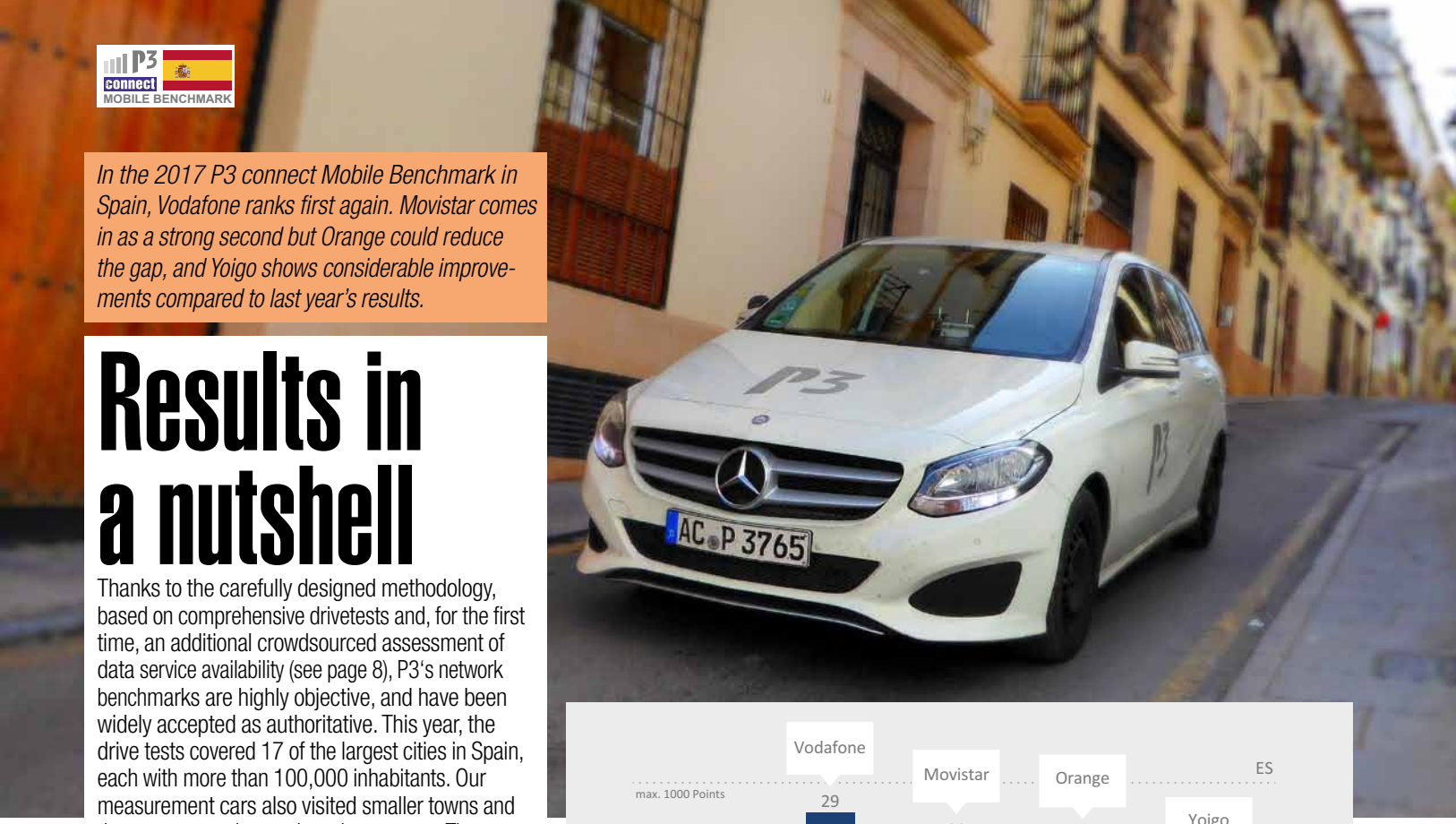
The 2017 Mobile Network Test in Spain

For the third time in a row, the consulting, engineering and testing company P3 communications and connect magazine have examined the Spanish mobile networks. As all of Spain's four mobile operators have worked hard to improve regarding performance and coverage, the P3 connect Mobile Benchmark Spain promises interesting results. Which network is the best choice for voice and for data communications? And how does our new crowdsourced operational excellence score affect the results?



In the 2017 P3 connect Mobile Benchmark in Spain, Vodafone ranks first again. Movistar comes in as a strong second but Orange could reduce the gap, and Yoigo shows considerable improvements compared to last year's results.

Results in a nutshell

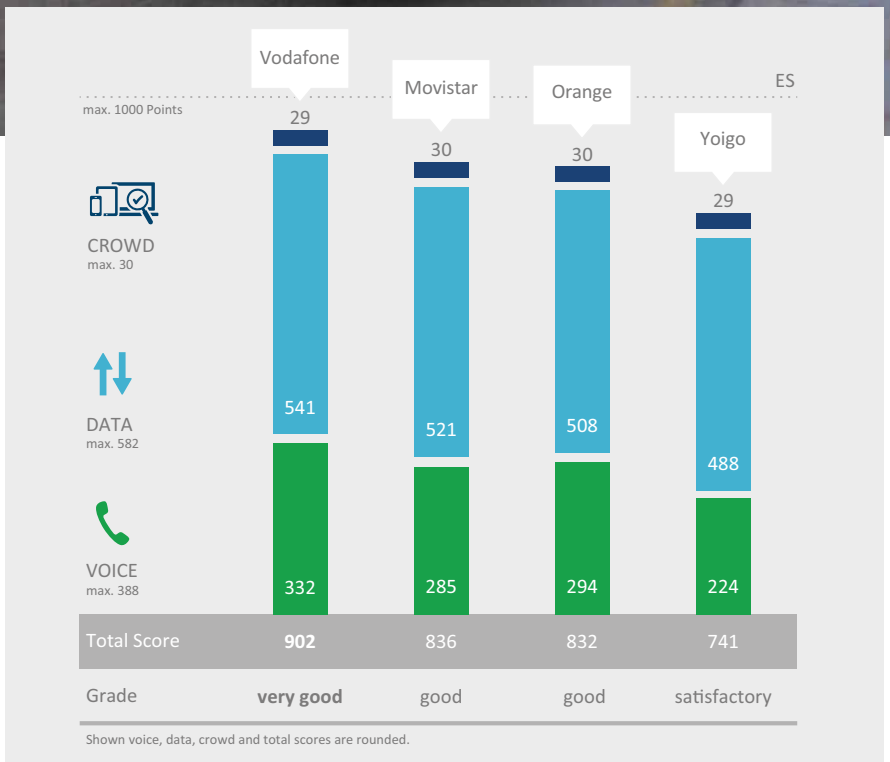
Thanks to the carefully designed methodology, based on comprehensive drivetests and, for the first time, an additional crowdsourced assessment of data service availability (see page 8), P3's network benchmarks are highly objective, and have been widely accepted as authoritative. This year, the drive tests covered 17 of the largest cities in Spain, each with more than 100,000 inhabitants. Our measurement cars also visited smaller towns and drove on connecting roads and motorways. The areas in which we tested account for more than 11.5 million people, or almost 25 per cent of the Spanish population.

P3's rigorous measurements included the use of up-to-date LTE Cat 9 as well as VoLTE-capable smartphones for the tests. Also, we constantly re-adjust the thresholds of our evaluation. With steps like these, we reflect the latest technical developments in the mobile networks and once more emphasise the scope of our benchmarking: How do the mobile networks perform at the edge of what is technically feasible – and to what extent do customers benefit from these capabilities? In order to provide valid answers to these questions, we have used the most comprehensive mobile plans available from each operator.

Substantial improvements in the Spanish networks, Vodafone once again clear winner

Almost all Spanish operators improved their performance levels in comparison to our 2016 mobile network benchmark. For the third time in a row, the overall winner is Vodafone with the grade "very good", showing clear improvements in the data discipline and similar voice results as in 2016. A reduction in the total voice points can be explained with the addition of the crowd score resulting in adjustments in the maximum achievable points in the other disciplines.

Movistar comes in second with the overall grade "good". In comparison to 2016 and also to its competitors Vodafone and Orange, Movistar falls a little behind in the voice category, but can make up for this with strong data results. Orange still ranks third and achieves the grade "good", as in 2016, but manages to reduce the gap to Movistar thus showing a clear overall improvement. The smallest Spanish operator Yoigo ranks last again, but achieves considerable improvements, particularly in the data category. This results in the rating "satisfactory", which is a full grade above its last year's result.



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

Overall Results Voice and Data		Vodafone	Movistar	Orange	Yoigo
Voice	max. 388	332	285	294	224
Cities (Drivetest)	232.8	89 %	73 %	80 %	65 %
Towns (Drivetest)	77.6	88 %	80 %	75 %	57 %
Roads (Drivetest)	77.6	74 %	68 %	64 %	37 %
Data	max. 582	541	521	508	488
Cities (Drivetest)	349.2	96 %	92 %	90 %	88 %
Towns (Drivetest)	116.4	93%	88 %	87 %	82 %
Roads (Drivetest)	116.4	85 %	84 %	80 %	74 %
Crowd	max. 30	29	30	30	29
2017-08	10	100 %	100 %	100 %	90 %
2017-09	10	100 %	100 %	100 %	100 %
2017-10	10	90 %	100 %	100 %	100 %
Connect Rating	max. 1000	902	836	832	741

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

The Spanish mobile network market is highly competitive with the top three contenders permanently competing over market share. Also, all four Spanish operators have constantly increased their LTE coverage and speeds.

Spain's operators

movistar

Movistar is the brand name that 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 present in 21 countries with a total of 127,000 employees and achieved worldwide revenues of over €52 billion in 2016.

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 15.3 million subscribers, which equals a market share of roughly 32 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 of 150 Mbps. The operator claims to reach 89 per cent of the Spanish population with its 4G network.

vodafone

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 now reports 14.4 million mobile customers, adding up to a market share of about 30 per cent and making Vodafone the second largest operator in the country with a narrow lead over its competitor Orange.

In the fiscal year 2016/2017, Vodafone Spain achieved revenues of €4.5 billion which contributes about nine per cent to the whole Vodafone Group's financial result.

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 downlink speeds of 300 Mbps.

Vodafone España claims to offer the best LTE coverage in Spain, reaching approximately 94 per cent of the Spanish population.

orange™

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 on the internet. Also, its network serves a number of mobile virtual network operators such as MasMovil, Carrefour Móvil and others. With 14.1 million customers, Orange is the third largest Spanish mobile operator with a market share of about 29 per cent. In the fiscal year 2016, Orange Spain achieved a revenue of €5 billion which contributed 12 per cent to the whole Orange Group's results.

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 93 per cent of the Spanish population. Also, Orange is the first Spanish operator to offer VoLTE to its 4G customers.

yoigo

Yoigo was the latest mobile operator to enter the Spanish market. Founded in the year 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". This name was supposed to reflect the simplicity and ease in rates as well as in the use of the service. In June 2016, the former MVNO (mobile virtual network operator) Másmóvil bought the company.

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.

The current customer base of Yoigo is 4.2 million subscribers, which equals a market share of 9 per cent.

Today, Yoigo operates 3G at 2100 MHz as well as 4G at 1800 MHz. The operator currently claims a LTE coverage of approximately 89 per cent of the Spanish population.

A close look at Spain's networks

In the past three years, Vodafone won, with Movistar and Orange constantly competing for the second rank, and Yoigo steadily working on improvements. How do the Spanish operators score in 2017?

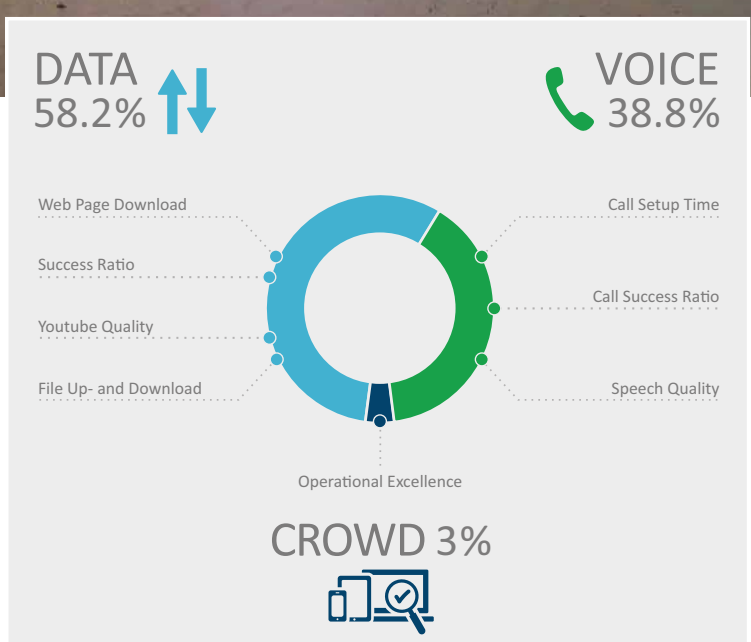
P3 communications GmbH, based in Aachen, Germany, is a world leader in mobile network testing. It is part of the P3 group, with over 3000 employees worldwide and a turnover of more than €300 million. P3 is partnering with the international telecommunications magazine connect, which has more than 20 years of editorial expertise and is one of the leading test authorities in Europe for telecommunications products and services.

Together, P3 and connect have been conducting the most important network benchmark test in Germany for 15 years, extending it to Austria and Switzerland in 2009. Since 2014, the range of public benchmarks has continuously been expanded, today covering Spain, the Netherlands, Sweden, the UK and Australia.

In 2016 alone, P3 compiled more than 60,000 measurement hours in 65 countries across five continents, with its test vehicles covering more than one million kilometres. As the de-facto industry standard, the P3 benchmarking methodology focuses on customer-perceived network quality – examining voice telephony that makes up 38.8 per cent of the result, data connectivity that contributes 58.2 per cent as well as operational excellence, currently accounting for three per cent of the total result. P3's network benchmarks are widely accepted as a completely objective authority.

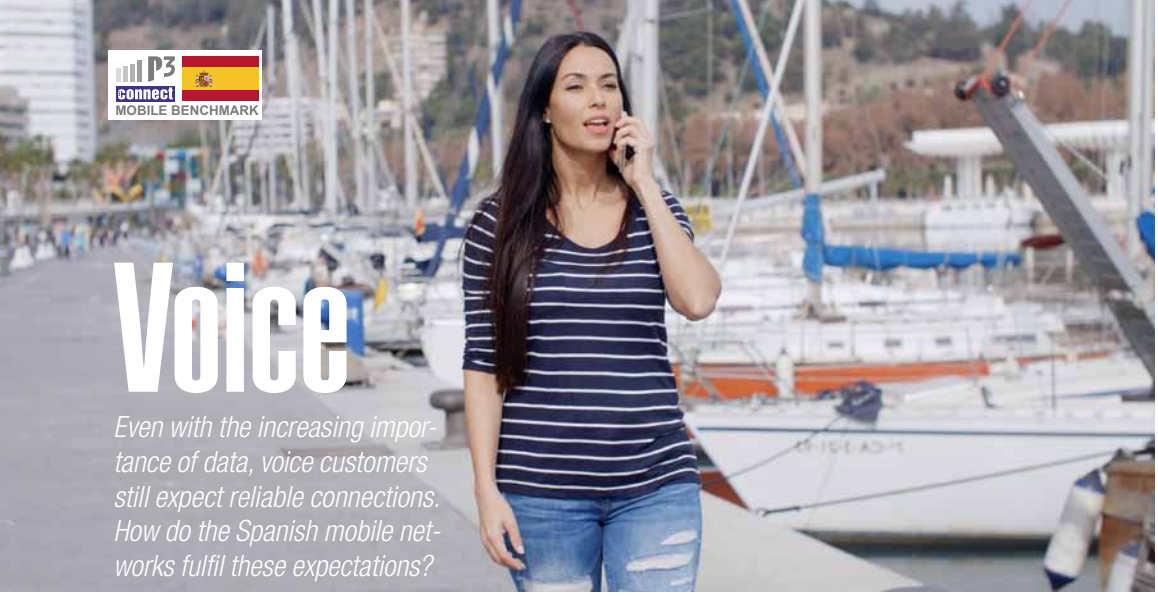
New Crowd Score confirms the established ranking order

In order to also reflect the operational excellence of the Spanish networks, we have added a crowdsourcing component to our methodology (see page 8). But even these additional results only underline the familiar ranking order in Spain – see the details for yourself on the following pages.



Hakan Ekmen, Managing Director of P3 communications GmbH.

"All operators took the challenge of the P3 connect Mobile Benchmark and have increased their LTE coverage. In 2018, over the top content services, technologies like carrier aggregation and voice over LTE as well as crowdsourcing-based use cases will become more important. This will make the results even more exciting."



Voice

Even with the increasing importance of data, voice customers still expect reliable connections. How do the Spanish mobile networks fulfil these expectations?

On their tour through Spain, P3's four test cars visited 17 of the largest Spanish cities and many smaller towns and also covered the connecting roads. For the voice rating, each car carried eight Samsung Galaxy S7 smartphones that permanently called each other. The connected testing equipment registered success ratios, setup times and speech quality. In order to simulate normal smartphone usage, data transfers took place in the background of the test calls.

Vodafone ranks best in voice and overall, Orange is second in the voice discipline

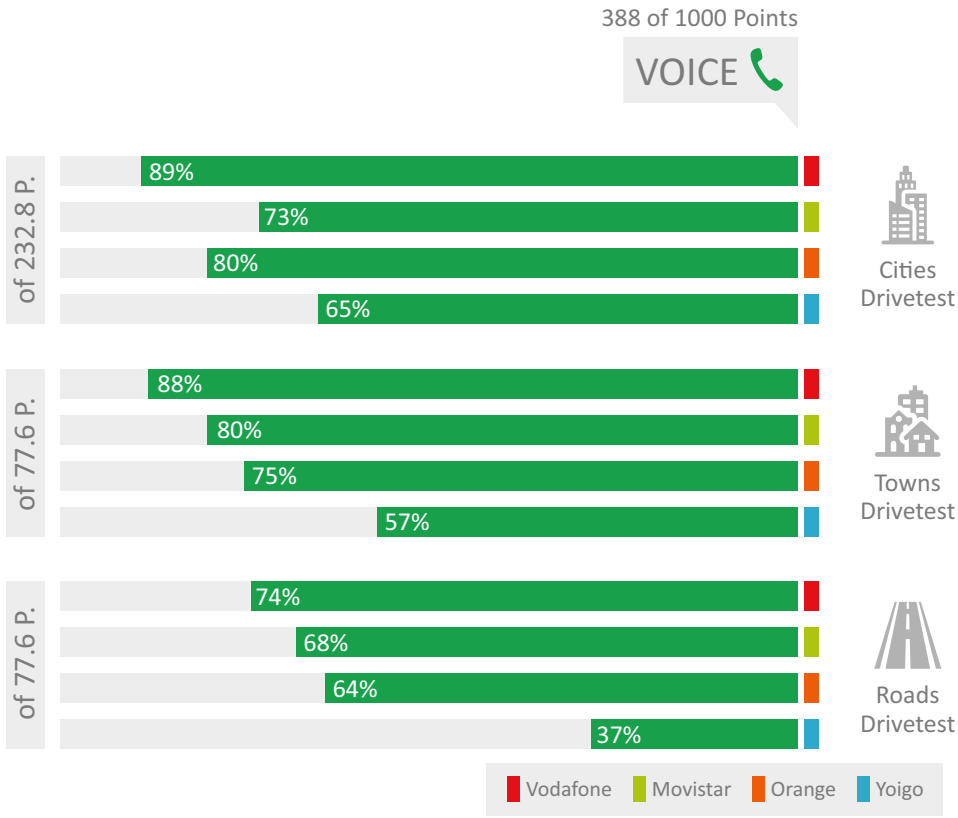
At the time of testing, Orange was the only operator that offered VoLTE (Voice over LTE) to its customers. This resulted in fastest call setup times in all categories. However, Vodafone delivered the best speech quality and also showed excellent success ratios especially in big cities and smaller towns.

In terms of call success ratios, Movistar follows closely behind Vodafone and takes the lead on connecting roads. When analysing speech quality, Movistar is on par with Orange in big cities and slightly ahead of Orange in towns and on the roads. In the overall voice ranking, however, Orange comes in second after Vodafone due to the significantly faster call setup times, relegating Movistar to the third rank.

Yoigo's results are particularly interesting, bearing in mind, that the smallest contender recently switched from Movistar to Orange for national roaming. Yoigo still scores clearly behind its competitors. In comparison to the previous year, Yoigos voice results declined somewhat in the bigger cities and considerably in smaller towns, while they noticeably improved on the connecting roads.

VOICE RESULTS AT A GLANCE

Vodafone delivers the best results in all tested voice categories. Orange achieves a second rank, probably due to its unique VoLTE offering. Movistar had the best success ratios on connecting roads. Yoigo ranks last with mixed results compared to the previous year.



Voice - Drivetest	Vodafone	Movistar	Orange	Yoigo
Cities				
Call Success Ratio (%)	99.8	98.2	98.1	97.4
Call Setup Time (s)	5.2	7.5	4.5	7.8
Speech Quality (MOS-LQO)	3.6	3.3	3.3	3.0
Towns				
Call Success Ratio (%)	99.8	99.4	97.0	95.9
Call Setup Time (s)	5.5	7.2	4.2	7.4
Speech Quality (MOS-LQO)	3.5	3.4	3.3	2.9
Roads				
Call Success Ratio (%)	95.9	96.1	92.9	88.9
Call Setup Time (s)	5.7	7.6	4.8	8.0
Speech Quality (MOS-LQO)	3.4	3.3	3.2	2.7

Data

The volume of transmitted data is steadily growing. So, all operators face the challenge how to maintain data rates and reaction times at a high level. Which of the Spanish operators manages to best meet the growing demand?

The volume of mobile data downloads and uploads is exponentially growing. 4G/LTE currently is the best technology to cope with these increasing demands, while all Spanish 4G networks have increased their coverage in terms of the population. While Movistar, Orange and Vodafone also compete about who delivers the highest data rates, Yoigo is still mainly concentrating on expanding its LTE footprint. According to its own claims (also see page 3), the smallest Spanish contender has now reached 89 per cent 4G coverage of the Spanish population.

P3's testing rewards coverage and stability as well as fast data rates. The benchmarking of web-page downloads as well as file downloads and uploads is testing the maximum throughputs available to customers. At the same time, it assesses the networks' availability and stability by examining success ratios.

In order to assess typical performance as well as peak speeds, we determined 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.

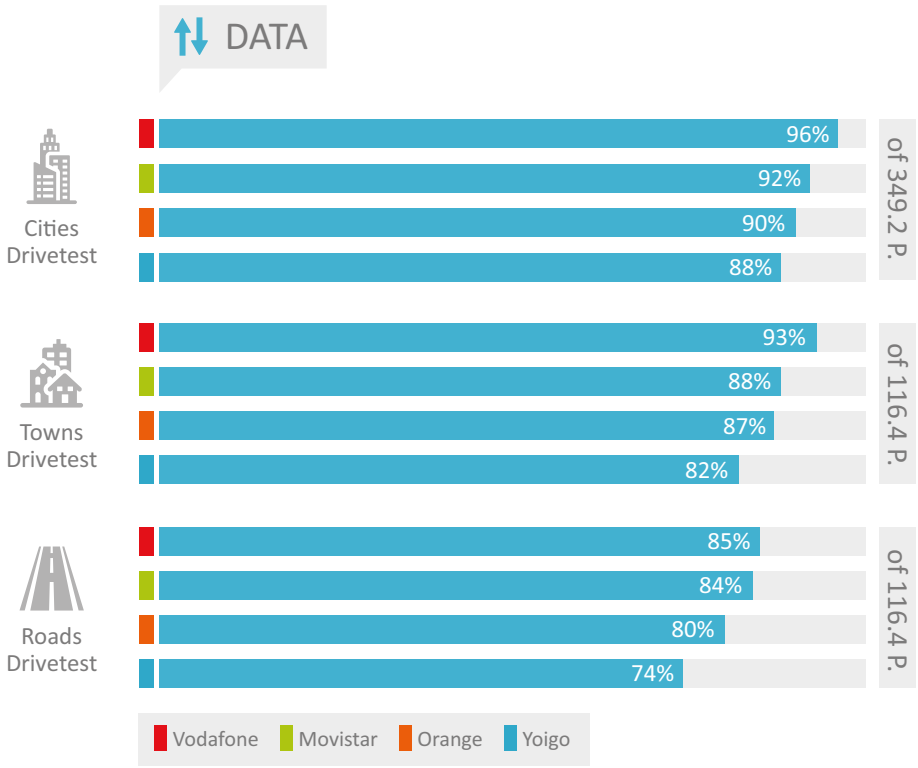
P3's approach for Youtube testing recognises that the popular video service uses adaptive bit rates. This method strives for a better user experience, subordinating pixel resolution to stable playback. As a consequence, besides success ratios, start times and the absence of interruptions, we have added the average video resolution as another important performance indicator.

Vodafone leads in data in the cities, but faces strong competitors – including Yoigo

The results show that all operators offer a mature level of LTE coverage in the big cities. Here, all four Spanish networks show excellent success ratios. All four candidates reach their best performance values in this environment, but in contrast to the previous year, the gap between big cities and smaller towns has narrowed.

In the web-page category examined in the cities, Orange comes in closely behind Vodafone and with a narrow lead over Movistar. However, on the whole Movistar achieves the second rank in the "data in cities" category – mainly due to higher data rates achieved in the file downloads and uploads.

Yoigo ranks behind the other three contenders also in this category – but presents its strongest data results in the cities. With high success ratios and data rates not far behind the middle field, Yoigo is a serious alternative for data communications in the cities. >>



Data in Cities - Drivetest	Vodafone	Movistar	Orange	Yoigo
Web-Page Download (Live/Static)				
Success Ratio (%/%)	99.7/99.9	99.6/99.7	99.6/99.9	99.3/99.5
Static: Avg. Session Time (s)	1.2	1.6	1.5	1.3
Live: Reaction Time (ms)	555	595	594	597
Live: Initial DL Speed 1st second (kB/s)	511	435	458	474
File Download (3 MB)				
Success Ratio/Avg. Session Time (%/s)	99.9/0.9	99.9/1.3	99.9/1.7	99.7/2.0
90%/10% faster than (kbit/s)	19228/66852	15660/58111	9828/47337	9448/39933
File Upload (1 MB)				
Success Ratio/Avg. Session Time (%/s)	100.0/0.7	99.8/0.8	99.8/1.1	98.9/1.2
90%/10% faster than (kbit/s)	9632/26490	8778/23669	5146/18463	4378/19608
File Download (7 Seconds)				
Success Ratio (%)	99.8	99.8	99.9	99.8
Avg. Throughput (kbit/s)	67792	54290	46620	32713
90%/10% faster than (kbit/s)	22992/128199	19175/97874	13452/89111	12067/57974
File Upload (7 Seconds)				
Success Ratio (%)	99.8	99.8	99.7	98.4
Avg. Throughput (kbit/s)	33284	28638	24580	19645
90%/10% faster than (kbit/s)	13044/45368	10955/39483	6283/40058	5039/30202
Youtube Video				
Success Ratio/Start Time (%/s)	99.9/2.0	99.4/2.3	99.3/2.2	99.6/2.1
Playouts without Interruptions (%)	100.0	99.2	99.8	99.7
Average Video Resolution (p)	1080	1078	1076	1077

All operators have improved in smaller towns
In the smaller towns, the four Spanish operators show similar results and a similar ranking order as in the bigger cities. The best news, however, is that the reliability and performance of each Spanish mobile network has clearly improved over last year's results. Another nice observation are the excellent Youtube results of all Spanish networks that we determined in the towns as well as in cities and even on the roads. Watching video streams on the go in Spain in 2017 is a far more pleasant experience than it used to be one year ago.

Yoigo shows biggest improvement in data
What was true for the smaller towns, also applies to the connecting roads: The ranking order in the data disciplines remains the same in all tested categories. And, in comparison to 2016's results, all operators clearly managed to improve their scores. This is especially applicable for Yoigo, which only achieved 41 per cent of the possible points in this category in the previous year, and improved its score to a respectable 74 per cent this time. This is a truly remarkable result for Spain's smallest contender.

Overall, Movistar ranks second in data discipline
In the overall examination, Movistar ranks second in the data discipline after a strong Vodafone – but also Orange is following at a not too far distance.

Data in Towns - Drivetest	Vodafone	Movistar	Orange	Yoigo
Web-Page Download (Live/Static)				
Success Ratio (%/%)	99.6/99.9	99.4/99.5	99.8/99.8	99.1/98.6
Static: Avg. Session Time (s)	1.4	1.8	1.7	1.5
Live: Reaction Time (ms)	574	615	611	644
Live: Initial DL Speed 1st second (kB/s)	501	423	434	442
File Download (3 MB)				
Success Ratio/Avg. Session Time (%/s)	100.0/1.2	99.6/1.5	100.0/2.2	99.3/2.7
90%/10% faster than (kbit/s)	13085/65164	14148/57307	7790/36997	6373/37975
File Upload (1 MB)				
Success Ratio/Avg. Session Time (%/s)	99.6/0.9	99.0/1.1	98.7/1.3	98.3/1.6
90%/10% faster than (kbit/s)	7212/25974	5978/22198	4233/16333	2471/17058
File Download (7 Seconds)				
Success Ratio (%)	100.0	99.4	99.8	99.1
Avg. Throughput (kbit/s)	61961	56386	41829	32814
90%/10% faster than (kbit/s)	17599/110722	18376/102061	10086/78764	10409/57006
File Upload (7 Seconds)				
Success Ratio (%)	99.6	99.2	98.7	98.9
Avg. Throughput (kbit/s)	27175	24633	21754	17065
90%/10% faster than (kbit/s)	7587/45771	7294/37936	5064/39155	3246/30524
Youtube Video				
Success Ratio/Start Time (%/s)	99.8/2.1	98.2/2.3	99.2/2.3	97.9/2.3
Playouts without Interruptions (%)	99.1	99.6	99.2	99.2
Average Video Resolution (p)	1075	1075	1074	1074

DATA RESULTS AT A GLANCE

Vodafone also clearly wins the data categories, resulting in the overall win of this benchmark. Movistar ranks second in all tested data scenarios, with Orange closely following. Yoigo still ranks last, but improved its results considerably over the previous year's P3 connect Mobile Benchmark in Spain. Especially pleasant is the distinct advancement of the results in smaller towns and on the connecting roads – the Spanish operators have obviously taken great efforts to narrow the former gap over the big cities.

Data on Roads - Drivetest	Vodafone	Movistar	Orange	Yoigo
Web-Page Download (Live/Static)				
Success Ratio (%/%)	98.0/97.7	98.2/98.0	97.4/97.6	96.4/96.1
Static: Avg. Session Time (s)	1.6	2.0	2.0	1.9
Live: Reaction Time (ms)	625	796	724	808
Live: Initial DL Speed 1st second (kB/s)	436	372	390	371
File Download (3 MB)				
Success Ratio/Avg. Session Time (%/s)	98.5/2.2	99.1/2.3	98.7/3.2	97.4/3.5
90%/10% faster than (kbit/s)	5612/59850	6080/48622	3833/32810	4190/30480
File Upload (1 MB)				
Success Ratio/Avg. Session Time (%/s)	97.4/1.8	98.0/2.0	97.2/2.3	95.4/2.7
90%/10% faster than (kbit/s)	1941/22148	2029/18779	1770/14804	1383/14981
File Download (7 Seconds)				
Success Ratio (%)	98.6	98.9	98.8	97.0
Avg. Throughput (kbit/s)	40096	34970	30980	25588
90%/10% faster than (kbit/s)	6695/89252	6127/78118	5260/66989	4610/51588
File Upload (7 Seconds)				
Success Ratio (%)	96.2	97.2	95.1	93.5
Avg. Throughput (kbit/s)	19146	16260	14871	12630
90%/10% faster than (kbit/s)	2557/42503	2610/35219	2041/32800	1577/27890
Youtube Video				
Success Ratio/Start Time (%/s)	96.5/2.5	97.0/2.7	94.7/2.7	94.2/2.7
Playouts without Interruptions (%)	99.0	97.1	98.4	97.4
Average Video Resolution (p)	1061	1067	1060	1055

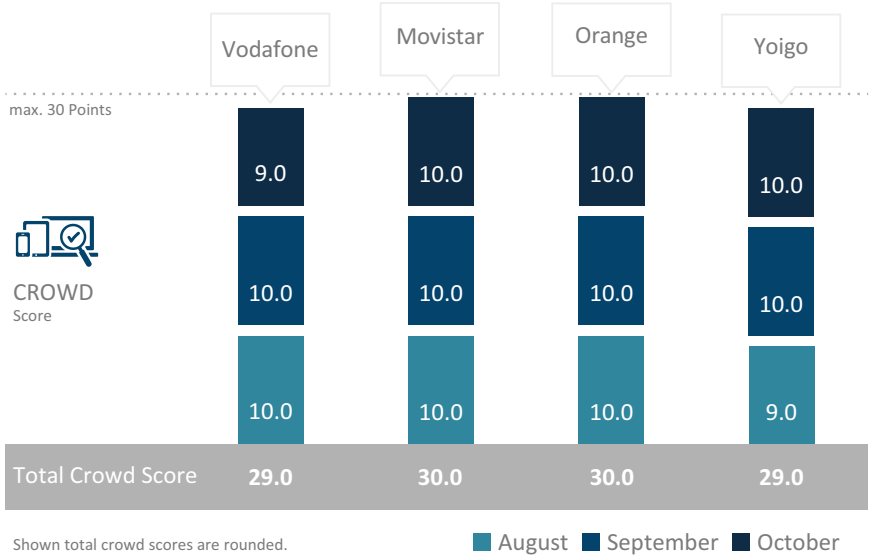
Operational Excellence

As an addition to our methodology, we have complemented our measurements with a new, crowdsourced assessment of service availability. In the 2017 P3 connect Mobile Benchmark in Spain the operational excellence results are included in the total score.

An additional important aspect of mobile service quality – complementing performance and measured values – is the actual availability of mobile connectivity to the customers. Obviously, even the best performing network is only of limited benefit to its users, if it is frequently impaired by outages or disruptions. Therefore, P3 has been looking into additional methods for the quantitative determination of network availability: collecting data via crowdsourcing. This method must however not be confused with the drivetests described on the previous pages. We are convinced that crowdsourcing can significantly enhance the aspects of benchmarking: Drivetesting has obvious advantages as a very controlled environment, while crowdsourcing accelerates when looking for longer time periods or geography beyond defined test routes. So, when it comes to diagnosing the sheer availability of the respective mobile networks, a crowdsourcing approach can provide additional insights. Therefore, P3 has developed an app-based crowdsourcing mechanism in order to assess how a large number of mobile customers experience the availability of their mobile network. We call this aspect “operational excellence”.

The P3 connect Mobile Benchmark in Spain is one of the first occasions where we expand our scoring scheme with the results of this crowdsourced investigation. As we have considered the results from August, September and October 2017, and each month is represented by a maximum of ten achievable points, in the benchmark at hand, the so called “crowd-score” contributes up to 30 points to the total result. >>

CROWD
3%



Shown total crowd scores are rounded.

The detailed methodology of our analysis and the calculation of the resulting points is described on page 11 of this report. As a consequence of this addition, the P3 connect Mobile Benchmark is the only mobile network test which combines the two aspects drivetesting and crowdsourcing, thus providing the most comprehensive view on network performance.

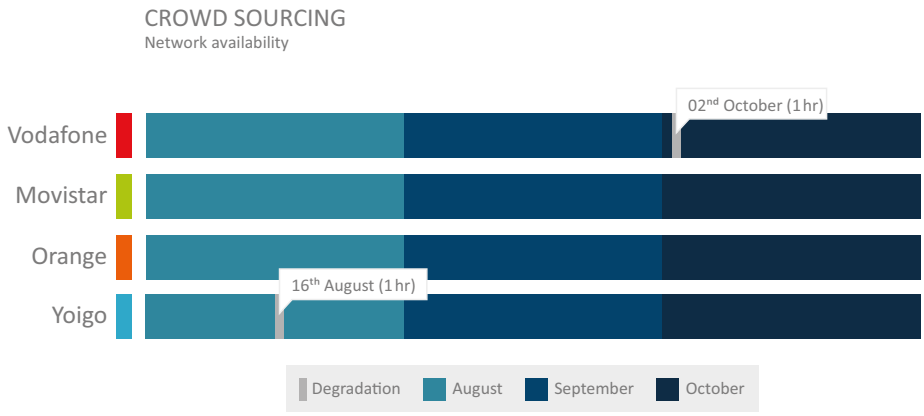
Crowdsourcing shows Spanish networks are highly reliable

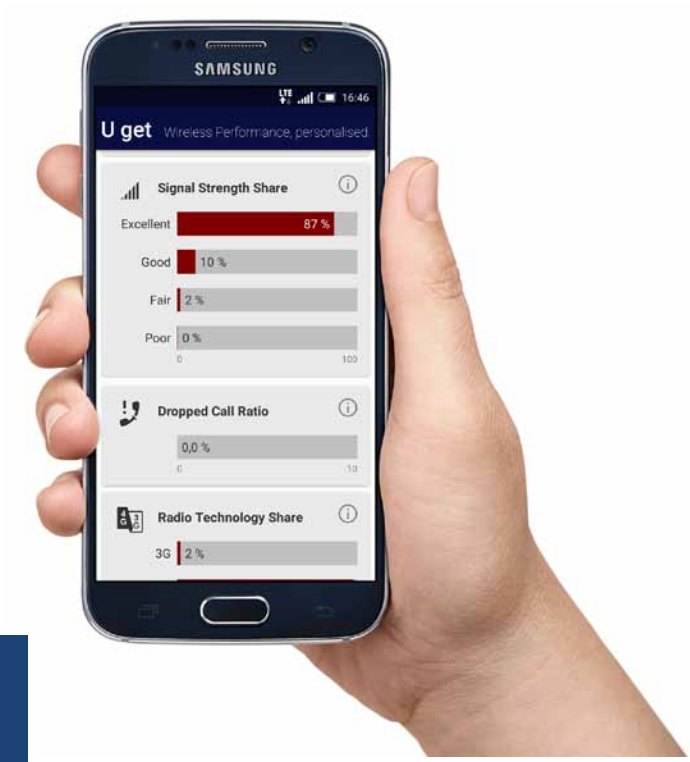
The in-depth analysis of our crowdsourcing data gathered in the three months preceding and including our measurement campaign in Spain, shows that the Spanish networks are all in all very stable and reliable. As degradations observed in the night hours between 0.00 a.m. and 6.00 a.m. are not accounted for, we did not register any incidents for Movistar and Orange during the observation period.

In the relevant period, Vodafone only suffered a one hour service degradation in the evening of October 2nd. According to our scoring principle, this one-hour degradation costs one point – so Vodafone scored a total of 29 out of 30 possible crowd score points.

In the Yoigo network, we registered an incident that occurred in the early morning of August 16th. As we only count degradations after 6.00 a.m., this also led to a take-off of one point. For this reason, also Yoigo scored 29 out of 30 possible points in total in the operational excellence category.

While these reductions of service availability were certainly annoying to the customers of the affected networks, they only have a limited impact to the overall results and did not change the actual ranking in Spain. However, for next year, we plan to consider a larger number of months and will increase the share that our crowd score has in the total result.





The collection of crowdsourced data is based on apps like "U get" (see below) and others, that constantly perform and report anonymised service availability measurements in the background.

OPERATIONAL EXCELLENCE AT A GLANCE

Considering August, September and October of 2017, we could determine a one-hour degradation in the Vodafone network and an incident in the Yoigo network that due to our nightly hold-off interval only counts as one hour. For Movistar and Orange, we did not observe any relevant incidents. As we considered a three-month period, which contributes 30 to the total maximum of 1000 achievable points, both Vodafone and Yoigo score 29 out of 30 points, while Movistar and Orange both score the full 30 points.

PARTICIPATE IN OUR CROWDSOURCING

Everybody interested in being a part of our "operational excellence" global 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 **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 the mobile customer experience.**

The methodology of the P3 connect Mobile Benchmark is the result of P3's many years of experience. It was carefully designed to evaluate and objectively compare the performance and service quality of Spain's mobile networks from the users' perspective.

Testing Methodology

The P3 connect Mobile Benchmark in Spain took place throughout October 2017. All samples were collected during the day, between 8.00 a.m. and 10.00 p.m. The network tests covered 17 large cities with more than 100,000 inhabitants. Measurements were also taken in smaller towns as well as on connecting roads and motorways. The combination of test areas was selected to provide significant test results covering a relevant part of the Spanish population. The areas chosen for the 2017 test account for more than 11.5 million people, or approximately 24.7 per cent of Spain's total population.

P3 conducted the tests with four drivetest cars, equipped with arrays of Samsung Galaxy S7 Cat 9 smartphones as well as a mixed allocation of Samsung Galaxy S7 and Sony Xperia XZ Cat 9 smartphones for simultaneous measurement of voice and data services.

Voice testing

Two smartphones per operator were used for voice evaluation in each car, resulting in a total of eight voice test devices per car. They set up test calls from car to car. The audio quality was evaluated based on the HD-voice capable and ITU standardised so-called POLQA wideband algorithm. All Spanish operators offer 4G capable subscriptions. All of the smartphones in the voice tests were set to 4G preferred mode. This reflects the common behaviour of customers. At the time of the 2017 P3 connect Mobile Benchmark in Spain, Orange was the only operator offering VoLTE. So, in this case, the phones would prefer this voice mode. However, in situations where 4G but no VoLTE would be available, the smartphones would have to switch ("fall back") to 2G or 3G for the voice calls (so called "circuit-switched fall back" or CSFB). In the networks of Movistar, Vodafone, and Yoigo this was the standard behaviour.

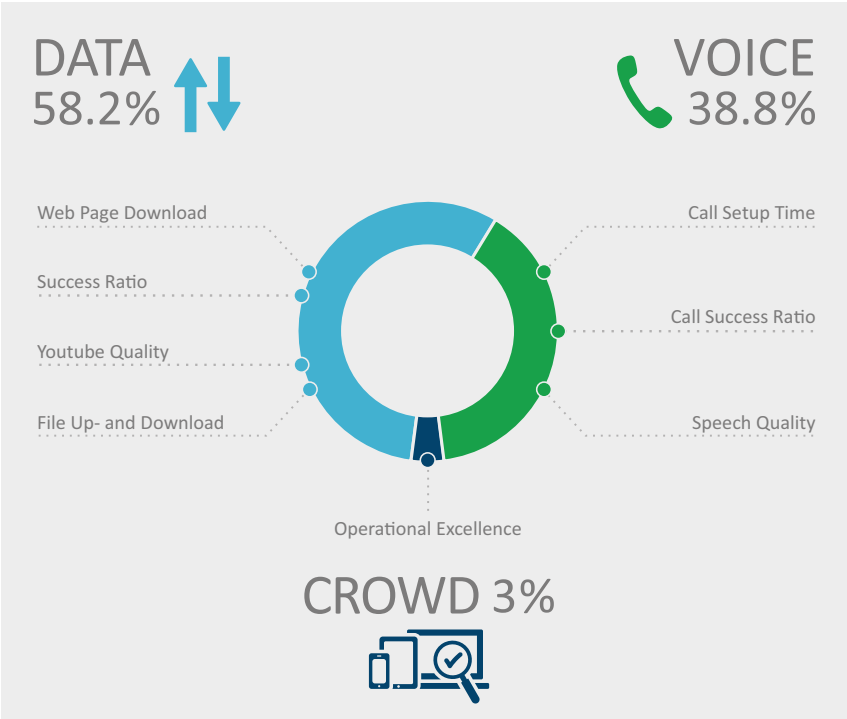
In order to further reflect typical smartphone usage scenarios during the voice tests, background data traffic was generated in a controlled way through random injection of small amounts of HTTP traffic. The voice test scores account for 38.8 per cent of the total benchmark results.

Data testing

Data performance was measured using one smartphone per operator per car. Two of the drivetest cars were equipped with four Samsung Galaxy S7 each while the other two were carrying four Sony Xperia XZ each. This setup was chosen in order to respect the variable data performance of different smartphones in different networks. In total, the drivetest cars carried 16 devices for the data tests. For all data test devices, the radio access technology was set to LTE preferred mode.

The web tests accessed web pages according to the widely recognized 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 3MB and 1MB for download and upload respectively were transferred from or to a test server located on the Internet. 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. Another discipline was the playback of Youtube videos. It took into account that Youtube dynamically adapts the video resolution to the available bandwidth. So, in addition to success ratios, start times and playouts without interruptions, Youtube measurements also determined the average video resolution.

All tests were conducted with the best-performing mobile plan available from each operator. Data scores account for 58.2 per cent of the total results. >>



Each car carried four phones for the data tests and eight phones for the voice tests. They were housed in three special boxes, containing four smartphones each.

Routes and samples

The test routes are shown on page 1 of this report. In the big cities and smaller towns indicated, the cars had to follow predefined routes. Altogether, the four test cars covered more than 11,520 kilometres, of which approximately 4040 led through the big cities and smaller towns, while 7480 kilometres were covered on connecting roads.

Performance indicators and rating

The score weighting reflects both the geographical distribution of the Spanish population and the ranking of usage scenarios. Therefore, 582 of the total of 1000 maximum points were assigned to the cities – 232.8 maximum points refer to the voice results and 349.2 maximum points reflect the data results. For the towns and the roads, a maximum of 194 points each is available. In both categories, the possible maximum is 77.6 points in the voice, and 116.4 points in the data category. The table on pages 2 and 12 of this report shows the percentage of maximum points that each operator has achieved in each discipline.

Crowdsourcing operational excellence

The remaining 30 points are awarded for operational excellence. For this survey, P3 uses a crowdsourcing method. To acquire these data, P3 considers connectivity reports that are gathered by background diagnosis processes included in a number of popular smartphone apps. While the customer uses one of these apps, a diagnosis report is generated daily and is evaluated per hour. As such reports only contain information about the current network availability, it generates just a small number of bytes per message and does not include any personal user data.

In order to differentiate network glitches from normal variations in network coverage, we apply a precise definition of "service degradation": A degradation is an event where data connectivity is impacted by a number of cases that significantly exceeds the expectation level.

Hakan Ekmen, Managing Director, P3 communications GmbH and Bernd Theiss, Head of connect's test lab, inspect the testing equipment.

To judge whether an hour of interest is an hour with degraded service, the algorithm looks at a sliding window of 168 hours before the hour of interest. This ensures that we only consider actual network service degradations in contrast to a simple loss of network coverage of the respective smartphone due to prolonged indoor stays or similar reasons.

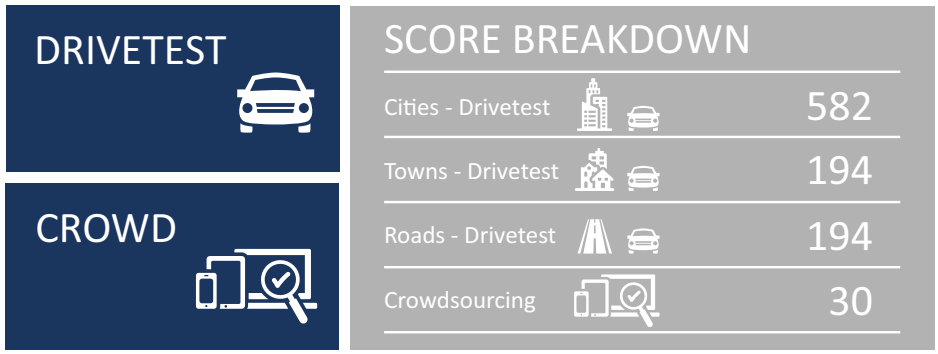
In order to ensure the statistical relevance of this approach, a valid assessment month must fulfil clearly designated prerequisites: A valid assessment hour consists of a predefined number of samples per hour and per operator. The exact number depends on factors like market size and number of operators. A valid assessment month must be comprised of at least 90 per cent of valid assessment hours (again per month and per operator). Degradations observed in the night hours between 0.00 a.m. and 6.00 a.m. are not accounted for.

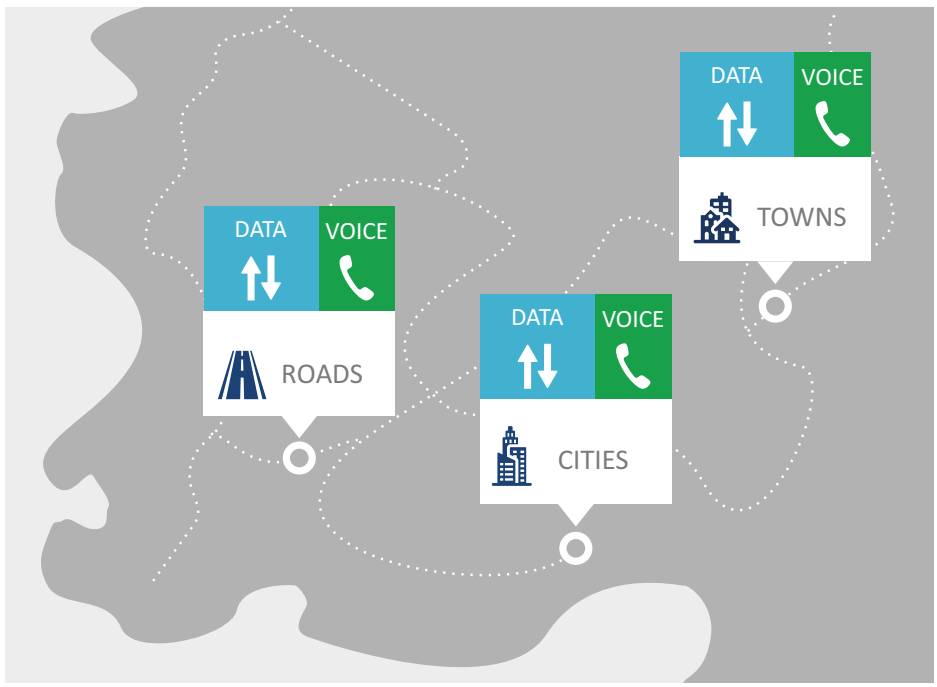
Sophisticated scoring model for operational excellence

The relevant KPIs are then based on the number of days when degradations occurred as well as the total count of hours affected by service degradations. In the scoring model that we apply to the gathered crowdsourcing data, 60 per cent of the available points (in this case a maximum of 18) will consider the number of days affected by service degradations – thus representing the larger-scale network availability. An additional 40 per cent of the total score (here 12 points) is derived from the total count of hours affected by degradations, thus representing a finer-grained measurement of operational excellence.

Each considered month is then represented by a maximum of ten achievable points. The maximum of six points (60 per cent) for the number of affected days is diminished by one point for each day affected by a service degradation. One affected day will cost one point and so on until six affected days out of a month will reduce this part of a score to zero.

The remaining four points are awarded based on the total number of hours affected by degradations. Here, we apply increments of six hours: Six hours with degradations will cost one point, twelve hours will cost two points and so on, until a total number of 24 affected hours will lead to zero points in this part of the score.





Conclusion

Three out of four Spanish operators improved over last year's results. The advancements of the smallest contender, Yoigo, are especially impressive.

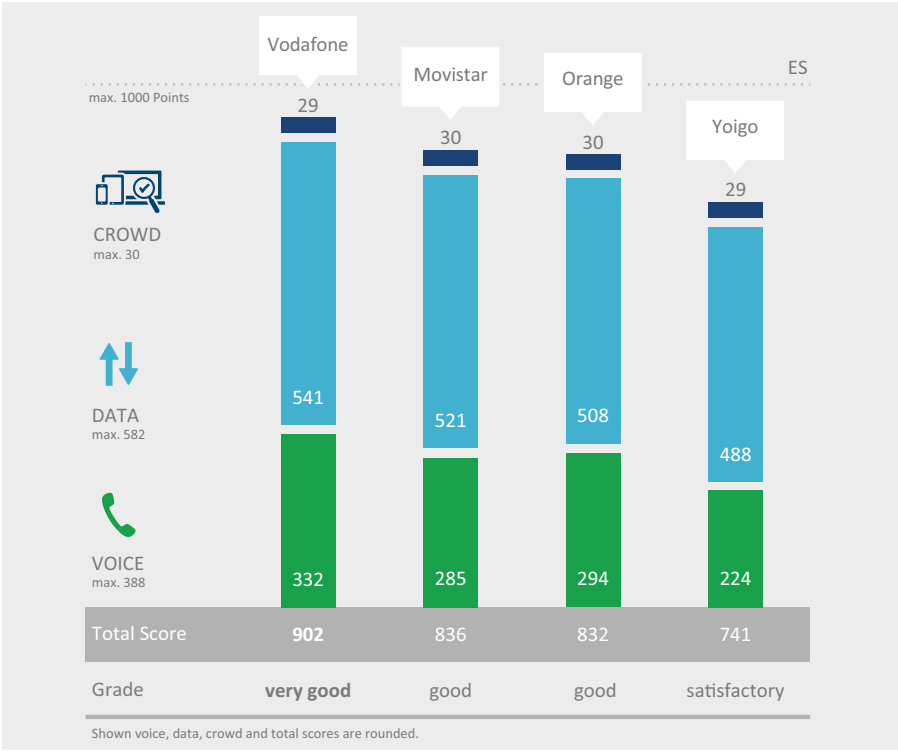
For the third time in a row, Vodafone is the clear winner of the P3 connect Mobile Benchmark in Spain. This may not come as a surprise, but one should bear in mind that it takes a lot of effort to secure the top position.

While also Yoigo and Orange show considerable improvements in their scores, Movistar remained essentially at the same level. Telefónica's mobile network scores quite well in the data discipline, but it falls behind its competitor Orange in the voice tests. All in all, this is a good result for Spain's largest operator, with Movistar well deserving the second rank.

Orange also improves over 2016's results and while still scoring third, it narrows the gap to Movistar to only four points. In the voice discipline, Orange delivers short call setup times and good speech quality thanks to its introduction of VoLTE. Currently, Orange is the only Spanish operator which offers this modern technology to its customers.

Yoigo improves by more than 100 points

Yoigo makes the biggest jump ahead. Even when taking the changes to the maximum available points entailed by our new crowd score into account, the smallest contender improved its score by more than 100 points. This is a remarkable accomplishment and good news for Yoigo's customers. Above that, our new crowdsourced operational excellence score also delivers enjoyable results, confirming a high level of stability and availability of all Spanish networks in the observation period.



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

Overall Results Voice and Data		Vodafone	Movistar	Orange	Yoigo
Voice	max. 388	332	285	294	224
Cities (Drivetest)	232.8	89%	73%	80%	65%
Towns (Drivetest)	77.6	88%	80%	75%	57%
Roads (Drivetest)	77.6	74%	68%	64%	37%
Data	max. 582	541	521	508	488
Cities (Drivetest)	349.2	96%	92%	90%	88%
Towns (Drivetest)	116.4	93%	88%	87%	82%
Roads (Drivetest)	116.4	85%	84%	80%	74%
Crowd	max. 30	29	30	30	29
2017-08	10	100%	100%	100%	90%
2017-09	10	100%	100%	100%	100%
2017-10	10	90%	100%	100%	100%
Connect Rating	max. 1000	902	836	832	741

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

1 vodafone

As in the two previous years, Vodafone once more is the overall winner in Spain thanks to excellent voice and data results. Vodafone takes a clear lead in both categories and also shows a compelling level of operational excellence. The lead over its pursuers Movistar and Orange is even more distinct than in 2016.

2 movistar

Compared to the previous year, Movistar has improved in the data category, but hast lost some points in the voice discipline. In our new operational excellence evaluation, the Telefónica brand reaches the full possible score of 30 points. In the future, Movistar will have to improve in the voice category if it wants to stay ahead of Orange.

3 orange

France Telecom's Spanish brand comes in third, with a close distance to its constant rival Movistar. In the voice discipline in big cities, Orange already has managed to outrank the Telefónica network – and in the other categories, it is following at close distance. Also, our crowd score hast attested a high level of operational excellence.

4 yoigo

Yoigo shows the biggest improvement in comparison to our 2016 benchmark, which it mainly achieves in the data category. Improving from last year's grade "sufficient" to this year's "satisfactory" is a big step. Also, Yoigo scores high in our new operational excellence discipline. All of this is really good news to its customers.