



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 2021. 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.

The results of the measurements showed Orange as operator with the best overall score for the quality of experience of mobile services in Romania. Orange Romania presented very good results for data services achieving highest data speeds in capacity tests and shortest session times for file transfer tests. These results were possible due to the deployment of 5G NR bands in cities and use of widest bandwidth in data services tested.

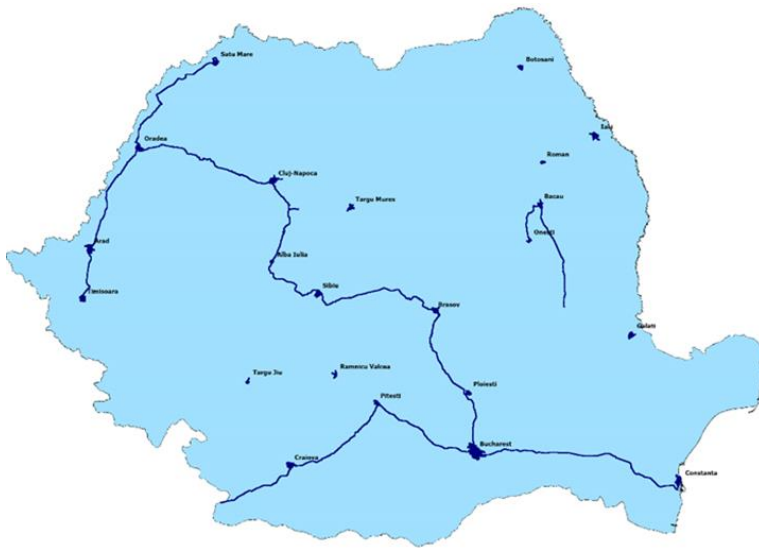
Orange Romania S.A. can therefore be certified as the operator with the fastest data services and the highest overall quality of mobile services in the test.

Certificate Date: 12.09.2021


Jan Kondej
Chief Technical Officer

Test Route

The periodical drive tests of mobile networks allows 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 2021 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 19th and August 7th of 2021 on representative areas of Romania including cities and roads covering more than 50% of the population.

The total distance covered by each of 2 drive test cars used was over 3600 km. Measurements took more than 120 hours delivering ~3500 voice service tests and ~2100 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: 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

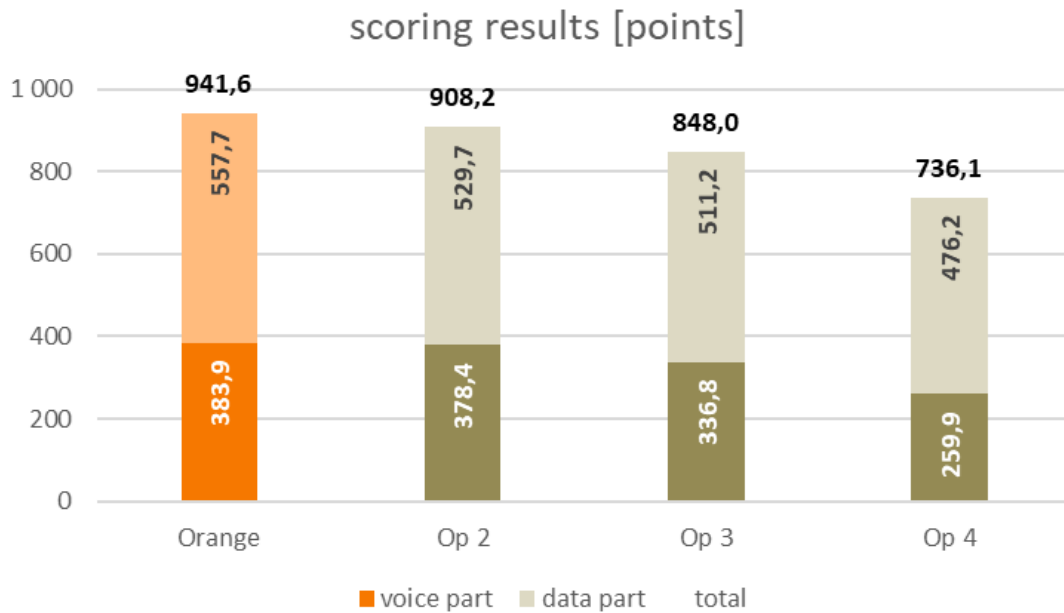
The test area was designed to cover cities and connecting roads (with villages along roads) that constitute around 50% of the population of Romania.

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 were used.

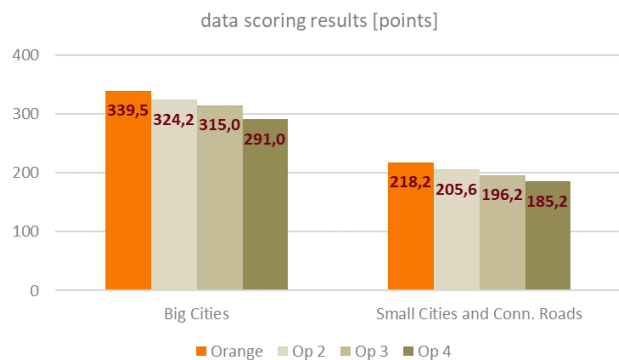
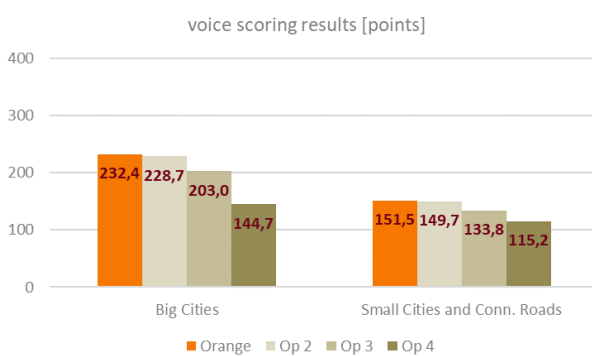
The selection of web pages to be tested was done based on Alexa rank of most popular web destinations in Slovakia which are accessible for drive testing (automated test by robots).

Scoring Results

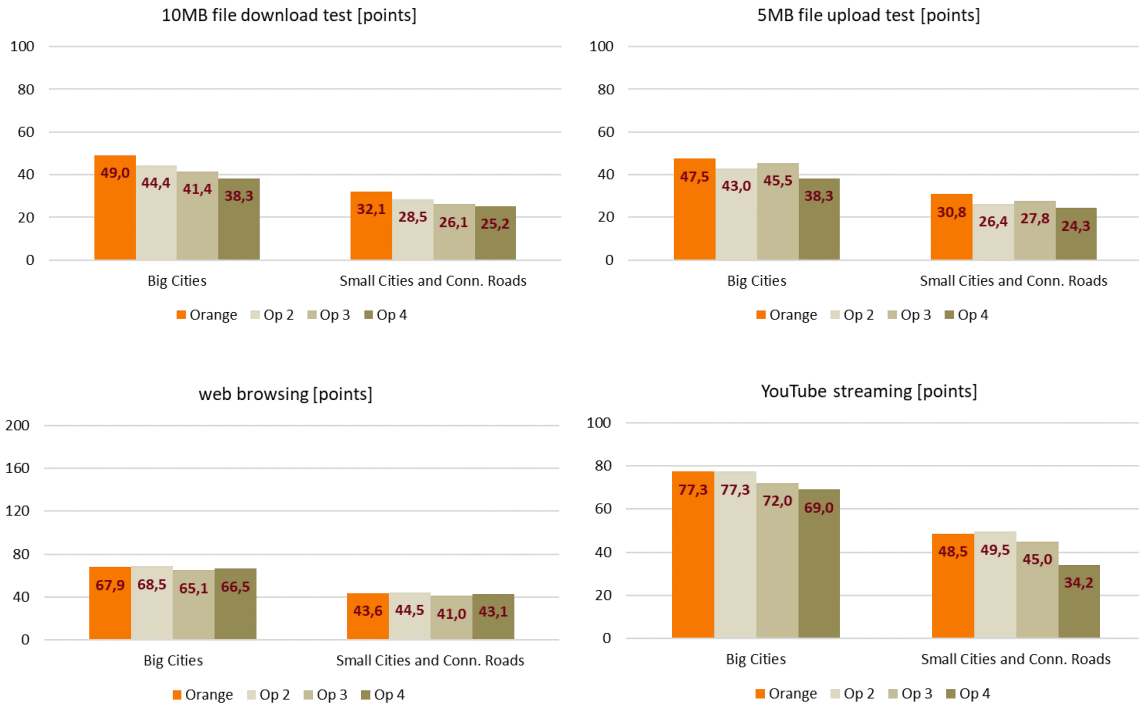
With applied scoring methodology the highest number of points in overall scoring was achieved by Orange and was equal to 941.6 out of 1000 of maximum achievable. The other operators scored 908.2, 848.0 and 736.1. Orange got the best score in both voice and data tests.



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.

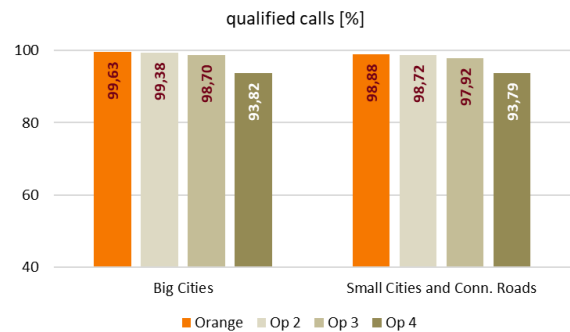


The comparison of the scoring results for selected data tests for big cities and other areas is presented on charts below.

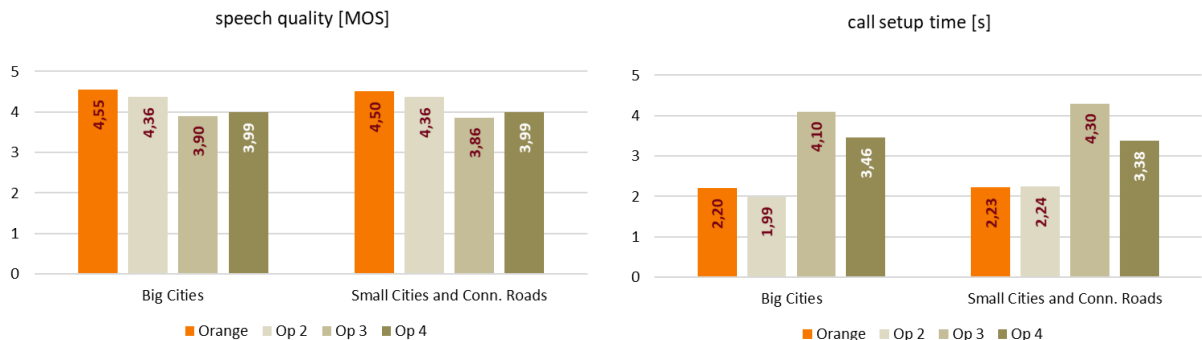


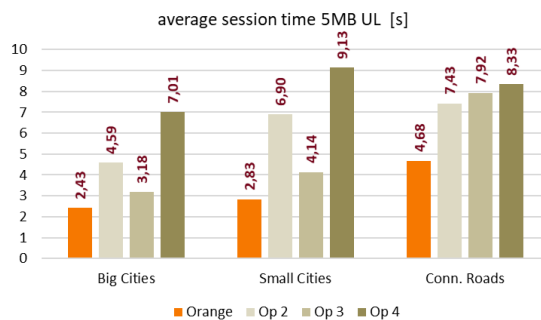
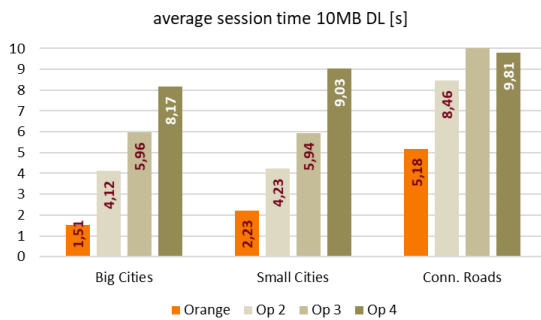
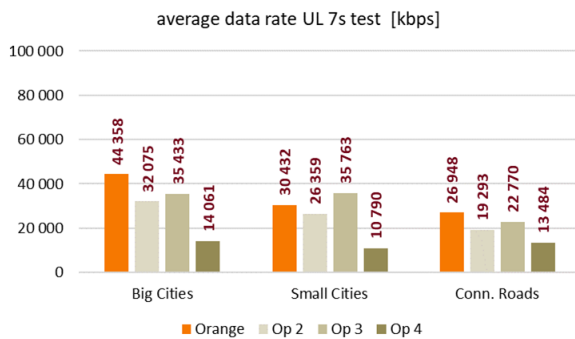
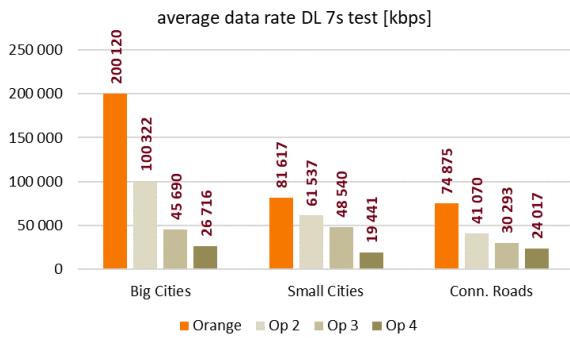
Tests Results in Details

All operators except Op4 presents good availability of voice services. Op3 doesn't offer VoLTE but other operators provides VoLTE for over 98% of connections. Orange demonstrates the best speech quality and lowest call setup time). Orange and Op2 use EVS codec for more than 96% of test calls while Op4 offers only AMR Wide Band.



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 481Mbps in big cities. For Op2 which was the second that value was 234Mbps.

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 and Op3 that value was 59Mbps. Op3 reached the best results for this KPI in small cities achieving 63Mbps while Orange and Op2 reported value not worse than 48Mbps.

Orange achieved shortest average session time among all operators for 10MB file download in all tested area types. Op2 follows Orange in this competition but with the result over 2 times worse. The worst results are achieved by Op3 and Op4 on connecting roads with results above and close to 10 seconds.

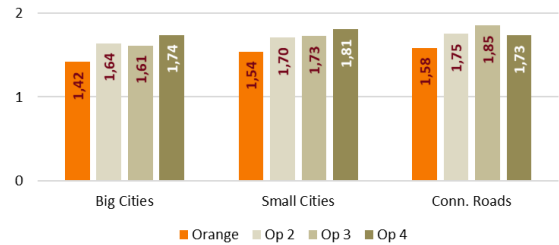
Also for upload of 5MB file test the shortest upload time is in Orange network followed by Op3 in big and small cities. The throughput of the best 10% of 10MB file transfer DL tests is not worse than 205 Mbps in Big Cities, 107Mbps in Small Cities and 108Mbps on Connecting Road. Other operators achieved this KPI between 34Mbps and 46Mbps in all area types.

Orange reports the shortest access to live web content (time to 1st paint). 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.

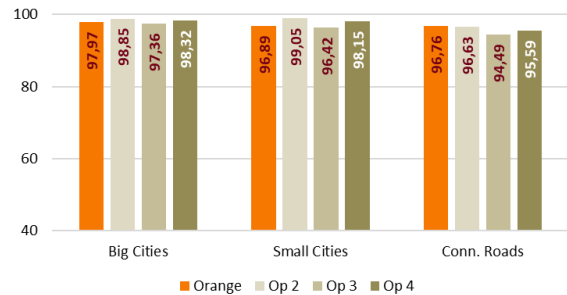
Orange and Op3 show the fastest Youtube playout start time. The best YouTube reliability was measured in Orange network. On connecting roads the result was more than 5 percent points better than Op3 and Op4. Almost all operators achieve similar VMOS scoring above 4 points but Orange take a lead in term of avg. picture resolution. In 60% of the time video is played with 1080p and in over 66% of the time video is played with resolution not worse than 720p.

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

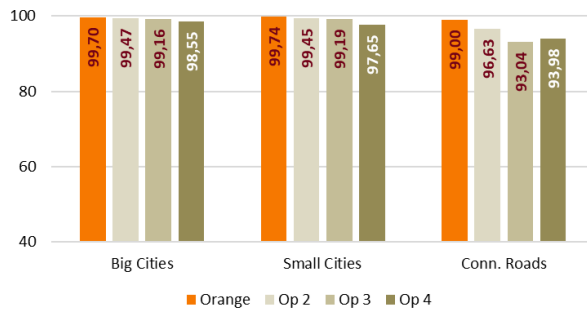
web browsing time to first paint [s]



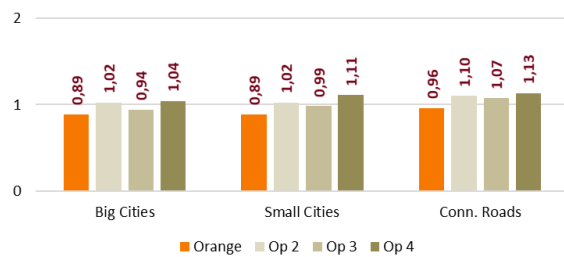
web browsing qualified sessions [%]



YouTube qualified playouts [%]



YouTube playout start time [s]



Orange shows the best latency in all aggregations (below 47ms for TCP round trip time test. Op3 reported the latency not worse 57ms. Results for Op2 and Op4 were 69ms and 66ms respectively.

The testing included WhatsApp performance even it was not a part of the scoring. WhatsApp Application was up-to-date 2021 version. WhatsApp speech quality is similar in all networks and 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 very similar Call Setup Time around 1.6 second. Orange encountered service access problems during the test thus the availability of WhatsApp service in Orange network was worse than competition.

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.