Directique
Customer Quality Perspectives

هيئة تنظيم الاتصالات
TELECOMMUNICATIONS REGULATORY AUTHORITY
Kingdom of Bahrain - مملكة البحرين

QUALITY OF MOBILE SERVICES
KINGDOM OF BAHRAIN - 2019

Version	Date	Author	Changelog
1	11/05/2019	Edouard CLISSON	Creation of document
2	03/12/2019	Edouard CLISSON	Modification
5	02/03/2020	Edouard CLISSON	Modification
6	11/03/2020	Edouard CLISSON	Modification

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This study is published in accordance with Articles 3(b)(1), 3(c)(2), 3(c)(4) and Article 54 of the Telecommunications Law promulgated by Legislative Decree No. (48) of 2002. The purpose of the study is to evaluate and benchmark Quality Levels offered by Mobile Network Operators, Batelco, STC Bahrain and Zain, in the Kingdom of Bahrain. The independent study was conducted with an objective End-user perspective by Cabinet Directique and does not represent any views of the Authority.

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1. READER'S ADVICE

For a proper understanding of this report, readers are advised to take into account the following key elements:
Quality of Mobile Services Audit is a snapshot of the observed quality and performance offered by Mobile Operators at the time of the measurements campaign.
Mobile Operators are continuously performing modifications and upgrades (including during the audit). Performance at the time of reading the report may be different.
TRA deliberately chose to assess quality from the end user perspective, which involves for example carrying out measurements with mobile devices which are available in Mobile Operator shops, behaving like the user on the field and cross network testing. Please read section 4 carefully for a full understanding of the test protocol and measurement conditions.

As with any quality audit or survey, the statistical accuracy is systematically presented in the results tables. Accuracy is the error margin to the actual values, so any comparison between results should take this confidence interval into account.

To be consistent with this level of accuracy, results have been rounded up or down to the nearest tenth of a unit. It is reminded that:

- the sum of two rounded results can be different from the rounding of their sum,
- Multiplying one rounded result by another is different than rounding the result of their multiplication.

Other statistical aggregates used in the report are:

- **Standard deviation** shows how much variation there is from the average. A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data are spread out over a large range of values.
- **Min** and **Max** show the worse and best results (such as delay, throughput) obtained during successful measurements.
- **Average** is always the arithmetic mean of the referred sample.

2. End to End Audit Performance Approach

This audit is a benchmark focused on qualitative assessment of the end to end service provided from the user point of view.

This means that measurements are performed through an end to end user perspective, in order to gather a faithful record of the customer's quality experience.

The end to end perspective consists in verifying that the service offered by the service providers is accessible for their customers, and measuring probabilities of malfunction, depending on the customer location and types of usage.

To achieve this objective, verifying that a signal is received by the handset is not sufficient, in addition is confirmed that the radio link can be bilaterally established to support the tested service; And that this radio link, with the rest of the network, can be used to initiate calls and establish data communications; And, finally, assess this communication performance, once established (voice and data).

The diagram below shows the end to end service path, from end user handsets to services platform located on or outside of the operator network.

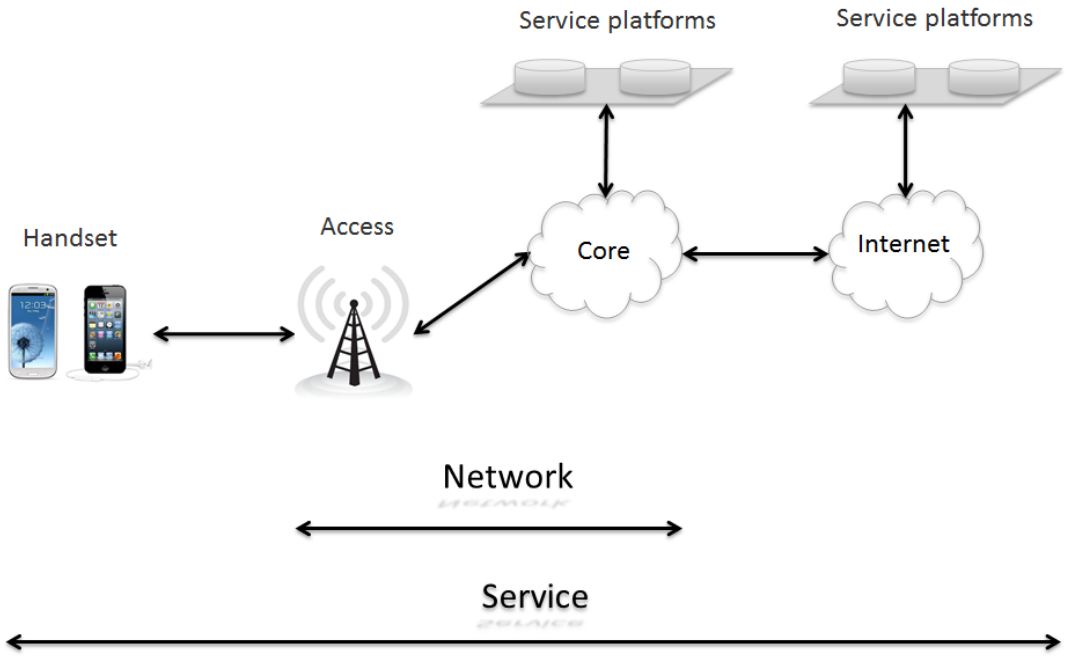


Figure 1 - End to end customer experience

The selected testing methodology reproduces a customer use of the range of mobile services, including:

- Handsets and subscriptions available to a large public. These are then selected from a list of current best sellers provided by the mobile operators. The results observed can therefore be subject to degradations induced by the device provided.
- A representative use of the market: incar, pedestrian inside and outside buildings, or under conditions that simulate correctly these uses.

3. EXECUTIVE SUMMARY

3.1. INTRODUCTION

The availability and quality of modern telecommunications services are critical elements for the success of the Kingdom of Bahrain's economy. Mobile telecommunications services are heavily used by consumers and businesses, either located in Bahrain or visiting the Kingdom.

In releasing this study, TRA aimed at evaluating and benchmarking quality levels offered by Mobile Network Operators in the Kingdom of Bahrain, Batelco, STC Bahrain and, Zain from an end-user perspective, for the following set of services:

- Voice
- Short Message Services (SMS)
- Smartphones data tests (Web surfing, HTTP file transfers)
- Smartphones data tests on hotspots * (HTTP file transfers)
- Video streaming assessment using Smartphones

**a specific Hotspots list is given by operators. Those hotspots are locations where radio configuration allows better data performances for each operator on mobile network. Those are not to be confused with Wi-Fi hotspot.*

The Authority selected Directique, an international consulting firm to conduct the assessment using a test method designed to gather a faithful qualitative record from an end users' point of view, avoiding assessing quality through a pure technical angle as this is performed by Mobile Operators themselves on a regular basis.

This Quality of Service (QoS) audit was conducted from 12th September to 9th October 2019 inclusive. Measurements were performed between 9:00 am and 11:00 pm every day except Saturdays.

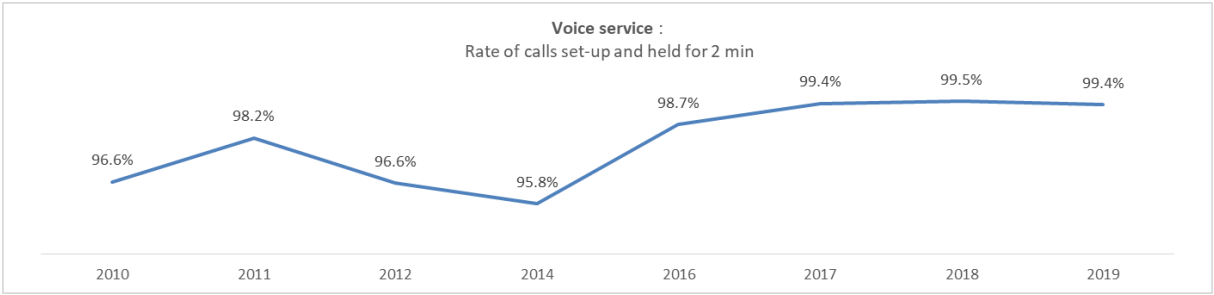
3.2. INDUSTRY RESULTS

The following tables show the average combined results achieved by the three Mobile Operators for all measurements. Detailed results for each Operator are available in section 6 of this report.

3.2.1. VOICE AND MESSAGING SERVICES

		2019	2018	2017	2016	2014	2012
Global **VOICE** service		3 133	4 734	6 707	6 611	6 673	6 828
Rate of calls set-up and held for 2 min (SHR)		**99.4%**	**99.5%**	**99.4%**	**98.7%**	**95.8%**	**96.6%**
	statistical accuracy	*+/-0.3%*	*+/-0.2%*	*+/-0.2%*	*+/-0.3%*	*+/-0.5%*	*+/-0.4%*
and marked	**4-perfect (PQR)**	**98.1%**	**99.1%**	**99.3%**	**96.3%**	**93.8%**	**94.1%**
	statistical accuracy	*+/-0.5%*	*+/-0.3%*	*+/-0.2%*	*+/-0.5%*	*+/-0.6%*	*+/-0.6%*
	4-perfect or 3-fair (CQR)	**99.2%**	**99.4%**	**99.3%**	**97.6%**	**95.0%**	**96.2%**
	statistical accuracy	*+/-0.3%*	*+/-0.2%*	*+/-0.2%*	*+/-0.4%*	*+/-0.5%*	*+/-0.5%*

Figure 2 – Voice service – industry results

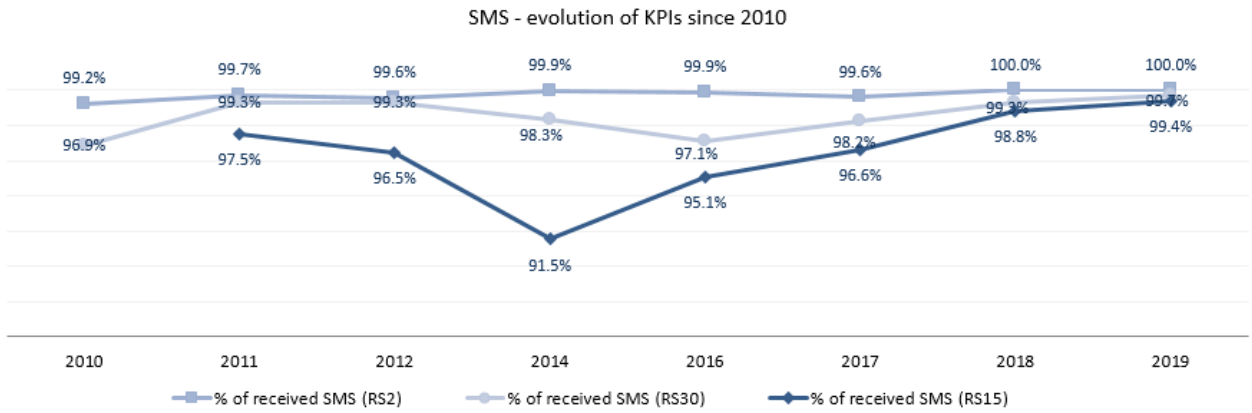


The three networks offered the same excellent level of service as 2018, with an average setup and held calls rate of 99.4%.

	2019	2018	2017	2016	2014	2012
Global SMS Service	2 874 tests	3 110 tests	3 001 tests	2 591 tests	4 547 tests	2 637 tests
% of received SMS (RS2)	**100.0%**	**100.0%**	**99.6%**	**99.9%**	**99.9%**	**99.6%**
statistical accuracy	*+/-0.0%*	*+/-0.0%*	*+/-0.2%*	*+/-0.1%*	*+/-0.1%*	*+/-0.2%*
% of received SMS (RS30)	**99.7%**	**99.3%**	**98.2%**	**97.1%**	**98.3%**	**99.3%**
statistical accuracy	*+/-0.2%*	*+/-0.3%*	*+/-0.5%*	*+/-0.6%*	*+/-0.4%*	*+/-0.3%*
% of received SMS (RS15)	**99.4%**	**98.8%**	**96.6%**	**95.1%**	**91.5%**	**96.5%**
statistical accuracy	*+/-0.3%*	*+/-0.4%*	*+/-0.6%*	*+/-0.8%*	*+/-0.8%*	*+/-0.7%*
Average reception delay (s)	**2.6**	**3.2**	**5.1**	**6.6**	**6.7**	**8.1**

Figure 3 – SMS service – industry results

All networks offered very good SMS service within two minutes with 99.4% of messages received within 15 seconds.



The average observed SMS reception delay was under 3 seconds, which is the best performance since 2010.

3.2.2. SMARTPHONE DATA MEASUREMENTS

An evolution of protocol for HTTP data transfers measurements has been decided with TRA for the 2019 audit, due to the enhanced performances of mobile networks and consumer behaviors.

The measurement consists of a 10 seconds data transfer, using a large file of 1GB, for both download and upload tests.

Until 2018, those tests were made as followed:

- HTTP DL: download a 100MB file, within a time out of 300 seconds,
- HTTP UL: download a 50MB file, within a time out of 120 seconds

However, throughputs are compared only.

4G HANDSET:

		2014	2016	2017	2018	2019
HTTP DL	Average Throughputs	30 717	29 783	37 276	61 908	80 831
HTTP UL	Average Throughputs	12 639	26 665	23 389	24 294	29 444

Figure 4 – 4G Handset data service – industry results

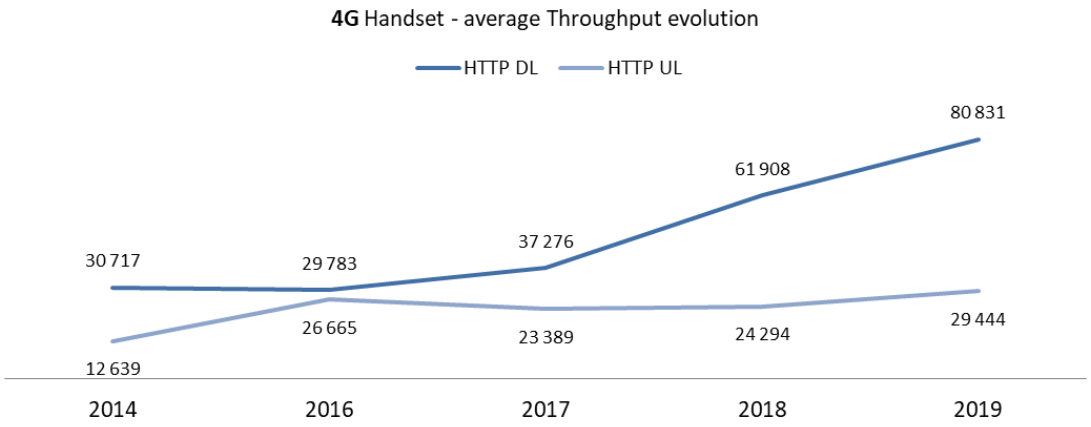


Figure 5 – 4G Handset – HTTP transfers – average throughputs

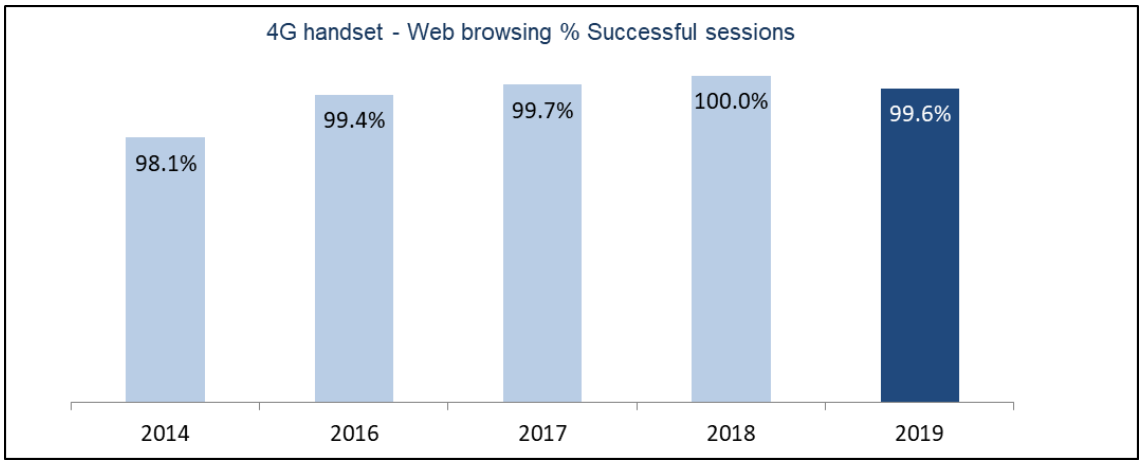


Figure 6 – 4G Handset – WEB browsing – % Successful sessions

3G HANDSET:

		2010	2011	2012	2014	2016	2017	2018	2019
HTTP DL	Average Throughputs	1 844	3 229	3 207	8 534	9 977	10 154	9 319	10 422
HTTP UL	Average Throughputs	937	891	877	1 081	2 347	2 146	2 822	2 809

Figure 7 – 3G Handset data service – industry results

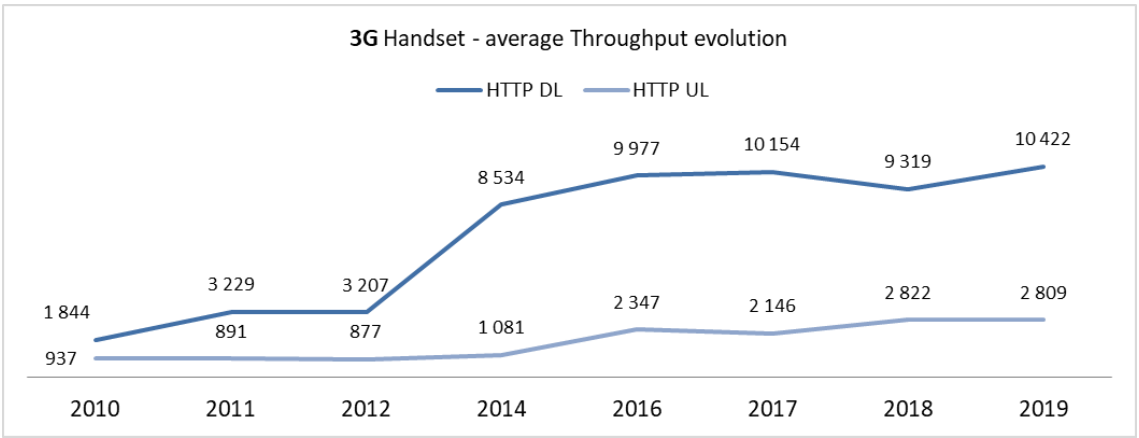


Figure 8 – 3G Handset – HTTP transfers – average throughputs

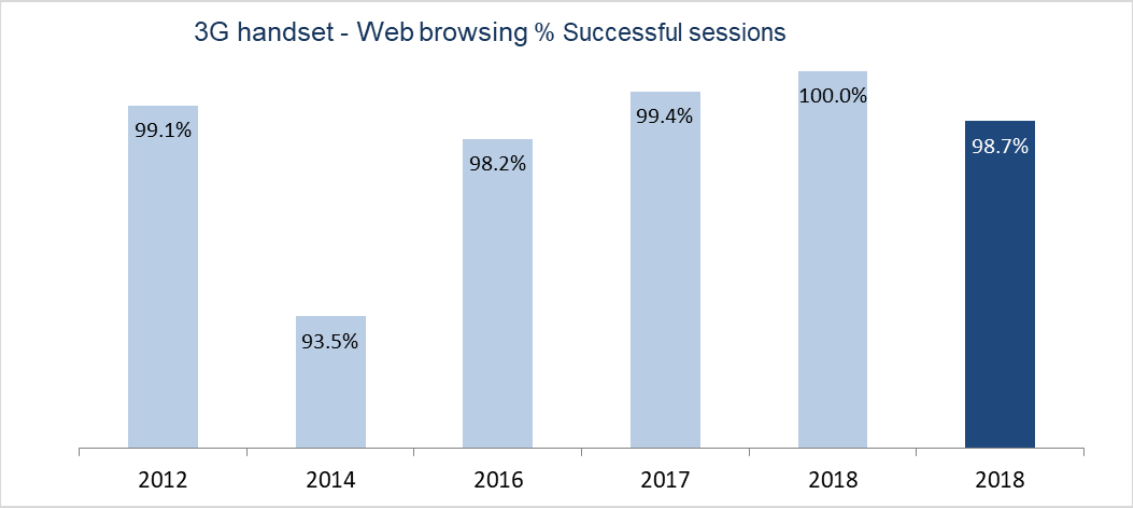


Figure 9 – 3G Handset – WEB browsing – % Successful sessions

3.2.3. STREAMING MEASUREMENTS

Streaming - 4G HANDSET

	2019	2018	2017	2016	2014
Sample	**1 835 tests**	1 830 tests	1 514 tests	1 025 tests	513 tests
LHV : % of videos set-up and held for 2 min	**100.0%**	100.0%	99.3%	100.0%	97.3%
statistical accuracy	***+/-0.0%***	*+/-0.0%*	*+/-0.5%*	*+/-0.0%*	*+/-1.4%*
VPQR : % of videos set-up, held for 2 min, and marked 4	**94.7%**	93.6%	82.1%	87.1%	95.9%
statistical accuracy	***+/-1.0%***	*+/-1.1%*	*+/-3.3%*	*+/-2.1%*	*+/-1.7%*
VCQR : % of videos set-up, held for 2 min, and marked 3 or 4	**96.3%**	95.7%	90.6%	90.4%	93.5%
statistical accuracy	***+/-0.9%***	*+/-0.9%*	*+/-2.5%*	*+/-1.8%*	*+/-2.1%*
Average delay – access to video (s)	**2.5**	2.6	3.3	1.0	3.0

Figure 10 – 4G Handset Streaming service – industry results

LVH: Launched and Held for 2 minutes Videos

VPQR: Video Perfect Quality Rate

VCQR: Video Correct Quality Rate

In comparison with 2018, video quality rate has been enhanced on both LHV and VPQR.

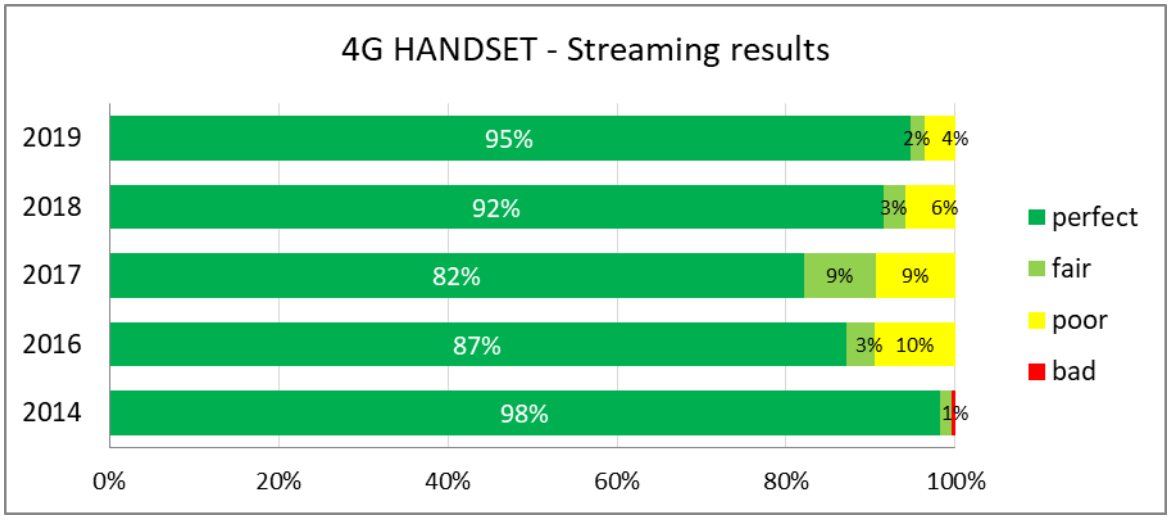


Figure 11 – 4G Handset Streaming service – Quality distribution

Streaming - 3G HANDSET

	2019	2018	2017	2016	2014	2012
Sample	**1 825 tests**	1 814 tests	1 535 tests	1 017 tests	513 tests	673 tests
LHV : % of videos set-up and held for 2 min	**100.0%**	100.0%	99.5%	99.7%	92.0%	95.0%
statistical accuracy	***+/-0.0%***	*+/-0.0%*	*+/-0.5%*	*+/-0.3%*	*+/-2.3%*	*+/-3.1%*
VPQR : % of videos set-up, held for 2 min, and marked 4	**89.4%**	87.9%	71.2%	68.2%	75.0%	20.0%
statistical accuracy	***+/-1.4%***	*+/-1.5%*	*-+/-3.8%*	*+/-2.9%*	*+/-3.7%*	*+/-5.7%*
VCQR : % of videos set-up, held for 2 min, and marked 3 or 4	**92.5%**	92.1%	90.1%	77.5%	77.6%	93.5%
statistical accuracy	***+/-1.2%***	*+/-1.2%*	*+/-2.4%*	*+/-2.6%*	*+/-3.6%*	*+/-3.5%*
Average delay – access to video (s)	**3.0**	3.1	4.8	2.8	5.0	9.0

Figure 12 – 3G Handset Streaming service – industry results

In comparison with 2018, quality of the video is better on 3G, both on fair and perfect video quality.

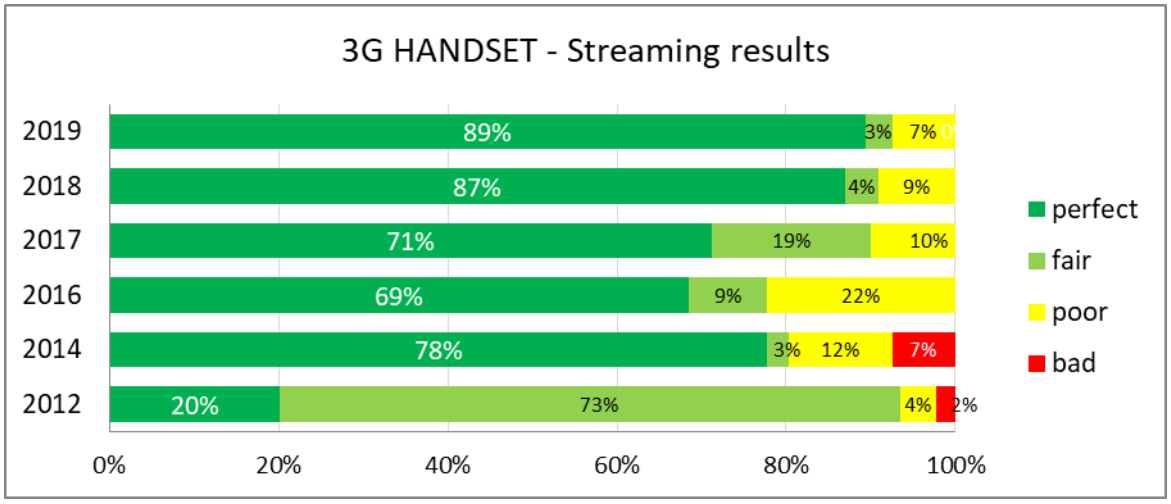


Figure 13 – 3G Handset Streaming service – Quality distribution

3.2.4. BROADBAND PERFORMANCES

Each operator has provided a list of hotspots (which are newly deployed technologies) where network settings should allow higher data performance, in comparison with other locations that have been tested randomly. These results show that the operators have deployed enhanced network at certain areas in Bahrain to reach much higher speeds, the average throughput on hotspots was more than twice higher than in random locations.

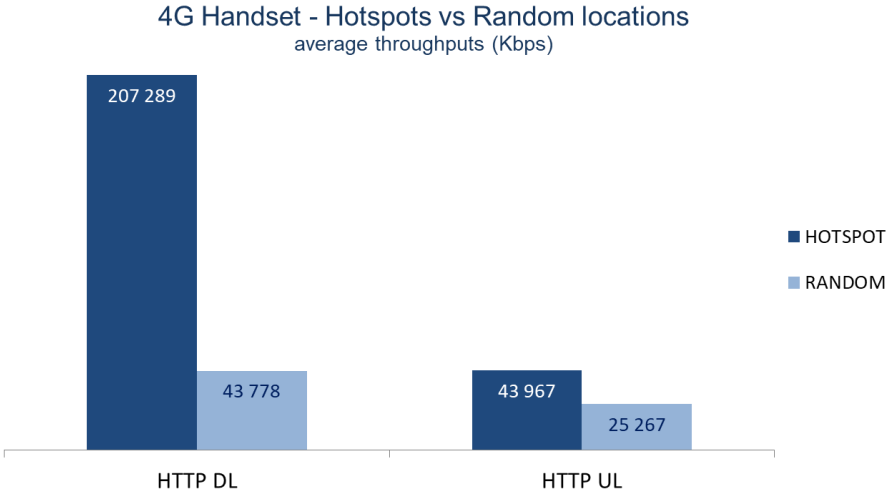


Figure 14 – 4G Handset Hotspots vs Random – average throughputs

The maximum throughput that have been reached during the audit is represented below:

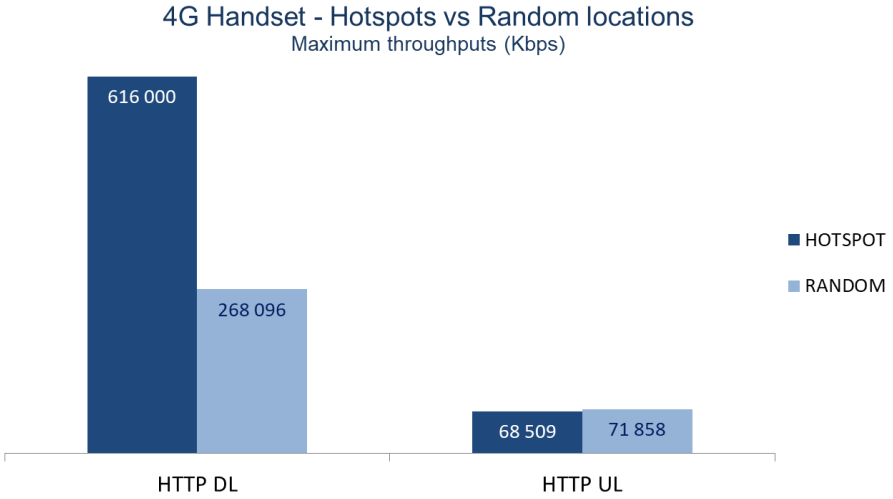
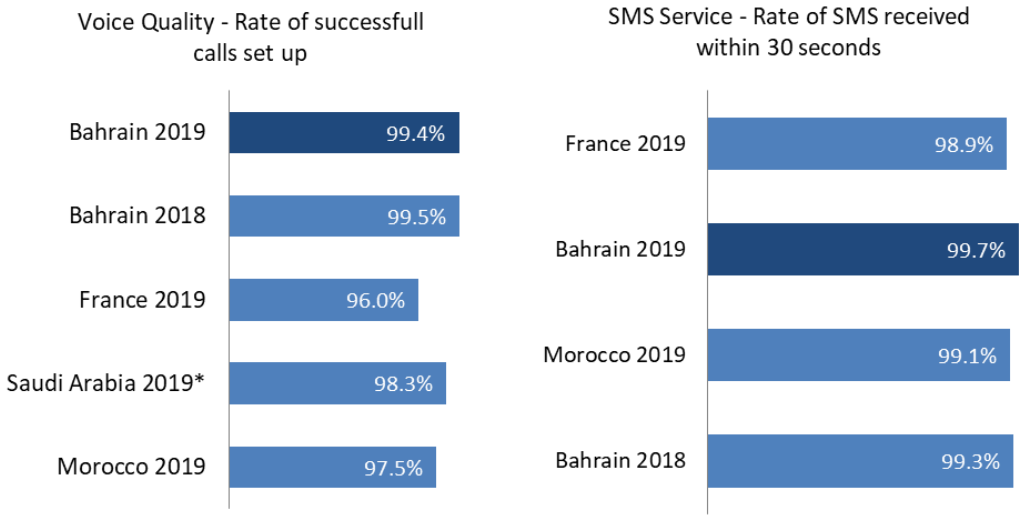


Figure 15 – 4G Handset Hotspots vs Random – maximum throughputs

4. International Benchmark to Reference Operators

The following charts compare the average results achieved by the three Mobile Operators in the Kingdom of Bahrain, Batelco, STC Bahrain and Zain, with the average results obtained by National Mobile Operators in the respective benchmarked markets. Measurements are based on compatible test procedures.

Results for Bahrain are the average combined results achieved by the 3 Mobile Operators.



*Saudi data is provided by the licensees and not gathered on the field and so may be more optimistic than TRA's approach.

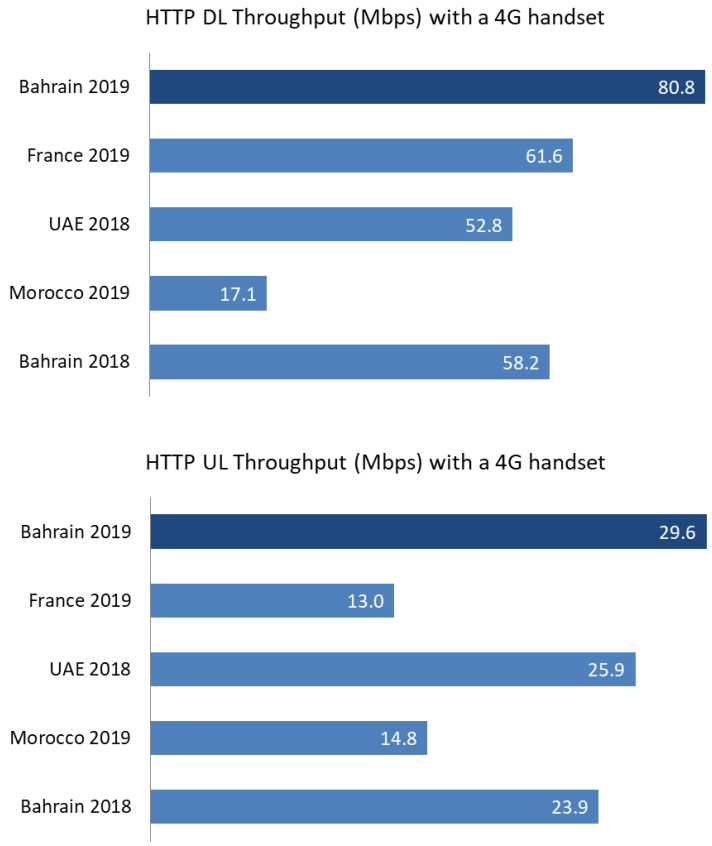


Figure 16 – Benchmark to reference operators

5. MEASUREMENTS SPECIFICATIONS

5.1. TEAM AND EQUIPMENT

5.1.1. TEAM

The project was managed by Directique Operations Director with the following project team:

- A dedicated project manager present in the Kingdom during audit launch phase.
- A field supervisor based in the Kingdom for the whole audit duration.
- Test team A performing voice and SMS measurements:
  - 2 engineers and a driver in the field;
  - 2 engineers in an office.
- Test team B performing data measurements:
  - 1 engineer in the field (tests were not carried out while driving)

5.1.2. EQUIPMENT

The following mobile devices have been selected, in agreement with Mobile Operators:

3G Handset	4G Handset
Samsung Galaxy S9	**Samsung Galaxy S10**
SM-G928F	SM-G975F
H+ 42 Mbps (HSPA+)	H+ 42 Mbps (HSPA+)
LTE 1024 Mbps (**Cat.18**)	LTE 2 Gbps (**Cat.20**)

All devices were compatible with voice, SMS and data technologies and were recommended or sold by Mobile Operators for 2G, 3G and 4G technologies. Batelco land lines were equipped with a standard fixed phone.

During Incar measurements, mobile phones were used without external antenna. For all voice measurements, a hands-free kit was used with mobile phones.

5.1.3. SIM CARDS

Directique has sourced the necessary SIM cards locally, from each tested mobile network operator, in a blind test approach.

50% of the tests have been done with prepaid SIMs, and 50% on the following postpaid packages:

SIM & Packages	PostPaid
Batelco	Super Package BD 16
STC Bahrain	New Postpaid LTE BD 19 Plan
Zain	Postpaid 15

5.2. VOICE SERVICE QUALITY TESTING

5.2.1. MEASUREMENT

A voice measurement was a call attempt followed by a 2 minutes conversation. Calls were placed on all networks simultaneously from the same physical location. A measurement was therefore a set of three calls, one per Mobile Operator.

A field engineer was conversing over his mobile phone with an engineer in the fixed office. The engineer in the office was using either a fixed-line phone or a mobile phone.

Each field team had one phone for each mobile network. Either side could initiate the call following pre-defined call sample objectives.

Call distribution was as follow:

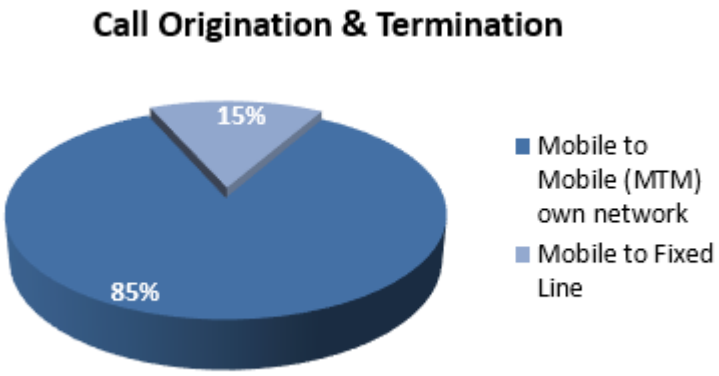


Figure 17 – Voice calls distribution

Voice measurements were performed in three configurations:

- Indoor : Pedestrian Indoor in public and private buildings
- Outdoor: Pedestrian Outdoor in the busiest outdoor places. 50% of the measurements were dynamic, and 50% were static.
- Incar: On road links (In car Road) and within Town borders (In car Town)

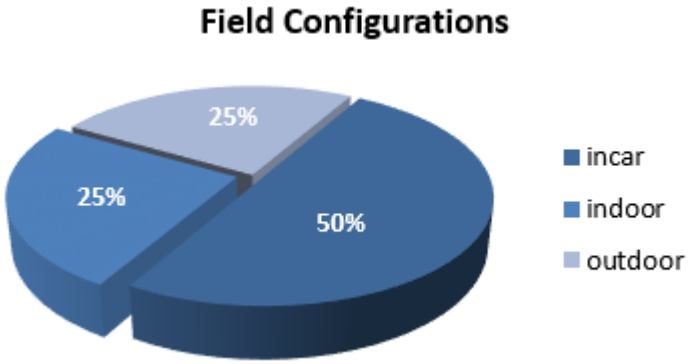


Figure 18 – Voice measurements type

Audio Quality marking:

Failed and dropped calls were registered in the database. Otherwise the audio quality was evaluated for established and 2 minutes maintained calls. Once a call was established, engineers followed a speech guideline, simulating an average conversation, and audio quality was marked on a scale from 1 to 4 as follows:

Level 4 : Perfect	Engineer doesn't notice any defect
Level 3 : Fair	One defect occurs while the conversation goes on uninterrupted
Level 2 : Poor	The natural flow of the conversation is altered and the engineer has to repeat himself
Level 1 : Bad	The defect is so strong that conversation cannot proceed.

Figure 19 – Audio Quality marking

As the call went on, each engineer took note of the identified defects such as metallic noises, voice distortion, echo... At the end of the call the fixed located engineer collected both marks on a scale from 1 to 4, did input results in the database, along with standard description of specific defect(s), if any. In the case field and fixed-end engineers had different evaluation for the call, the worst mark was retained.

5.2.2. TESTING AREA AND SAMPLE SIZE

Sampling distribution between towns was based on population data and organized as follow:

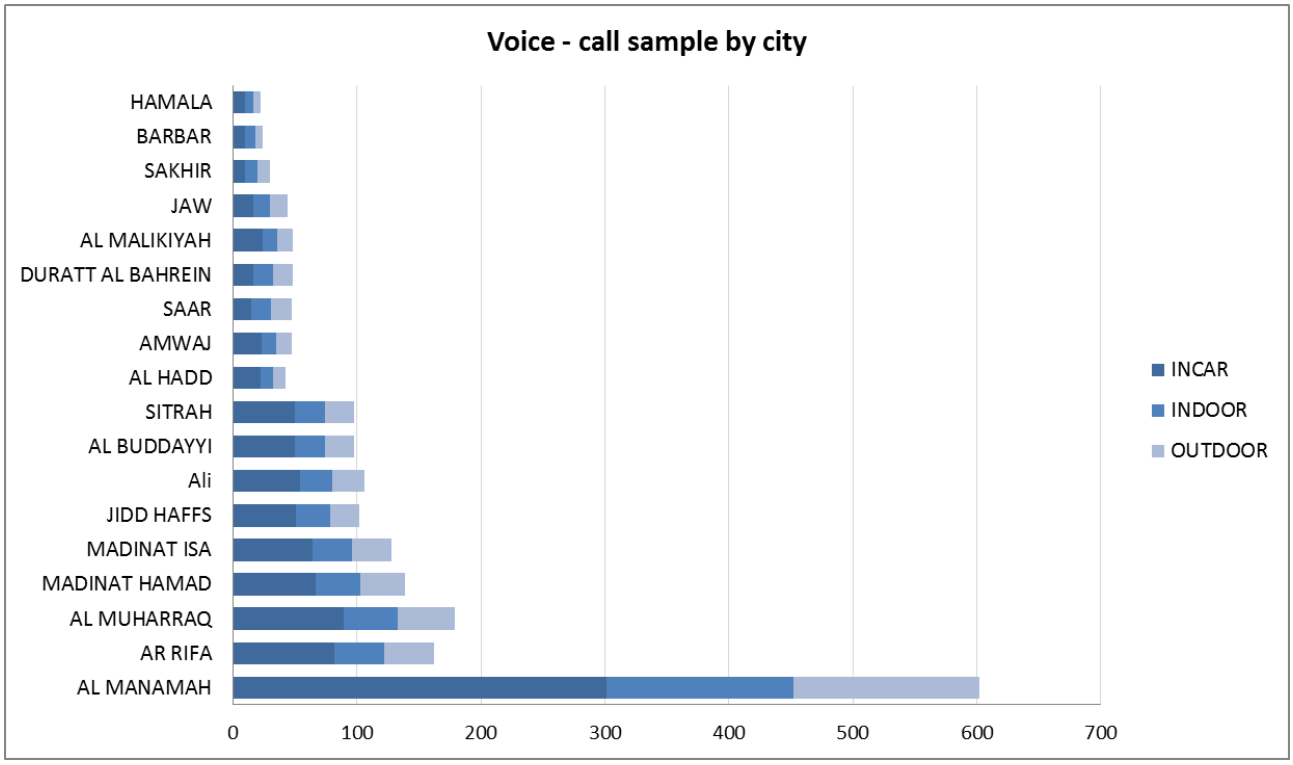


Figure 20 – Voice calls – sample by city

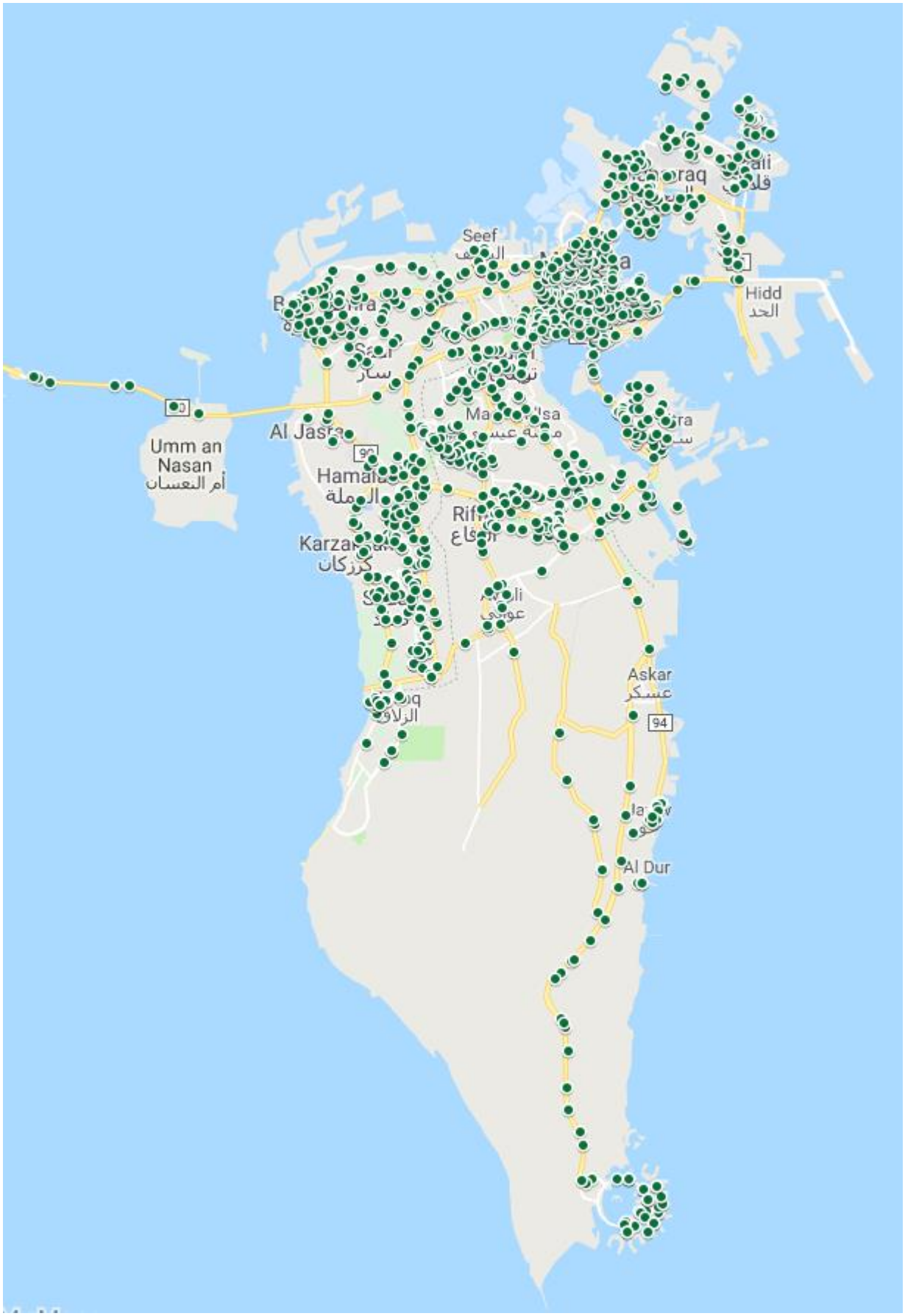


Figure 21 – Test locations: voice service

5.2.3. MEASUREMENTS SPECIFICATIONS – TOWNS

❖ ***In car measurements***

In Towns of more than 50,000 inhabitants, tested zone were divided into equal areas, and a number of calls were allocated to each of these areas. Field engineers did adapt their journey depending on external events (traffic, one way roads…), with the aim of covering the whole area as per test plan.

In smaller Towns (less than 50,000 inhabitants), measurements were performed on a paths that included major roads and constructed zones (Downtown, malls, stations, touristic places and business centres).

❖ ***Pedestrian measurements***

Pedestrian measurements were equally distributed over an area

- Pedestrian outdoor measurements

1/3 of measurements were dynamic (from a point to another) and 2/3 were static. A single test was performed for each location, to always ensure best repartition over the tested zone. Locations were selected among high-attendance pedestrian places (buildings, parks, malls ...)

- Pedestrian indoor measurements

Calls were placed preferably on daylight indoor (less than 3 meters from a window) or on deep indoor. Any floor in a particular building was tested, except basement and above 12th floor.

Measurements were adapted according to building types: 46% in the public places and 54% in offices and residential areas:

- Large locations: 3 to 4 measurements were performed
- Small locations: 1 to 2 measurements were performed

5.2.4. MEASUREMENTS SPECIFICATIONS – ROAD LINKS

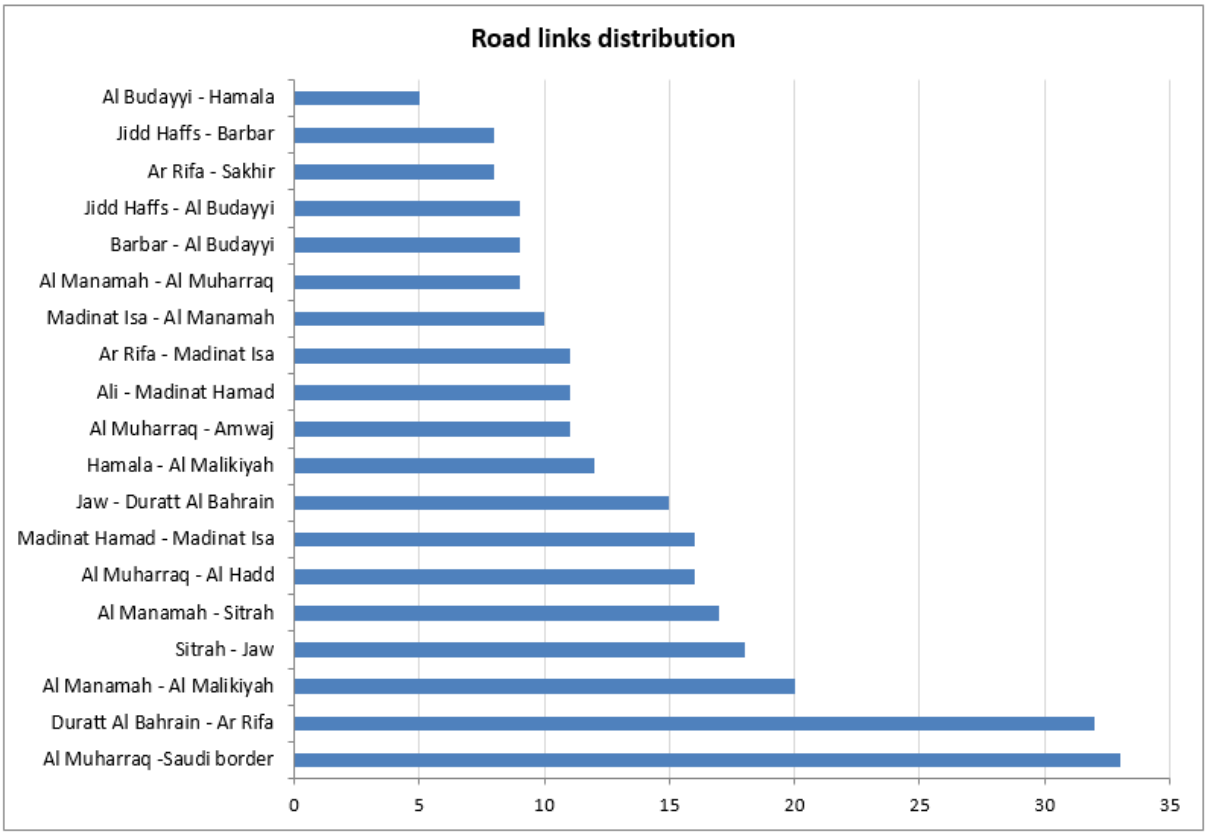


Figure 22 – Road links distribution

This histogram shows the number of incar voice calls made on each road link.

5.2.5. METHOD

Test methodology followed ITU ref P.800 Mean Opinion Score for voice specification.

The corner stone of Directique test methodology is based on a training method performed on a specifically developed software **FormaTest** ©.This training method allows for a clear and faithful marking system of audio and video quality problems. Directique guarantees consistency across engineers, and a minimum standard deviation of the marks.

All tests were timed stamped and GPS tagged, in order to ensure full traceability of each measurement.

Test phones were verified on a daily basis, and when allocated for field testing, handsets were rotated between teams regularly to avoid bias due to potential small differences between same model phones in radio frequency sensitivity and processor performance.

Measurements software assisted by **ChronoTest** ©, were started simultaneously by the mobile and the fixed operators to synchronize call start. The software provided engineers with all necessary information related to a test call, when a call had to be placed (either mobile originated or mobile terminated) and ended, in order to guarantee a strict adherence to test protocol. **ChronoTest** © was combined with a GPS receiver recording the location of the mobile team every second.

All information concerning test location and call marks were recorded by the engineer at the fixed-end location in a database who ran live coherence checks to guarantee error free recording.

Hands-free kits were used on mobile phones in order to minimize ambient noise and provide a better environment to the field engineer to measure quality of the voice service.

Outdoor, the phone was either held by hand, or placed in a pocket in areas where discretion was required.

5.2.6. NO DEFAULT PROCEDURE

In order to guarantee the same level of assessment for all Mobile Operators, engineers were regularly switched from one operator to another.

In order to prevent a faulty phone polluting measurement samples, phones used for the tests were new and tested prior the start of measurements campaign.

In case of abnormal behaviour of a handset, it was replaced and removed from the test pool.

Every week, test results were computed in a way that singled out any problem that could be related to a test phone.

5.2.7. STATISTICAL ACCURACY

For each KPI rate, the statistical accuracy gives the confidence interval of the result, under or above it; and is correlated to the size of the sample.

It is calculated using the following formula:

Statistical Accuracy = 1.96*SQR(R*(1-R)/N), where:

R = Result

N = Sample

SQR = Square Root

5.3. SMS MEASUREMENTS

The mobile phones used to receive SMS were at a fixed location in an area served by a strong radio signal from the Mobile Operators. The mobile phones transmitting the SMS were in the field with the testing team. SMS were sent from indoor and outdoor locations used for voice testing to a fixed location.

A measurement, made simultaneously on all Mobile Networks, consisted of:

- Sending a 26 characters message including an index, and recording time
- Observing reception of the message on the other phone and taking note of the time; a message not received after 2 minutes elapse time was marked as failed.
- Opening and checking integrity of the received message and index matching

SMS test areas excluded road links, SMS testing schedule was the same as for voice testing.

5.4. DATA SERVICE TESTING

5.4.1. DESCRIPTION

Data measurements are spread between hotspots and random places.

Hotspots are pre-defined locations where operators have deployed newly deployed technologies at those specific cell sites, which are supposed to have better performances. A list of 10 hotspots has been given by each operator, among which 9 have been selected for the audit.

Data measurements were done on 2 sets of smartphones for each operator:

- a set of smartphones LTE enabled – Network mode = auto (2G/3G/4G)
- a set of smartphones with no LTE enabled – Network mode = auto (2G/3G)

Tests have been done simultaneously on every location, on test servers provided by each operator for its own set of measurements.

		3G - Smartphone	4G - Smartphone
RANDOM	**HTTP DL / HTTP UL / /WEB**	✓	✓
	Video streaming	✓	✓
	Social Networks (Facebook, Instagram and WhatsApp)	✓	✓
HOTSPOTS	**HTTP DL / HTTP UL / /WEB**	✓	✓
	Video streaming	✓	✓
	Social Networks (Facebook, Instagram and WhatsApp)	✓	✓

Figure 23 – Data tests matrix

5.4.2. HTTP TRANSFER MEASUREMENTS

New Protocol in 2019 :

On each network, a measurement consists of:

- Downloading a large file* through HTTP during 10 seconds
- Uploading a file* through HTTP during 10 seconds

* File size = 1GB

Test servers, with sufficient bandwidth (100Mb/s) have been provided by the operators.

Data measurements were carried out automatically via ***Mobispeed***©, a data test app developed by Directique.

5.4.3. WEB BROWSING MEASUREMENTS

WEB measurements were carried out automatically via ***Mobispeed***©.

On each network, a measurement consists of downloading one of the 10 most visited public homepages and one page from each Operator, taking note of completion time, errors on the page if any, with a 30 seconds timeout.

The final list of websites retained (which are common among the three operators) for the tests and after analysis of the results is:

http://www.amazon.com
http://www.apple.com
http://www.expatriates.com
http://www.facebook.com
http://www.instagram.com
http://www.microsoft.com
http://www.msn.com
http://www.youtube.com
http:/www.facebook.com

Figure 24 – List of webpages tested

5.4.4. STREAMING MEASUREMENTS

Streaming Measurements have been carried out by assessing the quality of selected ***YouTube*** videos with smartphones in order to represent the customer experience as close as possible. The evaluation started when the video was launched and lasted 2 minutes.
Each video and audio defect was categorized and its duration was collected in order to determine if the viewing was perfect, fair, poor or bad. Once the sequence had been completed, a grade was given to describe 3 global appraisal criteria (sharpness, audio/video synchronization and sound quality)

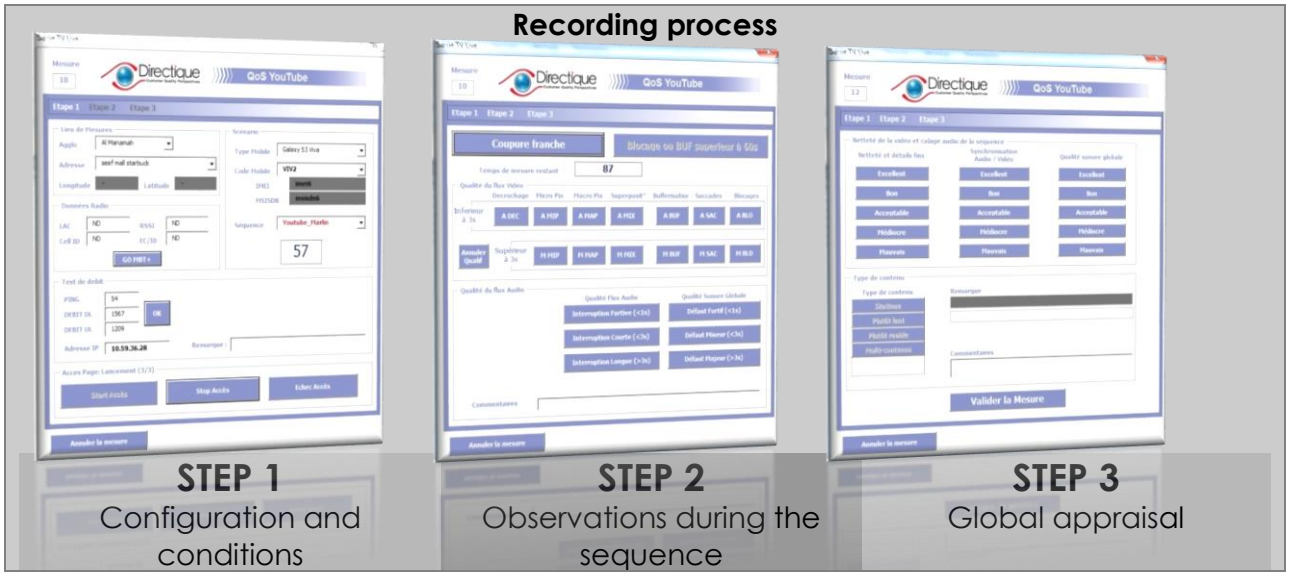


Figure 25 – Streaming tests – recording process

Defects correspond to damages occurring during the assessment and detailed hereafter:

Video appraisal criteria	
SUPERIMPOSITION	Superimposition or interlaced images during transitions between frames
PIXELATION	Single-colored square display elements that comprise the bitmap are visible.
BUFFERING	The sequence stops, a message showing the buffering percentage appears.
JERKINESS	When the frame rate is under 18fps, individual still images may be perceived by the viewer.
FREEZE	A Freeze occurs when the sequence shows a still image during a few seconds
Audio appraisal criteria	
AUDIO INTERRUPTIONS	Silences are categorized as furtive (< 1s), short (< 3s) or long (> 3s)
AUDIO DEFECTS	Punctual audio defects perceived by the user including distortions, crackling, metallic sounds and echoes.
Global appraisal criteria	
AUDIO SEQUENCE QUALITY	Overall audio quality of the sequence
SHARPNESS	Sharpness reflects the level of detail in the images displayed.
AUDIO/VIDEO SYNCHRONIZATION	The level of desynchronization is measured proportionally to the length of the delay between audio and video.

Figure 26 – video streaming – quality appraisal

2 types of video are evaluated: 50% of Standard Definition (480p) and 50% of High Definition (1 080p)

However, global result is calculated without type distinction.

5.4.5. SOCIAL NETWORKS

- **Facebook**

Facebook measurements have been made manually in 2019
The test consisted in taking a photo with the device, and sharing it on Facebook.
The technician measured the total delay for posting the photo, using a semi-automatic input tool to save the results in a data base.

- **Instagram**

Instagram tests have been made manually by the tester, using a semi-automatic input tool to save the results in a data base.
Each operator have been tested separately, one after the other, in order to keep the same testing conditions.
In order to simulate a regular customer experience, the test consisted in sharing content on Instagram.

- **WhatsApp**

WhatsApp has been tested on both Voice and Messaging services, with the exact protocol used for Voice and SMS audit.

5.4.6. SAMPLE

CITY	HTTP DL	HTTP UL	WEB	STREAMING	FACEBOOK	INSTAGRAM	Total
Al Budayyi	87	88	851	151	22	18	**1 217**
Al Hadd	96	96	954	116	20	16	**1298**
Al Malikiyah	58	58	571	108	6	12	**813**
Al Manamah	606	613	5 938	910	131	151	**8 349**
Al Muharraq	100	100	920	148	22	10	**1 300**
Ali	60	60	520	78	16	6	**740**
Amwaj	60	60	569	120	24	12	**845**
Ar Rifa	169	168	1 360	249	30	34	**2 010**
Barbar	44	44	437	40	10	4	**579**
Duratt Al Bahrein	187	187	1777	192	24	20	**2387**
Hamala	113	113	1035	102	12	16	**1391**
Jaww	54	55	546	108	6	12	**781**
Jidd Hafs	195	193	1 811	291	36	40	**2 566**
Madinat Hamad	182	181	1 780	341	46	42	**2 572**
Madinat Isa	131	132	1 270	246	28	28	**1 835**
Saar	141	141	1377	231	24	32	**1 946**
Sakhir	53	52	514	81	6	16	**722**
Sitrah	68	68	663	148	12	12	**971**
Total	**2404**	**2 409**	**22 893**	**3 660**	**475**	**481**	**32 322**

Figure 27 – Smartphone test sample distribution

5.5. INTERCONNECTIVITY MEASUREMENTS

In order to evaluate the interconnectivity between networks, we have used an automated system that launched crossed network calls following a predefined script. Those platforms, which consist of a laptop connected to regular phones through our tool Mobitrace, have been installed in several places in Manama and have launched calls continuously during several hours' sessions.
The called mobiles were installed in, our office in Manama, under good radio conditions, and were configured to pick up automatically when called.
On each location, 2 configurations have been tested:

- 1st configuration : Batelco to STC Bahrain / STC Bahrain to Zain / Zain to Batelco
- 2nd configuration : Batelco to Zain / STC Bahrain to Batelco / Zain to STC Bahrain

The rate of calls set-up has been compared with Voice audit results (own network) within each operators section in the report.

6. AUDITS RESULTS

6.1. KEY PERFORMANCE INDICATORS

6.1.1. VOICE KPIS

A voice measurement is a successful call attempt followed by a 2 minutes conversation, with an assessment of the audio voice quality for each operator service.

KPIs	Definition
SHC (Set-up and held for 2 min calls)	% of calls set-up and held for 2 min. Call set-up on first attempt and held for 2 min without drop.
PQR (Perfect quality rate)	% of calls set-up held for 2 min and marked 4. Calls excluded = failed on first attempt, dropped before 2 min, or been marked 3 or lower. Rate based on total sample
CQR (Correct quality rate)	% of calls set-up held for 2 min and marked 4. Calls excluded = failed on first attempt, dropped before 2 min, or been marked 2 or lower. Rate based on total sample

6.1.2. SMS KPIS

KPIs	Definition
RS 2 (% of received SMS within 2 minutes)	SMS not refused when sent out and received within 2 minutes. Rate based on total sample
RS 30 (% of SMS received SMS within 30 sec)	SMS not refused when sent out and received within 30 seconds without being altered. Rate based on total sample
RS 15 (% of SMS received SMS within 15 sec)	SMS not refused when sent out and received within 15 seconds without being altered.

6.1.3. HTTP

KPIs	Definition
Average Throughput	Average throughput once connected, applied only to successful data transfers
Best Throughput	Best throughput recorded for a data transfer measurement

6.1.4. WEB KPIs

KPIs	Definition
% of successful data transfers	Successful page loading within 60s. Rate based on total sample
Average download time	Average delay once connected, applied only to successful data transfers
Min download time	Best delay to load a webpage
Standard deviation download time	Standard download time deviation applied only to successful data transfers
WEB10 : % of successful data transfers within 10 seconds	Successful page loading within 10s. Rate based on total sample

6.1.5. STREAMING KPIs

KPIs	Definition
LHV : % of videos set-up and held for 2 min	Video launched on first attempt, and held for 2 min without drop
VPQR : % of videos set-up, held for 2 min, and marked 4	Video excluded = failed on first attempt, dropped before 2 min, or been marked 3 or lower - (PQR : Perfect Quality Rate)
VCQR : % of videos set-up, held for 2 min, and marked 3 or 4	Video excluded = failed on first attempt, dropped before 2 min, or been marked 2 or lower - (CQR : Correct Quality Rate)
Delay (min, average)	delay between the launch click and the beginning of the sequence

6.1.6. FACEBOOK

KPIs	Definition
Average Upload Throughput	Average throughput during the 30 seconds of upload
Best Throughput	Best throughput during the 30 seconds of upload

6.1.7. INSTAGRAM

KPIs	Definition
Rate of successful publications (%)	Successful data transfer without radio drop. Indicator is based on the total number of connection attempts
Average delay to publish (access+post) (s)	delay between the selection of "Share/Instagram" and the publication of the picture

6.1.8. WHATSAPP

KPIs	Definition
PQR (Perfect quality rate)	% of calls set-up held for 2 min and marked 4. Calls excluded = failed on first attempt, dropped before 2 min, or been marked 3 or lower. Rate based on total sample
RS 30 (% of received messages within 30 sec)	Messages not refused when sent out and received within 30 seconds without being altered.

6.2. BATELCO RESULTS

6.2.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

		Batelco
Global voice service		943 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.5%** *+/-0.5%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**98.9%** *+/-0.7%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**99.4%** *+/-0.5%*

Figure 28 – Voice – Global results

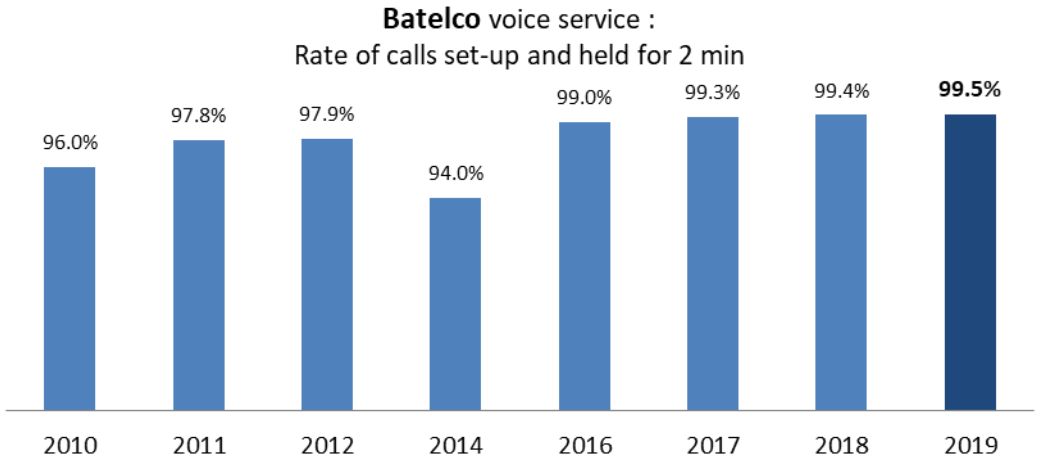


Figure 29 – Voice – Global results evolution

		Batelco
Cities voice service (incar, outdoor, indoor)		832 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.8%** *+/-0.3%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.3%** *+/-0.6%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**99.6%** *+/-0.4%*

Figure 30 – Voice – Cities results

		Batelco
Cities voice service (incar only)		425 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.5%** *+/-0.7%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.3%** *+/-0.8%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**99.6%** *+/-0.7%*

Figure 31 – Voice – Cities incar results

		Batelco
Roads (incar)		111 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**97.3%** *+/-3.0%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**96.4%** *+/-3.5%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**97.3%** *+/-3.0%*

Figure 32 – Voice – road links results

VoLTE:
50% of voice measurements were in volte, in cities and on road links.
Device for those tests was the Samsung Galaxy S10.

		Batelco
Global voice service		1 248 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.3%** *+/-0.5%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.0%** *+/-0.6%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**99.2%** *+/-0.5%*

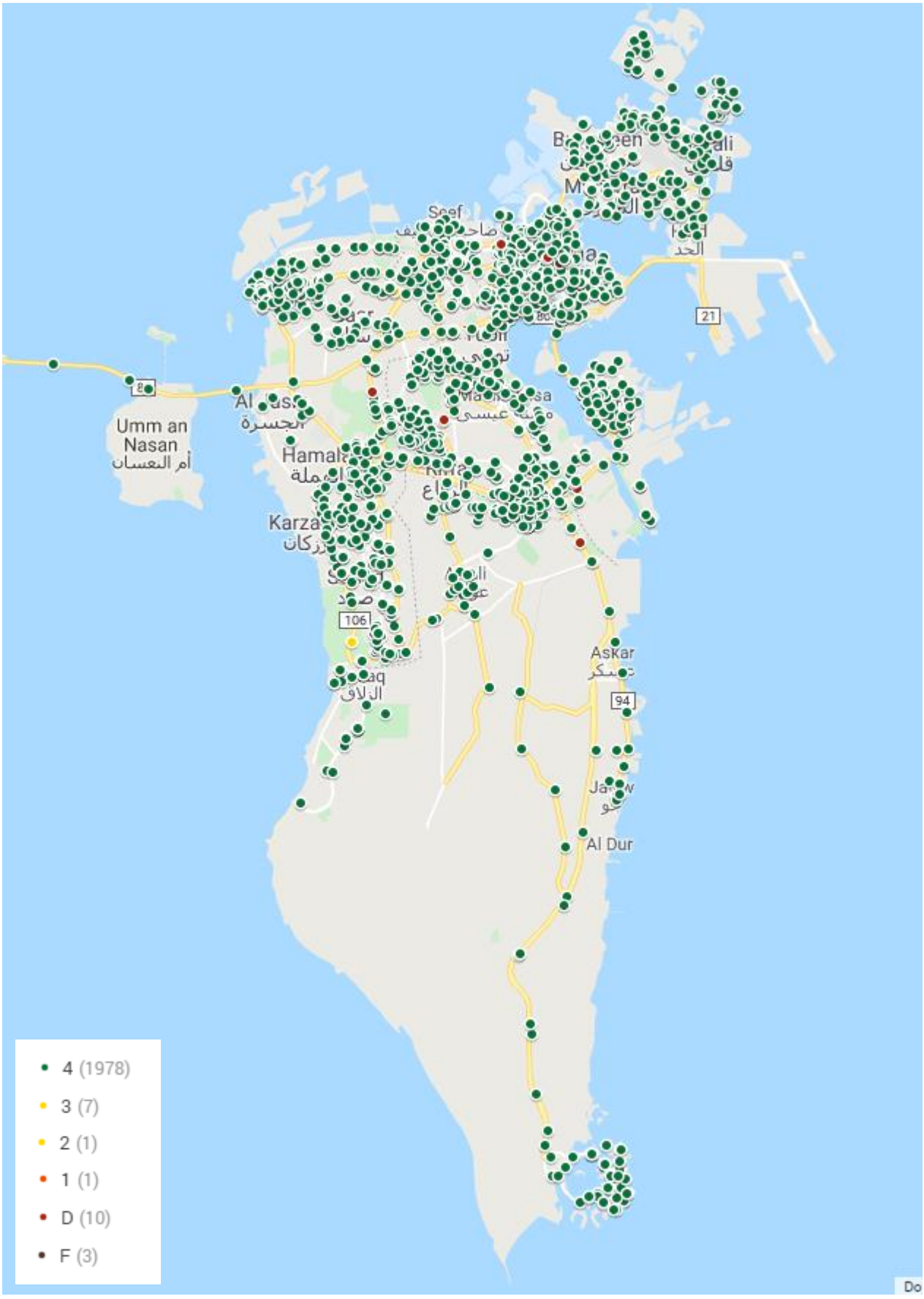


Figure 33 – BATELCO Global voice results

6.2.2. SMS RESULTS

	Batelco
SMS service	978 tests
% of received SMS (RS2)	**100%**
Statistical accuracy	*+/-0.0%*
% of received SMS (RS30)	99.9%
Statistical accuracy	*+/-0.2%*
% of received SMS (RS15)	99.7%
Statistical accuracy	*+/-0.3%*
Average reception delay (s)	2.4

Figure 34 – SMS - Global results

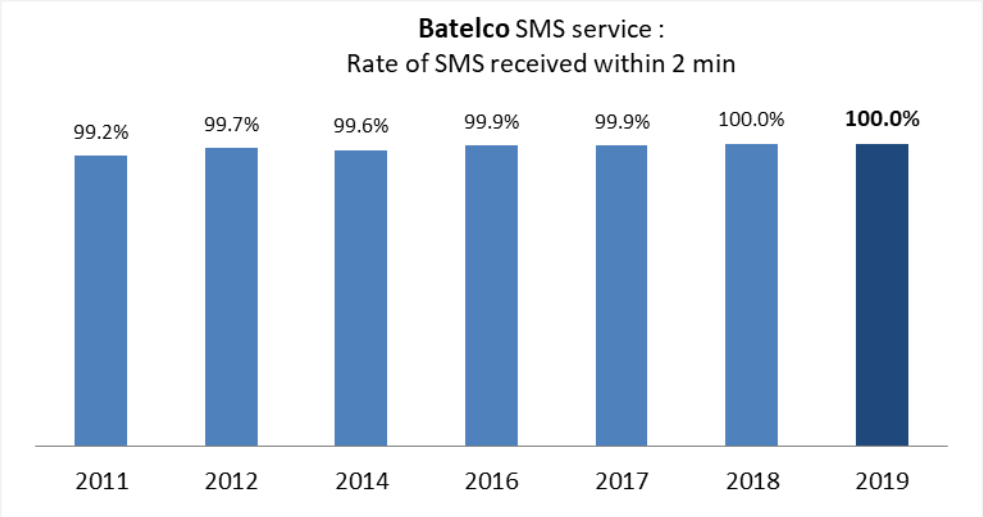


Figure 35 – SMS - Global results evolution

6.2.3. DATA SMARTPHONE RESULTS

6.2.3.1. 3G HANDSET

	Batelco
HTTP DL	385 tests
Average Throughput (kbps)	**9 480**
Max throughput (kbps)	**26 645**
Standard deviation throughput (kbps)	6 597
% data transfers with a throughput > 2Mbps	86.2%
% data transfers with a throughput > 5.1Mbps	67.0%

Figure 36 – 3G Handset – HTTP DL

	Batelco
HTTP UL	386 tests
Average Throughput (kbps)	**2 253**
Max throughput (kbps)	**4 223**
Standard deviation throughput (kbps)	1 159
% data transfers with a throughput > 2Mbps	86.2%

Figure 37 – 3G Handset – HTTP UL

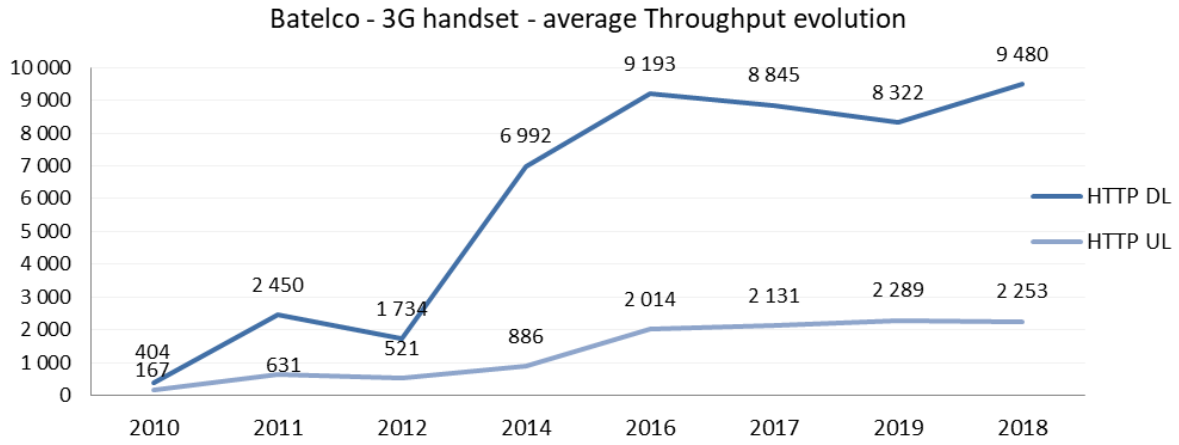


Figure 38 – 3G Handset – HTTP DL&UL – Throughputs evolution

	Batelco
WEB	3 863 tests
Rate of successful webpage download Statistical accuracy	**98.2%** +/-0.4%
Average download time (s)	4.5
Min download time (s)	1.0
Standard deviation download time (s)	3.5
% webpage download within 10 seconds	93.2%

Figure 39 – 3G Handset – WEB Browsing

6.2.3.2. 4G HANDSET

	Batelco
HTTP DL	388 tests
Average Throughput (kbps)	**116 802**
Max throughput (kbps)	**616 000**
Standard deviation throughput (kbps)	130 054
% data transfers with a throughput > 2Mbps	99.2%
% data transfers with a throughput > 5.1Mbps	95.6%

Figure 40 – 4G Handset – HTTP DL

	Batelco
HTTP UL	390 tests
Average Throughput (kbps)	**28 360**
Max throughput (kbps)	**66 233**
Standard deviation throughput (kbps)	15 313
% data transfers with a throughput > 2Mbps	99.0%

Figure 41 – 4G Handset – HTTP UL

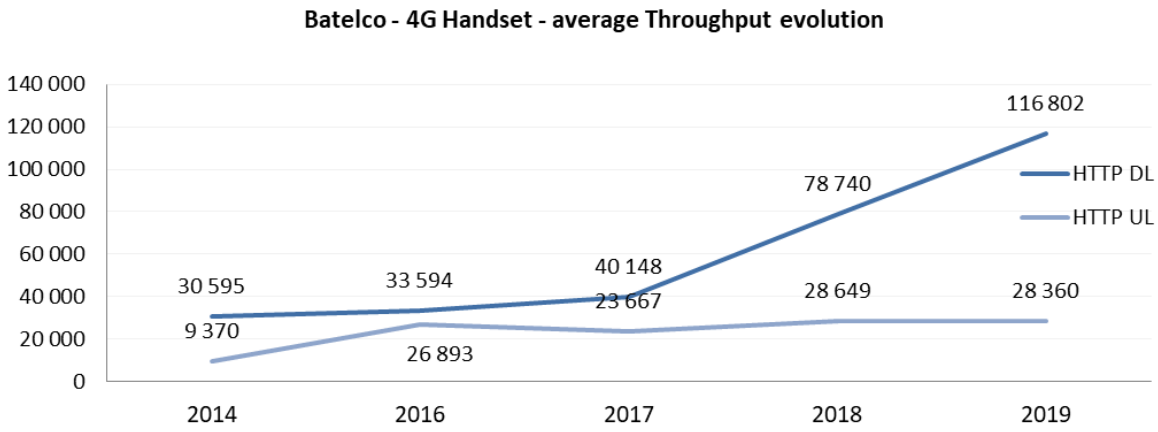


Figure 42 – 4G Handset – HTTP DL&UL – Throughputs evolution

	Batelco
WEB	3 824 tests
Rate of successful webpage download Statistical accuracy	**99.9%** +/-0.1%
Average download time (s)	2.5
Min download time (s)	0.5
Standard deviation download time (s)	2.3
% webpage download within 10 seconds	98.0%

Figure 43 – 4G Handset – WEB Browsing

6.2.4. STREAMING KPIS

6.2.4.1. STREAMING – 3G HANDSET VS 4G HANDSET

	4G HANDSET	3G HANDSET
Sample	625 tests	609 tests
LHV : % of videos set-up and held for 2 min statistical accuracy	**100.0%** *+/-0.0%*	**100.0%** *+/-0.0%*
VPQR : % of videos set-up, held for 2 min, and marked 4 statistical accuracy	98.6% *+/-0.9%*	85.1% *+/-2.8%*
VCQR : % of videos set-up, held for 2 min, and marked 3 or 4 statistical accuracy	99.0% *+/-0.8%*	88.5% *+/-2.5%*
Average delay	2.3	3.1
Minimum delay	0.8	1.0

Figure 44 – Video Streaming

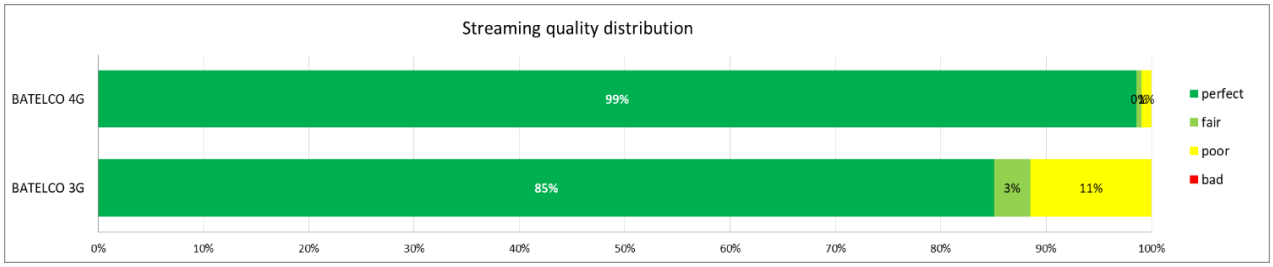


Figure 45 – Streaming – Quality distribution

6.2.4.2. STREAMING – HIGH DEF. (HD) VS STANDARD DEF. (SD)

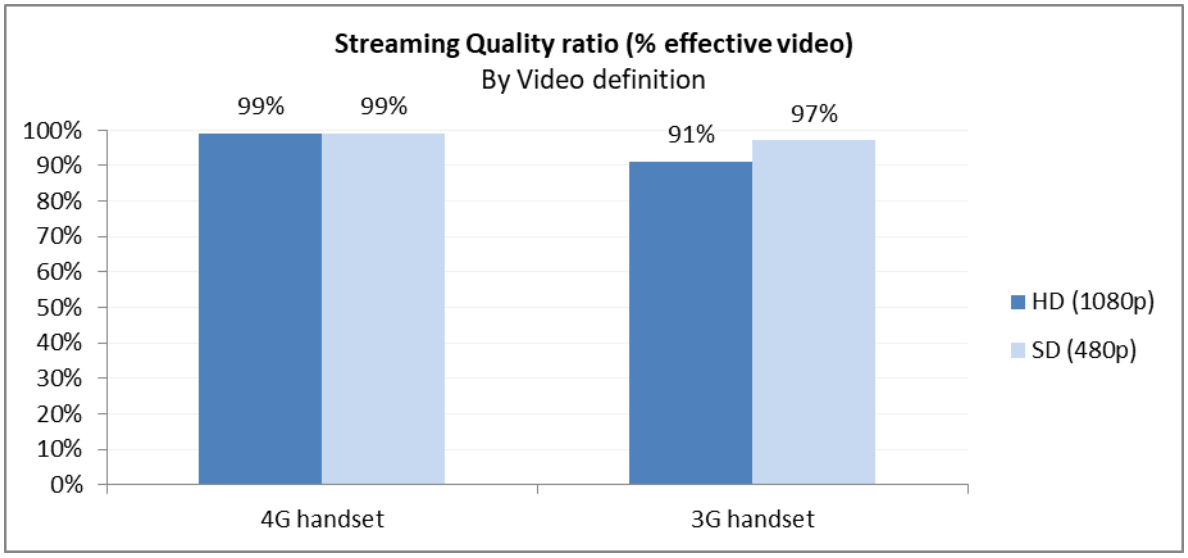


Figure 46 – Quality ratio by video definition: % of time playing video flow, not impacted by video freeze

6.2.5. FACEBOOK KPIS

	Batelco	
	4G handset	3G handset
Total sample	84 tests	85 tests
Rate of successful publications (%)	100.0%	100.0%
Average delay to publish (access + post) (s)	3.9	4.4

Figure 47 – Facebook results

6.2.6. INSTAGRAM KPIS

	Batelco	
	4G handset	3G handset
Total sample	76 tests	75 tests
Rate of successful publications (%)	100.0%	100.0%
Average delay to publish (access + post) (s)	4.5	5.1

Figure 48 – Instagram results

6.2.7. WHATSAPP KPIS

	Batelco
Sample	158 tests
Rate of calls set-up and held for 2 min 4-perfect (PQR)	**98.1%**
statistical accuracy	+/-2.1%
Rate of successful received Messages (%)	99.4%
Average delay to send a message (seconds)	1.0

Figure 49 – WhatsApp results

6.2.8. INTERCONNECTIVITY CALLS

	Batelco to STC Bahrain	Batelco to Zain	Batelco to other networks
Sample	705 tests	705 tests	1 410 tests
Rate of calls set-up	99.9%	100.0%	99.9%
statistical accuracy	+/-0.3%	+/-0.0%	+/-0.1%

Figure 50 – Interconnectivity results

Cross network testing show no issues and is at least at the same quality level than own.

6.3. STC BAHRAIN RESULTS

6.3.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

		STC Bahrain
Global voice service		938 tests
Rate of calls set-up and held for 2 min	*statistical accuracy*	**99.7%** *+/-0.4%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.4%** *+/-0.5%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**99.6%** *+/-0.5%*

Figure 51 – Voice – Global results

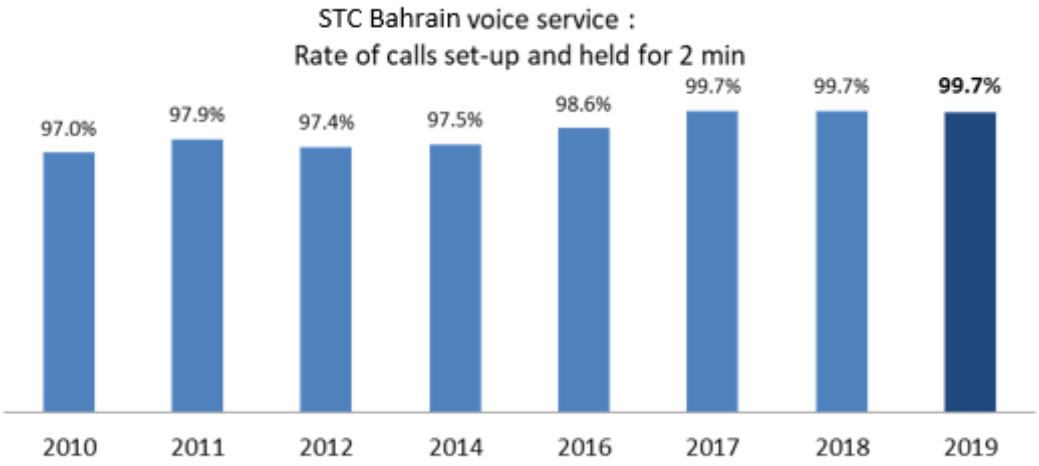


Figure 52 – Voice – Global results evolution

		STC Bahrain
Cities voice service (incar, outdoor, indoor)		826 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.6%** *+/-0.4%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.3%** *+/-0.6%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**99.5%** *+/-0.5%*

Figure 53 – Voice – Cities results

		STC Bahrain
Cities voice service (incar only)		187 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**100%** *+/-0.0%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.5%** *+/-1.0%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**100%** *+/-0.0%*

Figure 54 – Voice – Cities incar results

		STC Bahrain
Road links service		112 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**100%** *+/-0.0%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**100%** *+/-0.0%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**100%** *+/-0.0%*

Figure 55 – Voice – road links results

VoLTE:
50% of voice measurements were in volte, in cities and on road links.
Device for those tests was the Samsung Galaxy S10.

		STC Bahrain
Global voice service		1 249 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.9%** *+/-0.2%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.6%** *+/-0.4%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**99.8%** *+/-0.2%*

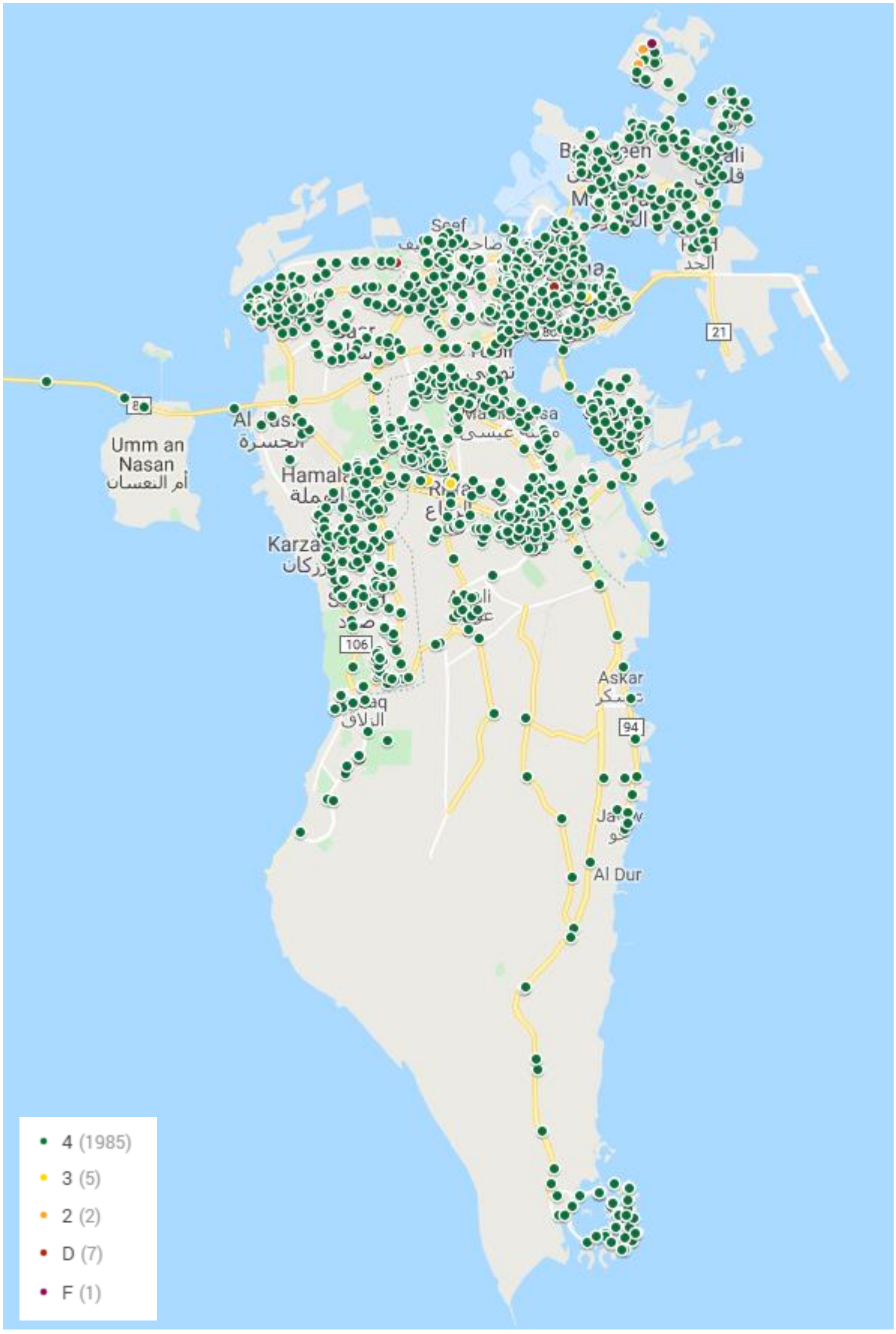


Figure 56 – STC BAHRAIN Global voice results

6.3.2. SMS RESULTS

	STC Bahrain
SMS service	865 tests
% of received SMS (RS2)	**100%**
Statistical accuracy	*+/-0.0%*
% of received SMS (RS30)	99.8%
Statistical accuracy	*+/-0.3%*
% of received SMS (RS15)	99.7%
Statistical accuracy	*+/-0.4%*
Average reception delay (s)	2.5

Figure 57 – SMS - Global results

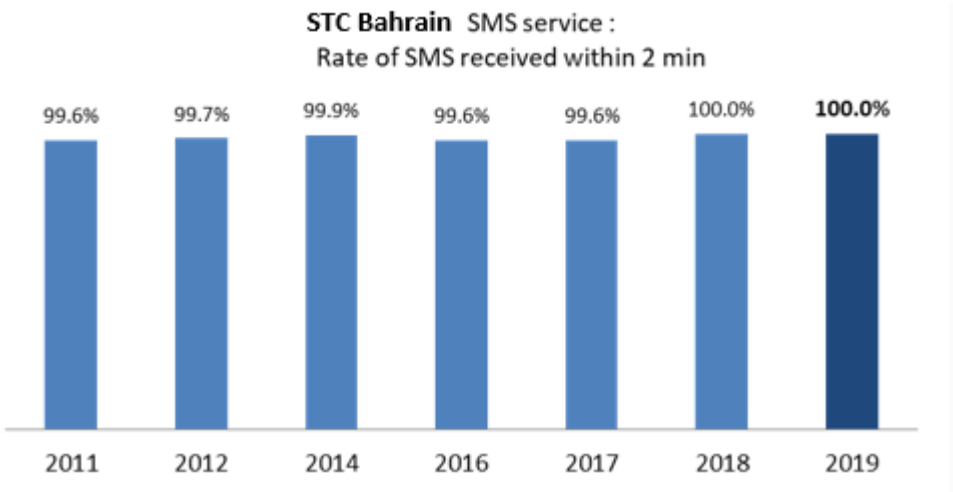


Figure 58 – SMS - Global results evolution

6.3.3. DATA SMARTPHONE RESULTS

6.3.3.1. 3G HANDSET

	STC Bahrain
HTTP DL	385 tests
Average Throughput (kbps)	**10 474**
Max throughput (kbps)	**34 569**
Standard deviation throughput (kbps)	6 652
% data transfers with a throughput > 2Mbps	94.8%
% data transfers with a throughput > 5.1Mbps	75.3%

Figure 59 – 3G Handset – HTTP DL

	STC Bahrain
HTTP UL	386 tests
Average Throughput (kbps)	**3 167**
Max throughput (kbps)	**4 736**
Standard deviation throughput (kbps)	998
% data transfers with a throughput > 2Mbps	94.8%

Figure 60 – 3G Handset – HTTP UL

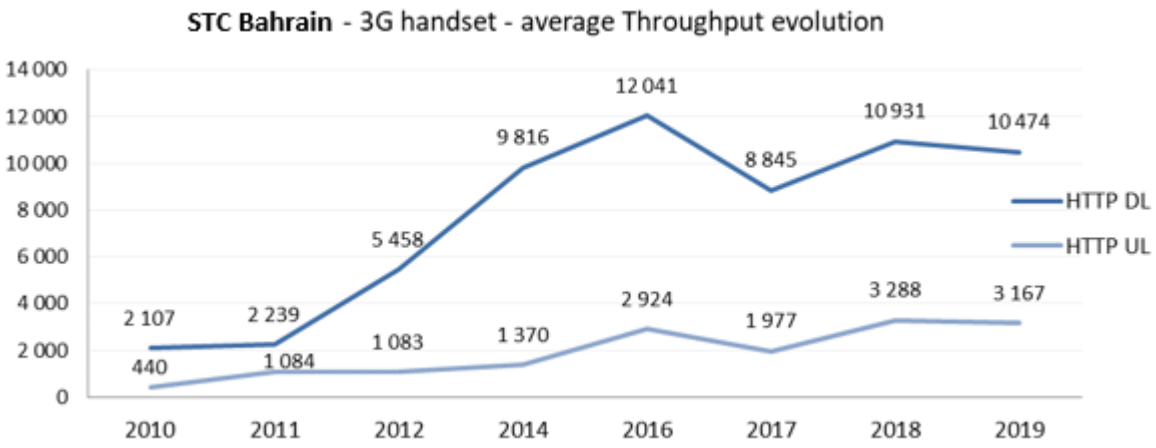


Figure 61 – 3G HANDSET – HTTP DL and UL - throughput evolution

	STC Bahrain
WEB	3 851 tests
Rate of successful webpage download Statistical accuracy	**99.3%** +/-0.3%
Average download time (s)	3.8
Min download time (s)	0.2
Standard deviation download time (s)	2.5
% webpage download within 10 seconds	96.8%

Figure 62 – 3G Handset – WEB Browsing

6.3.3.2. 4G HANDSET

	STC Bahrain
HTTP DL	399 tests
Average Throughput (kbps)	**94 167**
Max throughput (kbps)	**384 942**
Standard deviation throughput (kbps)	101 965
% data transfers with a throughput > 2Mbps	99.0%
% data transfers with a throughput > 5.1Mbps	96.0%

Figure 63 – 4G Handset – HTTP DL

	STC Bahrain
HTTP UL	399 tests
Average Throughput (kbps)	**37 150**
Max throughput (kbps)	**71 858**
Standard deviation throughput (kbps)	21 113
% data transfers with a throughput > 2Mbps	99.2%

Figure 64 – 4G Handset – HTTP UL

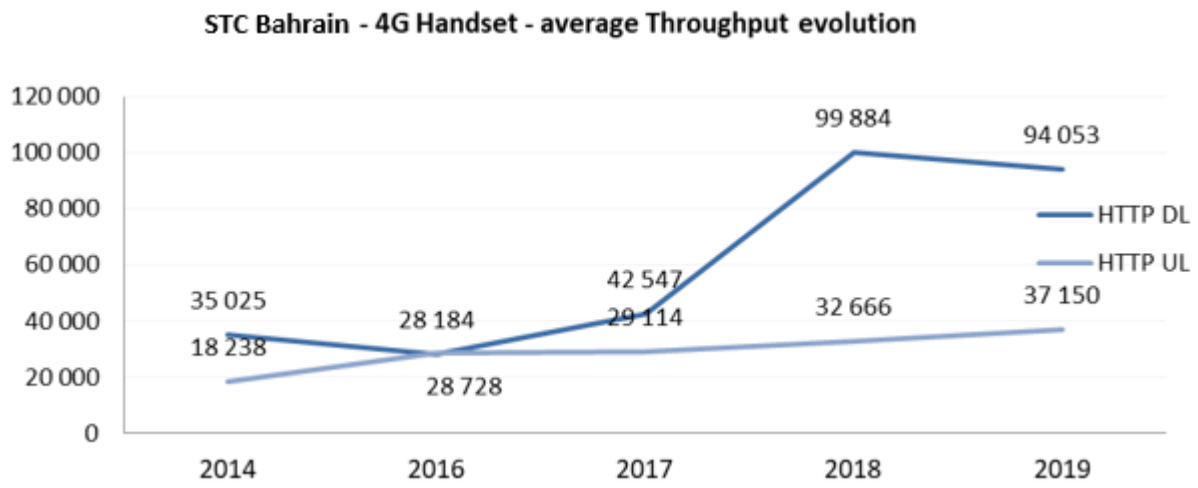


Figure 65 – 4G Handset – HTTP DL&UL – Throughputs evolution

	STC Bahrain
WEB	3 718 tests
Rate of successful webpage download Statistical accuracy	**99.9%** +/-0.1%
Average download time (s)	2.6
Min download time (s)	0.2
Standard deviation download time (s)	1.9
% webpage download within 10 seconds	98.5%

Figure 66 – 4G Handset – WEB Browsing

6.3.4. STREAMING KPIS

6.3.4.1. STREAMING – 3G HANDSET VS 4G HANDSET

	4G HANDSET	3G HANDSET
Sample	605 tests	609 tests
LHV : % of videos set-up and held for 2 min	**100.0%**	**100.0%**
statistical accuracy	*+/-0.0%*	*+/-0.0%*
VPQR : % of videos set-up, held for 2 min, and marked 4	97.9%	92.3%
statistical accuracy	*+/-1.2%*	*+/-2.1%*
VCQR : % of videos set-up, held for 2 min, and marked 3 or 4	99.3%	95.2%
statistical accuracy	*+/-0.6%*	*+/-1.7%*
Average delay	2.6	2.7
Minimum delay	0.7	1.0

Figure 67 – Video Streaming

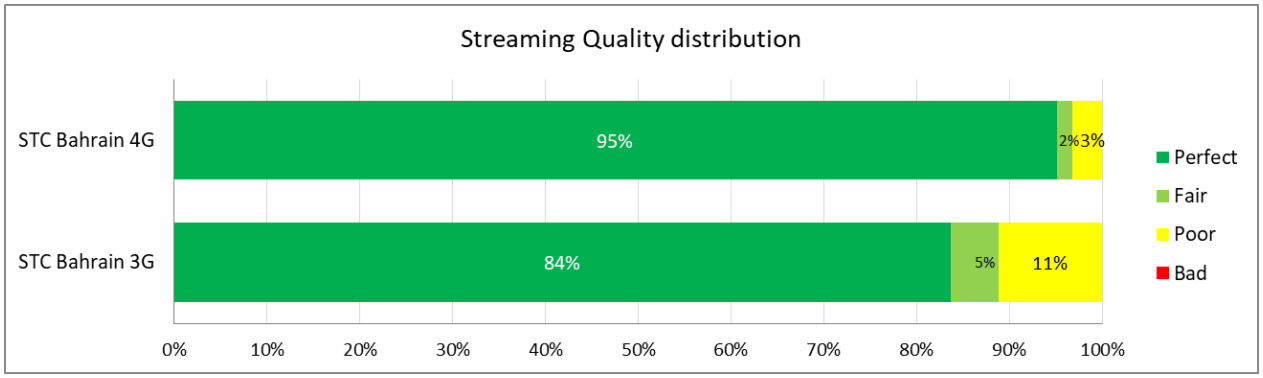


Figure 68 – Streaming – Quality distribution

6.3.4.2. STREAMING – HIGH DEF. (HD) VS STANDARD DEF. (SD)

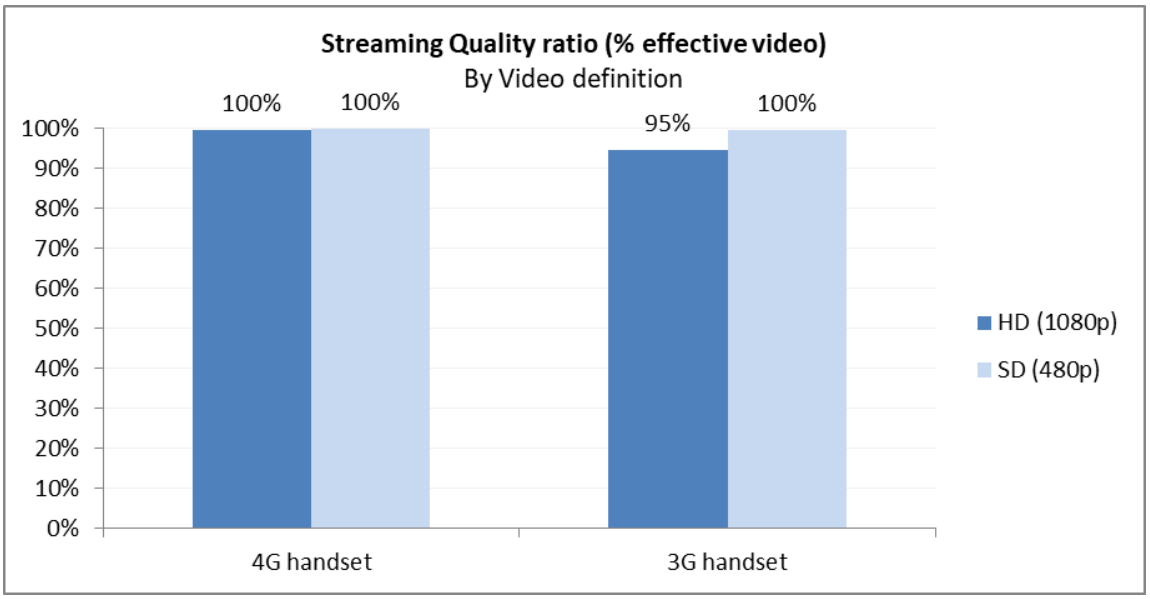


Figure 69 – Quality ratio by video definition: % of time playing video flow, not impacted by video freeze

6.3.5. FACEBOOK KPIS

	STC Bahrain	
	4G handset	3G handset
Total sample	74 tests	74 tests
Rate of successful publications (%)	100.0%	100.0%
Average delay to publish (access + post) (s)	4.1	4.6

Figure 70 – Facebook results

6.3.6. INSTAGRAM KPIS

	STC Bahrain	
	4G handset	3G handset
Total sample	83 tests	85 tests
Rate of successful publications (%)	100.0%	100.0%
Average delay to publish (access + post) (s)	4.0	4.7

Figure 71 – Instagram results

6.3.7. WHATSAPP KPIS

	STC Bahrain
Sample	160 tests
Rate of calls set-up and held for 2 min 4-perfect (PQR)	**98.1%**
statistical accuracy	+/-2.1%
Rate of successful received Messages (%)	100%
Average delay to send a message (seconds)	1.0

Figure 72 – WhatsApp results

6.3.8. INTERCONNECTIVITY CALLS

	STC Bahrain to Batelco	STC Bahrain to Zain	STC Bahrain to other networks
Sample	708 tests	707 tests	969 tests
Rate of calls set-up	**99.9%**	**99.7%**	**99.8%**
statistical accuracy	*+/-0.3%*	*+/-0.4%*	*+/-0.5%*

Figure 73 – Interconnectivity results

Cross network testing show no issues and is at least at the same quality level than own.

6.4. ZAIN RESULTS

6.4.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

		Zain
Global voice service		1 252 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.1%** *+/-0.5%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**96.0%** *+/-1.1%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**98.6%** *+/-0.7%*

Figure 74 – Voice – Global results

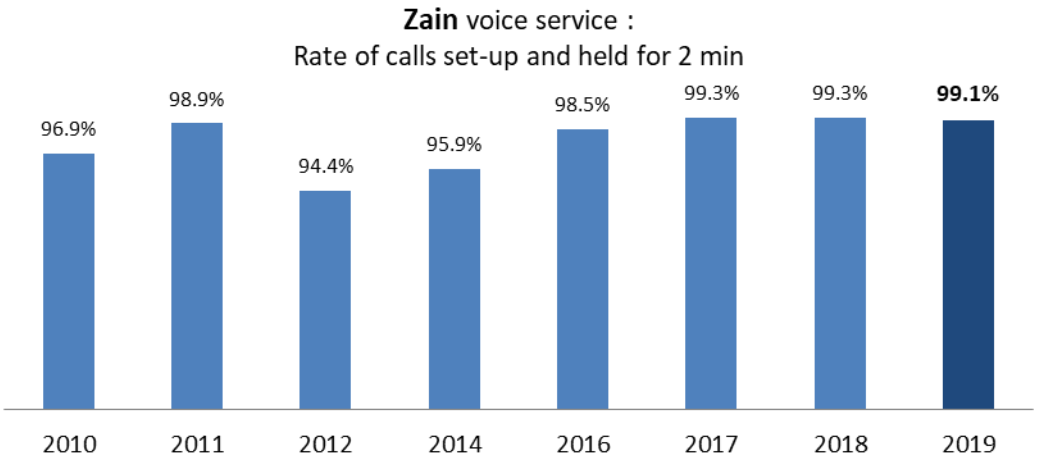


Figure 75 – Voice – Global results evolution

		Zain
Cities voice service (incar, outdoor, indoor)		1 127 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.4%** *+/-0.5%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**96.7%** *+/-1.0%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**98.8%** *+/-0.6%*

Figure 76 – Voice – Cities results

		Zain
Cities voice service (incar only)		541 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.4%** *+/-0.6%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**96.5%** *+/-1.6%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**98.5%** *+/-1.0%*

Figure 77 – Voice – Cities incar results

		Zain
Road links service		125 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**96.8%** *+/-3.1%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**89.6%** *+/-5.4%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**96.0%** *+/-3.4%*

Figure 78 – Voice – road links results

VoLTE:
50% of voice measurements were in volte, in cities and on road links.
Device for those tests was the Samsung Galaxy S10.

		Zain
Global voice service		940 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.1%** *+/-0.6%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**96.1%** *+/-1.2%*
	Rate of calls marked 4-perfect or 3-fair (CQR) *statistical accuracy*	**97.8%** *+/-0.9%*

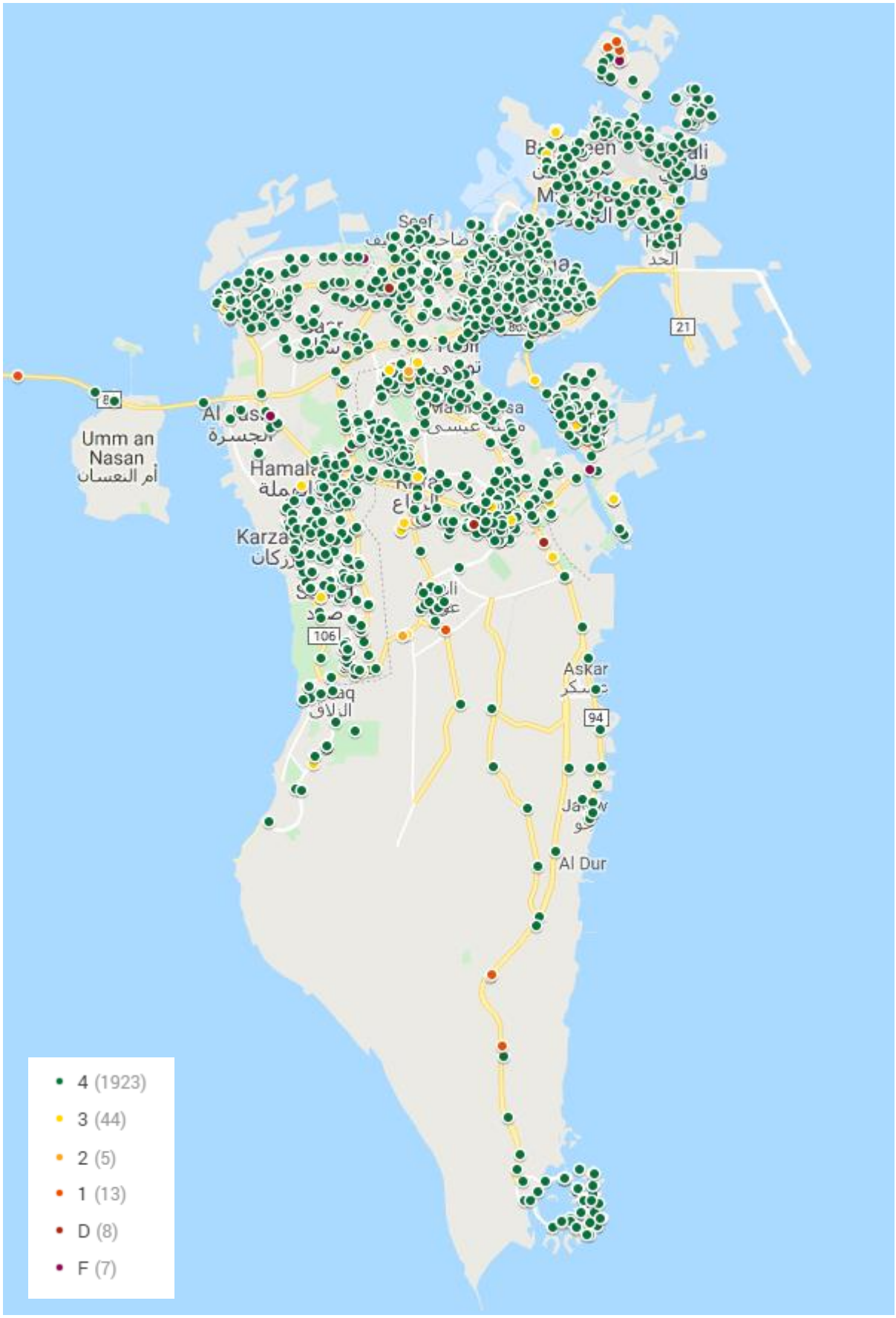


Figure 79 – ZAIN Global voice results

6.4.2. SMS RESULTS

	Zain
SMS service	1 031 tests
% of received SMS (RS2)	**100%**
Statistical accuracy	*+/-0.0%*
% of received SMS (RS30)	99.5%
Statistical accuracy	*+/-0.4%*
% of received SMS (RS15)	98.9%
Statistical accuracy	*+/-0.6%*
Average reception delay (s)	2.8

Figure 80 – SMS - Global results

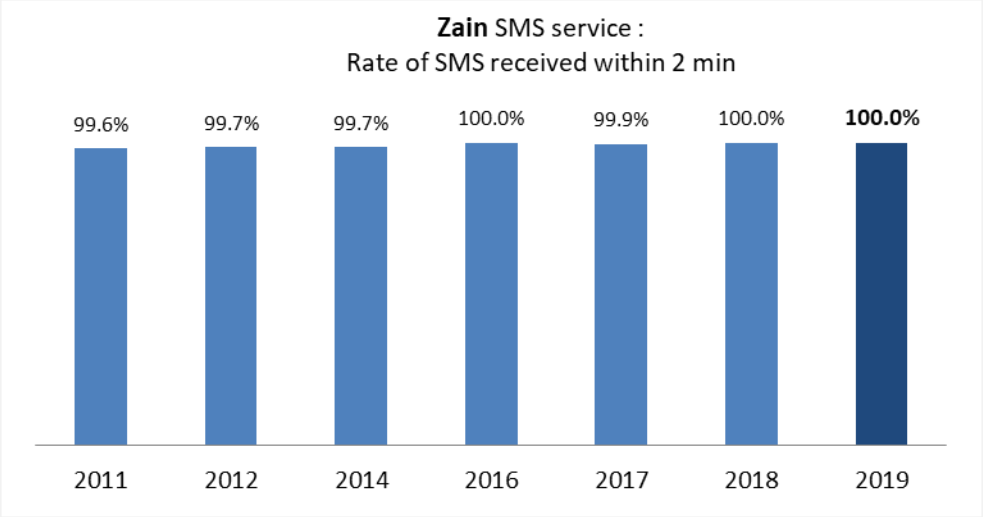


Figure 81 – SMS - Global results evolution

6.4.3. DATA SMARTPHONE RESULTS

6.4.3.1. 3G HANDSET

	Zain
HTTP DL	379 tests
Average Throughput (kbps)	**11 326**
Max throughput (kbps)	30 779
Standard deviation throughput (kbps)	7 348
% data transfers with a throughput > 2Mbps	93.7%
% data transfers with a throughput > 5.1Mbps	76.8%

Figure 82 – 3G Handset – HTTP DL

	Zain
HTTP UL	375 tests
Average Throughput (kbps)	**3 014**
Max throughput (kbps)	4 381
Standard deviation throughput (kbps)	1 080
% data transfers with a throughput > 2Mbps	93.7%

Figure 83 – 3G Handset – HTTP UL

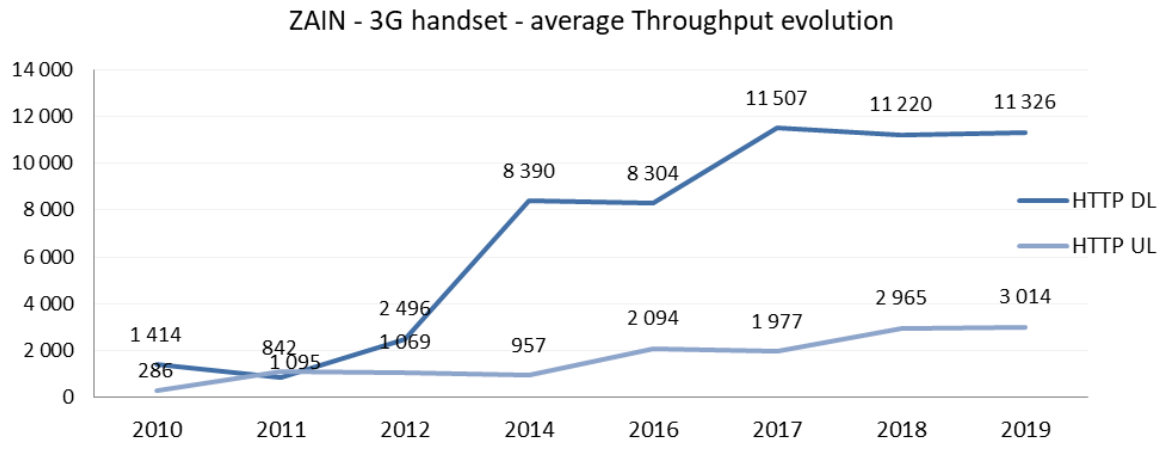


Figure 84 – 3G HANDSET – HTTP DL and UL - throughput evolution

	Zain
WEB	3 782 tests
Rate of successful webpage download Statistical accuracy	**98.5%** +/-0.4%
Average download time (s)	4.5
Min download time (s)	0.8
Standard deviation download time (s)	3.4
% webpage download within 10 seconds	93.7%

Figure 85 – 3G Handset – WEB Browsing

6.4.3.2. 4G HANDSET

	Zain
HTTP DL	378 tests
Average Throughput (kbps)	**29 951**
Max throughput (kbps)	127 700
Standard deviation throughput (kbps)	29 960
% data transfers with a throughput > 2Mbps	86.2%
% data transfers with a throughput > 5.1Mbps	75.1%

Figure 86 – 4G Handset – HTTP DL

	Zain
HTTP UL	384 tests
Average Throughput (kbps)	**22 536**
Max throughput (kbps)	52 172
Standard deviation throughput (kbps)	12 516
% data transfers with a throughput > 2Mbps	98.2%

Figure 87 – 4G Handset – HTTP UL

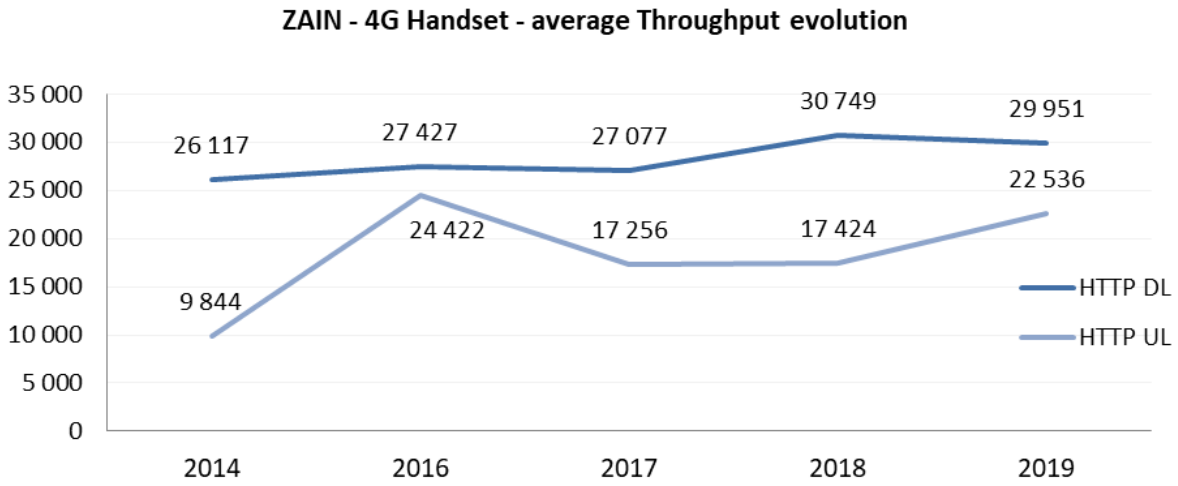


Figure 88 – 4G Handset – HTTP DL&UL – Throughputs evolution

	Zain
WEB	3 837 tests
Rate of successful webpage download Statistical accuracy	**98.9%** +/-0.3%
Average download time (s)	3.4
Min download time (s)	0.0
Standard deviation download time (s)	3.8
% webpage download within 10 seconds	94.3%

Figure 89 – 4G Handset – WEB Browsing

6.4.4. STREAMING KPIS

6.4.4.1. STREAMING – 3G HANDSET VS 4G HANDSET

	4G HANDSET	3G HANDSET
Sample	605 tests	607 tests
LHV : % of videos set-up and held for 2 min statistical accuracy	**100.0%** *+/-0.0%*	**100.0%** *+/-0.0%*
VPQR : % of videos set-up, held for 2 min, and marked 4 statistical accuracy	87.6% *+/-2.6%*	90.9% *+/-2.3%*
VCQR : % of videos set-up, held for 2 min, and marked 3 or 4 statistical accuracy	90.6% *+/-2.3%*	93.9% *+/-1.9%*
Average delay	2.5	3.2
Minimum delay	0.8	0.9

Figure 90 – Video Streaming

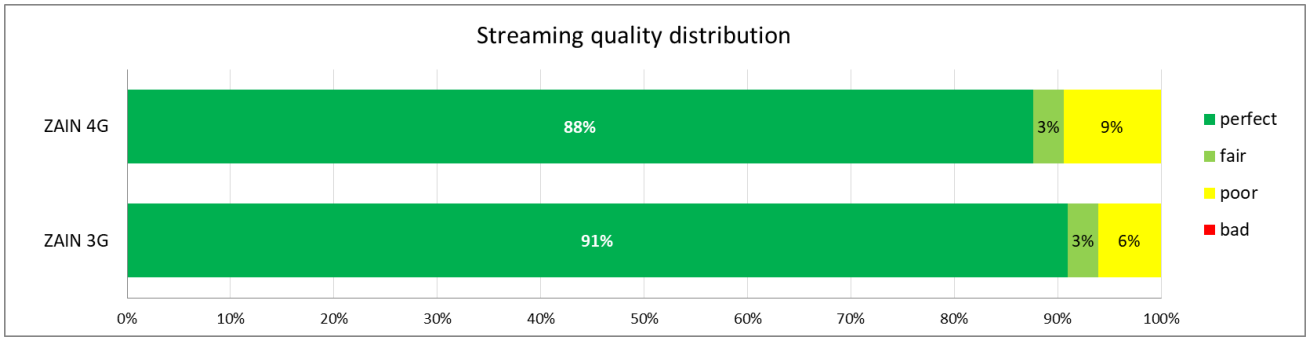


Figure 91 – Streaming – Quality distribution

6.4.4.2. STREAMING – HIGH DEF. (HD) VS STANDARD DEF. (SD)

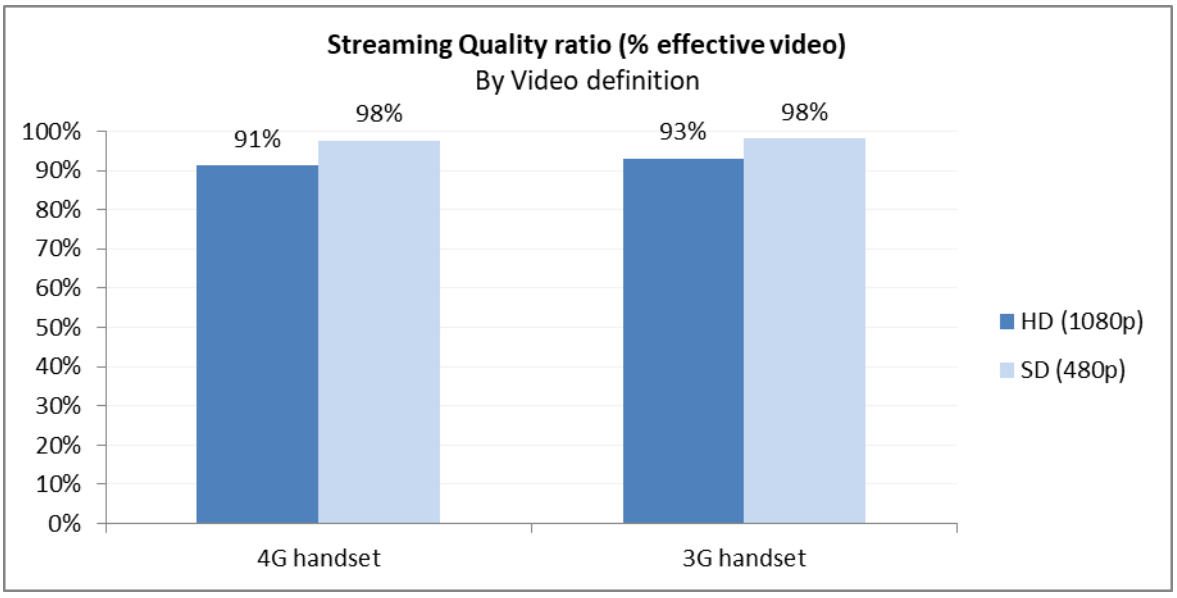


Figure 92 – Quality ratio by video definition: % of time playing video flow, not impacted by video freeze

6.4.5. FACEBOOK KPIS

	Zain	
	4G handset	3G handset
Total sample	81 tests	81 tests
Rate of successful publications (%)	100.0%	100.0%
Average delay to publish (access + post) (s)	4.2	4.2

Figure 93 – Facebook results

6.4.6. INSTAGRAM KPIS

	Zain	
	4G handset	3G handset
Total sample	81 tests	81 tests
Rate of successful publications (%)	100.0%	100.0%
Average delay to publish (access + post) (s)	4.2	4.5

Figure 94 – Instagram results

6.4.7. WHATSAPP KPIS

	Zain
Sample	160 tests
Rate of calls set-up and held for 2 min 4-perfect (PQR)	**98.8%**
statistical accuracy	+/-1.7%
Rate of successful received Messages (%)	99.4%
Average delay to send a message (seconds)	1.0

Figure 95 – WhatsApp results

6.4.8. INTERCONNECTIVITY CALLS

	Zain to Batelco	Zain to STC Bahrain	Zain to other networks
Sample	704 tests	703 tests	1 407tests

Rate of calls set-up	**100.0%**	**100.0%**	**100.0%**
statistical accuracy	*+/-0.2%*	*+/-0.0%*	*+/-0.1%*

Figure 96 – Interconnectivity results

Cross network testing show no issues and is at least at the same quality level than own.

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