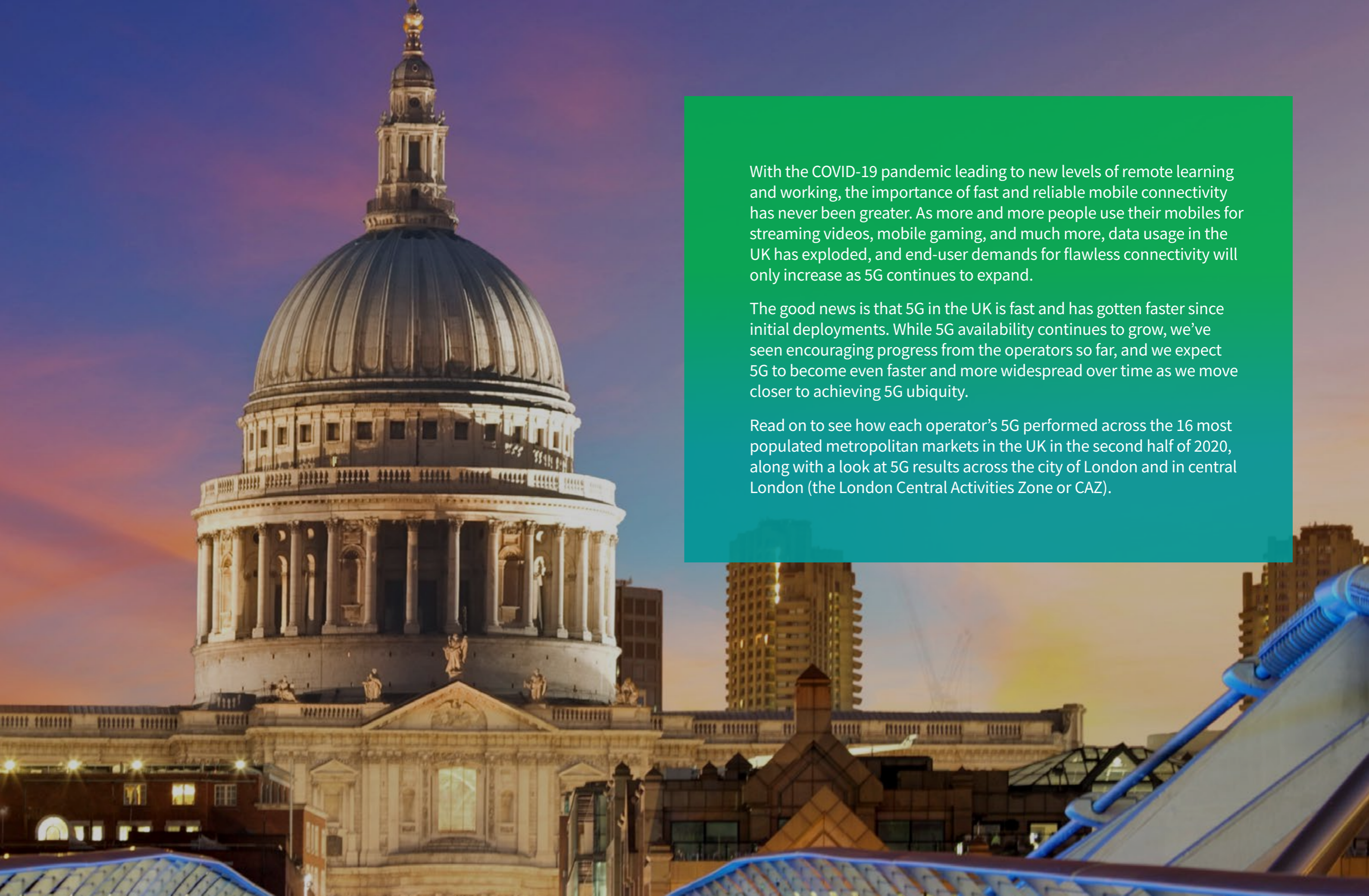


## 5G in the UK

The 5G experience in major UK cities, with a look at 5G in central London







With the COVID-19 pandemic leading to new levels of remote learning and working, the importance of fast and reliable mobile connectivity has never been greater. As more and more people use their mobiles for streaming videos, mobile gaming, and much more, data usage in the UK has exploded, and end-user demands for flawless connectivity will only increase as 5G continues to expand.

The good news is that 5G in the UK is fast and has gotten faster since initial deployments. While 5G availability continues to grow, we've seen encouraging progress from the operators so far, and we expect 5G to become even faster and more widespread over time as we move closer to achieving 5G ubiquity.

Read on to see how each operator's 5G performed across the 16 most populated metropolitan markets in the UK in the second half of 2020, along with a look at 5G results across the city of London and in central London (the London Central Activities Zone or CAZ).



# 5G and spectrum

When it comes to the real-world 5G experience, spectrum is key. There is no one-size-fits-all 5G solution, and the end-user 5G experience can vary considerably depending on the type of spectrum operators use for deployments. In the context of 5G, spectrum at or below 6 GHz can be separated into “low-band” or “mid-band” spectrum, while spectrum at 24 GHz or higher is considered millimeter wave (mmWave) spectrum. It’s worth noting that low- and mid-band spectrum can also be used for 4G LTE service, whereas mmWave cannot be used for 4G LTE.

All four operators in the UK utilise mid-band spectrum for 5G, which is often considered a spectrum “sweet spot,” offering both fast speeds and broad geographic coverage, rather than one or the other, which is the case with either low-band or mmWave. In March of 2021, the operators will be able to acquire additional mid-band spectrum (3.6 - 3.8 GHz) at **auction**, along with low-band 700 MHz spectrum. The addition of more mid-band spectrum could help the operators provide improved results going forward. To learn more about spectrum, read our article [understanding spectrum](#).

There are two key considerations when it comes to spectrum:



**Speed performance**



**Geographical coverage**



## Low-band spectrum 5G (under 1 GHz):

Low-band spectrum can cover long distances and penetrate deep within buildings and other structures, but it doesn’t have the capability to provide high-end speeds as fast as those of mid-band or, especially, mmWave spectrum. While low-band spectrum can help operators bring 5G to rural areas, its speeds are generally closer to those on 4G LTE, rather than the blistering speeds 5G can deliver on other types of spectrum.

\* Not used by UK operators

## Mid-band spectrum 5G (1 GHz – 6 GHz): used by EE, O2, Three, and Vodafone

Mid-band spectrum, which is also used for 4G LTE networks, is often considered the most desirable type of spectrum for 5G. It carries the advantages of both low-band and mmWave spectrum, with not only fast speeds but also broad geographic coverage. Mid-band spectrum also provides additional capacity in areas with heavy congestion such as event venues, busy city centres, and other areas where finding strong mobile service can be a problem. All four UK operators currently use mid-band spectrum (3.5 GHz) for 5G.

## mmWave spectrum 5G (24 GHz+):

mmWave is currently being used in the US at frequencies of 28 GHz and 39 GHz, but operators in the UK are not using mmWave. The primary upside of mmWave spectrum is that it’s fast. It offers the potential to deliver speeds theoretically as high as 5.0 Gbps or better and can provide broadband connectivity to busy office buildings and other densely populated areas of cities much more easily (and cost effectively) than wired broadband. However, the downside to mmWave is that signals don’t travel more than about one city block and can be obstructed by architecture and other physical objects relatively easily.

\* Not used by UK operators

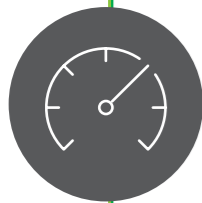
# Benchmarking what matters most

To provide a holistic view of each network's real-world 5G performance, we've included visuals below showing each operator's 5G availability and speed results along with key insights for the end-user 5G experience. We've also taken a look at how consistently the operators delivered download speeds across all network technologies (4G LTE and 5G, if available) to show the speeds end users are likely to experience on each operator's network when not connected purely to 5G. Taken together, this complementary information provides a full picture of the current end-user 5G experience.



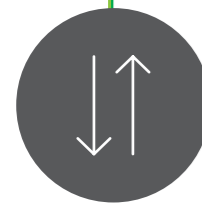
## 5G availability

Our 5G availability results provide an understanding of how often we connected to 5G across our suite of data tests (download, upload, and web and app testing). When people use their mobiles, they may switch between 5G, 4G LTE, and mixed mode (the user experience of switching between 5G and 4G LTE during the same data activity), but performance during mixed mode is typically not as strong as that on 5G-only. Therefore, to provide the most accurate view of a true 5G experience and to provide the most direct comparisons between operators, the 5G availability metrics in this report reflect results recorded purely on 5G and do not factor in mixed mode results. Note that we consider 5G availability of 25% as a benchmark for relatively widespread 5G availability, though that number will certainly go up as the networks continue to expand.



## 5G median and maximum download speeds

5G median download speeds offer a look at "everyday" 5G performance, while 5G maximum download speeds show what topline performance might be and highlight the potential of an operator's 5G network. To provide the most accurate view of a true 5G speed experience and to allow for the most direct comparisons between performance on 5G and 4G LTE, we did not include mixed mode speed results in our reporting. In this report, we use 5G median download speed of at least 100 Mbps as a benchmark for a "true" 5G speed, which is in line with [International Mobile Telecommunications \(IMT-2020\)](#) expectations of 5G networks eventually achieving consistent 5G median download speeds of 100 Mbps.



## 4G LTE median and maximum download speeds

We also looked at speed results on 4G LTE. Comparing 4G LTE speeds to those entirely on 5G helps give a more nuanced view of the experience on different network technologies. 4G LTE median download speeds offer a look at typical 4G LTE speed performance and indicate what to expect when not on 5G, while 4G LTE maximum download speeds reflect the potential of 4G LTE.



## Speed consistency across all network technologies

At the end of the day, consistency of speed performance has the most impact on the end-user experience. Our speed intervals bring together overall speed results across all network technologies (4G LTE, any sub-4G technologies, and 5G, where available) to show how many cities in which each operator reached or surpassed various median download speed thresholds across the 16 most populated cities in the UK. Since users won't access 5G all the time and may switch between different network technologies, overall speeds reflect the most typical real-world speed experience.



## Latency

Latency refers to response time (or delay) between a user request and an action being taken by a simple function, application, or machine. The latency metrics in this report are from our secure web and app latency testing, which characterises use cases that require secure connections with continuous data usage such as gaming, streaming videos, and AR/VR applications, among others. The lower the latency, the better the end-user experience. As a frame of reference, major cloud gaming platform Microsoft Xbox Game Pass [recommends latency below 60ms for optimal mobile cloud gaming](#), and within this report, we consider 60ms a benchmark for low latency.

To learn about some of the common misconceptions of 5G and your health, read our eBook [5G and your health: misconceptions, realities, and benefits](#).





# Strong 5G reliability and latency for all four operators

**A look at reliability:** We measure each operator's reliability for both getting connected to the network and staying connected long enough to complete our tests during our secure web and app testing, which serves as a good proxy for overall data reliability.

Data reliability on 5G was generally outstanding for all operators in most of the 16 cities tested. In fact, each operator delivered reliability success rates of at least 99.5% for getting connected in a majority of cities; Vodafone's success rate of 94.7% in Bristol was the only instance of a network recording a reliability success rate below 98.0%. Reliability was also excellent in terms of staying connected, with all four networks recording success rates of 99.5% or better on 5G in most markets, with no operator recording a reliability success rate below 98.4%.

**A look at latency:** Like with reliability, we measure latency during our secure web and app testing. Low latency is particularly important for use cases in which any delay is critical, such as mobile cloud gaming.

As noted above, latency below 60ms is optimal for gaming (and other activities), and with a few exceptions, each operator's 5G latency was below 60ms in most markets. Three had the lowest latency of any operator in any city at 28.5ms in London, though O2 was close behind with 5G latency of 30.0ms in Leeds and Bradford. While latencies were generally low across the board, it's worth noting that the latencies we recorded on 5G in the UK were relatively similar to those on 4G LTE, but we do expect to see lower 5G latency going forward as the networks mature.



# Operator-by-operator performance highlights





# EE offers broad 5G availability and fast 5G speeds

## EE's 5G, in short:

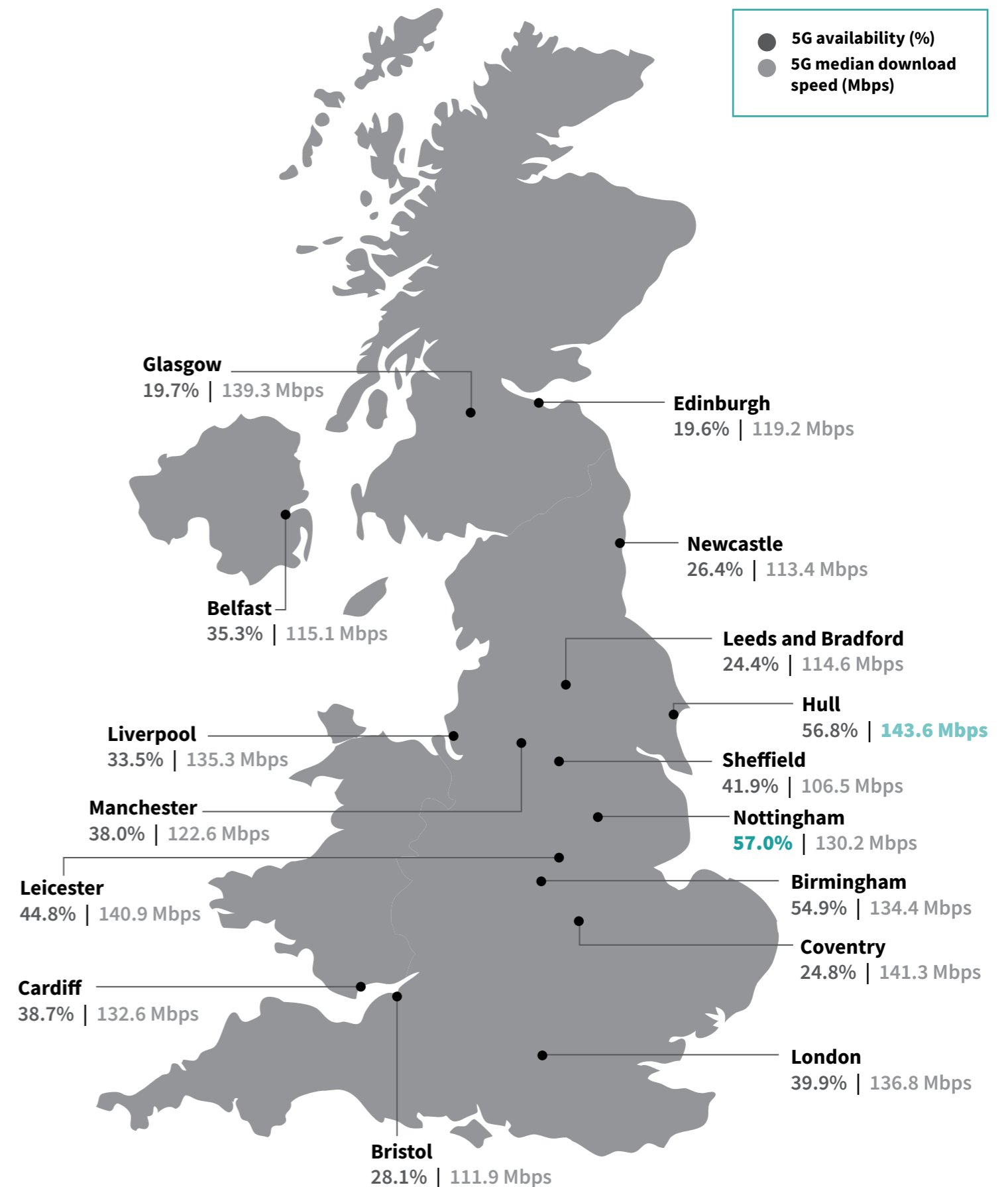
The first network to launch 5G in the UK, EE's 5G performance was strong across the board, recording the highest 5G availability in 15 of the 16 cities we tested along with consistently fast 5G speeds. EE's 12 cities with 5G availability above 25% was by far the most any operator. What's more, EE was the only operator whose 5G median download speeds surpassed 100 Mbps in every city we tested.

## Speed consistency on all network technologies

EE's median download speed intervals (all network technologies)						
Median download speed intervals	0-10 Mbps	10-20 Mbps	20-30 Mbps	30-40 Mbps	40-50 Mbps	50+ Mbps
1H 2020	0	0	0	3	5	8
2H 2020	0	0	0	1	3	12

- Number of markets out of 16 in which EE delivered median download speeds at various intervals.  
 - Median download speeds on the table above represent speeds recorded on all network technologies, including 5G where available.

Since end users won't access 5G all the time, looking at EE's overall median download speeds across all network technologies shows the most accurate picture of the end-user's real-world experience, and the consistency with which EE delivered fast speeds was unmatched. When looking at the experience across all technology types, EE remained the only operator to register median download speeds above 30 Mbps in all 16 markets, and EE clocked speeds above 50 Mbps in 12 of those cities, easily the most of an operator. In short, even if users can't consistently access 5G in a given city, they should still be able to download or stream content quickly.



Note:  
 - 5G availability is based on the percentage of tests recorded on 5G across all data tests (download, upload, and web and app tests).  
 - Highlighted figures represent the fastest 5G median download speed and highest 5G availability.

# O2 shows consistently fast speeds, but limited availability overall

## O2's 5G, in short:

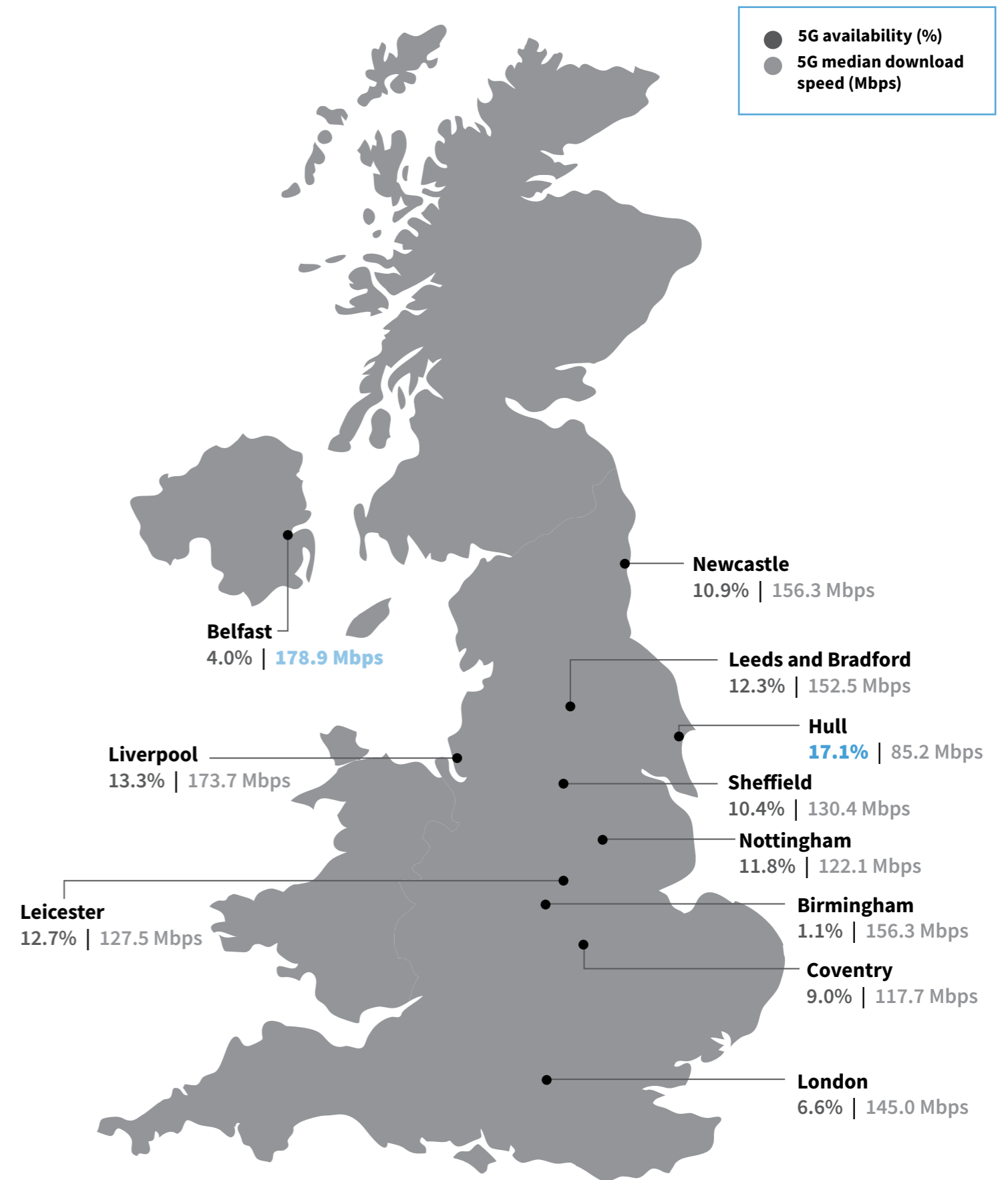
Good news for O2's 5G users: the number of cities in which we recorded 5G results for O2 increased from 4 in 1H 2020 to 11 this time, and O2's speeds were strong, with 5G median download speeds of at least 100 Mbps in 10 of those markets. That said, 5G availability remained limited in our testing: O2 was the only operator that didn't register 5G availability greater than 25% in any city. For context, O2's highest 5G availability was lower than EE's lowest 5G availability (19.6%).

O2's median download speed intervals (all network technologies)						
Median download speed intervals	0-10 Mbps	10-20 Mbps	20-30 Mbps	30-40 Mbps	40-50 Mbps	50+ Mbps
1H 2020	1	10	5	0	0	0
2H 2020	3	7	5	1	0	0

- Number of markets out of 16 in which O2 delivered median download speeds at various intervals.  
 - Median download speeds on the table above represent speeds recorded on all network technologies, including 5G where available.

## Speed consistency on all network technologies

Most of O2's overall median download speeds clocked in below 30 Mbps, and O2 was the only network that registered overall median download speeds below 10 Mbps in any city. In short, though O2's 5G can be fast, its relatively low availability means that a consumer's overall experience is likely to still fall on the slower end of our testing. That said, it's important to keep in mind that speeds on the table above are across all network technologies, so as O2's 5G availability grows, the operator's overall speeds should also improve.



Note:  
 - 5G availability is based on the percentage of tests recorded on 5G across all data tests (download, upload, and web and app tests).  
 - Highlighted figures represent the fastest 5G median download speed and highest 5G availability.



# Three shows a growing 5G footprint, fast speeds, but low availability

## Three's 5G, in short:

Three offered 5G in all 16 cities we visited in 2H 2020, an increase from 11 in 1H 2020, and the operator's speeds were generally good. While Three didn't record 5G median download speeds above 100 Mbps in as many cities as the other operators (seven total), Three's "slowest" 5G speed was a still-solid 79.1 Mbps. However, Three's 5G availability was relatively low, exceeding 25% in only two cities.

### Three's median download speed intervals (all network technologies)

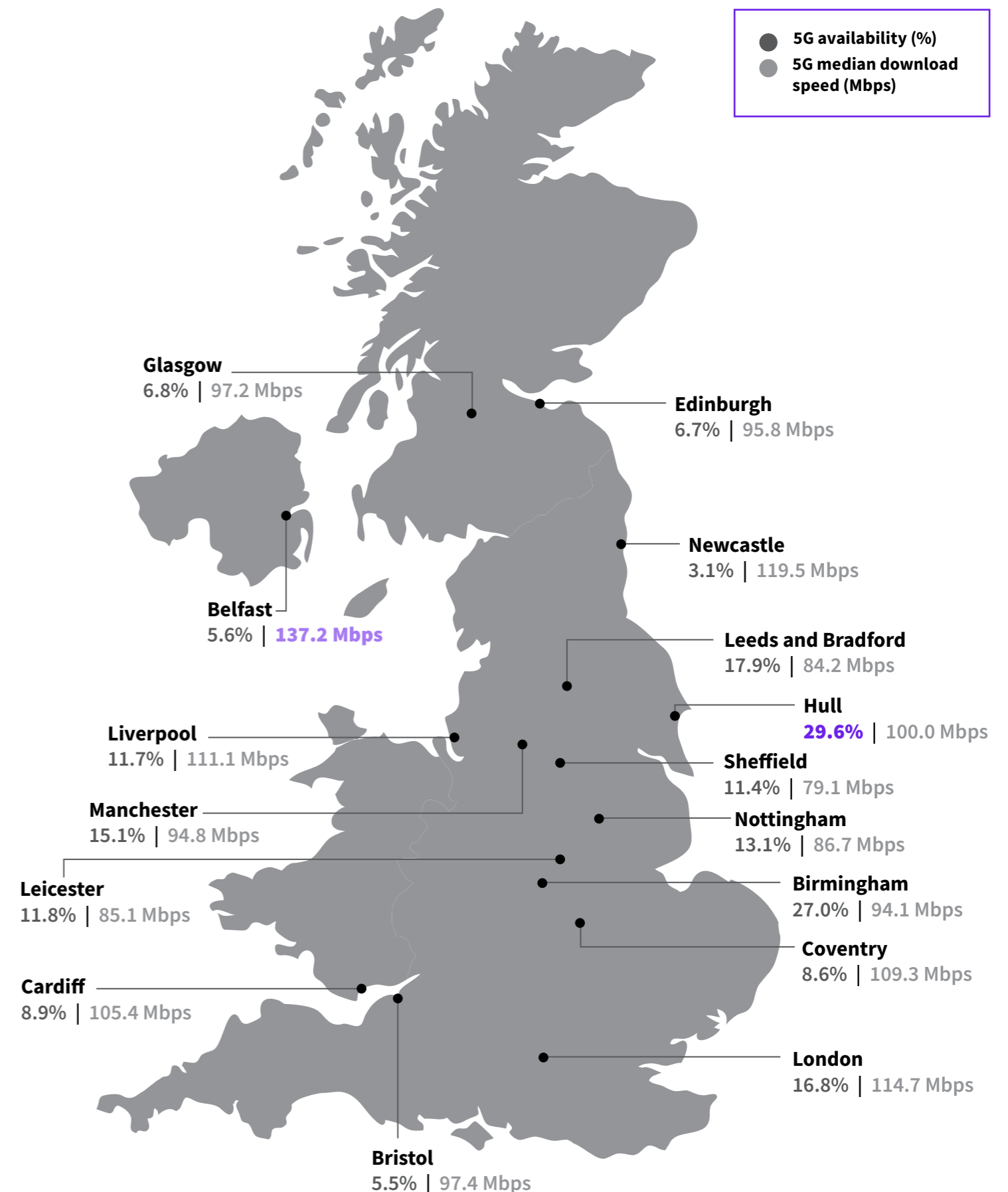
Median download speed intervals	0-10 Mbps	10-20 Mbps	20-30 Mbps	30-40 Mbps	40-50 Mbps	50+ Mbps
1H 2020	0	14	2	0	0	0
2H 2020	0	13	3	0	0	0

- Number of markets out of 16 in which Three delivered median download speeds at various intervals.

- Median download speeds on the table above represent speeds recorded on all network technologies, including 5G where available.

## Speed consistency on all network technologies

Three's speed consistency results were generally consistent with those from the first half of 2020, with the majority of its overall median download speeds falling in the 10-20 Mbps range, reaching a high of 27.8 Mbps in Birmingham. As with O2, looking holistically across the operator's performance shows that fast 5G but low availability means consumers are still more likely to experience slower speeds. The flipside, however, is that the operator's overall speeds should improve as its 5G availability expands.



Note:

- 5G availability is based on the percentage of tests recorded on 5G across all data tests (download, upload, and web and app tests).

- Highlighted figures represent the fastest 5G median download speed and highest 5G availability.



# Vodafone's 5G shines in London and was fast elsewhere, but availability has room to grow

## Vodafone's 5G, in short:

Vodafone was one of the first operators to launch 5G in the UK, and its 5G speeds were impressive across the board. Vodafone was particularly fast in London, where its 5G speed of 216.6 Mbps was the single fastest 5G median download speed of any network in any of the 16 cities we tested. On the other hand, while Vodafone offered the highest 5G availability in one city (44.0% in Liverpool), that was an exception to its otherwise limited availability. Vodafone's availability was above 25% in only one market (but came close in another at 24.9%), significantly trailing what we found for EE (12 cities with availability above 25%).

## Vodafone's median download speed intervals (all network technologies)

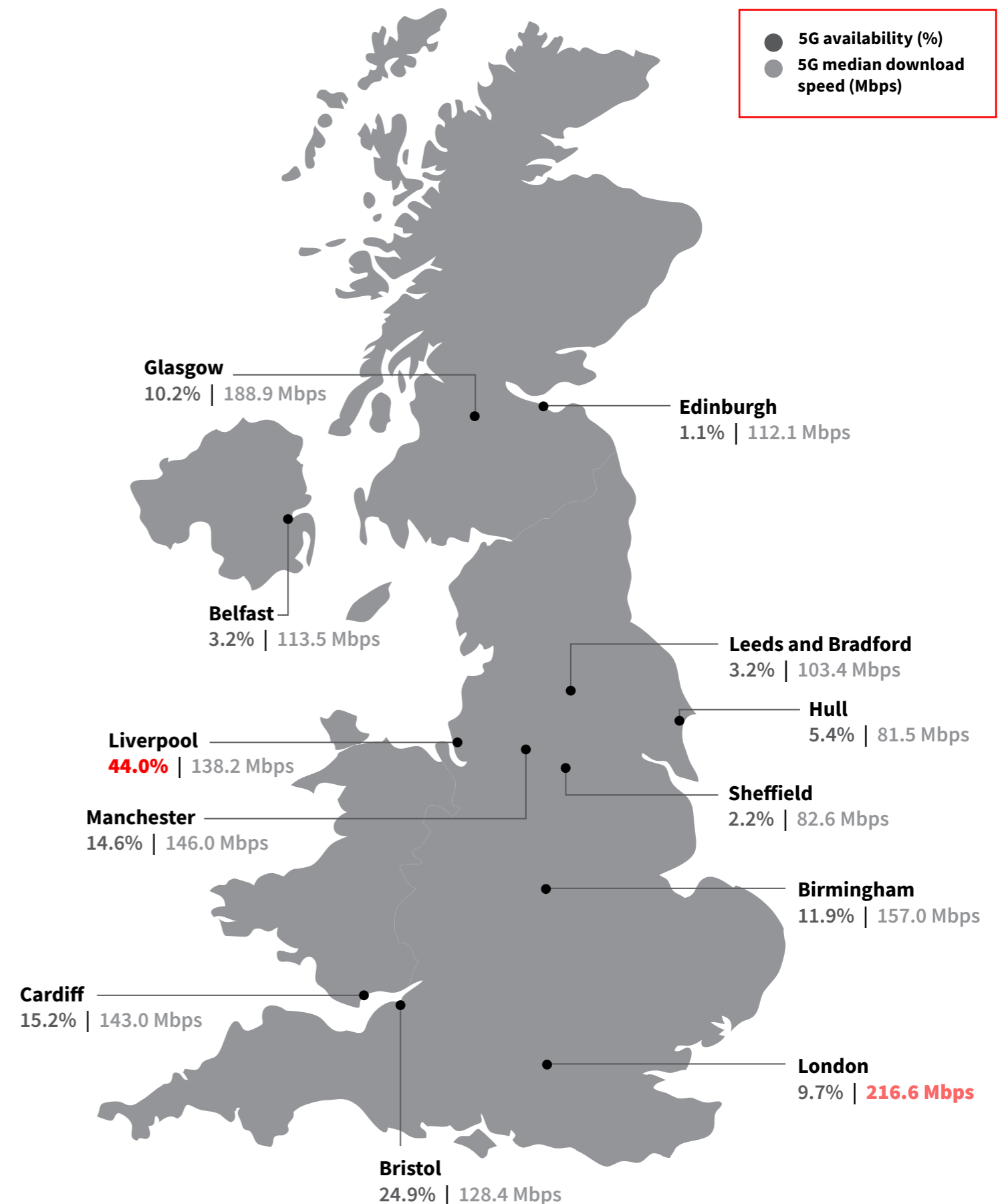
Median download speed intervals	0-10 Mbps	10-20 Mbps	20-30 Mbps	30-40 Mbps	40-50 Mbps	50+ Mbps
1H 2020	0	8	2	1	4	1
2H 2020	0	4	6	1	3	2

- Number of markets out of 16 in which Vodafone delivered median download speeds at various intervals.

- Median download speeds on the table above represent speeds recorded on all network technologies, including 5G where available.

## Speed consistency on all network technologies

Vodafone was one of two operators that delivered median download speeds faster than 50 Mbps in any city, and that number rose from one in 1H 2020 to two this time. Vodafone also showed improvement at the slower end, delivering overall speeds between 10-20 Mbps in four fewer markets than it did in our previous round of testing. While Vodafone's overall speed consistency results were a step above those of O2 and Three, they weren't quite as strong as those of EE, but Vodafone's overall speeds should become faster and more consistent as its 5G continues to grow.



Note:

- 5G availability is based on the percentage of tests recorded on 5G across all data tests (download, upload, and web and app tests).

- Highlighted figures represent the fastest 5G median download speed and highest 5G availability.



## 5G in greater London

# A look at 5G across the UK's capital city

● 5G ● 4G

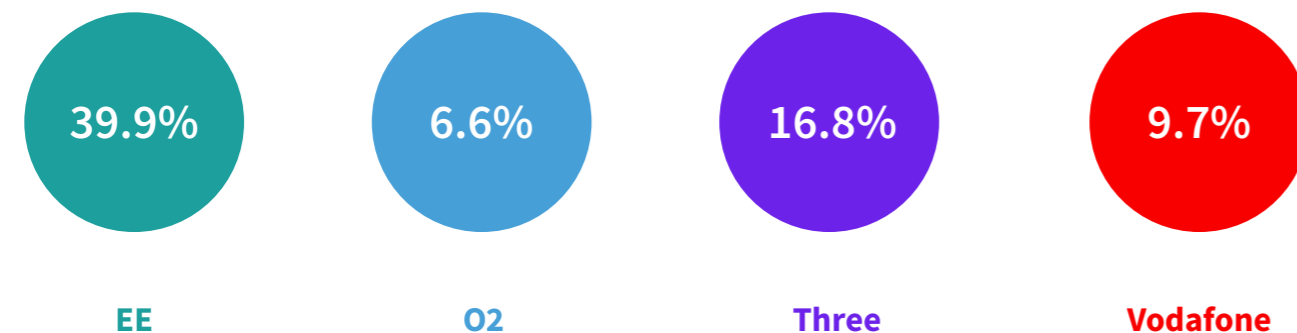
With 5G rollouts and optimisations typically occurring first and foremost in major cities—and even within specific sections of major cities—we're using London as a case study to help show how technology deployments can occur and ultimately perform. To that end, we're showing 5G results for the greater London area (as defined by the Eurostat's Larger Urban Zone) as well as in central London (as defined by the London Central Activities Zone or CAZ).

The generally strong 5G results we found in greater London demonstrate just how quickly and effectively rollouts can cover an entire metropolitan market, while our testing in central London shows how the operators perform across a concentrated and critical area of the city.

Take a look at the charts to see each operator's 5G availability in greater London, as well as each operator's median and maximum download speeds on both 5G and 4G LTE. Median download speeds represent typical, everyday speeds, while maximum speeds show the potential of an operator's 5G network.

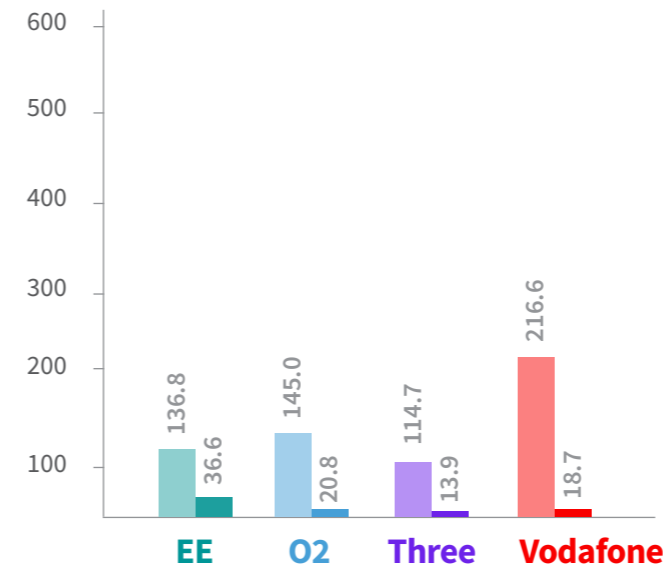
To put the speeds of 5G in perspective, we've compared 5G median and maximum download speeds to those purely on 4G LTE, rather than overall speeds recorded across all network technologies.

### Greater London 5G availability (%)

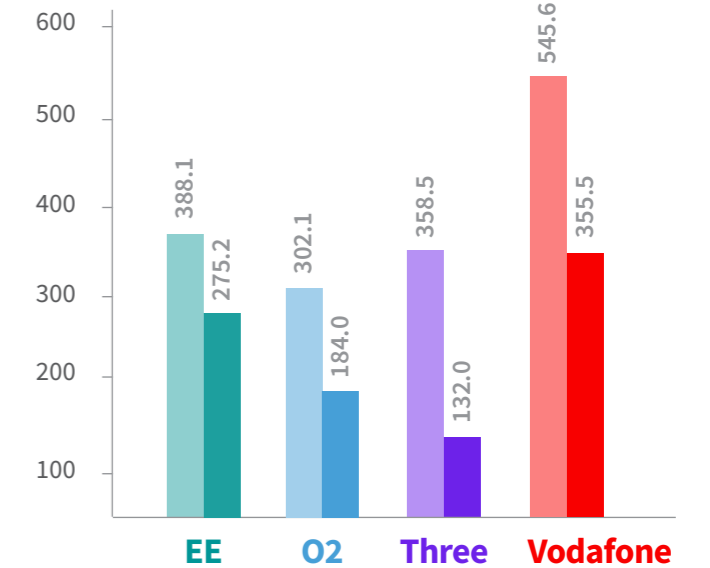


Note: 5G availability is based on the percentage of 5G recorded across all data tests (download, upload, and web and app tests).

### Greater London 5G & 4G LTE median download speeds (Mbps)



### Greater London 5G & 4G LTE maximum download speeds (Mbps)



### London 5G, in short:

#### EE stands out when comparing 5G availability in London:

EE pulled ahead of the other operators by registering generally broad 5G availability in greater London at 39.9%—up from 28.8% in 1H 2020. In fact, EE's 5G availability was well over twice as high as that of any other operator in the city.

#### 5G in greater London is fast:

Even though 5G availability was generally limited for most networks in London, 5G speeds in the city were outstanding, with each operator delivering a 5G median download speed of at least 114.7 Mbps, providing users on any network with incredibly fast access to content. Vodafone was the speed standout, delivering the fastest 5G median and maximum download speeds in the city.

#### 5G speeds were much faster than those on 4G LTE in greater London:

Vodafone's 5G median download speed of 216.6 Mbps in London was over 11 times faster than its speed on 4G LTE in the city. In fact, each operator's 5G median download speed in London was at least 3.7 times faster than that its speed on 4G LTE.

#### EE delivers the fastest overall median download speed in greater London:

When looking at speeds on all network technologies, including 5G and 4G LTE, EE's overall median download speed of 68.1 Mbps was the fastest across greater London and well over twice as fast as the next-fastest overall speed (Vodafone's 24.3 Mbps). Meanwhile, O2's overall median download speed of 22.8 Mbps was a bit behind that of Vodafone, while Three trailed with an overall speed of 17.9 Mbps.



## 5G in central London

# The London Central Activities Zone (CAZ)

While London is the UK's most populated city and one of the largest cities on the planet, central London is one of the world's most competitive business centres, and 5G is poised to become an important driver of economic growth in the area. Home to the seat of national government and world renowned for its culture, shopping, and heritage, central London is a major centre of activity for consumers, businesses, and government agencies alike, and the need for seamless connectivity in the area is of critical importance. Throughout this report, we refer to central London and the London CAZ interchangeably.

Performance in central London generally surpassed what we found across greater London and showed clear advantages for users, including higher 5G availability and generally faster speeds. Even better news for those in central London is that the 5G results we recorded in the area could be a harbinger of stronger 5G results to follow across the rest of London and other cities.



### Key figures for the London Central Activities Zone



3.5 million daily trips on public transit, cycling, and walking



£139 billion output in 2012 (10% of entire UK)



1.7 million jobs



125,000+ businesses



113,000 households



230,000 residents



4,000 listed buildings



400 London squares



11 opportunity areas



4 royal parks



2 intensification areas



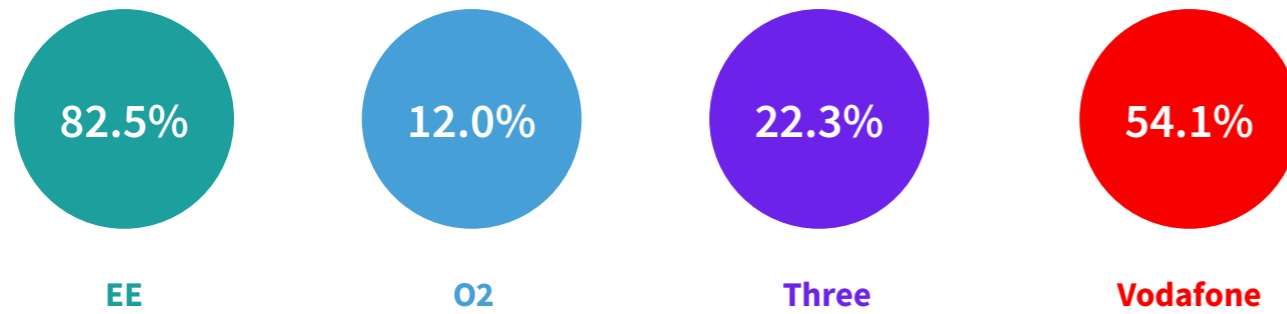
2 world heritage sites

#### Source

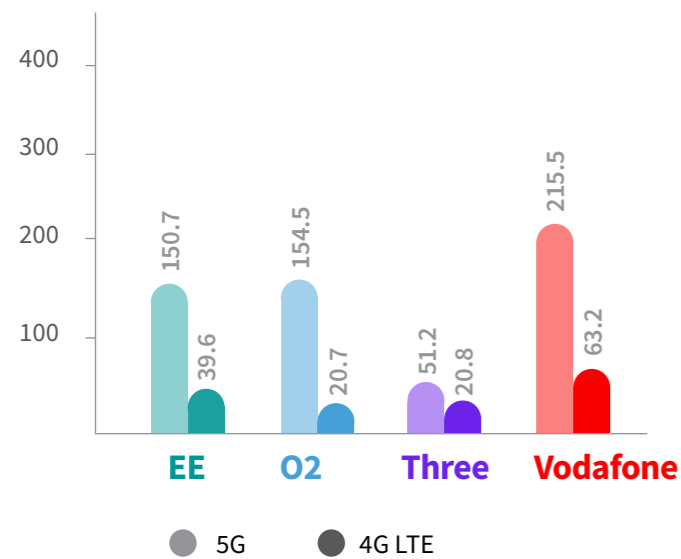
<https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/planning-guidance/central-activities-zone>  
[https://www.london.gov.uk/sites/default/files/caz\\_spg\\_final\\_v4.pdf](https://www.london.gov.uk/sites/default/files/caz_spg_final_v4.pdf)



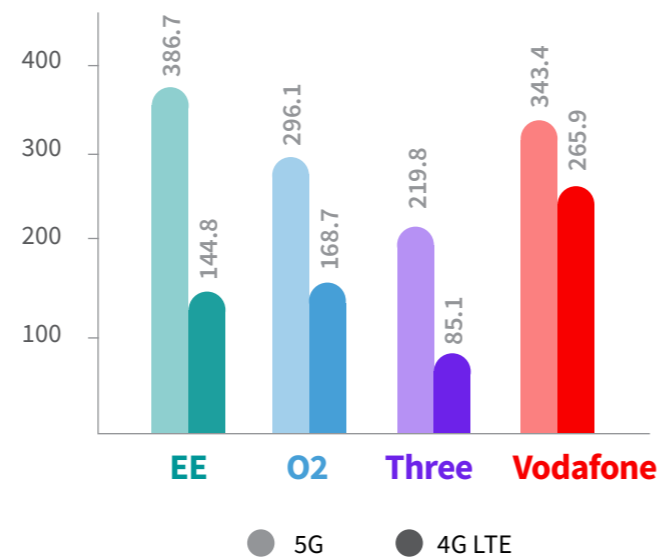
## 5G availability for each operator in central London



## 5G and 4G LTE median download speeds in central London (Mbps)



## 5G and 4G LTE maximum download speeds in central London (Mbps)



## Key takeaways from testing in central London

### EE's 5G was fast and nearly ubiquitous in central London:

Great news for EE users: EE's remarkable 5G availability of 82.5% in central London will allow EE users to access the operator's excellent 5G median download speed of 150.7 Mbps nearly all the time. In fact, EE's 5G availability in central London was over twice as high as its 5G availability in greater London (39.9%) and easily the highest among all operators in the heart of the city.

### O2's 5G delivers impressive speeds but the lowest availability:

In the first half of 2020, we didn't record any 5G results on O2's network in central London, but it was a different story this time, with O2 clocking the second-fastest 5G median download speed in the area at 154.5 Mbps. That said, connecting to O2's 5G network could prove challenging, with O2 recording 5G availability of 12.0%, easily the lowest in central London (though almost twice as high as its availability in greater London).

### Three's 5G availability was higher than that in greater London, but 5G speeds lag:

Three was the only operator whose 5G speeds in central London weren't as fast as those across greater London. In fact, Three's 5G median download speed of 51.2 Mbps in central London, while over twice as fast as its non-5G speed, significantly trailed those of the other operators and was much slower than its 5G speed of 114.7 Mbps in greater London. On the other hand, Three's 5G availability of 22.3% in central London was higher than its availability across the entire city (16.8%).

### Vodafone incredibly fast in central London:

Vodafone's 5G median download speed of 215.5 Mbps was easily the fastest in central London. While Vodafone's 5G availability of 54.1% trailed that of EE by a wide margin, it was still generally broad, much higher than that of either O2 or Three, and far greater than Vodafone's own availability in greater London (9.7%).





# Conclusion and looking ahead

As the 5G era in the UK continues to expand, some UK operators currently have greater 5G footprints and higher 5G availability than others, but we've already seen impressive 5G expansion since the first half of 2020, and all four operators' 5G networks are clearly fast. EE stood out during testing with its consistently broad 5G availability and excellent speeds, but the other operators each delivered strong results on 5G, with Vodafone providing particularly fast speeds in London.

The results we found in central London were particularly impressive and encouraging for the rest of the UK. If and when the comparatively broad 5G availability and generally fast speeds we found in central London expand to other cities across the country, we could witness a fundamental improvement to the end-user mobile experience along with further growth of our connected communities.

Indeed, as we move further into 2021 and beyond, the results we recorded in central London could act as an encouraging blueprint for continued 5G growth and improvement across the UK at large. In the meantime, the good news is that we're seeing impressive results on 5G in central London and other cities across the UK, and the future of 5G and connectivity in general is clearly bright.





# How we test

We believe that real-world results come from real-world testing. All RootMetrics testing is conducted from the consumer's point of view. For UK-wide, nation, and metro testing in 1H 2020, we used Samsung Note 10+ 5G smartphones purchased off the shelf from operator stores to test both 4G LTE and 5G performance, and tests were conducted during the day and night while walking and driving. We utilise random sampling techniques to ensure our results offer a robust characterisation of performance in the places consumers most often use their mobiles, and all testing is focused on the activities for which consumers typically use their mobiles, including data, call, and text usage. To learn more about our testing, visit the [methodology](#) page of our website.

## A note about our 5G results

With all four operators having launched 5G in the UK, we used 5G-enabled smartphones to test performance on both 5G and other network technologies, such as 4G LTE or sub-4G LTE technologies. Our 5G metrics were collected during our scientific Metro Area RootScore testing across the UK's 16 largest metropolitan cities, as defined by the Eurostat's Larger Urban Zone (LUZ). Our scientific metro area testing is designed to characterise network performance as a whole across an entire metropolitan market or within a subset of a market, such as central London.





For more information, visit