



SYSTEMICS PAB
Network Quality Experts

CERTIFICATE

Systemics-PAB Sp. z o.o.

Wolodyjowskiego 46B, 02-724 Warsaw, Poland

hereby certifies that

Orange Romania S.A.

Europe House, Bulevardul Lascăr Catargiu, nr 47-53, Sector 1, Bucuresti, România

Received the title for

THE BEST ROMANIAN MOBILE NETWORK IN THE TEST

This certificate is based on the results of the measurement campaign, which was carried out by Systemics-PAB in July and August 2022. The measurement campaign assessed the quality of experience of mobile voice and data services in Romania. All mobile Network Operators in Romania: Orange Romania S.A. (Orange), RCS & RDS S.A. (Digi), Telekom Romania Mobile Communications S.A. (Telekom) and Vodafone Romania S.A. (Vodafone) were tested. Systemics-PAB performed the benchmarking measurements throughout Romania covering 22 largest cities as measured by population, and national roads across the country. The project have also included testing 5G data networks. The measurements were carried out using Swissqual Smart Benchmarker system equipped with Samsung Galaxy S10 terminals for voice/VoLTE tests and Samsung Galaxy S21 + 5G terminals for data tests. For the coverage assessment Rohde and Schwarz radio scanners were used. Voice tests were done in mobile to mobile mode. The assessment of quality of services was done using international standards and Systemics-PAB expert knowledge.

Orange Romania achieved highest data speeds in capacity tests and shortest session times for file transfer tests due to the deployment of 5G NR bands in cities and use of widest bandwidth. The quality of voice services in tests have been finding the best in Orange Romania network too.

The results of the measurements gave Orange the best overall score for the quality of experience of mobile telecommunication services in Romania. It entitles us to certify Orange Romania S.A. as the operator with the fastest data services and the highest overall quality of mobile services in the test.

Certificate Date: 26.08.2022



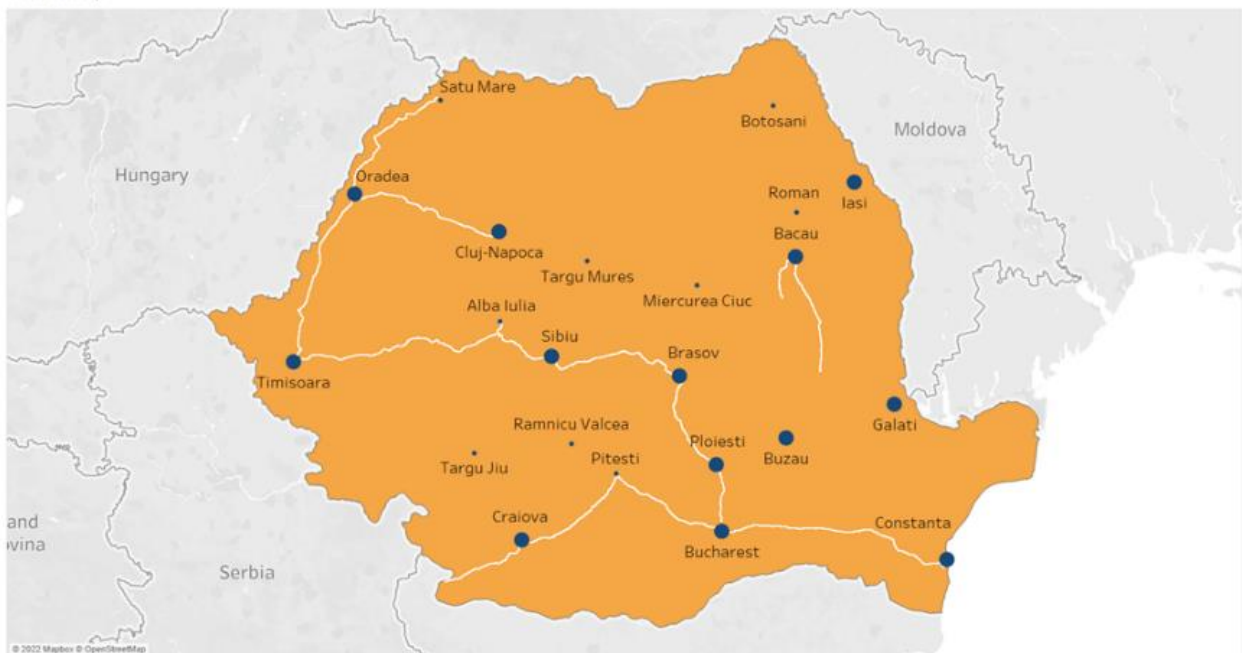
Jan Kondej
Chief Technical Officer

Test Route

The periodical drive tests of mobile networks allow operators to maintaining the highest standards of the telecommunication services quality and customer experience when using the network. It allows to assess the situation on the market and is one of the tools for stimulating the competitiveness.

As a part of DSBO 2022 project Systemics-PAB delivered extensive benchmarking campaign across the country to measure the quality of mobile telecommunication services offered by four mobile networks operators in Romania. The benchmarking measurements took place between July 11th and August 9th of 2022 on representative areas of Romania including cities and roads covering more than 50% of the population.

Route Map



The total distance covered by 2 drive test cars used was over 3500 km each. Measurements took more than 120 hours delivering ~3500 voice and WhatsApp tests and ~2200 for each of data services tests. All the tests were conducted using SwissQual (Rohde&Schwarz Group) benchmarking solution installed in the roof boxes on measurement cars.

Measurement Setup

	Voice/VOLTE testing	Data testing
Device	Samsung Galaxy S10 (SM-G973FDS) LTE / HSPA+ DC / HSUPA 5.76 attenuation - 7dB	Samsung Galaxy S21+ (SM-G996B) 5G NR / LTE / HSPA+ DC / HSUPA 5.76 attenuation - 7dB
Test Cases	Mobile-to-Mobile Best available Voice technology: 115 sec call window 85 sec call duration 15 sec call setup time out HTTP Transfer 100kB Data traffic injection (1 test per call window)	Data 5G preferred: APN with default IPv4/IPv6 settings HTTP UL and DL stress test 7s HTTP 5MB UL and 10MB DL fixed file transfer Live Web Browsing 8 pages (http & https) YouTube Streaming
Testing scenario	100% Drive test Big Cities, Small Cities and Connecting Roads	

* attenuation inserted to simulate usage conditions

Scoring Methodology

The quality assessment and the comparison between operators was prepared using the ETSI Technical Report 103559 Annex B approach. The Report was developed and published in August 2019. It fulfils market needs for open and "standardized" countrywide mobile network benchmarking and scoring. TR103599 allows to get results which are transparent about how the actual scoring has been achieved including methods and underlying assumptions.

The document discusses the construction and methods of such a countrywide measurement campaign, with respect to the area and population to be covered, the collection and aggregation of the test results and the weighting of the various aspects tested. The experienced quality of service varies over time so that the individual score of a particular throughput cannot be fixed once and for all. In order to reflect 5G implementation values for data KPIs thresholds were adopted and bigger files were used for emulation of receiving/sending attachments (fixed size file DL/UL test).

The basic philosophy of the scoring is driven by customer's experience with the network and service quality. In assessing the overall performance and overall score of each mobile network, 2 main categories of services (with subcategories) have been evaluated:

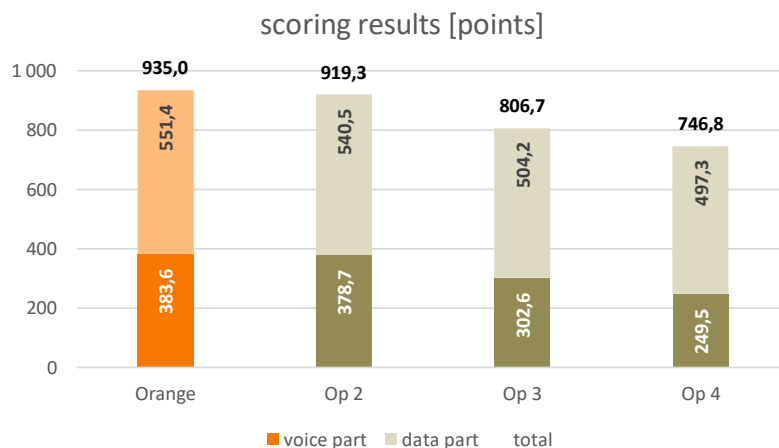
- Voice services, affecting 40% of the overall score
- Data services, affecting 60% of the overall score and consisting of following tests:
 - Fixed Size File DL
 - Fixed Size File UL
 - Fixed Duration File DL
 - Fixed Duration File UL
 - Web Browsing
 - YouTube streaming

Additional assumptions

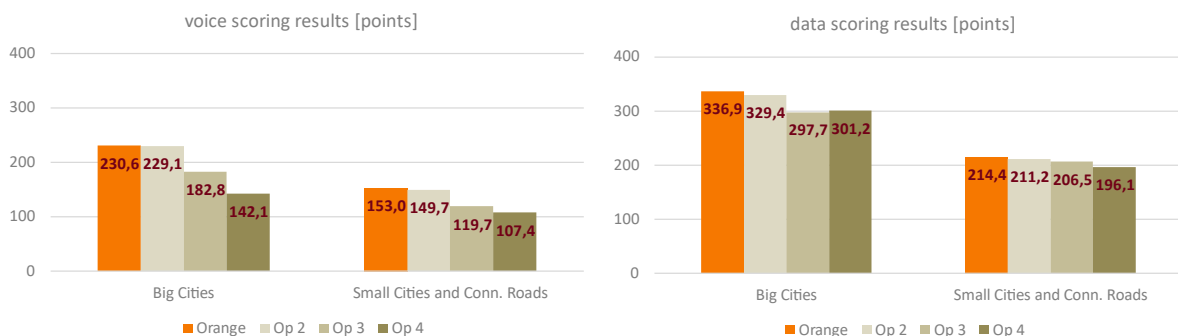
The test area was designed to cover cities and connecting roads (with villages along roads) that constitute around 50% of the population of Romania. In order to keep the fairness of testing methodology all the operators in the benchmark were tested using the same measurement terminal type supporting functionalities offered by networks to achieve the best performance. The selection of measurement terminals models for data and voice tests took also into account the stability of the terminal itself as well as availability of the appropriate firmware version to support VoLTE and high data throughputs. The quality of services was not limited by SIM cards used in the project. Commercial tariffs publicly available were used. In the test we used the selection of the most popular web destinations in Romania accessible for drive testing (automated test by robots).

Scoring Results

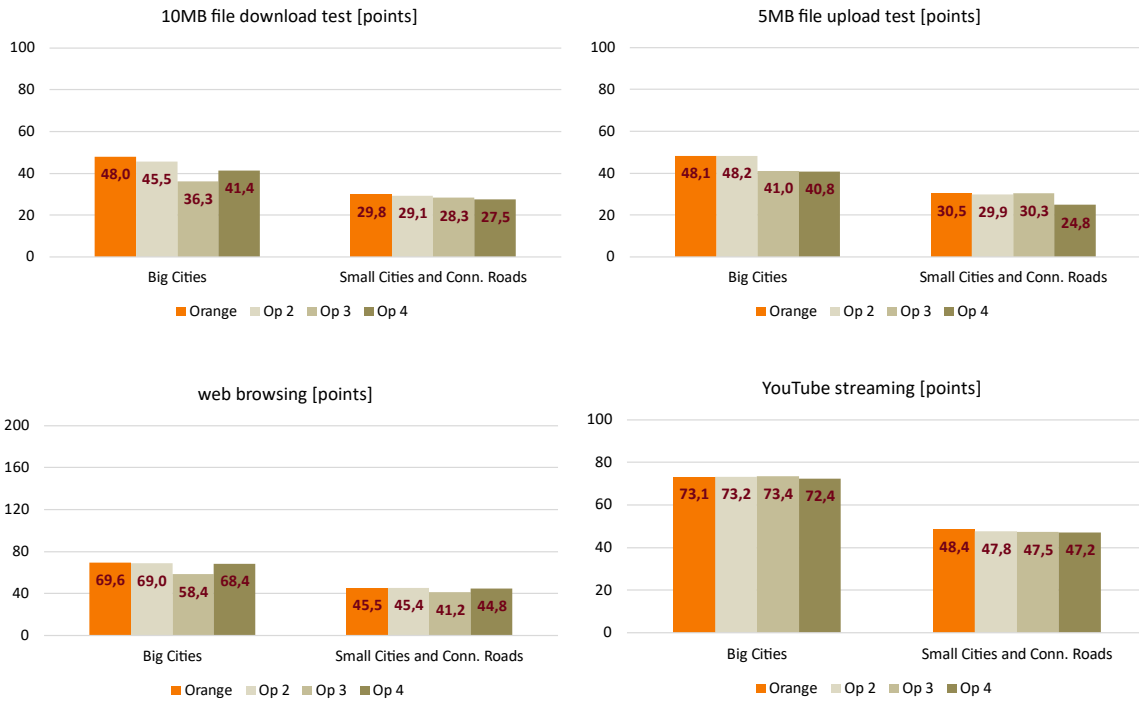
With applied scoring methodology the highest number of points in overall scoring was achieved by Orange and was equal to 935.0 out of 1000 of maximum achievable. The other operators scored 919.32, 806.7 and 746.8. Orange got the best score in both voice and data tests.



Orange achieved the highest overall score due to the best quality of services in all measured aggregations, in Large Cities, Small Cities and on Roads. Op2 and Op3 are following Orange in voice and data tests results. Worst results in both voice and data tests in all aggregations are reported by Op4 especially in voice testing.

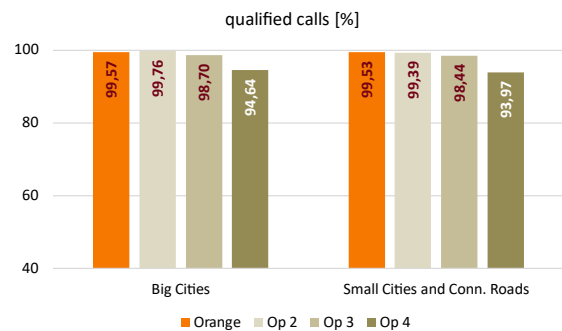


The comparison of the scoring results for selected data tests for big cities and other areas is presented on charts below.

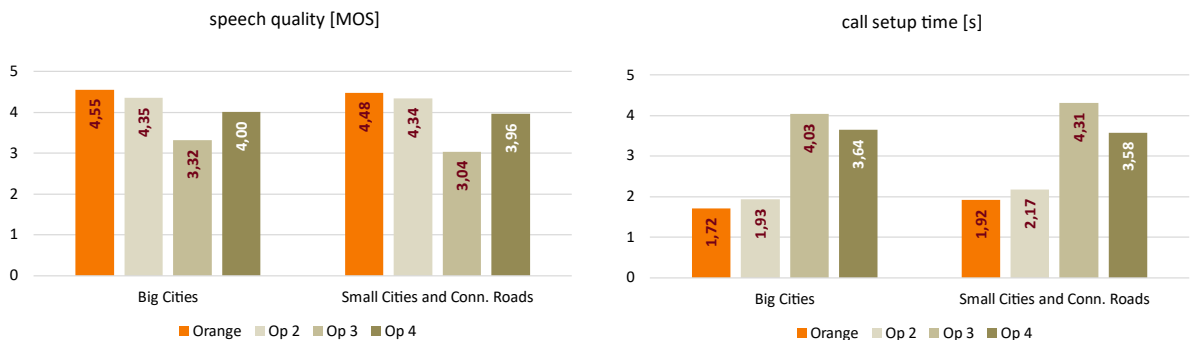


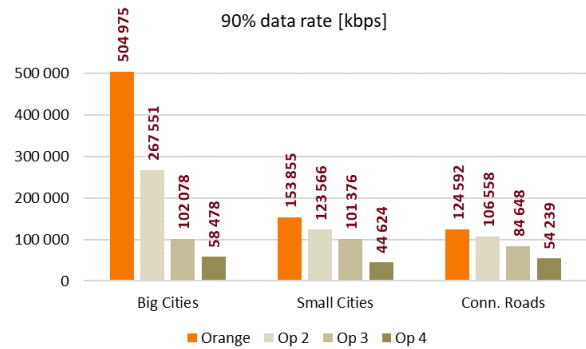
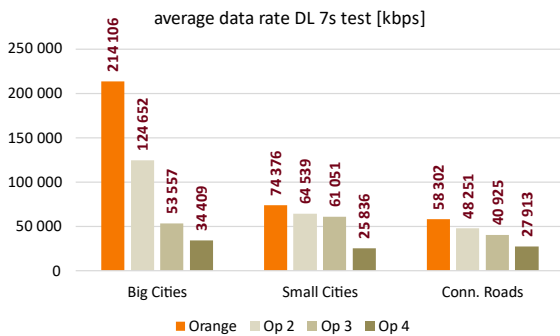
Tests Results in Details

All operators except Op4 presents good availability of voice services. Op3 doesn't offer VoLTE but other operators provide VoLTE for over 99% of connections. Orange demonstrates the best speech quality and lowest call setup time). Orange and Op2 use EVS codec for close to 99% of test calls while Op3 offers only AMR Wide Band. Results for year 2022 are very similar to these of 2021.

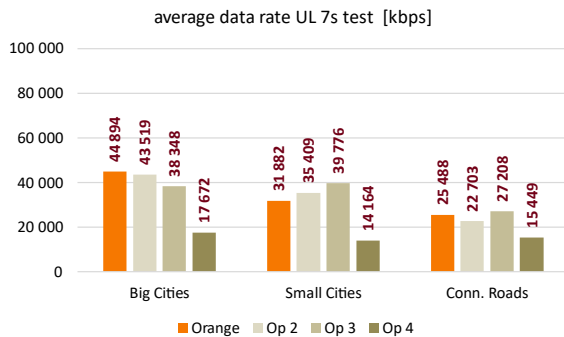


Orange has the fastest call setup time thanks to the extensive use and very good performance of VoLTE-VoLTE calls. EVS codec implementation in Op2 is not fully utilized what is reflected in slightly worse performance. The longest call setup time in Op3 is caused by lack of VoLTE.

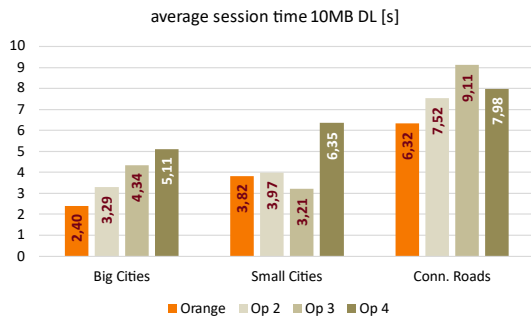




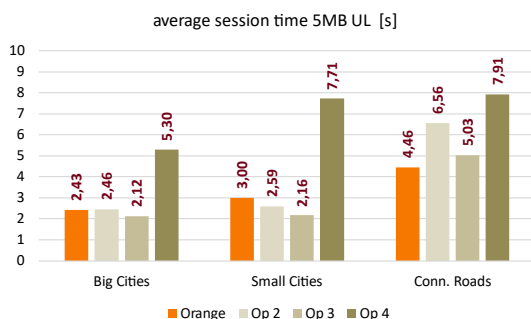
Orange DL throughput performance in capacity test (7s test) is significantly ahead of competition. Orange DL throughput performance clearly ahead of competition and has significantly improved its DL performance. These results were possible due to the deployment of 5G NR bands in cities and use of widest bandwidth in data services tested. Op2 scored as 2nd best operator, leading confidently over Op3 and Op4. Op4 downlink throughput results are much lower than of other competitors. The throughput of the best 10% of transfer DL tests in case of Orange was not worse than 504 Mbps in big cities. For Op2 which was the second that value was 267Mbps.



In case of UL throughput in 7s test, Orange and Op3 leads the competition. The throughput of the best 10% of transfer UL tests in case of Orange was not worse than 81Mbps in big cities. For Op2 that value was 73 Mbps. Op3 reached the best results for this KPI in small cities achieving 62Mbps. The result of Orange in this KPI was similar to year 2021 results. The Op2 has improved reported value of that KPI from close to 50Mbps to 73Mbps in 2022.



Orange achieved shortest average session time among all operators for 10MB file download. Op2 follows Orange in this competition. In small cities all Orange and Op2 and Op3 are very close each other. The worst results are achieved by Op4 in small cities and on connecting roads with results above 7 seconds.



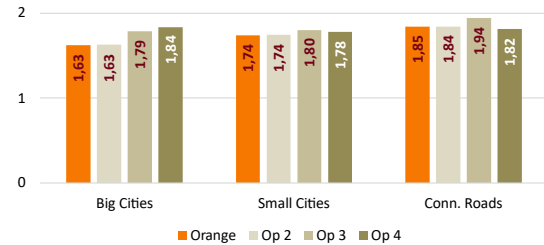
Also, for upload of 5MB file test the upload time is in Orange network is very good but the best result was reported by Op3 in big and small cities. The throughput of the best 10% of 10MB file transfer DL tests is not worse than 153 Mbps in Big Cities and this result is worse than year ago. Op2 and Op3 are much closer to Orange than in 2021 reporting 92Mbps and 63Mbps respectively. On Connecting roads all operators present similar throughputs for this KPI.

Orange reports the shortest access to live web content (time to 1st 500kB loaded). The service reliability in all aggregations is similar for all measured operators. Orange is best on connecting roads but Op2 in big and small cities.

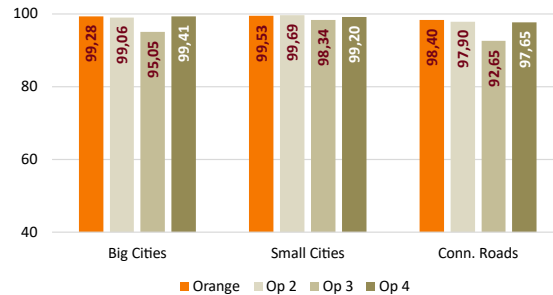
All operators show the similar Youtube playout start time slightly above 1 second. The best YouTube reliability was measured in Orange network. All operators improved the quality on connecting roads achieving results close to 99% except Orange reaching 99,4%. All operators achieve similar VMOS scoring above 4 points but Orange and Op4 take a lead in term of avg. picture resolution. In more than 66% of the time video is played with played with 1080p and in over 68% of the time video is played with played with resolution not worse than 720p.

All operators download video content mainly from Google Global Cache placed in their own network.

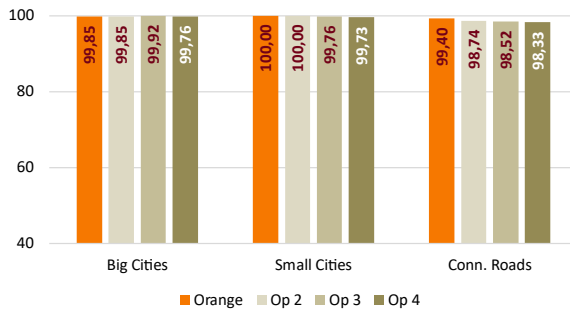
web browsing time to 1st 500kB[s]



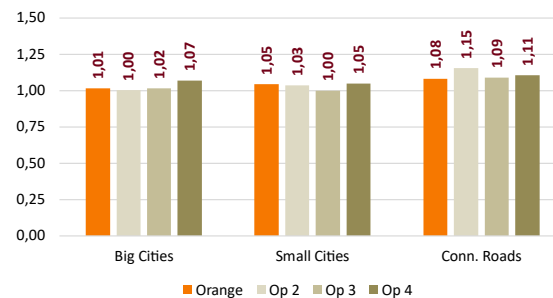
web browsing qualified sessions [%]



YouTube qualified playouts [%]



YouTube playout start time [s]



Orange shows the best latency in all aggregations (below 48ms for TCP round trip time test. Op 2 and Op3 reported the latency not worse 54ms. Results for Op4 was 56ms.

The testing included WhatsApp performance even it was not a part of the scoring. WhatsApp Application was up-to-date version. WhatsApp speech quality for Orange is close to 4.5 MOS. The speech quality of WhatsApp in Orange network is similar to VoLTE speech quality. For other networks WhatsApp speech quality outperforms Legacy Voice technologies (3G/2G/4G CSFB) and VoLTE. All MNOs demonstrate short Call Setup Time between 2,24s for Orange and 2,63s for Op2.

Orange, Op2 and Op4 implemented 5G network but 5G coverage from Op4 is small. Op3 bases its services on 2/3/4G network only. In the data tests the use of 5G network in case of Orange was 35% using both 3600Mhz and 2100Mhz bands.

Systemics-PAB is well known European company providing comprehensive surveys and measurements of the quality of network services and the end-user experience. Systemics-PAB conducts complex projects in multiple countries worldwide for telecom operators, regulators, network equipment providers, lab testing organizations and enterprises. Systemics-PAB offers the expert know-how developed over more than 15 years in this business.