REVISED QUALITY OF SERVICE (QoS) MONITORING FRAMEWORK FOR MOBILE SERVICES

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Acronyms

Abbreviation	Meaning
2G	2nd Generation of Mobile Radio Access Network (GSM)
3G	3rd Generation Mobile Radio Access Network (UMTS)
4G	4th Generation Mobile Radio Access Network (LTE)
5G	5th Generation Mobile Radio Access Network
5G NSA	5G Non-Stand-Alone
5G SA	5G Stand-Alone
CA	Communications Authority of Kenya
CSFB	Circuit-Switched Fall Back
dBm	Decibel-milliwatts
Ec/Io	Energy per chip to total interference ratio
EN-DC	E-UTRAN New Radio Dual Connectivity
ETSI	European Telecommunications Standards Institute
HTTP	Hyper Text Transfer Protocol
ITU	International Telecommunications Union
KICA	Kenya Information and Communications Act
KPI	Key Performance Indicators
Mbps	Megabits Per Second
MNO	Mobile Network Operators
MOS	Mean Opinion Score
NP	Network Performance
OMC	Operations & Maintenance Centre
POLQA	Perceptual Objective Listening Quality Assessment
QoE	Quality of Experience
QoS	Quality of Service
RF	Radio Frequency
RS CP	Received Signal Code Power
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
USF	Universal Service Fund
VoLTE	Voice over LTE
VoNR	Voice over New Radio

Definition of Technical terms

Network Availability *(Layer 1):*
This is the degree to which a network is functional and not in a state of failure or outage. This indicator also carries with it the element of network coverage often expressed in the received signal level. Network availability, however, goes beyond coverage in view of the requirement of a network to be reliable and capable of guaranteeing continuity of a service. The QoS parameters in respect of these are aimed at reflecting the user's experience of the performance of the services provided by the service provider within the coverage area. Network coverage information captured and presented in terms of signal strength will also be reflected separately under this KPI category.

Network Accessibility (Layer 2):
This is the degree to which a user can perform a successful registration on the network, which delivers the service. Please note that the network can only be accessed if it is available to the user.

Service Accessibility (Layer 3):
This is the degree to which a user can access the service he wants to use. A given Network Accessibility is a precondition for this phase

Service Integrity (Layer 3):
This describes the QoS during service use and contains elements such as the quality of the transmitted content, speech quality, video quality or number of bit errors in a transmitted file. The Service Integrity can only be determined if the service has been accessed successfully.

Service Retainability (Layer 3):
This describes the degree to which a service is retained or terminated while in use. Examples for QoS parameters under this KPI are cut-off parameters, e.g. the call drop rate, or the data link drop ratio. A previously performed successful service access is a precondition for this phase.

Quality of experience (QoE):
Quality of Experience relates to the overall quality of service that include the network, devices as well as the users' experience and expectations of a particular service. QoE therefore is more about subjective considerations that vary from person to person. QoE is however determined using objective measurements statistical analysis through Customer Satisfaction Surveys.

1. BACKGROUND

The Communications Authority of Kenya (CA) is the regulatory authority for the ICT sector in Kenya, established by the **Kenya Information and Communications Act, 1998 as amended.** CA is mandated to regulate the fields of Telecommunications, E-commerce, broadcasting, postal/courier services and cyber security and for managing the country's numbering and frequency spectrum resources as well as safeguarding interests of consumers of ICT services. CA is also responsible for managing the country's numbering and frequency spectrum resources and administering the Universal Service Fund (USF) as well as safeguarding the interest of users of ICT services.

The 2023-2027 Strategic mission of the Authority is to Enable a Sustainable Digital Society through Responsive Regulation with a commitment to ensuring that everyone in Kenya has access to affordable, reliable, and high-quality communication services. In view of this, the Authority maintains a framework for assessing the Quality of Service for Telecommunication Systems and services which serves as a guide to ensure Kenyans receive Quality services from mobile operators.

The current framework for the assessment of the Quality of Service (QoS) of Telecommunication Systems and Services was gazetted on 23rd February 2018 (Gazette Notice no. 1712). Since then, several technological advancements have emerged in the sector, including the deployment of newer mobile technologies such as 4G and 5G. The KPIs for 4G and 5G were not encompassed within the original framework, resulting in challenges when conducting assessments of mobile networks which have a combination of all these technologies.

The framework made provision for regular reviews to cope with the rapid advancements in Technology, coupled with the need to ensure services offered by new technologies to the public meet the quality requirements acceptable by the international best practice. The aim is to ensure that consumers continue to have access to high quality telecommunications services by setting basic minimum quality levels for all operators.

2. INTRODUCTION

The Communications Authority of Kenya (CA) is mandated by the KICA to ensure mobile operators maintain the highest standards of services while offering communication services to the public.
As such, the Authority maintains a framework for monitoring Quality of service (QoS) for mobile Telecommunication industry by setting minimum QoS standards in service delivery for the telecommunications industry in Kenya.
Under the current framework for assessment, the three (3) main components that constitute Mobile Network Quality of Service (QoS) Monitoring framework for Voice, Data and SMS are elaborated as follows:

2.1. Current End-to -End (E2E) Quality of Service (QoS)

The End-to-End (E2E) Quality of Service (QoS) is defined as the totality of characteristics (end- to-end) of a telecommunications service that bear on its ability to satisfy the stated and implied needs of the user of the service (Recommendation ITU-T E.800). These are QoS measurements that takes into account user experience on all network equipment and customer equipment, undertaken using vehicle mounted and backpack QoS monitoring tools.

2.2. Current Network Performance (NP)

The Network Performance (NP) assessment is the gathering and analyzing of network statistics called performance indicators to assess the quality of service provided by a telecommunication network. It relates to the assessment of the network part of the service without considering user influencing factors such as devices. It is undertaken through a system connected directly to the mobile networks core interfaces to obtain network QoS counters for quality-of-service assessment.

It is both a quantitative and a qualitative analysis and is a crucial tool for understanding the health of the network. E2E and NP generally seek to address the following:

Availability
Availability is the measure of the proportion of up-time of each network element (nodes, servers, base stations etc.). With this indicator we understand how long the functioning element was out of work, it is the first indicator to consider when assessing the health of a system.

Accessibility
Accessibility measures the proportion of the ability to access the network which in general is provided by the establishment rate meaning the proportion of channels that could be accessed/used for establishing a call or a data session.

Retainability
Retainability measures the proportion of calls or sessions that went undisturbed during its entirety, meaning the sessions/calls that had no drops, and call drop rate.

Integrity
Integrity measures the proportion of calls/sessions that went undisturbed during its life, so where the real quality is measured in terms of clearness for calls, latency, throughput, jitter and round- trip-time for data sessions.

Usability
Usability is the level of usage of a network meaning the traffic; number of calls and their duration, volume of data, number of simultaneous connections and its time and space distribution.

2.3. Current Quality of Experience (QoE)

The Quality of Experience (QoE) is defined as the overall acceptability of an application or service, as perceived subjectively by the end-user (Recommendation ITU-T P.10/G.100). It is the degree of delight or annoyance of the user of an application or service.

The assessment of QoE relates to the overall quality of service that includes the network, devices as well as the users' experiences and expectations of a particular service. It is a subjective customer perception on QoS, obtained through an objective statistical measurement undertaken through surveys alongside the customer satisfaction surveys.

The E2E QoS, NP and QoE framework is illustrated in figure 1(a) and (b). Fig 1(a): Architecture of End-to-End QoS, Network Performance & QoE

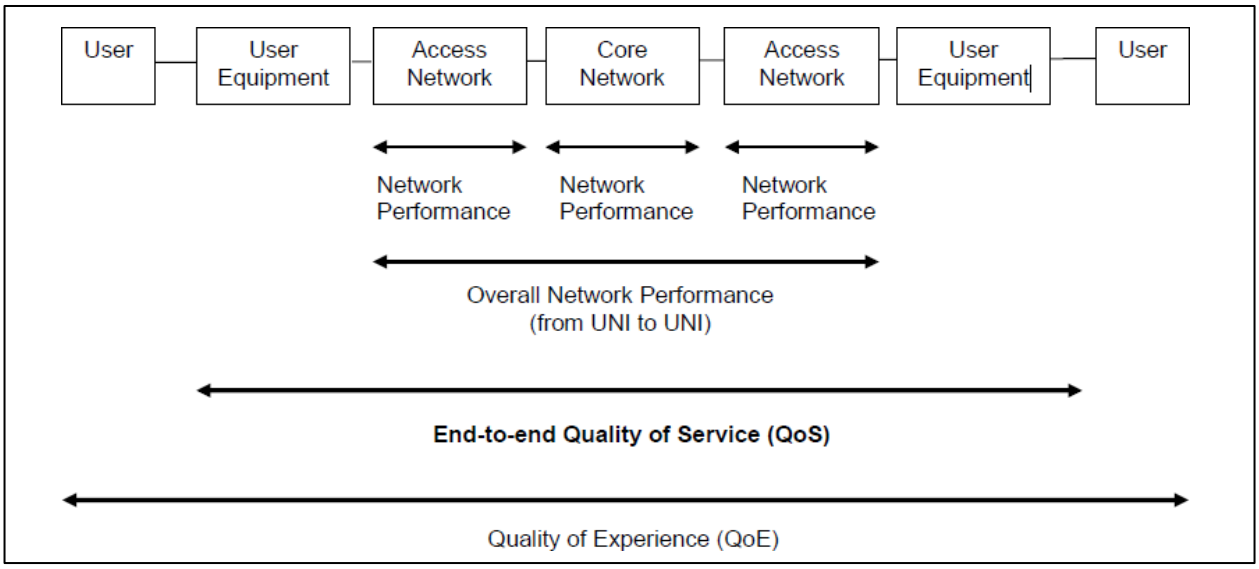
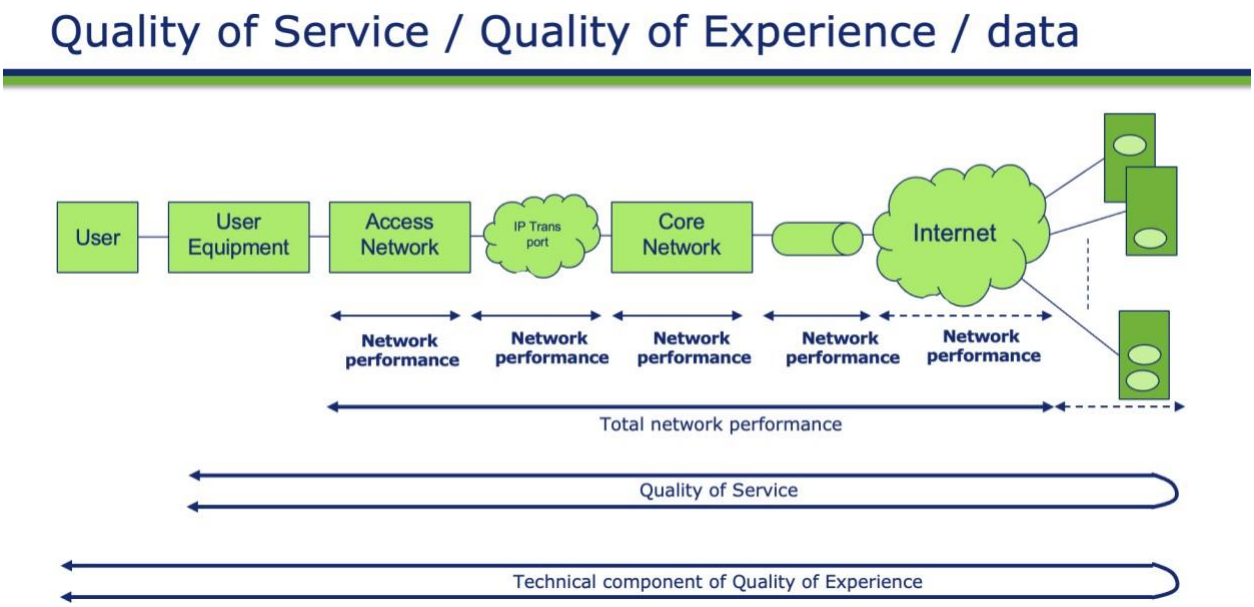


Fig 1(b): Architecture of End-to-End QoS, Network Performance & QoE



2.4. Current QoS Components Weighting

The framework also provided for weightings to be applied on the three components to come up with a weighted average of the QoS performance. The current weighting of the components is provided in Table 1, in which the threshold for compliance was set at 80%.

Table 1: QoS Components' Weighting

QoS Component	Weighting
End to End (E2E) Drive Test QoS	60%
Network Performance QoS	25%
Quality of Experience (QoE)	15%

2.5. Current QoS KPIs QoS Monitored

The current end-to-end QoS Key Performance Indicators (KPIs) for Voice, Data and SMS services that are currently monitored are presented in Table 2.

Table 2: End to End QoS of Voice, Data and SMS Key Performance Indicators (KPIs) Monitored

	KPI Hierarchy	Parameter	Current Target
Mobile Telephony (Voice)	Network Coverage	Coverage Roll Out	≥ 103 dBm
	Network Availability	Received Signal Level	≥ 95 dBm
	Network Accessibility	Unsuccessful Call Ratio	< 5%
	Service Integrity	Call Setup Time	< 12s
		Voice Quality (MOS/POLQA)	> 3.4
	Service Retainability	Handover Success Rate	> 96%
		Dropped Call Ratio	< 2%
SMS	Network Accessibility	Successful SMS Ratio	> 95%
	Service Availability	SMS Completion Rate	> 95%
	Service Integrity	SMS End-to-End Delivery Time	> 95% within 30s
Data transfer/ Internet access	Network Accessibility	Latency	< 100ms
	Service Availability	Data Transfer Failure Ratio (DL)	< 10%
		Data Transfer Failure Ratio (UL)	< 10%
	Network Accessibility	Internet Accessibility	> 98%
	Service Availability	HTTP Setup Failure Ratio	< 2%
		HTTP Setup Time	> 95% within 20s
		HTTP Completion Failure Ratio	≤ 10%
		HTTP Completion Time	> 95% within 20s
		HTTP Generic Scenario Availability	≥ 85%

Since the framework was adopted, several technological advancements have emerged in the sector, including the deployment of newer mobile technologies such as 4G and 5G. The current KPIs listed

in Table 2 do not encompass parameters for 5G, hence the Authority has reviewed them in line with the Network QoS benchmark scoring methodology.

3. REVISED FRAMEWORK FOR MOBILE NETWORK ASSESSMENT

The revised framework establishes a structured methodology for assessing mobile network performance. It integrates multiple dimensions of Quality of Service (QoS), including Drive Test (DT) KPIs, OSS-based Network Performance (NP) KPIs, and Quality of Experience (QoE). The framework is designed to provide a standardized approach for evaluating mobile networks, ensure comparability across Mobile Network Operators (MNOs), and enhance accountability through auditable scoring and reporting mechanisms. By balancing technical performance indicators with user-perceived service quality, the framework aligns with international best practices while remaining adaptable to local regulatory requirements.

3.1. Scoring Overview

The Authority recommends adopting a **granular weighted approach** aligned with the ETSI TR 103 559 standard to ensure a fair and balanced evaluation of mobile network performance. This approach recognizes that KPI categories and parameters contribute differently to overall service quality and user experience. Each KPI is assigned a weight based on its importance within its service domain and the technology layer (2G–5G). To enable aggregation across KPIs with different scales, raw KPI results are normalized to a standardized 0–100 scale. Weights are then dynamically redistributed to account for missing or non-applicable technologies, and aggregated scores provide a transparent and auditable measure of overall mobile network performance.

3.1.1. Normalization

Each KPI is defined with **technology-specific thresholds and performance targets**, ranging from a *Worst Acceptable Limit* to an *Excellent Target* where:

- **Worst Acceptable Limit (Performance Floor):** Represents the minimum threshold for service viability. Performance at or below this level indicates a degraded state that likely leads to user frustration or service failure.
- **Excellent Target (Performance Ceiling):** Represents the "Gold Standard" of network optimization, where the service provides a seamless and high-quality experience.

To allow aggregation of metrics expressed in different units (e.g., decibels, seconds, percentages), raw KPI data is normalized to a standardized **0–100% scale**, ensuring a multi-dimensional benchmark for service quality.

Two mathematical models are applied depending on KPI behavior:

- **Linear models** are used for technical success rates and non-perceptual KPIs that follow a direct proportional relationship.
    - *Linear Increasing*: applied where higher values indicate superior performance.
    - *Linear Decreasing*: applied where lower values indicate superior performance.
- **Sigmoid (S-Curve) models** are reserved for perceptual metrics—particularly time-based measures—where improvements near the threshold are more meaningful than those at the extremes. This ensures that scoring accurately reflects human sensitivity to network delays and quality fluctuations.

The detailed mathematical functions underlying these models are presented in **Appendix 1**.

3.1.2. Weight Redistribution and Aggregation

To maintain fairness when data for certain tiers or technologies is missing, the framework applies **Dynamic Weight Redistribution**. In such cases, weights originally assigned to unavailable KPIs are proportionally reallocated to the available ones within the same tier, ensuring that all measured parameters contribute meaningfully to the composite score. The aggregation process then combines these weighted results into a single composite index. This ensures completeness, comparability, fairness, and transparency in the overall scoring process.

3.2. Drive Test (DT) KPIs

The framework introduces a set of Key Performance Indicators (KPIs) that distinctly separate **Radio Frequency (RF) Coverage** from **End-to-End (E2E) Service**, ensuring that both dimensions of mobile network performance are independently and objectively assessed. This segregation enables accurate determination of whether observed deficiencies stem from coverage limitations or from service-level constraints within the network, thereby enhancing diagnostic precision and strengthening regulatory decision-making.

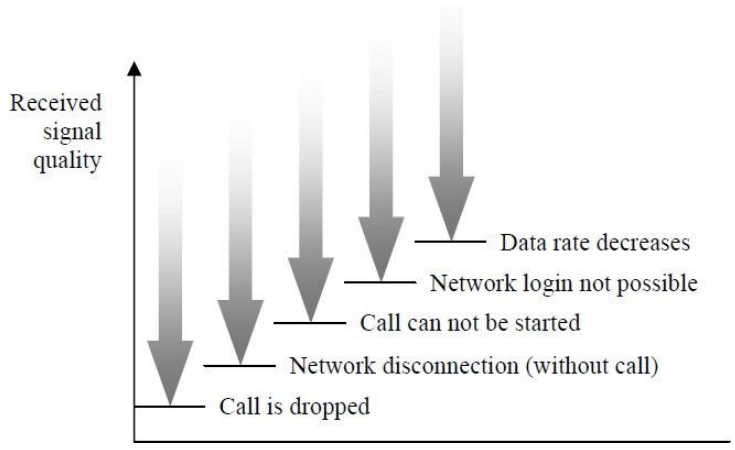
3.2.1. RF Coverage

RF coverage represents the foundational layer of mobile service delivery and serves as the physical foundation of the assessment framework. It evaluates the fundamental availability and integrity of the "air interface" across all active technology layers to ensure that subscribers can access voice and data services reliably, regardless of location.

By auditing these metrics, the Authority ensures that the network provides a reliable and consistent signal blanket—the essential prerequisite for all mobile services. Furthermore, the Authority emphasizes RF coverage assessment to safeguard equitable service provision and to identify underserved areas where infrastructure improvements are required to enhance overall network reach and public connectivity.

3.2.1.1. Proposed KPIs and Targets

The RF Coverage KPIs are designed to segregate **signal strength** from **signal quality**, while recognizing that both dimensions ultimately contribute to the overall RF Coverage score. Signal strength reflects the extent of availability, while signal quality captures the integrity of the received signal. Together, they provide a comprehensive view of how effectively an operator's radio infrastructure delivers service to end users.



Source: ECC Report 103

As highlighted in **ECC Report 103**, degradation in reception quality leads to observable service impacts such as reduced data rates, dropped calls, failed call attempts, and network access failures. These effects underscore the importance of robust RF coverage as the technical basis upon which higher-layer performance indicators, such as speech quality and data throughput, are evaluated. **Table 3** presents the proposed RF Coverage KPI parameters, their respective thresholds, and assigned weights.

Table 3: Proposed RF Coverage KPI Parameters, Thresholds, and Weights

KPI Metric	Technology	Signal Threshold	Samples Threshold (%)		Weighting (%)		
			Worst Acceptable Limit	Excellent Target	Weight of KPI Metric	Weight in Technology	Overall Weight
Signal Strength	4G/5G	RSRP ≥ –100 dBm	60	85	45	60	27
	3G	RSCP ≥ –100 dBm	60	85	45	20	9
	2G	RxLev ≥ –100 dBm	60	85	45	20	9
Signal Quality	4G/5G	RSRQ ≥ –14 dB	60	85	55	60	33
	3G	Ec/Io ≥ –14 dB	60	85	55	20	11
	2G	RxQual ≤ 4	60	85	55	20	11
Total Weight							100

1. *To ensure fairness, if a technology like 5G SA is not detected in a specific cluster, its weight is mathematically redistributed among the active layers. This ensures that an operator is only judged on the technologies actually deployed in that specific location.*
2. *Normalization assumes Linear mathematical model for all the KPI metrics in Table 4 above*

Rationale for Targets

- **Signal Strength Threshold (–100 dBm)**: This limit is established to ensure adequate indoor penetration and link stability. While connectivity is possible at lower levels, –100 dBm is the engineering benchmark for maintaining high-order modulation and preventing frequent session timeouts in cluttered environments.
- **Signal Quality Thresholds (RSRQ, Ec/Io –14 dB; RxQual Grade 4)**: These limits represent the boundaries for "clean" signal reception. Maintaining these levels minimizes the Bit Error Rate (BER), ensuring that the receiver can decode data packets accurately without excessive retransmissions.
- **Samples Threshold (60% to 85%)**: Rather than using simple averages, the framework measures consistency. An *Excellent* rating requires that 85% of the tested area meets the signal threshold, ensuring a seamless experience for the user during mobility. The *Acceptability Floor* of 60% defines minimum viability; networks below this are deemed unreliable and require optimization.

3.2.1.2. Scoring of RF Coverage KPIs

The weighting framework reflects the relative importance of signal presence versus signal integrity in overall network performance, as summarized in **Table 3**:

- **Signal Strength (Weight: 45%)** - Signal Strength (RSRP, RSCP, RxLev) represents basic network availability. A significant weight is assigned because the fundamental "reach" of the network is the first step in user connection, ensuring devices can attach reliably across the target geography.
- **Signal Quality (Weight: 55%)** - Signal Quality (RSRQ, Ec/Io, RxQual) carries the highest weight as it is the most accurate predictor of service performance. In interference-limited networks, strong signal alone is insufficient if quality is degraded. Prioritizing Quality ensures networks are penalized for congestion and interference that directly reduce data speeds and voice clarity.
- **Technology Distribution** - Within the Quality domain, weights are tiered to reflect service criticality:
    - **4G/5G (60%)** – prioritized as the primary carriers for high-speed data and VoLTE services.
    - **3G (20%)** – retained for legacy voice and transitional coverage.
    - **2G (20%)** – preserved for basic voice and machine-to-machine (M2M) connectivity in areas where newer technologies are not yet fully deployed.

By synthesizing these weighted measurements, the composite RF Coverage score provides a transparent and auditable representation of the network's radio environment and its capacity to deliver consistent service quality.

3.2.2. End-to-End (E2E) Service KPIs

E2E Service KPIs assess the actual user experience by measuring service performance across the entire network path — from the radio access to the core and external interconnections. Unlike RF Coverage KPIs, which focus on signal availability and quality, E2E KPIs evaluate the service outcomes experienced by end users.

These indicators cover **Voice, Data,** and **SMS** services, providing insight into network accessibility, retainability, reliability, and overall performance. They form the basis for benchmarking operator compliance with Quality of Service (QoS) standards and for driving continuous service improvement.

3.2.2.1. Proposed KPIs and Targets

The framework evaluates E2E performance by establishing clear performance ranges for each parameter, as detailed in **Table 4**. These benchmarks are anchored in global industry standards and established human-perception limits, ensuring the scoring reflects the actual subscriber experience.

Rationale for Targets

- **Accessibility and Response Times**: The thresholds for **Call Setup Time** and **Data Latency** are derived from the limits of human patience and application sensitivity. For VoLTE, an Excellent Target of 3 seconds provides the near-instantaneous connectivity expected of modern IP-based infrastructure. Conversely, the Worst Acceptable Limit of 10 seconds marks the point where users typically perceive a network "hang" or signaling failure. Similarly, a 40ms Latency target on 4G is required for lag-free real-time interaction, whereas the 100ms limit represents the boundary where performance-sensitive applications, such as video conferencing, begin to experience noticeable jitter.

- **Retainability and Service Stability:** These targets measure the network's ability to maintain a session, defined by the statistical probability of successful completion. The 1.0% Excellent Target for **Drop Call Rates** represents a highly optimized network where 99% of calls are concluded naturally. Setting the Worst Acceptable Limit at 3.5% acknowledges that higher failure rates significantly impact customer churn and reliability perceptions. For data, the 3% **Download Transfer Failure Ratio** ensures that large-file transfers are completed successfully without the need for multiple re-attempts.

- **Perceptual Quality (MOS and Video)**: Integrity metrics quantify the qualitative fidelity of the service experience once established. The framework uses a range for **Voice Quality (MOS)** of 3.0 (Worst Acceptable) to 4.0 (Excellent). A score below 3.0 indicates audible noise and distortion that impairs intelligibility. For Video, the Excellent Target for 5G (4.3 MOS) ensures that high-definition content is delivered without buffering, recognizing that 5G subscribers expect a premium visual experience compared to legacy technologies.

Table 4: Proposed E2E Service KPI Parameters, Thresholds, and Weights

Service	KPI Hierarchy	Parameter	Technology	Unit	Norma-lization Model	Service Target		Weighting (%)			
						Worst Acceptable Limit	Excellent Target	Weight of Service (Data or Telephony or SMS (%))	Weight in Service (%)	Weight in Technology (%)	Overall Weight
Telephony (Voice)	Accessibility	Unsuccessful Call Ratio	All	%	Linear	5	0.5	50	25	100	12.5
		Call Setup Time	2G, 3G, 4G (CSFB)	s	Sigmoid	12	5	50	10	50	2.5
			VoLTE	s	Sigmoid	10	3	50	10	40	2
			5G SA (VoNR)[1]	s	Sigmoid	4	1	50	10	10	0.5
		Call Setup Time > 15 s	All	%	Linear	3	0	50	5	100	2.5
	Retainability	Drop Call Rate	2G, 3G, 4G	%	Linear	3.5	1	50	30	90	13.5
			5G SA (VoNR)[1]	%	Linear	2	0.5	50	30	10	1.5
		Handover Success Rate	All	%	Linear	95	99	50	5	100	2.5
	Integrity	Voice Quality (MOS, POLQA)	2G, 3G, 4G	-	Linear	3	4	50	20	90	9
			5G SA (VoNR)[1]	-	Linear	3.5	4.3	50	20	10	1
		Voice Quality (MOS < 1.6, POLQA)	All	%	Linear	10	0	50	5	100	2.5
SMS	Retainability	Completion Rate for SMS	All	%	Linear	95	99	5	70	100	3.5
	Integrity	End-to-End Delivery Time for SMS	All	s	Sigmoid	15	3	5	30	100	1.5
Data	Accessibility	EN-DC Setup Success Rate	5G (NSA)[2]	%	Linear	94	98	45	10	100	4.5
	Retainability	Download Transfer Failure Ratio	All	%	Linear	13.5	3	45	15	100	6.75
		Upload Transfer Failure Ratio	All	%	Linear	13.5	3	45	10	100	4.5
		HTTP Completion Failure Ratio	All	%	Linear	11.5	2	45	10	100	4.5
	Integrity	Latency	3G	ms	Sigmoid	250	80	45	25	30	3.375

Service	KPI Hierarchy	Parameter	Technology	Unit	Norma-lization Model	Service Target		Weighting (%)			
						Worst Acceptable Limit	Excellent Target	Weight of Service (Data or Telephony or SMS (%))	Weight in Service (%)	Weight in Technology (%)	Overall Weight
			4G	ms	Sigmoid	100	40	45	25	60	6.75
			5G SA (VoNR)[1]	ms	Sigmoid	25	8	45	25	10	1.125
		Video Success Ratio	4G	%	Linear	80	95	45	10	90	4.05
			5G SA (VoNR)[1]	%	Linear	90	98	45	10	10	0.45
		Video MOS Average	4G	-	Sigmoid	3	4	45	10	90	4.05
			5G SA (VoNR)[1]	-	Sigmoid	3.5	4.3	45	10	10	0.45
		HTTP Completion Time	All	s	Sigmoid	8	2	45	10	100	4.5
Total Weight											**100**

[1] *5G SA (VoNR) refers to **Voice over New Radio (VoNR)**, a technology that allows voice calls to be made over a standalone (SA) 5G network architecture*

[2] *5G NSA, or Non-Standalone, is the initial deployment method for 5G networks that uses the existing 4G LTE core network to support a new 5G radio access network (RAN)*

***NB:** To ensure fairness, if a technology like 5G SA is not detected in a specific cluster, its weight is mathematically redistributed among the active layers. This ensures that an operator is only judged on the technologies actually deployed in that specific location.*

3.2.2.2. Scoring of E2E Service KPIs

The scoring logic utilizes a tiered weighting system to ensure that the final performance index is balanced between traditional communication reliability and the evolving demands of the digital economy. As detailed in **Table 4**, these weights are distributed across three distinct levels: **Service-Level**, **Within-Service (Parameter)**, and **Technology-Layer**.

a) Service-Level Weighting (Telephony 50%, Data 45%, SMS 5%)
The framework prioritizes services based on their criticality to the public and their impact on daily economic activities:

- **Telephony (50%):** Voice communication remains the most fundamental service for the public. This high weight ensures that core connectivity is prioritized, particularly for rural accessibility and emergency communications.
- **Data (45%):** Reflects the critical role of mobile broadband in the modern digital economy, acknowledging that data performance is a primary driver of modern subscriber satisfaction and economic productivity.
- **SMS (5%):** Safeguards the reliability of essential text-based notifications such as banking alerts, security authentications (OTPs), and critical government services.

b) Within-Service Parameter Weighting
Weights are distributed within each service pillar to emphasize the specific parameters that most directly influence user experience and service utility.

I. Telephony (Voice) Parameters

- **Unsuccessful Call Ratio (25%):** The most critical voice metric; it determines if the service is accessible. Its high weight reflects the baseline requirement for a functional network.
- **Call Setup Time (10%):** Evaluates signaling efficiency. Weights are split across technologies to reflect the transition from legacy fallback to high-speed VoLTE/VoNR.
- **Call Setup Time > 15s (5%):** Acts as a penalty for extreme signaling delays that fall outside the bounds of reasonable human patience.
- **Drop Call Rate (30%):** The highest-weighted voice parameter because call continuity is the most significant driver of user perception and network reliability.
- **Handover Success Rate (5%):** Ensures seamless mobility, preventing call drops as users move between cell towers.
- **Voice Quality/MOS (20%):** Measures audio clarity, ensuring the network provides intelligible communication rather than just a basic connection.
- **MOS < 1.6 (5%):** Specifically targets "mute" calls or extreme distortion that renders the service unusable.

II. Data Service Parameters

- **EN-DC Setup Success Rate (10%):** Evaluates the network's ability to successfully anchor 5G sessions on the 4G layer (NSA), critical for modern high-speed service entry.
- **Download/Upload/HTTP Failure Ratios (35% combined):** These metrics ensure data sessions are persistent. A high combined weight ensures the network is penalized for "broken" web or file transfers.
- **Latency (25%):** The highest-weighted data parameter, reflecting its importance for real-time applications like video conferencing, gaming, and financial transactions.
- **Video Success & Video MOS (20%):** Acknowledges that video streaming is the dominant traffic type, requiring both successful initiation and high visual quality.
- **HTTP Completion Time (10%):** Measures the responsiveness of standard web browsing, a fundamental daily utility for all users.

III. SMS Service Parameters

- **Completion Rate (70%):** Heavily weighted to ensure that critical, time-sensitive notifications actually reach the user.
- **End-to-End Delivery Time (30%):** Measures the latency of message delivery, ensuring alerts are received within an acceptable timeframe.

c) Technology-Layer Weighting and Strategic Allocation

Weights are assigned to specific technologies (2G, 3G, 4G, and 5G) based on their current operational role and subscriber density.

- **Legacy Priority for Essential Services:** In certain instances, 2G and 3G are assigned higher weights (e.g., 90% for Voice Quality or 50% for Legacy Call Setup) than 5G. This acknowledges that the vast majority of voice traffic and rural connectivity still relies on these layers. Ensuring these "workhorse" technologies perform at high standards is critical for maintaining a reliable safety net for the entire subscriber base.
- **4G as the Primary Data Carrier:** 4G typically receives the highest weight for data services (e.g., 60% for Data Latency). This reflects its position as the current primary infrastructure for mobile broadband.
- **5G as the Emerging Tier:** While 5G SA (VoNR) carries a lower technology weight, it is held to much stricter Excellent Targets. This allows the framework to monitor 5G performance without allowing a limited 5G deployment to unfairly skew the overall network score.

3.2.3. Aggregation of RF Coverage and E2E Service Scores

To derive a single, definitive measure of network performance during drive tests, the framework aggregates the results of the RF Coverage KPIs and the E2E Service KPIs into a **Composite Drive Test (DT) Score**. The final performance grade is determined using the weighted average:

Composite DT Score = (RF Coverage Score × 0.10) + (E2E Service Score × 0.90)

Weighting Rationale

- **RF Coverage Score (10%):**
  Coverage represents the mandatory entry barrier. While signal strength (RSRP) and quality (RSRQ) are essential prerequisites, they do not inherently guarantee service usability. This 10% weight ensures operators maintain basic infrastructure standards without allowing "strong signal" to mask poor service performance.

- **E2E Service Score (90%):**
  This captures the functional outcomes across Voice, Data, and SMS. The 90% weighting reflects the "Functional Utility" of the network, ensuring compliance is judged on the actual experience (Accessibility, Retainability, and Integrity). This drives operators to optimize the entire network chain—from the radio link to the core—rather than just signal availability.

3.3. Network Performance KPIs

Network Performance (NP) KPIs extend beyond drive test measurements to provide a holistic view of service delivery across the operator's infrastructure. They capture performance at scale, using aggregated statistics from the radio access, transmission, and core domains. Unlike DT KPIs, which reflect localized user experience, NP KPIs measure sustained service quality across the entire network footprint.

3.3.1. Proposed KPIs and Targets

The KPIs are grouped into five areas as presented in **Table 5**, each with defined thresholds and targets:

- **Availability** – Measures the operational uptime of cells to ensure the network is consistently "on-air."
- **Accessibility** – Evaluates the success rate of initiating voice and data sessions across all technology layers (2G–5G).
- **Integrity** – Captures the quality and stability of voice services, including call drops and seamless transitions between 4G and legacy networks.
- **Mobility** – Assesses the continuity of service as users move between cells and different radio technologies.
- **Retainability** – Measures the stability of active data sessions, ensuring broadband connections are not prematurely terminated.

Table 5: Proposed NP KPI Parameters, Thresholds, and Weights

KPI Area	Proposed KPI	Technology	Service Target		Weighting (%)			
			Excellent Limit (%)	Worst Limit (%)	KPI Area Weight (%)	KPI Weight (%)	Tech. Weight Factor (%)	Overall Weight
Availability	Cell Availability	All	99.95	99.5	30	100	100	30
Accessibility	Call Setup Success Rate (CSSR)	2G	98.5	95	35	35	35	4.2875
		3G	98.5	95	35	35	25	3.0625
		4G (VoLTE)	98.5	95	35	35	40	4.9
	CS Fallback Success Rate (CSFB SR)	2G/3G	98	94	35	25	100	8.75
	Session Setup Success Rate (SSSR - Data)	4G (E-RAB)	99	96	35	25	100	8.75
	NSA Access Success Rate (SgNB Addition SR - Data)	5G (NSA)	98	95	35	15	100	5.25
Integrity	Call Drop Rate (CDR)	2G, 3G	1	3	15	70	60	6.3
		4G (VoLTE)	1	3	15	70	40	4.2
	SRVCC Handover Success Rate	4G (VoLTE)	98.5	95	15	30	100	4.5
Mobility	Inter-/Intra-RAT Handover Success Rate	All	98	95	5	100	100	5
Retainability	Data Service Drop Rate	3G, 4G	1	3	15	100	60	9
		5G (NSA)	1	3	15	100	40	6
Total Weight								**100**

1. *To ensure fairness, if a technology like 5G SA is not detected in a specific cluster, its weight is mathematically redistributed among the active layers. This ensures that an operator is only judged on the technologies actually deployed in that specific location.*
2. *Normalization assumes Linear mathematical model for all the KPI metrics in Table 5 above*

3.3.2. Scoring of NP KPIs

The assigned weights and thresholds reflect the relative importance of each KPI area in maintaining overall network stability and user satisfaction.

I. Availability (30%)

Cell Availability (100% of area): This is the foundational KPI. Because failure here implies a total service collapse in a given geography, it receives the full weight of the area to ensure operators prioritize basic operational uptime across all technologies.

II. Accessibility (35%)

This area measures the success of initiating voice and data sessions, with weights distributed by technology:

- **Voice (CSSR): 4G VoLTE** carries the highest weight, emphasizing the push for modern, premium voice. **2G** and **3G** are assigned lower weights, reflecting their declining roles as legacy or transitional layers.
- **CS Fallback (CSFB):** Weighted at **4%** due to its critical role in ensuring call initiation for 4G devices in areas where VoLTE is unavailable.
- **Data (SSSR & 5G NSA): 4G E-RAB** success is prioritized as the primary broadband bearer. **5G NSA** is given a moderate weight (**2%**) to support successful technology launches while acknowledging that 4G still carries the bulk of traffic.

III. Integrity (15%)

Integrity safeguards the continuity and quality of voice services:

- **Call Drop Rate (CDR):** 2G/3G and 4G VoLTE are weighted equally (**6% each**) to ensure stability for both legacy users and those on premium modern infrastructure.
- **SRVCC Handover:** Weighted at **3%** to ensure that VoLTE calls do not drop when a user moves out of 4G coverage.

IV. Mobility (5%)

- **Inter-/Intra-RAT Handover Success Rate (100% of area):** This ensures a contiguous network experience. It receives the full area weight because mobility is the defining feature of a functional cellular network.

V. Retainability (15%)

This area measures the ability to sustain active data sessions:

- **Data Service Drop Rate: 3G/4G** is weighted heavily (**9%**) due to its current dominance in broadband traffic. **5G NSA** (**6%**) is weighted to encourage investment in stability as the 5G user base expands.

3.4. Quality of Experience (QoE)

The Authority also assesses the non-technical aspects of Quality of Service (QoS), namely the Quality of Experience (QoE), through questionnaires administered annually as part of the customer satisfaction survey. The objective is to obtain consumer perceptions of Mobile Network Operator services in relation to expectations and service management. The core indicators evaluated include service provisioning, billing, complaints handling, and the ease of accessing customer support services.

To keep pace with the vast nature of the network and the growing connected population, the Authority will explore crowdsourcing as a more immediate and continuous way to measure QoE. This approach is distinct from questionnaires, which incorporate human factors such as expectations and context.

Crowdsourcing may involve passive data collection, where information is retrieved in the background of an application (without user initiation), or active measurements, where an application performs tests upon user initiation. The information gathered includes both measured data and user experience on parameters such as throughput (data speed), latency, stability, and geographical location (coverage) where the test was conducted.

The Authority has also reviewed the questionnaire currently in use, refining its content to capture the most critical elements of QoE. A draft of the revised questionnaire is presented in Annex 5.

3.5. Overall QoS Score and Threshold

The overall Quality of Service (QoS) score is determined by aggregating three components: End-to-End (E2E) Drive Test QoS, Quality of Experience (QoE), and Network Performance KPIs. The weighting framework is shown in **Table 6**.

Table 6: QoS Components' Weighting

QoS Component	Weighting
End to End (E2E) Drive Test QoS	60%
Quality of Experience (QoE)	20%
Network Performance KPIs	20%

The compliance threshold is currently set at **80%**, with a planned upward revision to **85% within the next five years**. This progressive adjustment underscores the Authority's commitment to continuous improvement and alignment with international best practices in service quality.

4. DATA CAPTURE, SOURCING, AND GENERAL REQUIREMENTS

4.1. Data Capture & Sourcing

The data capture and analysis strategy shall be structured based on the 3 QoS components namely: Network Performance, end-to-end QoS Performance and Customer satisfaction assessments as expounded below.

4.1.1. Overall Network Performance

i) Respective network operators and services providers will provide the network coverage and the overall network performance data and analysis on Quarterly basis to the Authority based on data out of their network operations & maintenance facilities.

ii) The tools they will need may differ from one network/service operator/provider to the other. They include the network Operations & Maintenance Centre (OMC) resources, Protocol Analyzers, Automatic Applications Testers among other tools. Raw data shall be streamed automatically by the operators' systems to CA's server.

iii) At the same time the Licensees will analyze the same data and send the subsequent reports in an agreed format to CA, specifying the manner in which the sampling has been done with sufficient detail to enable the Authority to verify the accuracy of the any given report.

iv) CA on the other hand will randomly sample raw data of particular months, analyze and compare with the relevant reports provided by the Licensees.

v) This will enable CA to independently verify the reports submitted by the Licensees. Recommendation ITU-T E.804 will be the general guiding document in this respect.

vi) It is noted that there exist solutions that can take in near real-time data and perform data analysis on the data dump from operators' OMC systems to determine QoS performance KPIs, which systems will be procured by the Authority for this purpose.

4.1.2. E2E Quality of Service (QoS)

End-to-end QoS assessment is normally based on simulation of end user experience. Several methodologies exist in the determination of this QoS assessment. They include the following:

i) Conducting service usage tests through drive/walk test as presently undertaken by CA;

ii) Based on benchmarks conducted by CA, there are other solutions in place, which employ the use of: Specialized stationery or mobile units installed on vehicles.

In order to manage the cost of doing this, the sample size will be restricted to the minimal level that is scientifically sufficient to provide an accurate reflection of the end-to-end QoS status of a particular network and service across the coverage area. The weighting will be on population sampling levels only; Recommendation ITU-T E.804 will be the general guiding document in this respect.

4.1.3. Quality of Experience (QoE)

QoE will be determined based an annual Customer Satisfaction Surveys undertaken with a view to eliciting customers' views relating to Network Availability, Service Quality, Service Tariffs, and Customer Care aspects among others. When evaluating consumer quality of experience, the Authority will evaluate core parameters that tend to mirror what consumers feel directly when accessing and using a service. Core indicators to be evaluated will include network availability, reliability, voice clarity, data speeds, call setup time, call completion rates, and the ease of accessing customer-support services.

In keeping pace with the vast nature of the network and growing connected population, the Authority will explore crowdsourcing as a more immediate and continuous way to measure quality of experience distinct from subjective questionnaire which incorporates human factors like expectations and context.

Crowdsourcing may involve passive data collection where information is retrieved in the background of an application (without user initiation) or active measurements where an application performs tests to gather information upon initiation by a user. The information gathered includes the network parameters such as throughput and well as geographical location where the test was conducted.

4.1.4. Data Sampling/Processing Guidelines

The data sampling in general shall be guided by international best practices and the guidelines contained herein. This QoS framework has been developed with due regard to international standards, most of which are from ITU-T and ETSI. Measurements shall be made, where relevant, under similar conditions such as tests carried out in an automatic way in order to eliminate the possible subjectivity inherent in human intervention situations.

Time factors with regard to distribution of the tests shall be such that it reflects traffic variations over the period of day and days of the week, and type of calls for example originating vs. terminating, etc. Measurements will be performed wherever there is network availability. The number of observations (sample size) shall aim at obtaining a minimum absolute statistical accuracy of less or equal to 2 % with a confidence level of 95%. Coverage assessment statistical accuracy shall be, as a minimum, less or equal to 0.5%.

There shall be a pilot period whose results shall form the basis for making any necessary adjustments to the framework. Where contracted entities are using different test platforms/tools, at the beginning of the Pilot Phase, the said platforms/tools shall be appropriately configured, calibration undertaken and confirmed, and necessary adjustments undertaken to avoid significant variance of the results.

The test platforms/tools shall be periodically verified by the Authority during field-tests as appropriate. Contracted firms shall use qualified and experienced personnel. Where exceptional conditions arise that may distort assessment measurements, CA may exclude the results of such measurements and may order a retake of the measurements. The QoS Regulatory Framework shall be reviewed and updated periodically.

4.1.5. Measurement and Auditing Tools

The Authority reserves the right to apply a combination of the following measurement and auditing tools among other methods that may be used in accordance with this framework and the Act:

i. **Surveys:** One of the ways to evaluate quality and experience perceived by end-user. Concerned service provider will be notified two weeks prior to a consumer quality satisfaction survey.

ii. **Network Performance Measuring System (NP)**: Service providers are obliged to avail their network data for analysis by a network performance (NP) system that shall be resident at the Regulator's server. The NP system shall analyze real-time data from the operators' networks to determine network performance.

iii. **Drive Test for Mobile Measurements (Drive Test)**: Carried out with a calibrated test tool, recording of readings of discrete measurements in frequent, and short intervals (usually every few seconds). The measurement readings can be a multitude of values measured at every time interval in parallel, and therefore comparable. In this setting, multiple probes within one test system can perform multiple test calls in the same time in parallel, for comparative tests of multiple service providers for the same service.

4.2. General Guidelines

4.2.1. Compliance Declaration & Application of Penalties

A licensee will be deemed compliant if they attain an aggregate of 80% or above. In the event of failure by a Licensee, penalties and/or other sanctions will be applied in accordance with the Act.

4.2.2. Publishing of QoS Reports

The network coverage/points of presence and the results of the overall QoS assessments as well as the various components assessed shall be analyzed per county or areas with rollout obligations. The results shall be published on CA's website and/or in local dailies.

4.2.3. Launch of the Framework and Methodology

This framework has been developed by the Authority with input from earlier work undertaken by a consultant, and was subsequently subjected to stakeholder consultation. The comments and suggestions received from respondents have been considered and incorporated to the greatest extent possible, with due regard to the rights of all stakeholders. It is scheduled to take effect upon gazettement, with a piloting period of one year.

4.2.4. Transition from Current Framework to New Framework

A phased approach will be adopted for the introduction of the revised KPIs under the new framework. This phased approach will ensure smooth adoption while maintaining compliance oversight throughout the pilot period.

4.2.5. Implementation of the Framework

The Authority will commence the implementation of this framework by implementing the End-to-End QoS, QoE and the Network Performance components for all the identified Technologies starting upon launch of the framework. The pilot phases will enable the Authority, together with the MNOs, to fine-tune the processes and the tools to be used for the determination of the QoE.

After the respective pilot phases have ended, the various QoS components will be included in the assessment. It should be noted that where any component of the new framework is not operational on account of piloting or other factors, the percentage to be contributed by each component not affected by those factors shall be determined by the Authority and communicated to the Licensees and such weighting shall continue to be applicable until such a time as the relevant component(s) will have come into full operation.

In this regard, the weighting that will be adopted will be based on a proportionate redistribution of the percentage contributed by the component of the framework that cannot be implemented because of the challenge faced. The appropriate weighting set out in the table above will be reinstated thereafter.

4.2.6. Reporting and Publishing of Measurement Results

i. Templates for service providers reporting will be provided by the Authority, and it may modify templates as it deems appropriate to ensure compatibility with post-processing and publishing tools.
ii. Service Providers must publish the indicator reports on their website. CA may decide to publish the results on its website or identify other channels for publishing QoS reports or parts of the reports in such a way that allows the public to evaluate and compare the performance of service providers.

4.2.7. Network Coverage Reporting Requirements

To ensure accountability and consumer awareness, Mobile Network Operators (MNOs) are required to:

- Publish coverage details outlining the areas served and services available on their websites for public access.
- Submit **geospatial and technical data** (KML/KMZ files with site distribution and parameters such as coordinates, configured carriers/cells, transmitter power, azimuth angle, mechanical and electrical tilts, antenna height, antenna beamwidth, antenna gain, and any other information that may be requested by the Authority) to facilitate transparent validation and accurate simulation of coverage claims. This information serves as the baseline for the Authority to conduct transparent validation, perform accurate coverage simulations, and investigate consumer complaints with high precision.

4.2.8. Corrective Action Requirements

Upon formal issuance of the Drive Test (DT) findings for any specific county or cluster, Mobile Network Operators (MNOs) are required to:

- Provide a detailed Corrective Action Plan (CAP) to the Authority within **three (3) weeks** of receipt of the report. The plan must specifically address every identified KPI failure or coverage gap, detailing the technical solution (e.g. optimization, hardware upgrade, or new site build). Further, it must specify clear and measurable resolution timelines. The Authority may track these milestones and conduct follow-up "spot-check" drive tests to verify the effectiveness of the implemented changes.

4.2.9. Drive Test Data Handling and Analysis

The Authority is responsible for the primary processing and analysis of all Drive Test (DT) data. To ensure a fair and technically sound assessment, the following protocols shall apply:

- **"No Service"** DT logs shall be excluded from the **E2E Service KPI** calculations. This ensures that service performance is measured only where a network footprint exists.
- The Authority's processed results shall serve as the official record for compliance assessment. In the event of significant inconsistencies between the Authority's findings and an MNO's internal records, the Authority will engage the operator in a technical reconciliation process.
- The Authority reserves the right to review the raw log files and the post-processing methodologies used by MNOs during these discussions to ensure that any counter-arguments are based on consistent, transparent, and fair engineering practices.

4.2.10. General Provisions

i. The Authority shall periodically review this framework every **three (3) years** to ensure continued alignment with industry standards. However, an earlier review may be conducted whenever deemed necessary to accommodate rapid Technological changes in the industry. In such cases, the Authority will consult with the MNOs before implementing significant updates to the framework.
ii. The Authority has the right to add, remove or modify KPIs and QOS Components and their target values whenever justifiable need arises. Such modification may include specifying target values without the need to update this regulation, provided that relevant service providers will be notified of such changes.
iii. Service providers shall bear all costs related to fulfilling their obligations under these regulations, including, but not limited to costs resulting from measurement procedures related to QoS and experience, or any additional procedures requested by the Authority.
iv. Service providers shall submit Quality of service reports in their networks whenever called upon by the Authority.

5. APPENDICES

Appendix 1: Normalization Functions

A. Linear Scaling (Technical Metrics)

Linear normalization is applied to non-perceptual KPIs that follow a direct proportional relationship.

- **Linear Increasing:** For KPIs where higher values indicate superior performance

$$\frac{x_{\text{floor}} - x}{x_{\text{floor}} - x_{\text{ceil}}}$$

- **Linear Decreasing:** For KPIs where lower values indicate superior performance

$$\frac{x - x_{floor}}{x_{ceil} - x_{floor}}$$

B. Sigmoid / S-Curve Scaling (Perceptual Metrics)

For metrics sensitive to human perception—where improvements at the "tails" of the distribution matter less than improvements near the threshold—a **Sigmoid function** is applied. This is primarily used for time-based metrics

$$\frac{1}{1 + e^{k(x - x_0)}}$$

Where:

- x_{floor} is the worst acceptable limit
- x_{ceil} is the excellent (optimal) target
- x_0 is the is the **Inflection Point** (Midpoint)

$$x_0 = \frac{\text{Excellent Target} + \text{Worst Acceptable Limit}}{2}$$

- $f(x_{\text{ceil}}) \approx 0.95$— score is near-perfect at the aspirational target
- $f(x_{\text{floor}}) \approx 0.05$— score is near-zero at the hard failure boundary
- k is the **Steepness Factor**, calculated to ensure the curve anchors correctly at the boundaries:

$$k = \frac{2 \cdot \ln(19)}{x_{\text{floor}} - x_{\text{ceil}}}$$

Appendix 2: LTE (VoLTE) QOS Parameters

Refs- ITU-T Rec G.1028, E.800, E.804, IR.42)

i) To achieve proper quality of service in LTE networks, MNOs must have;
   a. Internet Protocol Multimedia Subsystem (IMS)
   b. Session Border Control (SBC) for measuring Mean Opinion Score

ii) Single Radio Voice Call Continuity (SRVCC) and Circuit Switched Fall Back (CSFB) are network features that MNOs must put in place to support User Equipment (UE) to ensure continuity/handover of user calls from 2G/3G to 4G and vice versa.

iii) CSFB is required where LTE network has no VoLTE capability. It helps the network to handover/push an attempted call on LTE to 2G/3G network while SRVCC feature enables a call to be made on VoLTE network and handed over to 2G/3G network when signal deteriorates in the LTE network.

iv) The functionalities of these features need to be monitored for effectiveness in delivering quality services to the public.

v) Failure to Monitor the LTE relevant parameters can lead to failure to misleading MNO performance and inability to detect QOS challenges affecting users and therefore inability to find solutions from MNOs on the challenges.

2.1.RSR (%) : Registration Success Rate that denotes the probability of UE successfully registering to IMS Network , **Impact of KPI** : With Low RSR , Customers will not be able to use VoLTE Services . Target 99% (ITU-T G.1028)

$$\text{Registration Success Rate (RSR)} = \frac{Count\ of (200OK) for\ registration\ completed}{Count\ of\ SIP\ REGISTERS\ Sent\ from\ UE\ excluding\ 401\ Error\ Attempts} X100\%$$

2.2.CSSR (%) : Call Setup Success Rate- indicates the probability of successful calls initiated by the MS , **Impact of KPI** : With Low CSSR , Customers will not be able to use make or Received VoLTE Calls - Target 99%

$$\text{Call Set Up Success Rate (CSSR)} = \frac{Count\ of (Normal\ End\ of\ Call + Call\ Failed\ with\ User\ behavious}{Sum\ of\ All\ Call\ Attempts} X100\%$$

2.3.CST (s) :Call Setup Time CST is Time between the start of the call and the moment the phone of the called party starts ringing. **Impact** : High CST will lead to delays & Silence

period before Ring, High CST will obviously deteriorate user experience - Target 2.5sec

2.4. Mute Rate (%) – 5age of calls that experience loss of voice (silence) in both direction of the call occasioned by loss of packets during conversation. **Impact:**- User unable to Talk leading to degraded user experience. Target 1%

% of Calls Muted (samples > 2 or 5s RTP loss in both directions will be treated as Muted call)

2.5. Mean Opinion Score (MOS) (1-5) - is a measure of voice quality on a scale of 1-5, to assess the human users opinion of call quality . **Impact** :- Low MOS bad speech Quality measured through the Session Border Control (SBC) or External Probe / Packet capture. IR.42. Target MOS=4, 3.8 , (LTE-LTE, LTE-3G, LTE-2G) (ITU-T G.1028)

2.6. RTP Packet Loss (%) - *% Percentage of RTP packets lost in the uplink or Downlink direction.* **Impact** :- High Packet loss will lead to Mutes , One Way talk , Call Drops , Bad Quality , Garbled Voice. Target <1%

2.7. One Way Calls (%) - % of Calls having no Voice Packets Counts for 2 or 5 Sec in either the upstream or downstream direction, but not both. **Impact** :- One Way talk , leading to degraded user experience Target <1%

2.8. Volte Attach Success Rate (%) - Impact:-Low Success Rate will lead to VoLTE Registration failures and customers will not be able to use VoLTE IMS Service. Target 99%

2.9. Bearer Activation Success Rate (%) - Impact:-Low Success Rate will lead to VoLTE Registration failures and customers will not be able to use VoLTE IMS Service,. Target 99%

2.10. VoLTE Paging Success Rate (%) - % of Paging responses on ***QCI:5 received at MME.*** **Impact** :- Low QCI:5 PSR will lead to difficulties for users to receive Incoming Calls , They will remain in Out of Coverage. Target 99%

2.11. CSFB call setup failure ratio

Definition: Number of calls successfully started by end users on a 4G/LTE network that are unsuccessfully switched to a 2G/3G network, divided by the total number of call attempts, expressed as a percentage. Target <1%

$$\text{CSFB Call Setup Failure Ratio [\%]} = \frac{\text{unsuccessful CSFB call setup attempts}}{\text{Total number of CSFB call setup attempts}} X 100\%$$

2.12. CSFB call set-up time

Definition: The time it takes to perform the CSFB procedure, i.e., the total time required to start and complete the CSFB procedure from the UE of the calling party. From the end-user's perspective, this metric is strictly equivalent to post dialing delay. Target 2.5 sec

It corresponds to the sum of the CSFB Time –calling party and of the call setup time on the CS (2G or 3G) network

CSFB Call Setup Time (s) = (t calling party receives alerting tone – t user press call button)

2.13. CSFB return to 4G/LTE time

Definition: The average time (in seconds) it takes for a UE to return to 4G from a legacy (2G/3G) network after a CSFB call has been ended by end-user. It is the time needed by the UE to re-join the LTE network after a CSFB call. Target 2.5secs

$Return\ to\ 4G/LTE[s]$= (t first System information block in LTE received $-t$ call disconnected)

2.14. CSFB return to 4G/LTE failure ratio

Definition: The probability that a UE is able, in a given time interval, to return to 4G from a legacy (2G/3G) network after a CSFB call has been ended by end-user. Target <1%

$$\text{Return to 4G LTE Failure Ratio (\%)} = \left(1 \frac{\text{unsuccessful Return to LTE attempts}}{\text{TTotal Return to LTE attempts}}\right) X\ 100\%$$

2.15. SRVCC Success Ratio

Definition: This is the probability that UE successfully handover a VoLTE call to UMTS or GSM. Target 99%

$$\text{SRVCC Success Ratio [\%]} = \frac{\text{Successful SRVCC handovers}}{\text{Total SRVCC attempts}} X100\%$$

2.16. SRVCC Time

Definition: This is the time taken to successfully handover a VoLTE call to UMTS or GSM for a successful SRVCC handover to UMTS or GSM. Target 2.5 seconds

SRVCC Tme (s) = ($t_{\text{SRVCC handover successfully completed}} - t_{\text{SRVCC invoked}}$)

2.17. Video Success Ratio

Video success ratio considers all tests that achieve the defined display time of the video. These tests are classified as completed. The typical display time applied for live YouTube streams is 45s. Attempts include tests with the following states: completed, failed and dropped. It is calculated as

$$\text{Video Success Ratio} = \frac{\text{Number of successfully completed tests}}{\text{Number of attempts}}$$

Where:

$$\text{Number of attempts} = \text{Completed} + \text{Failed} + \text{Dropped}$$

Thus:

$$\text{Video Success Ratio} = \frac{\text{Number of test status Completed}}{\text{Number of test status Completed + Failed + Dropped}}$$

2.18. Video MOS average

Video MOS average is calculated for all successfully completed tests. It is defined as the average of the already averaged video MOS (ITU-T J.343.1) per test. It incorporates all visible degradations during the video display into a MOS.

Appendix 3 - 5G QoS Parameters

Ref: GSM IR 5.2

3.1.New Radio (NR) Reference Signal Received Power (RSRP)

This is the measurement of the power of the main signal the user equipment (UE) is getting from a single cell tower (gNodeB), a better indicator of signal strength, usually appropriate for LTE and 5G RSRP.

When combined with RSRQ (Reference Signal Received Quality) and SiNR (Signal over noise) will provide an holistic view of Radio Quality for the target network. Target -90dBm

$$RSRP\ SIGNAL\ (dBm) = \left(\frac{\Sigma\ \text{NR\_RSRP\_measurements\_taken}}{\Sigma\ \text{Total\_Samples}}\right) X 100\%$$

3.2.VoNR Call Quality Score

The audio quality perceived calculated based on POLQA algorithm and by comparison on reference audio sent vs audio recorded on other side using POLQA algorithm which will provide a score from 1 to 5 (the higher the better). Target 4 MOS

3.3.VoNR Call Setup Time

This indicates the network delay to route the call from originator to destination. Target 2 secs

$$CallSetup\ Time\ [milliseconds] = AVG\ (InviteAccepted - CallAttempt)$$

3.4.VoNR Call Drop Rate

This indicates when network abnormally releases the call interrupting it from the normal code expected from one of the sides. Target 2%

$$Call\ Drop\ Rate\ \% = \left(\frac{\Sigma\ Abnormal\ Call\ Release}{\Sigma\ CallConnect}\right) X 100\%$$

3.5.Jitter

This refers to variation in delay between packets in during the voice call and indicates the difference delay between consecutives packets calculated in both directions Transmit (Tx) and Receive (Rx) directions.

Jitter Tx(Milliseconds) = RTP-Jitter Tx

Jitter Rx(Milliseconds) = RTP-Jitter Rx

3.6.Packet Loss

The amount of data which does not reach destination, causing degragadation in the communication. It is calculated as a percentage of packets lost during the voice call by calculating the packets which never arrive to destination diving by the total packets sent. The metric is in both side Tx and Rx. Target 5%

$$Packet\ Loss\ Tx\ (\%) = (\frac{\Sigma\ Packets\ Lost\ Tx}{\Sigma\ Packets\ Tx})X100\%$$

$$Packet\ Loss\ Rx\ (\%) = (\frac{\Sigma\ Packets\ Lost\ Rx}{\Sigma\ Totla\ Packets\ Rx})X100\%$$

3.7.Latency

It is the time audio signal takes to travel from source to destination and is the average delay between the reference and the test signal. Target 5-10ms

Latency (Milliseconds) = Average Delay

3.8.Data Rate

This indicates the incoming Rx streams and outgoing Tx streams, in kbits per second, from each side during the communication.

3.9.SMS Submission Success Rate

This KPI indicates the successful sending of SMS from the originating party by a confirmation message “OK” at the sending side

$$SMS\ Submission\ Success\ Rate\ (\%) = (\frac{\Sigma\ Received\ Ack}{\Sigma\ Total\ SMS\ Send\ Attempts})X100\%$$

3.10. SMS Submission Delay

This indicates the time in milliseconds it takes to send the SMS from originating party and getting the ACK from SMSC that was effectively submitted

$$SMS\ Submit\ Delay = SMS\ Submit\ \ Ack - SMS\ Submit$$

3.11. SMS End To End Delivery Success Rate

This indicates the success (OK) on SMS delivery to the destination party

$$E2E\ SMS\ Delivery\ Success\ \% = \left(\frac{\Sigma\ Delivered < b - side >}{\Sigma\ Total\ \ Attempts}\right) X100\%$$

3.12. SMS End To End Latency

This indicates the time in milliseconds taken for the SMS delivery from origination party to the destination party

$$SMS\ Submit\ Delay\ (Milliseconds) = SMS\ Received\ time - SMS\ Submit\ time$$

Appendix 4: Definition and References for End-to-End QoS KPI Metrics

A. TELEPHONY

KPI No.	KPI Name	Related indicator definition	Comment / Reference
1.	Unsuccessful call ratio	An unsuccessful call is a call attempt to a valid (and supposed not busy) number, properly dialled following dial tone, where no ringing tone, or answer, is recognized on the access line of the calling user within 30 seconds from the instant when the address information required for setting up a call is sent from the user equipment Unsuccessful telephony call ratio is defined as the ratio of unsuccessful calls to the total number of call attempts in a specified time period. The following statistics shall be provided The percentage of unsuccessful telephony "on-net" (inside the same network) calls (including Mobile to Mobile calls), together with the number of observations made and the accuracy limits for 95 % confidence calculated from this number.	Due to network problems and despite B- party being not busy, it may even be possible for the A-party to receive a busy or not reachable signal. In this case, since no "Alerting" or "Connect" message will be sent, the test sample will be treated as a failure. References: ETSI ES 202 765-2, clause 7.3 ETSI EG 201 769 ETSI EG 202 057-3 V1.1.1 ITU-T E.804, clause 7.3.6.1 (trigger point 7.3.6.1.3) / ETSI EG 202 057-2 V1.3.2, clause 6.6.1 (trigger point 6.6.1.3)
2.	Dropped call ratio	The dropped call telephony dropped call ratio is the probability that a successful call attempt is ended during a standard duration of the communication by a cause other than the intentional termination by the calling or called party.	References: ETSI ES 202 765-2, clause 7.4 ETSI EG 201 769

KPI No.	KPI Name	Related indicator definition	Comment / Reference
		Dropped telephony call ratio is defined as the ratio of unintentionally terminated telephony calls to the total of successful call attempts in a specified time period. The following statistics shall be provided: The percentage of dropped telephony "on-net" (inside the same network) calls (including Mobile to Mobile calls), together with the number of observations made and the accuracy limits for 95 % confidence calculated from this number.	ETSI EG 202 057-3 V1.1.1 ITU-T E.804, clause 7.3.6.5 (trigger point 7.3.6.5.3) / ETSI EG 202 057-2 V1.3.2, clause 6.6.5 (trigger point 6.6.5.3)
3.	Call Set-up time	The period starting when the address information, properly dialled following dial tone, to a valid (and supposed not busy) number required for setting up a call is sent from the calling party and finishing when the called party ringing tone, or answer signal, is received by the calling party. The following statistics should be provided: The following statistics shall be provided: The mean value in seconds for "on-net" (inside the same network) calls (including M-M calls) together with the number of observations made and the accuracy limits for 95 % confidence calculated from this number.	"Alerting" or "Connect" message received by the called party. ETSI ES 202 765-2, clause 7.1 (post dialling delay) ETSI EG 201 769 ETSI EG 202 057-2, clause 5.2} ITU-T E.804, clause 7.3.6.2 (trigger point 7.3.6.2.3) / ETSI EG 202 057-2 V1.3.2, clause 6.6.2 (trigger point 6.6.2.3)
4.	Voice Quality	Represents the intrinsic quality of speech signal after transmission. This indicator takes into account the degradations generated on the signal by the transmission links. The following statistics shall be provided:	Voice quality should be measured using a special equipment enabling to handle ITU- T P.863 (POLQA) References:

KPI No.	KPI Name	Related indicator definition	Comment / Reference
		The mean value for "on-net" (inside the same network) calls (including M-M calls) together with the number of observations made and the accuracy limits for 95 % confidence calculated from this number.	ITU-T P.863 (09/2014)
5.	Handov er Success Rate	The capacity to sustain connection while in motion. Mobility test	

B. SMS

KPI No.	KPI Name	Related indicator definition	Comment / Reference
1.	Completion Rate for SMS	Ratio of correctly sent and received SMS between two terminal equipment. The following statistics should be provided separately: a) Ratio of successfully sent and received short messages; b) Number of observations used and the absolute accuracy limits for 95 % confidence calculated from this number.	This rate is the probability of an SMS to be successfully delivered to its destination, i.e., the rate between the number of messages successfully received at the destination terminal equipment and the number of message sent. An SMS is considered to be received with an error when it has at least one incorrect bit upon reception. Message sent without receiving notification "message sent" are considered failed message. References: ETSI EG 202 009-2 V1.3.1 ETSI EG 202 057-2 V1.3.2 (5.6.2)

KPI No.	KPI Name	Related indicator definition	Comment / Reference
			ETSI TS 102 250-2 V2.3.1 (7.4.4 – completion failure ratio) ETSI TS 102 250-5 V2.4.1
2.	End-to-End delivery time for SMS	The end-to-end delivery time for SMS is the period starting when sending a SMS from a terminal equipment to a Short Message centre and finishing when receiving the very same SMS on another terminal equipment.	A message is received within less than 5 seconds if the message is received matching the criteria of the metric 'Completion rate for SMS" and if the receiving time of the received message does not exceed 5 seconds. References: ETSI EG 202 009-2 V1.3.1 ETSI EG 202 057-2 V1.3.2 (5.6.3) ETSI TS 102 250-2 V2.3.1 ETSI TS 102 250-5 V2.4.1

C. DATA/INTERNET

KPI No.	KPI Name	Related indicator definition	Comment / Reference
1.	Latency	Amount of time it takes for a packet to reach the receiving endpoint after being transmitted from the sending endpoint. This metric includes the definition of Delay (one way transmission time) defined in clause 5.5 of EG 202 057-4 [1], for the ping delay. The following statistics should be provided: o The mean values of the latency in milliseconds The latency is calculated from the ping echo responses delay. Latency [milliseconds] = One_way_delay = average (½ time (Echo Reply Message)) (refer to UIT-T Y.1540 and UIT-T Y.1541 for definition, conditions and calculation)	Tests are carried with a remote test- server in the close vicinity of the Licensee networks Ping (using IP address of the test- server) can be used to measure this latency, in this case delay is half the time, in milliseconds, that is needed for an ICMP Echo Request/Reply Ping delay = average (time (Echo Reply Message)) References: ETSI EG 202 057-4 ETSI ES 202 765-4 RFC 792 UIT-T Y.1540 UIT-T Y.1541
2.	Jitter	The difference in the end-to-end latency between packets. The jitter is assessed by the standard deviation of the delay when ping delay measurements are performed (see latency	References: ETSI EG 202 057-4 ETSI ES 202 765-4 RFC 792

KPI No.	KPI Name	Related indicator definition	Comment / Reference
		metric above) Jitter [milliseconds] (refer to UIT-T Y.1540 and UIT-T Y.1541for definition, conditions and calculation)	UIT-T Y.1540 UIT-T Y.1541
3.	EN-DC Set-up Success Rate	5G (NSA)*	
4.	Download transfer failure ratio	The average throughput of successful data transfer over a communication channel (client/server measurement). o Download in failure ratio [%] = (Download in failure / number of tests) x 100	
5.	Upload transfer failure ratio	The average throughput of successful data transfer over a communication channel (client/server measurement). o Upload in failure ratio [%] = (Upload in failure / number of tests) x 100	
6.		The number of packets lost as a percentage of the total number of packets transmitted Packet loss ratio [%] = (Total number of packet lost / Total number of packet transmitted) x 100	Packet loss is impacting for real time data like VoIP/ToIP, video conferencing or gaming regarding end user perception of the quality of service. It is also impacting web browsing regarding delays/slowness.

KPI No.	KPI Name	Related indicator definition	Comment / Reference
	Ratio of Packet Loss	(Refer to UIT-T Y.1540 and UIT-T Y.1541for definition, conditions and calculation)	Tests are carried out with a remote test- server in the close vicinity of the Licensee networks or on a remote (foreign) location or both. Pack loss measurement in the Licensee network assesses the quality of the Licensee own network. Pack loss measurement outside the Licensee (remote server test case) assesses the quality of the service provided to the customers of the Licensee (not considered here). References: UIT-T Y1540 UIT-T Y1541
7.	HTTP Completion failure ratio	HTTP completion failure ratio [%] = (Total number of successful completed downloaded page/Total number of requested pages) x 100	HTTP completion Time can only be measured for “established” HTTP connection.
8.	HTTP Completion Time	The HTTP completion Time is the period of time starting from the instant when the connection to the web page is requested to the instant when the complete web page content is fully received. The ratio of web pages that failed to be successfully downloaded / completed is also recorded.	HTTP completion Time can only be measured for “established” HTTP connection.

KPI No.	KPI Name	Related indicator definition	Comment / Reference
		T = period of time from the instant when the connection to the web page is requested to the instant when the complete web page content is fully received W = size of the web page in Mbytes Because all web pages do not have the same size it is necessary to scale the download period to the size of the downloaded page. HTTP completion Time [s] = T x 1/W	
9.	Video Success Ratio	The probability that a video streaming session is successfully initiated and starts playback within a predefined setup time (e.g., < 5 seconds). It is calculated as the ratio of successful playback starts to the total number of playback attempts.	This reflects the network's ability to handle initial buffering and content delivery. It identifies bottlenecks in the initial TCP/QUIC handshake or high latency in the CDN/Core network. References: ITU-T G.1010 ITU-T E.800
10.	Video MOS Average	The average **Mean Opinion Score (MOS)** recorded throughout the duration of the video session. It quantifies the perceptual quality of the video, accounting for resolution changes (bitrate adaptation), frame freezing (stalling), and initial loading delay.	Unlike binary success/failure metrics, MOS captures the "Utility" of the service. In adaptive bitrate environments (4G/5G), this measures how often the network forces a down-switch in resolution due to congestion or poor SINR. References: ITU-T P.1203

Appendix 5: Draft Quality of Experience (QoE) Survey for Mobile Services

SECTION A: DEMOGRAPHICS

1. Gender: Male ☐ Female ☐
2. Age (years): Below 18☐ 18–24 ☐ 25–34 ☐ 35–44 ☐ 45–54 ☐ Above 54 ☐

SECTION B: QUALITY OF EXPERIENCE (QoE) WITH MOBILE NETWORK SERVICE PROVIDERS

3. Current mobile service provider(s): MNO-A ☐ MNO-B ☐ MNO-C ☐ MNO-D ☐ Other: _____
4. Factors considered when choosing provider (tick all): Coverage ☐ Pricing ☐ Service Quality ☐ Promotions ☐ Other: _____
5. Challenges experienced (tick all): Coverage ☐ Billing ☐ Customer Care ☐ Roaming ☐ Call Drop ☐ Other: _____
6. Frequency of loss of service: All the time ☐ Most ☐ Some ☐ Rarely ☐ Never ☐
7. Able to send SMS? Yes ☐ No ☐ Don't use SMS ☐ | Frequency: Never ☐ Rarely ☐ Often ☐
8. Unsolicited SMS? Yes ☐ No ☐ | Frequency: Daily ☐ Weekly ☐ Monthly ☐ Yearly ☐
9. Mobile Internet quality: Never drops ☐ Stable but varying speed ☐ Drops regularly ☐ Very poor ☐ Don't use mobile internet ☐
10. Mobile internet challenges: Website access issues ☐ Poor customer service ☐ Other: _____
11. Mobile internet satisfaction (1–5; *1 being very dissatisfied and 5 very satisfied*): 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Billing & Charges

12. Billing accuracy (1–5): Calls ☐ SMS ☐ Data ☐
13. Billing clarity: Consistent ☐ Clear ☐ Accurate ☐
14. Billing satisfaction (1–5; *1 being very dissatisfied and 5 very satisfied*): 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Complaints Handling

15. Are you aware of complaint procedures and where to complain? Yes ☐ No ☐
16. Have you ever lodged a complaint? Yes ☐ No ☐ | Ease (1–5): 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
17. Complaint resolution satisfaction (1–5; *1 being very dissatisfied and 5 very satisfied*): 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Customer Care

18. Overall customer care experience (1–5; *1 being very dissatisfied and 5 very satisfied*): 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
19. Accessibility rating (1–5; *1 being very Inaccessible and 5 very accessible*): 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

SECTION C: OVERALL PERFORMANCE & RECOMMENDATIONS

20. Overall network quality rating: Very poor ☐ Unsatisfactory ☐ Average ☐ Satisfactory ☐ Superior ☐ Additional comments: _____