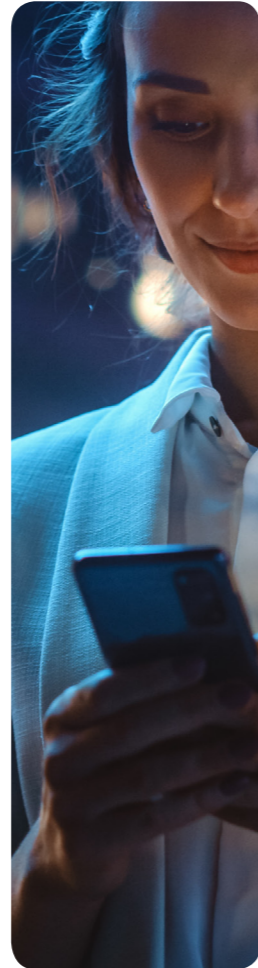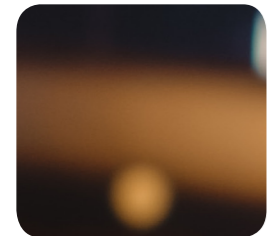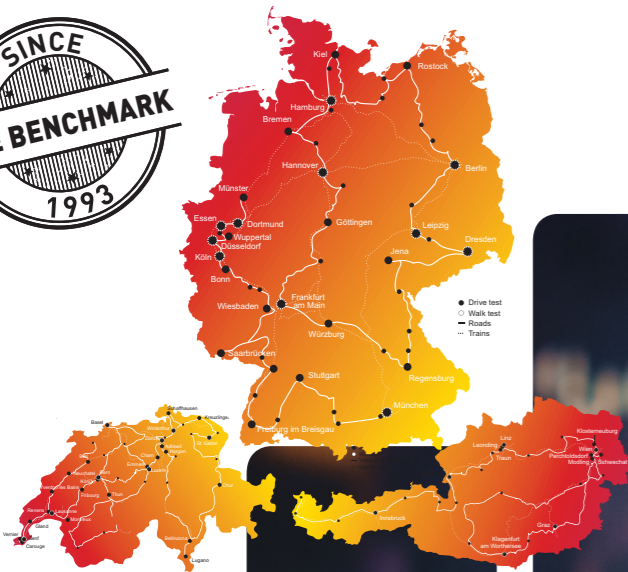30 years is a round number: that's how long the connect mobile network test already exists. And for 20 years now, we have been conducting it at the highest methodological level in close cooperation with our test partner, which now goes by the name of umlaut. What are the results in Germany, Austria and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

SINCE
THE BENCHMARK
1993

The Great Mobile Network Test 2024

umlaut
Part of Accenture
+ connect

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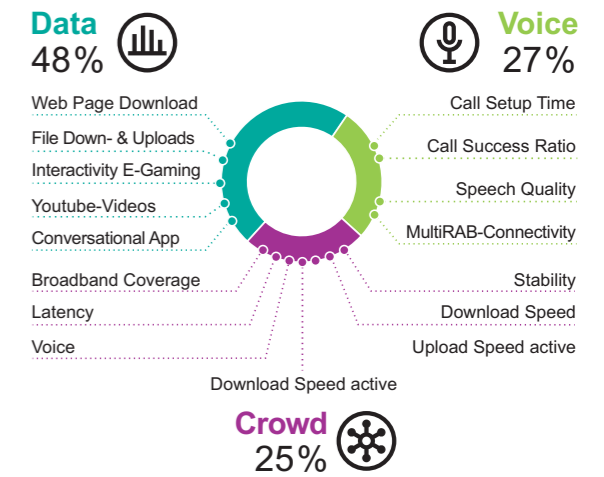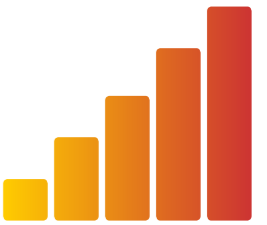ognised benchmark in the industry. CTOs base their planning on its results, and many customers make their decision in favour of a provider on the basis of our test results. After 30 years, we therefore cannot help but take a moment to look back on what we have achieved with a little pride.

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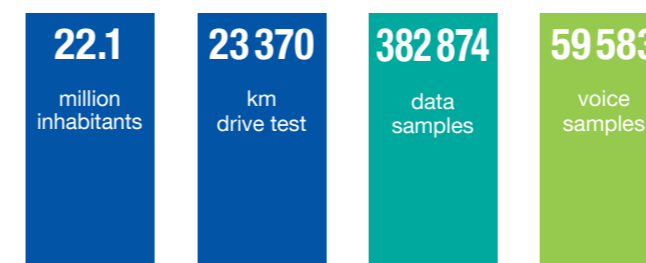
Our goal remains to investigate the maximum network performance while keeping an eye on everyday aspects. Read on to find out how the mobile network providers in Germany, Austria and Switzerland are coping with these requirements. **Hannes Rügheimer**

Data
48%

Web Page Download
File Down- & Uploads
Interactivity E-Gaming
Youtube-Videos
Conversational App
Broadband Coverage
Latency
Voice
Download Speed active

Crowd
25%

Voice
27%

Call Setup Time
Call Success Ratio
Speech Quality
MultiRAB-Connectivity
Stability
Download Speed
Upload Speed active

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

| 22.1 million inhabitants | 23 370 km drive test | 382 874 data samples | 59 583 voice samples | 100.9 million inhabitants covered | 2.51 million participants in the crowd-sourcing | 13.1 billion samples | 98.4 % average coverage of built-up area |
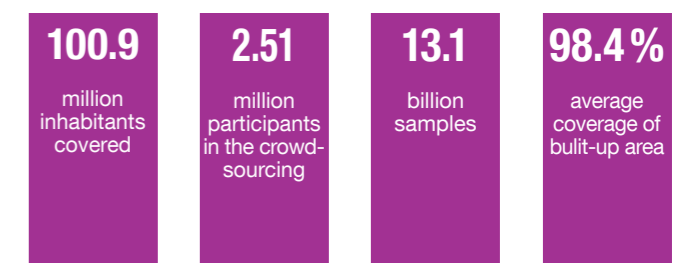
The combined values for Germany, Austria and Switzerland are shown here. For individual values per country, see Methodolody on page 66.

Germany

Data

Telekom and Vodafone have risen their scores significantly compared to the previous year – with the important data category accounting for the largest share.
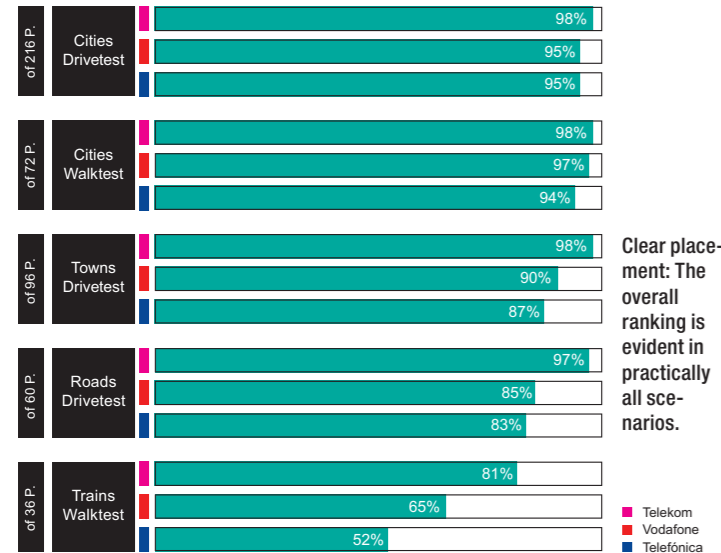
The ranking looks familiar – but a closer look at this year's results reveals that both Deutsche Telekom and Vodafone have improved significantly compared to the previous year. In both cases, the biggest increase in points came from the data category. And even though Telefónica was only able to increase its previous year's result by one point and the gap between Vodafone and Telefónica is therefore growing, the Munich-based provider also managed to significantly improve its result in the data category.

Overall, the 5G roll-out being pursued at full speed by all providers is paying off here – see also the column on the right. At Telefónica/O2, progress is still limited to certain regions, but is already being made in major cities such as the company's home base of Munich.

Telekom ahead in cities, Vodafone strong in walk tests

As also in the other scenarios, Telekom is ahead in the drive tests in large and small towns and in the walk tests conducted in large cities. In the metropolitan drive tests, Vodafone and Telefónica/O2 are on a par overall, but at a distance from Telekom. In the walk tests, Vodafone is almost able to catch up with Telekom, while Telefónica comes in third at a slightly wider gap.

All three providers achieve high success rates in the large and small city scenarios – there are differences in performance, but a usable data connection is generally available. In the fastest ten per cent of measured values for the download data rates, Telefónica took second place behind Telekom. For uploads, Vodafone again delivers slightly higher data rates than Telefónica in some cases.

Advantage for Telekom in rural areas

The gaps are wider in rural areas. While Telekom essentially maintains the points level seen in the major cities here, the other two networks fall behind more significantly. This applies in small towns as well as on connecting roads. Here, also, the usual ranking still applies, but Vodafone and Telefónica/O2 come closer together, while Telekom has a clear lead. If you are looking for connectivity in your car and have no other experiences on your typical routes, Telekom is the best choice.

Railways still a problem case

Unfortunately, there were no improvements in the results of the tests conducted on German trains in comparison to the previous year. Only Telekom managed to achieve a slight improvement here, while Vodafone and Telefónica even lost some points – although this may be due to the frequent rerouting of trains around the rail sections with good coverage. At least the already long-suffering German railway customers can draw some hope with regard to mobile phone coverage, as all three network operators now want to tackle this well-known problem more intensively.

5G

The new standard has long since arrived on the market and is therefore also the norm in our measurements. But how is the further roll-out going?

A look at the detailed data from the drive tests and walk tests shows that Deutsche Telekom has already achieved a 5G share of over 90 per cent of the recorded data samples in all tested scenarios – even on connecting roads and in trains. Remarkably, Telefónica achieves a higher 5G share than Vodafone in the major cities. Outside the centres, however, the picture is reversed.

As an example, let's take a closer look at the results of the 7-second download measurements – the other data tests essentially show the same trends. The figures show that both Telekom and Vodafone continue to rely on Dynamic Spectrum Sharing (DSS) to a greater extent, even more so in rural areas than in cities.

Telefónica, on the other hand, is predominantly focussing on pure 5G. The data rates achieved by Telekom are particularly high in cities, but the results of the other two providers are also impressive.

Operator	Telekom	Vodafone	Telefónica
Data (Cities; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	99.9/1.0	99.9/1.1	99.7/1.1
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.8	99.9/1.6	99.9/1.4
90%/10% faster than (Mbit/s)	101.3/313.7	32.9/237.5	39.2/293.0
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	99.9/1.5	99.9/2.4	99.9/2.4
90%/10% faster than (Mbit/s)	17.8/83.2	9.1/79.3	9.4/73.7
File Download (7 Seconds)			
Sucess Ratio (%)	99.9	99.9	99.8
10% faster than (Mbit/s)	853.2	537.7	566.3
Speed > 20Mbit/s / 100Mbit/s (%)	99.5/95.1	97.2/70.7	96.7/81.5
File Upload (7 Seconds)			
Sucess Ratio (%)	99.9	99.8	99.8
10% faster than (Mbit/s)	134.2	112.1	102.3
Speed > 2Mbit/s / 5Mbit/s (%)	99.9/99.0	98.5/96.0	99.1/97.4
Youtube Video			
Success Ratio/Start Time (%/s)	99.9/1.6	99.7/1.7	99.6/1.8
Average Video Resolution (p)	1079	1079	1078
Youtube Live			
Success Ratio/Start Time (%/s)	99.7/1.9	99.6/2.1	99.3/2.1
Average Video Resolution (p)	1080	1078	1079
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	100.0/4.1	99.9/3.6	99.8/3.6
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	98.8/85.7	98.0/81.2	95.8/78.6
Data (Cities; Walktest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	99.9/0.9	100.0/1.0	99.8/1.2
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	99.9/0.7	100.0/1.3	100.0/1.5
90%/10% faster than (Mbit/s)	112.9/300.8	45.6/251.7	41.7/273.0
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.3	99.9/2.1	100.0/2.4
90%/10% faster than (Mbit/s)	25.7/85.5	17.3/81.0	10.6/67.3
File Download (7 Seconds)			
Sucess Ratio (%)	100.0	100.0	99.9
10% faster than (Mbit/s)	804.8	424.7	510.1
Speed > 20Mbit/s / 100Mbit/s (%)	100.0/96.1	98.4/78.1	96.3/75.6
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	99.7	99.7
10% faster than (Mbit/s)	134.0	119.6	97.3
Speed > 2Mbit/s / 5Mbit/s (%)	99.7/99.1	99.3/97.8	99.4/97.6
Youtube Video			
Success Ratio/Start Time (%/s)	99.4/1.5	99.9/1.6	99.1/1.8
Average Video Resolution (p)	1078	1079	1079
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.9	99.6/2.0	98.4/2.2
Average Video Resolution (p)	1079	1080	1078
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	100.0/4.4	100.0/4.1	99.7/3.9
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	99.3/88.3	99.4/84.4	95.1/77.4
Data (Towns; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	99.9/1.1	99.5/1.2	99.4/1.3
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	99.8/1.0	100.0/2.4	100.0/3.2
90%/10% faster than (Mbit/s)	62.6/248.4	23.2/182.5	13.1/179.2
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.6	100.0/3.1	99.8/3.3
90%/10% faster than (Mbit/s)	15.4/78.6	6.1/67.3	6.3/59.9
File Download (7 Seconds)			
Sucess Ratio (%)	100.0	99.7	99.4
10% faster than (Mbit/s)	631.8	321.2	276.0
Speed > 20Mbit/s / 100Mbit/s (%)	99.1/86.8	93.1/52.4	85.9/37.9
File Upload (7 Seconds)			
Sucess Ratio (%)	99.8	99.7	99.7
10% faster than (Mbit/s)	123.8	93.5	91.1
Speed > 2Mbit/s / 5Mbit/s (%)	99.7/98.9	98.4/93.9	97.4/93.4
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.7	98.7/1.9	98.9/2.1
Average Video Resolution (p)	1078	1076	1074
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/2.0	98.6/2.3	98.5/2.6
Average Video Resolution (p)	1079	1077	1072
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	100.0/4.0	100.0/3.5	99.7/3.7
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	98.9/83.4	96.8/76.9	93.1/69.7

Operator	Telekom	Vodafone	Telefónica
Data (Roads; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	99.9/1.1	98.2/1.5	98.7/1.6
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.4	98.8/4.0	100.0/5.5
90%/10% faster than (Mbit/s)	37.3/183.7	9.2/152.1	6.8/128.8
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.5	99.5/4.3	99.3/5.5
90%/10% faster than (Mbit/s)	10.0/73.7	3.9/61.1	3.5/51.6
File Download (7 Seconds)			
Sucess Ratio (%)	99.3	98.5	98.7
10% faster than (Mbit/s)	342.7	216.2	173.0
Speed > 20Mbit/s / 100Mbit/s (%)	96.9/74.1	78.9/34.7	69.4/21.2
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	99.8	99.1
10% faster than (Mbit/s)	115.9	84.1	73.3
Speed > 2Mbit/s / 5Mbit/s (%)	99.8/96.6	96.7/87.9	93.6/85.0
Youtube Video			
Success Ratio/Start Time (%/s)	99.6/1.8	97.0/2.3	97.3/2.4
Average Video Resolution (p)	1076	1076	1068
Youtube Live			
Success Ratio/Start Time (%/s)	99.8/2.1	95.3/2.7	94.8/2.8
Average Video Resolution (p)	1078	1069	1065
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.8/3.8	99.5/3.4	99.0/3.5
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	98.0/82.0	88.1/72.9	91.1/66.7

Operator	Telekom	Vodafone	Telefónica
Data (Trains; Walktest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	97.1/1.8	94.6/2.0	90.6/2.3
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	98.4/5.4	98.9/8.2	94.0/9.3
90%/10% faster than (Mbit/s)	5.5/226.7	4.1/149.8	2.8/206.4
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	99.7/3.8	98.6/7.3	98.5/8.7
90%/10% faster than (Mbit/s)	5.6/47.7	2.3/44.4	1.9/38.8
File Download (7 Seconds)			
Sucess Ratio (%)	97.6	94.7	91.2
10% faster than (Mbit/s)	470.5	285.2	295.7
Speed > 20Mbit/s / 100Mbit/s (%)	76.1/47.8	66.0/32.0	62.5/33.4
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	99.7	95.9
10% faster than (Mbit/s)	67.4	61.5	48.2
Speed > 2Mbit/s / 5Mbit/s (%)	98.4/91.0	92.7/79.8	91.7/82.2
Youtube Video			
Success Ratio/Start Time (%/s)	96.0/2.5	89.7/2.8	80.6/2.9
Average Video Resolution (p)	1072	1065	1068
Youtube Live			
Success Ratio/Start Time (%/s)	91.4/2.7	85.0/3.2	77.3/3.4
Average Video Resolution (p)	1074	1045	1054
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.8/3.1	98.9/2.7	98.6/2.7
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	84.5/72.5	78.3/67.0	69.8/59.6

Clear placement: The overall ranking is evident in practically all scenarios.

- Cities Drivetest (of 216 P.): 98% / 95% / 95%
- Cities Walktest (of 72 P.): 98% / 97% / 94%
- Towns Drivetest (of 96 P.): 98% / 90% / 87%
- Roads Drivetest (of 60 P.): 97% / 85% / 83%
- Trains Walktest (of 36 P.): 81% / 65% / 52%

■ Telekom ■ Vodafone ■ Telefónica

Tour of Germany: This year's test tour led through 24 major cities (11 with walking tests) and 25 small towns.

○ Drive test ○ Walk test — Roads — Trains

Data rates 7s Download	Telekom			Vodafone			Telefónica		
Samples with 5G	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)
Cities – Drivetest	77.9%	568.9	898.1	41.4%	340.4	685.8	91.1%	311.9	580.4
Cities – Walktest	85.3%	543.5	820.4	46.2%	301.2	568.6	86.0%	264.4	526.8
Towns – Drivetest	30.0%	548.3	889.6	24.5%	266.5	566.9	43.8%	187.1	455.1
Roads – Drivetest	10.8%	279.7	587.3	6.1%	214.8	439.1	34.4%	127.3	289.5
Trains – Walktest	34.2%	376.2	648.2	25.2%	223.1	435.7	53.3%	168.5	420.0
Samples with 5G-DSS	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)
Cities – Drivetest	21.6%	200.2	332.0	36.1%	186.6	356.0	–	–	–
Cities – Walktest	13.0%	174.5	259.8	25.1%	194.6	287.0	–	–	–
Towns – Drivetest	69.0%	192.1	316.3	44.5%	136.0	275.1	0.3%	74.6	84.7
Roads – Drivetest	84.2%	176.0	312.6	58.6%	104.3	224.2	0.4%	52.1	71.9
Trains – Walktest	61.7%	66.3	147.3	40.5%	73.8	229.4	–	–	–

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.
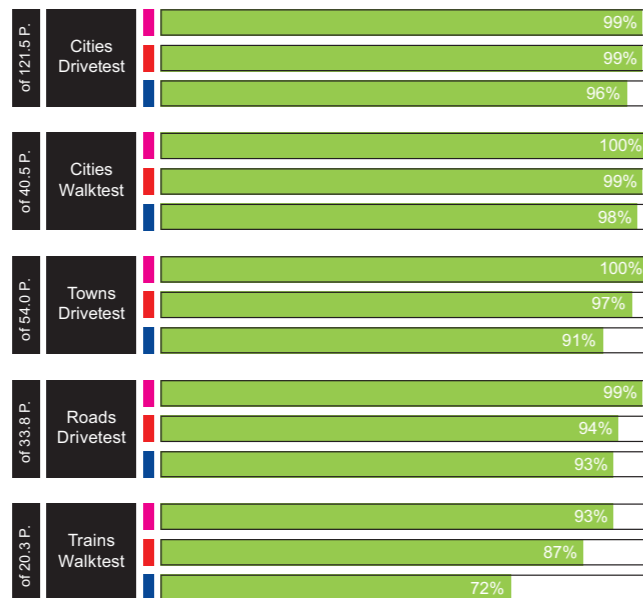
Best supply in large cities

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.

	of 121.5 P.	Cities Drivetest	99%
			99%
			96%
	of 40.5 P.	Cities Walktest	100%
			99%
			98%
	of 54.0 P.	Towns Drivetest	100%
			97%
			91%
	of 33.8 P.	Roads Drivetest	99%
			94%
			93%
	of 20.3 P.	Trains Walktest	93%
			87%
			72%

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

- Telekom
- Vodafone
- Telefónica

Operator	Telekom	Vodafone	Telefónica
Voice Cities (Drivetest)			
Sucess 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)			
Sucess 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)			
Sucess 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)			
Sucess 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)			
Sucess 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

T... 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 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.

O₂ 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	134
Drivetest	115.1	99%	96%	92%
Walktest	33.4	96%	92%	84%
Data	max. 264.0 points	258	248	241
Drivetest	204.6	99%	96%	95%
Walktest	59.4	93%	87%	79%
Crowd	max. 116.9 points	110	107	105
Crowd	116.9	94%	92%	89%
Total		**529**	**514**	**497**	**480**

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).

Austria

Data

Once again, the level of performance in the Alpine republic has risen – even significantly at the top. The results in the data category played the biggest part in this.

It has become a tradition in our network test that the score level in Austria is slightly above the results from Germany, but below the results from Switzerland. This long-standing trend is continuing this year. Even though the performance in Germany has increased again, the Austrian winner Magenta is also following this trend and scores five points ahead of the German winner and its sister company Deutsche Telekom.

However, A1 and Hutchison Drei have also improved compared to their results from the previous year – although the gaps in the overall ranking between the candidates in the Alpine country remain roughly the same.

Looking at the detailed results, it becomes obvious that the Austrian providers achieved this year's increase in points primarily with their results in the data category.
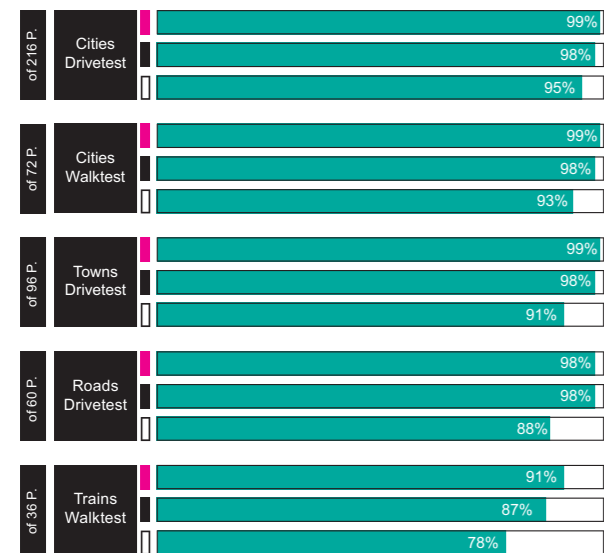
Close race in major cities

In the drive tests and walk tests carried out in major Austrian cities, Magenta leads by a narrow margin ahead of A1, followed by Drei at a slightly greater distance, but still with convincing results.

The two frontrunners in particular show very high success rates and also very high data rates in the metropolitan scenarios. For Magenta, we see the best results for file uploads and in the YouTube category, while A1 is ahead in the download tests. Overall, Drei can keep up well in most test scenarios, while the Hutchison network falls behind somewhat more clearly in e-gaming.

Top performance also in smaller cities

A look at the 16 smaller cities visited by the umlaut drive test teams also reveals a tight race between Magenta and A1. The gap between Drei and Magenta

widens slightly here. It is worth noting that the fastest ten per cent of data rates observed for downloads in the A1 network are even above 1 Gbit/s – both in large cities as well as in small towns. This puts A1 ahead in this KPI. Magenta in turn delivers the best voice quality in all scenarios via the conversational app.

More distinct distances on roads and trains

On the connecting roads between the cities visited, Magenta and A1 are even on a par in the points ranking, while Drei once again falls slightly further behind. The high success rates on the roads are particularly pleasing. They prove that mobile Internet connections also work reliably on car journeys through Austria.

In the most difficult scenario, in the train connections used by the test teams, the achieved points drop more significantly and the ranking becomes more pronounced again: Magenta achieves the highest success rates in most test disciplines, with A1 being further ahead only in YouTube and e-gaming. Three shows the greatest potential for improvement in the trains.

5G

Although 5G has long been standard in our measurements, we are once again taking a separate look at the 5G roll-out in Austria this year.

In its test drives and walk tests, umlaut observed that Magenta achieved the highest 5G shares in the drive tests in larger and smaller cities, while A1 was ahead in the metropolitan walk tests and on the connecting roads. For A1, the combination of several frequencies ("carrier aggregation", short CA) was particularly noticeable for both 5G and 4G, while Magenta had a share of over 50 per cent with the constellation 5G plus LTE with 4CA.

The results of the 7-second download tests shown in the table below are presented as examples – but they allow conclusions to be drawn about the other data tests carried out. As before, in Austria only Magenta relies on DSS (Dynamic Spectrum Sharing - the dynamic allocation of frequencies between 5G and 4G), and even with this operator, the proportion is decreasing. Encouragingly, the 5G shares have increased almost everywhere compared to the previous year.

Operator	Magenta	A1	Drei
Data (Cities; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	100.0/0.8	99.9/1.0	99.6/1.2
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.5	100.0/0.6	99.9/0.9
90%/10% faster than (Mbit/s)	113.3/349.8	130.0/357.1	76.5/339.0
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.1	100.0/1.3	99.8/1.7
90%/10% faster than (Mbit/s)	25.6/92.2	19.6/86.2	16.4/83.9
File Download (7 Seconds)			
Sucess Ratio (%)	100.0	100.0	99.8
10% faster than (Mbit/s)	890.2	1011.5	768.1
Speed > 20Mbit/s / 100Mbit/s (%)	99.9/97.6	100.0/97.5	98.1/92.2
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	99.9	99.0
10% faster than (Mbit/s)	142.7	123.1	120.4
Speed > 2Mbit/s / 5Mbit/s (%)	100.0/99.3	99.5/99.2	99.8/99.4
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.4	100.0/1.7	99.3/1.7
Average Video Resolution (p)	1080	1079	1080
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.8	99.8/2.1	99.4/2.2
Average Video Resolution (p)	1080	1080	1080
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	100.0/4.2	100.0/3.9	99.4/3.5
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	99.7/85.1	99.6/79.2	96.9/76.2
Data (Cities; Walktest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	100.0/0.8	99.9/1.0	99.7/1.3
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.7	100.0/0.6	99.8/1.0
90%/10% faster than (Mbit/s)	119.1/336.1	117.3/337.6	51.9/336.4
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.4	100.0/1.6	99.2/2.5
90%/10% faster than (Mbit/s)	21.7/87.0	19.8/82.6	12.1/81.4
File Download (7 Seconds)			
Sucess Ratio (%)	100.0	100.0	99.6
10% faster than (Mbit/s)	1030.4	1090.3	813.4
Speed > 20Mbit/s / 100Mbit/s (%)	98.7/94.6	99.6/97.5	97.1/83.8
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	99.8	99.2
10% faster than (Mbit/s)	136.8	127.6	117.5
Speed > 2Mbit/s / 5Mbit/s (%)	99.4/98.5	99.2/98.3	99.4/98.1
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.5	99.8/1.7	98.9/2.0
Average Video Resolution (p)	1079	1079	1079
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.8	99.8/2.1	98.8/2.4
Average Video Resolution (p)	1079	1080	1080
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	100.0/4.3	100.0/4.2	99.7/3.7
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	99.1/82.8	99.2/78.1	96.4/72.3
Data (Towns; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	100.0/0.9	99.9/1.0	99.5/1.3
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.6	100.0/0.7	99.5/1.2
90%/10% faster than (Mbit/s)	98.1/347.8	102.4/317.8	41.0/312.5
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.4	100.0/1.4	99.8/2.8
90%/10% faster than (Mbit/s)	17.7/83.9	16.7/79.9	10.2/67.3
File Download (7 Seconds)			
Sucess Ratio (%)	99.5	100.0	99.3
10% faster than (Mbit/s)	785.2	1031.2	668.6
Speed > 20Mbit/s / 100Mbit/s (%)	99.5/93.1	99.0/93.5	97.3/77.4
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	100.0	99.8
10% faster than (Mbit/s)	132.3	120.9	96.0
Speed > 2Mbit/s / 5Mbit/s (%)	100.0/99.8	100.0/99.5	99.0/96.2
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.5	100.0/1.8	98.5/2.1
Average Video Resolution (p)	1080	1079	1079
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.9	99.5/2.1	99.0/2.5
Average Video Resolution (p)	1080	1080	1077
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	100.0/4.2	99.7/3.9	98.7/3.1
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	99.8/81.3	99.8/74.0	95.5/65.1

Operator	Magenta	A1	Drei
Data (Roads; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	100.0/1.0	99.9/1.1	98.6/1.5
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.4	100.0/1.3	99.1/2.6
90%/10% faster than (Mbit/s)	28.8/279.0	34.2/261.8	18.5/200.3
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/2.5	100.0/2.1	98.2/3.3
90%/10% faster than (Mbit/s)	9.2/65.6	9.4/79.0	6.7/51.3
File Download (7 Seconds)			
Success Ratio (%)	100.0	100.0	98.8
10% faster than (Mbit/s)	534.0	569.0	289.0
Speed > 20Mbit/s / 100Mbit/s (%)	95.9/62.5	98.8/76.7	92.2/44.6
File Upload (7 Seconds)			
Success Ratio (%)	99.4	99.7	98.8
10% faster than (Mbit/s)	102.2	115.7	75.0
Speed > 2Mbit/s / 5Mbit/s (%)	99.1/96.8	99.1/96.4	97.0/92.4
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.6	100.0/1.8	97.7/2.2
Average Video Resolution (p)	1079	1079	1078
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.6	100.0/1.8	97.7/2.2
Average Video Resolution (p)	1079	1079	1078
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	100.0/4.1	99.7/3.7	97.0/2.9
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	97.1/75.5	98.0/75.1	90.5/60.5

Operator	Magenta	A1	Drei
Data (Trains; Walktest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	99.0/1.2	97.2/1.3	96.7/1.6
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	98.9/2.6	98.0/1.9	98.4/3.2
90%/10% faster than (Mbit/s)	17.1/305.7	20.1/261.4	13.6/274.0
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	99.2/3.3	97.3/2.9	95.7/4.5
90%/10% faster than (Mbit/s)	6.6/55.5	8.2/60.2	4.6/44.3
File Download (7 Seconds)			
Success Ratio (%)	100.0	98.5	97.6
10% faster than (Mbit/s)	527.5	750.3	538.9
Speed > 20Mbit/s / 100Mbit/s (%)	89.0/53.5	93.0/67.2	82.8/38.9
File Upload (7 Seconds)			
Sucess Ratio (%)	98.5	95.8	96.5
10% faster than (Mbit/s)	77.1	80.2	62.1
Speed > 2Mbit/s / 5Mbit/s (%)	97.7/91.5	99.2/96.8	95.5/88.3
Youtube Video			
Success Ratio/Start Time (%/s)	97.0/2.0	98.0/2.1	94.9/2.4
Average Video Resolution (p)	1077	1079	1075
Youtube Live			
Success Ratio/Start Time (%/s)	97.7/2.3	95.8/2.6	94.8/2.9
Average Video Resolution (p)	1079	1079	1062
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.1/4.0	98.1/3.7	97.1/3.0
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	89.9/74.2	92.0/70.7	84.1/57.1

Bar chart (of 216 P.):
- Cities Drivetest: Magenta 99%, A1 98%, Hutchison3 95%

Bar chart (of 72 P.):
- Cities Walktest: Magenta 99%, A1 98%, Hutchison3 93%

Bar chart (of 96 P.):
- Towns Drivetest: Magenta 99%, A1 98%, Hutchison3 91%

Bar chart (of 60 P.):
- Roads Drivetest: Magenta 98%, A1 98%, Hutchison3 88%

Bar chart (of 36 P.):
- Trains Walktest: Magenta 91%, A1 87%, Hutchison3 78%

Close race: Except for the tests in trains, Magenta and A1 are close together.

■ Magenta
■ A1
□ Hutchison3

Alpine tour: The drive tests led through twelve large and 16 small Austrian towns, plus walking tests in six cities.

Map labels: Klosterneuburg, Linz, Leonding, Wien, Traun, Perchtoldsdorf, Mödling, Schwechat, Salzburg, Graz, Innsbruck, Klagenfurt am Wörthersee

Map legend: Drive test, Walk test, Roads, Trains

Data rates 7s Download	Magenta			A1			Hutchison Drei		
Samples with 5G	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)
Cities – Drivetest	98.2%	521.3	898.2	97.0%	598.9	1013.6	95.7%	464.5	775.0
Cities – Walktest	85.6%	562.6	1072.6	93.4%	617.7	1099.5	86.1%	500.1	830.9
Towns – Drivetest	96.0%	477.6	785.9	92.1%	591.3	1047.2	80.1%	405.6	699.0
Roads – Drivetest	60.2%	313.9	657.5	77.6%	331.4	603.3	24.3%	270.2	547.0
Trains – Walktest	61.8%	284.7	619.8	80.1%	312.3	779.1	39.8%	379.5	686.7
Samples with 5G-DSS	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)
Cities – Drivetest	1.1%	181.2	271.2	–	–	–	–	–	–
Cities – Walktest	2.8%	188.3	241.6	–	–	–	–	–	–
Towns – Drivetest	0.7%	113.4	160.3	–	–	–	–	–	–
Roads – Drivetest	2.1%	147.5	202.3	–	–	–	–	–	–
Trains – Walktest	2.4%	89.4	118.7	–	–	–	–	–	–

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.
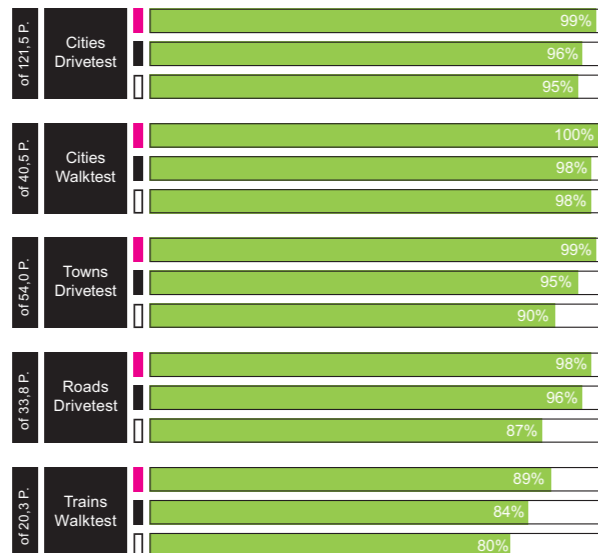
Top results in major cities
In the larger cities, the results of the voice measurements are slightly better in the walk tests than in the drive tests. Magenta is ahead in both cases, with A1 and Drei performing equally well in the walk tests. In the drive tests both conducted in large cities and small 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.

Cities Drivetest	of 121.5 P.		99% / 96% / 95%
Cities Walktest	of 40.5 P.		100% / 98% / 98%
Towns Drivetest	of 154.0 P.		99% / 95% / 90%
Roads Drivetest	of 33.8 P.		98% / 96% / 87%
Trains Walktest	of 20.3 P.		89% / 84% / 80%

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

Legend: ■ Magenta ■ A1 ☐ Hutchison3

Operator	Magenta	A1	Drei
Voice Cities (Drivetest)			
Sucess 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)			
Sucess 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)			
Sucess 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)			
Sucess 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)			
Sucess 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	136
Drivetest	115.1	98%	97%	92%
Walktest	33.4	93%	91%	89%
Data	max. 264.0 points	262	259	245
Drivetest	204.6	100%	99%	94%
Walktest	59.4	97%	93%	88%
Crowd	max. 116.9 points	112	109	107
Crowd	116.9	96%	93%	92%
Total		529	518	510	488

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).

Switzerland

Data

In Switzerland, too, we have seen significant improvements in performance this year - especially in the data discipline. Test winner Swisscom achieves a record result.
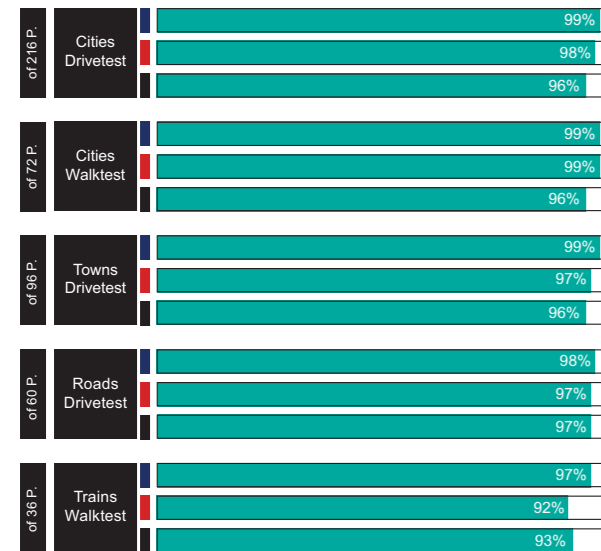
This is also a long-standing tradition: in Switzerland, the scores achieved in our mobile network test are as high as the mountains there. The Swiss network operators were once again able to significantly improve their performance – which is all the more difficult when the score is already particularly high. Now all three of them have even been awarded the exceptional rating of "outstanding". Test winner Swisscom even achieved the highest score that we have ever recorded in a mobile network test to date. The providers achieved the largest share of these improvements earned in the data category.

In all scenarios considered in the test, the perfect or almost perfect success rates are immediately noticeable – when using data services, Swiss users can fairly much assume network availability when using data services – with high performance.

High level, but still clear ranking in cities

But even at the highest level, there are differences in detail: In the drive tests in major Swiss cities, Swisscom is just ahead of Sunrise, with Salt following at a slight distance. In the walk tests conducted in large cities, Swisscom and Sunrise are even on a par, with Salt maintaining the level already observed in the drive tests. The high performance can be clearly seen in the download data rates, for example, where Swisscom and Sunrise offer well over 800 Mbit/s at the peak in the scenarios mentioned. In the test cases conversational app and e-gaming, all three networks show top performance, with Salt slightly ahead in these categories.

Swisscom is also ahead in the smaller cities that our drive test teams visited in Switzerland, with the two competitors Sunrise and Salt following only slightly behind.
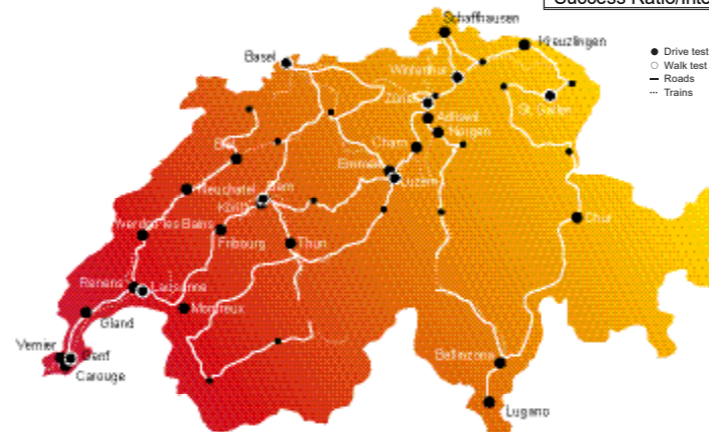
Overall, however, the level of performance outside the larger centres only falls slightly.

Top performance also on roads and in trains

On the connecting roads travelled by the umlaut teams, the score level between the three providers is almost equalised, with Swisscom also slightly ahead here. It is particularly noteworthy that here, too, the performance hardly falls behind that of the larger and smaller cities – good news for car drivers in Switzerland who want to use data services in their vehicles while travelling.

In the most difficult scenario, on the trains, the performance level also falls back somewhat even for mobile network leader Switzerland, although this operator still shows almost the same high performance here as in the other scenarios.

In addition, Salt just moved up to second place ahead of Sunrise in Swiss trains. In particular, Sunrise shows potential for improvement in the file uploads and YouTube tests, while Salt falls slightly behind in file downloads. Overall, however, this assessment still applies: Customers in other countries can only dream of the mobile phone quality on Swiss trains.

5G

5G has long been standard on the market and in our measurements. Nevertheless, it is worth taking a look at the operators' progress with their roll-out.

In the Swisscom network, umlaut's test drivers observed a high proportion of connections in the constellations 5GNR plus LTE 5CA ("carrier aggregation" or short CA of five frequencies) or 5GNR plus LTE 4CA. The lead over the competition is distinct. Only Swisscom still relies on „Dynamic Specsharing (DSS) - albeit with a downward trend.

In cities, Swisscom and Sunrise are almost on a par in terms of 5G coverage; outside of the cities, Swisscom is leading. The table below shows the results of the 7-second download tests as an example – however, the results of the other data tests are in a similar order of magnitude. Salt shows a significant increase in 5G coverage compared to the previous year – but where it is still lacking, the umlaut testers were able to record good LTE coverage. Swisscom delivers the highest data rates. In urban regions, they peak at up to 1 Gbit/s, on roads and in trains only slightly lower.

Operator	Swisscom	Sunrise	Salt
Data (Cities; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	99.9/0.9	99.9/0.9	99.9/1.0
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.6	100.0/0.9	100.0/1.2
90%/10% faster than (Mbit/s)	89.5/476.2	55.0/392.2	40.7/249.2
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	99.9/1.0	100.0/1.6	100.0/1.3
90%/10% faster than (Mbit/s)	26.3/114.6	15.7/101.5	18.5/84.9
File Download (7 Seconds)			
Sucess Ratio (%)	99.9	100.0	99.9
10% faster than (Mbit/s)	982.2	844.4	302.6
Speed > 20Mbit/s / 100Mbit/s (%)	99.5/92.6	97.9/84.1	90.8/52.7
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	100.0	100.0
10% faster than (Mbit/s)	166.4	141.6	119.2
Speed > 2Mbit/s / 5Mbit/s (%)	99.9/99.6	99.7/98.4	99.8/99.5
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.4	99.9/1.4	99.5/1.6
Average Video Resolution (p)	1080	1079	1079
Youtube Live			
Success Ratio/Start Time (%/s)	99.8/1.7	99.9/1.8	99.4/2.1
Average Video Resolution (p)	1080	1080	1076
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.9/3.6	99.9/4.2	99.9/4.2
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	96.6/90.3	98.0/88.4	98.4/87.5
Data (Cities; Walktest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	100.0/0.9	100.0/0.9	100.0/1.1
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.5	100.0/0.7	100.0/1.2
90%/10% faster than (Mbit/s)	101.3/481.9	75.7/413.7	35.6/255.4
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.0	100.0/1.4	100.0/1.4
90%/10% faster than (Mbit/s)	35.0/111.7	22.0/107.2	19.4/81.2
File Download (7 Seconds)			
Sucess Ratio (%)	99.8	100.0	99.8
10% faster than (Mbit/s)	995.3	929.4	331.2
Speed > 20Mbit/s / 100Mbit/s (%)	99.6/93.5	98.7/88.0	91.3/47.2
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	99.8	100.0
10% faster than (Mbit/s)	162.7	157.5	119.2
Speed > 2Mbit/s / 5Mbit/s (%)	100.0/99.8	99.8/99.6	100.0/99.6
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.4	100.0/1.3	100.0/1.7
Average Video Resolution (p)	1080	1079	1079
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.7	100.0/1.7	99.8/2.1
Average Video Resolution (p)	1080	1079	1078
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.9/4.2	99.8/4.3	99.9/4.3
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	98.9/92.4	98.9/91.6	99.1/87.4
Data (Towns; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	99.9/0.9	100.0/1.0	100.0/1.1
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.7	100.0/1.1	100.0/1.4
90%/10% faster than (Mbit/s)	93.0/455.1	37.1/341.9	38.0/261.5
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.1	100.0/2.1	100.0/1.4
90%/10% faster than (Mbit/s)	19.9/112.4	10.4/86.1	16.5/80.2
File Download (7 Seconds)			
Sucess Ratio (%)	99.8	99.6	100.0
10% faster than (Mbit/s)	971.4	707.7	308.9
Speed > 20Mbit/s / 100Mbit/s (%)	99.6/92.1	95.4/78.8	92.5/53.5
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	99.8	100.0
10% faster than (Mbit/s)	157.6	115.8	108.8
Speed > 2Mbit/s / 5Mbit/s (%)	100.0/99.8	99.6/97.2	100.0/100.0
Youtube Video			
Success Ratio/Start Time (%/s)	99.8/1.4	99.8/1.5	99.8/1.6
Average Video Resolution (p)	1080	1080	1079
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.8	100.0/1.9	99.4/2.1
Average Video Resolution (p)	1080	1079	1078
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.9/3.6	99.5/4.1	99.9/4.0
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	98.6/89.2	97.1/87.2	97.9/85.3

Operator	Swisscom	Sunrise	Salt
Data (Roads; Drivetest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	100.0/1.0	100.0/1.1	99.6/1.2
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/0.9	100.0/1.7	100.0/1.7
90%/10% faster than (Mbit/s)	52.3/419.5	21.5/320.3	37.6/212.4
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/1.9	100.0/3.1	100.0/2.1
90%/10% faster than (Mbit/s)	10.6/94.1	6.9/70.5	12.4/75.2
File Download (7 Seconds)			
Sucess Ratio (%)	100.0	100.0	99.6
10% faster than (Mbit/s)	770.4	604.2	272.7
Speed > 20Mbit/s / 100Mbit/s (%)	99.6/85.0	91.9/61.0	92.6/59.8
File Upload (7 Seconds)			
Sucess Ratio (%)	100.0	100.0	99.6
10% faster than (Mbit/s)	124.8	100.3	102.4
Speed > 2Mbit/s / 5Mbit/s (%)	99.3/97.9	99.3/94.6	98.9/97.8
Youtube Video			
Success Ratio/Start Time (%/s)	100.0/1.5	100.0/1.6	99.6/1.7
Average Video Resolution (p)	1079	1080	1079
Youtube Live			
Success Ratio/Start Time (%/s)	100.0/1.9	99.6/2.0	99.6/2.2
Average Video Resolution (p)	1078	1080	1075
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.6/3.2	99.8/4.1	99.8/4.1
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	97.3/86.0	92.6/85.3	97.0/86.2

Operator	Swisscom	Sunrise	Salt
Data (Trains; Walktest)			
Web Page Download			
Success Ratio / Avg. Session Time (%/s)	100.0/1.1	99.1/1.3	99.6/1.4
File Download (10MB)			
Success Ratio / Avg. Session Time (%/s)	99.6/1.3	100.0/2.3	100.0/2.7
90%/10% faster than (Mbit/s)	29.7/400.6	22.3/292.0	17.0/177.9
File Upload (5MB)			
Success Ratio / Avg. Session Time (%/s)	100.0/2.1	99.6/3.8	100.0/2.8
90%/10% faster than (Mbit/s)	11.1/82.5	5.4/52.6	8.1/58.6
File Download (7 Seconds)			
Sucess Ratio (%)	100.0	99.3	99.6
10% faster than (Mbit/s)	603.3	520.4	210.0
Speed > 20Mbit/s / 100Mbit/s (%)	95.1/69.3	92.1/52.4	85.5/37.2
File Upload (7 Seconds)			
Sucess Ratio (%)	99.6	98.9	98.9
10% faster than (Mbit/s)	104.5	71.3	76.4
Speed > 2Mbit/s / 5Mbit/s (%)	99.3/97.5	98.1/93.2	98.5/93.7
Youtube Video			
Success Ratio/Start Time (%/s)	98.9/1.6	98.5/2.1	99.6/2.0
Average Video Resolution (p)	1079	1078	1079
Youtube Live			
Success Ratio/Start Time (%/s)	98.9/1.6	98.5/2.1	99.6/2.0
Average Video Resolution (p)	1079	1078	1079
Conversational-App			
Success Ratio/Speech Quality P10(%/MOS-LQO)	99.9/3.4	99.7/3.8	99.9/4.1
Interactivity e-Gaming			
Success Ratio/Interactivity e-Gaming (%)	94.6/82.2	90.5/77.6	93.1/80.6

Summit climbers: The performance level is very high in all test categories.

Cities Drivetest of 216 P.: 99% Swisscom, 98% Sunrise, 96% Salt
Cities Walktest of 72 P.: 99% Swisscom, 99% Sunrise, 96% Salt
Towns Drivetest of 96 P.: 99% Swisscom, 97% Sunrise, 96% Salt
Roads Drivetest of 60 P.: 98% Swisscom, 97% Sunrise, 97% Salt
Trains Walktest of 36 P.: 97% Swisscom, 92% Sunrise, 93% Salt

● Drive test ○ Walk test — Roads ⋯ Trains

Across the land of the Confederates: The test routes took the umlaut teams through almost the whole of Switzerland.

| Data rates 7s Download	Swisscom			Sunrise			Salt		
Samples with 5G	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)
Cities – Drivetest	83.2%	587.6	1013.1	96.7%	422.8	852.3	89.0%	148.0	317.1
Cities – Walktest	81.5%	626.8	1032.5	91.6%	505.4	953.4	72.1%	148.7	345.2
Towns – Drivetest	81.3%	584.3	1017.1	93.9%	356.6	714.8	80.7%	156.8	336.7
Roads – Drivetest	50.8%	527.0	966.3	70.6%	288.5	652.1	55.0%	139.6	283.1
Trains – Walktest	50.2%	410.6	830.0	80.5%	213.7	552.1	59.5%	99.4	228.5
Samples with 5G-DSS	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)	Share	Average (Mbps)	10% faster than (Mbps)
Cities – Drivetest	15.4%	160.7	283.2	–	–	–	–	–	–
Cities – Walktest	9.4%	145.0	253.9	–	–	–	–	–	–
Towns – Drivetest	17.1%	161.3	302.5	–	–	–	–	–	–
Roads – Drivetest	41.0%	182.3	312.0	–	–	–	–	–	–
Trains – Walktest	39.2%	123.0	271.4	–	–	–	–	–	–

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.
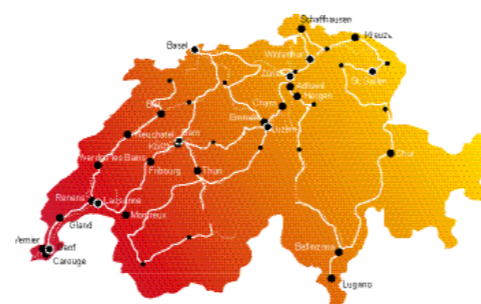
The results for calls on Swiss trains are also at a very high level. Swisscom and Sunrise perform equally well here. Salt follows closely behind, but with significantly better results than on the connecting roads.
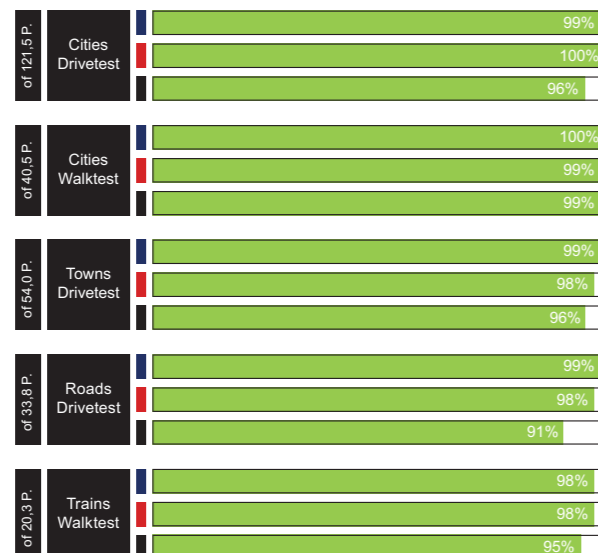
A grain of Salt: Salt shows slight potential for improvement when making calls on connecting roads.

■ Swisscom
■ Sunrise
■ Salt

Single review

FOR THE SIXTH TIME IN A ROW, SWISS-COM 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 ALSO ACHIE-VED 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 OPE-RATOR HAS ALSO IMPROVED COMPARED TO THE PREVIOUS YEAR. ITS RESULT ALSO DESERVES THE HIGHEST RECOGNITION.

WITH ITS EXCELLENT PERFORMANCE, THE SMALLEST SWISS OPERATOR MAKES THE LEAP TO THE GRADE "OUTSTANDING" THIS TIME - PRI-MARILY THANKS TO TOP PERFORMANCE IN THE DATA DISCIPLINE, BUT ALSO IN THE VOICE RATINGS. THERE IS STILL SOME ROOM FOR IMPROVEMENT IN THE AVAILA-BILITY OF VOICE TELEPHONY ON THE CONNECTING ROADS.

Operator	Swisscom	Sunrise	Salt
Voice Cities (Drivetest)			
Sucess 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)			
Sucess 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)			
Sucess 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)			
Sucess 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)			
Sucess 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

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	137
Drivetest	115.1	99%	98%	91%
Walktest	33.4	99%	98%	96%
Data	max. 264.0 points	262	261	260
Drivetest	204.6	99%	99%	98%
Walktest	59.4	99%	97%	98%
Crowd	max. 116.9 points	112	110	110
Crowd	116.9	96%	94%	94%
Total		529	521	517	507

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

umlaut + connect
Part of Accenture

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

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 "**r**adio **a**ccess **b**earers" provides data connections in the background of the voice calls.

The transmission quality was evaluated using the POLQA wideband 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 times 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 recorded 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.
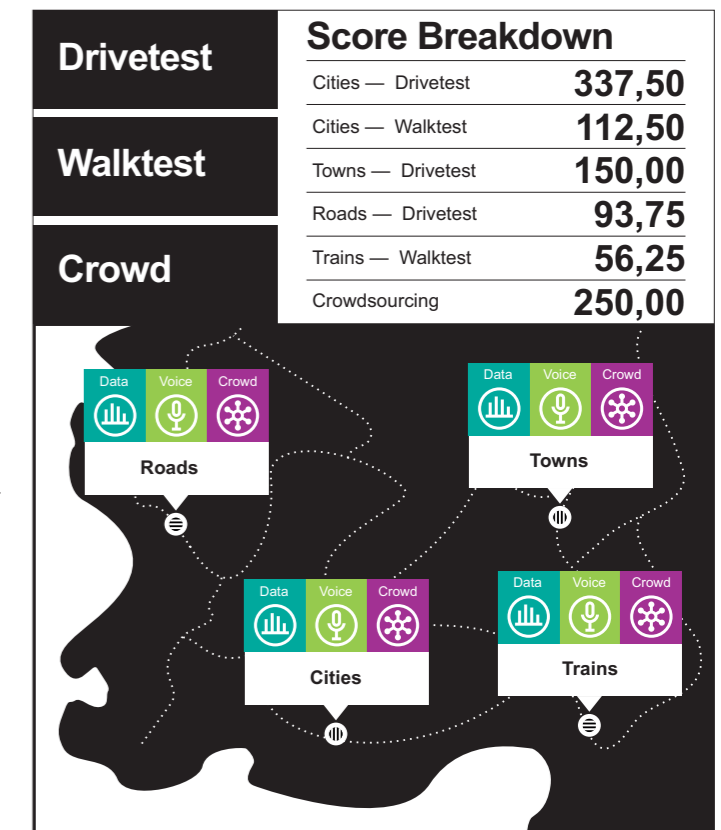
Stability
Based on the determined data rates and additional browsing and connection tests, umlaut also examined when a broadband connection could be used at all. The averaged and weighted results define the percentage of *transaction success*. This allows conclusions to be drawn about the stability of 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.

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.

Score Breakdown

Drivetest		
	Cities — Drivetest	337,50
	Cities — Walktest	112,50
Walktest	Towns — Drivetest	150,00
	Roads — Drivetest	93,75
	Trains — Walktest	56,25
Crowd	Crowdsourcing	250,00

Roads — Data / Voice / Crowd
Towns — Data / Voice / Crowd
Cities — Data / Voice / Crowd
Trains — Data / Voice / Crowd

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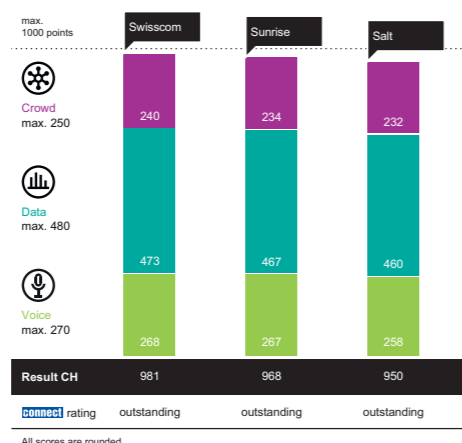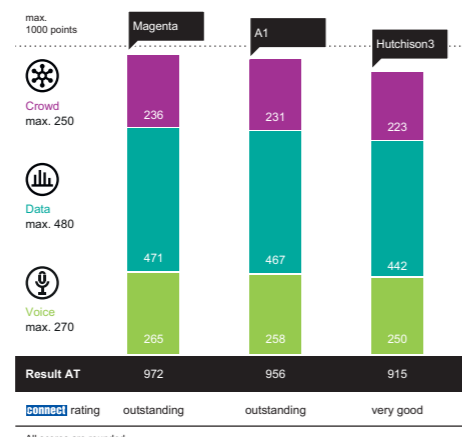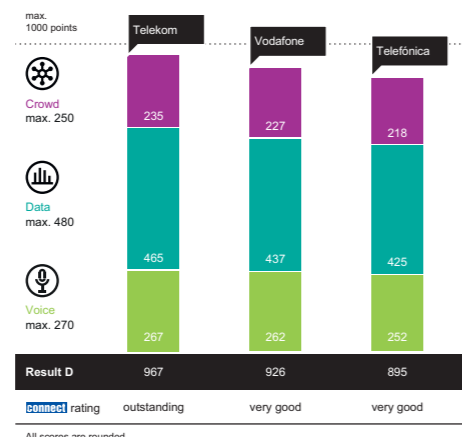
Hakan Ekmen,
Global Networks Lead,
Comms Industry and
simultaneously
CEO umlaut

"We did not notice any reductions in performance or quality."

Hannes Rügheimer,
connect author

INTERVIEW

Why are energy efficiency and sustainability important for mobile network operators?

Hakan Ekmen: Energy consumption for mobile networks accounts for a significant portion of operational expenses. More importantly, decreasing the energy requirements of mobile networks will minimize the impact on the environment by reducing carbon emissions. Investing in energy-efficient technologies will help mobile network operators to lower energy consumption and achieve cost savings over time. **In autumn of this year, you, connect magazine and CTOs from German mobile network operators discussed the impact of energy efficiency measures in the networks. What effect has our testing methodology had since?**

Hakan Ekmen: We have been talking to the telecom industry about combining three important topics in the context of sustainability: Energy efficiency, Network performance and User Experience. As a result, we see a clear focus to combine energy efficiency measures while improving network quality. We emphasize this in our Reliability rating, where we highlight a network's performance per radiated watt. This supports the narrative to continue deploying energy efficiency measures to enhance network resilience.

What have these standards in the testing methodology shown this year?

Hakan Ekmen: Our test is a result of a value-based initiative, and the responsibility we as an industry undertake to create a cleaner and more sustainable future. The fact that all mobile network operators were able to implement energy efficiency features and measures and were able to improve their results – in some cases significantly – speaks for itself. Chapeau to the industry.

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 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 Telefónica, 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.

Overall Results

Voice, Data & Crowd		
Voice	max. 270.00 points	
Cities	Drivetest	121.50
Cities	Walktest	40.50
Towns	Drivetest	54.00
Roads	Drivetest	33.75
Trains	Walktest	20.25
Data	max. 480.00 points	
Cities	Drivetest	216.00
Cities	Walktest	72.00
Towns	Drivetest	96.00
Roads	Drivetest	60.00
Trains	Walktest	36.00
Crowd	max. 250.00 points	
Crowd		250.00
Total	max. 1000.00 points	

connect -rating

Germany

	Telekom	Vodafone	Telefónica
Voice	267	262	252
	99%	99%	96%
	100%	99%	98%
	100%	97%	91%
	99%	94%	93%
	93%	87%	72%
Data	465	437	425
	98%	95%	95%
	98%	97%	94%
	98%	90%	87%
	97%	85%	83%
	81%	65%	52%
Crowd	235	227	218
	94%	91%	87%
	967	926	895
	outstanding	very good	very good

Austria

	Magenta	A1	Drei
Voice	265	258	250
	99%	96%	95%
	100%	98%	98%
	99%	95%	90%
	98%	96%	87%
	89%	84%	80%
Data	471	467	442
	99%	98%	95%
	99%	98%	93%
	99%	98%	91%
	98%	98%	88%
	91%	87%	78%
Crowd	236	231	223
	94%	92%	89%
	972	956	915
	outstanding	outstanding	very good

Switzerland

	Swisscom	Sunrise	Salt
Voice	268	267	258
	99%	100%	96%
	100%	99%	99%
	99%	98%	96%
	99%	98%	91%
	98%	98%	95%
Data	473	467	460
	99%	98%	96%
	99%	99%	96%
	99%	97%	96%
	98%	97%	97%
	97%	92%	93%
Crowd	240	234	232
	96%	94%	93%
	981	968	950
	outstanding	outstanding	outstanding

All values rounded to whole numbers. The internal calculation of points and percentages was carried out with three decimal places. Intermediate results may therefore differ slightly from the stated values.

connect BEST IN TEST — MOBILE NETWORK AND 5G TEST — Deutsche Telekom — Issue 1/2024 — www.connect.de

connect VERY GOOD — MOBILE NETWORK AND 5G TEST — Vodafone — Issue 1/2024 — www.connect.de

connect VERY GOOD — MOBILE NETWORK AND 5G TEST — Telefónica/O2 — Issue 1/2024 — www.connect.de

connect BEST IN TEST — MOBILE NETWORK AND 5G TEST — Magenta — Issue 1/2024 — www.connect.de

connect OUTSTANDING — MOBILE NETWORK AND 5G TEST — A1 — Issue 1/2024 — www.connect.de

connect VERY GOOD — MOBILE NETWORK AND 5G TEST — Drei — Issue 1/2024 — www.connect.de

connect BEST IN TEST — MOBILE NETWORK AND 5G TEST — Swisscom — Issue 1/2024 — www.connect.de

connect OUTSTANDING — MOBILE NETWORK AND 5G TEST — Sunrise — Issue 1/2024 — www.connect.de

connect OUTSTANDING — MOBILE NETWORK AND 5G TEST — Salt — Issue 1/2024 — www.connect.de

max. 1000 points

Crowd max. 250 / Data max. 480 / Voice max. 270

	Telekom	Vodafone	Telefónica
Crowd	235	227	218
Data	465	437	425
Voice	267	262	252
Result D	967	926	895
connect rating	outstanding	very good	very good

All scores are rounded.

	Magenta	A1	Hutchison3
Crowd	236	231	223
Data	471	467	442
Voice	265	258	250
Result AT	972	956	915
connect rating	outstanding	outstanding	very good

All scores are rounded.

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

All scores are rounded.