



### **CiquaL Response to BEREC Position Paper**

***Question 1: Should BEREC define common metrics for mobile coverage? Please explain your answer, for example by setting out the reasons why BEREC should or should not define common metric, including views on the potential benefits and risks to consumers and other stakeholders.***

**Summary Response:** Yes, with caveats.

**Detailed Response:** In CiquaL's opinion, BEREC's approach is correct to focus on establishing a common set of metrics and methods for measuring mobile coverage, and thus enable individual NRAs to understand the set of common metrics and methods available and to be able to select an appropriate subset for local use and adjust thresholds accordingly.

Our view is that common metrics are essential to establishing a common understanding and standard terminology amongst NRAs, vendors and citizens. However, the unique combination of circumstances within each individual country means there is no single "one-size-fits-all" metric and set of thresholds that can deliver the required mobile coverage measurements for all countries. Local differences that exist between countries in the areas of regulatory regime, license conditions, competitive market situation, geographical challenges, population distributions and spectrum allocation mean that slightly different metrics and thresholds may be appropriate for each country.

Coverage metrics are only useful if they provide useful and actionable information to NRAs and service consumers. Theoretical signal predictions, or accurately-measured signal levels compared with various threshold levels, will at best give a prediction of general mobile coverage but not for specific services. Adequate RF signal levels are a necessary prerequisite for mobile service coverage, but they are not enough on their own to give an actionable insight into the performance of specific services at each location. Signal levels do not take into account other major influences on service coverage, for example: frequency band, radio resource limitations, network congestion, core network latency, cell backhaul bandwidth, gateway congestion, IPX latency, etc. For services, it is a combination of all influencing factors that determines service coverage, and not simply the RF signal levels.

Consumers don't purchase "mobile coverage", they purchase a specific set of mobile services along with a set of expectations as to reasonable coverage. NRAs should perhaps look to evaluate coverage in the same way as subscribers to evaluate service adequacy. RF signal levels by themselves (or any other technical measurement and corresponding threshold set) mean nothing to the consumer.

***Question 2: What service availability definition and minimum requirements would you consider appropriate? What multi-level requirements would be appropriate to represent different level of coverage? Please explain your answer, for example by detailing how your figures for minimum service availability were established and by providing evidence.***

Service availability should be based on actual measurements of subscriber experiences, rather than on theoretical models. Models are becoming increasingly irrelevant as mobile networks become more dynamic. Many emerging technologies currently being deployed in 4G and (soon) 5G networks mean that modelling the network is becoming impractical due to increased complexity and the dynamically evolving network configuration. For example:

**Virtualisation:** Network functions (including disaggregated RAN elements) have migrated to software entities deployed within remote data centres. These are dynamically orchestrated according to service load and demand, and service performance will therefore vary dynamically with the number and location of these network functions

**Cell heterogeneity:** Networks are increasingly relying on large numbers of smaller cells to provide service coverage in challenging environments, e.g. dense urban areas, in-building coverage, metro rail coverage, etc. Cell size and 3D coverage patterns are much more complex and therefore more difficult to model and to predict performance.

**Massive MIMO and Beamforming:** Multiple antennae and complex software algorithms are used in realtime to constantly monitor RF conditions and adapt transmissions to try and maximise signal quality and data throughput. Modelling the resulting propagation paths is inherently as complex as the MIMO/Beamforming system itself, and impractical on a network-wide basis.

**Self-Optimising Networks (SON):** Many of the automated SON technologies currently being deployed will directly impact the network model by dynamically changing the configuration and behaviour of the network, for example Automatic Neighbour Relations (ANR) and Intelligent Power Management.

Making actual measurements from subscriber devices is the only approach to determining service coverage that will be sustainable against the background of increasingly complex networks. Cical's many experiences with deploying mobile network Quality of Experience (QoE) measurement solutions with network operators and NRAs have enabled us to develop a common approach and sets of metrics. Measurements are made on end-user (consumer/customer) devices, these are transmitted for anonymised analysis and reporting, where aggregated KPIs and KQIs are calculated. The data generated can be considered to be a hierarchy, with Measurements at the lowest level, KPIs calculated from aggregated measurements, and KQIs calculated from aggregated KPIs. Some examples are:

Measurements: Data session Throughput, Latency, Packet Loss and Jitter, RSRP, RSCP, RxLev, Voice Call Attempts

KPIs: Call Failures per Cell, Failed Data Sessions per Subscriber

KQIs: No Internet Connection (NIC), Device Quality Index (DQI), Video Quality Index (VQI), Mobile Quality Index (MQI)

In a regulatory environment, KQIs should be used that focus on the availability and performance of Services, and not on simplistic RF measurements. For example, the KQI "No Internet Coverage" (NIC) is defined as the aggregated % of data connections that failed due to no connectivity for this specific time period/location/device/cell/customer. This is a more useful coverage metric for a NRA or Consumer, compared to an overly-simplistic RF signal level.

***Question 3: What signal power thresholds would you consider appropriate for different mobile technologies? What multi-level thresholds would be appropriate to represent different level of coverage? Please explain your answer, for example by providing rational for such thresholds and by detailing how they were derived, including assumptions made and how they are linked to minimum service availability.***

NRAs should look to evaluate coverage in the same way subscribers decide if the services are adequate or not. Citizens/subscribers do not subscribe to an RF signal service, they purchase a specific set of mobile services along with a set of expectations as to reasonable coverage. Therefore, a specific signal power level does not indicate if services are usable, and is not a good proxy for service coverage. RF signal levels (or any other technical measurement and corresponding threshold set) mean nothing to the consumer, and are not an adequate predictor of service coverage and performance. Signal levels do not take into account other major influences on service coverage, for example: frequency band, radio resource limitations, network congestion, core network latency, cell backhaul bandwidth, gateway congestion, IPX latency, etc. For services, it is a combination of all influencing factors that determines service coverage, and not simply the RF signal levels.

Using crowdsourced QoE or QoS KQIs is a better approach for measuring coverage, as the data is service-specific and reflects the actual service coverage experienced by a large sample set of subscribers.

Regarding thresholds for service KQIs, in our experience no single threshold set can be used everywhere. Thresholds for Service Coverage metrics (e.g. NIC) should be set on a per-country basis to reflect local conditions and regulatory objectives. If the objective is to measure network operators against license conditions, then appropriate KQIs and Thresholds should be selected for that purpose, based on corresponding license terms and conditions (e.g. population coverage). If the objective is to provide consumers with information to enable an informed choice of service provider, then a different set of metrics and thresholds should be selected, based on KQIs that are understandable to the consumer, for example No Internet Connection (NIC). RF signal levels are meaningless to the consumer, and are not an adequate predictor of service performance.

The set of local conditions that should be taken into account when selecting appropriate thresholds should include the regulatory regime, license conditions, geographical challenges, population distributions, competitive market situation and spectrum allocation.

An example of evolving metrics and thresholds is where one of our Cignal network operator customers was deploying a new 4G network and wanted to focus management onto a successful rollout. Initially, the KQI selected to measure service performance was Mobile Quality Index (MQI) for 4G, reflecting only the QoE experienced on the 4G technology network and not on any other technologies. Once the 4G network rollout project was successfully completed, a different KQI was then selected: No Internet Connection (NIC). This then had the effect of focusing the management team of the network operator on improving coverage based on Data Connectivity, with the NIC target improving each quarter and tied to management recognition and rewards.

***Question 4: What might be the practical implications associated with selecting thresholds such as the impact of factors outside of the control of the mobile network operators (for example please see the discussion on key elements for monitoring mobile coverage from the consumer perspective as set out in the consultation)?***

The set of thresholds chosen for each NRA should ideally be based on actual empirical measurements made within the NRA's region of responsibility. Actual measurements will give visibility into the relative performance of competing network operators, and can be used by NRAs to drive desired behaviours amongst the network operators. For example setting service availability thresholds above the level of the highest performing operator will drive coverage improvements from all operators, whereas setting thresholds to match the highest performing network operator may drive other operators to improve their networks to match while driving the top performer to differentiate their services by offering new innovative services. The metrics and thresholds used to measure the performance of network operators will have a large influence on their behaviour towards their target markets.

As the networks evolve to support increased data consumption, the metrics used to measure adequate service coverage should be evolved and adjusted accordingly. In our experience with deploying device-based crowdsourced QoE solutions, thresholds need to be adjusted regularly to reflect changing usage patterns, new services and evolving subscriber expectations. As the external influencing factors are evolving within the measured networks (technologies, frequency bands, radio resource limitations, network congestion, core network latency, cell backhaul bandwidth, gateway congestion, IPX latency, etc.), then the thresholds (and even the KQI set used) will also need to evolve.

If NRAs are focused on delivering good QoE to their citizens, then a Subjective Feedback mechanism will be valuable to enable subscribers to deliver their opinions and perspectives on the services delivered by their selected network operators directly to the NRA. The NRA can use this information analytically to identify problem areas for discussion with operators, and can also statistically correlate the Subjective Feedback data against corresponding KQIs from the same subscribers to help calibrate and adjust KQI thresholds over time.

***Question 5: Given the rapid evolution of mobile data consumption, how often do you consider that common metrics should be reviewed to remain fit for purpose or useful for consumers in the future?***

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In our experience during deployments of QoE/QoS monitoring projects, the set of metrics used should be evaluated annually, to reflect new services. Additionally, the set of thresholds applied to the metrics should be reviewed quarterly, to reflect evolving networks, behaviours and devices.

NRAs should use metrics that closely match consumer expectations.

Cigital recommends that BEREC defines high-level service coverage KQI metric for each service in a hierarchical manner, consisting of multiple subordinate KPIs. For example for Mobile Internet data services a Mobile Data Quality Index (MDQI) could be constructed using subordinate KPIs for Downlink Throughput, RTT latency.

License conditions (in terms of the service coverage levels required from the network operator) have historically been based on the available compliance measurement technologies, these have primarily been RF signal measurements and drive test sampling. As consumer-device based crowdsourcing solutions are becoming widely available, our suggestion is that BEREC adopts this as a recommended approach. Where service coverage problems are identified through the crowdsourced coverage data, a statistically large enough sample of the KQIs and KPIs provide enough evidence to support discussions and negotiations with the network operator. Where additional evidence is required (e.g. due to a smaller data sample), selective and focused (i.e. cost-effective) drive-test activities can be used. This will be a more cost-effective approach for both NRAs and Network Operators, as only those areas not adequately covered by the crowdsourcing solution will need an expensive drive-test.