Europe's Traffic Hotspots

Measuring the impact of congestion in Europe

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ABOUT INRIX RESEARCH

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

We achieve this by leveraging INRIX's 500 Terabytes of data from 300 million different sources covering over five million miles of road, and combining it with our other data sources including global parking, 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 will continue to develop the global, annual benchmark the INRIX Traffic Scorecard as well as developing new industry-leading metrics, and original research reports. In addition to our research outputs, INRIX Research is a valuable and free resource for journalists, researchers and policymakers. We are able to assist with data, analysis and expert commentary on all aspects of urban mobility and smart cities. Spokespeople are available globally for interview.

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1 EXECUTIVE SUMMARY

1.1 INTRODUCTION

The launch of INRIX Roadway Analytics in October 2016 provided INRIX Research with the opportunity to take a deep dive into Europe's traffic hotspots.

INRIX Roadway Analytics is the first portfolio of cloud-based, on-demand traffic insight tools available in Europe and the Middle East providing transport agencies with quick and easy access to in-depth roadway analysis and visualisations. Built on INRIX XD Traffic, which covers 1.7 million miles of road in 28 countries in Europe and the Middle East and available to users as a browser-based application, INRIX Roadway Analytics enables the efficient planning, monitoring and assessment of road performance by road authorities, cities and municipalities, and transportation consultancies.

This study analysed every traffic jam in September 2016 in 19 European countries, over 200,000 instances at more than 45,000 traffic hotspots in 123 European cities. Using this rich dataset, Europe's worst traffic hotspots were ranked by their total impact on car drivers and passengers. Additionally, cities were ranked by the total, collective impact of their respective traffic hotspots.

For the first time the economic cost of these traffic hotspots is estimated: over £183 billion over the period to 2025. This figure represents the cost in just 123 cities in 19 countries. The total economic impact of congestion across the entire EMEA region is therefore enormous and likely in the trillions of Pounds. Tackling the causes of congestion at the worst traffic hotspots has the potential to unlock significant time savings for road users worth billions of Pounds.

INRIX Roadway Analytics is the first step to understanding and tackling this £183 billion problem (Euro 213 billion).

1.2 DATA AND METHODS

This study identified and ranked over 45,000 traffic hotspots across 123 cities in 19 European countries based upon the impact of over 200,000 traffic jams in September 2016 using the new INRIX Roadway Analytics tool, the first on-demand, cloud based traffic analysis tool that leverages INRIX vast data.

The Bottleneck Tool in INRIX Roadway Analytics produced the Impact Factor of every traffic hotspot in the study, which was the product of the average length (in kilometres), average duration (in minutes) and the number of occurrences of traffic jams at these traffic hotspot locations.

The traffic hotspots were ranked by their Impact Factors, and cities by the total of the Impact Factors of every traffic hotspot in their area.

The estimated cost of the time spent in congestion at each traffic hotspot was monetised (i.e. converted into money) using UK Department for Transport approved values of time. The present value of the cost of congestion over the next 10 years was estimated using the social discount rate of 3.5%. This is a useful figure for public agencies to consider when planning where the most benefit could be generated through future road investment. Focusing investment on the traffic hotspots that are causing the greatest economic impact on road users will maximise total benefits and help to optimise public expenditure.

1.3
KEY FINDINGS

Across the 19 countries, the total economic impact of the traffic hotspots identified in the study is £183.2 billion over the next decade. The UK faces the greatest cost (£61.8 billion) followed by Germany (£41.9 billion). This is largely because they have a great number of very large and highly dense cities. They therefore have the most to gain by tackling this congestion.

London had the most traffic hotspots and suffered the greatest total impact from them: five times more than the second placed city, Rome, and 28 times the average. London is the largest city in the study and has the most to gain from tackling its worst traffic hotspots.

However, all cities in the top 10 have a proportionally high traffic hotspot 'Impact Factor', and the total economic impact on road users over the next decade ranges from £3.3 billion in Milan at 10 in the ranking, to £5.5 billion for Madrid at five in the ranking, to £8 billion in Paris at three in the ranking and £8.4 billion for drivers in Rome.

Although London is at the top of the European city ranking, the capital's worst hotspot is third in the list of the top 10 worst in Europe. The A7 in Hamburg has Europe's worst traffic hotspot, followed by the A8 in Stuttgart. Interestingly, 40% of the top 10 traffic hotspots are in Germany. Roads in Cologne, Antwerp, Luxembourg City, Paris and Karlsruhe also feature in the top 10.

An analysis of recent road improvement projects demonstrates that significant improvements in average speeds, and a consequential reduction in wasted time and traffic jams is possible. For example, the implementation of all lane running on the M25 (London, UK) reduced hours wasted by 50% on one stretch and 25% on another.

Focusing on the worst traffic hotspots can generate disproportionate amounts of potential benefits because they generate a disproportionate level of economic impact. For example, the top 10 traffic hotspots in this study (fewer than 0.02% of all hotspots) will generate £7.2 billion of wasted time over the next decade or 4% of the total cost (£183.2 billion) identified in the study. INRIX Roadway Analytics users such as road authorities, cities and municipalities, and transportation professionals and consultants can identify such locations in order to prioritise budgets and maximise benefits.

2 DATA AND METHODOLOGY

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2.1 INRIX ROADWAY ANALYTICS: BOTTLENECKS & TRAFFIC HOTSPOTS

Today, INRIX operates the most robust driver network in the world that includes 300 million vehicles, smartphones, cameras, incidents and other sensors with the ability to cover nearly eight million kilometres (five million miles) of road, ramp and interchange in over 40 countries. Our breakthrough technologies enable us to intelligently gather and analyse complex data streams containing nearly two billion data points per day to create automotive-grade traffic services.

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

This real-time traffic data is at the heart of the new INRIX Roadway Analytics platform. A key feature of the platform is the Bottleneck Tool that identifies and evaluates every traffic jam in the user defined study area and study period. The detection of bottlenecks is based on comparisons of speeds to reference speeds, which are the proxy of the free flow or uncongested speed. A potential bottleneck is detected when speeds on a segment drop to 65% of the reference speed, and a bottleneck is published if speeds stay below 65% and causes 120 seconds of delay. As long as the speed remains below 75% of the reference speed, the bottleneck will not be cleared.

In common parlance, a "bottleneck" is an incidence of congestion at a specific site on the road network: a traffic jam. It may be caused by a physical bottleneck (e.g. where three lanes of traffic are reduced to two), an accident, roadworks, or simply by the volume of traffic relative to the available road space as is common during peak hours. The INRIX Roadway Analytics tool is agnostic to the cause of the congestion or bottleneck, and is meant to be used as a planning and evaluation tool that allows users to prioritise investment spending to maximise benefits for road users.

As bottlenecks frequently occur at the same location the Bottleneck Tool summarises these locations. In this report the locations of these repeated bottlenecks are called Traffic Hotspots. Therefore, there are one or more bottlenecks (congestion incidents) at a traffic hotspot.

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. FRCs are set by the provider of the mapping software used by each satellite navigation system.

FRC1 = Main national connecting routes, usually dual carriageway, with limited access, that connect major cities and towns (e.g., M6, M1, M25, but also A34 Oxford/Southampton and A556 between M6 and M56).

FRC2 = The next level of main route that connects from the FRC1 routes into the centres of towns and cities, or distributes traffic within cities and towns. Many are dual carriageway, but some may be single (e.g. A40 Western Ave, A406 North Circular Rd, A580 East Lancs Road).

FRC3 = More minor connecting A-roads (and some B roads) that connect smaller towns and villages in rural areas, or suburban districts of larger towns (e.g. old A2 through the Medway Towns, the old A5 Edgware Road, the A538 Stamford New Rd in Altrincham.

FRC4 and **FRC5** roads are even smaller B and local, unnumbered roads.

Taking September as an average month, as schools and workplaces are in session across Europe, the annual impact of traffic hotspots was estimated by multiplying September's Impact Factors by 12. Where traffic problems are caused by short-term roadworks or causes this may generate some bias, but this should be minimal across more than 200,000 traffic jams or bottlenecks that were analysed.

In total, 19 European cities were selected that provide a broad representation of Europe including Western and Eastern Europe, Scandinavia and Southern Europe. The following countries were included: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Norway, Poland, Spain, Sweden, Switzerland, and United Kingdom. For each of these countries every major urban area with more than 250,000 people was included, which for the sake of brevity are called a 'city' in this report. Population statistics were taken from Eurostat[1] and were based on those within the main section of the city and not the greater, metropolitan or commuter areas to ensure a fair comparison. As the dates of the censuses are different across different countries, and to enable a fair comparison, all population figures were extrapolated to 2016 based upon the World Bank country population growth rates[2].

1 Source: http://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-data

2 Source: http://data.worldbank.org/indicator/SP.POP.GROW

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2.1.1 TRAFFIC HOTSPOT EXAMPLE: LONDON'S WORST HOTSPOT

Figure 1 shows the results of running the Bottleneck Tool from INRIX Roadway Analytics for London (UK) in September 2016. It highlights that the M25 Northbound was the worst traffic hotspot. This road section is highlighted by the tool in Figure 2 and is between Junction 15 (for M4) and Junction 16 (M40). A bottleneck occurred here 690 times in September with an average duration of 20 minutes and an average length of 9.48 kilometres (5.98 miles). This gives an Impact Factor of 130,830 (20 x 9.48 x 690).

In September, there were 62,885 bottlenecks at 12,776 traffic hotspots across the whole of London with a combined Impact Factor of over 7.8 million. Within the tool it is possible to study each individual occurrence of a bottleneck, the summary of all occurrences at one traffic hotspot, or to focus on all traffic hotspots within a city. In this study, individual occurrences of bottlenecks were ignored and instead the study focused on (i) traffic hotspots, and (ii) the summaries of all traffic hotspots within a city. In the case of London, the study focused on the 12,776 traffic hotspots, or on London as a whole.

Figure 1: INRIX Roadway Analytics Bottleneck Report

Figure 2: Traffic Hotspot Marking in INRIX Roadway Analytics

2.2 ECONOMIC COST OF CONGESTION

The economic impact of traffic hotspots can be estimated by valuing the time spent in them. To value the total time lost in traffic hotspots the total number of hours wasted by all drivers must be estimated. INRIX Roadway Analytics provided an estimate of the duration of the bottlenecks, but the number of people affected by the bottleneck was estimated by making assumptions about the following three variables:

1. **The average number of lanes of traffic in bottlenecks**

2. **The average number of vehicles per kilometre of bottleneck**

3. **The average vehicle occupancy**

Once the amount of time lost in each bottleneck was estimated, this was aggregated at each traffic hotspot location. Finally, a value of time was assumed. Time spent in congestion is time that is not spent at work or in leisure: there is an opportunity cost. Numerous studies have been conducted to estimate the value of time to be used in transport appraisals. One of the most robust studies was performed by the Institute of Transport Studies[3] at Leeds University (UK) and is used by the UK Department for Transport (DfT) as well as widely within the UK public and private sectors for transport appraisal. These values were adopted for this study, however as incomes, personal preferences and the split of work and non-work trips will vary from country to country the UK figures are an approximation of the value of time for non-UK cities.

The DfT values of time updated to 2016 prices are £26.26 for business travel by car and £11.44 for all non-work trips by all modes. Roughly 40% of miles driven in England in 2014 had a business purpose[4]. Weighting these values of time by this percentage gave an estimated average value of time of £17.37 for trips of an unknown purpose. Or equivalently £0.29 per minute.

To enable comparison across countries and because of the volatile exchange rates at present, the study used British Pound Sterling. However, the Appendix includes conversions to local currency units using World Bank Purchasing Power Parity rates.

Table 1 presents the values used, along with upper and lower bounds to determine the plausible range of economic cost.

Table 1: Model Assumptions

VARIABLE	LOWER VALUE	BASE VALUE	UPPER VALUE
Lanes of traffic	1	1.5	2
Vehicles per km	50	100	200
Occupants	1	1.2	1.5
Value of Time (p.m.)	£0.19	£0.29	£0.44

Multiplying these four assumptions together provided a conversion factor, which was applied to the Impact Factor produced in INRIX Roadway Analytics to generate the economic cost of the traffic hotspots. Table 2 presents the conversion factors. As this only values the time lost in congestion, this is only a partial measure of the total economic cost imposed on drivers and society because it excludes other direct costs such as fuel wasted, or indirect costs such as productivity losses. The study therefore underestimated the true economic impact of congestion.

Table 2: Conversion Factors

VARIABLE	LOWER VALUE	BASE VALUE	UPPER VALUE
Conversion Factor	9.5	52.2	264

As September is an average month, the annual economic cost of congestion at each traffic hotspot was estimated by multiplying September's cost by 12. The larger the economic cost the more that road users would gain from tackling congestion at a traffic hotspot.

3 Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470229/vtts-phase-2-report-non-technical-summary-issue-august-2015.pdf

4 Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/489894/tsgb-2015.pdf

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2.2 ECONOMIC COST OF CONGESTION (CONTINUED)

However, it is impossible to predict how much of this economic cost could be saved by taking appropriate action. For example, the implementation of all lane running on the M25 (London, UK) reduced hours wasted by 50% on one stretch and 25% on another. In London, traffic light optimisation reduced delay by 13% on average. The optimal strategy for dealing with congestion at a traffic hotspot will depend upon the underlying cause.

Instead of estimating the potential time that could be saved by tackling congestion, the present value of the cost of congestion over the next 10 years was estimated using the social discount rate of 3.5%. This is a useful figure for public agencies to consider when planning where the most benefit could be generated through future road investment. Focusing investment on the traffic hotspots that are causing the greatest economic impact on road users will maximise total benefits and help to optimise public expenditure.

2.2.1 ECONOMIC EXAMPLE: CONGESTION COSTS IN LONDON

An example will make this methodology clear. INRIX Roadway Analytics calculated the total Impact Factor for London in September 2016 as 7,782,677 for all roads in all 32 London Boroughs and the City of London. Using base values for the assumptions, the economic cost in September was £406 million (range: £74 million to £2 billion) and provided an estimate of the annual cost of £4.9 billion (range: £888 million to £24.7 billion).

3 EUROPE'S TRAFFIC HOTSPOTS

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3.1 EUROPE-WIDE RANKING BY TRAFFIC HOTSPOT

Using INRIX Roadway Analytics, INRIX Research analysed more than 200,000 traffic jams from September 2016 to identify and rank 45,662 traffic hotspots in 123 cities across 19 European countries. Together these traffic hotspots could generate over £183 billion of economic cost by 2025.

Table 3 presents the worst top 10 traffic hotspots in the 19 European countries analysed in this study. The German Autobahns on the outskirts of Hamburg and Stuttgart take the top two slots with these two individual hotspots on the A7 and A8 costing drivers £262 million annually, and represent a potential cost of £2.2 billion over the next 10 years.

It is important to remember that these are not the only traffic hotspots on these particular roads. For example, there were 1,990 traffic jams at 34 traffic hotspots on the A7 alone around Hamburg in September 2016. This one road costs Hamburgers an estimated £261 million per annum. Similarly, the A8 around Stuttgart had 1,576 traffic jams at 24 hotspots costing Stuttgarters £132 million per year.

Two further German Autobahns make it into the top 10, with the A3 outside Cologne and the A5 at Karlsruhe taking 6th and 10th place respectively. The ringroad (R1) at Antwerp takes the 3rd and 7th slot in the top 10 of worst hotspots. The M25 in London is both 4th and 5th with hotspots between Junctions 15 and 16, and 16 and 17 on the Western Section threatening a potential cost of £1.3 billion over the next decade.

The impact of congestion on drivers is enormous, which means that cities and traffic authorities could realise significant economic benefits by reducing congestion. For instance, the total cost over the next decade at these top 10 traffic hotspots is an estimated £7.2 billion. Hypothetically, reducing congestion and delay by 20% at just these top 10 traffic hotspots could save drivers an estimated £1.4 billion over the next 10 years. Due to the intensity of traffic building at these bottleneck locations, congested periods often extend far beyond the typical peak commute hours. With the exception of Luxembourg's A6, which only had 65 occurrences in September 2016, other hotspots saw traffic jams an average of 391 times each, or 13 times a day, on average. Understanding where, when and why jams occur is the first step in tackling this £7.2 billion problem. Whilst it may be unrealistic, hypothetically if all 45,662 traffic hotspots had traffic reduced by 20%, drivers could save £37 billion over the next decade.

Table 3: Europe's Top 10 Worst Traffic Hotspots

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURRENCES	2025 ECONOMIC COST OF CONGESTION
1	Hamburg	Germany	A7 N at J29 HH-Othmarschen	94	8.7	257	£1.1bn
2	Stuttgart	Germany	A8 W at J48 (B295) Leonberg-West	24	10.93	790	£1.1bn
3	Antwerp	Belgium	R1/E19 E and E34 E at J3 (Borgerhout)	80	5.77	396	£985m
4	London	UK	M25 N between J15 (M4) and J16 (M40)	20	9.48	690	£705m
5	London	UK	M25 N between J16 (M40) and J17 (Rickmansworth)	30	7.79	456	£575m
6	Cologne	Germany	A3 N at J25 (Koln-Mulheim)	56	6.89	264	£549m
7	Antwerp	Belgium	R1 (E34) E after J3 (Borgerhout)	67	6.37	237	£545m
8	Luxembourg	Luxembourg	A6 W before J4 (Strassen)	286	5.44	65	£545m
9	Paris	France	A1 S (Autoroute du Nord) at junction with Boulevard Périphérique	109	3.64	252	£538m
10	Karlsruhe	Germany	A5 (S) at J43 (Karlsruhe Nord)	92	5.75	178	£508m

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3.2 EUROPE STUDY BY CITY

Impact Factors for 45,662 traffic hotspots were aggregated at the city level to provide a ranking of 123 European cities by the total impact to drivers (Table 4). London (including all 32 London Boroughs and the City of London) tops the list with 12,776 bottlenecks causing a total impact of almost 7.8 million in September 2016 alone.

Unsurprisingly, many of Europe's capital cities make the list of the top 25, including Rome (2), Paris (3), Madrid (5), Budapest (11), Barcelona (12), Frankfurt (13), Oslo (14), Luxembourg (21) and Vienna (23). The rest of the list is made up of the largest cities in Europe, many of which are important transport hubs such as Hamburg (4) and Antwerp (6).

The rankings, however, deserve context. For example, whilst the impact of traffic hotspots in London is almost five times that of the second placed city, Rome, London has almost four times the population in roughly 50% more land mass, making London's population density roughly three times that of Rome. To adjust for this, the final column of Table 4 ranks the cities by the population adjusted Impact Factor[5]. After adjusting for population, London falls to fifth place in the ranking behind Antwerp, Stuttgart, Edinburgh and Zürich.

Across the 123 European cities included in this study, drivers face a potential £183.2 billion of cost through time lost in traffic jams. However, the total impact of traffic hotspots across Europe is heavily concentrated in the largest and most congested cities. The top 25 cities, ranked by the total impact of September's traffic hotspots, account for 69% of all the impact across the 123 cities. Therefore, drivers in the top 25 cities face an enormous £126.8 billion of lost time over the next 10 years. In London alone, this is £42 billion. If congestion and the associated time delay in these 25 cities could be reduced by 10, 20 or even 30% then drivers could save £12.7, £25.4 or £38 billion by 2025. Thus, whilst the predicted cost of congestion is significant so is the potential benefit that could be realised by addressing congestion.

5 To adjust for population size, the Impact Factor is divided by the city population to obtain an impact per capita figure. This is then used as the basis for the ranking in the final column.

Table 4: Europe's Top 25 Cities by Traffic Hotspots

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION	RANK (IPC)*
1	London	UK	12,776	7,782,677	£42bn	5
2	Rome	Italy	1,684	1,566,115	£8.4bn	26
3	Paris	France	703	1,479,535	£8.0bn	22
4	Hamburg	Germany	1,305	1,264,783	£6.8bn	15
5	Madrid	Spain	837	1,017,770	£5.5bn	46
6	Antwerp	Belgium	459	970,351	£5.2bn	1
7	Munich	Germany	841	917,570	£4.9bn	21
8	Stuttgart	Germany	539	850,815	£4.6bn	2
9	Cologne	Germany	740	816,260	£4.4bn	10
10	Milan	Italy	1,053	618,657	£3.3bn	32
11	Budapest	Hungary	1,284	537,595	£2.8bn	50
12	Barcelona	Spain	461	526,780	£2.8bn	44
13	Edinburgh	UK	455	512,834	£2.8bn	3
14	Berlin	Germany	1,070	502,580	£2.7bn	85
15	Frankfurt	Germany	448	471,315	£2.5bn	19
16	Oslo	Norway	321	469,880	£2.5bn	12
17	Glasgow	UK	357	418,560	£2.3bn	18
18	Hanover	Germany	290	378,308	£2.0bn	13
19	Birmingham	UK	872	370,303	£2.0bn	45
20	Manchester	UK	768	360,021	£1.9bn	20
21	Luxembourg	Luxembourg	167	356,663	£1.9bn	24
22	Zürich	Switzerland	214	356,658	£1.9bn	4
23	Vienna	Austria	528	338,995	£1.8bn	75
24	Palermo	Italy	369	326,782	£1.8bn	31
25	Duisburg	Germany	213	308,973	£1.7bn	23
	Total Cost				**£126.8bn**	

** Rank based upon IPC – Impact (Factor) Per Capita.*

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3.3 COUNTRY-LEVEL ANALYSIS

The data for each of the 123 cities in the dataset was aggregated up to country level and presented in Table 5.

As there was a varying number of cities from each country, and the cities are of vastly varying sizes, the traffic hotspot Impact Factors have been weighted by population and aggregated up to country size[6]. Doing this alters the country ranking in comparison to merely ranking countries based upon the total Impact Factor which biases the results towards countries that have a greater number of cities (of 250,000 or more people).

This can be seen by comparing the ranking weighted by population (the first column of Table 5) to the unadjusted ranking by Impact Factor (the last column of Table 5). For instance, smaller but more densely populated countries like Belgium and Switzerland move up the population-adjusted rankings.

The UK and Germany, which have many densely populated cities with significant levels of congestion, have the most to gain from tackling their traffic hotspots because congestion is causing them the greatest economic loss. The UK faces over a third (£61.8 billion) of the £183.2 billion total cost, whilst German drivers face a substantial £41.9 billion cost. Taken together, the top five countries (UK, Germany, France, Italy and Belgium) represent 78% of the total economic cost (and therefore potential savings) that could be made over the next decade by tackling the worst traffic hotspots.

6 The sum of the Impact Factors for all cities within a country was weighted by the percentage of the country's population that the included cities represented.

Table 5: Country Ranking by Population-Weighted Impact Factor

RANK	COUNTRY	NO. OF CITIES (POPULATION OVER 250K)	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION	POPULATION WEIGHTED IMPACT FACTOR	RANK BY IMPACT FACTOR
1	UK	21	20,375	11,466,416	£61.8bn	42,902,767	1
2	Germany	27	8,517	7,777,834	£41.9bn	35,706,922	2
3	France	9	1,844	2,753,484	£14.9bn	31,314,772	5
4	Italy	12	5,069	3,540,815	£19.1bn	24,039,326	3
5	Belgium	3	925	1,457,345	£7.9bn	8,466,083	8
6	Spain	16	2,335	1,950,810	£10.5bn	8,295,884	4
7	Switzerland	1	214	356,658	£1.9bn	7,568,147	18
8	Portugal	1	311	307,512	£1.7bn	6,081,399	16
9	Netherlands	4	416	639,416	£3.5bn	4,748,394	14
10	Slovakia	1	306	285,362	£1.5bn	3,725,506	17
11	Czech Republic	3	484	634,545	£3.4bn	3,463,006	10
12	Hungary	1	1,284	537,595	£2.9bn	3,070,512	6
13	Norway	2	432	519,331	£2.8bn	2,979,077	13
14	Sweden	3	461	433,584	£2.3bn	1,834,036	11
15	Poland	12	1,072	298,897	£1.6bn	1,693,514	7
16	Austria	2	628	368,369	£2.0bn	1,539,139	9
17	Denmark	2	449	164,231	£886m	1,042,802	12
18	Finland	2	373	126,293	£681m	806,351	15
19	Luxembourg	1	167	356,663	£1.9bn	357,597	19
Total	**19**	**123**	**45,662**	**33,975,160**	**£183.2bn**	**187,362,343**	

4 IN-DEPTH STUDIES

An in-depth study of the two countries that top the INRIX Traffic Hotspot ranking was performed and the results reported in the following sections. In total these countries make up 39% of the 123 cities (Germany 27, UK 21) in the main study and account for 57% of the total impact or cost imposed by congestion in this study.

4.1 GERMANY STUDY

There were 27 German cities with more than 250,000 inhabitants included in the study. More than 48,000 traffic jams at some 8,572 traffic hotspots were analysed. German drivers are likely to face £41.9 billion (€47.6 billion) of lost time over the next 10 years at these traffic hotspots.

Table 6 presents that data aggregated at city level. Traffic hotspots are again concentrated in the largest German cities. The top six cities in the ranking account for 62% of the impact of all traffic hotspots in Germany in September 2016. Congestion at these traffic hotspots will impose a collective £23.5 billion (€26.6 billion) over the next decade on road users.

Hamburg tops the list of the cities suffering from the greatest impact from traffic hotspots. Hamburg had 6,938 traffic jams across 1,305 traffic hotspots costing drivers £66 million (€75 million) in September 2016 alone. Over the next decade, the city of Hamburg could face £6.8 billion (€7.7 billion) of lost time at these 1,305 traffic hotspots.

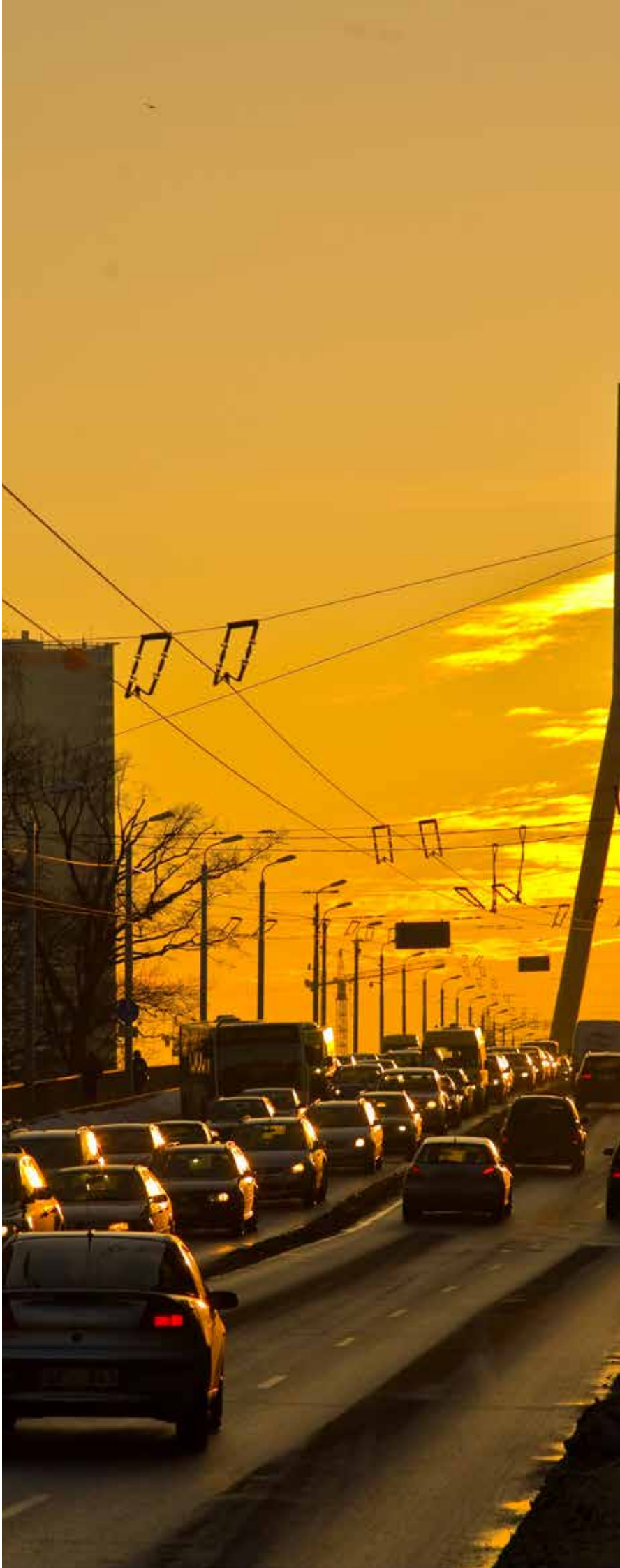
Hamburg is the second largest port in Europe and is therefore a major transport hub. However, whilst it is the second-most populous city in Germany, it is one of the smallest by geographic area, making it incredibly densely populated. Congestion, therefore, is almost inevitable at this population density.

Germany's largest (most populous) cities make the top of the list behind Hamburg, with Munich, Stuttgart, Cologne, Berlin and Frankfurt taking the next five places.

Table 7 lists Germany's top 10 traffic hotspots. These top 10 (0.1%) hotspots account for 13% or £5.6 billion (€6.4 billion) of the total economic cost imposed on German drivers across the 8,572 traffic hotspots analysed. This demonstrates a clear advantage of the INRIX Roadway Analytics tool as being able to focus transport investment to get the most benefit for transport users. With the exception of Munich's inner ring road (B2R Mittlerer Ring), all of these hotspots are on Germany's Autobahns. The exact locations are always around junctions to/from the major arterial roads in to and out of these major cities.

The German Autobahns on the outskirts of Hamburg and Stuttgart take the top two slots with these two individual hotspots on the A7 and A8 costing drivers £262 million (€297 million) annually, and represent a potential £2.2 billion (€2.6 billion) future cost over the next 10 years if congestion is not reduced at these two spots. It is important to remember that these are not the only traffic hotspots on these particular roads. For example, there were 1,990 traffic jams at 34 traffic hotspots on the A7 alone around Hamburg in September 2016. This one road costs Hamburgers an estimated £261 million (€296 million) per annum. Similarly, the A8 around Stuttgart had 1,576 traffic jams at 24 hotspots costing Stuttgarters £132 million (€150 million) per year.

The A8 is a well-known problem route that suffers from severe fog that can cause accidents and often leaves significant stretches of the Autobahn under variable speed limits. Additionally, a significant amount of on-going roadworks, including the complete closure of numerous other roads in the area, have led to increased traffic on the A8 at the same time as a temporary limit to the road supply.



4 IN-DEPTH STUDIES

4.1.1 CASE STUDY: CONSTRUCTION ON MUNICH'S MITLERER RING

Technology often has the answer to many of the world's problems including congestion. The next case study highlights the role technology plays in reducing congestion. Yet sometimes, traditional engineering solutions are also necessary to improve traffic flows.

In the 2015 INRIX Traffic Scorecard, Munich's ring road, the Mittlerer Ring was Germany's most congested road, wasting as much as four days of the average commuters' time every year. In response, the Government of Upper Bavaria committed €400 million on a range of infrastructure projects to improve travel times.

A major part of this investment was the 1.5 kilometre Luise-Kiesselbach-Platz tunnel that opened in July 2015 after six years of construction.

Using INRIX Roadway Analytics the impact of the tunnel on local congestion can be evaluated by comparing average speeds before (in October 2014) and after (in October 2015) project completion. This evaluation demonstrates that average peak hour speeds increased by 10 kph after the tunnel opened moving from 28.9 to 38.3 kph in the morning peak and from 31.2 to 40.7 kph in the afternoon peak: an impressive 31% in average peak hour speeds.

Other sections of the Mittlerer Ring continue to cause Munich drivers significant delay. For instance, the section of road travelling northbound through the English Garden had congestion lasting an average of five hours twice a day during September. Hopefully, the Government's continued investments will provide similar levels of improvement delivered by the Luise-Kiesselbach-Platz programme.

Table 6: German Cities by Worst Traffic Hotspots

RANK	GERMAN CITY (POPULATION OVER 250K)	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURR-ENCES
1	Hamburg	1,305	1,264,783	€7.7bn	A7 N at J29 HH-Othmarschen	94	8.7	257
2	Munich	841	917,570	€5.6bn	B2R N (Mittlerer Ring) in Englischer Garten	314	3.11	63
3	Stuttgart	539	850,815	€5.2bn	A8 W at J48 (B295) Leonberg-West	24	10.93	790
4	Cologne	740	816,260	€5.0bn	A3 N at J25 (Koln-Mulheim)	56	6.89	264
5	Berlin	1,070	502,580	€3.1bn	A100 N between J6 and J5	34	6.8	168
6	Frankfurt	448	471,315	€2.9bn	A3 E after J53 (Oberthausen)	28	6.77	321
7	Hanover	290	378,308	€2.3bn	A2 W between J46 (Hannover Lahe) and J47 (Hannover-Buchholz)	44	8.68	212
8	Duisburg	213	308,973	€1.9bn	A3 N after J12 (Kreuz Oberhausen-West)	23	5.12	304
9	Karlsruhe	120	255,858	€1.6bn	A5 (S) at J43 (Karlsruhe Nord)	92	5.75	178
10	Düsseldorf	373	219,346	€1.3bn	B8 S at Junction with B1 and B7	66	3.83	60
11	Dortmund	247	202,121	€1.2bn	A44 E at J53 (B233)	195	7.99	14
12	Bochum	121	180,969	€1.1bn	A43 N after J12 (for A2 J8)	83	10.09	44
13	Dresden	287	169,726	€1.0bn	A4 E between J79 (Dresden Neustadt) and J80 (Dresden Wilder Mann)	75	7.15	44
14	Essen	238	164,446	€1.0bn	A40 W between J26 (L191) and J27 (L643)	101	8.5	26
15	Nuremberg	229	158,893	€972m	A6 S before J92A (B299)	49	5.44	59
16	Braunschweig	138	147,313	€902m	A2 E after J58 (Kreuz-Wolfsburg)	194	11.8	33
17	Wuppertal	102	146,340	€896m	A46 W between J33 (L429) and J34 (L70)	33	5.62	121
18	Bremen	133	144,616	€885m	A1 N after J57 (Bremen-Brinkum)	173	6.96	59
19	Mannheim	90	73,324	€449m	A656 N before J4 (L597)	121	3.75	44
20	Mönchengladbach	138	69,894	€428m	A52 W between J7 and J8	68	6.06	41
21	Wiesbaden	94	66,091	€404m	A3 N around Medenbach	29	6.02	42
22	Bielefeld	134	60,106	€368m	B61 S (Ostwestfalendamm) junction with A33 J19	161	3.8	24
23	Gelsenkirchen	73	54,694	€335m	B224 S at Stadion Gladbeck	160	2.17	30
24	Bonn	117	50,821	€311m	A555 at J8 with Potsdamer Platz	71	3.23	21
25	Leipzig	223	43,029	€263m	B2 S junction with Berliner Strase	249	3.71	3
26	Munster	142	42,690	€261m	A1 N after K10 (Davert)	34	4.43	34
27	Augsburg	72	16,953	€104m	B17 S where becomes B300	27	13.55	4
	Total Cost	**8,517**	**7,777,834**	**€47.6bn**	**A7 N at J29 HH-Othmarschen**	**94**	**8.7**	**257**

4 IN-DEPTH STUDIES

4.1.1 CASE STUDY: CONSTRUCTION ON MUNICH'S MITLERER RING (CONTINUED)

Table 7: Germany's Top 10 Worst Traffic Hotspots

RANK	GERMAN CITY (POPULATION OVER 250K)	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURRENCES	2025 ECONOMIC COST OF CONGESTION
1	Hamburg	A7 N at J29 HH-Othmarschen	94	8.7	257	€1.3bn
2	Stuttgart	A8 W at J48 (B295) Leonberg-West	24	10.93	790	€1.3bn
3	Cologne	A3 N at J25 (Koln-Mulheim)	56	6.89	264	€623m
4	Karlsruhe	A5 (S) at J43 (Karlsruhe Nord)	92	5.75	178	€576m
5	Hanover	A2 W between J46 (Hannover Lahe) and J47 (Hannover-Buchholz)	44	8.68	212	€496m
6	Braunschweig	A2 E after J58 (Kreuz-Wolfsburg)	194	11.8	33	€462m
7	Stuttgart	A8 W at J47 (Rutesheim)	46	18.64	87	€456m
8	Bremen	A1 N after J57 (Bremen-Brinkum)	173	6.96	59	€435m
9	Munich	B2R N (Mittlerer Ring) in Englischer Garten	314	3.11	63	€377m
10	Frankfurt	A3 E	28	6.77	321	€372m
	Total Cost					**€6.4bn**

4.2
UK STUDY

There were 21 UK cities with more than 250,000 inhabitants included in the study. More than 90,000 traffic jams at some 20,375 traffic hotspots were analysed. UK drivers face a potential total cost of £61.8 billion from lost time over the next 10 years at these worst traffic hotspots, over a third of the £183.2 billion total identified in the study.

Table 8 presents that data aggregated at city level. Traffic hotspots are again concentrated in the largest UK cities. The top six cities in the ranking account for 85% of the impact of all traffic hotspots in the UK in September 2016. Taken together they face a collective cost of £52.6 billion over the next decade if congestion is not addressed at these traffic hotspots.

London tops the list of the cities suffering from the greatest impact from traffic hotspots. London accounted for 68% of the traffic hotspots in the UK study with almost 63,000 traffic jams across 12,776 traffic hotspots costing drivers £406 million in September 2016 alone. London had more traffic hotspots (12,776), and also the highest total impact, of all European cities analysed. The impact of hotspots in London was 28 times more than the average city[7] included in the study, and more than the following four cities combined in the European ranking (Rome, Paris, Hamburg, Madrid). This also means Londoners have the most to gain if congestion is reduced, because they face a potential £42 billion of time lost to congestion by 2025. London is the most populous city in the entire study, suffers from high population density and is home to the world's third busiest airport (London Heathrow[7]).

In the UK, the impact of all traffic hotspots in London, and the potential cost savings for drivers, is 15 times higher than that of the second ranked city, Edinburgh. Unsurprisingly, the UK's largest (most populous) cities make the top of the list behind London and Edinburgh. Glasgow and Birmingham follow, with Manchester, Bristol, Leeds, Cardiff, Bradford and Belfast rounding out the top ten. Together the top five cities account for 82% of the total traffic impact of traffic hotspots in the UK study.

Table 9 lists the UK's top 10 traffic hotspots. Just these 10 hotspots (of all 20,375 UK hotspots) may impose £3.7 billion of economic cost on UK drivers over the next 10 years, or 6% of the total cost. This demonstrates a clear advantage of the INRIX Roadway Analytics tool as being able to focus transport investment to get the most benefit for transport users.

The top 10 worst traffic bottlenecks are located primarily in London and Edinburgh, with the A8 (Glasgow and Edinburgh Road) making an appearance in sixth place. In London, the M25 takes the top three places with Junctions 15 (M4) to J16 (M40) and then J16 (M40) to J17 (Rickmansworth) taking first and second place. They are at the confluence of a number of strategic motorways and arterial roads, as well as being in close proximity to the exits for London Heathrow airport. Between J21 (M1) and J21A (A405) on the M25 is the third worst traffic hotspot. London's inner ring road (A406) around Southgate and Palmer's Green (Enfield) make it into sixth and seventh place. Finally, Edinburgh's ring road (A720) makes it into fourth, fifth, ninth and 10th place on the list with four hotspots around the Dregborn Barracks area of the city.

7 London Gatwick is located in West Sussex and is outside of the Greater London road network.

4 IN-DEPTH STUDIES

4.2.1 CASE STUDY: SMART MOTORWAYS

Since their introduction on the M42 in 2006, smart motorways have been steadily rolled out across the UK's motorway network. They have also evolved over time to become ever more sophisticated. The latest investment is £7 million on the M62 between Manchester and the junction in Warrington with the M6. Smart motorways incorporate a range of technologies in different combinations that monitor and respond to fluctuating traffic conditions on motorways. These include variable (enforceable) speed limits to moderate traffic flow during congestion, dynamic traffic lights on motorway entrances, and hard shoulder or all lane running that adds additional capacity by using the hard shoulder as an additional lane for some, or all, of the time.

Since its inception in 2006, the smart motorway sections of the M42 has seen journey reliability improved by 22%, personal injury accidents reduced by more than half, and where accidents did occur, severity was much lower overall with zero fatalities and fewer seriously injured[8]. Most of the M25 has the most basic implementation of smart motorways, a variable speed limit. However, two sections have used controlled all-lane running since 2014. A recent evaluation[9] of the smart motorway All Lane Running programme on the M25 at Junctions 23-27 (16 miles) found that all lane running reduced hours of delay by 50% in a before and after comparison despite a 10% increase in traffic, saving some 6,000 vehicle hours of delay every day. Over a typical year this would equate to a value of time saving of £30 million[10].

At £180 million[11] to construct, the scheme would pay off after three years and would generate a cost benefit ratio of 1:1.4 over a 10-year period. This is using very conservative estimates of the value of time and excludes additional economic benefits such as saved fuel, reduced accidents and productivity gains.

Another evaluation[12] of the smart motorway All Lane Running implementation at Junctions 5-7 (12.4 miles) on the M25 found a 25% reduction in hours of delay which generated 1,680 vehicle hours of delay per day or approximately £8.4 million per annum. INRIX Roadway Analytics also identified a significant reduction in the number of traffic jams on the M25 between Junctions 5-7 since the implementation of all lane running of 52%. This is comparing a year of data before the roadworks began on this section of motorway with a year of data after the new smart motorway was complete. There were 165 traffic jams a month on average after the project was complete compared to 343 beforehand. As a benchmark, a single queue per peak period, per working day in both directions of the motorway would generate 80 traffic jams per month[13].

The UK's worst traffic hotspots on the western portion of the M25 will hopefully be ameliorated by the planned smart motorway – All Lane Running programme that is due to start in the next five years and will cover 19 miles between Junctions 10 and 17 of the M25[14]. Moving forward, the All Lane Running programme may be replaced with Dynamic or Active Traffic Management that only utilises the hard shoulder during periods of severe congestion. Almost all of the same benefits are achieved but at a slightly higher cost[15].

8 Source: http://www.highways.gov.uk/smart-motorways-programme/

9 Source: http://assets.highways.gov.uk/specialist-information/knowledge-compendium/2014-2015/M25+J23-27+SM+ALR+Monitoring+12+Month+Evaluation+Report_v2.0_Final.pdf

10 Assuming 1.2 occupants per vehicle on average and using the DfT's value of time of £11.44 per hour (2016 values).

11 http://www.publications.parliament.uk/pa/cm201617/cmselect/cmtrans/63/6306.htm

12 http://assets.highways.gov.uk/specialist-information/knowledge-compendium/2014-2015/M25+J5-7+SM+ALR+Monitoring+12+Month+Evaluation+Report_v2.0_Final.pdf

13 2 directions x 2 peak periods per day x 20 working days per month = 80 traffic jams per month.

14 http://www.publications.parliament.uk/pa/cm201617/cmselect/cmtrans/63/63.pdf

15 Source: http://www.publications.parliament.uk/pa/cm201617/cmselect/cmtrans/63/6306.htm

Table 8: UK Cities by Worst Traffic Hotspots

RANK	UK CITY (POPULATION OVER 250K)	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURRENCES
1	London	12,776	7,782,677	£42bn	M25 N between J15 (M4) and J16 (M40)	20	9.48	690
2	Edinburgh	455	512,834	£2.8bn	A720 W (Edinburgh Bypass) at Dreghorn Barracks	86	8.71	101
3	Glasgow	357	418,560	£2.3bn	A8 E (Glasgow & Edinburgh Road) at junction with M8	96	7.98	76
4	Birmingham	872	370,303	£2.0bn	A38 N (M) junction with M6 (J6)	207	5.17	17
5	Manchester	768	360,021	£1.9bn	M60 N at J1 for A6 (Stockport)	74	6.95	36
6	Bristol	619	305,276	£1.6bn	M5 S at J20 (Clevedon)	47	8.87	57
7	Leeds	712	273,684	£1.5bn	M62 W (J26) junction with M606 (J1)	96	9.86	25
8	Cardiff	392	208,618	£1.1bn	A48 W (Eastern Avenue) at Riverside Park	61	4.6	54
9	Bradford	596	201,901	£1.1bn	A650 W (Bradford Road) at A6038 (Otley Rd)	65	3.86	31
10	Belfast	446	147,864	£797m	A12 E (York Link) at junction with M2 and M3	107	5.86	21
11	Sheffield	360	142,006	£766m	A61 N (London Rd) at junction with A621 (Wolseley Rd)	83	4.13	26
12	Nottingham	342	103,302	£557m	A52 E at Queen's Medical Centre	80	3.47	23
13	Stoke on Trent	207	98,684	£532m	A50 W at roundabout with A500 (Stoke City Stadium)	68	6.41	21
14	Coventry	178	94,967	£512m	M6 N between J3 and Corley Services	37	5.07	90
15	Leicester	260	88,302	£476m	A46 N (Leicester Bypass) at roundabout with A607 (Syston)	44	5.87	51
16	Southampton	209	83,606	£451m	M27 W at J5 (Southampton Airport)	37	6.19	58
17	Hull	183	73,373	£396m	A63 E at Kingston Retail Park	56	5.57	12
18	Newcastle	111	71,146	£384m	A1 S at roundabout with A696 and A167	25	5.42	60
19	Derby	112	54,361	£293m	A52 W before roundabout Pentagon Island	60	3.1	43
20	Liverpool	236	41,087	£222m	M62/A5080 W (J4) at A5058 Broad Green	164	4.15	5
21	Wolverhampton	184	33,844	£182m	A4039 W at junction with A449	109	3.56	8
	UK Total	**20,375**	**11,466,416**	**£61.8bn**				

4 IN-DEPTH STUDIES

4.2.1 CASE STUDY: SMART MOTORWAYS (CONTINUED)

Table 9: UK's Top 10 Worst Traffic Hotspots

RANK	UK CITY (POPULATION OVER 250K)	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURRENCES	2025 ECONOMIC COST OF CONGESTION
1	London	M25 N between J15 (M4) and J16 (M40)	20	9.48	690	£705m
2	London	M25 N between J16 (M40) and J17 (Rickmansworth)	30	7.79	456	£575m
3	London	M25 S between J21 (M1) and J21A (A405)	273	22.22	13	£425m
4	Edinburgh	A720 W (Edinburgh Bypass) at Dreghorn Barracks	86	8.71	101	£408m
5	Edinburgh	A720 E (Edinburgh Bypass) between A702 and A701	80	3.59	216	£334m
6	Glasgow	A8 E (Glasgow & Edinburgh Road) at junction with M8	96	7.98	76	£314m
7	London	A406 E (North Circular) at Powys Lane (B106)	197	2.61	92	£255m
8	London	A406 W (North Circular) at Station Rd (A109)	84	4.18	129	£244m
9	Edinburgh	A720 W (Edinburgh Bypass) between A702 and A701	76	7.69	76	£239m
10	Edinburgh	A720 W (Edinburgh Bypass) at Dreghorn Junction	51	7.32	114	£229m
	Total Cost					**£3.7bn**


METROPOLIS

5 SENSITIVITY ANALYSIS

Table 10 presents the results of a sensitivity analysis performed on the total economic cost to 2025. The cities are ordered alphabetically.

The assumptions were presented in Section 2.2 and include three assumptions that were used to estimate the number of hours wasted at traffic hotspots, and one on the value of this wasted time. These assumptions are altered together either up or down from the base case used in the study results presented so far.

As expected, the assumptions have a significant impact upon the results. At the upper level, the total economic impact across Europe in the next decade increases from £183.2 billion in the base case to as much as £926.5 billion. This is five times the base case. At the same time, at the lower level the economic impact falls to £33.3 billion, approximately one fifth of the base case.

Table 10: Sensitivity Analysis Results

ECONOMIC COST TO 2025	MODEL ASSUMPTIONS		
CITY	UPPER VALUES	BASE VALUES	LOWER VALUES
Aarhus	£1,620m	£320m	£58m
Alicante	£175m	£35m	£6m
Amsterdam	£2,962m	£586m	£107m
Antwerp	£26,461m	£5,232m	£952m
Augsburg	£462m	£91m	£17m
Barcelona	£14,365m	£2,840m	£517m
Bari	£1,822m	£360m	£66m
Belfast	£4,032m	£797m	£145m
Bergen	£1,348m	£267m	£49m
Berlin	£13,705m	£2,710m	£493m
Bialystok	£20m	£4m	£1m
Bielefeld	£1,639m	£324m	£59m
Bilbao	£115m	£23m	£4m
Birmingham	£10,098m	£1,997m	£363m
Bochum	£4,935m	£976m	£178m
Bologna	£8,051m	£1,592m	£290m
Bonn	£1,386m	£274m	£50m
Bradford	£5,506m	£1,089m	£198m
Bratislava	£7,782m	£1,539m	£280m
Braunschweig	£4,017m	£794m	£145m
Bremen	£3,944m	£780m	£142m
Bristol	£8,325m	£1,646m	£300m
Brno	£8,309m	£1,643m	£299m
Brussels	£8,298m	£1,641m	£299m
Budapest	£14,660m	£2,899m	£528m
Bydgoszcz	£103m	£20m	£4m
Cardiff	£5,689m	£1,125m	£205m
Catania	£2,084m	£412m	£75m
Cologne	£22,259m	£4,401m	£801m
Copenhagen	£2,858m	£565m	£103m
Cordoba	£653m	£129m	£24m
Coventry	£2,590m	£512m	£93m
Derby	£1,482m	£293m	£53m
Dortmund	£5,512m	£1,090m	£198m
Dresden	£4,628m	£915m	£167m
Duisburg	£8,425m	£1,666m	£303m
Düsseldorf	£5,981m	£1,183m	£215m
Edinburgh	£13,985m	£2,765m	£503m
Espoo	£652m	£129m	£23m
Essen	£4,484m	£887m	£161m
Florence	£2,717m	£537m	£98m
Frankfurt	£12,852m	£2,541m	£462m
Gdansk	£385m	£76m	£14m
Gdynia	£280m	£55m	£10m
Gelsenkirchen	£1,491m	£295m	£54m
Genoa	£2,936m	£581m	£106m

5 SENSITIVITY ANALYSIS

Table 10: Sensitivity Analysis Results (continued)

ECONOMIC COST TO 2025	MODEL ASSUMPTIONS		
CITY	UPPER VALUES	BASE VALUES	LOWER VALUES
Ghent	£4,982m	£985m	£179m
Gijon	£359m	£71m	£13m
Glasgow	£11,414m	£2,257m	£411m
Gothenburg	£3,929m	£777m	£141m
Graz	£801m	£158m	£29m
Hamburg	£34,490m	£6,820m	£1,241m
Hanover	£10,316m	£2,040m	£371m
Helsinki	£2,792m	£552m	£100m
Hull	£2,001m	£396m	£72m
Karlsruhe	£6,977m	£1,380m	£251m
Katowice	£305m	£60m	£11m
Krakow	£1,408m	£278m	£51m
Las Palmas	£85m	£17m	£3m
Leeds	£7,463m	£1,476m	£269m
Leicester	£2,408m	£476m	£87m
Leipzig	£1,173m	£232m	£42m
L'Hospitalet de Llobregat	£2,386m	£472m	£86m
Lisbon	£8,386m	£1,658m	£302m
Liverpool	£1,120m	£222m	£40m
Lodz	£105m	£21m	£4m
London	£212,227m	£41,963m	£7,637m
Lublin	£130m	£26m	£5m
Luxembourg	£9,726m	£1,923m	£350m
Lyon	£6,550m	£1,295m	£236m
Madrid	£27,754m	£5,488m	£999m
Malaga	£2,159m	£427m	£78m
Malmo	£131m	£26m	£5m
Manchester	£9,817m	£1,941m	£353m
Mannheim	£1,999m	£395m	£72m
Marseille	£7,375m	£1,458m	£265m
Milan	£16,870m	£3,336m	£607m
Mönchengladbach	£1,906m	£377m	£69m
Montpellier	£1,709m	£338m	£61m
Munich	£25,021m	£4,947m	£900m
Munster	£1,164m	£230m	£42m
Murcia	£787m	£156m	£28m
Nantes	£6,139m	£1,214m	£221m
Naples	£6,488m	£1,283m	£233m
Newcastle	£1,940m	£384m	£70m
Nice	£3,340m	£660m	£120m
Nottingham	£2,817m	£557m	£101m
Nuremberg	£4,333m	£857m	£156m
Orleans	£141m	£28m	£5m
Oslo	£12,813m	£2,534m	£461m
Ostrava	£756m	£150m	£27m
Palermo	£8,911m	£1,762m	£321m

Table 10: Sensitivity Analysis Results (continued)

ECONOMIC COST TO 2025	MODEL ASSUMPTIONS		
CITY	UPPER VALUES	BASE VALUES	LOWER VALUES
Palma	£663m	£131m	£24m
Paris	£40,346m	£7,977m	£1,452m
Poznan	£662m	£131m	£24m
Prague	£8,239m	£1,629m	£296m
Rome	£42,707m	£8,444m	£1,537m
Rotterdam	£2,061m	£407m	£74m
Seville	£1,976m	£391m	£71m
Sheffield	£3,872m	£766m	£139m
Southampton	£2,280m	£451m	£82m
Stockholm	£7,764m	£1,535m	£279m
Stoke on Trent	£2,691m	£532m	£97m
Strasbourg	£2,062m	£408m	£74m
Stuttgart	£23,201m	£4,587m	£835m
Szczecin	£76m	£15m	£3m
The Hague	£4,627m	£915m	£166m
Toulouse	£7,423m	£1,468m	£267m
Turin	£2,334m	£462m	£84m
Utrecht	£7,787m	£1,540m	£280m
Valencia	£901m	£17m8m	£32m
Valladolid	£278m	£55m	£10m
Venice	£632m	£125m	£23m
Verona	£1,003m	£198m	£36m
Vienna	£9,244m	£1,828m	£333m
Vigo	£15m	£3	£1m
Warsaw	£3,634m	£719m	£131m
Wiesbaden	£1,802m	£356m	£65m
Wolverhampton	£923m	£182m	£33m
Wroclaw	£1,042m	£206m	£38m
Wuppertal	£3,991m	£789m	£144m
Zaragoza	£526m	£104m	£19m
Zürich	£9,726m	£1,923m	£350m
Grand Total	**£926.5bn**	**£183.2bn**	**£33.3bn**

6 SUMMARY

This study identified and ranked over 45,000 traffic hotspots across 123 cities in 19 European countries based upon the impact of over 200,000 traffic jams in September 2016 using the new INRIX Roadway Analytics tool, the first on-demand, cloud based traffic analysis tool that leverages INRIX vast data.

The Bottleneck Tool in INRIX Roadway Analytics produced the Impact Factor of every traffic hotspot in the study, which was the product of the average length (in km), average duration (in minutes) and number of occurrences of traffic jams at these traffic hotspot locations. The traffic hotspots were ranked by their Impact Factors, and cities by the total of the Impact Factors of every traffic hotspot in their area.

The estimated time wasted in these traffic hotspots was monetised (i.e. converted into money) using the UK Department for Transport approved values of time, and the present value of this economic impact was calculated for the next decade using the social discount rate of 3.5%. This value is useful when planning where the most benefit could be generated through future road investment, focusing investment on the traffic hotspots that are causing the greatest economic impact on road users.

Across the 19 countries, the total economic cost over the next decade from the traffic hotspots identified in the study is £183.2 billion. The UK is the worst affected (£61.8 billion) followed by Germany (£41.9 billion). This is largely because they have a great number of very large and highly dense cities.

A search of the published evidence on recent road transport innovations such as intelligent transport systems like smart motorways, identified that they reduce delays by 15-25% on average with some savings as high as 50%. The potential savings from tackling congestion are therefore significant.

London had the most traffic hotspots and suffered the greatest total impact from them: five times more than the second placed city, Rome, and 28 times the average. However, London is the largest city in the study and has the most to gain from tackling its worst traffic hotspots.

However, all cities in the top 10 have a proportionally high traffic hotspot 'Impact Factor', and the total economic impact on road users over the next decade ranges from £3.3 billion in Milan at 10 in the ranking, to £5.5 billion for Madrid at five in the ranking, to £8 billion in Paris at three in the ranking and £8.4 billion for drivers in Rome.

Although London is at the top of the European city ranking, the capital's worst hotspot is third in the list of the top 10 worst in Europe. The A7 in Hamburg has Europe's worst traffic hotspot, followed by the A8 in Stuttgart – 40 percent of the top 10 traffic hotspots are in Germany. Roads in Cologne, Antwerp, Luxembourg City, Paris and Karlsruhe also feature in the top 10.

Focusing on the worst traffic hotspots can generate disproportionate amounts of benefits because they impose a disproportionate amount of cost. For example, reducing congestion the top 10 traffic hotspots in this study (about 0.02% of all hotspots) could help reduce the £7.2 billion of impact they will cause by 2025. INRIX Roadway Analytics allows users to identify such locations, and then to prioritise budgets accordingly to maximise benefits.

7 APPENDIX 1: CURRENCY CONVERSIONS

Table 11 and Table 12 convert the economic costs to countries and cities over the next decade from British Pounds Sterling into Local Currency Units. In each case, the name of the local currency unit is provided.

The conversions were performed using the World Bank's 2015 Purchasing Power Parity rates[16]. Table 11 presents the countries in alphabetical order, whilst Table 12 maintains the ranking based upon Impact Factor.

Table 11: Country Level Economic Cost to 2025 in Local Currency Units

	2025 ECONOMIC COST OF CONGESTION		
COUNTRY	POUNDS STERLING	LOCAL CURRENCY UNITS	LOCAL CURRENCY UNIT
Austria	1,986m	2,348m	Euro
Belgium	7,858m	9,354m	Euro
Czech Republic	3,421m	65,083m	Koruna
Denmark	886m	9,590m	Krone
Finland	681m	915m	Euro
France	14,846m	17,655m	Euro
Germany	41,937m	47,603m	Euro
Hungary	2,899m	560,141m	Forint
Italy	19,092m	20,663m	Euro
Luxembourg	1,923m	2,492m	Euro
Netherlands	3,448m	4,115m	Euro
Norway	2,800m	39,631m	Krone
Poland	1,612m	4,193m	Zloty
Portugal	1,658m	1,420m	Euro
Slovakia	1,539m	1,107m	Euro
Spain	10,518m	10,244m	Euro
Sweden	2,338m	30,829m	Krona
Switzerland	1,923m	3,540m	Franc
UK	61,825m	61,825m	Pounds Sterling

16 *Source: http://data.worldbank.org/indicator/PA.NUS.PPP*

Table 12: City Level Economic Cost to 2025 Converted to Local Currency Units

			2025 ECONOMIC COST OF CONGESTION		
RANK	CITY	COUNTRY	POUNDS STERLING	LOCAL CURRENCY UNITS	LOCAL CURRENCY UNIT
1	London	UK	41,963m	41,963m	Pounds Sterling
2	Rome	Italy	8,444m	9,140m	Euro
3	Paris	France	7,977m	9,487m	Euro
4	Hamburg	Germany	6,820m	7,741m	Euro
5	Madrid	Spain	5,488m	5,344m	Euro
6	Antwerp	Belgium	5,232m	6,228m	Euro
7	Munich	Germany	4,947m	5,616m	Euro
8	Stuttgart	Germany	4,587m	5,207m	Euro
9	Cologne	Germany	4,401m	4,996m	Euro
10	Milan	Italy	3,336m	3,610m	Euro
11	Budapest	Hungary	2,899m	560,141m	Forint
12	Barcelona	Spain	2,840m	2,766m	Euro
13	Edinburgh	UK	2,765m	2,765m	Pounds Sterling
14	Berlin	Germany	2,710m	3,076m	Euro
15	Frankfurt	Germany	2,541m	2,885m	Euro
16	Oslo	Norway	2,534m	35,858m	Krone
17	Glasgow	UK	2,257m	2,257m	Pounds Sterling
18	Hanover	Germany	2,040m	2,315m	Euro
19	Birmingham	UK	1,997m	1,997m	Pounds Sterling
20	Manchester	UK	1,941m	1,941m	Pounds Sterling
21	Luxembourg	Luxembourg	1,923m	2,492m	Euro
22	Zürich	Switzerland	1,923m	3,540m	Franc
23	Vienna	Austria	1,828m	2,161m	Euro
24	Palermo	Italy	1,762m	1,907m	Euro
25	Duisburg	Germany	1,666m	1,891m	Euro
26	Lisbon	Portugal	1,658m	1,420m	Euro
27	Bristol	UK	1,646m	1,646m	Pounds Sterling
28	Brno	Czech Republic	1,643m	31,251m	Koruna
29	Brussels	Belgium	1,641m	1,953m	Euro
30	Prague	Czech Republic	1,629m	30,987m	Koruna
31	Bologna	Italy	1,592m	1,723m	Euro
32	Utrecht	Netherlands	1,540m	1,838m	Euro
33	Bratislava	Slovakia	1,539m	1,107m	Euro
34	Stockholm	Sweden	1,535m	20,244m	Krona
35	Leeds	UK	1,476m	1,476m	Pounds Sterling
36	Toulouse	France	1,468m	1,745m	Euro
37	Marseille	France	1,458m	1,734m	Euro
38	Karlsruhe	Germany	1,380m	1,566m	Euro
39	Lyon	France	1,295m	1,540m	Euro
40	Naples	Italy	1,283m	1,388m	Euro
41	Nantes	France	1,214m	1,444m	Euro
42	Düsseldorf	Germany	1,183m	1,342m	Euro
43	Cardiff	UK	1,125m	1,125m	Pounds Sterling
44	Dortmund	Germany	1,090m	1,237m	Euro
45	Bradford	UK	1,089m	1,089m	Pounds Sterling
46	Ghent	Belgium	985m	1,173m	Euro

7 APPENDIX 1: CURRENCY CONVERSIONS

Table 12: City Level Economic Cost to 2025 Converted to Local Currency Units (continued)

			2025 ECONOMIC COST OF CONGESTION		
RANK	CITY	COUNTRY	POUNDS STERLING	LOCAL CURRENCY UNITS	LOCAL CURRENCY UNIT
47	Bochum	Germany	976m	1,108m	Euro
48	Dresden	Germany	915m	1,039m	Euro
49	The Hague	Netherlands	915m	1,092m	Euro
50	Essen	Germany	887m	1,006m	Euro
51	Nuremberg	Germany	857m	972m	Euro
52	Belfast	UK	797m	797m	Pounds Sterling
53	Braunschweig	Germany	794m	902m	Euro
54	Wuppertal	Germany	789m	896m	Euro
55	Bremen	Germany	780m	885m	Euro
56	Gothenburg	Sweden	777m	10,244m	Krona
57	Sheffield	UK	766m	766m	Pounds Sterling
58	Warsaw	Poland	719m	1,869m	Zloty
59	Nice	France	660m	785m	Euro
60	Amsterdam	Netherlands	586m	699m	Euro
61	Genoa	Italy	581m	628m	Euro
62	Copenhagen	Denmark	565m	6,121m	Krone
63	Nottingham	UK	557m	557m	Pounds Sterling
64	Helsinki	Finland	552m	742m	Euro
65	Florence	Italy	537m	582m	Euro
66	Stoke on Trent	UK	532m	532m	Pounds Sterling
67	Coventry	UK	512m	512m	Pounds Sterling
68	Leicester	UK	476m	476m	Pounds Sterling
69	L'Hospitalet de Llobregat	Spain	472m	460m	Euro
70	Turin	Italy	462m	500m	Euro
71	Southampton	UK	451m	451m	Pounds Sterling
72	Malaga	Spain	427m	416m	Euro
73	Catania	Italy	412m	446m	Euro
74	Strasbourg	France	408m	485m	Euro
75	Rotterdam	Netherlands	407m	486m	Euro
76	Hull	UK	396m	396m	Pounds Sterling
77	Mannheim	Germany	395m	449m	Euro
78	Seville	Spain	391m	380m	Euro
79	Newcastle	UK	384m	384m	Pounds Sterling
80	Mönchengladbach	Germany	377m	428m	Euro
81	Bari	Italy	360m	390m	Euro
82	Wiesbaden	Germany	356m	404m	Euro
83	Montpellier	France	338m	402m	Euro
84	Bielefeld	Germany	324m	368m	Euro
85	Aarhus	Denmark	320m	3,469m	Krone
86	Gelsenkirchen	Germany	295m	335m	Euro
87	Derby	UK	293m	293m	Pounds Sterling
88	Krakow	Poland	278m	724m	Zloty
89	Bonn	Germany	274m	311m	Euro
90	Bergen	Norway	267m	3,774m	Krone

Table 12: City Level Economic Cost to 2025 Converted to Local Currency Units (continued)

			2025 ECONOMIC COST OF CONGESTION		
RANK	CITY	COUNTRY	POUNDS STERLING	LOCAL CURRENCY UNITS	LOCAL CURRENCY UNIT
91	Leipzig	Germany	232m	263m	Euro
92	Munster	Germany	230m	261m	Euro
93	Liverpool	UK	222m	222m	Pounds Sterling
94	Wroclaw	Poland	206m	536m	Zloty
95	Verona	Italy	198m	215m	Euro
96	Wolverhampton	UK	182m	182m	Pounds Sterling
97	Valencia	Spain	178m	174m	Euro
98	Graz	Austria	158m	187m	Euro
99	Murcia	Spain	156m	152m	Euro
100	Ostrava	Czech Republic	150m	2,845m	Koruna
101	Palma	Spain	131m	128m	Euro
102	Poznan	Poland	131m	341m	Zloty
103	Cordoba	Spain	129m	126m	Euro
104	Espoo	Finland	129m	173m	Euro
105	Venice	Italy	125m	135m	Euro
106	Zaragoza	Spain	104m	101m	Euro
107	Augsburg	Germany	91m	104m	Euro
108	Gdansk	Poland	76m	198m	Zloty
109	Gijon	Spain	71m	69m	Euro
110	Katowice	Poland	60m	157m	Zloty
111	Gdynia	Poland	55m	144m	Zloty
112	Valladolid	Spain	55m	53m	Euro
113	Alicante	Spain	35m	34m	Euro
114	Orleans	France	28m	33m	Euro
115	Malmo	Sweden	26m	341m	Krona
116	Lublin	Poland	26m	67m	Zloty
117	Bilbao	Spain	23m	22m	Euro
118	Lodz	Poland	21m	54m	Zloty
119	Bydgoszcz	Poland	20m	53m	Zloty
120	Las Palmas	Spain	17m	16m	Euro
121	Szczecin	Poland	15m	39m	Zloty
122	Bialystok	Poland	4m	11m	Zloty
123	Vigo	Spain	3m	3m	Euro

8 APPENDIX 2: FULL RANKINGS

8.1 TRAFFIC HOTSPOT RANKINGS – TOP 100

Table 13 presents the top 100 traffic hotspots of the 45,662 ranked in the INRIX Roadway Analytics Ranking of 123 cities in 19 European countries. The combined cost imposed tackling congestion at these top 100 locations is £31.1 billion over the next decade. It is clear that several roads appear multiple times in the ranking.

These are typically the major arterial routes and strategic roads in a city that are used by the highest volumes of traffic. For example, Europe's second largest ring road the M25 in London (UK) appears several times but carries over 250,000 vehicles per day over its busiest segments. Similarly, Paris' inner ring road, the Boulevard Périphérique, appears multiple times but carries over a million vehicles a day and is thought to have 25% of all traffic in Paris.

Table 13: Europe's Top 100 Worst Traffic Hotspots

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURRENCES	2025 ECONOMIC COST OF CONGESTION
1	Hamburg	Germany	A7	94	8.7	257	£1,134m
2	Stuttgart	Germany	A8	24	10.93	790	£1,118m
3	Antwerp	Belgium	A21	80	5.77	396	£985m
4	London	UK	M25	20	9.48	690	£705m
5	London	UK	M25	30	7.79	456	£575m
6	Cologne	Germany	A3	56	6.89	264	£549m
7	Antwerp	Belgium	R1	67	6.37	237	£545m
8	Luxembourg	Luxembourg	A6	286	5.44	65	£545m
9	Paris	France	A1	109	3.64	252	£538m
10	Karlsruhe	Germany	A5	92	5.75	178	£508m
11	Milan	Italy	A4	161	6.23	83	£449m
12	Paris	France	A86	91	9.62	95	£448m
13	Hanover	Germany	A2	44	8.68	212	£437m
14	Paris	France	Boulevard Périphérique	125	5.35	120	£433m
15	Rome	Italy	A90	34	7.81	299	£428m
16	London	UK	M25	273	22.22	13	£425m
17	Antwerp	Belgium	A14	42	7.34	252	£419m
18	Brno	Czech Republic	D1	79	7.76	126	£416m
19	Edinburgh	UK	A720	86	8.71	101	£408m
20	Braunschweig	Germany	A2	194	11.8	33	£407m
21	Stuttgart	Germany	A8	46	18.64	87	£402m
22	Brussels	Belgium	R0	256	11.18	26	£401m
23	Paris	France	Boulevard Périphérique	75	6.53	147	£388m
24	Bremen	Germany	A1	173	6.96	59	£383m
25	Bratislava	Slovakia	D1	124	8.47	67	£380m
26	Lyon	France	Autoroute du Soleil	213	3.58	90	£370m
27	Madrid	Spain	M-40	92	4.4	167	£365m
28	Edinburgh	UK	A720	80	3.59	216	£334m
29	Munich	Germany	B2R	314	3.11	63	£332m
30	Stockholm	Sweden	E4	119	7.18	72	£332m

Table 13: Europe's Top 100 Worst Traffic Hotspots (continued)

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURRENCES	2025 ECONOMIC COST OF CONGESTION
31	Paris	France	Boulevard Périphérique	138	5.7	78	£331m
32	Frankfurt	Germany	A3	28	6.77	321	£328m
33	Ghent	Belgium	R4	264	3.09	73	£321m
34	Stuttgart	Germany	A8	50	9.94	119	£319m
35	Zürich	Switzerland	A4	86	5.82	117	£316m
36	Glasgow	UK	A8	96	7.98	76	£314m
37	Hanover	Germany	A2	34	7.94	215	£313m
38	Munich	Germany	A8	36	6.58	231	£295m
39	Paris	France	A10	112	5.27	91	£289m
40	Cologne	Germany	A3	143	5.48	67	£283m
41	Oslo	Norway	E6	99	13.47	39	£280m
42	Cologne	Germany	A3	112	5.39	84	£273m
43	Munich	Germany	A96	47	5.06	209	£268m
44	Brno	Czech Republic	D1	87	7.02	80	£263m
45	Utrecht	Netherlands	A28	40	4.96	241	£258m
46	London	UK	A406	197	2.61	92	£255m
47	Paris	France	Boulevard Périphérique	72	3.81	170	£251m
48	Hamburg	Germany	B75	120	4.32	89	£249m
49	Brussels	Belgium	R0	88	6.58	79	£247m
50	London	UK	A406	84	4.18	129	£244m
51	Paris	France	Boulevard Périphérique	124	7.29	50	£244m
52	Brno	Czech Republic	D1	252	5.78	31	£243m
53	The Hague	Netherlands	A4	57	6.37	124	£243m
54	Rome	Italy	A90	24	8.47	219	£240m
55	Munich	Germany	B2R	157	2.46	115	£240m
56	Edinburgh	UK	A720	76	7.69	76	£239m
57	Hamburg	Germany	A7	71	6.29	97	£234m
58	Karlsruhe	Germany	A5	79	7.19	76	£233m
59	Antwerp	Belgium	A21	55	4.29	182	£231m
60	Edinburgh	UK	A720	51	7.32	114	£229m
61	Antwerp	Belgium	R1	76	10.32	54	£228m
62	Milan	Italy	A7	32	6.75	196	£228m
63	Karlsruhe	Germany	A5	111	6.19	61	£226m
64	Paris	France	Boulevard Périphérique	106	3.73	105	£224m
65	Madrid	Spain	M-30	67	4.49	136	£220m
66	Brno	Czech Republic	D1	360	7.38	15	£215m
67	Lyon	France	Autoroute du Soleil	195	4.52	45	£214m
68	Rome	Italy	A90	34	5.11	228	£214m

8 APPENDIX 2: FULL RANKINGS

Table 13: Europe's Top 100 Worst Traffic Hotspots (continued)

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	WORST TRAFFIC HOTSPOT	AVE. DURATION (MINS)	AVE. LENGTH (KM)	TOTAL NO. OF OCCURRENCES	2025 ECONOMIC COST OF CONGESTION
69	Luxembourg	Luxembourg	A6	57	6.85	101	£213m
70	Oslo	Norway	E6	82	4.67	103	£213m
71	Hamburg	Germany	A1	32	7.52	162	£210m
72	Berlin	Germany	A100	34	6.8	168	£210m
73	Zürich	Switzerland	A4	77	5.5	90	£205m
74	Paris	France	Boulevard Périphérique	127	4.02	73	£201m
75	London	UK	M25	27	13.83	99	£199m
76	Frankfurt	Germany	A5	32	7	165	£199m
77	Bochum	Germany	A43	83	10.09	44	£199m
78	Edinburgh	UK	A720	55	6.29	106	£198m
79	Paris	France	Boulevard Périphérique	95	5.75	67	£197m
80	London	UK	A406	79	4.55	101	£196m
81	Milan	Italy	A7	59	5.19	118	£195m
82	Stuttgart	Germany	A8	32	10.63	106	£194m
83	Vienna	Austria	A23	62	4.06	143	£194m
84	Duisburg	Germany	A3	23	5.12	304	£193m
85	The Hague	Netherlands	A12	179	6.63	30	£192m
86	Rome	Italy	A90	50	6.28	111	£188m
87	Munich	Germany	A96	59	3.73	158	£188m
88	Paris	France	Boulevard Périphérique	54	3.42	187	£186m
89	Cologne	Germany	A1	99	4.77	73	£186m
90	Cologne	Germany	A3	47	2.78	264	£186m
91	London	UK	A13	137	6.25	40	£185m
92	Munich	Germany	A96	70	5.19	94	£184m
93	Rome	Italy	A90	50	6.56	103	£182m
94	London	UK	A13	137	6.6	37	£180m
95	Paris	France	Boulevard Périphérique	47	4.52	157	£180m
96	London	UK	M25	244	22.7	6	£179m
97	London	UK	M25	61	9.39	58	£179m
98	Munich	Germany	B2R	55	5.16	116	£177m
99	Hamburg	Germany	A1	22	4.95	301	£177m
100	Zürich	Switzerland	A1	77	9.23	46	£176m
						Total Cost	**£31.1bn**

8.2
CITY RANKINGS – ALL CITIES

Table 14 provides the ranking of all 123 European cities across the 19 countries studied, ranked by the total impact of traffic hotspots in September 2016.

In comparison, Table 15 presents the same data but attempts to adjust the ranking for population size. Adjusting for population has a significant impact on the ranking at the top of the table but relatively little to the bottom of the table.

Table 14: European City Ranking

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION
1	London	UK	12,776	7,782,677	£41,963m
2	Rome	Italy	1,684	1,566,115	£8,444m
3	Paris	France	703	1,479,535	£7,977m
4	Hamburg	Germany	1,305	1,264,783	£6,820m
5	Madrid	Spain	837	1,017,770	£5,488m
6	Antwerp	Belgium	459	970,351	£5,232m
7	Munich	Germany	841	917,570	£4,947m
8	Stuttgart	Germany	539	850,815	£4,587m
9	Cologne	Germany	740	816,260	£4,401m
10	Milan	Italy	1,053	618,657	£3,336m
11	Budapest	Hungary	1,284	537,595	£2,899m
12	Barcelona	Spain	461	526,780	£2,840m
13	Edinburgh	UK	455	512,834	£2,765m
14	Berlin	Germany	1,070	502,580	£2,710m
15	Frankfurt	Germany	448	471,315	£2,541m
16	Oslo	Norway	321	469,880	£2,534m
17	Glasgow	UK	357	418,560	£2,257m
18	Hanover	Germany	290	378,308	£2,040m
19	Birmingham	UK	872	370,303	£1,997m
20	Manchester	UK	768	360,021	£1,941m
21	Luxembourg	Luxembourg	167	356,663	£1,923m
22	Zürich	Switzerland	214	356,658	£1,923m
23	Vienna	Austria	528	338,995	£1,828m
24	Palermo	Italy	369	326,782	£1,762m
25	Duisburg	Germany	213	308,973	£1,666m
26	Lisbon	Portugal	311	307,512	£1,658m
27	Bristol	UK	619	305,276	£1,646m
28	Brno	Czech Republic	138	304,690	£1,643m
29	Brussels	Belgium	245	304,283	£1,641m
30	Prague	Czech Republic	267	302,120	£1,629m
31	Bologna	Italy	238	295,227	£1,592m
32	Utrecht	Netherlands	114	285,559	£1,540m
33	Bratislava	Slovakia	306	285,362	£1,539m
34	Stockholm	Sweden	285	284,714	£1,535m
35	Leeds	UK	712	273,684	£1,476m
36	Toulouse	France	243	272,210	£1,468m
37	Marseille	France	321	270,461	£1,458m
38	Karlsruhe	Germany	120	255,858	£1,380m

8 APPENDIX 2: FULL RANKINGS

Table 14: European City Ranking (continued)

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION
39	Lyon	France	118	240,211	£1,295m
40	Naples	Italy	414	237,920	£1,283m
41	Nantes	France	110	225,140	£1,214m
42	Düsseldorf	Germany	373	219,346	£1,183m
43	Cardiff	UK	392	208,618	£1,125m
44	Dortmund	Germany	247	202,121	£1,090m
45	Bradford	UK	596	201,901	£1,089m
46	Ghent	Belgium	221	182,711	£985m
47	Bochum	Germany	121	180,969	£976m
48	Dresden	Germany	287	169,726	£915m
49	The Hague	Netherlands	77	169,673	£915m
50	Essen	Germany	238	164,446	£887m
51	Nuremberg	Germany	229	158,893	£857m
52	Belfast	UK	446	147,864	£797m
53	Braunschweig	Germany	138	147,313	£794m
54	Wuppertal	Germany	102	146,340	£789m
55	Bremen	Germany	133	144,616	£780m
56	Gothenburg	Sweden	142	144,076	£777m
57	Sheffield	UK	360	142,006	£766m
58	Warsaw	Poland	376	133,268	£719m
59	Nice	France	156	122,469	£660m
60	Amsterdam	Netherlands	119	108,612	£586m
61	Genoa	Italy	325	107,672	£581m
62	Copenhagen	Denmark	255	104,824	£565m
63	Nottingham	UK	342	103,302	£557m
64	Helsinki	Finland	269	102,374	£552m
65	Florence	Italy	246	99,647	£537m
66	Stoke on Trent	UK	207	98,684	£532m
67	Coventry	UK	178	94,967	£512m
68	Leicester	UK	260	88,302	£476m
69	L'Hospitalet de Llobregat	Spain	71	87,506	£472m
70	Turin	Italy	193	85,598	£462m
71	Southampton	UK	209	83,606	£451m
72	Malaga	Spain	155	79,168	£427m
73	Catania	Italy	149	76,419	£412m
74	Strasbourg	France	41	75,633	£408m
75	Rotterdam	Netherlands	106	75,572	£407m
76	Hull	UK	183	73,373	£396m
77	Mannheim	Germany	90	73,324	£395m
78	Seville	Spain	103	72,456	£391m
79	Newcastle	UK	111	71,146	£384m
80	Mönchengladbach	Germany	138	69,894	£377m
81	Bari	Italy	166	66,810	£360m
82	Wiesbaden	Germany	94	66,091	£356m
83	Montpellier	France	126	62,663	£338m
84	Bielefeld	Germany	134	60,106	£324m

Table 14: European City Ranking (continued)

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION
85	Aarhus	Denmark	194	59,407	£320m
86	Gelsenkirchen	Germany	73	54,694	£295m
87	Derby	UK	112	54,361	£293m
88	Krakow	Poland	159	51,624	£278m
89	Bonn	Germany	117	50,821	£274m
90	Bergen	Norway	111	49,451	£267m
91	Leipzig	Germany	223	43,029	£232m
92	Munster	Germany	142	42,690	£230m
93	Liverpool	UK	236	41,087	£222m
94	Wroclaw	Poland	141	38,217	£206m
95	Verona	Italy	146	36,778	£198m
96	Wolverhampton	UK	184	33,844	£182m
97	Valencia	Spain	138	33,041	£178m
98	Graz	Austria	100	29,374	£158m
99	Murcia	Spain	119	28,856	£156m
100	Ostrava	Czech Republic	79	27,735	£150m
101	Palma	Spain	69	24,304	£131m
102	Poznan	Poland	109	24,279	£131m
103	Cordoba	Spain	63	23,964	£129m
104	Espoo	Finland	104	23,919	£129m
105	Venice	Italy	86	23,190	£125m
106	Zaragoza	Spain	111	19,286	£104m
107	Augsburg	Germany	72	16,953	£91m
108	Gdansk	Poland	72	14,132	£76m
109	Gijon	Spain	35	13,168	£71m
110	Katowice	Poland	32	11,196	£60m
111	Gdynia	Poland	44	10,266	£55m
112	Valladolid	Spain	52	10,187	£55m
113	Alicante	Spain	56	6,416	£35m
114	Orleans	France	26	5,162	£28m
115	Malmo	Sweden	34	4,794	£26m
116	Lublin	Poland	22	4,760	£26m
117	Bilbao	Spain	39	4,224	£23m
118	Lodz	Poland	44	3,845	£21m
119	Bydgoszcz	Poland	37	3,760	£20m
120	Las Palmas	Spain	20	3,125	£17m
121	Szczecin	Poland	27	2,800	£15m
122	Bialystok	Poland	9	750	£4m
123	Vigo	Spain	6	559	£3m
	Europe (123) Total	**19**	**45,662**	**33,975,160**	**£183.2bn**

8 APPENDIX 2: FULL RANKINGS

Table 15: European City Ranking – Population Adjusted

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION
1	Antwerp	Belgium	459	970,351	£5,232m
2	Stuttgart	Germany	539	850,815	£4,587m
3	Edinburgh	UK	455	512,834	£2,765m
4	Zürich	Switzerland	214	356,658	£1,923m
5	London	UK	12,776	7,782,677	£41,963m
6	Utrecht	Netherlands	114	285,559	£1,540m
7	Karlsruhe	Germany	120	255,858	£1,380m
8	Brno	Czech Republic	138	304,690	£1,643m
9	Bologna	Italy	238	295,227	£1,592m
10	Cologne	Germany	740	816,260	£4,401m
11	Nantes	France	110	225,140	£1,214m
12	Oslo	Norway	321	469,880	£2,534m
13	Hanover	Germany	290	378,308	£2,040m
14	Ghent	Belgium	221	182,711	£985m
15	Hamburg	Germany	1,305	1,264,783	£6,820m
16	Bratislava	Slovakia	306	285,362	£1,539m
17	Bristol	UK	619	305,276	£1,646m
18	Glasgow	UK	357	418,560	£2,257m
19	Frankfurt	Germany	448	471,315	£2,541m
20	Manchester	UK	768	360,021	£1,941m
21	Munich	Germany	841	917,570	£4,947m
22	Paris	France	703	1,479,535	£7,977m
23	Duisburg	Germany	213	308,973	£1,666m
24	Luxembourg	Luxembourg	167	356,663	£1,923m
25	Toulouse	France	243	272,210	£1,468m
26	Rome	Italy	1,684	1,566,115	£8,444m
27	Lisbon	Portugal	311	307,512	£1,658m
28	Cardiff	UK	392	208,618	£1,125m
29	Braunschweig	Germany	138	147,313	£794m
30	Leeds	UK	712	273,684	£1,476m
31	Palermo	Italy	369	326,782	£1,762m
32	Milan	Italy	1,053	618,657	£3,336m
33	Bochum	Germany	121	180,969	£976m
34	Lyon	France	118	240,211	£1,295m
35	Belfast	UK	446	147,864	£797m
36	Wuppertal	Germany	102	146,340	£789m
37	Stoke on Trent	UK	207	98,684	£532m
38	Bradford	UK	596	201,901	£1,089m
39	Düsseldorf	Germany	373	219,346	£1,183m
40	Nice	France	156	122,469	£660m
41	L'Hospitalet de Llobregat	Spain	71	87,506	£472m
42	Dortmund	Germany	247	202,121	£1,090m
43	The Hague	Netherlands	77	169,673	£915m
44	Barcelona	Spain	461	526,780	£2,840m
45	Birmingham	UK	872	370,303	£1,997m
46	Madrid	Spain	837	1,017,770	£5,488m

Table 15: European City Ranking – Population Adjusted (continued)

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION
47	Southampton	UK	209	83,606	£451m
48	Dresden	Germany	287	169,726	£915m
49	Nuremberg	Germany	229	158,893	£857m
50	Budapest	Hungary	1,284	537,595	£2,899m
51	Nottingham	UK	342	103,302	£557m
52	Marseille	France	321	270,461	£1,458m
53	Coventry	UK	178	94,967	£512m
54	Essen	Germany	238	164,446	£887m
55	Florence	Italy	246	99,647	£537m
56	Hull	UK	183	73,373	£396m
57	Strasbourg	France	41	75,633	£408m
58	Mönchengladbach	Germany	138	69,894	£377m
59	Catania	Italy	149	76,419	£412m
60	Brussels	Belgium	245	304,283	£1,641m
61	Bremen	Germany	133	144,616	£780m
62	Leicester	UK	260	88,302	£476m
63	Gothenburg	Sweden	142	144,076	£777m
64	Naples	Italy	414	237,920	£1,283m
65	Mannheim	Germany	90	73,324	£395m
66	Newcastle	UK	111	71,146	£384m
67	Sheffield	UK	360	142,006	£766m
68	Prague	Czech Republic	267	302,120	£1,629m
69	Montpellier	France	126	62,663	£338m
70	Wiesbaden	Germany	94	66,091	£356m
71	Bari	Italy	166	66,810	£360m
72	Derby	UK	112	54,361	£293m
73	Gelsenkirchen	Germany	73	54,694	£295m
74	Stockholm	Sweden	285	284,714	£1,535m
75	Vienna	Austria	528	338,995	£1,828m
76	Genoa	Italy	325	107,672	£581m
77	Copenhagen	Denmark	255	104,824	£565m
78	Aarhus	Denmark	194	59,407	£320m
79	Bielefeld	Germany	134	60,106	£324m
80	Bergen	Norway	111	49,451	£267m
81	Helsinki	Finland	269	102,374	£552m
82	Bonn	Germany	117	50,821	£274m
83	Verona	Italy	146	36,778	£198m
84	Munster	Germany	142	42,690	£230m
85	Berlin	Germany	1,070	502,580	£2,710m
86	Malaga	Spain	155	79,168	£427m
87	Amsterdam	Netherlands	119	108,612	£586m
88	Wolverhampton	UK	184	33,844	£182m
89	Rotterdam	Netherlands	106	75,572	£407m
90	Graz	Austria	100	29,374	£158m
91	Seville	Spain	103	72,456	£391m
92	Turin	Italy	193	85,598	£462m

8 APPENDIX 2: FULL RANKINGS

Table 15: European City Ranking – Population Adjusted (continued)

RANK	EUROPEAN CITY (POPULATION OVER 250K)	COUNTRY	NO. OF TRAFFIC HOTSPOTS	IMPACT FACTOR	2025 ECONOMIC COST OF CONGESTION
93	Ostrava	Czech Republic	79	27,735	£150m
94	Espoo	Finland	104	23,919	£129m
95	Venice	Italy	86	23,190	£125m
96	Liverpool	UK	236	41,087	£222m
97	Leipzig	Germany	223	43,029	£232m
98	Warsaw	Poland	376	133,268	£719m
99	Cordoba	Spain	63	23,964	£129m
100	Krakow	Poland	159	51,624	£278m
101	Murcia	Spain	119	28,856	£156m
102	Palma	Spain	69	24,304	£131m
103	Augsburg	Germany	72	16,953	£91m
104	Wroclaw	Poland	141	38,217	£206m
105	Gijon	Spain	35	13,168	£71m
106	Poznan	Poland	109	24,279	£131m
107	Valencia	Spain	138	33,041	£178m
108	Gdynia	Poland	44	10,266	£55m
109	Katowice	Poland	32	11,196	£60m
110	Valladolid	Spain	52	10,187	£55m
111	Gdansk	Poland	72	14,132	£76m
112	Zaragoza	Spain	111	19,286	£104m
113	Alicante	Spain	56	6,416	£35m
114	Malmo	Sweden	34	4,794	£26m
115	Lublin	Poland	22	4,760	£26m
116	Orleans	France	26	5,162	£28m
117	Bilbao	Spain	39	4,224	£23m
118	Bydgoszcz	Poland	37	3,760	£20m
119	Las Palmas	Spain	20	3,125	£17m
120	Szczecin	Poland	27	2,800	£15m
121	Lodz	Poland	44	3,845	£21m
122	Bialystok	Poland	9	750	£4m
123	Vigo	Spain	6	559	£3m

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