Directique
Customer Quality Perspectives

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

QUALITY OF MOBILE SERVICES
KINGDOM OF BAHRAIN – 2022

Version	Date	Author	Changelog
0	27/01/2023	Olivier GHIBAUDO	Creation of document
1	6/04/2023	Olivier GHIBAUDO	Update of the document
2	18/04/2023	Olivier GHIBAUDO	Update on Batelco Data results and STC Social Media
3	9/05/2023	Olivier GHIBAUDO	Update on Batelco 4G Data results

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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.

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 the arithmetic mean of the referred sample.

2. END TO END AUDIT PERFORMANCE APPROACH

This audit is a benchmark focused on end to end Quality of Service assessment 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, it is important to check first that the radio link can be established bilaterally to initiate voice and data communications and then, the voice and data performance can be evaluated.

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.
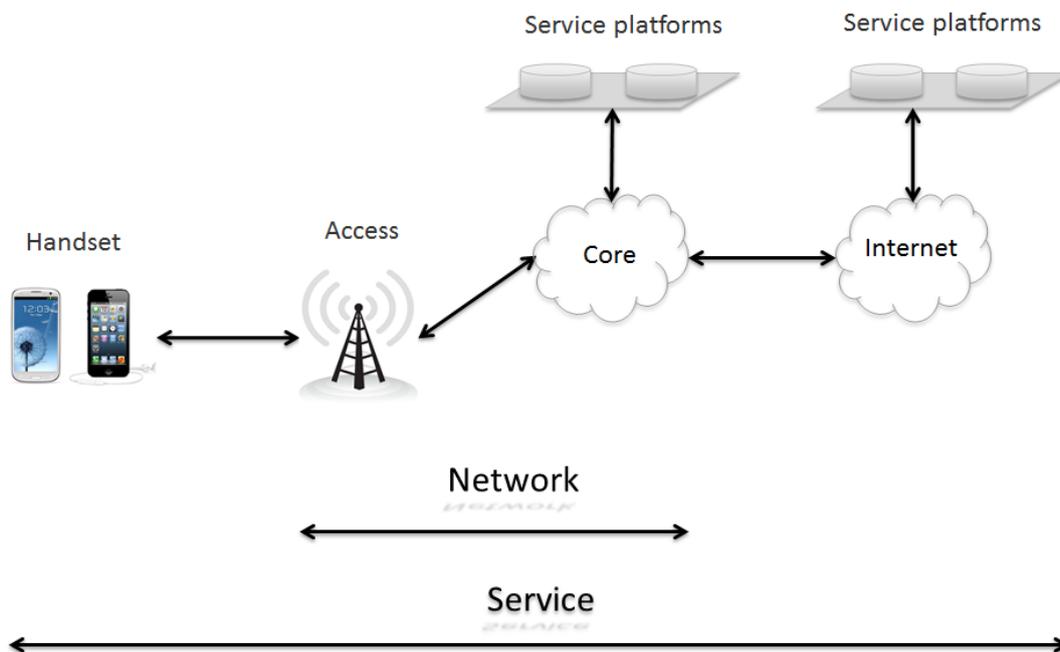
Figure 1 - End to end customer experience

The selected testing methodology mimics 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 Bahrain 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)

a specific Hotspots list is given by operators. Those hotspots are locations where radio configuration allows better data transfer 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 30th of October 2022 to the 18th of January 2023 inclusive. Measurements were performed between 9:00 am and 11:00 pm every day except Fridays.

In this report the Authority has made sure that as much as possible the results reflect realistic consumer experience. In order to achieve this we have had to exclude certain unreliable data to ensure that the report shows a realistic network performance.

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

	2022	2021	2020	2019	2018	2017	2016	2014	2012
Global **VOICE** service samples	**4797**	8,398	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)	**100%**	99.8%	99.4%	99.4%	99.5%	99.4%	98.7%	95.8%	96.6%
statistical accuracy	*+/-0.0%*	*+/-0.1%*	*+/-0.2%*	*+/-0.3%*	*+/-0.2%*	*+/-0.2%*	*+/-0.3%*	*+/-0.5%*	*+/-0.4%*
and marked **4-perfect (PQR)**	**100%**	99.6%	98.8%	98.1%	99.1%	99.3%	96.3%	93.8%	94.1%
statistical accuracy	*+/-0.0%*	*+/-0.1%*	*+/-0.2%*	*+/-0.5%*	*+/-0.3%*	*+/-0.2%*	*+/-0.5%*	*+/-0.6%*	*+/-0.6%*

Table 1 – Voice service – industry results
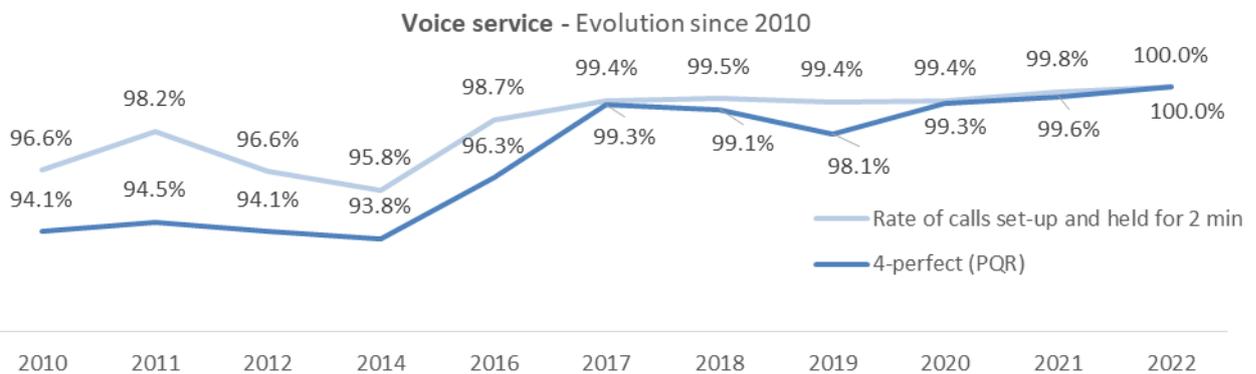
Figure 2 – Evolution of Voice Service since 2010

The three networks offered the same excellent level of service as 2018, with an average setup and held calls rate of 100% with improved quality of 0.4 point.

	2022	2021	2020	2019	2018	2017	2016	2014	2012
Global SMS Service samples	**3 835**	4,110	5,013	2,874	3,110	3,001	2,591	4,547	2,637
% of received SMS (RS2)	**100.0%**	99.7%	100.0%	100.0%	100.0%	99.6%	99.9%	99.9%	99.6%
statistical accuracy	***+/-0.0%***	*+/-0.2%*	*+/-0.0%*	*+/-0.0%*	*+/-0.0%*	*+/-0.2%*	*+/-0.1%*	*+/-0.1%*	*+/-0.2%*
% of received SMS (RS15)	**100.0%**	99.5%	99.6%	99.4%	98.8%	96.6%	95.1%	91.5%	96.5%
statistical accuracy	***+/-0.0%***	*+/-0.2%*	*+/-0.2%*	*+/-0.3%*	*+/-0.4%*	*+/-0.6%*	*+/-0.8%*	*+/-0.8%*	*+/-0.7%*
% of received SMS (RS10)	**100.0%**	99.4%	99.4%	98.3%	96.6%				
statistical accuracy	***+/-0.0%***	*+/-0.2%*	*+/-0.2%*	*+/-0.3%*	*+/-0.6%*				
% of received SMS (RS5)	**99.9%**	98.3%	98.4%						
statistical accuracy	***+/-0.1%***	*+/-0.4%*	*+/-0.3%*						
Average reception delay (s)	**0.4**	1.5	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 100% of messages received within 15 seconds, 100% within 10s and 99.9% within 5s. The last indicator was introduced two years ago and has only improved since then.
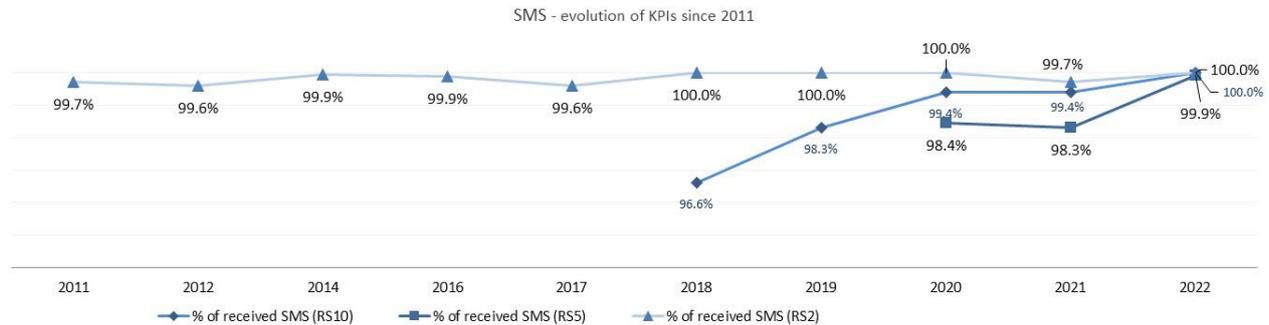
Figure 3 – SMS evolution of KPIs since 2011

The average observed SMS reception delay was 0.4 seconds, which is the best performance since 2010.

3.2.2. SMARTPHONE DATA MEASUREMENTS

Since 2019, an addition of protocol for HTTP data transfers measurements has been decided by 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 follow:

- 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.

Average Throughput presented in the report is calculated from weighted arithmetic mean.

5G HANDSET:

		2019	2020	2021	2022
HTTP DL	Average Throughputs in Mbps	429.00	440.36	721.10	**870.3**
HTTP UL	Average Throughputs in Mbps	41.00	65.82	76.24	**111.4**

Table 3 – 5G Handset data service – industry results

5G Handset - average Throughput evolution (Mbps)

— HTTP DL — HTTP UL

870.30

721.10

429.00 440.36

41.00 65.82 76.24 111.40
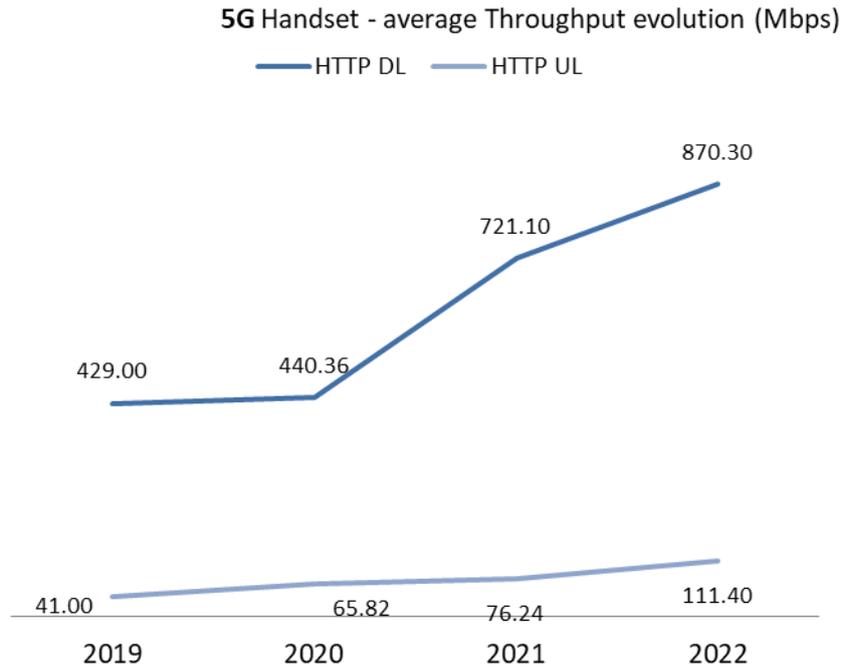
2019 2020 2021 2022

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

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

5G handset - Web browsing % Successful sessions

100.0% 99.9% 100.0%
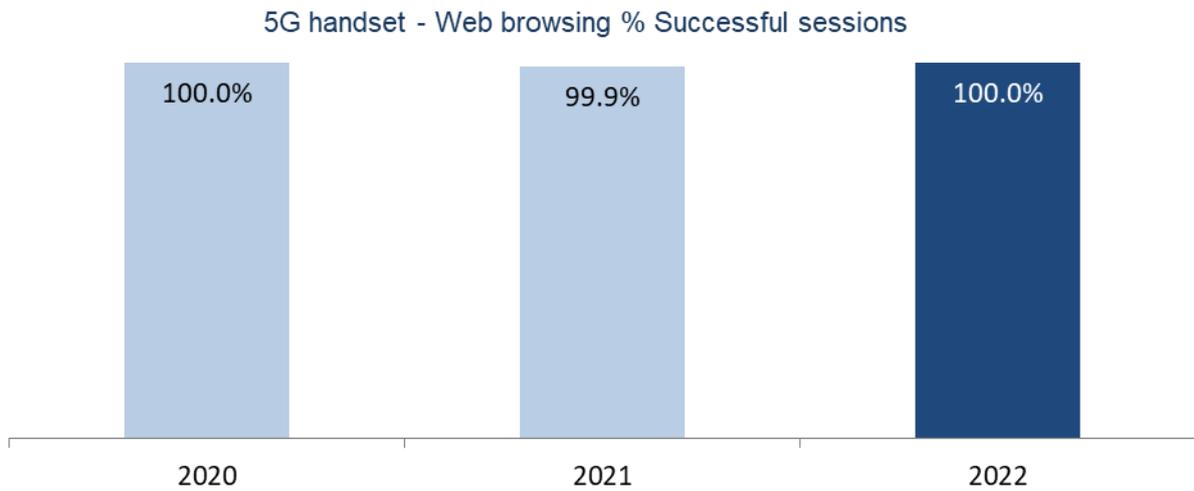
2020 2021 2022

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

4G HANDSET:

		2014	2016	2017	2018	2019	2020	2021	**2022**
HTTP DL	Average Throughputs in Mbps	30.717	29.783	37.276	61.908	80.831	84.690	190.52	**266.30**
HTTP UL	Average Throughputs in Mbps	12.639	26.665	23.389	24.294	29.444	28.530	36.46	**66.20**

Table 4 – 4G Handset data service – industry results

4G Handset - average Throughput evolution in Mbps

— HTTP DL — HTTP UL

30.72	29.78	37.28	61.91	80.83	84.69	190.52	266.30
12.64	26.67	23.39	24.29	29.44	28.53	36.46	66.20
2014	2016	2017	2018	2019	2020	2021	2022
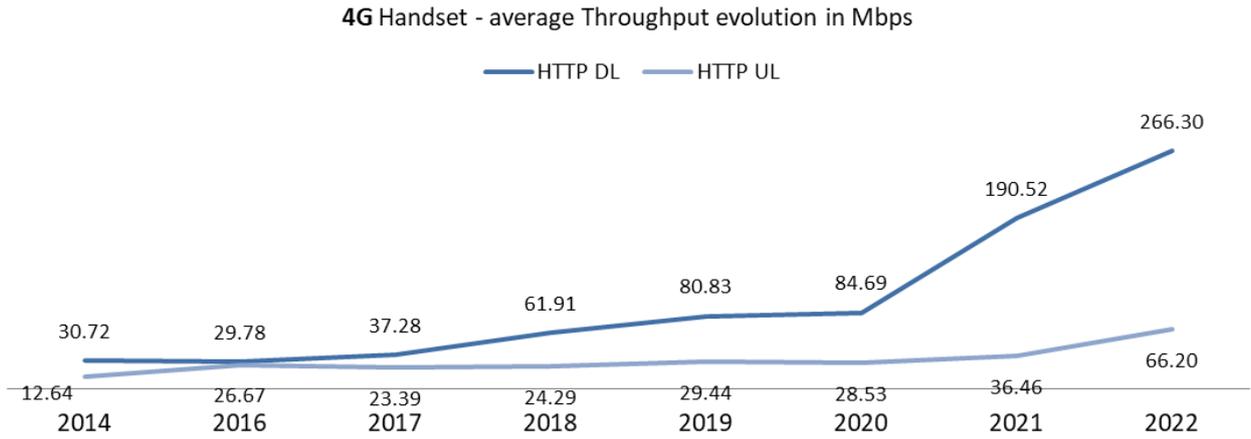
Figure 6 – 4G Handset – HTTP transfers – average throughputs

4G handset - Web browsing % Successful sessions

2014	2016	2017	2018	2019	2020	2021	2022
98.1%	99.4%	99.7%	100.0%	99.6%	100.0%	99.9%	100.0%
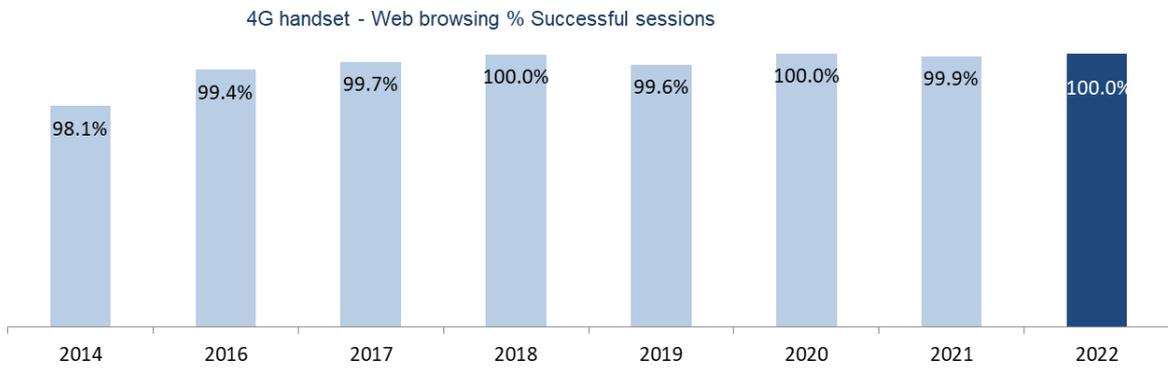
Figure 7 – 4G Handset – WEB browsing – % Successful sessions

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.

2019 - 2022 Comparison - 5G Handset - HTTP DL
Enhanced Technologies cell sites vs Random locations
average throughputs (Mbps)

	ET CELL SITES	RANDOM LOCATIONS
2019	903	333
2020	897	362
2021	1 378	533
2022	1 638	655
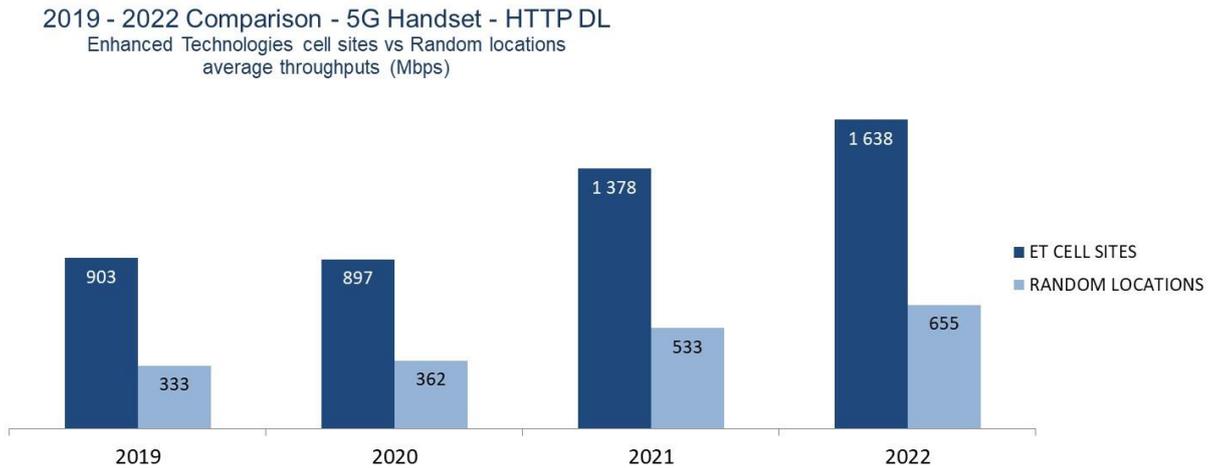
Figure 8 – 2019- 2022 - 5G Handset – HTTP DL - average throughputs

2022 to 2020 5G measurements include the three Mobile Operators, BATELCO, STC and ZAIN.

Comparing to 2019, where only BATELCO and STC had been measured.

2019 - 2022 Comparison - 5G Handset - HTTP UL
Enhanced Technologies cell sites vs Random locations
average throughputs (Mbps)

	ET CELL SITES	RANDOM LOCATIONS
2019	55	27
2020	113	57
2021	121	63
2022	163	97
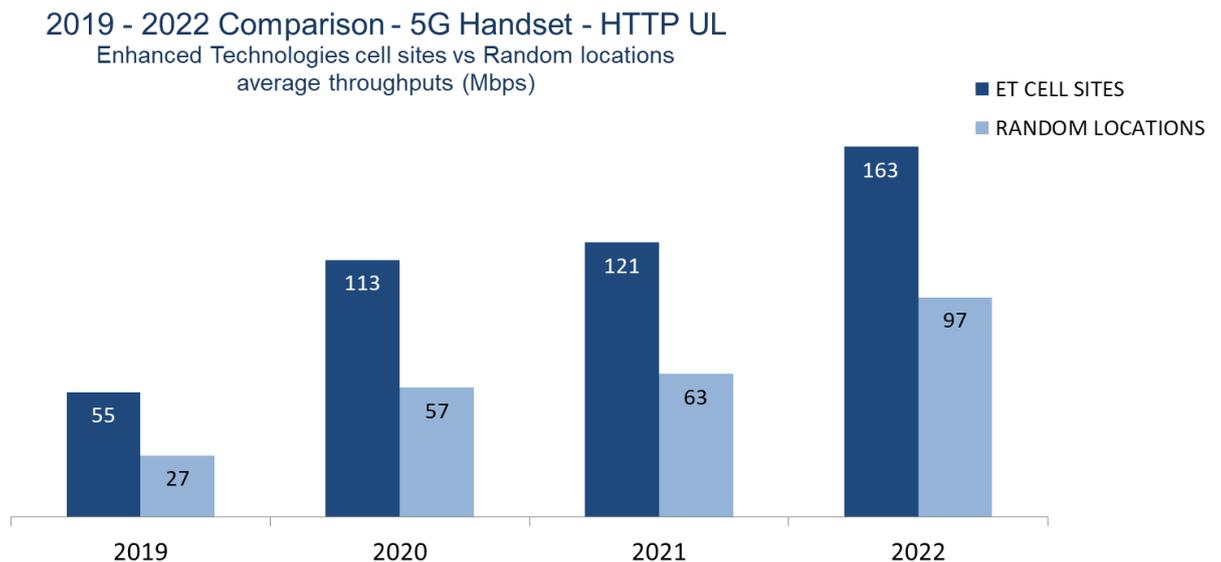
Figure 9 – 2019- 2022 - 5G Handset – HTTP UL - average throughputs

The maximum throughput that has been reached during the audit is represented below with comparison with 2019, 2020 and 2021:
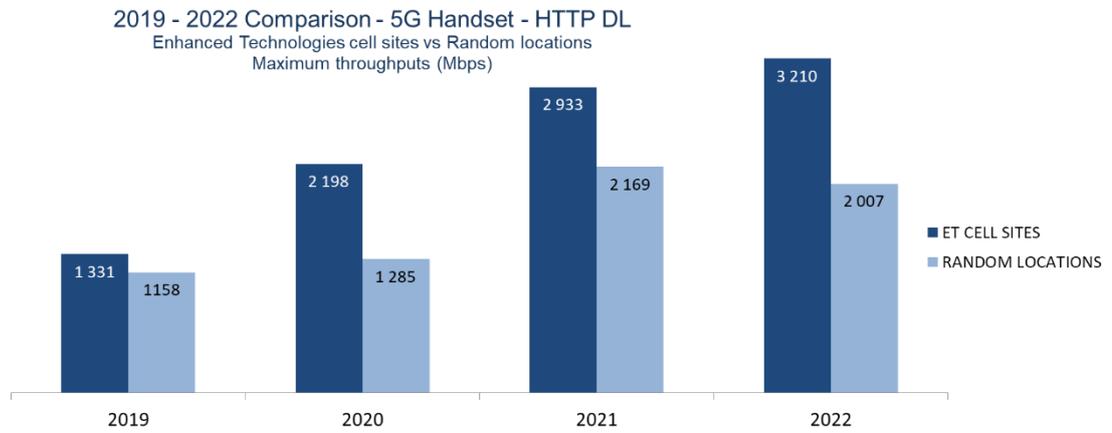
Figure 10 – 2019 - 2022 - 5G Handset – HTTP DL - maximum throughputs reached
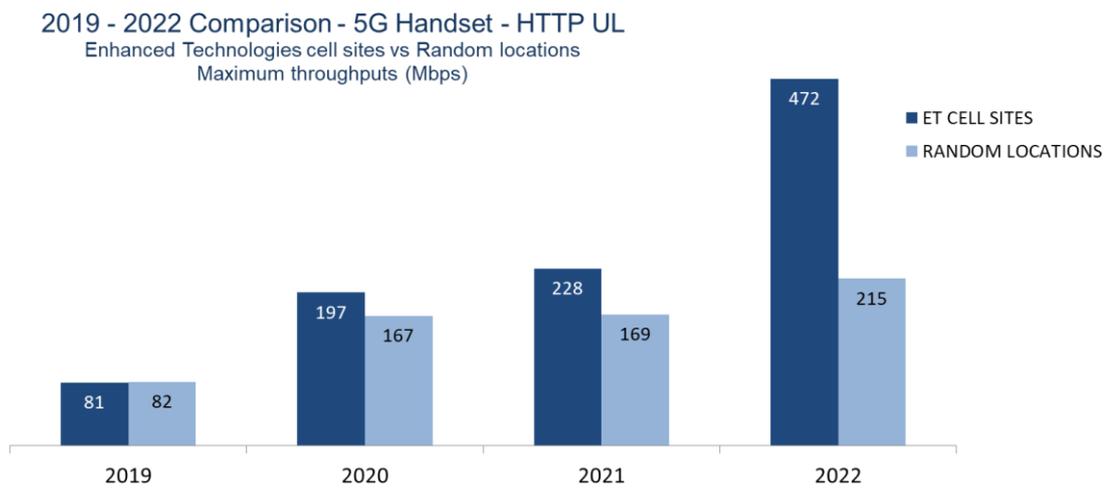
Figure 11 – 2019 - 2022 - 5G Handset - HTTP UL - maximum throughputs reached

2019 - 2022 Comparison - 4G Handset - HTTP DL
Enhanced Technologies cell sites vs Random locations
average throughputs (Mbps)
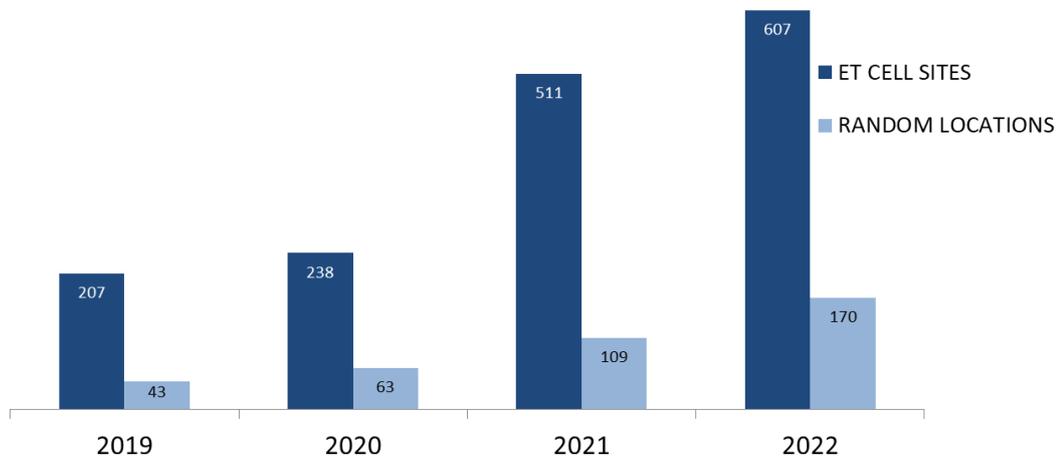
Figure 12 – 2019- 2022 - 4G Handset – HTTP DL - average throughputs

2019 - 2022 Comparison - 4G Handset - HTTP UL
Enhanced Technologies cell sites vs Random locations
average throughputs (Mbps)
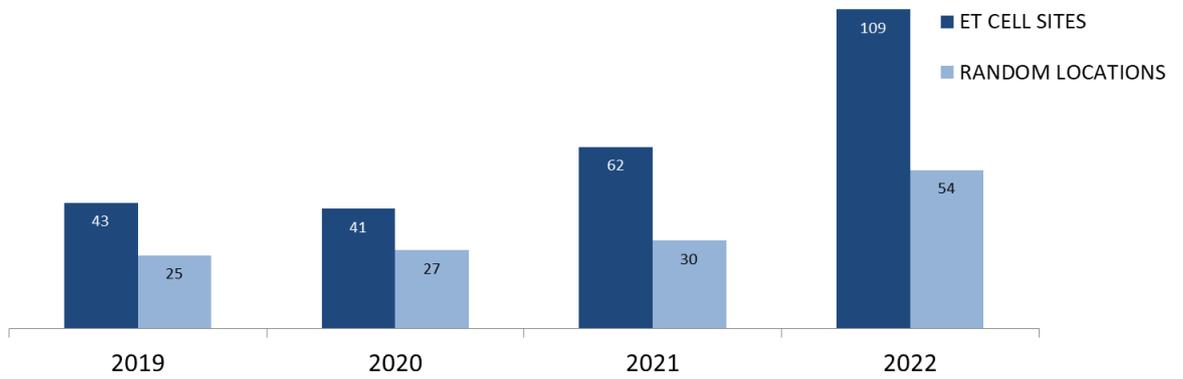
Figure 13 - 2019- 2022 - 4G Handset – HTTP UL - average throughputs

The maximum throughput that have been reached during the audit is represented below with comparison with 2019, 2020 and 2021:
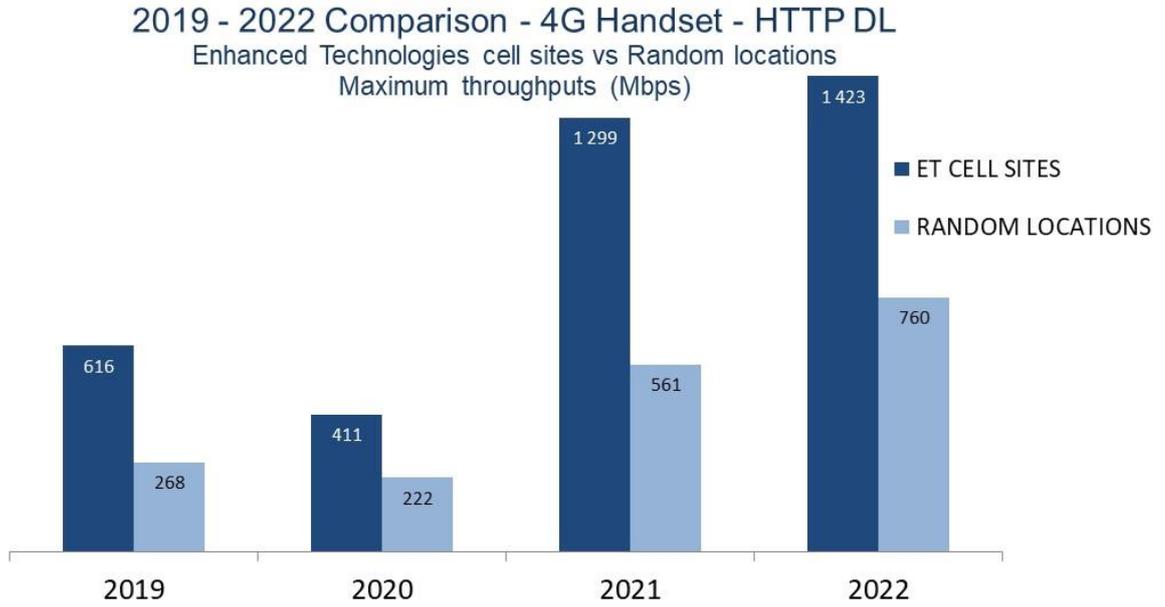
Figure 14 – 2019 - 2022 - 4G Handset – HTTP DL - maximum average throughputs
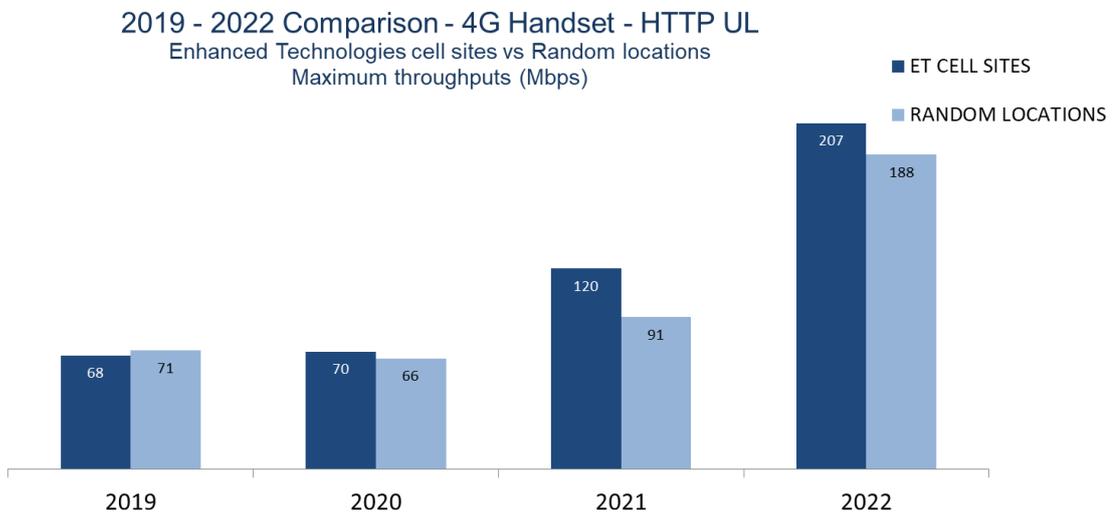
Figure 15 – 2019 - 2022 - 4G Handset – HTTP UL – maximum average throughputs

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.

HTTP Average DL Throughput (Mbps) with a 5G handset

Bahrain 2022	900.9
Bahrain 2021	721.1
Bahrain 2020	440.4
Bahrain 2019	429.0
France 2022	840.0
France 2021	340.0
France 2020	400.0

HTTP Max DL Throughput (Mbps) with a 5G handset

Bahrain 2022	3 210.0
Bahrain 2021	2 933.6
Bahrain 2020	2 197.7
Bahrain 2019	1 331.0
France 2022	1 850.0
France 2021	1 350.0
France 2020	1 100.0
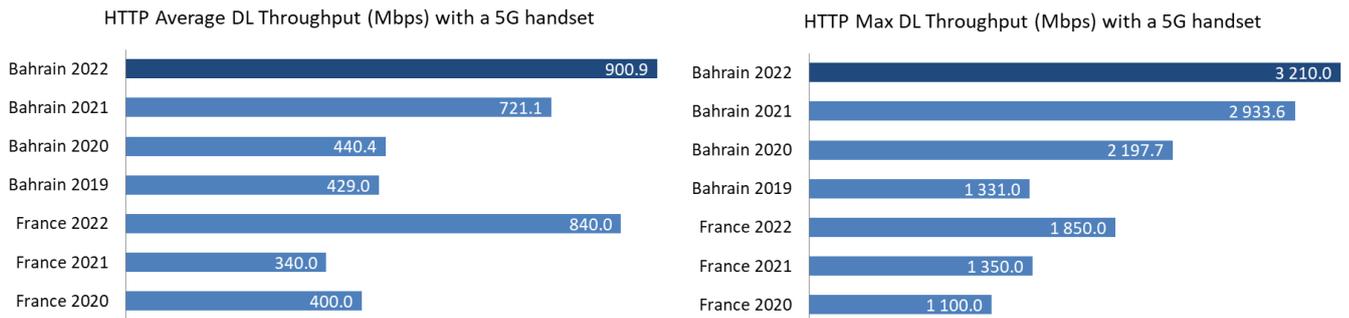
4G - HTTP Average Download Throughput (Mbps)

Bahrain 2022	281.5
Bahrain 2021	190.5
France 2022	94.0
France 2021	82.0
Morocco 2022	59.0
Morocco 2021	62.0
UAE 2022	184.0
UAE 2019	59.5
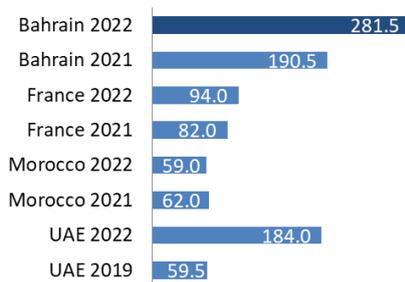
4G - HTTP Average Upload Throughput (Mbps)

Bahrain 2022	67.9
Bahrain 2021	36.5
France 2022	24.0
France 2021	18.0
Morocco 2022	23.0
Morocco 2021	22.0
UAE 2022	44.0
UAE 2019	34.8

Voice Quality - Rate of successfull calls set up

Bahrain 2022	100.0%
Bahrain 2021	99.8%
France 2022	98.4%
France 2021	96.5%
Saudi Arabia 2022	99.6%
Saudi Arabia 2021	99.6%
UAE 2022	99.8%
UAE 2021	99.9%

SMS Service - Rate of SMS received within 10 seconds

Bahrain 2022	100.0%
Bahrain 2021	99.4%
France 2022	97.5%
France 2021	97.4%
Morocco 2022	95.0%
Morocco 2021	94.0%

*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.
- A field supervisor based in the Kingdom for the whole audit duration.
- Test team "A" performing voice SMS and Social Media measurements:
    - 1 engineer 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	**Huawei P40 Pro**
SM-G928F	
H+ 42 Mbps (HSPA+)	
LTE 1024 Mbps (**Cat.18**)	**5G NSA / SA**

For Data QoS:

4G Handset	5G Handset
Samsung Galaxy Z Fold4	**Samsung Galaxy Z Fold4**
LTE (Cat.20)	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. Sɪᴍ Cᴀʀᴅs

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. Vᴏɪᴄᴇ sᴇʀᴠɪᴄᴇ ǫᴜᴀʟɪᴛʏ ᴛᴇsᴛɪɴɢ

5.2.1. Mᴇᴀsᴜʀᴇᴍᴇɴᴛ

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:

Call Origination & Termination

100%

■ Mobile to Mobile (MTM) On Net
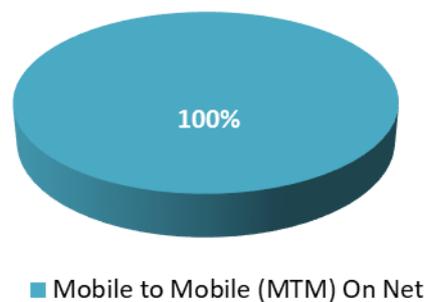
Figure 17 – Voice calls distribution

Voice measurements were performed in one configuration:

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

Field Configurations
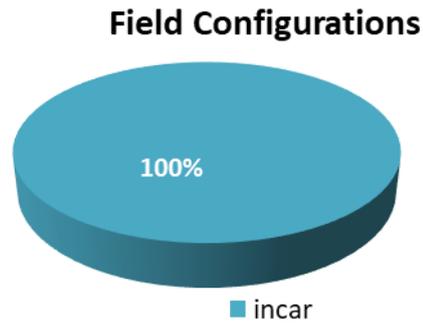
Figure 18 – Voice measurements type

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 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
Level 5 : Excellent	MOS notation > 3.1

Table 5 – Audio Quality Marking

5.2.2. TESTING AREA AND SAMPLE SIZE

A total of 8340 tests have been performed with the following distribution for each governorate:

By Governorate

	INCAR
CAPITAL	1417
AL MUHARRAQ	1107
NORTHERN	1032
SOUTHERN	1241
TOTAL	**4797**

Table 6 – Voice sampling by governorate

The geographical distribution of the Voice test is as shown on the map below:
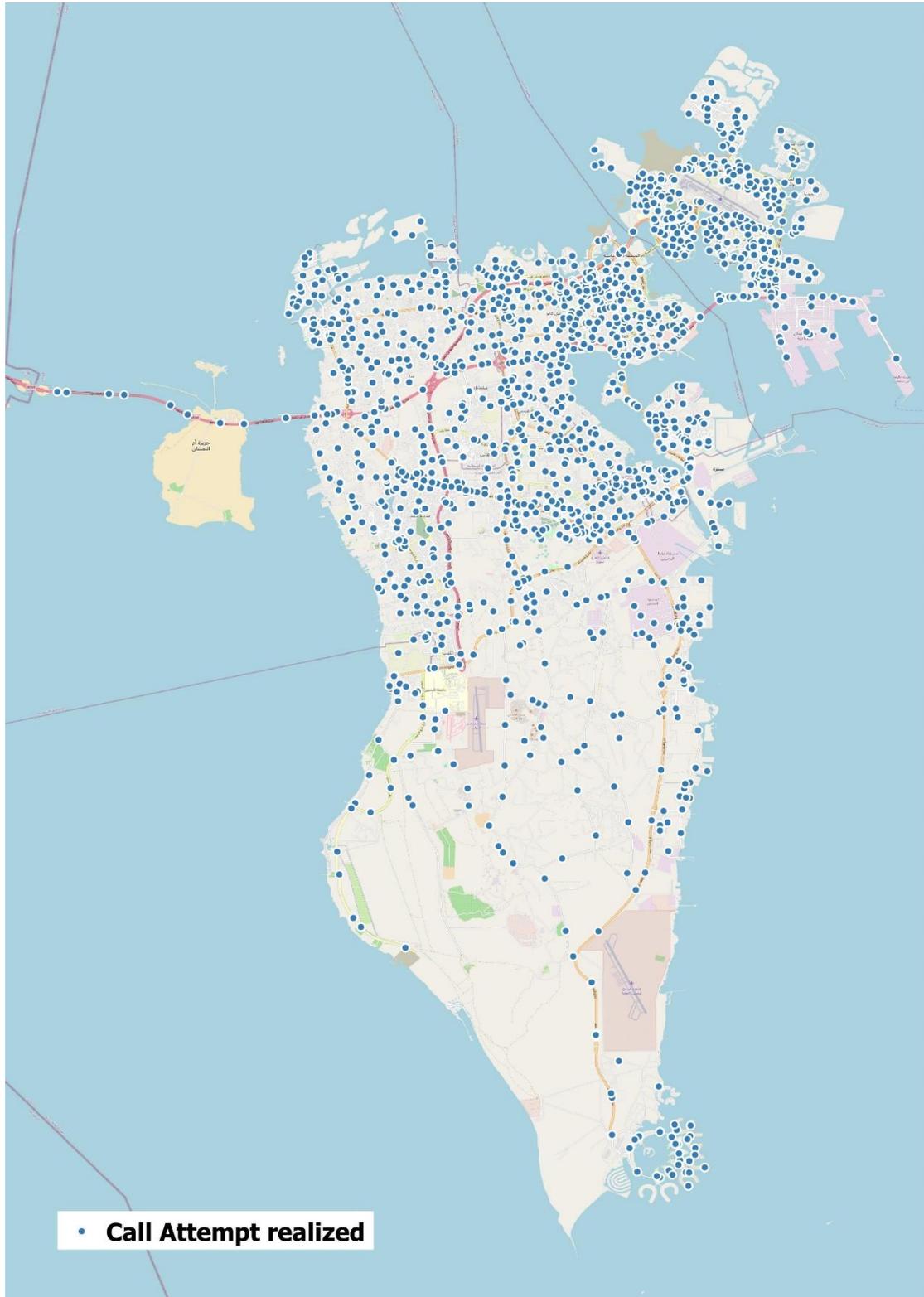
Figure 19 – Test locations: voice service

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 samples pool.

Every day, 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 divided between hotspots and random places.

60 hotspots location called Enhanced Technology Hotspots and 200 Random locations* have been tested in 4G and 5G for each MNOs.

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)

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

		4G - Smartphone	5G - Smartphone
RANDOM	**HTTP DL / HTTP UL / /WEB**	✓	✓
HOTSPOTS	**HTTP DL / HTTP UL / /WEB**	✓	✓

Table 7 – 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://bh.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 8 – List of webpages tested

5.4.4. SAMPLE

HTTP DL	HTTP UL	WEB	Total
7 800	7 800	70 027	**85 627**

Table 9 – 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
EQR (Excellent quality rate)	% of calls set-up held for 2 min and marked 5. 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

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

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

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

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. Facebook KPIs

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

6.1.9. YOUTUBE KPIS

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)

VoLTE:
Voice measurements were in VoLTE, in cities and on road links.
Device for those tests was the Samsung Galaxy S9.

		Batelco
Global voice service		1,586
Rate of calls set-up and held for 2 min		**100.0%**
	statistical accuracy	+/-0.0%
and marked	Rate of calls marked 4-perfect (PQR)	**100.0%**
	statistical accuracy	+/-0.0%
	Rate of calls marked 5-Excellent (EQR)	**99.6%**
	statistical accuracy	+/-0.2%

Table 10 – VoLTE – Global results

Batelco voice service :
Rate of calls set-up and held for 2 min

Year	Value
2010	96.0%
2011	97.8%
2012	97.9%
2014	94.0%
2016	99.0%
2017	99.3%
2018	99.4%
2019	99.5%
2020	100.0%
2021	100.0%
2022	100.0%
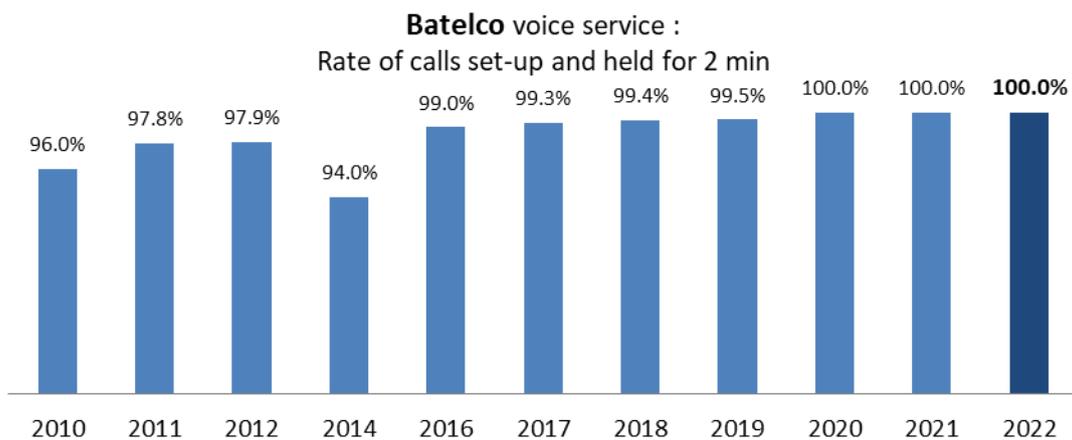
Figure 20 – Voice – Global results evolution
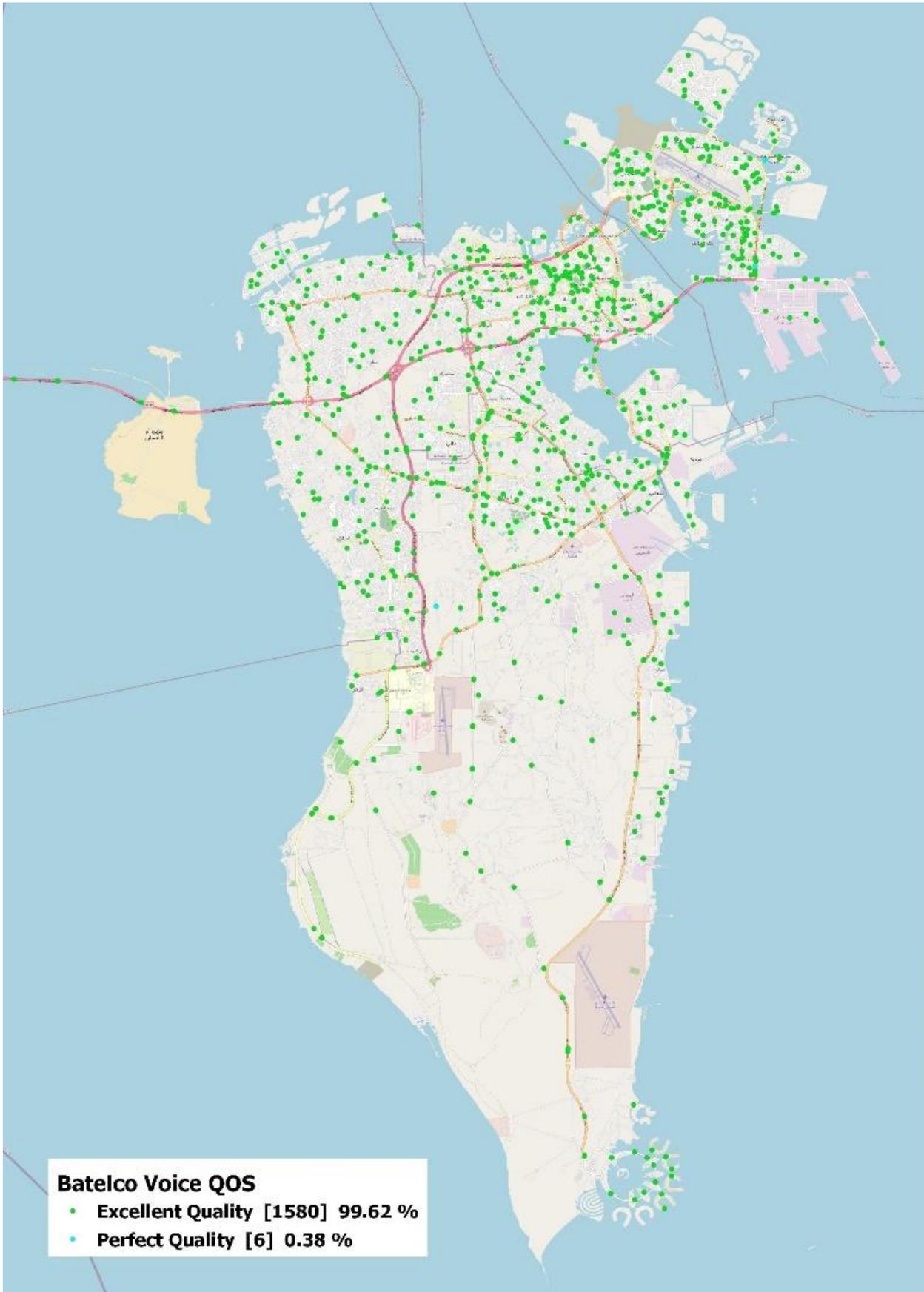
Figure 21 – **BATELCO** - Global voice results

6.2.2. SMS RESULTS

|	Batelco
SMS service	1,536
% of received SMS (RS2)	**100%**
Statistical accuracy	+/-0.0%
% of received SMS (RS10)	**100.0%**
+/-0.0%	+/-0.2%
% of received SMS (RS5)	**100.0%**
+/-0.2%	+/-0.0%
Average reception delay (s)	**0.4**

Table 11 – SMS - Global results
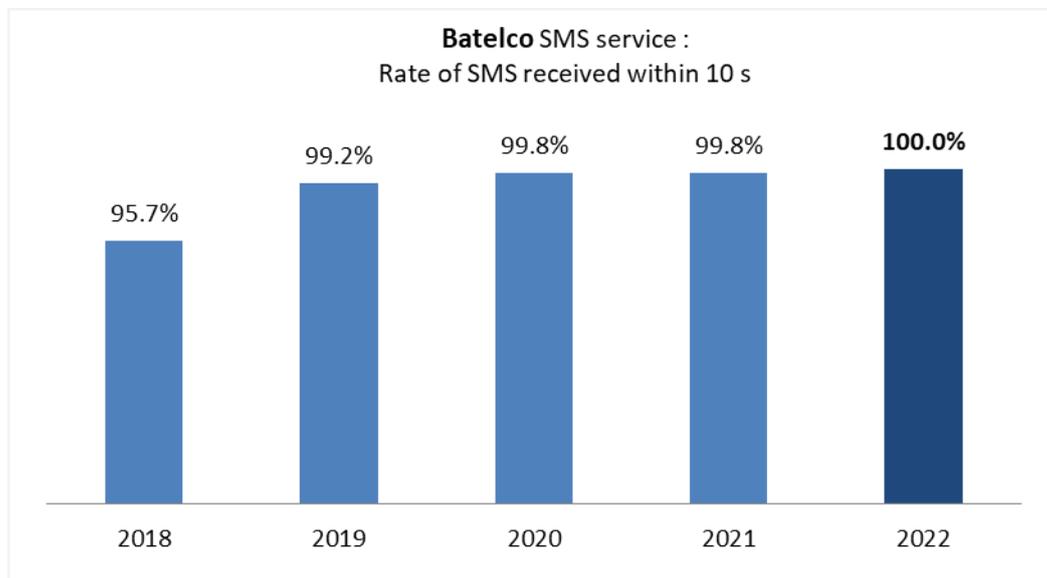
Figure 22 – SMS - Global results evolution

6.2.3. DATA SMARTPHONE RESULTS

60 hotspots location called Enhanced Technology Hotspots and 200 Random locations have been tested in 4G and 5G for each MNOs.

1.1.1.1. 5G HANDSET

	Batelco
HTTP DL	
Average Throughput (Mbps)	**1,157.40**
Max throughput reached (Mbps)	**2,862.8**

Table 12 – 5G Handset – HTTP DL

	Batelco
HTTP UL	
Average Throughput (Mbps)	**131.3**
Max throughput reached (Mbps)	**294.80**

**Table 13** – 5G Handset – HTTP UL
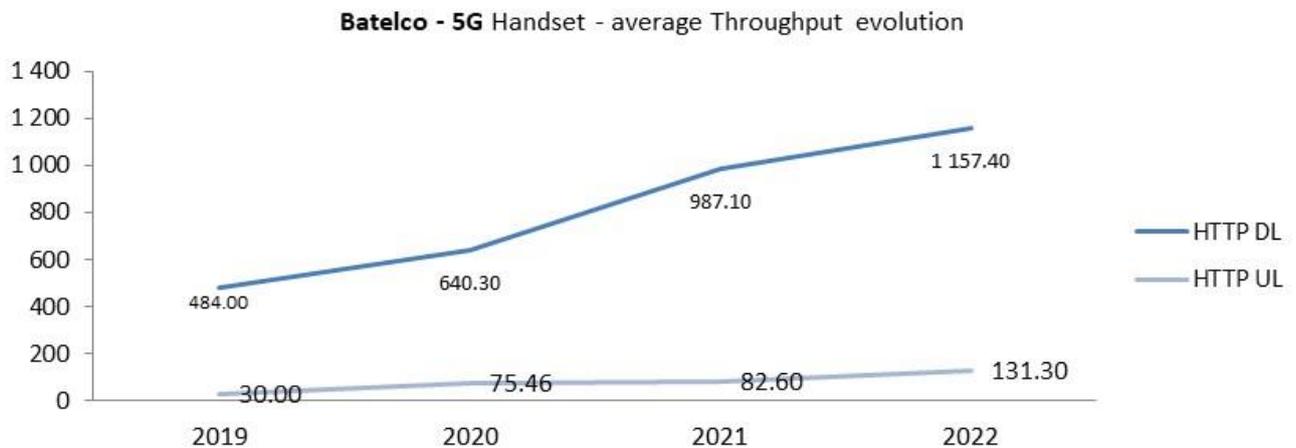
**Figure 23** – 5G Handset – HTTP DL&UL – Throughputs evolution
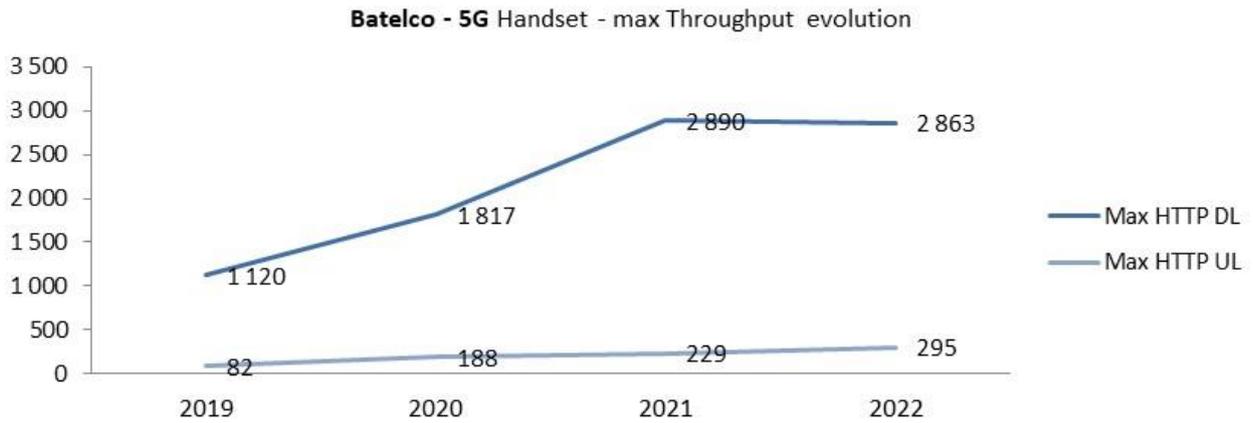
Figure 24 – 5G Handset – HTTP DL&UL – Max Throughputs reached evolution

	Batelco
WEB	
Rate of successful webpage download	**100.0%**
Statistical accuracy	+/-0.0%
Average Delay (s)	1.7
% successful webpage download within 10 seconds	99.6%

Table 14 – 5G Handset – WEB Browsing

1.1.1.2. 4G HANDSET

	Batelco
HTTP DL	
Average Throughput (Mbps)	**355.6**
Max throughput (Mbps)	**1422.90**

Table 15 – 4G Handset – HTTP DL

	Batelco
HTTP UL	
Average Throughput (Mbps)	**64.30**
Max throughput (Mbps)	**175.6**

Table 16 – 4G Handset – HTTP UL

Batelco - 4G Handset - average Throughput evolution

	HTTP DL	HTTP UL
2014	30.59	9.37
2016	33.59	26.89
2017	40.15	23.67
2018	78.74	28.65
2019	116.80	28.36
2020	133.86	34.07
2021	259.90	39.60
2022	355.60	64.30
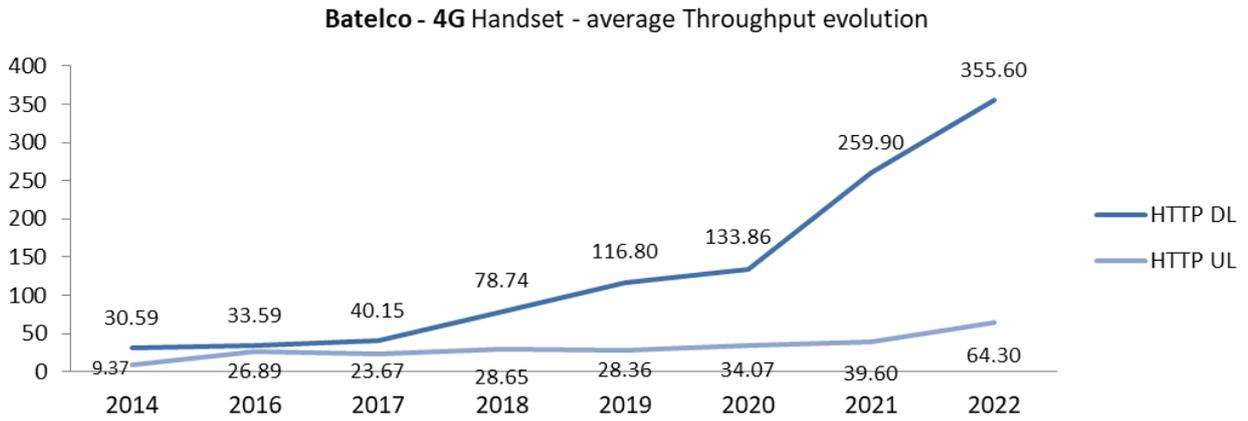
Figure 25 – 4G Handset – HTTP DL&UL – Throughputs evolution

	Batelco
WEB	
Rate of successful webpage download	**100%**
Statistical accuracy	+/-0.0%
Average Delay (s)	1.8
% successful webpage download within 10 seconds	99.5%

Table 17 – 4G Handset – WEB Browsing

6.2.4. SOCIAL MEDIA

28 185 Tests have been done on Social Media in Incar Condition across whole Bahrain.
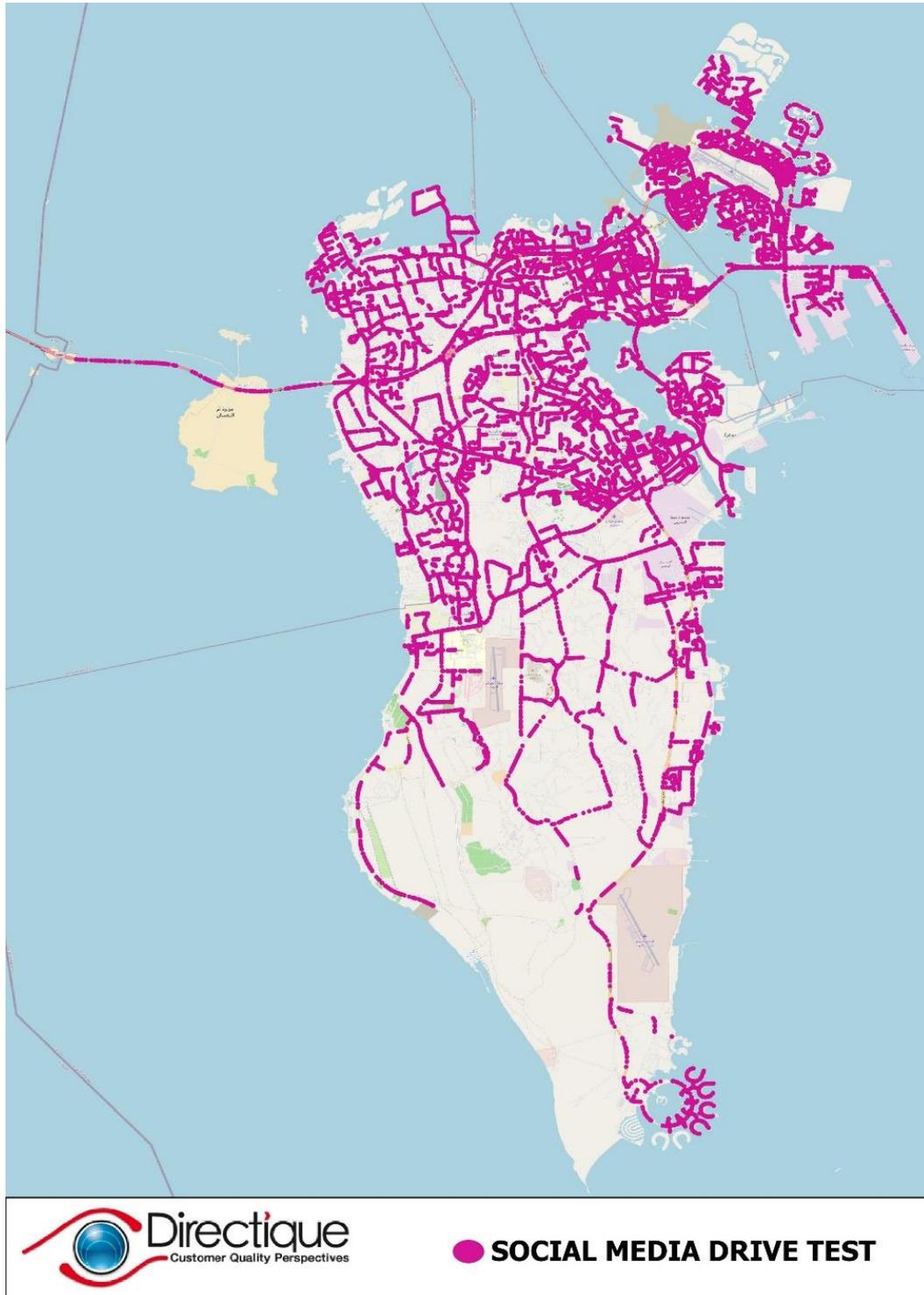
Figure 26 – Social Media – Measurement map

1.1.1.3. YouTube KPIs

1.

	Batelco
Rate of successful streaming (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to stream 1mn Video (access + streaming) (s)	60.6

Table 18 – YouTube results

1.1.1.4. Twitter KPIs

	Batelco
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	1.0

Table 19 – Twitter results

1.1.1.5. Instagram KPIs

2.

	Batelco
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	0.3

Table 20 – Instagram results

1.1.1.6. Facebook KPIs

3.

	Batelco
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	5.9

Table 21 – Facebook results

1.1.1.7. WhatsApp KPIs

4.

	Batelco
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	1.7

Table 22 – WhatsApp results

6.3. STC BAHRAIN RESULTS

6.3.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

VoLTE:
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		1,634
Rate of calls set-up and held for 2 min		**100.0%**
statistical accuracy		+/-0.0%
and marked	Rate of calls marked 4-perfect (PQR)	**100.0%**
	statistical accuracy	+/-0.0%
	Rate of calls marked 5-Excellent (EQR)	**99.9%**
	statistical accuracy	+/-0.1%

Table 23 – VoLTE – Global results
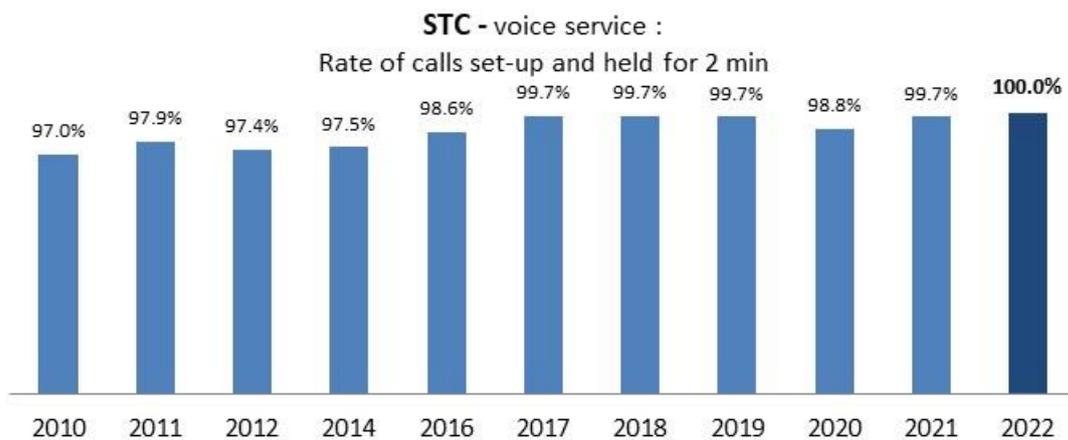
Figure 27 – Voice – Global results evolution
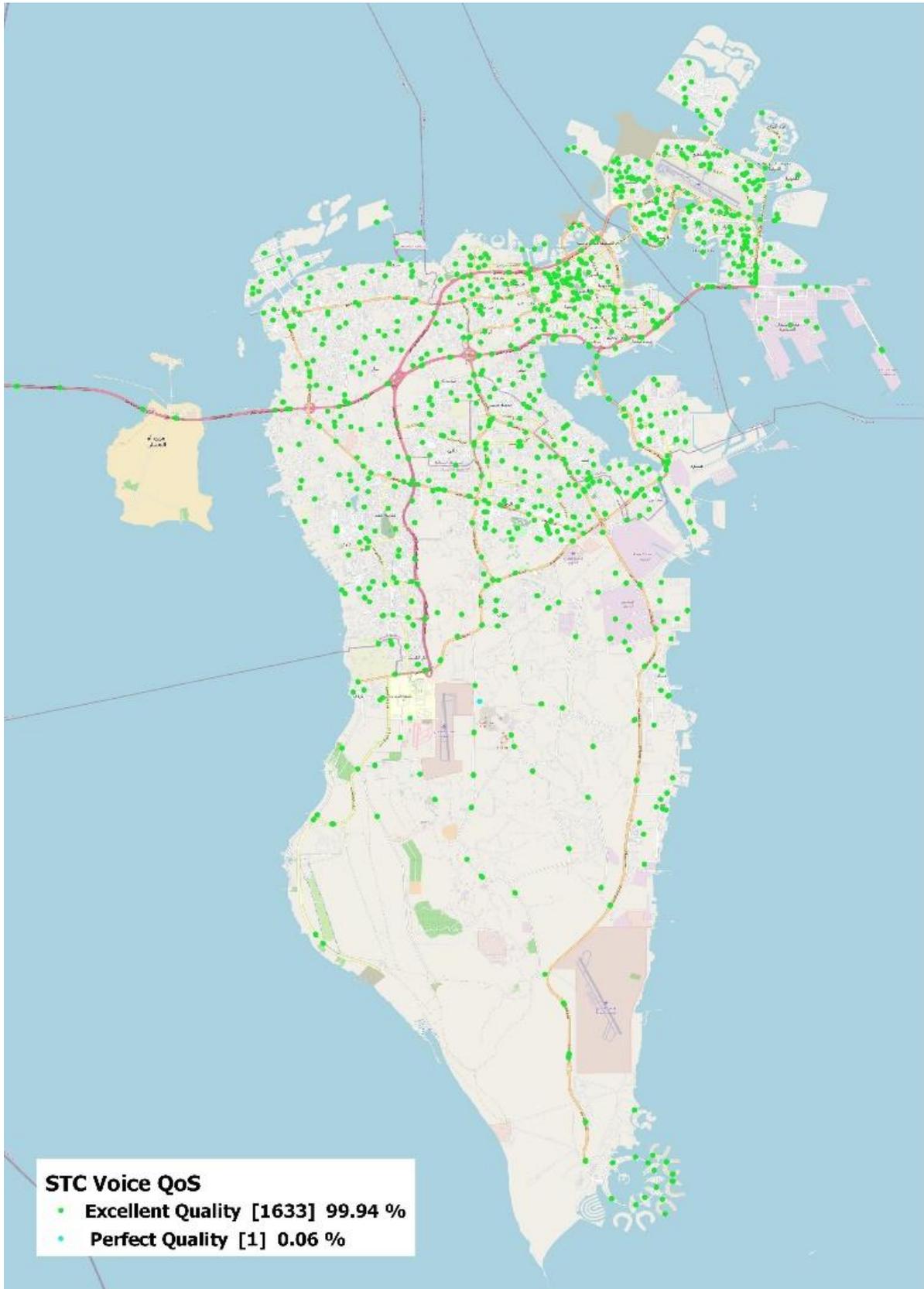
Figure 28 – **STC** - Global voice results

6.3.2. SMS RESULTS

|	STC Bahrain
SMS service	1,510
% of received SMS (RS2)	**100.0%**
+/-0.0%	+/-0.0%
% of received SMS (RS10)	**100.0%**
+/-0.0%	+/-0.4%
% of received SMS (RS5)	**100.0%**
+/-0.8%	+/-0.9%
Average reception delay (s)	**1.3**

Table 24 – SMS - Global results
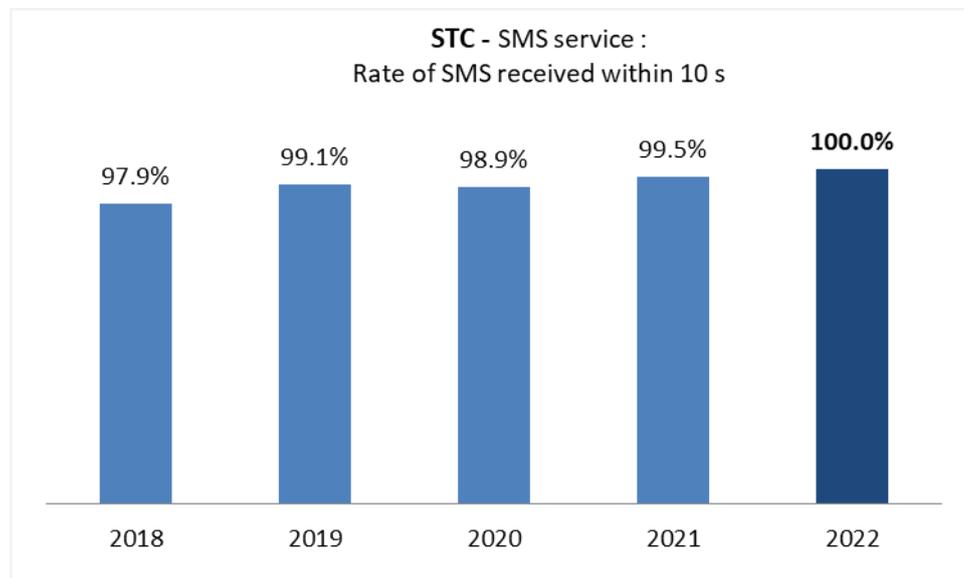
Figure 29 – SMS - Global results evolution

6.3.3. DATA SMARTPHONE RESULTS

60 hotspots location called Enhanced Technology Hotspots and 200 Random locations have been tested in 4G and 5G for each MNOs.

1.1.1.8. 5G HANDSET

	STC Bahrain
HTTP DL	
Average Throughput Mbps)	**892.10**
Max throughput reached (Mbps)	**3,210.01**

Table 25 – 5G Handset – HTTP DL

|	STC Bahrain
HTTP UL	
Average Throughput (Mbps)	**117.72**
Max throughput reached (Mbps)	**471.88**

Table 26 – 5G Handset – HTTP UL
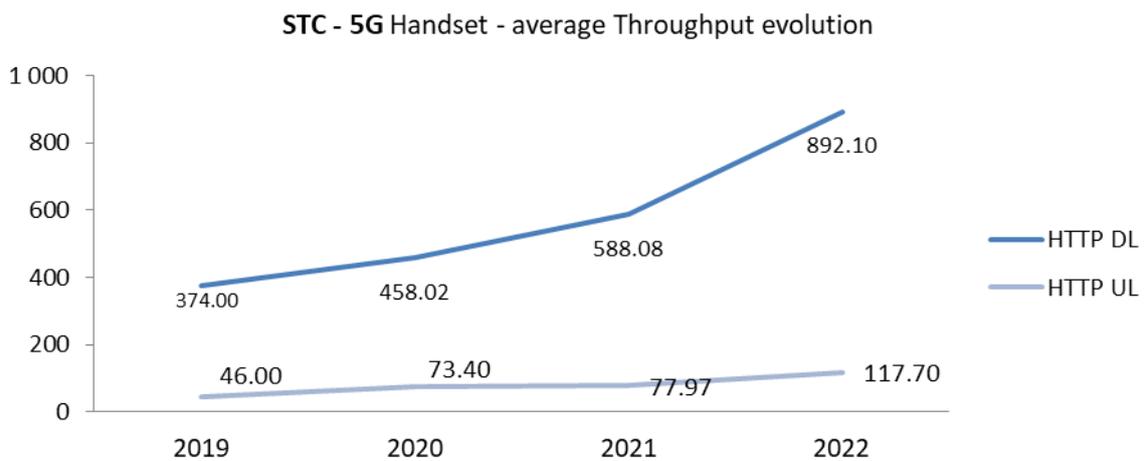
**Figure 30** – 5G Handset – HTTP DL&UL – Throughputs evolution
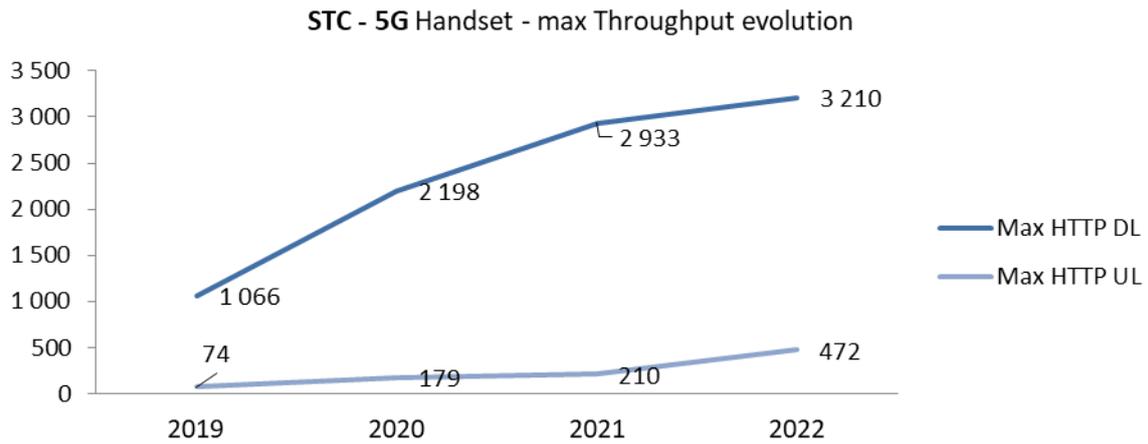
Figure 31 – 5G Handset – HTTP DL&UL – Max Throughputs reached evolution

	STC Bahrain
WEB	
Rate of successful webpage download	**100.0%**
Statistical accuracy	+/-0.0%
Average Delay (s)	1.5
% successful webpage download within 10 seconds	99.8%

Table 27 – 5G Handset – WEB Browsing

1.1.1.9. 4G HANDSET

	STC Bahrain
HTTP DL	
Average Throughput (Mbps)	**268.74**
Max throughput (Mbps)	**1,328.66**

Table 28 – 4G Handset – HTTP DL

	STC Bahrain
HTTP UL	
Average Throughput (Mbps)	**73.04**
Max throughput (Mbps)	**206.5**

Table 29 – 4G Handset – HTTP UL
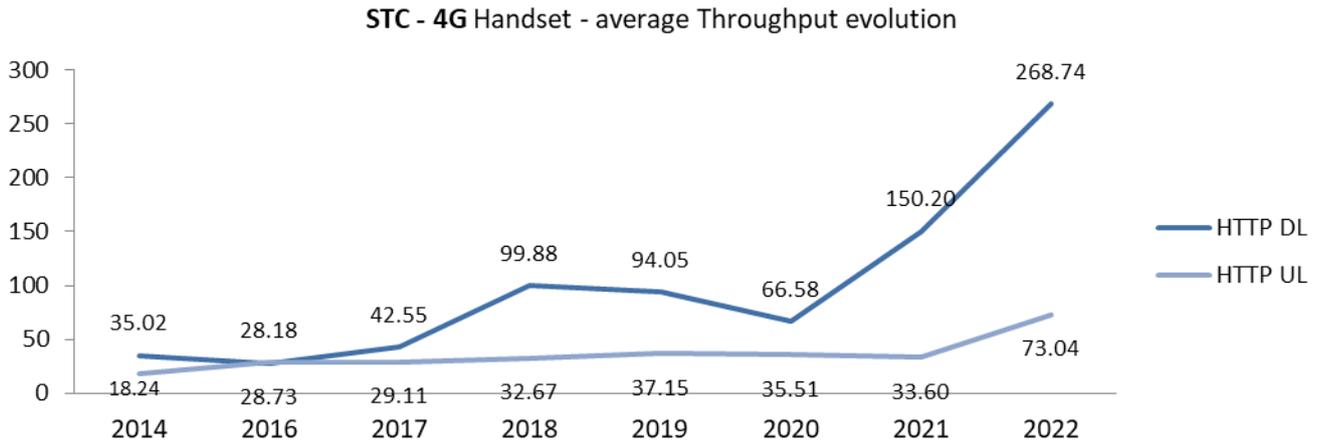
Figure 32 – 4G Handset – HTTP DL&UL – Throughputs evolution

	STC Bahrain
WEB	
Rate of successful webpage download	**100.0%**
Statistical accuracy	+/-0.0%
Average Delay (s)	1.6
% successful webpage download within 10 seconds	99.9%

Table 30 – 4G Handset – WEB Browsing

6.3.4. SOCIAL MEDIA

28 185 Tests have been done on Social Media in Incar Condition across whole Bahrain.
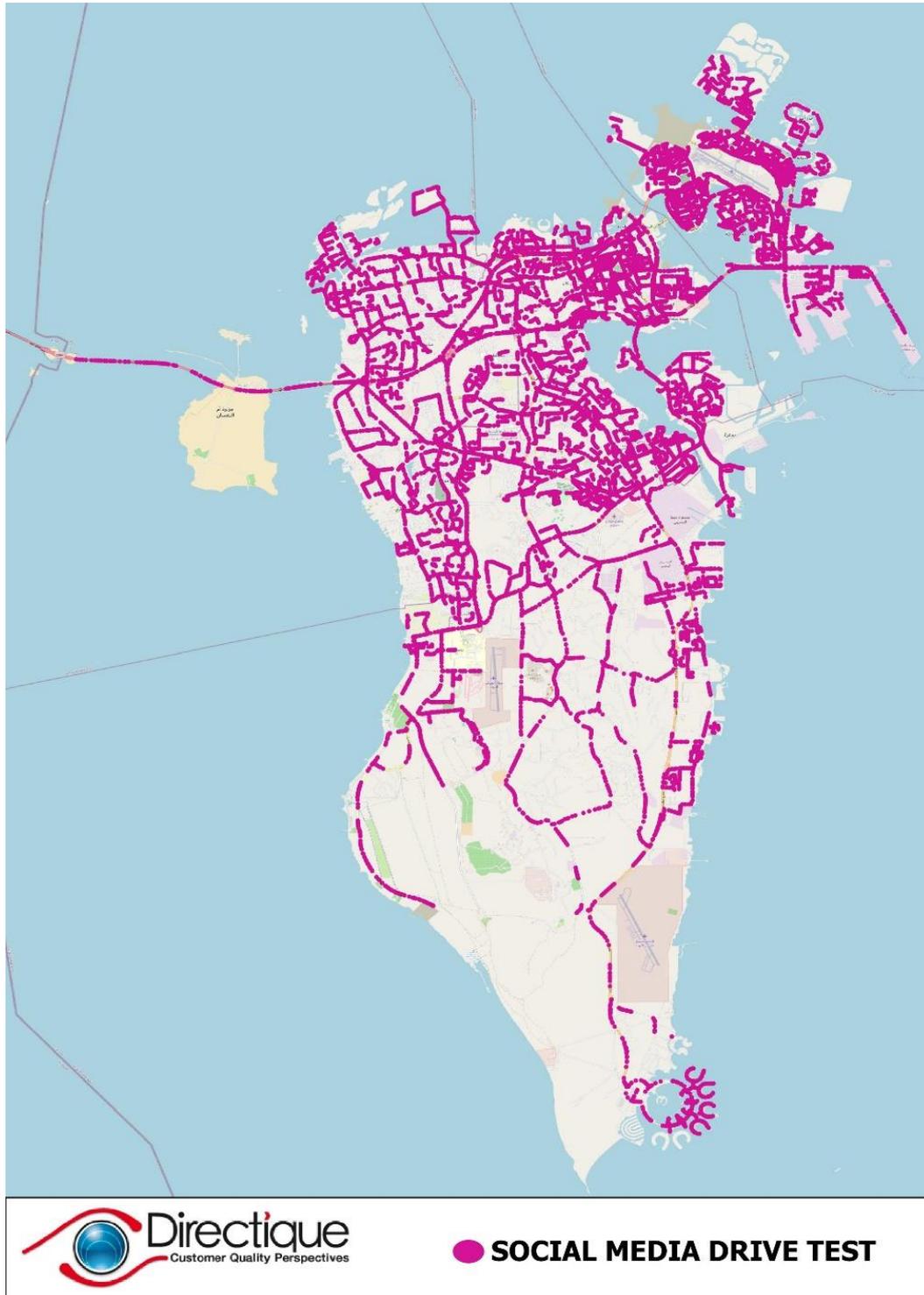
Figure 33 – Social Media – Measurement map

1.1.1.10. YOUTUBE KPIS

5.	STC Bahrain
Rate of successful streaming (%) statistical accuracy	**100%** *+/-0.0%*
Average time to stream 1mn Video (access + streaming) (s)	60.7

Table 31 – YouTube results

1.1.1.11. TWITTER KPIS

	STC Bahrain
Rate of successful publication (%) statistical accuracy	**100%** *+/-0.0%*
Average time to publish (access + post) (s)	1.0

Table 32 – Twitter results

1.1.1.12. INSTAGRAM KPIS

6.	STC Bahrain
Rate of successful publication (%) statistical accuracy	**100%** *+/-0.0%*
Average time to publish (access + post) (s)	0.2

Table 33 – Instagram results

1.1.1.13. FACEBOOK KPIS

7.	STC Bahrain
Rate of successful publication (%) statistical accuracy	**100%** *+/-0.0%*
Average time to publish (access + post) (s)	5.8

Table 34 – Facebook results

1.1.1.14. WHATSAPP KPIS

8.	STC Bahrain
Rate of successful publication (%) statistical accuracy	**100%** *+/-0.0%*
Average time to publish (access + post) (s)	1.6

Table 35 – WhatsApp results

6.4. ZAIN RESULTS

6.4.1. GLOBAL VOICE RESULTS (CITIES & ROAD LINKS)

VoLTE:
Voice measurements were in VoLTE, in cities and on road links.
Device for those tests was the Samsung Galaxy S9.

		ZAIN
Global voice service		1,577
Rate of calls set-up and held for 2 min		**100.0%**
statistical accuracy		+/-0.0%
and marked	Rate of calls marked 4-perfect (PQR)	**100.0%**
	statistical accuracy	+/-0.0%
	Rate of calls marked 5-Excellent (EQR)	**97.5%**
	statistical accuracy	+/-0.8%

Table 36 – VoLTE – Global results
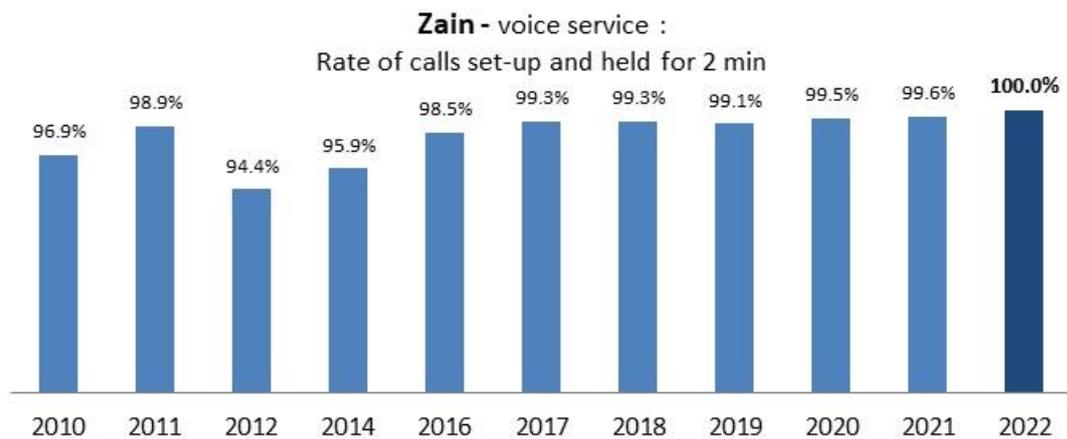
Figure 34 – Voice – Global results evolution
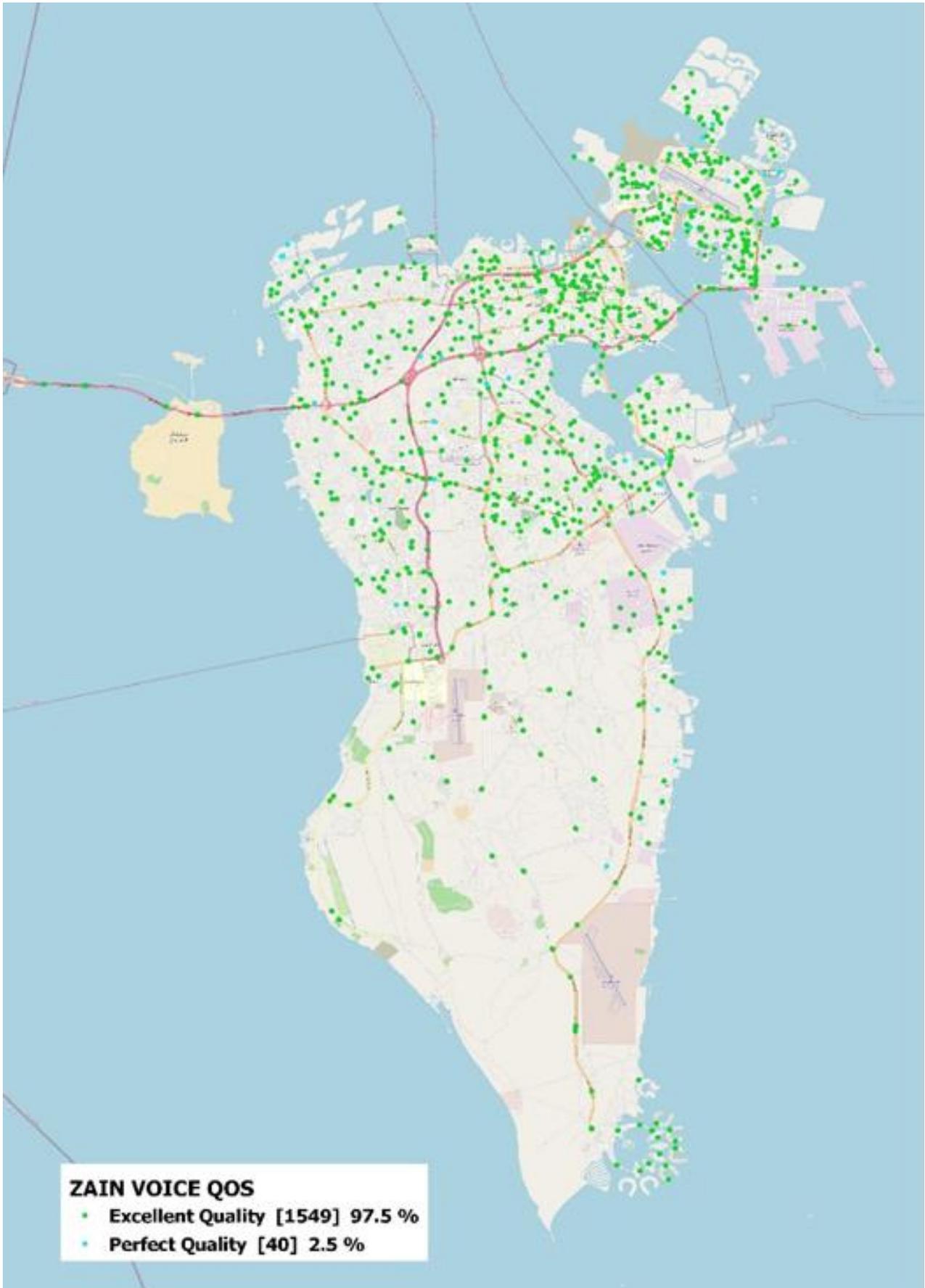
Figure 35 – **ZAIN** - Global voice results

6.4.2. SMS RESULTS

|	ZAIN
SMS service	789
% of received SMS (RS2)	**100.0%**
+/-0.0%	+/-0.0%
% of received SMS (RS10)	**100.0%**
+/-0.0%	+/-0.5%
% of received SMS (RS5)	**99.6%**
+/-0.5%	+/-0.7%
Average reception delay (s)	**0.7**

Table 37 – SMS - Global results
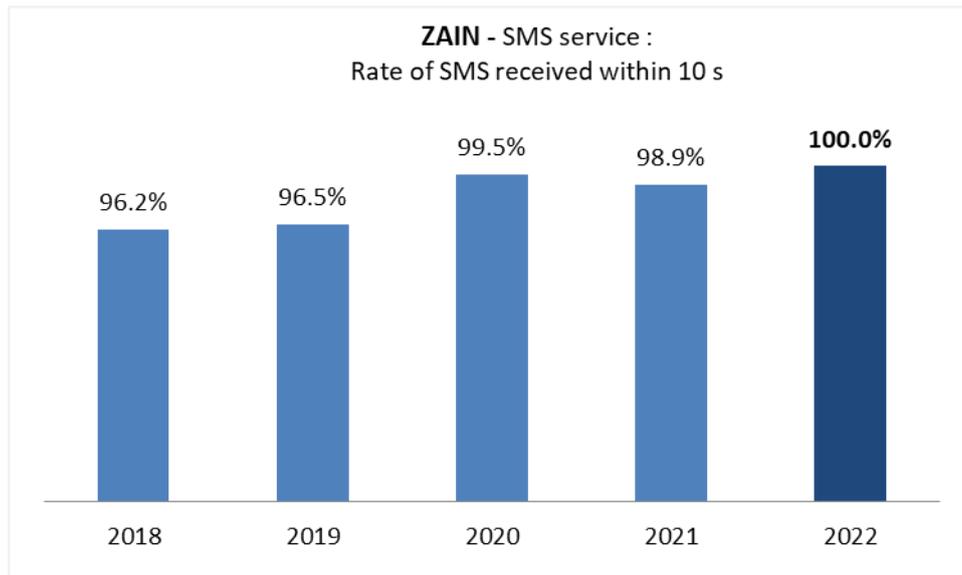
Figure 36 – SMS - Global results evolution

6.4.3. DATA SMARTPHONE RESULTS

60 hotspots location called Enhanced Technology Hotspots and 200 Random locations have been tested in 4G and 5G for each MNOs.

1.1.1.15. 5G HANDSET

	ZAIN
HTTP DL	
Average Throughput (Mbps)	**574.70**
Max throughput reached (Mbps)	**3,001.04**

Table 38 – 5G Handset – HTTP DL

	ZAIN
HTTP UL	
Average Throughput (Mbps)	**86.22**
Max throughput reached (Mbps)	**286.94**

Table 39 – 5G Handset – HTTP UL
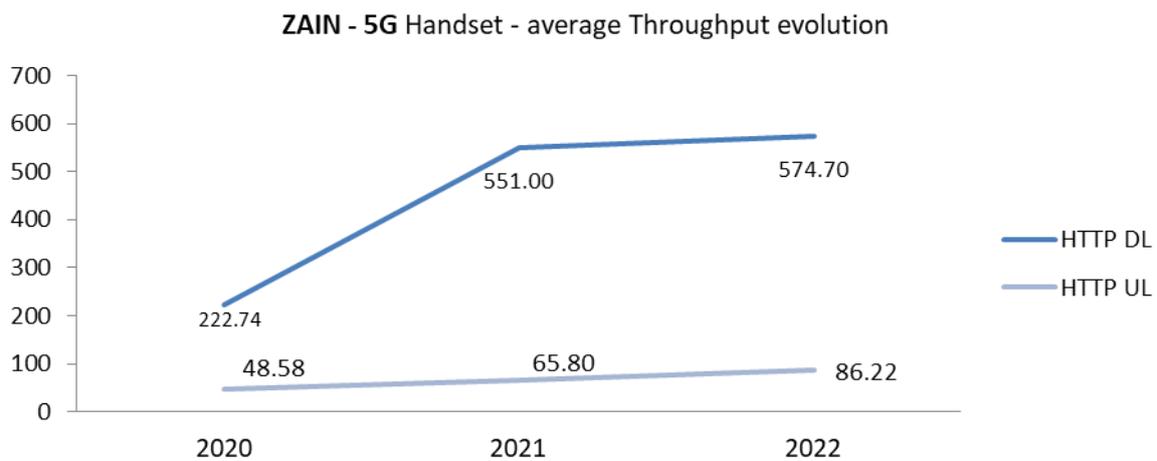
**Figure 37** – 5G Handset – HTTP DL&UL – Throughputs evolution

ZAIN - 5G Handset - max Throughput evolution
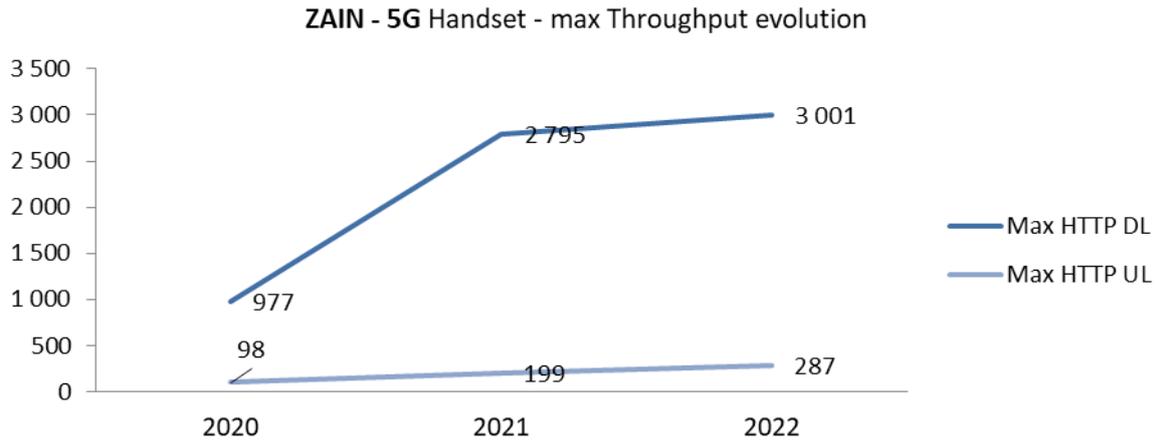
Figure 38 – 5G Handset – HTTP DL&UL – Max Throughputs reached evolution

	ZAIN
WEB	
Rate of successful webpage download	**100.0%**
Statistical accuracy	+/-0.0%
Average Delay (s)	1.8
% successful webpage download within 10 seconds	99.7%

Table 40 – 5G Handset – WEB Browsing

1.1.1.16. 4G Handset

	ZAIN
HTTP DL	
Average Throughput (Mbps)	**178.36**
Max throughput (Mbps)	**1,396.60**

Table 41 – 4G Handset – HTTP DL

	ZAIN
HTTP UL	
Average Throughput (Mbps)	**61.05**
Max throughput (Mbps)	**175.8**

Table 42 – 4G Handset – HTTP UL
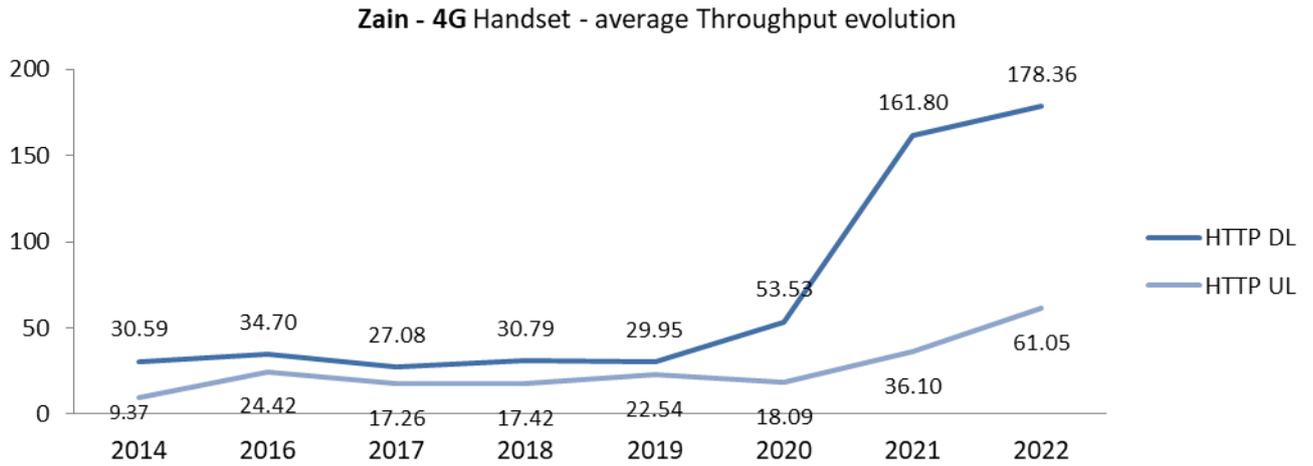
Figure 39 – 4G Handset – HTTP DL&UL – Throughputs evolution

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

Table 43 – 4G Handset – WEB Browsing

6.4.4. SOCIAL MEDIA

28 185 Tests have been done on Social Media in Incar Condition across whole Bahrain.
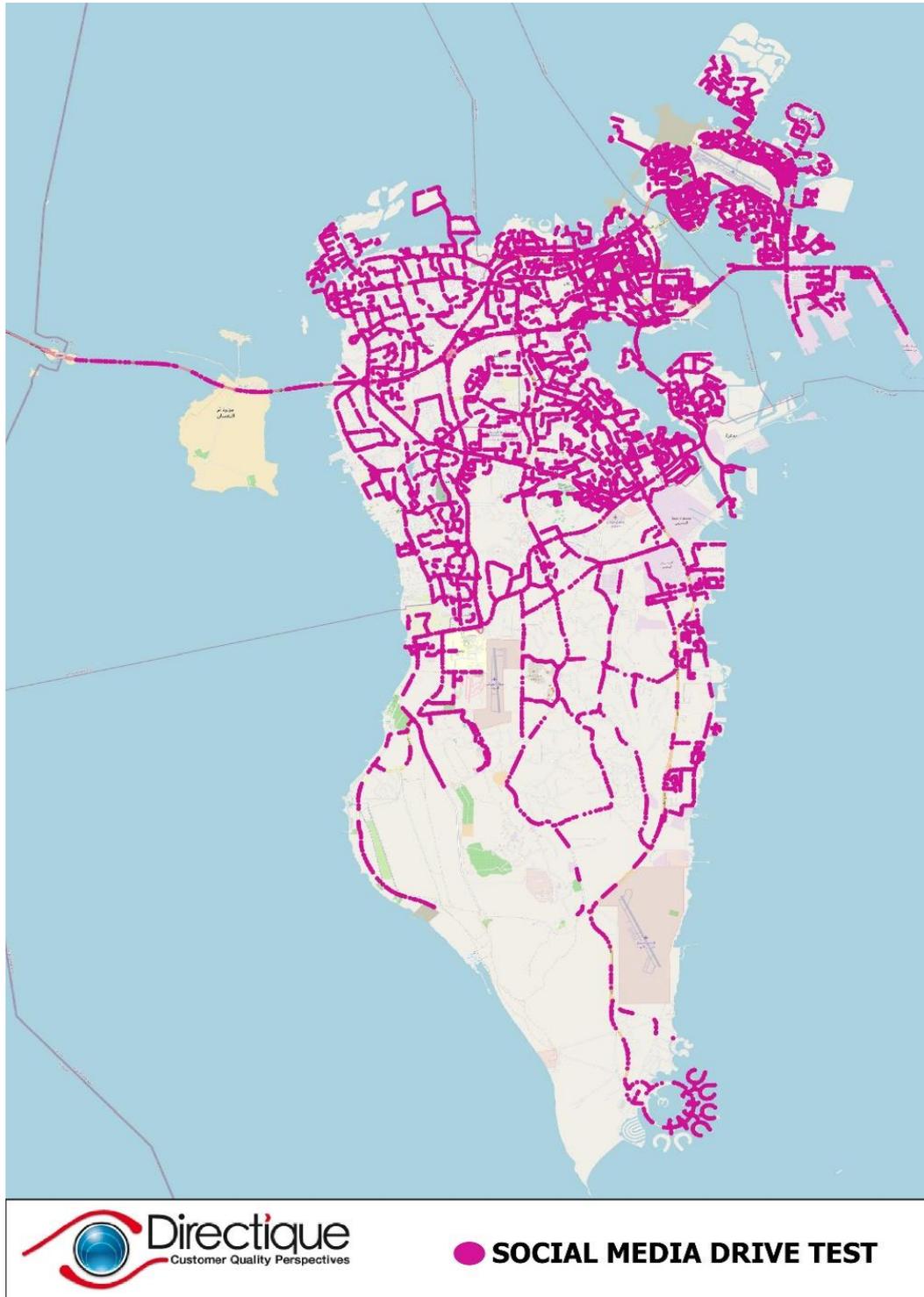
Figure 40 – Social Media – Measurement map

1.1.1.17. YOUTUBE KPIs

9.

	ZAIN
Rate of successful streaming (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to stream 1mn Video (access + streaming) (s)	60.7

Table 44 – YouTube results

1.1.1.18. TWITTER KPIs

	ZAIN
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	1.4

Table 45 – Twitter results

1.1.1.19. INSTAGRAM KPIs

10.

	ZAIN
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	0.5

Table 46 – Instagram results

1.1.1.20. FACEBOOK KPIs

11.

	ZAIN
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	6.3

Table 47 – Facebook results

1.1.1.21. WHATSAPP KPIs

12.

	ZAIN
Rate of successful publication (%)	**100%**
statistical accuracy	*+/-0.0%*
Average time to publish (access + post) (s)	1.9

Table 48 – WhatsApp results

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