Quality of Service – Case Studies

Pakistan

Source: http://www.pta.gov.pk/bb_qos_regs_2014.pdf

QoS Key Performance Indicators of Fixed Services

- Network Availability
- Link Speed
- Service Availability
- Bandwidth (D/L & U/L)
- Retainability
- Round Trip Time
- Customer Service Complaints
- Billing Complaints
- Service Provisioning Complaints

Network Availability

- **Availability of Network as claimed or advertised**
  - A binary Check
    - To verify operators coverage claim
- **Methodology**
  - Coverage Map to be obtained from BSP
  - Select different Areas for checking BSP availability

Advertised Network Available Area City Wise (ANAC)								
BSP-A								
	ANAC1		ANAC2		ANAC3		……	
	B	R	B	R	B	R	B	R
Network Availability	Y/N							
B = Business	R = Residential		BSP = Broadband Service Provider					
Y = Yes	N = No							

Service Availability

- **Success in accessing the Internet**
  - Availability = (1 – F/N) X 100 N = Attempts made , F = Attempts failed
    - Failure - if we are not able to connect to Internet within 75 seconds for wireline communications and 120 seconds for Wireless communications
- **Methodology**
  - N attempts in each T(1,2,3) to access Internet

BSP Name		T1		T2		T3		Service Availability (1-F/N) * 100
		Attempt	Connectivity (Y/N)	Attempt	Connectivity (Y/N)	Attempt	Connectivity (Y/N)	
	Day 1	1st						
		2nd						
		……						
		Nth						
	Day 2							
	Service Availability							

Service Availability				
Grade A	Grade B	Grade C	Grade D	Grade E
95% or above	> 80% & < 95 %	>70 % & < 80 %	>50 % & < 70 %	< 50 %

Retainability

- **To verify**
  - Service retainability for 60 minutes

- **Testing Methodology**
  - Note the time elapsed between start of test and first disconnection

BSP Name		T1	T2	T3	Retainability (min)
	Day 1				
	Day 2				
	Average				

Retainability				
Grade A	Grade B	Grade C	Grade D	Grade E
60 min (No DC)	45 min	30 – 45 min	15- 30 min	5-15 min

Download Speed

- **Measurement of actual D-L speed in terms of Kbps from the advertised speed**
  - 60% Pass for D-L
  - Data D-L speed = 10 MB / Time (sec)
- **Methodology**
  - Download a 5 MB file from web based email
  - Test to be repeated in T1, T2 & T3 & Calculate the actual speed
  - **Data download speed =Size of the test file (data) (in MB) / Transmission Time (in seconds)**

BSP Name		T1		T2		T3		Average Download Speed (kbps)
		Transmission Time	Download Speed	Transmission Time	Download Speed	Transmission Time	Download Speed	
	Day 1							
	Day 2							
Average								

Download Speed				
Grade A	Grade B	Grade C	Grade D	Grade E
> 75 %	> 60% & < 75 %	>45 % & < 60 %	>30 % & < 45 %	< 30 %

Upload Speed

- **Measurement of actual U-L speed in terms of Kbps from the advertised speed**
  - 60% Pass for U-L
  - Data U-L speed = 5 MB / Time (sec)
- **Methodology**
  - Attach a 5 MB file to web based email
  - Test to be repeated in T1, T2 & T3 & Calculate the actual speed
  - **Data upload speed =Size of the test file (data) (in MB) / Transmission Time (in seconds)**

BSP Name		T1		T2		T3		Average Upload Speed (kbps)
		Transmission Time	Upload Speed	Transmission Time	Upload Speed	Transmission Time	Upload Speed	
	Day 1							
	Day 2							
Average								

Upload Speed				
Grade A	Grade B	Grade C	Grade D	Grade E
> 75 %	> 60% & < 75 %	>45 % & < 60 %	>30 % & < 45 %	< 30 %

Contention Ratio (CR)

- **To measure the ratio of subscribers per unit of bandwidth**
- **Lower CR = Higher QoS**
  - CR = Total Bandwidth/Total No. Subscribers

- **Methodology**
  - BSP to provide the Total Bandwidth & Total number of subscribers
  - Calculate CR as per formula given above

Round Trip Time

- **Round Trip Delay is the time taken for the traffic to reach a particular destination and return.**

- **Testing Methodology**
  - Obtain IP address of BSP's BRAS
  - Ping or Trace-route in command/DOS mode
  - Repeat the test for different time slots

BSP Name	T1	T2	T3	Average Round Trip Time (RTT)
Day 1				
Day 2				

Average Round Trip Time (msec)			
Grade A	Grade B	Grade C	Grade D
< 70	Between 70 & 80	Between 80 & 90	Between 90 & 100 or above

Jitter

- **Jitter is the fluctuation/variation of end-to-end delay from one packet to the next packet within the same packet stream/connection/flow.**

- **Testing Methodology**
  - calculated using 'ping' command and the minimum samples shall be 100
  - If RTT_{avg} is the average RTT, derived out of 100 samples, and RTT_1,RTT_2….RTT_{100} are the RTT for individual packets then jitter shall be calculated as:-

    Jitter (ms) = ∑ (RTT_{avg}-RTT_k)/100 (magnitude shall be used)

BSP Name		T1		T2		T3		Average RTT (msec)
	Day 1	RTT_1		RTT_1		RTT_1		
		RTT_2		RTT_2		RTT_2		
		……		……		……		
		RTT_{100}		RTT_{100}		RTT_{100}		
	Day 2	…….		…….		…….		

Jitter			
Grade A	Grade B	Grade C	Grade D
< 15msec	Between 15msec & 20msec	Between 20msec & 25msec	Between 25msec & 30msec

Packet Loss

- **Number of packets (%) which doesn't reach the destination is called Packet Loss.**

- **Testing Methodology**
  - Calculated using 'ping' with 100 as minimum number of packets at one time
  - Packet Loss formula
  - ***Packet Loss = [L/ (L+R)]*100***

    Where, L = Number of Lost Packet, R = Number of packets received

BSP Name		Time	Packet Status in RTT		Packet Loss (%)
			Packets Lost (L)	Packets Received (R)	
	Day 1	T1			
		T2			
	Day 2				

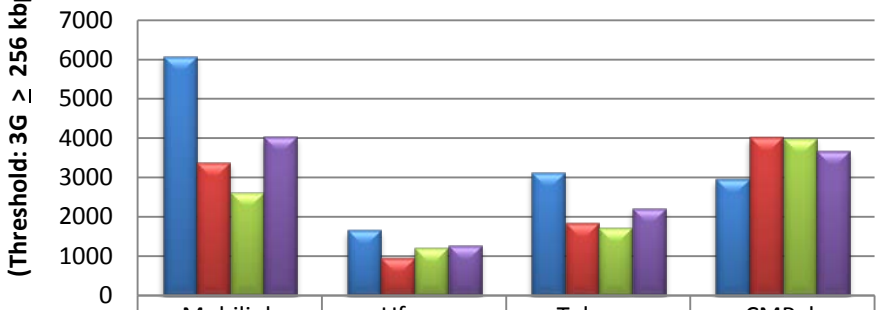
Packet Loss			
Grade A	Grade B	Grade C	Grade D
< 2%	Between 2% & 3%	Between 3% & 4%	Between 4% & 5%

Mobile Broadband QoS Methodology

Indicator		Details
Coverage Map		Obtaining of Coverage Map of 3G / 4G / LTE Network
Voice Call Samples		o Voice Calls in Auto Detect Mode o Both A & B-Party shall be moving o Distribution of Calls - Maximum 300 Calls • On Net Calls - 70% • Off Net Calls - 30%
SMS Samples		o 25 % of Sample Size of Voice Calls o Both A & B-Party shall be moving o Distribution of SMS • On Net Calls - 70% • Off Net Calls - 30%
Data Session	**Coverage Test**	o Mobile Terminals shall be in Network dedicated / locked mode. o Traverse Two different routes while the equipment being kept in idle mode o Record the session to measure network parameter signal strength (RSCP and RSRP etc.)
	Throughput Test	o Mobile Terminals shall be in Network dedicated / locked mode. o Carryout testing at Maximum 30 location, while keeping in view the coverage map • Downloaded a file of 40 MB from http server • ICMP Ping to (http://www.xyz.com.pk) • Downloaded a file of 20 MB from FTP Server

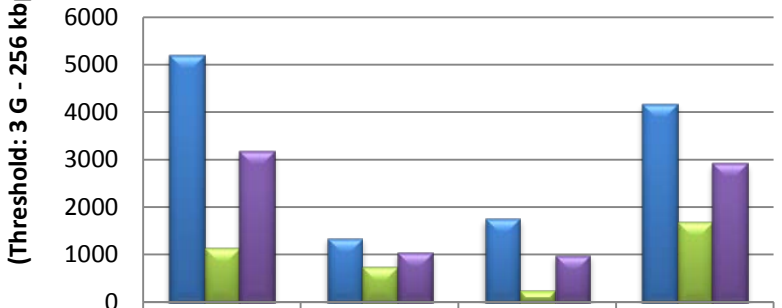
3G Coverage and Data KPIs Results

Data Throughput -HTTP Download



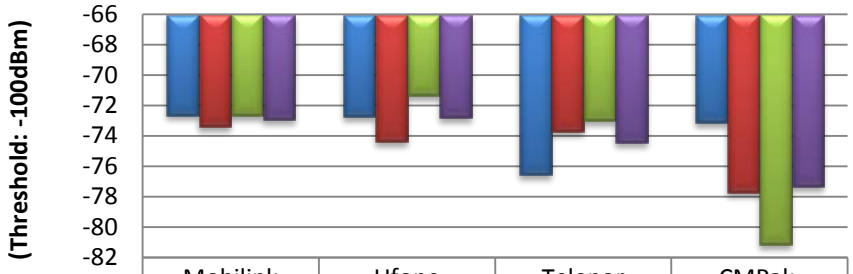
	Mobilink	Ufone	Telenor	CMPak
Lahore	6100.7	1657.5	3127.8	2957
Islamabad	3391.4	961	1842	4019
Peshawar	2641.6	1195.5	1709.8	4017.5
Overall	4044.57	1271.33	2226.53	3664.50

Data Throughput - FTP Download



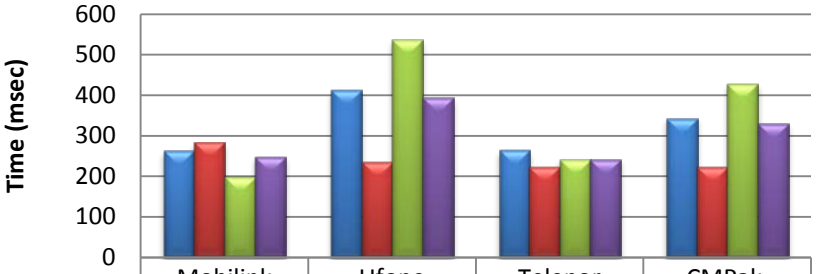
	Mobilink	Ufone	Telenor	CMPak
Lahore	5197.9	1358.7	1758	4174.8
Peshawar	1150.4	746	243.8	1689.7
Overall	3174.15	1052.35	1000.90	2932.25

Signal Strength RSCP (dBm)



	Mobilink	Ufone	Telenor	CMPak
Lahore	-72.617	-72.697	-76.532	-73.117
Islamabad	-73.4	-74.39	-73.7	-77.7
Peshawar	-72.66	-71.35	-73.01	-81.15
Overall	-72.89	-72.81	-74.41	-77.32

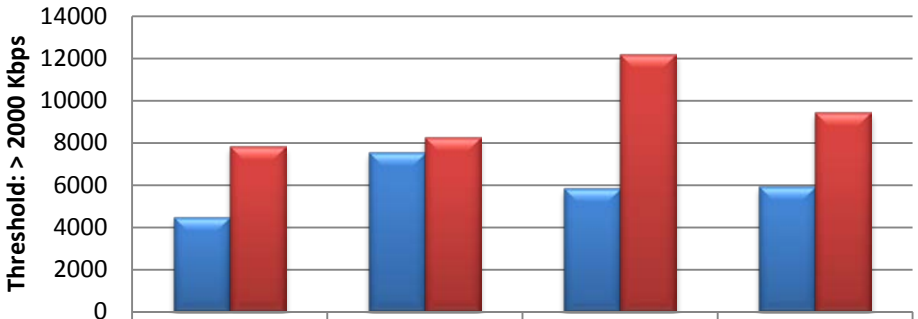
Round Trip Time



	Mobilink	Ufone	Telenor	CMPak
Lahore	265.2	412.4	263.7	344.7
Islamabad	283.7	236	223.6	223.6
Peshawar	197.6	537.5	243.5	428.4
Overall	248.83	395.30	243.60	332.23

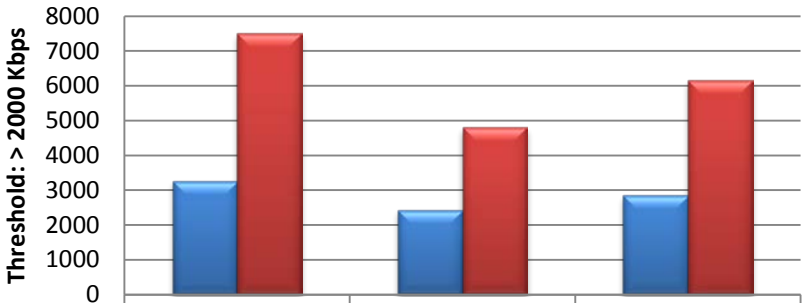
4G Coverage and Data KPIs Results

Data Throughput -HTTP Download



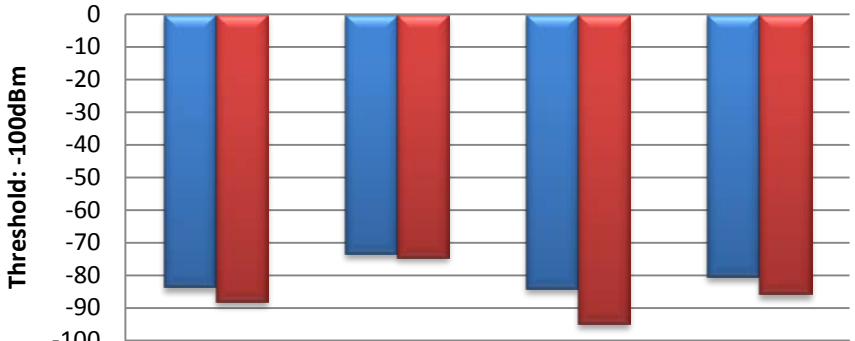
	Lahore	Islamabad	Peshawar	Overall
Warid	4489.5	7544.4	5859.6	5964.50
CMPak	7852.3	8262.4	12200.2	9438.30

Data Throughput - FTP Download



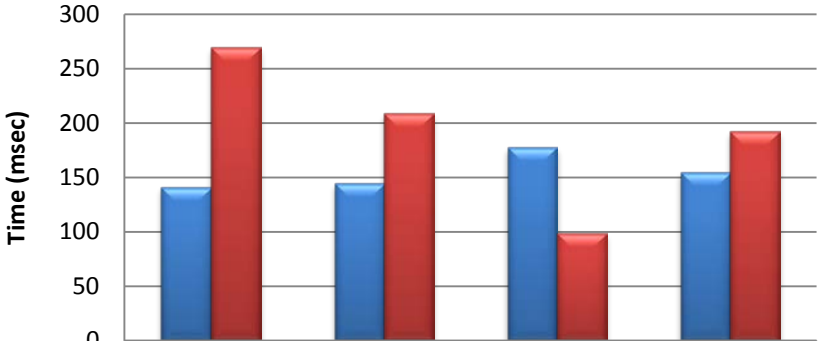
	Lahore	Peshawar	Overall
Warid	3274.7	2440.9	2857.80
CMPak	7505	4813.2	6159.10

Signal Strength RSRP (dBm)



	Lahore	Islamabad	Peshawar	Overall
Warid	-83.52	-73.4	-84.14	-80.35
CMPak	-87.92	-74.39	-94.77	-85.69

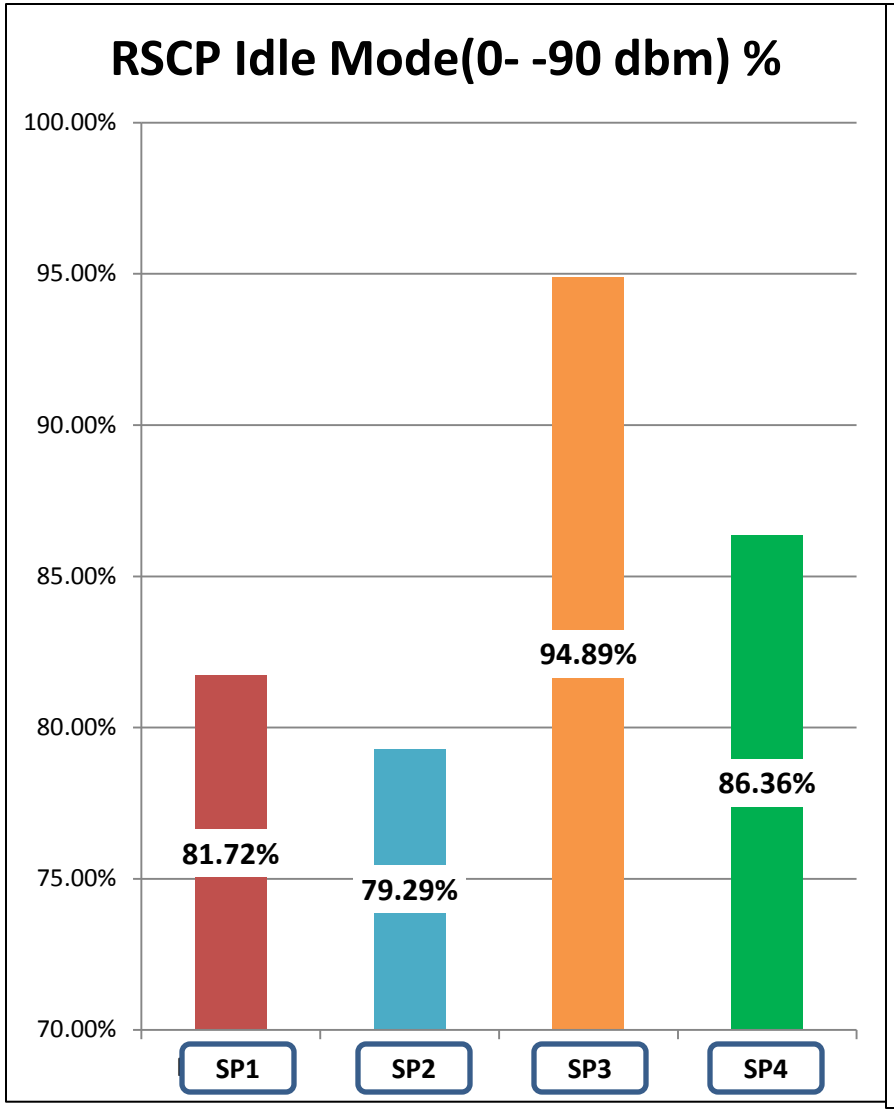
Round Trip Time

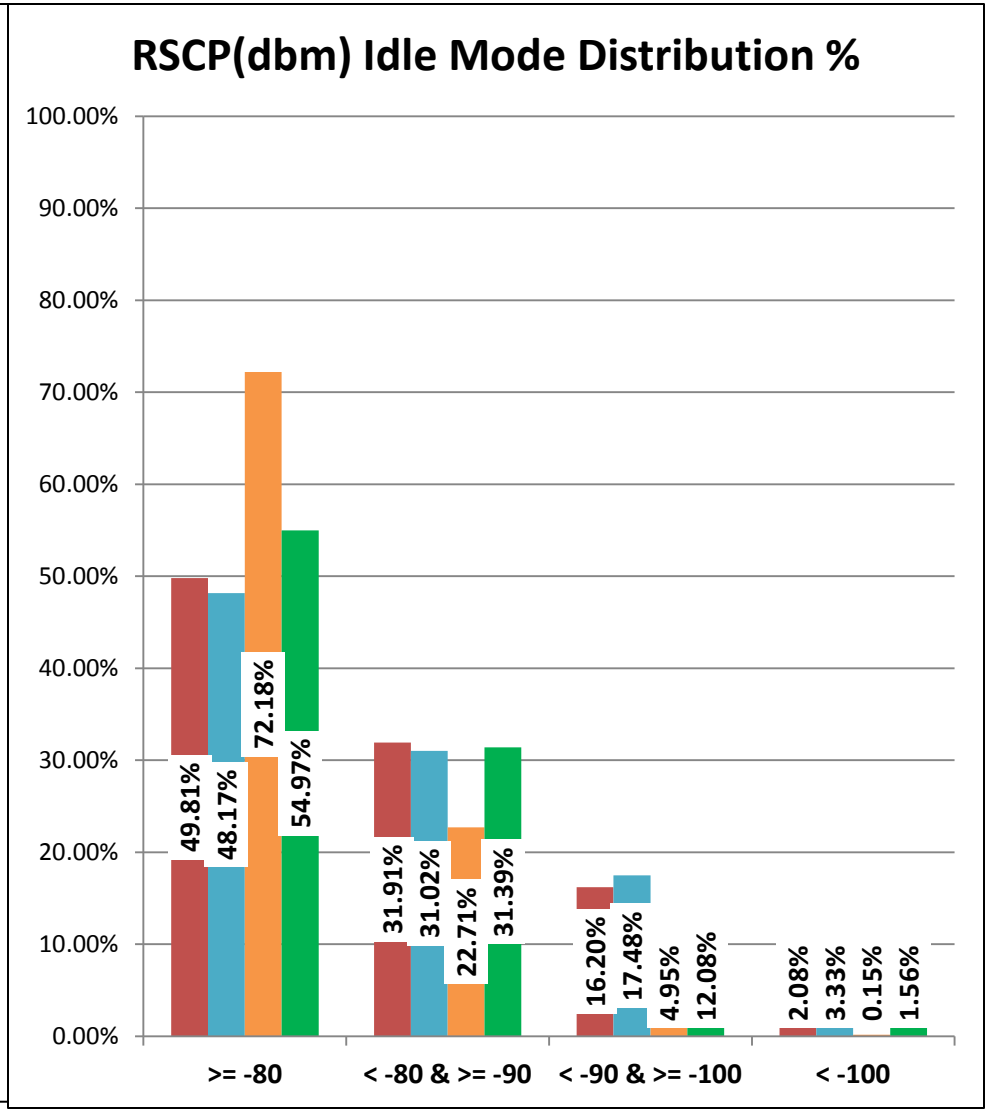


	Lahore	Islamabad	Peshawar	Overall
Warid	141.3	145	177.9	154.73
CMPak	269.4	209.3	98.9	192.53

3G Coverage & Data Test

RSCP Idel Mode





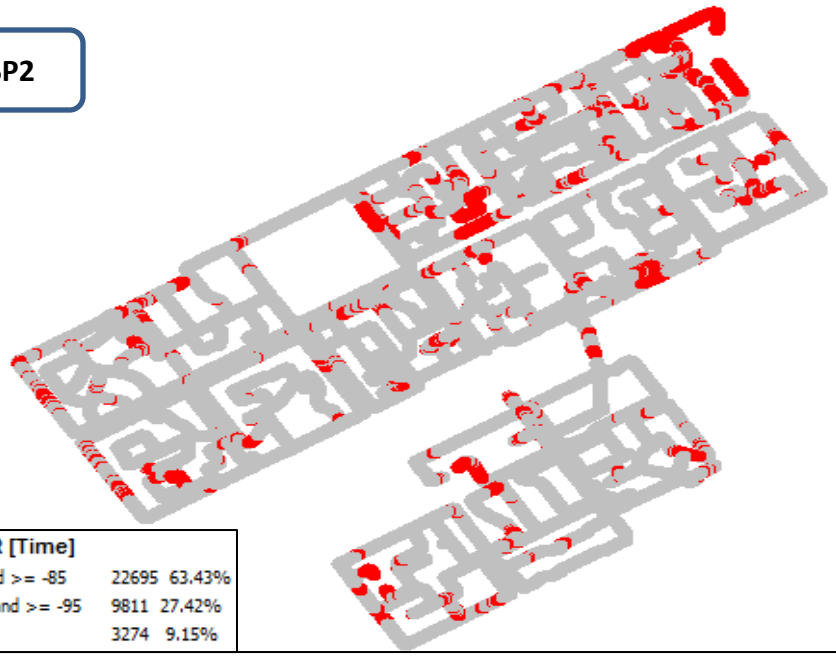
KPI	SP1	SP2	SP3	SP4
RSCP Idle Mode(0 - - 90dbm)%	81.72	79.29	94.89	86.36

RSCP Idle Mode

SP1

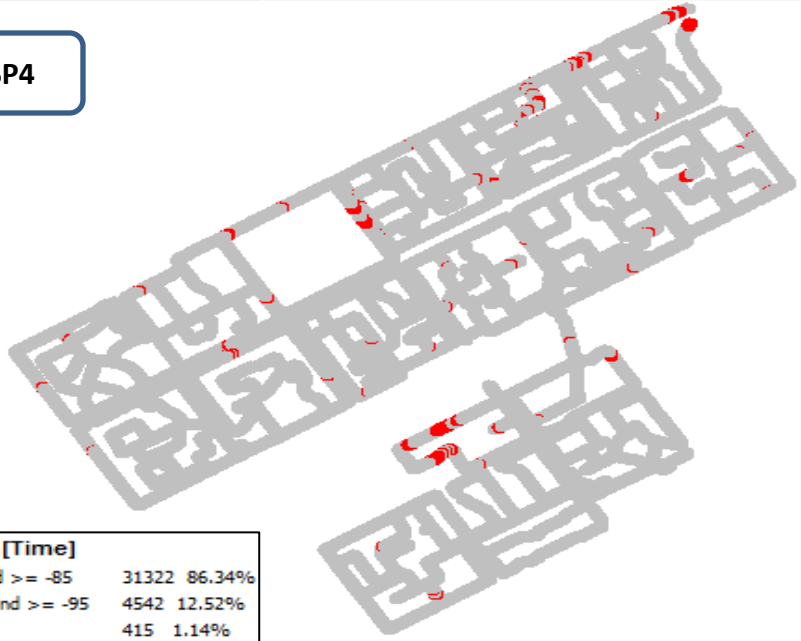
rscp_3g [Time]		
< 0 and >= -85	23036	66.23%
< -85 and >= -95	9255	26.61%
< -95	2493	7.17%

SP2



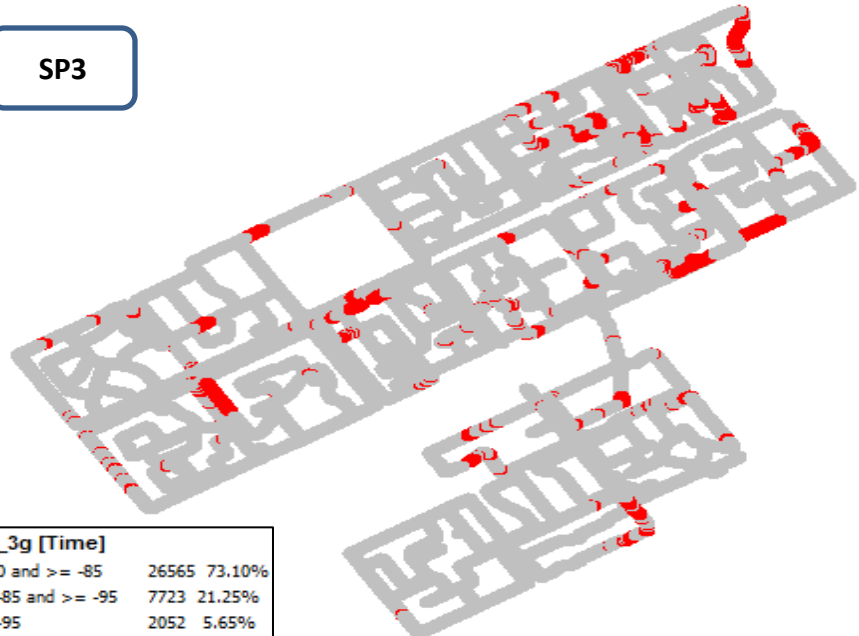
RSCP GR [Time]		
< 0 and >= -85	22695	63.43%
< -85 and >= -95	9811	27.42%
< -95	3274	9.15%

SP4



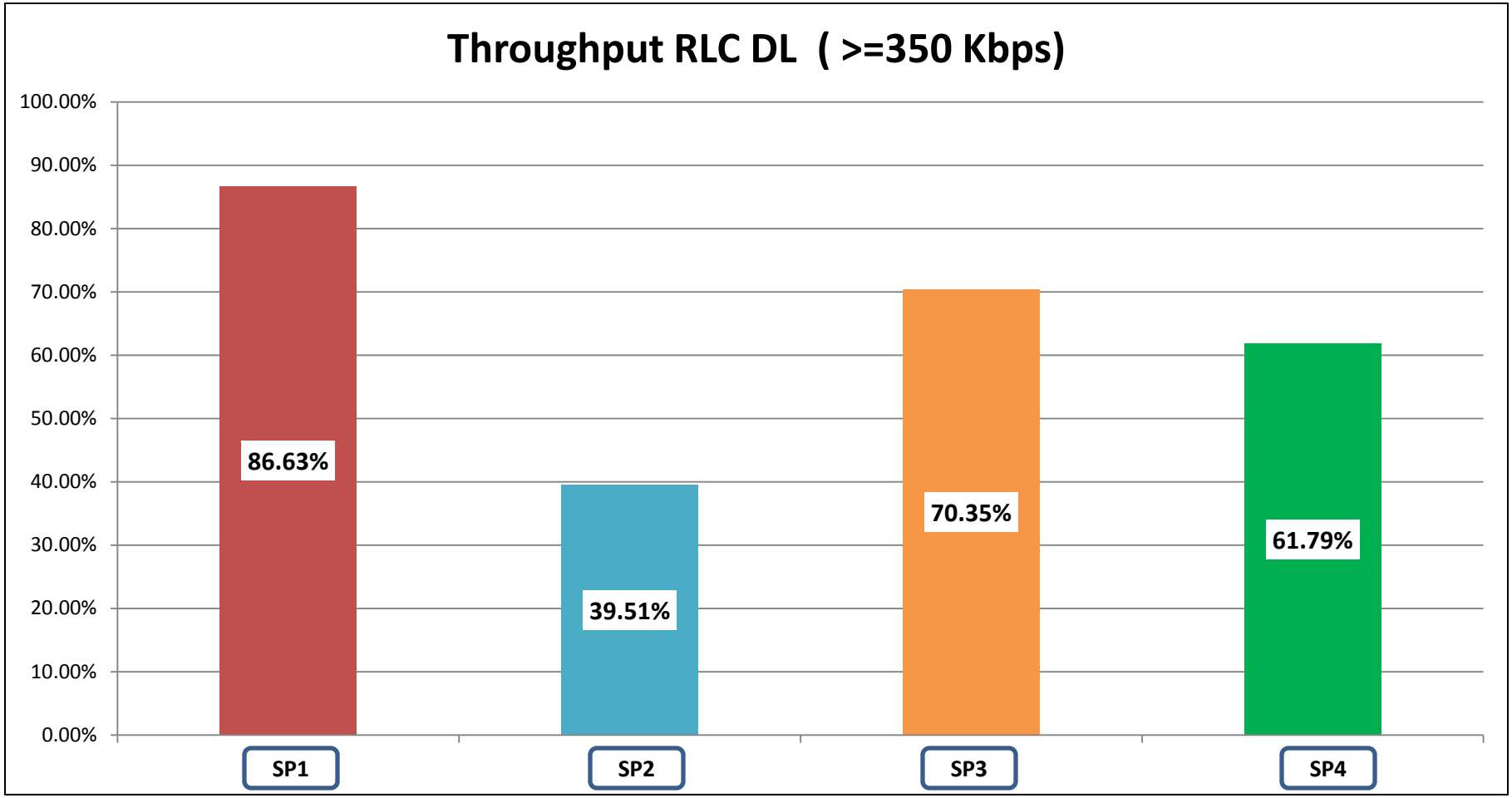
rscp_3g [Time]		
< 0 and >= -85	31322	86.34%
< -85 and >= -95	4542	12.52%
< -95	415	1.14%

SP3



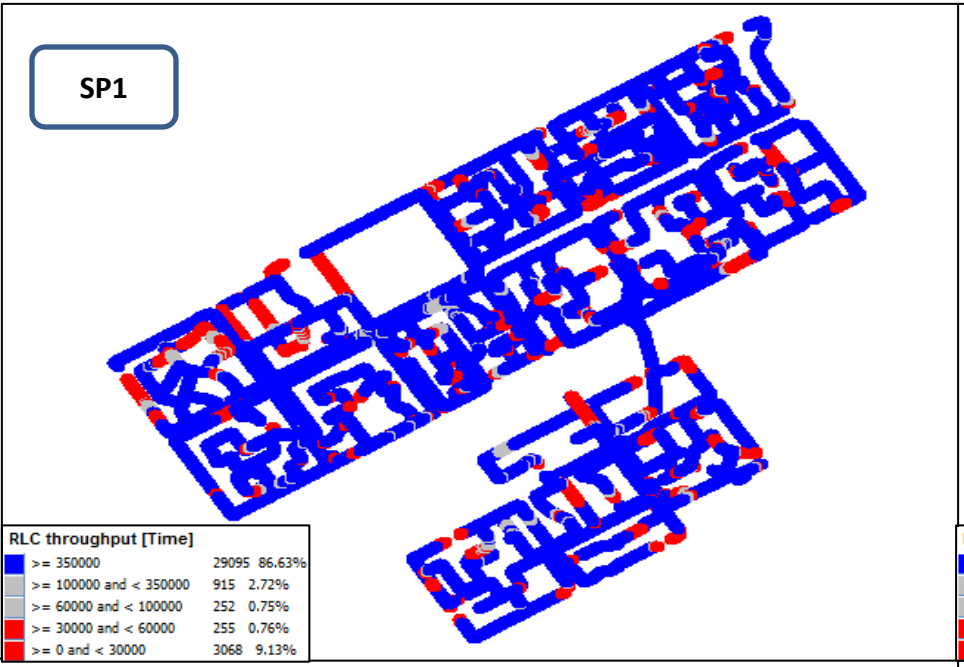
rscp_3g [Time]		
< 0 and >= -85	26565	73.10%
< -85 and >= -95	7723	21.25%
< -95	2052	5.65%

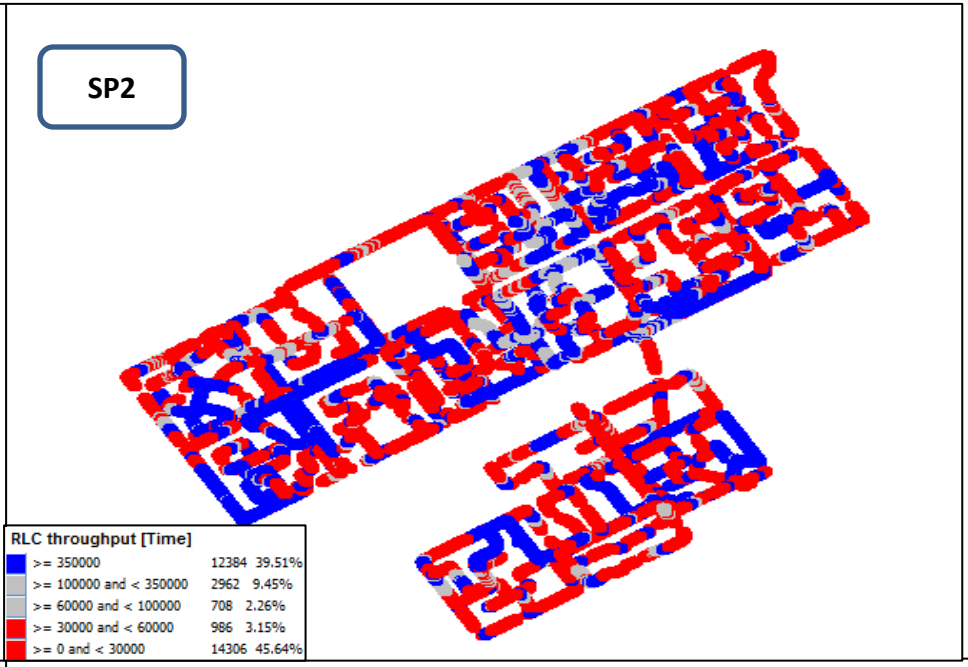
Data – RLC Throughput (RLC >= 350 Kbps)

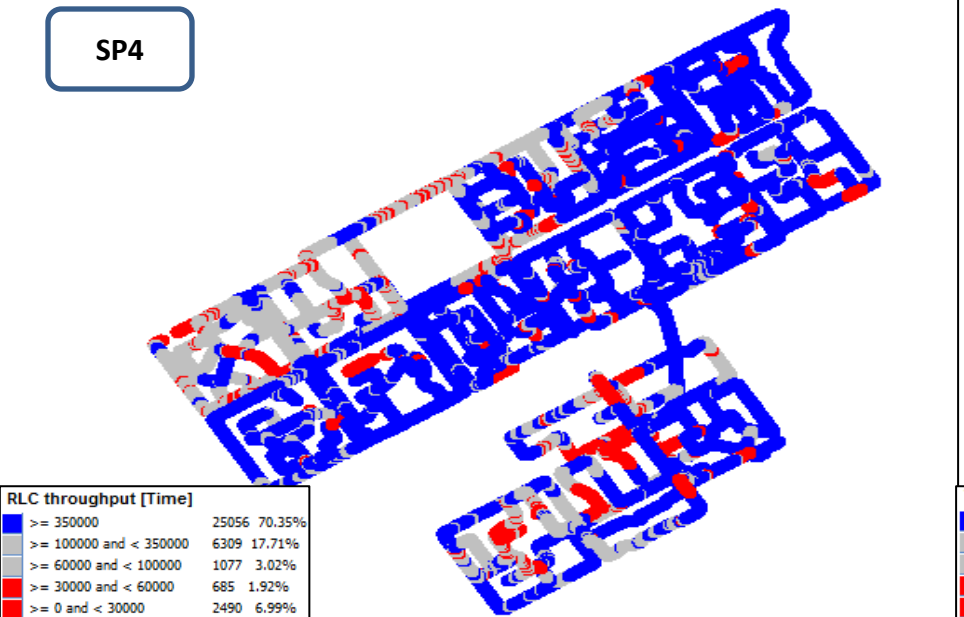


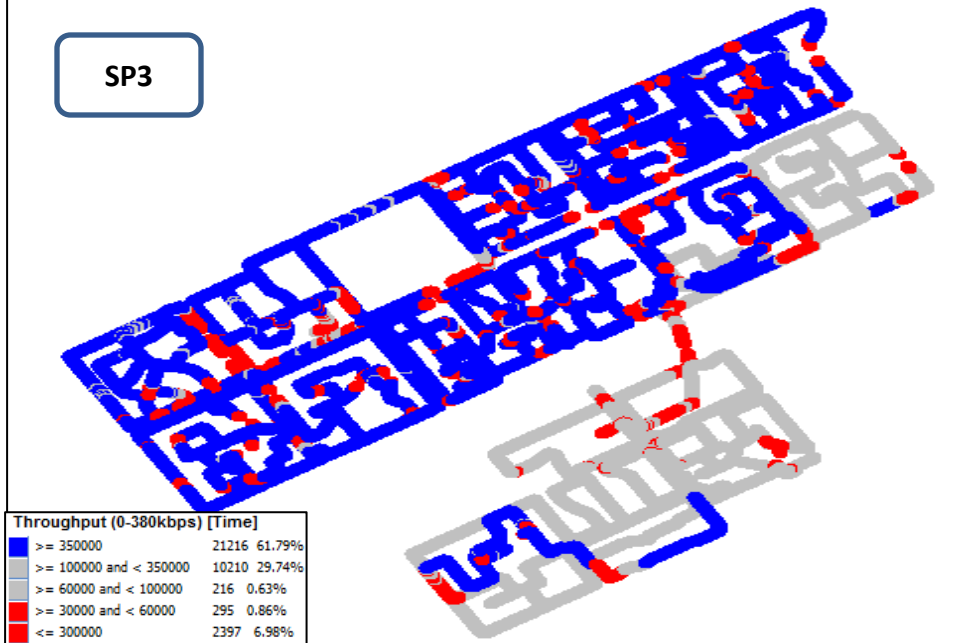
KPI	SP1	SP2	SP3	SP4
Avg.RLC DL (Mbits/s)	2.76	0.94	0.67	2.45
Max.RLC DL (Mbits/s)	9.39	9.71	3.80	10.76
Avg Application Throughput DL(Mbits/s)	2.92	1.07	0.67	2.51
Max Application Throughput DL(Mbits/s)	11.39	10.57	4.83	12.22

Data – RLC Throughput



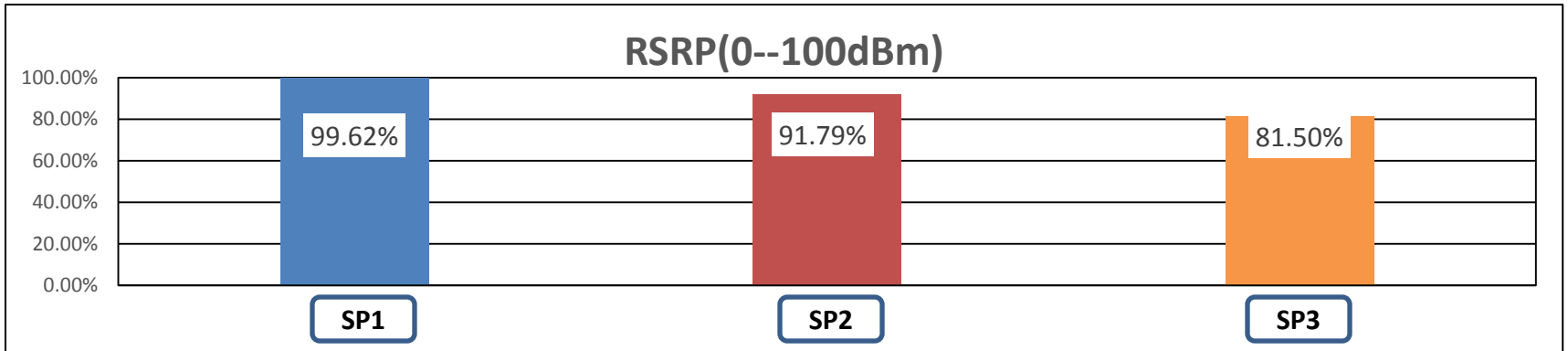




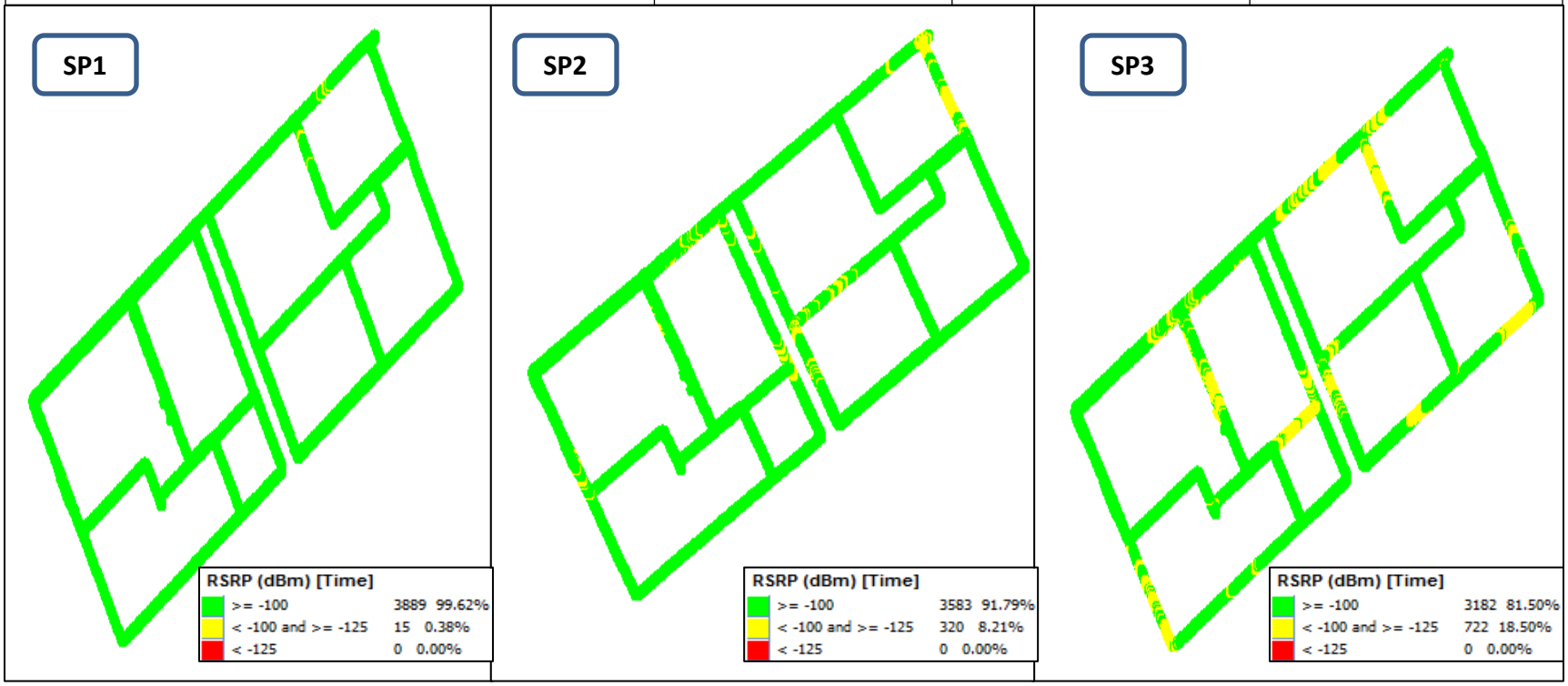


4G Coverage & Data Test

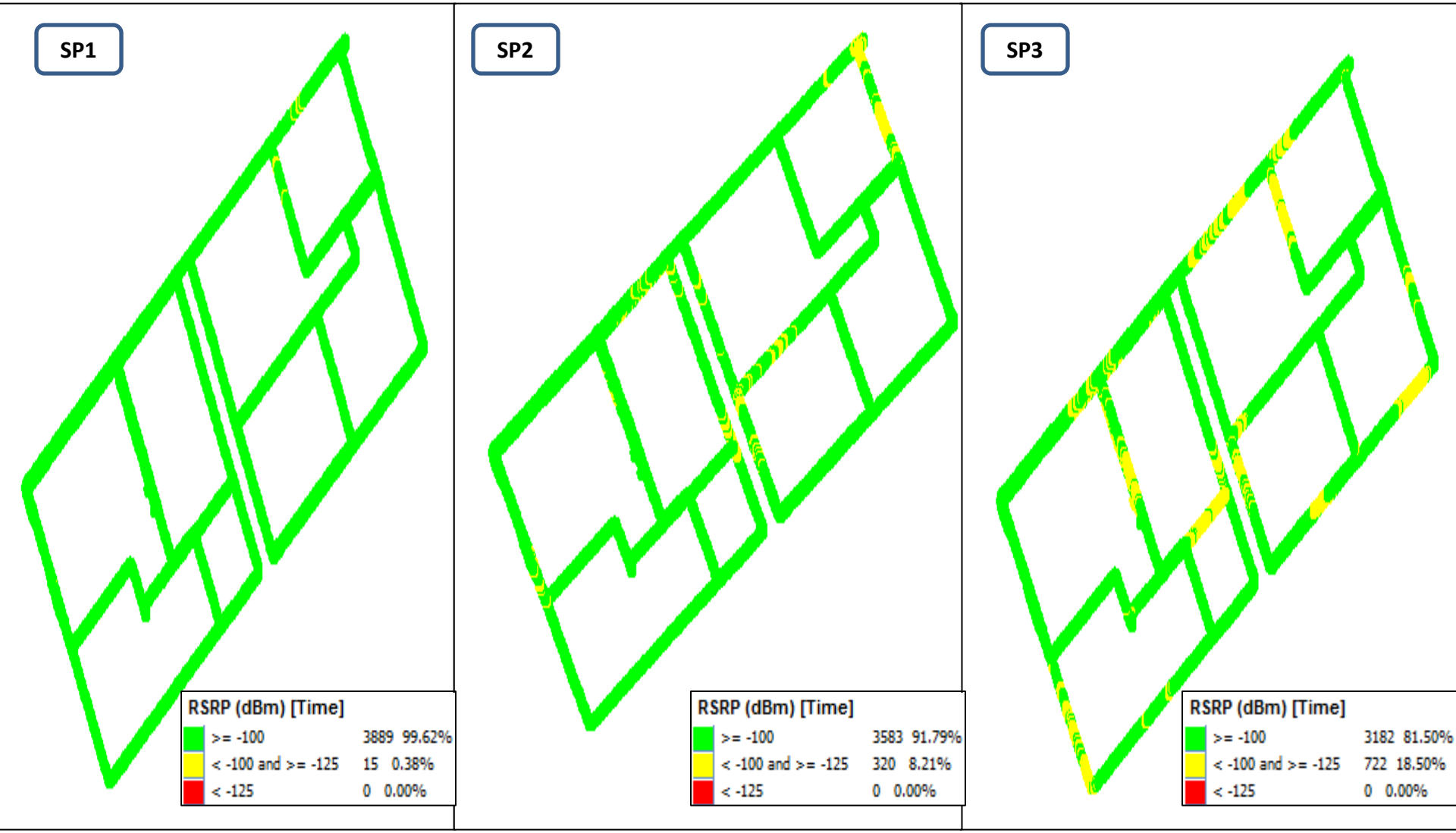
Signal Strength- RSRP (>= -100) %



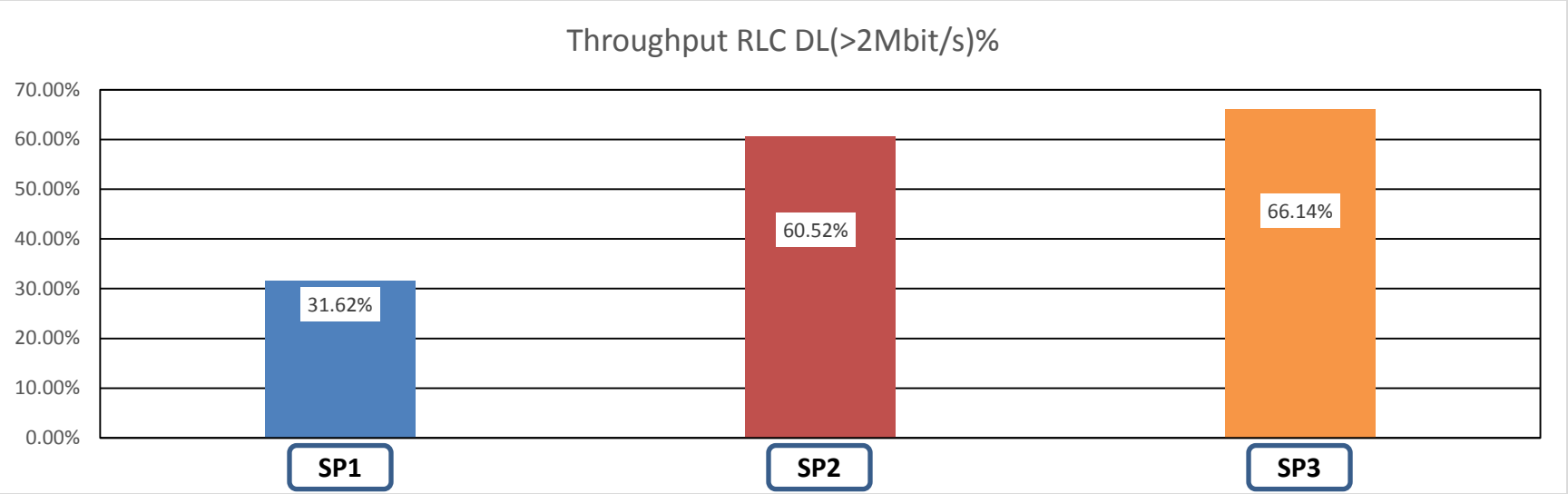
KPI	SP1	SP2	SP3
RSRP (=> -100dbm)%	99.62	91.79	81.50



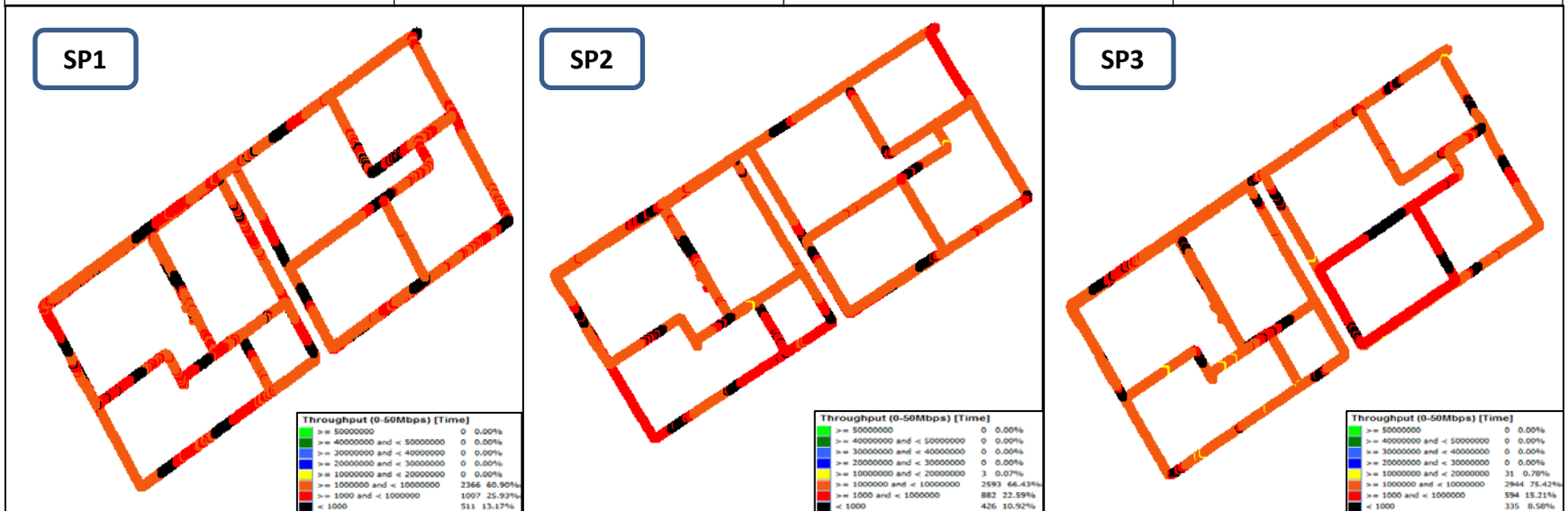
Signal Strength – RSRP Throughout



Data - RLC Throughput > 2Mbps



KPI	SP1	SP2	SP3
Avg.RLC DL (Mbits/s)	1.68	3.11	4.04
Max.RLC DL (Mbits/s)	9.77	11.29	13.64



Mobile Broadband QoS in UK

Source: http://stakeholders.ofcom.org.uk/binaries/research/broadband-research/mbb-nov14.pdf

Mobile Broadband Testing Methodology

- Every MNO was tested on a fair and equal basis
- Test applications was used on unmodified and unbranded publicly available smartphones (used ***Samsung Galaxy Note 3***)
- Took place in five cities between March and June 2014to ensure we tested in areas where all four MNOs had 4G and 3G coverage:
  - London , Birmingham , Manchester, Edinburgh & Glasgow
- Carried out by experienced Ofcom engineers from specialist spectrum engineering teams
- Involved a total of 210,000 individual tests
- Datum product from Spirent used for measuring the user experience of mobile devices and services
- Tested an equal number of indoor and outdoor locations i.e. 50:50 ratio of indoor and outdoor locations

Mobile Broadband Testing Methodology

- Each network was tested concurrently to ensure that environmental conditions were the same for each operator.
- Identical handsets were used for each network.
- SIMs were rotated between devices to eliminate any bias that might have occurred from variations in individual handset performance.
- All of our testing took place while stationary, to ensure repeatability.
- 16 measurements for each metric were taken, for each network at each test location. Handsets were rotated after four cycles to ensure that each handset spent the same amount of time at each point.
- Undue contention was avoided by testing networks in parallel and ensuring that no concurrent tests were run on the same network.
- All testing took place between 7am and 7pm, Monday to Friday.

Mobile Broadband Performance Metrics

- **HTTP download speed**

  the rate at which data can be transferred from the internet to a user's device (such as downloading apps, music or other files);
- **HTTP upload speed**

  the rate at which data can be transferred from the user's device to the internet (such as uploading photos or other content to social media sites);
- **Web browsing speed**

  the time that it takes to load a standard web page
- **Latency**

  the responsiveness of the network, measured by recording the time it takes for a small piece of data to travel to one point and return a response to the user's device.

Mobile Broadband Performance Metrics

- **HTTP download speed – higher number is faster**

  Measured by initiating the download of a 2GB file and downloading for 30 seconds. After 30 seconds, the connection times-out and the download speed metric is calculated by dividing the amount of data received by the 30-second period, to produce a metric of megabits per second (Mbit/s). This indicates the speed at which a network has downloaded data using HTTP.

- **HTTP upload speed – higher number is faster**

  Measured by initiating the upload of 100 MB of data and uploading for 15 seconds. After 15 seconds the connection times-out and the upload speed metric is calculated by dividing the amount of data sent by the 15-second period. As with download speed, this produces a metric of megabits per second (Mbit/s).

- **Web browsing speed – lower number is faster**

  Measured by loading an ETSI-standard reference page and recording the amount of time that this page takes to load. This produces a time in seconds (s).

- **Latency – lower number is faster**

  Measured using ICMP ping. Five packets are sent to a dedicated ICMP server and returned, and the average time that these packets take to complete this round trip is recorded. This produces a metric in milliseconds (ms).

Mobile Broadband Test Schedule

Figure 13: Areas and dates of our fieldwork

City	Dates of testing	Additional testing
Birmingham	28 April to 30 May 2014	26 June 2014
Edinburgh	28 April to 30 May 2014	-
Glasgow	24 March to 25 April 2014	-
London	24 March to 24 April 2014	11-12 & 24-25 June 2014
Manchester	18 March to 23 April 2014	-

Note: All of our test sites were chosen within a radius of 4km from the mainline train station (Charing Cross for London) in each of these cities.

Key Findings

- 4G download speeds were more than twice as fast as 3G speeds. The overall average speed for 4G was 15.1Mbit/s, while for 3G it was 6.1Mbit/s.

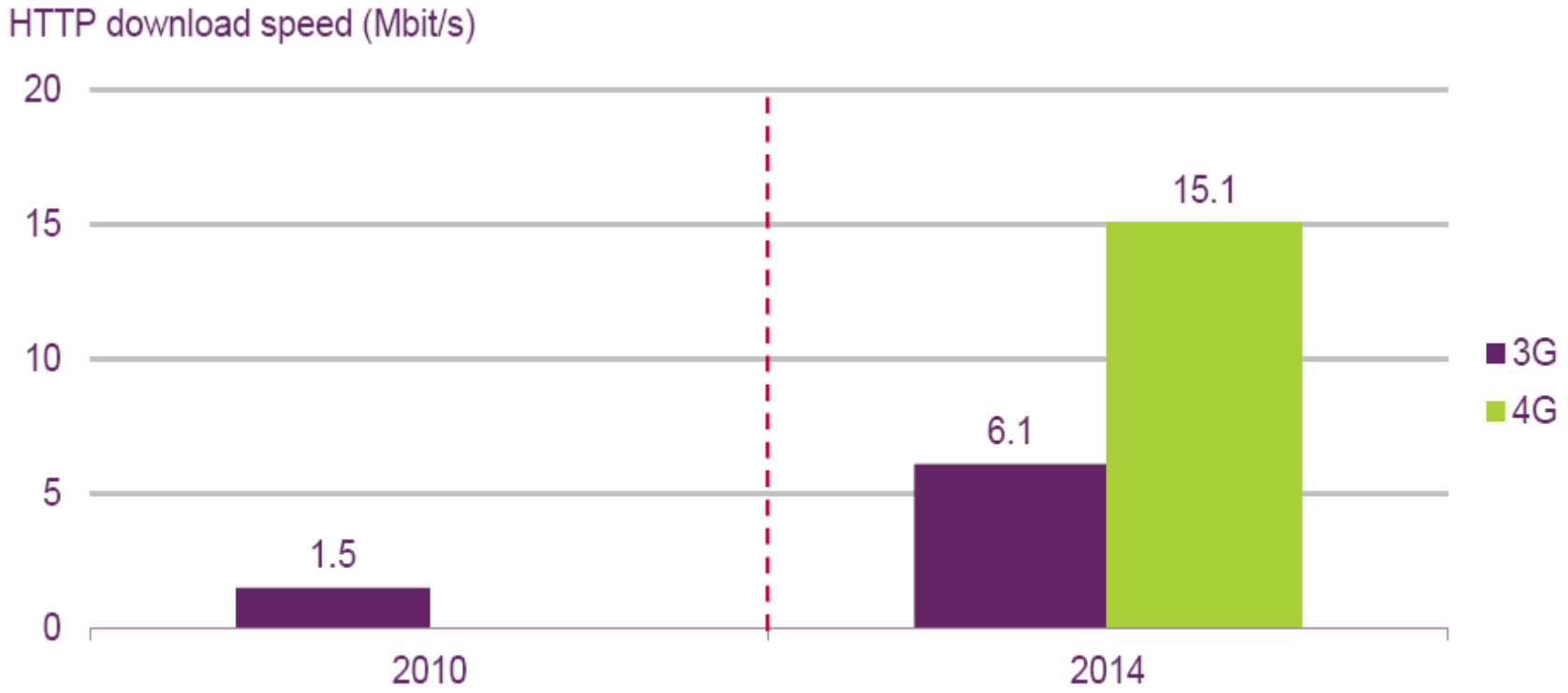
- Upload speeds over 4G were more than seven times faster than those on 3G. The overall average upload speed for 4G was 12.4Mbit/s, while for 3G it was 1.6Mbit/s.

- Web browsing was faster on 4G than on 3G. The average time taken to completely load a standard web page on 4G was 0.78 seconds, while for 3G it was 1.06 seconds.

- 4G networks had a lower latency than 3G networks. Across all of test sites, as an average of all of the networks tested, latency on 4G was 55.0ms, and latency on 3G was 66.8ms.

3G and 4G Mobile Broadband Speed Comparison

Figure 1: Mobile broadband speeds in 2010 and 2014



Source: Ofcom, Measuring Mobile Broadband in the UK: performance delivered to PCs via dongles/datacards September to December 2010 research report, May 2011; Ofcom mobile broadband measurement, fieldwork March to June 2014
Note: Data are not wholly comparable and are presented as an illustrative example only.

Mobile Broadband Metrics Test Result

Figure 17: Average 4G and 3G HTTP download speeds, by test location

Source: Ofcom mobile broadband measurement, fieldwork March to June 2014
Note: Average of all 4G tests and all 3G tests, by test location.

Mobile Broadband Metrics Test Result

Figure 28: Average 4G and 3G HTTP upload speeds, by test location

Source: Ofcom mobile broadband measurement, fieldwork March to June 2014
Note: Average of all 4G tests and all 3G tests, by test location.

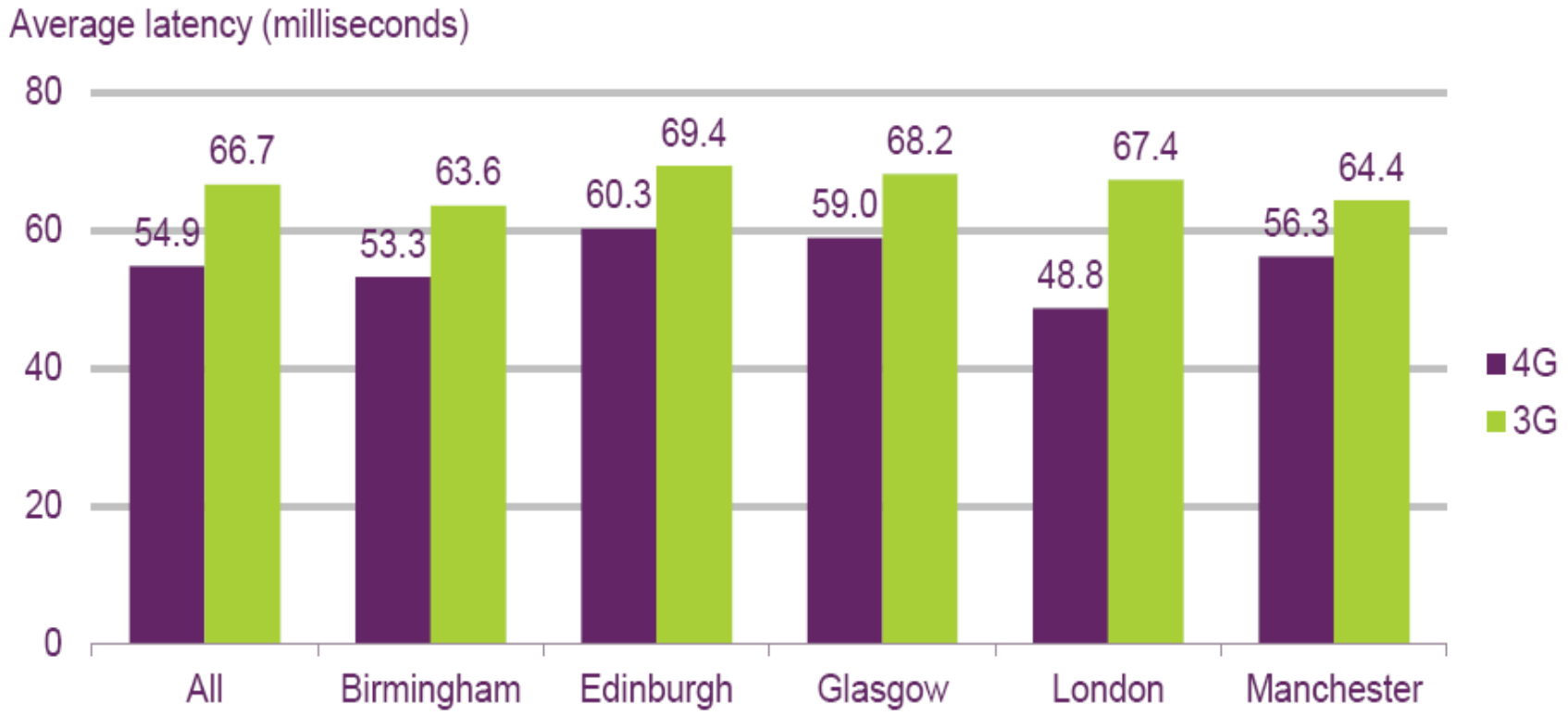
Mobile Broadband Metrics Test Result

Figure 36: Average time taken to load a web page on 4G and 3G, by test location (lower is better)

Source: Ofcom mobile broadband measurement, fieldwork March to June 2014
Note: Average (median) speed at 4G and at 3G at each test location.

Mobile Broadband Metrics Test Result

Figure 43: Average 4G and 3G latency, by test location (lower is better)



Source: Ofcom mobile broadband measurement, fieldwork March to June 2014
Note: Average of 4G and at 3G at each test location

Mobile Broadband QoS in France

Mobile Service Quality

- ARCEP has been conducting surveys periodically since 1997 to assess the quality of mobile operators' services in Metropolitan France
- Surveys are conducted in accordance with the terms of the 2G, 3G and 4G licenses that ARCEP has issued to operators.
- Users can choose their operator based on four criteria: the content of the offer, price, quality of service and coverage.
- If the information that is publicly available allows users to compare the first two criteria with considerable accuracy, it is much harder for them to compare quality and coverage levels, particularly for mobile services.
- ARCEP is thus committed to improving the market's transparency in this area, to better satisfy users' needs while also helping to shed a positive light on the investments that operators are making to improve the quality of their services.

Mobile QoS Indicators

Parameter	Definition
Success rate of access to the Internet site	Access to a website is considered successful when the site's home page is fully loaded within less than 30 seconds on the first try. This rate is calculated based on the total number of measurements.
Successful navigation rates maintained for a period of 5 minutes.	Navigation is considered successful if it is kept active for a period of 5 minutes without breaking Wireless data network. This rate is calculated on the basis of total number of measures including access to the portal succeeded.
File rate of 1 Mb sent * (TFE)	A file is considered received if it is received in full, without cutting the connection, within 2 minutes and if its Content is correct. The rate is calculated based on the number total files sent
Data rate reaches 90% 1MB files sent *	This indicator corresponds to the percentile 90% of received files within the meaning of TFE indicator
Data rate reaches 50% 1MB files sent *	This indicator corresponds to the percentile 50% of received files within the meaning of TFE indicator
Data rate reaches 10% 1MB files sent *	This indicator corresponds to the percentile 10% of received files within the meaning of TFE indicator

Source http://www.arcep.fr/uploads/tx_gspublication/rapport-QS-mobile-2014-230614.pdf

Mobile QoS Indicators

Parameter	Definition
File at 5 MB received * (FFT)	A file is considered received if the file is received in full within 5 minutes and if its content is correct. The rate is calculated based on the total number of files downloaded.
Data rate reaches 90% 5 MB file received *	This indicator corresponds to the percentile 90% of received files within the meaning of TFR indicator
Data rate reaches 50% 5 MB file received *	This indicator corresponds to the percentile 50% of received files within the meaning of TFR indicator
Data rate reaches 10% 5 MB file received *	This indicator corresponds to the percentile 10% of received files within the meaning of TFR indicator

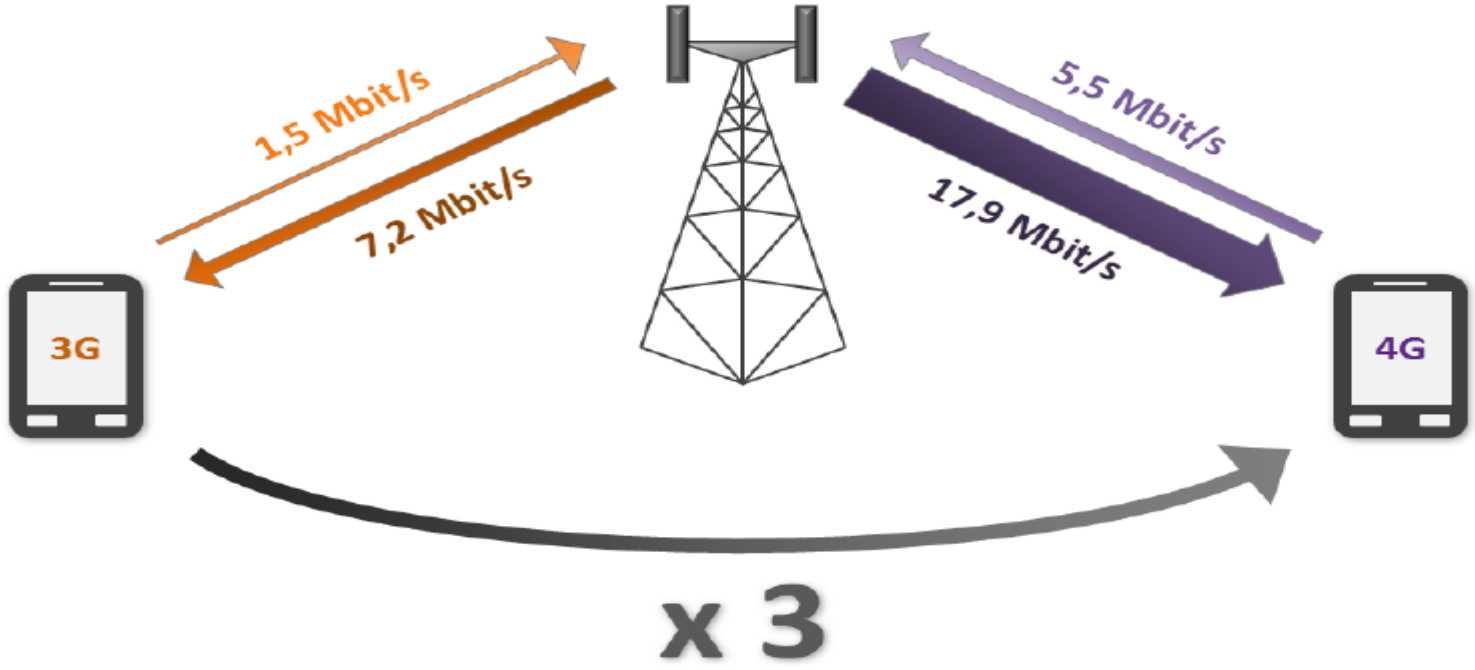
Source http://www.arcep.fr/uploads/tx_gspublication/rapport-QS-mobile-2014-230614.pdf

Mobile Service Quality 2014

- ARCEP conducted Mobile QoS Survey in the first quarter of 2014
- More than 90,000 measurements taken in the field, which are intended to encompass the vast array of situations that users encounter:
  - outdoors, indoors, in a car, on a train, in a city, in the country, etc.
  - Services offered i.e. calling, texting, mobile internet.
- Measurements were taken across the whole of mainland France, in metropolitan areas and, for the first time, in several hundred rural communities as well.
- For the first metrics for 4G networks were also measured on a trial basis.

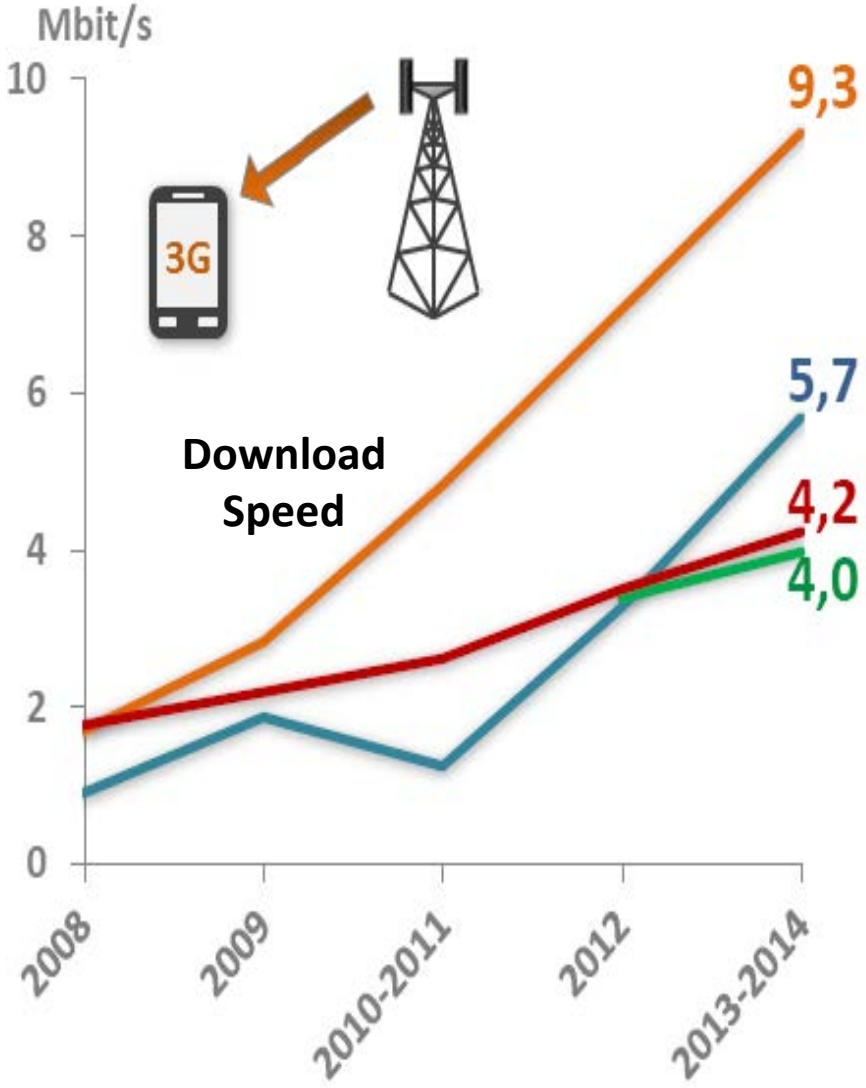
Comparison of Median Rates of 3G and 4G

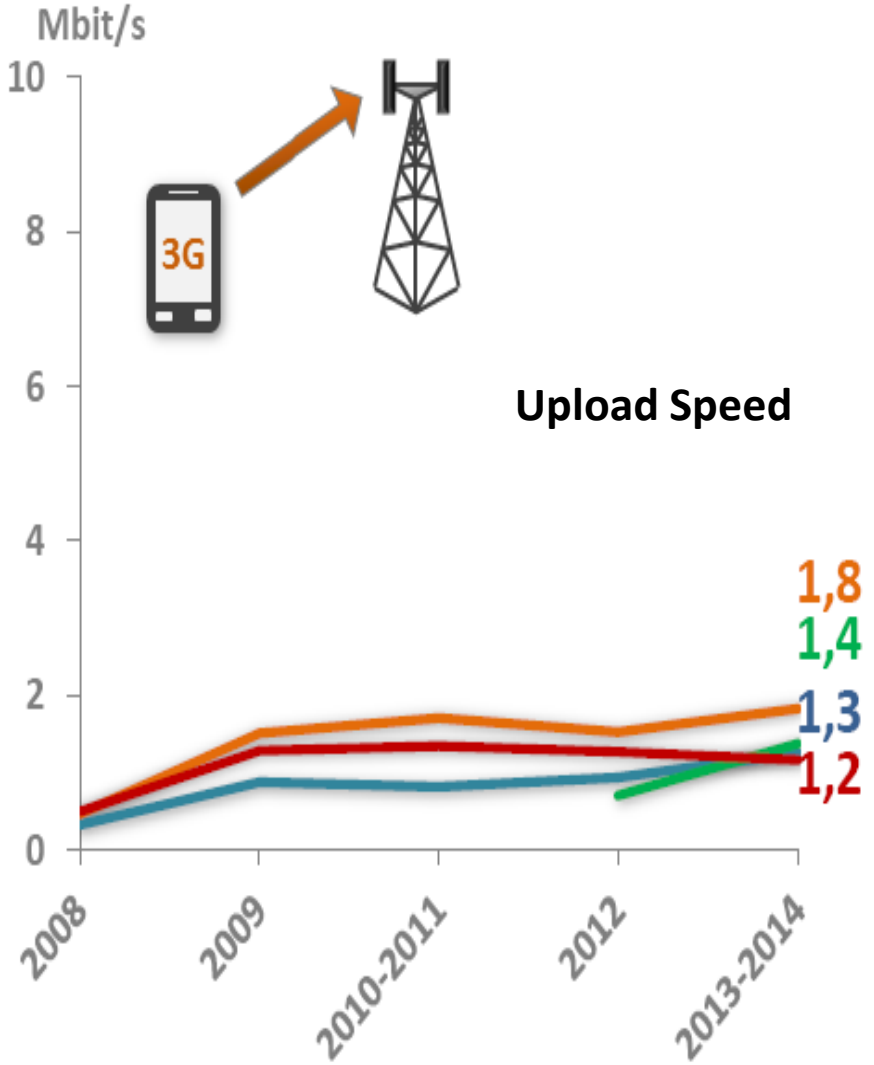
- Median download speed when using 4G is 17.9 Mbps, compared to 7.2 Mbps with 2G/3G.
- Upload speeds increase from 1.5 Mbps to 5.5 Mbps with 4G.
- There continue to be tremendous disparities between operators' 4G services, as there are with 2G/3G
- Median throughput with the best 4G operator is six times higher than the median throughput provided by the poorest.



Source: http://www.arcep.fr/uploads/tx_gspublication/synthese-QS-mobile-2014-230614.pdf

Median Downstream and Upstream Speed in 3G



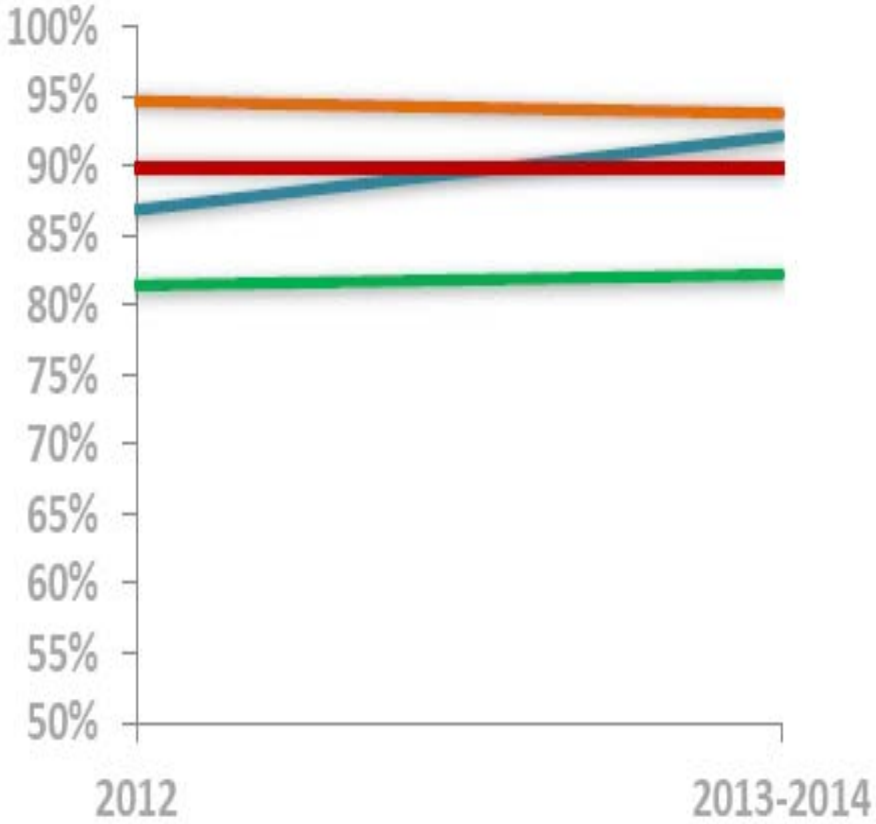


Orange Bouygues Telecom SFR Free Mobile

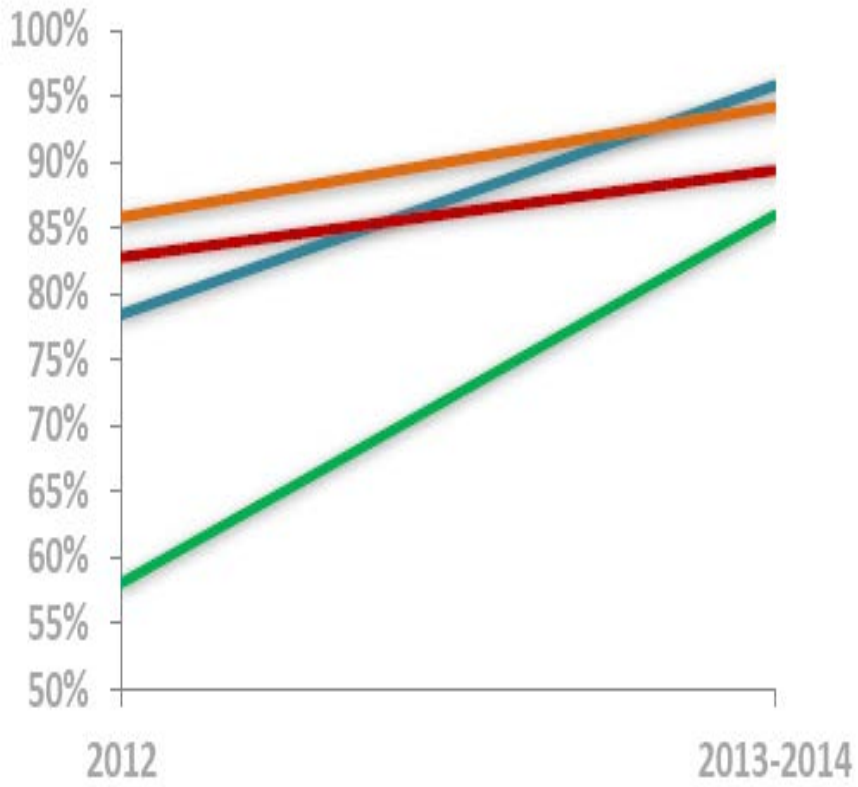
Source: http://www.arcep.fr/uploads/tx_gspublication/synthese-QS-mobile-2014-230614.pdf

Successful Video Viewed and Web Browsing in 3G

2-minutes Video viewed Successfully



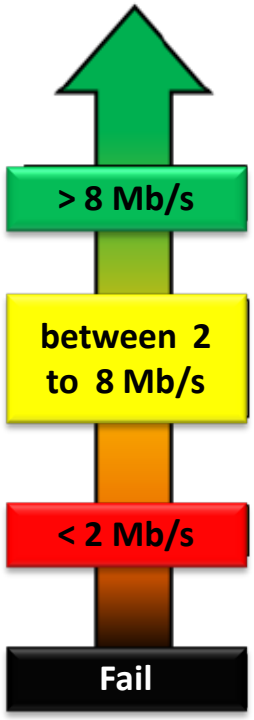
Web Navigations Successful for More than 5 Minutes

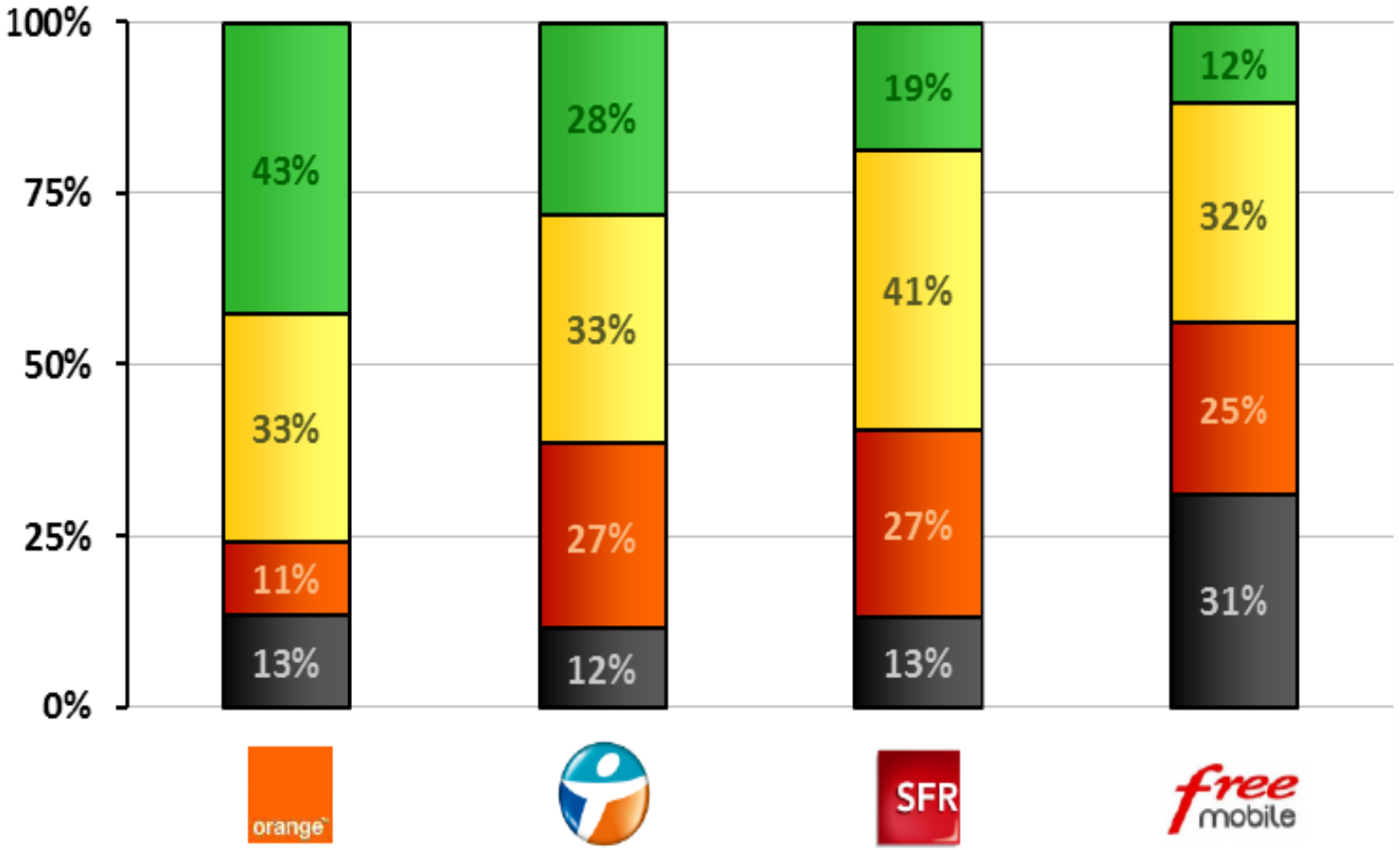


Orange Bouygues Telecom SFR Free Mobile

Source: http://www.arcep.fr/uploads/tx_gspublication/synthese-QS-mobile-2014-230614.pdf

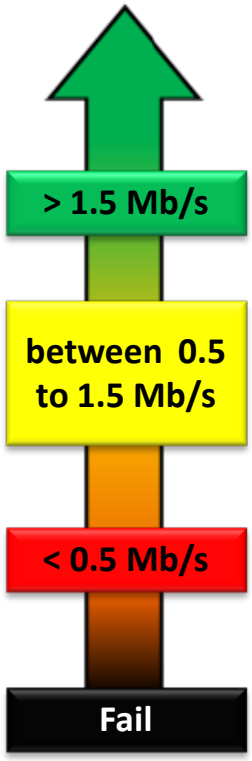
Distribution of Download Speed in 3G

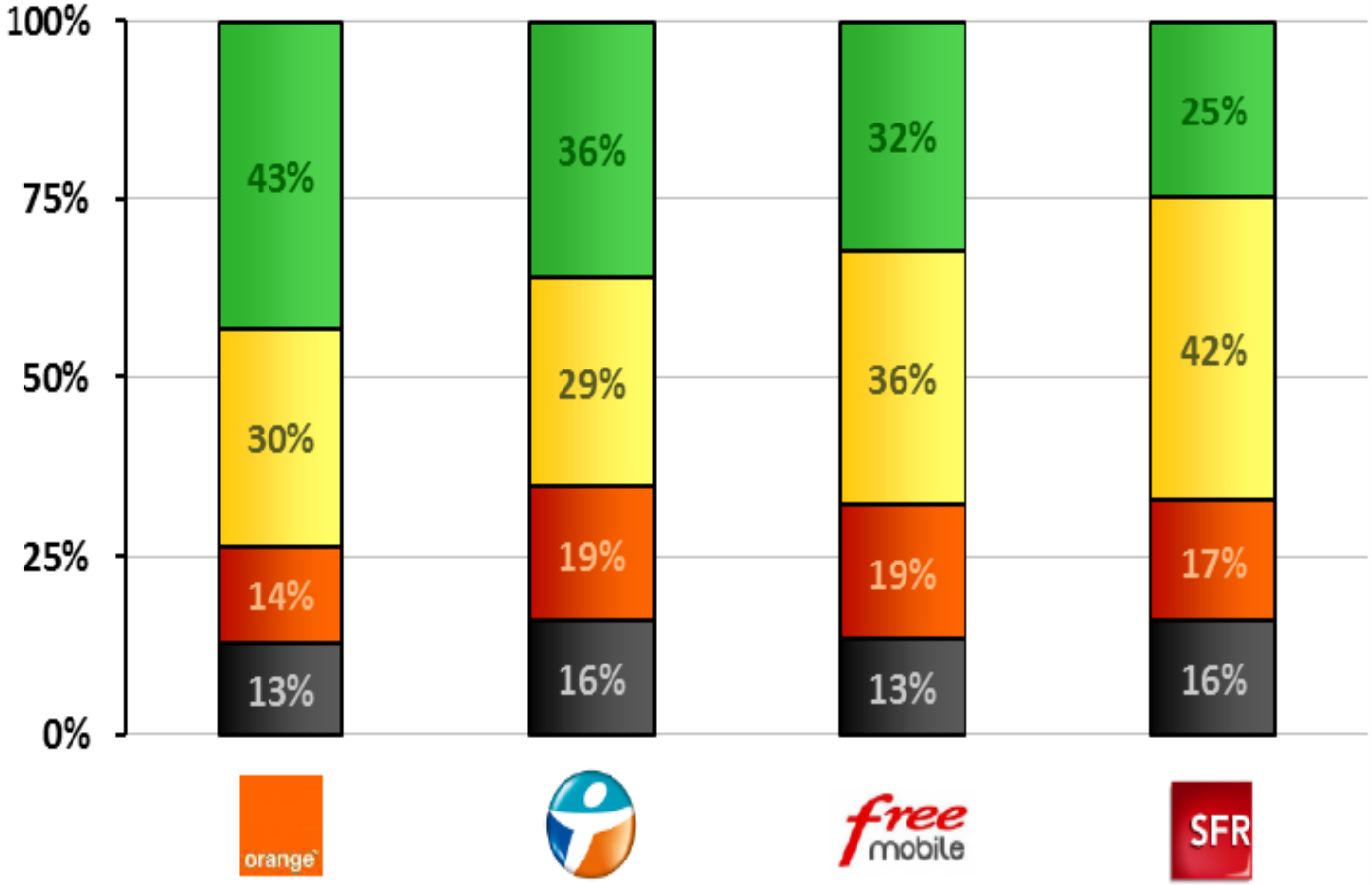




Source: http://www.arcep.fr/uploads/tx_gspublication/synthese-QS-mobile-2014-230614.pdf

Distribution of Upload Speed in 3G





Source: http://www.arcep.fr/uploads/tx_gspublication/synthese-QS-mobile-2014-230614.pdf