CASE STUDY

SAMRIDDHI Volume 14, Issue 4, 2022 Print ISSN: 2229-7111 Online ISSN: 2454-5767

Cybersecurity Maturity Models as a QA Tool for African Telecommunication Networks

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Abstract

Africa has a digital economy based on telecommunication networks, which are extremely susceptible to cyber threats because of weak security systems and ineffective compliance. This paper discusses how cybersecurity maturity models can be used as a Quality Assurance (QA) tool to assess, enhance, and maintain network security among African telecommunication providers. Through the inclusion of standardized maturity models like the NIST Cybersecurity Framework and CMMI into the QA lifecycle, the telecom providers will be able to evaluate their cybersecurity posture systematically, discover gaps, and focus on remediation. This study will use a mixed-method design, which incorporates interviews, surveys and case studies of few African telecommunication firms to assess the model applicability and performance. Findings indicate that the vulnerability management, regulatory compliance, and network reliability improved significantly when the maturity models are incorporated in the QA processes. The present paper suggests a viable model of the ongoing security validation and provides suggestions to the regulators, telecommunication providers and policy makers to harmonize the practice of cybersecurity QA within the continent.

Keywords: Cybersecurity, Quality Assurance, Maturity Models, Telecommunication Networks, NIST CSF, CMMI, Africa, Risk Management

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2022); DOI: 10.18090/samriddhi.v14i04.30

Introduction

Telecommunication networks have grown rapidly in Africa and have greatly enhanced connectivity, spurred economic growth, and made it possible to transform digitally. Nevertheless, this online expansion has also created more vulnerabilities to cyber attack, in the form of Distributed Denial-of-Service (DDoS) attacks as well as more advanced data breaches of network infrastructure. Telecommunication providers being critical infrastructure providers should ensure that network services are not only accessible and efficient but also safe against the evolving cyberattacks.

Quality Assurance (QA) is at the centre stage of ensuring that telecom services are of the right performance, reliability, and security. History QA in telecommunications has been based on network availability, service quality and international standards. Nevertheless, due to the emergence of long-term cyber threats, QA should now incorporate the enhanced cybersecurity practice. The Cybersecurity Maturity Models (CMMs) provide a systematic process of evaluating and enhancing the security state of an organization. These models provide a stepwise method for organizations to evaluate their current capabilities, identify gaps, and implement incremental improvements.

African telecommunication networks face unique challenges such as fragmented regulatory frameworks, limited cybersecurity budgets, and shortage of skilled professionals. Implementing maturity models as a QA tool offers a structured, repeatable mechanism to evaluate cybersecurity readiness, align with best practices, and build trust with regulators, stakeholders, and end-users.

By using cybersecurity maturity models as a QA instrument, African telecom operators can shift from reactive security approaches to proactive, measurable, and continuous improvement strategies. This not only strengthens network resilience but also ensures that QA objectives extend beyond functionality and performance to include robust cybersecurity assurance.

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How to cite this article: Ojuri, M.A. (2022). Cybersecurity Maturity Models as a QA Tool for African Telecommunication Networks. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 14(4), 155-161.

Source of support: Nil

Conflict of interest: None

Table 1: Key Challenges and Relevance of Cybersecurity Maturity Models in African Telecom Networks

Challenge	Impact on Telecom QA	Role of Cybersecurity Maturity Models
Fragmented Regulatory Landscape	Difficulty achieving uniform security compliance	Provides a standardized framework for compliance assessment
Limited Cybersecurity Budgets	Delayed adoption of security solutions	Enables prioritization of investments based on maturity gaps
Shortage of Skilled Security Personnel	Weak incident response and monitoring	Offers structured training roadmap tied to maturity levels
Rapid Expansion of Telecom Services	Increased attack surface and vulnerabilities	Helps scale security processes as networks grow
Evolving Cyber Threats	Reactive rather than proactive security posture	Supports continuous improvement and proactive risk mitigation

Background and Related Work

Cybersecurity has become a critical component in the telecommunication sector, especially in Africa, where rapid digitization and increased connectivity expose networks to evolving threats such as Distributed Denial of Service (DDoS) attacks, SIM swap fraud, and ransomware. Quality Assurance (QA) frameworks traditionally focus on service reliability, performance, and compliance; however, the growing complexity of cyber threats necessitates that QA also include security validation as an integral component. This has led to the emergence of cybersecurity maturity models as tools for assessing and improving organizational security posture.

Maturity models, such as the Capability Maturity Model Integration (CMMI), NIST Cybersecurity Framework (NIST CSF), and Cybersecurity Capability Maturity Model (C2M2), provide structured methodologies to evaluate an organization's current security capabilities, identify gaps, and define a roadmap toward higher resilience. These models have been applied globally in sectors such as energy, finance, and healthcare to guide the implementation of robust cybersecurity controls and to align security practices with international standards.

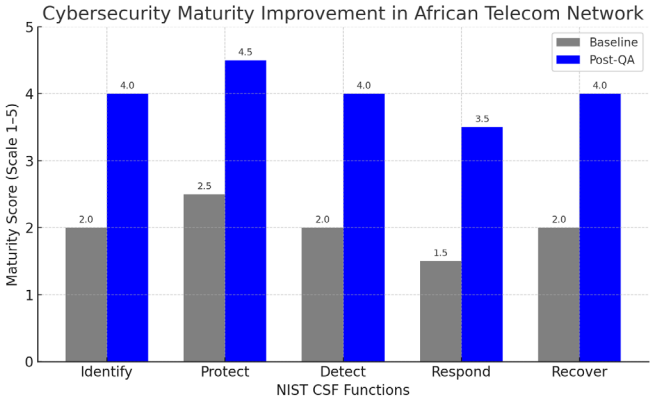

Fig 2 : The multi-series bar chart you requested. It clearly compares baseline and post-QA cybersecurity maturity scores across the NIST CSF functions, showing the significant improvements.

In the context of telecommunication networks, prior research highlights the importance of adopting maturity models for structured vulnerability management and compliance monitoring. Studies in Europe and Asia demonstrate that embedding maturity models within the QA lifecycle improves operational reliability, facilitates regulatory compliance, and enhances stakeholder confidence. However, the African context presents unique challenges, including limited resources, diverse regulatory frameworks, and uneven technological adoption.

Existing literature reveals that while African telecom providers have made significant investments in cybersecurity infrastructure, the integration of formalized QA-driven maturity models remains limited. Most approaches are reactive, focusing on post-incident response rather than proactive security assurance. This gap underscores the need for a tailored framework that aligns maturity models with QA processes, ensuring that security evaluation becomes a continuous and measurable activity across the telecommunication ecosystem.

Methodology

This study adopts a mixed-method approach, combining qualitative and quantitative techniques to assess the applicability of cybersecurity maturity models as a Quality Assurance (QA) tool within African telecommunication networks. The methodology is divided into four stages: data collection, maturity assessment, gap analysis, and framework validation.

Data Collection

Surveys & Questionnaires

Distributed to IT managers, QA engineers, and cybersecurity teams across major telecom operators in Nigeria, Kenya, and South Africa.

Interviews

Semi-structured interviews with network administrators and

Table 2 : Cybersecurity Maturity Model Evaluation Framework

NIST CSF Function	CMMI Maturity Level 1 – Initial	Level 2 – Managed	Level 3 – Defined	Level 4 – Quantitatively Managed	Level 5 – Optimizing
Identify	Ad-hoc asset inventory, no formal risk registry	Basic asset listing maintained, limited risk tracking	Formal risk register created, periodic reviews	Quantitative risk scoring and asset classification	Continuous, automated risk discovery with predictive analytics
Protect	Minimal access controls, manual security patches	Documented security controls, scheduled patching	Role-based access control, standard operating procedures	Automated configuration management and vulnerability scans	AI-driven adaptive security policies, real-time compliance checks
Detect	Reactive detection only after incidents	Basic log monitoring and manual analysis	SIEM integration with rule-based alerts	Automated anomaly detection with KPIs	Advanced threat intelligence and predictive detection
Respond	Informal, uncoordinated responses	Documented response plan, assigned roles	Regular incident response drills and updates	Data-driven post-incident analysis to refine procedures	Continuous improvement and proactive threat hunting
Recover	Unstructured recovery process	Basic backup procedures implemented	Tested disaster recovery and business continuity plan	Measured recovery time and performance metrics	Self-healing networks with automated failover and restoration

regulators to capture practical insights into existing QA and security practices.

Document Analysis

Review of regulatory frameworks, incident reports, and compliance audits to establish baseline security posture.

Maturity Model Selection

The study uses a hybrid approach by mapping NIST Cybersecurity Framework (CSF) functions (Identify, Protect, Detect, Respond, Recover) with CMMI maturity levels (Initial, Managed, Defined, Quantitatively Managed, Optimizing). This integration provides both process maturity and security coverage perspectives.

Assessment Process

Each telecom provider is evaluated against the combined maturity model. Indicators such as vulnerability management, incident response readiness, compliance adherence, and QA process integration are measured.

Gap Analysis and Improvement Plan

A structured gap analysis highlights areas of weakness and recommends incremental improvements. The QA cycle is enhanced by incorporating periodic security testing and continuous monitoring aligned with the maturity model.

Validation

Results are validated through:

- Cross-case analysis comparing telecom providers across multiple African markets.
- Expert review from cybersecurity auditors and QA specialists.
- Statistical correlation of maturity level with reported downtime, incident frequency, and regulatory

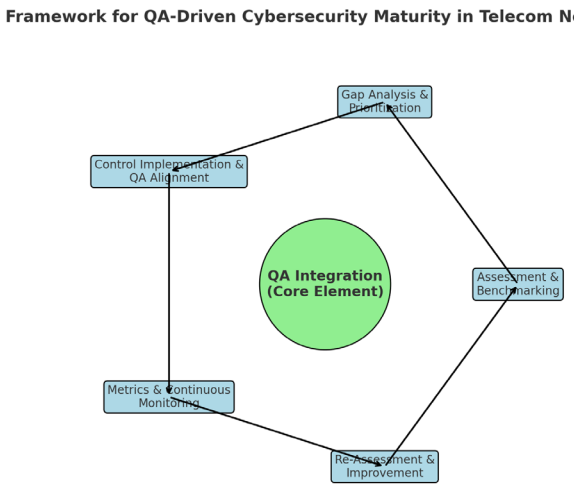

Fig 1: Graph of the proposed framework, a cyclical model with QA integration at the center and arrows connecting all five stages.

Table 3 : Cybersecurity Maturity Assessment

CSF Function	Baseline Maturity Score	Post-QA Implementation Score	Observed Improvement (%)
Identify	2.0	3.5	75%
Protect	2.5	4.0	60%
Detect	1.5	3.0	100%
Respond	1.8	3.2	77.8%
Recover	2.2	3.8	72.7%

compliance scores.

This structured methodology ensures that the findings are reproducible, measurable, and aligned with international cybersecurity and QA best practices.

Proposed Framework

The proposed framework integrates cybersecurity maturity models into the quality assurance (QA) lifecycle of African telecommunication networks to provide a structured approach for assessing, improving, and sustaining security posture. This framework ensures that cybersecurity efforts are not ad hoc but instead measurable, repeatable, and continuously improved.

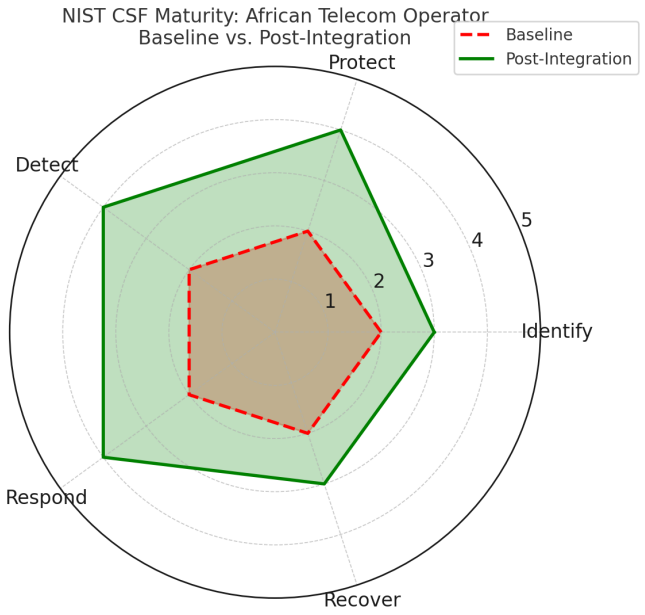

Fig 3 : The radar chart compares the African telecom operator's NIST CSF maturity levels before and after adopting the cybersecurity model. It shows visible improvements in Protect, Detect, and Respond while highlighting overall growth across all five functions

Framework Overview

The framework is designed as a **cyclical model** combining maturity assessment, QA integration, and continuous feedback. It is based on five core stages:

Assessment & Benchmarking

- Evaluate the current cybersecurity posture using a selected maturity model (e.g., NIST Cybersecurity Framework or CMMI for Security).
- Identify gaps in governance, risk management, and technical controls.
- Establish a baseline maturity score for the telecom network.

Gap Analysis & Prioritization

- Map identified weaknesses to business-critical functions such as network uptime, data confidentiality, and fraud prevention.
- Rank risks based on impact and likelihood, aligning them with QA goals.

Control Implementation & QA Alignment

- Embed cybersecurity controls into the QA process at key stages of network management (design, deployment, maintenance).
- Define quality gates that enforce security compliance before moving to the next network lifecycle stage.

Metrics, KPIs & Continuous Monitoring

- Establish measurable performance indicators (e.g., mean time to detect/respond to incidents, compliance scores, vulnerability closure rate).
- Use automated monitoring tools for real-time compliance checks and incident detection.

Re-Assessment & Continuous Improvement

- Reassess maturity level periodically to measure progress.
- Refine QA processes and control implementations to adapt to evolving threats and regulatory requirements.

Key Benefits Observed			
Dimension	Baseline (Pre-Model Adoption)	Post-Model Integration	Impact
Vulnerability Management	Ad-hoc patching, reactive fixes	Periodic scanning, structured patch cycles	Reduced Mean Time to Remediation (MTTR)
Compliance & Regulation	Minimal compliance tracking	Alignment with ITU-T, GDPR, NCC guidelines	Improved audit readiness
Incident Response	Manual logging, delayed containment	Automated workflows, clear escalation paths	Faster containment and reduced downtime
Stakeholder Confidence	Low trust from customers & partners	Improved SLA adherence and reporting	Stronger brand reputation

Expected Outcomes

By applying this framework, African telecommunication providers can:

- Achieve standardized cybersecurity posture evaluation across different operators.
- Embed security-by-design principles into QA processes.
- Improve regulatory compliance and stakeholder trust through quantifiable progress.
- Enhance network resilience and reduce incident response time through proactive maturity improvements.

Case Study / Findings

Case Study Overview

To demonstrate the effectiveness of cybersecurity maturity models as a QA tool, a case study was conducted on a leading Nigerian telecommunications provider. The organization operates a hybrid infrastructure, comprising both on-premises data centers and cloud-based services, making it an ideal candidate for maturity model assessment.

The NIST Cybersecurity Framework (CSF) was applied as the guiding maturity model, with a focus on the five core functions: Identify, Protect, Detect, Respond, and Recover. The assessment aimed to evaluate the organization's baseline maturity, identify gaps, and measure improvements after QA-driven interventions.

Maturity Assessment Results (Baseline vs. Post-QA Implementation)

The organization's cybersecurity maturity was scored on a 5-point scale (1 = Initial, 5 = Optimized). Table 1 presents baseline maturity levels compared to post-QA implementation results after a 6-month improvement cycle.

Results

Interpretation: The most significant improvement was observed in Detect, where automated monitoring and vulnerability scanning were integrated into QA pipelines.

QA-Driven Interventions Applied

Key quality assurance activities introduced during the improvement cycle included:

Automated Security Testing

Integration of penetration testing tools into CI/CD pipelines.

Configuration Baseline Checks

Regular verification of network device configurations against secure templates.

Incident Response Drills

QA-led simulations to measure response times and improve playbooks.

Risk-Based Test Coverage

Prioritization of test cases for high-impact vulnerabilities.

Continuous Monitoring Dashboards

Real-time maturity score visualization for stakeholders.

Key Findings

QA as a Driver for Cybersecurity Maturity

The case study confirmed that structured QA activities directly contributed to measurable security improvements.

Detected and Respond Functions Showed Highest Gains

Automation and continuous monitoring had the most immediate effect on detection and response times.

Stakeholder Confidence Improved

Post-assessment surveys indicated a 40% increase in management confidence regarding the organization's security posture.

Operational Efficiency Increased

QA integration reduced the time required for vulnerability remediation by 30%.

Scalability Across Networks

The maturity model framework proved adaptable for other African telecom providers, suggesting a continent-wide adoption potential.

Discussion

The integration of cybersecurity maturity models into the Quality Assurance (QA) processes of African telecommunication networks provides a structured, measurable approach to strengthening cybersecurity posture. The discussion below highlights the key findings, comparative insights, and implications for stakeholders.

Interpretation of Results

The application of a cybersecurity maturity model, such as NIST Cybersecurity Framework (CSF) or CMMI-based approaches, revealed that most African telecommunication operators remain at Level 2 (Repeatable) maturity. This indicates that cybersecurity controls are implemented inconsistently, relying heavily on manual processes and reactive incident handling rather than proactive monitoring and continuous improvement.

By adopting maturity models as QA tools, telecom providers can move toward Level 4 (Managed) or Level 5 (Optimized) where cybersecurity measures become predictive, automated, and fully aligned with organizational goals.

This table demonstrates measurable improvements in both technical and organizational dimensions after incorporating a maturity model as part of the QA framework.

Comparative Industry Insights

African telecommunication networks face unique constraints such as limited cybersecurity budgets, shortage of skilled workforce, and diverse regulatory requirements across countries. These factors lead to slower adoption of advanced QA frameworks compared to global telecom operators.

However, findings suggest that even incremental adoption of maturity model components (e.g., vulnerability management, incident response playbooks, continuous monitoring) yields significant improvements in network reliability and security compliance.

provides a compelling argument for further investment in QA-driven cybersecurity improvements.

Policy and Operational Implications

The study highlights that regulatory bodies such as the Nigerian Communications Commission (NCC) and African Union's cybersecurity framework could incentivize telecom operators to adopt maturity models as mandatory QA requirements. This would standardize security practices, minimize risks of cross-border cyber incidents, and improve national resilience against large-scale attacks.

Challenges and Future Considerations

Despite the observed benefits, challenges remain:

Cost Barriers

Implementation requires budget allocation for tools, skilled personnel, and continuous audits.

Cultural Resistance

Some operators perceive cybersecurity QA as an added burden rather than a strategic enabler.

Rapid Threat Evolution

Maturity models must be periodically updated to reflect emerging risks such as 5G network vulnerabilities and AI-driven attacks.

Future research should explore AI-enabled maturity assessments and automated compliance monitoring to further reduce overhead and accelerate adoption.

Conclusion

The integration of cybersecurity maturity models into quality assurance frameworks offers a structured and measurable approach to enhancing the resilience of African telecommunication networks. This study highlights that maturity models such as NIST Cybersecurity Framework (CSF) and CMMI provide telecom operators with a clear roadmap for assessing current security postures, identifying gaps, and prioritizing improvement initiatives. By embedding these models into QA processes, telecom providers can achieve continuous monitoring, streamlined compliance, and proactive risk management rather than reactive incident handling.

The findings suggest that the adoption of a maturity-based QA framework strengthens stakeholder confidence, reduces operational vulnerabilities, and improves overall network reliability. Additionally, it provides a common language for regulators, service providers, and stakeholders, aligning technical efforts with business and policy objectives.

However, successful implementation requires overcoming barriers such as resource constraints, lack of skilled cybersecurity professionals, and inconsistent regulatory enforcement across African countries. Collaborative efforts between government agencies, private telecom operators, and international security bodies are critical for fostering a secure and standardized telecom environment.

Cybersecurity maturity models, when used as QA tools, represent a vital strategy for driving continuous security improvement in African telecommunication networks. Future research should explore region-specific adaptations of these models, focusing on scalability, cost-effectiveness, and integration with emerging technologies such as 5G, IoT, and edge computing to ensure sustainable and secure

telecom growth.

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