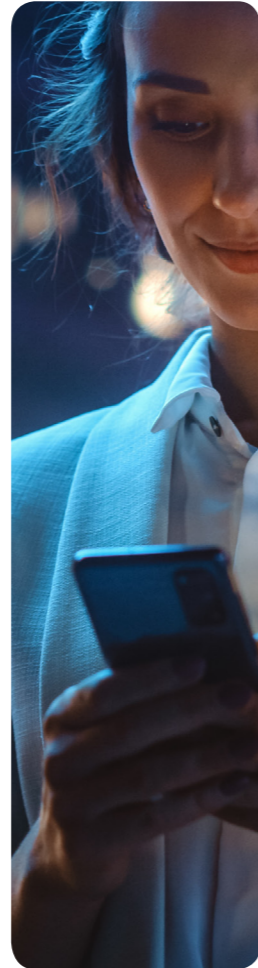
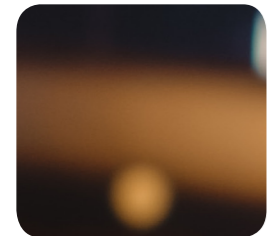
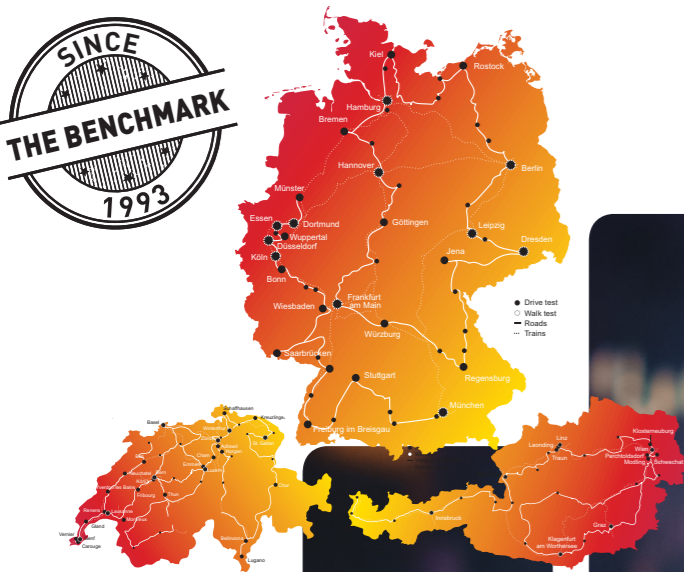


30 years is a round number: that's how long the connect mobile network test already exists. And for 20 years now, we have been conducting it at the highest methodological level in close cooperation with our test partner, which now goes by the name of umlaut. What are the results in Germany, Austria and Switzerland this year?



The Great Mobile Network Test 2024

The very first issue of connect, published in autumn 1993, already featured a mobile network test. The question at the time was “D1 versus D2: Who offers more?“, and the members of the founding editorial team sought the answer by test driving their private cars on motorways and major national roads. One colleague drove, the other logged on paper the reception of the test mobile phones they were carrying. Since then, the methodology has been massively developed and professionalised.

Since 2004, connect has been working with the Aachen-based test specialist for its mobile network tests, which at the time still traded as “P3“ and since 2019 has been operating under the name umlaut. We have also continuously expanded the area analysed: in 2011 to Switzerland, in 2012 to Austria and since then to many other countries. You can read how much more measurements and analyses go into today's test result than just answering the question “Is there network reception or not?“ in the detailed description of the methodology on page 66/67.

Our success has proved us right: our mobile network test has long been regarded as the most important and most widely recognised benchmark in the industry. CTOs

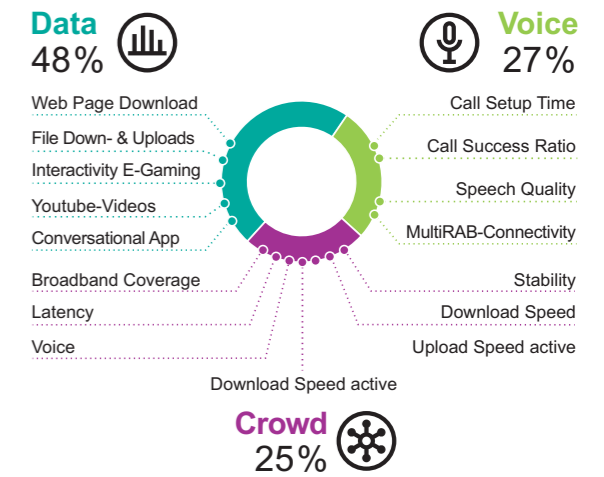
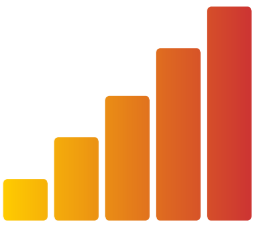
base their planning on its results, and many customers make their decision in favour of a provider on the basis of our test results. After 30 years, we therefore cannot help but take a moment to look back on what we have achieved with a little pride.

Many improvements in detail

But that's enough looking back – now let's face the future again. After all, one of the recipes for the success of our network test is that the underlying methodology always follows the technical developments in the market.

This year, for example, there were a number of methodological improvements “under the bonnet“ of our measurements – for example, in determining call setup success or the quality of YouTube streams. More simultaneous TCP connections are supported in the active upload and download tests and more websites as remote sites in crowdsourcing.

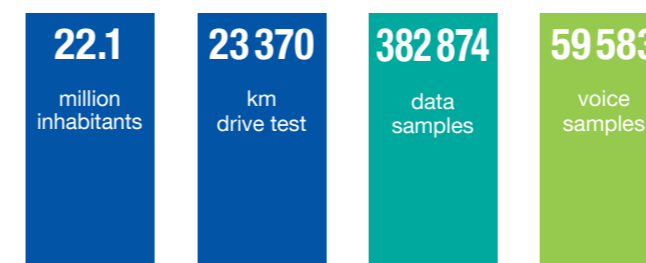
Our goal remains to investigate the maximum network performance while keeping an eye on everyday aspects. Read on to find out how the mobile network providers in Germany, Austria and Switzerland are coping with these requirements. **Hannes Rügheimer**



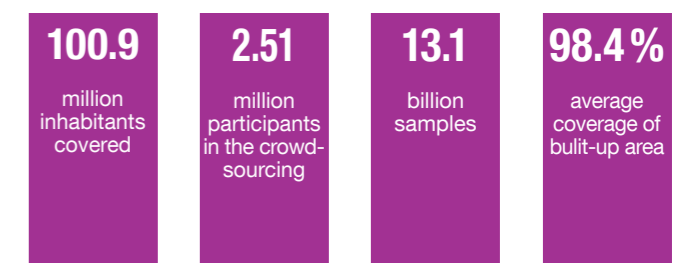
Practice-orientated scoring

Today, smartphones are primarily used for data communication, from messaging and surfing to the use of apps – our evaluation takes this into account, with the data category representing the largest share at 48 per cent. Here we evaluate a mix of typical mobile applications. Because voice telephony is still important, it is included in the result with a share of 27 per cent and with a clear focus on quality parameters. Finally, crowdsourcing, which contributes 25 per cent, supplements the performance-oriented measurements with analyses of the user experience as perceived by a large number of customers.

DRIVE TESTS AND WALK TESTS



CROWDSOURCING



The combined values for Germany, Austria and Switzerland are shown here. For individual values per country, see Methodology on page 66.

Voice

Making calls on a smartphone may become less important in everyday use – but when you need the function, it should deliver reliable connections.

The results in the voice discipline also consistently show the familiar ranking: Telekom is ahead in all scenarios and – with the exception of the railway – showing almost perfect results, not least thanks to very high success rates and very good MultiRAB connectivity (i.e. data connections even during phone calls). Vodafone and Telefónica follow close behind in the major cities. The further we move from there to the countryside, the clearer the gaps become.

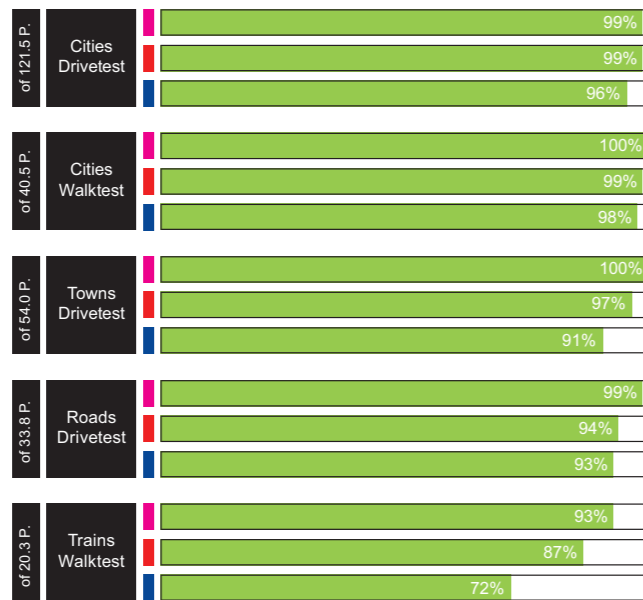
Best supply in large cities

The walk tests and drive tests in the major cities show almost perfect results for all three operators – only the values achieved by Telefónica/O2 in the drive tests should be a little better. This is even more pronounced in small towns, where Telefónica's roll-out activities have obviously not yet been fully realised.

Gaps on connecting roads and on trains

Telekom maintains its high level on the connecting roads, while Vodafone and Telefónica fall back somewhat and are almost on a par in this scenario.

The air is getting thinner for all three operators when making calls on trains, but Telekom still achieves the best results in this scenario. Lower success rates lead to Telefónica in particular falling behind its previous year's result. The speech quality of calls conducted on trains should be somewhat higher with Vodafone and Telefónica.



The picture is clear: Telekom is ahead everywhere, Vodafone and Telefónica should catch up in rural areas and on the railway.

Operator	Telekom	Vodafone	Telefónica
Voice Cities (Drivetest)			
Success Ratio (%)	99.9	99.8	99.5
Call Setup Time P90 (s)	1.0	1.0	1.2
Speech Quality P10 (MOS-LQO)	4.7	4.7	4.5
Multirab Connectivity (%)	99.9	99.8	99.6
Voice Cities (Walktest)			
Success Ratio (%)	100.0	99.8	99.8
Call Setup Time P90 (s)	0.9	1.0	1.0
Speech Quality P10 (MOS-LQO)	4.7	4.7	4.7
Multirab Connectivity (%)	100.0	99.8	99.6
Voice Towns (Drivetest)			
Success Ratio (%)	100.0	99.6	98.7
Call Setup Time P90 (s)	1.0	1.0	1.3
Speech Quality P10 (MOS-LQO)	4.7	4.7	4.5
Multirab Connectivity (%)	99.8	99.6	99.6
Voice Roads (Drivetest)			
Success Ratio (%)	99.7	98.5	98.6
Call Setup Time P90 (s)	1.0	1.1	1.4
Speech Quality P10 (MOS-LQO)	4.7	4.6	4.3
Multirab Connectivity (%)	100.0	98.5	99.4
Voice Trains (Walktest)			
Success Ratio (%)	98.1	97.0	93.4
Call Setup Time P90 (s)	1.1	1.3	1.5
Speech Quality P10 (MOS-LQO)	4.7	4.1	3.9
Multirab Connectivity (%)	99.9	99.0	98.5



Single review

THE NUMBER 13 IS A LUCKY NUMBER FOR TELEKOM THIS TIME, AS IT HAS WON OUR MOBILE NETWORK TEST IN GERMANY FOR THE THIRTEENTH TIME. THE BONN-BASED COMPANY NOT ONLY DEFENDED THE TOP SCORE OF "OUTSTANDING" ACHIEVED FOR THE FIRST TIME LAST YEAR, BUT ALSO IMPROVED ON THE PREVIOUS YEAR'S RESULT BY A WHOPPING 15 POINTS.

VODAFONE ALSO INCREASED ITS SCORE BY SIGNIFICANT ELEVEN POINTS COMPARED TO THE PREVIOUS YEAR. THE DÜSSELDORF-BASED COMPANY'S SECOND PLACE IS CONFIRMED ACROSS THE BOARD IN ALL TEST CATEGORIES AND ALMOST ALL INDIVIDUAL SCORES. THE 5G ROLL-OUT, WHICH IS ALSO IMPRESSIVE OUTSIDE THE MAJOR CENTRES, LOOKS PARTICULARLY GOOD.

TELEFÓNICA ESSENTIALLY MAINTAINED ITS VERY GOOD RESULT FROM THE PREVIOUS YEAR. THE FACT THAT THE MUNICH-BASED COMPANY IS WORKING INTENSIVELY ON ITS NETWORK CAN BE SEEN IN MANY ASPECTS – INCLUDING THE FACT THAT TELEFÓNICA ACHIEVED A HIGHER 5G SHARE THAN VODAFONE IN MAJOR CITIES AND ALSO FOUGHT ITS WAY UP TO SECOND PLACE IN SOME INDIVIDUAL KPIS.

Crowd

The crowdsourcing evaluation is based on the user experience of a large number of mobile phone customers and emphasises the results of the drive tests and walk tests.

While the drive tests and walk tests not least serve to determine the differences in the performances of the measured networks at the peak, crowdsourcing has a broader effect: analysing almost 12 billion samples contributed by 2.3 million users allows conclusions to be drawn about how well the performance of the networks is received by all of their customers.

The evaluation of broadband coverage shows that 5G or at least 4G is received by 96 per cent or more of customers. Telekom is ahead in terms of the coverage quality, but Telefónica has a slight advantage over Vodafone. Telefónica is even ahead of Telekom in terms of coverage reach (see page 66/67 for definitions).

The data rates achieved by the customers show the familiar ranking in all analysed speed classes. The same applies to latency. All three networks achieved convincingly high shares in the basic categories (basic internet and HD video in terms of speed, OTT voice class in terms of latency). Telefónica shows the most potential for improvement in the

demanding "Gaming" latency class (roundtrip times faster than 50 ms).

The actively conducted speed measurements confirm these results, with Vodafone and Telefónica scoring close together in terms of uploads and the O2 network even coming

out ahead of Vodafone in the "90% faster than" rating. Telefónica is also in second place behind Telekom for the proportion of calls in HD quality – while the second place for transaction success again goes to Vodafone.

Operator	Telekom	Vodafone	Telefónica
Broadband Coverage			
Coverage Quality (%)	97.8	96.0	96.1
Coverage Reach (%)	96.9	96.3	97.4
Time on Broadband (%)	98.3	96.3	95.3
Download Speed			
Basic Internet Class (%)	96.4	96.1	95.5
HD Video Class / UHD Video Class (%)	88.8/42.9	87.8/39.9	86.0/35.0
Latency			
Gaming Class / OTT Voice Class (%)	90.2/96.9	88.1/95.8	74.2/94.3
Voice			
HD Voice (%)	96.7	92.6	93.1
Download Speed (Active)			
Avg. Throughput (Mbit/s)	92.1	68.8	47.4
90%/10% faster than (Mbit/s)	6.7/222.6	5.9/164.4	3.8/113.3
Upload Speed (Active)			
Avg. Throughput (Mbit/s)	22.5	17.9	17.5
90%/10% faster than (Mbit/s)	2.8/50.5	1.9/42.9	2.2/39.3
Stability			
Transaction Success (%)	95.6	93.7	93.5

Reliability

Our separate look at the basic requirements does not show a different result from the overall ranking, but proves that all three networks deliver stable performance.

The „Reliability“ section is not a separate test discipline, but rather a different look at the results of the previous categories. The analysis here concentrates on the basic requirements and ignores those KPIs that focus more on top performance. The result shows how well the network operators provide their customers with the services relevant for everyday use.

The evaluation shows no significant differences compared to the overall picture. The ranking and the gaps between the three candidates remain roughly the same in all analyses. Telefónica has to accept a more pronounced loss of points, especially in the

walk tests in the voice discipline – here, the coverage weaknesses identified in the railway tests in particular have an impact. However, this also applies to the other two candidates – in addition, there may be gaps in indoor

coverage in public areas. Vodafone also achieved a solid second place in the reliability ranking in all categories behind the overall leader Telekom.

Operator	Telekom	Vodafone	Telefónica
Voice	max. 148.5 points	146	142
Drivetest	115.1	99%	96%
Walktest	33.4	96%	92%
Data	max. 264.0 points	258	248
Drivetest	204.6	99%	96%
Walktest	59.4	93%	87%
Crowd	max. 116.9 points	110	107
Crowd	116.9	94%	92%
Total	529	514	497

All values rounded to whole numbers. The internal calculation of points and percentages was carried out with three decimal places. The 529 maximum points achieved here are an extract from the overall result totalling 1000 points (see also p. 66/67).

Voice

When making mobile phone calls, the differences between the Austrian mobile networks become more apparent the further away you are from the major cities.

The results in the voice discipline show that the Austrian operators have also expanded telephony support in their networks. This applies in particular to the VoLTE ("Voice over LTE") connection technology. However, the 5G counterpart VoNR ("Voice over New Radio") is not yet supported anywhere in Austria either.

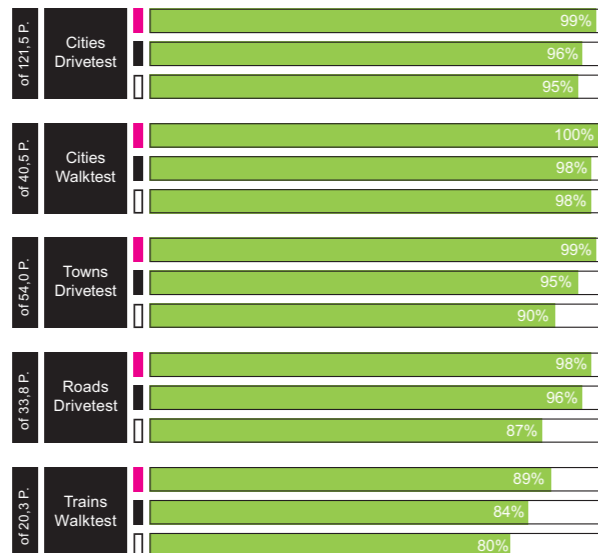
Top results in major cities

In the larger cities, the results of the voice measurements are slightly better in the walk tests than in the drive tests. Magenta is ahead in both cases, with A1 and Drei performing equally well in the walk tests. In the drive tests both conducted in large cities and small towns, A1 comes second and Drei third. The gap between A1 and Drei increases slightly in the small towns.

The high success rates and the high MultiRAB connectivity, which enables data to flow in the background even when calls are in progress, are pleasing. While Magenta and A1 excel with fast call setup times, they should be a little shorter at Drei.

Slight drops on connecting roads and on the railway

In the more difficult scenarios on connecting roads and in trains, the differences in the voice tests become clearer. Magenta is ahead in both cases, while A1 also achieves a good result on the roads. When making calls on trains, however, the Austrian providers fall behind Deutsche Telekom in Germany and behind their own results from the previous year.



Verkehrsstau: Auf Straßen und in der Bahn geben die Resultate etwas nach.

■ Magenta
■ A1
□ Hutchison3

Operator	Magenta	A1	Drei
Voice Cities (Drivetest)			
Success Ratio (%)	99.8	99.8	99.6
Call Setup Time P90 (s)	0.8	1.3	2.1
Speech Quality P10 (MOS-LQO)	4.7	4.2	4.4
Multirab Connectivity (%)	100.0	99.8	99.9
Voice Cities (Walktest)			
Success Ratio (%)	99.9	99.9	99.9
Call Setup Time P90 (s)	0.8	1.2	2.0
Speech Quality P10 (MOS-LQO)	4.7	4.6	4.7
Multirab Connectivity (%)	100.0	99.9	100.0
Voice Towns (Drivetest)			
Success Ratio (%)	99.8	99.5	98.7
Call Setup Time P90 (s)	0.8	1.3	2.1
Speech Quality P10 (MOS-LQO)	4.7	4.2	4.3
Multirab Connectivity (%)	100.0	100.0	100.0
Voice Roads (Drivetest)			
Success Ratio (%)	99.6	99.4	97.6
Call Setup Time P90 (s)	0.8	1.3	2.4
Speech Quality P10 (MOS-LQO)	4.7	4.2	4.0
Multirab Connectivity (%)	100.0	100.0	99.5
Voice Trains (Walktest)			
Success Ratio (%)	97.1	96.3	95.5
Call Setup Time P90 (s)	0.9	1.3	2.2
Speech Quality P10 (MOS-LQO)	4.7	4.0	4.0
Multirab Connectivity (%)	100.0	98.8	99.5



Single review

Magenta FOR THE SIXTH TIME IN A ROW, MAGENTA HAS MADE IT TO THE TOP OF THE WINNERS' PODIUM IN AUSTRIA, ONCE AGAIN WITH THE REMARKABLE RATING OF „OUTSTANDING“. THE OPERATOR HAS ONCE AGAIN IMPROVED SIGNIFICANTLY COMPARED TO THE PREVIOUS YEAR. WITH ITS 5G ROLL-OUT, MAGENTA ACHIEVED THE HIGHEST 5G SHARES IN THE DRIVE TESTS IN LARGER AND SMALLER CITIES.

A1 A1 ALSO SCORES „OUTSTANDING“, WHICH IS RARELY AWARDED, IMPROVES ON THE PREVIOUS YEAR AND IS CONVINCING IN ALL TEST DISCIPLINES. IN THE DATA TESTS, A1 ACHIEVED PARTICULARLY HIGH DOWNLOAD SPEEDS. IN TERMS OF ITS 5G ROLL-OUT, THE OPERATOR IS AHEAD ON THE CONNECTING ROADS, AND ITS 5G SHARE WAS ALSO THE HIGHEST FOR A1 IN THE WALK TESTS IN COMPARISON.

3 THIS YEAR, THE HUTCHISON BRAND ONCE AGAIN ACHIEVED A CLEAR IMPROVEMENT ON THE PREVIOUS YEAR. INCREASES WERE RECORDED IN BOTH THE DATA AND VOICE DISCIPLINES. THERE IS SOME POTENTIAL FOR IMPROVEMENT IN THE DATA CATEGORY IN PARTICULAR, ALTHOUGH DREI IS MAKING GOOD PROGRESS WITH ITS 5G ROLL-OUT.

Crowd

The crowdsourcing analyses, which reflect the actual customer experience of many users, confirm the ranking from the drive tests and walk tests.

The crowdsourcing analyses carried out by umlaut result in the same ranking as the voice and data measurements and as in the overall ranking for Austria: Magenta comes in first, A1 follows at a comparatively small gap and Hutchison Drei is in third place with a somewhat clearer points difference.

There are certainly differences in the detailed analyses of the respective disciplines: In the analysis of broadband coverage, Magenta takes the lead in the KPIs coverage quality and time on broadband. In terms of coverage reach (for definitions and explanations, see Methodology on page 66/67), A1 is again in the lead.

In terms of the data rates observed, all three providers are largely at the same level in the categories "Basic Internet" (at least 2 Mbit/s) and "HD video" (at least 5 Mbit/s).

In the most demanding download category "UHD video" (min. 20 Mbit/s), A1 is able to carve out a small lead over the rest of the test field. In the latency measurements, Magenta and Drei are ahead in the gaming category (less than 50 ms), while A1 achieves a slightly

higher score in the "OTT voice services" category (less than 100 ms).

Magenta is clearly ahead in terms of the proportion of voice connections in HD quality, while A1 and Drei follow some way behind. The same applies to the transaction successes assessed in the stability category.

In the active throughput measurements, A1 shows the best result for downloads, while Magenta achieves the highest average and P10 and P90 values for uploads.

Operator	Magenta	A1	Drei
Broadband Coverage			
Coverage Quality (%)	98.6	96.2	94.2
Coverage Reach (%)	90.4	91.8	85.9
Time on Broadband (%)	98.7	95.4	95.0
Download Speed			
Basic Internet Class (%)	97.0	96.6	96.1
HD Video Class / UHD Video Class (%)	89.5/38.1	89.4/41.5	88.3/37.1
Latency			
Gaming Class / OTT Voice Class (%)	93.9/98.1	92.8/98.3	93.8/97.4
Voice			
HD Voice (%)	97.1	92.5	91.3
Download Speed (Active)			
Avg. Throughput (Mbit/s)	61.6	70.9	53.4
90%/10% faster than (Mbit/s)	6.7/140.0	9.3/146.5	7.3/116.2
Upload Speed (Active)			
Avg. Throughput (Mbit/s)	22.8	19.8	16.6
90%/10% faster than (Mbit/s)	3.5/49.9	2.9/44.2	2.3/32.1
Stability			
Transaction Success (%)	96.5	93.7	91.7

Reliability

In the reliability ranking, which focusses on basic performance, the familiar ranking is also evident in Austria.

In the special consideration of reliability, only the KPIs that are relevant for good basic service are taken into account, while we exclude the assessments of top performance. This discipline is therefore not a separate evaluation category, but an additional look at the overall result.

Accordingly, the ranking in this chapter is the same as the overall ranking in Austria – the two stronger competitors Magenta and A1 are even closer together here. In the voice discipline they are separated by only two out of 149 possible points, in the data evaluation three out of 264. In the voice and crowd categories, Drei also comes close to the two

higher-ranked providers. In the data evaluation and even more so in the walk tests, the Hutchison network falls further behind Magenta and A1. Overall, the Austrian mobile networks offer their customers reliable

connections – but if you are looking for the maximum here too, you should address Magenta or A1.

Operator	Magenta	A1	Drei
Voice	max. 148.5 points	144	142
Drivetest	115.1	98%	97%
Walktest	33.4	93%	91%
Data	max. 264.0 points	262	259
Drivetest	204.6	100%	99%
Walktest	59.4	97%	93%
Crowd	max. 116.9 points	112	109
Crowd	116.9	96%	93%
Total	529	518	510

All values rounded to whole numbers. The internal calculation of points and percentages was carried out with three decimal places. The 529 maximum points achieved here are an extract from the overall result totalling 1000 points (see also p. 66/67).

Voice

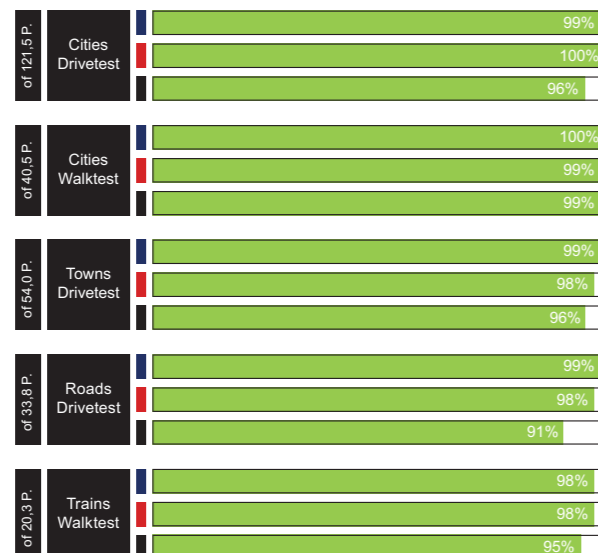
Customers can also expect top performance when making phone calls on the Swiss mobile networks.

If you want to make a phone call on the Swiss mobile networks, you will almost always get a connection – the success rates are high, even in the difficult railway scenario. The obviously consistent expansion of VoLTE (“Voice over LTE”) in all networks also leads to nice, short call setup times, which in most cases remain at one second or just below. MultiRAB connectivity is also impressive – simultaneous data transfers during mobile phone calls are not a noteworthy challenge for the Swiss networks.

In terms of voice quality, Sunrise and Salt are ahead overall, while Swisscom follows with a minimal gap.

Sunrise is slightly ahead in the metropolitan drive tests, while Swisscom again overtakes its competitors in the walk tests. Overall, the performance level in large and small cities is convincing – with minor limitations in the Salt network. The smallest Swiss network operator falls behind most distinctly in the drive tests on the connecting roads, while Swisscom and Sunrise offer comparably high performance here as in the cities. The reason for this is that Salt shows slightly lower success rates in this scenario.

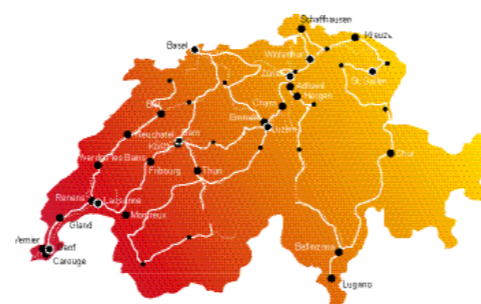
The results for calls on Swiss trains are also at a very high level. Swisscom and Sunrise perform equally well here. Salt follows closely behind, but with significantly better results than on the connecting roads.



A grain of Salt: Salt shows slight potential for improvement when making calls on connecting roads.

- Swisscom
- Sunrise
- Salt

Operator	Swisscom	Sunrise	Salt
Voice Cities (Drivetest)			
Success Ratio (%)	99.9	99.9	99.2
Call Setup Time P90 (s)	0.9	0.9	0.9
Speech Quality P10 (MOS-LQO)	4.6	4.7	4.7
Multirab Connectivity (%)	99.9	100.0	99.9
Voice Cities (Walktest)			
Success Ratio (%)	100.0	99.9	99.9
Call Setup Time P90 (s)	0.9	0.9	1.0
Speech Quality P10 (MOS-LQO)	4.7	4.7	4.7
Multirab Connectivity (%)	100.0	100.0	100.0
Voice Towns (Drivetest)			
Success Ratio (%)	99.9	99.6	99.3
Call Setup Time P90 (s)	1.0	1.0	1.0
Speech Quality P10 (MOS-LQO)	4.6	4.7	4.7
Multirab Connectivity (%)	100.0	100.0	100.0
Voice Roads (Drivetest)			
Success Ratio (%)	99.8	99.5	97.6
Call Setup Time P90 (s)	1.0	1.0	1.1
Speech Quality P10 (MOS-LQO)	4.5	4.7	4.7
Multirab Connectivity (%)	100.0	100.0	100.0
Voice Trains (Walktest)			
Success Ratio (%)	99.6	99.3	98.7
Call Setup Time P90 (s)	1.1	1.0	1.0
Speech Quality P10 (MOS-LQO)	4.6	4.7	4.7
Multirab Connectivity (%)	100.0	100.0	99.9



Single review

swisscom FOR THE SIXTH TIME IN A ROW, SWISSCOM HAS WON THE TEST IN SWITZERLAND – AND NOT ONLY GAINING THE ACTUALLY RARE GRADE OF “OUTSTANDING”, BUT ALSO WITH THE HIGHEST SCORE EVER ACHIEVED IN ONE OF OUR NETWORK TESTS. SWISSCOM ALSO CAME OUT ON TOP OVERALL FOR 5G. AN IMPRESSIVE RESULT!

Sunrise SUNRISE ALSO ACHIEVED AN OUTSTANDING RESULT, WHICH SEEMS MORE OBVIOUS IN SWITZERLAND THAN IT ACTUALLY IS. IN THE VOICE DISCIPLINE AND 5G EXPANSION IN CITIES, SUNRISE IS ALMOST ON A PAR WITH SWISSCOM, WHILE IN THE OTHER TEST CATEGORIES IT IS USUALLY ONLY JUST BEHIND. THIS OPERATOR HAS ALSO IMPROVED COMPARED TO THE PREVIOUS YEAR. ITS RESULT ALSO DESERVES THE HIGHEST RECOGNITION.

Salt. WITH ITS EXCELLENT PERFORMANCE, THE SMALLEST SWISS OPERATOR MAKES THE LEAP TO THE GRADE “OUTSTANDING” THIS TIME - PRIMARILY THANKS TO TOP PERFORMANCE IN THE DATA DISCIPLINE, BUT ALSO IN THE VOICE RATINGS. THERE IS STILL SOME ROOM FOR IMPROVEMENT IN THE AVAILABILITY OF VOICE TELEPHONY ON THE CONNECTING ROADS.

Crowd

The analysis of the user experience of a large number of mobile phone customers also leads to the same ranking as in the drive tests, walk tests and the overall evaluation.

With its crowdsourcing analyses, umlaut is supplementing the measured values of its drive tests and walk tests, which are aimed at maximum performance, with an analysis of the extent to which everyday relevant mobile phone performance is received by a large number of customers. These analyses also show Swisscom as the winner – here the gap to the runner-ups is even more pronounced, while Sunrise and Salt score closer together.

In the crowd-based surveys on broadband coverage, Swisscom takes the lead in terms of coverage reach, while Sunrise is slightly ahead in terms of coverage quality. Salt follows slightly behind in all broadband KPIs, but at a high level (for the exact definitions of these KPIs, see page 66/67).

Swisscom also leads in all speed classes for passively determined download data rates. For “Basic Internet” (min. 2 Mbit/s) and “HD video”, Sunrise remains ahead of Salt in the subsequent rankings, while interestingly, the two providers are on a par in the most demanding download category, “UHD video” (min. 20 Mbit/s).

Swisscom is also ahead in the latency ratings. Salt performs slightly better in the “OTT voice class” category (less than 100 ms), while Sunrise is in second place in the more demanding “gaming” category (less than 50 ms). The familiar Swisscom-Sunrise-Salt ranking is repeated for the proportion of

calls in HD quality. In the evaluation of transaction successes in the stability category, Salt was again able to work its way up to second place ahead of Sunrise – as well as in the results of the actively performed download and upload tests.

Operator	Swisscom	Sunrise	Salt
Broadband Coverage			
Coverage Quality (%)	98.0	98.4	97.6
Coverage Reach (%)	97.8	94.8	89.6
Time on Broadband (%)	98.6	98.5	98.1
Download Speed			
Basic Internet Class (%)	96.4	95.6	95.3
HD Video Class / UHD Video Class (%)	90.8/43.5	88.7/37.4	88.2/37.4
Latency			
Gaming Class / OTT Voice Class (%)	96.1/98.4	92.9/97.0	91.7/97.5
Voice			
HD Voice (%)	96.4	96.0	94.7
Download Speed (Active)			
Avg. Throughput (Mbit/s)	101.0	66.7	72.5
90%/10% faster than (Mbit/s)	9.9/227.2	5.7/147.1	6.4/173.9
Upload Speed (Active)			
Avg. Throughput (Mbit/s)	27.4	22.2	23.2
90%/10% faster than (Mbit/s)	3.9/54.8	2.6/49.7	3.6/47.0
Stability			
Transaction Success (%)	96.4	95.4	95.5

Reliability

This category is not a separate test discipline, but a different look at the results. However, this does not change the ranking.

The reliability score, which is shown separately, hides KPIs that are aimed at absolute peak performance. This leaves the test results that allow conclusions to be drawn about the quality of basic services relevant to everyday use.

This approach also retains the familiar ranking order and, roughly speaking, the gaps between the individual competitors as well. The most distinct differences in performance can be observed in the voice discipline, where Salt falls somewhat behind the almost equally strong providers Swisscom and Sunrise. In the data discipline, the three providers move closer together – here there is only a one-point gap between the individual

places, with Salt just leasing ahead of Sunrise in the walk tests. In crowdsourcing, Swisscom is two points ahead of the runner-ups out of a possible 117, with Sunrise and Salt performing on a par in this discipline.

Overall, the high level of the results in this consideration also confirms the excellent reliability of the Swiss networks.

Operator	Swisscom	Sunrise	Salt
Voice	max. 148.5 points	147	146
Drivetest	115.1	99%	98%
Walktest	33.4	99%	98%
Data	max. 264.0 points	262	261
Drivetest	204.6	99%	99%
Walktest	59.4	99%	97%
Crowd	max. 116.9 points	112	110
Crowd	116.9	96%	94%
Total	529	521	517

All values rounded to whole numbers. The internal calculation of points and percentages was carried out with three decimal places. The 529 maximum points achieved here are an extract from the overall result totalling 1000 points (see also p. 66/67).

Methodology



The sophisticated methodology of our network test considers both the top performance of the networks and everyday requirements of users.



Each drivetest vehicle carried nine smartphones for the voice and data tests.

A special control system monitors the test smartphones and logs the measured values they record.

The walk test teams used trolleys or backpacks with powerful batteries to power the test smartphones.

The measurements in Germany took place from October 16 to 30, 2023, in Austria from October 5 to 14, 2023 and in Switzerland from October 18 to 28, 2023.

connect network test partner umlaut sent four test vehicles to each country, each equipped with nine smartphones.

One Samsung Galaxy S23 per network operator carried out the voice measurements, another S23 was used for the data tests and a third established the connections for the “Conversational app” test case (see “data connections”).

For all measurements, the smartphones were set to “5G preferred” – wherever supported by the network, the data tests therefore took place via 5G.

In addition to the drive tests, two walk test teams carried out measurements on foot in each country, in areas with heavy public traffic such as railway station concourses, airport terminals, cafés, public transport and museums. The walking test programme also included journeys on long-distance and local “commuter” railway lines. For the walk tests, the same smartphone types were used for measurements per network operator as for the drive tests. The walk test teams transported the smartphones in backpacks or trolleys fitted with powerful batteries.

The firmware of the test smartphones corresponded to the original network operator version in each case.

Logistics

The drive tests and walk tests took place between 8 am and 10 pm. For the drive tests, two

vehicles were in the same city, but not in the same place, so that one car did not falsify the measurements of the other. On the connecting roads, two vehicles travelled the same routes but at different times and distances from each other.

In Germany, the drive tests took place in 24 large cities and 25 small towns, and the walk tests in eleven cities. This meant that around 16.6 million inhabitants were covered, which corresponds to around 19.9 per cent of the German population. The drive tests covered 11,110 kilometres.

In Austria, the testers drove through twelve large cities and 16 small towns, covering a distance of around 5960 kilometres. There were also walk tests conducted in six cities. This covered around 3.3 million inhabitants (around 36.7% of the population).

The drive tests in Switzerland took place in 24 large cities and 17 small towns, while the walk tests took place in eight cities. The test route in Switzerland was around 6300 km long, and the measurement campaign in Switzerland covered around 2.2 million inhabitants (25.9 per cent of the population).

To select the test routes, umlaut prepared four different proposals for each country, from which connect blindly selected a route.

Voice connections

Voice calls account for 27 per cent of the overall result. Phone connections were established from vehicle to vehicle (“mobile-to-mobile”) and their success

rates, call setup time and voice quality were measured. The smartphones of the walk test teams made calls to a stationary (smartphone) remote station for the voice tests.

To ensure realistic conditions, data traffic was handled simultaneously in the background. We also recorded MultiRAB connectivity: the use of several „radio access bearers“ provides data connections in the background of the voice calls.

The transmission quality was evaluated using the POLQA wide-band method suitable for HD voice. “VoLTE preferred“ was configured on all phones – from 5G, the phones thus fall back to telephony via LTE.

Data connections

The data measurements account for 48 per cent of the results. Several popular live pages (dynamic) and the ETSI reference page known as the Kepler page (static) were called up to assess Internet page views. In addition, 10 MB and 5 MB files were downloaded and uploaded to determine the performance for smaller data transfers.

We also determined the data rate within a 7-second period when uploading and downloading large files. As YouTube dynamically adapts the resolution to the available bandwidth, the evaluation takes into account the average image resolution or number of lines of the videos as well as the success rate and the time until playback starts.

A typical over-the-top (OTT) voice connection is modelled by the *conversational app* test case.

To do this, we set up a voice channel using the SIP and STUN protocols with the OPUS codec and determined the success rate and voice quality of this connection. In addition, our measurements simulated a highly interactive UDP multiplayer session in order to determine the latencies of the connection and any packet losses with the *interactivity of eGaming* test.

Crowdsourcing

The results of crowdsourcing account for 25 per cent of the overall rating. They show which network performance is received by the user – although the end devices and tariffs used also have an impact on these results.

The samples collected in all three countries from the beginning of May to mid-October 2023 (calendar week 19 to week 42) were analysed for this purpose. Around 11.9 billion individual readings were analysed from Germany, statistically representing 100 percent of the population. For Austria, umlaut analysed around 523 million samples (representing 99.9 percent of the population). In Switzerland, the approximately 671 million samples also statistically represent a 100 per cent of the population.

In order to obtain the database for the analyses, thousands of popular apps recorded the parameters described below in the background – provided the user previously agreed to this completely anonymous data collection. The measured values were recor-

ded in 15-minute intervals and transmitted to the umlaut servers once a day. The reports only contain a few bytes, so they hardly impact the user’s data volume.

Broadband coverage

In order to determine the broadband *coverage reach*, umlaut laid a grid of 2 x 2 km tiles (“Evaluation Areas”, EAs) over the test area. A minimum number of users and measured values had to be available for each EA. For the evaluation, umlaut awarded three points per EA if the network in question offered 4G or 5G coverage. The score achieved was divided by the achievable number of points (three points per EA in the “Union Footprint” – the area of the respective country measured by all testers with their smartphones).

We also looked at the *coverage quality*. For each operator, it indicates the average percentage of 4G or 5G coverage on an EA, averaged over all EAs in the common footprint, i.e. the area in which data is served by all operators.

The *time on broadband* in turn indicates how often a user had 4G or 5G reception in the period under review – regardless of the EAs in which the samples were recorded. For this purpose, umlaut sets the samples with 4G/5G coverage in relation to the total number of all samples. Important: The percentage values given for all three parameters reflect the respective

degree of fulfilment – not the 4G/5G coverage of area or population.

Data rates and Latencies

The passive determination of *download data rates* and latencies was carried out independently of the EAs and focused on the experience of each user. Samples that were captured via Wi-fi or when flight mode was activated, for example, were filtered out by umlaut before the analysis.

To take into account that many mobile phone tariffs throttle the usable data rate, umlaut defined three application-related speed classes: *Basic internet* requires a minimum of 2 Mbit/s, *HD video* requires 5 Mbit/s and *UHD video* requires 20 Mbit/s. For a sample to be valid, a minimum amount of data must have flowed in a 15-minute period. Similarly, the *latency* of the data packets is assigned to an application-related class: Roundtrip times up to 100 ms are sufficient for *OTT voice services*, less than 50 ms qualify a sample for *gaming*. In this way, the evaluation also does justice to the fact that the passively observed data rates depend on the applications used in each case. In order to better assess the maximum possible throughput, umlaut also conducted *active measurements* of *upload* and *download data rates* once a month. They determine the amount of data transferred in 3.5 seconds.

Telephony

The *HD telephony* parameter shows the proportion of voice

calls made by the user in HD quality – and therefore via VoLTE (Voice over LTE). A prerequisite is that the smartphone used actually supports this standard.

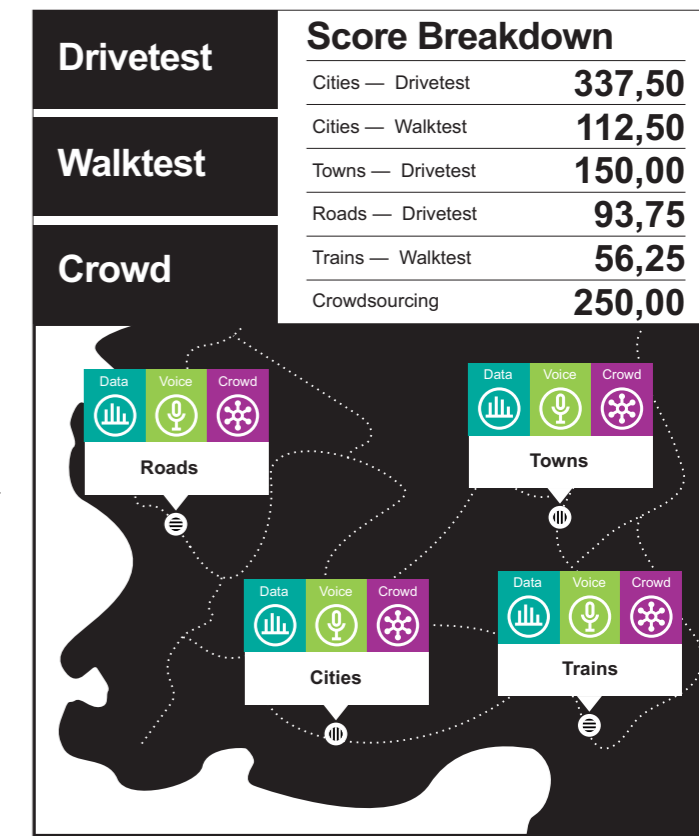
Stability

Based on the determined data rates and additional browsing and connection tests, umlaut also examined when a broadband connection could be used at all. The averaged and weighted results define the percentage of *transaction success*. This allows conclusions to be drawn about the stability of the networks.

Reliability

The reliability rating is not a separate category, but an additional view at the results of the previous categories. For this purpose, umlaut divides all measured values into basic or everyday requirements („Qualifier KPIs“) and values related to maximum performance („Differentiator KPIs“).

The depiction of reliability only takes into account the “Qualifier KPIs“ from the voice and data category as well as the basic results from the crowdsourcing. This makes it possible to investigate how well the networks fulfill everyday requirements.



Fairness and Transparency

How umlaut and connect have ensured that our mobile network test is fair and transparent.

In order to guarantee a fair and transparent execution and evaluation of our network test, certain procedures have proven useful. These include connect and umlaut informing the network operators about the framework conditions of the test at an early stage. The framework communicated for this purpose defines, among other things, the smartphones used for our measurements, the parameters taken into account in the measurements and analyses, the basic evaluation scheme and the schedule of testing in all three countries. connect and umlaut defined the framework for 2023 back in the spring and informed the network operators about it.

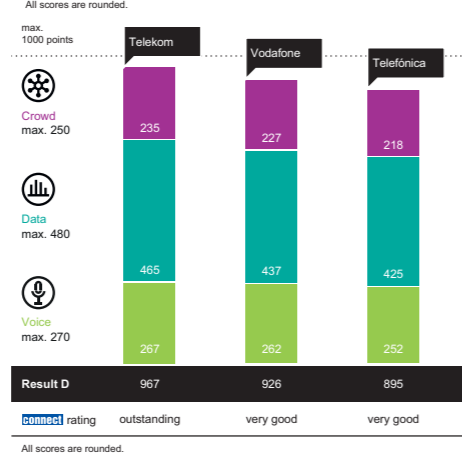
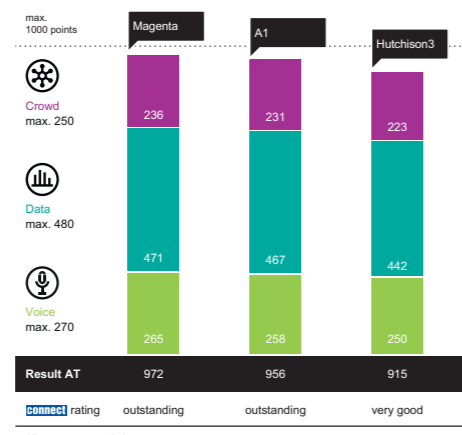
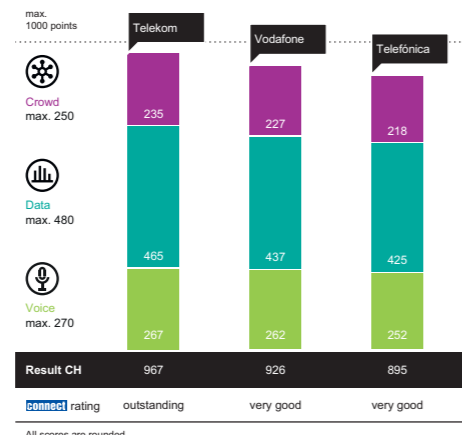
We are open to feedback and suggestions, but will review them critically and may have to reject some proposals. We are also in dialogue with the network operators during the preparation and implementation phase of the drive tests and walk tests. The firmware versions used on the test smartphones, for example, are discussed and updated if necessary – so that they optimally support technologies such as carrier aggregation or 5G variants such as DSS, NSA or SA.

Communication with the network operators also includes emphasising fair play rules. When carrying out and evaluating tests, umlaut analyses the measured values intensively to determine whether they show signs of possible manipulation attempts. If such an attempt is recognised, the possible countermeasures range from invalidating the samples deemed to be dubious to disqualifying the participant in question.

In particular, 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, the SIM cards would have to be constantly replaced during the tests due to tariff or fair use limitations being reached quickly. The SIM cards provided on loan by the providers are provisioned in exactly the same way as normal cards, but have no data limit.

In order to prevent possible attempts of manipulation in this area too, umlaut compares the measurement results obtained using these rental cards with random samples recorded using

regularly purchased SIM cards. If a deviation were to become apparent here, this would also give rise to more in-depth analyses and counter-measures.



Hakan Ekmen, Global Networks Lead, Comms Industry and simultaneously CEO umlaut

“We did not notice any reductions in performance or quality.”

INTERVIEW Energy efficiency and sustainability play an important role in the grids. Why is that? **Hakan Ekmen:** The energy required accounts for a large proportion of network operating costs, which counts in the billions. Sustainably generated energy contributes to a company’s goals of conserving resources and protecting the climate, while more energy-efficient technology and devices help to save energy and costs. **In autumn, umlaut, connect and the CTOs of the network operators discussed the**

impact of energy efficiency measures in the networks on our network test. What effect has this had? **Hakan Ekmen:** We discussed with the telecommunications industry about the KPIs that are related to energy efficiency in the area of performance and user experience – including the reliability rating or the performance per watt emitted. We see a lot of efforts in the industry to combine energy efficiency measures with high quality.

What do this year’s test results show in this respect? **Hakan Ekmen:** The fact that almost all operators were able to continue to improve their results – in some cases significantly – despite measures to increase energy efficiency in the networks speaks for itself. We did not notice any reduction in performance and quality compared to what we were used to.

Overall Results

Category	Test	Score
Voice, Data & Crowd	Voice	max. 270.00 points
	Cities	Drivetest 121.50
	Cities	Walktest 40.50
Data	Towns	Drivetest 54.00
	Roads	Drivetest 33.75
	Trains	Walktest 20.25
Crowd	Cities	Drivetest 216.00
	Cities	Walktest 72.00
	Towns	Drivetest 96.00
Total	Roads	Drivetest 60.00
	Trains	Walktest 36.00
	Crowd	max. 250.00 points
Total		max. 1000.00 points

connect -rating



Hannes Rügheimer, connect author

FAZIT

The massive rise in energy prices and the ongoing climate change mean that mobile network operators are now focussing more on the efficient operation of their networks than on the hunt for new top performances. Their concern expressed to connect that this could put them at a disadvantage in our demanding network test should be dispelled by this year’s test results: all the operators recorded an increase in points compared to their results from the previous year’s results, the

Germany

Operator	Voice	Data	Crowd	Total	connect rating
Telekom	267	465	235	967	outstanding
Vodafone	262	437	227	926	very good
Telefonica	252	425	218	895	very good

Austria

Operator	Voice	Data	Crowd	Total	connect rating
Magenta	265	471	236	972	outstanding
A1	258	467	231	956	outstanding
Drei	250	442	223	915	very good

Switzerland

Operator	Voice	Data	Crowd	Total	connect rating
Swisscom	268	473	240	981	outstanding
Sunrise	267	467	234	968	outstanding
Salt	258	460	232	950	outstanding

respective frontrunners even significantly. This is particularly pronounced at the test winner in Germany: Deutsche Telekom is clearly in the lead and is gradually catching up with the top candidates from the other two countries in terms of performance. Second-placed Vodafone is also improving significantly and is impressing with more and more 5G, especially in rural areas. At Telefonica, the increases in

performance are still regionally limited, but clearly show positive trends and thus allow hope for the future. Magenta, which is part of the Telekom Group, is the clear leader in Austria with distinct increases compared to the previous year. The second-placed A1, which also performed “outstandingly”, also shows improvements over the previous year. The smallest Austrian provider, the Hutchison brand Drei, achieved a rating of “very

good”, also with year-on-year improvements. The results also show that it too has made clear progress in the expansion of 5G. In Switzerland, where competition traditionally takes place at the highest level, all three providers now achieve the grade “outstanding”. Swisscom was once again able to maintain its top position and, in addition to a significant increase in points compared to the previous year, this time achieved the highest overall score we have ever

awarded in a network test to date. Second-placed Sunrise is almost on a par with the test winner in the voice discipline, in terms of 5G roll-out in Swiss cities and only just behind in the other categories. And even the smallest Swiss operator Salt has also significantly improved, which earned it the top grade “outstanding” for the first time and is also accompanied by visible progress in 5G roll-out. Our congratulations ultimately go out to all the candidates.