

best in test.

For adding something on top in Romania and reaching an overall score of 877 dots in mobile network benchmarking survey we proudly award this certificate to

Vodafone Romania

Score 877 out of 1000 in Total

Score 263 out of 270 in Voice Services

Score 392 out of 480 in Data Services

Score 222 out of 250 in Crowdsourced Quality



Hakan Ekmen
Chief Executive Officer Telecommunication





Measurement Overview

umlaut tested and measured the performance of its voice and data services on smartphones in comparison to other 5G/LTE mobile radio networks in metropolitan and rural areas of Romania.

The audit was done as a performance benchmark performed by umlaut between 18.02 and 23.03 2023 in cities and towns as well as on connection roads.

Dedicated measurements have been executed as drive tests outdoors using a Samsung Galaxy S21+ and a Samsung Galaxy S22+.

All data measurements have been performed in 5G preferred mode. Voice measurements have been done in 5G/5G preferred mode on both sides, while call origin has been alternated.

In addition crowdsourced performance data has been collected and evaluated between CW41 2022 and CW12 2023.

The following pages provide a comparative overview about the performance results observed for the different tested service types.



Measurement setup


	Drivetest	Voice	Data
Device	Samsung Galaxy S21+		Samsung Galaxy S22+
Test Cases	Mobile-to-Mobile (M2M) Side1 (VoLTE) to Side2 (VoLTE) 105 sec call window 70 sec call duration 15 sec call setup timeout Multi-RAB traffic injection on both sides Conversational Apps		5G preferred measurements with a Carrier Aggregation capable device 7s download datastream (FDTT fixed download time, multi-socket) 7s upload datastream (FDTT fixed upload time, multi-socket) HTTP/HTTPs fixed file download (10MB) HTTP/HTTPs fixed file upload (5MB) Interactivity eGaming (TWAMP approach, 10s compressed UDP traffic pattern) HTTPs Web browsing (ETSI Kepler) HTTP/HTTPs Live Web pages (9 live pages) YouTube (3 different videos, 40-50 sec, 2 Video on Demand + Live stream)
Mobility and Route Types	Drivetest and Walktest Drivetest: 52% in Cities, 20% in Towns and 28 % on Roads Walktest: 100% in Cities		
Samples	~ 20.624 in total		~ 148.931 in total
Dates	29 measurement days 18.02.2023. - 23.03.2023		
Crowd Data Assessment	24 weeks CW41 2022 - CW12 2023		



Testing areas

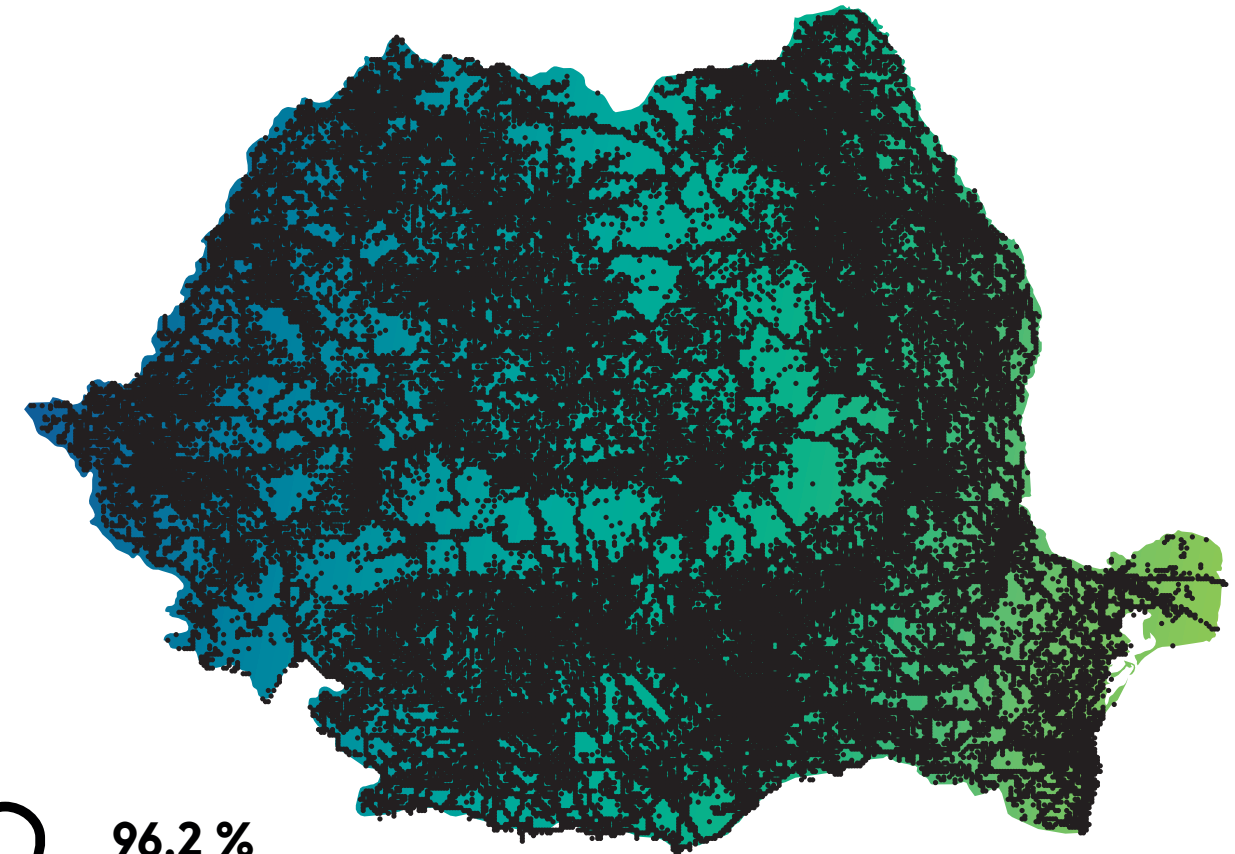
Drive route





 **~ 8.677 km**
measuring distance


 **~ 25 %**
of population measured

Crowdsourcing based test area




 **96.2 %**
of the 'build-up area' covered

 **97.7 %**
of the 'Population area' covered

 **118,229 km²**
size of tested area



Claims

Best in test
Vodafone Romania



Best in data
Vodafone Romania



Best in voice
Vodafone Romania



Best in Reliability
Vodafone Romania



Methodology

The leader in mobile benchmarking, umlaut, has analyzed the mobile networks of Romania with regards to mobile network performance. We measure smartphone voice and data performance based on extensive drivetests – from major metropolitan areas to smaller cities and connection roads.

We objectively define the routes and test methodology and publish the results through certificates or public benchmark reports. In addition crowdsourced performance data has been collected and evaluated. As the de-facto industry standard, our benchmarking methodology focuses on customer-perceived network quality and covers a wide range of mobile services. Today, more than 200 mobile networks in more than 120 countries are being evaluated by our unique scoring

methodology. It allows a technical analysis that is unprecedented in its level of detail and enables comparisons between the network performance and capability of each mobile network. Our public benchmarks as well as the certificate benchmarks help network operators to demonstrate how well they are delivering wireless connections to consumers, business users and enterprises and reveals the areas of improvement.



Score and breakdown

Vodafone achieved the highest overall score among competitors with 877 dots out of 1000.



↑ Shown total scores are rounded.

Overall score considering Voice, Data and Crowdsourcing.

Total score

		Vodafone	Operator 2	Operator 3	Operator 4
Voice	max. 270	263	252	246	190
Cities Drivetest	122	98%	91%	92%	61%
Cities Walktest	41	98%	97%	96%	87%
Towns Drivetest	54	98%	97%	93%	73%
Roads Drivetest	54	95%	91%	84%	75%
Data	max. 480	392	373	350	333
Cities Drivetest	216	84%	82%	76%	72%
Cities Walktest	72	84%	80%	70%	73%
Towns Drivetest	96	77%	68%	72%	60%
Roads Drivetest	96	80%	75%	69%	70%
Crowdsourced Quality	max. 250	222	225	207	225
Broadband Coverage	100	89%	92%	89%	96%
Download Speed	50	91%	91%	86%	90%
Latency	50	91%	88%	87%	88%
Voice	13	87%	88%	16%	94%
Download Speed Active	13	61%	68%	55%	57%
Upload Speed Active	13	91%	90%	87%	73%
Stability	13	92%	92%	93%	94%
Total	1000	877	850	803	748

Shown scores are rounded.



Achieved percentage of the maximum score in each of the different data services.

Data	Service Group	max	Vodafone	Operator 2	Operator 3	Operator 4
Cities Drivetest	Web Browsing	48,6	96%	93%	93%	91%
	File Download	48,6	89%	91%	68%	76%
	File Upload	48,6	92%	91%	85%	66%
	YouTube	48,6	58%	57%	53%	50%
	OTT	21,6	83%	80%	83%	82%
Cities Walktest	Web Browsing	16,2	95%	89%	81%	92%
	File Download	16,2	92%	90%	59%	85%
	File Upload	16,2	92%	82%	84%	59%
	YouTube	16,2	56%	57%	53%	53%
	OTT	7,2	86%	86%	80%	83%
Towns	Web Browsing	21,6	93%	81%	86%	79%
	File Download	21,6	76%	63%	67%	59%
	File Upload	21,6	85%	80%	83%	49%
	YouTube	21,6	54%	47%	53%	47%
	OTT	9,6	83%	70%	76%	74%
Roads	Web Browsing	21,6	94%	89%	84%	90%
	File Download	21,6	81%	76%	66%	76%
	File Upload	21,6	82%	82%	72%	58%
	YouTube	21,6	63%	56%	53%	54%
	OTT	9,6	81%	72%	74%	78%

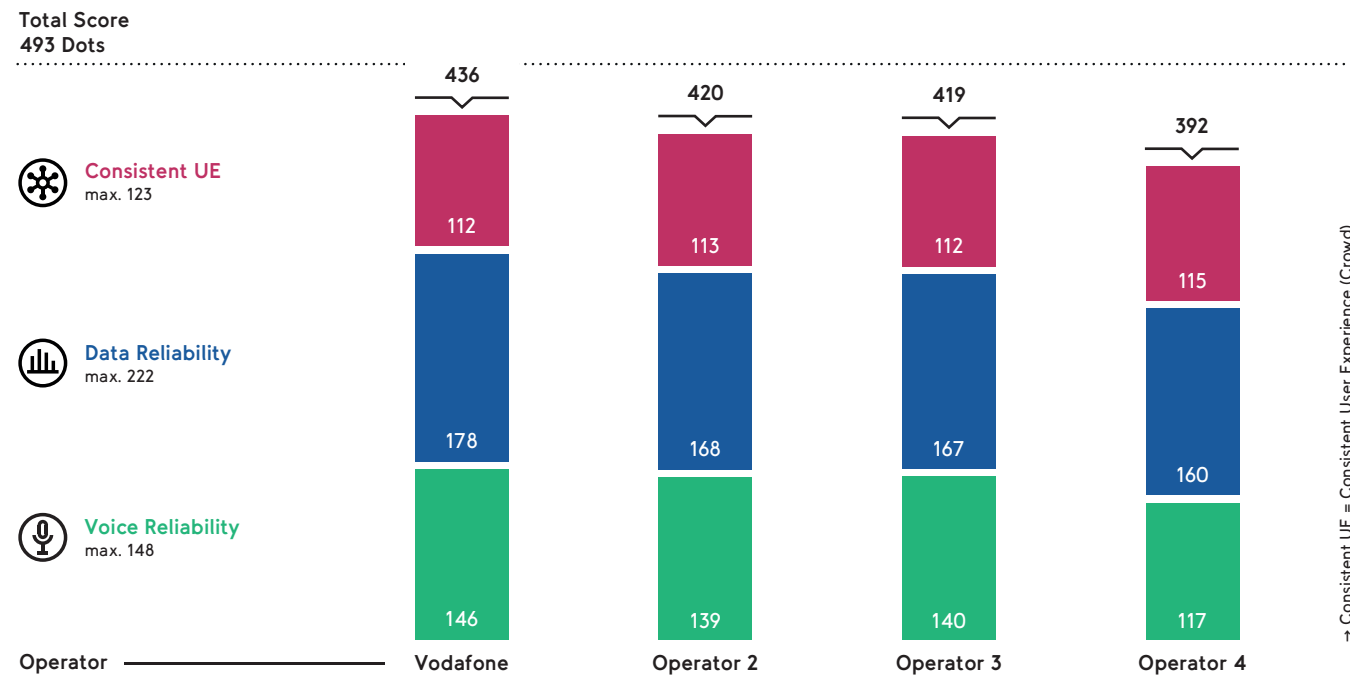


Achieved percentage of the maximum score in each of the different crowdsourcing services.

Crowd	Service Group	max	Vodafone	Operator 2	Operator 3	Operator 4
Crowdsourced Quality	Broadband Coverage	100	89%	92%	89%	96%
	DL Speed	50	91%	91%	86%	90%
	Latency	50	91%	88%	87%	88%
	Voice	13	87%	88%	16%	94%
	DL Speed Active	13	61%	68%	55%	57%
	UL Speed Active	13	91%	90%	87%	73%
	Stability	13	92%	92%	93%	94%



Reliability



Reliability score considering Voice Reliability, Data Reliability and Consistent UE.

Total score

	Service Group	max	Vodafone	Operator 2	Operator 3	Operator 4
Reliability	Voice Reliability	148	98%	94%	94%	79%
	Data Reliability	222	80%	76%	75%	72%
	Consistent User Experience	123	92%	92%	91%	94%

Score achievement in school grades:
outstanding ($\geq 95\%$), very good ($\geq 85\%$ and $< 95\%$), good ($\geq 75\%$ and $\leq 85\%$), satisfactory ($\leq 65\%$ and $< 75\%$), sufficient ($\leq 55\%$ and $< 65\%$).



Voice KPI overview

Achieved values of all networks under test in each of the relevant Voice Key Performance Indicators (KPIs) for the geographical categories "Cities", "Towns" and "Roads".

Voice	Service Group	Unit	Vodafone	Operator 2	Operator 3	Operator 4
Cities Drivetest	Qualifier	[%]	99,9	99,1	99,5	97,1
	Call Setup Time (P90)	[s]	1,3	2,6	2,1	5,2
	Speech Quality (P10)	[MOS-LQO]	4,1	4,3	4,1	3,3
	Multirab connectivity	[%]	100,0	100,0	97,8	99,4
Cities Walktest	Qualifier	[%]	100,0	99,9	99,8	99,7
	Call Setup Time (P90)	[s]	1,2	2,4	2,0	3,3
	Speech Quality (P10)	[MOS-LQO]	4,2	4,4	4,3	3,5
	Multirab connectivity	[%]	99,1	100,0	99,1	99,9
Towns	Qualifier	[%]	99,9	99,9	99,9	97,7
	Call Setup Time (P90)	[s]	1,3	2,1	2,5	3,4
	Speech Quality (P10)	[MOS-LQO]	4,2	4,2	4,1	3,3
	Multirab connectivity	[%]	100,0	99,9	97,0	99,2
Roads	Qualifier	[%]	99,2	98,2	97,5	97,0
	Call Setup Time (P90)	[s]	1,4	2,3	2,7	3,7
	Speech Quality (P10)	[MOS-LQO]	4,0	4,2	3,8	3,2
	Multirab connectivity	[%]	98,9	99,8	93,9	97,8



Data Services KPI overview

Achieved values of all networks under test in each of the relevant Data Key Performance Indicators (KPIs) for the geographical category "Cities Drivetest".

Data Cities DT	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
HTTP Web Page DL Smartphone	Qualifier	[%]	99,8	99,3	99,4	99,1
	Overall Session Time	[s]	1,5	1,6	1,7	1,6
HTTP 10MB DL Smartphone	Qualifier	[%]	100,0	99,6	99,9	99,7
	Overall Session Time	[s]	1,8	2,4	4,1	3,4
	90% faster than	[Mbit/s]	26,0	22,0	10,4	14,7
	10% faster than	[Mbit/s]	163,2	235,2	92,0	106,4
HTTP 5MB UL Smartphone	Qualifier	[%]	100,0	99,7	99,6	99,1
	Average Session Time	[s]	2,3	2,6	2,9	5,4
	90% faster than	[Mbit/s]	9,9	10,6	8,9	3,9
	10% faster than	[Mbit/s]	54,4	52,5	46,5	27,1
HTTP DL FDTT	Qualifier	[%]	99,7	99,7	98,4	99,5
	10% faster than	[Mbit/s]	260,8	543,4	103,8	116,9
	faster than 20 Mbit/s	[%]	97,5	94,2	76,6	84,8
	faster than 100 Mbit/s	[%]	48,9	63,5	11,3	17,1
HTTP UL FDTT	Qualifier	[%]	99,9	99,7	99,3	98,2
	10% faster than	[Mbit/s]	76,2	88,8	59,0	30,0
	faster than 2 Mbit/s	[%]	99,2	99,2	98,1	94,5
	faster than 5 Mbit/s	[%]	96,7	97,0	94,6	85,0
YouTube	Qualifier	[%]	89,6	87,6	89,9	83,0
	Start Time	[s]	1,9	2,0	2,0	2,0
	AVG Resolution	[p]	9,3	9,0	9,8	9,0
YouTube Live Smartphone	Qualifier	[%]	90,7	91,8	89,0	77,7
	Start Time	[s]	3,6	3,7	3,6	3,6
	AVG Resolution	[p]	7,9	8,2	8,1	7,9
YouTube 4K Smartphone	Qualifier	[%]	91,0	87,2	85,4	80,1
	Start Time	[s]	2,2	2,1	2,1	2,1
	AVG Resolution	[p]	9,2	9,7	10,2	9,7
Interactivity	Interactivity egaming	[%]	49,4	47,0	48,7	47,3
Conversational App	Qualifier	[%]	100,0	100,0	100,0	99,9
	Speech Quality (P10)	[MOS-LQO]	3,8	3,4	3,6	3,7



Data Services KPI overview

Achieved values of all networks under test in each of the relevant Data Key Performance Indicators (KPIs) for the geographical category "Cities Walktest".

Data Cities WT	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
HTTP Web Page DL Smartphone	Qualifier	[%]	99,7	98,6	97,7	99,1
	Overall Session Time	[s]	1,6	1,5	1,9	1,5
HTTP 10MB DL Smartphone	Qualifier	[%]	100,0	99,1	99,1	100,0
	Overall Session Time	[s]	1,7	2,8	5,7	2,4
	90% faster than	[Mbit/s]	29,2	25,7	6,9	22,3
	10% faster than	[Mbit/s]	170,6	290,9	78,0	152,2
HTTP 5MB UL Smartphone	Qualifier	[%]	100,0	98,8	99,7	99,4
	Average Session Time	[s]	2,1	2,5	2,8	6,4
	90% faster than	[Mbit/s]	11,9	11,8	10,0	2,3
HTTP DL FDTT	Qualifier	[%]	100,0	99,1	97,9	99,7
	10% faster than	[Mbit/s]	303,9	699,2	93,4	197,3
	faster than 20 Mbit/s	[%]	98,3	93,8	69,5	94,7
HTTP UL FDTT	Qualifier	[%]	100,0	97,6	98,9	97,6
	10% faster than	[Mbit/s]	72,0	101,5	60,2	32,4
	faster than 2 Mbit/s	[%]	98,5	98,1	97,8	92,1
	faster than 5 Mbit/s	[%]	97,1	97,2	96,4	80,5
YouTube	Qualifier	[%]	85,3	84,6	90,1	80,0
	Start Time	[s]	1,9	1,9	1,9	2,0
	AVG Resolution	[p]	9,1	8,9	9,5	8,8
YouTube Live Smartphone	Qualifier	[%]	86,2	87,4	88,1	84,1
	Start Time	[s]	3,5	3,5	3,5	3,5
	AVG Resolution	[p]	8,0	8,4	7,7	7,5
YouTube 4K Smartphone	Qualifier	[%]	88,0	89,5	84,9	83,9
	Start Time	[s]	2,2	2,1	2,0	2,1
	AVG Resolution	[p]	8,6	9,4	10,3	8,6
Interactivity	Interactivity egaming	[%]	52,0	52,9	44,0	48,5
Conversational App	Qualifier	[%]	100,0	100,0	100,0	99,9
	Speech Quality (P10)	[MOS-LQO]	4,0	3,7	3,9	3,9



Data Services KPI overview

Achieved values of all networks under test in each of the relevant Data Key Performance Indicators (KPIs) for the geographical category "Towns Drivetest".

Data Towns DT	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
HTTP Web Page DL Smartphone	Qualifier	[%]	99,4	98,0	98,7	97,5
	Overall Session Time	[s]	1,7	1,9	1,9	1,9
HTTP 10MB DL Smartphone	Qualifier	[%]	99,8	98,6	99,3	98,7
	Overall Session Time	[s]	2,8	5,5	4,8	5,4
	90% faster than	[Mbit/s]	14,2	6,6	8,0	7,6
	10% faster than	[Mbit/s]	103,1	81,9	93,7	79,3
HTTP 5MB UL Smartphone	Qualifier	[%]	100,0	99,8	100,0	98,7
	Average Session Time	[s]	3,0	4,0	3,8	8,7
	90% faster than	[Mbit/s]	7,2	6,1	5,4	2,0
HTTP DL FDTT	Qualifier	[%]	98,8	98,7	99,0	98,0
	10% faster than	[Mbit/s]	135,9	130,3	107,4	80,2
	faster than 20 Mbit/s	[%]	89,0	75,0	76,1	71,0
HTTP UL FDTT	Qualifier	[%]	99,1	98,5	99,2	96,2
	10% faster than	[Mbit/s]	66,4	55,5	53,9	29,6
	faster than 2 Mbit/s	[%]	98,2	98,3	98,1	88,0
	faster than 5 Mbit/s	[%]	92,8	94,0	92,8	68,9
YouTube	Qualifier	[%]	85,9	82,6	88,5	84,1
	Start Time	[s]	2,0	2,2	2,2	2,1
	AVG Resolution	[p]	9,3	9,6	9,8	9,4
YouTube Live Smartphone	Qualifier	[%]	88,5	84,6	87,2	83,1
	Start Time	[s]	3,6	3,7	3,7	3,7
	AVG Resolution	[p]	8,1	8,2	8,1	7,6
YouTube 4K Smartphone	Qualifier	[%]	86,2	77,9	85,2	75,2
	Start Time	[s]	2,1	2,2	2,1	2,1
	AVG Resolution	[p]	10,1	10,4	10,2	10,3
Interactivity	Interactivity egaming	[%]	48,3	31,4	39,4	36,2
Conversational App	Qualifier	[%]	99,9	100,0	99,9	99,9
	Speech Quality (P10)	[MOS-LQO]	3,9	3,5	3,7	3,7



Achieved values of all networks under test in each of the relevant Data Key Performance Indicators (KPIs) for the geographical category "Roads Drivetest".

Data Roads DT	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
HTTP Web Page DL Smartphone	Qualifier	[%]	98,7	97,9	97,8	97,2
	Overall Session Time	[s]	1,6	1,9	2,2	1,8
HTTP 10MB DL Smartphone	Qualifier	[%]	99,4	99,3	99,1	98,1
	Overall Session Time	[s]	4,1	5,3	8,2	5,3
	90% faster than	[Mbit/s]	10,4	7,0	4,0	9,0
	10% faster than	[Mbit/s]	106,9	87,2	90,4	84,7
HTTP 5MB UL Smartphone	Qualifier	[%]	98,8	99,1	98,9	96,5
	Average Session Time	[s]	4,3	4,7	8,3	7,9
	90% faster than	[Mbit/s]	4,6	4,0	2,2	2,0
	10% faster than	[Mbit/s]	41,0	38,2	39,2	26,9
	Qualifier	[%]	99,4	97,6	96,9	98,5
	10% faster than	[Mbit/s]	127,4	110,2	104,8	88,5
HTTP DL FDTT	faster than 20 Mbit/s	[%]	72,0	73,0	53,8	75,2
	faster than 100 Mbit/s	[%]	18,1	12,7	10,7	6,0
	Qualifier	[%]	97,8	97,9	97,2	94,7
HTTP UL FDTT	10% faster than	[Mbit/s]	53,2	55,6	46,6	31,2
	faster than 2 Mbit/s	[%]	95,9	97,0	92,7	87,5
	faster than 5 Mbit/s	[%]	88,8	88,2	77,6	74,6
	Qualifier	[%]	86,0	83,5	83,2	83,5
YouTube	Start Time	[s]	2,0	2,1	2,4	2,1
	AVG Resolution	[p]	9,3	9,6	9,8	9,1
	Qualifier	[%]	86,9	84,2	83,1	83,9
YouTube Live Smartphone	Start Time	[s]	3,7	3,7	3,8	3,7
	AVG Resolution	[p]	7,8	8,2	8,1	8,1
	Qualifier	[%]	81,7	79,8	75,1	76,1
YouTube 4K Smartphone	Start Time	[s]	2,0	2,1	2,3	2,2
	AVG Resolution	[p]	10,1	10,5	10,6	9,9
	Interactivity egaming	[%]	45,3	35,4	38,4	42,2
Conversational App	Qualifier	[%]	99,9	99,7	99,6	99,8
	Speech Quality (P10)	[MOS-LQO]	3,8	3,4	3,4	3,8



Crowd KPI overview

Achieved values of all networks under test in each of the relevant Crowd Key Performance Indicators (KPIs) for the categories "Broadband Coverage", "Download Speed", "Latency", "Voice Crowd" and "Stability".

Category	KPI name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
Broadband Coverage	Time on broadband	[%]	94.0	95.7	95.7	98.7
	Coverage Reach	[%]	78.5	85.3	70.0	83.4
	Coverage Quality	[%]	95.4	96.7	95.9	99.4
Download Speed	Basic internet class	[%]	94.5	94.8	92.6	94.1
	HD video class	[%]	84.9	85.5	72.4	83.6
	UHD video class	[%]	27.8	28.2	19.4	26.2
Latency	OTT voice class	[%]	84.4	82.3	77.2	81.5
	Gaming class	[%]	97.0	95.8	96.7	96.1
Voice	HD voice	[%]	93.7	93.9	57.9	97.0
	90% faster than	[Mbit/s]	3.4	3.8	3.1	3.4
	10% faster than	[Mbit/s]	75.4	90.7	64.3	60.9
Download Speed Active	AVG data rate	[Mbit/s]	31.2	38.8	26.9	27.3
	90% faster than	[Mbit/s]	2.9	2.6	2.4	1.7
Upload Speed Active	10% faster than	[Mbit/s]	37.2	38.0	37.1	27.9
	AVG data rate	[Mbit/s]	17.4	17.4	16.7	12.3
Stability	Transaction success	[%]	92.4	92.4	93.1	93.8



umlaut SE

Am Kraftversorgungsturm 3 · 52070 Aachen · Germany

Hakan Ekmen · Chief Executive Officer Telecommunication

cell +49 151 571 33 235 · hakan.ekmen@umlaut.com

www.umlaut.com