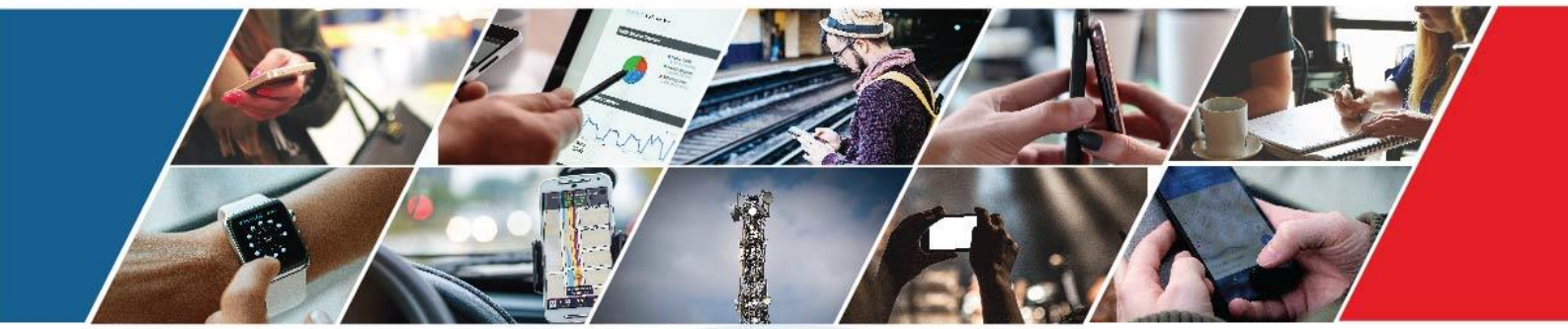
Directique
Customer Quality Perspectives



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

MOBILE NETWORKS COVERAGE AUDIT
KINGDOM OF BAHRAIN – 2021

Version	Date	Author	Changelog
1	29/01/2022	Olivier GHIBAUDO	Creation of document
2	16/02/2022	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.

1. EXECUTIVE SUMMARY

Mobile Network Operators are under a coverage obligation as a condition of their Individual Mobile Telecommunications license (IMTL), and it is the responsibility of TRA to verify and validate that each operator is meeting its obligation.

The provisions of the Individual Mobile Telecommunications Licence that was issued on 19 September 2013 require Licensees to provide a mobile telecommunication network that is capable of providing mobile telecommunication services with a nationwide coverage of at least 99% of the population in the Kingdom of Bahrain by no later than nine months from the effective date of such license.

The license obligation defines population coverage for each Mobile Operator's own telecommunication network. The coverage as perceived by the customers is independent of the deployed technology; coverage measurements have been made with handsets in following network mode:
For voice:

- a set of smartphones in Auto connect mode

For data:

- a set of smartphones with 5G enabled
- a set of smartphones with 4G enabled
- a set of smartphones with 3G enabled

It is important to point out that some areas were not accessible to the audit team, being either private land or reserved for government, which explains why the maps do not show any measurements in those areas of the Kingdom. However those areas are not open to general public.

Also this annual audit has taking into consideration that new areas that have been opened in the 4 governorates:

- **Muharraq**- East Hidd City, Bahrain Investment Gateway, Dilmunia Island & Busaiteen Seafront
- **Capital**- Water Garden City
- **Northern**- Nurana Island & Northern City
- **Southern**- Khalifa Town, Almahadeer City & Al Sahel Resort

With this in mind, results obtained are very good and show that there is no significant coverage difference from one operator to the other. All operators meet their coverage obligations.

Directique was also required to audit Mobile Network Operators coverage prediction maps with the actual observed coverage.

Results show that the Operators' maps are fully reliable.

2. OBJECTIVE

The objective of this audit was to:

- Measure the outdoor coverage of the 3 Mobile Operators; Batelco, STC Bahrain and Zain, via an accessibility test
- Establish for each operator a direct correlation between the number of households covered and the percentage of the population, resulting directly from such coverage
- Validate the coverage maps of each Mobile Operator against the outdoor coverage observed during the audit.

3. METHODOLOGY

The audit was conducted from the 8th of November to the 6th of January 2022 across the Kingdom's 4 Governorates for Voice, 3G, 4G and 5G coverage.

Audit results have been weighted with the population percentage living in each Governorate[1]. The result tables present the detailed coverage per Governorate as measured for each operator.

The coverage has been audited using tools which are fully representative of how a subscriber would access a mobile service – the audit therefore is fully representive of the subscriber experience, and completed with signal levels.

As 5G newtorks are non stand-alone network but closely linked to 4G network, 5G network signal strenght cannot be used as a reliable indicator, and so will not be presented.

Measurements have been performed with the following methodology:

- **Voice**: a set of smartphones in 2G/3G/4G auto connect mode, running accessibility voice calls *with* ***Nemo Drive Test Tool.***

  The accessibility test for voice service consist in placing a call and checking if signalling is ok.

- **3G, 4G and 5G Data**: data accessibility tests (HTTP DL) for 3G, 4G and 5G network with ***Nemo Drive Test Tool***:
  - 1 set in 5G auto mode to represent 5G users,
  - 1 set in 4G locked mode, to represent the LTE users,
  - 1 set in 3G locked mode, to represent the 3G users.

  The accessibility test for 3G and 4G data service consist of sending and receiving a 512 byte file with HTTP protocol.

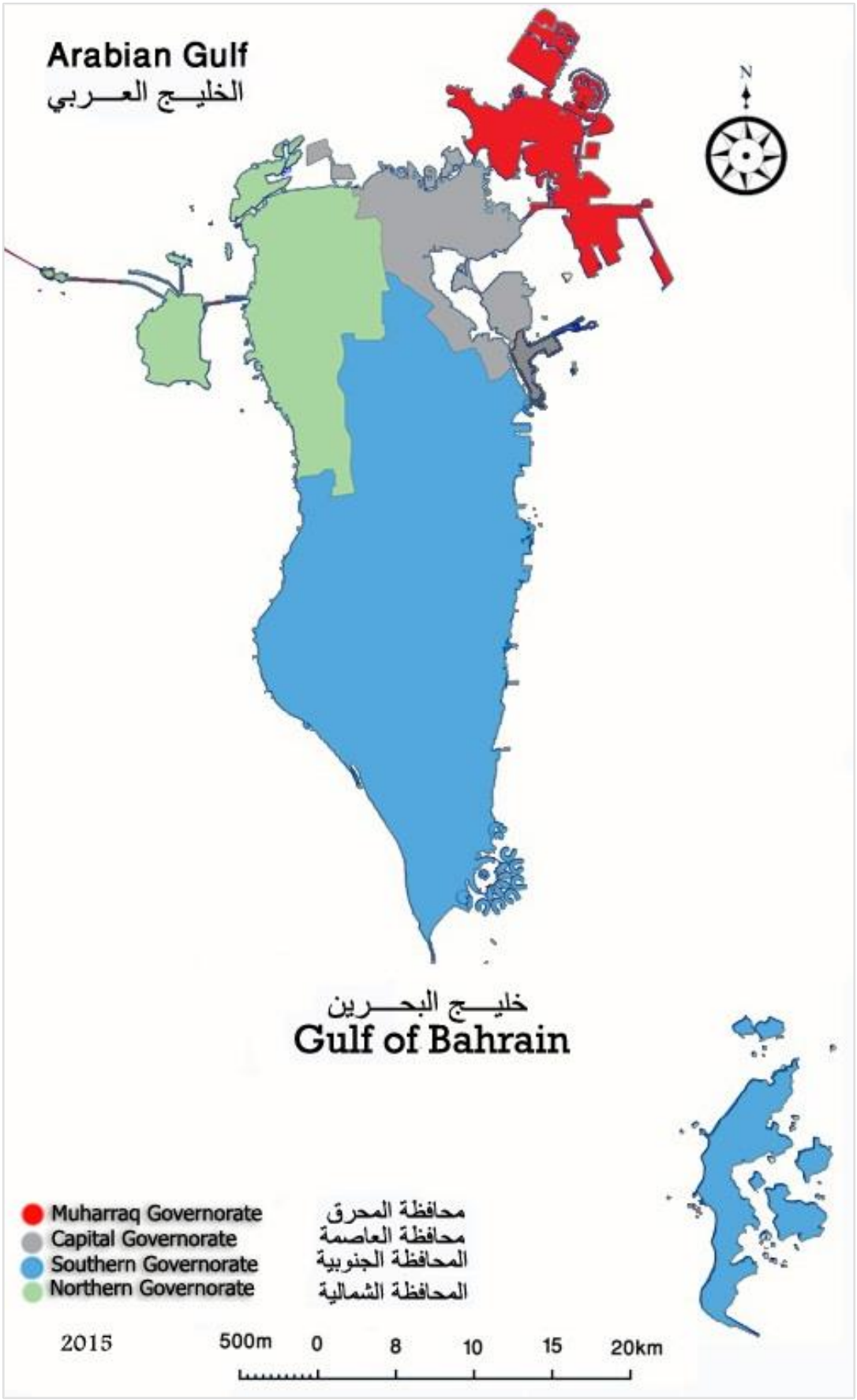
  For 5G, the accessibility test consists of requesting to download a very large file (100GB) and stopping the transfer after 30 seconds.

A set is 3 smartphones, one per Operator.

The test vehicle was equipped with the handsets and the software and followed a pre-determined route which was selected to ensure that it covered the 4 Governorates of the Kingdom. Tests were automatically software conducted.

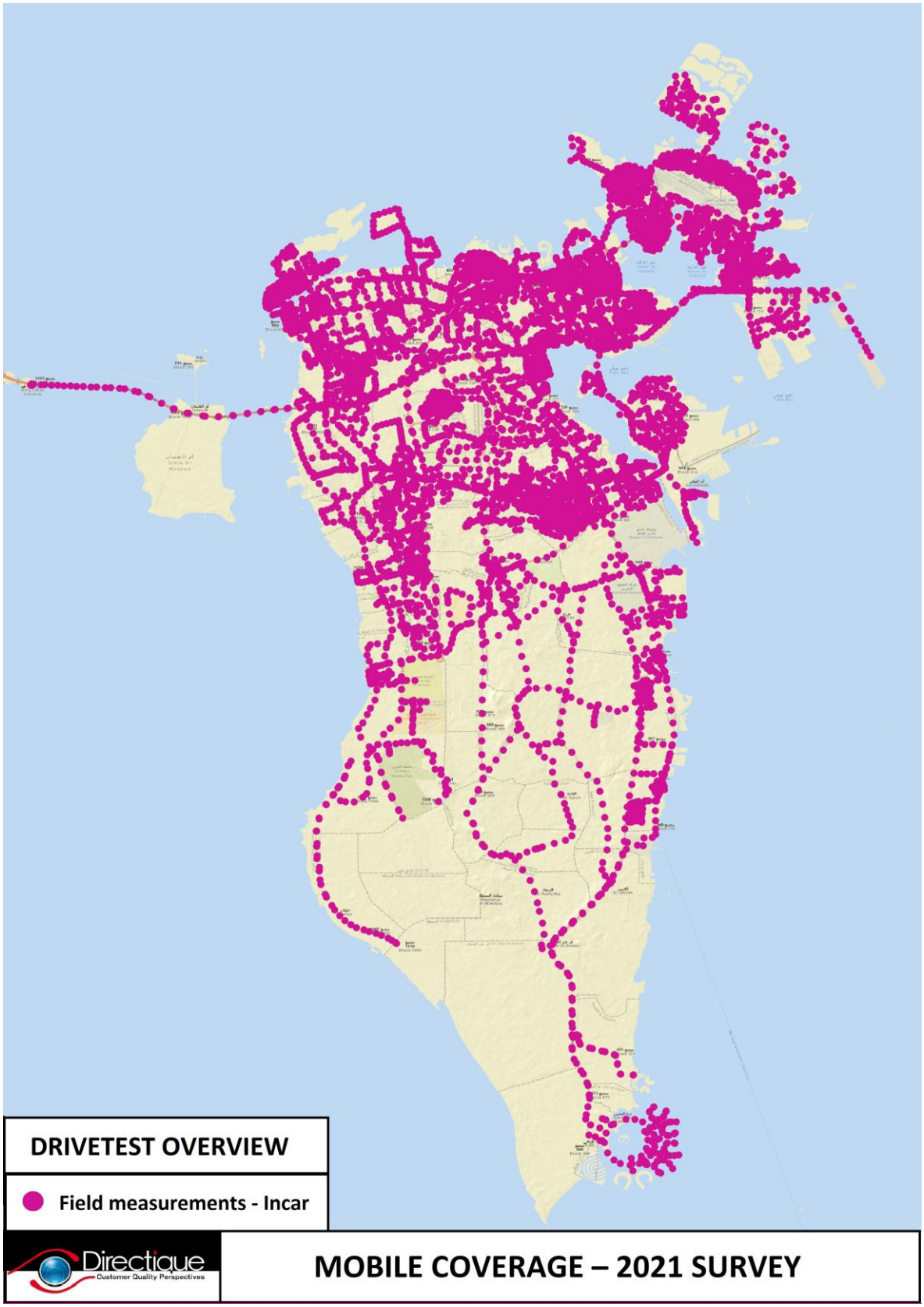
[1] Population data based on CIO latest census (2018)

3.1.1. ADMINISTRATIVE DIVISIONS



3.1.2. DRIVE-TEST ROUTES

Routes followed by the vehicle performing measurements.



3.1.3. EQUIPMENT

Audit measurements were performed using standard mobile phones.

Data coverage

Device: Samsung Galaxy S9 for 3G and 4G, Huawei P40 for 5G

Methodology: In order to have a representative experience of 3 types of services, all devices were set in the following technology mode:

- For 5G, one set of smartphones where network mode was **5G Auto Mode**
- For 4G, one set of smartphones where network mode was: **4G Locked**.
- For 3G, one set of smartphones where network mode was: **3G Locked**.

Voice coverage:

Device: Samsung Galaxy S9.

Methodology: 1 mobile phone was used for each network, in 2G/3G/4G auto connect, in order to evaluate coverage along the drive, regardless the available technology.
The same setup was repeated to cover all 3 mobile networks, i.e. Batelco, STC Bahrain and Zain.

Rooftop box and incar control station

Mobile phones were positioned vertically on a stable, specifically adapted base, to provide the best possible radio conditions. Electrical supply of each mobile phone was continuously guaranteed to ensure autonomy of the device and optimal radio conditions.

The platform was connected to computer based software recording test results. The set-up was completed with a GPS receiver, which recorded the exact location of each test.

3.1.4. COVERAGE RATE

The geographical coverage rate for each technology is computed using the number of successful measurements on this technology by the total number of measurements.

$$\text{Coverage rate} = \frac{\sum \text{OK}}{\sum \text{OK+NOK}}$$

Data coverage is calculated the same way, using the successful HTTP 512 byte tests or the successful 5G Download request among the total sample.

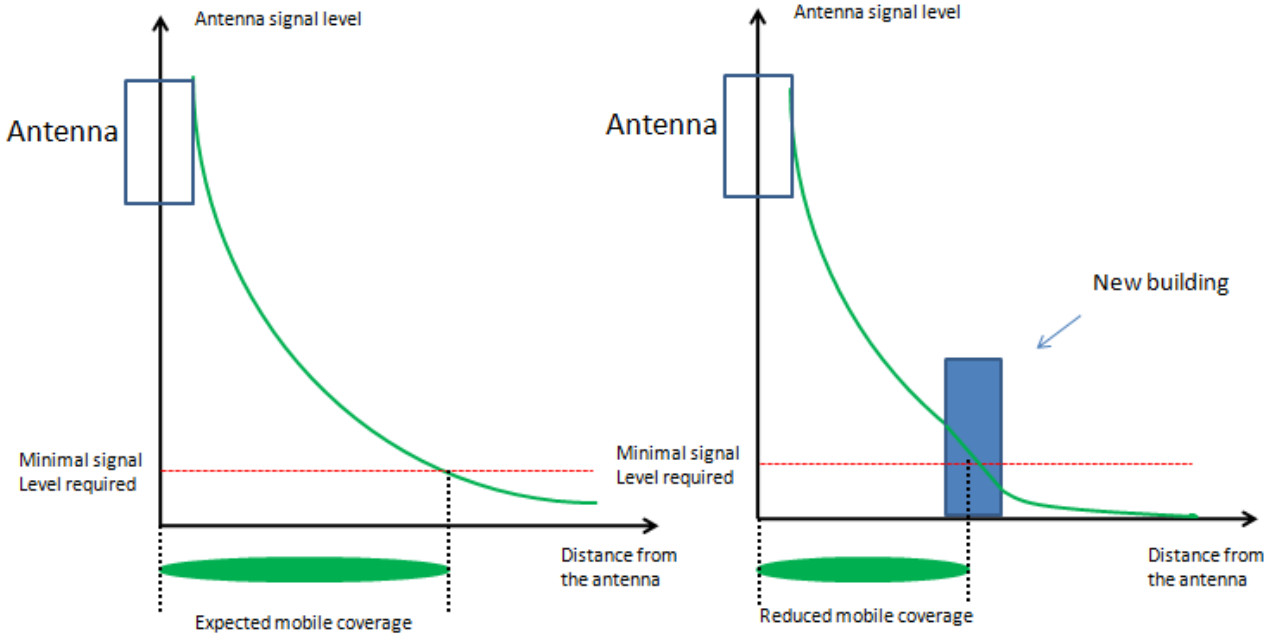
Population coverage is then calculated by weighting these results with the population percentage living in each Governorate, using latest available Central Informatics Organisation (CIO) census statistics for the Kingdom.

3.1.5. Additional Elements

It is important to understand that outdoor coverage is usually better than indoor coverage, because the base station providing the mobile signal is usually located outside, typically on a building roof or a telecommunications mast.

The mobile signal is attenuated when it penetrates a building structure, affected by the thickness of concrete wall and metallic elements used in the construction, thus resulting in lower signal strength inside the building.

In some instances such as malls and large shopping centres, hotels and airports, Mobile Operators implement additional indoor base stations to ensure adequate coverage, however the assessment of indoor coverage was not in the scope of this audit.



Coverage evolution following a new construction

Readers shall understand that mobile coverage can also vary with the evolution of the landscape, the diagram above showing the impact of a new building in a previously fully covered area, and illustrate the need for Mobile Operators to continuously monitor the coverage of their mobile network and take action when necessary to maintain the appropriate coverage level.

4. RESULTS

4.1. POPULATION COVERAGE FOR VOICE AND DATA

4.1.1. POPULATION COVERAGE FOR VOICE SERVICE

% of population with a handset with access to voice

		BATELCO		STC		ZAIN	
Governorate	% Pop	Nb	Coverage	Nb	Coverage	Nb	Coverage
Capital	37%	2524	100.0%	2524	100.0%	2526	100.0%
Northern	24%	2132	100.0%	2135	100.0%	2123	99.7%
Muharraq	18%	1604	100.0%	1605	99.9%	1610	99.7%
Southern	21%	2089	100.0%	2087	99.9%	2081	99.7%
Total		8 349	**100.0%**	8 351	**99.9%**	8 340	**99.8%**
Statistical accuracy on Coverage			+/-0.0%		+/-0.1%		+/-0.1%

Rate represents the % of successful voice accessibility calls.

4.1.2. POPULATION COVERAGE FOR DATA SERVICE: 5G USER

% of population with a 5G handset with access to 5G data

		BATELCO		STC		ZAIN	
Governorate	% Pop	Nb	Coverage	Nb	Coverage	Nb	Coverage
Capital	37%	1829	100.00%	1937	99.95%	1666	77.73%
Northern	24%	1598	100.00%	1615	99.20%	1425	74.74%
Muharraq	18%	1153	100.00%	1214	99.59%	1086	86.46%
Southern	21%	1700	100.00%	1680	98.33%	1647	67.33%
Total		6 280	**100.0%**	6 446	**99.4%**	5 824	**76.4%**
Statistical accuracy on Coverage			+/-0.0%		+/-0.2%		+/-1.1%

Rate represents the % of 5successful 5G Data accessibility tests

Legend:

Governorate: Governorate name
% Pop: Population percentage in the specific area
Sample: Number of measurements
Coverage: Resulting computed population coverage

4.1.3. Accuracy of the MNOs Coverage Maps for Data 5G

% of accuracy of the MNOs coverage maps provided for Data 5G and the measurement performed:

	BATELCO	STC	ZAIN
% of Accuracy of coverage map provided	100.00%	100.00%	100.00%

4.1.4. Population Coverage for Data service: 4G user

% of population with a LTE handset with access to 4G data

		BATELCO		STC		ZAIN	
Governorate	% Pop	Nb	Coverage	Nb	Coverage	Nb	Coverage
Capital	37%	2313	100.00%	2310	100.00%	2306	100.00%
Northern	24%	1959	100.00%	1971	100.00%	1949	100.00%
Muharraq	18%	1785	100.00%	1790	100.00%	1775	100.00%
Southern	21%	2483	100.00%	2487	100.00%	2470	100.00%
Total		8 540	**100.0%**	8 558	**100.0%**	8 500	**100.0%**
Statistical accuracy on Coverage			+/-0.0%		+/-0.0%		+/-0.0%

Rate represents the % of successful http data transfers.

Legend:

Governorate: Governorate name
% Pop: Population percentage in the specific area
Sample: Number of measurements
Coverage: Resulting computed population coverage

4.1.5. Population Coverage for Data service: 3G user

% of population with a 3G handset with access to 3G data

		BATELCO		STC		ZAIN	
Governorate	% Pop	Nb	Coverage	Nb	Coverage	Nb	Coverage
Capital	37%	2268	100.00%	2226	100.00%	2160	100.00%
Northern	24%	1930	100.00%	1898	100.00%	1899	100.00%
Muharraq	18%	1757	100.00%	1717	100.00%	1745	100.00%
Southern	21%	2439	100.00%	2313	100.00%	2401	100.00%
Total		8 394	**100.0%**	8 154	**100.0%**	8 205	**100.0%**
Statistical accuracy on Coverage			+/-0.0%		+/-0.0%		+/-0.0%

Rate represents the % of successful http data transfers.

Legend:

Governorate: Governorate name
% Pop: Population percentage in the specific area
Sample: Number of measurements
Coverage: Resulting computed population coverage

4.2. TECHNOLOGY DISTRIBUTION

Figures here below show the exact distribution of the data coverage measurements.

For 5G handset, first the rate of 5G successful download request is provided, as a location where the 5G download was NOK in a period time of 30 seconds, is considered as not 5G covered.
Then, graph showing the percentage of those successful 5G tests on each technology used by the mobile.

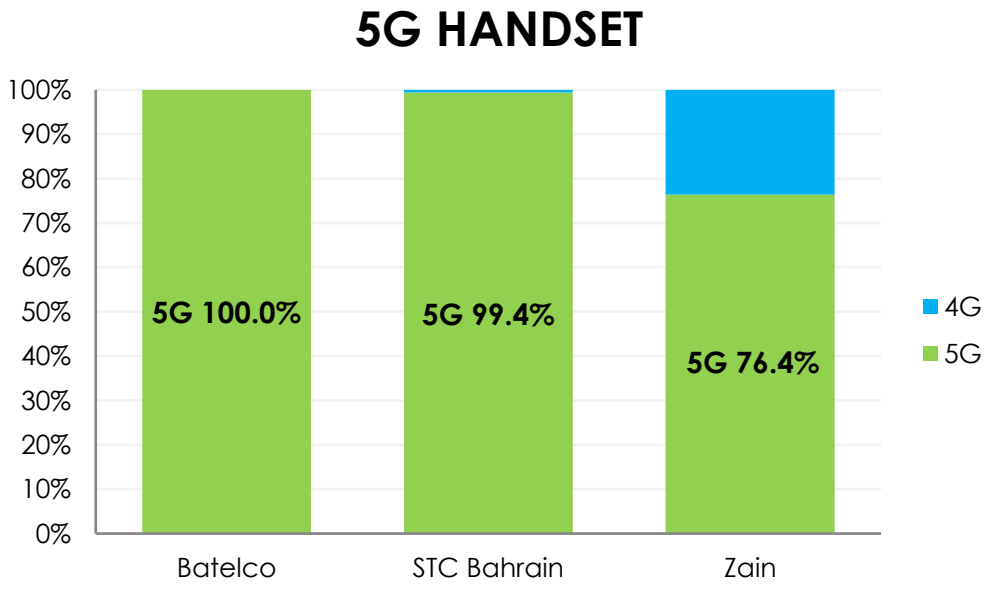
For 3G and 4G handset, first the rate of successful HTTP test is provided, as a location where the latency was NOK, is considered as not covered.
Then, graphs show the percentages of those successful tests on each technology used by the mobile.

4.2.1. 5G HANDSET

	BATELCO	STC	ZAIN
Rate of 5G successful download requests	100%	99.4%	76.4%

On technology:

5G	**100%**	**99.4%**	**76.4 %**
4G	**0%**	**0.6%**	**23.6 %**

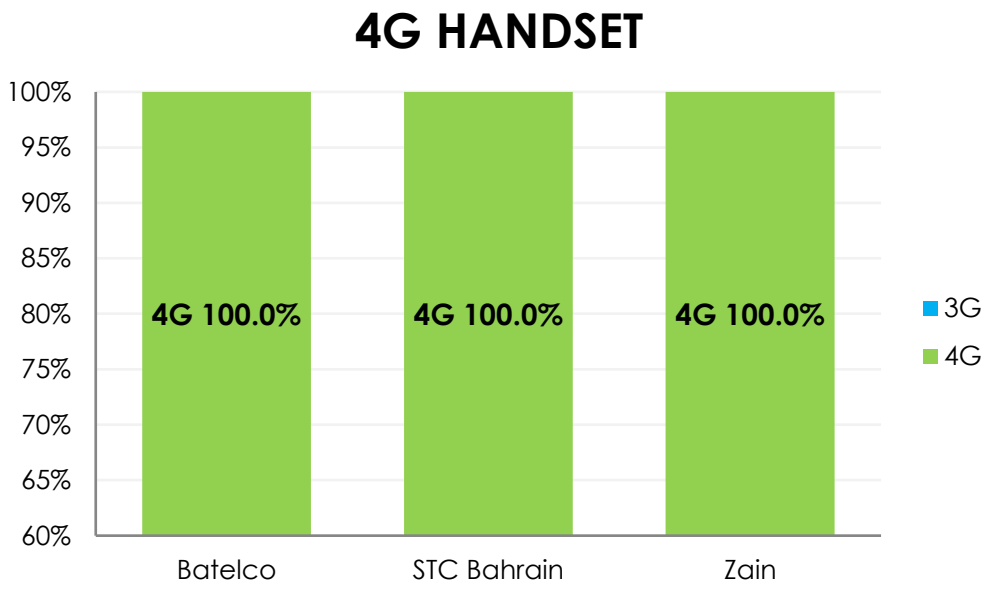


4.2.2. 4G HANDSET

	BATELCO	STC	ZAIN
Rate of successful HTTP tests	100%	100%	100%

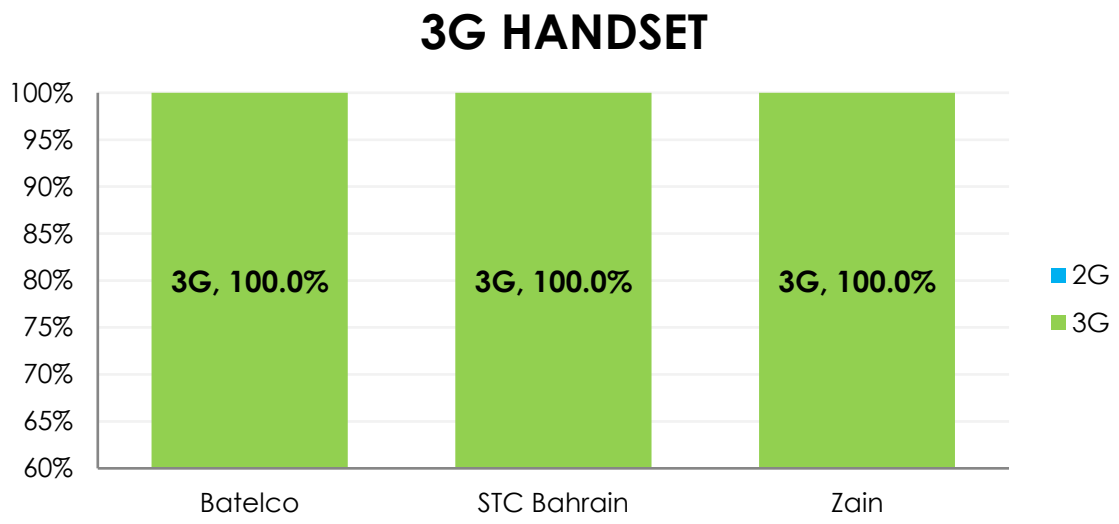
On technology:

4G	**100%**	**100%**	**100%**
3G	**0%**	**0%**	**0%**



4.2.3. 3G HANDSET

	BATELCO	STC	ZAIN
Rate of successful HTTP latency	100%	100%	100%
On technology:			
3G	**100%**	**100%**	**100%**
2G	**0%**	**0%**	**0%**



4.3. AUDIT OF OPERATORS' COVERAGE MAPS

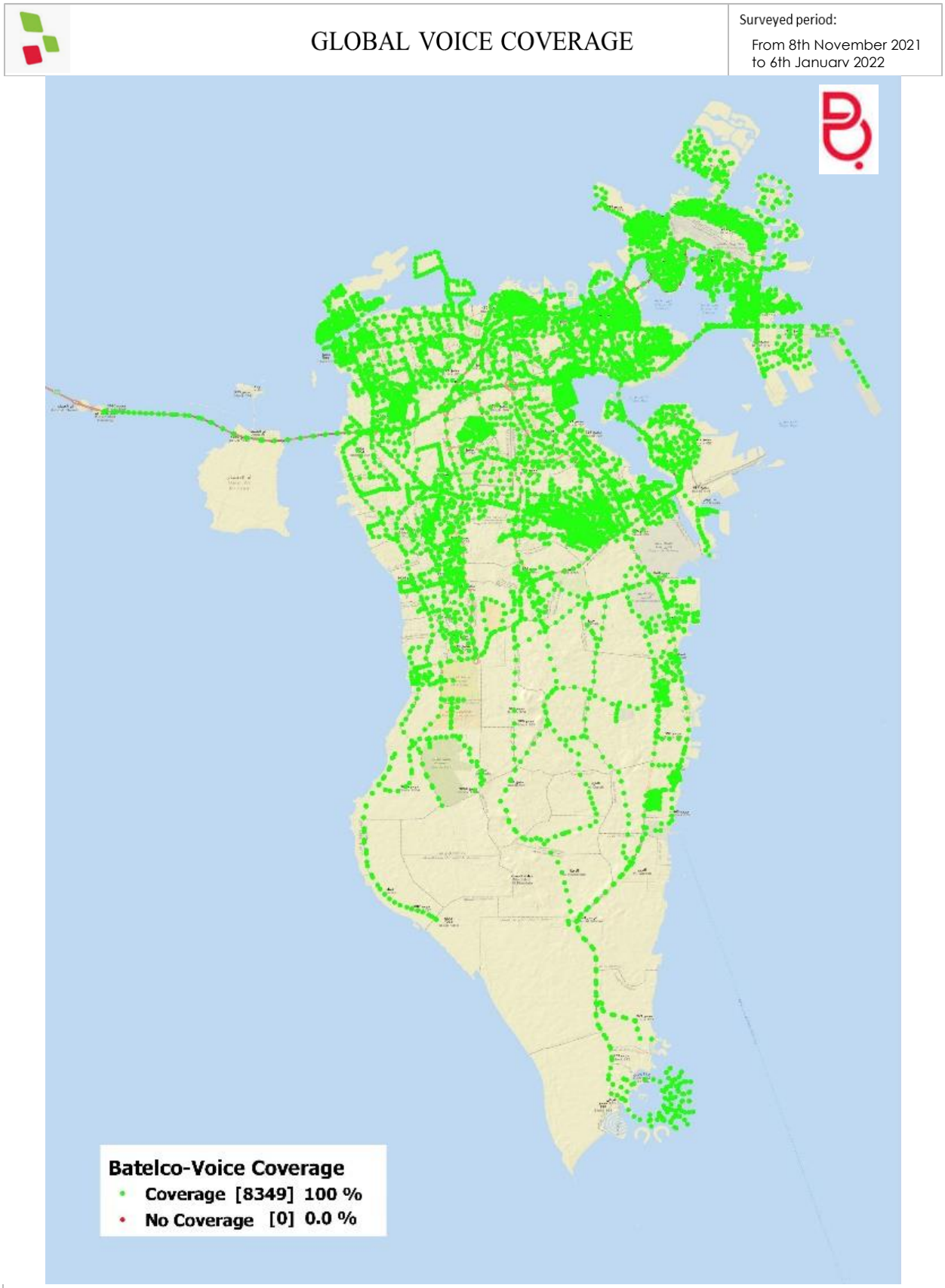
Another objective of this audit was to verify operator's coverage maps reliability.
Maps have been provided by each operator at the beginning of this audit.
The documents presented hereafter show each operator's coverage maps with a superimposed layer showing results of the coverage measurements performed by Directique, using the following colour code:

If the spot is **green**, the test was inside the coverage zone of the operator and accessibility to network was effective on the handset

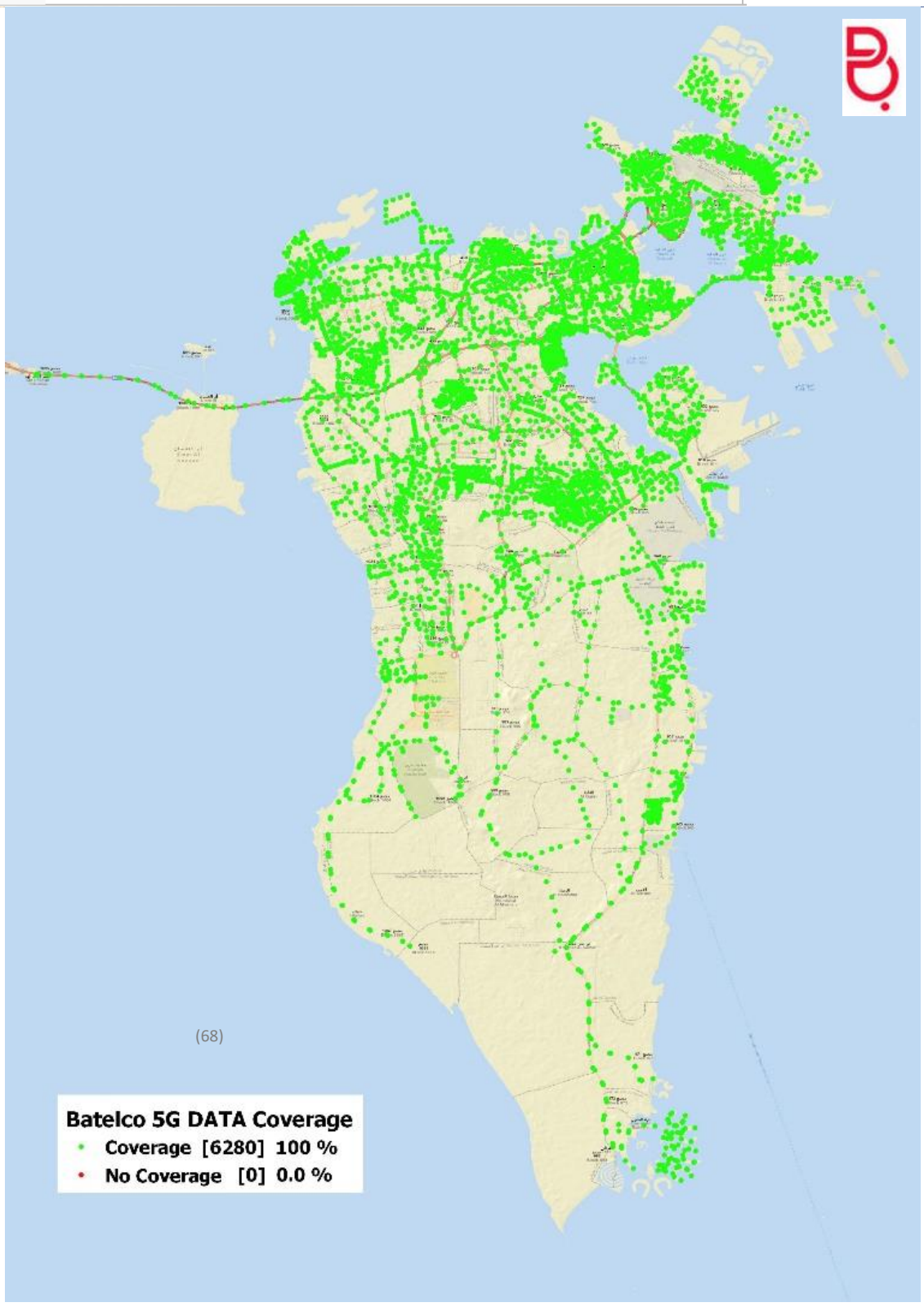
If the spot is **red**, the test was inside the coverage zone of the operator and accessibility to network was not effective on the handset

For data measurements, separate maps have been produced for both LTE and non-LTE users.

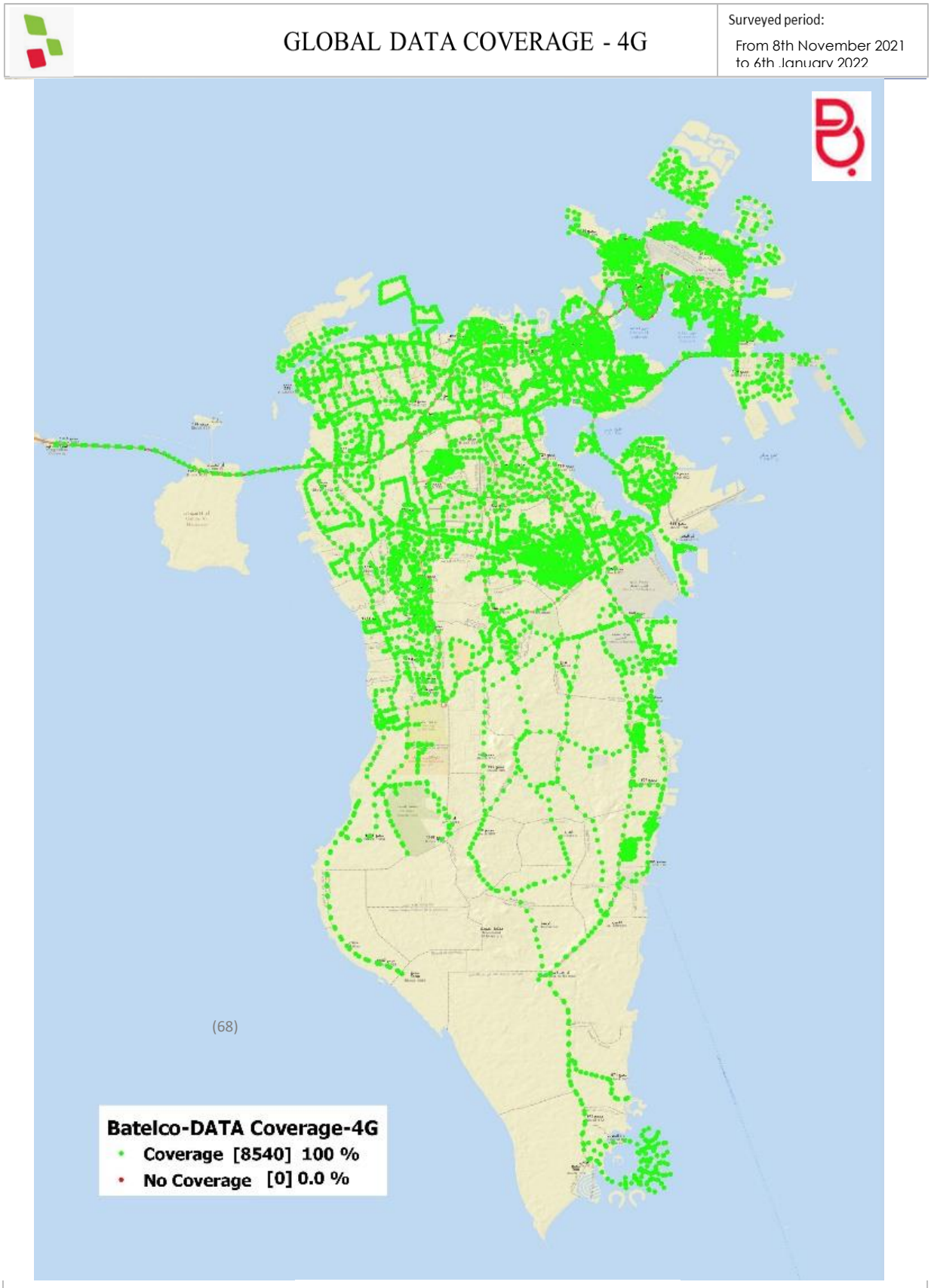
4.3.1. BATELCO – VOICE COVERAGE



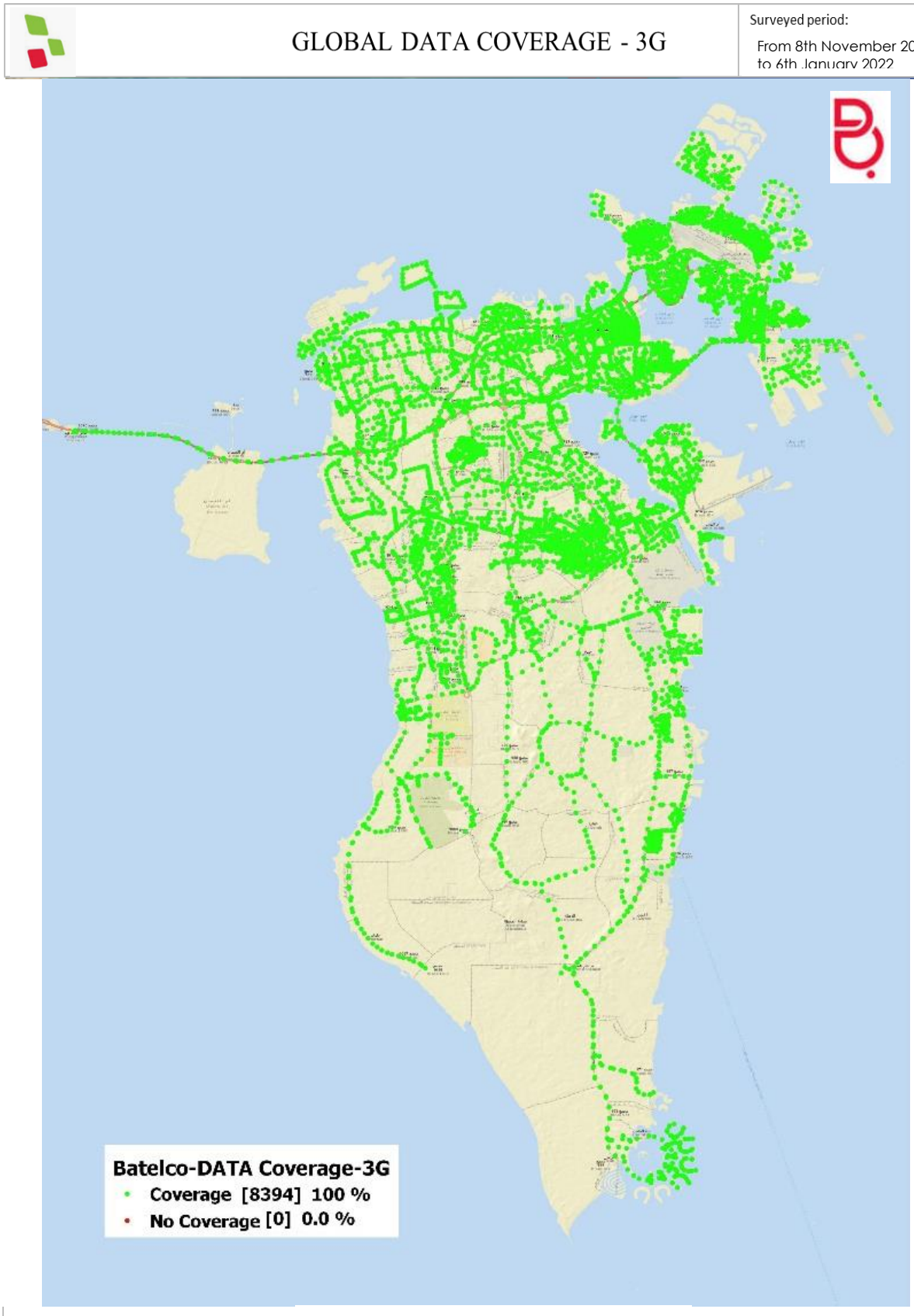
4.3.2. BATELCO 5G – DATA COVERAGE FOR A 5G USER



4.3.3. BATELCO 4G – DATA COVERAGE FOR A LTE USER



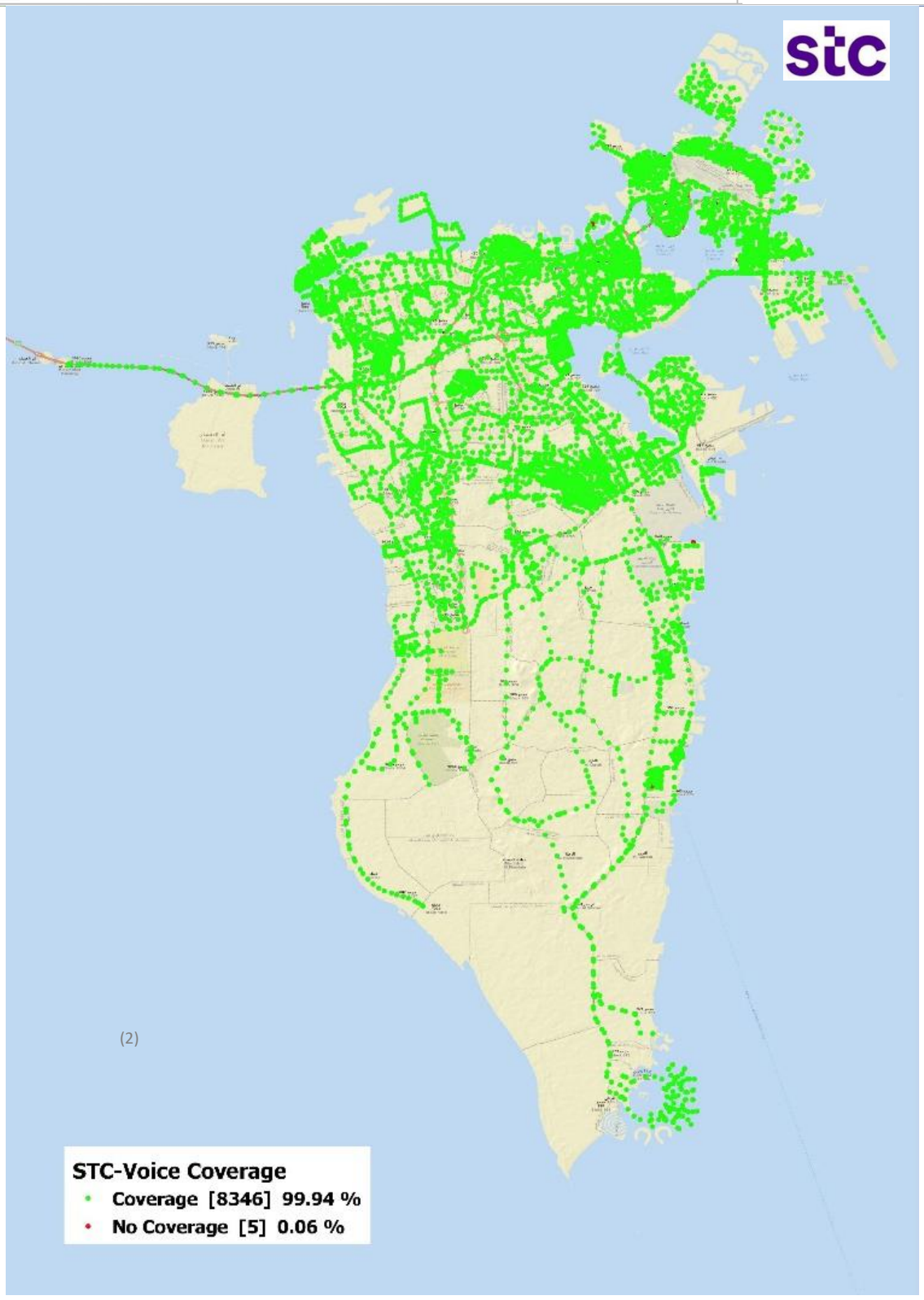
4.3.4. BATELCO 3G – DATA COVERAGE FOR A 3G USER



4.3.5. STC BAHRAIN – VOICE COVERAGE

GLOBAL VOICE COVERAGE

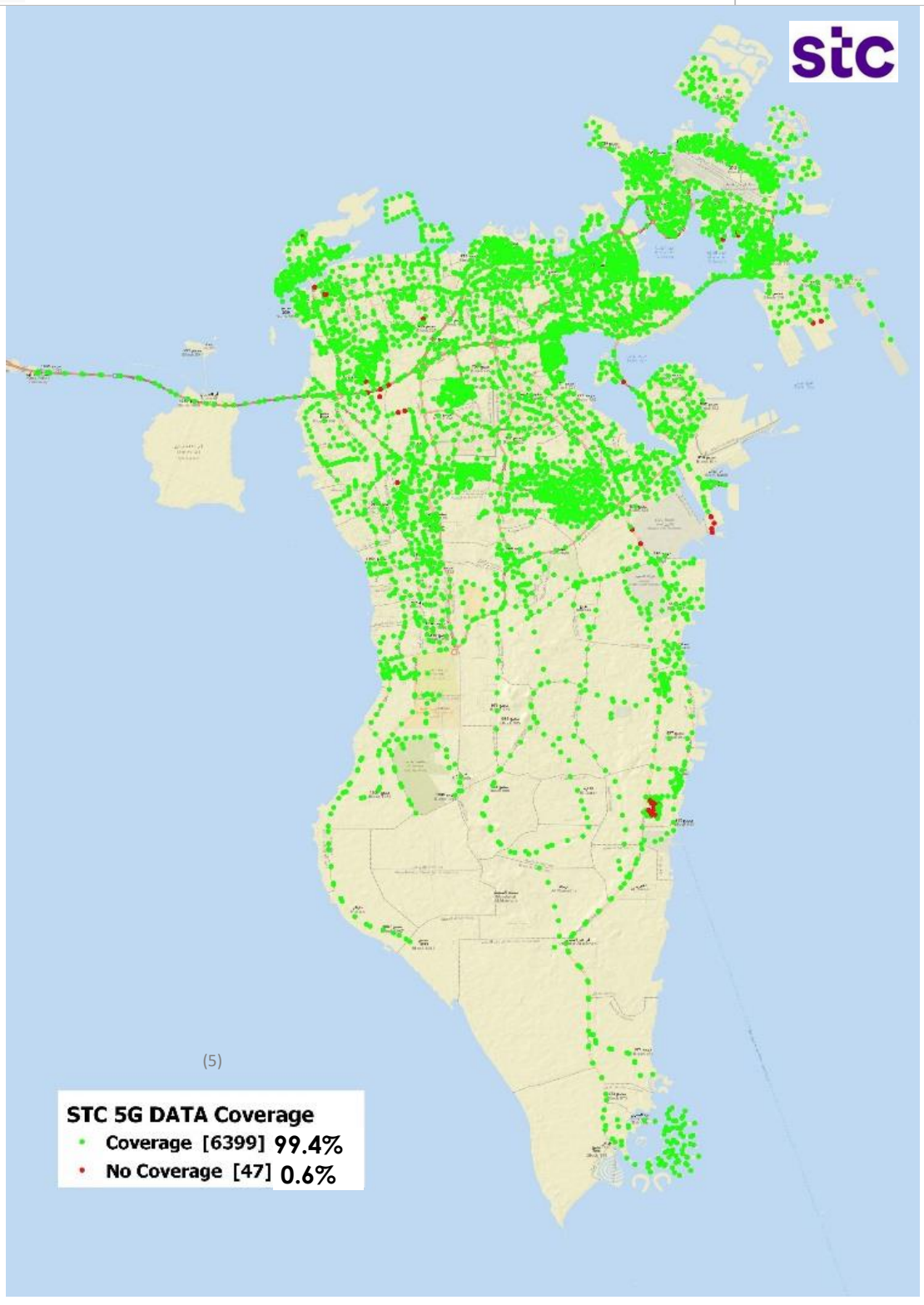
Surveyed period:
From 8th November 2021
to 6th January 2022



4.3.6. STC BAHRAIN 5G – DATA COVERAGE FOR A 5G USER

DATA COVERAGE - 5G

Surveyed period:
From 8th November 2021
to 6th January 2022



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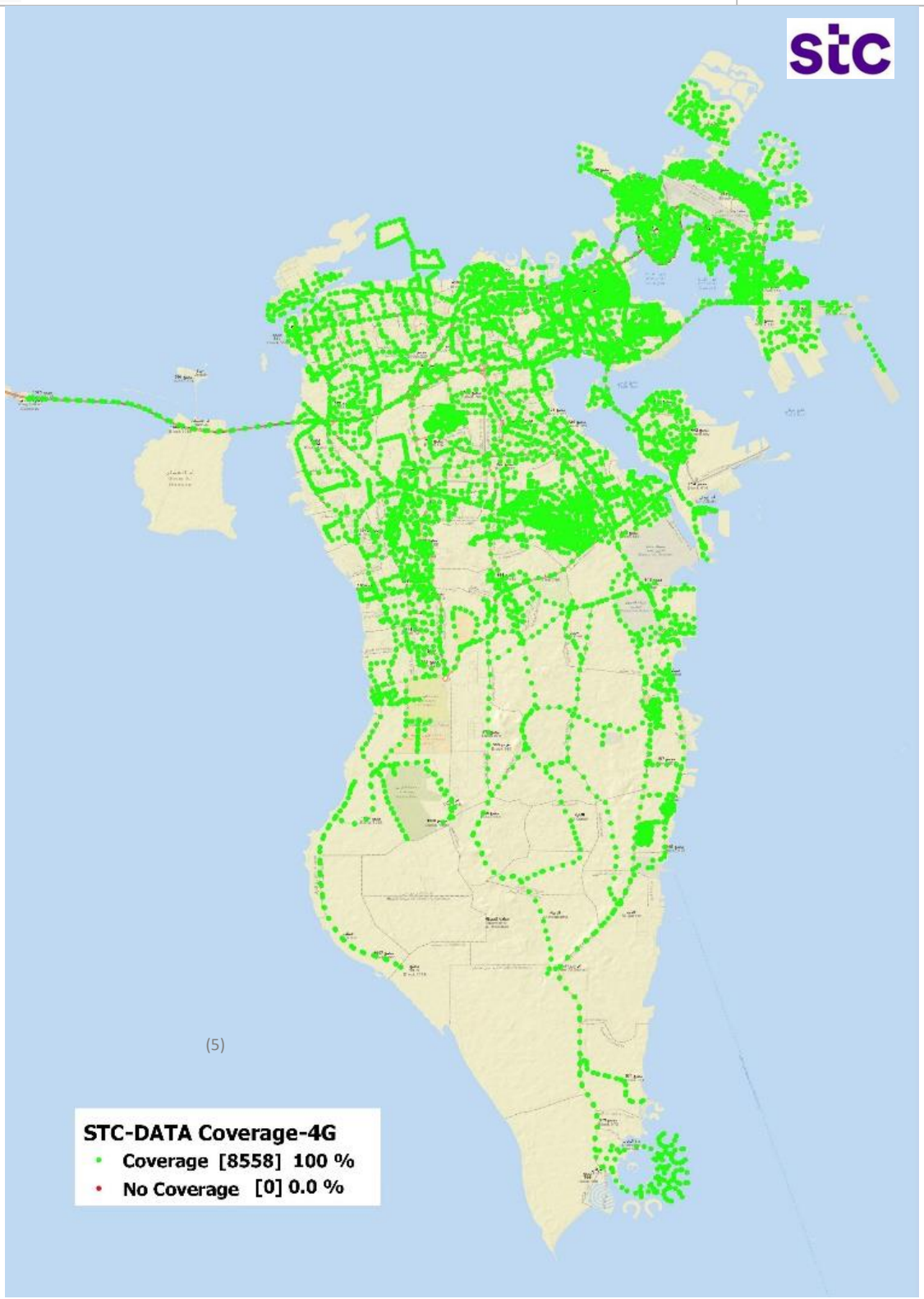
Mobile Coverage – 2021 Survey

4.3.7. STC BAHRAIN 4G – DATA COVERAGE FOR A LTE USER

DATA COVERAGE - 4G

Surveyed period:
From 8th November 2021
to 6th January 2022



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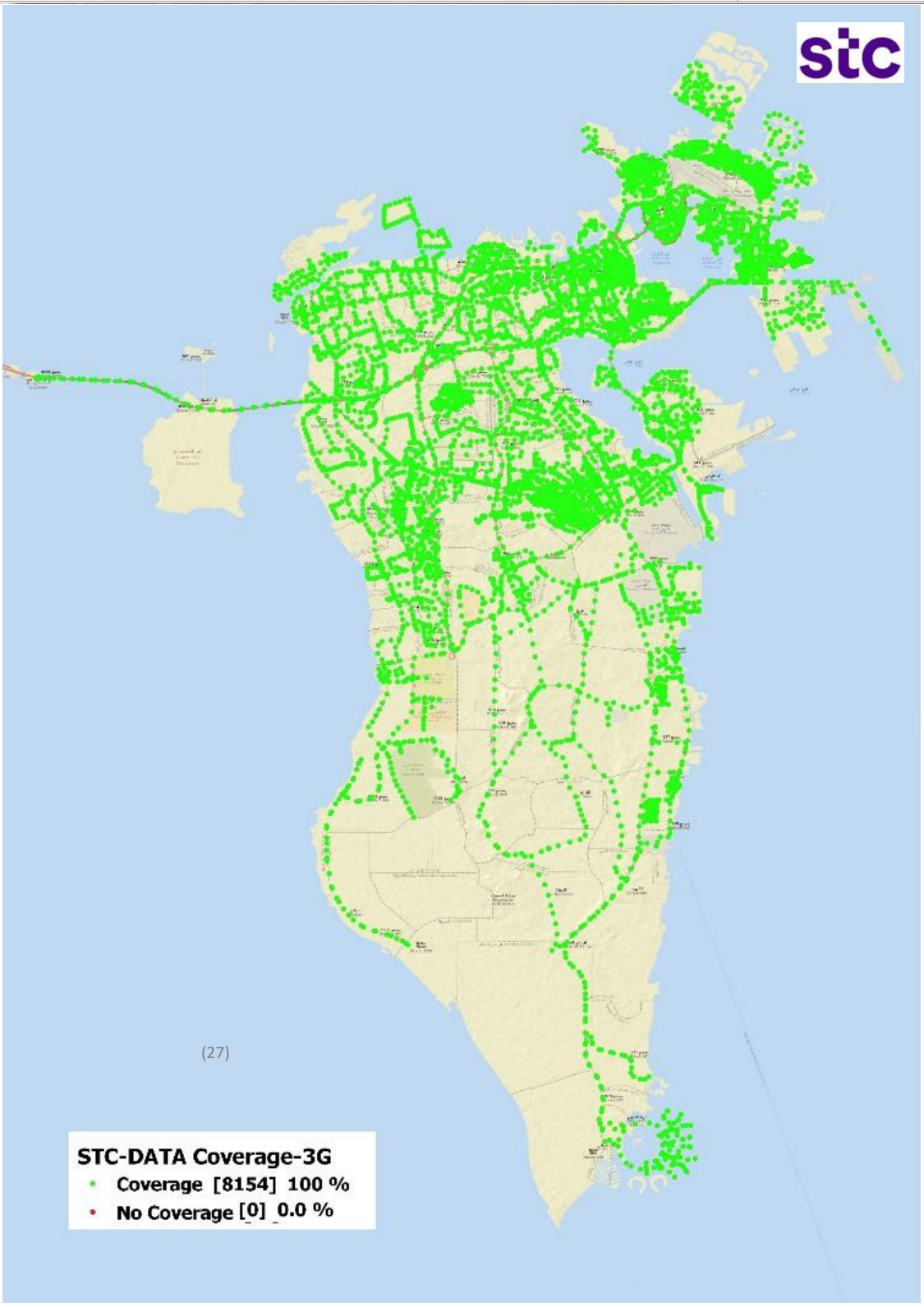
Mobile Coverage – 2021 Survey

4.3.8. STC BAHRAIN 3G – DATA COVERAGE FOR A 3G USER

DATA COVERAGE - 3G

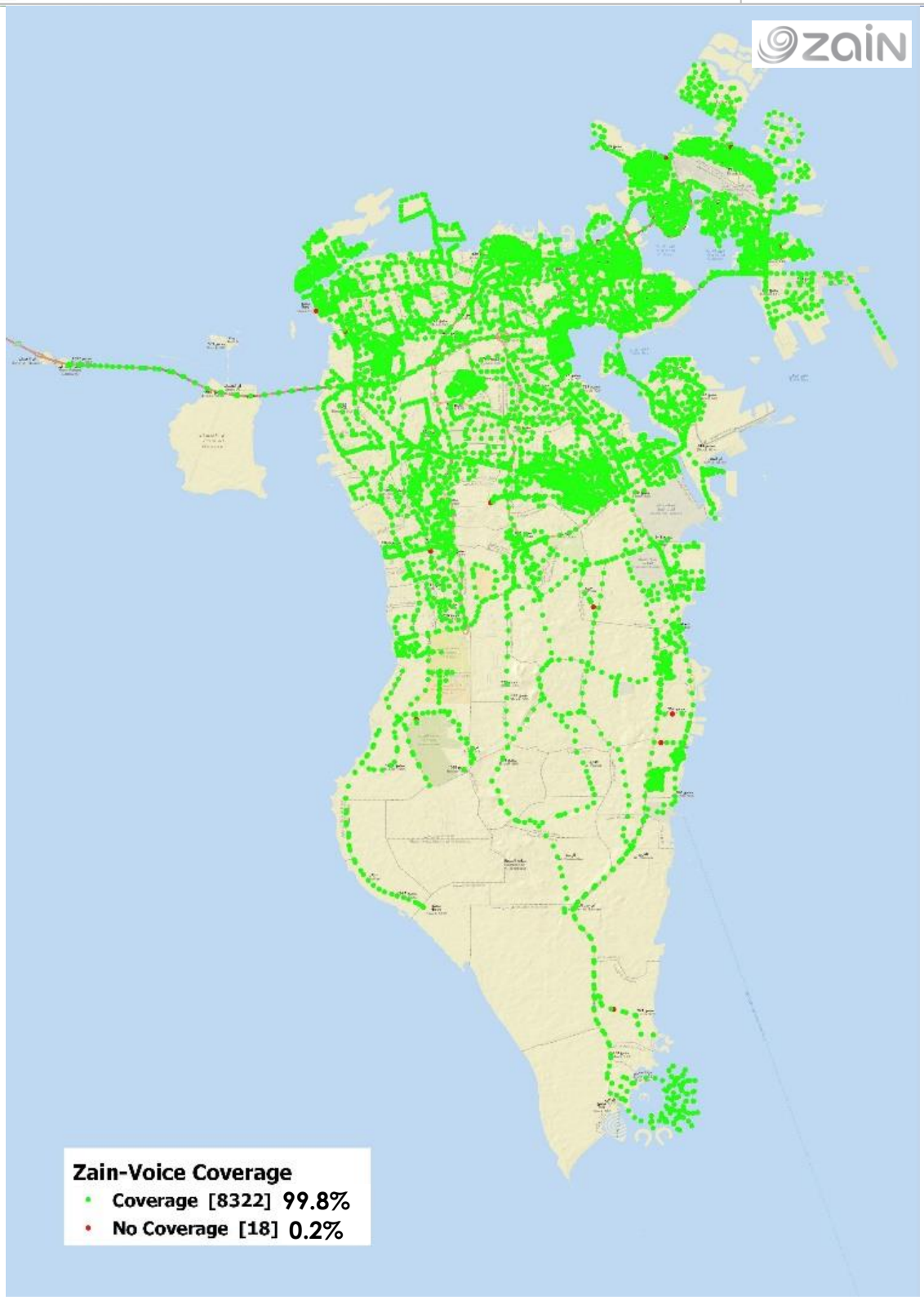
Surveyed period:
From 8th November 2021
to 6th January 2022



4.3.9. ZAIN – VOICE COVERAGE

GLOBAL VOICE COVERAGE

Surveyed period:
From 8th November 2021 to 6th January 2022



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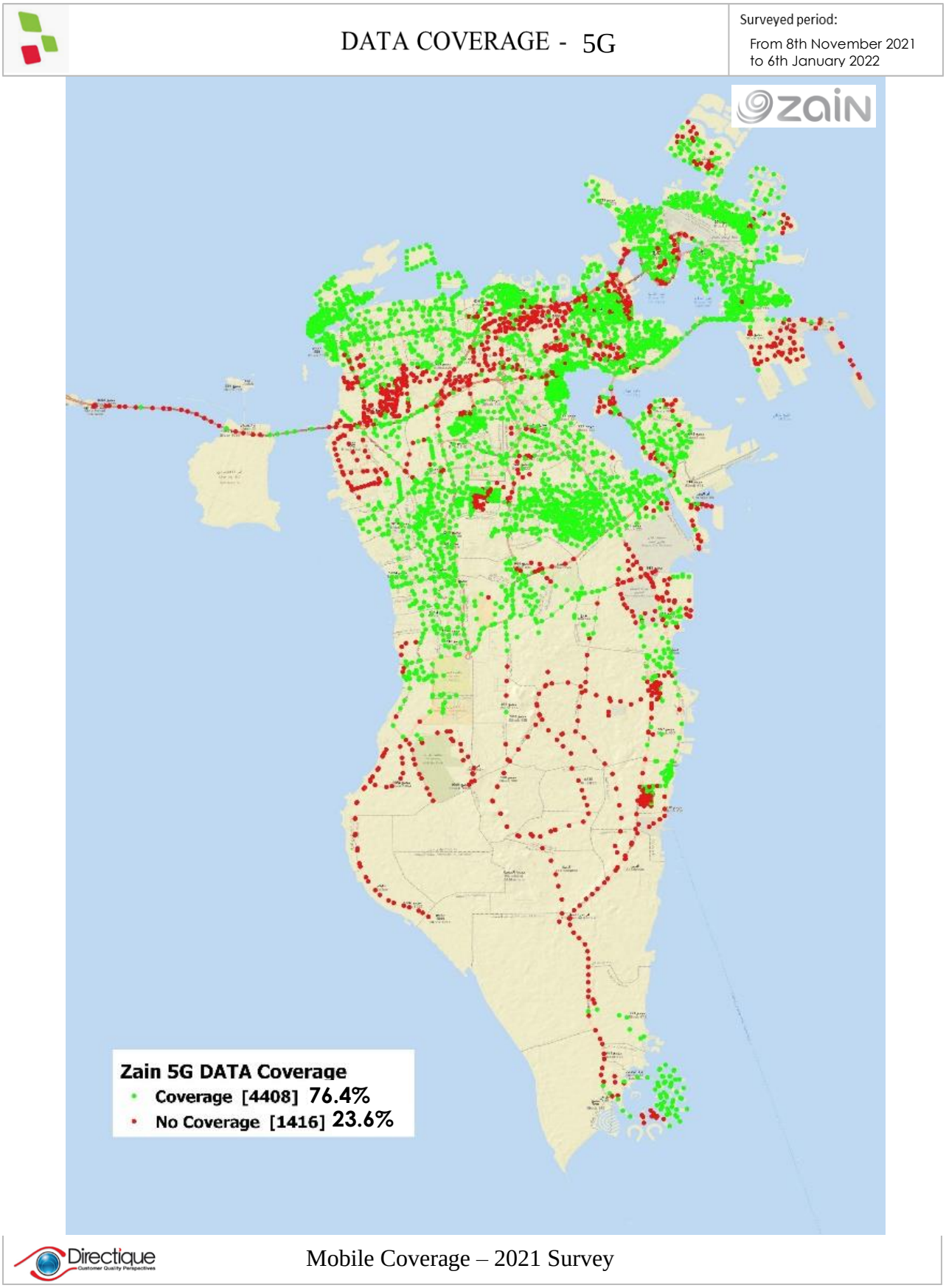
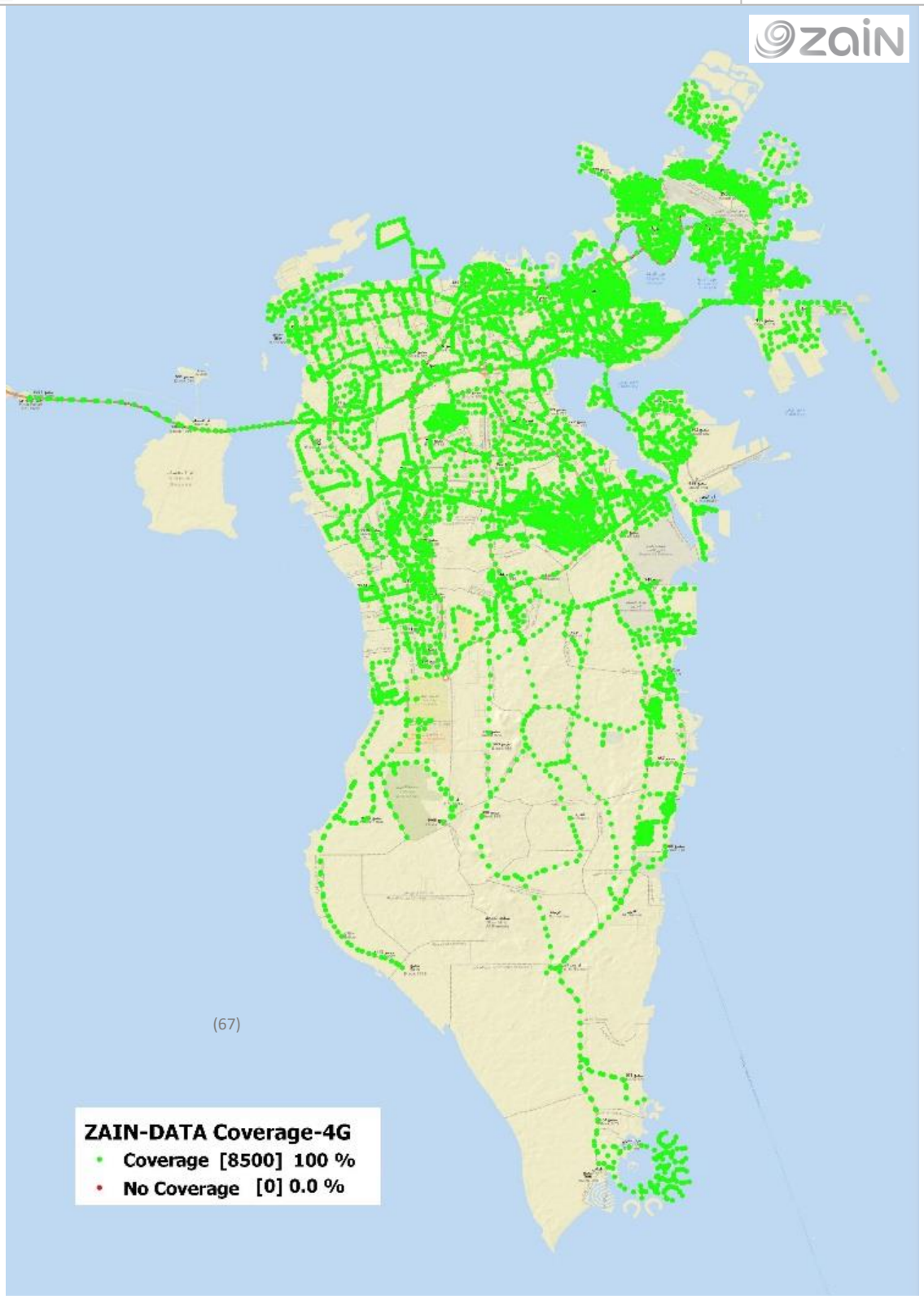
4.3.10. ZAIN 5G – DATA COVERAGE FOR A 5G USER



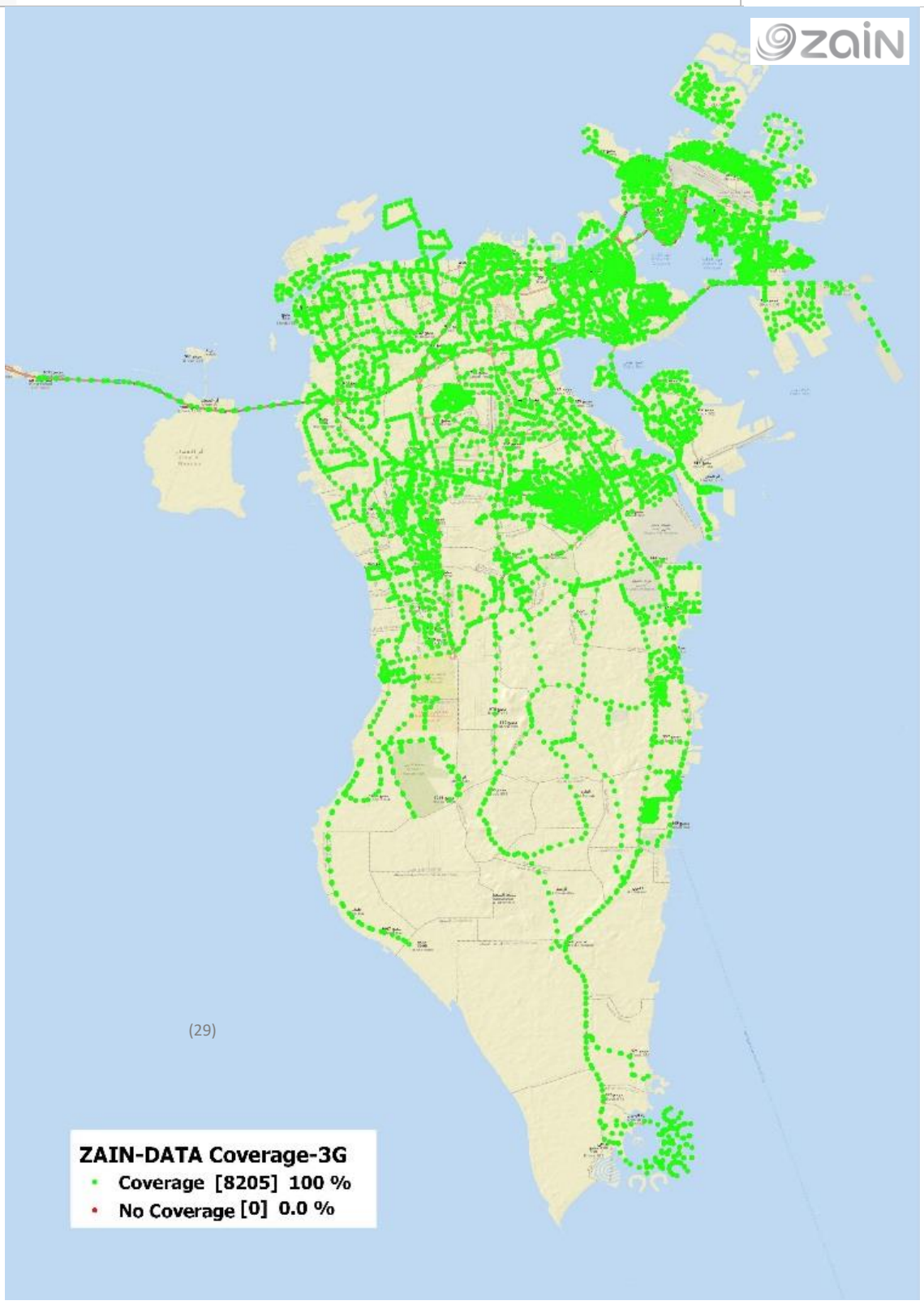
4.3.11. ZAIN 4G – DATA COVERAGE FOR A LTE USER

DATA COVERAGE - 4G

Surveyed period:
From 8th November 2021
to 6th January 2022



4.3.12. ZAIN 3G – DATA COVERAGE FOR A 3G USER



4.4. IDLE COVERAGE – SIGNAL STRENGTH DISTRIBUTION

The following results have been calculated using signal strength on the handset while in IDLE, i.e. between accessibility calls.

Batelco - Signal strength distribution (IDLE mode):

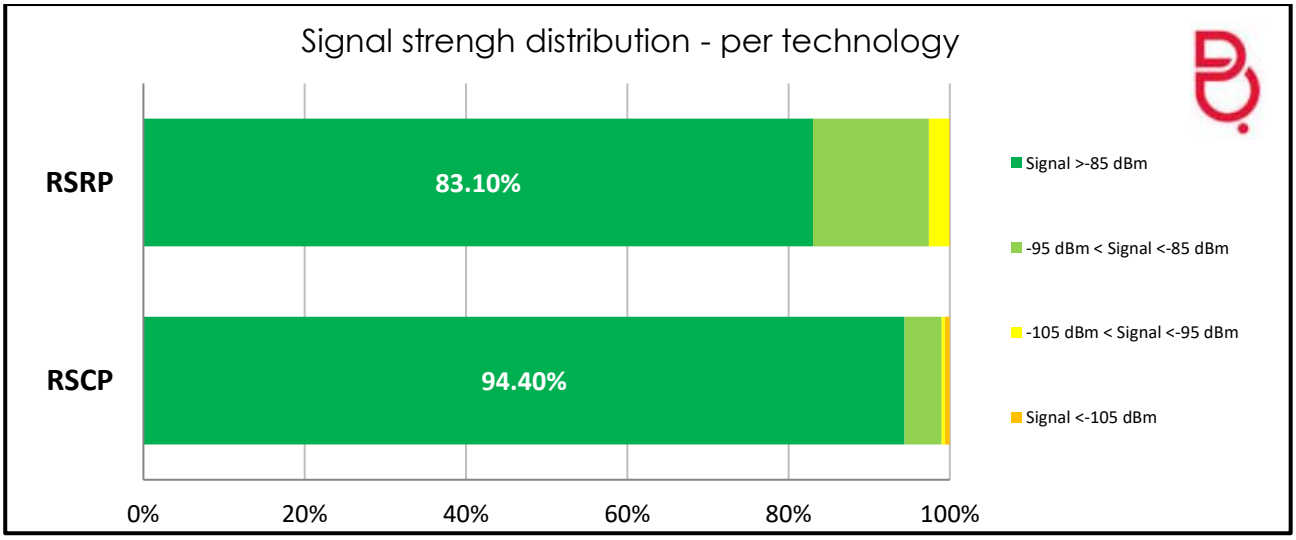
BATELCO	3G RSCP	4G RSRP
Samples	2,290	2,300
Signal >-85 dBm	94.4%	83.1%
-95 dBm < Signal <-85 dBm	4.6%	14.4%
-105 dBm < Signal <-95 dBm	0.4%	2.5%
Signal <-105 dBm	0.6%	0.1%

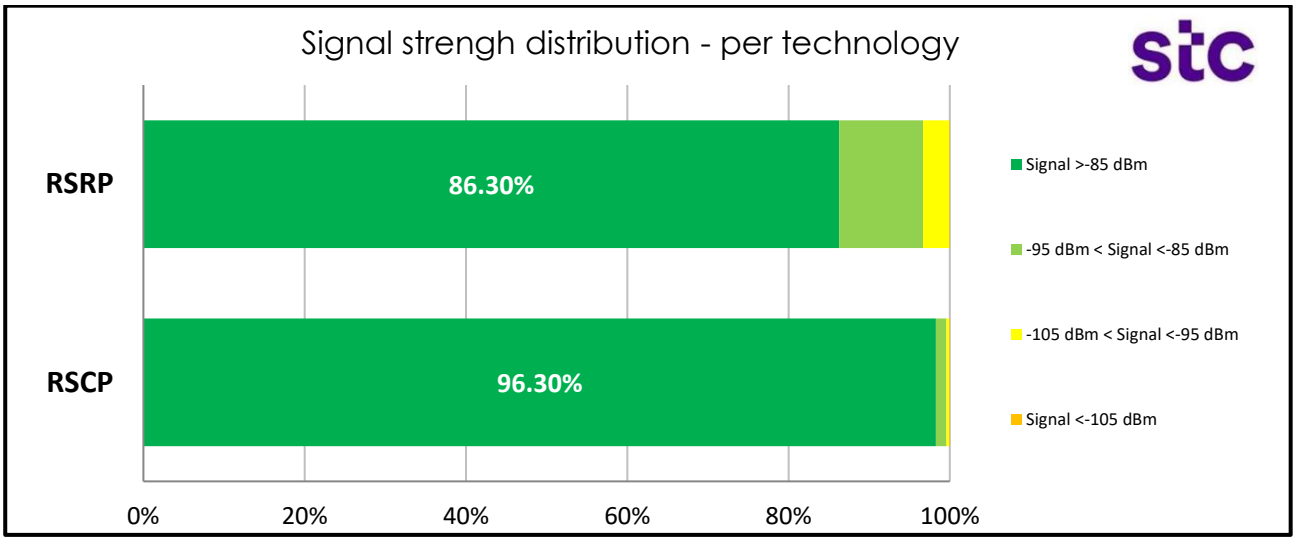
STC Bahrain - Signal strength distribution (IDLE mode):

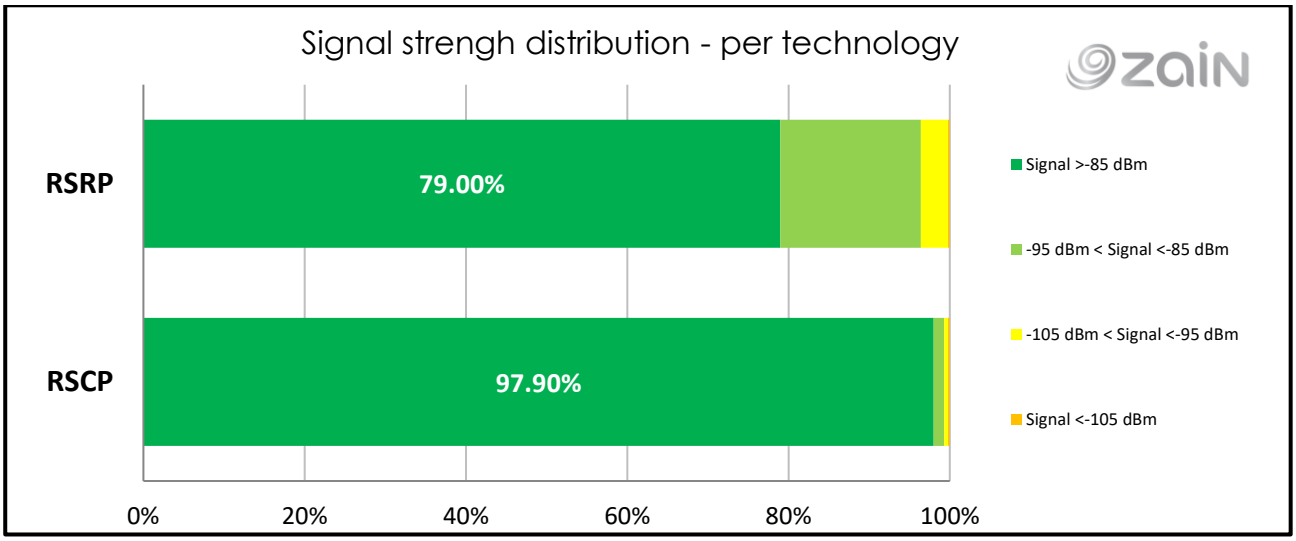
STC	3G RSCP	4G RSRP
Samples	2,300	2,584
Signal >-85 dBm	96.3%	86.3%
-95 dBm < Signal <-85 dBm	1.3%	10.4%
-105 dBm < Signal <-95 dBm	0.3%	3.2%
Signal <-105 dBm	0.1%	0.1%

Zain - Signal strength distribution (IDLE mode):

ZAIN	3G RSCP	4G RSRP
Samples	2,465	2,615
Signal >-85 dBm	97.9%	79.0%
-95 dBm < Signal <-85 dBm	1.3%	17.4%
-105 dBm < Signal <-95 dBm	0.5%	3.4%
Signal <-105 dBm	0.2%	0.2%


Signal strengh distribution - per technology
RSRP
83.10%
RSCP
94.40%
0%
20%
40%
60%
80%
100%
Signal >-85 dBm
-95 dBm < Signal <-85 dBm
-105 dBm < Signal <-95 dBm
Signal <-105 dBm


Signal strengh distribution - per technology
RSRP
86.30%
RSCP
96.30%
0%
20%
40%
60%
80%
100%
Signal >-85 dBm
-95 dBm < Signal <-85 dBm
-105 dBm < Signal <-95 dBm
Signal <-105 dBm


Signal strengh distribution - per technology
RSRP
79.00%
RSCP
97.90%
0%
20%
40%
60%
80%
100%
Signal >-85 dBm
-95 dBm < Signal <-85 dBm
-105 dBm < Signal <-95 dBm
Signal <-105 dBm

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