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

5G NETWORKS
QOS AND COVERAGE AUDIT
KINGDOM OF BAHRAIN

In Cooperation with

Directique
Customer Quality Perspectives

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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 and STC BAHRAIN, 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.

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.

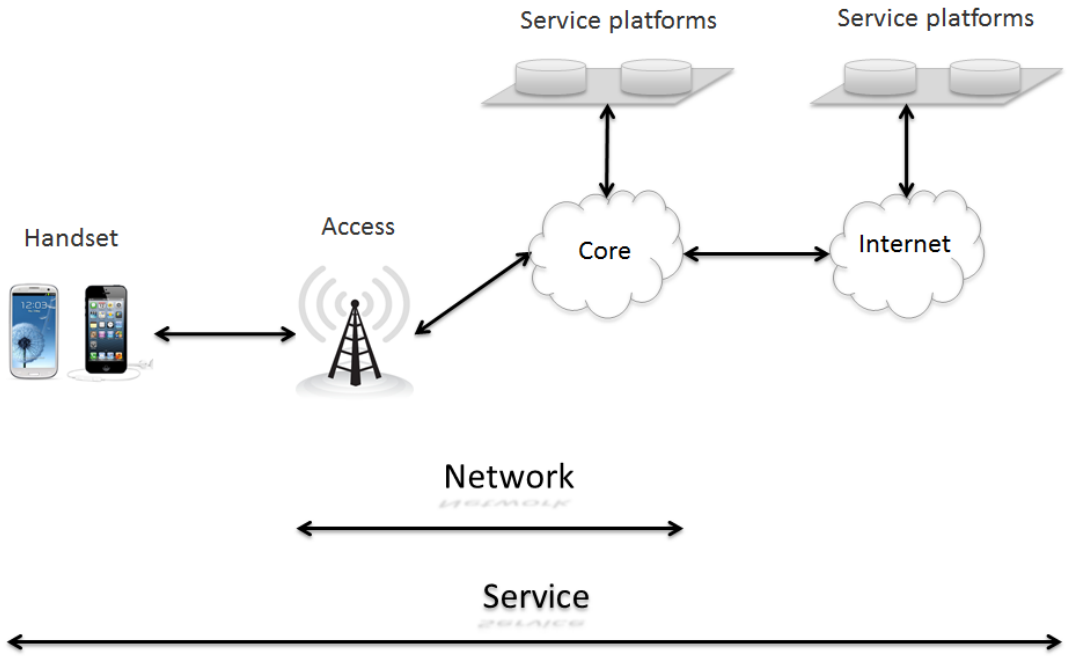


Figure 1 – End to end customer experience

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** and **STC BAHRAIN**, from an end-user perspective, for the following set of services:

- Smartphones data tests (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 performances for each operator on mobile network. Those are not to be confused with Wi-Fi hotspot.*

The objective of this audit was also to:

- Measure the 5G outdoor coverage of Batelco and STC BAHRAIN, 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 map of each Mobile Operator against the outdoor coverage observed during the audit

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 5G QoS and Coverage audit was conducted:
- from 20th to 21st November 2019, on 5G hotspots
- from 12th to 16th January 2020, on random spots
- from the 12th to the 14th January 2020 for 5G coverage

3.2. INDUSTRY RESULTS

The following tables show the average combined results achieved by the two Mobile Operators for all measurements. Detailed results for each Operator are available in section 5 of this report.

3.2.1. QUALITY OF SERVICE

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

5G measurements have been made on Batelco and STC BAHRAIN, with a specific handset (Xiaomi Mi Mix 3 5G):

- on specific locations (hotspots) provided by the operators,
- on random locations

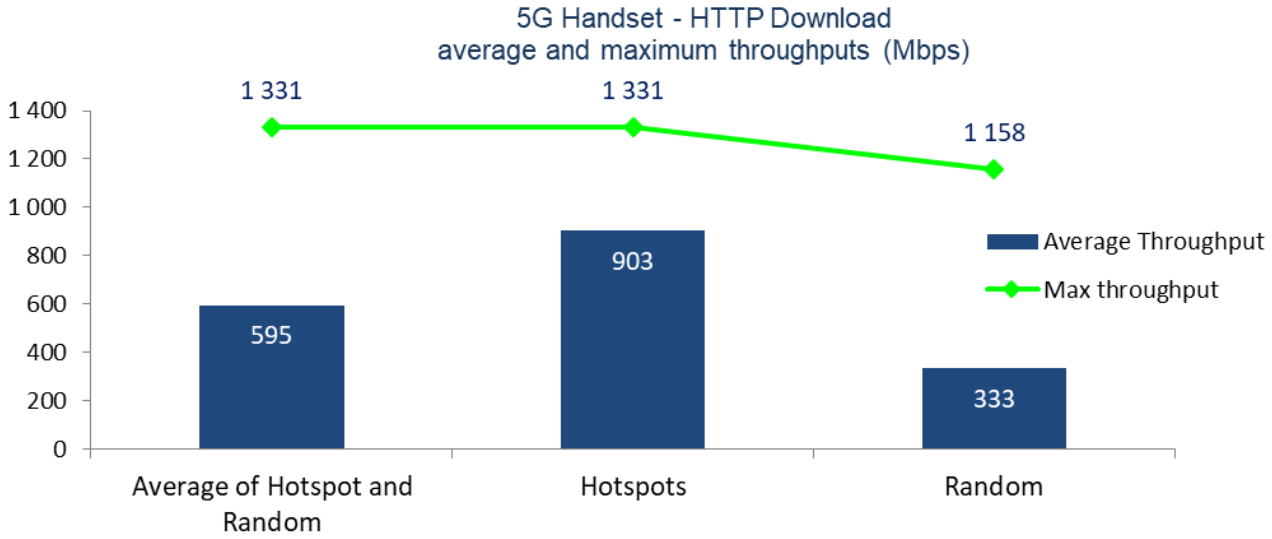
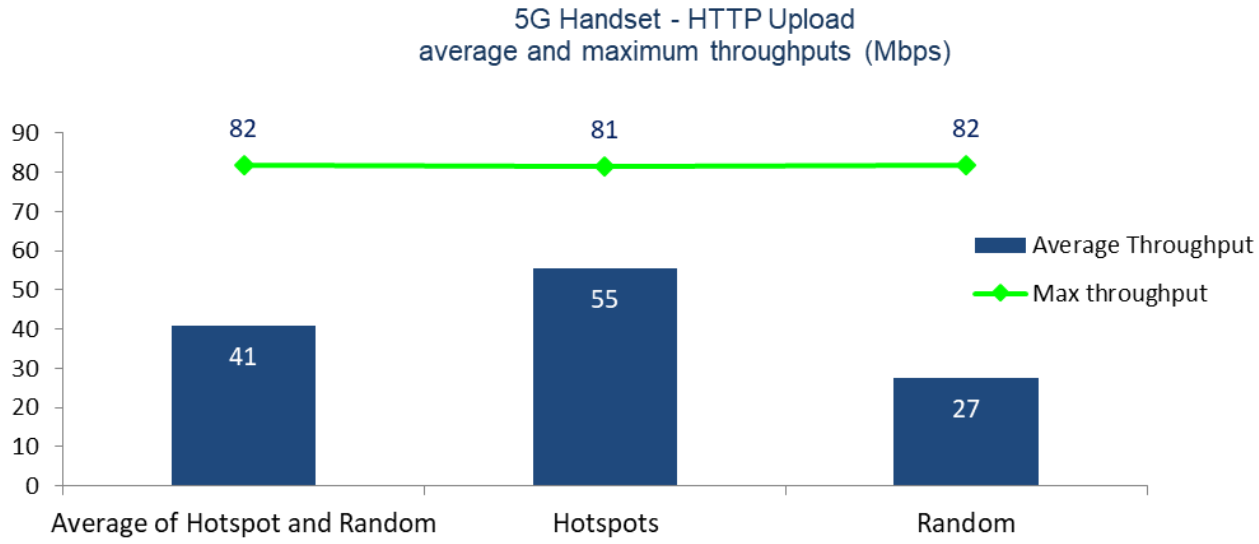


Figure 2 – 5G Handset data



service – industry results

In comparison, here are the performances measured with a 4G smartphone during the 2019 audit:

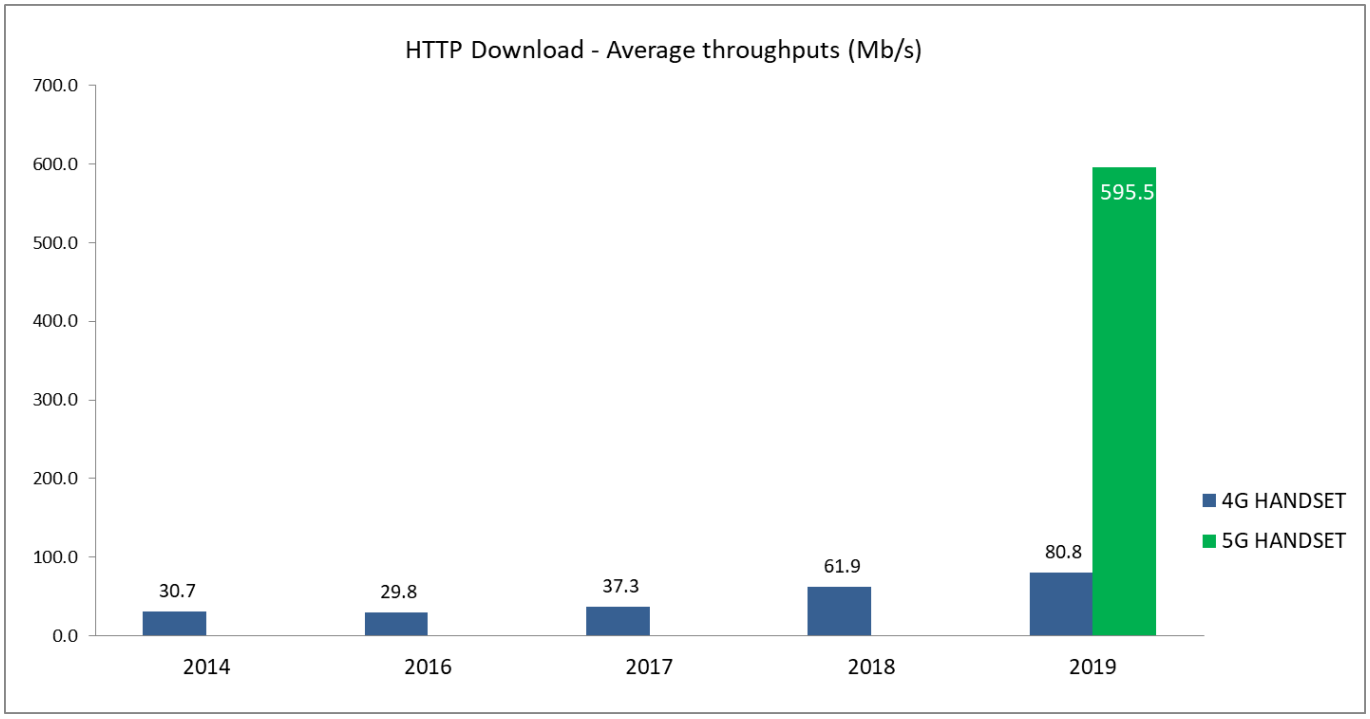


Figure 3 – 4G Handset data service – HHTP DL - industry results

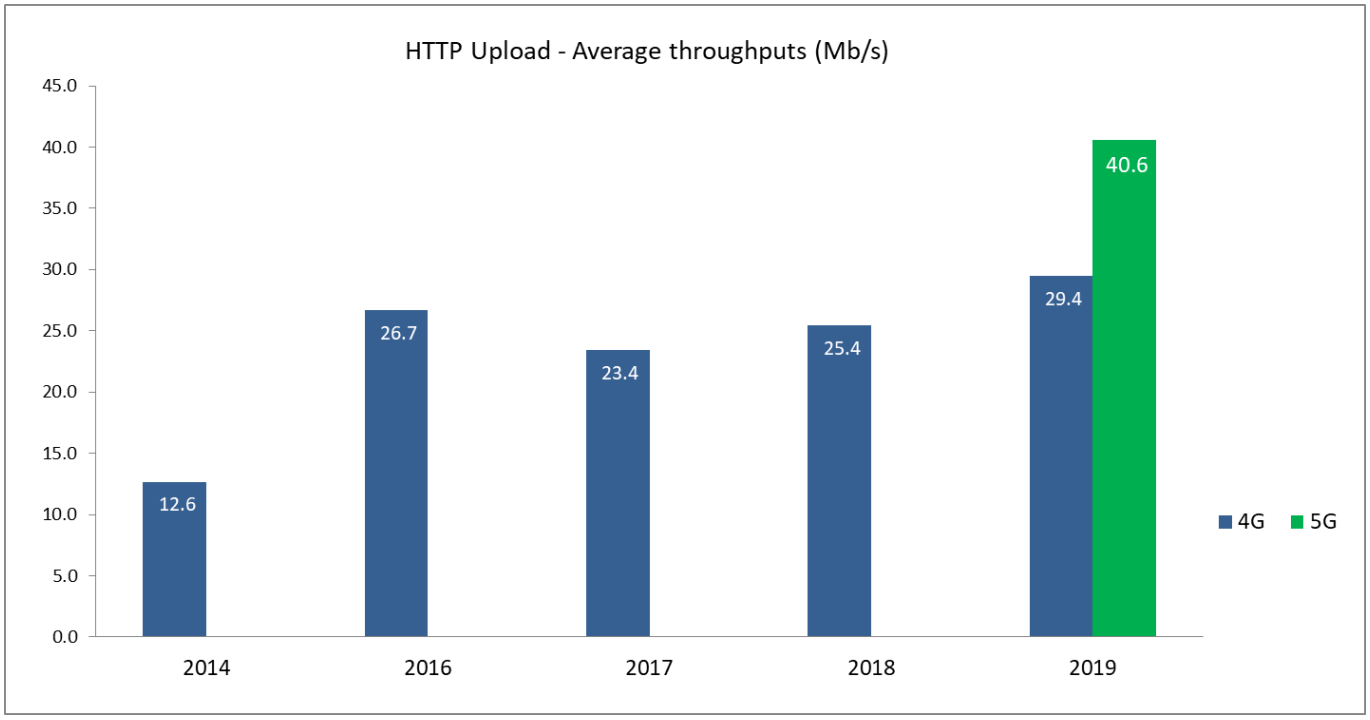


Figure 4 – 4G Handset data service – HHTP UL – industry results

3.2.2. 5G COVERAGE

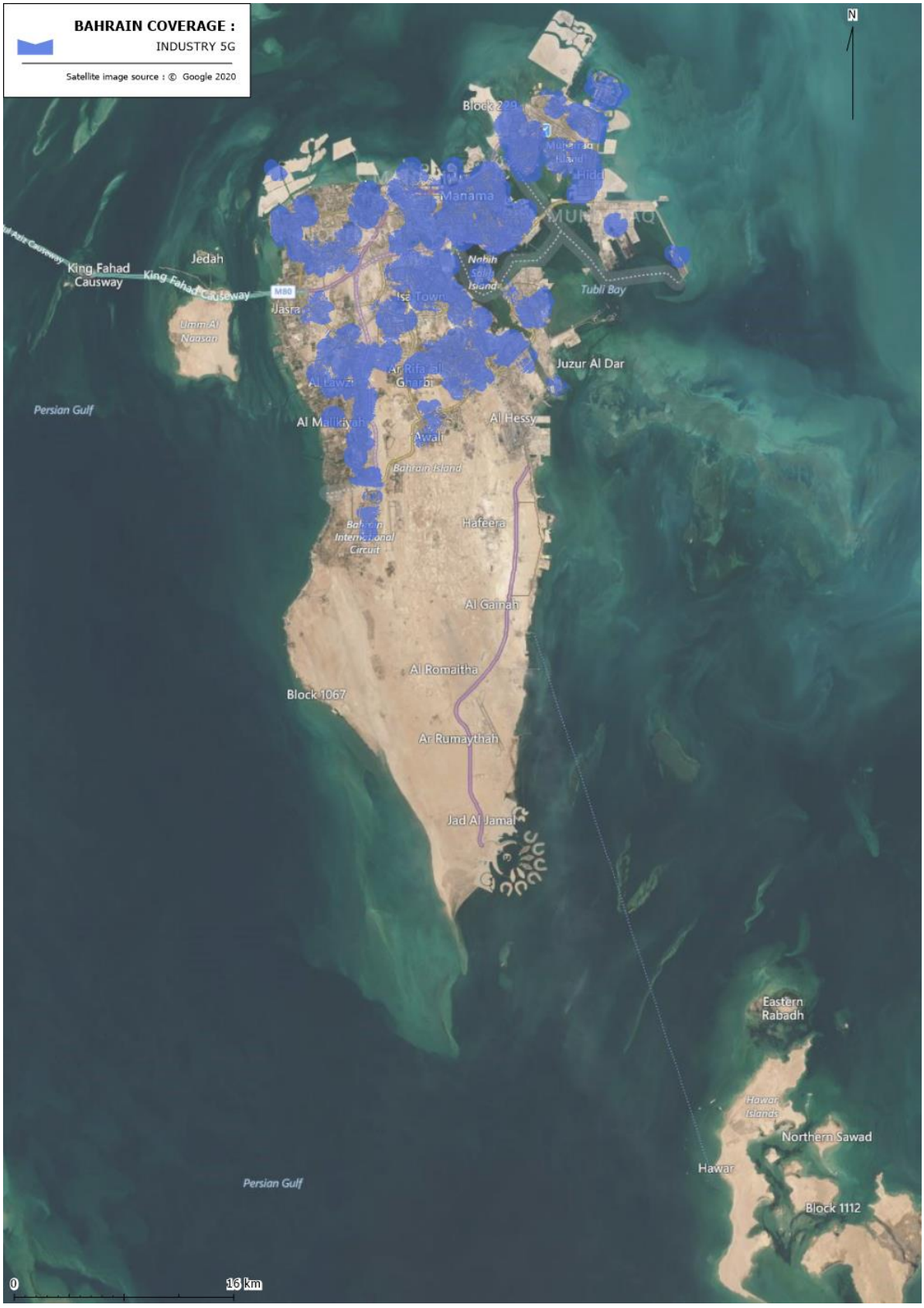


Figure 5 – 5G combined Coverage

Note: the maps provided by Mobile operators are prediction maps based on technical deployments.

4. MEASUREMENTS SPECIFICATIONS

4.1. TEAM AND EQUIPMENT

4.1.1. TEAM

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

- A dedicated project manager present in the Kingdom during audit launch phase.
- A field supervisor based in the Kingdom for the whole audit duration.
- Test team performing QoS and Coverage measurements: 2 engineers and a driver in a car

4.1.2. EQUIPMENT

2 different devices have been selected, one for each type of measurements, in agreement with Mobile Operators:

- QOS : **Xiaomi Mi Mix 3 5G**, which offers the best Data performances ("1T4R" hardware)
- Coverage : **Huawei Mate 20X**, which allows to get a basic radio trace, particularly the technology used during the transfer

For Data coverage, 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.

4.1.3. SIM CARDS

In order to have a sufficient fair use, regarding the large amount of data transfer on each network, SIM cards have been directly provided by Operators to Directique, in accordance with TRA.

5. AUDITS RESULTS

5.1. KEY PERFORMANCE INDICATORS

5.1.1. QOS – HTTP RESULTS

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

5.1.2. COVERAGE

Geographical coverage:

Rate is computed using the number of successful measurements on this technology by the total number of measurements.

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

Figure 6 – Coverage rate

Population coverage:

Both Batelco and STC BAHRAIN's coverage shapes were not covering the whole territory at the time of the audit. So, in order to calculate a population coverage rate, following method has been used:

1. **Covered territory:** for each municipality, the % of surface covered in 5G (in squared km) has been calculated.
2. This rate has then been applied to the effective geographical coverage measured inside the theoretical 5G zone to calculate the **Territory Coverage.**
3. **Global Population coverage** is then calculated by weighting these results with the population percentage living in each Governorate, using latest available Information & eGovernment Authority (iGA) census statistics for the Kingdom.

3.1. BATELCO RESULTS

3.1.1. QOS RESULTS

	Batelco
HTTP DL	107 tests
Average Throughput (Mbps)	**511 Mbps**
Max throughput (Mbps)	**1 133 Mbps**
Standard deviation throughput (Mbps)	245 Mbps
% data transfers with a throughput > 2Mbps	100%
% data transfers with a throughput > 5.1Mbps	100%

Figure 7 – 5G Handset – HTTP DL

	Batelco
HTTP UL	112 tests
Average Throughput (kbps)	**30 Mbps**
Max throughput (kbps)	**80 Mbps**
Standard deviation throughput (kbps)	14 Mbps
% data transfers with a throughput > 2Mbps	100%

Figure 8 – 5G Handset – HTTP UL

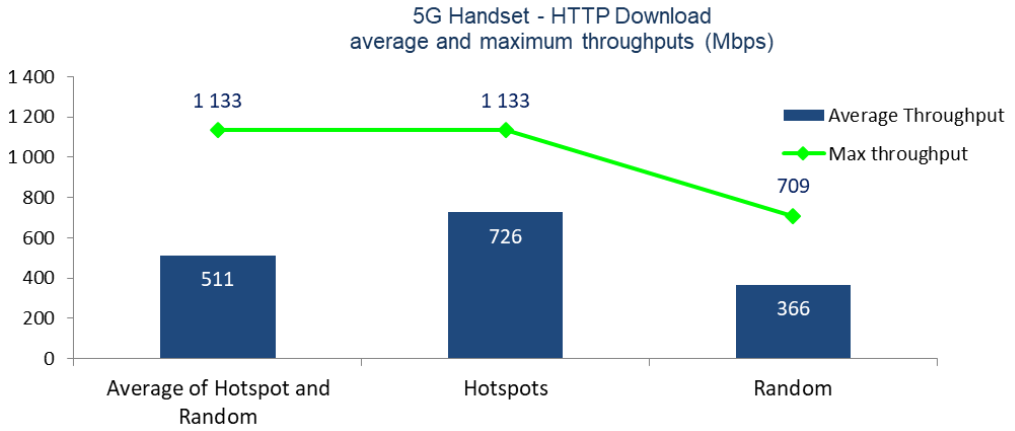


Figure 9 – 5G Handset – HTTP DL – Random vs Hotspots

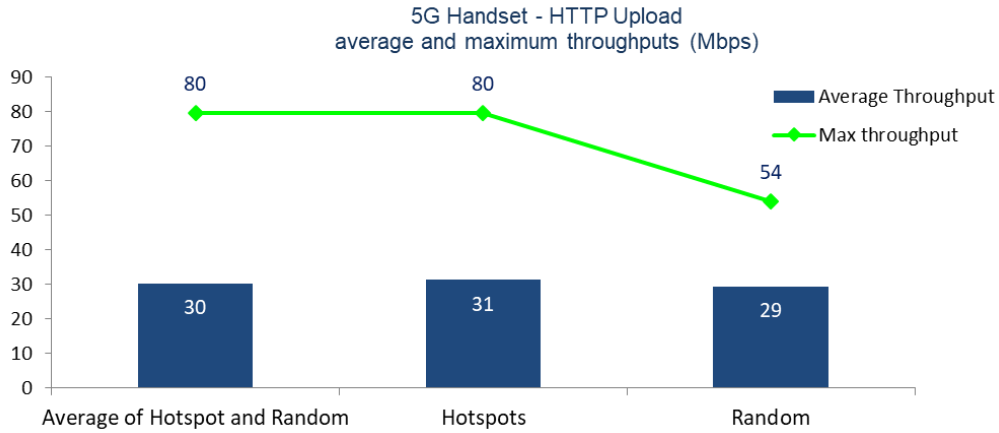


Figure 10 – 5G Handset – HTTP UL – Random vs Hotspots

3.1.2. COVERAGE RESULTS

3.1.2.1. TECHNOLOGY DISTRIBUTION

Figures here below show the exact distribution of the data coverage measurements.
First, the rate of successful HTTP test, as a location were 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.

	Batelco
Rate of successful HTTP	99.9%
On technology:	
5G	**80.6%**
4G	**19.3%**
3G+	**0.0%**

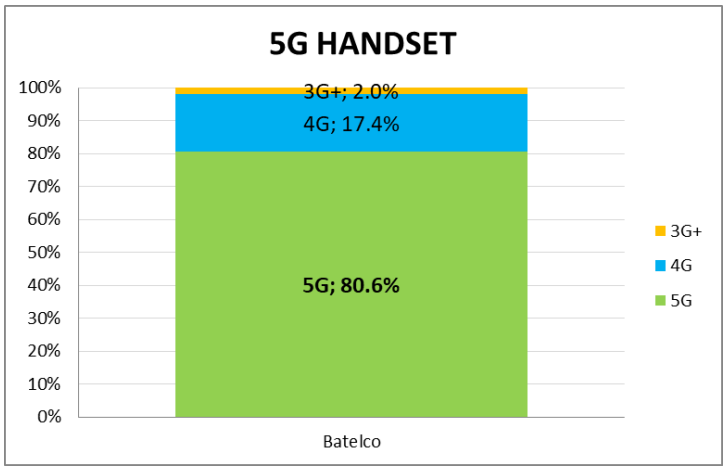


Figure 11 – 5G Handset – Batelco – Technology distribution

3.1.2.2. 5G COVERAGE MAP

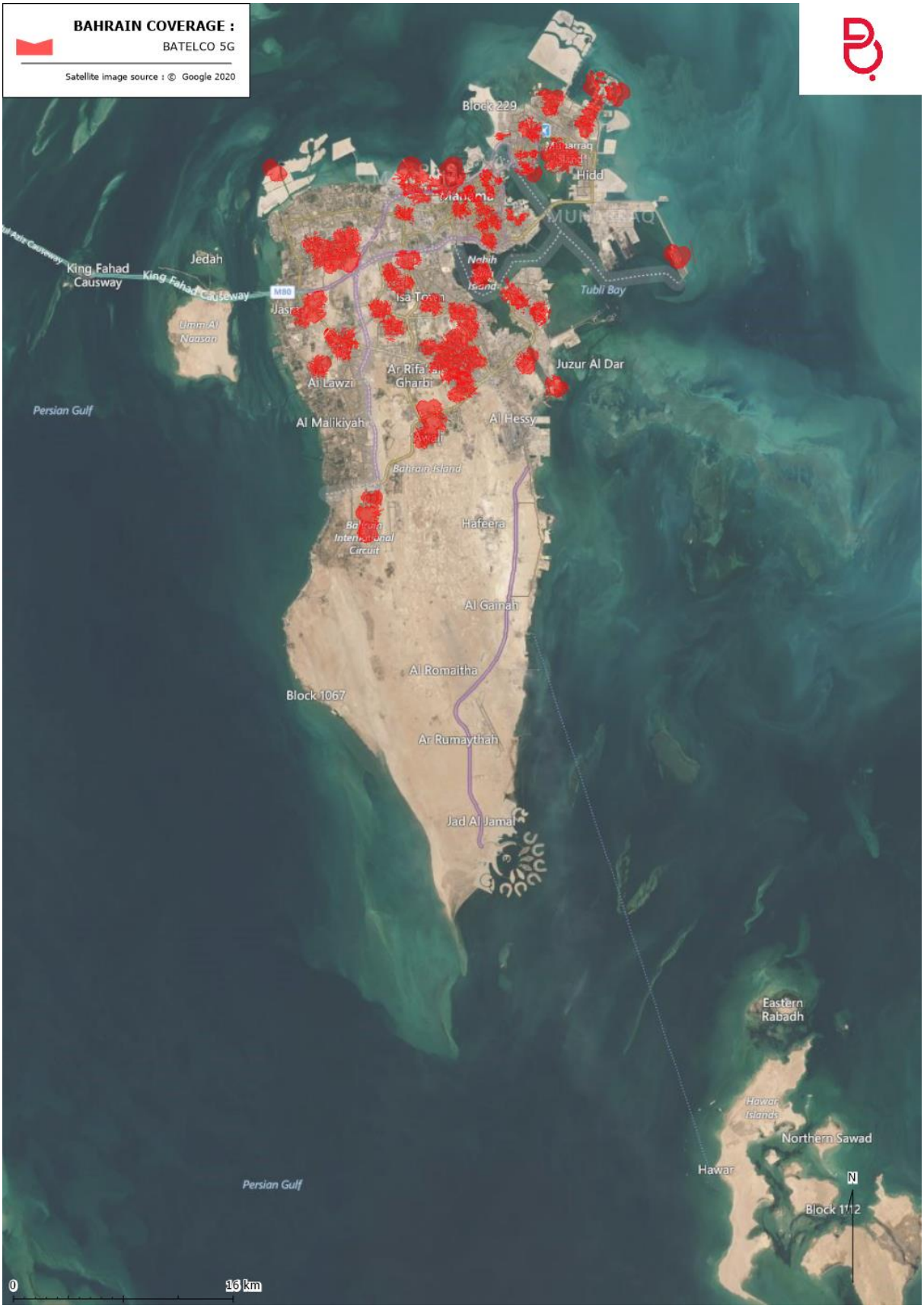


Figure 12 – 5G Handset – Batelco – Coverage heat map

Note: the maps provided by Mobile operators are prediction maps based on technical deployments.

3.2. STC BAHRAIN RESULTS

3.2.1. QOS RESULTS

	STC BAHRAIN
HTTP DL	145 tests
Average Throughput (Mbps)	**658 Mbps**
Max throughput (Mbps)	**1 331 Mbps**
Standard deviation throughput (Mbps)	407 Mbps
% data transfers with a throughput > 2Mbps	100%
% data transfers with a throughput > 5.1Mbps	100%

Figure 13 – 5G Handset – HTTP DL

	STC BAHRAIN
HTTP UL	143 tests
Average Throughput (kbps)	**49 Mbps**
Max throughput (kbps)	**82 Mbps**
Standard deviation throughput (kbps)	27 Mbps
% data transfers with a throughput > 2Mbps	98.6%

Figure 14 – 5G Handset – HTTP UL

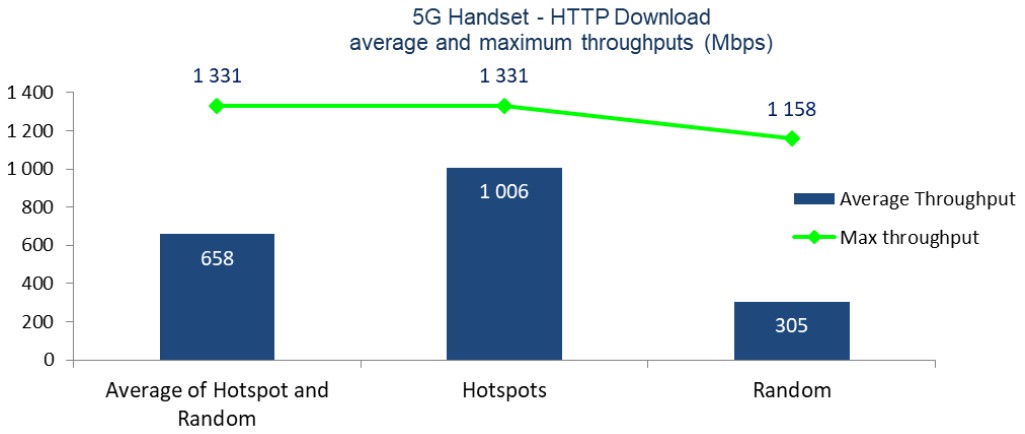


Figure 15 – 5G Handset – HTTP DL – Random vs Hotspots

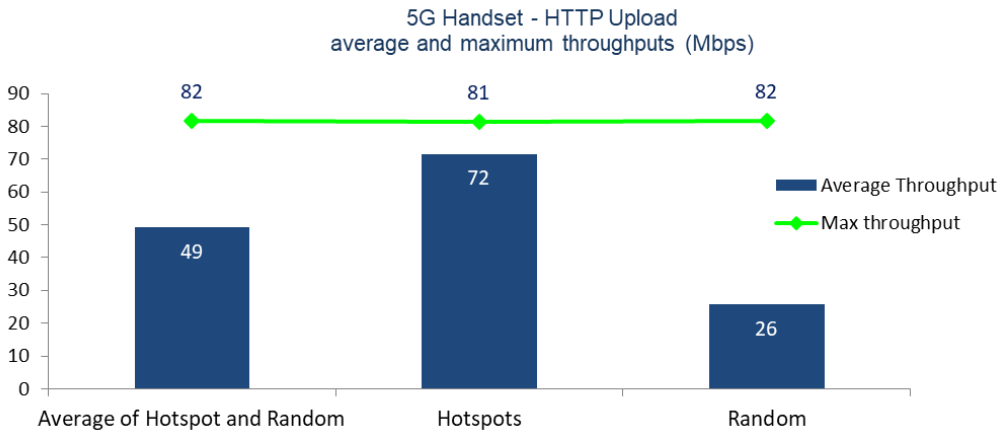


Figure 16 – 5G Handset – HTTP UL – Random vs Hotspots

3.2.2. COVERAGE RESULTS

3.2.2.1. TECHNOLOGY DISTRIBUTION

Figures here below show the exact distribution of the data coverage measurements.
First, the rate of successful HTTP test, as a location were 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.

	STC BAHRAIN
Rate of successful HTTP	99.2%
On technology:	
5G	**98.2%**
4G	**1.8%**
3G+	**0.0%**

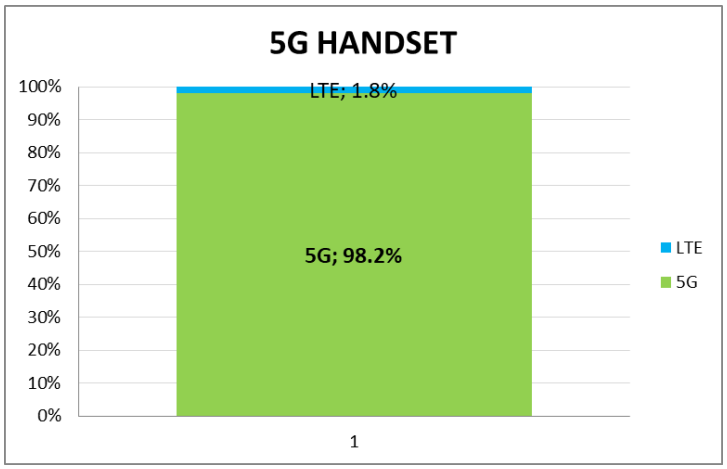


Figure 17 – 5G Handset – STC BAHRAIN – Technology distribution

3.2.2.2. 5G COVERAGE MAP

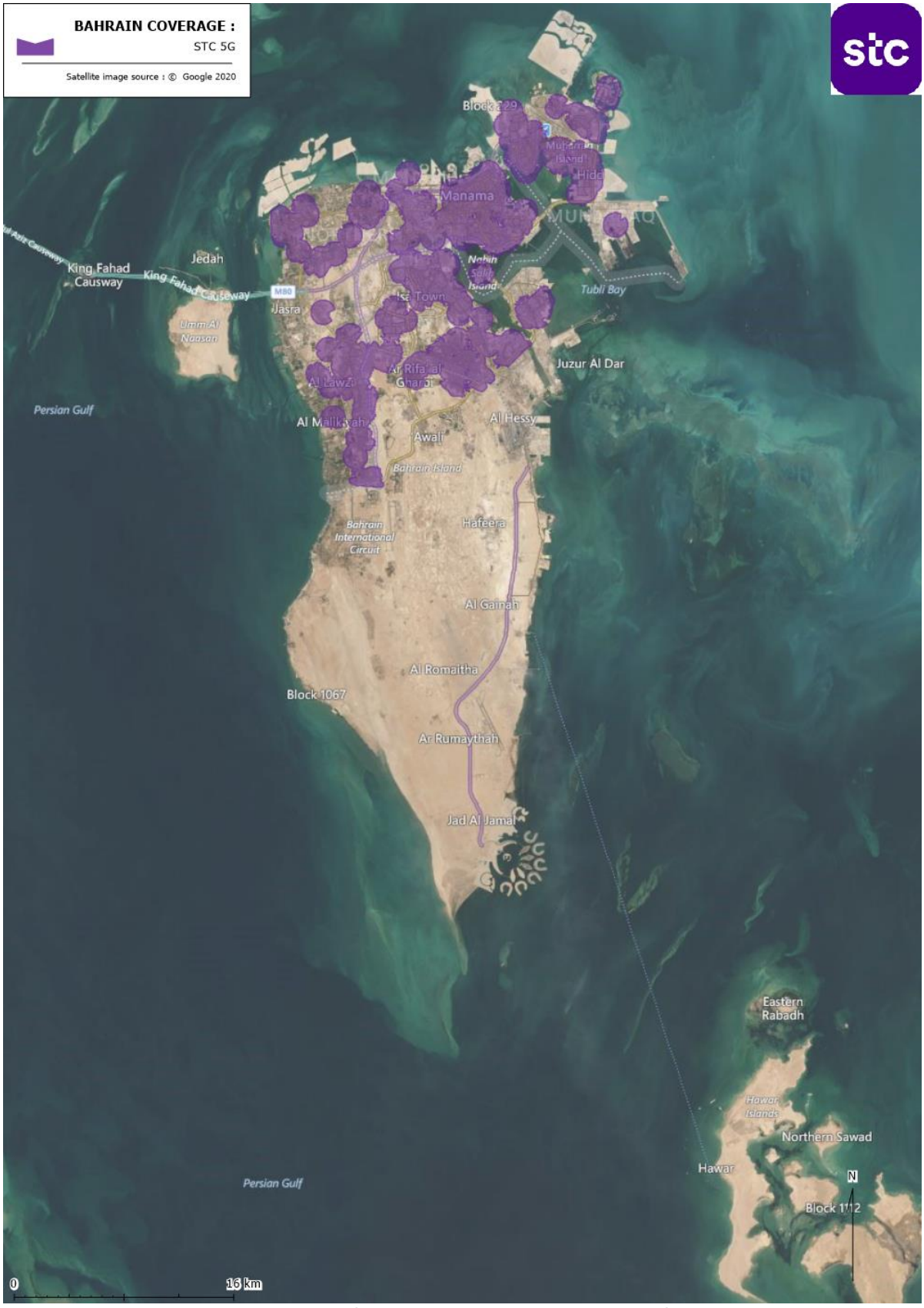


Figure 18 – 5G Handset – STC BAHRAIN – Coverage heat map

Note: the maps provided by Mobile operators are prediction maps based on technical deployments.

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