

Benchmarking test
of mobile operators
in Serbia

October – November 2017

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Benchmarking test of mobile operators in Serbia - overview

The Regulatory Agency for Electronic Communications and Postal Services (RATEL) conducts state strategy and policy in the field of electronic communications and postal services in the Republic of Serbia. It also assures highest Quality of Service standards by enforcing country-wide coverage of mobile services and continued improvement of their performance.

The strategy of RATEL is to encourage further investments and development of telecommunications market by fostering competition, cost-effectiveness and efficiency in the mobile communications, as well as to provide subscribers with fair and unbiased information about the quality of service in the mobile networks in the Republic of Serbia. Therefore RATEL carried out the first extensive benchmarking tests of three mobile network operators: Telekom Srbija, Telenor and Vip mobile.

The measurements and benchmarking of mobile services were done by Systemics-PAB with the support of the local partner CRONY d. o. o. from Belgrade.

The measurements results are available on the dedicated interactive portal created especially for the purpose of the project. It is publicly available using the link <http://benchmark.ratel.rs/en>. The portal allows to navigate through the results with reach filtering features. There is also interpretation of results available for readers.

Benchmarking measurements covered 35 cities and 10,000 km of Serbian roads. During the campaign, over 6,000 voice calls and 100,000 data sessions were performed for each mobile network operator across all technologies (2G, 3G, 4G). These measurements included:

- Measurement of mobile Key Performance Indicators (KPIs) for voice and data services,
- Measurement of radio parameters for 2G / 3G / 4G technologies.

The mobile market in Serbia is divided between three mobile network operators (MNO). Respective mobile subscribers' shares are presented in Chart 1. Chart 2 presents the mobile market share in Serbia in terms of revenues generated by operators.

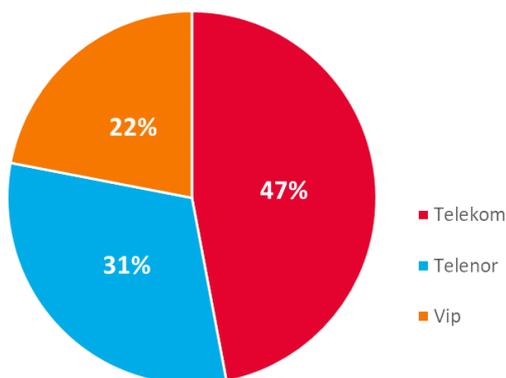


Chart 1. Mobile subscriber share

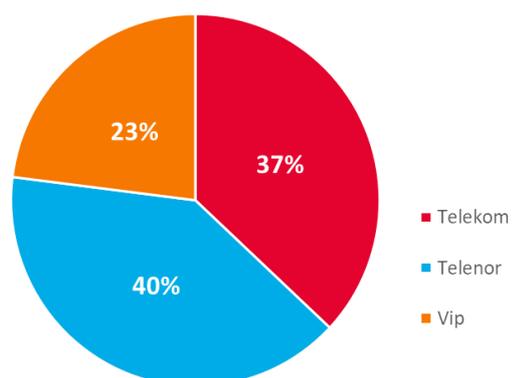


Chart 2. Mobile market value share

Source: 2016 Market Overview, RATEL

The number of mobile subscribers in Serbia fluctuate around 9 million, what corresponds to 130% of SIM penetration. The voice users generated more than 4 billion minutes in the third quarter of 2017. Close to 70% of the voice traffic was on-net traffic. 6.3 million of subscribers base were active mobile broadband subscribers generating over 22 million GB of data traffic in the Q3 2017. (Source: Q3 2017 market report for Serbia, RATEL)

With approximately 4.1 million subscribers, Telekom Srbija - MTS is the mobile network operator with the greatest number of subscribers in Serbia. It was founded in 1997 and started to provide mobile communications service in 1998. Telekom Srbija operates its 4G network at 800 MHz and 1800 MHz. Additionally it operates 3G network at 900 MHz and 2100 MHz and 2G network at 900 MHz.

Telenor has been present in Serbia since 2006, when they bought Mobi63, a former Mobtel, that was founded in 1994. It has 2.7 million subscribers. Telenor operates its 4G network at 800 MHz and 1800 MHz. It operates its 3G network mainly at 900 MHz, with limited additional 2100 MHz coverage, and its 2G network at 900 MHz and 1800 MHz.

Vip mobile was established in 2006 and is part of Telekom Austria Group. It has around 2 million subscribers. Vip mobile offers 4G network at 800 MHz and 1800 MHz, 3G network at 2100 MHz and 2G network at 900 MHz and 1800 MHz.

Geographical coverage of the test

The campaign covered 35 cities and 10,000 km of Serbian roads and was divided into three area type categories: Large Cities, Small Cities and Roads.

Large Cities:

- Beograd
- Čačak
- Kragujevac
- Niš
- Novi Sad
- Pančevo
- Subotica
- Zrenjanin

Small Cities:

- Bačka Palanka
- Bor
- Gornji Milanovac
- Jagodina
- Kikinda
- Kraljevo
- Kruševac
- Leskovac
- Loznica
- Negotin
- Novi Pazar
- Obrenovac
- Paraćin
- Pirot
- Požarevac
- Prokuplje
- Ruma
- Šabac
- Smederevo
- Smederevska Palanka
- Sombor
- Sremska Mitrovica
- Užice
- Valjevo
- Vranje
- Vršac
- Zaječar

Drive test routes that were measured, are presented on Map 1.



Map 1. Drive test routes

How the survey was conducted

Measurements were performed in a drive test mode, which means that measurement equipment was installed in moving vehicles. Measurement equipment collects network data by running voice and data tests and using scanner to obtain radio network parameters. All three mobile networks were measured at the same time and on the same drive test routes using the same smartphones, Samsung Galaxy S4 for voice tests and Samsung Galaxy Note 4 for data tests. Samsung Galaxy Note 4 is Cat. 6 mobile device, which means it supports 4G (LTE) data speed up to 300 Mbps for data receiving and 50 Mbps for data sending. All smartphones worked in automatic technology selection mode. To reflect the latest technical developments in the mobile networks and to examine the benefits from available capabilities, SIM cards with the most comprehensive mobile tariff plans (tariff plans with the highest data rates, highest number of minutes, largest amount of data volume) available from each operator were used.

Measurement system consisted of two test cars equipped with identical measurement equipment (SwissQual Diversity Benchmark II) capable to measure all network technologies and services simultaneously to very high accuracy. In order to perform voice tests, Samsung Galaxy S4 smartphones permanently called each other, within the same mobile network. In Large Cities, voice tests were executed in mobile to mobile scenario between two cars, in Small Cities and on the Roads mobile to mobile calls were done within the same car. The aforementioned specific setup in Large Cities allowed for effective data collection without performing too much voice traffic within the single radio cell in areas where higher mobile traffic is expected. Voice tests assess network accessibility, retainability and quality of speech. Voice call with 85 seconds call duration was measured during benchmarking.

The receiving or sending of additional data during the voice test call was added to measurement scenario in order to simulate behaviour of regular subscriber using smartphone device, for which background data transmissions are typical during the voice call. For each of the voice call, quality of speech samples was measured (MOS – Mean Opinion Score) using POLQA P.863 algorithm.

Data tests were done using Samsung Galaxy Note 4 smartphones and dedicated measurement server located at Serbian Open eXchange (SoX) in Belgrade, which ensured fair transmission path to all three mobile networks. Data tests assess network availability, stability, typical performance and highest capabilities. The most representative data services were measured during benchmarking:

- HTTP File Transfer - Download (throughput of 3 MB file transmission over HTTP protocol from measurement server to smartphone). Small file transfer Download test is designed to measure responsiveness of the network and simulate user downloading small files such as pictures, mp3 files or email attachments.
- HTTP File Transfer - Upload (throughput of 1 MB file transmission over HTTP protocol from smartphone to measurement server). Small file transfer Upload test is designed to measure responsiveness of the network and simulate user uploading small files such as pictures, mp3 files or email attachments.
- FDTT HTTP Capacity Transfer - Download (throughput of 400 MB file transmission over HTTP protocol from measurement server to smartphone during the transmission time of 10 seconds). This test is designed to reach network capabilities to deliver highest continuous throughput which is important for heavy users downloading large files – typical for users using mobile connections for their PC / laptops.
- FDTT HTTP Capacity Transfer - Upload (throughput of 400 MB file transmission over HTTP protocol, from smartphone to measurement server, during the transmission time of 10 seconds). This test is designed to reach network capabilities to deliver

highest continuous throughput which is important for heavy users uploading large files – typical for users using mobile connections for their PC / laptops.

- HTTP Browsing Static (testing how fast is the reference ETSI Kepler web page received and opened on smartphones).
- HTTP browsing Live Page (testing how fast are the real web pages received and opened on smartphones).
- YouTube (testing the quality of live stream video transmission).
- Ping (measuring delay between sending and receiving packets inserted by the network).

To simulate the behaviour of average mobile subscriber in Serbia surfing Internet, a set of websites was tested, based on their popularity amongst Serbian users:

<https://www.google.rs>

<https://www.facebook.com>

<https://m.kupujemprodajem.com>

<https://www.kupindo.com>

Measurements were performed in September and October 2017. Over 6000 test calls were made for each of the tested operators. Assessing data services, we carried out around 32,000 tests for each operator. Additionally over 3500 YouTube tests were done in each of networks.

Voice services results

Mobile Network Benchmarking measurements were done in September and October 2017 and the obtained results are referring to that time period only. Please note that the current results may differ from those shown here. The results of main KPIs for voice tests achieved by operators with the split per the aggregation type are presented in Chart 4.



Chart 4. Results of main KPIs for voice tests

Large Cities:

Vip mobile showed the best call success rate, whereas call success rate in Telekom Srbija and Telenor networks were behind and close to each other.

The longest average call setup time was 6.8 seconds in Telekom Srbija network, while the shortest average time to establish the call was 5.0 seconds in Telenor network.

Telenor had the best speech quality (MOS) and the lowest percentage of bad speech samples. Telekom Srbija had the highest percentage of bad speech samples – 7.3% of samples had MOS lower than 2.3, which is perceived as bad speech quality.

Small Cities:

Call success rate for Vip mobile is the best amongst all aggregations. Call success rates in Telekom Srbija and Telenor were similar, but not reaching minimum expected value of 97%. The longest average call setup time was 7.5 seconds in Telekom Srbija network, while the shortest was measured in Telenor network, 4.8 seconds. The best quality of the speech was measured in Telenor network at the MOS level of 3.51. Telenor had the least amount of bad quality speech samples (3.9%), while Telekom Srbija had the most (7.0%).

Roads:

Call success rates in Telekom Srbija and Telenor networks were similar, Vip mobile was worse by 1percent. No network reached minimum expected call success rate value. The longest average call setup time was 7.1 seconds for Telekom Srbija, while shortest (4.7s) was measured in Telenor network. The best quality of the speech was found in Telenor network at the MOS level of 3.45. Vip mobile achieved MOS at level of 3.39 and Telekom Srbija of 3.23. The percentage of samples with MOS worse than 2.3 in Telekom Srbija network exceeded 10%, while other competitors scored better in this metric.

Data services results

Mobile Network Benchmarking measurements were done in September and October 2017 and the obtained results are referring to that time period only. Please note that the current results may differ from those shown here.

The selected KPIs for data tests achieved by operators with the split per the aggregation type are presented in Chart 5. Those show differences between operators for browsing, data transfer and YouTube video watching.



Chart 5. Selected KPI from data test

FDTT HTTP Capacity Transfer - Download (FDTT HTTP DL) test results

Results for FDTT HTTP DL (400 MB file transmission) tests are presented in Chart 6.



Chart 6. KPIs results for FDTT HTTP Capacity Transfer - Download (FDTT HTTP DL)

Large Cities

All operators had near perfect session success rates. Vip mobile had much higher average data rate, with 10 Mbps lead over the other two operators. All three mobile operators had low share of samples with data rate below 4 Mbps. All three operators achieved high data rates due to the Carrier Aggregation (CA) usage. Vip mobile achieved the best result, despite Telenor having the highest CA usage. Telekom Srbija network had similar data rate performance as Telenor, even though Telekom Srbija had the lowest CA usage among all operators.

Small Cities

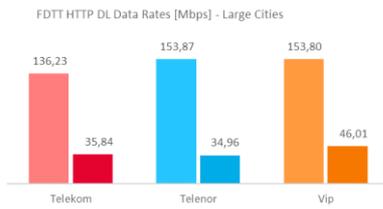
In Small Cities, the success rate was nearly the same for all competitors. CA usage was much smaller compared to Large Cities, with only Telenor and Vip mobile having some availability of CA. Vip mobile achieved the highest data rates.

Roads

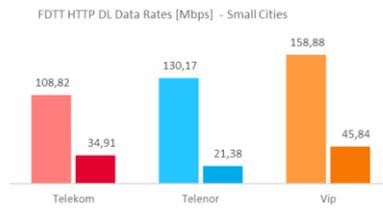
Telenor took the clear lead in terms of success rate, with Vip mobile following closely and Telekom staying behind by 1.6 percent. In terms of data rate, Vip mobile advantage over competitors. 4 out on the Roads was significantly lower compared to other aggregations, except for Vip mobile which had around 92% of LTE CA. Telenor and Telekom Srbija stayed behind with data rate lower by 10 Mbps on average and higher share of samples below 4 Mbps threshold.

FDDT HTTP DL – Average and Maximum data rates

Large Cities



Small Cities



Roads

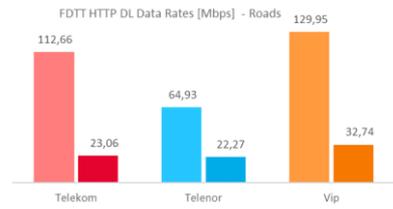


Chart 7. Average and Maximum data rates for FDDT HTTP Capacity Transfer – Download

FDTT HTTP Capacity Transfer – Upload (FDTT HTTP UL) test results

Results for FDTT HTTP UL (400 MB file transmission) tests are presented in Chart 8.



Chart 8. KPIs results for FDTT HTTP Capacity Transfer – Upload (FDTT HTTP UL)

Large Cities

All operators had near perfect overall success rates and very high 4G usage. Vip mobile had the best average data rate, with Telekom Srbija being second and Telenor last. Telekom Srbija was able to achieve high average data rate, despite having almost 10% of samples below 2 Mbps threshold.

Small Cities

The success rate in Small Cities was still on a near perfect level. The average data rate values dropped for Telekom Srbija and Telenor, but the rank remained the same. Vip mobile was still in the lead. In Telekom Srbija network there was 13.7% of low data rate samples (below 2 Mbps threshold).

Roads

The success rate for all operators was a bit worse compared to the cities, but still on a very good level. Only Vip retained high 4G usage on the Roads.

Web browsing test results

Tests results for HTTP Browsing tests are presented in Chart 9.

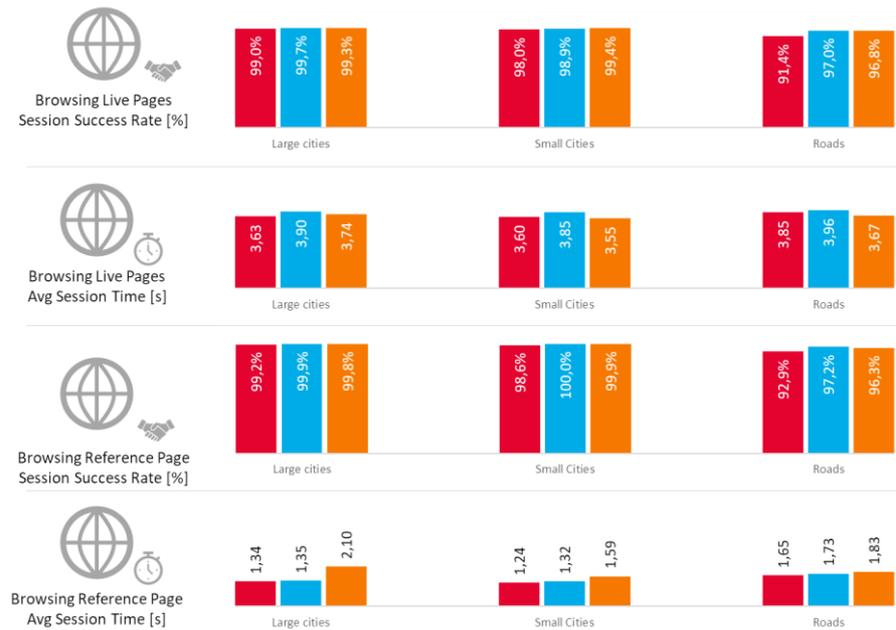


Chart 9. KPIs results for HTTP Browsing tests

Large Cities

Success rates for both live and reference Kepler web pages were on a very good level for all three operators, with the reference Kepler page having slightly better results, mainly due to the smaller page size. All three operators had a very high 4G utilization resulting in low session times. Telekom Srbija, despite having the lowest success rate, had the best average sessions times for browsing. Vip mobile was far behind the competition in the reference Kepler page session time results, but second in live pages session time results.

Small Cities

In Small Cities, Telekom Srbija was having the low success rates, but the short session times. Vip mobile took the lead in the Live Pages session times.

Roads

Success rates were much lower on the Roads comparing to the cities. Telenor and Telekom Srbija had large 3G usage, while Vip retained its results with over 93% of samples in 4G. Telekom Srbija was far behind the competition in success rates for both Kepler and Live Pages. Telenor had the best success rates.

YouTube test results

YouTube video quality tests were done according to ITU Recommendation J.343.1 which is relevant for the assessment of quality at the user end. The model measures the visual effect of spatial and temporal degradations as a result of video coding, erroneous transmission or video rescaling. The J.341.1 model is no reference method, what allows assessing the quality of any content, even not known. The live streaming content was used to observe and measure quality of the video with real time data transmission to avoid buffering of whole clip and play it out from memory. As a result, model provides an subjective assessment of visual quality on the 1 to 5 mean opinion score scale for video (VMOS) where 5 is the best possible result.

YouTube test results of testing the quality of live stream video transmission are presented in Chart 10.



Chart 10. KPIs results for YouTube video tests

Large Cities

Telenor and Vip mobile had very similar results in success rates and time needed to display the first picture of the YouTube video, Telekom Srbija was close behind with slightly lower results. Telenor had the best rate of playouts without interruptions, with Telekom Srbija being the second and Vip mobile the third. All three operators had a very good average VMOS. Telenor had slightly higher VMOS than competitors due to the higher share of samples in full HD resolution (1080p) and no samples below 480p resolution.

Small Cities

All three operators had very good success rates, with Vip mobile being slightly ahead of the competition. Telenor achieved the shortest time to display the first picture of the YouTube video. The playout rate for Telenor and Vip mobile was very similar and on a good level - over 97.5% of video playouts were without any interruption. Average VMOS was very good for all three operators.

Roads

Telekom Srbija was behind the competition in success rates. An increase in time to display the first picture of the video could be observed for Telekom Srbija and Telenor. Playout rate degraded mostly for Telekom Srbija and Telenor, while Vip mobile retained a good 95.7% level of video playouts without interruption.

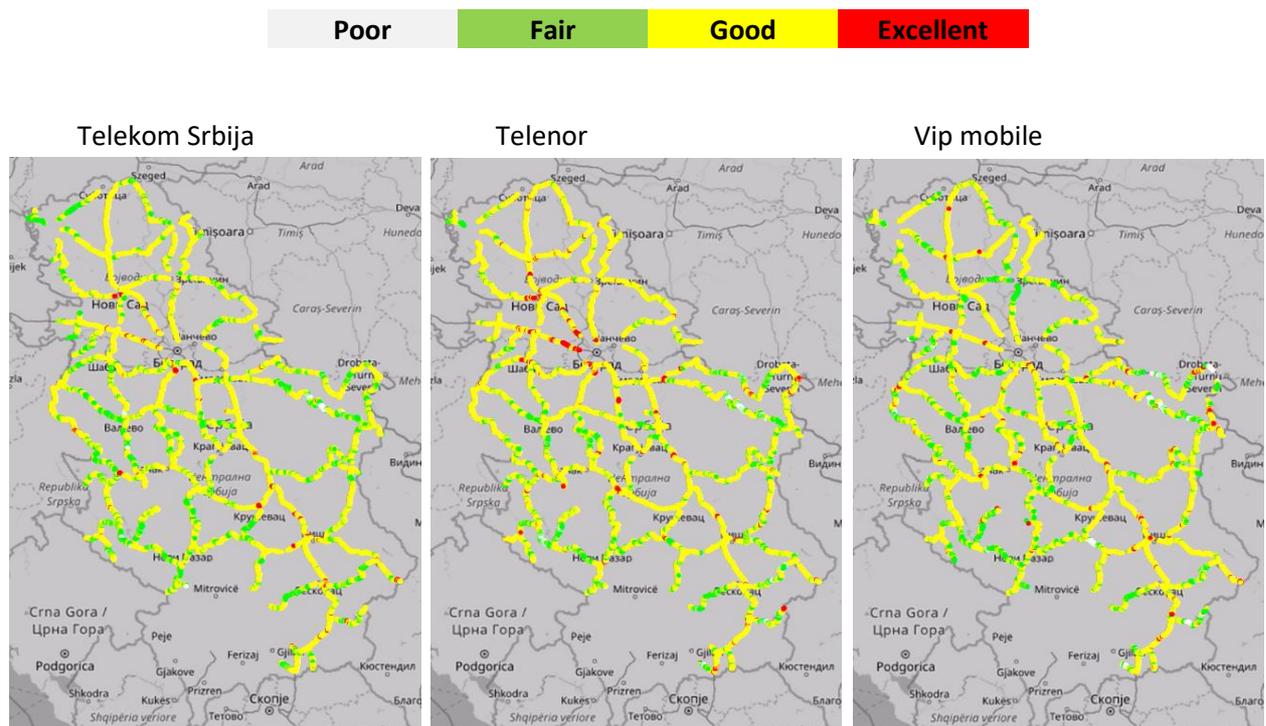
Telekom Srbija and Telenor VMOS degraded compared to the cities results, mainly due to lower 4G usage. Vip mobile was clearly the best with over 94% of video samples in full HD and VMOS result of 3.86.

Radio Coverage

Frequency bands (2G, 3G, 4G) used by operators, during the Mobile Network Benchmarking activity:

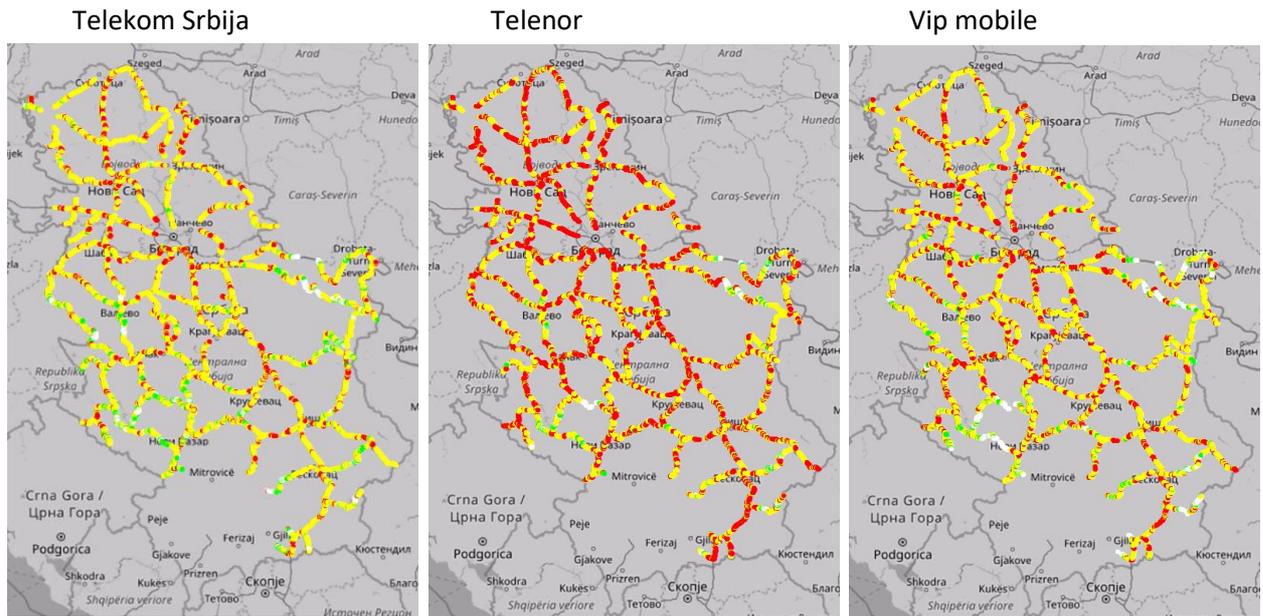
- 2G/GSM: All three operators used 900 MHz band. 1800 MHz band was used by Telenor and Vip mobile.
- 3G/UMTS: All three operators used 2100 MHz band. 900 MHz band was used mainly by Telenor and in a very small extend by Telekom Srbija.
- 4G/LTE: All three operators used 800 MHz and 1800 MHz bands. Telekom Srbija and Vip mobile used both bands evenly in all aggregations, while Telenor was using mainly 800 MHz outside Large Cities. In all aggregations for data tests, Telekom Srbija and Vip mobile were mainly using LTE 20 MHz bandwidth, while Telenor was mainly using LTE 10 MHz bandwidth. Carrier Aggregation (CA) usage depends on the network configuration and amount of data sent during the test. In Large Cities, Telenor had over 20% usage of LTE CA, Vip mobile had over 7% and Telekom Srbija around 4% usage of LTE CA. Usage of LTE CA in Small Cities was much lower than in Large Cities, Telekom Srbija had none, Telenor only around 2%, while Vip mobile had over 6%. There were only few samples on roads where LTE CA usage was detected.

The coverage of operators in different technologies is presented on maps. Colours represents coverage classes:



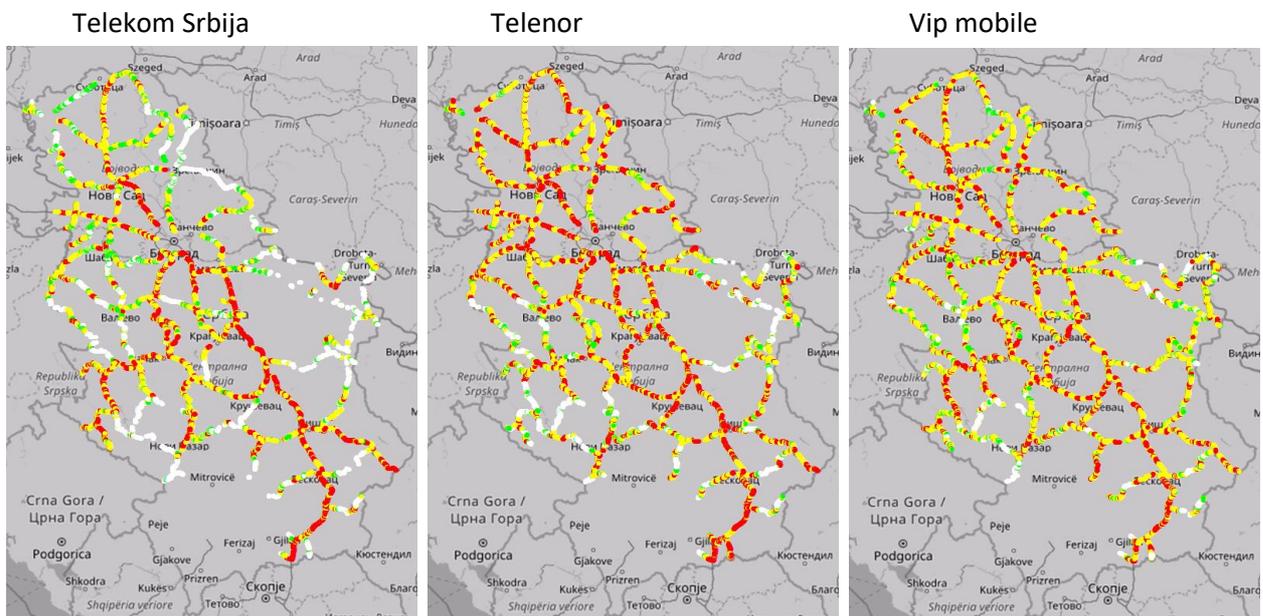
Map 2. Coverage maps for 2G/GSM

The best coverage of 2G network was enabled by Telekom Srbija network due to the highest share of samples with good 2G radio signal levels. Telenor and Vip mobile had some visible areas with very bad 2G coverage and low signal quality, mostly near the eastern border.



Map 3. Coverage maps for 3G/UMTS

The network with best 3G coverage was Telenor due to the highest number of samples with good 3G radio signal levels. This result was caused by the widest UMTS 900 MHz footprint, with well-developed UMTS 900 MHz coverage outside of cities.



Map 4. Coverage maps for 4G/LTE

The 4G coverage showed different strategies operators adopted to deploy LTE coverage. Telenor offered widest LTE 800 MHz deployment outside of cities. Vip mobile showed slightly lower level of deployment for LTE 800 MHz band, while it was more advanced in deploying LTE 1800 MHz band. Telekom Srbija focused on deploying LTE 800 MHz coverage across main transfer roads.

When summarizing results for all bands, Vip mobile showed the smallest share of samples with poor 4G signal level, while Telenor had the highest share of samples with good 4G signal level. Telekom Srbija stayed behind competitors in both categories.

About Systemics Group

The Systemics Group is a leading provider of independent Quality of Experience benchmarking services for mobile operators and regulators. We have conducted national benchmarking campaigns of mobile networks in more than 20 countries.

The benchmarking tests that we perform are carried out using a fleet of 50+ Diversity Benchmarking II Rohde & Schwarz measurement systems with over 30 vehicles and Systemics has recently become the first certified partner of Rohde & Schwarz in the mobile testing domain.

The Systemics Group comprises of Systemics-PAB, Nexus Telecom, Commsquare and NetQPro allowing us to offer a unique set of monitoring and testing tools for both mobile and fixed networks. We operate globally with offices and subsidiaries in Poland, Germany, Austria, Belgium, Greece, Ireland, United Kingdom, Canada, Russia, Jordan and Malaysia.

Our mission is to assist customers understand and address the variety of issues affecting quality in mobile and fixed telecommunication networks. Expert know-how developed over many years, combined with large scale operations and efficient cloud based data post-processing, allows us unparalleled flexibility in conducting high quality large benchmarking projects in multiple countries world-wide.