massachusetts Tpke E at Boston U Bridge to Oak St	35	6.16	401	86,456	$672m
33	Portland, OR	US-26 E at I-405 to NW 185th Ave	77	4.2	253	81,820	$636m
39	Columbia, MD	I-695 CCW at Baltimore Nat'l Pike to Providence Rd	81	6.64	148	79,600	$619m
45	Philadelphia, PA	Mid-County Expy S at E Rose Valley Rd to Pearl Harbor Memorial Bridge	31	5.31	466	76,708	$597m
58	Stamford, CT	I-95 S at Route 136 to Stratford Ave	56	6.32	197	69,722	$542m
63	Nashville, TN	I-24 W at Antioch Pike to Rocky Fork Rd	39	4.85	353	66,770	$519m
64	Austin, TX	I-35 N at Stassney Ln to Exit 223	97	3.67	185	65,858	$512m
74	Denver, CO	US-36 W / I-270 at Exit 1 to Smith Rd	133	3.87	119	61,250	$476m
81	Miami, FL	I-95 N at Exit 12A to US-1	33	7.79	229	58,869	$458m
83	Baton Rouge, LA	I-10 E at College Dr to Port Allen Lock	161	7.17	50	57,719	$449m
84	Dallas, TX	I-20 W at Exit 451 to Exit 466	109	4.57	115	57,285	$446m
122	Phoenix, AZ	I-10 W at Exit 138 to Exit 151	32	7.56	212	51,287	$399m
158	Pittsburgh, PA	Lincoln Hwy E at Fort Pitt Tunnel to Settlers Ridge	59	2.9	274	46,881	$365m
385	Detroit, MI	I-94 W at Inkster Rd to Gratiot Ave	28	5.54	179	27,766	$216m
401	Minneapolis, MN	I-94 W at State Hwy 128 to 250th St	36	3.8	198	27,086	$211m
670	Santa Barbara, CA	US-101 N at San Ysidro Rd to La Conchita	50	5.65	66	18,645	$145m

3.3 CITY TOTALS

To show the effects of all traffic hotspots at the city level, the total number of hotspots ranked by Impact Factor and Impact Factor per capita are provided in Table 4.

While New York had more traffic hotspots than any other city analyzed, drivers in Los Angeles faced the greatest impact from traffic hotspots, both in aggregate and per-capita. In L.A., INRIX Roadway Analytics identified 10,385 traffic hotspots comprised of more than 128,000 traffic jams between March and April 2017. These hotspots summed to an Impact Factor of 11.7 million. Based on Impact Factor, Los Angeles' hotspots were estimated to cost drivers in the city more than $90 billion over the next ten years.

New York ranked second, with an aggregated Impact Factor of 8.2 million, 30 percent lower than L.A, despite having just 12 percent fewer traffic jams, resulting in an estimated $64 billion in lost time and wasted fuel over the next decade. The Impact Factor of hotspots in Los Angeles and New York combined surpassed the next five cities together: Washington D.C. (IF: 3.8m; $29bn), Atlanta (IF: 3.7m; $29bn), Dallas (IF: 3.6m; $28bn), Chicago (IF: 3.6m; $28bn) and San Francisco (IF: 3.5m; $27bn).

Across all 25 cities, the total cost of all hotspots over the next decade were estimated at more than $480 billion. Extrapolated across the country as a whole, the cost of hotspots are expected to reach $2.2 trillion through 2026.

Impact Factor can also be used with other metrics to provide a better understanding of traffic congestion across varying city sizes, densities and travel patterns. For example, Stamford ranked 22nd in overall Impact Factor, indicating a moderate level of congestion at traffic hotspots compared to its peers. Yet Stamford had the second-highest Impact Factor per capita and the highest Impact Factor per traffic jam. This suggests that the area has a disproportionately-high level of congestion at traffic hotspots for its size, something not reflected in its 22nd overall ranking.

In another example, San Francisco (ranked seventh) had nearly double the Impact Factor per traffic jam than Atlanta (ranked fourth), despite a total Impact Factor just six percent lower than Atlanta. This suggests that traffic jams, when they occur, are more severe in the Bay Area than Atlanta.

Table 4: INRIX Roadway Analytics Impact Factor Ranking – U.S. Cities

IMPACT FACTOR RANK	IMPACT FACTOR PER CAPITA RANK	CITY	TRAFFIC JAMS	TRAFFIC HOTSPOTS	IMPACT FACTOR	IMPACT FACTOR PER TRAFFIC JAM	2026 COST OF CONGESTION
1	1	Los Angeles, CA	128,116	10,385	11,692,591	91.3	$90.9bn
2	17	New York, NY	113,373	13,608	8,215,036	72.5	$63.9bn
3	5	Washington, D.C.	50,077	6,097	3,758,733	75.1	$29.2bn
4	4	Atlanta, GA	58,536	8,554	3,714,123	63.5	$28.9bn
5	9	Dallas, TX	44,754	6,720	3,644,525	81.4	$28.3bn
6	18	Chicago, IL	40,259	7,719	3,631,591	90.2	$28.2bn
7	3	San Francisco, CA	29,964	2,587	3,458,305	115.4	$26.9bn
8	13	Houston, TX	34,836	4,417	3,058,004	87.8	$23.8bn
9	16	Miami, FL	60,008	6,596	2,449,631	40.8	$19.1bn
10	10	Boston, MA	26,844	4,158	2,429,229	90.5	$18.9bn
11	8	Seattle, WA	23,562	2,675	1,929,802	81.9	$15.0bn
12	21	Philadelphia, PA	29,979	6,232	1,896,048	63.2	$14.7bn
13	12	San Diego, CA	14,971	1,936	1,602,278	107.0	$12.5bn
14	15	Denver, CO	16,636	2,258	1,226,504	73.7	$9.5bn
15	22	Phoenix, AZ	18,937	3,441	1,220,561	64.5	$9.5bn
16	11	Portland, OR	15,086	2,365	1,154,218	76.5	$9.0bn
17	6	Nashville, TN	18,128	2,602	1,081,459	59.7	$8.4bn
18	7	Austin, TX	12,231	1,727	1,076,441	88.0	$8.4bn
19	19	Columbia, MD	16,132	2,856	1,046,558	64.9	$8.1bn
20	23	Detroit, MI	17,158	4,284	1,019,345	59.4	$7.9bn
21	24	Minneapolis, MN	9,767	1,903	799,619	81.9	$6.2bn
22	2	Stamford, CT	5,687	777	729,130	128.2	$5.7bn
23	25	Pittsburgh, PA	10,253	2,744	530,395	51.7	$4.1bn
24	14	Baton Rouge, LA	5,389	1,090	389,416	72.3	$3.0bn
25	20	Santa Barbara, CA	1,671	174	146,996	88.0	$1.1bn

4 INRIX CASE STUDIES

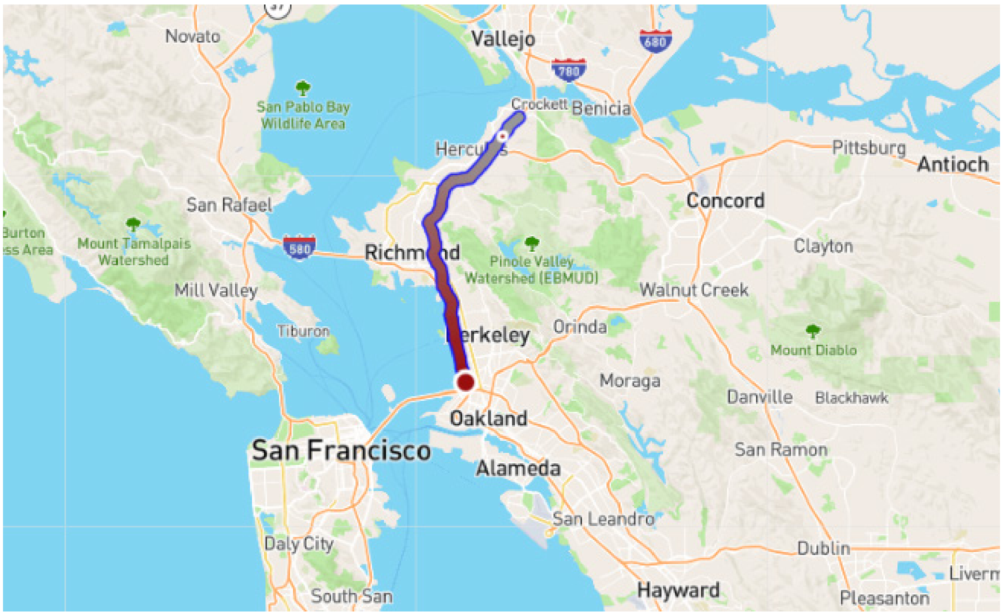
4.1 SAN FRANCISCO BAY AREA

The San Francisco area ranked seventh in the traffic hotspot study for impact – third in the U.S. in the INRIX 2016 Global Traffic Scorecard. Yet despite the high rankings in both studies, the Bay Area only registered about 2,500 traffic hotspots comprised of nearly 30,000 traffic jams – 5,100 fewer traffic hotspots than sixth-placed Chicago and 1,800 fewer than eighth-ranked Houston.

San Francisco also had fewer individual traffic jams than Chicago (40,000 jams) and Houston (35,000 jams). This suggests that traffic congestion is far more severe and concentrated in the Bay Area than in many of the other cities studied, reflected in San Francisco's second-highest Impact Factor per traffic jam.

I-80 Westbound was the Bay Area's largest traffic hotspot, stretching nearly the whole corridor, starting close to the Bay Bridge and ending just before the Carquinez Bridge – as shown in Figure 4. Noting that this corridor is chronically congested, transportation officials recently upgraded this stretch of I-80 to a "smart corridor." The technology improvements regulate entrance ramps onto the freeway, provide drivers up-to-date information travel and incident information, and adjust traffic lights on adjacent and parallel roads to ease congestion. Part of the smart corridor technology went into official operation beginning in April 2016 and was nearly fully operational by September of last year. The primary goal of the project was to reduce secondary accidents and improve safety.

Figure 4: The Bay Area's Worst Hotspot



INRIX analyzed traffic conditions between the Bay Bridge and the Carquinez Bridge between 2014 and 2017, using the January through May period, to study the year over year impact to I-80 specifically.

Table 5 shows westbound and eastbound travel time changes on I-80 between Emeryville and the Carquinez Bridge. Because the smart corridor is only active in the westbound direction, eastbound figures have been included to compare travel time changes to the original configuration.

Heading westbound, average travel times increased between three and six percent over 2016 levels during the 6:00AM to 8:00AM morning commute period, yet decreased in the 9:00AM and 10:00AM hours. However, the increases have been lower than the annual growth rate between 2014 and 2016. For example, between 2014 and 2016 travel times grew at an average 8.75 percent annually, yet the 2016 to 2017 change was 5.26 percent. It should be noted that 2016 saw a significant increase in travel times over 2015.

Outside of the morning period, eastbound travel on I-80 saw a relative decrease in travel times versus 2016 in the 5:00PM to 10:00PM hours and a lower than average increase in the earlier afternoon hours.

INRIX Research recommends that more data be used to analyze the health of the I-80 corridor. Though not the primary goal of the project, another year of data would help determine if the westbound enhancements had a sizeable effect on travel times.

Table 5: I-80 Smart Corridor Before and After

PERCENTAGE GROWTH IN TRAVEL TIMES - WESTBOUND		
TIME	% CHANGE 2016 TO 2017	AGR 2014 TO 2016
6:00am	5.96%	11.80%
7:00am	5.26%	8.75%
8:00am	3.66%	3.38%
9:00am	-1.45%	3.49%
10:00am	-0.30%	4.35%
11:00am	2.03%	4.68%
12:00pm	1.55%	5.82%
1:00pm	2.02%	5.06%
2:00pm	-0.52%	5.02%
3:00pm	-5.44%	2.72%
4:00pm	-2.57%	-1.30%
5:00pm	-3.07%	-2.29%
6:00pm	-2.24%	-2.05%
7:00pm	2.83%	-0.84%
8:00pm	3.10%	0.44%
9:00pm	2.52%	0.44%
10:00pm	3.90%	0.34%
11:00pm	4.98%	0.74%

PERCENTAGE GROWTH IN TRAVEL TIMES - EASTBOUND		
TIME	% CHANGE 2016 TO 2017	AGR 2014 TO 2016
6:00am	1.38%	-0.10%
7:00am	-0.48%	0.00%
8:00am	-0.58%	-0.38%
9:00am	0.38%	-0.66%
10:00am	0.19%	-0.34%
11:00am	-0.57%	0.43%
12:00pm	-3.52%	2.58%
1:00pm	-2.03%	3.24%
2:00pm	6.53%	5.55%
3:00pm	4.27%	12.84%
4:00pm	1.91%	13.21%
5:00pm	-0.42%	10.98%
6:00pm	-3.62%	11.27%
7:00pm	-2.72%	8.89%
8:00pm	-8.30%	8.23%
9:00pm	-14.31%	10.49%
10:00pm	-10.19%	7.22%
11:00pm	-4.16%	4.91%

4.2 SEATTLE REGION

Interstate 405, along with Interstate 5, are main North-South corridors in the Seattle region. In September 2015, the Washington State Department of Transportation (WSDOT) implemented Express Toll Lanes on the I-405 corridor, managed with variable pricing, between Bellevue in the south end and Lynnwood on the north end.

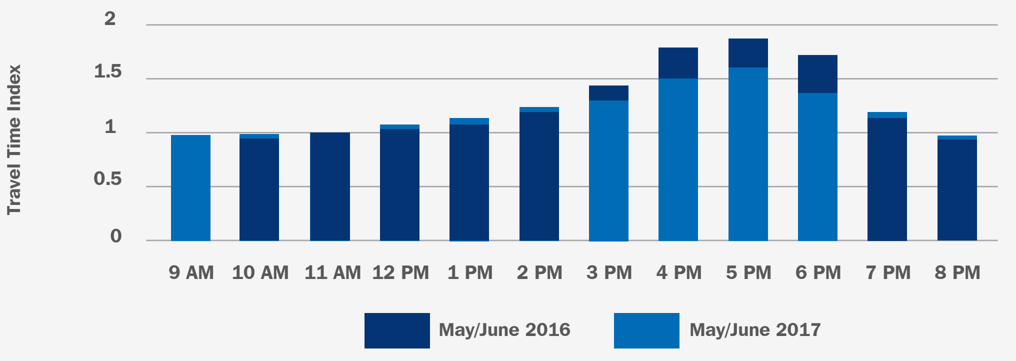
Approximately half way through the corridor, heading northbound at State Route 522, two toll lanes merge into one toll lane, while general purpose capacity reduces from three lanes to two. The high occupancy vehicle lane was converted to a toll lane in this section with no added capacity, creating a physical traffic bottleneck. This traffic hotspot was causing chronic congestion heading northbound between Bothell and Lynnwood, with the general-purpose lanes and the toll lane congested during the PM peak period commute.

To reduce congestion on that stretch of I-405, WSDOT converted the shoulder to a "hard running shoulder" during the PM commute period. This 1.8-mile addition to the roadway is similar in principle to the "Smart Motorways" concept in the U.K., using shoulders and lane management to improve traffic flow during the peak period. I-405's shoulder running began in Spring 2017 and has greatly reduced congestion on the I-405 Corridor, thereby freeing up the toll lane and lowering toll prices.

Using INRIX Roadway Analytics Performance Charts, INRIX Research compared weekday travel on the two-month period between June and July of 2016 to June and July of 2017 for a view of before and after operations. Figure 4 displays the Travel Time Index (TTI) on northbound travel on the stretch of I-405 between Bothell and Lynnwood. TTI reflects speeds above the reference, or free-flow speed. For example, the northbound TTI in 2016 at 5:00pm was 1.93, indicating a 93 percent increase in travel times over free-flow. After WSDOT completed the shoulder running project, TTI dropped to 1.58 in 2017, leading to an 18 percent decrease in travel times.

This large decrease during the PM commute came at a cost of $11.6 million and appears to be having a positive impact on travel times. Using the Smart Motorways concept can be an effective tool to provide congestion relief without the need to purchase additional rights of way.

Figure 5: Northbound I-405 Weekday Travel Time Index



5 CONCLUSION

Many state and local transportation agencies have enacted long-term programs to improve urban mobility. Yet despite future gains, transportation agencies face a few uphill battles to tackle congestion at traffic hotspots.

Though Los Angeles drivers have it the worst, traffic hotspots affect nearly every major American city, sometimes disproportionately, as in the case of cities like Stamford. To combat traffic hotspots, many state and local governments are moving forward with a host of projects to improve travel times and reduce delay.

Chicago's top hotspot, for example, on I-90 westbound at North Newcastle Avenue, is just four miles east of a recent roadway expansion project on the Jane Addams Memorial Tollway. Illinois Tollway recently added a lane in each direction, which increased westbound peak hour travel speeds by 64 percent. It also activated "smart" features, such as dynamic travel time information, active lane management and shoulder running for buses and emergency vehicles.

As noted in Wired Magazine, states are stepping up to fill the gap in federal infrastructure spending:[4]

"On Election Day, Americans in cities and regions across the US approved some $170 billion in public transit funding, plus billions more to improve roads, rail, ports, and bicycle and pedestrian infrastructure."

Although in the early stages, government officials across the country have enacted long-term transportation programs, such as California's recently-passed Senate Bill 1 - the Road Repair and Accountability Act of 2017. This package invests $54 billion over the next decade to fix roads, freeways and bridges in communities across California and puts more dollars toward transit and safety. These funds will be split equally between state and local investments. Similar legislation has recently been enacted in other states to pay for maintenance, preservation and transportation enhancements, like Washington state's $16 billion Connecting Washington plan and New Jersey's $16 billion Transportation Trust Fund capital program.

The New York City Department of Transportation is focusing on improving mobility, enhancing safety and reducing emissions at the city-level through the Citywide Congested Corridors Project. This planning study concentrates on fourteen roadways throughout the city, and will implement recommendations to reduce congestion and improve New Yorkers' quality of life.

4."*US Cities, Spurned by Washington, Fund Transit Themselves," by Aarian Marshall, WIRED, Nov. 2016, at https://www.wired.com/2016/11/us-cities-spurned-washington-fund-transit/*

Other regional efforts are also underway. Atlanta's Transform 285/400 project will reduce congestion and improve safety in metro Atlanta. Measure M in Los Angeles, New York's B.Q.E. from Atlantic Avenue to Sands Street and the long running Transnet program in San Diego are all helping to improve mobility in their respective regions. Even with bold programs like these, however, budgets remain tight, requiring transportation agencies to target investments for the most severe traffic hotspots.

In many areas, local, state and federal funding doesn't meet basic maintenance, preservation and expansion needs. The federal gas tax has not increased since 1993, losing 40 percent of its purchasing power to inflation. In many states, roadblocks to public-private partnerships or an increasing difficulty to raise funds or borrow on existing tax sources restrict agencies to provide congestion relief that could provide immediate benefit to travelers.

That's why so many people are focused on the White House's intent to spend one trillion dollars on infrastructure – and dedicating a good amount to surface transportation. Regardless of the funding or financing mechanism, state and local transportation agencies will need to rely on data and analytics to provide a cohesive and accurate benefit-cost analysis – and target any future funds to maximize investments to benefit drivers, transit riders and freight movers. INRIX Roadway Analytics allows transportation professionals the ability to recognize, analyze, visualize and prioritize to improve urban mobility in their city, region or state.

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