Regulating for Quality of Service in Egypt

A report for the GSMA

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Executive Summary

Quality of service is one the key metrics by which a mobile service is measured. Improving the quality of service that consumers experience is rightly important for Egyptian policymakers and regulators. This report, commissioned by the GSMA, explores how quality of service can be improved on Egyptian mobile networks to the benefit of consumers. International experience is analysed and applied to Egypt in order to assist with the development of an environment that makes excellent quality of service achievable.

A distinction can be made between the network coverage and the quality of the services that the network is able to offer. Both are important: a network needs both good coverage and good quality to offer good quality of service to consumers.

Quality of service is dependent on network inputs. These drivers are crucial for mobile operators to be able to offer good quality of service. Network coverage relies upon access to spectrum; access to base station sites; and backhaul. Network quality depends on the quality of the core network; international gateways; and the reliability of mains power. These drivers are often outside the control of the mobile operators – there is a key role for regulators in ensuring that the drivers of quality of service are available, reliable and not prohibitively costly.

International experience in regulating quality of service can be summarised:

- **Network coverage**. Regulators often impose coverage obligations in respect of voice and data services, which may be on the basis of population or geographic coverage. There has been a move by Ofcom in the UK to set a single coverage requirement that can be met by using any frequency band or technology to which the network operator has access. This has merit as any network operator will want to optimise their network deployment and the outcome might differ from that required by detailed coverage obligations for each frequency band. The intervals between checking are generally annual and involve detailed modelling or drive testing.

- **Network quality**. Measurements range from just two or three parameters (e.g. call set up success rate, call drop rate and call completion success) to including voice quality and transfer data rate for a range of data services. In general these measurements have been made using drive testing. There are also instances where the regulator has required the network operator to provide network data on dropped calls and so on. Again, publication of reports tends to mainly be on an annual basis. It is also noted that some countries, such as the UK, do not measure mobile network quality, instead relying on market forces to provide the incentive to provide good quality to consumers.

International best practice is not necessarily to impose the most stringent quality of service regulation. Onerous regulation is costly for mobile operators and distracts them from responding to the competitive forces that drive progress. Stringent quality of service regulation can also stifle innovation by restricting operators to offering previously defined services and by hindering them from experimenting with new services.

The Egyptian mobile market is competitive with three strong players providing competitive pressure to improve the quality of service that consumers' experience. The stumbling block to further quality of service improvements is not a lack of incentive on the part of the operators; rather it is primarily an inability to increase network capacity through spectrum scarcity. Other hindrances to backhaul and site access also make network build-out difficult. Given this situation, the best way for the regulator to improve quality of service and help Egyptian consumers is through ensuring operator access to the key network inputs of spectrum, sites and backhaul. Until such inputs are available quality of service will be constrained, almost regardless of the quality of service regulation put in place.

The international experience with quality of service regulation illustrates that the Egyptian mobile operators have relatively onerous regulation to adhere to. A reduction in the amount of quality of service regulation in Egypt would assist each mobile operator as it battles to increase market share through lower prices and better quality of service.

Thus the key recommendations for the NTRA are:

- **Release additional spectrum** for mobile at the earliest opportunity.
- **Allow operators flexibility** to deploy new, more spectrally efficient, technologies (refarming 2G and 3G for 4G).
- Consult with operators about how to **improve backhaul and access to new base station sites**.
- Consult with industry about **reducing the regulatory burden** of QoS regulation to the benefit of consumers.

1 Introduction

This report, commissioned by the GSMA, examines how quality of service is defined, measured, and regulated in terms of mobile networks. The report looks at international experience, and how this can be used in the Egyptian market to ensure that high quality is achieved and maintained while not constraining operators' investment decisions and business strategy. It has been created in consultation with the Egyptian mobile operators, and highlights the issues that are hindrances to better quality of service in Egypt.

This report is designed to be useful for policymakers and the regulator in Egypt, the NTRA, in pursuing excellent mobile quality of service in the country. It identifies key actions that the NTRA can take to rapidly improve quality of service, such as prioritising the release of new spectrum.

Report structure

The structure of this report is as follows:

- Section 2 explores how quality is defined in a mobile network and how it is measured.
- Section 3 lists the drivers of quality in a mobile network, such as the availability of spectrum and the ability to build base stations.
- Section 4 introduces the rationale for why quality of service might be regulated and introduces principles for effective regulation of quality of service.
- Sections 5 and 6 explore international experience in the imposition of both coverage obligations and other quality of service metrics on mobile networks.
- Section 8 analyses the current situation in Egypt and demonstrates the most effective ways in which the regulator can act to improve quality of service in mobile networks.

2 What is quality in terms of a mobile network?

Customer experience is extremely important for mobile operators as it influences their ability to attract and retain subscribers. Mobile operators will therefore regularly evaluate the performance of their networks and the quality of service they provide to their subscribers, in order to identify where improvements may be necessary to ensure customer satisfaction. In many cases operators will publish reports on the outcome of such monitoring.

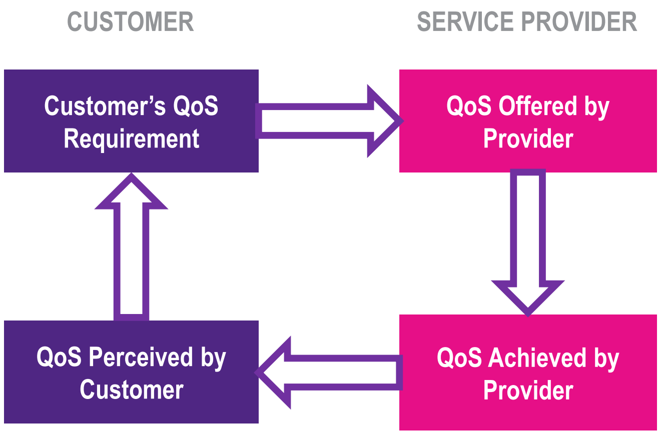
The following sections explain what is meant by quality of mobile networks and associated services. In particular, we will explore how a mobile operator's quality of service is dependent on factors outside the mobile operator's network.

The main term used throughout the world is Quality of Service (QoS), which can include both technical and non-technical aspects. QoS is described in ITU-T Recommendation E.800 as the:

> *"Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service."*

The emphasis is therefore on the end user's viewpoint, but the overall experience is based on a number of separate parts making up the network[1]. There is an interrelation between the user's QoS requirements and what the service provider offers and then what is achieved, as shown in the figure below.

Figure 2-1: Different views of QoS

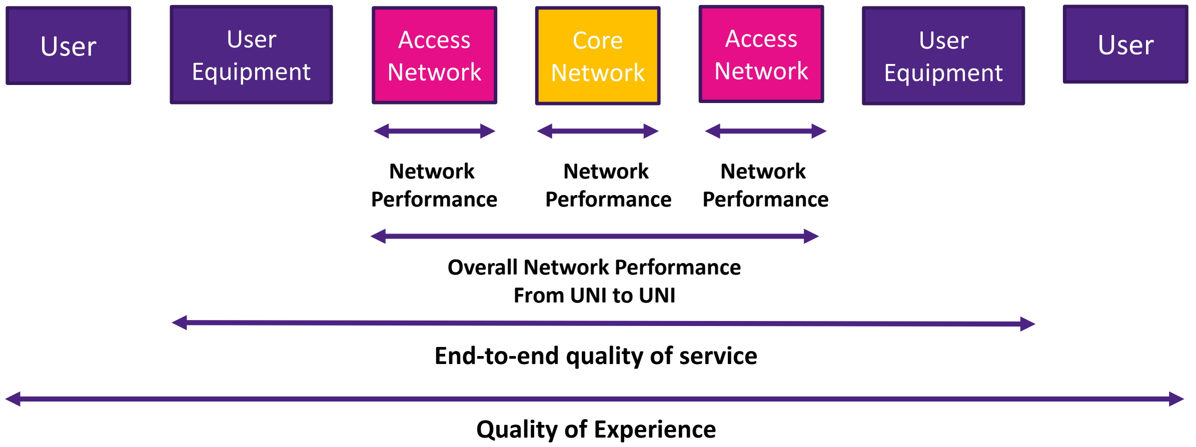


Source: ITU-T Recommendation G.100

There are a number of different and related quality measures in a telecommunications network that will have an influence on the end-to-end quality of service and also the quality of experience (QoE). These are illustrated in the figure below. The end to end QoS will only be as good as the weakest link in the chain, which may be outside the control of the mobile operator whose QoS is being measured.

[1] Each of these network parts can be analysed separately and independently. Any network or user equipment (terminal) that do not meet their individual QoS requirements can have an impact on the end to end QoS

Figure 2-2: End-to-end QoS



Source: ITU-T Recommendation E.804 based on ITU-T Recommendation E.800

It can be seen that in respect of QoS this considers all elements except for the user. The assessment of QoS is made in an objective manner and measurements are based on service requirements but not the individual network elements described below in Section 2.1.

The end to end QoS includes the user equipment which in some may have limited capabilities and for this reason any testing is normally undertaken with a range of different terminals.

2.1 Quality of network performance

The network performance will have an influence on the QoS and is normally defined in technical terms such as achieved bit error rate, capacity to support traffic (for example network availability and capacity), transmission delay etc.

The network performance requirements and assessment may refer to the sub-networks – for example in the case of a call from one mobile user to another there may be two different mobile operator access networks connected by a separate core network. The quality of the core network and the bandwidth available on the core network is vital to the end-to-end QoS. Practically, this may come down to the use of fibre on the core network. Additionally, this high quality core network has to be available at a cost that the mobile operators are willing to pay – a factor that is set by consumer willingness to pay.

Each sub-network needs to meet a set of technical criteria to meet the overall network performance between the two User Network Interfaces (UNI). Therefore if, for example, the core network provided by another operator violates the agreed Service Level Agreements (SLAs) then this could impact on the end-to-end QoS and the perception of the service provided by the mobile operator. Similarly, if there is not sufficient bandwidth available in the transmission link of the access networks this could lead to similar results.

2.2 Quality of experience

QoE includes the experience of the end user and is therefore a more subjective measurement. QoE may not just include the technology based factors but also the whole user experience over their contract period including customer care, billing and the actual terms of the contract. It is important to recognise also that there may be significant differences between the expectations of one user and another. These different expectations may be reflected in the complaints received by the regulator on the perceived quality of each of the mobile operator's networks. Metrics for QoE tend to take a different form to those for QoS, such as assessment of the voice quality of a call.

2.3 Relationships between metrics

As shown in Figure 2-2 earlier, there is a clear relationship between the different quality measures. When planning a network the mobile operator will look to optimise the end-to-end QoS by careful planning of their access network and putting in place appropriate interconnection agreements and SLA agreements with the core network providers. However, they are not in a position to guarantee the QoS provided by the recipient of any calls or the speed of data upload provided by web-sites. This may be taken into account by measurement methods (e.g. calls are checked between mobiles on the same network, HTTP down-load speeds are checked based on accessing the same web-sites).

One of the challenges facing the mobile operators is to support an increasing number of subscribers requiring access to broadband services. This requires the capacity (available bandwidth) to be increased, not only of the access network but also of the associated core network(s). In addition to increased capacity planning there is a need to extend geographic coverage as the network(s) are rolled out[2] and to meet coverage obligations contained in licences.

2.3.1 Quality of Service assessment

There are a number of ITU-T and ETSI documents that provide information on QoS assessment for a range of different technologies and services. For example, ETSI Technical Specification TS 102 250 specifically addresses the requirements for mobile networks and the associated popular services and cross refers to relevant ITU-T publications.

Another example is ITU-T Recommendation G.1010 that provides a model based on end-to-end user perception of impairments and is technology independent. It considers the key factors that best influence QoS such as delay, delay variation and information loss and as shown in the figure below defines the different user-centric QoS categories.

[2] Coverage has been a significant factor operators market to potential subscribers. Often coverage maps are provided to indicate where services are available across a country.

Figure 2-3: Model for user-centric QoS categories

Error tolerant	Conversational voice and video	Voice/video messaging	Streaming audio and video	Fax
Error intolerant	Command/control (e.g. Telnet, interactive games)	Transactions (e.g. E-commerce, WWW browsing, Email access)	Messaging, Downloads (e.g. FTP, still image)	Background (e.g. Usenet)
	Interactive (delay <<1 s)	**Responsive** (delay ~2 s)	**Timely** (delay ~10 s)	**Non-critical** (delay >>10 s)

Source: ITU-T Recommendation G.1010

The important point to remember is that any QoS assessment, to be meaningful, has to be correlated to the broader business objectives. The mobile operators themselves will select QoS indicators and undertake measurements depending on the specific aspects to be addressed. For example, the aim may be to improve the Customer Experience or to meet the Regulations or to ensure that the Service Level Agreement is being met and still relates to the traffic requirements. The equipment deployed in the networks will have inbuilt monitoring capabilities such as the ability to measure the Bit Error Rate or to monitor and record the down-time of any links in the network. There are other indicators that may require field measurements such as coverage or ASR (Answer Seizure Ratio)[3] which is a measure of customer experience.

[3] ASR is the ratio of successfully answered calls versus total outgoing calls that are made from a carrier's network. Successful calls are defined as those answered by a called party or a machine (fax / answering machine etc.)

3 What are the drivers of quality?

The QoS that is delivered by a mobile network is dependent on the way in which the network is run and the inputs which it relies upon. For example, network coverage will be restricted if the operator cannot build new sites and network reliability will be undermined if the reliability of the backhaul is poor.

A distinction can be made between the network coverage and the quality of the services that the network is able to offer. Both are important: a network needs both good coverage and good quality to offer good QoS. There are different drivers of quality for coverage and network quality, although some factors, such as spectrum, inevitably impact both. These drivers are explored below.

3.1 Network coverage

There are a number of factors that impact on an operator providing network capacity and coverage, most notably access to spectrum.

3.1.1 Access to spectrum

The frequency and bandwidth of available spectrum are key determinants of how cost-effectively a given level of service can be delivered. Access to suitable and sufficient spectrum is a key consideration when developing a network roll-out plan.

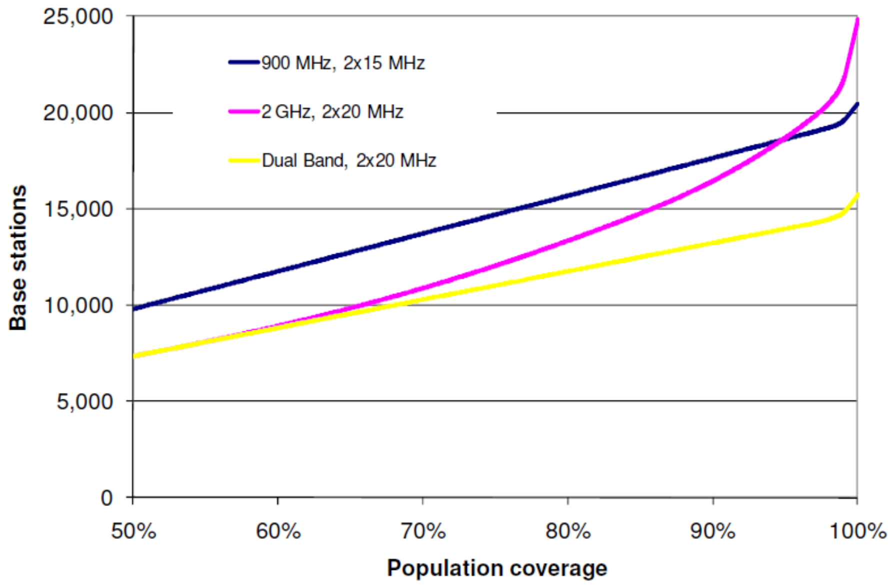
There is a range of different frequency bands that have been identified for IMT (mobile networks) and they can be split into three different categories:

- Below 1 GHz (for example, 800 and 900 MHz bands)
- Below 2.3 GHz (for example, 1800 MHz and 2 GHz bands)
- 2.3 GHz and above (for example, 2.3 and 2.6 GHz bands).

In any network there will be a need for base stations to provide coverage and base stations to provide capacity. The difference between the frequency ranges above is the attenuation of the radio signal which increases significantly with frequency and so limits the coverage that can be provided from each base station. Therefore to provide cost effective coverage there is a need for lower frequencies below 1 GHz – especially in sub-urban and rural areas. The lower frequencies also provide better in-building penetration. However, where capacity is required in a network, mainly in urban areas, the higher frequency bands provide the advantage of more intensive re-use of frequencies and also smaller base station antennas. Also the higher frequency bands typically have more spectrum available and so can support the higher bandwidths of 20 MHz required for IMT-Advanced networks.

A study undertaken by Plum Consulting staff compared the number of base stations that would be required to provide population coverage in the UK based on the deployment of 900 MHz, 2 GHz or a combination of the two frequency bands. It can be seen that extending coverage at 2 GHz to the last 5% of the population requires a significant number of additional base stations. Using a combination of the 900 MHz and 2 GHz bands means that there is the potential for a single base station that can support both frequency bands and so overall there are fewer base stations required.

Figure 3-1: Comparison of base station requirements with different frequency assignments



Source: Plum Consulting

Note: assumes average 10 kbps per user (busy hour), 100% market penetration, 30% market share. Traffic assumed to be distributed across network in line with population density

3.1.2 Access to sites

Clearly, to meet coverage and capacity requirements it is necessary to deploy base stations at geographic locations which allow the coverage to be maximised or where there is a traffic hot spot. Non-optimal site locations can have an impact on network roll-out especially if that leads to the need for additional sites which increases both the one-off costs of network implementation but also the ongoing site maintenance costs.

Also, delays in agreeing planning of new sites, constraints on base station implementations (e.g. tower and antenna heights, number of transmitters allowed, limits on transmitter powers) or development of existing sites will all impact on network roll-out and coverage that can be achieved by the operator.

It is important to recognise that if there is limited spectrum operators will need to invest in more infrastructure and so access to sites becomes even more important to ensure coverage and support capacity (traffic) requirements.

3.1.3 Backhaul

Each base station will need to be connected back into the network and therefore suitable backhaul solutions need to be available. These can include radio links (point-to-point or point-to-multipoint) and fibre connections.

In the case of radio links there needs to be suitable frequencies available and the possibility of installing the equipment and antennas at base station sites. Fibre solutions are more likely to require agreements with other parties to lease dark fibre or the installation of fibre links to interconnection points with other carriers' networks.

3.2 Network quality

The quality of the network is impacted by drivers that influence the reliability and speed of the network.

- The mobile network will be required to carry voice traffic, text messages and data traffic. The speed and reliability of the network depends on a number of factors: The **core network** is typically provided by another third party such as the fixed operator(s). The core network has to be planned to ensure that sufficient bandwidth is available. This is achieved by establishing the necessary committed bandwidth service level agreements with the providers as part of interconnect agreements[4]. In addition, it is important to minimise the occurrence of outages over these networks to meet SLAs. This will then ensure that the availability of this part of the end to end network can meet the necessary requirements.
- In some instances it may be necessary to connect to **international gateways** as, for example, the web-site may not be located within Egypt or the voice call is made to a user who is located in another country. Again the QoS will depend on the international network. If the international links do not provide sufficient bandwidth to download the data at the speeds commensurate with the service provision speeds then there will be the perception that for example web-surfing is slow or the video quality (freezing of frames) is poor. This is one of the reasons for undertaking tests using the same web-sites for all the network operators.
- There are other external factors that might impact on end to end QoS performance such as guaranteed availability of **mains power** to sites. The provision of back-up power to sites is extremely expensive and typical mobile networks will provide 24 to 48 hour back-up power, using batteries or sometimes generators, to key sites in their network but at others there may be limited or no alternative power supplies. Therefore if the power outages are significant this will impact on the overall operation of the network in those geographic areas where such occurrences are common place.

[4] Information on interconnect agreements can be found at http://www.itu.int/ITU-D/treg/Documentation/Infodev_handbook/3_Interconnection.pdf .

4 How can quality be regulated?

In principle, regulation should be used where there is market failure. Over-regulation presents a cost to doing business and may distort the market causing inefficiency. Ultimately, over-burdensome regulation on quality of service will not help mobile consumers, and it may end up doing the opposite – both by shifting mobile operator's resources to administrative data collection and by focussing operator attention on aspects of QoS which may not reflect consumer priorities. For these reasons, regulation should be approached carefully with an eye to doing the least regulation to achieve the best result for consumers.

4.1 Is there a need for regulation?

Market failure justifies regulation. Market failure is where there is an inefficient allocation of resources, in telecommunications and other sectors there may be market failure if there is insufficient competition to drive quality improvements. There may be good infrastructure policy reasons for shifting the telecommunications market from one equilibrium (with low quality of service) to another (with high quality of service).

By mandating certain QoS standards the regulator can shift the market equilibrium. However, quality is to a large extent correlated with consumer prices. Each market equilibrium with a slightly better QoS will have slightly higher consumer prices. The regulator needs to be mindful of these feedback loops before setting QoS criteria.

In relation to coverage obligations, the mobile operators may not be incentivised to cover some sparsely populated areas (as the investment in the network would not be recouped) except to provide a competitive advantage on the basis of coverage. Coverage can be regulated through coverage obligations or a universal service fund (usually funded through general taxation). Coverage obligations reduce the value of spectrum licences to mobile operators – the value paid at auction for spectrum licences will be less if there are coverage obligations.

There are already strong incentives for mobile operators to provide the QoS which consumers demand at the prices they demand. As noted earlier customer experience is one of the most important aspects for mobile operators as this influences their ability to attract and retain subscribers. Coverage has been a significant selling point for the mobile operators right from the beginning – firstly on the basis of voice services over 2G networks but more recently also on the basis of data coverage and associated data speeds, over 3G and 4G networks, with the increasing availability of smartphones.

However coverage does not necessarily directly relate to the number of successful calls made over a network or the number of dropped calls or slow download or upload of data. There is also a need for adequate capacity to be available over the networks to support the users demand. Operators are tending to publicise and compete on this basis as well.

There are also other considerations that may impact on a user's perception of their QoE such as accuracy of billing, experience of customer care (accessibility, speed of response).

The key requirement of any regulation that may be set is that it is measurable, transparent and relates to the overarching objectives of managing and licensing the spectrum.

4.1.1 Coverage obligations

In general, regulators have set coverage requirements when issuing licences, to ensure that a minimum coverage (population, geographic) is met within a set timescale. The aim of the coverage obligations is twofold – firstly to ensure the spectrum is used efficiently and secondly to meet government objectives of providing coverage to those living in less populated geographic areas where it is less likely that the installation of a mobile site will be cost effective in terms of the revenue generated.

It is interesting to note that in the case of the higher frequency bands, used to provide capacity in urban and sub-urban geographic areas, it is less likely that there will be coverage obligations. Also there are examples where the coverage obligations are not frequency or technology specific. This has the advantage of allowing the operator to determine their own optimum solution in terms of how they deploy their networks and utilise their available frequencies. It assumes that the operator will utilise all the available spectrum to provide services and not hoard it to avoid access by competitors. This would be a reasonable expectation with the ever increasing demand for wider bandwidth services and pressure on obtaining suitable spectrum.

There are also instances where the regulator may specify that services to specific geographic areas must meet a minimum capacity (normally in the downlink but sometimes in the uplink). Such requirements are often driven by the need to provide wider bandwidth services to rural areas where mobile maybe the only service available to users.

4.1.2 Other quality obligations

It is less clear whether there should be obligations to cover other quality measures, such as minimum rates for successful calls etc. There are a few examples in the benchmarking (such as Kenya and Nigeria) where there are licence conditions that relate to such parameters but in general information, if published by the regulator, is intended to inform mobile users and may be based on analysis of the operator’s network reporting data.

It is also possible for regulator’s to publish data on complaints that are received on a per operator basis and these may again provide information to users without the need for any specific measurement campaigns. Of course the down-side is that quality problems may not be directly related to the mobile operator – see Section 3.

In many instances the quality measurements are published with a warning making it clear that they only reflect the outcome at a specific point in time. As operators are continuously modifying and rolling out their networks to reflect traffic demand by adding or even re-positioning base stations then if the measurements were repeated there might be a different outcome.

4.2 Effective regulation

Effective QoS regulation focusses on the aspects of quality within the control of those being regulated. Quality in a mobile network, as discussed in Section 3, is heavily based on access to spectrum and other factors. Regulation which does not take into account the drivers of quality and which focusses solely on setting targets will likely be ineffective at improving QoS.

5 International experience in coverage obligations

The following sections consider the different QoS measurements and methods that are undertaken by regulators for countries at a variety of different stages of development and with a variety of topographies.

In many countries there are coverage requirements or obligations that are included in the conditions of providing a mobile service or of obtaining a radio spectrum licence. These obligations tend to vary from country to country and may be defined in terms of, for example:

- Population coverage
- Geographic coverage including specifically identified areas where coverage must be provided
- Indoor and outdoor coverage
- Signal strength levels necessary to provide a certain level of coverage
- Technology
- Minimum data rates.

These obligations may be set to support specific national policy objectives such as minimum broadband speeds to users or to promote rural coverage. There have also been recent examples, such as in the UK where licence renewal of some frequency bands has required the mobile operators to increase their coverage sometimes with the allowance to meet the requirements using any frequencies and technologies available to the Licensee.

5.1 Europe

In Europe the ECC[5] recently published a report on mobile coverage obligations[6] which identifies the different coverage obligations, types of criteria used to assess compliance and associated methods of measurement used across the CEPT countries[7].

Coverage obligations

It was noted from the responses to the Questionnaires, which were analysed to inform the report, that there were 2 main types of coverage obligations:

- Population coverage: where the operator needs to cover a percentage of the population.
- Area coverage: where the operator needs to cover a percentage of the territory.

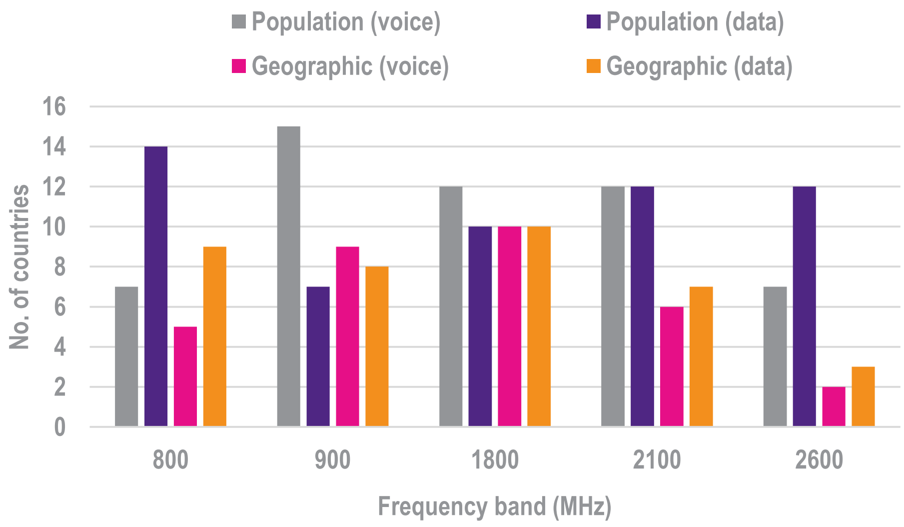
The figure below summarises the different coverage obligations by number of countries for each frequency band. It is important to note that some administrations do not have coverage obligations directed to a specific frequency band or technology. 29 administrations responded to the Questionnaire including a number of non-EU countries that had a significant interest in the topic.

[5] ECC is the Electronic Communications Committee

[6] See ECC Report 231, approved in March 2015 at http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP231.PDF

[7] 29 countries (administrations) answered from the total number of 48 within the CEPT (European Conference of Postal and Telecommunications Administrations)

Figure 5-1: Comparison of number of CEPT administrations that have indicated coverage obligations for voice / data and demographic / geographic



Source: ECC

The coverage targets specified could increase over time or be a single target for a specified year.

Also, in some instances the coverage obligations may vary between licensees due to auction rules or restrictions on roll-out due to coordination agreements with neighbouring countries or the refarming of existing users from the band.

Finland is cited in the report as an example of the above where one mobile operator has a higher obligation than the other two (i.e. cover 99% of Finland's population within 5 years compared with 97% of the population).

There are also examples of specific coverage obligations such as:

- In Portugal the obligation is specified as coverage of specific geographic locations.
- In France to maximise the geographic coverage the obligations are related to those areas with low population density.
- In Sweden one licence in the 800 MHz band had to provide data communications coverage to certain permanent homes and businesses where there was no existing mobile service.

Criteria

The criteria set to assess whether the obligations are met also varies depending on the service and administration. The table below provides a summary of the voice coverage criteria:

Table 5-1: Criteria specified for voice coverage

Type of criteria	Range (if relevant)	Possible additional prerequisites	Counts[8]
"It must be possible to make a voice call"	-	Phone call of 1 minute duration using a regular terminal	3
Field strength	38 to 58 dBµV/m	1.5 – 1.7 m above ground 50 – 75% probability at cell edge	11
Signal strength	-106 to -75 dBm	1.7 – 3m above ground 30% cell load (@2.1 GHz)	17
Bitrate	12.2 – 144 kbit/s	Outdoor	3
No requirement	-	-	20[9]
No criteria defined	-	-	21[10]

Source: ECC Report 231

In the case of data coverage the main criteria were for broadband data where the down-link requirements were specified.

Supervision and measurements

In the report it is noted that there were 3 main methods adopted by administrations to ensure compliance with coverage and these are:

- Mobile operators provide regular reports on their network coverage (e.g. annually).
- The administration undertakes theoretical calculations to assess the network coverage either on a population or geographic basis. This requires the administration to have full details of the base stations and also a suitable modelling tool to undertake the necessary calculations. In some countries these theoretical studies may be verified by spot or field measurements.
- The administration undertakes field measurements at specific locations and times to verify, for example, base station locations, parameters and field strength and quality of service at some end users locations. This can be as extensive as considered necessary by the administration.

ECC Report 231 also mentions a further possible option referred to as "ground sourcing" that may prove useful in the future with the increase in smartphones. In this instance, for example, a smartphone application may be used to log signal strength and co-ordinates for further analysis[11].

[8] Total of frequency and band administrations combinations

[9] 9 administrations did not specify voice coverage obligations in any of the bands (800, 900, 1800, 2100 and 2600 MHz)

[10] 10 administrations had one or more licensees with coverage obligations but no criteria were defined

[11] See one example at http://opensignal.com/

Conclusions of Report

The report concluded that on the basis of the analysis of the responses received from the different administrations there were many different approaches chosen to define coverage obligations and that it was difficult to establish a harmonised approach mainly due to the different policy reasons for setting the obligations.

It also noted the difficulty of “establishing a comprehensive and precise measure to verify coverage obligations” and gaining agreement of such with the mobile operators. This could lead to difficulties to enforcing the coverage obligations.

5.2 Bahrain

It is noted on the TRA’s web-site that one of their duties set out in the Telecommunications Law is to protect the interests of subscribers and consumers in respect of quality of service. They accordingly monitor key performance indicators of mobile, WiMAX and fixed broadband networks and also internet.

TRA Bahrain included coverage obligations of at least 99% of the population, independent of technology, before the 19 June 2014 in the modified Individual Mobile Telecommunications Licences[12]. The TRA has published Coverage Audit Reports in 2010 and 2014[13]. The 2014 report provides information on the results of an independent audit that was based on defined test routes in the Kingdom and used smartphones to assess whether a call was successful and so there was coverage. The coverage achieved was then assessed against the population in the areas measured and also the coverage maps for each Mobile Operator.

5.3 Qatar

In Qatar, in 2013, an independent audit was undertaken to evaluate and benchmark the QoS offered by the mobile operators[14]. The aim was to verify coverage obligations and benchmark the quality levels of the services and networks.

Coverage obligations

The two mobile network operators, Ooredoo and Vodafone**,** are required to provide 100% geographic coverage[15] with their 2G networks and just Vodafone is required to provide 3G and 3.5G services to 90% of Qatar’s population. The coverage is considered to be met, for voice calls, if the minimum signal strength is -85 dBm at ≥95% of the locations within any outdoor area of 100m × 100m at a height of 1.5 metres above ground level[16].

[12] The IMTL licences were updated on 19 September 2013

[13] See http://www.tra.org.bh/en/media/quality-of-service/

[14] See http://www.cra.gov.qa/sites/default/files/documents/Mobile%20Services%20Network%20Audit%20Report%20-2013.pdf

[15] This relates to the primary physical landmass of the State of Qatari and does not include territorial waters or offshore islands.

[16] This requirement is specified in Annex G of the licences

Measurements

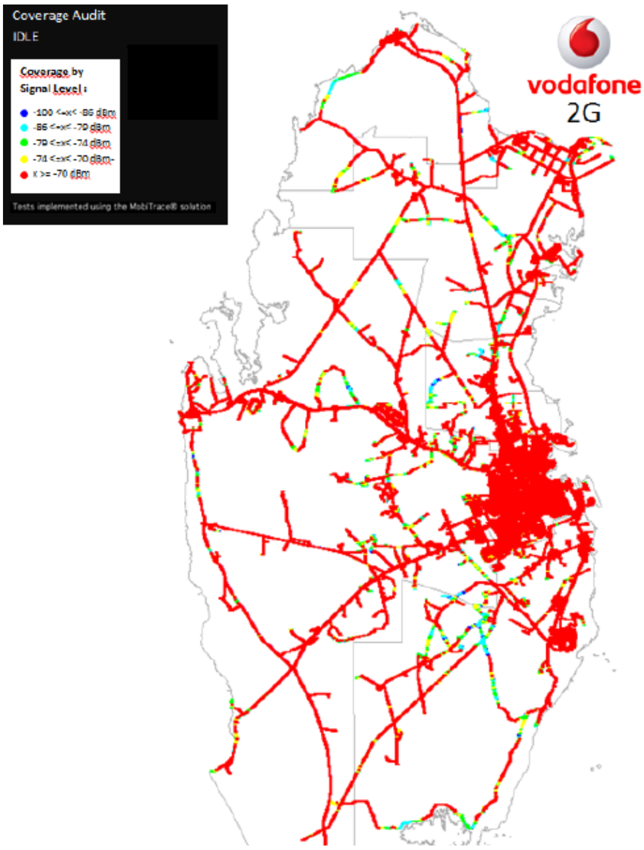
The outdoor coverage of the mobile operators was assessed by drive testing carried out over a period of three months across the entire State of Qatar. Between November 2013 and February 2014 measurements were made using mobile equipment set for 2G only, 3G only and 4G only.

The test were undertaken using standard mobile phones that placed calls following an automatic test script. IDLE Measurements of the signal strength in 2G (RxLev), 3G (RSCP) and 4G (RSRP) were recorded every second and for each 100m × 100m area[17] the rate of locations where the signal strength is greater than -85 dBm is calculated. Provided this value is over 95% it was considered that the coverage obligations had been met at that location.

Results

The results were used to develop idle coverage maps and these were compared with the operator's own coverage maps. The map below is an example and shows the coverage of the Vodafone 2G network:

Figure 5-2: 2G Vodafone coverage from measurement audit

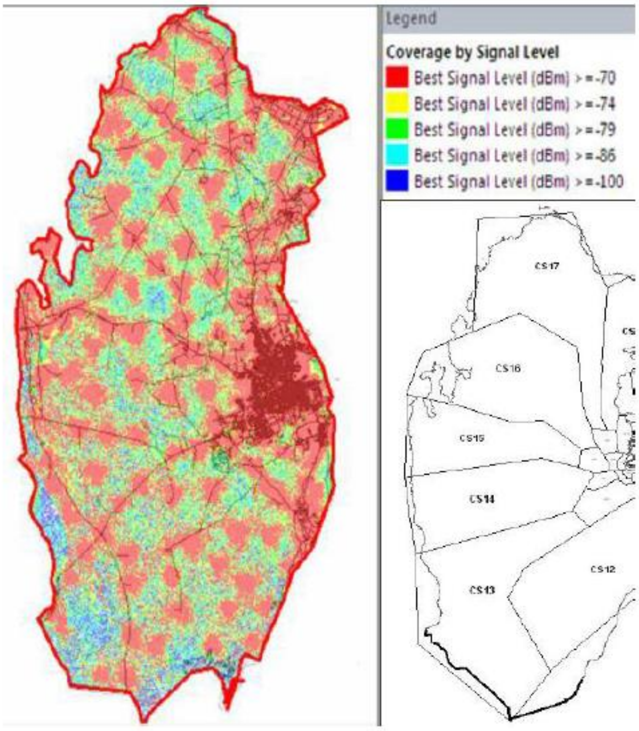


Source: CRA

[17] The State of Qatar was divided into 100m*100m areas.

In comparison the coverage map provided by Vodafone is shown below:

Figure 5-3: 2G coverage map provided by Vodafone



Source: CRA

5.4 Singapore

The IDA of Singapore published quarterly QoS reports for the three operators in Singapore[18]. The small size of the country means that it places stringent 3G coverage obligations on the operators.

Coverage obligations

There are five key performance indicators (KPIs) that the IDA measures of which three are related to the 3G coverage obligations that the operators face. There are no longer quality reports provided for 2G coverage as these were stopped in 2011.

[18] http://www.ida.gov.sg/Policies-and-Regulations/Industry-and-Licensees/Standards-and-Quality-of-Service/3G-Services/Quality-of-Service-Performance-Results-for-October-December-2014

Table 5-2: Coverage obligations in Singapore

KPI	Definition	Target
Outdoor 3G coverage	Minimum signal strength of at least -100 dBm	>99%
In-building 3G coverage	Minimum signal strength of at least -100 dBm	>85% per building
Tunnel 3G coverage	Minimum signal strength of at least -100 dBm	>95% (in tunnels built before 2012) >99% (in tunnels built from 2012)

Source: IDA

Measurements

The IDA has used mobile handsets to collect the signal strength readings since Q2 2013 so the results can be compared over time.

For the outdoor coverage the IDA uses drive testing in areas such as housing estates and town centres, and also makes measurements at outdoor recreational areas and along the above ground MRT (railway) system.

In-building coverage is measured by the IDA at 60 randomly selected buildings (the same ones for each operator). Publically accessible areas within each building are used for the testing.

Results

The quarterly reports give data by month. The results in Table 5-3 relate to December 2014 only.

Table 5-3: KPI results in Singapore (December 2014)

Operator	M1	SingTel	Starhub
Outdoor 3G coverage (%)	99.36	99.27	99.61
In-building 3G coverage (no of buildings meeting 85% coverage)	58 out of 60	60 out of 60	60 out of 60
Tunnel 3G coverage (% tunnels meeting standard)	100	100	100

Source: IDA

Buildings in which an operator fails to have at least 85% coverage are tested again after six months, at which point the coverage must be above 85%.

5.5 UAE

The UAE Telecommunications Authority (TRA) undertakes measurements of the service coverage based on a required signal strength of -100 dBm for both 2G and 3G networks. Further information is provided in section 6.6 which discusses measurements of KPIs.

5.6 UK

In the UK mobile licences have generally included obligations to roll-out services to a defined percentage of the UK population. Ofcom has undertaken a number of studies not only to inform whether these obligations are being met but also to investigate specific coverage concerns from consumers in respect of not-spots (geographic locations where there is no mobile service) and to provide information on or confirm the coverage claimed by the individual mobile operators.

The approach adopted by Ofcom has varied – in some instances calculations have been used based on base station deployments to evaluate the coverage achieved by a mobile operator and in others measurement campaigns have been undertaken. Some examples of each are provided below:

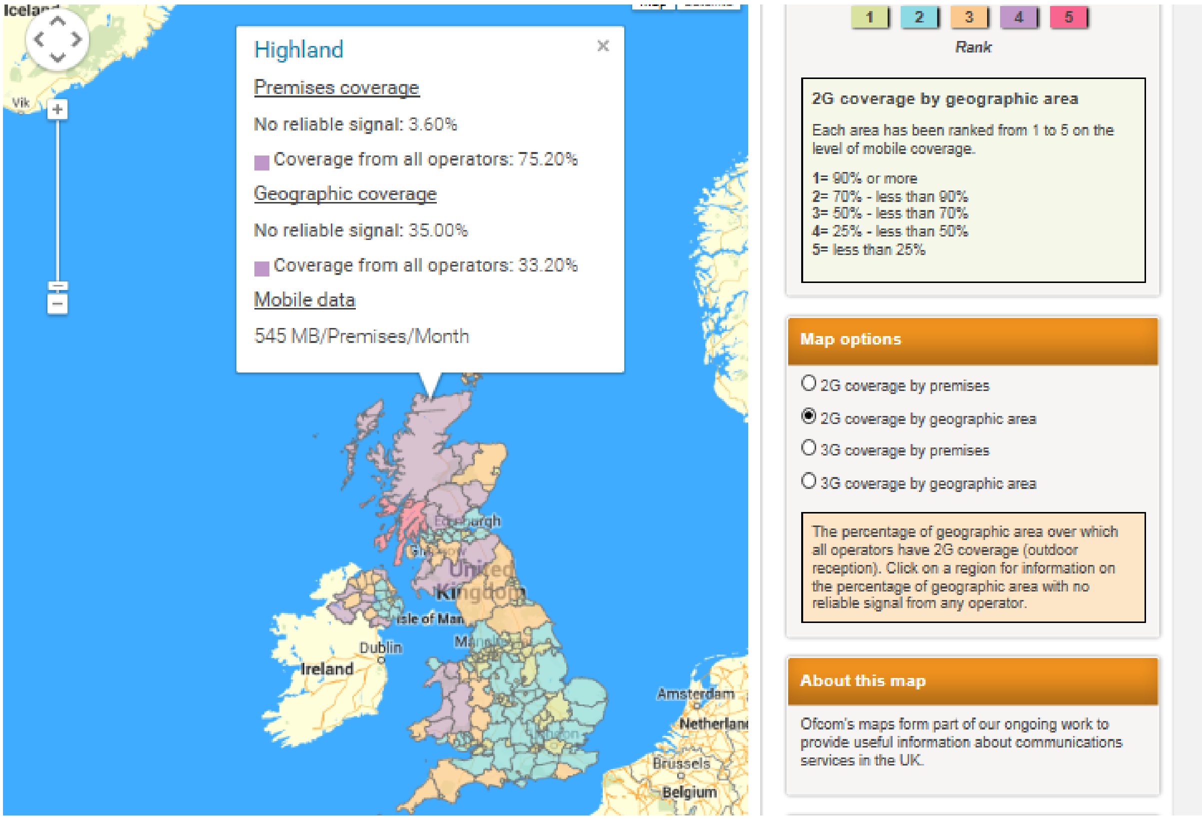
Coverage maps and associated measurements

In 2011 Ofcom undertook research[19] to understand the different factors that determine the customer experience of using voice services on a mobile. The research, where consumers were interviewed to obtain their views, indicated that mobile operator's coverage checkers were useful to inform likely coverage at home and at work. It was noted that these maps are developed based on predictions of signal strength calculated by the operators themselves based on propagation models and the approach adopted might differ between the operators. Ofcom therefore commissioned a measurement study in a region of the UK to measure the signal strength so the values could be compared with the operators' predictions. It was found that there was reasonable correlation for 2G but for 3G there was more variability.

Ofcom has continued to publish data on mobile coverage and what factors can affect mobile coverage to inform consumers. For example there are coverage maps provided from 2013 and these can be found at http://maps.ofcom.org.uk/mobile-services/. An example of the data provided is shown below, taken directly from the Ofcom web-site.

[19] See http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/mobile-not-spots/mobile-coverage-for-consumers/

Figure 5-4: Example of coverage data provided on the Ofcom web-site



Licence obligations and associated measurements

In the recent auction of the 800 MHz and 2.6 GHz frequency bands one of the 800 MHz licences (for the centre frequencies 811 – 821 MHz paired with 852 – 862 MHz) had a coverage obligation. The coverage obligation required the licensee to provide and maintain an electronic communications network, by no later than 31 December 2017, with 90% confidence that it can sustain a downlink speed of not less than 2 Mbps when the network is lightly loaded, to users:

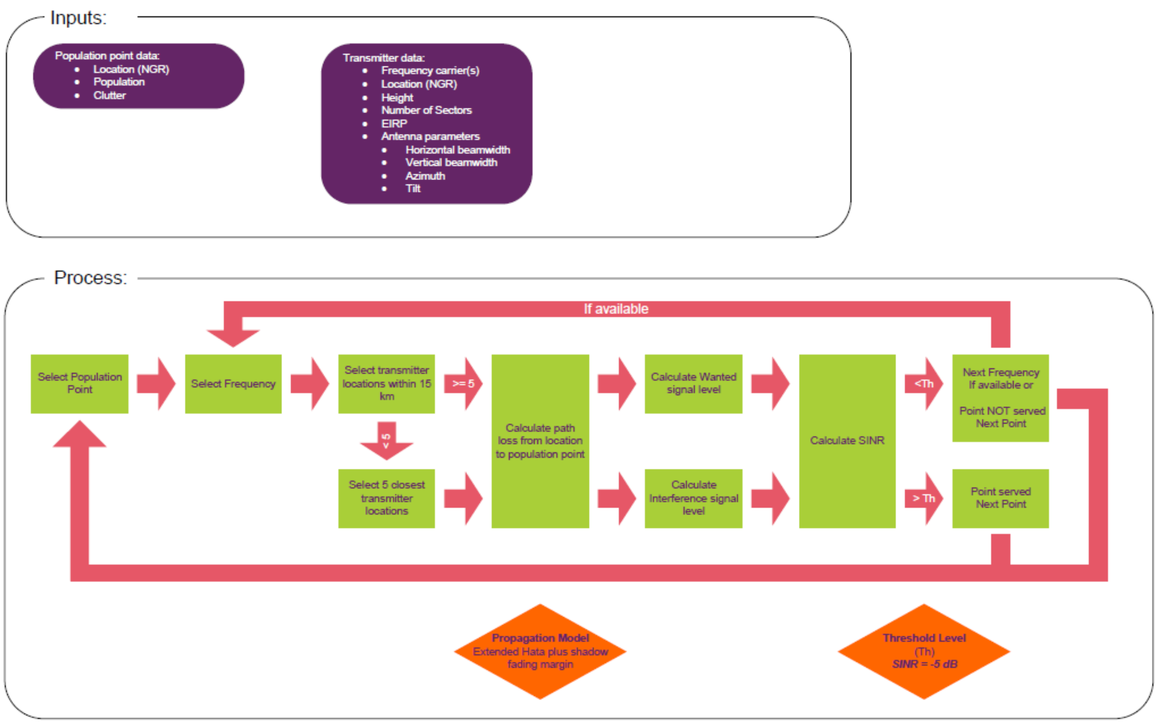
- In an area of which at least:
  - 98% of the population of the United Kingdom lives, and
  - 95% of the population of each of England, Wales, Scotland and Northern Ireland lives, and
- at indoor locations within the areas above but using equipment installed outside the residential premises

“Lightly loaded” is defined as where a single user requires services within the serving cell and the surrounding cells are loaded lightly (common channels only transmitting at 22% of the maximum cell power).

Ofcom has defined the approach to monitoring and defining compliance with the obligations[20] noting that the licensee could meet the obligations through the use of any of its mobile spectrum[21]. The approach adopted is summarised in Appendix B.

As noted earlier, coverage obligations may be modified by agreement with the operators. For example, in the UK the obligation on the 3G licences in the 2100 MHz frequency band was increased to provide coverage to an area within which at least 90% of the population of the United Kingdom lives[22]. In addition there should be a 90% probability that users in outdoor locations within that area can receive a sustained down link speed service of not less than 768 kbps in a lightly loaded cell. The deadline for meeting this revised coverage obligation was 30 June 2013[23]. Ofcom also published a coverage verification methodology[24] that is similar to the approach explained above for the 800 MHz band and is based on calculating the signal to interference plus noise ratio (SINR) of the HS-DSCH channel (High Speed Downlink Shared Channel) for a hypothetical test terminal located at each population point taking into account signals from the 20 closest base stations. Coverage of the population is considered achieved if the SINR for any of the base stations is greater than the threshold level of -5 dB. The process for undertaking the calculations is shown below:

Figure 5-5: Process overview for assessing coverage



[20] See, for example, Ofcom statement from November 2012 on "4G Coverage Obligation, Notice of Compliance, Verification Methodology: LTE" at http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/4GCov-verification.pdf

[21] Even allows for the possibility of using alternative mobile broadband technologies.

[22] The Government directed Ofcom to make these changes to coverage as part of making the licences for an indefinite duration.

[23] See http://media.ofcom.org.uk/news/2013/3g-coverage-compliance/

[24] See http://stakeholders.ofcom.org.uk/binaries/consultations/2100-MHz-Third-Generation-Mobile/annexes/methodology.pdf

Finally, it should be noted that in the UK the Government has recently agreed (December 2014) with the mobile network operators a new obligation to provide geographic voice coverage across 90% of the UK landmass no later than 31 December 2017 to increase provision of services in rural areas[25]. This was implemented through a variation of the mobile network operators' licences in January 2015[26].

[25] As a result of this change Ofcom has reviewed the licence fees for the 900 and 1800 MHz spectrum to take into account the impact of the geographical obligation (i.e. increase investment in the networks with no corresponding increase in income)

[26] See http://media.ofcom.org.uk/news/2015/alf-further-consultation/

6 International experience in measurements

In addition to modelling or measurement campaigns to ensure compliance with any coverage obligations, a number of regulators also measure specific parameters that are intended to provide information on the performance of the network from the perspective of the end user.

6.1 Bahrain

In addition to the coverage measurements TRA undertakes an annual qualitative assessment of mobile service quality from the user point of view. This involves measurements that assess the end to end performance to identify the quality as experienced by the end user(s).

Measurement methods

The testing methodology used reproduces the range of mobile services available - specifically those that are best sellers according to data from the mobile operators and associated handsets. It also considers typical use such as in vehicle, pedestrian and indoor and outdoor.

The measurements include:

Voice measurements:

- Failed and dropped calls
- Audio quality evaluated over a 2 minute call. Test method follows ITU ref P.800 Mean Opinion Score.

SMS measurements, using a set length SMS message of 26 characters:

- Measured time between sent and receive (if greater than 2 minutes considered as a fail)
- Check that message is the same

Data measurements which were undertaken using 3G and 4G smartphones for both hot spots and random locations. A range of measurements undertaken including:

- File transfer in up-link and down-link
- Web access for downloading popular web-sites with a 30 second timeout
- Video streaming based on the quality (audio and video\) on selected YouTube videos.

Fuller information on the testing undertaken is provided in the 2014 Bahrain Mobile Quality of Service Report[27].

[27] See http://www.tra.org.bh/en/media/quality-of-service/

6.2 Kenya

The Communications Authority of Kenya (CA) monitors the quality of service provided by mobile operators to consumers. The CA has a well-defined service quality assessment framework based on eight KPIs and publishes its findings on an annual basis[28].

Key performance indicators

The KPI's are shown in Table 6-1. As shown, the targets have become more stringent over time. The four Kenyan operators consolidated into three in 2014, but the KPIs are reported for the four operators. For an operator to be deemed compliant it needs to meet at least seven of the eight KPIs at a national level.

The KPIs are chosen in compliance with the CA regulations[29] which state that quality of service standards should be developed with the following principles:

- The parameters related to QoS are clearly defined and measurable;
- Information about the standards relating to QoS are sufficient, comparable and accessible;
- Communications infrastructure and services are compatible with international standards;
- Practices increasing the user satisfaction and decreasing user complaints are encouraged;
- Discrimination, relating to the quality of the service offered, between similar users is avoided; and
- Special needs of disabled users are also considered when developing QoS parameters.

The QoS standards may be based on:

- Parameters, defining the applicable QoS measurements for specific services;
- Methods of measuring service performance against predetermined parameters;
- Measurable service characteristics of parameters determined by the Commission; and
- Any applicable targets for parameters identified by the Commission from time to time.

It should be noted that the CA is consulting on an updated version of these regulations[30]. The proposed updated version makes clear that the licensee is responsible for taking the measurements using the method specified for the parameter. The measurements then need to be submitted in the prescribed format to the Authority. In addition the Authority may publish independent measurement results relating to QoS and QoE.

[28] Communications Authority of Kenya, "*Quality Of Service Monitoring Report For Mobile Telecommunication Network Services 2013-2014*" http://ca.go.ke/images/downloads/RESEARCH/Quality%20of%20Service%20Report%202013-2014.pdf

[29] The Minister for Information and Communication, "*The Kenya Information And Communications (Licensing And Quality Of Service) Regulations, 2010*" http://ca.go.ke/images//downloads/sector_regulations/(Licensing%20and%20Quality%20of%20Service)%20Regulations,%202010.pdf

[30] http://www.ca.go.ke/index.php/public-consultations

Table 6-1: Key performance indicators in Kenya

No.	KPI	2009-2012 Target	2012 onwards Target
1	Completed calls	90%	95%
2	Call drop rate	2%	2%
3	Call block rate	10%	5%
4	Call set up time	13.5 seconds	13.5 seconds
5	Call set up success rate	90%	95%
6	Handover success rate	85%	90%
7	Speech quality	Mean opinion score for 95% of samples > 2.7	Mean opinion score for 95% of samples > 3.1
8	Received signal level	Outdoor = -102 dBm	Outdoor = -102 dBm
		Indoor = -95 dBm	Indoor = -95 dBm
		In car = -100 dBm	In car = -100 dBm

Source: CA

Measurement method

The approach adopted for the 2013 – 2014 assessments undertaken by the CA[31] tested the four networks simultaneously and measurements were taken throughout Kenya (all eight regions). The assessment covered all the four mobile networks undertaken simultaneously and were based on intra-network configurations so that no network depended on the performance of another for terminating or originating calls.

The CA noted that:

- Coverage "*was aimed at collecting and sampling data that most represents the experience of the general public*" and the measurements were mainly focussed on major highways and shopping centres.
- Measurements between regions occasionally overlap due to the intertwined road network.
- Some areas could not be covered for security reasons.

The results are aggregated for the whole country to provide an overview of conformance for each operator.

Results

The results are published by the CA for each of the eight regions and a national average by operator and KPI. The overall results for the last few years are summarised in Table 6-2. Compliance levels fell after 2011/12 because the targets were more demanding in 2012.

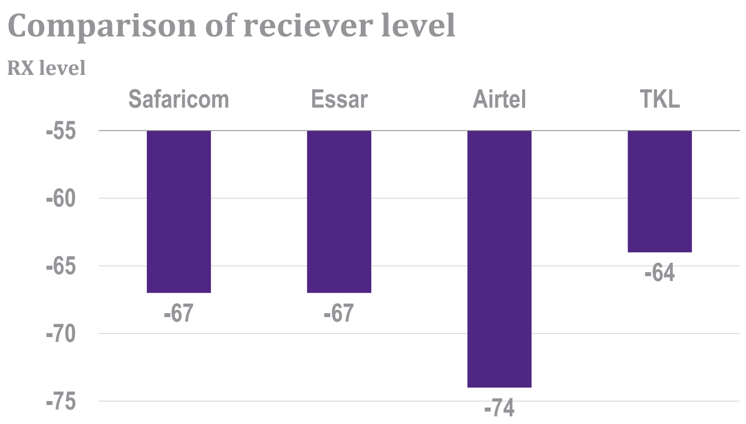
[31] See http://www.moseskemibaro.com/wp-content/uploads/2015/06/Quality-of-Service-Report-2013-2014.pdf

Table 6-2: Compliance with key performance indicators in Kenya (Source: CA)

Operator	Number of assessed KPIs	2011/12 compliance	2012/13 compliance	2013/14 compliance
Safaricom Ltd	8	50%	50%	62.5%
Airtel Kenya	8	62.5%	50%	62.5%
Telkom Kenya Ltd	8	87.5%	62.5%	62.5%
Essar Telecom Ltd	8	87.5%	50%	50%

It is noted that the received signal level was also measured and a minimum value target was -102 dBm. The results of this are shown below:

Figure 6-1



Source: Plum Consulting, CA

6.3 Nigeria

The Nigeria Communications Commission (NCC) states that operators face a number of QoS measures[32]. We focus here on measures that are publically reported. These do not include a large number of commercial focus parameters such as customer care which apply to all operators not just those providing mobile services. It should be noted that the results from the QoS measurements have been used to fine the mobile operators[33].

Key performance indicators

Four KPIs are publically reported each quarter, as shown in Table 6-3.

[32] http://www.ncc.gov.ng/index.php?option=com_content&view=article&id=112&Itemid=104

[33] See, for example http://www.biztechafrica.com/article/ncc-imposes-n647m-fine-airtel-glo-mtn/7765/#.VYv8kflViko

Table 6-3: KPIs in Nigeria

KPI	Definition	Target
Call setup success rate (%)	The number of the unblocked call attempts divided by the total number of call attempts.	98%
Call drop rate (%)	The number of dropped calls divided by the total number of call attempts.	1%
Traffic channel congestion (TCHCONG)	The probability of failure of accessing a traffic channel during call setup.	0.2%
Stand-alone dedicated control channel congestion (SDCCH)	The probability of failure of accessing a stand-alone dedicated control channel during call set up.[34]	2%

Source: NCC

The NCC also has end-to-end QoS parameters for calls that involve interconnect between operators (i.e. call terminates on a different network to that on which it originates). These include point of interconnect congestion and trunk network utilisation at peak hour. The last available data on the NCC website is for 2013[35].

Measurement method

The NCC collates the relevant statistics obtained from the network operating centres of the four mobile operators. The operators are required to report the KPIs for their network each quarter[36]. The KPIs are reported on a national, regional and city basis and the NCC publishes the national results. Note that this means the data represents actual network usage rather than sampling tests carried out by the regulator. However, reliability of the results may not be as complete as they depend on the data captured at the networking centres.

Results

The January 2015 results are shown in Table 6-4. Green cells indicate where the target was met and red cells indicate where the target was not met. As can be seen the operators had a mixed performance.

[34] http://www.nca.org.gh/downloads/QoS_Trends_for_April_2012.pdf

[35] http://www.ncc.gov.ng/index.php?option=com_content&view=article&id=1312&Itemid=104

[36] http://www.ncc.gov.ng/index.php?option=com_content&view=category&id=76&Itemid=104

Table 6-4: KPI results in Nigeria, January 2015

	CSSR (%)	DCR (%)	SDCCH (%)	TCHCONG (%)
Airtel	96.99	0.84	0.40	0.79
Etisalat	99.20	0.55	0.10	0.27
MTN	96.85	1.21	0.17	0.55
GLO	96.89	1.19	0.58	0.79

Source: NCC

6.4 Qatar

As part of the 2013 mobile network audit an independent study was undertaken to evaluate and benchmark the quality levels offered by the two operators.

Key performance indicators

The following quality levels were measured:

Table 6-5: KPIs in Qatar

Service	Measurement
Voice	Rate of calls set up and held for 2 minutes
	Audio quality of calls established and maintained for 2 minutes. Approach followed ITU P.800 – Mean Opinion Score for voice specification
Short message service (SMS) – 26 characters plus index	Rate of received SMS within 2 minutes, 30 seconds and 15 seconds
	Statistical accuracy of message
	Average time reception
Multi-media message (MMS) – 26 characters plus index and 50 kB picture attachment	Rate of received MMS within 5 minutes and 2 minutes
	Average time reception
Blackberry messenger (BBM)	Same as SMS
Video streaming – based on quality of a popular YouTube video over 2 minutes	End-to-end quality based on access, dropped sequences and non-quality sequences
FTTP download and upload	Successful radio connection before 1 minute timeout
	Time to download 5 Mb file
	Time to upload 1 Mb file
Web browsing and e-mail	Rate of successful data transfers
Smartphone (FTTP and HTTP)	Rate of data transfers in downlink and uplink
	Average throughput
	Maximum throughput

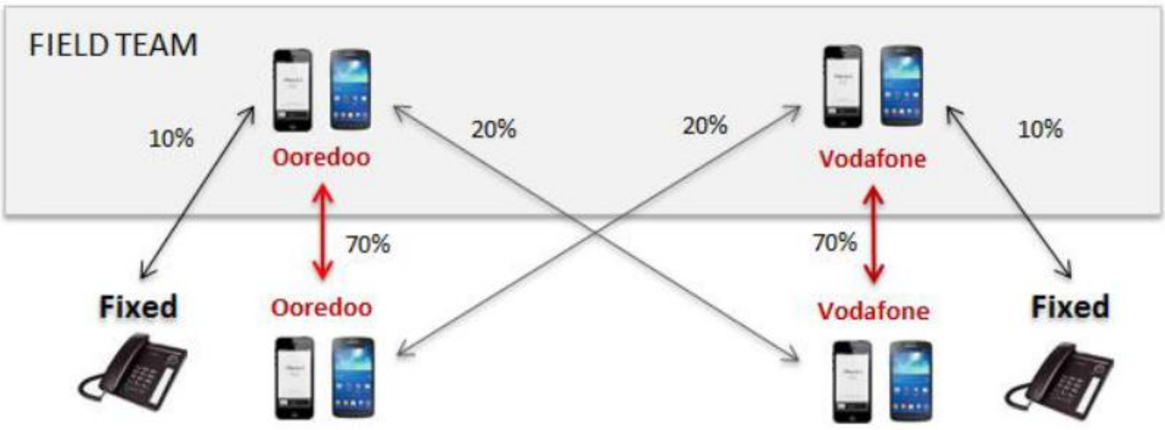
Source: CRA

Measurement method

The approach adopted was field measurements using devices compatible with voice, SMS and MMS technologies and recommended or sold by MNO's for use on their networks (2G and 3G). There were a number of field teams that undertook the measurements as well as a central office. The geographic areas over which measurements were undertaken were compatible to where such services were most likely to be used. The figure below provides an example of the voice measurements and shows the split of calls to a fixed line or a mobile.[37]

[37] Information on the other measurements can be found in the report at http://www.cra.gov.qa/sites/default/files/documents/Mobile%20Services%20Network%20Audit%20Report%20-2013.pdf

Figure 6-2: Measurement approach for voice



Source: CRA

Results

The results for each of the parameters are provided by the CRA.[38]

6.5 Singapore

In addition to the coverage QoS reporting the IDA reports on call success and call drop rates based on data provided by the operators.

Key performance measures

There two KPIs that the IDA also measures in addition to those that relate to coverage.

Table 6-6: KPIs in Singapore

KPI	Definition	Target
Call success rate	A call attempt is deemed successful when the calling party (the individual who makes the call) gets connected to the called party or receives busy tone.	>99%
Call drop rate	The percentage of unintended disconnection of 3G mobile calls by the cellular network during a 100 second call.	<1%

Source: IDA

[38] http://www.cra.gov.qa/sites/default/files/documents/Mobile%20Services%20Network%20Audit%20Report%20-2013.pdf

Measurement method

The information used to assess the call success rate and call drop rate is derived from the mobile network operator's actual network traffic logs.

Results

The quarterly reports give data by month. The results in Table 5-3 relate to December 2014 only.

Table 6-7: KPI results in Singapore (December 2014)

Operator	M1	SingTel	Starhub
Call success rate (%)	99.92	99.88	99.98
Call drop rate (%)	0.25	0.33	0.16

Source: IDA

6.5.1 South Africa

The Independent Communications Authority of South Africa (ICASA) regularly monitors the quality of 2G (GSM) service offered by mobile operators. It does this by focussing on specific regions rather than the whole country. This less thorough approach is less costly for the regulator. ICASA has published ten reports since 2012[39]. The most recent report covers the North West region and was published in April 2015[40].

Key performance indicators

ICASA defines QoS as:

> *"the collective effect of service performance that determines the degree of satisfaction of a user of the service. QoS provides an indication of what the customer experiences"*

To this end ICASA measures two KPIs:

- The call setup success rate (CSSR): the percentage of attempted calls that are not connected. The stated target is to have over 95% connected.
- The dropped call rate (CDR): the percentage of calls that fail to stay connected. The stated target is to have fewer than 3% of calls dropped.

The quality of these voice calls is not measured.

The 900 MHz, 1800 MHz and 2100 MHz frequency bands are tested.

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[39] https://www.icasa.org.za/LegislationRegulations/EngineeringTechnology/QualityofServiceReports/tabid/546/Default.aspx

[40] ICASA, "*Quality of Service Report: North West Province (Ngaka Modiri Molema, Dr Kenneth Kaunda, Bojanala Platinum District Municipalities) 2014/2015 Quarter 2"*, 28th April 2015 https://www.icasa.org.za/Portals/0/Regulations/Engineering%20&%20Technology/QOSNorthWest15.pdf

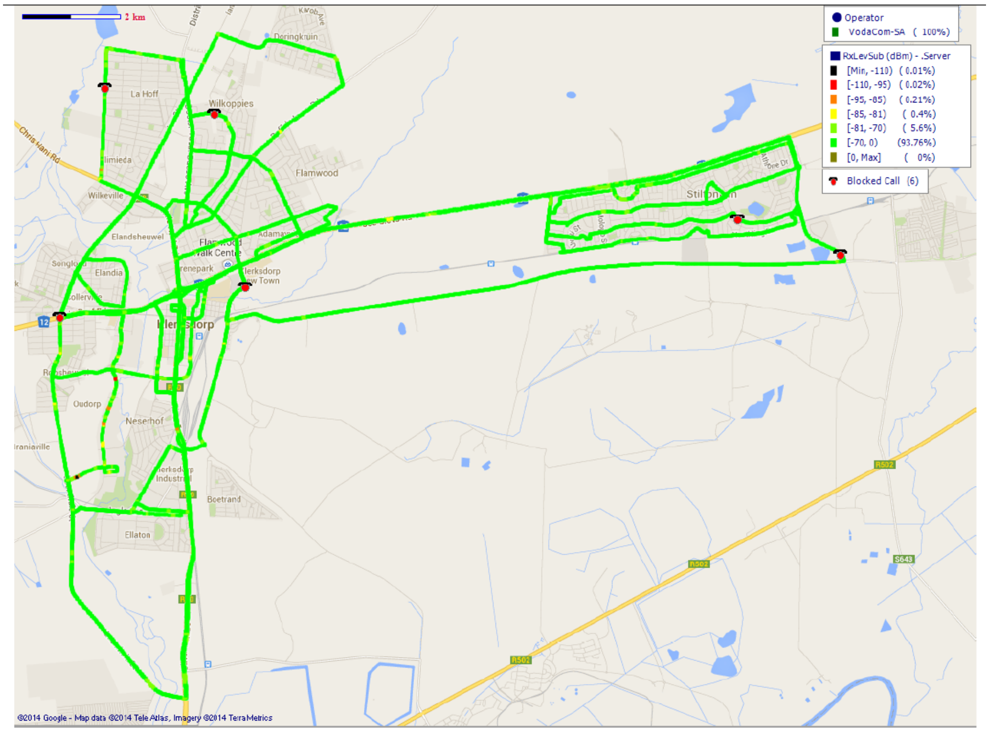
Measurement method

The measurement method involved driving along selected roads in the North West region, with antennas mounted on the vehicle roof. Figure 6-3 shows one of the five routes used in the North West region, with the DCR results for one of the operators.

ICASA designed the route to be representative of the population and the measurements were scheduled to reflect traffic variation over the course of the day. Each route was driven three times. ICASA used the exact same route for each operator (as the tests were conducted simultaneously) and a broadly similar number of calls were made to each network. In measuring the CSSR attempted calls were terminated after 10 seconds. In measuring the DCR calls lasted two minutes.

Figure 6-3: Klerksdorp Route

Vodacom



Source: ICASA

Results

The results that are published by ICASA are demonstrated below in Table 6-8 and Table 6-9 where the average values of the measurements for the North West region are shown:

Table 6-8: DCR results

Route:	Vodacom	MTN	Cell-C
	%		
Klerksdorp	98.99	98.99	98.44
Jouberton	99.04	98.42	99.13
Lichtenburg	98.82	99.75	94.80
Mahikeng	98.25	98.90	98.05
Sun City	99.07	98.87	97.63
Average	98.83	98.98	97.61

Source: ICASA

Table 6-9: CSSR results

Route:	Vodacom	MTN	Cell-C
	%		
Klerksdorp	0.00	0.78	0.39
Jouberton	0.00	1.92	1.13
Lichtenburg	0.00	0.24	0.50
Mahikeng	0.00	0.89	0.00
Sun City	1.43	1.81	1.52
Average	0.29	1.13	0.71

Source: ICASA

In this instance all three operators met the targets in the North West region, with the one exception being Cell-C's CSSR on the Lichtenburg route.

6.6 UAE

The UAE Telecommunications Regulatory Authority (TRA) publishes annual reports on quality of service of the two mobile operators, Etisalat and Du[41].

Key performance indicators

The TRA tests six KPIs, as listed in Table 6-10, which are specified by the 2010 regulations[42]. Some of the KPIs have explicit targets but others are intended to be informative.

[41] Telecommunications Regulatory Authority, *Mobile Networks Benchmarking Results 2014* http://www.tra.gov.ae/processfile.php?file=20150517080654-Mobile%20Networks%20Benchmarking%20Results%20For%20Year%202014-en.pdf&l=en

Table 6-10: Key performance indicators in the UAE

KPI	Definition	Target (if set)
Call completion success rate	% calls that were successfully set up and normally terminated	n/a
Call setup success rate	% of attempts that resulted in successful calls	n/a
Call drop rate	% calls dropped in a two minute call	<2% calls dropped
Voice quality	The average voice quality on the downlink and uplink which refers to the network's ability in achieving an acceptable level of voice quality using the Mean Opinion Score (MOS) measure.	>2.8
Service coverage	Signal strength	-100 dBm or higher
Data transfer rate	Rate at which data is transmitted (uplink and downlink) over the application protocol levels. Both FTP & HTTP have been tested: - FTP (File Transfer Protocol): used to upload files from a workstation to a FTP server or download files from a FTP server to a workstation. - HTTP (Hyper Text Transfer Protocol): used to transfer files from a Web server onto a browser in order to view a Web page that is on the Internet.	n/a

Source: TRA

Measurement method

The measurements covered over 13,000 km of roads (in-car measurement) and 34 static sites (indoor measurement) in the UAE which involved thousands of calls. The route is shown in Figure 6-4. The TRA tested the KPIs in relation to different mobile technologies (GSM, UMTS, LTE).

[42] Telecommunications Regulatory Authority, "*Reporting Specifications Quality of Service Regulatory Policy*", Version 1.3, 27th September 2010 http://xn-----7sdgaaakkdc3k8a1neipn1dg.xn--mgbaam7a8h/TRA%20Regulations.php

Figure 6-4: Test paths in the UAE

Source: TRA

Results

The results are reported separately for indoor and in-car measurements. For example, Table 6-11 gives the results for the in-car measurements.

Table 6-11: In-car KPI results in the UAE (2014)

KPI			Du	Etisalat
Call completion success rate (%)			98.55	98.59
Call setup success rate (%)			98.84	98.83
Call drop rate (%)			0.30	0.25
Voice quality (% greater than 2.8 MOS)			97.02	95.33
Service coverage (% at least -100 dBm)		2G	99.98	99.91
		3G	99.93	99.85
Data transfer rate (Mb) (FTP)	Downlink	2G/3G	4.583	4.724
		4G	10.786	17.116
	Uplink	2G/3G	0.796	0.681
		4G	1.614	2.100
Data transfer rate (Mb) (HTTP)	Downlink	2G/3G	5.570	5.630
		4G	7.858	11.968
	Uplink	2G/3G	0.857	0.721
		4G	1.624	2.111

Source: TRA

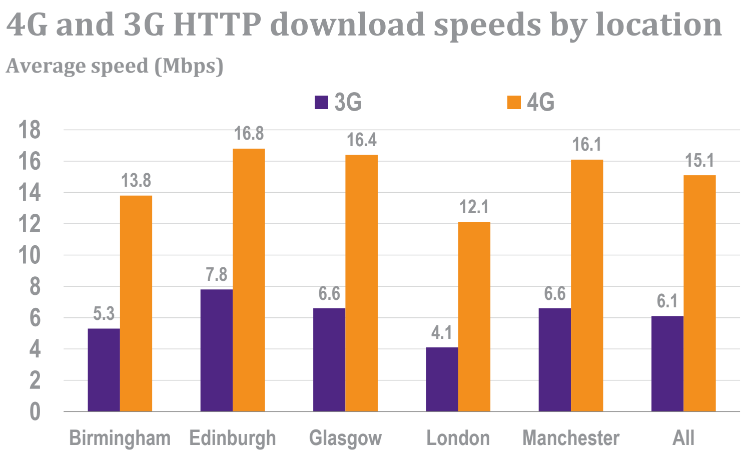
6.7 UK

In the UK Ofcom undertook has undertaken research into the performance of 3G and 4G services offered by the four national mobile network operators (MNOs)[43] to inform consumers. The report published in November 2014 was based on using smartphones to measure four key metrics that relate to data performance (downlink, uplink and web browsing speeds and latency). The measurements were made in five cities where 4G coverage was available from all the MNOs in a radius of 4km around the railway station. An equal number of indoor and outdoor[44] locations were used and the same smartphone was used for all four networks. The outcome of the measurements has been provided in the published report such as, for example, the comparison of average download speeds in the five cities:

[43] See http://www.ofcom.org.uk/static/research/mbb.pdf

[44] Measurements were made when the vehicle was stationary at the location.

Figure 6-5



Source: Plum Consulting, Ofcom

7 Summary of international experience

The benchmarking in the previous two sections has demonstrated a range of approaches that have been adopted to set QoS and in some cases QoE targets.

In the case of coverage obligations these are often set in respect of voice and data services and may be on the basis of population or geographic coverage. There has been a move by Ofcom in the UK to set a single coverage requirement that can be met by using any frequency band or technology to which the network operator has access. This has merit as any network operator will want to optimise their network deployment and the outcome might differ from that required by detailed coverage obligations for each frequency band.

Confirmation that coverage obligations have been met is either achieved by:

- Undertaking modelling based on the base station locations and details provided by the network operator and checking that specific signal strengths are met.
- Drive testing along pre-determined routes or testing within specific buildings and ensuring the signal strength meets the minimum requirements.

There is no single approach preferred but what is noted is that the intervals between checking are generally annual but in some cases quarterly.

In the case of QoS and QoE, measurements have ranged from just two or three parameters (e.g. call set up success rate, call drop rate and call completion success) to including voice quality and transfer data rate for a range of data services. In general these measurements have been made using drive testing, sometimes undertaken by an independent third party on behalf of the regulator. There are also instances where the regulator has required the network operator to provide network data and analysis to also report on dropped calls and so on. Again, publication of reports tends to mainly be on an annual basis.

It is also noted that some countries, such as the UK, do not measure mobile QoS. The table below, which was provided in a consultation undertaken in 2013 by the Channel Islands[45], provides some information and compares mobile with other services.

[45] See “Measures of Quality of Telecomms Services in the Channel Islands” at http://www.cicra.gg/_files/Telecoms%20Quality%20of%20Service%20Consultation%20Paper%20Revised%20(2).pdf

Table 7-1: Comparison of QoS regulations and measurements

	United Kingdom	France	Germany	Italy	Belgium	Finalnd	Czech Republic	Turkey	United States	Canada	India	Singapore
Types of services under QoS regulation												
Universal	✓	✓	✓	✓	✓		✓	✓			✓	✓
Fixed-line telephony		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Mobile telephony				✓	✓		✓	✓			✓	✓
Internet				✓	✓						✓	✓
Parties measuring QoS												
Operators	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Regulators		✓										
Third party	✓			✓				✓				
Frequency of publication of QoS data												
Quarterly		✓				✓		✓		✓	✓	✓
Half-year	✓			✓	✓							
Annual		✓	✓	✓				✓	✓			

Source: AT Kearney as published in Channel Islands Consultation in 2013

8 Application to Egypt

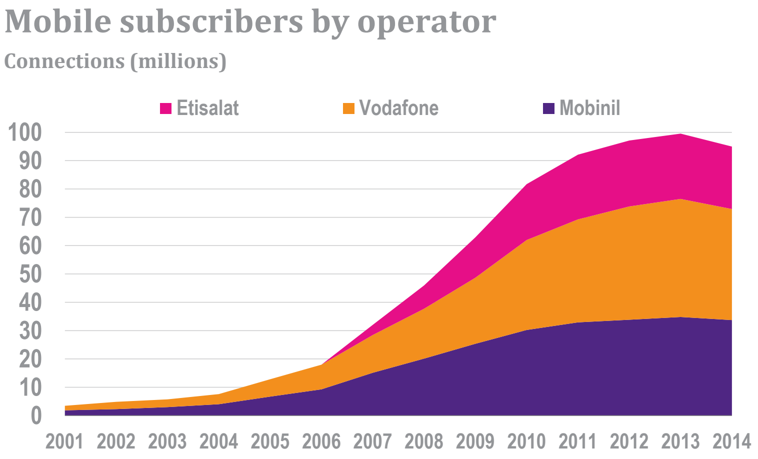
This report has discussed how to define QoS in a mobile network; analysed the drivers of QoS; examined the rationale and limitations of regulating for QoS; and explored international experience in regulating QoS. This Section builds on this to offer recommendations for Egyptian policymakers and the NTRA on how to best assist the development of QoS in Egypt.

8.1 The mobile market

The mobile market in Egypt is relatively dynamic with strong competition and falling ARPU. There have been significant changes in the market in recent years and it may change again if Telecom Egypt is granted a unified telecommunications licence.

The mobile market has experienced huge growth in Egypt over the last 15 years, with the number of mobile connections at 95 million by the end of 2014[46] as shown in Figure 8-1. The penetration of mobile connections is over 110%, while it was estimated that the unique subscriber penetration was 53% in 2013.[47]

Figure 8-1



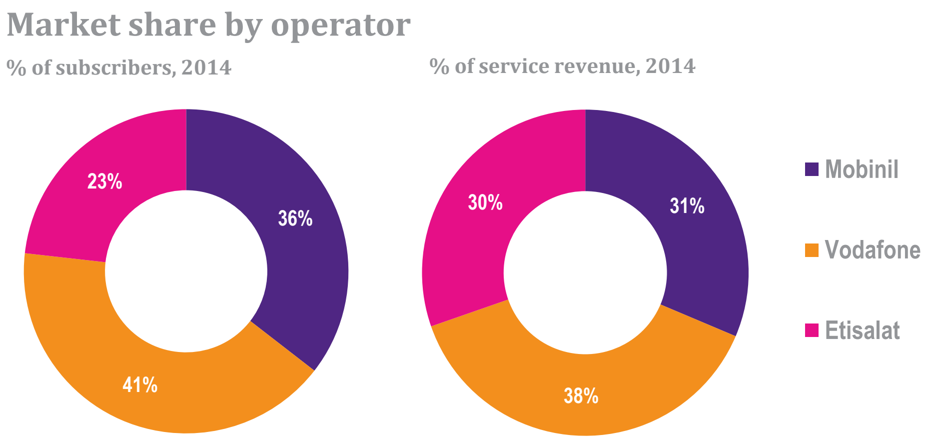
Source: Plum Consulting, Merrill Lynch Global Wireless Matrix

The market shares of the three operators, Mobinil, Vodafone and Etisalat, are shown in Figure 8-2. Vodafone is the largest operator by both subscribers and revenues. Etisalat is the smallest operator by both subscribers and revenues, but it has a larger share of revenues than it does subscribers. The higher revenue per subscriber is reflected in Figure 8-3.

[46] The number of mobile connections fell in 2014, possibly due to the NTRA not granting new numbers to the operators. See http://www.thecairopost.com/news/100979/business/ntra-decides-not-to-grant-mobile-operators-new-number-ranges

[47] GSMA, 'The Mobile Economy Arab States 2014', http://arabstates.gsmamobileeconomy.com/GSMA_ME_Arab_States_2014.pdf

Figure 8-2

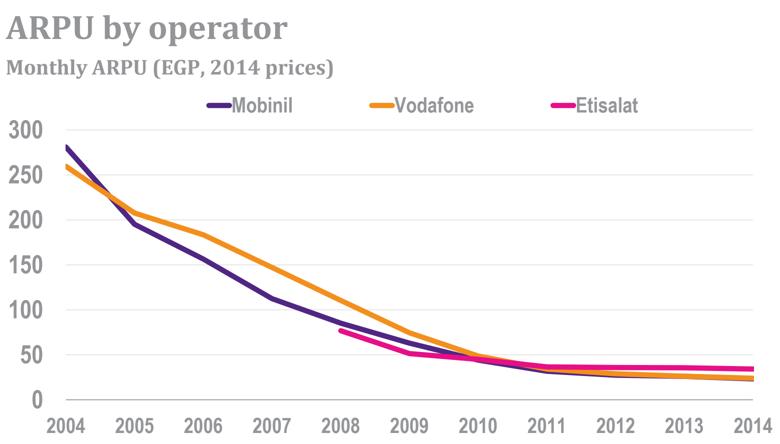


Source: Plum Consulting, Merrill Lynch Global Wireless Matrix

Regarding market concentration, the Herfindahl–Hirschman Index (HHI, a measure of concentration) fell from 0.50 in 2005 to 0.35 in 2014 as the market became less concentrated. The absolute HHI is usually high in mobile markets across the world as there tends to be a few large operators, but the downwards trend in HHI of the Egyptian mobile market does indicate reducing concentration. This is likely to indicate that the operators face significant competitive pressure from each other and that one operator does not dominate the market. Moving between operators is healthy showing that there is competition for subscribers: Mobinil, Vodafone and Etisalat experienced churn rates of 4.7%, 1.7% and 6.3%, respectively.

Post-paid subscribers tend to be more profitable for mobile operators; however the proportion of post-paid subscriptions is low in Egypt: 3.6% for Mobinil and 6.3% for Vodafone (Etisalat unknown). All three operators have seen average revenue per user drop over the last decade, as shown in Figure 8-3.

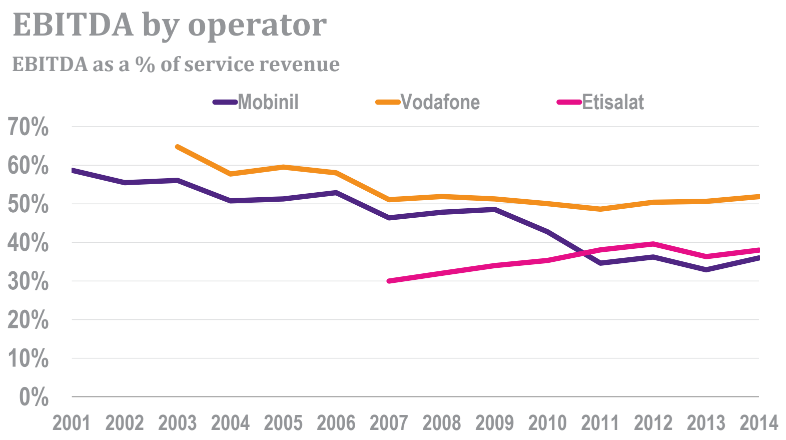
Figure 8-3



Source: Plum Consulting, CBE, Merrill Lynch Global Wireless Matrix

It is in the context of falling revenues per user that earnings before interest, taxation, depreciation and amortisation (EBITDA) has fallen slightly as a proportion of service revenue – see Figure 8-4.

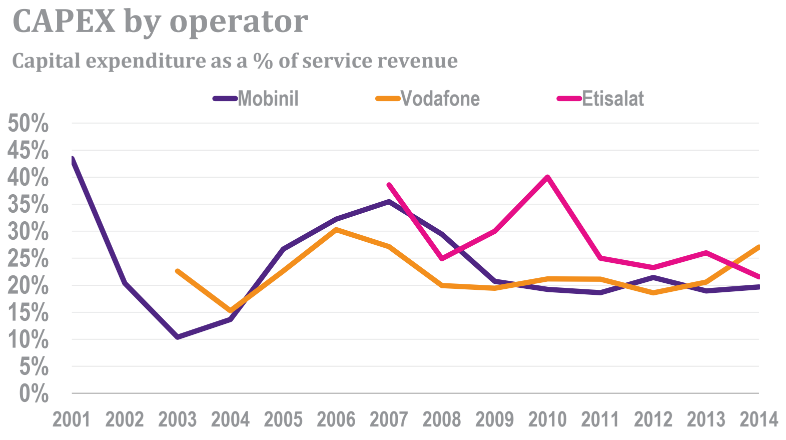
Figure 8-4



Source: Plum Consulting, Merrill Lynch Global Wireless Matrix

Capital investment has fluctuated by operator over the last 15 years, as shown in Figure 8-5, currently averaging 23% of service revenue across the three operators which is relatively low for operators worldwide, likely due to the lack of investment in new networks and also the lower capital expenditure on backhaul.

Figure 8-5



Source: Plum Consulting, Merrill Lynch Global Wireless Matrix

In conclusion, the Egyptian mobile market is competitive – operators face competitive pressure to gain and retain consumers; no single operator has more than 41% market share and all three are reducing prices and investing in their networks.

8.2 The regulator's objectives

The NTRA, established in 2003, has clear objectives in regulating Egyptian telecommunications:

> *"The main activities of the NTRA are to be an "independent and prudent arbiter" among the stakeholders (industry, the state and the consumer) taking into account the aims of "transparency, open competition, universal service and protection of users rights"."*[48]

In regard to specific measures, the NTRA states that:

> *"By deregulating the market and attracting investments, NTRA should pave the way for the steady growth of the industry. Albeit this should be done without forgoing the need to consider Egypt's national interests, including its developmental and security concerns. Consumers… also place high expectations on the shoulders of NTRA, seeing that their satisfaction and safety are crucial elements in the regulator's mission."*[49]

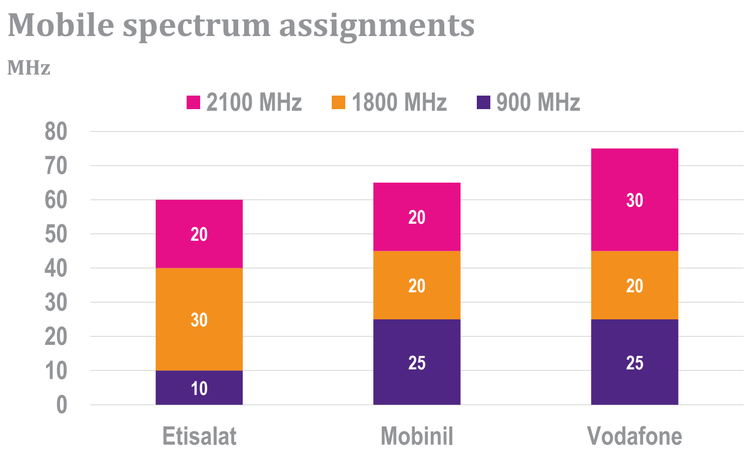
Thus the NTRA aims to balance deregulation with consumer protection, keeping in mind that deregulation stimulates investment which benefits consumers. It is this balance between regulation of specific QoS criteria and encouraging long term industry growth that should determine the extent of QoS regulation.

8.3 Drivers of quality

QoS is impacted by a number of different factors, as described in Section 3. The mobile operators are capacity constrained in Egypt, and this congestion adversely affects QoS as connection to network becomes difficult and traffic rates slow. This means that QoS would improve if they added capacity to their network; this can be done through adding spectrum or through the slower and more costly process of building more base stations.

Current spectrum holdings in the 900 MHz, 1800 MHz and 2100 MHz bands are shown in Figure 8-6.

Figure 8-6



Source: Plum Consulting

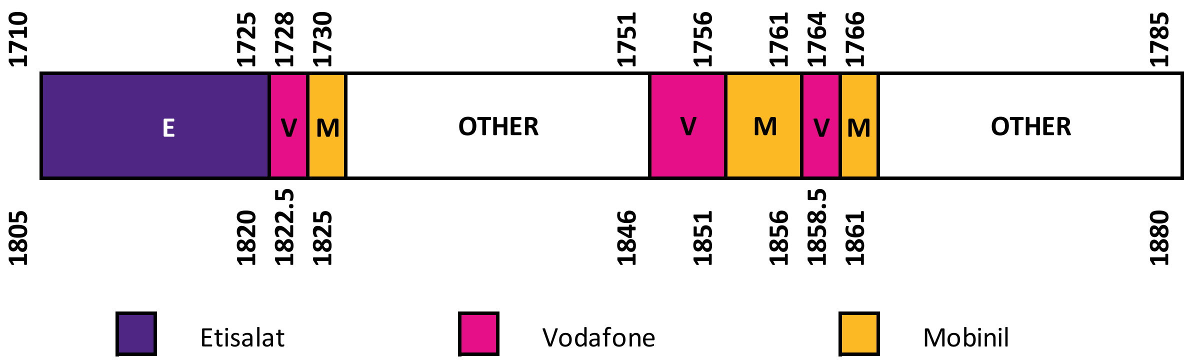
[48] http://www.tra.gov.eg/english/DPages_DPagesDetails.asp?ID=224&Menu=5

[49] http://www.tra.gov.eg/english/DPages_DPagesDetails.asp?ID=188&Menu=5

The total amount of spectrum available to mobile operators is low by international standards[50] and operators require additional spectrum in order to offer much needed LTE services in Egypt. LTE offers better QoS than 3G networks and the enabling of LTE networks should be a priority for the NTRA. Additional spectrum for mobile would be the most efficient way to add capacity and thus improve QoS in the Egyptian mobile market. However, it is not solely about the quantity of spectrum.

In order to offer 4G services to Egyptian consumers the mobile operators need access to contiguous spectrum. International experience suggests that LTE networks are best run over blocks of at least 2×10 MHz. The 1800 MHz band is currently assigned in fragmented blocks, as shown in Figure 8-7, therefore one way in which the NTRA could assist the evolution of higher QoS is to consult with operators about rationalising 18000 MHz assignments.

Figure 8-7: 1800 MHz band plan



The alternative way of adding capacity to a mobile network is to build more base stations (cell-splitting) but this is far more costly than using more spectrum and will be reflected in consumer prices. In any case, building more base stations relies on the ability of the operators to access new sites and supply them with backhaul. Egyptian operators are constrained in the number of sites they can build by planning restrictions and the requirement to use Telecom Egypt as the backhaul provider.

The quality of backhaul is also important: as the consumer demand for data increases the backhaul needs to be able to carry larger quantities of traffic and at higher speeds. The reliability of the network is also crucial when it comes to QoS.

8.4 Current regulations and obligations

As part of its regulatory framework, the NTRA currently places QoS obligations on the mobile operators. A full list can be found in 8.5Appendix A:.

The licences of the three operators in Egypt are required to supply services that meet or exceed international quality standards and that comply with the latest ITU and ETSI technical standards. If the operator fails to meet the QoS standards set by the NTRA then then it may issue fines to the operator. More information about these fines can also be found in 8.5Appendix A:.

[50] See Plum Consulting, 'Releasing Spectrum for Mobile Broadband in Egypt', September 2015

In order to monitor compliance the NTRA requires operators to report data. Each operator is required to provide weekly, monthly and quarterly reports, with additional reports in the case of service failure. The reports are disaggregated into the 27 governorates of Egypt (with Cairo and Alexandria divided into sub areas). The metrics relate to both QoS and QoE.

The numbers of QoS metrics are increased after the first year of operation. Table 8-1 gives the metrics for the first year of operation.

Additionally, after the first year of operations data is categorised into four traffic classes:

- Conversational class. There are four metrics for this class.
- Streaming class. There are four metrics for this class.
- Interactive class. There are four metrics for this class.
- Background class. There are two metrics for this class.

Also, there are nine QoE targets which do not directly relate to the operator's network, such as complaint handling and response time.

Table 8-1: Initial QoS metrics in Egypt

Metric	Definition	Target
Call blocking rate	Due to network congestion measured in busy hours, averaged over a week.	<2%
Call drop rate	Due to network congestion measured in busy hours, averaged over a week.	<2%
Voice quality	Measured on the Mean Opinion Score (MOS) scale for voice samples carried on voice calls between mobile and fixed phones. The scale ranges from 1 to 5 and applies one of the algorithms (PACE – PESQ LQ). Samples shall be collected during DRIVE TESTS for the entire system.	2.8 MOS for >90% of calls
GPRS throughput	The rate of valid data sent to the user when using GPRS service.	9.6kbps for >98% of samples
GPRS unavailability	The rate of failure to use GPRS service for 45 seconds after requesting it.	<8%
3G unavailability	The rate of the failure to use 3G services after 45 seconds of requesting it.	<10%
3G call completion rate	The rate of 3G service calls successfully completed.	>90%

Source: NTRA

Thus there are in total 30 metrics on which Egyptian operators report to the NTRA, see Appendix A. As the international experience section shows, most countries have fewer QoS metrics than Egypt, lessening the administrative burden on the operators and the regulator.

The NTRA also conducts its own test sampling (drive tests) in certain cities.[51]

8.5 Recommendations

The Egyptian mobile market is competitive with three strong players providing competitive pressure to improve the QoS that consumers experience. The stumbling block to further QoS improvements is not a lack of incentive on the part of the operators; rather it is primarily an inability to increase network capacity through spectrum scarcity. Other hindrances to backhaul and site access also make network build-out and the improvement of QoS difficult.

Given this situation, the best way for the regulator to improve QoS and help Egyptian consumers is through ensuring operator access to the key network inputs of spectrum, sites and backhaul. Until such inputs are available QoS will be constrained, almost regardless of the QoS regulation put in place.

The international experience with QoS regulation illustrates that the Egyptian mobile operators have relatively onerous regulation to adhere to both in terms of parameters and frequency of measurement. This burden is costly for the operators and will prevent them from responding to the competitive forces that drive progress, instead forcing them to concentrate on very short term regulatory objectives. Stringent QoS regulation can also stifle innovation by restricting operators to offering previously defined services and by hindering them from experimenting with new services. A reduction in the amount of QoS regulation in Egypt would assist each mobile operator as it battles to increase market share through lower prices and better QoS.

Thus the key recommendations for the NTRA are:

- Release additional spectrum for mobile at the earliest opportunity.
- Allow operators flexibility to deploy new, more spectrally efficient, technologies (refarming 2G and 3G for 4G)
- Consult with operators about how to improve backhaul and access to new base station sites.
- Consult with industry about reducing the regulatory burden of QoS regulation to the benefit of consumers.

[51] See for example the April 2015 report http://www.ntra.gov.eg/Uploads/Forms/2015April.pdf

Appendix A: Egyptian requirements[52]

There are specific licence obligations that apply to Quality of Service (QoS) and requirements for regular reporting and measurement campaigns. These are detailed below:

According to the license with the three mobile operators in Egypt:

i. The Licensee shall design, upgrade and modify his system in a way that guarantees provisioning of the licensed Services with a quality level that meets or exceeds the international standard quality specifications and international operating rates.
ii. The Licensee shall comply, as far as possible, with the latest ITU and ETSI technical standards related to any QoS indicators that is affecting the service not mentioned in this annex.
iii. The Licensee shall establish the measurement systems consistent with QoS indicators.
iv. The Licensee shall submit weekly reports to the Licensor including but not limited to performance, traffic and roll-out indicators. The reports must also present the results of the Quality of Service indicators based on statistical measurements taken from the system, averaged over a week.
v. The Licensee shall deliver monthly report to the Licensor indicating the results of the measurement of the Quality of Service indicators according to agree upon borders for measured geographical areas of Egypt based on QoS field drive test survey. The governorates that are divided into more than one geographical area are :
   - Greater Cairo, divided into 5 geographical areas (East, West, North, South & Down Town)
   - Alexandria, divided into two geographical areas (East & West).
   - Other governorates should be reported each as one area including measurements survey in populated areas (main cites & main roads).
vi. The measurement of the Quality of Service level performed by the Licensee does not cancel the Licensor's right to conduct these measurements on his own.
vii. The network quarterly report shall be submitted within 15 days from the end of each quarter. The Licensor and the Licensee shall hold a meeting every three months to discuss and study the submitted reports after. Both the Licensor and the Licensee shall exchange the results of the measurements.
viii. In case of the occurrence of technical faults which cause service unavailability for 10% of the subscribers or more for more than one hour, the Licensee shall notify the Licensor immediately, hence shall urgently present a report to the Licensor explaining the causes of the fault, the procedures that the Licensee shall take to fix the fault, the expected duration of the fixing procedure, and the impact of this fault on the Quality of Service. This does not apply for the planned maintenance tasks.

The Licensor shall apply the following phases for QoS monitoring and assurance over the time frame of the license as follows:

[52] These have been supplied by the NTRA.

1st Monitoring Period

This period starts from the date of commercial launch of the Service Indicators of targeted standards to be monitored and reported to evaluate the network performance for each geographical area of the entire system using calls (End to End) during this period are:

i. Telephony Service
   a. Call Blocking rate:
      Call Block Rate due to network congestion measured in the average Busy-hours of working days for a period of a week.
      Target value < 2%
   b. Call drop rate:
      Call Drop Rate calculated from the total calls have been correctly established measured in the average Busy hours within working day for a period of a week.
      Target value < 2%
   c. Voice Quality
      Measured on the Mean Opinion Score (MOS) scale for voice samples carried on voice calls between mobile and fixed phones. The scale ranges from 1 to 5 and applies one of the algorithms (PACE – PESQ LQ). Samples shall be collected during DRIVE TESTS for the entire system.
      Target value 2.8 MOS grading for at least 90% of the test calls.

ii. GPRS Service
   a. Throughput:
      Is the rate of valid data sent to the user when using GPRS service.
      The data rate of valid data should be at least 9.6 kbps for more than 98% of the samples.
   b. GPRS unavailability
      Is the rate of the attempts failure to use GPRS service for 45 seconds after requesting it.
      Maximum value for GPRS unavailability should not exceed 8% of the total attempts.

iii. 3G Services
   a. Unavailability :
      Is the rate of the attempts failure to use 3G services after 45 seconds of requesting it.
      Maximum value for 3G unavailability should not exceed 10 % of the total attempts.
   b. Successful completion rate :
      Is the rate of 3G service calls successfully completed.
      Target value for 3G calls completion rate are 90 % of the total attempts.

2nd Monitoring Period

This period starts after one year from the date of the commercial launch of the Service. The indicators which shall be monitored and reported to evaluate the network performance for each geographical area of the entire system using calls (End to End) during the 2nd monitoring period are:

i. Indicators which have been applied during the first monitoring period.

ii. Conversational class
   a. Definition
      Indicator represents the end-to-end data transmission quality of conversational class data service. This represents full duplex transfer of data in near real time.
   b. Computation

The end-to-end data quality is validated by measuring the average data throughput in both up-link and down-link direction on a best effort basis. The data throughput measurement shall be computed and averaged over the duration of the session/call and reported as bits per second.

Additionally the minimum throughput averaged over 10% of the overall call/session length and the maximum throughput averaged over 10% of the overall call/session length should be measured and the worst delay time for the call/session should also be reported.

Data Quality – Received A side = X bits/sec

Data Quality – Received B side = X bits/sec

Table A-1: QoS parameter target values for Conversational Services

Medium	Application	Degree of symmetry	Data rate	Key performance parameters and target values		
				End-to-end one way delay	Delay variation within a call	Information loss
Video	Videophone	Two-way	32-384 kb/s	< 150 msec preferred < 400 msec limit	-	< 1% FER
data	Telemetry two way control	Two-way	<28.8kb/s	< 250 msec	-	Zero
data	Interactive game	Two-way	<1KB	< 250 msec	-	Zero
data	Telnet	Two-way asymmetric	<1KB	< 250 msec	-	Zero

Source: NTRA

iii. Streaming Class

a. Definition:

Indicator represents end-to-end data transmission quality of the mobile, circuit switched streaming class data service. This measure represents a delivery of data in one direction in near real time.

b. Computation

The end-to-end data quality is validated by measuring the data throughput in down-link direction on a best effort basis. The data throughput measurement shall be computed and averaged over the duration of the call/session and be reported in bits per second.

Data Quality (Received A side) = X bits/sec

Table A-2: QoS parameter target values for Streaming Services

Medium	Application	Degree of symmetry	Data rate	Key performance parameters and target values		
				End-to-end one way delay	Delay variation within a call	Information loss
audio	High quality streaming audio	Primarily one-way	32-128 kb/s	< 10 sec	< 1msec	< 1% FER
Video	One-way	One-way	32-384 kb/s	< 10 sec	-	< 1% FER
data	Bulk data transfer/retrieval	Primarily one-way	-	< 10 sec	-	Zero
data	Still image	One-way	-	< 10 sec	-	Zero

Source: NTRA

iv. Interactive Class

a. Definition:

Indicator represents end-to-end data transmission quality of the mobile circuit switched interactive class data service. This represents duplex transfer of data in near real time.

b. Computation:

The validation of end-to-end data quality is made by the time taken to download specified files of fixed data size to the A party DTE when requested by the A party sending a request to the data server.

c. Assumption: the A party DTE has already connected to the data server as part of the call setup process.

Data Quality Download Time = t2-t1

where

t2 : point of time when A party receives the complete uncorrupted requested file/s

t1 : point of time when A party DTE sends data request

Table A-3: QoS parameter target values for interactive Services

Medium	Application	Degree of symmetry	Data rate	Key performance parameters and target values		
				End-to-end one way delay	Delay variation within a call	Information loss
audio	Voice messaging	Primarily one-way	4-13 kb/s	< 1 sec for playback < 2 sec for record	< 1msec	< 3% FER
data	Web browsing - HTML	Primarily one-way	-	< 4 sec/page	-	Zero
data	Transaction services-High priority(e-commerce-ATM)	Two-way	-	< 4 sec	-	Zero
data	E-mail (server access)	Primarily one-way	-	< 4 sec	-	Zero

Source: NTRA

v. Background Class

a. Definition:

Indicator representing the end-to-end data transmission quality of the mobile circuit switched background class data service. This represents data transfer with no real time dependency.

b. Computation:

The validation of the end-to-end data quality is made by time taken to download a file/s of fixed data size to the A party DTE when requested by the A party sending a request to the target server.

c. Assumption:

The A party DTE has already connected to the data server as part of the call setup process.

Data Quality File Download Time = t2-t1

where

t2 : point of time when A party receives complete uncorrupted file/s

t1 : point of time when A party DTE sends data transfer request

d. Target QoS parameters values

Data Quality File Download Time = 30 Sec for Fax

Data Quality File Download Time = 30 Sec for Low priority transaction (SMS)

vi. Subjective Indicators

Conducting customer satisfaction surveys to measure the perceptual QoS by customers, the operator should take the following indicators into consideration as Quality of Service indicators from the end user point of view and that the QoS is evaluated according to them:

a. Response time for directory enquiry services (max 20 Seconds)

b. Response time for admin/billing enquiries 2 weeks (10 working days)

c. Response time for operator services (2 working days)

d. Proportion of problems with number portability procedures under control of the licensee (3 working days)
e. No. of general complaints per 1000 lines shall not exceed 50 complaints.
f. Billing complaints percentage in any one billing period shall not exceed 2% of the total number of bills issued during that billing period
g. 90% of billing complaints shall be resolved within 15 working days of receipt of the complaint and 95% within 30working days
h. Percentage of customer reported service complaints per month.

   Expected: max = 6%
i. Percentage of faults per 100 subscribers per month.

   Expected: max = 4%

To verify the stated acceptable values, the Licensee must perform the following:

Predefined standardized Field surveys on the customers samples.

Complaints statistics at the customer service centre.

Hence, the Licensee must establish a customer service centre with a published phone number and immediately respond to the customers' requests.

If any of the Quality of Service indicators' limits specified in this annex exceeded its permissible limit for a reason that falls under the Licensee's responsibility for a week, and this degradation of the Quality of Service continued for the next three consecutive weeks, then the Licensor informs the Licensee to repair the causes of this degradation immediately. If the degradation continues for the next four weeks, then the Licensee must pay the amount of 500,000 L.E (Five hundred thousand Egyptian Pounds) as a penalty for this degradation of the Quality of Service, And if it occurs again in any month of the year starting from the first week when the Quality of Service level was deteriorated, then the penalty increases to become 1,000,000 L.E (one million Egyptian Pounds)

After two years starting from the date of commercial launch of the services the Licensor and the Licensee will review and update the QoS annex based on mutual agreement to guarantee the provision of a high quality of service during the Term(s) of the License.

Appendix B: International examples

This section includes examples of quality of service metrics from the UK and Nigeria.

B.1 UK assessment of LTE network compliance

The approach adopted to assess the compliance of LTE networks with the coverage obligations is detailed at http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/4GCov-verification.pdf . The aim is to assess whether a terminal located at any specific reference indoor location can receive the minimum downlink speed of 2 Mbps using redo which is not situated inside the premises.

Ofcom uses the calculation of signal to interference plus noise ratio (SINR) of the relevant data channel (i.e. downlink shared channel for LTE systems), based on the characteristics of deployed base stations, to ensure that the threshold needed to support a downlink of 2 Mbps is met. The table below shows the required threshold depending on the channel bandwidth:

Table B-1: SINR threshold values

Bandwidth (MHz)	Theoretical SINR Threshold	SINR Threshold applied in verification
10	-4.1 dB	-4.1 dB
15	-6.1 dB	-5.0 dB
20	-7.5 dB	-5.0 dB

Source: Ofcom

The mobile operator supplies data for each site on its network and as part of the calculation process Ofcom identifies the nearest 20 base stations to the data point (location) where the value of SINR is to be calculated. In turn each base station sector, assuming it is transmitting at maximum power and the other non-serving sector are lightly loaded (transmit at 22%), is assessed to see if it meets the SINR threshold. If the SINR requirements are met it is assumed that coverage, providing a minimum downlink speed of 2 Mbps, is available at that location.

As part of the calculation process the propagation model (in this instance ITU-R recommendation P1812-2) is specified as well as the terrain data base[53].

B.2 Interconnect Quality of Service measurements

In Nigeria measurements are made to assess the quality of interconnection between networks. ASR is the Answer Seizure Ratio (ratio of the number of answered calls to the total number of calls) and the targets defined by the Nigerian Communications Commission are 50% intra-network and 45% internetwork.

[53] Uses 50 metre terrain resolution data.

Table B-2: Interconnection QoS in Nigeria

Originating Network	Terminating Network	PoI Congestion at Busy Hour	Busy Hour Trunk Utilisation	Busy Hour Availability	Busy Hour ASR Incoming	Busy Hour ASR Outgoing	Comment
Target		≤0.5%	≤70%	≥99.999%			
MTN	Globacom	0.02	29.26	93.31	35.72	25.56	Good
	Airtel	0.02	26.32	83.08	30.28	23.60	Good
	Etisalat	0.00	28.21	99.62	38.28	29.80	V. Good
Etisalat	MTN	0.91	45.35	99.64	34.34	29.04	Good
	Globacom	0.87	40.02	98.43	28.94	30.54	Poor
	Airtel	0.65	29.10	98.81	32.07	32.61	Poor
Globacom	MTN	0.00	56.00	100.00	26.86	34.72	V. Good
	Airtel	0.00	44.00	96.00	30.00	30.63	Good
	Etisalat	0.00	39.00	100.00	31.72	29.94	V. Good
Airtel	MTN	0.00	38.74	99.26	31.87	33.98	V. Good
	Globacom	0.01	26.64	97.75	32.40	29.53	Good
	Etisalat	0.01	23.02	99.34	33.71	32.30	V. Good

Source: NCC