CERTIFICATE

Systemics-PAB Sp. z o.o.
Wolodyjowskiego 46B, 02-724 Warsaw, Poland

hereby certifies that

Orange Slovensko a.s.
Metodova 8, 821 08 Bratislava, Slovakia

Received the title for

THE BEST SLOVAKIAN MOBILE NETWORK IN THE TEST

This certificate is based on the results of the measurement campaign, which was carried out by Systemics-PAB in June and July 2021. The measurement campaign assessed the quality of experience of mobile voice and data services in Slovakia. All mobile Network Operators in Slovakia: Orange Slovensko a.s. (Orange), SWAN a.s. (SWAN), Slovak Telekom a.s. (Telekom) and O2 Slovakia s.r.o. (O2) were tested. Systemics-PAB performed the benchmarking measurements throughout Slovakia covering 24 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 achieving the highest overall results for the quality of experience of mobile services in Slovakia.

Orange Slovensko a.s. can therefore be certified as the operator with the highest overall quality of mobile services in the test.

Certificate Date: 23.07.2021

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 project Systemics-PAB delivered extensive benchmarking campaign to measure the quality of mobile telecommunication services offered by mobile networks operators in Slovakia across the country.

The benchmarking measurements took place between June 26th and July 9th of 2021 and covered representative areas of Slovakia including 24 cities and Slovakian roads. The total distance covered by each of 2 drive test cars used was over 3000 km. Measurements took more than 100 hours delivering ~2660 voice service tests and ~1680 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 Slovakia.

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).
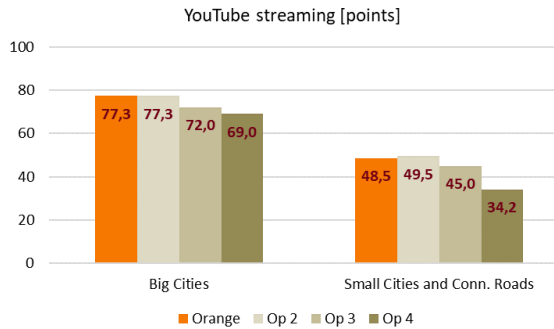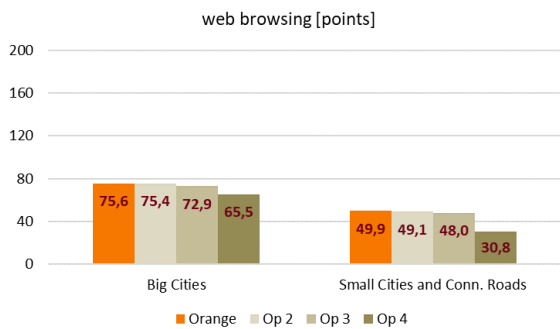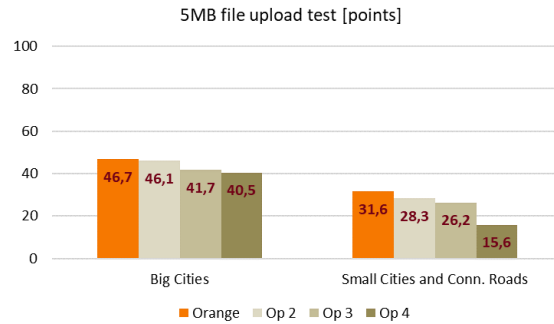
Scoring Results

With applied scoring methodology the highest number of points in overall scoring was achieved by Orange and was equal to 953.4 out of 1000 of maximum achievable. The other operators scored 903.7, 849.6 and 681.4. Orange got the best score in both voice and data tests.

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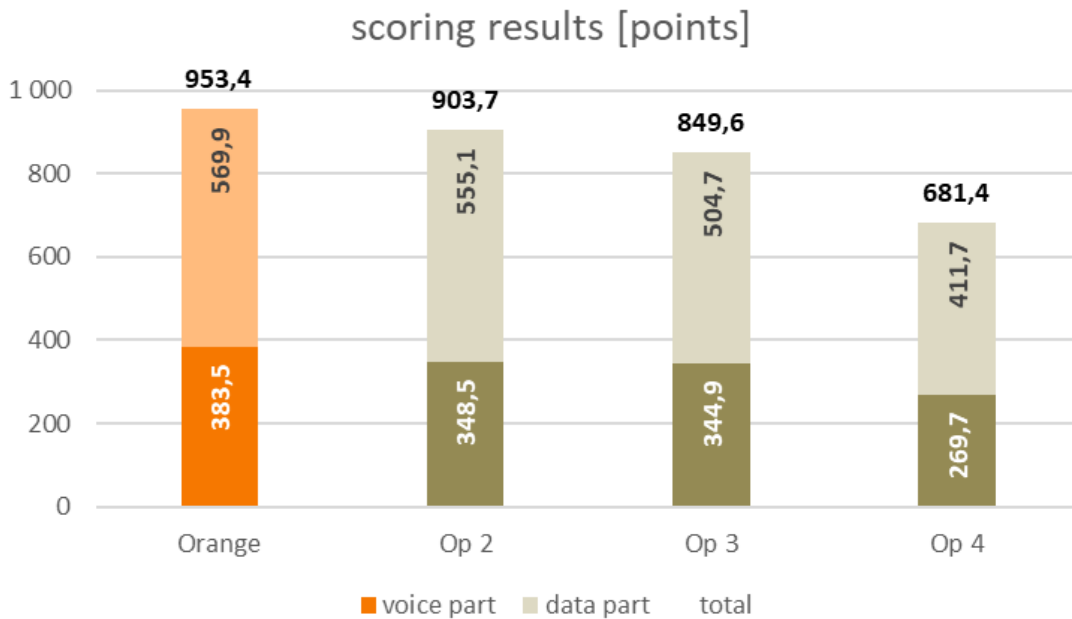
Orange achieved the highest overall score due to the best quality of services in all measured aggregations, in Large Cities, Small Cities and on Roads. Op2 and Op3 are following Orange in voice testing results. In data tests Op2 only is close to Orange. Worst results in both voice and data tests in all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

voice scoring results [points]

data scoring results [points]
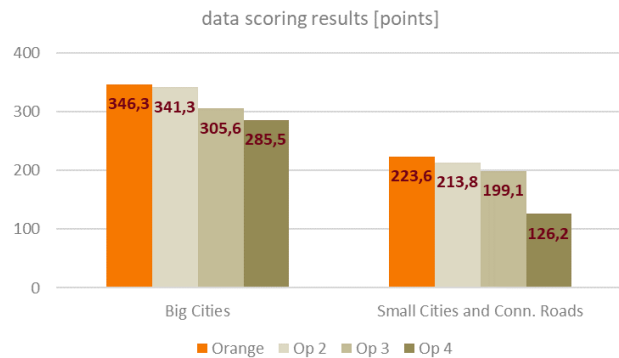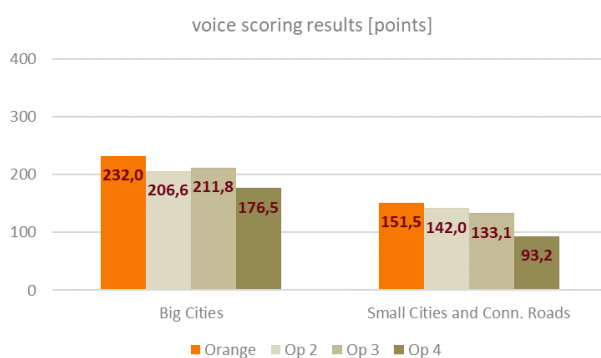
The comparison of the scoring results for selected tests for big cities and other areas is presented on charts below.
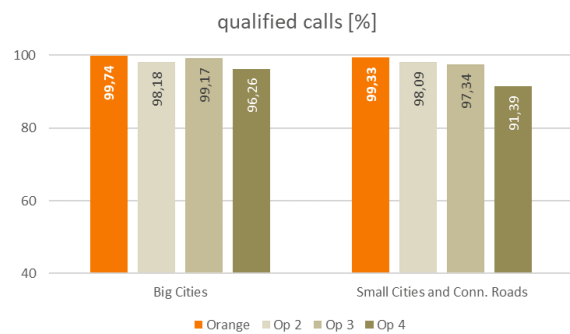
10MB file download test [points]
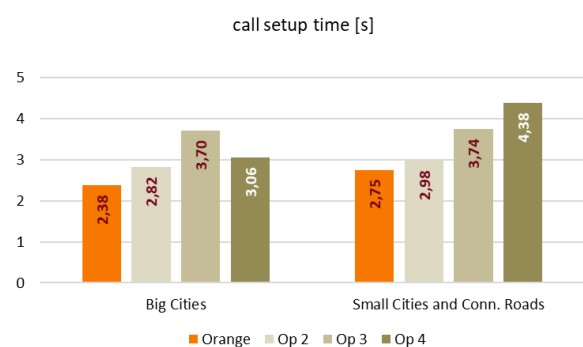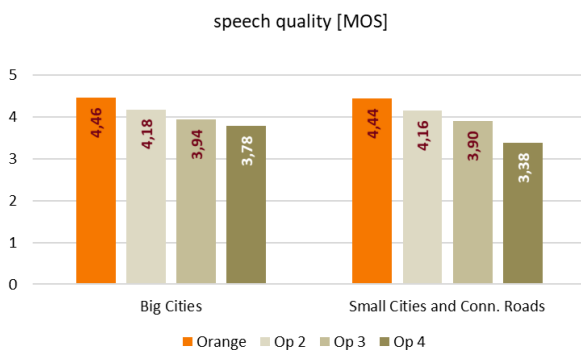

	Big Cities	Small Cities and Conn. Roads
Orange	50,3	31,8
Op 2	46,3	29,3
Op 3	39,7	27,4
Op 4	36,9	16,1

Orange ■ Op 2 ■ Op 3 ■ Op 4

5MB file upload test [points]

	Big Cities	Small Cities and Conn. Roads
Orange	46,7	31,6
Op 2	46,1	28,3
Op 3	41,7	26,2
Op 4	40,5	15,6

Orange ■ Op 2 ■ Op 3 ■ Op 4

web browsing [points]

	Big Cities	Small Cities and Conn. Roads
Orange	75,6	49,9
Op 2	75,4	49,1
Op 3	72,9	48,0
Op 4	65,5	30,8

Orange ■ Op 2 ■ Op 3 ■ Op 4

YouTube streaming [points]

	Big Cities	Small Cities and Conn. Roads
Orange	77,3	48,5
Op 2	77,3	49,5
Op 3	72,0	45,0
Op 4	69,0	34,2

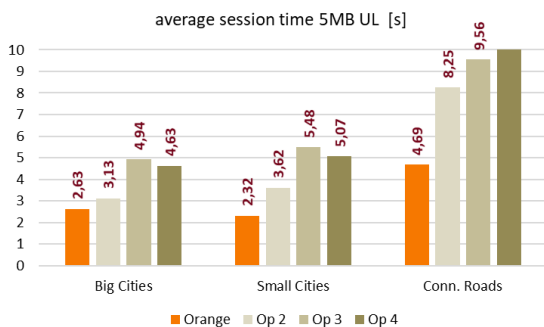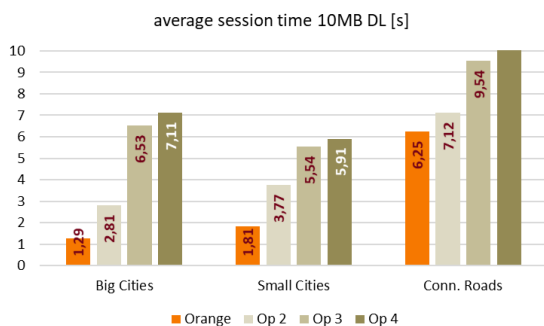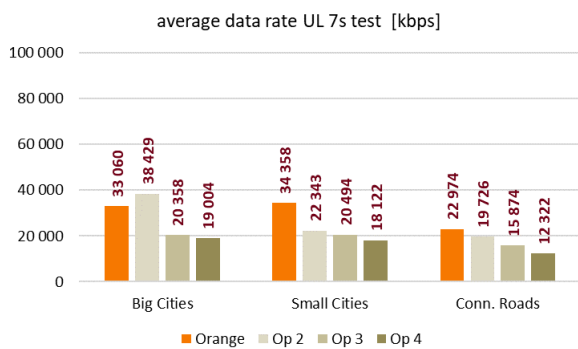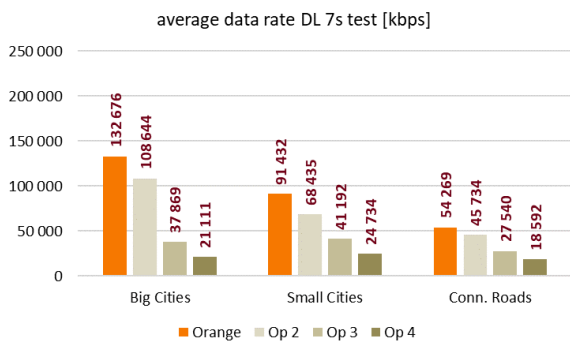Orange ■ Op 2 ■ Op 3 ■ Op 4

Tests Results in Details

Except Op4 all other operators present good availability of voice services. All operators provide VoLTE connections. Orange demonstrates the best speech quality and lowest call setup time). Orange, Op2 & Op3 report ~99% VoLTE usage in test.

Orange has best speech quality MOS ahead of Op2.

qualified calls [%]

	Big Cities	Small Cities and Conn. Roads
Orange	99,74	99,33
Op 2	98,18	98,09
Op 3	99,17	97,34
Op 4	96,26	91,39

Orange ■ Op 2 ■ Op 3 ■ Op 4

Both leading operators utilize EVS codec, which is VoLTE codec offering superior speech quality compared to legacy (2G/3G) codecs. Op2 and Op3 utilize AMR WB codecs, which provide lower speech quality score. Orange has the fastest call setup time thanks to the extensive use and very good performance of VoLTE-VoLTE calls. Other operators present longer call setup time even in case of VoLTE calls.

speech quality [MOS]

	Big Cities	Small Cities and Conn. Roads
Orange	4,46	4,44
Op 2	4,18	4,16
Op 3	3,94	3,90
Op 4	3,78	3,38

Orange ■ Op 2 ■ Op 3 ■ Op 4

call setup time [s]

	Big Cities	Small Cities and Conn. Roads
Orange	2,38	2,75
Op 2	2,82	2,98
Op 3	3,70	3,74
Op 4	3,06	4,38

Orange ■ Op 2 ■ Op 3 ■ Op 4

average data rate DL 7s test [kbps]

Orange DL throughput performance is significantly ahead of competition. Compared with 2020 benchmark, vast increase in Orange throughput are observed, due to extension of 4G capacity by massive LTE 4CA and limited implementation of 5G. 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 230Mbps in big cities. For Op2 which was the second that value was 188Mbps.

average data rate DL 7s test [kbps]

	Big Cities	Small Cities	Conn. Roads
Orange	132 676	91 432	54 269
Op 2	108 644	68 435	45 734
Op 3	37 869	41 192	27 540
Op 4	21 111	24 734	18 592

average data rate UL 7s test [kbps]

In case of Uplink throughput, Orange and Op2 are broadly on pair on Connecting Roads. In Small cities, Orange offers better throughput than Op4. In Big Cities Op2 presented the highet avarage upload throughput.

average data rate UL 7s test [kbps]

	Big Cities	Small Cities	Conn. Roads
Orange	33 060	34 358	22 974
Op 2	38 429	22 343	19 726
Op 3	20 358	20 494	15 874
Op 4	19 004	18 122	12 322

Orange achieved shortest average session time among all operators for 10MB file download in all tested area types. Op2 follows Orange in this competition. Other two operator are close to leading ones only Small Cities.

average session time 10MB DL [s]

Also, for upload of 5MB file test the shorted upload time is in Orange network follow by Op2. In both tests Op4 presents much longer session times than competition with average well above 12 seconds. Connecting roads are very demanding to Op3 with result close to 10 seconds.

average session time 10MB DL [s]

	Big Cities	Small Cities	Conn. Roads
Orange	1,29	1,81	6,25
Op 2	2,81	3,77	7,12
Op 3	6,53	5,54	9,54
Op 4	7,11	5,91	10

The throughput of the best 10% of 10MB file transfer DL tests in Big Cities, 104Mbps in Small Cities and 98Mbps on Connecting Road. Other operators achieved this KPI between 34Mbps and 46Mbps in all area types.

average session time 5MB UL [s]

Orange DL throughput performance is clearly ahead of competition mostly thanks to higher bandwidth and MIMO utilization. The performance of data services has improved in big cities and on connecting roads comparing to 2020. Orange DL performance was elevated by 5G implementation but very little due to very minor 5G deployment mainly in Bratislava

average session time 5MB UL [s]

|	Big Cities	Small Cities	Conn. Roads
Orange	2,63	2,32	4,69
Op 2	3,13	3,62	8,25
Op 3	4,94	5,48	9,56
Op 4	4,63	5,07	10

Orange UL throughput performance is broadly on par with Op2 which takes a lead in big cities while Orange shows better UL performance in small cities and on roads.

Orange with the shortest access to live web content (time to 1st paint) and the best service reliability in all aggregations, Op2 stays very close (within 50ms behind) with good service reliability. Op4 well behind competition in term of service reliability especially on Connecting Roads.

Orange and Op2 show the fastest YouTube playout start time and the best YouTube reliability. Almost all operators achieve similar VMOS scoring well above 4 points but Orange and Op2 take a lead in term of avg. picture resolution. In over 60% of the time video is played with played with 1080p. In over 66% of the time video is played with played with resolution not worse than 720p.

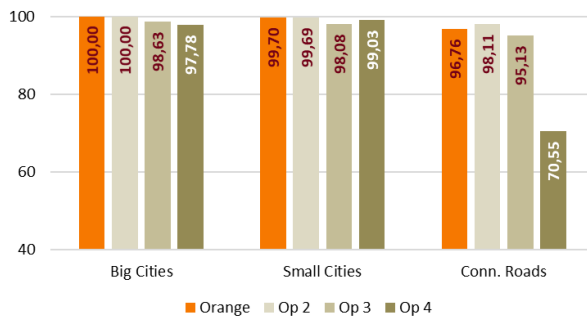All operators download video content mainly from

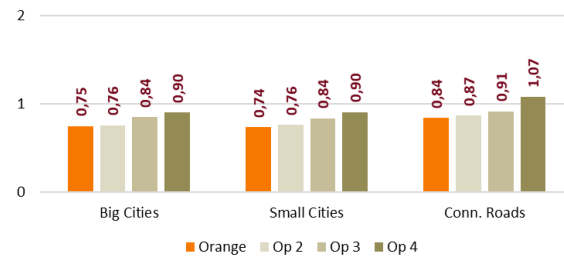**web browsing time to first paint [s]**
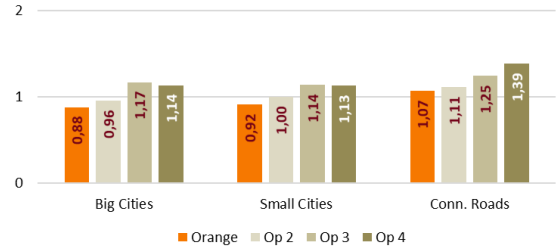
web browsing qualified sessions [%]
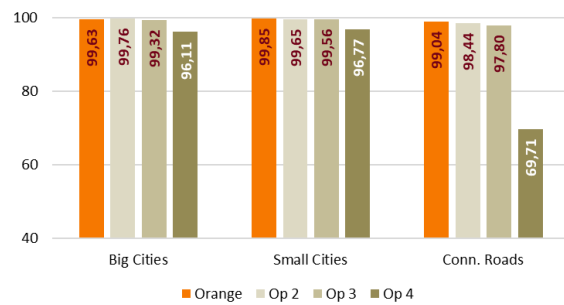
YouTube qualified playouts [%]

YouTube playout start time [s]

Orange shows the best latency in all aggregations (below 38ms for TCP round trip time test) and Op3 ranked the second with 55ms. The latency in Op4 network was longest (75ms) for the same test.

It is also worth to mention that 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 lays between 4,24 and 4,31. The speech quality of WhatsApp is better than speech quality offered by Legacy Voice technologies (3G/2G/4G CSFB) but VoLTE outperforms it in all measurement locations in Orange network. All MNOs demonstrate very similar performance in terms of Call Setup Time and speech quality. Orange has improved its WhatsApp service reliability vs 2020 thanks to reduction of failed and dropped calls.

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.