

R E P O R T C I T I E S

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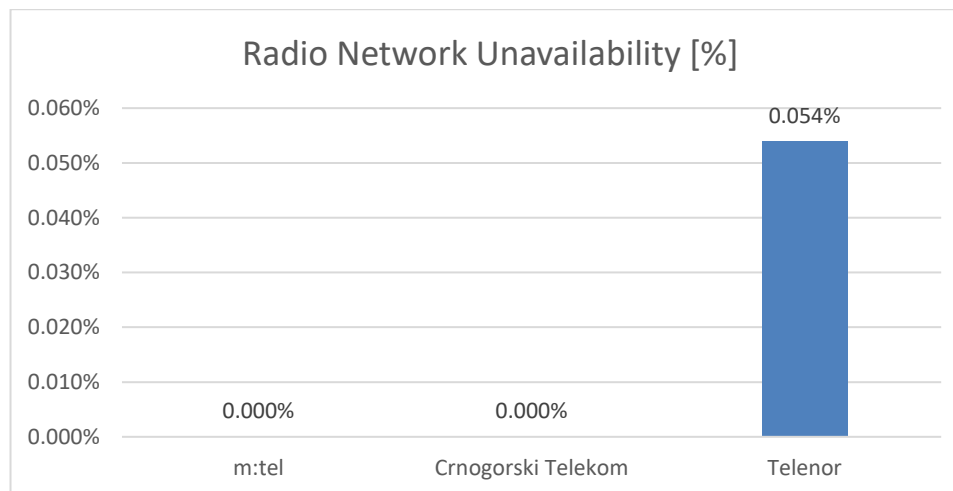
TELEPHONY SERVICE

For Telephony Service 4 parameters have been measured: Radio Network Unavailability, Telephony Service Non-Accessibility, Telephony Setup Time and Telephony Cut-off Call.

Radio Network Unavailability [%] – probability that the end user has not been provided with mobile services.

$$\text{Radio Network Unavailability [\%]} = \frac{\text{number of failed attempts in providing services, i.e. attempts to access mobile network}}{\text{total number of attempts}} * 100$$

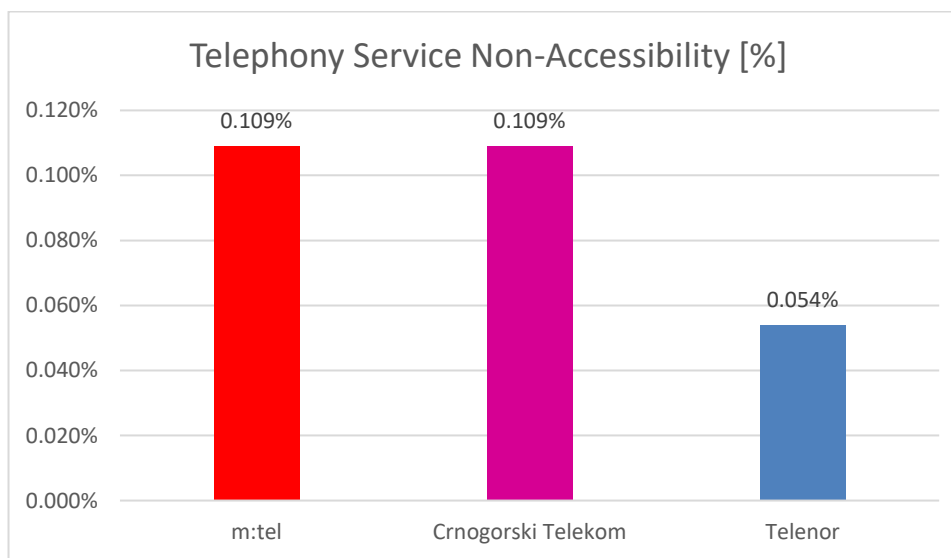
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1837	1833	1835
Unsuccessful	0	0	1
Total of samples	1837	1833	1836
Failure rate [%]	0	0	0,054
Interval of reliability of results [%] with confidence level of 99 %	0 – 0,29	0 – 0,29	0 – 0,4



Telephony Service Non-Accessibility [%] – probability that the end user cannot setup a call, although there is an indication on the mobile device that telephony service is accessible.

$$\text{Telephony Service Non-Accessibility [\%]} = \frac{\text{number of failed attempts to setup a call}}{\text{total number of attempts}} * 100$$

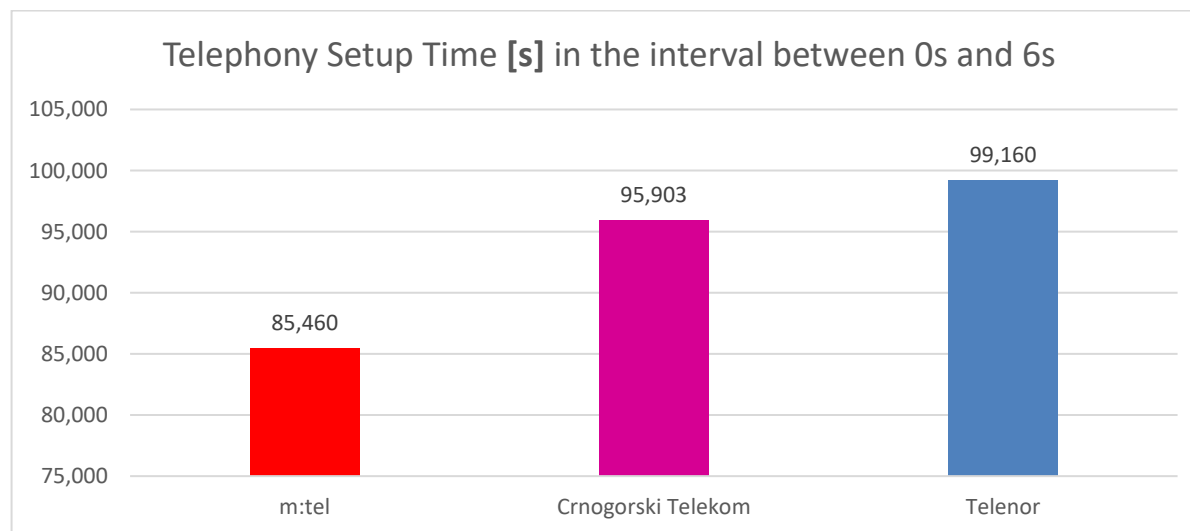
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1821	1827	1831
Unsuccessful	2	2	1
Total of samples	1823	1829	1832
Failure rate [%]	0,109	0,109	0,054
Interval of reliability of results [%] with confidence level of 99 %	0,04 – 0,51	0,04 – 0,51	0 - 0,4



Telephony Setup Time [s] – time after the request to setup a call has been sent and the signal for setting up the call is received.

$$\text{Telephony Setup Time [s]} = (\text{time for setting up a call} - \text{time for sending request to setup a call}) \text{ [s]}$$

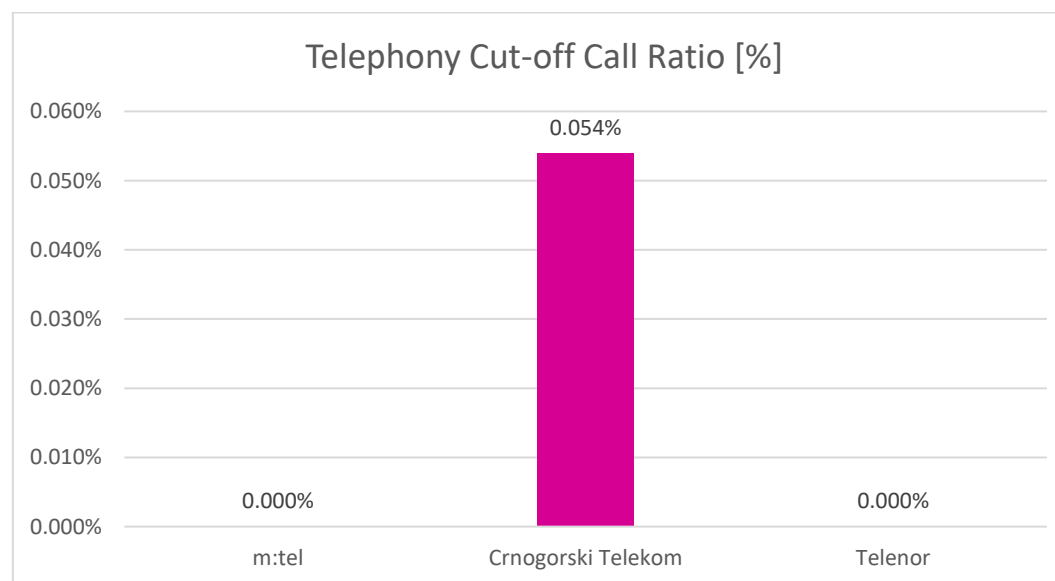
Operator	m:tel	Crnogorski Telekom	Telenor
Telephony Setup Time in the interval between 0s and 6s	1393	1709	1772
Telephony Setup Time longer than 6s	237	73	15
Total of samples	1630	1782	1787
Rate of the calls setup in the interval between 0s and 6s [%]	85,460	95,903	99,160
Interval of reliability of results [%] with confidence level of 99 %	83,08 – 87,63	94,54 – 97,02	98,43 – 99,61



Telephony Cut-off Call [%] – probability that a successful attempt in setting up a call is cut-off, when the cut-off has not been initiated neither by the user who made a call and/nor by the user who received a call.

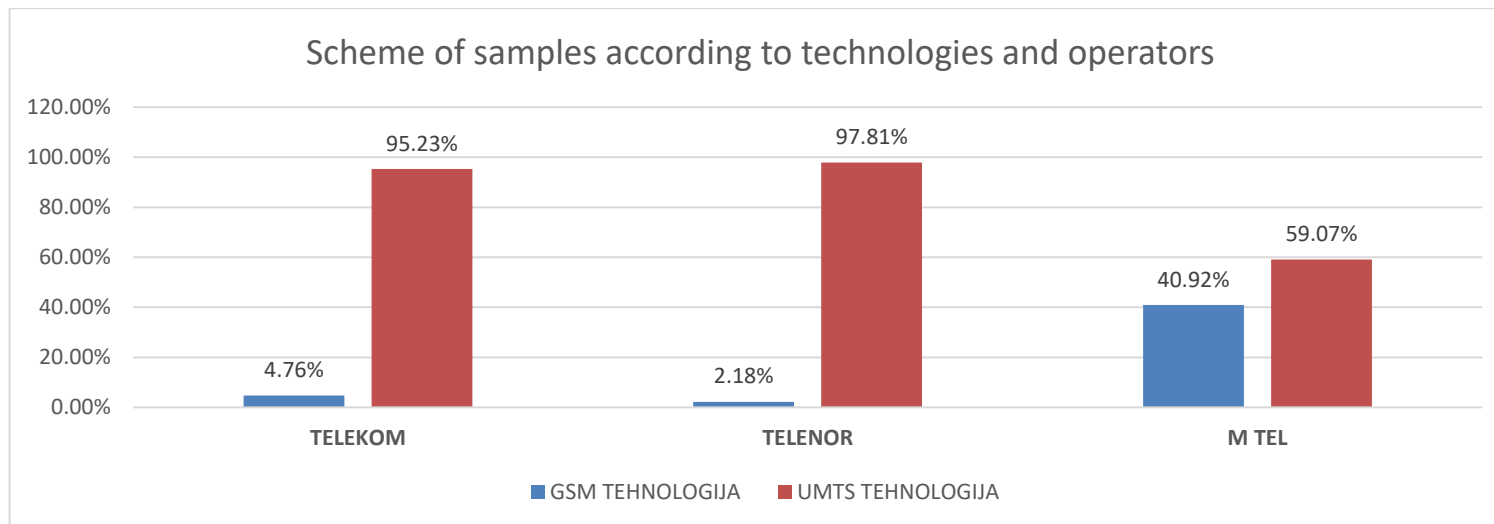
$$\text{Telephony Cut-off Call Ratio [\%]} = \frac{\text{number of calls cut-off unintentionally}}{\text{number of calls setup successfully}} * 100$$

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1820	1821	1828
Unsuccessful	0	1	0
Total of samples	1820	1822	1828
Failure rate [%]	0	0,054	0
Interval of results reliability [%] with confidence level of 99 %	0 – 0,29	0 – 0,41	0 – 0,29



Figures showing technologies deployed in telephony service

OPERATOR	GSM TECHNOLOGY (%)	UMTS TECHNOLOGY (%)
Crnogorski Telekom	4,76	95,23
Telenor	2,18	97,81
m:tel	40,92	59,07



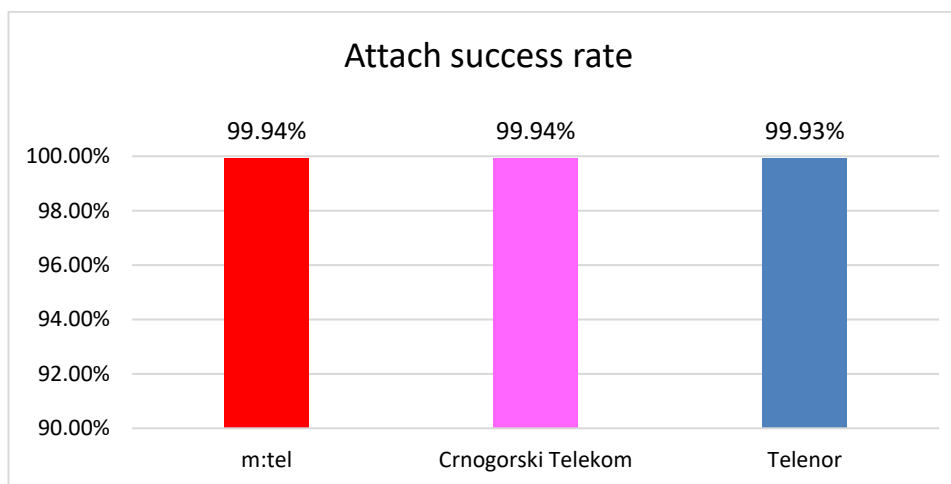
DATA SERVICE

For data service 12 parameters have been measured: Attach Success Ratio, PDP Context Activation Success Ratio, PDP Context Cut-off Ratio, EPS bearer allocation success ratio, FTP IP-Service Access Success Ratio, FTP {Download|Upload} Data Transfer Cut-off Ratio, HTTP browsing IP-Service Access Success Ratio, HTTP browsing Data Transfer Cut-off Ratio, FTP data rate download, FTP mean data rate download per session, FTP data rate upload, FTP mean data rate upload per session.

Attach Success Ratio [%] – probability that the user can be attached to the PS Network.

$$\text{Attach Success Ratio [\%]} = \frac{\text{number of successful attaches to the PS Network}}{\text{total number of attempts to attach to the PS Network}} * 100$$

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1552	1538	1527
Unsuccessful	1	1	1
Total of samples	1553	1539	1528
Success rate [%]	99,94	99,94	99,93
Interval of reliability of results [%] with confidence level of 99 %	99,64-100	99,64-100	99,64-100



PDP Context Activation Success [%] – probability that the PDP (packet data protocol) context can be activated successfully. It refers to GSM and UMTS technologies.

$$\text{PDP Context Activation Success Ratio [\%]} = \frac{\text{number of successful activations of PDP context}}{\text{number of attempts to activate PDP context}} * 100$$

Due to a small number of samples available for this parameter, making statistics has no meaning. Number of samples is small, as all the operators in the cities mostly use LTE technology. In the Table below is given the number of samples used for this parameter.

Operator	m:tel	Crnogorski Telekom	Telenor
Number of samples	53	3	18

PDP Context Cut-off [%] – probability that the PDP context is deactivated while the user hasn't started the procedure of deactivation. It refers to GSM and UMTS technologies.

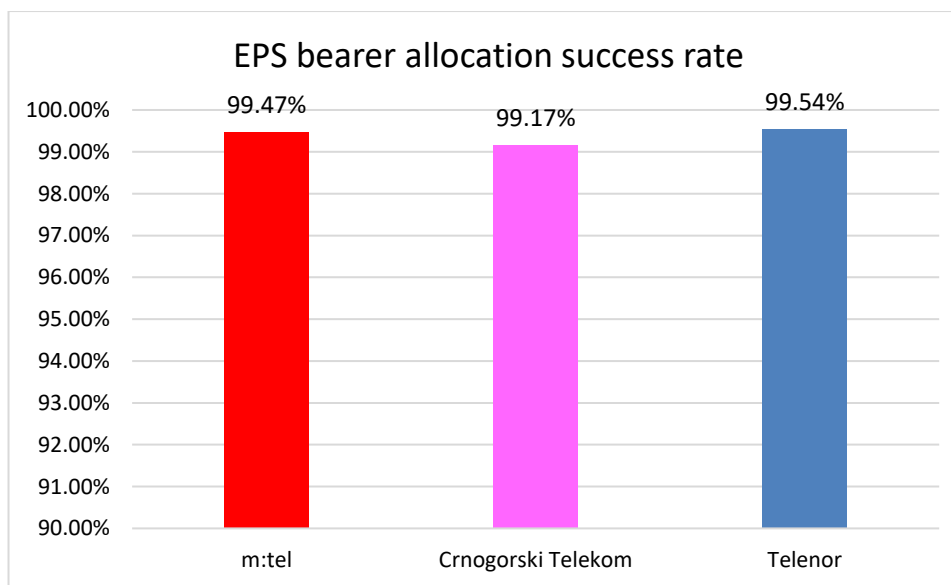
$$\text{PDP Context Cut-off Ratio [\%]} = \frac{\text{number of PDP cut-offs}}{\text{number of PDP contexts successfully setup}} * 100$$

Due to a small number of samples available for this parameter, making statistics has no meaning. Number of samples is small, as all the operators in the cities mostly use LTE technology.

EPS bearer allocation success [%] – success in establishing default and dedicated EPS bearers. This parameter refers only to LTE technology.

$$\text{EPS bearer allocation success rate [\%]} = \frac{\text{number of successfully allocated EPS bearers}}{\text{number of attempts in allocation of EPS bearers}} * 100$$

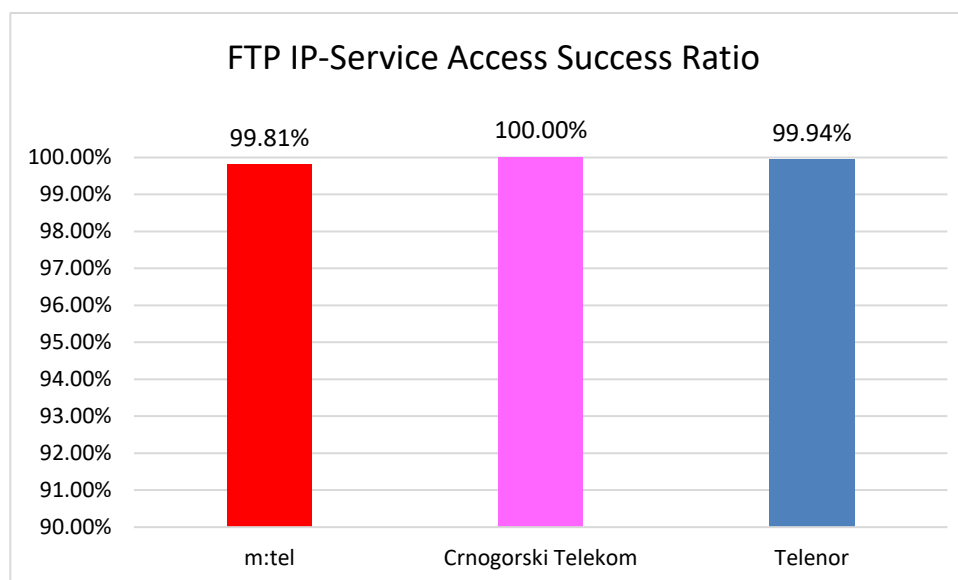
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1506	1548	1522
Unsuccessful	8	12	8
Total of samples	1514	1560	1530
Success rate [%]	99,47	99,17	99,54
Interval of reliability of results [%] with confidence level of 95 %	98,96-99,77	98,58-99,56	99,06-99,82



FTP IP-Service Access Success, Method B (Server connection setup success rate) [%] – probability that the user has successfully setup TCP/IP session with the server. It is measured jointly for upload and download.

$$\text{FTP IP-Service Access Success Ratio [\%]} = \frac{\text{number of sessions successfully setup}}{\text{number of attempts in setting up sessions}} * 100$$

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	3092	3130	3079
Unsuccessful	6	0	1
Total of samples	3098	3130	3080
Success rate [%]	99,81	100,00	99,94
Interval of reliability of results [%] with confidence level of 95 %	99,58-99,93	99,88-100	99,82-100

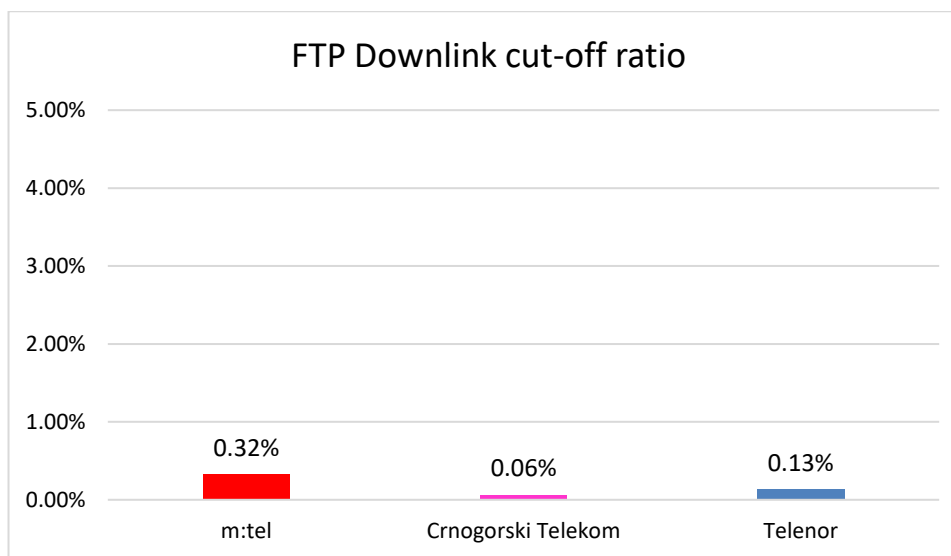


FTP {Download|Upload} Data Transfer Cut-off [%] – probability that downlink/uplink data transfer is cut-off without intention of the user to do so. Measuring the parameter starts with the first request for sending data, after the connection with the server has been established. Measuring the parameter is completed upon receiving the last data packet.

$$\text{FTP \{Download|Upload\} Data Transfer Cut-off Ratio [\%]} = \frac{\text{number of data transfers completed unsuccessfully}}{\text{number of data transfers successfully set-up}} * 100$$

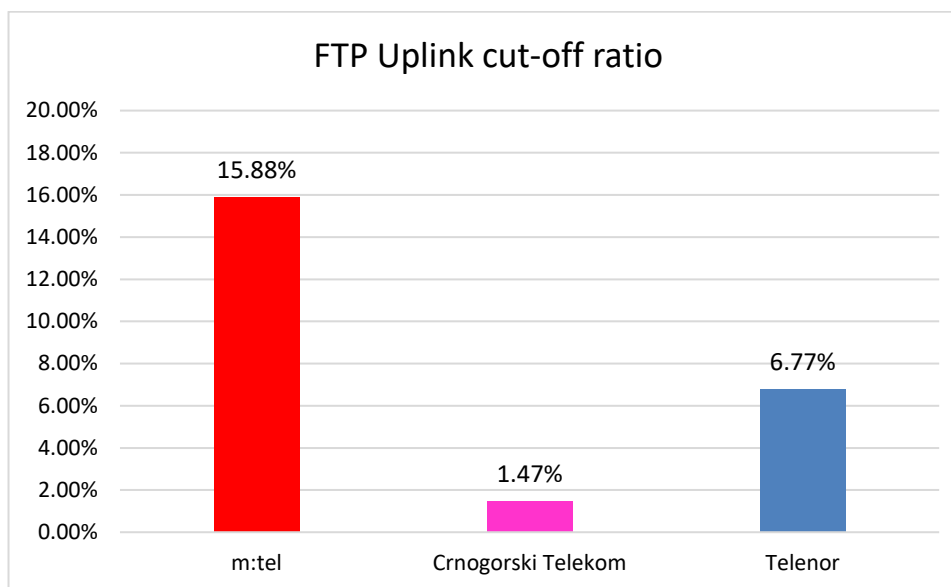
FTP Download:

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1543	1567	1543
Unsuccessful	5	1	2
Failure rate [%]	0,32	0,06	0,13
Interval of reliability of results [%] with confidence level of 95 %	0,1-0,7	0,0-0,36	0,02-0,4



FTP upload:

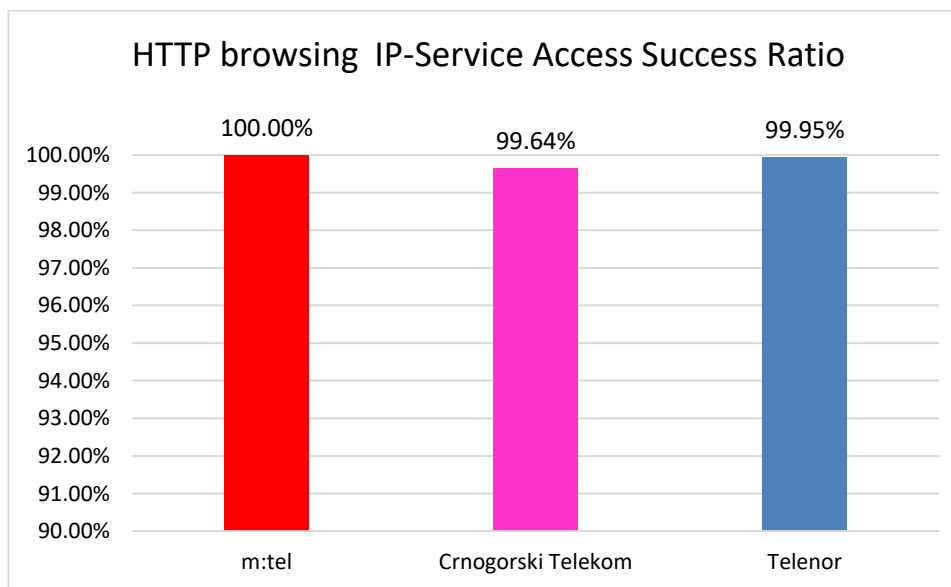
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1549	1563	1536
Unsuccessful	246	23	104
Failure ratio [%]	15,88	1,47	6,77
Interval of reliability of results [%] with confidence level of 95 %	14,09-17,8	0,94-2,20	5,57-8,14



HTTP browsing IP-Service Access Success (Server connection setup success rate) [%] – probability that the user has successfully set up TCP/IP session with the server. It is measured jointly for upload and download.

$$\text{HTTP browsing IP-Service Access Success Ratio [\%]} = \frac{\text{number of sessions successfully setup}}{\text{number of attempts in setting up sessions}} * 100$$

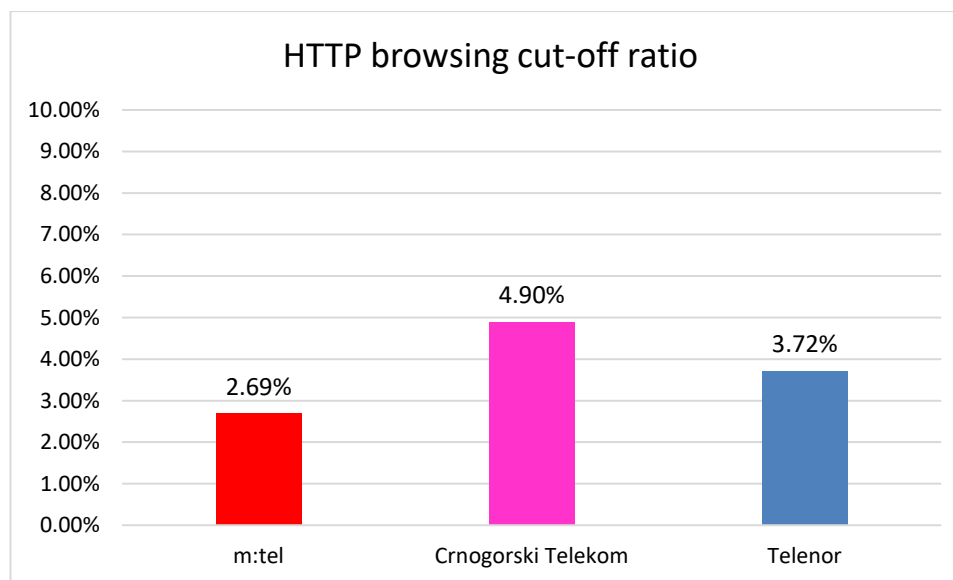
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	2232	2226	2207
Unsuccessful	0	8	1
Total of samples	2232	2234	2208
Success rate [%]	100,00	99,64	99,95
Interval of reliability of results [%] with confidence level of 95 %	99,83-100	99,30-99,85	99,75-100



HTTP browsing Data Transfer Cut-off [%] – probability that data transfer is cut-off without intention of the user to do so. Measuring the parameter starts with the first request for sending data, after the connection with the server has been established. Measuring the parameter is completed upon receiving the last data packet.

$$\text{HTTP browsing Data Transfer Cut-off Ratio [\%]} = \frac{\text{number of data transfer unsuccessfully completed}}{\text{number of data transfer successfully commenced}} * 100$$

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	2232	2226	2207
Unsuccessful	60	109	82
Failure ratio [%]	2,69	4,90	3,72
Interval of reliability of results [%] with confidence level of 95 %	2,06-3,45	4,04-5,88	2,97-4,59



FTP data rate download [Mb/s] – speed of data transfer according to the sample measured within 1 second in the process of file transfer download.

Data given in percentiles*:

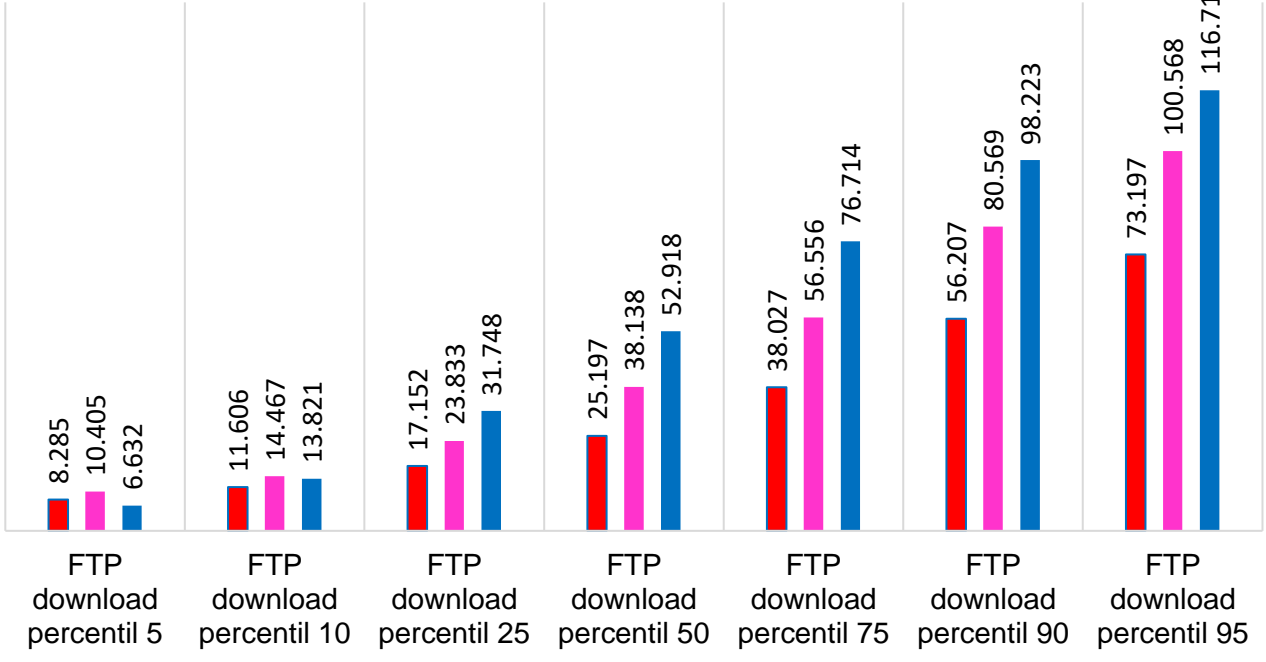
Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	8.285	10.405	6.632
percentile 10	11.606	14.467	13.821
percentie 25	17.152	23.833	31.748
percentie 50	25.197	38.138	52.918
percentile 75	38.027	56.556	76.714
percentile 90	56.207	80.569	98.223
percentile 95	73.197	100.568	116.718
Total of samples	22 820	23 151	22 859

	m:tel	Crnogorski Telekom	Telenor
Mean data rate [Mb/s]	30.803	43.757	55.959

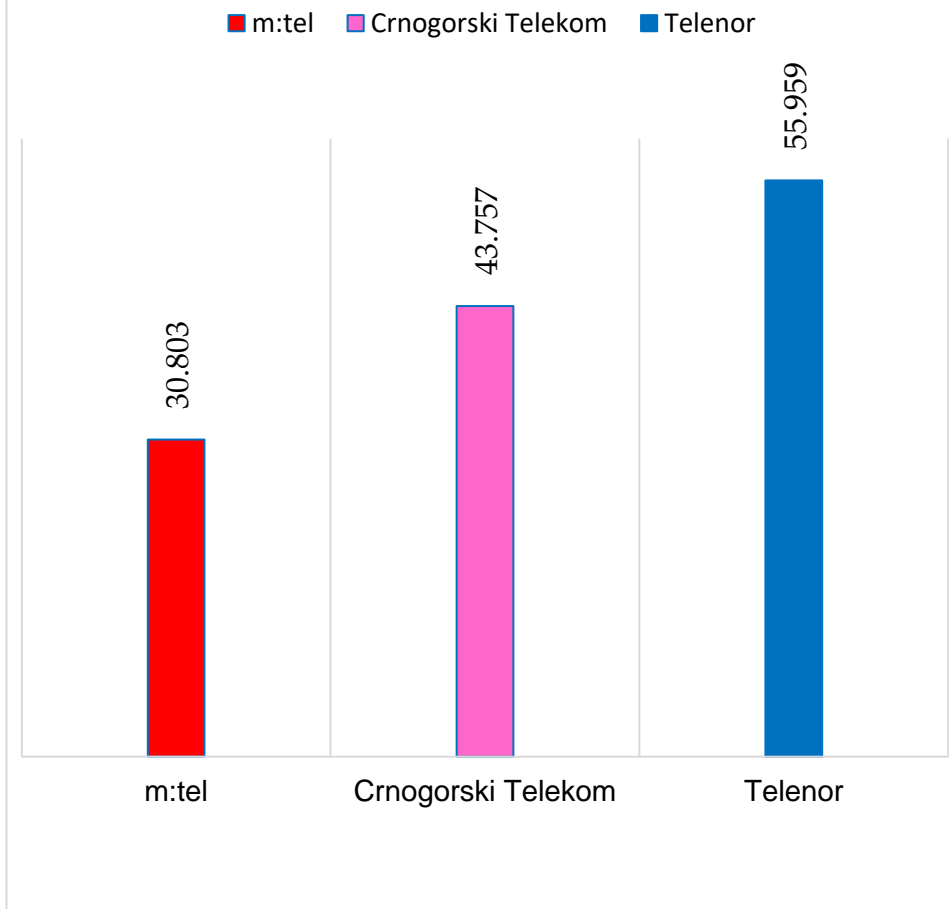
*The term percentile 10 means that 10% of the samples have their values lower than or equal to the speed given in the Table (in Mb/s).

FTP data rate download [Mb/s]

m:tel Crnogorski Telekom Telenor



FTP mean data rate download [Mb/s]



FTP mean data rate download per session [Mb/s] – mean speed of data transfer measured within one session i.e. of the test file download.

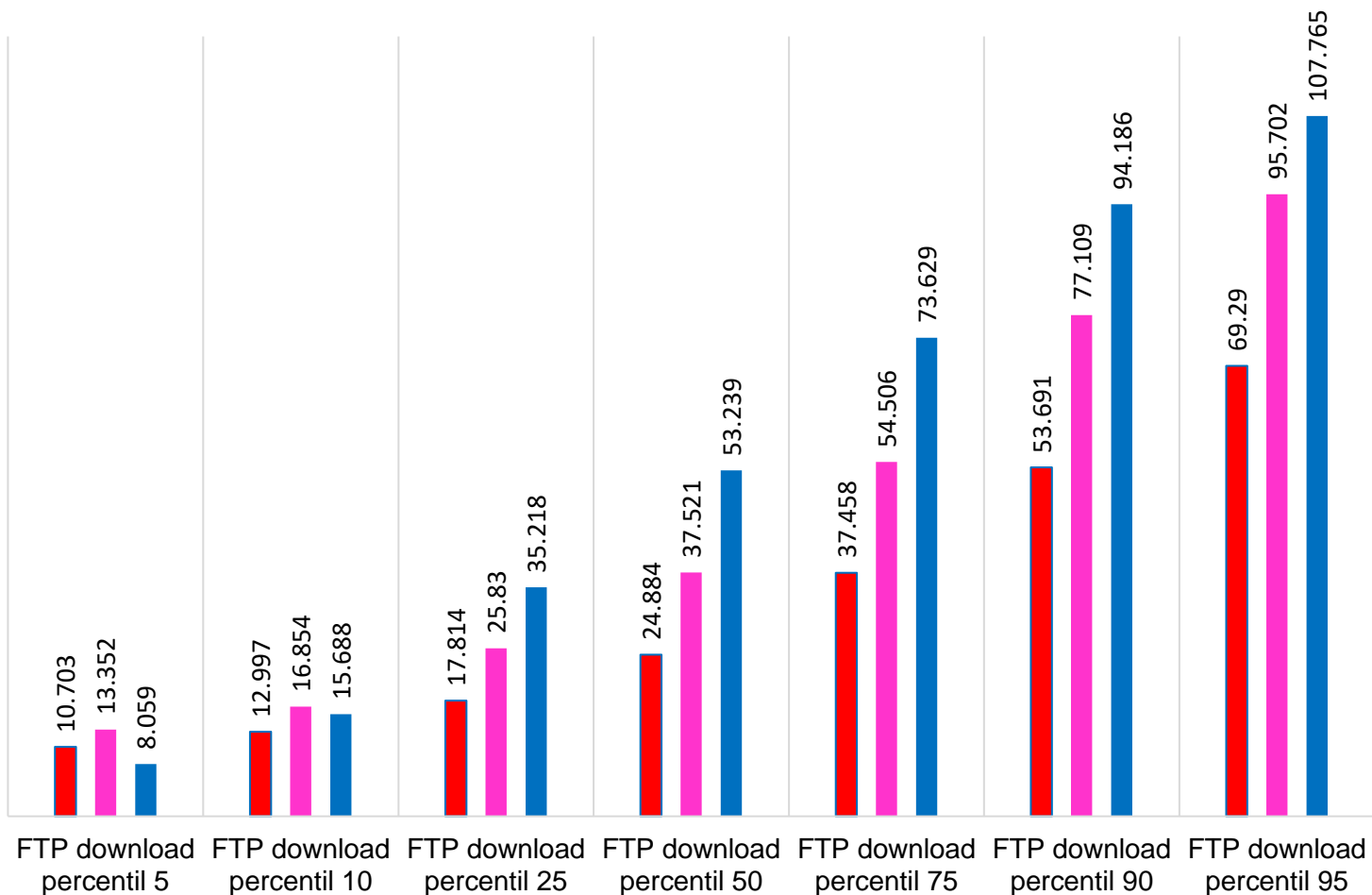
$$\text{FTP mean data rate download [Mb/s]} = \frac{\text{size of downloaded data (of the test file)}}{(\text{time of completion of the file download} - \text{time of commencement of the file download}) [\text{s}]}$$

Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	10.703	13.352	8.059
percentile 10	12.997	16.854	15.688
percentile 25	17.814	25.830	35.218
percentile 50	24.884	37.521	53.239
percentile 75	37.458	54.506	73.629
percentile 90	53.691	77.109	94.186
percentile 95	69.290	95.702	107.765
Total of samples	1544	1567	1544

	m:tel	Crnogorski Telekom	Telenor
Mean data rate per session[Mb/s]	30.44979563	43.30211836	55.2080659

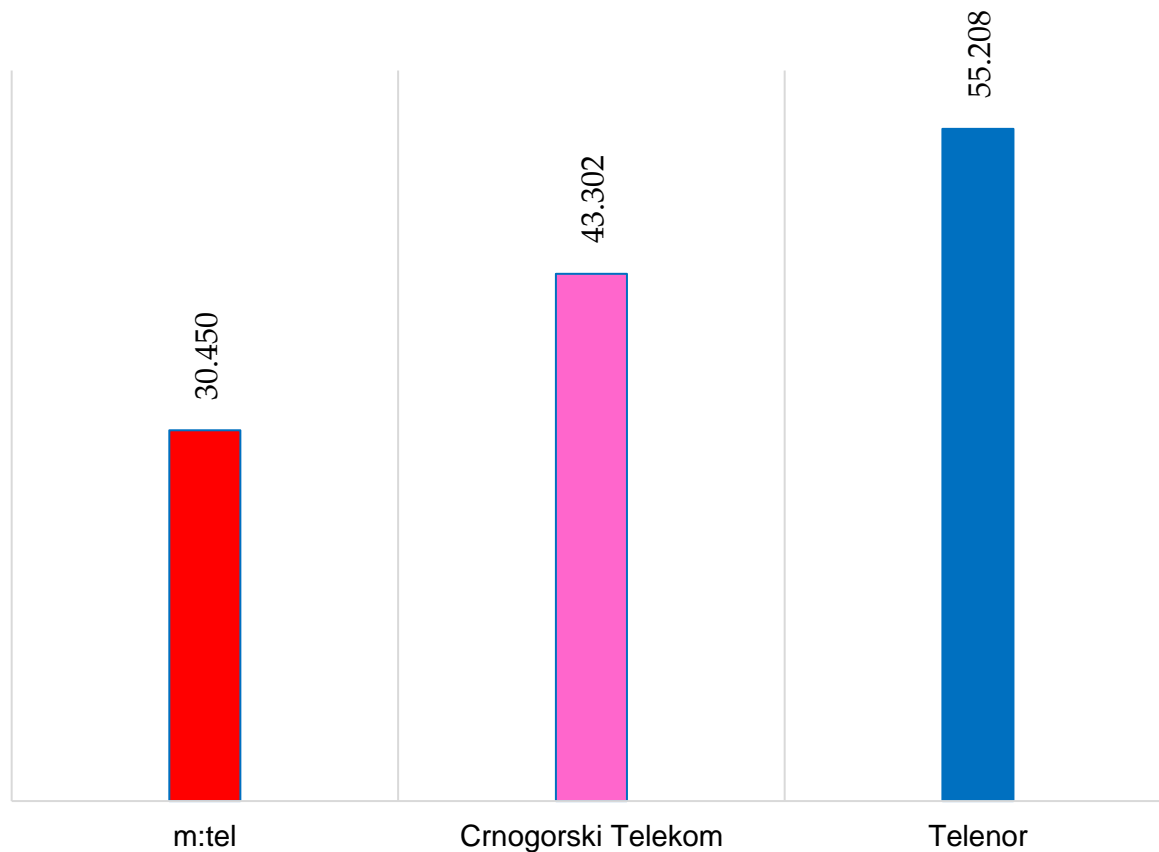
FTP data rate download per session [Mb/s]

m:tel Crnogorski Telekom Telenor



FTP mean data rate download per session [Mb/s]

■ m:tel ■ Crnogorski Telekom ■ Telenor



FTP data rate upload [Mb/s] – Speed of data transfer according to the sample measured within 1 second in the process of the file transfer upload.

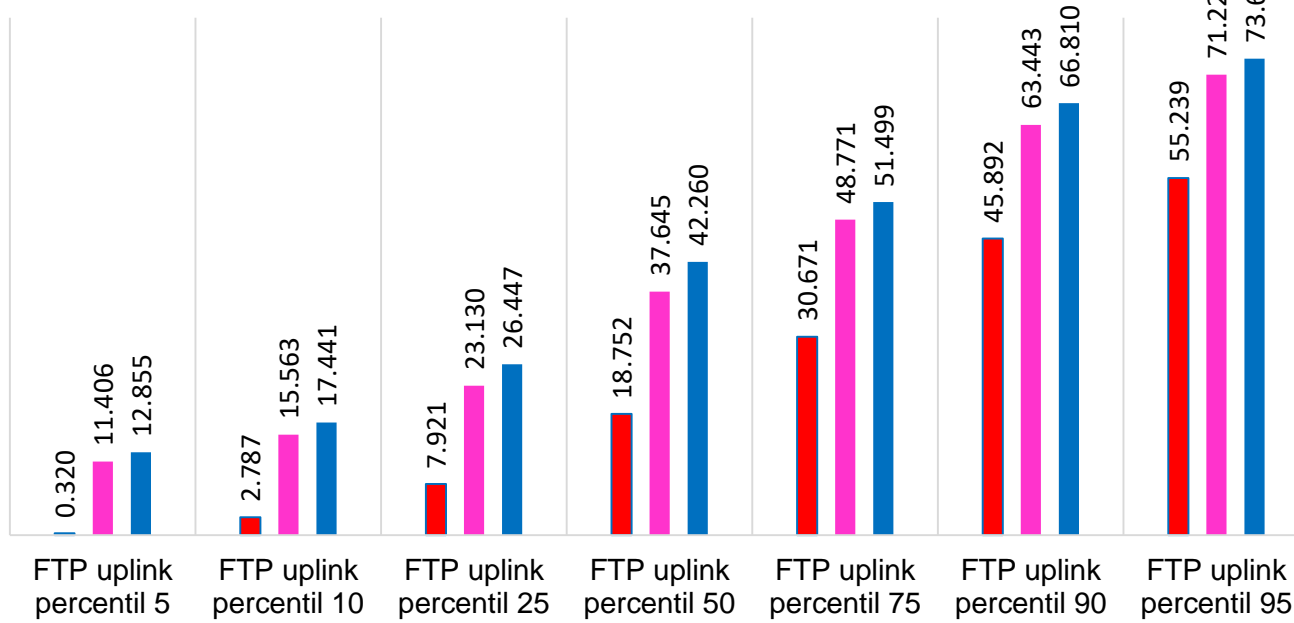
- Data given in percentiles:

Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	0.320	11.406	12.855
percentile 10	2.787	15.563	17.441
percentile 25	7.921	23.130	26.447
percentile 50	18.752	37.645	42.260
percentile 75	30.671	48.771	51.499
percentile 90	45.892	63.443	66.810
percentile 95	55.239	71.224	73.663
Total of samples	9987	17437	17512

	m:tel	Crnogorski Telekom	Telenor
Mean data rate upload [Mb/s]	21.502	37.977	41.548

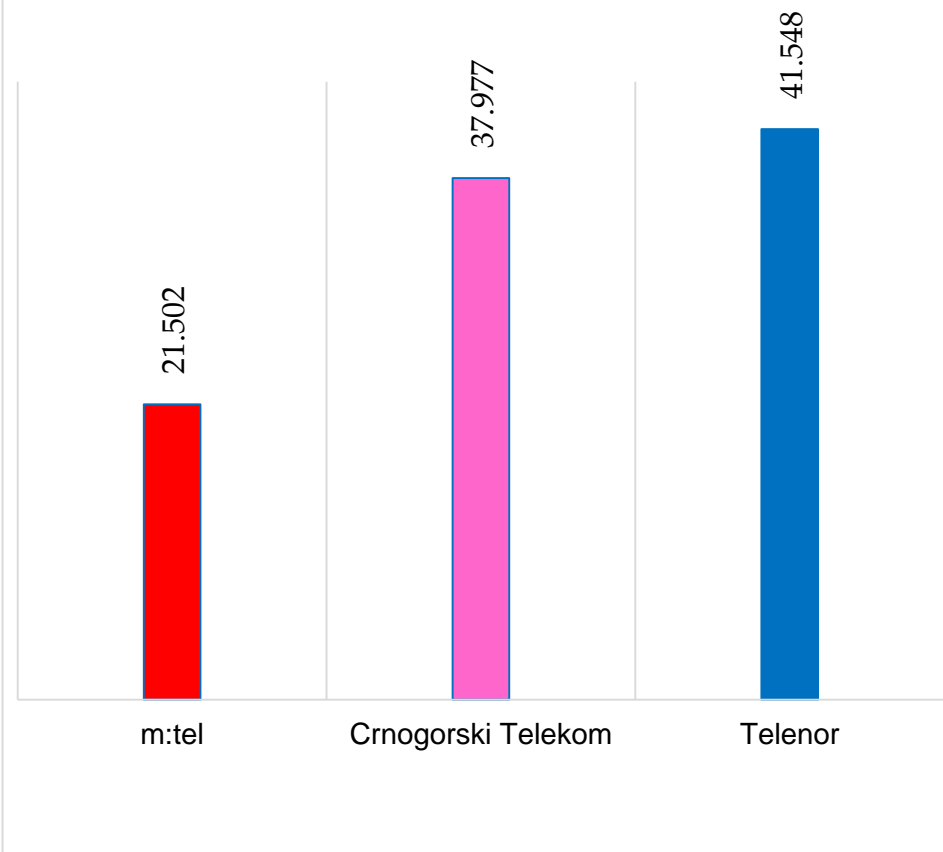
FTP data rate upload [Mb/s]

■ m:tel ■ Crnogorski Telekom ■ Telenor



FTP mean data rate upload [Mb/s]

■ m:tel ■ Crnogorski Telekom ■ Telenor



FTP mean data rate upload per session [Mb/s] – mean speed of data transfer measured within one session i.e. of the test file upload.

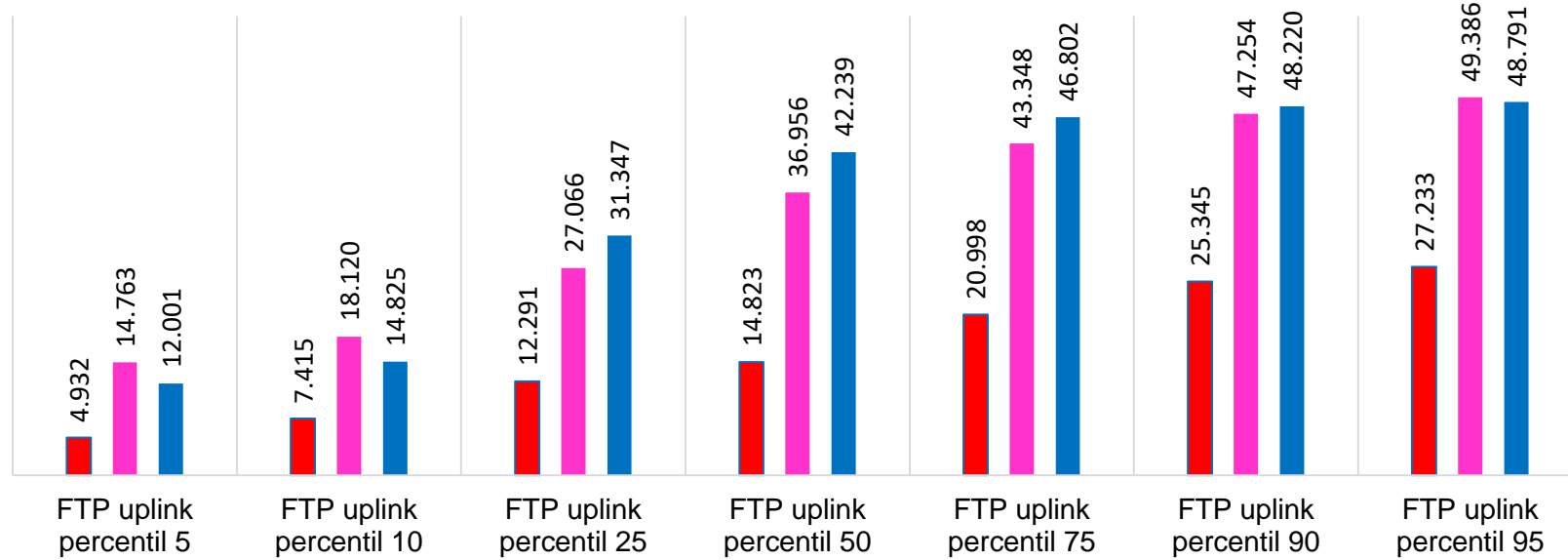
$$\text{FTP mean data rate upload [Mb/s]} = \frac{\text{size of uploaded data (of test file)}}{(\text{completion time of the file upload} - \text{time of commencement of the file upload}) [\text{s}]}$$

Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	4.932	14.763	12.001
percentile 10	7.415	18.120	14.825
percentile 25	12.291	27.066	31.347
percentile 50	14.823	36.956	42.239
percentile 75	20.998	43.348	46.802
percentile 90	25.345	47.254	48.220
percentile 95	27.233	49.386	48.791
Total of samples	1562	1560	1534

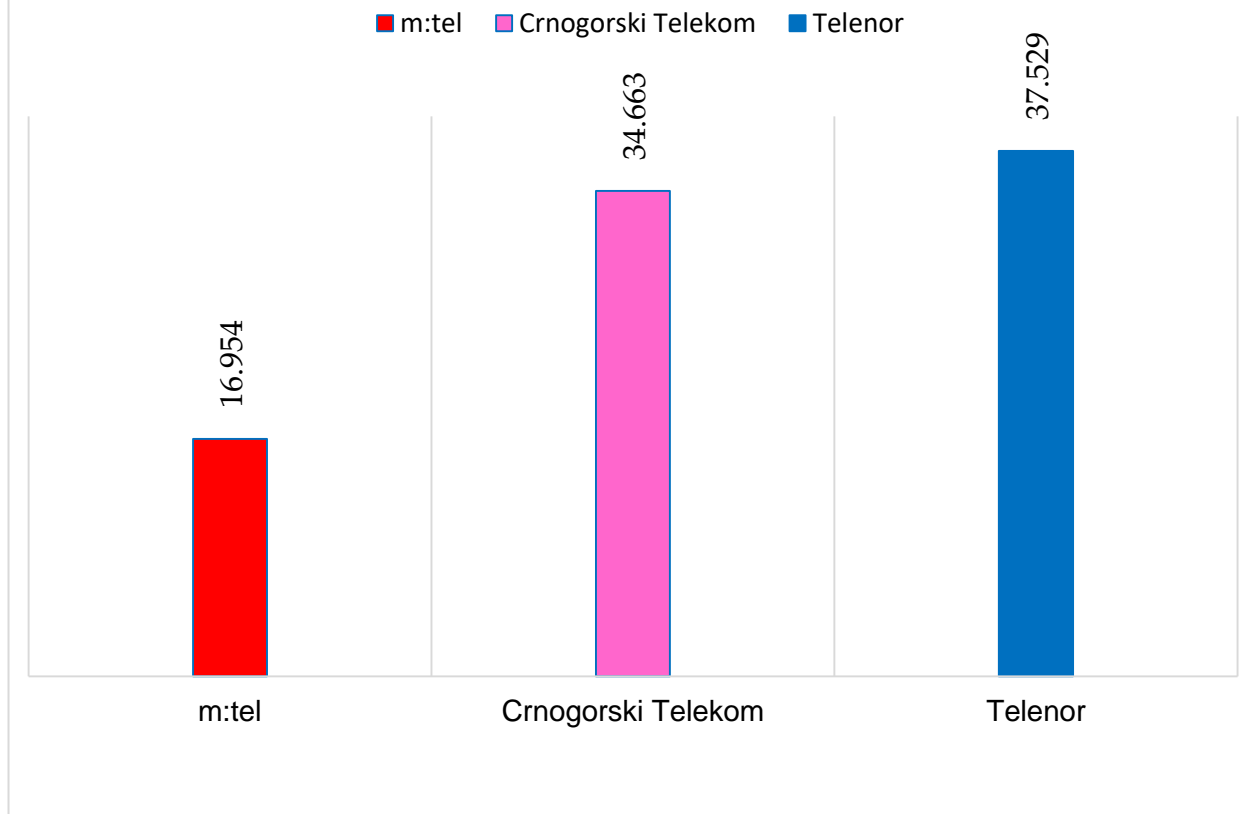
	m:tel	Crnogorski Telekom	Telenor
Mean data rate upload per session [Mb/s]	16.954	34.663	37.529

FTP data rate upload per session [Mb/s]

■ m:tel ■ Crnogorski Telekom ■ Telenor



Mean data rate upload per session [Mb/s]



Figures showing technologies deployed for data transfer.

Deployment of technologies	m:tel	Crnogorski Telekom	Telenor
2G (%)	0.00	0.00	0.00
3G (%)	3.20	0.22	0.71
4G (%)	96.80	99.77	99.30

