THE 2019 MOBILE NETWORK TEST IN SPAIN

Gijon
Santander
Donostia-San Sebastián
A Coruña
Oviedo
Bilbao
Pamplona
Valladolid
Barcelona
Zaragoza
Reus
Salamanca
Madrid
Valencia
Albacete
Cartagena
Huelva
Sevilla
Málaga

- Drivetest
- Walktest
— Roads

Santa Cruz de Tenerife
Las Palmas de Gran Canaria

For the fifth time, the benchmarking expert umlaut and connect magazine have conducted their authoritative benchmark of the Spanish mobile networks. Once again, we have enhanced the underlying methodology.

The detailed findings show a mix of familiar results and some surprises. The winner holds its solid lead for the fifth time in a row, while the second place contender has improved considerably. But not all operators managed to improve their scores.

RESULTS IN A NUTSHELL

Vodafone wins the umlaut connect Mobile Benchmark Spain for the fifth time in a row. Orange holds its second place position and shows impressive score improvements over last year's results. Movistar ranks third and Yoigo fourth, both with overall "good" results.

umlaut's network benchmarks are widely accepted as the de-facto industry standard and for being highly objective. The carefully designed methodology of our 2019 benchmark in Spain represents umlaut's holistic approach to network benchmarking. It combines drivetests and walktests for executing detailed voice and data measurements under controlled circumstances with a sophisticated crowdsourcing approach. This provides profound insights into the overall coverage of voice, data and 4G services, real-world User Download Speeds and Data Service Availability.

The drivetests and walktests allow for evaluating the maximum of the networks' capabilities. 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 authoritative assessment of the rated networks' true potential and performance.

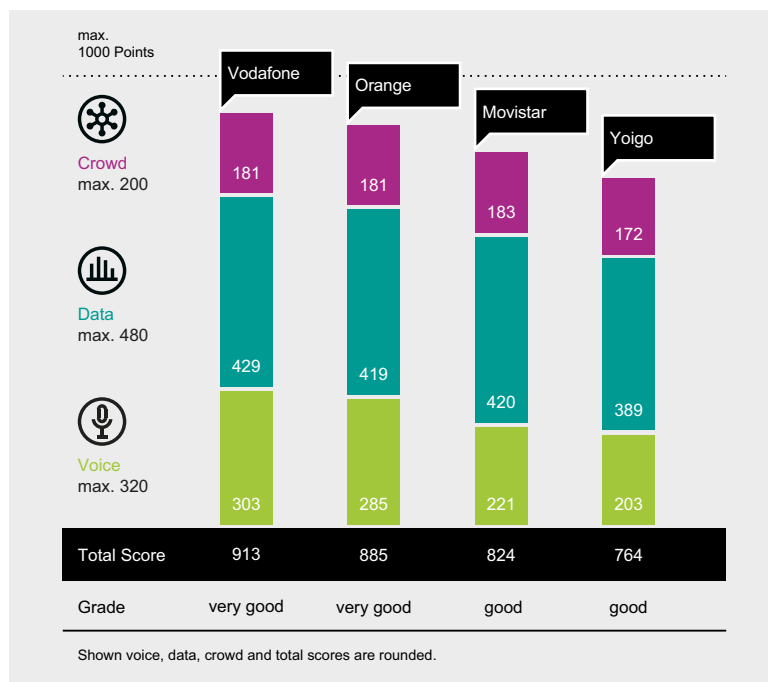### VODAFONE IS THE OVERALL WINNER, ORANGE SHOWS BIGGEST SCORE IMPROVEMENTS

As in the four previous years, the overall winner is Vodafone. Orange scores second and shows the biggest improvements over the score achieved in last year's benchmark. Both Vodafone and Orange have earned the grade "very good".

Movistar ranks third and Yoigo fourth as in last year's evaluation. When comparing the overall scores with those of our 2018 benchmark in Spain, both Movistar and Yoigo lose some points. But both still show strong performances, achieving the grade "good".

In the crowdsourcing category, Movistar has taken over the lead from Orange this year, scoring two points ahead of the also strong contenders Orange and Vodafone. Particularly pleasant are the results of our Data Service Availability assessment which did not identify any degradations in any Spanish network throughout the whole 24-week evaluation period spanning from mid-April to end of September 2019.

As a case study, we also conducted 5G measurements in die Vodafone network in Madrid for the first time. The results emphasize the performance advantages of 5G, showing very short latencies and impressively high data rates.

> Vodafone and Orange improve their scores over our 2018 benchmark – Orange even with a plus of 18 points. Movistar and Yoigo lost a couple of points but both achieve good results.

max. 1000 Points	Vodafone	Orange	Movistar	Yoigo
Crowd max. 200	181	181	183	172
Data max. 480	429	419	420	389
Voice max. 320	303	285	221	203
Total Score	913	885	824	764
Grade	very good	very good	good	good

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

Overall Results		Vodafone	Orange	Movistar	Yoigo
Voice	max. 320 P.	303	285	221	203
Cities (Drivetest)	144	94%	87%	68%	64%
Cities (Walktest)	48	98%	93%	69%	64%
Towns (Drivetest)	64	98%	97%	71%	70%
Roads (Drivetest)	64	92%	82%	71%	55%
Data	max. 480 P.	429	419	420	389
Cities (Drivetest)	216	89%	88%	88%	82%
Cities (Walktest)	72	91%	85%	86%	76%
Towns (Drivetest)	96	89%	88%	87%	82%
Roads (Drivetest)	96	88%	86%	88%	83%
Crowdsourced Quality	max. 200P.	181	181	183	172
Country	60	100%	100%	100%	100%
Urban	84	86%	86%	87%	77%
Non-urban (Benchmark view)	44	88%	90%	90%	85%
Non-urban (Own network view)	12	83%	83%	85%	81%
Connect Rating	max. 1000 P.	913	885	824	764

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

SPAIN'S OPERATORS

The three largest Spanish mobile network operators are in constant competition for subscribers and market share. Also, all four Spanish operators have consistently increased their LTE coverage and speeds – and Vodafone has already deployed first 5G installations in 15 cities.

movistar

orange™

vodafone

yoigo

Movistar is the brand name the Spanish telecommunications company Telefónica uses for the mobile network in its home market. Telefónica S.A. itself is one of the largest telco companies in the world. The operator is active in 17 countries with a total of 121,800 employees and achieved worldwide revenues of over €48 billion in its fiscal year 2018.

While the company introduced the Movistar brand in Latin American countries in 2005, it has been active in Spain since the launch of GSM services back in 1995. Today, Movistar is the largest mobile operator in Spain with about 17.6 million subscribers, which equates to a market share of over 30 per cent. It offers GSM service at 900 and 1800 MHz, UMTS/3G at 900 and 2100 MHz and LTE at 800, 1800 and 2600 MHz. Since the end of 2014, Movistar has supported 4G+ carrier aggregation with maximum speeds reaching up to 500 Mbps today. The operator claims to provide 4G coverage of more than 96 per cent of the Spanish population and has also recently introduced VoLTE.

Orange España is the brand name of France Telecom's mobile network in Spain. It has been operating under this name since 2006. Previously, the network was known as "Amena" – this brand name lives on in Orange Spain's portfolio as a low-cost offer that is only available via the internet. Also, its network serves a number of mobile virtual network operators such as MasMovil, Carrefour Móvil and others.

With approx.15.9 million customers, Orange is the second largest Spanish mobile operator with a market share of about 26 per cent. In the fiscal year 2018, Orange Spain achieved a revenue of €5.3 billion which contributed 15 per cent to the total revenue of the Orange Group.

Orange Spain has deployed 2G networks at 900 and 1800 MHz, 3G networks at 900 and 2100 MHz and 4G at 800, 1800 and 2600 MHz. The operator claims that its 4G network reaches more than 97 per cent of the Spanish population. Also, Orange was the first Spanish operator to offer VoLTE to its 4G customers.

Vodafone España has been present on the Spanish mobile communications market since the year 2000. Then, the British Vodafone Group acquired Airtel Móviles which had operated in Spain since 1994. In Spain, Vodafone reports 13.5 million mobile customers, adding up to a market share of about 24 per cent. This makes Vodafone the third largest operator in the country following at close distance behind its competitor Orange. In the fiscal year 2018/2019, Vodafone Spain achieved revenues of €4.3 billion which contributes about nine per cent to the whole Vodafone Group's financial results.

Vodafone's mobile network in Spain offers GSM service at 900 and 1800 MHz, UMTS/3G at 900 and 2100 MHz and LTE at 800, 1800, 2100 and 2600 MHz. The Vodafone 4G network in Spain supports LTE carrier aggregation ("4G+") with maximum speeds of 500 Mbps as well as VoLTE. Vodafone España claims to offer the best LTE coverage in Spain, reaching approx. 98 per cent of the Spanish population, and has now launched Spain's first 5G network cells in 15 cities.

Yoigo was the latest mobile operator to enter the Spanish market. Founded in 2000 under the name Xfera, the company started its actual operation in 2006, offering only a UMTS/3G network at 2100 MHz. At this time, the Swedish telecommunications company TeliaSonera acquired the majority of shares and rebranded the network as "Yoigo". In June 2016, the former MVNO (mobile virtual network operator) Másmóvil bought the company. For its fiscal year 2018, Másmóvil reported revenues in Spain of €1.5 billion. Yoigo had a national roaming agreement with Movistar until the end of 2016. Since January 2017, Yoigo customers freely roam in the 2G and 3G networks of Orange at locations without Yoigo coverage. Yoigo claims a mobile customer base of 6.8 million mobile subscribers, which equals a market share of approx. 13 per cent. Today, Yoigo operates 3G at 2100 MHz as well as 4G at 1800 MHz. Thanks to its roaming agreements, the operator claims an LTE coverage of approx. 98 per cent of the population.

umlaut's network benchmarks are widely accepted as a completely objective authority. In 2019, we conduct the umlaut connect Mobile Benchmark Spain for the fifth time, further enhancing its methodology.

A CLOSE LOOK AT THE SPANISH NETWORKS

umlaut, based in Aachen, Germany, is a world leader in mobile network testing. The company was formerly known as P3 communications and changed its name in fall 2019 in the course of restructuring and refocusing its activities. umlaut has over 4,300 employees, distributed over about 50 locations all over the world, and 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
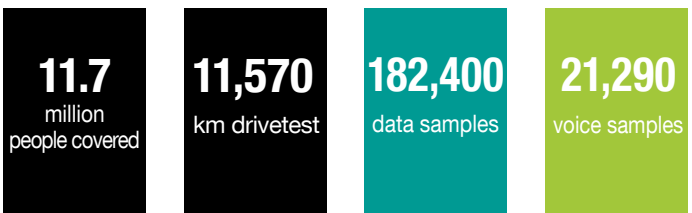
network benchmark test in Germany for more than 15 years, extending it to other European countries since 2009. As the de-facto industry standard, umlaut's benchmarking methodology focuses on customer-perceived network quality.

The 2019 umlaut connect Mobile Benchmark Spain consists of drivetests and walktests conducted in September and October 2019. Four drive test cars together covered 11,570 kilometres. The test areas account for 11.7 million people, or roughly 25.2 per cent of the total population of Spain. In addition, the results of extensive crowdsourcing analyses considering 24 weeks from April to September 2019 are included in the score.
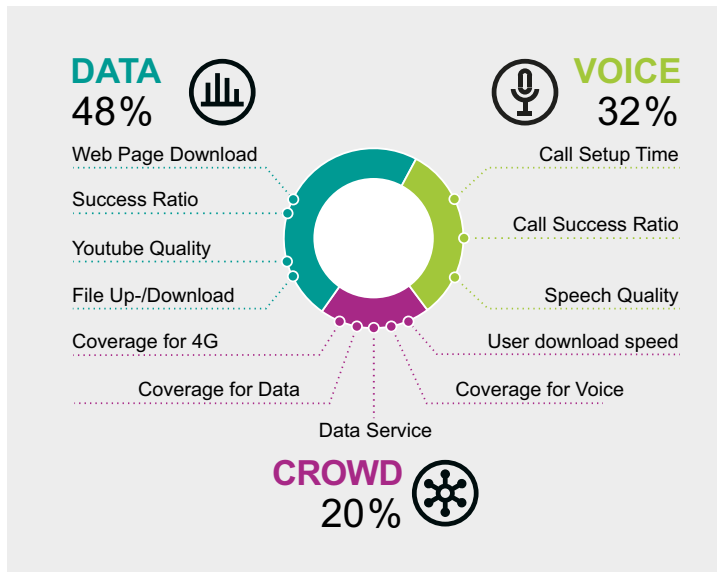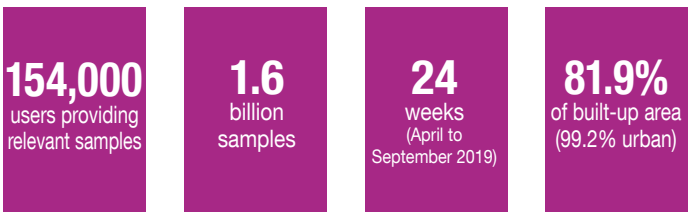
> Congratulations to Vodafone, leading in Spain for the fifth time in a row. Orange shows the biggest score improvements this year, ranking second overall. With our new brand umlaut we are also adding something on top: We have measured 5G for the first time in Spain. The results are quite impressive with throughputs above 500 Mbit/s in the downlink and 70 Mbit/s in the uplink. This I would call real early innovation.
>
> Hakan Ekmen, CEO umlaut

DRIVETEST AND WALKTEST FACTS

11.7 million people covered	**11,570** km drivetest	**182,400** data samples	**21,290** voice samples

CROWDSOURCING FACTS

154,000 users providing relevant samples	**1.6** billion samples	**24** weeks (April to September 2019)	**81.9%** of built-up area (99.2% urban)

DATA 48%
- Web Page Download
- Success Ratio
- Youtube Quality
- File Up-/Download
- Coverage for 4G
- Coverage for Data

VOICE 32%
- Call Setup Time
- Call Success Ratio
- Speech Quality
- User download speed
- Coverage for Voice

Data Service

CROWD 20%

🎙 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 Spanish networks fulfill these expectations?

Vodafone, Orange and recently also Movistar support Voice over LTE (VoLTE) in their networks. 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 codecs potentially support a wider audio bandwidth providing operators with the opportunity to deliver higher speech quality to their customers. Thus, currently Yoigo remains the only Spanish operator who does not support this modern voice standard.

However, Movistar only launched VoLTE immediately before the measurements for our benchmark started. As there was not enough time to adapt our test setup accordingly, this year's test results could not yet consider the possible performance and quality benefits of VoLTE in the Movistar network. But in order to honor this operator's efforts and to give an indication how Movistar might score next time when VoLTE is considered in its evaluation, we ran some simulations. In a corridor of possible scenarios we extrapolated how the operator would have scored with VoLTE – based on the average and best voice results of its competitors who already support the newer voice standard.

According to these simulations, Movistar may expect a plus between 40 and 50 points when scored with VoLTE. However, we must emphasize that the official result of this year's benchmark is of course based only on the actually gathered measurement values. Furthermore, even with VoLTE considered for Movistar, the overall ranking would not have changed.

CITIES DRIVETEST
VODAFONE

VODAFONE SHOWS STRONGEST VOICE RESULTS IN THE DRIVETESTS IN CITIES

In the larger cities, Vodafone achieves the highest success ratios and together with Orange also the shortest call setup times thanks to VoLTE. The determined speech quality is particularly high in the Vodafone network.

TOWNS DRIVETEST
VODAFONE & ORANGE

VODAFONE AND ORANGE AHEAD IN DRIVETEST VOICE RESULTS DETERMINED IN SMALLER TOWNS

In the smaller towns, Orange achieves an impressive 100 per cent call success ratio, closely followed by Vodafone. Call setup times are again the shortest for both candidates using VoLTE. And Vodafone leads once more in terms of speech quality in the towns.

VODAFONE SHOWS THE BEST VOICE RESULTS, ORANGE RANKS SECOND, MOVISTAR THIRD AND YOIGO FOURTH.

Voice 🎙
320 of 1000 Points

■ Vodafone
■ Orange
■ Movistar
■ Yoigo

Cities Drivetest (of 144 P.)
- 94%
- 87%
- 68%
- 64%

Cities Walktest (of 48 P.)
- 98%
- 93%
- 69%
- 64%

Towns Drivetest (of 64 P.)
- 98%
- 97%
- 71%
- 70%

Roads Drivetest (of 64 P.)
- 92%
- 82%
- 71%
- 55%

ROADS DRIVETEST

VODAFONE

FOR VOICE TELEPHONY ON THE ROADS, VODAFONE LEADS THE FIELD, FOLLOWED BY ORANGE

In the drivetests conducted on the connecting roads, the call success ratios and speech quality determined for all Spanish operators more or less decrease while the call setup times increase. Only Movistar achieves slightly shorter call setup times on the roads compared to its results in the cities and towns. However, in comparison to last year's results, all four operators managed to somewhat improve their call success ratios on the connecting roads. In the overall assessment, Vodafone achieves the highest score for voice telephony in this category.

CITIES WALKTEST

VODAFONE

VODAFONE ALSO LEADS IN THE VOICE WALKTESTS CONDUCTED IN SEVEN LARGER SPANISH CITIES

In the walktests that umlaut conducted in seven larger cities (Barcelona, Las Palmas, Madrid, Málaga, Sevilla, Valencia and Zaragoza), again Vodafone achieves the best score, providing a high call success ratio, the shortest call setup times and the highest speech quality. Orange ranks second, reaching the same high success ratio as Vodafone and only slightly longer call setup times. Movistar ranks third and Yoigo fourth, but both also show good success ratios in the voice walktests.

VOICE RESULTS AT A GLANCE

Vodafone achieves the highest score in the voice discipline, making use of the full potential of VoLTE and providing excellent speech quality to their users. Orange ranks second, showing very good call reliability particularly in the cities and towns. Movistar scores behind the leading two contenders and ranks third in this discipline. Yoigo ranks behind its competitors but achieves good voice results especially in the cities and towns.

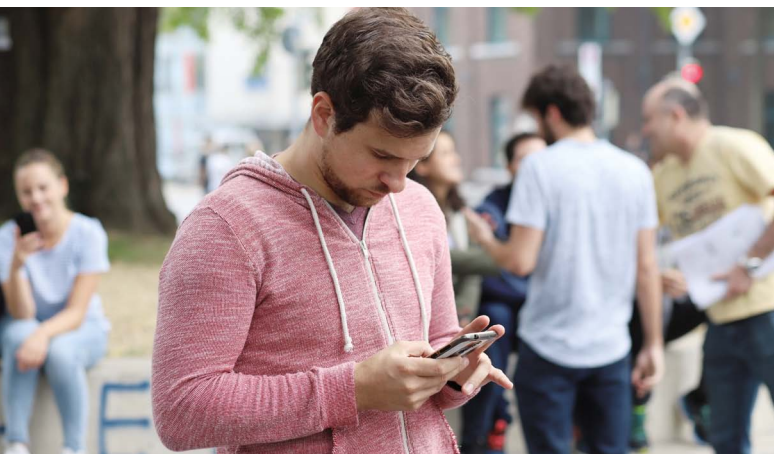| Operator	Vodafone	Orange	Movistar	Yoigo
Cities (Drivetest)				
Sucess Ratio (%)	99.1	98.4	97.8	98.2
Call Setup Time (s)	2.1	2.1	6.0	6.2
Call Setup Time P90 (s)	2.5	2.5	8.1	7.8
Speech Quality (MOS-LQO)	4.5	3.7	3.6	3.0
Speech Quality P10 (MOS-LQO)	4.1	3.0	2.9	2.4
Multirab Connectivity (%)	100.0	99.5	95.5	87.1
Towns (Drivetest)				
Sucess Ratio (%)	99.8	100.0	98.2	98.9
Call Setup Time (s)	2.1	2.0	5.8	6.0
Call Setup Time P90 (s)	2.5	2.4	7.8	7.1
Speech Quality (MOS-LQO)	4.5	3.7	3.6	3.0
Speech Quality P10 (MOS-LQO)	4.1	3.1	2.9	2.5
Multirab Connectivity (%)	100.0	100.0	95.8	86.7
Roads (Drivetest)				
Sucess Ratio (%)	97.9	96.1	96.5	94.8
Call Setup Time (s)	2.2	2.3	5.6	6.6
Call Setup Time P90 (s)	2.8	3.1	7.6	8.3
Speech Quality (MOS-LQO)	4.3	3.6	3.6	2.9
Speech Quality P10 (MOS-LQO)	3.7	2.8	3.0	2.4
Multirab Connectivity (%)	99.2	98.3	93.6	80.0
Cities (Walktest)				
Sucess Ratio (%)	99.7	99.7	97.8	97.8
Call Setup Time (s)	1.7	1.8	5.8	5.8
Call Setup Time P90 (s)	2.2	2.5	7.2	6.7
Speech Quality (MOS-LQO)	4.6	3.6	3.6	3.0
Speech Quality P10 (MOS-LQO)	4.5	2.9	3.0	2.4
Multirab Connectivity (%)	100.0	96.7	94.3	82.3

DATA

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

VODAFONE IS THE WINNER IN THE DATA DISCIPLINE, MOVISTAR RANKS SECOND WITH ORANGE FOLLOWING AT A CLOSE DISTANCE OF JUST ONE POINT.

Mobile Operators are constantly striving to provide their customers with the best LTE coverage as well as to deliver the highest data rates. In Spain, Vodafone, Orange and Movistar are constantly competing for the lead in these areas. The smallest Spanish operator, Yoigo is still mainly concentrating on expanding its 4G footprint – but claims to have reached 98 per cent LTE coverage of the population thanks to roaming agreements.

In order to assess the performance and reliability of data connections, each of our four drivetest cars and also the walktest team carried one Samsung Galaxy S9 per operator. Supporting the LTE category 18, these smartphones are able to benefit from the so-called carrier aggregation – the combined use of theoretically up to 32 LTE carrier frequencies. Practically, Vodafone and Movistar today offer 4CA – four combined LTE carriers. With a theoretical maximum speed of 1.2 Gbps, the Galaxy S9 can make full use of such network configurations.

umlaut's testing considers 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 per cent of the cases, and additionally the peak data rate that is surpassed in 10 per cent of the cases. Web page and file downloads or file uploads reward fast speeds, while the determination of success ratios and assessing YouTube play-outs concentrate on reliability aspects. As YouTube streams videos at adaptive bitrates, the average value of the received video resolution is another important performance indicator.
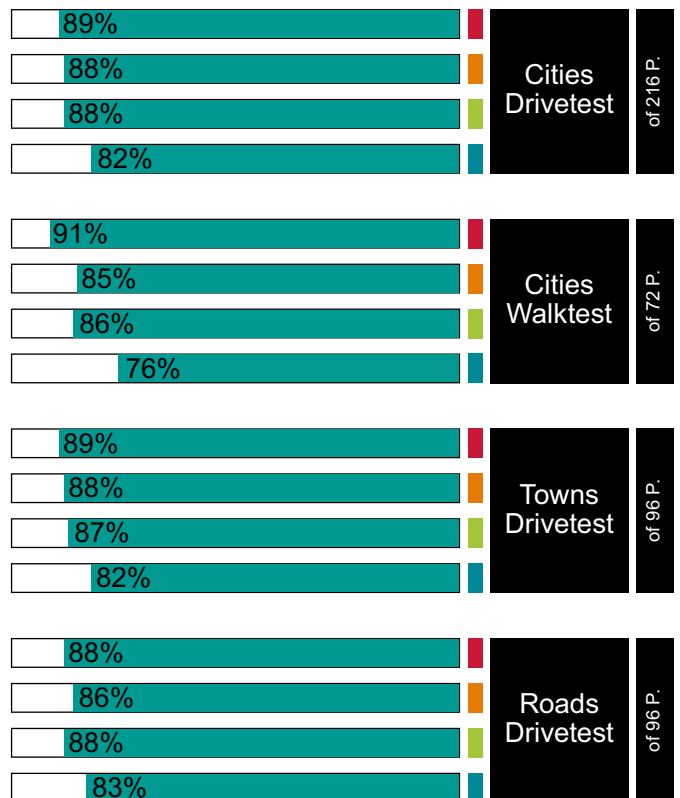
Data

480 of 1000 Points

Legend:
- Vodafone
- Orange
- Movistar
- Yoigo

Cities Drivetest — of 216 P.
- 89%
- 88%
- 88%
- 82%

Cities Walktest — of 72 P.
- 91%
- 85%
- 86%
- 76%

Towns Drivetest — of 96 P.
- 89%
- 88%
- 87%
- 82%

Roads Drivetest — of 96 P.
- 88%
- 86%
- 88%
- 83%

CLOSE RACE BETWEEN VODAFONE, ORANGE AND MOVISTAR IN LARGER CITY DATA DRIVETESTS

In the drive tests conducted in 20 cities with a population of more than 100,000 inhabitants, we see a neck-and-neck race between Vodafone, Orange and Movistar. Ultimately, Vodafone leads by a narrow margin, followed by Orange and Movistar who score on a par in this category. Yoigo ranks fourth at a distance of only about six percent of the achievable points.

All operators achieve excellent success ratios in the cities. The described ranking originates mainly in the observed data throughput rates of the tested file downloads and uploads. Also, in the category of YouTube live videos, Movistar performs slightly behind the other contenders.

VODAFONE CLEARLY LEADS IN THE LARGER CITIES DATA WALKTESTS

The results of the walktests conducted in Barcelona, Las Palmas, Madrid, Málaga, Sevilla, Valencia and Zaragoza are a little more distinct than those of the drivetests that took place in the larger cities: Vodafone takes a clear lead. Movistar ranks second in this category, followed at close distance by Orange. As in the other data assessments, Yoigo falls a little behind.

The success ratios of web page access and file transfers are overall good, with Yoigo losing some points in the category of file uploads as well as for slower download and upload data rates. As in the drivetests, Movistar performs a little behind the competition when it comes to YouTube live videos.

Data Cities (Drivetest)	Vodafone	Orange	Movistar	Yoigo
Web-Page Download (Live/Static)				
Success Ratio (%/%)	99.5/99.5	99.7/99.7	99.8/99.8	99.7/99.7
Overall Session Time (s)	1.3	1.2	1.1	1.3
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.8/3.0	99.8/2.7	99.9/2.0	99.3/3.9
90%/10% faster than (Mbit/s)	7.1/68.4	7.7/76.3	12.6/72.7	4.9/46.7
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.8/1.4	99.9/1.8	100.0/1.4	98.7/3.1
90%/10% faster than (Mbit/s)	9.5/37.3	6.5/30.9	9.9/35.8	3.3/24.5
File Download (7 Seconds)				
Sucess Ratio (%)	99.9	99.7	99.8	99.8
Avg. Throughput (Mbit/s)	49.1	49.0	57.6	29.1
90%/10% faster than (Mbit/s)	8.9/102.6	9.8/105.4	14.0/117.6	8.4/53.9
File Upload (7 Seconds)				
Sucess Ratio (%)	99.5	99.5	99.7	97.7
Avg. Throughput (Mbit/s)	32.3	27.6	33.6	17.3
90%/10% faster than (Mbit/s)	10.0/56.9	6.7/50.7	10.3/53.8	3.6/32.3
Youtube Video				
Success Ratio/Start Time (%/s)	98.5/1.4	98.2/1.3	98.9/1.2	98.5/1.4
Average Video Resolution (p)	909	911	916	906
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	98.2/1.6	97.8/1.5	90.4/3.4	98.6/1.6
Average Video Resolution (p)	1015	1018	1026	1010

Data Cities (Walktest)	Vodafone	Orange	Movistar	Yoigo
Web-Page Download (Live/Static)				
Success Ratio (%/%)	99.8/99.8	99.3/99.3	99.5/99.5	99.0/99.0
Overall Session Time (s)	1.3	1.2	1.1	1.4
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.8/2.5	98.9/2.5	100.0/2.1	98.2/5.0
90%/10% faster than (Mbit/s)	10.1/74.8	11.6/82.6	12.9/79.1	4.0/53.5
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	100.0/1.8	98.9/2.0	99.8/1.2	95.2/3.0
90%/10% faster than (Mbit/s)	7.7/34.6	8.3/34.0	12.3/37.8	3.5/23.9
File Download (7 Seconds)				
Sucess Ratio (%)	99.8	99.2	99.0	99.6
Avg. Throughput (Mbit/s)	59.2	60.5	68.0	33.1
90%/10% faster than (Mbit/s)	12.4/137.0	12.4/120.7	13.7/139.9	5.0/69.5
File Upload (7 Seconds)				
Sucess Ratio (%)	99.8	97.7	98.9	98.4
Avg. Throughput (Mbit/s)	29.6	32.5	36.0	17.4
90%/10% faster than (Mbit/s)	7.2/54.5	8.4/54.5	13.4/55.6	2.5/30.3
Youtube Video				
Success Ratio/Start Time (%/s)	99.4/1.1	98.5/1.2	98.5/1.2	98.3/1.4
Average Video Resolution (p)	910	909	915	904
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	98.6/1.4	96.3/1.6	83.4/3.8	97.6/1.7
Average Video Resolution (p)	1018	1018	1030	1013

**TOWNS
DRIVETEST**

VODAFONE

VODAFONE LEADS IN DATA DRIVE-TESTS IN SMALLER TOWNS, CLOSELY FOLLOWED BY ORANGE AND MOVISTAR

In the data drivetests that our measurement cars performed in 24 smaller Spanish towns, the three top contenders rank closely together. Once again, Vodafone manages to take the lead by a narrow margin. At distances of one per cent of the obtainable points in this category, Orange comes in second and Movistar third. Yoigo ranks last but achieves about the same score in the smaller towns as it did in the data drivetests conducted in the larger cities. The strengths and weaknesses of each candidate are very similar to those observed in the cities.

**ROADS
DRIVETEST**

**VODAFONE
& MOVISTAR**

VODAFONE AND MOVISTAR ON A PAR IN DATA DRIVETESTS ON CONNECTING ROADS, ORANGE RANKS THIRD

On the 7,630 km of connecting roads covered by our test cars, Vodafone and Movistar performed particularly well and score on a par. Orange ranks third at a distance of two per cent of the achievable points. Yoigo ranks fourth but shows a distinct improvement over its results in last year's benchmark in this category.

"

DATA RESULTS AT A GLANCE

As already in the voice discipline, Vodafone leads the field in the data discipline too. Movistar ranks second in this category and shows convincing results especially with the highest average downlink and uplink data rates observed in the cities. Orange follows at a distance of just one point in the overall data discipline. Yoigo shows some room for improvement particularly in the uplink scenarios. However, the smallest Spanish operator achieved distinct improvements over last year's results in the drivetests on connecting roads.

Data Towns (Drivetest)	Vodafone	Orange	Movistar	Yoigo
Web-Page Download (Live/Static)				
Success Ratio (%/%)	99.2/99.2	99.9/99.9	99.6/99.6	99.5/99.5
Overall Session Time (s)	1.6	1.3	1.1	1.3
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	100.0/2.6	99.8/2.9	99.6/1.7	99.2/3.2
90%/10% faster than (Mbit/s)	10.8/69.0	8.1/74.1	14.7/71.8	7.3/51.3
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	100.0/1.7	100.0/1.9	99.6/1.6	98.5/3.6
90%/10% faster than (Mbit/s)	8.5/35.2	6.6/29.4	8.8/32.6	2.5/25.4
File Download (7 Seconds)				
Sucess Ratio (%)	99.8	100.0	99.8	99.8
Avg. Throughput (Mbit/s)	53.0	49.1	62.2	36.8
90%/10% faster than (Mbit/s)	11.7/102.5	9.9/101.1	16.0/120.5	12.3/63.8
File Upload (7 Seconds)				
Sucess Ratio (%)	100.0	99.8	99.6	98.5
Avg. Throughput (Mbit/s)	29.8	25.6	28.5	16.6
90%/10% faster than (Mbit/s)	7.9/55.5	6.3/47.1	7.7/51.2	2.4/34.5
Youtube Video				
Success Ratio/Start Time (%/s)	99.2/1.5	98.1/1.3	99.4/1.3	98.3/1.3
Average Video Resolution (p)	918	908	918	914
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	98.3/2.0	97.4/1.5	85.6/4.2	97.3/1.6
Average Video Resolution (p)	1027	1019	1030	1018

Data Roads (Drivetest)	Vodafone	Orange	Movistar	Yoigo
Web-Page Download (Live/Static)				
Success Ratio (%/%)	98.7/98.7	99.0/99.0	99.4/99.4	98.8/98.8
Overall Session Time (s)	1.6	1.4	1.3	1.5
File Download (5 MB)				
Success Ratio/Avg. Session Time (%/s)	99.5/3.4	99.8/3.8	99.5/2.5	99.6/3.7
90%/10% faster than (Mbit/s)	6.1/63.6	5.5/70.7	8.0/68.8	5.4/55.3
File Upload (2.5 MB)				
Success Ratio/Avg. Session Time (%/s)	98.9/2.7	99.0/3.3	98.8/2.4	97.6/4.1
90%/10% faster than (Mbit/s)	3.8/32.6	2.7/26.9	4.3/30.2	2.1/23.7
File Download (7 Seconds)				
Sucess Ratio (%)	99.3	98.7	99.4	98.3
Avg. Throughput (Mbit/s)	40.4	42.4	51.7	35.3
90%/10% faster than (Mbit/s)	7.5/85.4	6.8/97.2	10.8/111.9	6.8/70.6
File Upload (7 Seconds)				
Sucess Ratio (%)	97.8	96.4	98.6	95.9
Avg. Throughput (Mbit/s)	22.6	19.2	22.9	15.7
90%/10% faster than (Mbit/s)	4.8/49.3	2.9/40.6	4.5/47.1	2.2/33.1
Youtube Video				
Success Ratio/Start Time (%/s)	98.1/1.7	96.9/1.5	97.7/1.4	97.1/1.5
Average Video Resolution (p)	908	898	909	905
Youtube live Smartphone				
Success Ratio/Start Time (%/s)	97.3/2.0	96.2/1.7	86.5/4.0	95.4/1.8
Average Video Resolution (p)	1019	1009	1017	1011

✳ CROWD

154,000 Spanish users have contributed around 1.6 billion measurement samples between April and September 2019. We have conducted a thorough analysis of this extensive data base, using an even more refined crowdsourcing methodology compared to previous years.

MOVISTAR TAKES THE LEAD IN THE CROWD EVALUATION, SLIGHTLY AHEAD OF ORANGE AND VODAFONE. YOIGO FOLLOWS AT A DISTANCE.

While the drivetests and walktests 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 14. Based on the total population count of 46.7 million people, one of 303 inhabitants of Spain have provided relevant samples to our crowd data. The test area of our crowdsourcing represents 81.9 per cent of the built-up area of Spain and even 99.2 per cent of the urban built-up area.

COVERAGE

ALL NETWORKS

OVERALL, GOOD COVERAGE RESULTS IN ALL FOUR SPANISH NETWORKS
Starting in 2019, we differentiate the coverage in urban and non-urban areas. The coverage with voice services is at a very high level in all four networks. Urban data coverage is particularly high at Yoigo, Movistar and Vodafone, while Orange falls slightly behind. In non-urban areas, all operators achieve good results. As could be expected, the coverage with 4G services is a little lower. In this category, Movistar and Vodafone take the lead in urban areas. In non-urban areas, Movistar and Orange score highest.

Crowd	Vodafone	Orange	Movistar	Yoigo
Crowd Country — Operational Excellence				
Number of degraded days (d)	0	0	0	0
Number of degraded periods (-)	0	0	0	0
Crowd Urban				
Voice Coverage (%)	99.4	99.7	99.7	99.6
Data Coverage (%)	99.5	98.8	99.6	99.7
4G Coverage (%)	95.4	94.5	95.6	92.7
DL Data Speed (Mbit/s)	71.2	76.2	72.1	50.9
UL Data Speed (Mbit/s)	26.7	26.7	23.7	16.7
Crowd Non-Urban (Benchmark view)				
Voice Coverage (%)	99.8	99.6	99.9	99.9
Data Coverage (%)	99.8	99.6	99.9	99.8
4G Coverage (%)	97.3	98.2	98.6	97.5
DL Data Speed (Mbit/s)	29.3	31.6	29.9	25.7
UL Data Speed (Mbit/s)	7.6	8.4	6.8	5.0
Crowd Non-Urban (Own network view)				
Voice Coverage (%)	99.6	99.2	99.7	99.8
Data Coverage (%)	99.5	99.0	99.6	99.7
4G Coverage (%)	95.6	96.0	97.3	96.6
DL Data Speed (Mbit/s)	26.5	28.0	26.8	23.8
UL Data Speed (Mbit/s)	5.7	6.0	5.1	4.1

Crowd ✱

200 of 1000 Points

■ Vodafone
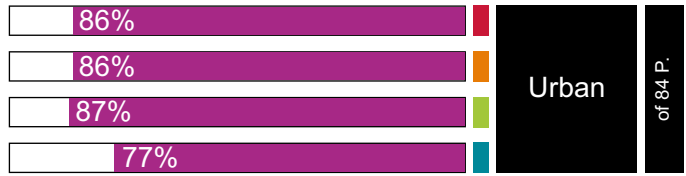■ Orange
■ Movistar
■ Yoigo

DATA SPEEDS

ORANGE

ORANGE DELIVERS BEST USER DOWNLOAD AND UPLOAD SPEEDS

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

In the overall assessment, Orange shows the best speeds both for downloads and uploads and also both in urban and non-urban areas. Movistar ranks second in the download speed metrics, whereas Vodafone is rated second in the upload scenario. In this category, Yoigo falls behind in all considered aggregations.

However, when comparing the determined average data rates to the theoretical maximum data speeds of today's mobile transmission standards, it should be taken into consideration that a part of the actual user base probably experiences data speed limitations caused by their mobile tariffs.

100%	Country	of 60 P.
100%		
100%		
100%		
86%	Urban	of 84 P.
86%		
87%		
77%		
88%	Non-Urban Benchmark view	of 44 P.
90%		
90%		
85%		
83%	Non-Urban Own network view	of 12 P.
83%		
85%		
81%		

OPERATIONAL EXCELLENCE

ALL NETWORKS

NO DEGRADATIONS IN ANY OF THE SPANISH NETWORKS FROM MID-APRIL TO END OF SEPTEMBER 2019

Examining the Data Service Availability in the observation period from mid-April to end of September 2019), shows a very pleasant result: In the considered period we could not identify any degradations in any of the four Spanish networks – thus confirming a very high degree of Operational Excellence for all four Spanish operators. This results in awarding the full amount of possible points to each of the candidates in this category.

” CROWD RESULTS AT A GLANCE

In the crowd-based score, Movistar takes the lead, slightly ahead of Orange and Vodafone. Yoigo comes in fourth with a distinct gap towards its competition.
Overall, all four Spanish networks achieve good coverage results, with Yoigo falling slightly behind the competition regarding 4G coverage in urban areas.
In the analysis of data speeds, Orange takes the lead for downloads and uploads both in urban and non-urban areas. As we could not identify any anomalies in Data Service Availability during the entire 24 weeks under consideration, all four Spanish operators receive the maximum score for Operational Excellence.

CASE STUDY: 5G MEASUREMENTS

As Vodafone already rolled out some first 5G network cells in Madrid, our drivetest team seized the opportunity to take some first measurements of these early 5G deployments.

All over the world, operators are starting to establish 5G mobile networks or extend their existing infrastructures with first 5G cells. These first 5G "islands" are still too scarce to already factor in 5G measurements in this year's benchmarks. But of course, umlaut and connect take a great interest in finding out what early 5G deployments already offer to their users.

Therefore we have decided to perform 5G-based measurements in selected countries as a case study.

MEASUREMENT SCENARIOS FOCUSED ON 5G DATA CONNECTIVITY

In Spain, we took a closer look at selected 5G locations of the Vodafone network, conducting drive-tests in the metropolitan area of Madrid. This was done with Samsung Galaxy S10 5G devices on two measurement days – on the first day we used the setting "5G preferred", on the second one we switched the smartphone to "4G preferred". The measurements concentrated on data connectivity – we did not perform any voice measurements. We then evaluated the results of these data tests based on our 2019 methodology. The focus of these assessments is comparing the performance of 5G with that of 4G.

### SIGNIFICANTLY HIGHER DATA RATES AND LOWER LATENCY

The findings of these tests confirm what could be expected – but were nonetheless quite impressive: The peak download data rates in 5G mode rose up to 511.5 Mbps. Cross checks performed with LTE phones only achieved 218.3 Mbps at the same locations even with four carrier (4CA) aggregation. Upload data rates also benefited from 5G, but to a lesser extent: The maximum 5G upload speed was determined at 69.6 Mbps as compared to 50.4 Mbps in LTE-only mode.

As has been frequently stated, 5G is not only about high data rates but even more about low latencies. This was also confirmed by our measurements: Pings to several web services showed an average latency of around 47 to 50 ms via LTE. In 5G mode, the same pings decreased to around 20 ms.
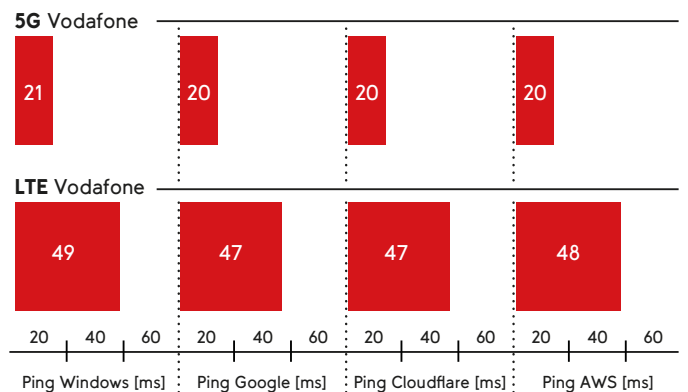
Keeping in mind that 5G stands only at its very beginning, these are very impressive results – which indicate a bright and high-performance future for connected mobile services. We very much look forward to keep accompanying this development.
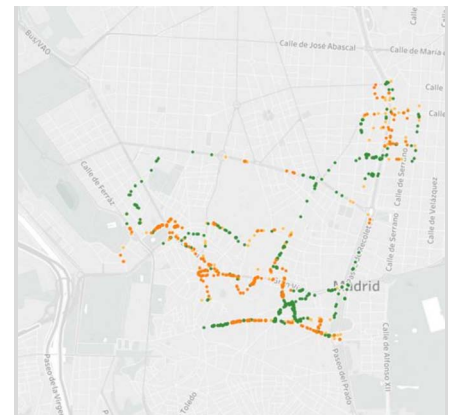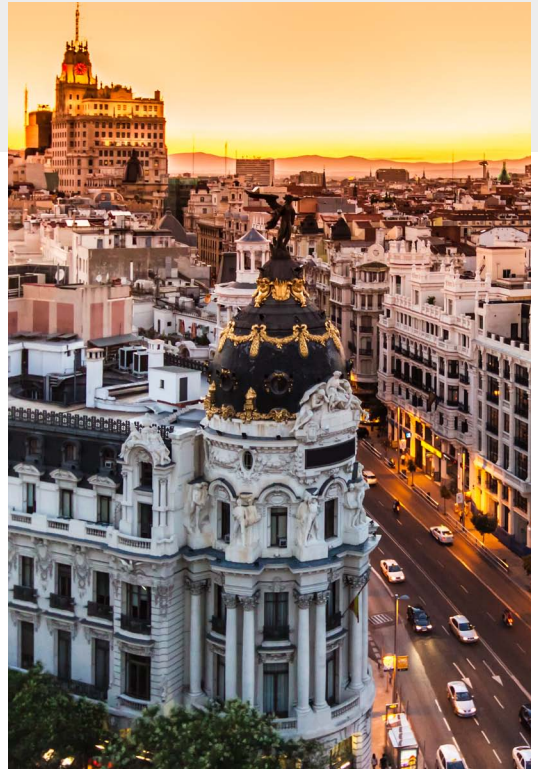
The orange colored spots mark areas where the 5G test systems actually had a 5G connection to the Vodafone network in the inner-city areas of Madrid.

HTTP Downloads (Mbps)

Vodafone	5G	LTE	LTE 2CA	LTE 3CA	LTE 4CA
	511.5	149.1	124.5	210.6	218.3
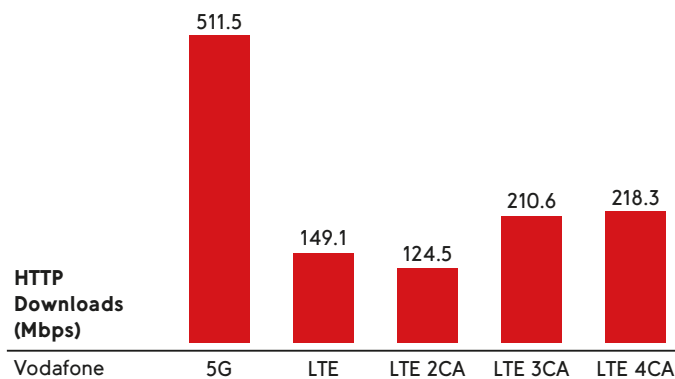
5G download speeds are significantly higher than those of LTE – even with various levels of carrier aggregation.

5G Vodafone

Ping Windows [ms]	Ping Google [ms]	Ping Cloudflare [ms]	Ping AWS [ms]
21	20	20	20

LTE Vodafone

Ping Windows [ms]	Ping Google [ms]	Ping Cloudflare [ms]	Ping AWS [ms]
49	47	47	48

The latencies or "ping times" determined in the 5G network are also clearly lower than those measured in 4G mode.

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.
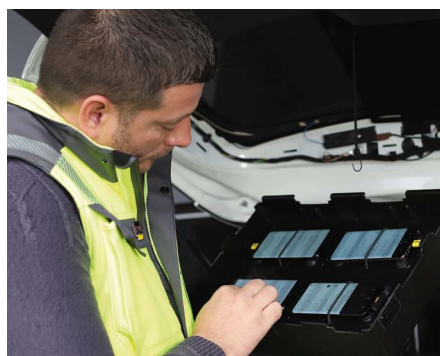
The umlaut connect Mobile Benchmark Spain comprises of the results of extensive voice and data drivetests and walktests as well as a sophisticated crowdsourcing approach.

DRIVETESTS AND WALKTESTS

The drivetests and walktests in Spain took place between late September and mid-October 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 1,900 kilometres per car – 7,630 kilometres for all four cars. In total, the four vehicles together have covered about 11,570 kilometres.

The combination of test areas has been selected to provide representative test results across the Spanish population. The areas selected for the 2019 test account for 11.7 million people, or roughly 25.2 per cent of the total popula-

tion of Spain. The test routes and all visited cities and towns are shown on page 1 of this report.

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 walktest 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

Two boxes were mounted into the rear and side windows of each measurement car in order to support eight smartphones per car.

P90 value. Such values specify the threshold in a statistical distribution, below which 90 per cent 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 2019, 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 per cent 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 ▶

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.

a test server located in the cloud. 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 per cent of the total results.

CROWDSOURCING

Additionally, umlaut conducted crowd-based analyses of the Spanish networks which contribute 20 per cent to the end result. They are based on data gathered between mid-April and end of September 2019.

For the collection of crowd data, umlaut has integrated a background diagnosis processes 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 considered 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-timeslices, for each of which we
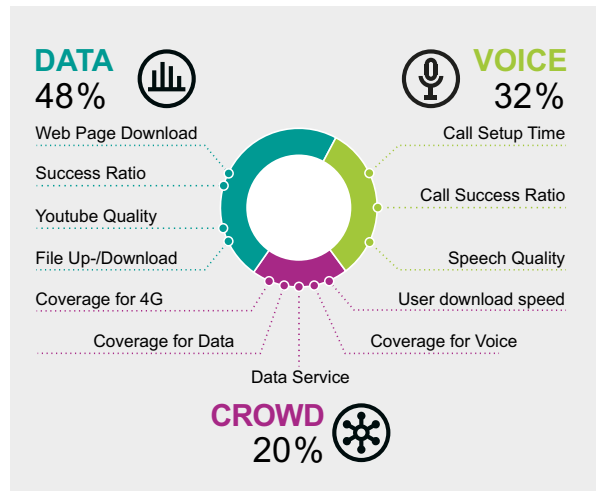
determine the P90 value. For the final calculation of this KPI we then calculate the average of the results of the six timeslices.

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 fulfill 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.

DATA 48%
- Web Page Download
- Success Ratio
- Youtube Quality
- File Up-/Download
- Coverage for 4G
- Coverage for Data

VOICE 32%
- Call Setup Time
- Call Success Ratio
- Speech Quality
- User download speed
- Coverage for Voice
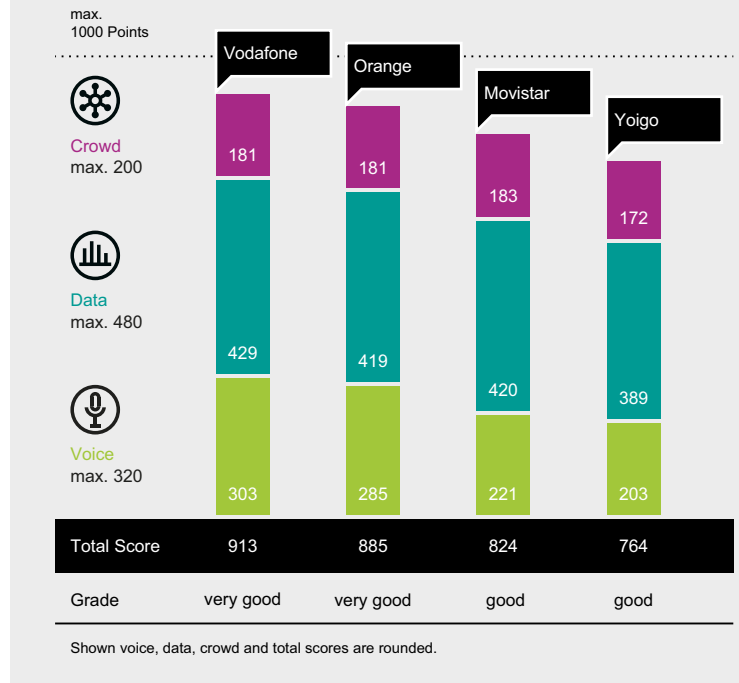
Data Service

CROWD 20%

CONCLUSION

Vodafone wins for the fifth time in a row. Orange manages to defend its second rank and shows the most distinct score improvements over last year's results. Movistar ranks third and Yoigo fourth, both with overall "good" results.

The clear winner of the umlaut connect Mobile Benchmark Spain is Vodafone – for the fifth time in a row. Orange succeeds in defending the second rank, which it took last year from its constant rival Movistar. Achieving a substantial improvement over it's 2018 score, Orange solidifies its position. Like the winner, Orange also achieves the overall grade „very good".

Movistar ranks third overall but still holds the second position in the data discipline. As in the previous year, the Telefónica brand achieves the grade „good". The same is applicable for the smallest Spanish operator, Yoigo. In the overall assessment, Yoigo loses some points but also manages to improve in some areas such as the reliability of data connections on rural roads.

In our crowdsourced assessment which is designed to augment and verify the drivetest and walktest results, Movistar takes the lead from Orange. In the Data Service Availability category, we could not identify any degradations in any Spanish network in the whole 24-week evaluation period. And our first trial measurements for 5G in the Vodafone network emphasize the distinct advantages of this future mobile communications standard.

	max. 1000 Points				
Crowd max. 200		Vodafone 181	Orange 181	Movistar 183	Yoigo 172
Data max. 480		429	419	420	389
Voice max. 320		303	285	221	203
Total Score		**913**	**885**	**824**	**764**
Grade		very good	very good	good	good

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

Overall Results		Vodafone	Orange	Movistar	Yoigo
Voice	max. 320 P.	303	285	221	203
Cities (Drivetest)	144	94%	87%	68%	64%
Cities (Walktest)	48	98%	93%	69%	64%
Towns (Drivetest)	64	98%	97%	71%	70%
Roads (Drivetest)	64	92%	82%	71%	55%
Data	max. 480 P.	429	419	420	389
Cities (Drivetest)	216	89%	88%	88%	82%
Cities (Walktest)	72	91%	85%	86%	76%
Towns (Drivetest)	96	89%	88%	87%	82%
Roads (Drivetest)	96	88%	86%	88%	83%
Crowdsourced Quality	max. 200P.	181	181	183	172
Country	60	100%	100%	100%	100%
Urban	84	86%	86%	87%	77%
Non-urban (Benchmark view)	44	88%	90%	90%	85%
Non-urban (Own network view)	12	83%	83%	85%	81%
Connect Rating	max. 1000 P.	913	885	824	764

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

1 vodafone

For the fifth time in a row, Vodafone is the winner of our Mobile Benchmark in Spain. The operator clearly leads both in the voice and data categories. Also, providing us with an outlook at the capabilities of 5G connectivity, Vodafone proves that it is well positioned for the future.

2 orange™

Orange keeps the second rank which it took from its constant rival Movistar in the previous year. Showing an overall "very good" performance, the operator ranks second in the voice and crowdsourcing disciplines and third by a close margin in the data assessment. It managed to distinctly improve its score over the previous year.

3 movistar

With strong data results and an overall good voice score, the largest Spanish operator ranks third. It achieved the best result in our crowdsourcing evaluations. Compared to its 2018 scores, the Telefónica brand has lost some points, but it managed to still achieve the overall grade "good".

4 yoigo

Spain's smallest operator scores fourth, but still achieves the overall grade "good". In comparison to last year's results, Yoigo lost some points. But the operator manages to improve in some areas such as the reliability of data connectivity evaluated in our drive-tests on rural roads.