



# THE GREAT 2021 MOBILE NETWORK TEST



In the 27<sup>th</sup> year of our mobile network test, connect and their long time partner, umlaut, have once again taken the pulse of the mobile networks in Germany, Austria and Switzerland.

Even under normal circumstances there would have been more than enough innovations and special features to report about our annual mobile network test: for the first time 5G is part of the regular scope of measurement. The evaluation scheme of our crowdsourcing assessment, now for the third time part of the score, has been considerably enhanced. And the tested network operators continue to confirm that despite numerous alleged competitors in the market the mobile network test carried out by umlaut and connect is considered to be the most meaningful, methodologically and statistically robust and therefore by far the most serious exemplar of its kind in the industry.

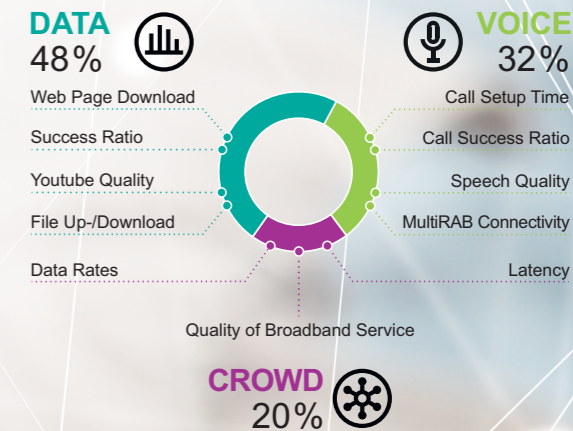
But then came the Corona pandemic. And with it came the question of whether we would be able to carry out the tests as planned. In this context, it turned out to be very beneficial that umlaut constantly monitors the network quality and performance within the scope of its regular analysis and was therefore able to quickly give the all-clear from the technical side:

even if the usage behaviour has changed significantly due to home office and lockdowns in various forms, the networks remained stable. Also, in their efforts to expand their networks, the operators could hardly be slowed down. In order to provide optimum protection for the teams that carried out our drive and walk tests, we have also carefully adapted the logistics of our tests.

### Peculiar and proven aspects

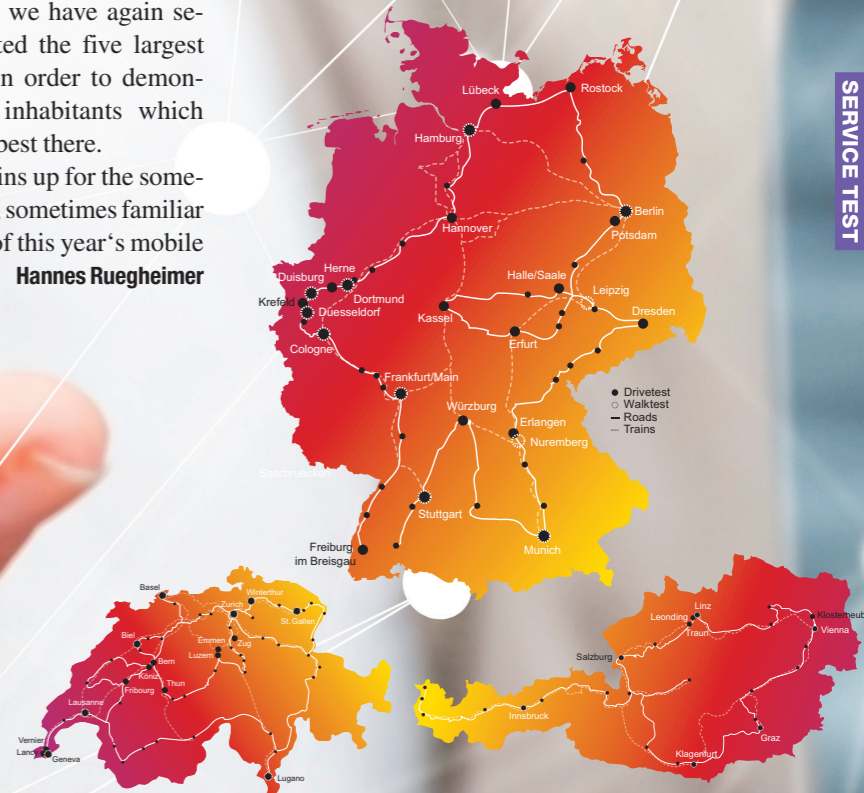
Despite all the peculiarities, there are also many aspects which have been tried and tested. For example, the great effort we put into determining our test results and ensuring their statistical relevance. The key figures listed below give an impression of this once again this year. As in the previous year, in addition to the nationwide test, we have again separately evaluated the five largest German cities in order to demonstrate to their inhabitants which operator scores best there.

So now: curtains up for the sometimes surprising, sometimes familiar looking results of this year's mobile network test! **Hannes Ruegheimer**



### A 360 degree view at network quality

We have not changed the overall distribution of points in the categories Voice, Data and Crowdsourcing in comparison to the previous year. However, we have made a multitude of adjustments and enhancements of our test and assessment methods within the individual disciplines. You can find an overview over the new as well as over the time-tested elements of our methodology on the pages 88/89.



### DRIVE TESTS AND WALK TESTS



### CROWDSOURCING



Indicated are the combined values for Germany, Austria and Switzerland. See the separate values per country under "Methodology" on pages 88/89

# Germany

## Voice

► Overall, the results of our voice measurements in the three German mobile networks are at a pleasantly high level. Since all three candidates have already been supporting VoLTE (“Voice over LTE”) for a number of years, they offer short call set-up times and overall high success rates in that area. In all tested scenarios, the call set-up times at Telekom and Vodafone are around one second, Telefónica follows with values around 2 seconds – in cities even faster. The reliability in larger and smaller cities is at or close to 100 per cent. However, this value somewhat drops on the

Even if data applications are the main focus for many smartphone users: Those who call their counterparts in the conventional way expect stable connections and good voice quality.

connecting roads - most pronounced at Telefónica/O2. Drivers have to expect minor restrictions when making phone calls via Telekom’s competitors. Overall, Deutsche Telekom is ahead in the drive tests in large and small cities as well as on the roads and also in the walk tests in large cities. The more demanding the test environment, the more distinctly Vodafone and Telefónica fall behind the class winner from Bonn.

### Restrictions in railways

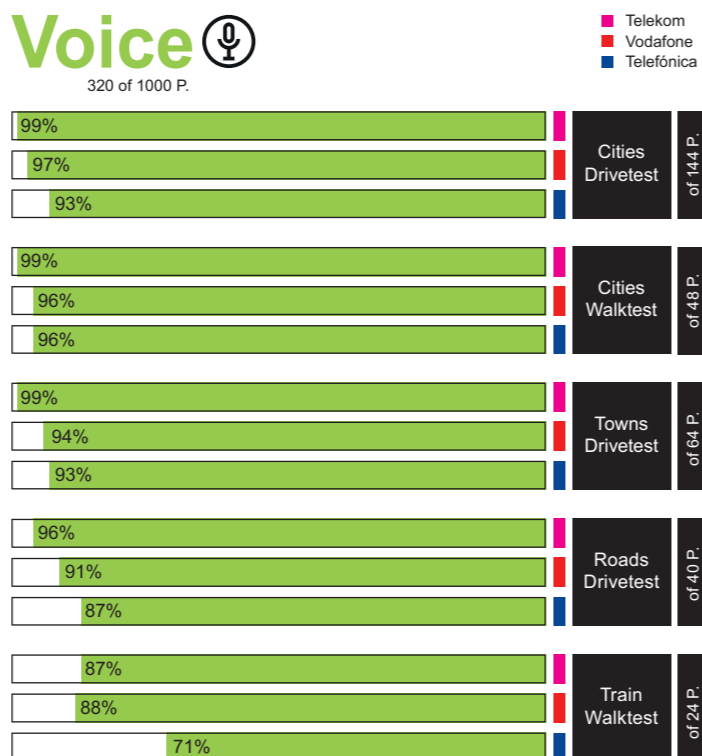
This chapter has a sad tradition in our network test: those who rely on Deutsche Bahn for

travel have to expect even more pronounced quality constraints than car drivers when using their mobile phones during transport. So it should be of only little consolation to Vodafone that the Duesseldorfers are only a wafer-thin margin ahead of their Bonn competitor in this

sub-discipline. For the Telefónica network, the gap is even more pronounced. But there is also a ray of hope: compared to the previous year, the results for voice telephony in railways have improved for all three providers. So the development is heading in the right direction.



Operator	Telekom	Vodafone	Telefónica
<b>Voice Cities (Drivetest)</b>			
Call Success Ratio (%)	100.0	99.7	99.3
Call Setup Time Ø (s) / P90 (s)	1.0/1.2	1.0/1.3	1.9/2.2
Speech Quality Ø / P10 (MOS-LQO)	4.5/3.9	4.5/3.9	4.3/3.7
MultiRAB Connectivity (%)	99.7	99.3	98.6
<b>Voice Cities (Walktest)</b>			
Call Success Ratio (%)	99.9	99.5	99.6
Call Setup Time Ø (s) / P90 (s)	1.0/1.1	1.0/1.3	1.7/2.0
Speech Quality Ø / P10 (MOS-LQO)	4.5/4.0	4.5/4.1	4.4/3.8
MultiRAB Connectivity (%)	99.8	99.5	99.8
<b>Voice Towns (Drivetest)</b>			
Call Success Ratio (%)	100.0	99.4	99.6
Call Setup Time Ø (s) / P90 (s)	1.0/1.3	1.1/1.4	2.0/2.3
Speech Quality Ø / P10 (MOS-LQO)	4.4/3.8	4.4/3.9	4.3/3.6
MultiRAB Connectivity (%)	99.8	97.3	96.9
<b>Voice Roads (Drivetest)</b>			
Call Success Ratio (%)	99.4	98.9	97.6
Call Setup Time Ø (s) / P90 (s)	1.1/1.3	1.3/1.7	2.1/2.4
Speech Quality Ø / P10 (MOS-LQO)	4.4/3.7	4.3/3.5	4.2/3.4
MultiRAB Connectivity (%)	98.5	91.7	94.7
<b>Voice Trains (Walktest)</b>			
Call Success Ratio (%)	96.9	97.2	92.9
Call Setup Time Ø (s) / P90 (s)	1.2/1.5	1.3/1.6	2.2/3.1
Speech Quality Ø / P10 (MOS-LQO)	4.2/3.3	4.3/3.4	4.1/3.0
MultiRAB Connectivity (%)	99.5	98.9	98.3



## Data

Web surfing, messaging, video calls and streaming determine our daily usage behaviour and make data communication the supreme discipline in our test.

► Already the first look at this year’s data results shows that this time the familiar is mixed with the surprising. On familiar aspects, Deutsche Telekom is ahead in all disciplines. On the other hand, a rather surprising development is the significant growth that Telefónica has achieved in this area.

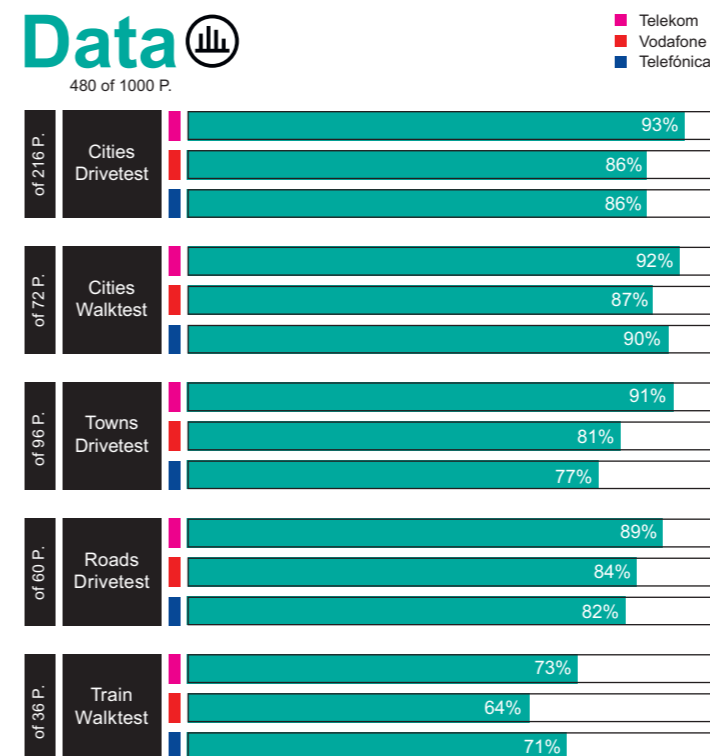
It is remarkable that the Munich-based company is on par with Vodafone in the drive tests in large cities, and even takes the second place in the walk tests, coming close to the first-ranking Bonn-based competitor. This shows that the network expansion which has been underway for years, including the merger of the former sub-networks of O2 and E-Plus, has now clearly borne fruit.

Still, Vodafone has also managed to improve in some areas of our test.

### The gap between operators is shrinking in rural areas

And even if Telekom is still clearly ahead in small towns and on connecting roads, its lead over the two runners up has diminished, especially in the more rural areas.

This is a pleasing observation and proves that besides Telefónica, Vodafone has made good progress in expanding its mobile network. Nevertheless, all three operators still have a lot to do in small towns and on the roads. If there is any need for a stimulus, just take a closer look at our two southern neighbouring countries.



Operator	Telekom	Vodafone	Telefónica
<b>Data (Cities; Drivetest)</b>			
Web Page Download			
Success Ratio (%)	99.8	99.6	99.7
Total Session Time (s)	0.9	1.1	1.1
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.9/1.4	99.9/2.6	99.8/2.5
90%/10% faster than (Mbps)	23.1/114.3	10.1/79.8	9.3/81.4
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.9/1.7	99.8/2.6	99.3/2.4
90%/10% faster than (Mbps)	8.8/38.6	4.3/27.8	5.5/28.8
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.6	99.8	99.9
Ø Throughput (Mbps)	132.7	72.8	60.1
90%/10% faster than (Mbps)	35.3/244.5	11.9/157.7	10.5/125.1
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.8	99.4	99.2
Ø Throughput (Mbps)	37.2	21.9	23.8
90%/10% faster than (Mbps)	9.3/67.4	4.4/46.0	5.6/45.9
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.4/1.1	98.2/1.3	98.7/1.4
Ø Video Resolution (p)	916	914	912
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	99.1/1.2	98.4/1.4	99.0/1.4
Ø Video Resolution (p)	1036	1029	1025
<b>Data (Cities; Walktest)</b>			
Web Page Download			
Success Ratio (%)	99.6	99.6	99.8
Total Session Time (s)	0.9	1.1	1.1
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.7/1.1	99.4/2.4	100.0/1.8
90%/10% faster than (Mbps)	29.4/150.0	11.7/80.5	14.7/79.1
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.7/2.0	99.4/2.3	99.7/2.0
90%/10% faster than (Mbps)	7.8/31.9	6.1/23.7	6.2/23.2
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.3	99.7	100.0
Ø Throughput (Mbps)	191.6	77.3	72.2
90%/10% faster than (Mbps)	34.1/529.1	16.0/161.5	19.0/144.0
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.1	99.3	99.3
Ø Throughput (Mbps)	41.4	25.2	31.3
90%/10% faster than (Mbps)	9.3/76.5	6.4/49.6	7.8/53.1
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.3/1.0	99.3/1.3	99.9/1.5
Ø Video Resolution (p)	919	911	918
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	99.4/1.1	98.7/1.4	99.7/1.5
Ø Video Resolution (p)	1037	1028	1039
<b>Daten (Towns; Drivetest)</b>			
Web Page Download			
Success Ratio (%)	99.8	99.4	98.3
Total Session Time (s)	1.0	1.2	1.1
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.8/1.8	100.0/3.6	98.6/3.5
90%/10% faster than (Mbps)	15.4/99.0	5.7/60.2	7.3/59.3
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/1.9	100.0/2.9	97.6/3.1
90%/10% faster than (Mbps)	7.1/35.1	3.9/21.7	3.6/20.4
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.8	99.4	99.1
Ø Throughput (Mbps)	94.3	46.7	37.4
90%/10% faster than (Mbps)	24.7/189.9	6.5/92.2	6.5/82.0
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.4	99.6	98.1
Ø Throughput (Mbps)	30.9	16.2	15.9
90%/10% faster than (Mbps)	7.9/57.8	4.5/27.7	3.1/33.5
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.8/1.1	96.4/1.4	98.1/1.4
Ø Video Resolution (p)	914	912	908
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	98.5/1.3	95.5/1.6	92.3/1.7
Ø Video Resolution (p)	1030	973	972

Operator	Telekom	Vodafone	Telefónica
<b>Data (Roads; Drivetest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	99.4	98.4	98.3
Total Session Time (s)	1.1	1.2	1.1
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.5/2.6	98.7/3.4	98.2/3.3
90%/10% faster than (Mbps)	7.7/90.6	6.9/70.1	6.9/59.1
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.5/2.7	98.5/3.5	98.0/3.4
90%/10% faster than (Mbps)	4.0/33.0	3.0/22.0	3.1/21.2
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.0	98.7	98.8
Ø Throughput (Mbps)	78.1	51.6	36.5
90%/10% faster than (Mbps)	9.1/168.1	6.8/110.9	5.7/83.7
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	98.8	97.8	96.3
Ø Throughput (Mbps)	25.4	16.0	15.0
90%/10% faster than (Mbps)	4.1/56.0	3.6/30.1	2.9/30.4
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	97.7/1.3	95.9/1.4	97.2/1.4
Ø Video Resolution (p)	911	911	903
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	97.9/1.3	97.4/1.5	96.6/1.4
Ø Video Resolution (p)	1027	1027	1022

Operator	Telekom	Vodafone	Telefónica
<b>Data (Trains; Walktest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	97.4	97.1	97.4
Total Session Time (s)	1.7	2.0	1.7
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	98.6/5.8	99.0/9.2	98.5/7.1
90%/10% faster than (Mbps)	3.7/46.9	2.2/35.8	3.1/29.9
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	98.6/3.6	98.5/4.2	97.5/3.9
90%/10% faster than (Mbps)	2.8/22.2	2.5/17.1	2.6/15.1
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.2	96.8	98.2
Ø Throughput (Mbps)	25.9	15.1	15.8
90%/10% faster than (Mbps)	2.6/59.1	1.9/37.4	3.1/30.6
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	96.3	95.3	96.2
Ø Throughput (Mbps)	18.7	11.8	11.2
90%/10% faster than (Mbps)	3.4/39.5	2.1/25.4	2.8/21.2
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	90.5/2.0	82.1/2.1	89.4/2.1
Ø Video Resolution (p)	897	872	886
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	86.1/1.8	87.7/2.4	94.2/1.8
Ø Video Resolution (p)	1017	963	998

The gap between Deutsche Telekom and the other two operators becomes particularly prominent in the data rates – with the lead in the 5G roll-out (see box below) probably taking the lion's share.

However, all three candidates still have potential for improvement in rural areas and on connecting roads. Degrees of fulfilment rates in a magnitude of 80 per cent are a start at

best – only Telekom, gaining around 90 per cent of the achievable points in rural areas, shows a similar level of performance to that in large cities.

#### Improvements in trains

But this is over as soon as smartphone users board German trains within Germany. In this scenario, the performance level of all three

providers drops significantly. Telekom is ahead, but for example success rates of 90 per cent for accessing YouTube videos are no glorious record. Once again, Telefónica deserves a special praise: particularly in the railway scenario, the Munich-based company clearly overtakes its competitors from Duesseldorf and moves closer to the category as well as overall winner Telekom. But

despite all the complaining, it should not go unmentioned that all three network operators were able to improve their scores in the railway tests compared to their results in the previous year. It remains to be hoped that this trend will continue – then German railway customers might one day be able to enjoy internet services similar to those in Austria and Switzerland.

## 5G

For the first time this year, 5G is a regular part of our network test. Where the new network is already available, it was also registered in our drive tests and walk tests and thus already plays an important role in the data discipline – depending, of course, on the roll-out status already achieved.

Through the extensive use of DSS (Dynamic Spectrum Sharing – demand-based distribution of the bandwidth between 4G and 5G), Telekom already achieves quite a large 5G penetration in the 2.1 GHz range – almost one third of the area visited in the drive tests and walk tests showed 5G samples. However, 5G tends to play out its strengths (currently mainly higher download data rates) on the higher 5G frequencies around 3.5 GHz. Here one of the test smartphones recorded a peak value of 1.16 Gbit/s. In this frequency band, 8 per cent of the metropolitan drive tests and 22 per cent of the walk test samples already showed 5G

coverage in the Telekom network. In comparison, Vodafone appears to be only at the start of its 5G roll-out. In the drive tests we observed 5G coverage in only 1.6 per cent of the samples in big cities, in the walktests 0.3 per cent. Pure 5G scanner measurements on board of the measurement vehicles, as they are sometimes referred to in other sources, usually show higher values. However, it should be noted that the mere presence of 5G radio signals does not mean that a 5G capable smartphone can also log into the appropriate network and can thus

benefit from the higher 5G download rates for example. In any case, Vodafone can convince in all disciplines with a 100 per cent reliability. Telefónica's 5G launch at the beginning of October came so close to our network test that it could not yet be included in the setup. In view of the surprisingly good results of some candidates and the importance of 5G for the future, connect decided to award an innovation prize for the 5G roll-out in Germany, Austria and Switzerland. In Germany, the award goes clearly to Telekom.

Data rates 7s Download	Telekom			Vodafone			Telefónica		
	Share	Reliability	Data rate (Ø, Mbps)	Share	Reliability	Data rate (Ø, Mbps)	Share	Reliability	Data rate (Ø, Mbps)
Samples with 5G									
Cities – Drivetest	32.6%	99.4%	233.4	1.6%	100.0%	360.8	–	–	–
Cities – Walktest	28.6%	100.0%	424.4	0.3%	100.0%	265.3	–	–	–
Towns – Drivetest	44.0%	100.0%	101.4	2.2%	100.0%	446.6	–	–	–
Roads – Drivetest	33.6%	100.0%	85.1	2.7%	100.0%	352.0	–	–	–
Trains – Walktest	24.4%	98.9%	29.6	0.5%	100.0%	109.1	–	–	–



## Crowd

The crowdsourcing results provide a possibility to check whether the results from the other categories match the actual customer experience.

The results of our crowdsourcing analyses confirm the trends from the voice and data disciplines. This proves that the results determined in our measurements are well received by users in their everyday lives. Telekom is also ahead in the crowd discipline, Vodafone follows with a four-point gap, Telefónica at a distance of a further 13 points behind the runner-up. Compared to the previous year, however, all three candidates were able to improve. The fact that Vodafone is ahead in the quality of broadband supply with 70.3 per cent of the achievable points suggests that this provider is increasingly expanding its network in areas where the competitors are less well represented.

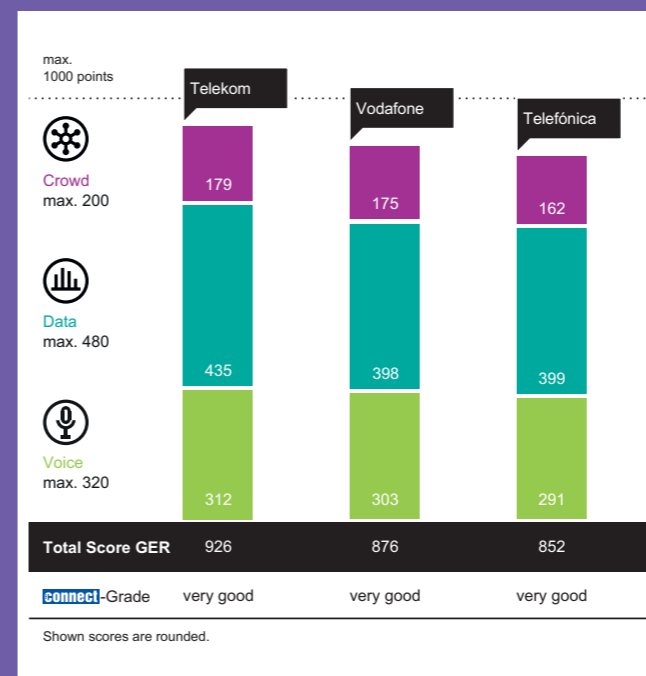
In this respect, Telefónica still has the greatest need to catch up. However, when it comes to the time on broadband – i.e. how often an individual customer will

actually have 4G or even 5G reception – Telekom is again in the lead. The data rates observed in the application classes defined by umlaut once again show the familiar ranking: Telekom is ahead, followed by Vodafone and Telefónica in third place. The fact that the shares in the UHD video class (up to 20 Mbps) are lower than in the other two

data rate classes can also be explained by the “passive observation“ taking place in crowdsourcing: bandwidth-intensive applications are just used less frequently by customers. In terms of latency, Telefónica makes it to second place, just ahead of Vodafone. However, in the demanding gaming category, Telekom is clearly ahead.

Operator	Telekom	Vodafone	Telefónica
<b>Broadband Coverage</b>			
Coverage Excellence (%)	64.4	70.3	55.3
Time on Broadband (%)	93.9	92.4	88.4
<b>Download Speed</b>			
Basic Internet Class (%)	93.1	92.2	86.2
HD Video Class (%)	78.1	75.0	66.5
UHD Video Class (%)	23.9	19.5	16.0
<b>Latency</b>			
Gaming Class (%)	82.8	75.6	76.5
OTT Voice Class (%)	95.2	93.0	94.2

## Single Review



This year, Telekom is rounding off its anniversary: For the tenth time in a row, the Bonn-based company has won our mobile network test in Germany. Compared to the previous year, Telekom was able to improve slightly in the voice and data disciplines and significantly in crowdsourcing. The ongoing 5G roll-out at Telekom makes the most distinctive contribution to the overall result.



Vodafone was also able to improve in comparison to the previous year – in all three test disciplines. The Duesseldorf-based company's network development efforts are also clearly having an effect. Keep up the good work! Particularly as it is not least the customers who benefit from the competition between the providers. And this time Vodafone has also significantly reduced the gap to the test winner.



This performance deserves special recognition: Telefónica improved its score by almost 100 points compared to the previous year. Its efforts to expand and consolidate its network, which are obviously considerable, are bearing very visible fruit. And this puts the Munich-based company within reach of the two higher-ranking providers – the race should become really exciting in the future!

# Austria

Traditionally, the competition in the Alpine republic takes place at a very high level. This is also true this year – although the scores have not risen compared to last year.

► We have almost got used to this in recent years: when it comes to the level of points scored, Austrian providers are traditionally well ahead of their counterparts from Germany. In principle, this is still true this year – but the score increases achieved by Austria’s northern neighbour in the meantime make the gap shrink. In comparison, the level of performance in the two Alpine countries has remained essentially unchanged – on a very high level.

Most of the general conditions were also unchanged: Austrian customers are still happy about the still significantly lower tariff level in the Alpine republic compared to

Germany. And Austrian customers are still annoyed that their providers charge extra for smartphone use in the non-EU country Switzerland – and sometimes quite expensively, depending on the provider and tariff.

## Voice connections

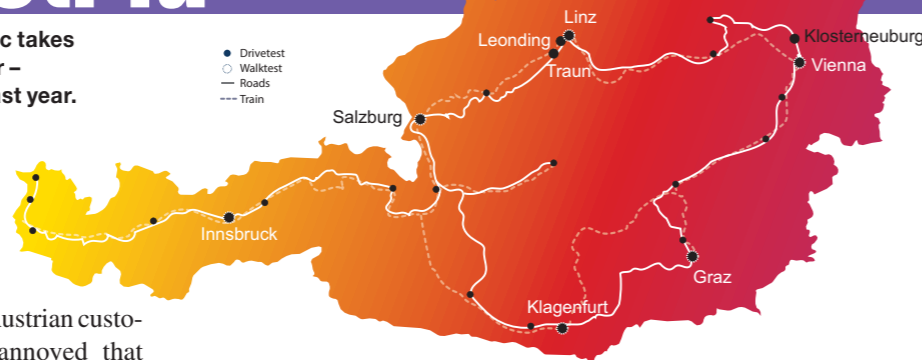
But there is also continuity on the bright side: Since 2018 all three network operators in Austria have been supporting the fast and high-quality voice telephony via VoLTE (Voice over LTE). It is the basis for

convincing voice results and predominantly very good measurement results. The average call set-up times of less than one second achieved by Magenta in all tested scenarios speak for themselves.

Although A1 needs a little longer to set up a connection, the results are also impressive and quite close to the first-placed provider Magenta, especially in large cities. In the case of Three, setting up a call takes well over 2 seconds on average, but here too, success rates and voice quality are quite high. In small towns, Three’s overall score is even

slightly better than the one achieved by A1 – but on the connecting roads the gap between the Hutchison network and the two competitors is somewhat more pronounced.

In the walk tests carried out in Austrian trains, the performance level falls back considerably. Still, A1 and Three were once again able to significantly improve in this discipline compared to the results in previous years. And in particular the smallest provider, Three, offers railway passengers significantly more stable mobile phone calls than just a year ago.



## Data connections

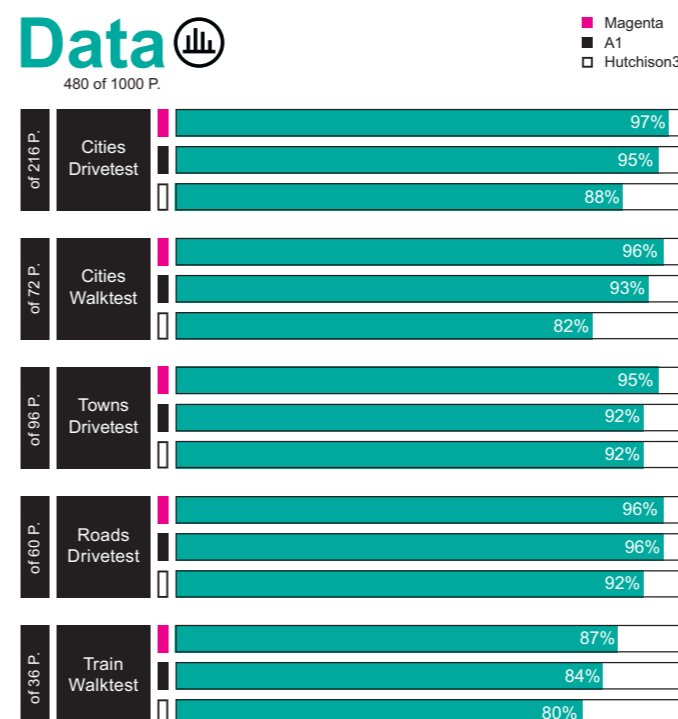
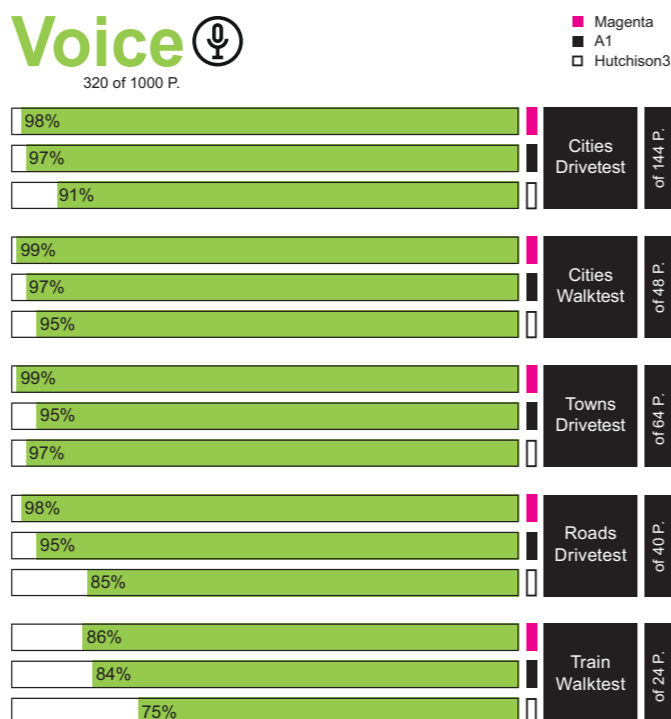
The data measurements show an overall similar picture as in the voice discipline. Magenta and A1 are in a neck-and-neck race, Three ranks slightly behind but can catch up to the overall field, especially in the rural scenarios.

In large cities, Magenta and A1 are further ahead – probably not least because of the support of 4CA in their LTE networks (4 Carrier Aggregation: combination of up to four frequency bands). For all three Austrian mobile networks the results of the drive and walk tests already show a respec-

table share of samples with 5G reception (see box on page 82).

The high success rates achieved by Magenta and A1 in larger cities, smaller towns and on connecting roads are particularly pleasing. Three also achieves good values here – only for file uploads we see some room for improvement. Clear differences can be seen in the top ten per cent of the measured values (so-called P90 values) for the data rates: Here, Magenta with more than 475 Mbps is in the top position in the big city drive tests and with even 750 Mbps far ahead in the big city walk tests. A1 achieves

Operator	Magenta	A1	Hutchison3
<b>Voice Cities (Drivetest)</b>			
Call Success Ratio (%)	99.7	99.8	99.6
Call Setup Time Ø (s) / P90 (s)	0.6/0.7	1.4/1.6	2.3/4.2
Speech Quality Ø / P10 (MOS-LQO)	4.5/4.0	4.3/3.7	4.4/3.8
MultiRAB Connectivity (%)	100.0	99.9	99.7
<b>Voice Cities (Walktest)</b>			
Call Success Ratio (%)	100.0	99.8	99.7
Call Setup Time Ø (s) / P90 (s)	0.7/0.8	1.4/1.5	2.1/2.6
Speech Quality Ø / P10 (MOS-LQO)	4.5/4.1	4.4/3.8	4.5/4.1
MultiRAB Connectivity (%)	100.0	99.7	99.2
<b>Voice Towns (Drivetest)</b>			
Call Success Ratio (%)	100.0	99.5	100.0
Call Setup Time Ø (s) / P90 (s)	0.7/0.8	1.4/1.6	2.2/2.5
Speech Quality Ø / P10 (MOS-LQO)	4.5/4.0	4.3/3.7	4.5/3.9
MultiRAB Connectivity (%)	99.7	100.0	99.7
<b>Voice Roads (Drivetest)</b>			
Call Success Ratio (%)	99.9	99.1	97.8
Call Setup Time Ø (s) / P90 (s)	0.7/0.8	1.4/1.6	2.4/4.4
Speech Quality Ø / P10 (MOS-LQO)	4.5/3.8	4.3/3.7	4.4/3.8
MultiRAB Connectivity (%)	99.9	99.1	99.1
<b>Voice Trains (Walktest)</b>			
Call Success Ratio (%)	95.9	95.4	95.1
Call Setup Time Ø (s) / P90 (s)	0.8/0.8	1.5/1.6	2.5/4.7
Speech Quality Ø / P10 (MOS-LQO)	4.4/3.7	4.3/3.5	4.3/3.5
MultiRAB Connectivity (%)	99.2	99.8	98.0



Operator	Magenta	A1	Hutchison3
<b>Data (Cities; Drivetest)</b>			
Web Page Download			
Success Ratio (%)	99.9	99.8	99.6
Total Session Time (s)	0.7	0.8	0.9
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/0.9	99.6/1.0	99.4/1.5
90%/10% faster than (Mbps)	31.6/168.5	30.9/141.3	19.8/126.1
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.9/1.0	99.9/1.3	99.3/1.9
90%/10% faster than (Mbps)	15.4/45.6	11.5/37.5	8.3/29.3
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.9	99.8	99.5
Ø Throughput (Mbps)	192.6	167.0	106.4
90%/10% faster than (Mbps)	40.7/475.6	38.0/328.5	22.9/211.1
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.8	99.6	97.3
Ø Throughput (Mbps)	46.7	35.8	25.6
90%/10% faster than (Mbps)	18.5/62.3	15.9/49.3	9.9/37.7
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.9/0.9	100.0/1.0	98.4/1.1
Ø Video Resolution (p)	920	920	920
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	99.8/1.0	99.0/1.2	99.7/1.2
Ø Video Resolution (p)	1039	1040	1039
<b>Data (Cities; Walktest)</b>			
Web Page Download			
Success Ratio (%)	99.9	99.8	98.8
Total Session Time (s)	0.8	0.9	1.0
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.6/1.2	99.4/1.0	99.4/1.5
90%/10% faster than (Mbps)	42.1/191.4	35.8/139.5	20.1/128.5
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/1.2	99.8/1.6	98.9/2.7
90%/10% faster than (Mbps)	16.7/45.4	9.7/29.2	5.4/24.6
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.2	100.0	99.4
Ø Throughput (Mbps)	297.3	179.8	122.8
90%/10% faster than (Mbps)	56.0/749.8	43.5/387.0	26.3/245.6
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	100.0	99.0	93.2
Ø Throughput (Mbps)	54.7	33.8	24.9
90%/10% faster than (Mbps)	22.1/99.7	13.0/48.8	8.4/38.7
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.6/1.0	99.8/1.1	96.8/1.2
Ø Video Resolution (p)	917	920	920
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	98.7/1.0	99.6/1.2	99.5/1.2
Ø Video Resolution (p)	1036	1040	1039
<b>Data (Towns; Drivetest)</b>			
Web Page Download			
Success Ratio (%)	99.9	99.6	100.0
Total Session Time (s)	0.7	0.9	0.9
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/1.0	99.7/1.0	100.0/1.2
90%/10% faster than (Mbps)	30.1/137.0	34.2/129.6	24.1/109.8
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.7/1.2	99.7/2.0	100.0/1.6
90%/10% faster than (Mbps)	11.2/41.8	8.4/35.0	9.1/28.1
<b>File Download (7 seconds)</b>			
Success Ratio (%)	100.0	100.0	100.0
Ø Throughput (Mbps)	145.2	159.4	86.6
90%/10% faster than (Mbps)	33.5/234.7	46.0/288.1	27.2/150.6
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	100.0	99.7	99.2
Ø Throughput (Mbps)	41.1	34.4	26.4
90%/10% faster than (Mbps)	12.2/59.3	7.9/53.6	9.8/38.4
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	100.0/0.9	99.4/1.1	99.7/1.0
Ø Video Resolution (p)	919	920	921
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	99.4/1.0	98.9/1.3	100.0/1.2
Ø Video Resolution (p)	1038	1040	1040

Operator	Magenta	A1	Hutchison3
<b>Data (Roads; Drivetest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	99.9	99.7	99.0
Total Session Time (s)	0.8	0.9	1.0
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.6/1.4	99.2/1.1	99.0/1.4
90%/10% faster than (Mbps)	18.8/121.7	30.8/141.3	18.6/110.0
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/1.8	99.6/1.6	98.6/2.4
90%/10% faster than (Mbps)	7.6/38.4	9.1/34.8	4.9/28.9
<b>File Download (7 seconds)</b>			
Success Ratio (%)	100.0	99.6	99.6
Ø Throughput (Mbps)	103.0	134.4	86.6
90%/10% faster than (Mbps)	18.7/200.8	37.2/252.8	20.6/160.5
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	100.0	98.9	97.7
Ø Throughput (Mbps)	31.9	33.5	24.9
90%/10% faster than (Mbps)	7.9/57.5	8.5/59.1	7.0/39.0
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	100.0/1.0	100.0/1.1	99.4/1.1
Ø Video Resolution (p)	916	917	919
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	100.0/1.1	98.8/1.2	99.6/1.2
Ø Video Resolution (p)	1038	1036	1039

Operator	Magenta	A1	Hutchison3
<b>Data (Trains; Walktest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	97.8	97.1	97.0
Total Session Time (s)	1.0	1.1	1.2
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	98.6/2.3	95.3/1.9	96.3/2.4
90%/10% faster than (Mbps)	10.0/83.8	14.0/98.3	10.0/65.8
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	98.1/2.0	98.1/2.2	95.8/2.4
90%/10% faster than (Mbps)	6.9/26.1	7.8/24.9	6.0/21.3
<b>File Download (7 seconds)</b>			
Success Ratio (%)	97.3	96.8	97.3
Ø Throughput (Mbps)	59.3	79.7	45.8
90%/10% faster than (Mbps)	10.1/122.8	19.6/137.8	9.7/86.1
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	97.7	95.9	94.6
Ø Throughput (Mbps)	26.0	28.3	18.6
90%/10% faster than (Mbps)	8.8/42.9	7.9/48.4	6.1/30.5
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	97.3/1.2	96.3/1.3	95.4/1.3
Ø Video Resolution (p)	916	918	916
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	94.5/1.2	92.5/1.5	95.4/1.4
Ø Video Resolution (p)	1030	1031	1029

around 329 and 387 Mbps respectively, and Three follows with around 211 and 246 Mbps. Three also shows potential for improvement in some of the upload measurements.

Entertainment fans will be happy to hear that all three providers are performing very well in terms of success rates and video resolution achieved

in the tests of YouTube video and live content reception.

### Data connections on trains

The otherwise convincing data results are subject to some limitations when it comes to mobile internet use on train journeys. Here, the performances determined by umlaut correspond in general to the picture that could already be

seen in the Voice tests: compared to the other usage scenarios, there is still room for improvement in the railways. A comparison with the results of the Swiss providers in this sub-discipline shows that this is not technically im-

possible. And even if the German networks have improved in the railway scenarios this year,

the Austrian operators still come out on top. In addition, while the networks in the Alpine republic have essentially maintained their previous year's results in the other sub-disciplines of the data category, all of them have been able to improve significantly in the field of mobile data communication while travelling on railways.

## 5G

In the individual evaluations of the drive tests and walk tests with regard to 5G, all three Austrian providers perform surprisingly well. Especially the smallest provider Three can keep up astonishingly well. However, overall Magenta is ahead once again – also in this respect.

In the major Austrian cities and also on the connecting roads, Magenta has the highest share of 5G samples. On the other hand, A1 is ahead in smaller cities and on trains – in line with its claim to push 5G coverage also in more rural areas. Overall, the measured values for all three Austrian providers show the clear speed advantage of 5G. In this respect, Magenta is clearly ahead - in addition to the measurement results from big cities, also those from smaller towns

as well as in on the connecting roads and in trains. But the 5G speeds measured in the networks of A1 and Three are also impressive. In terms of reliability, A1 came out on top in the big city walk tests, while Magenta scored slightly higher in the big city drive tests. In other scenarios, the opponents are on a par. Regarding the result of

Three, it should be noted that this smallest Austrian operator delivers much better 5G results than the third place winner in Switzerland and even the runner-up in Germany. In the overall 5G evaluation, however, Magenta is clearly ahead by a wide margin – and thus deserves the 5G Innovation prize awarded by connect this year.

Data rates 7s Download	Magenta			A1			Hutchison Drei		
	Share	Reliability	Data rate (Ø, Mbps)	Share	Reliability	Data rate (Ø, Mbps)	Share	Reliability	Data rate (Ø, Mbps)
Samples with 5G									
Cities – Drivetest	41.7%	99.6%	471.3	26.0%	98.8%	374.1	28.5%	96.7%	271.3
Cities – Walktest	39.0%	98.5%	566.7	14.2%	100.0%	479.7	17.7%	97.8%	298.8
Towns – Drivetest	17.1%	100.0%	520.0	25.1%	100.0%	330.1	7.9%	100.0%	189.4
Roads – Drivetest	9.7%	100.0%	439.7	6.7%	94.4%	214.1	5.6%	100.0%	250.6
Trains – Walktest	3.2%	100.0%	318.1	6.2%	100.0%	250.7	3.7%	100.0%	230.2



## Crowd

As in the previous year, A1 has a head start in the crowdsourcing discipline – but this time at a relatively close margin.

As in previous years, our crowdsourcing category, which focuses on what the customers of an operator actually receive as opposed to the maximum possible performance, shows that A1 is ahead of the game. This year, however, the gap to the other candidates is relatively narrow – compared to Magenta ranking in second place in the crowd assessment it is only three points. And Hutchison Three is also catching up relatively close, ranking five points behind Magenta.

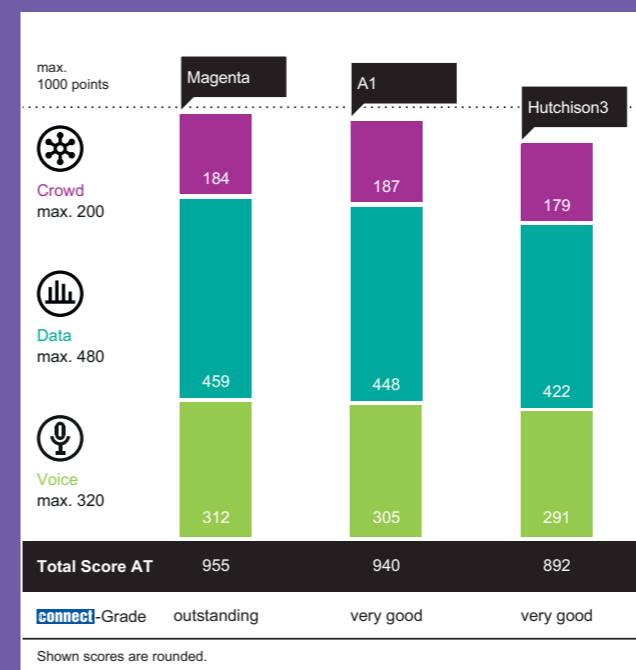
What is remarkable about A1's lead is that the provider is ahead in literally all individual evaluations within the crowd category. The best value for the Quality of Broadband Service rewards the fact that the largest Austrian provider is expanding its network in regions where the two competitors offer fewer broadband connections. High values for the Time on

Broadband show that customers have correspondingly frequent broadband contact with their network. With regard to the likewise overall convincing values for download data rates, it is interesting to note that Magenta achieves the second place for Basic Internet (up to 2 Mbps), while in the two more demanding speed classes HD video (up to 5 Mbps)

and UHD video (up to 20 Mbps), the operator Three moves up to second place. The same applies to the time share with broadband reception (Time on Broadband), showing that Three customers are increasingly using high data rates. In terms of latencies, Magenta and Three rank close to each other in the demanding Gaming speed class.

Operator	Magenta	A1	Hutchison3
<b>Broadband Coverage</b>			
Coverage Excellence (%)	66.0	70.2	53.7
Time on Broadband (%)	94.1	95.0	94.6
<b>Download Speed</b>			
Basic Internet Class (%)	95.2	96.1	94.4
HD Video Class (%)	80.0	83.8	83.0
UHD Video Class (%)	19.1	23.5	21.4
<b>Latency</b>			
Gaming Class (%)	94.7	95.2	94.6
OTT Voice Class (%)	98.3	98.9	96.5

## Single review



For the third time in a row Magenta (formerly T-Mobile Austria) achieves the overall victory in Austria. The score is the same as in the previous year, making Magenta the only provider in the Alpine republic to receive the grade "outstanding". The provider achieves the most points in both the voice and data categories – the latter also thanks to a strong performance in 5G.



Compared to the previous year, A1 Telekom falls a little behind, but its results are "very good" in any case – and the grade "outstanding" is only ten points away. In the crowd discipline A1 is ahead by a narrow margin. Nevertheless, the Austrian market leader loses some points in the voice category compared to the previous year. The data result – this time including 5G – is practically unchanged.



Three also falls back a little compared to the previous year, but still earns the grade "very good". The loss of points compared to last year's test is distributed over all three test categories. In the crowdsourcing, however, Three comes close to the result of the overall winner Magenta. The Hutchison brand can certainly be proud of its results in the 5G individual analysis – after all being the smallest provider in Austria.

# Switzerland

Since the battle for the top among the Swiss operator is traditionally fought at the highest level, the question remains exciting: Who will be number one in Switzerland this time?

► For many years now, Swiss providers have been showing network operators in Germany and Austria where the top is. In Switzerland, the verdict “outstanding“, which is only rarely awarded by connect, can be regularly found at the top ranks. This year is no different – although the distance between the countries has somewhat narrowed.

In addition, 5G is gaining momentum. We examine how the roll-out of the latest generation of mobile communication has progressed on the strongest playing field of our three-country comparison. This much in advance: once again, there was a neck-and-neck race between the strong opponents Swisscom and

Sunrise. And the smallest Swiss provider, Salt, in particular managed to gain a few more points.

## Voice connections

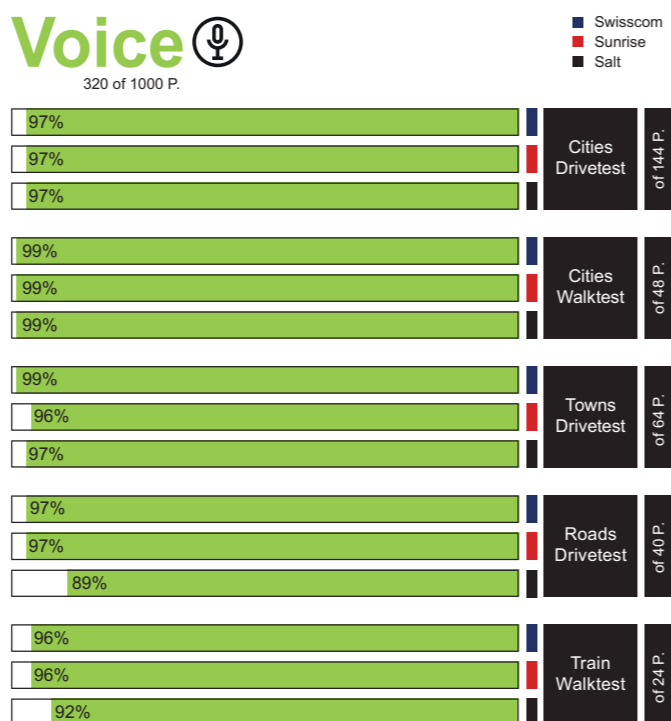
Since last year, all three network operators in Switzerland have been supporting VoLTE (Voice over LTE). Salt was the last of the three to launch this more modern telephony standard in its network. In turn, Swiss networks bring out a lot from this strong technological basis: success rates for telephony in bigger cities and

smaller towns are close to 100 per cent for all three candidates. Swisscom even reaches this mark in the drive test conducted in smaller towns. When it comes to call set-up times, Sunrise achieves the fantastic average value of 0.6 seconds (or 0.7 seconds on the roads tested), Swisscom follows with an equally impressive 1.0 seconds. And even in the network of the smallest Swiss contender, Salt, call setup times remain pleasingly short at an average of 1.2 to 1.5 seconds, depending on the test scenario.

In all these cases, the voice quality achieved also ranges from high to the highest level. Most notably, the results on Swiss trains are particularly impressive: even in the demanding environment of rail ways, Swisscom offers a success rate for smartphone calls of 99 per cent. The two competitors are only a hint behind. Call set-up times and voice quality are also largely unimpressed by train journeys. This is how you would wish for mobile connectivity when travelling on trains throughout Europe!



Operator	Swisscom	Sunrise	Salt
<b>Voice Cities (Drivetest)</b>			
Call Success Ratio (%)	99.7	99.7	99.7
Call Setup Time Ø (s) / P90 (s)	1.0/1.1	0.6/0.7	1.3/1.6
Speech Quality Ø / P10 (MOS-LQO)	4.4/3.8	4.5/4.0	4.4/3.9
MultiRAB Connectivity (%)	99.9	99.9	100.0
<b>Voice Cities (Walktest)</b>			
Call Success Ratio (%)	99.9	99.9	99.9
Call Setup Time Ø (s) / P90 (s)	1.0/1.2	0.6/0.7	1.2/1.4
Speech Quality Ø / P10 (MOS-LQO)	4.5/4.1	4.6/4.2	4.5/4.1
MultiRAB Connectivity (%)	100.0	100.0	100.0
<b>Voice Towns (Drivetest)</b>			
Call Success Ratio (%)	100.0	99.5	99.8
Call Setup Time Ø (s) / P90 (s)	1.0/1.2	0.6/0.7	1.3/1.7
Speech Quality Ø / P10 (MOS-LQO)	4.5/3.9	4.5/3.9	4.4/3.9
MultiRAB Connectivity (%)	100.0	100.0	100.0
<b>Voice Roads (Drivetest)</b>			
Call Success Ratio (%)	99.5	99.5	97.2
Call Setup Time Ø (s) / P90 (s)	1.0/1.2	0.7/0.8	1.5/1.8
Speech Quality Ø / P10 (MOS-LQO)	4.4/3.8	4.5/3.9	4.3/3.8
MultiRAB Connectivity (%)	99.8	100.0	99.9
<b>Voice Trains (Walktest)</b>			
Call Success Ratio (%)	99.0	98.9	98.2
Call Setup Time Ø (s) / P90 (s)	1.1/1.3	0.7/0.7	1.6/1.8
Speech Quality Ø / P10 (MOS-LQO)	4.4/3.6	4.5/3.8	4.3/3.6
MultiRAB Connectivity (%)	100.0	100.0	99.6

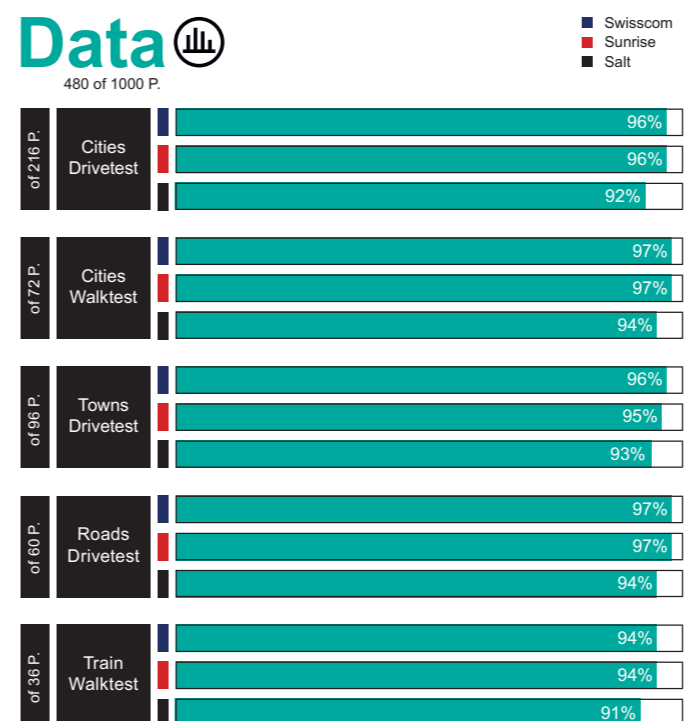


## Data connections

The Swiss candidates are also close to each other in the data measurements. In larger cities in particular, the readings obtained during the drive and walk tests in the networks of Swisscom and Sunrise show a high proportion with LTE4CA – the combination of four LTE carrier frequencies known as “4 Carrier Aggregation“. For example, the fastest ten per cent (P90 value) of the download data rates captured during the walk tests in large cities are at 573.9 Mbps in the Sunrise network, at

425.5 Mbps in the Swisscom network and at 199.4 Mbps in the Salt network. Sunrise also delivers the fastest results in terms of uploads as well as of data rates captured during the drive tests in smaller Swiss cities.

Swisscom and Sunrise are engaged in a neck-and-neck race in the final scoring of all measured values considered. In large cities and on the streets, the two rivals are on par, while in small towns Swisscom shows a minimal lead. Salt follows at a slight distance, but still with respect



Operator	Swisscom	Sunrise	Salt
<b>Data (Cities; Drivetest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	99.9	100.0	99.6
Total Session Time (s)	0.7	0.7	0.8
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.9/1.1	99.9/1.0	99.6/1.7
90%/10% faster than (Mbps)	23.0/147.1	27.0/191.4	17.2/114.5
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.9/0.9	100.0/1.1	99.7/1.2
90%/10% faster than (Mbps)	18.2/46.3	13.2/47.1	14.2/42.2
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.8	99.9	99.3
Ø Throughput (Mbps)	135.7	173.5	88.0
90%/10% faster than (Mbps)	29.2/295.6	31.1/429.4	17.9/185.8
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.7	99.9	99.6
Ø Throughput (Mbps)	45.1	41.7	39.1
90%/10% faster than (Mbps)	20.1/60.2	14.0/63.5	15.4/56.3
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.8/0.9	99.8/0.8	99.1/0.9
Ø Video Resolution (p)	920	920	919
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	99.2/1.0	99.9/0.9	98.3/1.0
Ø Video Resolution (p)	1038	1038	1036
<b>Data (Cities; Walktest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	99.9	99.9	99.9
Total Session Time (s)	0.7	0.6	0.7
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/1.0	99.8/0.7	99.8/1.3
90%/10% faster than (Mbps)	28.6/192.9	40.7/240.8	21.7/127.8
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/0.9	100.0/0.9	100.0/1.1
90%/10% faster than (Mbps)	23.1/48.7	18.1/50.6	16.5/41.1
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.8	99.8	99.8
Ø Throughput (Mbps)	209.3	268.0	86.9
90%/10% faster than (Mbps)	38.8/425.5	40.9/573.9	19.8/199.4
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.6	99.8	99.6
Ø Throughput (Mbps)	50.0	47.6	39.2
90%/10% faster than (Mbps)	28.9/62.9	24.3/66.6	19.9/55.9
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.8/0.9	99.6/0.7	99.6/0.9
Ø Video Resolution (p)	920	921	916
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	100.0/1.0	100.0/0.9	98.8/1.0
Ø Video Resolution (p)	1037	1039	1035
<b>Data (Towns; Drivetest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	99.9	99.9	99.9
Total Session Time (s)	0.7	0.7	0.8
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.8/1.0	99.8/1.0	100.0/1.4
90%/10% faster than (Mbps)	23.3/133.2	26.8/167.8	19.1/109.9
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/0.9	100.0/1.4	99.8/1.3
90%/10% faster than (Mbps)	18.9/45.4	9.9/44.9	11.4/41.5
<b>File Download (7 seconds)</b>			
Success Ratio (%)	100.0	100.0	99.8
Ø Throughput (Mbps)	127.1	153.3	78.1
90%/10% faster than (Mbps)	30.4/271.6	35.5/361.7	20.1/152.7
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	100.0	99.6	99.8
Ø Throughput (Mbps)	44.0	35.0	34.6
90%/10% faster than (Mbps)	22.6/59.8	10.6/61.2	12.2/55.1
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.6/0.9	100.0/0.8	99.8/0.9
Ø Video Resolution (p)	920	919	920
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	99.3/1.0	99.6/0.9	99.6/1.1
Ø Video Resolution (p)	1038	1036	1039

Operator	Swisscom	Sunrise	Salt
<b>Data (Roads; Drivetest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	99.9	99.9	99.3
Total Session Time (s)	0.7	0.7	0.8
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.8/1.0	100.0/1.2	99.1/1.4
90%/10% faster than (Mbps)	30.2/131.9	21.9/141.5	21.2/120.3
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/1.1	99.8/1.6	99.3/1.4
90%/10% faster than (Mbps)	13.3/45.2	8.0/45.0	10.2/41.2
<b>File Download (7 seconds)</b>			
Success Ratio (%)	99.8	99.8	99.6
Ø Throughput (Mbps)	148.9	118.9	83.8
90%/10% faster than (Mbps)	38.9/296.2	24.9/242.9	20.0/152.5
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.8	100.0	98.7
Ø Throughput (Mbps)	39.9	32.9	33.3
90%/10% faster than (Mbps)	15.7/58.8	8.7/59.3	10.1/54.4
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.8/0.9	99.5/0.9	98.6/0.9
Ø Video Resolution (p)	920	919	918
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	98.6/1.0	99.6/1.0	99.3/1.1
Ø Video Resolution (p)	1039	1039	1037

Operator	Swisscom	Sunrise	Salt
<b>Data (Trains; Walktest)</b>			
<b>Web Page Download</b>			
Success Ratio (%)	99.7	99.8	99.1
Total Session Time (s)	0.9	0.8	1.0
<b>File Download (5MB)</b>			
Success Ratio/Ø Session Time (%/s)	100.0/2.2	100.0/2.2	100.0/2.6
90%/10% faster than (Mbps)	10.0/94.1	9.6/104.2	9.6/81.1
<b>File Upload (2.5MB)</b>			
Success Ratio/Ø Session Time (%/s)	99.7/1.6	100.0/1.3	98.9/1.4
90%/10% faster than (Mbps)	10.2/36.4	10.8/40.6	10.6/34.3
<b>File Download (7 seconds)</b>			
Success Ratio (%)	100.0	100.0	98.4
Ø Throughput (Mbps)	65.6	64.2	46.4
90%/10% faster than (Mbps)	12.3/127.3	11.1/111.1	10.3/96.0
<b>File Upload (7 seconds)</b>			
Success Ratio (%)	99.0	99.3	98.4
Ø Throughput (Mbps)	31.0	30.9	27.7
90%/10% faster than (Mbps)	14.0/46.6	12.0/51.0	9.7/42.3
<b>Youtube Videos</b>			
Success Ratio/Start Time (%/s)	99.0/1.2	99.0/1.1	97.7/1.1
Ø Video Resolution (p)	910	918	911
<b>Youtube Live</b>			
Success Ratio/Start Time (%/s)	99.3/1.2	98.0/1.1	99.3/1.2
Ø Video Resolution (p)	1031	1037	1034

table results. The results of our Youtube measurements are equally impressive: depending on the scenario and provider, their success rates are at 100 per cent or very close – and the video resolution is also top. Of course, the observed high data rates are also due in part to the 5G roll-out, which is particularly advanced among the Swiss operators – see box below. This applies to Swiss-

com and Sunrise to a surprisingly high degree also in smaller towns and on connecting roads. Even in these more difficult environments for mobile operators, all Swiss providers deliver virtually the same level of service as in the big cities.

**Data connections on trains**  
With only minor exceptions, this also applies to the tests

conducted in Swiss railways. Here the Swiss operators once again demonstrate how mobile phone coverage should really look like when their customers are travelling by train. In this discipline again, the familiar picture from the previous categories is repeated: Swisscom and Sunrise duel at the highest level and cross the finish line of the

railway assessment together at the end. Salt follows at only a small gap. The fact that all three Swiss network operators achieve success rates of 100 per cent in some of the download tests and are not far behind in the other test cases is already a minor sensation. Still, we have almost got used to this in our network tests conducted in Switzerland.

## 5G

The Swiss providers also achieve particularly high results in the analysis of the 5G results. Swisscom and Sunrise offer the latest generation of mobile telephony not only in the cities, but also already to a large extent in the more rural areas. According to our analysis, they are on a par regarding 5G.

In the individual analysis of the effect of the 5G roll-out in Switzerland, Swisscom and Sunrise are close to each other as usual. If we look at the proportion of areas in which unlaunched registered 5G samples in the drive tests and walk tests, Swisscom ranks slightly ahead. In terms of the data rates achieved via 5G in all test scenarios considered, Sunrise again takes the lead.

Salt is still in the early stages of its 5G roll-out – but where the smallest Swiss network operator can already offer the new standard, it also delivers impressive data rates. And with a clear gap compared to the levels of 5G roll-outs in the neighbouring countries, the Swisscom and Sunrise networks already contribute a fairly high number of 5G samples even in smaller

cities and on the connecting roads. For both strong competitors, the following also applies: Where 5G can already be received, the new network is also available with high reliability. Both big players are doing an excellent job in their 5G roll-out! With the best will, in the 5G race between Swisscom and Sunrise we are not able to choose a sole winner.

Data rates 7s Download	Swisscom			Sunrise			Salt		
	Share	Reliability	Data rate (Ø, Mbps)	Share	Reliability	Data rate (Ø, Mbps)	Share	Reliability	Data rate (Ø, Mbps)
Cities – Drivetest	43.9%	99.7%	278.1	41.1%	99.7%	432.5	2.8%	78.6%	280.9
Cities – Walktest	47.4%	100.0%	295.1	41.7%	100.0%	469.0	1.1%	85.7%	516.3
Towns – Drivetest	38.4%	100.0%	253.4	33.7%	100.0%	405.4	3.9%	100.0%	123.5
Roads – Drivetest	31.4%	98.9%	258.6	22.1%	100.0%	343.8	2.1%	100.0%	162.6
Trains – Walktest	11.6%	100.0%	118.5	6.4%	100.0%	202.9	0.7%	66.7%	37.2



## Crowd

In Switzerland, our crowdsourcing analysis shows the same ranking as in the overall assessment: Swisscom ranks first, Sunrise just behind and Salt follows on a very good third rank.

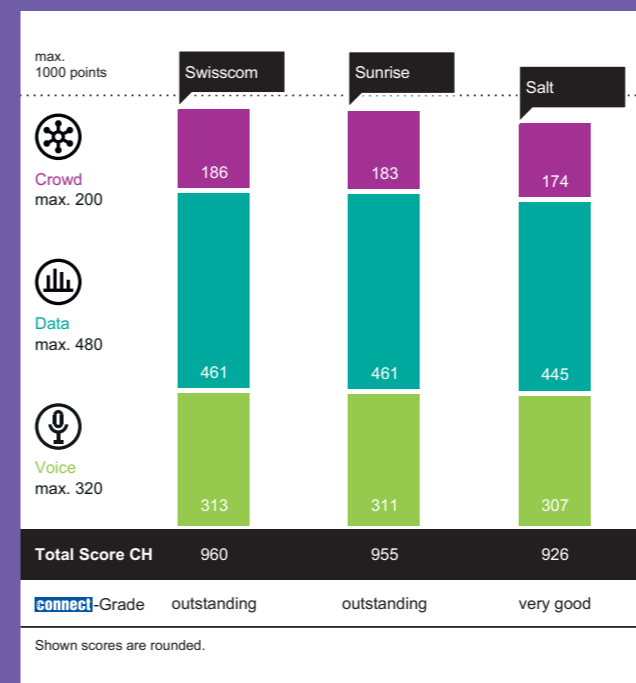
The results of our crowdsourcing analyses in Switzerland reflect the results of the previous categories as well as the overall ranking: with a gap of only three points, the runner-up Sunrise is behind the leading Swisscom. With a nine-point difference, Salt follows in third place. The Quality of Broadband Service has a large share in these scores. It not only rewards the expansion of 4G and 5G service in the area, but also rewards operators who provide mobile communications with high bandwidths in individual “evaluation areas” alone or with only one competitor. It is therefore not surprising that Swisscom is ahead in this discipline, Sunrise follows closely behind and Salt achieves a somewhat lower percentage. However, Sunrise is ahead in the question of how often each individual customer

actually has contact with 4G or 5G (the “Time on Broadband”). Swisscom also achieves an excellent score in this respect, and also Salt shows a very respectable result. The data rates determined via crowdsourcing show a similar picture – with Salt even outperforming Sunrise by half a percentage point in the lowest speed

category of Basic Internet, which underlines Salt’s strong focus on basic supply. We made a similar observation regarding the latencies: Here, behind the leading Swisscom, Salt again follows in the somewhat less demanding OTT Voice class. In the more demanding Gaming class, the familiar ranking is again apparent: Swisscom – Sunrise – Salt.

Operator	Swisscom	Sunrise	Salt
<b>Broadband Coverage</b>			
Coverage Excellence (%)	70.8	68.0	47.8
Time on Broadband (%)	96.7	97.1	92.8
<b>Download Speed</b>			
Basic Internet Class (%)	94.2	92.2	92.7
HD Video Class (%)	81.2	75.6	74.6
UHD Video Class (%)	23.8	19.3	15.8
<b>Latency</b>			
Gaming Class (%)	95.3	89.8	86.3
OTT Voice Class (%)	98.5	97.5	98.1

## Single review



For the third time in a row, Swisscom has managed to take the lead among the two outstanding Swiss network operators. While being on a par with Sunrise in the Data evaluation, the market leader wins the overall assessment with a slight point advantage in the Voice and Crowdsourcing categories. Regarding 5G, Swisscom shares the top spot with Sunrise.



With a five-point gap to the test winner, Sunrise again receives the grade “outstanding”. While both providers achieve the same number of points in the Data discipline, Sunrise is slightly behind Swisscom in the evaluations for Voice and Crowdsourcing – given the high Swiss level, just a few points are decisive. According to our analysis, Sunrise is on a par with Swisscom in 5G.



As the only provider in Switzerland this time, Salt has improved in comparison to the previous year – in the Voice discipline as well as in the Data discipline and quite clearly in Swiss trains. Overall, the third place winner in Switzerland achieved the same score as the overall winner in Germany and the whopping grade “very good”. Salt is still in its early stages with 5G – but already offers top values in its first 5G cells.

## Methodology

The tests in Germany took place from October 22nd to November 2nd, 2020, the tests in Austria from October 12th to 19th, and the tests in Switzerland from October 21st to 31st, 2020. For each country, connect's partner for the network measurements, umlaut, used four vehicles for drive testing on the chosen routes. Each car carried a total of six smartphones. One Samsung Galaxy S10 per operator was used for the voice tests, another smartphone per operator took the data measurements: In two of the cars this were Samsung Galaxy S10, set to "4G preferred", in the two other cars Galaxy S20+ with the setting "5G preferred". In Switzerland, in accordance with the operators instead of the S20+ the Samsung S10 5G was used – again with "5G preferred". In addition to the drive tests in each country a walk test team took measurements by foot – visiting so-called "areas of interest" with a strong visitor frequency like train stations, airport terminals, coffee shops, museums and also local public transport. Part of the schedule of the walk tests were also rides on long distance trains. The walk test teams also utilised Galaxy S10 smartphones for the voice tests and

Galaxy S20+ for the data tests (in Switzerland again: S10 5G) set to "5G preferred" mode. The smartphones were installed on trolleys and backpacks with additional strong batteries. The devices used each operator's current firmware version. If such software was not available, the according regional "open market" firmware was used.

### Logistics

All drive tests and walk tests were done between 8 am and 10 pm. During the drive tests, two cars were present in the same cities, but on different routes to avoid any interference of one car's measurement by the other car's. In Germany, the measurements included 21 larger cities and 25 smaller towns, while the walk tests frequented ten cities. The measurement cars drove a total of approx. 10,379 kilometers. With their drive tests, they covered a population of about 14.6 million which equals about 17.7 per cent of the inhabitants of Germany. In Austria, the drive tests covered 9 big cities and 17 smaller towns, the walk test team visited seven cities. Here, the vehicles covered about 5,280 km equaling 3.1 million inhabitants or 35.1 per cent of the population. In Switzerland, the drive tests covered



With a fleet of specially equipped test vehicles, the umlaut teams conducted the drive tests in three countries.

17 big cities and 36 smaller towns, the walk tests took place in eight cities. The test route in Switzerland was about 6,720 km long, equalling about 2.3 million inhabitants or approximately 27.5 per cent of the population. For the definition of the test routes umlaut generates four independent plans, from which connect then randomly chooses one

### Voice telephony

Voice services were measured with the smartphones performing calls alternating between the measurement cars ("mobile to mobile"). The walk test teams called a stationary (smartphone) counterpart for all voice tests. Background data traffic was transmitted by one of the smartphones simultaneously in order to reflect a realistic usage scenario. As part of the tests we also evaluate the so-called MultiRAB (Multi Radio Access Bearer) Connectivity. This value denotes whether data connectivity is available during the phone calls. Audio quality was assessed by using the HD-Voice capable POLQA wide band scoring. All devices were configured in "VoLTE preferred" mode.

### Data connectivity

To assess cellular data performance, top websites (according to the Alexa ranking) were dynamically downloaded. Additionally a static website was tested, the industry standard ETSI (European Telecommunications Standards Institute) Kepler reference page. HTTP downloads

and uploads were conducted with 5 MB and 2.5 MB files, simulating small file transfers. The networks' peak performance was tested with a seven second download and upload of a single, very large file. Youtube measurements consider the "adaptive resolution" feature of this video platform and thus assess the success ratio, the time until the playback starts as well as the videos' average resolution.

### Crowdsourcing

The results of the crowdsourcing analysis performed by umlaut contribute 20 per cent to the total score. For this purpose, in all three countries samples collected from mid-May until end of October 2020 were evaluated. For Germany, a total of approx. 2 billion single measurement values from about 401,300 users was analysed. This represents about 99.6 per cent of the country's built-up area. For Austria, umlaut considered approx. 707 million values from a total of about 58,200 users, representing a 100 per cent of the built-up area in cities and 92.1 per cent of the built-up area outside of them. The figures for Switzerland: Approx. 33,400 users contributed 177 million samples. This covers about 97 per cent of the built-up area in Switzerland. The data base for these analysis is obtained by more than 1000 popular apps. They log in the background whether there is a network connection, which mobile network technologies are available and what download



data rate and latency can be achieved – provided that the user has agreed to this completely anonymous data collection beforehand. These values are gathered every 15 minutes and transmitted once a day to umlaut's servers. The reports only comprise a small number of bytes so that they do not put a substantial strain to the users' data volumes.

### Quality of Broadband Service

For the assessment of the Coverage Excellence, umlaut applies a grid of 2 x 2 km tiles (so-called evaluation areas or EAs) over the test area. For each tile, a minimum number of users and measurement values must be available. For the evaluation, umlaut awards one point if the considered network provides 4G or 5G coverage in an EA. Another point is awarded to a candidate for each competitor who provides a smaller or no share of broadband usage. In a country with three contenders, a candidate can thus reach up to three points per tile: one for providing broadband coverage and up to two additional ones for "beaten" competitors. The assessment then relates the obtained points to the total possible points for Coverage Excellence. In addition, we con-

sider the Time on Broadband. It reveals how often a single user had 4G or 5G reception in the observation period – independent from the EAs in which the samples were obtained. In order to calculate this, umlaut puts the number of samples with 4G/5G coverage into relation to the total number of all samples. Coverage Excellence and Time on Broadband results each provide 50 per cent of the points for the Quality of Broadband Service. Important: The percentages determined for both parameters reflect the respective degrees of fulfilment. They do not correspond to the percentage of 4G/5G coverage of an area or population.

### Data rates and Latencies

Additionally, umlaut investigates the Data rates and Latencies that were actually available to each user. The examination of these parameters is independent from the EAs and thus concentrates on the experience of each single user. Samples which were for instance obtained via WiFi or with the smartphone's flight mode being active, are filtered from the data pool before further analysis. In order to take the fact into account that many mobile phone tariffs limit data



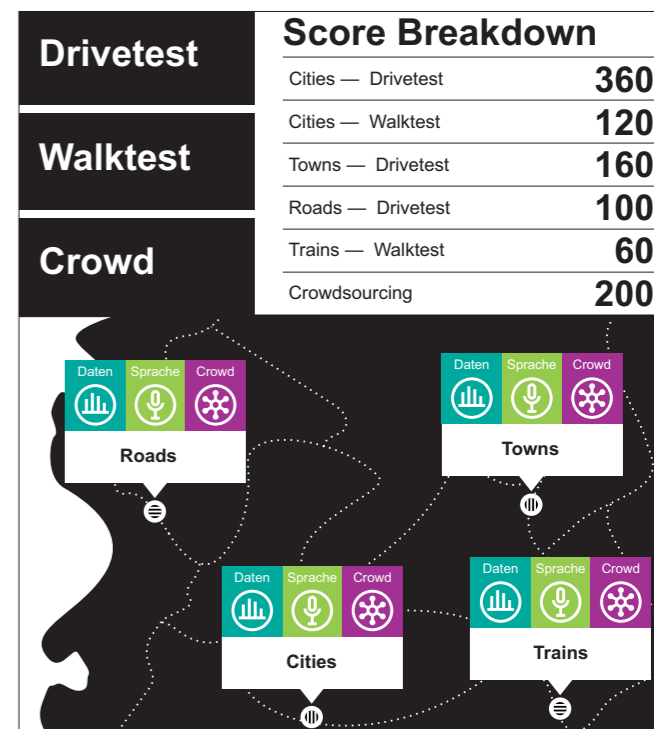
The walk test teams used trolleys or backpacks, in which strong batteries powered the test smartphones.



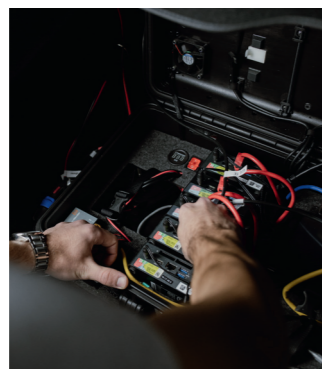
The umlaut staff analysed hundreds of thousands of measurement values during and after the tests.

rates, umlaut has defined speed classes which are corresponding to particular applications: For Basic Internet, a minimum of 2 Mbps must be met. HD Video requires 5 Mbps. And for UHD Video the minimum is 20 Mbps. In order for a sample to count as valid, a minimum amount of data must have been transmitted within a 15 minute period. The same principle also applies to the assignment of a data packet's latency to the according application-based classes: Roundtrip times up to 100 ms are sufficient for OTT Voice, 50ms and faster

qualify a sample for Gaming. In the assessment, umlaut assigns the data rate and latency observed in a sample to one of these performance classes. Then, Basic Internet accounts for 60 per cent of the Data Rate score, HD Video for 30 per cent and UHD Video for 10 per cent. The Latency score incorporates OTT Voice with a share of 80 per cent, Gaming with a share of 20 per cent. An even more detailed description of our methods and the results for other countries can be found online at [www.connect-testlab.com](http://www.connect-testlab.com).



Each drive test car transported six smartphones for the voice and data measurements.



A unique control system supervises the smartphones and registers the collected measurement values.



# Fairness and Transparency

Our mobile phone network test begins long before the actual measurements are taken. But even during and after the tests, umlaut and connect make sure that the network operators adhere to fair-play rules.

To ensure fair and transparent testing, in recent years certain routines proved to be helpful. This includes connect and umlaut informing the operators at an early stage about the basic parameters of our tests.

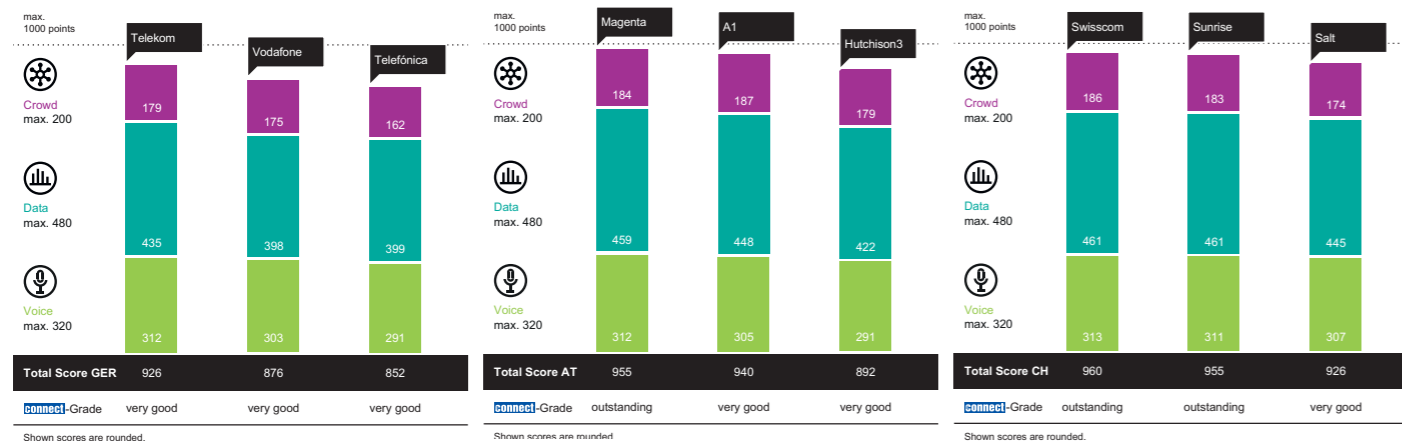
This “framework” includes among other factors the smartphones used for testing, the KPIs gathered during the measurements and being considered in the evaluation, the basic scoring scheme and the exact timing. connect and umlaut defined these frame conditions for this year’s mobile network test early in 2020 and subsequently informed the CTOs of the operators about them. We are then open for feedback and suggestions, but critically check every single one and also have to reject many of them.

Furthermore, during the phase of preparing and executing the drive tests and walk tests, connect and umlaut are in

constant contact with the operators. For example, we then discuss and if necessary update the firmware versions installed on the smartphones used for the measurements – so that they optimally support all technologies supported by the operators such as for instance VoLTE, Carrier Aggregation or 5G-DSS (Dynamic Spectrum Sharing).

However, communication with the network operators also includes a strong reference to adhering to fair play rules. During test execution and evaluation, umlaut analyses the measured values intensively to see whether they show any signs of possible manipulation attempts. If such an attempt is detected, the possible countermeasures range from invalidating the samples assessed as doubtful all the way to disqualifying the concerned participant.

Especially the extensive data connections that have to be established during the tests make it unavoidable to use SIM cards provided by the network operators for this purpose. Otherwise, not only would extremely high costs be incurred, but the SIM cards would have to be constantly replaced during the tests because of quickly reached tariff or fair-use limits. The SIM cards provided by the operators on loan are provisioned in exactly the same way as normal cards, but have no data limit. In order to prevent possible manipulation attempts in this area, umlaut compares the measurement results obtained using these loan cards with random samples taken with regularly purchased SIM cards. If a deviation were to be found here, this would also be a reason for more in-depth analyses and appropriate countermeasures.



			GERMANY			AUSTRIA			SWITZERLAND		
Overall Results Voice, Data & Crowd			Telekom	Vodafone	Telefónica	Magenta	A1	Hutchison3	Swisscom	Sunrise	Salt
Voice	max. 320 points		312	303	291	312	305	291	313	311	307
Cities	Drivetest	144	99%	97%	93%	98%	97%	91%	97%	97%	97%
Cities	Walktest	48	99%	96%	96%	99%	97%	95%	99%	99%	99%
Towns	Drivetest	64	99%	94%	93%	99%	95%	97%	99%	96%	97%
Roads	Drivetest	40	96%	91%	87%	98%	95%	85%	97%	97%	89%
Trains	Walktest	24	87%	88%	71%	86%	84%	75%	96%	96%	92%
Data	max. 480 points		435	398	399	459	448	422	461	461	445
Cities	Drivetest	216	93%	86%	86%	97%	95%	88%	96%	96%	92%
Cities	Walktest	72	92%	87%	90%	96%	93%	82%	97%	97%	94%
Towns	Drivetest	96	91%	81%	77%	95%	92%	92%	96%	95%	93%
Roads	Drivetest	60	89%	84%	82%	96%	96%	92%	97%	97%	94%
Trains	Walktest	36	73%	64%	71%	87%	84%	80%	94%	94%	91%
Crowd	max. 200 points		179	175	162	184	187	179	186	183	174
Crowd	200		89%	87%	81%	92%	93%	90%	93%	92%	87%
Total	max. 1000 points		926	876	852	955	940	892	960	955	926
connect rating			very good	very good	very good	outstanding	very good	very good	outstanding	outstanding	very good

All values have been rounded to integer numbers. The internal calculation of points and percentages was based on three decimal places. Intermediate results therefore can slightly deviate from the specified values.



## Conclusion

Hannes Rügheimer, connect- author



There were no surprises in the rankings this year again – the rank order of the operators in all three tested countries remains stable for the third year in a row. This does not mean, however, that not every single network operator is making extreme efforts to improve its position. This leads to the pleasant result that we can conform very clear improvements across the entire test field in Germany and that Telefónica now also joins the ranks of the providers rated “very good”.

In the neighbouring countries, which were already at a very high level before, this time there are no serious increases to be seen. But there have been pleasing improvements in details – such as the improvement in mobile phone coverage in trains on the whole and particularly pronounced among the third-placed

providers in each country. In Germany, Deutsche Telekom is the overall winner for the tenth time in a row. The Bonn-based company was able to achieve a slight year-on-year increase in both voice and data discipline, and even a significant improvement in the crowdsourcing category. In addition, our individual analyses show that Deutsche Telekom is also clearly ahead in terms of 5G expansion. Vodafone in second place was also again able to improve in all three test disciplines compared to the previous year. The biggest surprise, however, came from Telefónica/O2. After the Munich-based provider had already improved significantly in the previous year, this year it is finally able to catch up with the overall field. If this trend continues, we can expect exciting rank fights in the future.

In Austria, Magenta continues the now also established ranking order and achieves the overall victory for the third time in a row as well as the top mark “outstanding” for the second time. A clear lead regarding the 5G roll-out in the Alpine Republic has very probably also a share in this.

A1 Telekom achieves a very good second place – in the overall ranking as well as in the 5G assessment. The Hutchison brand Three, once again receives the overall mark “very good”, although with a few points less than in the previous year. Considering the fact that it is the smallest provider in Austria, Three can be particularly proud of the results of our 5G analyses.

In the hotly contested Switzerland, Swisscom also manages to outperform its strong rival Sunrise for the third time in

a row. While the two providers are on a par in the data ranking, Swisscom can win the tight race in the disciplines of Voice and Crowdsourcing. With the best will, we cannot find a winner between Swisscom and Sunrise



in terms of the 5G roll-out. Salt was able to improve slightly in comparison to the previous year and also shows great potential in the 5G area.

However, the biggest winners in all countries are the customers – as they benefit from very good to outstanding mobile networks.

## Interview



Hakan Ekmen, CEO Telecommunication at umlaut

### “Mobile phone users are the real winners“

Mr Ekmen, for the first time our German mobile network test results are consistently “very good“. How do you assess this result?

**Hakan Ekmen:** Apart from the winners, our congratulations go to all mobile phone users, the real winners of this year’s mobile network test. The German networks in particular have improved considerably compared to their international competitors. In addition, Telefónica was able to catch up strongly in Germany.

All providers in the three countries are currently focusing mainly on their 5G roll-outs. But the current analyses show clear differences. How should they be interpreted?

**Hakan Ekmen:** Currently, Switzerland is clearly the pioneer in 5G. However, our analyses of the last few weeks also show an increasingly rapid 5G roll-out in Germany and Austria. So the race has really just started and promises to become very exciting in the next year.

What is the reason for the ranking determined in the crowd discipline partly deviating from the results of the drive and walk tests?

**Hakan Ekmen:** For the most part, we are seeing consistent results. However, while drive and walk tests probe the technical possibilities of a network, crowdsourcing takes additional factors into account that are influenced by users, such as their choice of terminal equipment and tariff.