Directique
Customer Quality Perspectives

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

QUALITY OF MOBILE SERVICES
KINGDOM OF BAHRAIN – 2020

Version	Date	Author	Changelog
1	1/03/2021	Olivier GHIBAUDO	Creation of document
2	9/03/2021	Olivier GHIBAUDO	Updated from TRA comments
3	12/03/2021	Olivier GHIBAUDO	Updated from STC & BATELCO comments
4	14/03/2021	Olivier GHIBAUDO	Updated from TRA comments
5	15/03/2021	Olivier GHIBAUDO	Updated from TRA comments
6	15/03/2021	Olivier GHIBAUDO	Updated from TRA comments
7	06/04/2021	Olivier GHIBAUDO	Updated from MNOs Comments
8	07/04/2021	Olivier GHIBAUDO	Updated from TRA comments

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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.

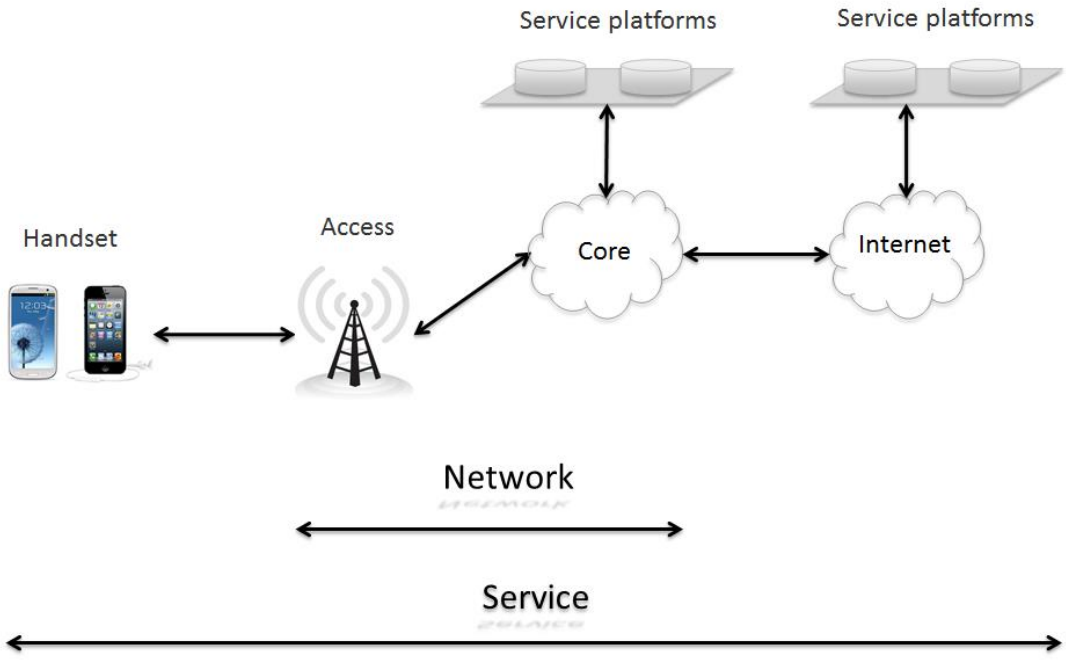


Figure 1 - End to end customer experience

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 20th November 2020 to 13th January 2021 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

		2020	2019	2018	2017	2016	2014	2012
Global **VOICE** service		7 741	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%**	**99.4%**	**99.5%**	**99.4%**	**98.7%**	**95.8%**	**96.6%**
	statistical accuracy	*+/-0.2%*	*+/-0.3%*	*+/-0.2%*	*+/-0.2%*	*+/-0.3%*	*+/-0.5%*	*+/-0.4%*
and marked	**4-perfect (PQR)**	**98.8%**	**98.1%**	**99.1%**	**99.3%**	**96.3%**	**93.8%**	**94.1%**
	statistical accuracy	*+/-0.2%*	*+/-0.5%*	*+/-0.3%*	*+/-0.2%*	*+/-0.5%*	*+/-0.6%*	*+/-0.6%*

Table 1 – Voice service – industry results

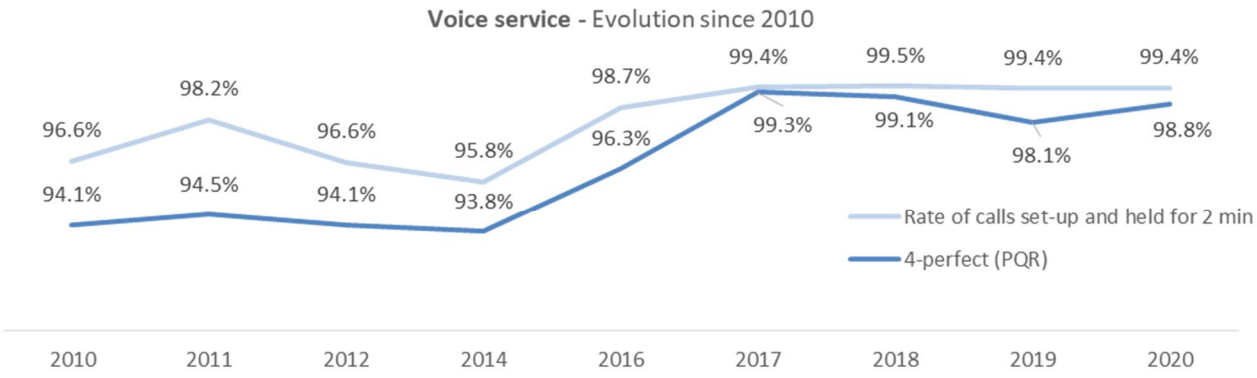


Figure 2 – Evolution of Voice Service since 2010

The three networks offered the same excellent level of service as 2018, with an average setup and held calls rate of 99.4% with improved quality of 0.7 point.

	2020	2019	2018	2017	2016	2014	2012
Global SMS Service	5013	2 874	3 110	3 001	2 591	4 547	2 637
% of received SMS (RS2)	**100%**	**100.0%**	**100.0%**	**99.6%**	**99.9%**	**99.9%**	**99.6%**
statistical accuracy	*+/-0.0%*	*+/-0.0%*	*+/-0.0%*	*+/-0.2%*	*+/-0.1%*	*+/-0.1%*	*+/-0.2%*
% of received SMS (RS15)	**99.6%**	**99.4%**	**98.8%**	**96.6%**	**95.1%**	**91.5%**	**96.5%**
statistical accuracy	*+/-0.3%*	*+/-0.3%*	*+/-0.4%*	*+/-0.6%*	*+/-0.8%*	*+/-0.8%*	*+/-0.7%*
% of received SMS (RS10)	**99.4%**	**98.3%**	**96.6%**				
statistical accuracy	*+/-0.2%*	*+/-0.3%*	*+/-0.6%*				
% of received SMS (RS5)	**98.4%**						
statistical accuracy	*+/-0.3%*						
Average reception delay (s)	**2.4**	**2.6**	**3.2**	**5.1**	**6.6**	**6.7**	**8.1**

Table 2 – SMS service – industry results

All networks offered very good SMS service within two minutes with 99.6% of messages received within 15 seconds.

A new indicator has been introduced this year RS5, which is SMS received within 5 seconds.

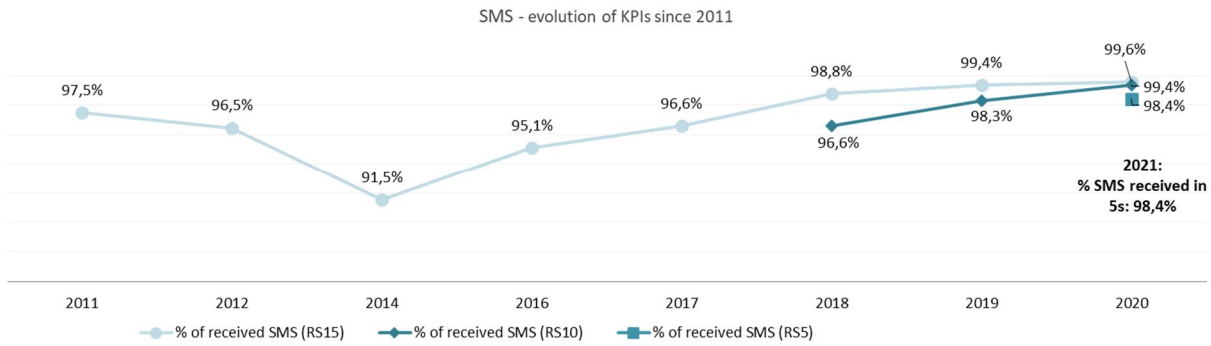


Figure 3 – SMS evolution of KPIs since 2011

The average observed SMS reception delay was under 2.5 seconds, which is the best performance since 2010.

3.2.2. SMARTPHONE DATA MEASUREMENTS

Since 2019, an evolution of protocol for HTTP data transfers measurements has been decided with TRA 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 over time.

5G HANDSET:

		2019	2020
HTTP DL	Average Throughputs in Mbps	429.000	440.36
HTTP UL	Average Throughputs in Mbps	41.000	65.82

Table 3 – 5G Handset data service – industry results

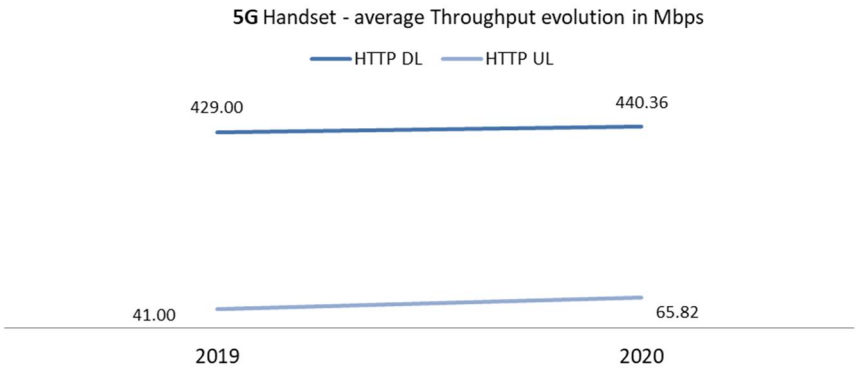


Figure 4 – 5G Handset – HTTP transfers – average throughputs

5G Web browsing is only conducted in 2020 for the three Mobile Operators.

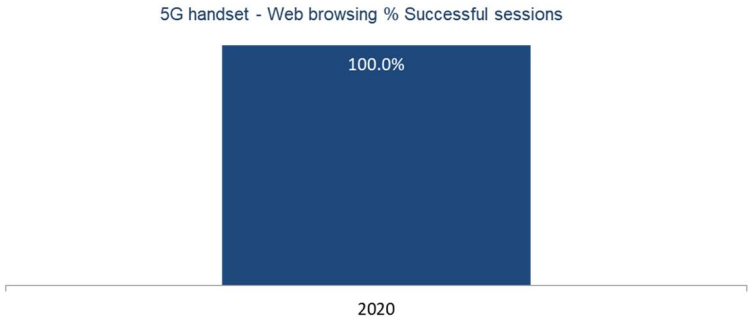


Figure 5 – 5G Handset – WEB browsing – % Successful sessions

4G HANDSET:

		2014	2016	2017	2018	2019	2020
HTTP DL	Average Throughputs in Mbps	30.717	29.783	37.276	61.908	80.831	84.690
HTTP UL	Average Throughputs in Mbps	12.639	26.665	23.389	24.294	29.444	28.530

Table 4 – 4G Handset data service – industry results

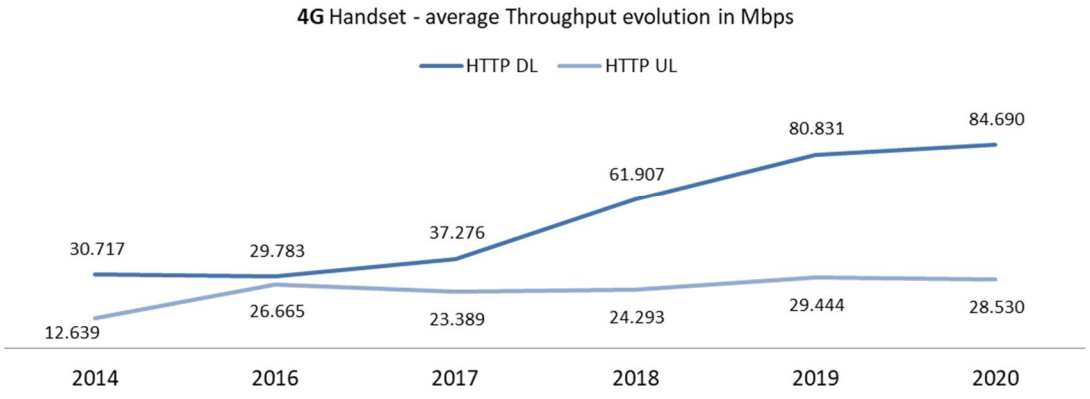


Figure 6 – 4G Handset – HTTP transfers – average throughputs

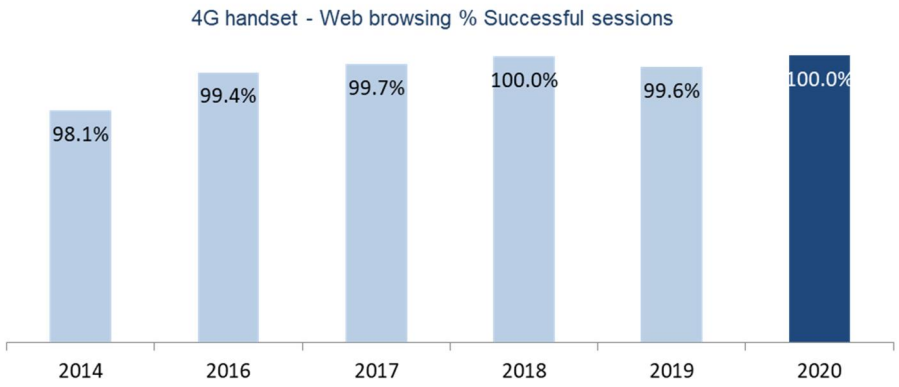


Figure 7 – 4G Handset – WEB browsing – % Successful sessions

3G HANDSET:

		2010	2011	2012	2014	2016	2017	2018	2019	2020
HTTP DL	Average Throughputs in Mbps	1.84	3.23	3.21	8.53	9.98	10.15	9.32	10.42	11.04
HTTP UL	Average Throughputs in Mbps	0.94	0.89	0.88	1.08	2.35	2.15	2.82	2.81	3.01

Table 5 – 3G Handset data service – industry results

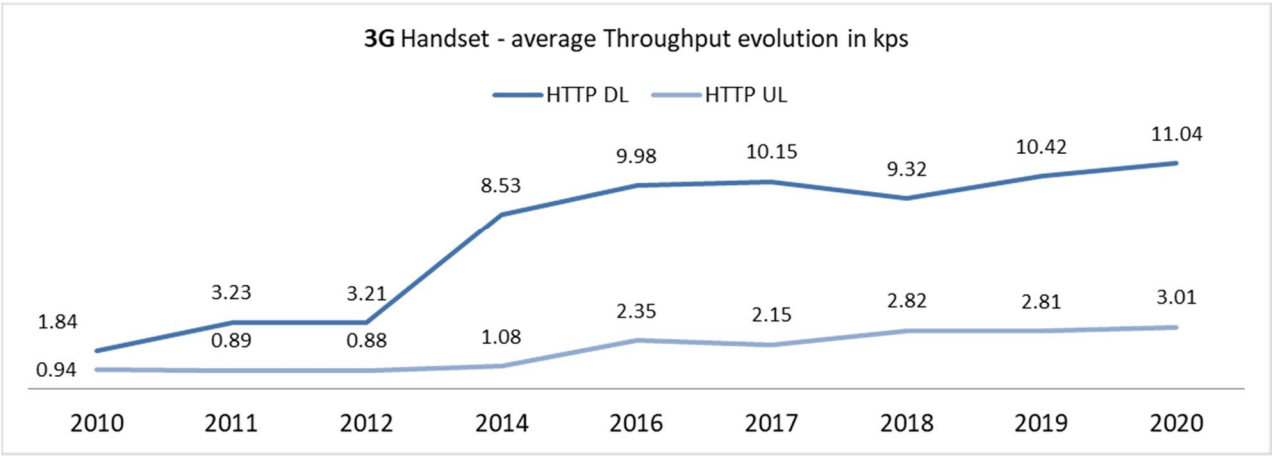


Figure 8 – 3G Handset – HTTP transfers – average throughputs

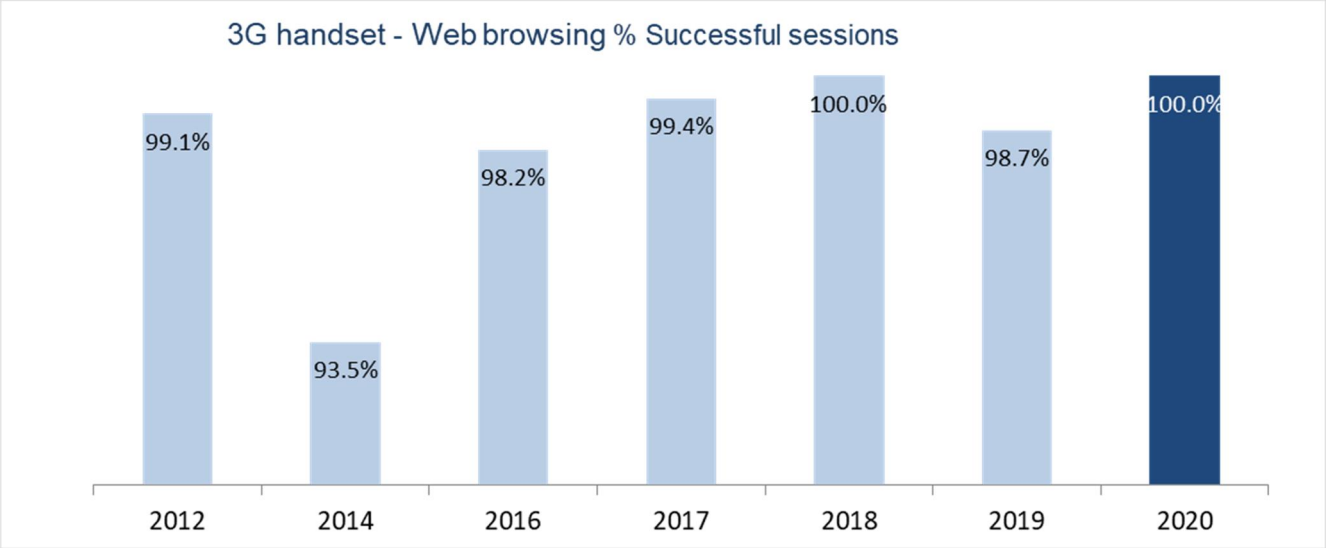


Figure 9 – 3G Handset – WEB browsing – % Successful sessions

3.2.3. BROADBAND PERFORMANCES

Each operator has provided a list of cell sites (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 Technologies (ET) at certain areas in Bahrain to reach much higher speeds, the average throughput on Enhanced Technologies cell sites was more than twice higher than in random locations.

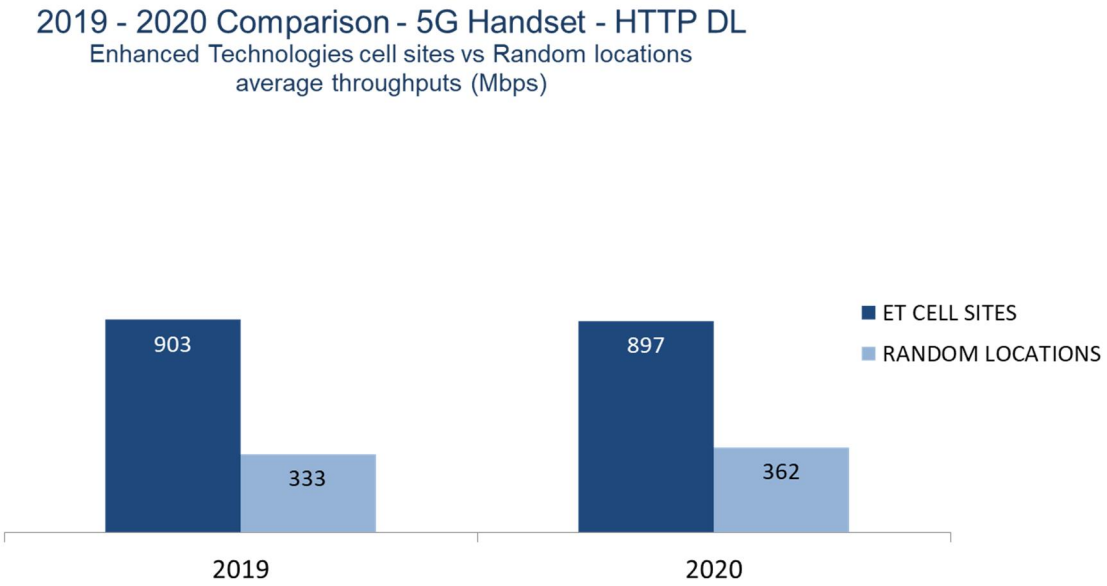


Figure 10 – 2019- 2020 - 5G Handset – HTTP DL - average throughputs

2020 5G measurements include the three Mobile Operators, BATELCO, STC and ZAIN. Comparing to 2019, where only BATELCO and STC had been measured.

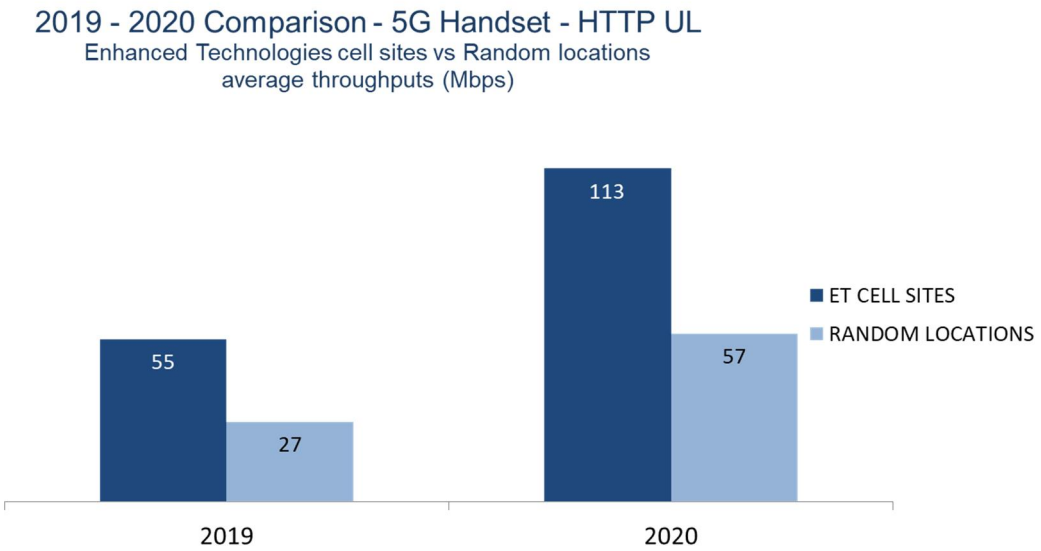


Figure 11 – 2019- 2020 - 5G Handset – HTTP UL - average throughputs

The maximum throughput that has been reached during the audit is represented below with comparison with 2019:

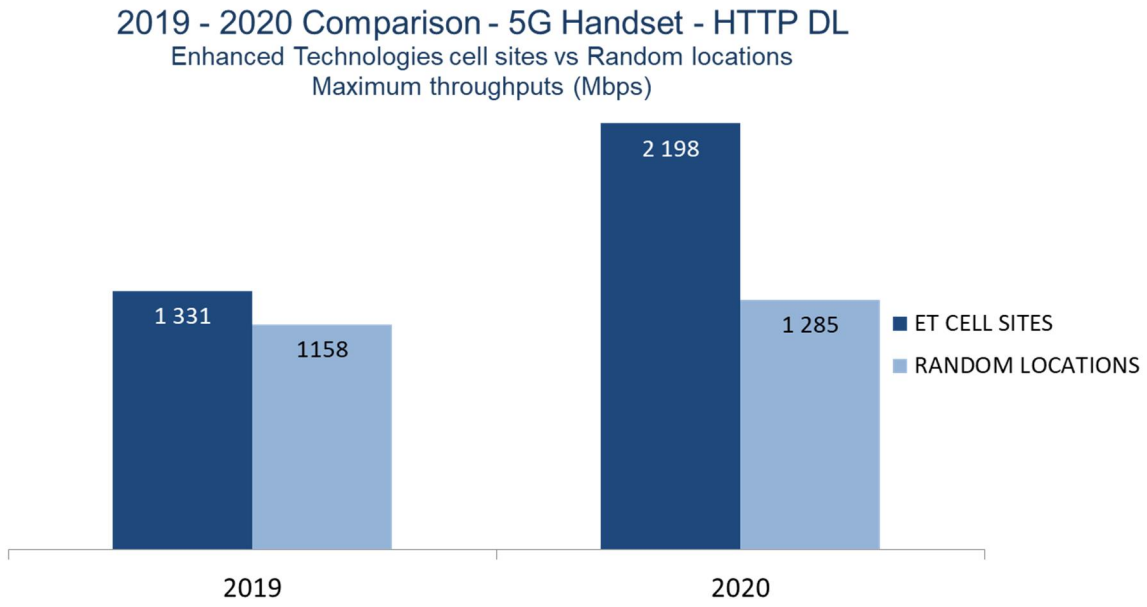


Figure 12 – 2019 - 2020 - 5G Handset – HTTP DL - maximum throughputs reached

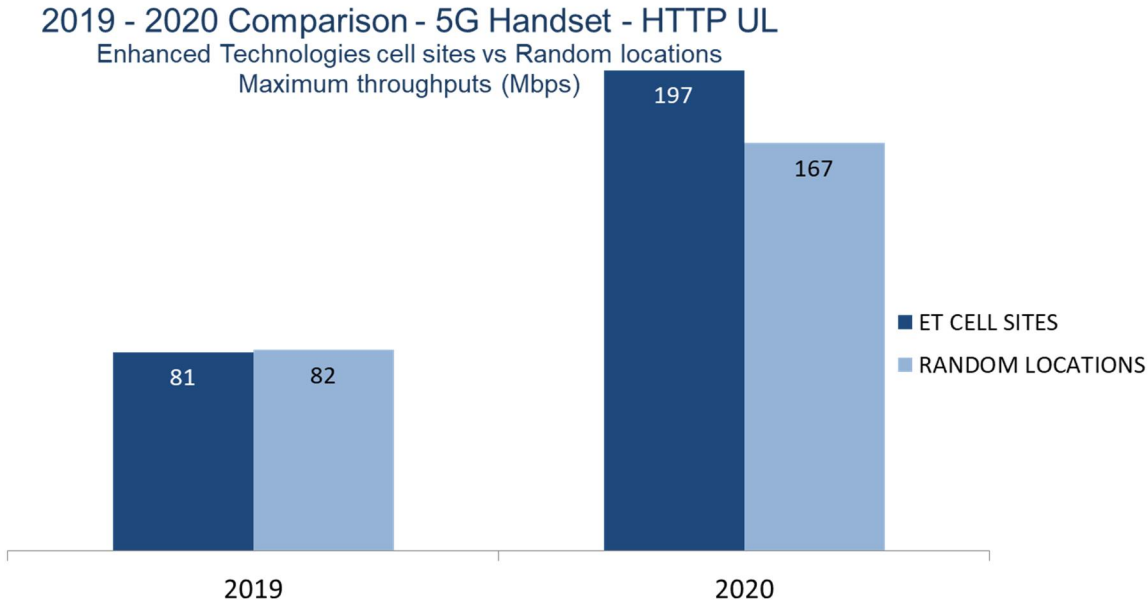


Figure 13 – 2019 - 5G Handset - HTTP UL - maximum throughputs reached

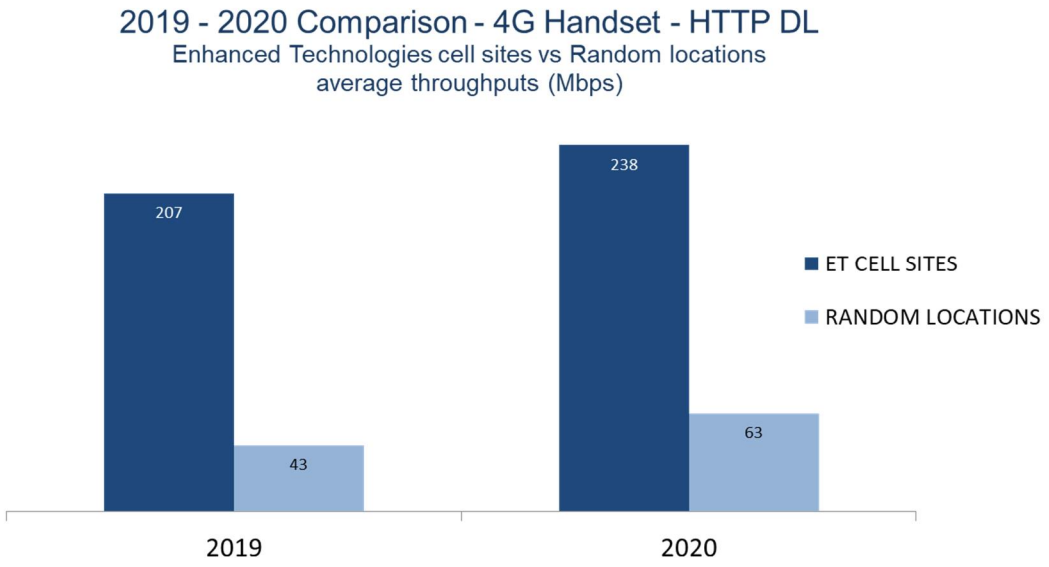


Figure 14 – 2019- 2020 - 4G Handset – HTTP DL - average throughputs

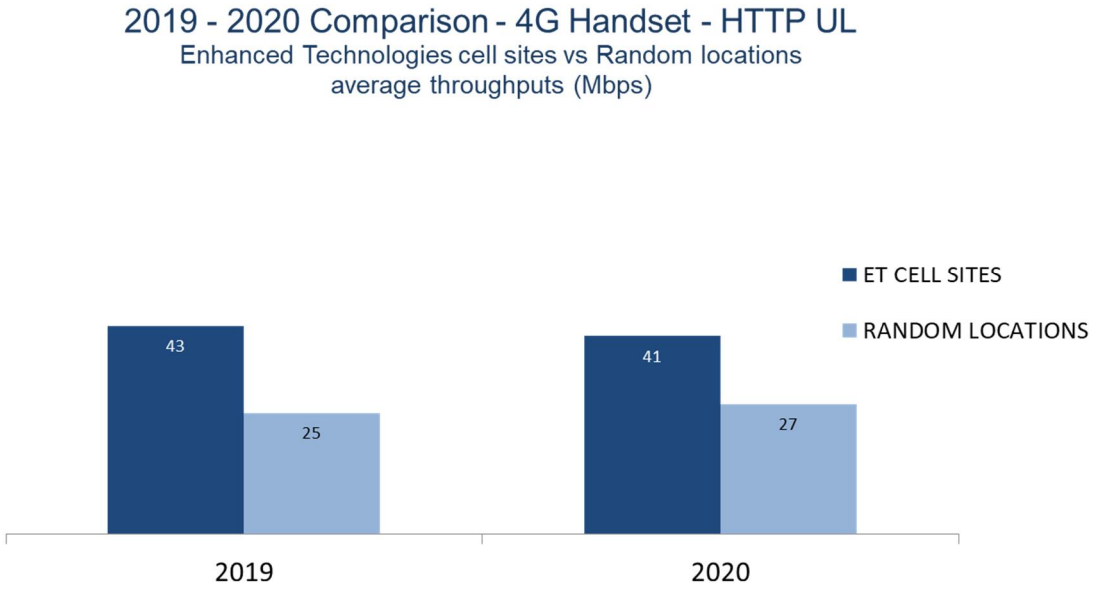


Figure 15 - 2019- 2020 - 4G Handset – HTTP UL - average throughputs

The maximum throughput that have been reached during the audit is represented below with comparison with 2019:

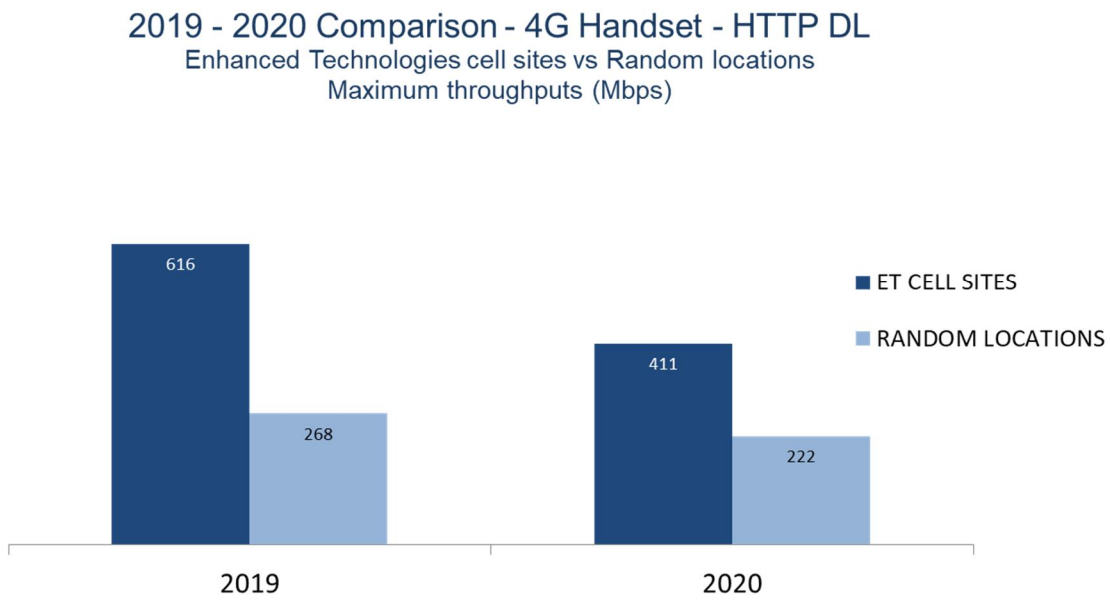


Figure 16 – 2019 - 2020 - 4G Handset – HTTP DL - maximum average throughputs

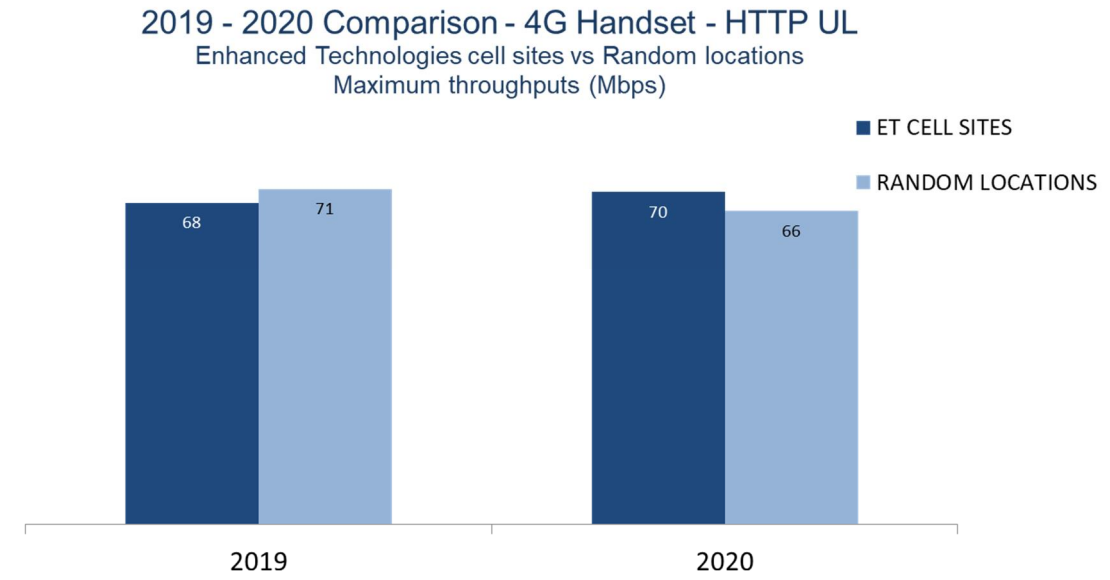
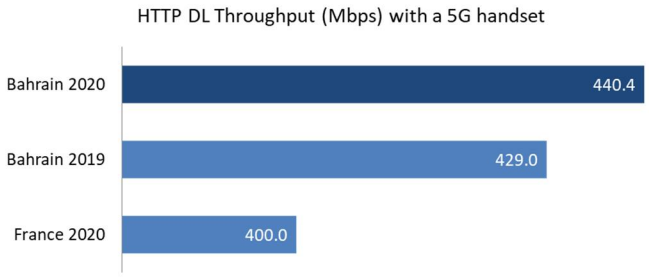


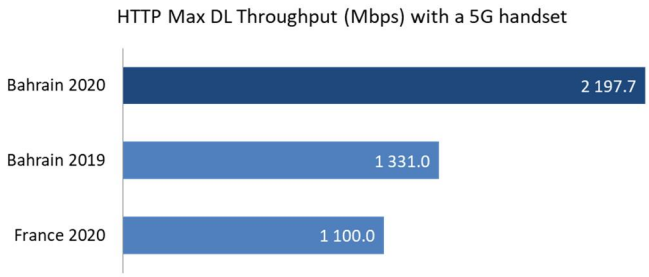
Figure 17 – 2019 - 2020 - 4G Handset – HTTP UL – maximum average throughputs

4. International Benchmark to Reference Operators

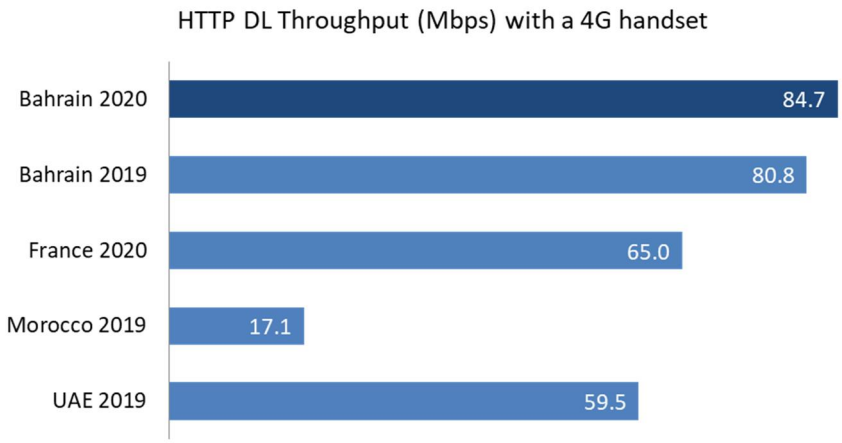
The following charts compare the average results achieved by the three Mobile Operators in the Kingdom of Bahrain, Batelco, STC Bahrain and Zain, with the average results obtained by National Mobile Operators in the respective benchmarked markets. Measurements are based on compatible test procedures.

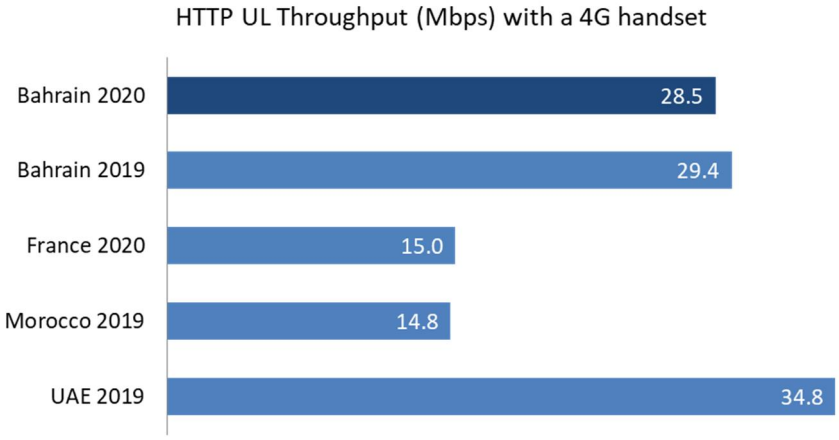
Results for Bahrain are the average combined results achieved by the 3 Mobile Operators.

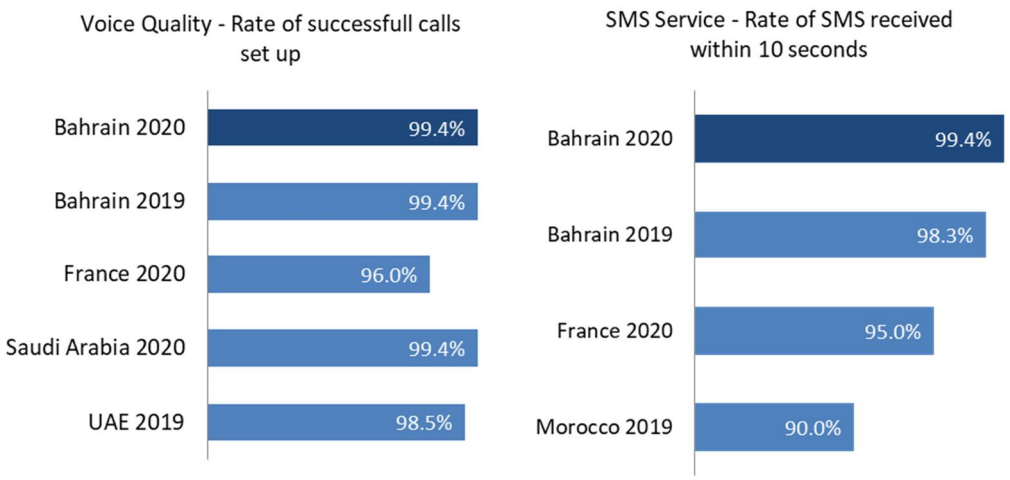




*5G in France is commercially open since end 2020 and not official audit has been performed on 5G networks, these results come from Operators' tests and are subject to variations in time.







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

Figure 18 – 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.
- A field supervisor based in the Kingdom for the whole audit duration.
- Test team A performing voice SMS and Social Media measurements:
  - 1 engineers and a driver in the field;
- Test team B performing data measurements:
  - 1 engineer and a driver in the field
- A back office with 2 engineers in charge of the daily post processing.

5.1.2. EQUIPMENT

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

For Voice Coverage, SMS and Voice QoS:

3G Handset
Samsung Galaxy S9
SM-G928F
H+ 42 Mbps (HSPA+)
LTE 1024 Mbps (**Cat.18**)

For Data Coverage:

3G – 4G Handset	5G Handset
Samsung Galaxy S9	**Xiaomi Mi Mix 3 5G**
SM-G928F	
H+ 42 Mbps (HSPA+)	LTE 1.2 Gbps (**Cat.18)**
LTE 1024 Mbps (**Cat.18**)	**5G NSA**

For Data QoS:

3G Handset	4G Handset	5G Handset
Samsung Galaxy S9	**Samsung Galaxy Note 20**	**Huawei P40 Pro**
H+ 42 Mbps (HSPA+)	LTE (Cat.19)	5G NSA / SA

All devices were compatible with voice, SMS and data technologies and were recommended or sold by Mobile Operators for 2G, 3G, 4G and 5G technologies.

During Incar measurements, mobile phones were used without external antenna.

5.1.3. SIM CARDS

Directique has sourced the necessary SIM cards locally, from each tested mobile network operator.

SIM & Packages	PostPaid
Batelco	Contract BD 16 / Data only 1TB Unlimited / 5G Broadband 40
STC Bahrain	STC BD 8 / Home Broadband 30 LTE Plan / 5G Broadband 35
Zain	Super eeZee Prepaid BD 8 / Postpaid 5G 16GB

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.

NEMO© Drive Test tool has been used for Automatic Voice Call with MOS test for Voice specification ITU ref P.863 POLQA.

Call distribution was as follow:

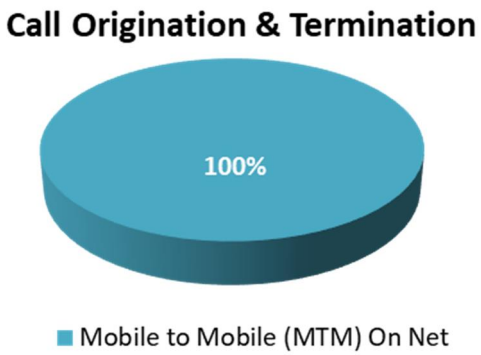


Figure 19 – Voice calls distribution

Voice measurements were performed in one configuration:

- Incar: On road links (In car Road) and within Town borders (In car Town)

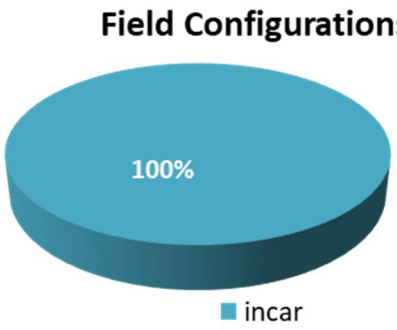


Figure 20 – Voice measurements type

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 by using MOS POLQA. Once a call was established, audio quality was marked on a scale as follows:

Level 4 : Perfect	MOS notation > 2.1

Table 6 – Audio Quality marking

5.2.2. Testing Area and sample size

A total of 7734 tests have been performed with the following distribution for each governorate:

By Governorate	INCAR
CAPITAL	2412
AL MUHARRAQ	1365
NOTHERN	2211
SOUTHERN	1746
TOTAL	**7734**

Table 7 – Voice sampling by governorate

The geographical distribution of the Voice test is as shown on the map below:

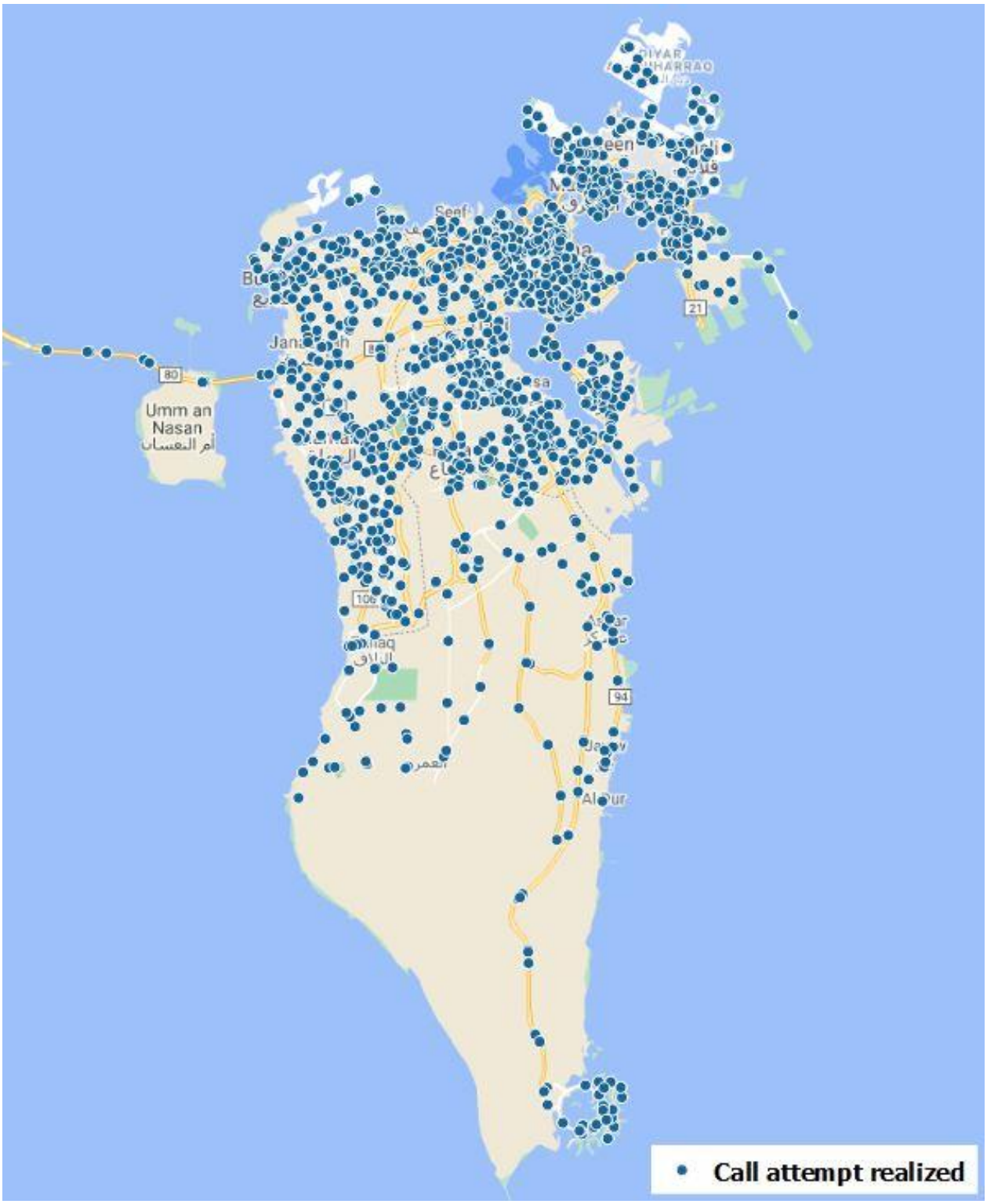


Figure 21 – Test locations: voice service

5.2.3. NO DEFAULT PROCEDURE

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.

5.2.4. 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 transmitting and receiving the SMS were in the field with the testing team. SMS were sent to co-located incar mobile phones.

A measurement, made simultaneously on all Mobile Networks via ***NEMO© Drive Test tool***, consisted of the following script:

- Sending a 26 characters message
- Saving all information in order to calculate receiving SMS Time.
- A SMS message not received after 2 minutes elapse time was marked as failed.

SMS testing location and 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 hotspots has been given by each operator.

Data measurements were done on 3 sets of smartphones for each operator:

- a set of smartphones 5G enabled – Network mode = auto (2G/3G/4G/5G)
- 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	5G - Smartphone
RANDOM	**HTTP DL / HTTP UL / /WEB**	✓	✓	✓
HOTSPOTS	**HTTP DL / HTTP UL / /WEB**	✓	✓	✓

Table 8 – Data tests matrix

On Random locations, 5G has been tested only for operators which have 5G coverage on these locations.

5.4.2. HTTP TRANSFER MEASUREMENTS

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 9 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 is:

Operators Web Pages		
http://www.batelco.com	http://stc.com	http://staging.bb.zain.com

9 most visited public homepages in Bahrain		
http://www.amazon.com	http://www.apple.com	http://www.expatriates.com
http://www.facebook.com	http://www.google.com	http://www.instagram.com
http://www.microsoft.com	http://www.msn.com	http://www.youtube.com

Table 9 – List of webpages tested

5.4.4. SOCIAL NETWORKS

- **Twitter**

Twitter measurements have been made automatically via ***NEMO© Drive Test tool***.
The test consisted in text a message and post a picture of 15KB.

- **Instagram**

Instagram tests have been made automatically via ***NEMO© Drive Test tool***
The test consisted in connect to account user and load feed.

- **WhatsApp**

WhatsApp tests have been made automatically via ***NEMO© Drive Test tool***.
The test consisted in text a message and post a picture of 15KB.

- **YouTube**

YouTube measurements have been made automatically via ***NEMO© Drive Test tool***.
The test consisted in view a 1 minute public video.

5.4.5. SAMPLE

HTTP DL	HTTP UL	WEB	STREAMING	TWITTER	INSTAGRAM	WhatsApp	Total
2 264	2 265	22 459	4 311	2 883	1 437	2 903	**38 522**

Table 10 – Smartphone test sample distribution

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

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 10 (% of SMS received SMS within 15 sec)	SMS not refused when sent out and received within 10 seconds without being altered.
RS 5 (% of SMS received SMS within 15 sec)	SMS not refused when sent out and received within 5 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
WEB10 : % of data transfers within 10 seconds	Successful page loading within 10s. Rate based on total sample

6.1.5. TWITTER

KPIs	Definition
% of successful publications	Successful data transfer without radio drop. Indicator is based on the total number of connection attempts
Average time to publish (access + post) (s)	Average time to publish text and picture including access time

6.1.6. INSTAGRAM

KPIs	Definition
Rate of successful access and load Instagram feed (%)	Successful access and load Instagram feed without radio drop. Indicator is based on the total number of connection attempts
Average delay to connect and load Instagram feed (s)	Average delay to connect and load Instagram feed on user account

6.1.7. WHATSAPP

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)	Average delay to publish text and picture including access time

6.1.8. YOUTUBE

KPIs	Definition
Rate of successful streaming (%)	Successful streaming during 1 minute without radio drop. Indicator is based on the total number of connection attempts
Average time to stream 1mn Video (access + streaming) (s)	Average time to stream 1mn public video including access time

6.2. BATELCO RESULTS

6.2.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

		Batelco
Global voice service		2 569 tests
Rate of calls set-up and held for 2 min	*statistical accuracy*	**100.0%** *+/-0.1%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.4%** *+/-0.3%*

Table 11 – Voice – Global results

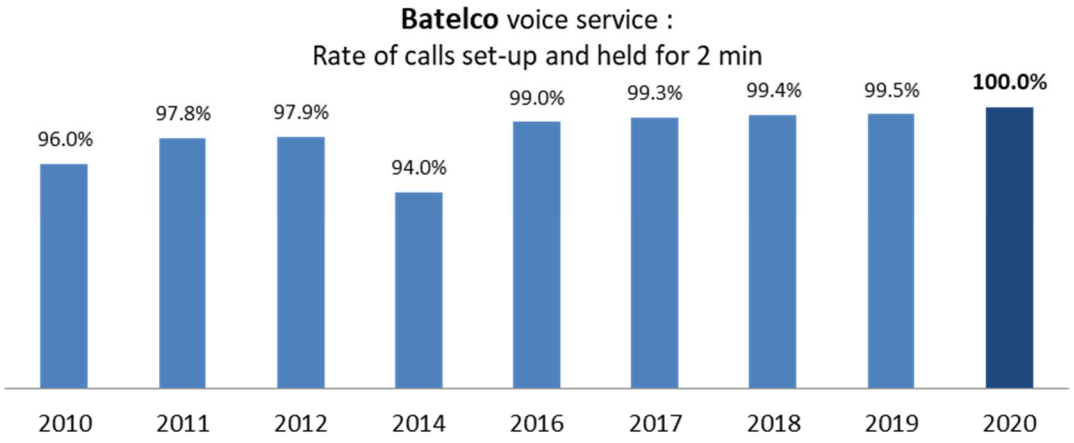


Figure 22 – Voice – Global results evolution

VoLTE:
50% of voice measurements were in volte, in cities and on road links.
Device for those tests was the Samsung Galaxy S9.

		Batelco
Global voice service		1 302 tests
Rate of calls set-up and held for 2 min	*statistical accuracy*	**100.0%** *+/-0.0%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.7%** *+/-0.2%*

Table 12 – VoLTE – Global results

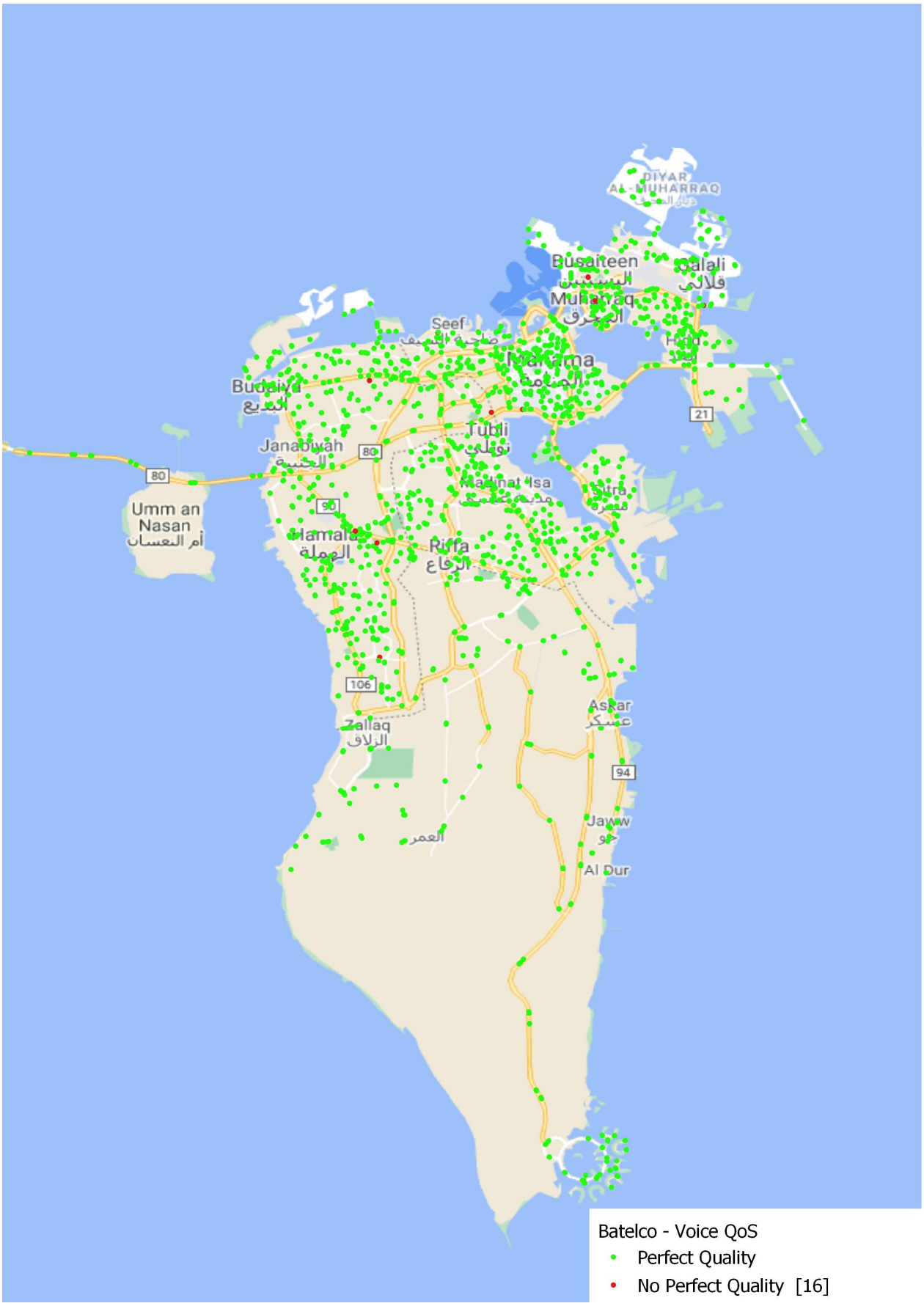


Figure 23 – **BATELCO** - Global voice results

6.2.2. SMS RESULTS

	Batelco
SMS service	1 671 tests
% of received SMS (RS2)	**100%**
Statistical accuracy	*+/-0.0%*
% of received SMS (RS10)	99.8%
Statistical accuracy	*+/-0.2%*
% of received SMS (RS5)	99.0%
Statistical accuracy	*+/-0.5%*
Average reception delay (s)	2.4

Table 13 – SMS - Global results

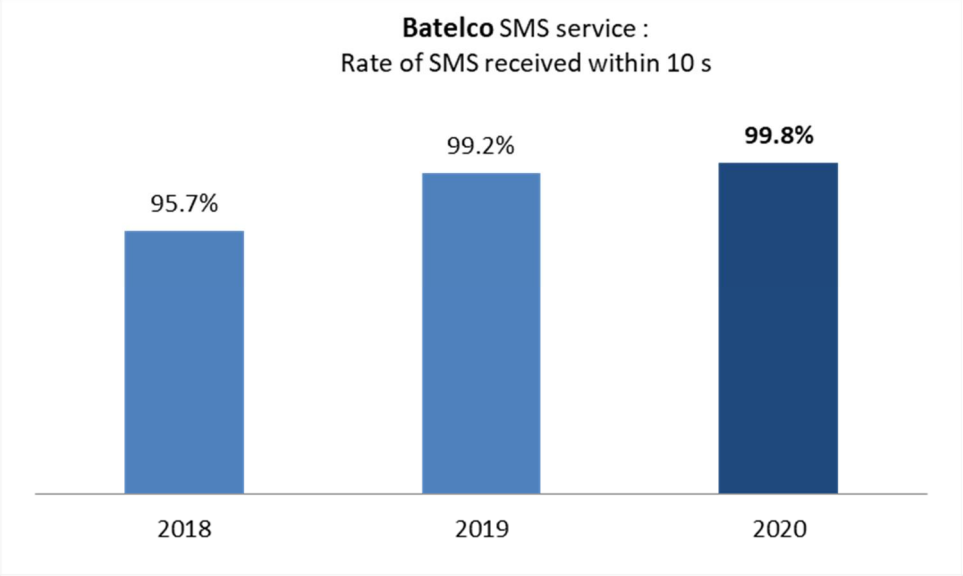


Figure 24 – SMS - Global results evolution

6.2.3. DATA SMARTPHONE RESULTS

6.2.3.1. 5G HANDSET

	Batelco
HTTP DL	794 tests
Average Throughput (Mbps)	**640.31**
Max throughput reached (Mbps)	**1 817.42**

Table 14 – 5G Handset – HTTP DL

	Batelco
HTTP UL	795 tests
Average Throughput (Mbps)	**75.46**
Max throughput reached (Mbps)	**187.96**

Table 15 – 5G Handset – HTTP UL

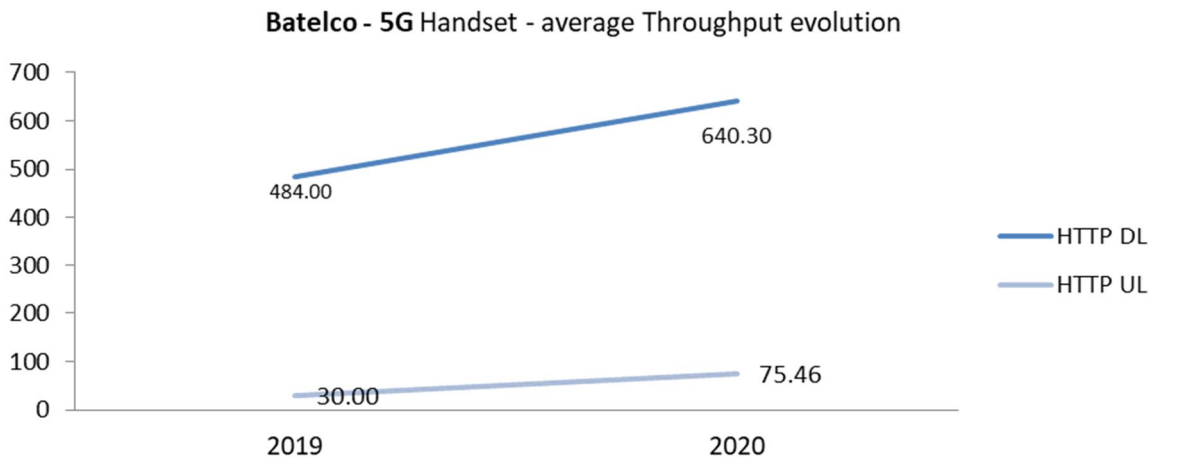


Figure 25 – 5G Handset – HTTP DL&UL – Throughputs evolution

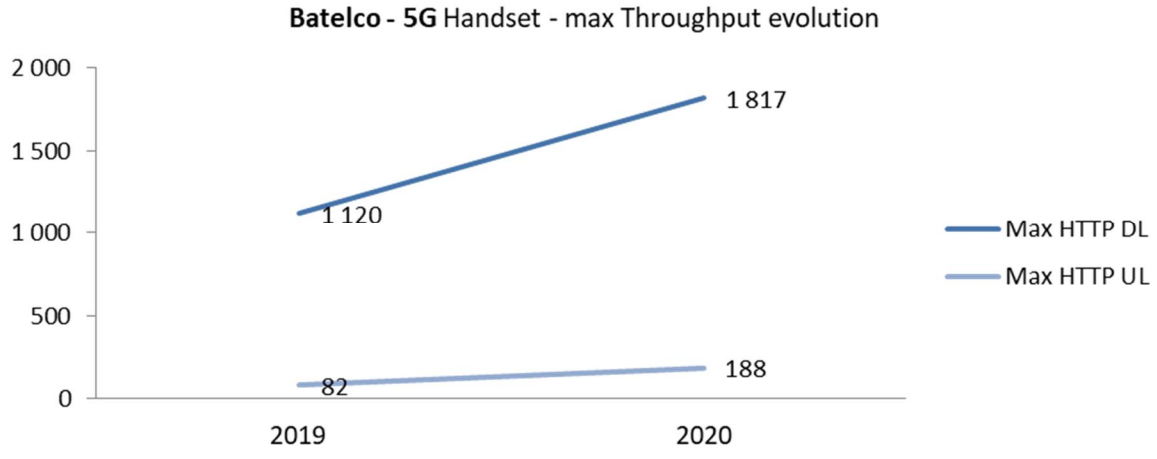


Figure 26 – 5G Handset – HTTP DL&UL – Max Throughputs reached evolution

	Batelco
WEB	7 950 tests
Rate of successful webpage download	**100.0%**
Statistical accuracy	+/-0.0%
Average Delay (s)	2.2
% data transfers within 10 seconds	99.3%

Table 16 – 5G Handset – WEB Browsing

1.1.1.1. 4G HANDSET

	Batelco
HTTP DL	799 tests
Average Throughput (Mbps)	**133.86**
Max throughput (Mbps)	**699.42**

Table 17 – 4G Handset – HTTP DL

	Batelco
HTTP UL	799 tests
Average Throughput (Mbps)	**34.07**
Max throughput (Mbps)	**88.14**

Table 18 – 4G Handset – HTTP UL

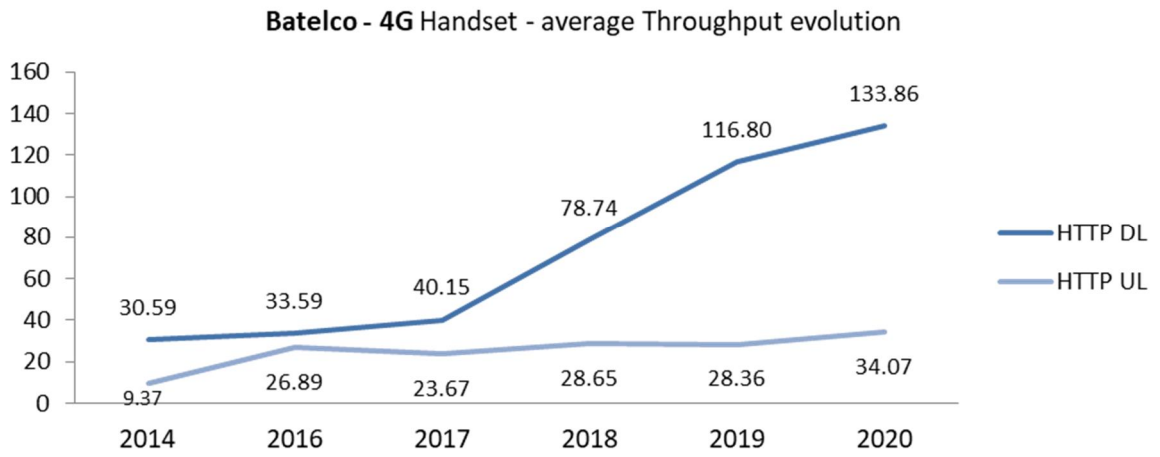


Figure 27 – 4G Handset – HTTP DL&UL – Throughputs evolution

	Batelco
WEB	8 000 tests
Rate of successful webpage download	**100.0%**
Statistical accuracy	+/-0.0%
Average Delay (s)	2.5
% data transfers within 10 seconds	99.7%

Table 19 – 4G Handset – WEB Browsing

1.1.1.2. 3G HANDSET

	Batelco
HTTP DL	669 tests
Average Throughput (Mbps)	**12.50**
Max throughput (Mbps)	**28.92**

Table 20 – 3G Handset – HTTP DL

	Batelco
HTTP UL	669 tests
Average Throughput (Mbps)	**3.08**
Max throughput (Mbps)	**5.67**

Table 21 – 3G Handset – HTTP UL

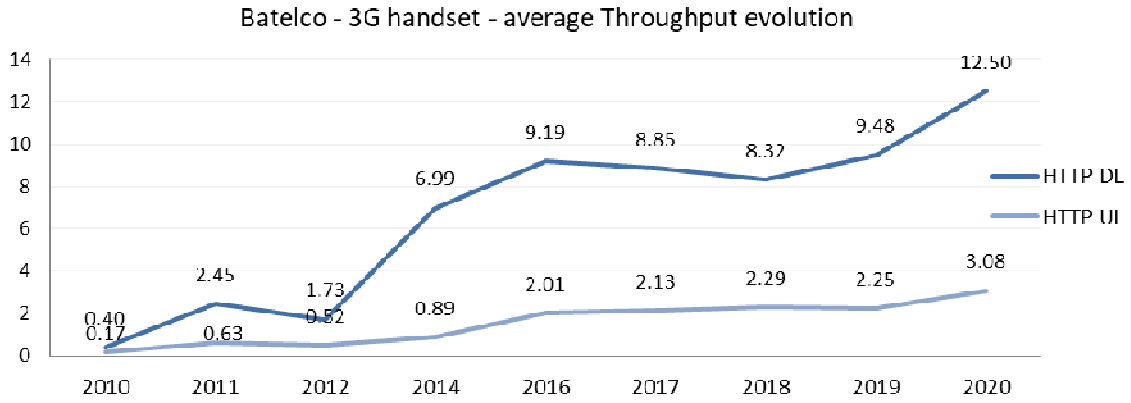


Figure 28 – 3G Handset – HTTP DL&UL – Throughputs evolution

	Batelco
WEB	6 496 tests
Rate of successful webpage download Statistical accuracy	**100.0%** +/-0.0%
Average Delay (s)	3.6
% data transfers within 10 seconds	99.3%

Table 22 – 3G Handset – WEB Browsing

1.1.2. YOUTUBE KPIS

2.

	Batelco
Total sample	1 433 tests
Rate of successful streaming (%) statistical accuracy	**99.0%** *+/-0.4%*
Average time to stream 1mn Video (access + streaming) (s)	76.6

Table 23 – YouTube results

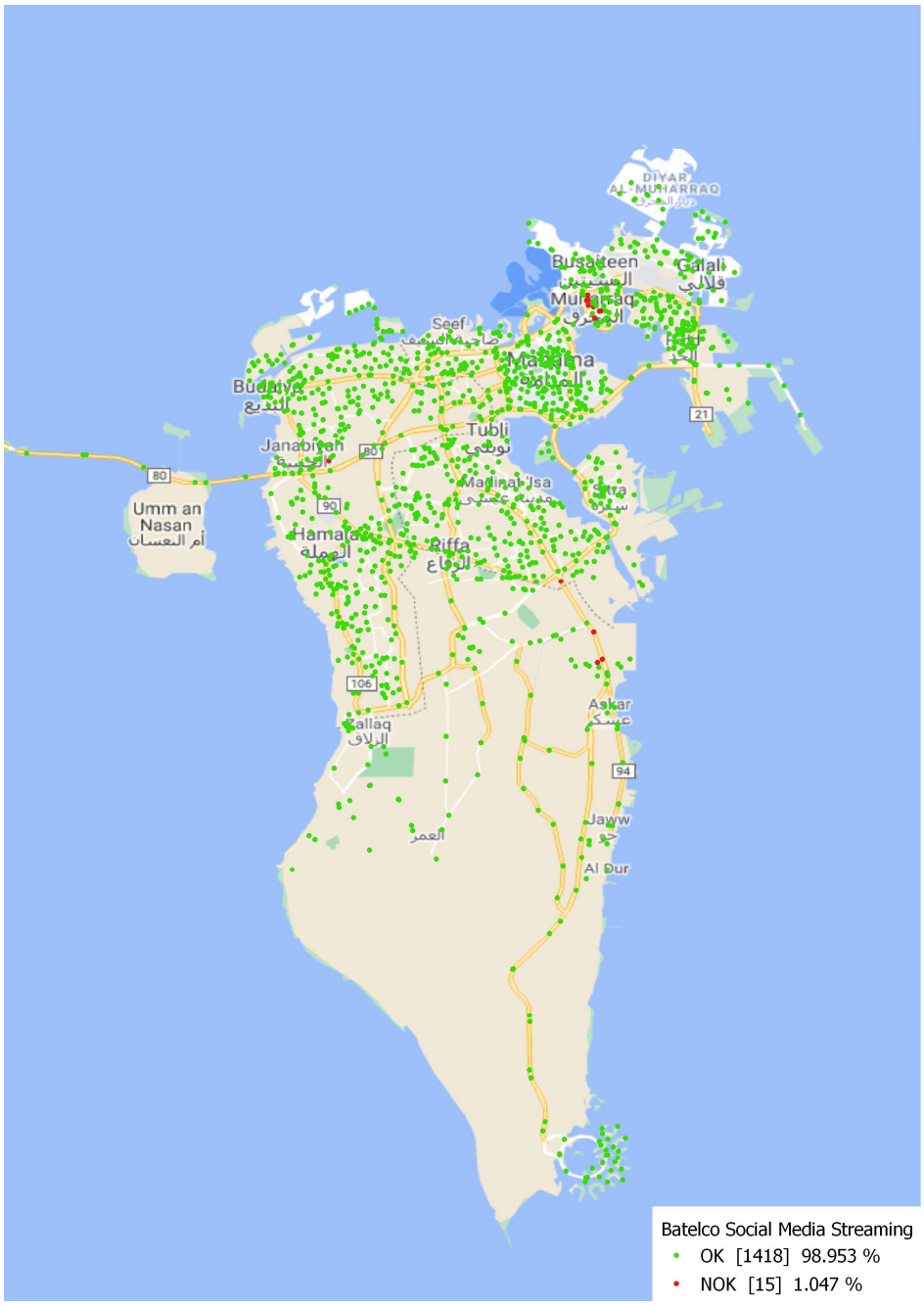


Figure 29 – BATELCO - Streaming results map

2.1.1. TWITTER KPIS

	Batelco
Total sample	2 892 tests
Rate of successful publication (%) statistical accuracy	**99.9%** *+/-0.1%*
Average time to publish (access + post) (s)	2.6

Table 24 – Twitter results

2.1.2. INSTAGRAM KPIS

3.

	Batelco
Total sample	1 440 tests
Rate of successful publication (%) statistical accuracy	**99.8%** *+/-0.2%*
Average time to publish (access + post) (s)	1.4

Table 25 – Instagram results

3.1.1. WHATSAPP KPIS

4.

	Batelco
Total sample	2916 tests
Rate of successful publication (%) statistical accuracy	**99.9%** *+/-0.1%*
Average time to publish (access + post) (s)	4.4

Table 26 – WhatsApp results

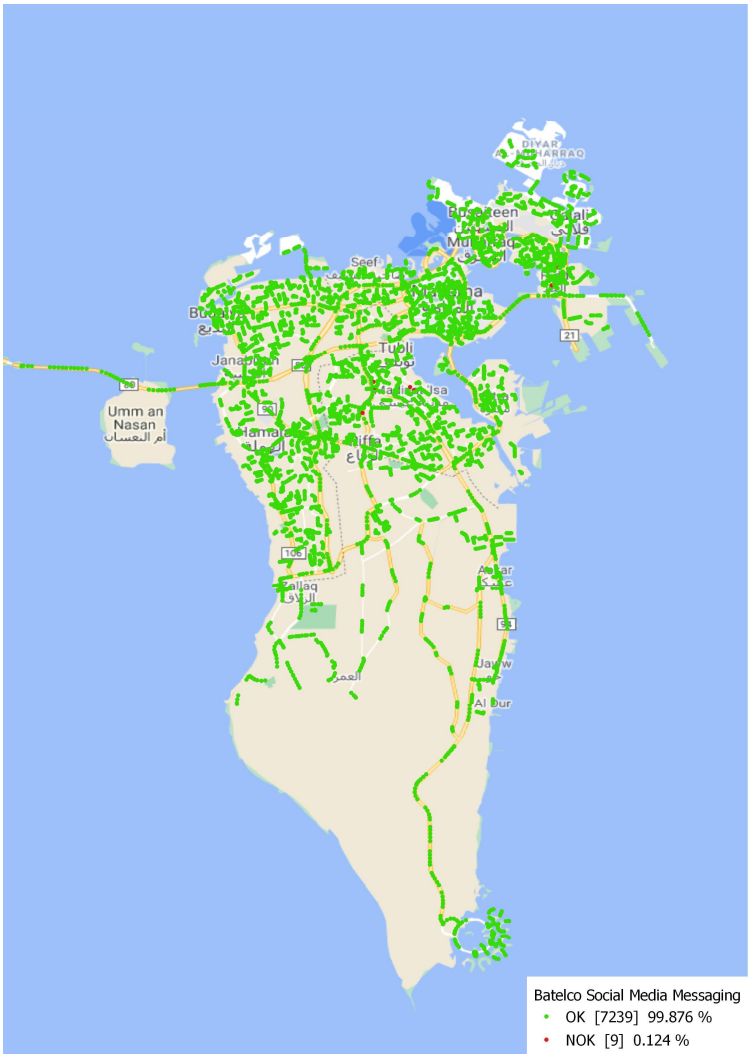


Figure 30 – BATELCO – Global Messaging results map

6.3. STC BAHRAIN RESULTS

6.3.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

		STC Bahrain
Global voice service		2 578 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**98.8%** *+/-0.4%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**97.8%** *+/-0.6%*

Table 27 – Voice – Global results

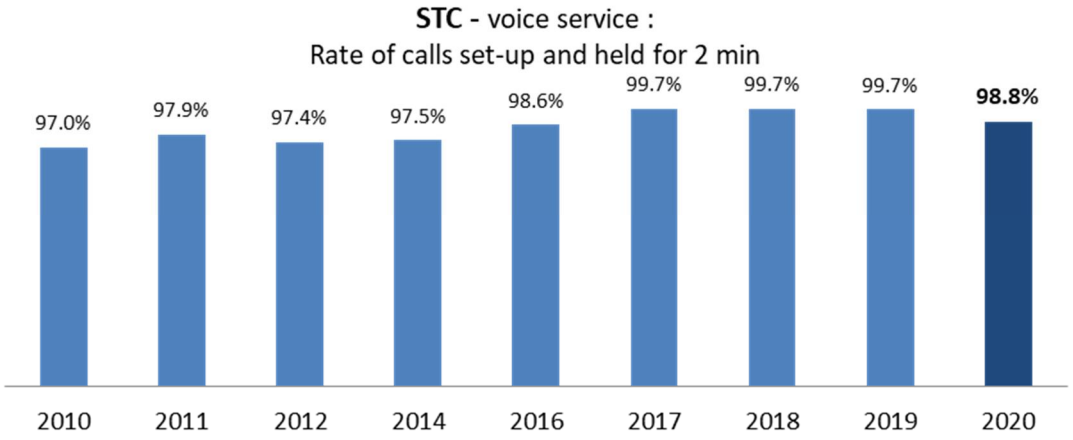


Figure 31 – Voice – Global results evolution

VoLTE:
50% of voice measurements were in volte, in cities and on road links.
Device for those tests was the Samsung Galaxy S9.

		STC Bahrain
Global voice service		1 306 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.3%** *+/-0.3%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**98.8%** *+/-0.4%*

Table 28 – VoLTE – Global results

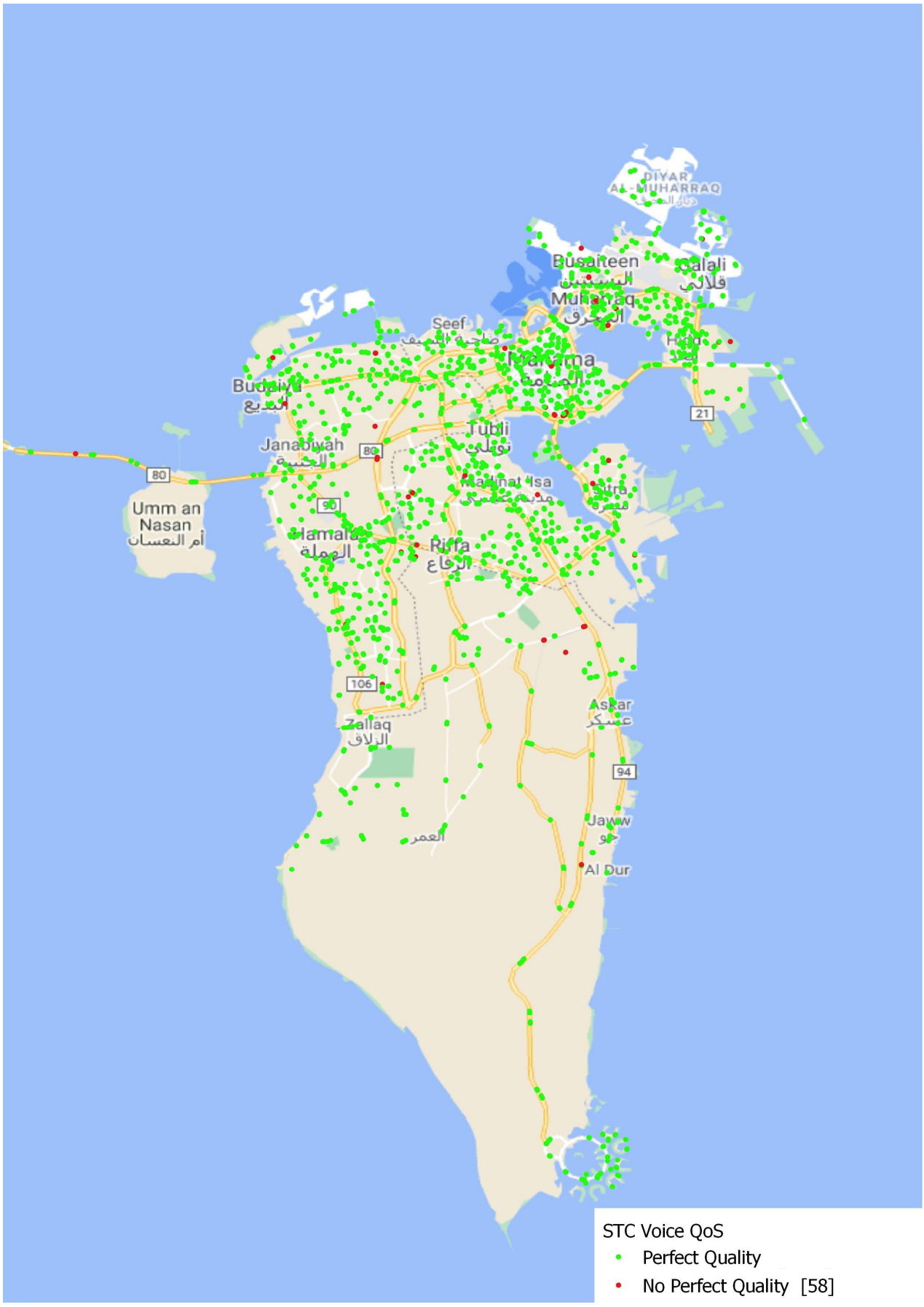


Figure 31 – **STC** - Global voice results

6.3.2. SMS RESULTS

	STC Bahrain
SMS service	1 671 tests
% of received SMS (RS2)	**100%**
Statistical accuracy	*+/-0.0%*
% of received SMS (RS10)	98.9%
Statistical accuracy	*+/-0.5%*
% of received SMS (RS5)	97.8%
Statistical accuracy	*+/-0.7%*
Average reception delay (s)	2.5

Table 29 – SMS - Global results

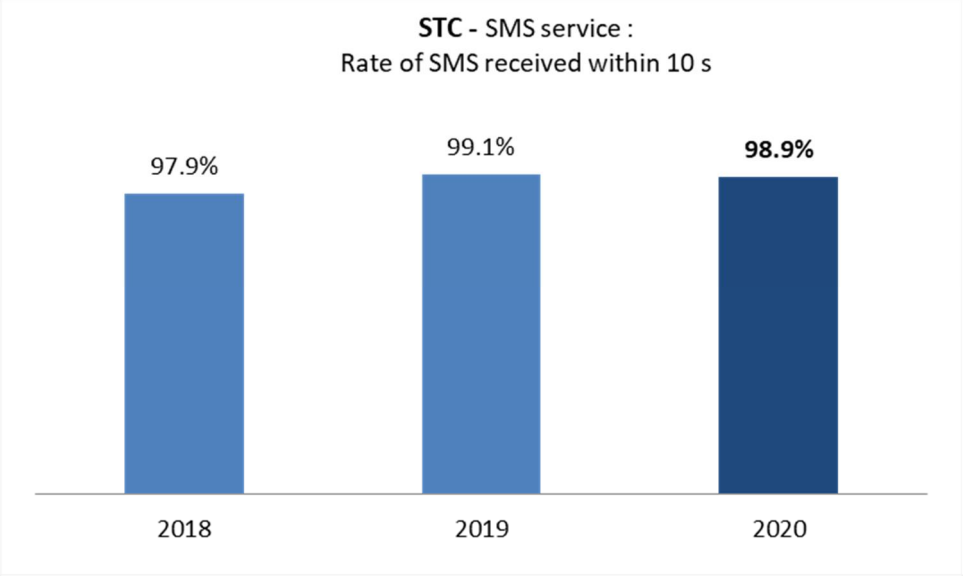


Figure 32 – SMS - Global results evolution

6.3.3. DATA SMARTPHONE RESULTS

6.3.3.1. 5G HANDSET

	STC Bahrain
HTTP DL	765 tests
Average Throughput Mbps)	**458.02**
Max throughput reached (Mbps)	**2 197.68**

Table 30 – 5G Handset – HTTP DL

	STC Bahrain
HTTP UL	770 tests
Average Throughput (Mbps)	**73.40**
Max throughput reached (Mbps)	**179.10**

Table 31 – 5G Handset – HTTP UL

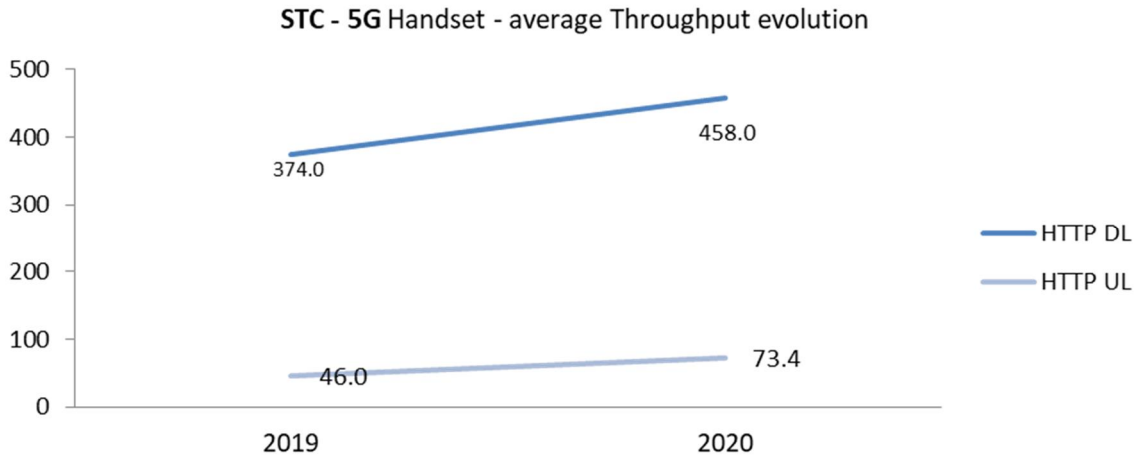


Figure 33 – 5G Handset – HTTP DL&UL – Throughputs evolution

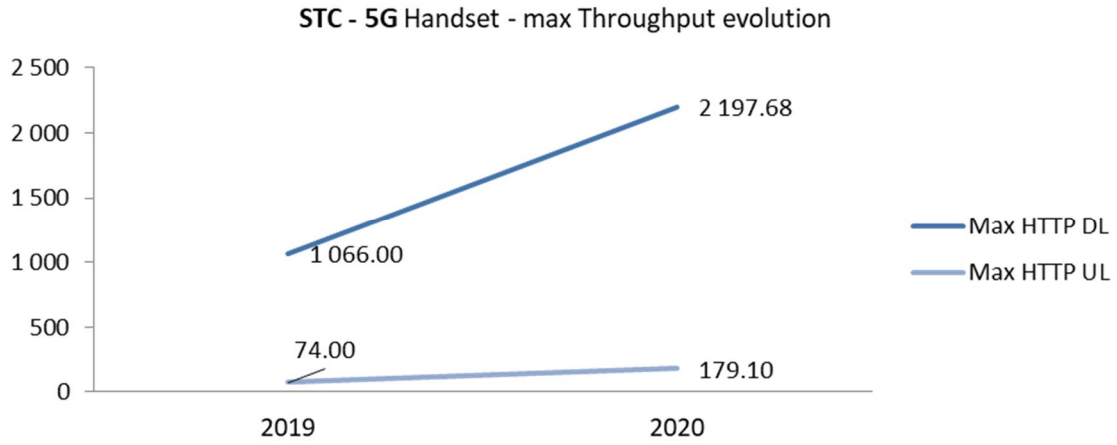


Figure 34 – 5G Handset – HTTP DL&UL – Max Throughputs reached evolution

	STC Bahrain
WEB	7 894 tests
Rate of successful webpage download Statistical accuracy	**100.0%** +/-0.0%
Average Delay (s)	1.9
% data transfers within 10 seconds	99.7%

Table 32 – 5G Handset – WEB Browsing

4.1.1.1. 4G HANDSET

	STC Bahrain
HTTP DL	800 tests
Average Throughput (Mbps)	**66.67**
Max throughput (Mbps)	**353.90**

Table 33 – 4G Handset – HTTP DL

	STC Bahrain
HTTP UL	800 tests
Average Throughput (Mbps)	**33.46**
Max throughput (Mbps)	**67.97**

Table 34 – 4G Handset – HTTP UL

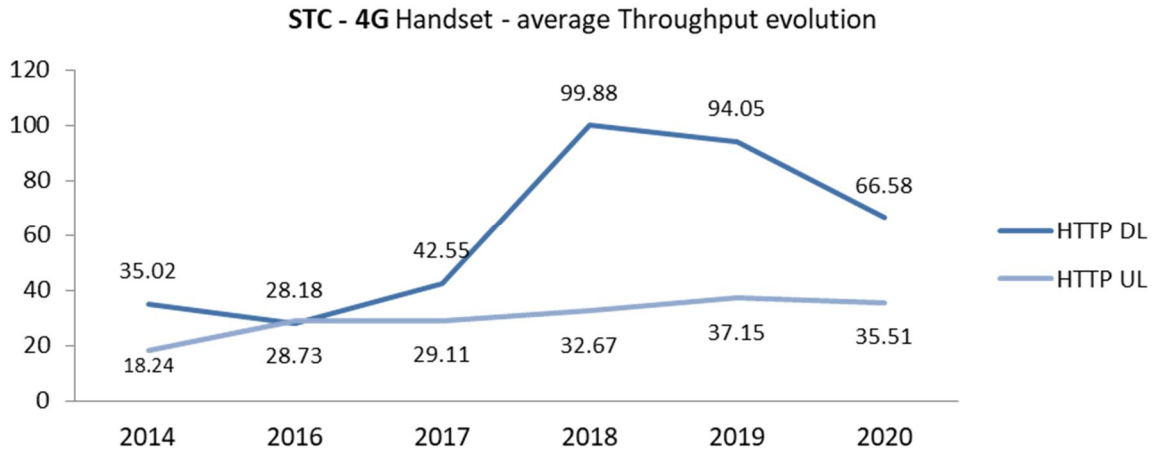


Figure 35 – 4G Handset – HTTP DL&UL – Throughputs evolution

	STC Bahrain
WEB	8 000 tests
Rate of successful webpage download Statistical accuracy	**100.0%** +/-0.0%
Average Delay (s)	2.3
% data transfers within 10 seconds	99.9%

Table 35 – 4G Handset – WEB Browsing

4.1.1.2. 3G HANDSET

	STC Bahrain
HTTP DL	660 tests
Average Throughput (Mbps)	**13.51**
Max throughput (Mbps)	**31.31**

Table 36 – 3G Handset – HTTP DL

	STC Bahrain
HTTP UL	658 tests
Average Throughput (kbps)	**2.85**
Max throughput (kbps)	**5.03**

Table 37 – 3G Handset – HTTP UL

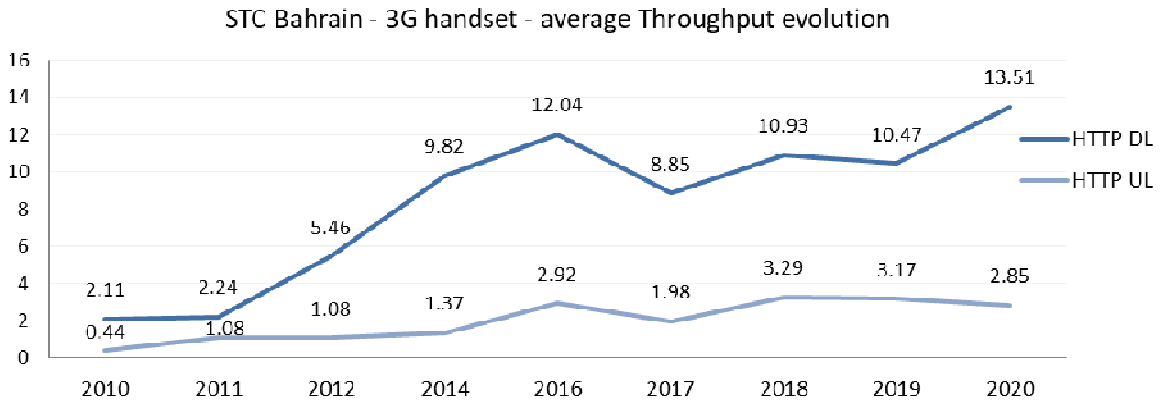


Figure 36 – 3G Handset – HTTP DL&UL – Throughputs evolution

	STC Bahrain
WEB	6 537 tests
Rate of successful webpage download Statistical accuracy	**100.0%** +/-0.0%
Average Delay (s)	3.9
% data transfers within 10 seconds	99.8%

Table 38 – 3G Handset – WEB Browsing

4.1.2. YOUTUBE KPIS

5.

	STC Bahrain
Total sample	1 437 tests
Rate of successful streaming (%) statistical accuracy	**99.6%** *+/-0.3%*
Average time to stream 1mn Video (access + streaming) (s)	77.0

Table 39 – YouTube results

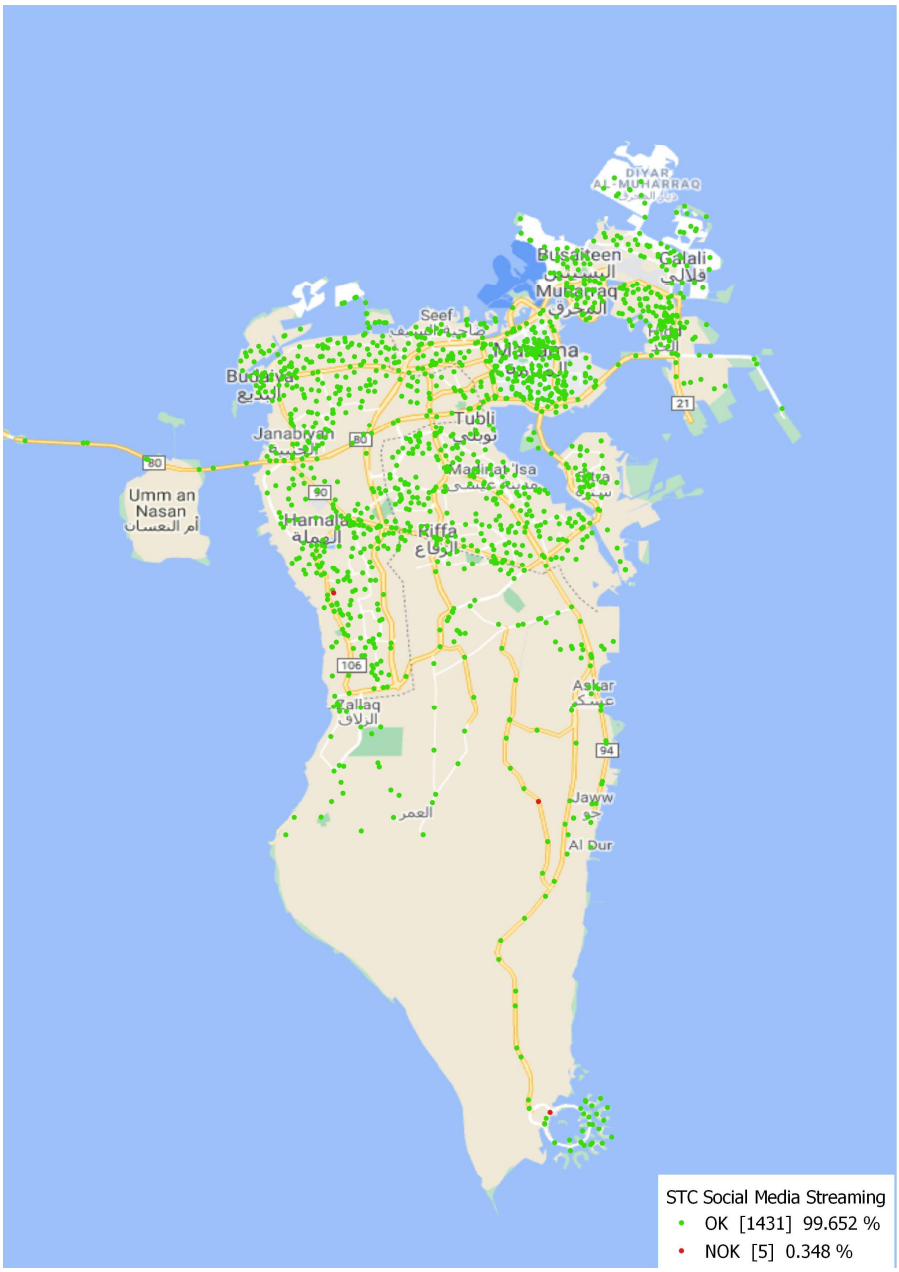


Figure 37 – STC - Streaming results map

5.1.1. TWITTER KPIS

	STC Bahrain
Total sample	2 883 tests
Rate of successful publication (%) statistical accuracy	**99.9%** *+/-0.1%*
Average time to publish (access + post) (s)	2.4

Table 40 – Twitter results

5.1.2. INSTAGRAM KPIS

6.

	STC Bahrain
Total sample	1 436 tests
Rate of successful publication (%) statistical accuracy	**99.9%** *+/-0.1%*
Average time to publish (access + post) (s)	1.6

Table 41 – Instagram results

6.1.1. WHATSAPP KPIS

7.

	STC Bahrain
Total sample	2900 tests
Rate of successful publication (%) statistical accuracy	**100.0%** *+/-0.0%*
Average time to publish (access + post) (s)	4.4

Table 42 – WhatsApp results

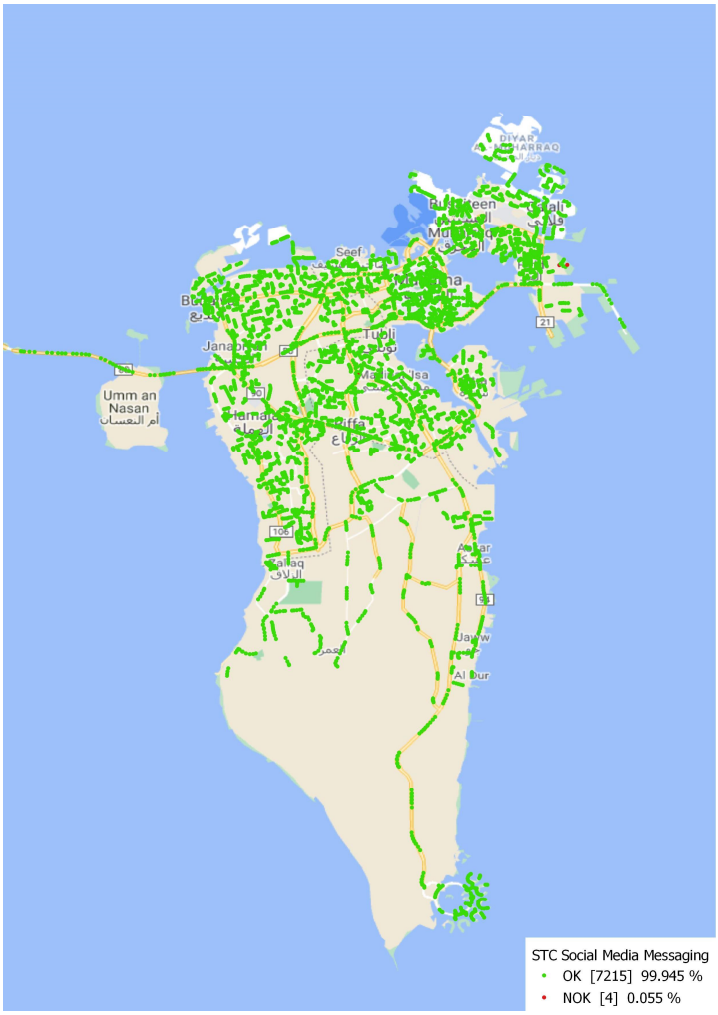


Figure 38 – STC – Global Messaging results map

6.4. ZAIN RESULTS

6.4.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

		ZAIN
Global voice service		2 594 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.5%** *+/-0.3%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.2%** *+/-0.3%*

Table 43 – Voice – Global results

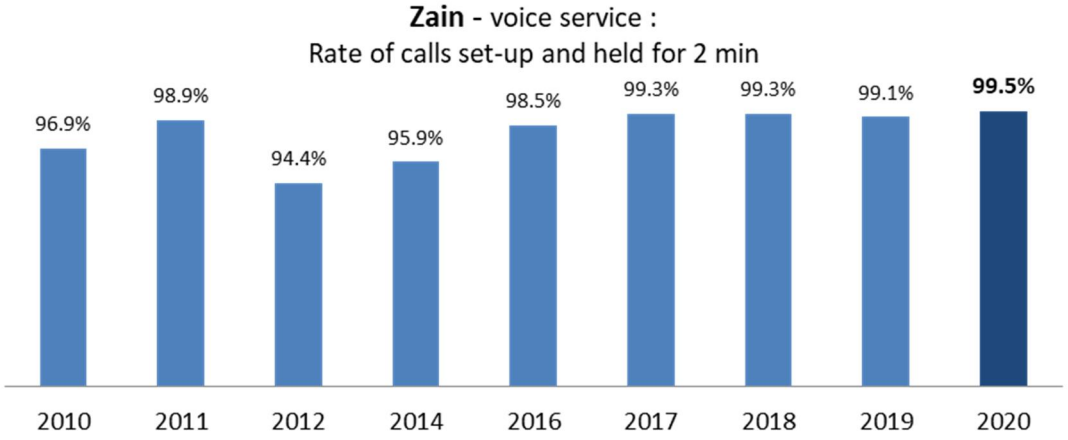


Figure 39 – Voice – Global results evolution

VoLTE:
50% of voice measurements were in volte, in cities and on road links.
Device for those tests was the Samsung Galaxy S9.

		ZAIN
Global voice service		1 313 tests
Rate of calls set-up and held for 2 min *statistical accuracy*		**99.6%** *+/-0.2%*
and marked	Rate of calls marked 4-perfect (PQR) *statistical accuracy*	**99.4%** *+/-0.3%*

Table 44 – VoLTE – Global results

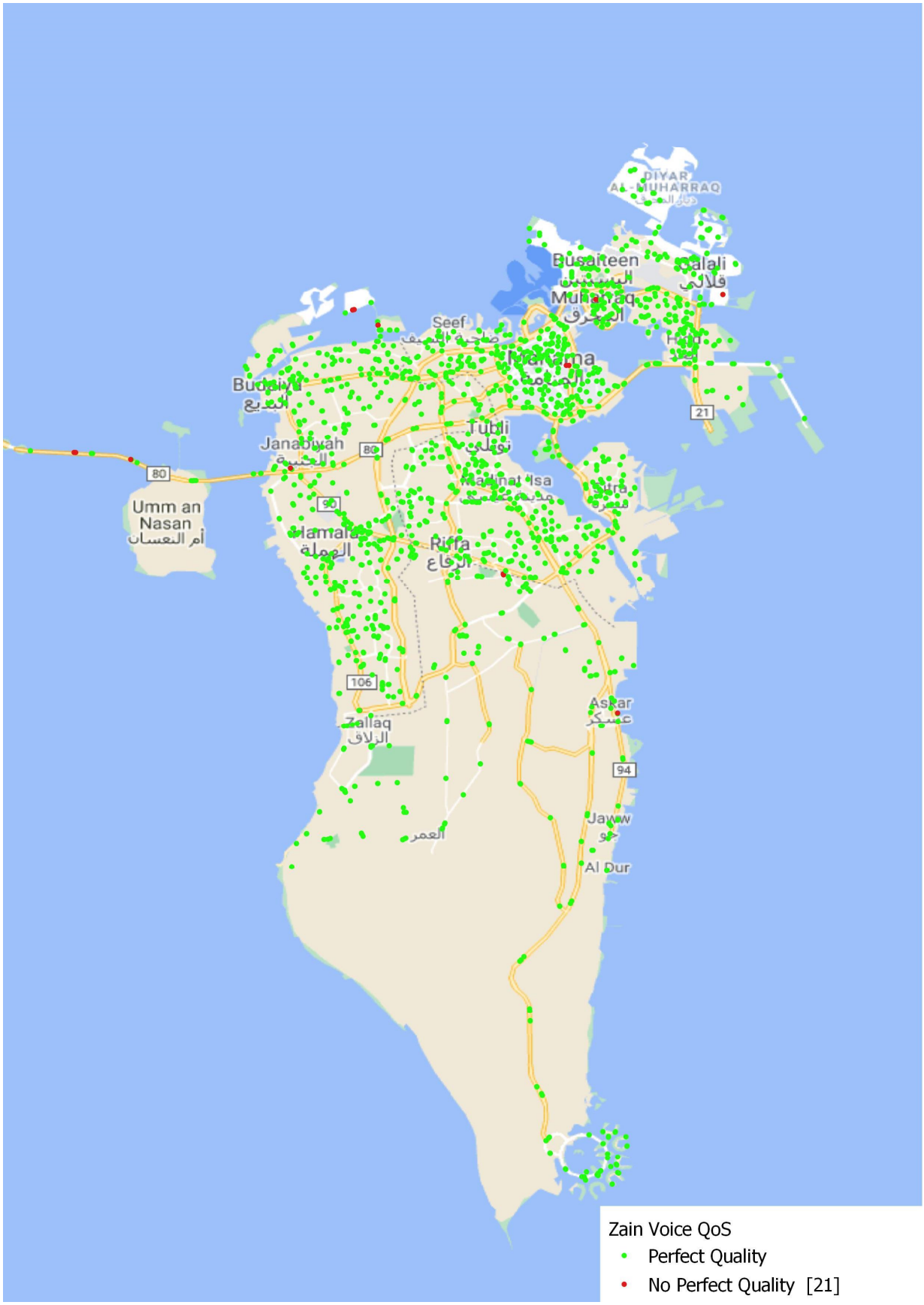


Figure 40 – **ZAIN** - Global voice results

6.4.2. SMS RESULTS

	ZAIN
SMS service	1 671 tests
% of received SMS (RS2)	**100%**
Statistical accuracy	*+/-0.0%*
% of received SMS (RS10)	99.5%
Statistical accuracy	*+/-0.3%*
% of received SMS (RS5)	98.5%
Statistical accuracy	*+/-0.6%*
Average reception delay (s)	2.4

Table 45 – SMS - Global results

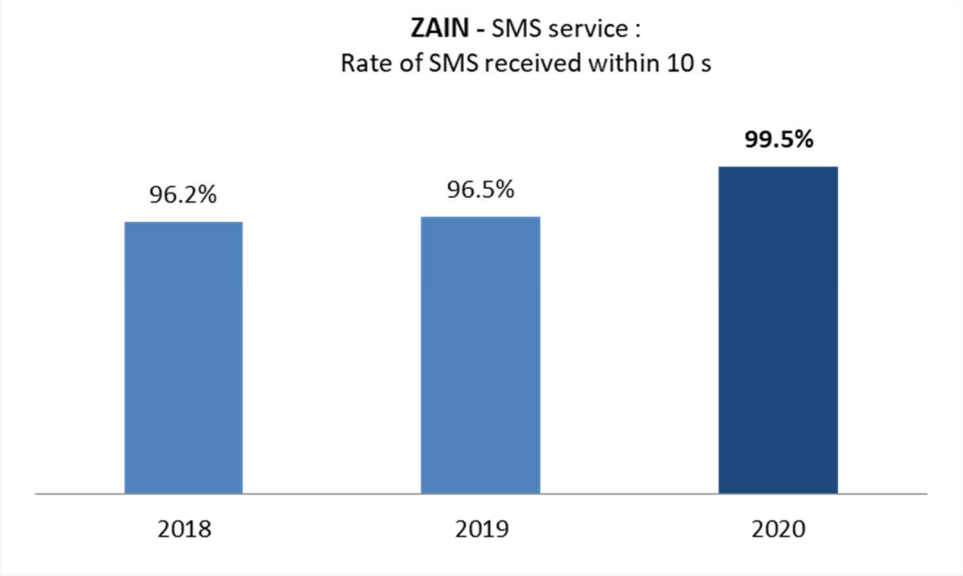


Figure 41 – SMS - Global results evolution

6.4.3. DATA SMARTPHONE RESULTS

6.4.3.1. 5G HANDSET

	ZAIN
HTTP DL	344 tests
Average Throughput (Mbps)	**222.74**
Max throughput reached (Mbps)	**976.97**

Table 46 – 5G Handset – HTTP DL

	ZAIN
HTTP UL	336 tests
Average Throughput (Mbps)	**48.58**
Max throughput reached (Mbps)	**98.03**

Table 47 – 5G Handset – HTTP UL

	ZAIN
WEB	3 403 tests
Rate of successful webpage download	**100.0%**
Statistical accuracy	+/-0.0%
Average Delay (s)	1.8
% data transfers within 10 seconds	99.9%

Table 48 – 5G Handset – WEB Browsing

First year of test conducted on 5G Network.

7.1.1.1. 4G HANDSET

	ZAIN
HTTP DL	755 tests
Average Throughput (Mbps)	**53.53**
Max throughput (Mbps)	**178.21**

Table 49 – 4G Handset – HTTP DL

	ZAIN
HTTP UL	754 tests
Average Throughput (Mbps)	**18.09**
Max throughput (Mbps)	**61.81**

Table 50 – 4G Handset – HTTP UL

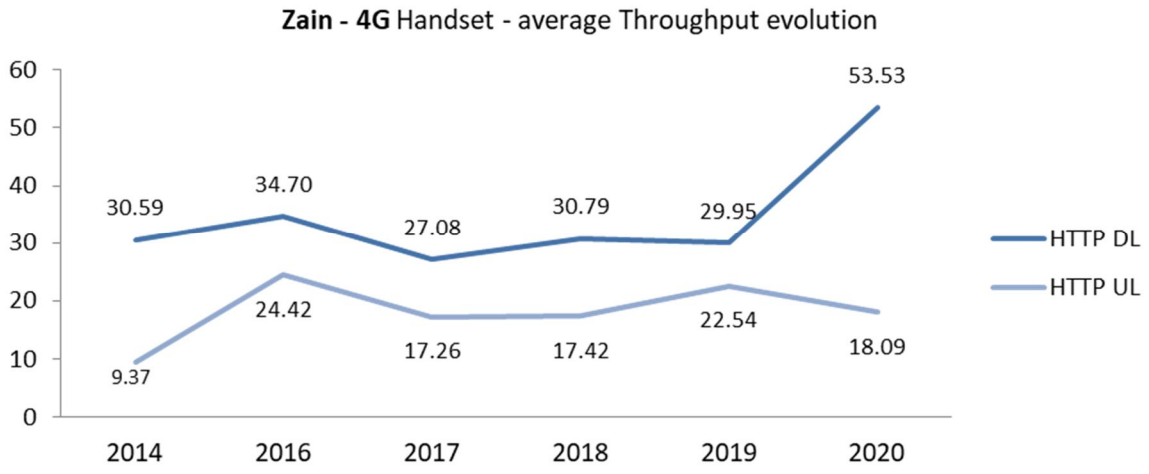


Figure 42 – 4G Handset – HTTP DL&UL – Throughputs evolution

	ZAIN
WEB	7 550 tests
Rate of successful webpage download Statistical accuracy	**100.0%** +/-0.0%
Average Delay (s)	2.2
% data transfers within 10 seconds	100%

Table 51 – 4G Handset – WEB Browsing

7.1.1.2. 3G HANDSET

	ZAIN
HTTP DL	695 tests
Average Throughput (Mbps)	**7.10**
Max throughput (Mbps)	**15.43**

Table 52 – 3G Handset – HTTP DL

	ZAIN
HTTP UL	695 tests
Average Throughput (Mbps)	**3.11**
Max throughput (Mbps)	**4.86**

Table 53 – 3G Handset – HTTP UL

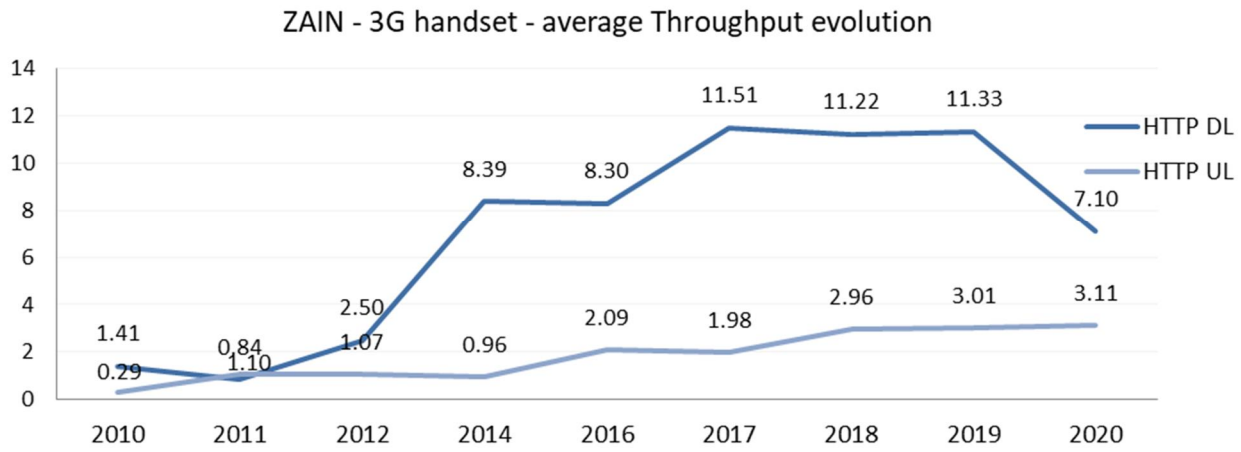


Figure 43 – 3G Handset – HTTP DL&UL – Throughputs evolution

	ZAIN
WEB	6 815 tests
Rate of successful webpage download Statistical accuracy	**100.0%** +/-0.0%
Average Delay (s)	3.7
% data transfers within 10 seconds	99.8%%

Table 54 – 3G Handset – WEB Browsing

7.1.2. YOUTUBE KPIS

8.

	ZAIN
Total sample	1 445 tests
Rate of successful streaming (%) statistical accuracy	**99.7%** *+/-0.3%*
Average time to stream 1mn Video (access + streaming) (s)	76.5

Table 55 – YouTube results

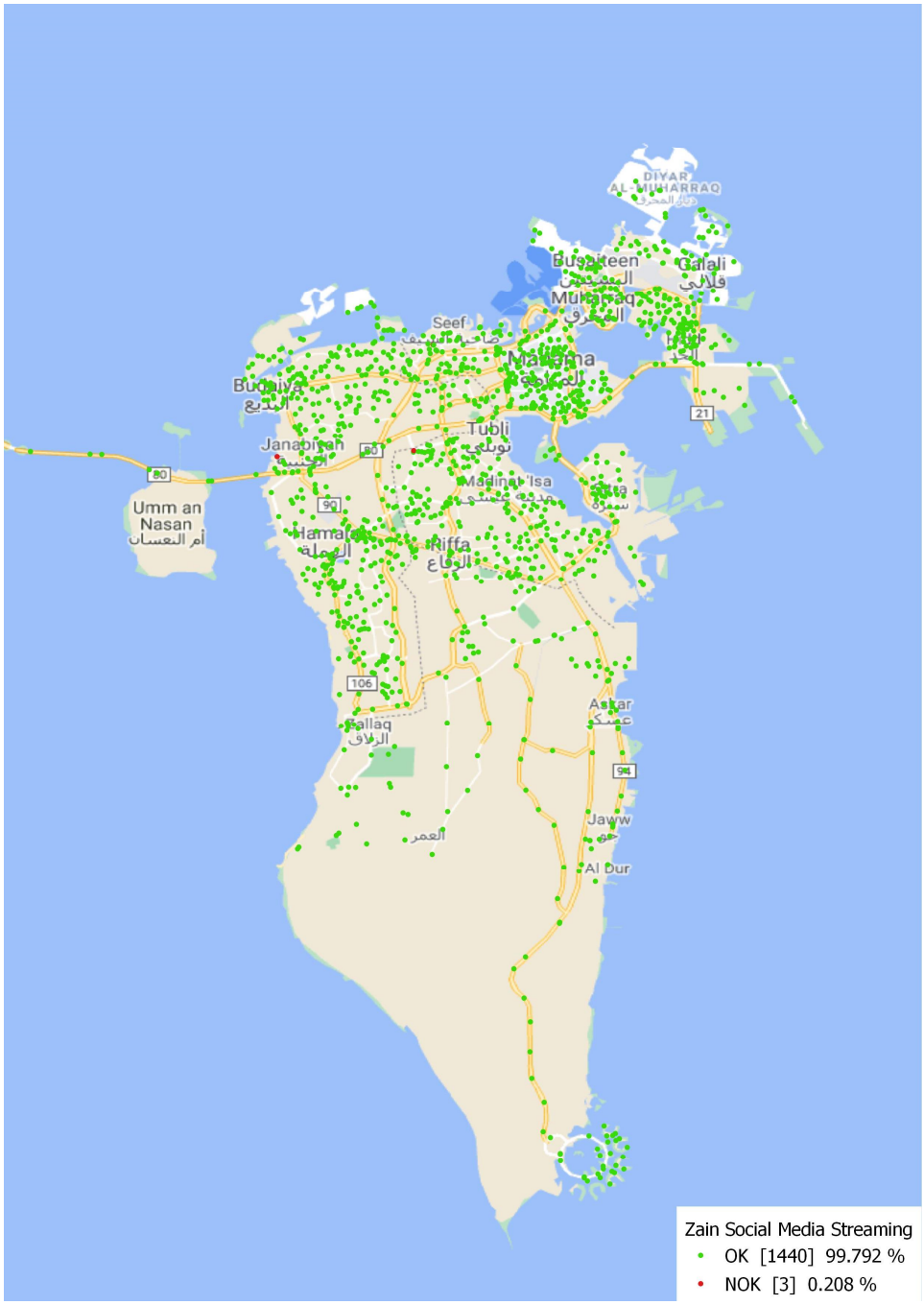


Figure 44 – ZAIN - Streaming results map

8.1.1. TWITTER KPIS

	ZAIN
Total sample	2 905 tests
Rate of successful publication (%) statistical accuracy	**100%** *+/-0.0%*
Average time to publish (access + post) (s)	2.3

Table 56 – Twitter results

8.1.2. INSTAGRAM KPIS

9.

	ZAIN
Total sample	1 442 tests
Rate of successful publication (%) statistical accuracy	**100.0%** *+/-0.0%*
Average time to publish (access + post) (s)	1.3

Table 57 – Instagram results

9.1.1. WHATSAPP KPIS

10.

	ZAIN
Total sample	2928 tests
Rate of successful publication (%) statistical accuracy	**99.9%** *+/-0.1%*
Average time to publish (access + post) (s)	4.3

Table 58 – WhatsApp results

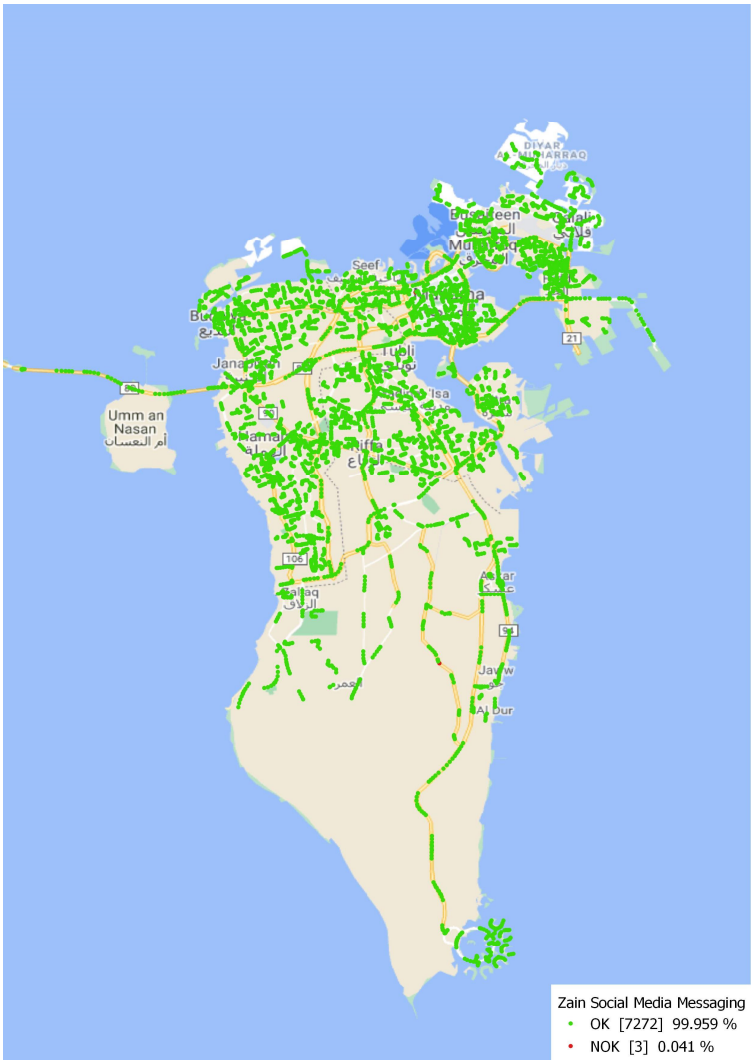


Figure 45 – ZAIN – Global Messaging results map

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