Directique
Customer Quality Perspectives

هيئة تنظيم الاتصالات
Telecommunications Regulatory Authority

Mobile Networks Coverage Audit

Kingdom of Bahrain - 2016

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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. The purpose of the study is to evaluate and benchmark Quality Levels offered by Mobile Network Operators, Batelco, Viva 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 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 issued on 19 September 2013 require Licensees to provide a mobile telecommunications network that is capable of providing mobile telecommunications services with a nationwide coverage of at least 99% of the population in the Kingdom of Bahrain on or before the 19 June 2014".
Viva has to provide minimum 99.8% population coverage, in accordance with Schedule B-1 of the original IMTL granted to STC Bahrain B.S.C (VIVA Bahrain) on March 1, 2009."

The license obligation defines population coverage for each Mobile Operator's own telecommunications network. The coverage is independent of the technology deployed; coverage measurements have been made with handsets in automatic network mode (not locked on any technology):
For voice:

- a set of smartphones LTE enabled

For data:

- a set of smartphones LTE enabled
- a set of smartphones with no LTE 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. With this in mind, results are very good and show that there is no significant coverage difference from one operator to the other.

Directique was also required to audit Mobile Network Operators coverage prediction maps with the actual coverage observed. The maps included in this report contain two layers: a first layer showing the coverage predictions provided by the operators themselves, on top of which, a second layer superimposed is showing results of the coverage measurements.

2 OBJECTIVE

The objective of this audit was to:

- Measure the outdoor coverage of the 3 Mobile Operators; Batelco, Viva 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 1st to the 19th September 2016 cross the Kingdom's 5 Governorates.

Audit results have been weighted with the population percentage living in each Governorate[1]. The tables in Annex 6 present the detailed coverage per Governorate as measured for each operator.

Coverage, from a end-user perspective, cannot be measured based on signal level. A scanner cannot distinguish the difference between the live cells and the other emitting cells and the result would give an over optimistic coverage measurement.
Beside such tools would measure reception levels in dB, and this cannot be interpreted or be easily understood by the end user.

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

For voice : 2G/3G/4G auto connect
For data :

- 1 set in 2G/3G/4G auto connect, to represent LTE's users
- 1 set in 2G/3G auto connect, to represent non LTE's users

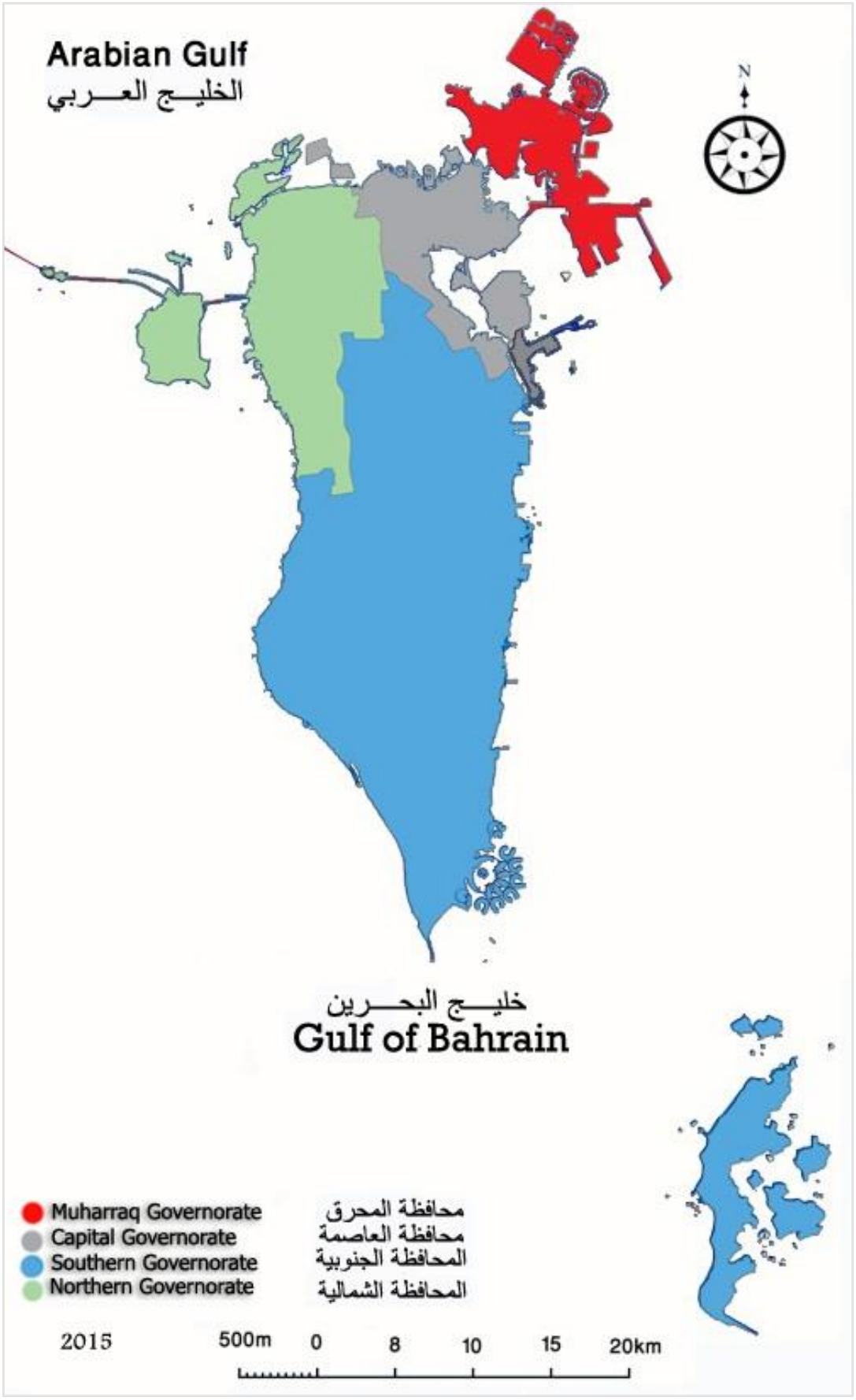
Measurements have been performed with the following platform:

- **Voice** :a set of smartphones in 2G/3G/4G auto connect mode, running accessibility voice calls with Directique's proprietary software ***MobiTrace***
- **Data** : data accessibility tests (HTTP DL) with our proprietary software ***MobiSpeed***:
    - 1 set in 2G/3G/4G auto connect, to represent LTE's users
    - 1 set in 2G/3G auto connect, to represent non LTE's users

The vehicle equipped with to the test platfrom followed a pre-determined route which was selected to ensure that it covered the 4 Governorates of the Kingdom. Test were conducted automaticaly.

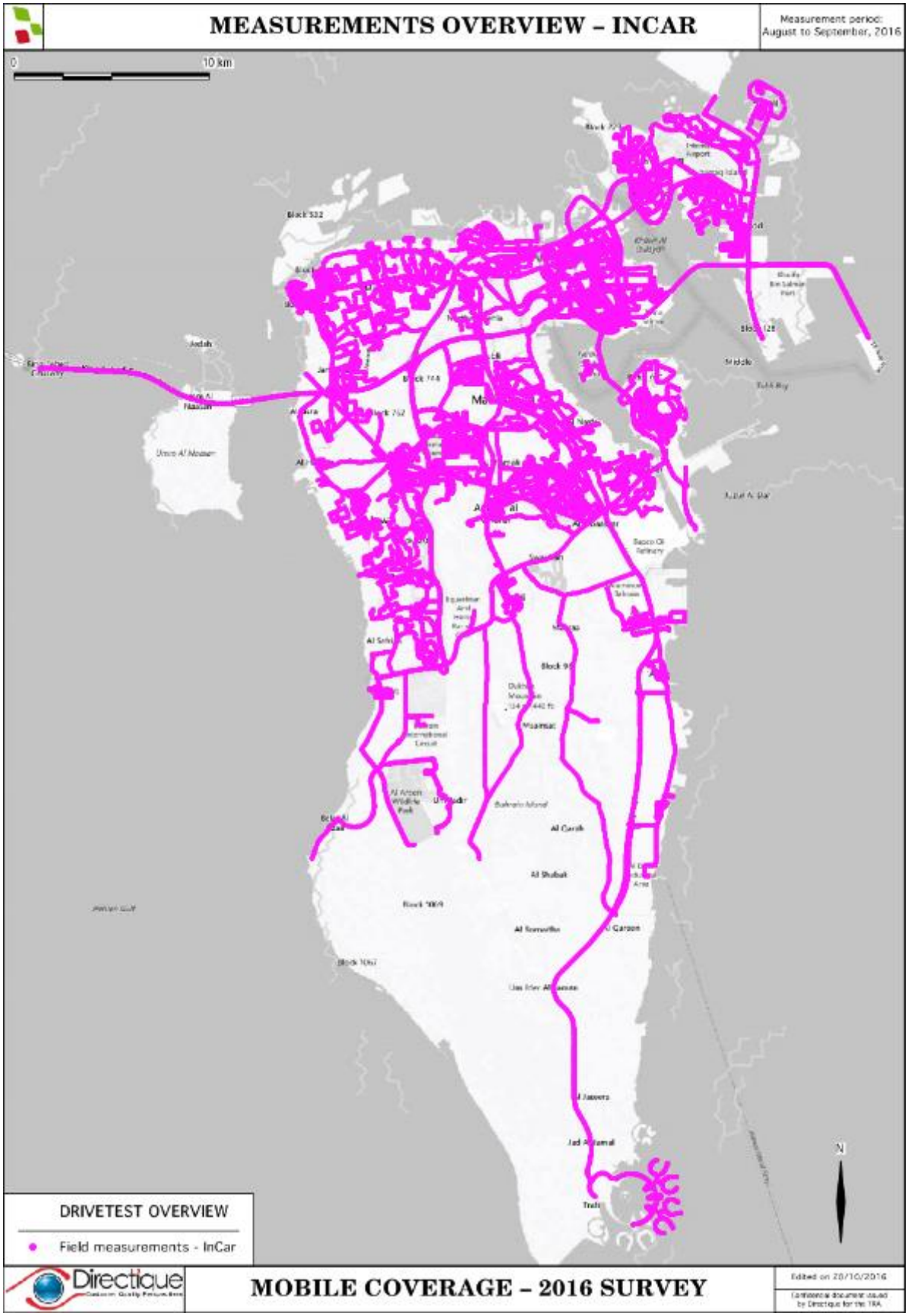
[1] Population data based on CIO latest census (2010)

3.1.1 **Administrative divisions**



3.1.2 **Drive test**

Routes followed by the vehicle performing measurements.



3.1.3 Equipment

Audit measurements were performed using standard mobile phones.

Data coverage

Device:

Samsung Note4

Methodology: All devices were set in automatic mode, which means that each data measurement was launched on the best technology offered by the network at the time of the test.

In order to have a representative experience of 2 types of services, those with 4G and those restricted to 3G, devices were set differently:

- One set of smartphones, network mode was: **LTE/WCDMA/GSM (auto connect**).
- On the other set of smartphones, LTE was disabled; network modes were: **WCDMA/GSM (auto connect)**.

Voice coverage:

Device:

Samsung Galaxy S5.

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, Viva and Zain.

Rooftop box and incar control station

For outdoor test conditions mobile phones were positioned in a plastic rooftop box. The rooftop box was tested in measuring using a reference signal, attenuation outside and then inside the rooftop box, to validate the absence of significant radio signal attenuation. Similarly the test platform was calibrated using a reference signal to identify and correct any significant difference between mobile phones sensibility.

Inside the rooftop box, 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 latency tests among the total sample.

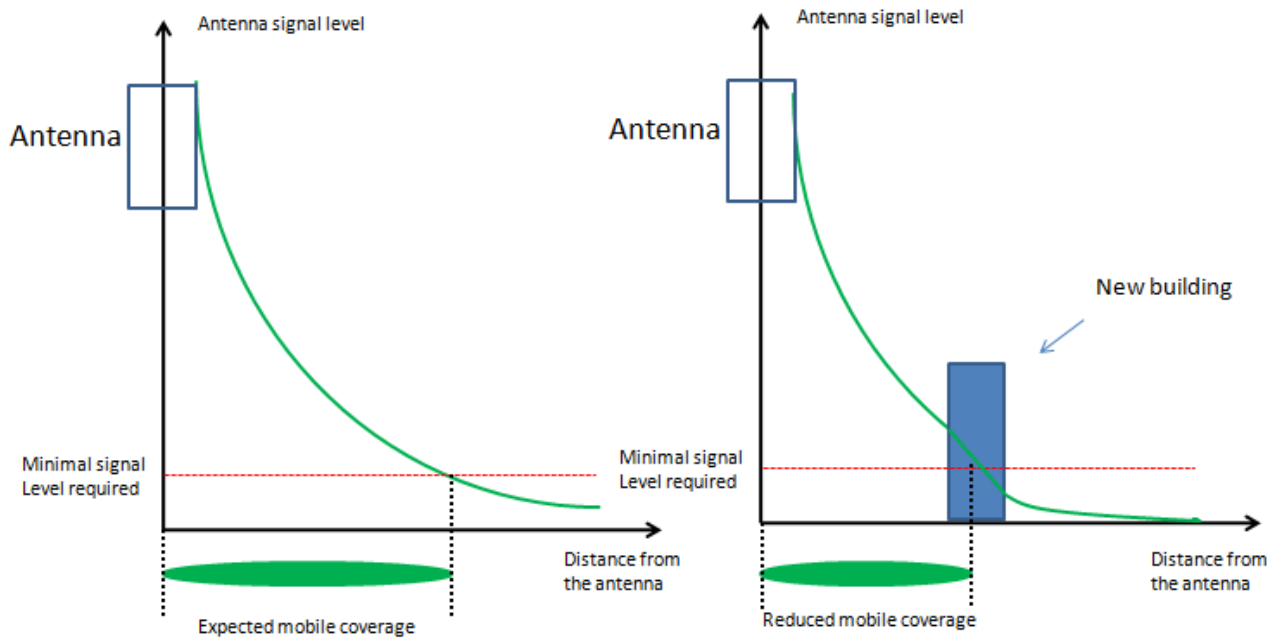
Population coverage is then calculated by weighting these results with the population percentage living in each Governorate, using latest available Central Informatics Organisation (CIO) census statistics for the Kingdom.

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 base stations to ensure adequate indoor 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.

3.2 Population coverage for voice and data

3.2.1 Population Coverage for voice service

		Batelco		Viva		Zain	
Governorate	% Pop	Nb	Coverage	Nb	Coverage	Nb	Coverage
Capital	43%	2 793	100.0%	2 825	100.00%	2 905	99.97%
Northern	26%	2 461	99.7%	2 674	99.89%	2 581	99.88%
Muharraq	17%	1 199	99.8%	1 192	100.00%	1 271	99.92%
Southern	13%	2 197	99.8%	2 465	100.00%	2 385	100.00%
Total		8 650	**99.85%**	9 156	**99.97%**	**9 142**	**99.95%**

Rate represents the % of successful voice accessibility calls.

3.2.2 Population Coverage for Data service: 4G user

% of population with a LTE handset with access to data

		Batelco		Viva		Zain	
Governorate	% Pop	Nb	Coverage	Nb	Coverage	Nb	Coverage
Capital	43%	2 490	100.0%	2 760	100.0%	2 736	100.0%
Northern	26%	1 927	100.0%	2 181	100.0%	2 278	100.0%
Muharraq	17%	869	100.0%	1 157	100.0%	1 015	100.0%
Southern	13%	2 194	100.0%	2 153	100.0%	2 176	100.0%
Total		**7 480**	**100.0%**	**8 251**	**100.0%**	**8 205**	**100.0%**

Rate represents the % of successful http data transfers.

Legend:

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

3.2.3 Population Coverage for Data service: 3G user

% of population with a non LTE handset with access to data

		Batelco		Viva		Zain	
Governorate	% Pop	Nb	Coverage	Nb	Coverage	Nb	Coverage
Capital	43%	2 280	100.0%	2 621	100.0%	2 736	100.0%
Northern	26%	2 124	100.0%	2 139	100.0%	2 278	100.0%
Muharraq	17%	798	100.0%	1 047	100.0%	1 015	100.0%
Southern	13%	1 979	100.0%	2 030	100.0%	2 176	100.0%
Total		**7 181**	**100.0%**	**7 837**	**100.0%**	**6 429**	**100.0%**

Rate represents the % of successful http data transfers.

Legend:

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

3.3 Technology distribution

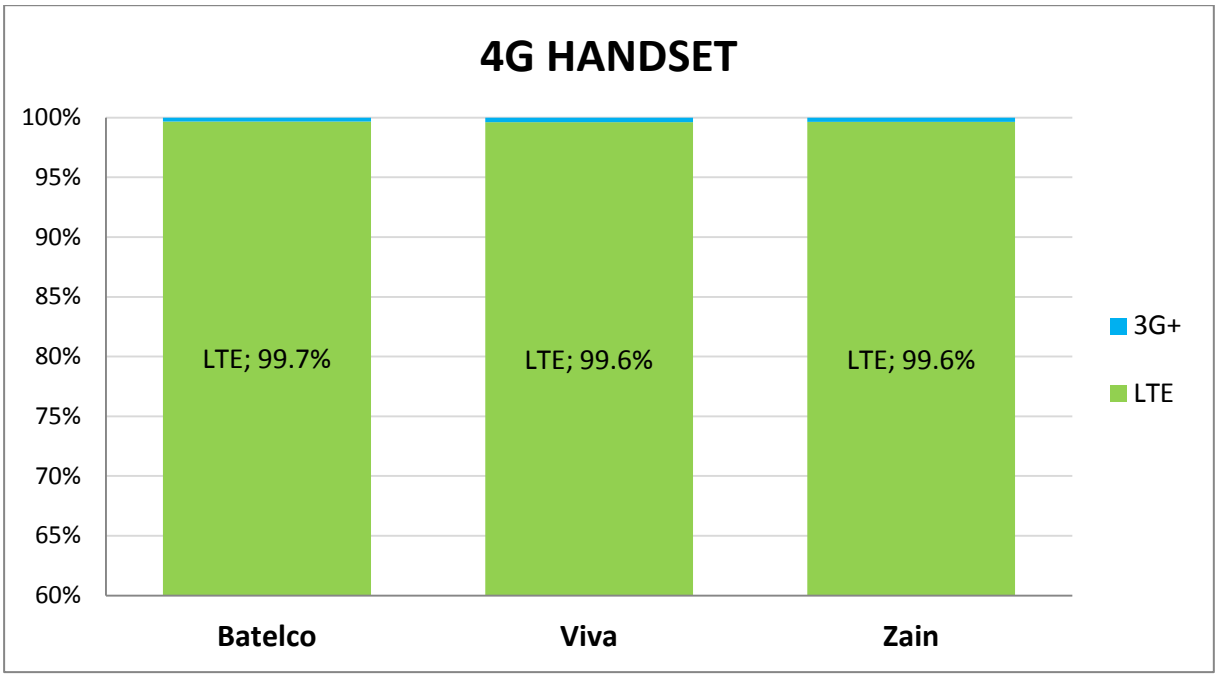
Figures here below show the exact distribution of the data coverage measurements.
First, the rate of successful HTTP download (latency test), as a location were the latency was NOK is considered as not covered.
Then, graph show the percentages of those successful tests on each technology used by the mobile.

3.3.1 4G handset

	Batelco	Viva	Zain
Rate of successful HTTP latency	**100.0%**	**100.0%**	**100.0%**

On technology:

LTE	**99.7%**	**99.6%**	**99.6%**
HSPAP	**0.3%**	**0.3%**	**0.4%**
HSPA	**0.0%**	**0.1%**	**0.0%**

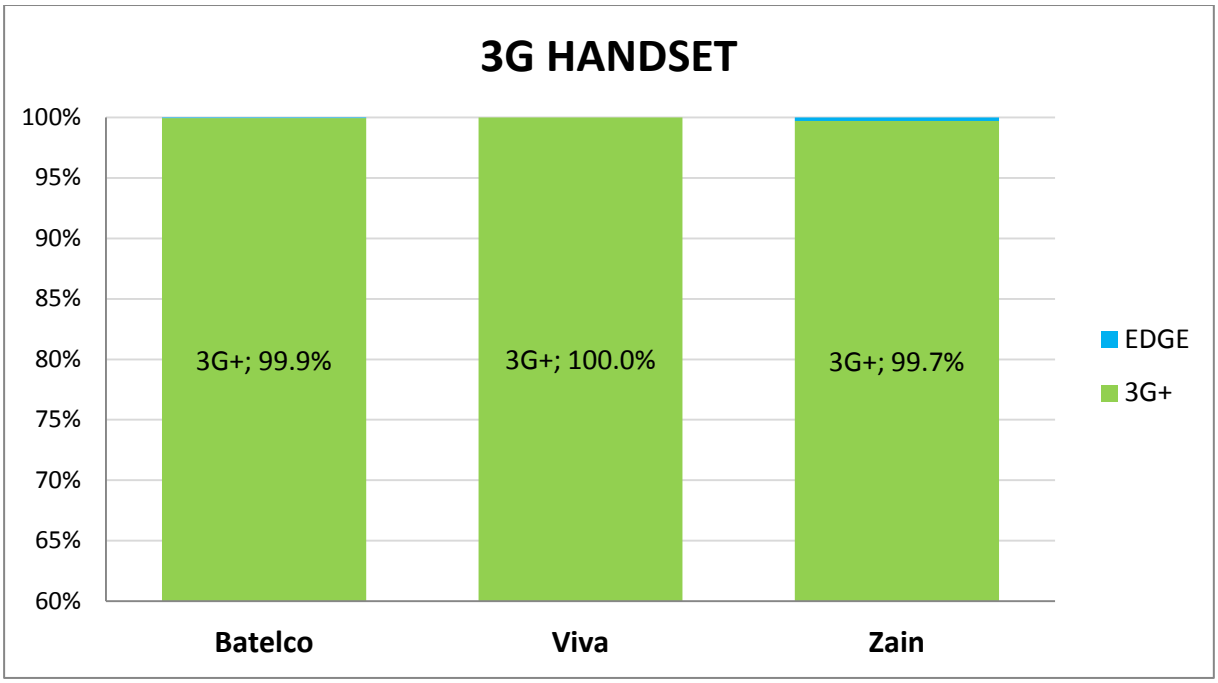


3.3.1 3G handset

	Batelco	Viva	Zain
Rate of successful HTTP latency	**100.0%**	**100.0%**	**100.0%**

On technology:

HSPAP	**99.9%**	**100.0%**	**99.7%**
EDGE	**0.1%**	**0.0%**	**0.3%**



3.4 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:

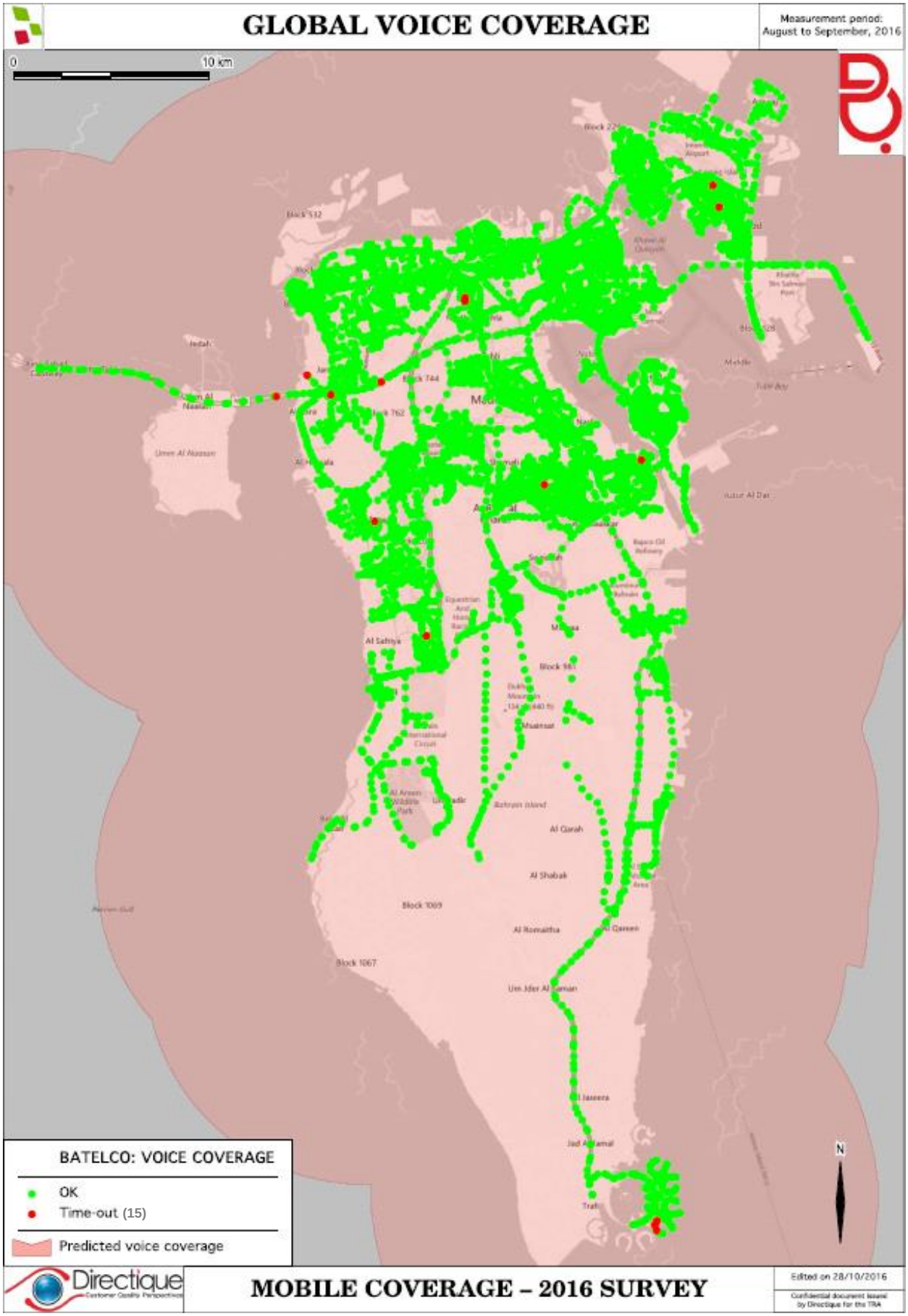
If the spot is **grey**, the test was outside the coverage zone of the operator.

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

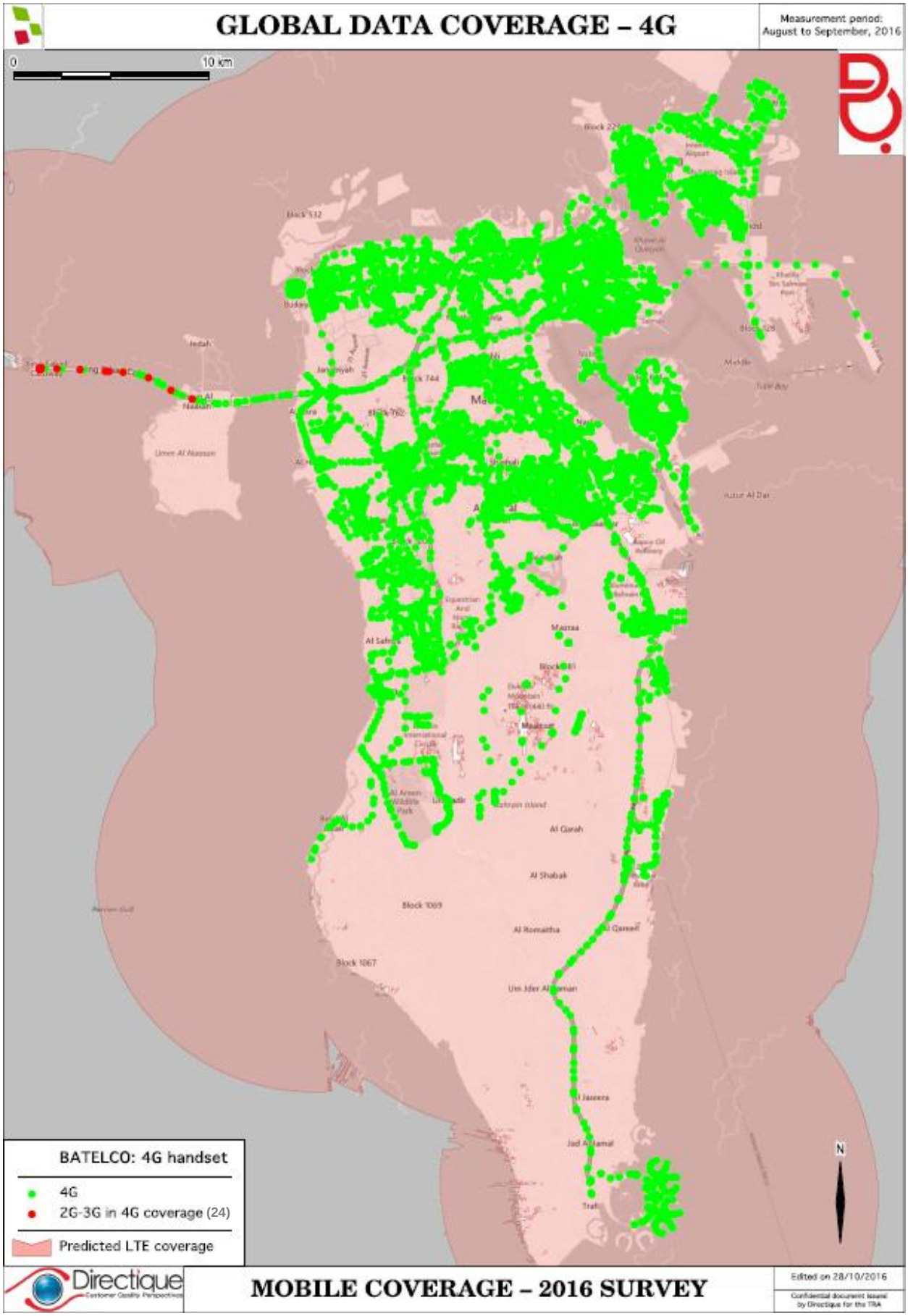
If the spot is **red**, the test was inside the coverage zone of the operator and accessibility to network was not effective on the handset

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

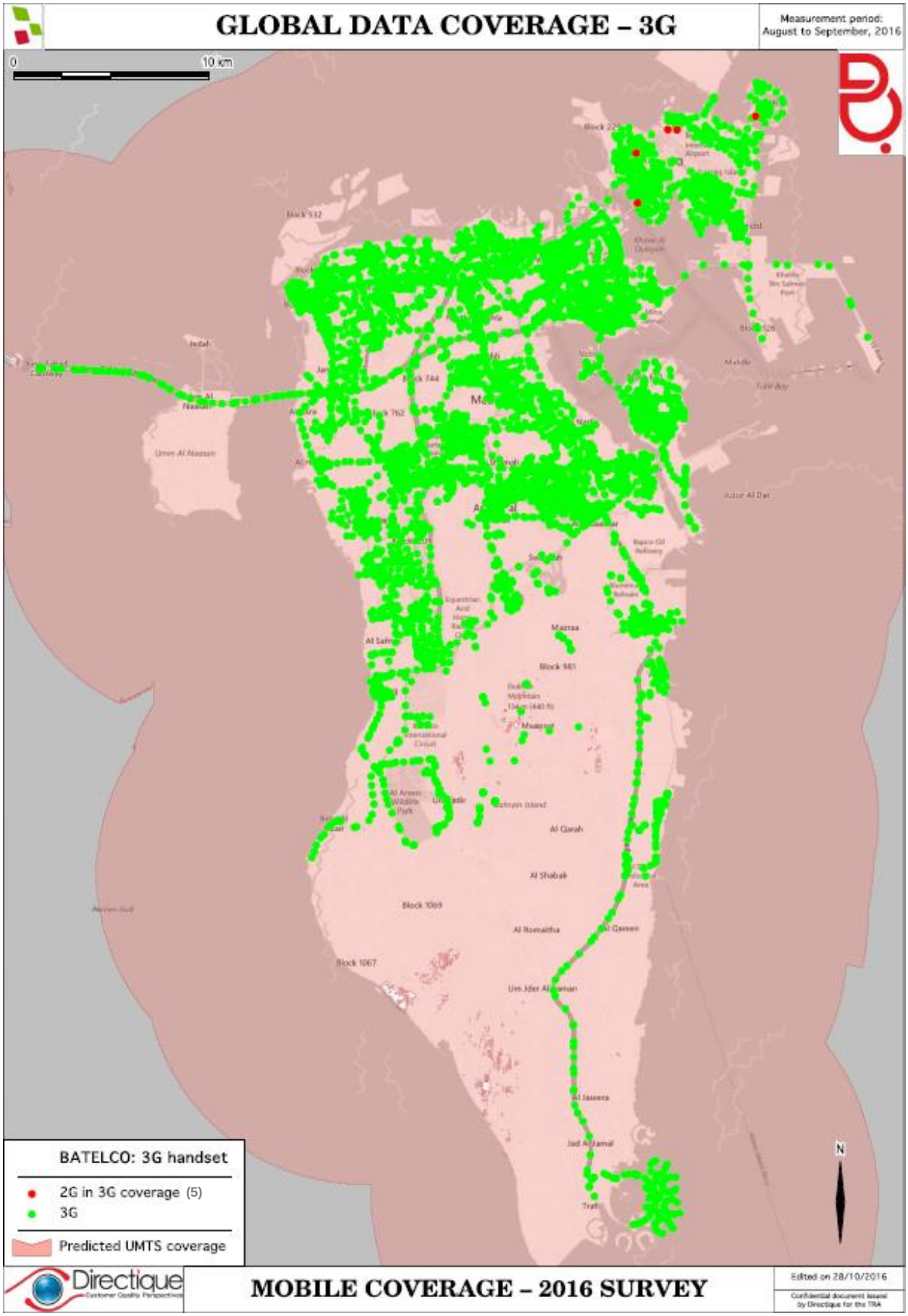
3.4.1 **Batelco – Voice Coverage**



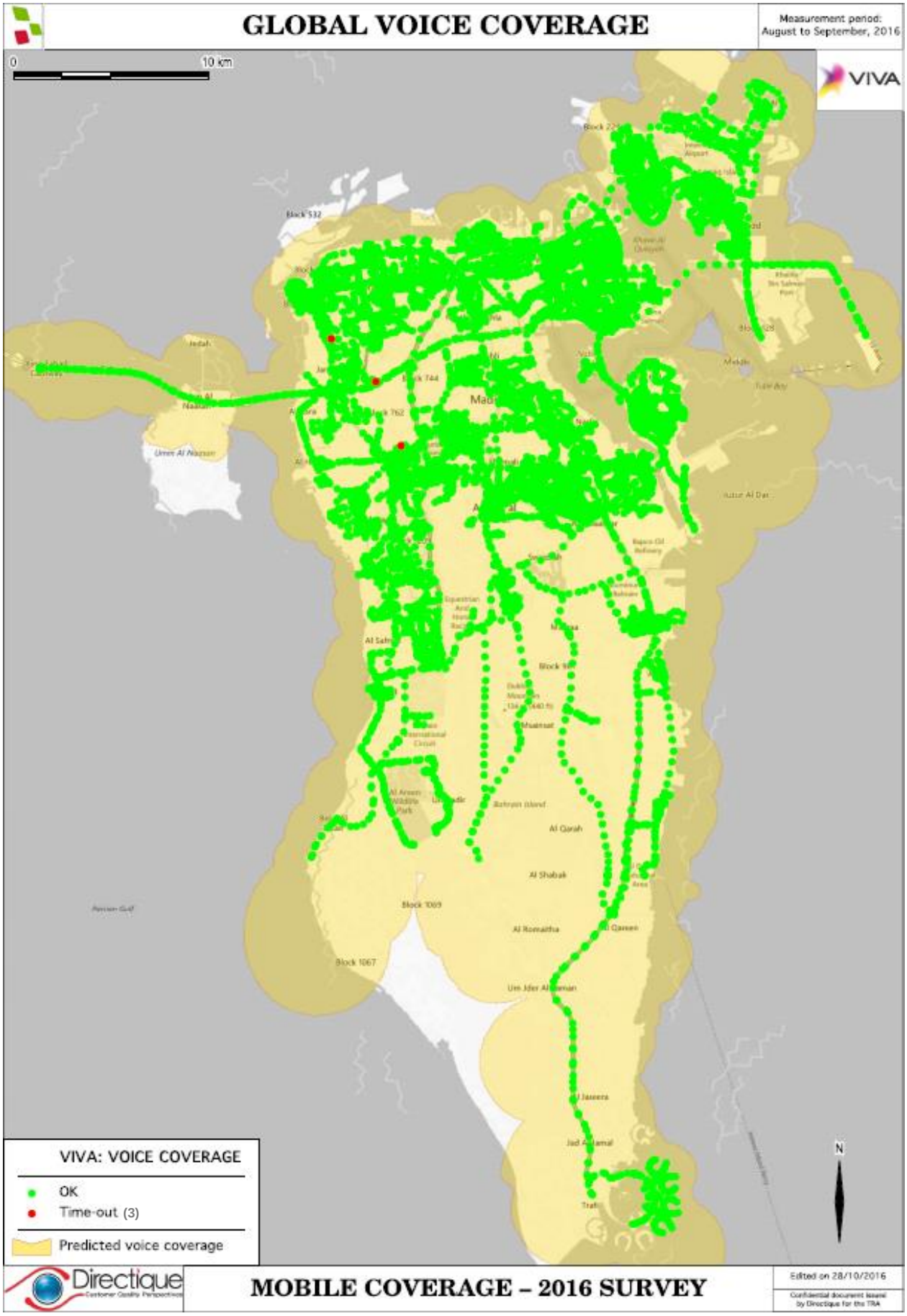
3.4.2 Batelco 4G – data coverage for a LTE user



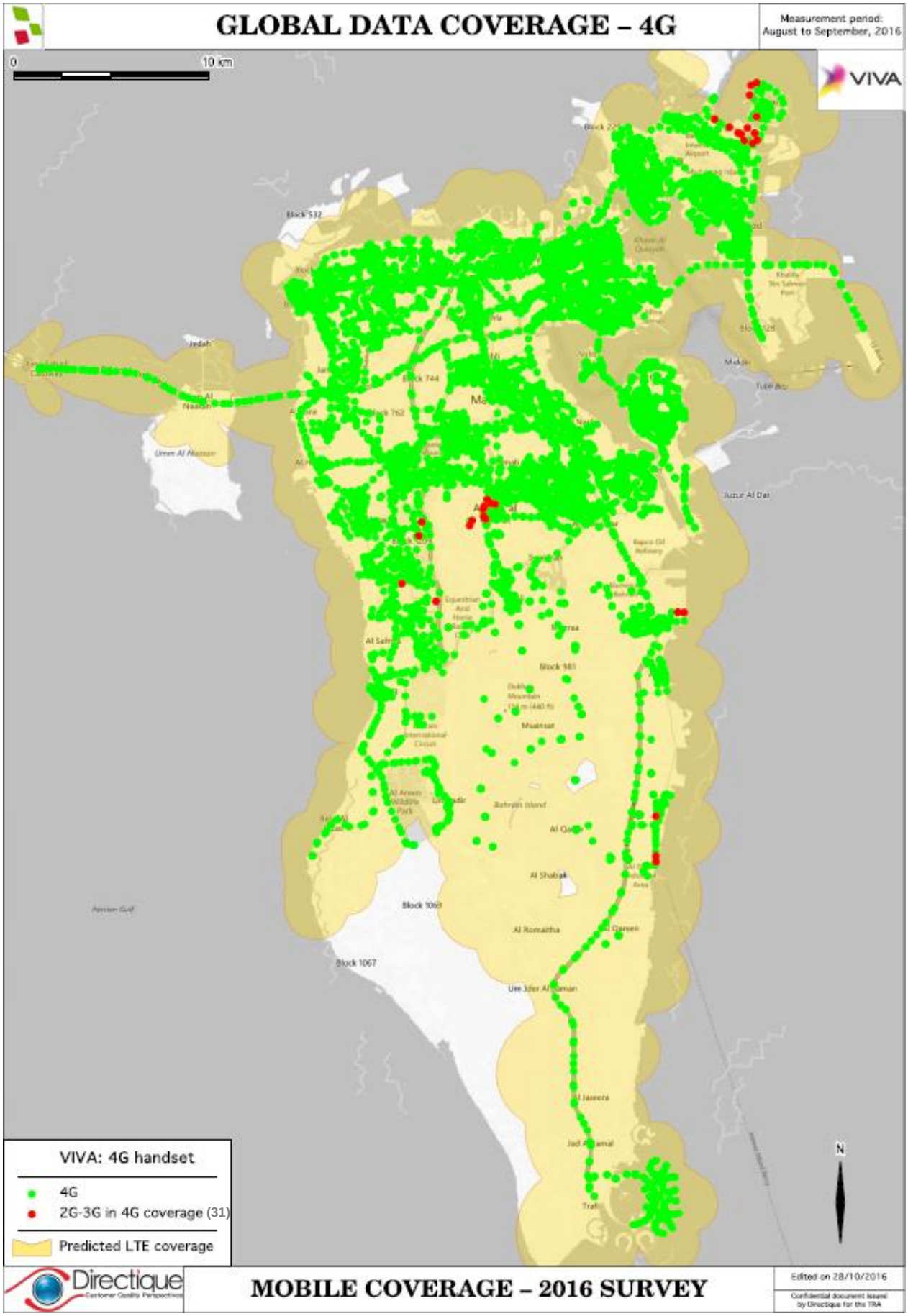
3.4.3 Batelco 3G – data coverage for a 3G user



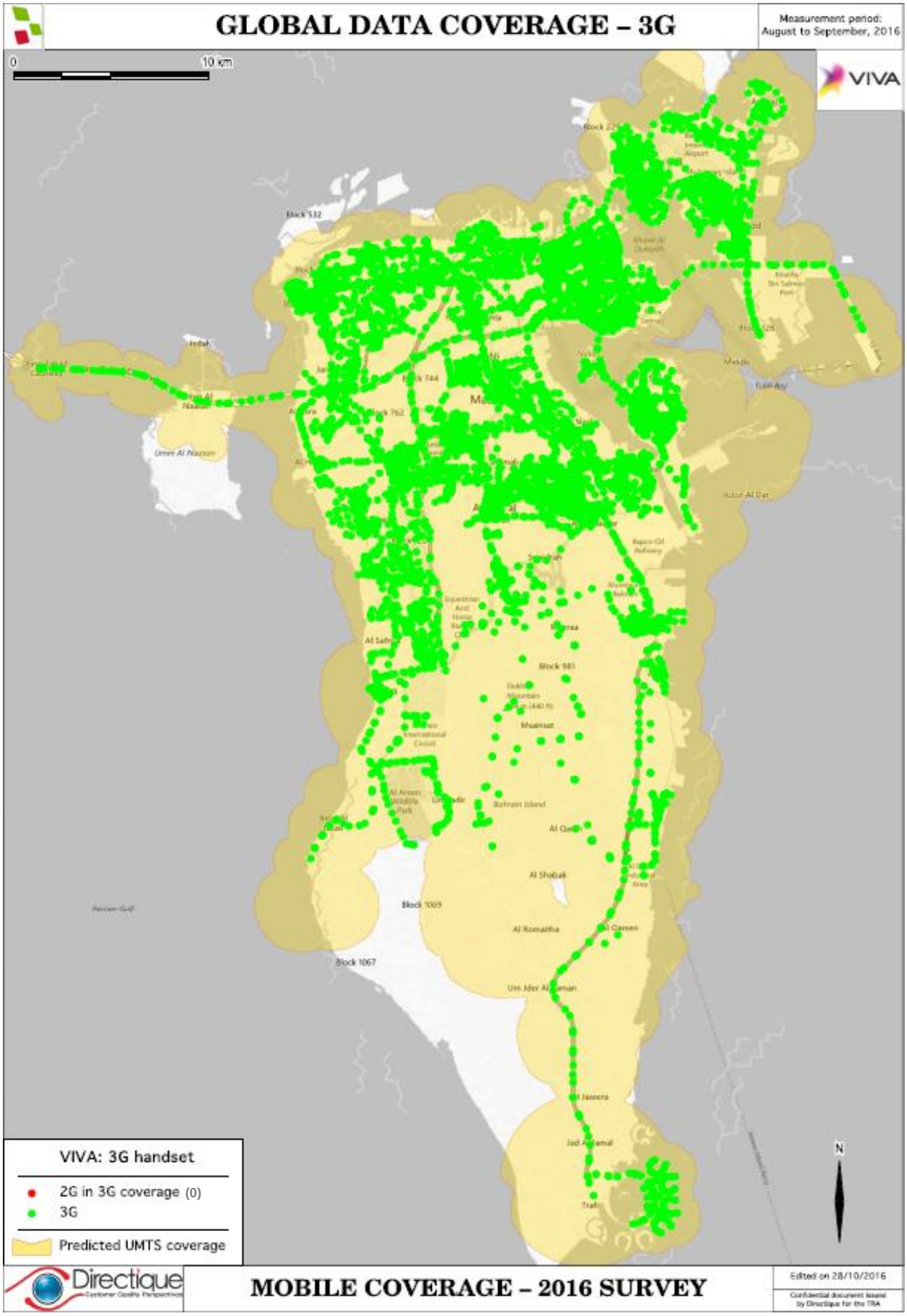
3.4.4 Viva 4G – Voice Coverage



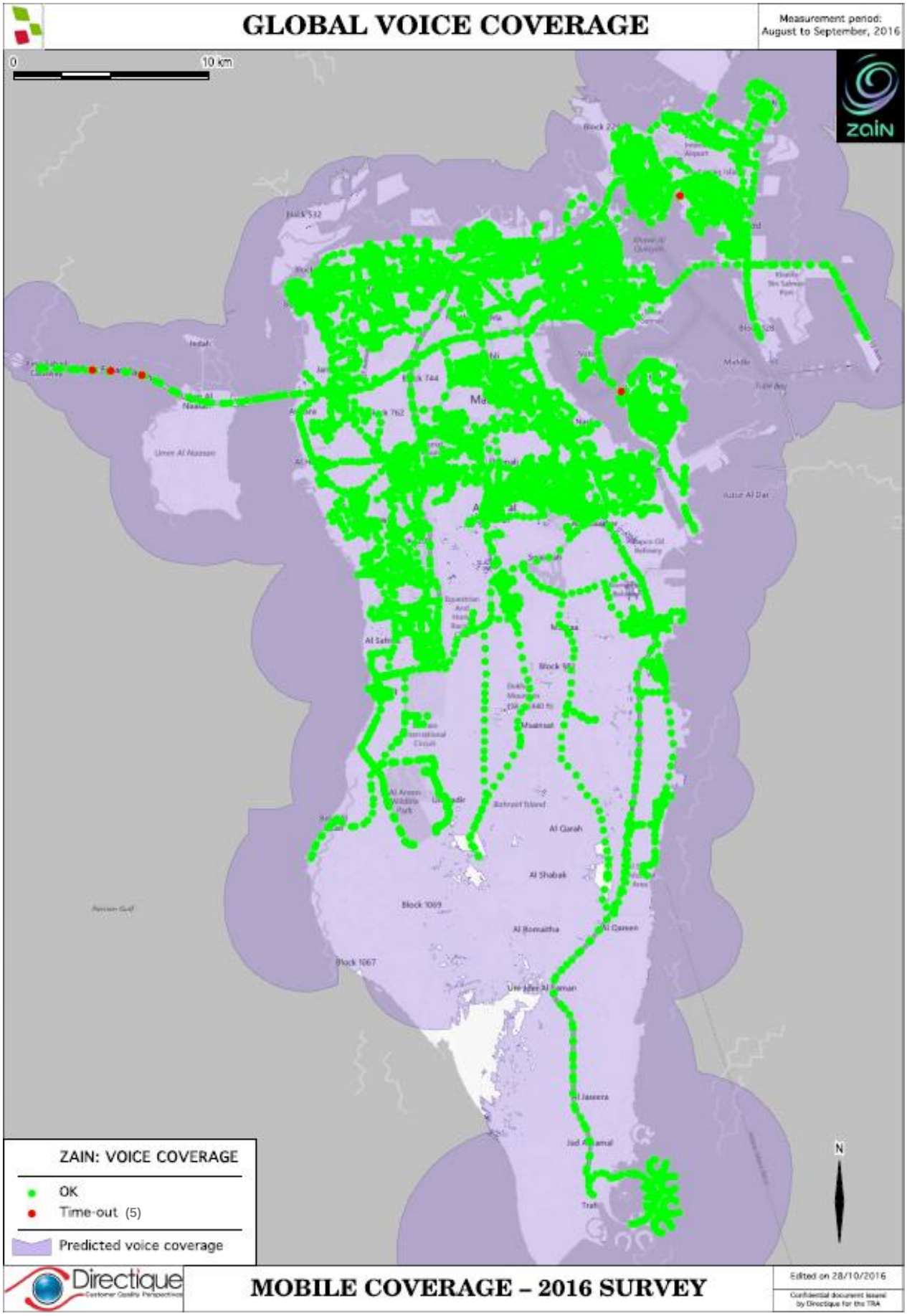
3.4.5 Viva 3G – for a LTE user



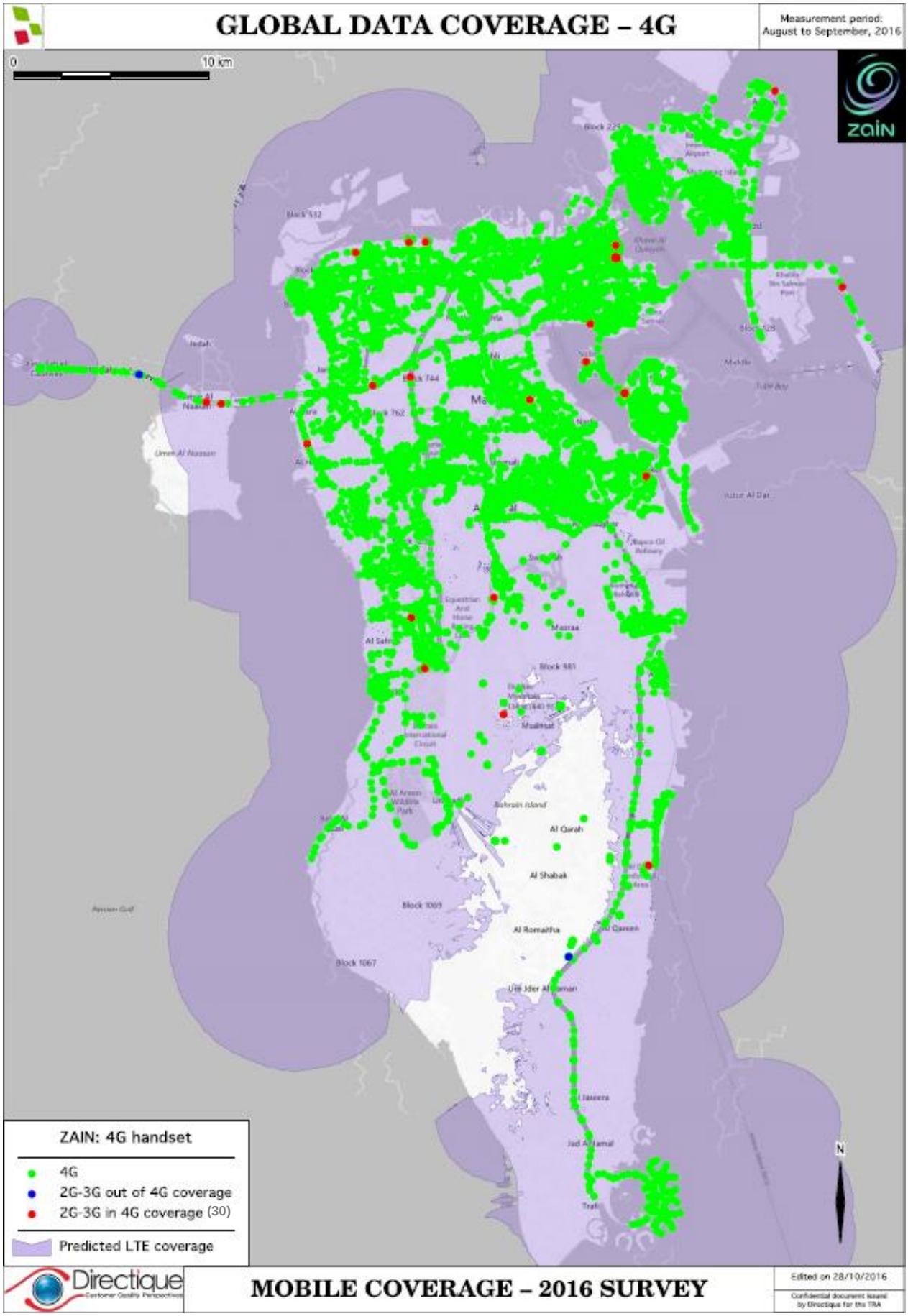
3.4.6 Viva 3G – for a 3G user



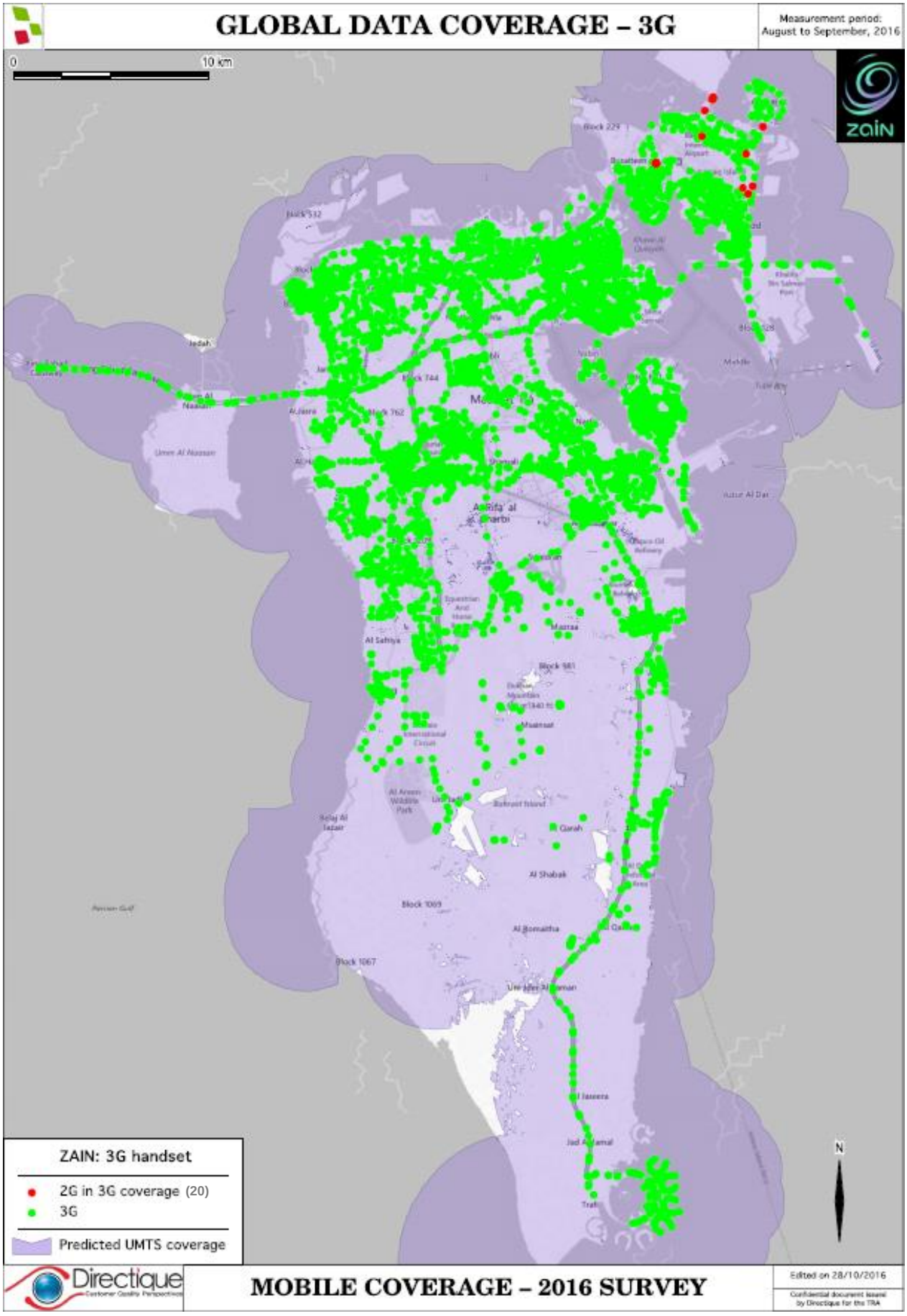
3.4.7 Zain – Voice Coverage



3.4.8 Zain 4G – for a LTE user



3.4.9 Zain 3G – for a 3G user



3.5 IDLE Coverage – signal strength distribution

All devices were in auto connect mode.

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

Batelco - Signal strength distribution (IDLE mode):

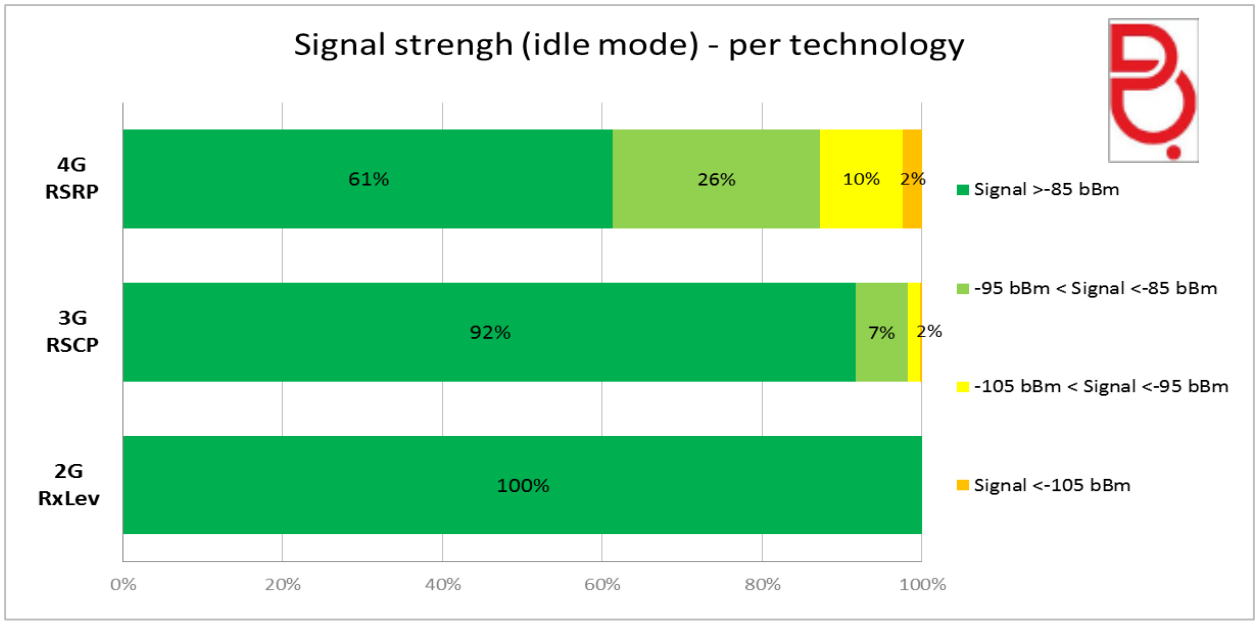
BATELCO	2G RxLev	3G RSCP	4G RSRP
Sample	2 972	24 719	143 093
Signal >-85 dBm	100%	92%	61%
-95 dBm < Signal <-85 dBm	0%	7%	26%
-105 dBm < Signal <-95 dBm	0%	2%	10%
Signal <-105 dBm	0%	0%	2%

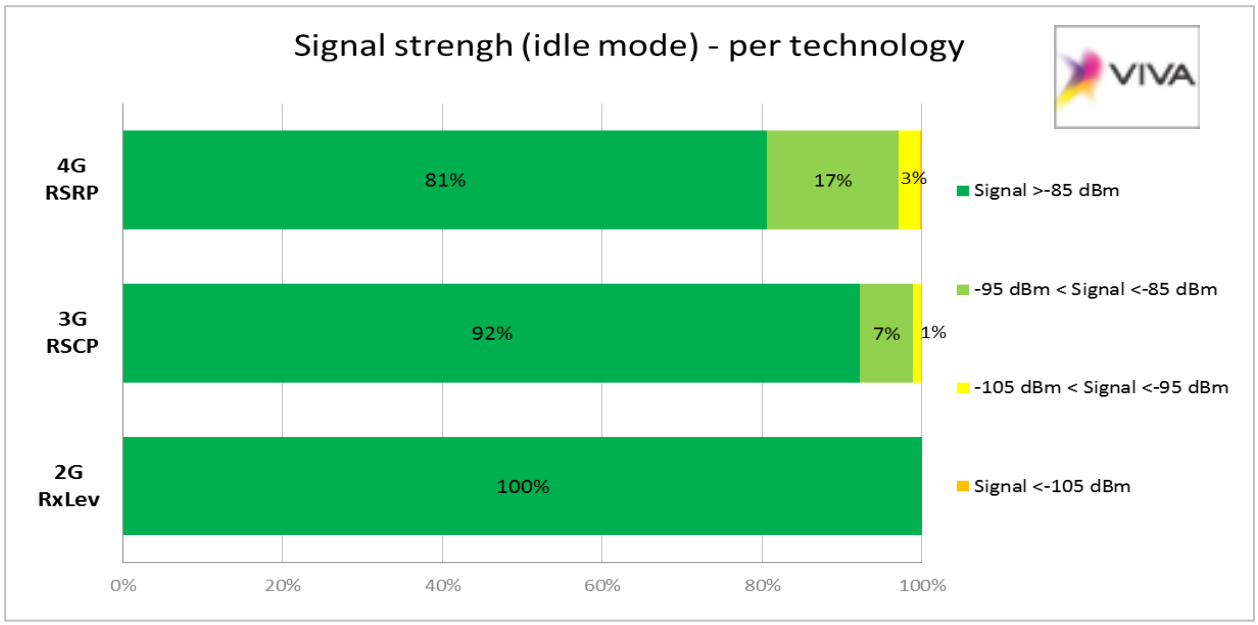
Viva - Signal strength distribution (IDLE mode):

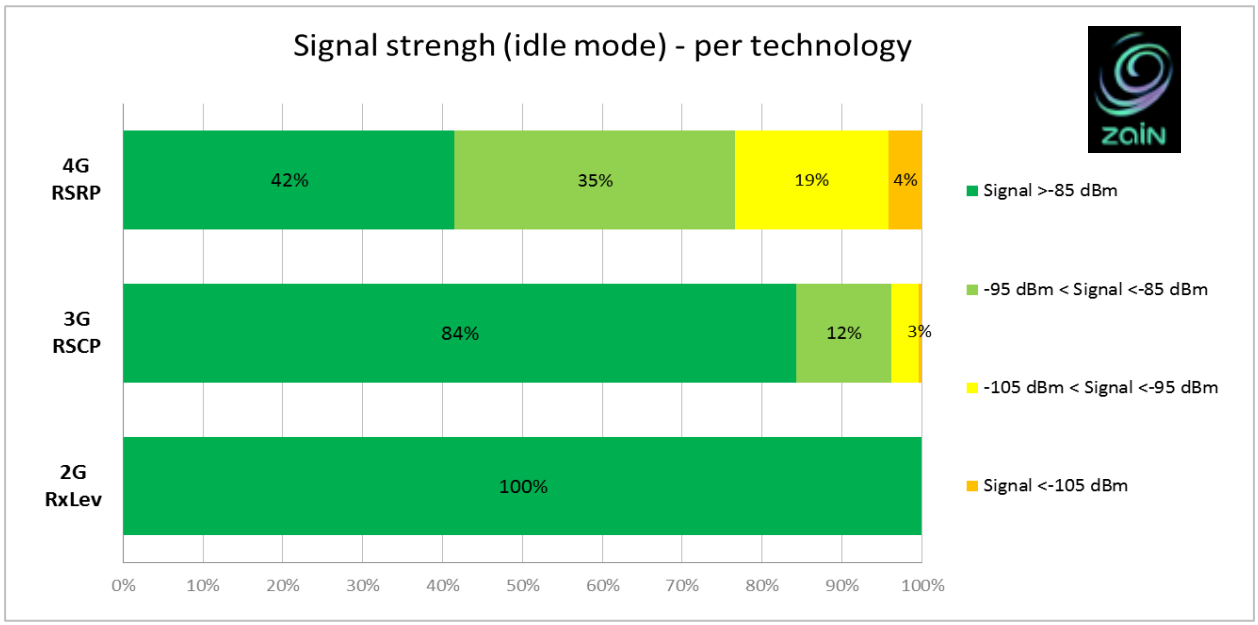
VIVA	2G RxLev	3G RSCP	4G RSRP
Sample	358	15 104	190 402
Signal >-85 dBm	100%	92%	81%
-95 dBm < Signal <-85 dbM	0%	7%	17%
-105 dBm < Signal <-95 dBm	0%	1%	3%
Signal <-105 dBm	0%	0%	0%

Zain - Signal strength distribution (IDLE mode):

ZAIN	2G RxLev	3G RSCP	4G RSRP
Sample	1 649	15 423	189 318
Signal >-85 dBm	100%	84%	42%
-95 dBm < Signal <-85 dBm	0%	12%	35%
-105 dBm < Signal <-95 dBm	0%	3%	19%
Signal <-105 dBm	0%	0%	4%


Signal strengh (idle mode) - per technology
4G RSRP
3G RSCP
2G RxLev
61%
26%
10%
2%
92%
7%
2%
100%
0%
20%
40%
60%
80%
100%
Signal >-85 bBm
-95 bBm < Signal <-85 bBm
-105 bBm < Signal <-95 bBm
Signal <-105 bBm


Signal strengh (idle mode) - per technology
VIVA
4G RSRP
3G RSCP
2G RxLev
81%
17%
3%
92%
7%
1%
100%
0%
20%
40%
60%
80%
100%
Signal >-85 dBm
-95 dBm < Signal <-85 dBm
-105 dBm < Signal <-95 dBm
Signal <-105 dBm


Signal strengh (idle mode) - per technology
zain
4G RSRP
3G RSCP
2G RxLev
42%
35%
19%
4%
84%
12%
3%
100%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Signal >-85 dBm
-95 dBm < Signal <-85 dBm
-105 dBm < Signal <-95 dBm
Signal <-105 dBm

3.6 Accessibility of public emergency call service

Principle: Launch an emergency call on 112 and 999 and check out if succeeded

Tests have been made on 50 different locations all over the kingdom.

On each network, 50% of the tests were made with an active SIM registered on the network, and 50% with an "emergency calls only" SIM.

For each attempts, the tester calling has measured:

- the delay to establish the call (delay between the launch of the call and the first tone)
- the delay of response of the emergency service (delay between the first tone and the pick-up)
- the success/failure of the call

For each SIM registered on a mobile network:

	Batelco	Viva	Zain
Sample	100 tests	100 tests	100 tests
Rate of successful emergency calls statistical accuracy	100.0% *+/-0.0%*	99.0% *+/-2.0%*	99.0% *+/-2.0%*
Average Delay to establish the call	5.7	6.4	6.8
Average Delay of response (seconds)	11.9	15.0	13.3

For a SIM not registered on a mobile network (emergency calls only):

	Out of Network
Sample	300 tests
Rate of successful emergency calls statistical accuracy	97.3% *+/-1.8%*
Average Delay to establish the call	6.5
Average Delay of response	13.4

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