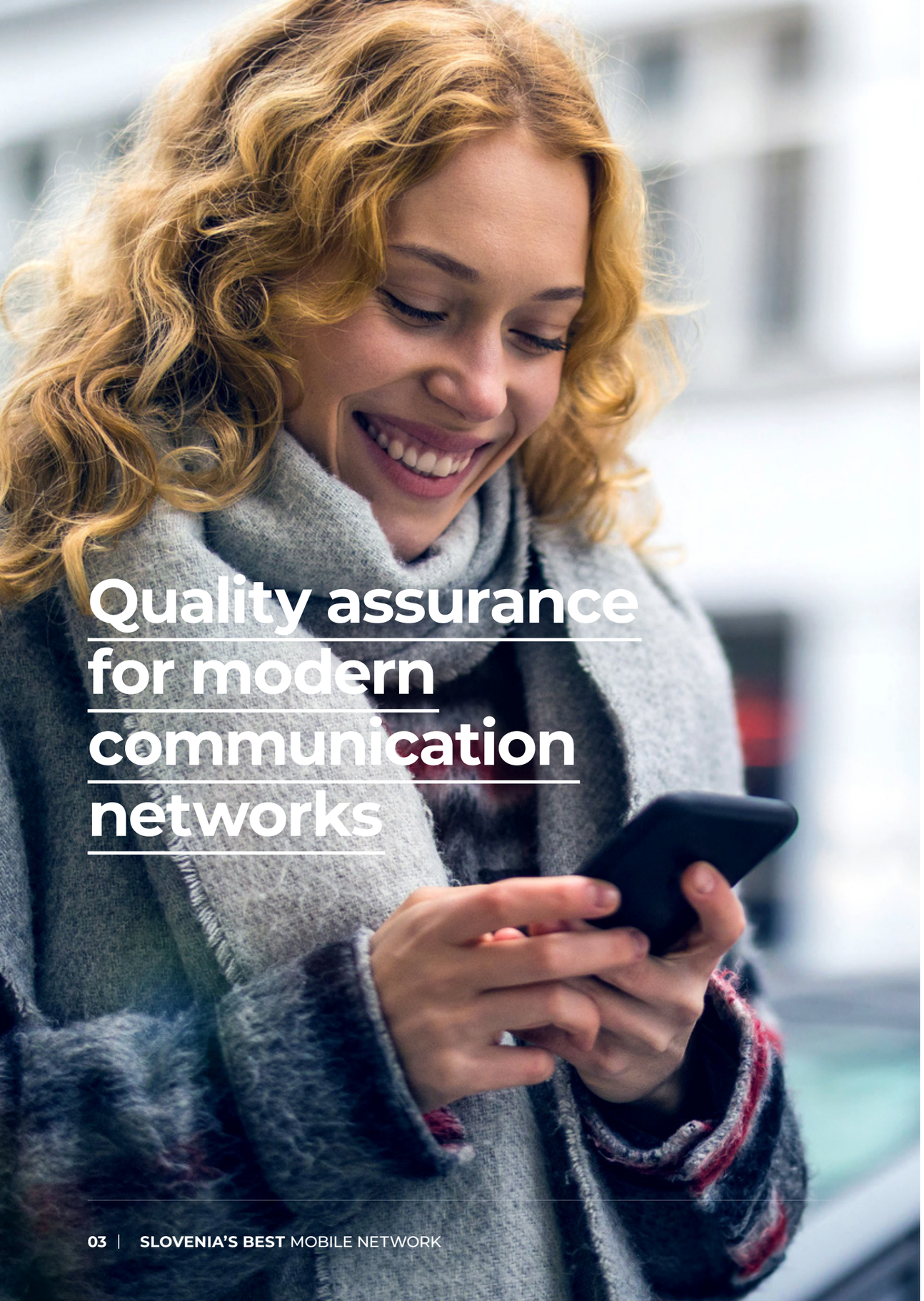
SLOVENIA'S BEST MOBILE NETWORK

MOBILE BENCHMARK MEASUREMENT REPORT
JULY 2023

NET CHECK



Quality assurance for modern communication networks

ABOUT NET CHECK

NET CHECK was founded in 1999 to improve the quality of communication networks. Since then, NET CHECK has become one of the leading partners of network operators and infrastructure providers in the operation and optimisation of mobile and fixed communication networks of all technologies.

NET CHECK's core competencies include international network benchmarking (comparative measurements), network planning and fault analyses, covering drive test services, optimisation, site audit, network planning, rollouts, upgrades, swaps, root cause analysis, and advanced custom reporting.

NET CHECK is part of the NC Group, headquartered in Berlin (Germany), and independent of any industry stakeholders. It is a trusted partner of scientific and government institutions due to its high level of expertise, data quality and security.

To ensure the sustainability and reproducibility of reliable results in repeating campaigns, NET CHECK has implemented an ISO-certified management system, and approved its testing and post-processing procedures according to telecommunication industry standards.

The criteria according to which the network operators are assessed and the benchmarking created are determined exclusively by NET CHECK's experts. They follow the NET CHECK benchmarking methodology and are the same for all countries and test areas. The network operators have no influence on the routing of the tests within the test area. They also have no influence on the timing of the tests within the test period.

#1 provider of quality assurance

BENCHMARKING METHODOLOGY

The NET CHECK testing methodology strives to provide an accurate, unbiased, and balanced assessment of network performance. It is based on ETSI (European Telecommunications Standards Institute) and has been successfully implemented in various countries and by different network operators.

To ensure that sample collection provides a representative view of the network performance across different-sized communities, NET CHECK carried out comprehensive drive tests.

The drive tests cover big, medium and small cities, motorways, main roads and rural roads.

The measuring equipment is placed in the roof boxes and collects data on the performance of voice and data services.

Measuring various KPIs (Key Performance Indicators) for voice and data services, NET CHECK's goal is to present real customer experience, as users perceive it when using a mobile communications network. Operators can earn a maximum of **1000 points**, with **350 points** for voice services and **650 points** for data services.

The network operator receives ranking points based on the measured KPI value. Each KPI can contribute a predefined number of ranking points.

350 pts

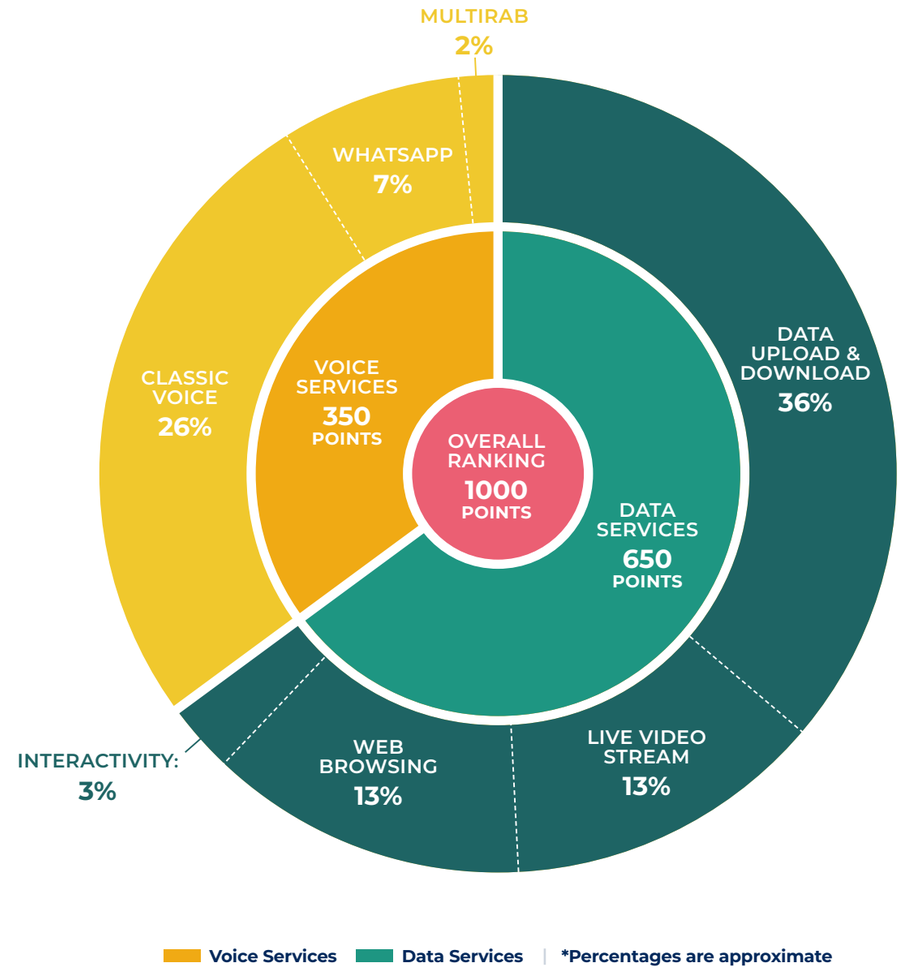
VOICE SERVICE

650 pts

DATA SERVICE

1000 pts

OVERALL RANKING POINTS



MEASUREMENT SPECIFICATIONS

MEASUREMENT AREA

The measurement area covered all 12 administrative entities of Slovenia as defined as statistical regions in 2000.

NET CHECK drove its measurement vehicle to **27 cities** and collected measurements along the entire route, both in the cities and on the motorways, connecting roads and Rural Roads.

MEASUREMENT PERIOD

The measurements were conducted between 3rd and 25th of July 2023.

DISTANCE COVERED

The measurement technicians spent a total of 100 hours and 49 minutes on test drives, covering a total measurement distance of **2927 kilometers.**

Of these, **1754 kilometers** came from inner-city test drives in a total of **27 cities. 1173 kilometers** were completed by the test drivers on connecting roads.

NET CHECK drive testing

19 districts
27 cities

DRIVE TESTS

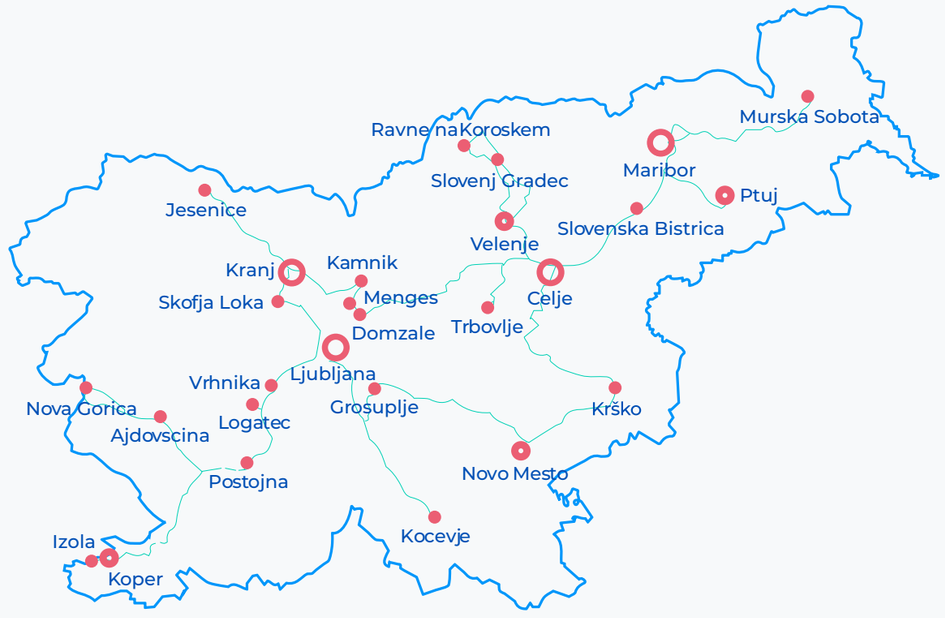
1754 kilometres
4871 minutes

CITY DRIVE TESTS

1173 kilometres
1178 minutes

CONNECTING ROADS

TESTING AREA



KEY:

- Boundary of Slovenia
- Testing Routes
- Big Cities
- Medium Cities
- Small Cities

NET CHECK attaches great importance to using high quality and state-of-the-art measurement technology for all tests

DRIVE TESTING

Measurement equipment for drive testing:
***SwissQual Benchmarker II* (Rohde & Schwarz)**

The measuring equipment was placed in the roof box of a passenger car, collecting data on the performance of voice and data services during the tests. The phones were cooled down to avoid overheating due to sun and extensive use. The measuring equipment was placed in the roof box of a passenger car, collecting data on the performance of voice and data services during the tests.
The phones were cooled down to avoid overheating due to sun and extensive use.

This approach allows performance measurement for all the operators simultaneously and on the same locations.

For all tests, current models of Android mobile phones of Samsung were used.

NET CHECK drive testing

TESTING OF SERVICES

For data services, a total of around 25,000 data samples per operator were collected. For voice services, around 2,200 test calls were made and 10 speech samples were collected in each test call, resulting in a total of around 22,000 speech samples.

VOICE SERVICES

Voice services are tested through sequences consisting of a series of five mobile-to-mobile voice calls:

- 2 standard calls
- 2 calls during which a data download session is executed simulating internet usage during a call
- 1 WhatsApp call.

Then the sequence repeats.

DATA SERVICES

Data services are tested through sequences consisting of:

- Web browsing on frequently visited web-pages
- Playing a YouTube video
- Network capacity tests: downloading and uploading files of given sizes or during a given time
- Interactivity tests: Simulating online gaming and online meetings.

The sequence repeats during the entire measurement.

	VOICE SERVICES	DATA SERVICES
MEASUREMENT DEVICE	Samsung S23+	Samsung S23+
MEASUREMENT OBJECTIVE	Cities and Connecting Roads	Cities and Connecting Roads
MEASUREMENT SAMPLE	2,200 calls per operator	25,000 tests per operator
TEST CASE SCENARIO	Max Call Setup Time: 30 (s) Call duration: 120 (s) Call window: 160 (s) Call mode: VoLTE preferred Speech quality: POLQA WB Reference File: English Scenario: 4 x VoLTE preferred (2 x Classic Call + 2 x MultiRAB) +1 x WhatsApp call	YouTube 4K (livestream) Web Browsing, static and dynamic (Kepler as static, and dynamic based on Alexa ranking) Download and Upload tests: • HTTP time based: FDTT DL 10 (s)/ UL UDP FDTT 10 (s) • HTTP file based: FDFS DL/ UL (10MB/5MB) Online gaming and online meeting simulations
	2,200 test calls	**25,000** data samples

OVERALL RESULTS

A1 achieved the best overall ranking result. Out of a possible 1000 points, A1 scored with 927.6, close behind is Telemach with 20.8 points less. With a difference of 33.2 points, Telekom is in third place.

In voice, A1 scored nearly 3 points less than Telekom, and almost 18 points more than Telemach.

But, in the data category, A1 scored 36 points more than Telekom, and 3 points more than Telemach, securing first place in the overall ranking.

OVERALL RESULTS

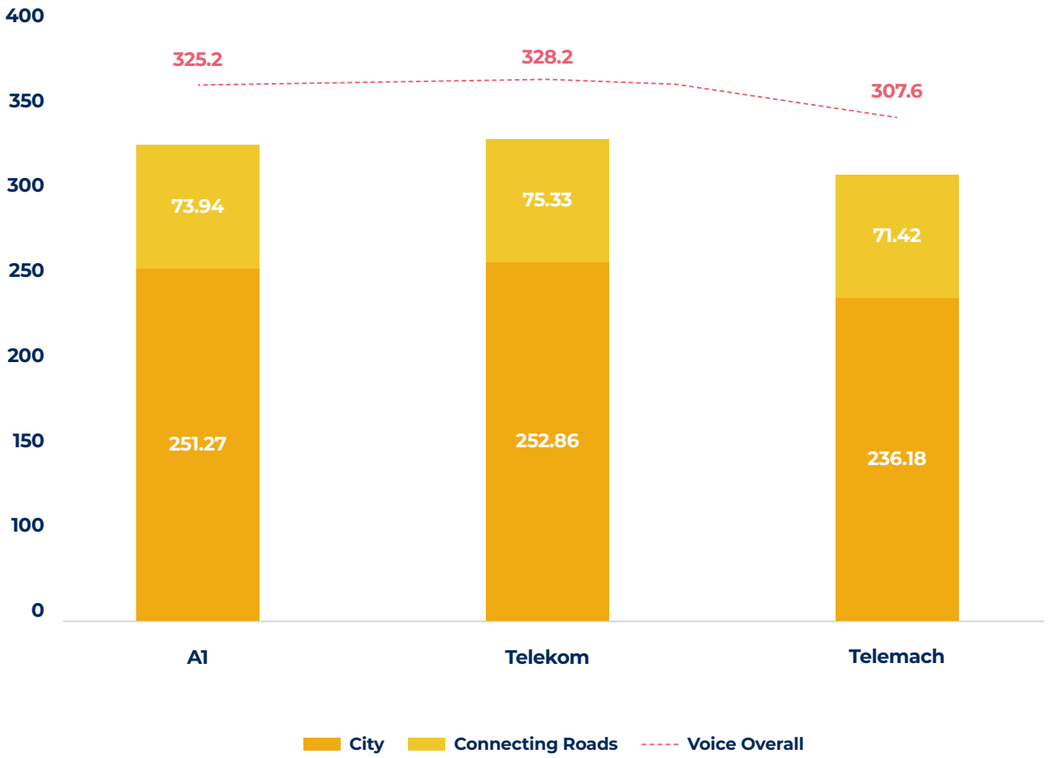
927.6 pts

#1: A1

VOICE RESULTS

In the voice services tests, Telekom ranks first by scoring 328.2 points out of 350 possible ranking points for voice services. A1 scores 3 points less, 325.2 points out of 350 possible. Telemach ranks third with 307.6 points.

If we look at the results of the voice service differentiated by city and connecting roads, we find that all the Operators perform better in the cities. The ranking remains the same, and Telemach has the smallest percentage difference between performance in the city and on connecting routes.



VOICE RESULTS

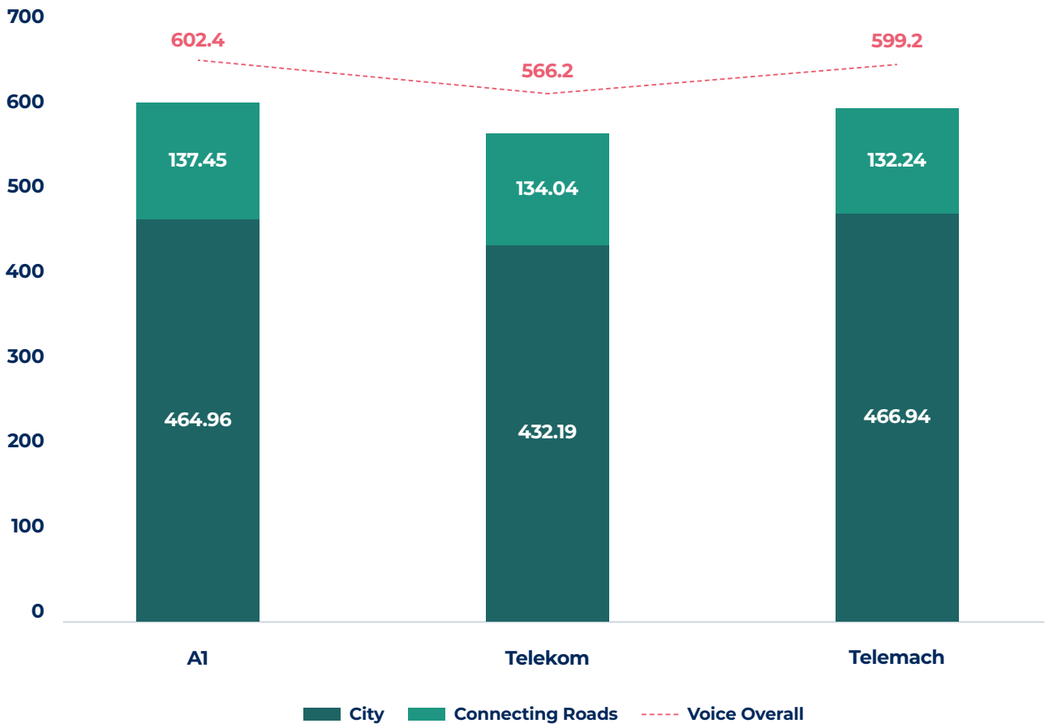
328.2 pts

#1: Telekom

DATA RESULTS

In the data services tests, A1 scores 602.4 points out of 650 possible ranking points for data services, followed by Telemach with 599.2. Telekom with 566.2 follows at a greater distance.

Similar to voice, the data services in cities outperform that on connecting roads. Telemach even slightly tops A1 in the city category, but on the connecting roads the difference is a bit larger in favor of A1, resulting in an overall win for A1 in the data services as well.



DATA RESULTS

602.4 pts

#1: A1

DATA & VOICE
KPI REPORT

Voice KPIs

Ranking Identifiers	A1		telemach
CLASSIC CALLS			
Call Setup Success Ratio (%)	99.58	99.05	99.17
Dropped Call Ratio (%)	0.24	0.06	1.50
Avg CST (s)	3.59	4.25	4.48
Bad CST Ratio (> 15 s) (%)	0.12	0.12	0.06
MOS <= 1.6 RATIO (%)	0.34	0.29	0.66
POLQA AVG (MOS)	4.56	4.54	4.45
Disturbed and Impaired Call Ratio (%)	0.00	0.00	0.00
WHATSAPP CALLS			
Call Setup Success Ratio (%)	98.97	99.59	100.00
Dropped Call Ratio (%)	0.62	0.21	0.41
MOS <= 1.6 RATIO (%)	0.61	0.19	0.56
POLQA AVG (MOS)	4.49	4.48	4.49
Disturbed and Impaired Call Ratio (%)	0.42	0.00	0.21
MULTIRAB DATA			
MultiRAB Data Success Ratio (%)	99.62	99.35	99.49

Data KPIs

Ranking Identifiers	A1		telemach
DOWNLOAD (File Size 10MB)			
FDFS DL Success Ratio (%)	99.19	99.22	99.25
UPLOAD (File Size 5MB)			
FDFS UL Success Ratio (%)	99.24	99.66	99.14
DOWNLOAD (Test Duration 10 seconds)			
FDTT DL 10 PCTL Data Rate (Mbit/s)	69.578	22.135	35.480
FDTT DL Average Data Rate (Mbit/s)	367.458	97.505	353.769
FDTT DL 90 PCTL Data Rate (Mbit/s)	645.467	196.328	707.703
UPLOAD (Test Duration 10 seconds)			
FDTT UL 10 PCTL Data Rate (Mbit/s)	11.256	12.566	11.741
FDTT UL Average Data Rate (Mbit/s)	53.906	40.803	53.308
FDTT UL 90 PCTL Data Rate (Mbit/s)	105.010	77.159	112.111
BROWSING (Web Browsing)			
HTTP Browsing 1MB Reached Time Average (ms)	1025.5	1297.6	1123.4
HTTP Browsing Success Ratio (%)	99.23	99.45	99.22
VIDEO STREAM (YouTube Live Stream 4k)			
Video Stream Success Ratio (%)	99.57	99.78	99.40
TTFP >= 10 s Ratio (%)	0.11	0.06	0.00
Video Stream Irritating Experience Ratio (%)	0.32	0.83	0.16
INTERACTIVITY KPIS			
Interactivity Packet Error Ratio (%)	1.99	4.37	3.31
Interactivity Median RTT (ms)	42	42	38

PERFORMANCE DEVELOPMENT

A1 achieved a remarkable improvement in two KPIs:

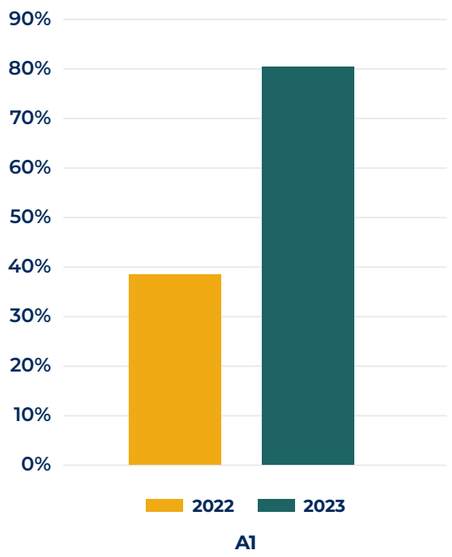
The percentage of data tests performed in 5G doubled from almost 40% in 2022 to nearly 80% in 2023.

The average download data rate increased from 120 Mbit/s in 2022 to 367 Mbit/s in 2023. This means, the users of A1 experienced an average speed increase of more than three times.

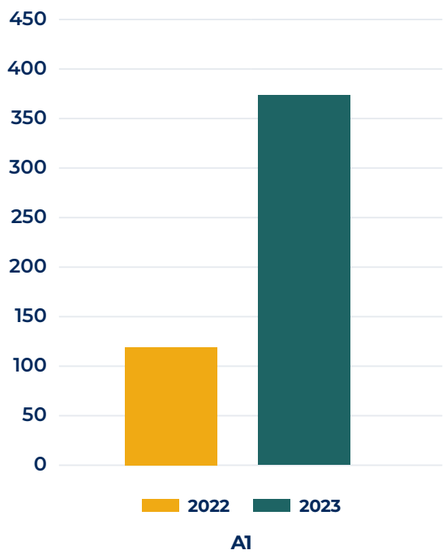
The increase of the 5G share within the performed data tests reflects the successful nation-wide expansion of the 5G network by A1.

In both KPIs, A1 could secure a pole position compared to its main competitors (see table page 11).

Data tests performed in 5G



Average download data rate (Mbit/s)



KPI DESCRIPTION

What we measured:

Ranking Identifiers	
CLASSIC CALLS	
Call Setup Success Ratio	Percentage of successfully established calls
Dropped Call Ratio	Percentage of dropped calls
Avg Call Setup Time	Average time to establish a call
Call Setup Time >= 15 s Ratio	Percentage of successfully established calls, where call establishment takes more than 15 seconds
POLQA <= 1.6 RATIO	Percentage of speech samples where the voice signal quality (MOS) is lower than 1.6
POLQA AVG (MOS)	The average value of the voice signal quality (MOS)
Disturbed Call Ratio	Call flow where for three or more consecutive samples (out of a total of ten) for speech quality measurement, the quality is less than 1.6
Impaired Call Ratio	Call flow where for five samples (out of a total of ten) for measuring speech quality, the quality is less than 1.6
WHATSAPP CALLS	
Call Setup Success Ratio	Percentage of successfully established calls
Dropped Call Ratio	Percentage of dropped calls
POLQA <= 1.6 Ratio	Percentage of speech samples where the voice signal quality (MOS) is lower than 1.6
POLQA AVG (MOS)	The average value of the voice signal quality (MOS)
Disturbed Call Ratio	Call flow where for three or more consecutive samples (out of a total of ten) for speech quality measurement, the quality is less than 1.6
Impaired Call Ratio	Call flow where for five samples (out of a total of ten) for measuring speech quality, the quality is less than 1.6
MULTIRAB DATA	
MultiRAB Data Success Ratio	The percentage of successfully completed data transfers during the duration of the voice service

Ranking Identifiers	
DOWNLOAD (File Size 10MB)	
HTTP Transfer FDFS DL Success Ratio	Percentage of successfully completed data download transfer tests
UPLOAD (File Size 5MB)	
HTTP Transfer FDFS UL Success Ratio	Percentage of successfully completed data upload transfer tests
DOWNLOAD (Test Duration 10 seconds)	
HTTP Transfer FDTT DL MDR P10	10% of total measured tests slower than (MB)
HTTP Transfer FDTT DL MDR AVG	Average file download speed (MB)
HTTP Transfer FDTT DL MDR P90	90% of total measured tests slower than (MB)
UPLOAD (Test Duration 10 seconds)	
UDP FDTT UL MDR P10	10% of total measured tests slower than (MB)
UDP FDTT UL FDTT DL MDR AVG	Average file upload speed (MB)
UDP FDTT UL FDTT DL MDR P90	90% of total measured tests slower than (MB)
BROWSING (Web Browsing)	
HTTP Browsing Time To 1MB	The time required to open a 1MB page
HTTP Browsing Success Ratio	Percentage of successfully completed web browsing tests
VIDEO STREAM (YouTube Live Stream 4k)	
Video Stream Success Ratio	Percentage of successfully completed video streaming tests
Video Stream TTFP >= 10 s Ratio	Percentage of tests where the video started after ten seconds or more
Video Stream Irritating Experience Ratio	Percentage of tests with significantly reduced quality of video transmission

OUR CONCLUSION

As in the 2022 benchmark, A1 again achieved the highest score this year. Compared with last year's measurement results, A1 was even able to improve once again and extend its lead over the runner-up with a total of 927.62 points. Telemach came in second with 906.78 points, a difference of more than 20 points.

The improvement in the quality of the A1 network compared with the 2022 benchmark is thus obvious. Maximum scores were achieved for several ranking key performance indicators, resulting in an increase of almost 10 points compared with the previous year.

The larger lead is also due to the fact that Telemach and Telecom both performed slightly below the previous year. Overall, though, it can be said that all operators tested achieved high scores, indicating that Slovenia has a very good network in its cities and on connecting roads.

The improvement in the quality of the A1 network compared to the 2022 benchmark is obvious.

Maximum scores were achieved for several ranking KPIs.

SLOVENIA'S BEST MOBILE NETWORK

NET CHECK

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