

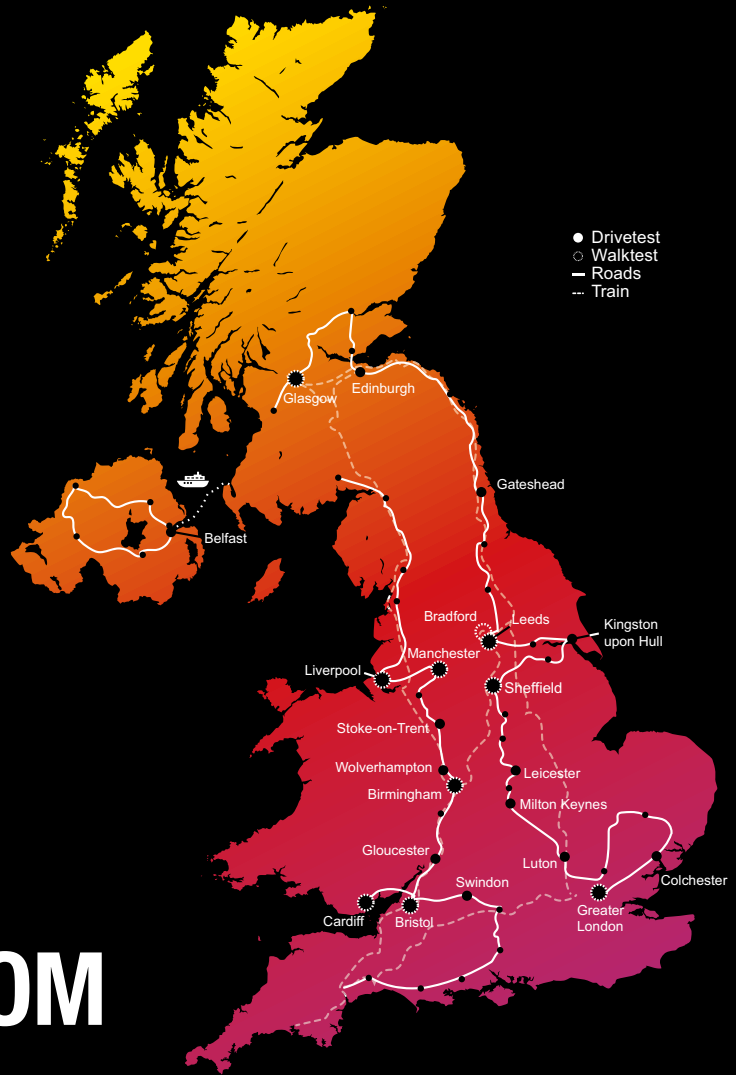
 umlaut

 connect

THE 2019 MOBILE NETWORK TEST IN THE UNITED KINGDOM

For the sixth time, the benchmarking expert umlaut and connect magazine have conducted their definitive benchmark of the UK's mobile networks. Once again, we have enhanced the underlying methodology.

While all operators in the UK worked strongly on expanding their 4G networks and establishing their first 5G installations, we wanted to find out: Which contender offers the best performance and the highest reliability of mobile voice and data services?



RESULTS IN A NUTSHELL

EE wins the umlaut connect Mobile Benchmark in the UK for the sixth time. Vodafone maintains the second place and shows clear score improvements over last year's results. O2 and Three swap places, with O2 ranking third and Three fourth.

The network benchmarks conducted by umlaut and connect are widely accepted as the de-facto industry standard and for being highly objective. The carefully designed methodology of our 2019 benchmark in the United Kingdom represents a holistic approach to network benchmarking. It combines drive tests and walk tests for executing detailed voice and data measurements under controlled circumstances combined with a sophisticated crowdsourcing methodology. This provides profound insights into the overall coverage of voice, data and 4G services, real-world User Download Speeds and Data Service Availability. The drive tests and walk tests allow for the maximum capabilities of the networks to be evaluated. Crowdsourcing unveils the service quality and performance actually experienced by real users. We have thoroughly weighed these components in order to give a realistic and conclusive assessment of the rated networks' true potential and performance.

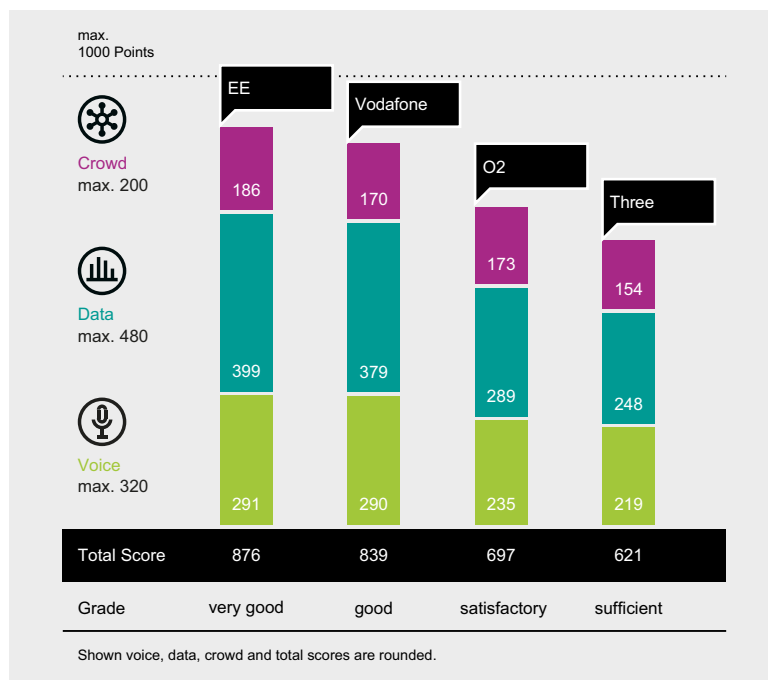
EE IS THE OVERALL WINNER, VODAFONE SHOWS DISTINCT SCORE IMPROVEMENTS

As in the five previous years, the overall winner is EE. (In 2016, Vodafone shared the first place with EE). The largest mobile operator in the UK defended its position and earned the grade very good. EE scores best in all three categories of our Benchmark: voice, data and crowdsourcing. As in the two previous years, Vodafone maintains the second place. In comparison to last year's results, the operator manages to improve considerably in the voice and crowd disciplines, and slightly in the data discipline. In our city comparison, Vodafone turns out to be a local champion in Bristol, Liverpool and Manchester, and scores on par with EE in Birmingham.

O2 overtakes Three this year and claws its way back to third place. The second largest UK operator outperforms Three in all evaluated categories and receives the grade satisfactory. In the crowd score, O2 is even a little stronger than the second-placed Vodafone.

With a noticeably lower score than O2, Three achieves the overall grade sufficient. Its performance levels fall behind last year's results. But in our crowdsourced evaluation, Three shows some improvements over the previous year.

EE is the winner for the sixth time. Vodafone ranks second with the highest score improvement since our 2018 Benchmark, O2 takes the third rank from Three this year.



Overall Results		EE	Vodafone	O2	Three
Voice	max. 320 P.	291	290	235	219
Cities (Drivetest)		144	96%	92%	75%
Cities (Walktest)		48	90%	98%	90%
Towns (Drivetest)		64	97%	95%	75%
Roads (Drivetest)		40	92%	92%	70%
Railways (Walktest)		24	43%	52%	33%
Data	max. 480 P.	399	379	289	248
Cities (Drivetest)		216	87%	84%	63%
Cities (Walktest)		72	80%	87%	50%
Towns (Drivetest)		96	83%	69%	63%
Roads (Drivetest)		60	93%	86%	78%
Railways (Walktest)		36	49%	47%	27%
Crowdsourced Quality	max. 200P.	186	170	173	154
Country		60	100%	97%	100%
Urban		84	89%	79%	78%
Non-urban (Benchmark view)		44	92%	82%	86%
Non-urban (Own network view)		12	88%	79%	80%
Connect Rating	max. 1000 P.	876	839	697	621

Percentages and points rounded to integer numbers. For the calculation of points and totals, the accurate, unrounded values were used.

THE UK OPERATORS

EE and O2 are the largest mobile network operators in the UK, followed by Vodafone, with the smaller Three attacking with aggressive tariffs. Each of the mobile networks is constantly increasing its 4G coverage, additionally all four contenders have started the deployment of their first 5G network cells.



With approximately 29 million customers, EE (formerly Everything Everywhere) is the biggest mobile network operator in the UK. Since 2016, EE has been part of the British Telecom Group. EE started offering a 4G service in 2012. Regarding 4G coverage, EE reports geographic coverage instead of population coverage. They quote to currently offer 91 percent 4G geographic coverage. EE operates its 4G network at 800 MHz, 1800 MHz and 2600 MHz. Additionally, it offers 2G at 1800 and 3G at 2100 MHz. EE offers two LTE high-speed services based on Carrier Aggregation: “Double speed 4G” uses 2 x 10 MHz in the 1800 MHz spectrum. For this variant, EE advertises download speeds of at least 60 Mbps. Additionally, EE operates a growing number of “4G+” network cells that support up to 5CA (five carrier frequencies) with up to 1 Gbps under the name “4GEE”. Voice over LTE (VoLTE) is available in most of its 4G network. Furthermore, EE has launched 5G in approximately 50 UK cities and towns and plans further rollouts during 2020.



O2 claims to be the second largest mobile network operator in the UK with approximately 26 million customers. Formerly a subsidiary of British Telecom, O2 plc was purchased by the Spanish telecommunications company Telefónica in 2006. Today, the company also owns half of the mobile virtual network operator Tesco Mobile which operates on the O2 network in the UK. O2 started providing its 4G service in 2013 and has expanded it across the UK since. In late 2019, O2 claimed to cover approximately 99 percent of the UK population with its 4G service. O2 operates its 4G network mainly on 800 MHz with limited additional 1800 and 2100 MHz coverage in metropolitan areas. Additionally, O2 provides 2G on 900 and 1800 MHz and 3G on 900 and 2100 MHz. Like the other UK operators, O2 has rolled out Voice over LTE (VoLTE) in most of its 4G network. In 2019, O2 has launched first 5G installations in parts of Belfast, Cardiff, Edinburgh, London, Slough and Leeds, and is planning to roll out 5G in areas of 50 towns by mid-2020.



Vodafone UK is part of the Vodafone Group which is also headquartered in the UK. The Vodafone Group owns and operates networks in 30 countries. Vodafone UK launched 4G/LTE in 2013. With around 18 million mobile subscribers, Vodafone is the third largest mobile network in the UK after EE and O2. In June 2012, Vodafone and O2 signed a deal to “pool” their network technologies, creating a single national grid of 18,500 transmitter sites. Both operators however announced they would continue to use their own independent spectrum. Vodafone operates 4G/LTE at 800, 1800, 2100 and 2600 MHz and claims to cover 99 percent of the UK population. Additionally, Vodafone offers 2G at 900 and 1800 MHz plus 3G at 900 and 2100 MHz. With “Carrier Aggregation”, Vodafone is upgrading its 4G network to “4G+”, offering up to 1 Gbps – as well as Voice over LTE (VoLTE) telephony. Also, the operator has launched its first 5G cells in about 22 locations during 2019 and has announced the speed up of its 5G deployment during 2020.



Three UK is a subsidiary of Hutchison Whampoa and launched its mobile service in the UK in 2003. As a relatively young operator Three started as a 3G-only network supplemented by 2G via national roaming. In December 2013, Three began to roll out its 4G/LTE service and expanded it rapidly all over the UK. With about 10 million customers Three is the smallest mobile network operator in the UK but claims to carry over 36 percent of the nation’s mobile data traffic. Offering the cheapest price for 4G and unlimited data plans (excluding tethering) may well support this claim. In addition to 1800 MHz, Three offers 4G also at 800 MHz as well as 3G on 2100 MHz. The company claims to cover 99 percent of the UK’s population with at least 3G. According to their own account, about 85 percent of Three’s customer base is using 4G. The operator has deployed Voice over LTE (VoLTE) in most of its 4G network. The operator has launched 5G network cells in London and announced it will spread its 5G coverage to approx. 25 additional cities and towns in 2020.

A CLOSE LOOK AT THE UK NETWORKS

The network benchmarks conducted by umlaut and connect are widely accepted as a completely objective authority. In 2019/2020, we present the umlaut connect Mobile Benchmark in the United Kingdom for the sixth time, further enhancing the methodology.



umlaut, headquartered in Aachen, Germany, is a world leader in mobile network testing. The company was formerly known as P3 communications and changed its name in autumn 2019 as part of restructuring and refocusing its activities. umlaut has over 4,300 employees, distributed in over 50 locations all around the world, with a turnover of more than 400 million Euros. umlaut is partnering with the international telecommunications magazine connect, which has more than 25 years of editorial expertise and is one of the leading test authorities in Europe for telecommunications products and services. Together, umlaut and connect have been conducting the most important network benchmark test in Germany for more than

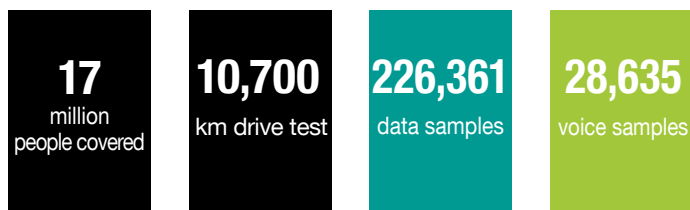
15 years, extending it to other European countries since 2009. As the de-facto industry standard, our benchmarking methodology focuses on customer-perceived network quality.

The 2019 umlaut connect Mobile Benchmark in the UK consists of drive tests and walk tests conducted in November 2019. Four drive test cars together covered about 10,700 kilometres, visiting 21 cities and 29 towns. Additionally, two walk test teams visited ten cities and travelled on trains between them. The test areas account for 17 million people, or approx. 27 percent of the total population of the UK. In addition, the results of extensive crowdsourcing analysis, considering 24 weeks from early June to mid-November 2019 are included in the score.

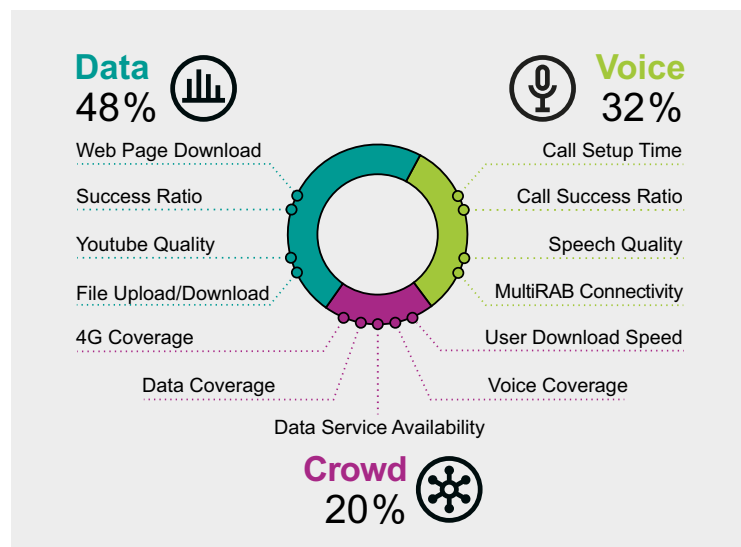
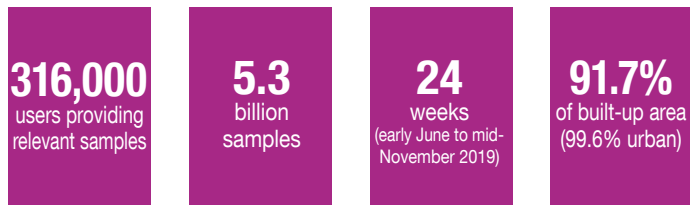
Congratulations to EE for being the winner of this year's benchmark. Vodafone followed with the highest score improvement, while O2 also deserves acknowledgment for a clear score improvement, compared to our previous Benchmark, and advancing to third place. Finally, Three provides good voice services, particularly in towns and on roads. With all UK operators starting to deploy 5G, we are looking forward to evaluate their 5G performance next year.

Hakan Ekmen, CEO umlaut

DRIVE TEST AND WALK TEST FACTS



CROWDSOURCING FACTS



VOICE

Although smartphones offer many means of communication, voice telephony is still important. When actually taking or placing a phone call, customers expect reliable connections. How do the mobile networks in the UK fulfil these expectations?

All four operators in the UK have been supporting Voice over LTE (VoLTE) in their networks since 2018. VoLTE transmits voice calls as data packets over a 4G connection. This way, the otherwise necessary “circuit-switched fallback”, which forces smartphones to switch back to 3G or 2G in order to take or place a phone call, can be avoided. Also, VoLTE speech codecs potentially support a wider audio bandwidth providing operators with the opportunity to deliver higher speech quality to their customers.

For the voice rating, each drive test car and each walk test team carried one Samsung Galaxy S9 smartphone per operator. The phones in the cars called a counterpart in one of the other cars. The phones carried by the walk test teams in the cities and travelling on trains called a stationary counterpart. The connected testing equipment registered the success ratios, call setup times and speech quality of the test calls. In order to simulate normal smartphone usage, additional data transfers took place in the background of the test calls. As a new KPI in our 2019 setup, we also evaluate the so-called Multirab (Multi Radio Access Bearer) Connectivity. This value denominates whether data connectivity is available during the phone calls. The voice scores account for 32 percent of the total result.

CITIES DRIVE TEST

EE

EE SHOWS THE STRONGEST VOICE RESULTS IN THE DRIVE TESTS IN CITIES, FOLLOWED BY VODAFONE

In the larger cities, EE achieves the highest success ratios and also the shortest call setup times. On average, EE, Vodafone and O2 show a very good speech quality in this and also all the other considered scenarios, while Three is falling somewhat behind the competition. EE and Vodafone also provide the best Multirab connectivity in all tested scenarios.

CITIES WALK TEST

VODAFONE

VODAFONE AHEAD IN CITY WALK TESTS, FOLLOWED BY EQUALLY STRONG EE AND O2

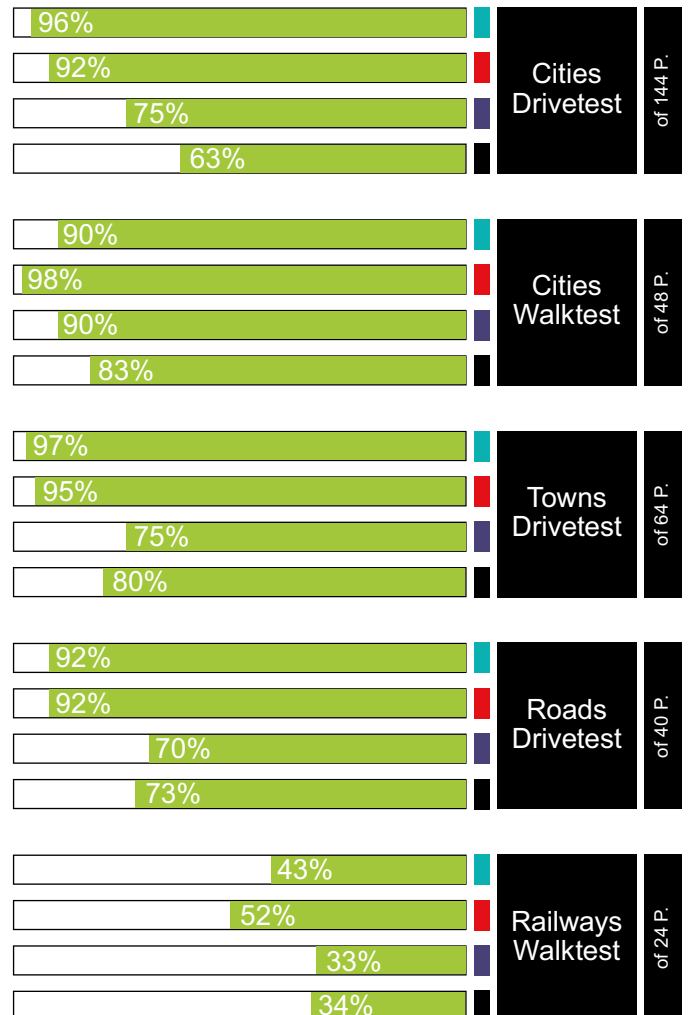
In the walk tests conducted in the UK’s larger cities, Vodafone takes the lead, providing the highest success ratios and a 100 percent of Multirab connectivity. EE and O2 follow at a distance and are on par in their overall performance, with EE showing faster call setup times and O2 achieving slightly higher call success ratios. Again, Three scores last in this discipline.

EE SHOWS THE BEST OVERALL VOICE RESULTS, VODAFONE IS ALMOST ON PAR WITH EE WITH LEADS IN CITY WALK TESTS AND TRAINS. O2 RANKS THIRD IN VOICE, AND THREE LAST.

Voice

320 of 1000 Points

- EE
- Vodafone
- O2
- Three



**TOWNS
DRIVE TEST**

EE

EE TAKES THE LEAD IN THE DRIVE TESTS CONDUCTED IN TOWNS, FOLLOWED CLOSELY BY VODAFONE

In the drive tests conducted in smaller towns, EE again takes the overall lead, but Vodafone follows at a narrow distance. Both contenders offer conveniently short call setup times and comparably high success ratios. The speech quality determined in the towns is slightly better in the EE network. In this category, Three achieves the third rank due to higher success ratios and a slightly better speech quality, while O2 scores last. Both O2 and Three show distinctly longer call setup times in the towns than EE and Vodafone.

**ROADS
DRIVE TEST**

EE AND
VODAFONE

EE AND VODAFONE ARE ALIKE IN DRIVE TESTS CONDUCTED ON THE UK ROADS. THREE SLIGHTLY AHEAD OF O2

While travelling on the connecting roads between the cities and towns, the drive test cars determined equally good voice results for EE and Vodafone. EE provides a slightly higher speech quality and shorter setup times in this discipline, while Vodafone shows slightly higher success ratios. As in the towns, Three scores a little higher than O2 also on the roads. Three achieved somewhat higher success ratios, while O2 provides a slightly higher speech quality. Again, the call setup times of Three and O2 are considerably longer than those of EE and Vodafone.

**RAILWAYS
WALK TEST**

VODAFONE

VODAFONE AHEAD IN UK TRAINS, EE RANKS SECOND. THREE AND O2 FOLLOW AT DISTINCT DISTANCE

For the second time in the UK, we have also examined the quality of voice calls conducted in trains. While the results have slightly improved since the previous year, they are still by far weaker than in the other categories. However, Vodafone takes a distinct lead when it comes to voice calls on the UK railways, offering still the highest success ratios. EE follows at a distance of almost ten percent of the intermediate result, while Three and O2 are behind with a gap of another ten percent.



VOICE RESULTS AT A GLANCE

EE achieves the highest score in the voice discipline, providing the shortest call setup times and excellent success ratios in the drive tests conducted in the cities and towns. Vodafone shows the best call reliability in the city walk tests, on the roads and on the railways. EE, Vodafone and O2 offer a very good average speech quality in all scenarios, EE and Vodafone also providing a good Multirab connectivity. Three is falling a little behind the competition.

Operator	EE	Vodafone	O2	Three
Cities (Drivetest)				
Success Ratio (%)	99.5	98.9	97.1	95.6
Call Setup Time (s)	1.7	2.2	3.8	3.6
Call Setup Time P90 (s)	2.2	2.8	5.4	6.1
Speech Quality (MOS-LQO)	4.5	4.4	4.3	3.6
Speech Quality P10 (MOS-LQO)	4.2	3.8	3.4	3.1
Multirab Connectivity (%)	99.9	99.7	99.2	98.2
Towns (Drivetest)				
Success Ratio (%)	99.7	99.5	98.8	99.2
Call Setup Time (s)	2.3	2.2	5.0	5.8
Call Setup Time P90 (s)	2.7	2.8	8.7	6.8
Speech Quality (MOS-LQO)	4.5	4.3	4.1	3.7
Speech Quality P10 (MOS-LQO)	4.2	3.6	3.3	3.1
Multirab Connectivity (%)	99.7	98.7	94.9	95.0
Roads (Drivetest)				
Success Ratio (%)	97.9	98.2	96.2	96.7
Call Setup Time (s)	2.3	2.4	4.9	5.7
Call Setup Time P90 (s)	2.6	3.1	8.7	7.1
Speech Quality (MOS-LQO)	4.4	4.3	4.1	3.6
Speech Quality P10 (MOS-LQO)	4.0	3.4	3.2	3.0
Multirab Connectivity (%)	99.9	99.1	96.1	93.6
Cities (Walktest)				
Success Ratio (%)	98.4	99.7	99.0	97.6
Call Setup Time (s)	1.6	1.9	3.5	2.8
Call Setup Time P90 (s)	2.0	2.3	4.3	3.5
Speech Quality (MOS-LQO)	4.7	4.6	4.4	3.8
Speech Quality P10 (MOS-LQO)	4.6	4.4	3.8	3.5
Multirab Connectivity (%)	99.9	100.0	98.9	98.7
Railways (Walktest)				
Success Ratio (%)	80.7	87.3	81.1	82.0
Call Setup Time (s)	2.3	2.5	4.1	4.1
Call Setup Time P90 (s)	3.0	3.9	6.5	5.9
Speech Quality (MOS-LQO)	4.3	4.1	4.0	3.6
Speech Quality P10 (MOS-LQO)	3.1	2.9	2.9	3.1
Multirab Connectivity (%)	98.6	96.5	95.7	95.2



DATA

With the volume of transmitted data permanently growing, data connectivity constantly becomes more important. Which operator in the UK manages best to meet the increasing demand?

Mobile Operators are constantly striving to provide their customers with the best LTE coverage as well as to deliver the highest data rates. All four UK networks claim to cover a large part of the population with their 4G/LTE services – the claimed percentages range in the high nineties. And all four contenders are continuing to spend billions on upgrading and expanding their networks to meet the increasing demand – including the rollout of their first 5G network cells. However, as the total amount of spectrum necessary for commercial 5G deployments was not yet available to the operators at the time of testing, we have decided to not yet consider this mobile network technology in this year’s umlaut connect Mobile Benchmark in the UK.

In order to assess the performance and reliability of data connections, each of our four drive test cars and also the walk test team carried one Samsung Galaxy S9 per operator. Supporting the LTE category 18, these smartphones are able to benefit from the combined use of currently up to five LTE carrier frequencies, “5CA”, as provided in the EE network (also see page 3). Vodafone and O2 widely use “3CA” in urban areas – the combination of three carriers. So practically, the Galaxy S9 can benefit from the “4G+” offerings provided by these operators, which currently support up to 1 Gbps download data rates.

umlaut’s testing rewards fast throughputs as well as the networks’ availability and stability. In order to assess typical performance as well as peak speeds, we consider two values: the minimum data rate that is available in 90 percent of the cases, and additionally the peak data rate that is surpassed in 10 percent of the cases. Web page and file downloads or file uploads reward fast speeds, while the determination of success ratios and assessing YouTube payouts concentrate on reliability aspects.

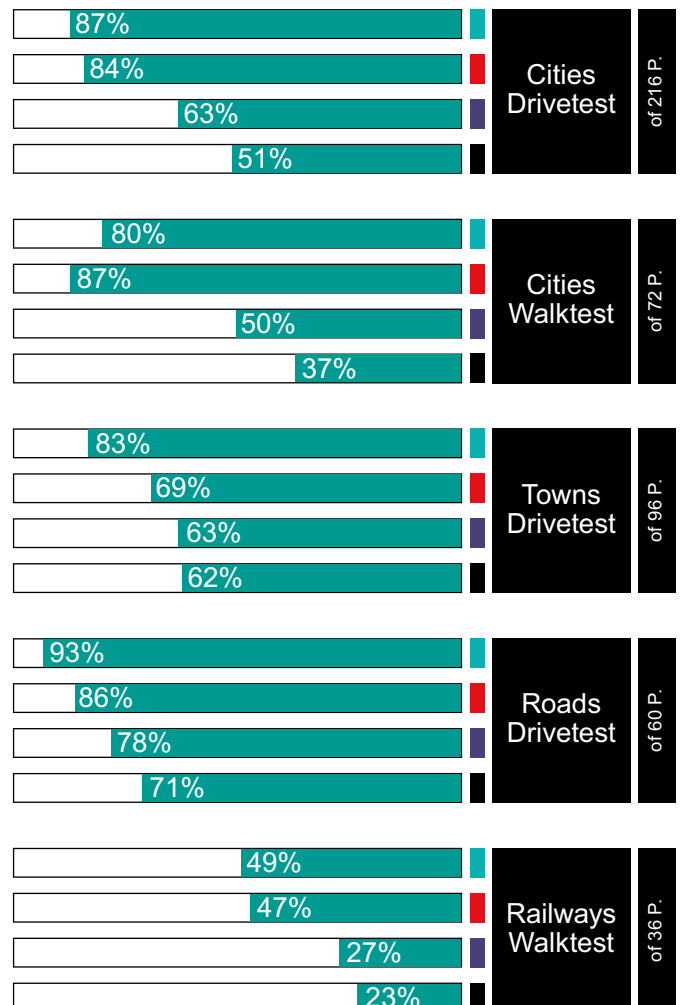


EE IS THE CLEAR WINNER IN THE DATA DISCIPLINE, VODAFONE RANKS SECOND. O2 FOLLOWS AT SOME DISTANCE, WHILE THREE RANKS LAST.

Data

480 of 1000 Points

- EE
- Vodafone
- O2
- Three



CITIES DRIVE TEST

EE

EE LEADS IN DATA DRIVE TESTS, VODAFONE FOLLOWS CLOSELY

In the drive tests conducted in 21 larger cities, EE leads by a narrow margin, followed by Vodafone. O2 achieves a solid third position, while Three ranks last. This ranking can be seen in most of the data KPIs such as the success ratios and session times of web page accesses, the success ratios and transfer speeds of file downloads and the success ratios and video resolutions of YouTube playbacks. In terms of data rates, EE and Vodafone provide considerably faster speeds compared to O2 and Three in all aggregations.

CITIES WALK TEST

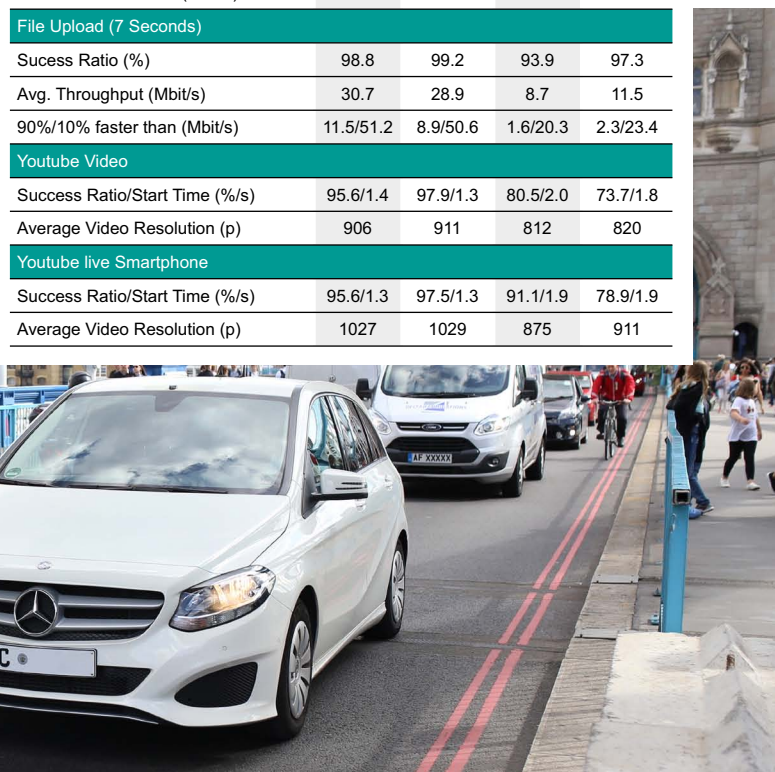
VODAFONE

VODAFONE AHEAD OF EE IN BIG CITY DATA WALK TESTS

In the overall results of the walk tests conducted in Birmingham, Bradford, Bristol, Cardiff, Glasgow, Leeds, Liverpool, Greater London, Manchester and Sheffield, Vodafone scores ahead of EE with a distinct lead, but both on a high level. O2 ranks third and Three ranks fourth, with both contenders performing weaker than in the drive tests. O2 and Three show a clear need for improvement in the YouTube tests – which applies to all tested scenarios, but is particularly pronounced in the big city walk tests.

Data Cities (Drivetest)	EE	Vodafone	O2	Three
Web-Page Download				
Success Ratio (%)	99.5	99.4	98.1	94.1
Overall Session Time (s)	1.2	1.3	1.6	1.7
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.7/2.6	99.8/3.8	99.0/6.7	96.8/10.9
90%/10% faster than (Mbit/s)	8.4/72.8	4.6/72.5	2.4/39.8	1.2/47.5
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.9/1.8	99.9/2.3	98.5/4.6	98.6/3.2
90%/10% faster than (Mbit/s)	6.2/37.7	4.5/33.3	1.9/19.4	3.6/19.1
File Download (7 Seconds)				
Success Ratio (%)	99.5	99.4	98.6	93.9
Avg. Throughput (Mbit/s)	64.1	58.6	26.1	19.6
90%/10% faster than (Mbit/s)	9.5/145.5	8.2/131.2	2.8/62.5	1.5/50.0
File Upload (7 Seconds)				
Success Ratio (%)	99.6	98.9	96.7	96.4
Avg. Throughput (Mbit/s)	27.7	23.9	9.7	14.6
90%/10% faster than (Mbit/s)	6.4/52.6	5.3/47.2	1.9/21.5	3.5/29.0
Youtube Video				
Success Ratio/Start Time (%/s)	97.5/1.3	97.2/1.3	90.7/1.7	79.9/1.7
Average Video Resolution (p)	903	903	850	846
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	97.3/1.3	96.5/1.4	91.1/1.7	80.5/1.8
Average Video Resolution (p)	1024	1012	956	954

Data Cities (Walktest)	EE	Vodafone	O2	Three
Web-Page Download				
Success Ratio (%)	98.4	99.4	95.5	90.2
Overall Session Time (s)	1.2	1.2	1.9	1.9
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	98.5/3.0	99.7/3.3	97.9/11.1	89.8/13.2
90%/10% faster than (Mbit/s)	9.2/63.9	7.2/68.3	1.4/31.9	1.1/32.8
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.2/1.6	99.8/2.0	97.0/5.7	97.5/3.9
90%/10% faster than (Mbit/s)	9.7/36.9	5.8/35.5	1.4/18.4	2.9/15.8
File Download (7 Seconds)				
Success Ratio (%)	98.1	99.3	96.9	88.8
Avg. Throughput (Mbit/s)	49.0	62.3	15.8	13.1
90%/10% faster than (Mbit/s)	8.6/112.3	12.3/134.2	1.5/43.1	1.0/33.6
File Upload (7 Seconds)				
Success Ratio (%)	98.8	99.2	93.9	97.3
Avg. Throughput (Mbit/s)	30.7	28.9	8.7	11.5
90%/10% faster than (Mbit/s)	11.5/51.2	8.9/50.6	1.6/20.3	2.3/23.4
Youtube Video				
Success Ratio/Start Time (%/s)	95.6/1.4	97.9/1.3	80.5/2.0	73.7/1.8
Average Video Resolution (p)	906	911	812	820
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	95.6/1.3	97.5/1.3	91.1/1.9	78.9/1.9
Average Video Resolution (p)	1027	1029	875	911



TOWNS DRIVE TEST
EE

EE AHEAD IN DATA DRIVE TESTS IN SMALLER TOWNS

In the data drive tests that our measurement cars performed in 29 smaller towns, EE takes a clear lead with the highest success ratios and overall good results. The second-ranking Vodafone follows at a considerable distance, while O2 and Three rank closely together and are not too far from Vodafone's performance level.

ROADS DRIVE TEST
EE

EE LEADS ON CONNECTING ROADS, HIGHER OVERALL PERFORMANCE LEVEL ON ROADS THAN IN TOWNS

On the 6,080 km of connecting roads covered by our test cars, we see the already well-established ranking order: EE scores best, Vodafone follows, succeeded by O2 and Three – each at some distance. Interestingly, the performance level on the roads is overall higher than in the towns.

RAILWAYS WALK TEST
EE AND VODAFONE

EE AND VODAFONE AHEAD IN TRAINS – ON AN OVERALL LOW PERFORMANCE LEVEL

The tests performed in UK's trains reveal a two-tier system: EE and Vodafone perform a little better, O2 and Three considerably weaker. However, the performance level and reliability of data connections on UK's railways generally leave much to be desired.

Data Railways (Walktest)	EE	Vodafone	O2	Three
Web-Page Download				
Success Ratio (%)	90.9	90.7	82.9	80.7
Overall Session Time (s)	2.0	2.0	2.3	2.8
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	94.6/8.0	92.2/9.0	85.1/13.7	84.2/13.5
90%/10% faster than (Mbit/s)	2.4/48.2	1.8/36.1	1.1/24.0	1.3/28.9
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	91.7/5.9	92.6/6.4	88.8/8.8	78.5/10.2
90%/10% faster than (Mbit/s)	1.2/25.0	1.5/16.4	0.9/13.5	0.9/12.2
File Download (7 Seconds)				
Success Ratio (%)	92.2	92.4	83.3	85.5
Avg. Throughput (Mbit/s)	23.8	20.3	11.7	12.9
90%/10% faster than (Mbit/s)	2.0/63.0	1.6/45.1	1.4/27.3	1.3/35.1
File Upload (7 Seconds)				
Success Ratio (%)	81.4	84.9	78.2	74.0
Avg. Throughput (Mbit/s)	14.6	8.7	7.3	5.0
90%/10% faster than (Mbit/s)	1.4/32.1	1.4/18.7	1.0/16.3	0.8/12.0
Youtube Video				
Success Ratio/Start Time (%/s)	78.2/2.1	79.7/2.1	65.7/2.7	62.8/3.1
Average Video Resolution (p)	829	837	779	726
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	79.1/2.2	73.1/1.8	57.0/2.7	67.8/2.9
Average Video Resolution (p)	905	932	817	824

Data Towns (Drivetest)	EE	Vodafone	O2	Three
Web-Page Download				
Success Ratio (%)	99.4	97.9	97.4	97.7
Overall Session Time (s)	1.3	1.6	1.8	1.7
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	100.0/3.7	98.9/6.8	98.1/8.2	98.8/7.4
90%/10% faster than (Mbit/s)	6.3/60.7	2.7/57.6	2.1/31.1	2.0/53.0
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	98.9/2.5	99.2/2.8	99.6/4.0	98.8/4.2
90%/10% faster than (Mbit/s)	4.6/33.5	4.1/24.4	2.6/19.0	2.3/18.6
File Download (7 Seconds)				
Success Ratio (%)	99.6	98.2	98.1	98.0
Avg. Throughput (Mbit/s)	38.8	30.7	16.7	25.7
90%/10% faster than (Mbit/s)	5.8/82.7	2.8/79.2	1.9/40.2	3.1/56.7
File Upload (7 Seconds)				
Success Ratio (%)	98.1	99.4	98.9	96.1
Avg. Throughput (Mbit/s)	21.9	15.1	10.6	13.8
90%/10% faster than (Mbit/s)	4.0/46.0	3.9/30.7	2.8/21.1	2.1/31.5
Youtube Video				
Success Ratio/Start Time (%/s)	97.4/1.4	91.3/1.7	85.5/1.8	90.8/1.7
Average Video Resolution (p)	901	872	842	875
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	97.7/1.4	93.6/1.7	89.8/1.8	89.7/1.8
Average Video Resolution (p)	1009	970	944	982

Data Roads (Drivetest)	EE	Vodafone	O2	Three
Web-Page Download				
Success Ratio (%)	99.6	99.1	98.4	96.2
Overall Session Time (s)	1.2	1.4	1.6	1.6
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.9/2.7	99.4/4.8	99.3/6.6	97.5/6.2
90%/10% faster than (Mbit/s)	8.8/64.1	3.8/51.8	2.7/33.6	2.7/54.4
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.4/2.2	99.5/3.1	99.2/3.4	97.6/4.6
90%/10% faster than (Mbit/s)	4.7/35.1	3.6/23.0	2.8/20.9	2.0/19.4
File Download (7 Seconds)				
Success Ratio (%)	99.4	99.4	99.2	96.7
Avg. Throughput (Mbit/s)	46.1	30.3	18.8	27.2
90%/10% faster than (Mbit/s)	10.1/94.5	4.5/72.8	2.6/42.5	3.3/64.0
File Upload (7 Seconds)				
Success Ratio (%)	99.4	98.6	98.6	94.5
Avg. Throughput (Mbit/s)	25.1	16.0	12.5	13.3
90%/10% faster than (Mbit/s)	5.3/48.6	4.1/28.2	3.0/23.7	1.7/31.1
Youtube Video				
Success Ratio/Start Time (%/s)	97.6/1.3	95.5/1.5	90.8/1.7	90.1/1.8
Average Video Resolution (p)	905	888	846	864
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	97.8/1.3	95.6/1.6	93.5/1.7	88.9/1.7
Average Video Resolution (p)	1027	994	945	990

DATA RESULTS AT A GLANCE
As in the voice discipline, EE leads in the data discipline too. Vodafone ranks second in this category and shows convincing results especially in the data walk tests conducted in larger cities. Interestingly, the performance level on roads is generally higher than in the smaller towns visited by our drive test cars. All operators show room for improvement on railways.

CROWD

316,000 users from the UK have contributed around 5.3 billion measurement samples between early April and mid-November, 2019. We have conducted a thorough analysis of this extensive data set, using an even more refined crowdsourcing methodology compared to previous years.

EE TAKES THE LEAD IN THE CROWD EVALUATION, AHEAD OF O2. VODAFONE COMES IN THIRD, AND THREE RANKS FOURTH.

While the drive tests and walk tests determine the peak performance of the examined networks, crowdsourcing can add important dimensions such as time, geography or variety in devices and tariff plans – if done in the right way. A detailed description of our crowdsourcing methodology can be found on page 15. A total of 316,000 mobile phone users in the UK have provided relevant samples to our crowd data. The test area of our crowdsourcing represents 91.7 percent of the built-up area of the UK and even 99.6 percent of the urban built-up area.

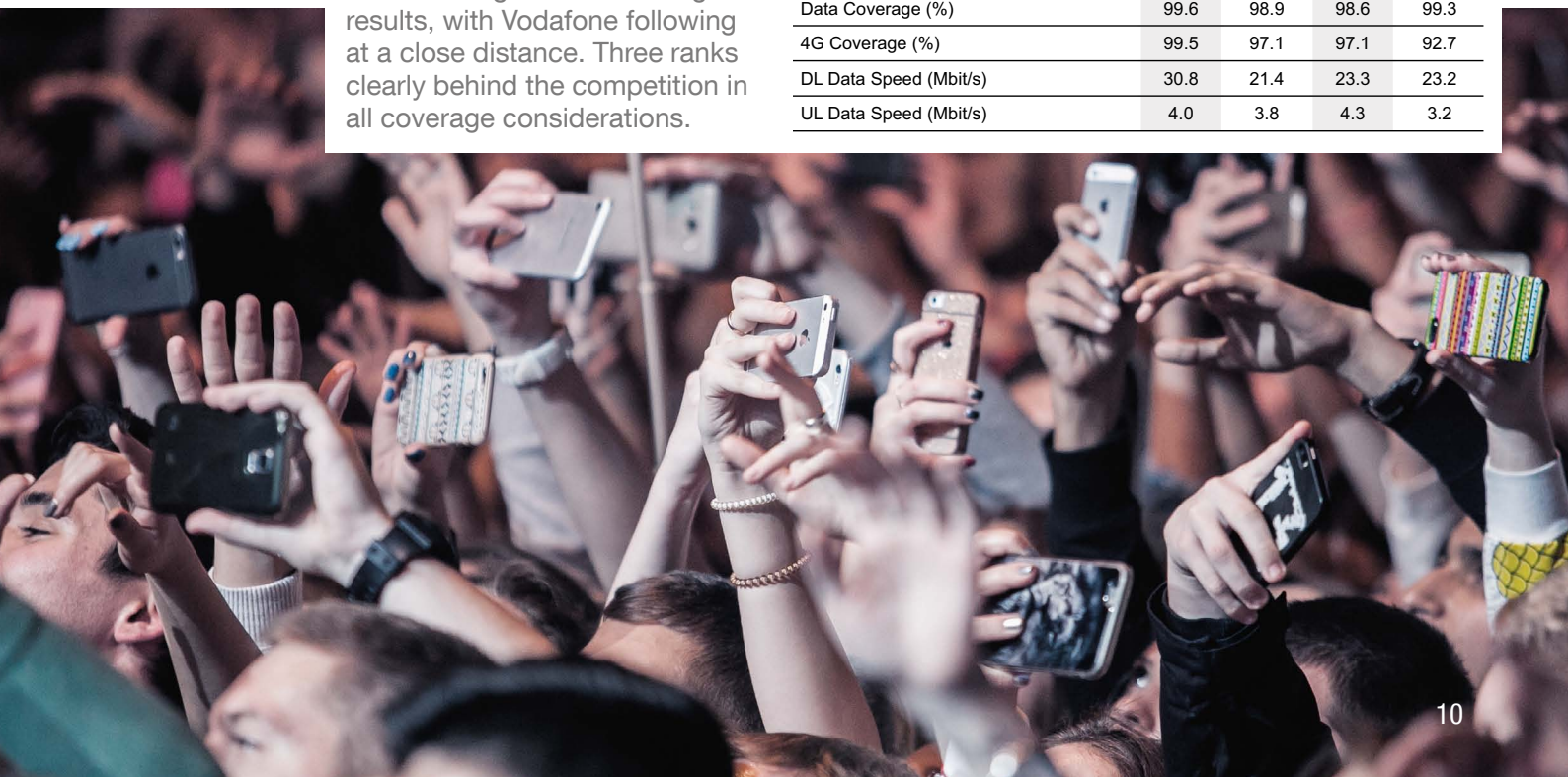
COVERAGE

EE

GOOD VOICE AND DATA COVERAGE FOR ALL UK OPERATORS, EE ALSO ACHIEVES GOOD SCORE FOR 4G

All four UK operators achieve a good score level for voice and data coverage. With our 2019 benchmark setup, we have started differentiating the coverage in urban and non-urban areas. In the urban consideration, EE provides the best 4G coverage, with Vodafone and O2 following at roughly the same level. In the non-urban areas, EE and O2 achieve good 4G coverage results, with Vodafone following at a close distance. Three ranks clearly behind the competition in all coverage considerations.

Crowd	EE	Vodafone	O2	Three
Crowd Country — Operational Excellence				
Number of degraded days (d)	0	1	0	3
Number of degraded periods (-)	0	2	0	14
Crowd Urban				
Voice Coverage (%)	99.6	99.8	99.5	99.4
Data Coverage (%)	98.9	99.6	99.2	98.6
4G Coverage (%)	97.4	94.4	94.2	87.8
DL Data Speed (Mbit/s)	78.4	54.2	53.5	54.1
UL Data Speed (Mbit/s)	20.9	13.4	15.2	17.8
Crowd Non-Urban (Benchmark view)				
Voice Coverage (%)	99.9	99.7	99.7	99.5
Data Coverage (%)	99.9	99.3	99.3	99.5
4G Coverage (%)	99.8	98.2	98.7	93.4
DL Data Speed (Mbit/s)	34.5	22.9	25.8	24.7
UL Data Speed (Mbit/s)	5.1	4.2	5.4	3.5
Crowd Non-Urban (Own network view)				
Voice Coverage (%)	99.7	99.5	99.4	99.3
Data Coverage (%)	99.6	98.9	98.6	99.3
4G Coverage (%)	99.5	97.1	97.1	92.7
DL Data Speed (Mbit/s)	30.8	21.4	23.3	23.2
UL Data Speed (Mbit/s)	4.0	3.8	4.3	3.2



DATA SPEEDS

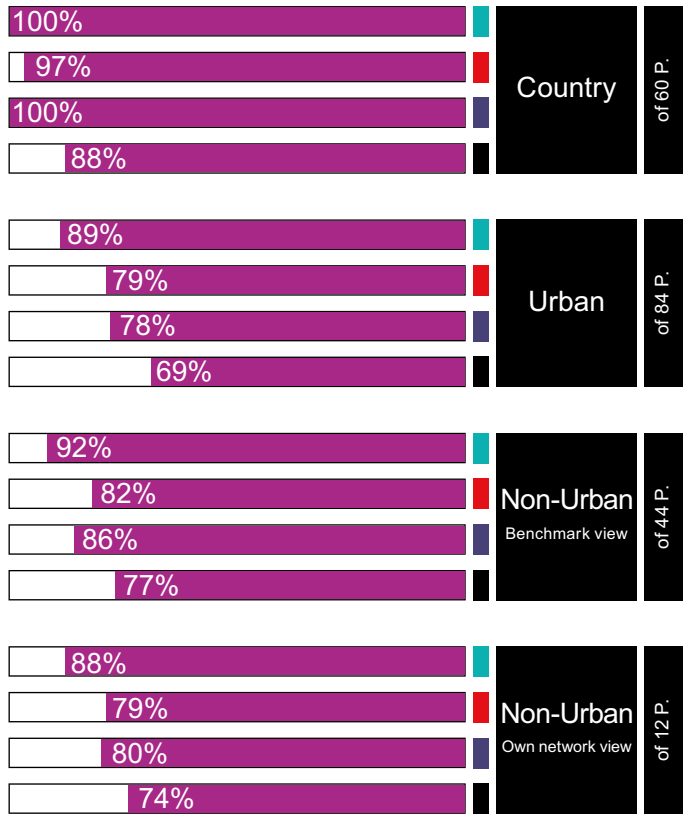
EE

EE DELIVERS BEST OVERALL USER DOWNLOAD AND UPLOAD SPEEDS

Our refined crowdsourcing methodology not only analyses User Download Speeds but now additionally Upload Speeds.

In the overall assessment, EE shows the best speeds both for downloads and uploads. In urban areas, Vodafone ranks second in the download speed metrics, closely followed by Three and O2. In the examination of upload speeds in urban areas, Three scores second best, followed by O2 and then Vodafone.

In non-urban areas, O2 takes the lead in the upload speeds, with EE following on the second rank. In contrast, EE delivers the best download, followed by O2, Three and Vodafone in this ranking order.



OPERATIONAL EXCELLENCE

EE AND O2

NO DEGRADATIONS IN THE NETWORKS OF EE AND O2, ONLY MINOR ANOMALIES AT VODAFONE AND THREE FROM EARLY JUNE TO MID-NOVEMBER 2019

In the networks of EE and O2, we could not identify any anomalies during the 24 weeks under consideration (from early June to mid-November 2019). In the Vodafone network, we observed one day with degradations and in the Three network a total of three days. Considering the long observation period of almost half a year, these are still very decent results, representing a high degree of reliability in the UK's mobile networks.



CROWD RESULTS AT A GLANCE

In the crowd-based score, EE takes the lead, ahead of O2. Vodafone comes in third, only slightly behind O2. Three ranks fourth with a distinct gap towards Vodafone. All four UK operators achieve a good score for voice and data coverage, with EE also scoring well for 4G coverage. Three falls significantly behind the competition when it comes to 4G coverage, but also Vodafone and O2 show room for improvement there. In urban areas, Vodafone ranks second behind EE in download speeds, and Three second best in upload speeds. In non-urban areas, O2 takes the lead in the upload category. EE and O2 showed no anomalies in the observation period. For Vodafone, we identified one day with anomalies, and for Three three days with anomalies.



LONDON

Traditionally, umlaut and connect take a closer look at the UK's capital to see how the operators cover this lively centre of business, politics and culture.

Greater London is by far the most densely populated area in the UK and also a vibrant business capital. This also makes the nation's capital an especially demanding terrain for deploying and maintaining a mobile network. For this reason, we regularly take a closer look to see how the performance in the capital compares to the rest of the United Kingdom.

So, as in the years before, we have filtered the results of the drive tests and walk tests as well as the crowd results obtained in the London area from the nationwide values. As the city scores neither contain the results of the drive tests conducted in the smaller towns or on the connecting roads nor the walk test results from the trains, we have adapted the maximum achievable points accordingly.

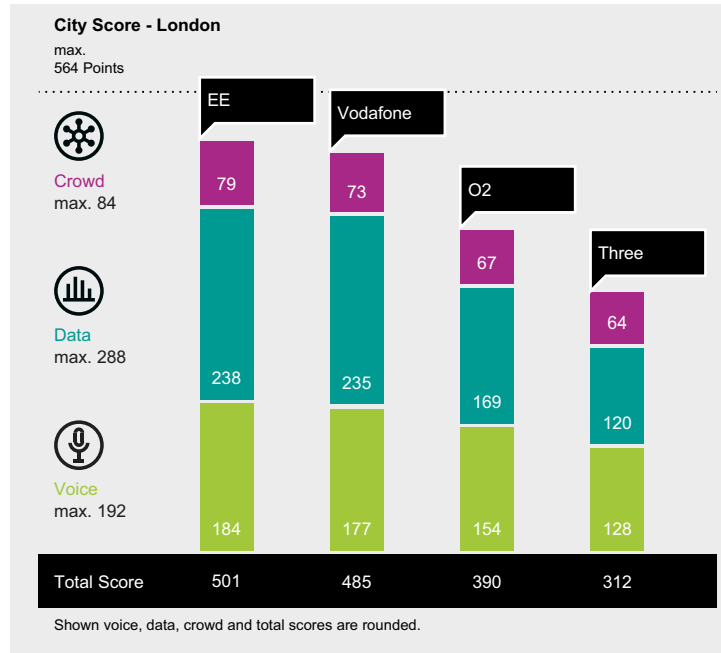
EE LEADS IN LONDON TOO, VODAFONE RANKS SECOND AND PERFORMS SLIGHTLY BETTER IN THE CAPITAL THAN NATIONWIDE

The overall ranking in the London area is the same as in the nationwide assessment. EE leads the field in the capital, showing stronger voice results compared to the evaluation for the whole United Kingdom. In the walk tests conducted in London, the largest UK operator even achieves a 100 percent of the possible points for its voice results. However, in the data walk tests, EE scores a little weaker in the London area than in the nationwide average – which might be explained with the higher demand put on the network by the particularly dense distribution of customers.

Vodafone ranks second and performs all in all on the same level as nationwide. But as already observed for EE, also Vodafone's data walk test results fall a little behind the score achieved in the nationwide assessment.

O2 SHOWS ABOUT THE SAME PERFORMANCE IN THE CAPITAL AS NATIONWIDE, THREE FALLS BEHIND IN LONDON DATA RESULTS

The third-placed O2 achieves slightly better voice results than in the average determined for the whole UK. In particular, its voice walk test results are a little better, its voice drive test results a little weaker than all over the nation. O2's data results are all in all on the same level as nationwide. Three's voice score is on a comparable level than all over the UK. However, the score obtained for the data measurements is surprisingly low in London, compared to the rest of the country. This may once again indicate the heavy stress that millions of Londoners and their visitors put on the mobile networks.



LONDON RESULTS AT A GLANCE

As in the nationwide assessment, EE is also the winner in London. Compared to the results for the whole UK, EE scores a little better in the voice discipline, but falls somewhat behind in the data walk tests. Vodafone performs overall on the same level as nationwide, but also loses some score points in the data walk tests. The third-placed O2 achieves a slightly better voice score than in the whole UK, its data results are all in all on the same level as nationwide. Three's voice results are comparable to the result for the whole country, but its data score for London is distinctly lower than in the rest of the UK.

Overall Results London	EE	Vodafone	O2	Three	
Voice max. 192 P.	184	177	154	128	
Cities (Drivetest)	144	95%	90%	80%	61%
Cities (Walktest)	48	100%	98%	80%	83%
Data max. 288 P.	238	235	169	120	
Cities (Drivetest)	216	85%	83%	62%	44%
Cities (Walktest)	72	75%	76%	49%	35%
Crowdsourced Quality max. 84 P.	79	73	67	64	
Urban	84	94%	87%	80%	77%
Total max. 564 P.	501	485	390	312	

Percentages and points rounded to integer numbers.
 For the calculation of points and totals, the accurate, unrounded values were used.

THE UK'S LARGEST CITIES

For the inhabitants of the other large cities in the UK, it is interesting to see how the different operators perform in their areas. Therefore, we performed additional analysis for nine large cities all over the United Kingdom.

As interesting as the focus on the densely populated London area is, the inhabitants of other large UK cities and the capitals of the other nations besides England have their own perspective on network performance and availability. In order to also provide valuable insights for their inhabitants, we have additionally analysed the performances of the four operators in nine large UK cities – specifically Belfast, Birmingham, Bristol, Cardiff, Edinburgh, Glasgow, Liverpool, Manchester and Sheffield.

When comparing the individual results, it must however be taken into account that we did not conduct walk tests in Belfast and Edinburgh – and thus have adapted the amount of maximum obtainable points accordingly.

SAME RANKING AS NATIONWIDE IN BELFAST, CARDIFF, EDINBURGH, GLASGOW AND SHEFFIELD: EE LEADS, VODAFONE RANKS SECOND

The same ranking as in the nationwide assessment can be seen in Belfast, Cardiff, Edinburgh and Sheffield. In these cities, EE is

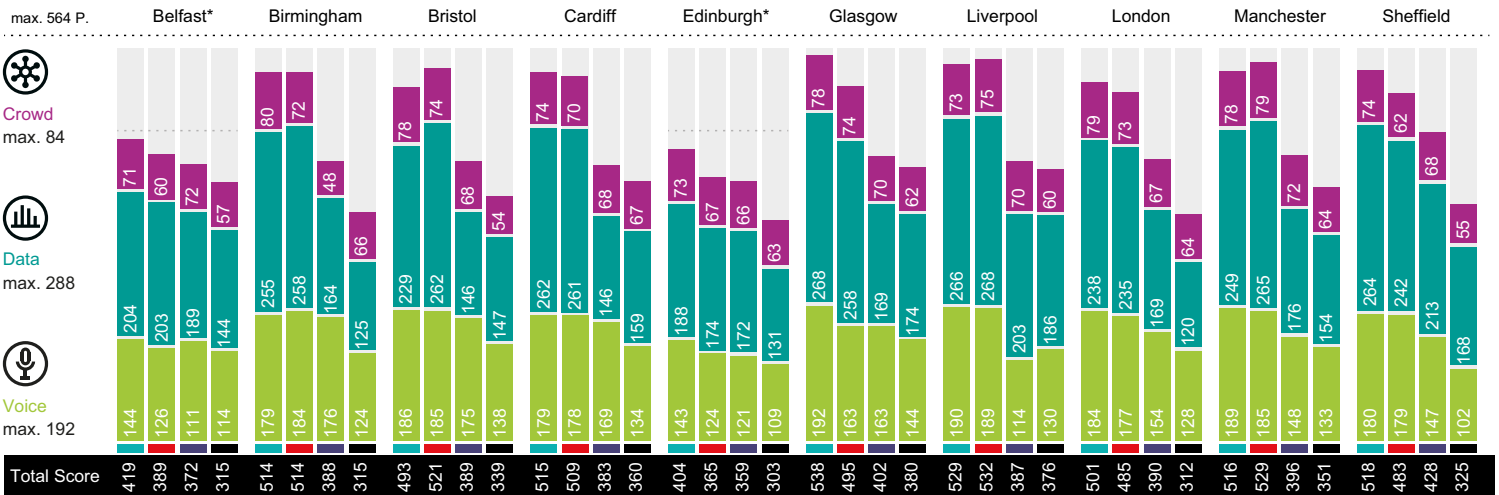
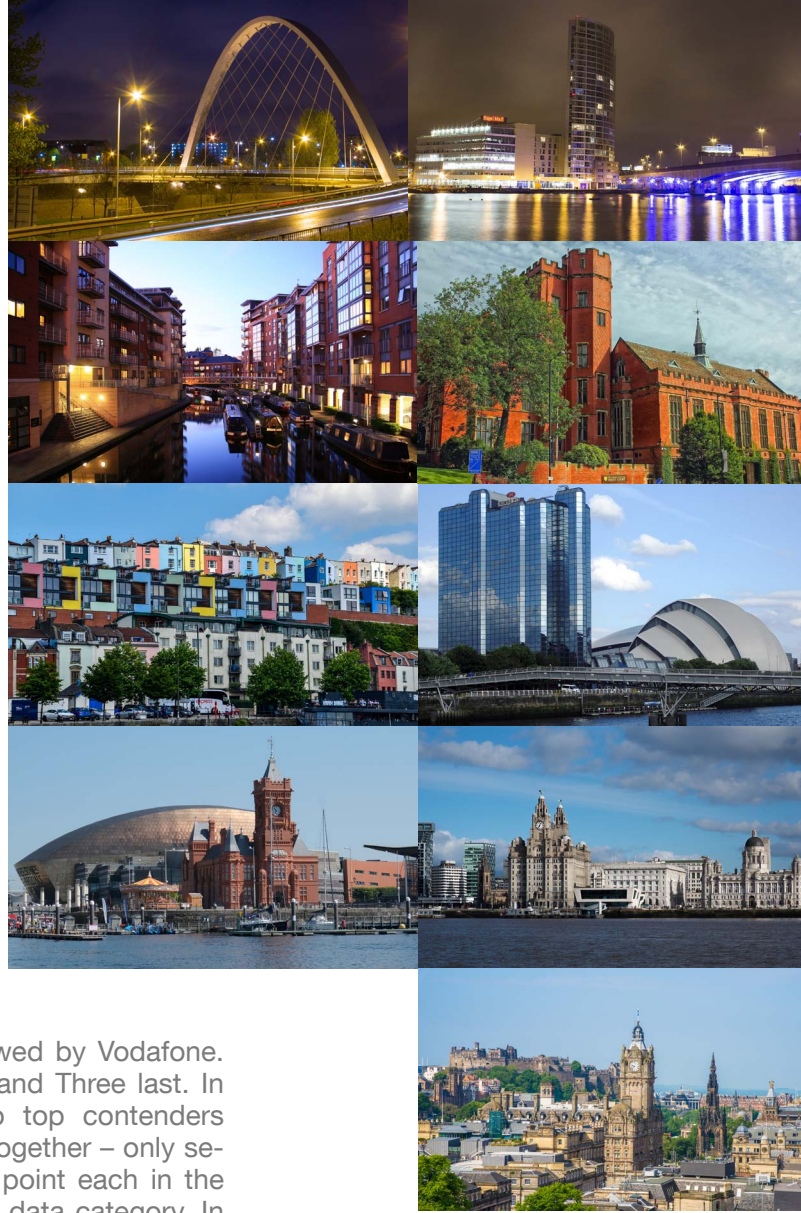
the leader, followed by Vodafone. O2 ranks third, and Three last. In Cardiff, the two top contenders are quite close together – only separated by one point each in the voice and in the data category. In Edinburgh, the still third-placed O2 comes comparably close to the second-placed Vodafone. In contrast, the ranking is quite distinct in Belfast, Glasgow and Sheffield.

VODAFONE ON PAR WITH EE IN BIRMINGHAM, AND LEADING IN BRISTOL, LIVERPOOL AND MANCHESTER

In Birmingham, Vodafone manages to achieve the same overall score as the UK-wide winner

EE, showing a particularly strong performance in the data discipline. In Bristol, Liverpool and Manchester, Vodafone turns out to be a local champion – again due to very strong results in the data discipline.

O2 shows particularly strong results in Sheffield, while Three scores distinctly above its nationwide average in the cities of Cardiff, Liverpool and Manchester.



* Drivetest only, max. 444 P. — Shown scores are rounded.

TESTING METHODOLOGY

The methodology of the umlaut connect Mobile Benchmark is the result of more than 15 years of testing mobile networks. Today, network tests are conducted in more than 80 countries. Our methodology was carefully designed to evaluate and objectively compare the performance and service quality of mobile networks from the users' perspective.

The umlaut connect Mobile Benchmark in the United Kingdom comprises of the results of extensive voice and data drive tests and walk tests as well as a sophisticated crowdsourcing approach.

DRIVE TESTS AND WALK TESTS

The drive tests and walk tests in the UK took place between November 6th and November 26th, 2019. All samples were collected during the day, between 8.00 a.m. and 10.00 p.m. The network tests covered inner-city areas, outer metropolitan and suburban areas. Measurements were also taken in smaller towns and cities along connecting highways. The connecting routes between the cities alone covered about 1,520 kilometres per car – 6,080 kilometres for all four cars. In total, the four vehicles together have covered about 10,700 kilometres.

The combination of test areas has been selected to provide representative test results across the UK's population. The areas selected for the 2019 test account for 17 million people, or roughly 27 percent of the total population

of the United Kingdom. The test routes are shown on page 1 of this report, all visited cities and towns are listed in the box on the right.

The four drive-test cars were equipped with arrays of Samsung Galaxy S9 smartphones for the simultaneous measurement of voice and data services.

VOICE TESTING

One smartphone per operator in each car was used for the voice tests, setting up test calls from one car to another. The walk test team also carried one smartphone per operator for the voice tests. In this case, the smartphones called a stationary counterpart. The audio quality of the transmitted speech samples was evaluated using the HD-voice capable and ITU standardised so-called POLQA wideband algorithm. All smartphones used for the voice tests were set to VoLTE preferred mode. In networks or areas where this modern 4G-based voice technology was not available, they would perform a fallback to 3G or 2G.

In the assessment of call setup times we also rate the so-called

Cities: Belfast, Birmingham (W), Bristol (W), Cardiff (W), Colchester, Edinburgh, Gateshead, Glasgow (W), Gloucester, Kingston upon Hull, Leeds (W), Leicester, Liverpool (W), Greater London (W), Luton, Manchester (W), Milton Keynes, Sheffield (W), Stoke-on-Trent, Swindon, Wolverhampton; (W) designates walk test cities. A walk test has also been conducted in Bradford.

Towns: Ballymena, Berwick-upon-Tweed, Bury St Edmunds, Carlisle, Craigavon, Darlington, Derry (Londonderry), Dorchester (West Dorset), Droitwich (Droitwich Spa), Dumfries, Dunfermline, Ferndown, Goole, Harlow, Honiton, Kendal, Kilmarnock, Lancaster, Long Eaton, Newbury/Berkshire, Newtownabbey, Northwich, Omagh, Perth, Ripon, Rugby, Scunthorpe, Sutton-in-Ashfield, Winchester

P90 value. Such values specify the threshold in a statistical distribution, below which 90 percent of the gathered values are ranging. For speech quality, we publish the P10 value (10 percent of the values are lower than the specified threshold), because in this case higher values are better.

In order to account for typical smartphone-use scenarios during the voice tests, background data traffic was generated in a controlled way through injection of 100 KB of data traffic (HTTP downloads). As a new KPI in our 2019 setup, we also evaluate the so-called Multirab (Multi Radio Access Bearer) Connectivity. This value denominates whether data connectivity is available during the phone calls. The voice scores account for 32 percent of the total results.

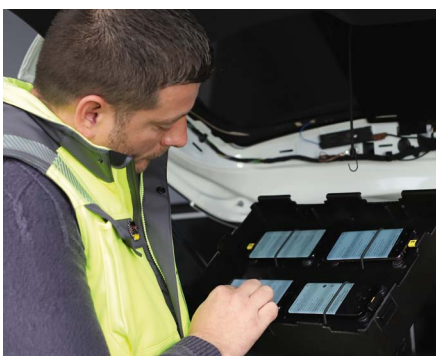
DATA TESTING

Data performance was measured by using four more Galaxy S9 in each car – one per operator. Their radio access technology was also set to LTE preferred mode.

For the web tests, they accessed web pages according to the widely recognised Alexa ranking.

In addition, the static "Kepler" test web page as specified by ETSI (European Telecommunications Standards Institute) was used. In order to test the data service performance, files of 5 MB and 2.5 MB for download and upload were transferred from or to a test server located in the cloud. ▶

One Samsung Galaxy S9 per operator took the voice measurements and one additional S9 per operator was used for the data tests. All test phones were operated and supervised by umlaut's unique control system.



In addition, the peak data performance was tested in uplink and downlink directions by assessing the amount of data that was transferred within a seven seconds time period.

The evaluation of YouTube playback takes into account that YouTube dynamically adapts the video resolution to the available bandwidth. So, in addition to success ratios and start times, the measurements also determined average video resolution.

All the tests were conducted with the best-performing mobile plan available from each operator. Data scores account for 48 percent of the total results.

CROWDSOURCING

Additionally, umlaut conducted crowd-based analyses of the UK's networks which contribute 20 percent to the end result. They are based on data gathered between early June and mid-November, 2019.

For the collection of crowd data, umlaut has integrated a background diagnosis process into 800+ diverse Android apps. If one of these applications is installed on the end-user's phone and the user authorizes the background analysis, data collection takes place 24/7, 365 days a year. Reports are generated for every hour and sent daily to umlaut's cloud servers. Such reports occupy just a small number of bytes per message and do not include any personal user data. Interested parties can deliberately take part in the data gathering with the specific "U get" app (see box on the right).

This unique crowdsourcing technology allows umlaut to collect data about real-world experience wherever and whenever customers use their smartphones.

NETWORK COVERAGE

For the assessment of network coverage, umlaut lays a grid of 2 by 2 kilometres over the whole test area. The "evaluation areas" generated this way are then

subdivided into 16 smaller tiles. To ensure statistical relevance, umlaut requires a certain number of users and measurement values per operator for each tile and each evaluation area.

In our 2019 benchmark framework, we differentiate between a "Benchmark View" and an "Own Network View" at the crowd results: For the Benchmark View, only those evaluation areas are considered for which we have determined valid results for all operators who are incorporated in the benchmark. In the "Own Network View" this exclusion is not made – an evaluation area will be considered if there are valid samples for the assessed operator, regardless of the presence of competitors.

Above that, we now distinguish urban and non-urban areas in our crowd evaluations – respecting that the coverage with mobile services is usually higher in urban areas than in rural surroundings. We specify according coverage values for the coverage of voice services (2G, 3G and 4G combined), data (3G and 4G combined) and 4G only.

DATA THROUGHPUTS

Additionally, umlaut investigates the data rates that were actually available to each user. For this purpose, we determine maximum download and upload data rates per user within 15 minute slices. These values are then aggregated per evaluation area in 4-week-time slices, for each of which we determine the P90 value. For the

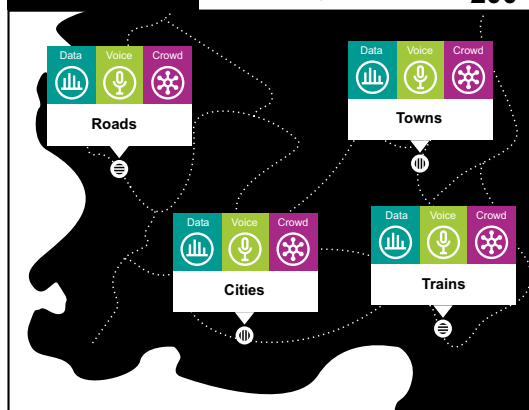
Drivetest

Score Breakdown

Cities — Drivetest	360
Cities — Walktest	120
Towns — Drivetest	160
Roads — Drivetest	100
Trains — Walktest	60
Crowdsourcing	200

Walktest

Crowd



final calculation of this KPI we then calculate the average of the results of the six time slices.

DATA SERVICE AVAILABILITY

Also called "operational excellence", this parameter indicates the number of "service degradations" – events where data connectivity is impacted by a number of identified anomalies with sufficient severity. To judge this, the algorithm compares similar time frames on similar days in a window around the day and time of interest. The algorithm looks at large scale anomalies on a network-wide level and ensures that individual users' degradations such as a simple loss of coverage due to an indoor stay or similar reasons can not affect the result.

In order to ensure statistical relevance, valid assessment weeks and hours must fulfil distinct requirements. Each operator must have sufficient statistics for trend and noise analyses per each evaluated time windows. The exact number depends on the market size and number of operators. Data Service Availability is based on the same 24-week observation period as our other crowd results.

PARTICIPATE IN OUR CROWDSOURCING

Everybody interested in being a part of our global crowdsourcing panel and obtaining insights into the reliability of the mobile network that her or his smartphone is logged into, can most easily participate by installing and using the "U get" app. This app exclusively concentrates on network analyses and is available under <http://uget-app.com> or via the adjoint QR code.

"U get" checks and visualises the current mobile network performance and contributes the results to our crowdsourcing platform. Join the global community of users who understand their personal wireless performance, while contributing to the world's most comprehensive picture of mobile customer experience.



CONCLUSION

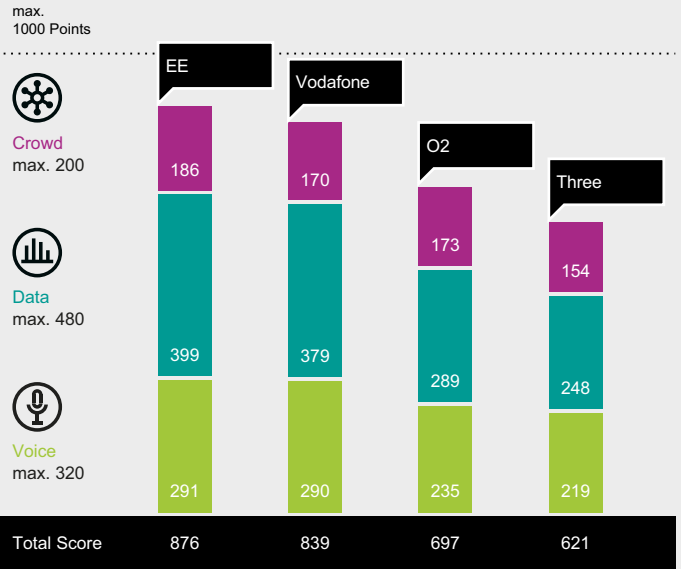
EE wins for the sixth time. Vodafone maintains the second place and shows clear score improvements over last year's results. O2 and Three swap places, with O2 ranking third and Three fourth.

The overall winner of the 2019 umlaur connect Mobile Benchmark in the UK is EE – for the sixth time (in 2016, EE shared the first place with Vodafone). EE's lead over the second-placed Vodafone is close in the voice discipline, but more distinct in the data and crowdsourcing categories. Overall, EE defends its position and deserves the grade very good.

As in 2017 and 2018, Vodafone holds the second place and shows a good performance level. The operator shows a distinct score distance to the third-placed contender, which separates the UK market into two stronger and two less powerful providers.

On the lower ranks, we see a swap of places: O2 manages to overtake Three and reach the third place, outperforming the Hutchison brand in all disciplines of our Benchmark and achieving the overall grade satisfactory. This is also confirmed by a distinct improvement especially in the Crowd score.

Three ranks last, falling below its performance levels from our previous Benchmark and achieving the overall grade sufficient. However, this operator shows some improvements in the results of our crowdsourcing.



Shown voice, data, crowd and total scores are rounded.

Overall Results	EE	Vodafone	O2	Three	
Voice max. 320 P.	291	290	235	219	
Cities (Drivetest)	144	96%	92%	75%	63%
Cities (Walktest)	48	90%	98%	90%	83%
Towns (Drivetest)	64	97%	95%	75%	80%
Roads (Drivetest)	40	92%	92%	70%	73%
Railways (Walktest)	24	43%	52%	33%	34%
Data max. 480 P.	399	379	289	248	
Cities (Drivetest)	216	87%	84%	63%	51%
Cities (Walktest)	72	80%	87%	50%	37%
Towns (Drivetest)	96	83%	69%	63%	62%
Roads (Drivetest)	60	93%	86%	78%	71%
Railways (Walktest)	36	49%	47%	27%	23%
Crowdsourced Quality max. 200P.	186	170	173	154	
Country	60	100%	97%	100%	88%
Urban	84	89%	79%	78%	69%
Non-urban (Benchmark view)	44	92%	82%	86%	77%
Non-urban (Own network view)	12	88%	79%	80%	74%
Connect Rating max. 1000 P.	876	839	697	621	

Percentages and points rounded to integer numbers.

For the calculation of points and totals, the accurate, unrounded values were used.



1

As in our previous UK Benchmarks, EE is the overall winner. The largest operator in the UK manages to hold its high performance levels and scores best in all three disciplines of our evaluation: voice, data and crowdsourcing. For this convincing result, EE is awarded the overall grade very good.



2

Vodafone defends the second place which it has been holding since 2017, after having scored on a par with EE in 2016. In comparison to last year's results, Vodafone managed to improve considerably in the voice and crowd disciplines, and also somewhat in the data discipline. This performance results in a solid good grading.



3

The second largest UK operator managed to advance its way to the third place by improving over last year's results especially in the crowd discipline. In our 2019 Benchmark, O2 outperforms Three in each category, achieving the grade satisfactory. In the crowd score, O2 is even a little stronger than Vodafone.



4

The smallest UK operator ranks last this time, but shows some strength in the assessment of voice calls in smaller towns and on the roads. However, in our walk tests and drive tests Three scored overall lower than in the previous year, resulting in a place swap with O2 and the overall grade sufficient.

REACTIONS

We asked the four UK mobile operators to comment on the results of the 2019 uKmlaut connect Mobile Benchmark in the United Kingdom. Here are their responses.



“Today’s results from uKmlaut’s and connect’s tests show the continued investment we’re making in expanding and enhancing our network across the UK. Taking the top spot for ‘Best in Test’ for another year is testament to the hard work of our engineers in upgrading and building new sites every day.”

Greg McCall, Managing Director, responsible for the EE Mobile Network



“The uKmlaut connect Mobile Benchmark results for 2019 highlight our continued strong momentum from last year. The report shows that we are the most improved mobile network in the UK, offer the best indoor performance and continue to invest heavily on providing greater capacity where customers use their devices most such as in business parks, shopping centres and key transport hubs. We are carrying this energy into 2020 by expanding our 5G network in the UK and overseas, further improving rural coverage and building on our position in the report as having the joint best network for voice. Our focus is on providing customers with the UK’s best unified mobile and fixed digital network infrastructure.”

Andrea Dona, Vodafone UK, Head of Networks



“Three is committed to creating the best customer experience in the UK. To that end a number of programmes to invest in our end-to-end network started in 2019 and they will ramp up throughout 2020. We are investing more than £2 billion to enhance our 4G network and, thanks to our leading spectrum portfolio, build the UK’s fastest 5G network.”

Patrick Binchy, CTO of 3UK



O2 was not available for comments about the 2019 results.