

WHITEPAPER

Co-Existence and Beyond

How AutoRAN Enhances, Not Replaces,
Your Existing Test Infrastructure

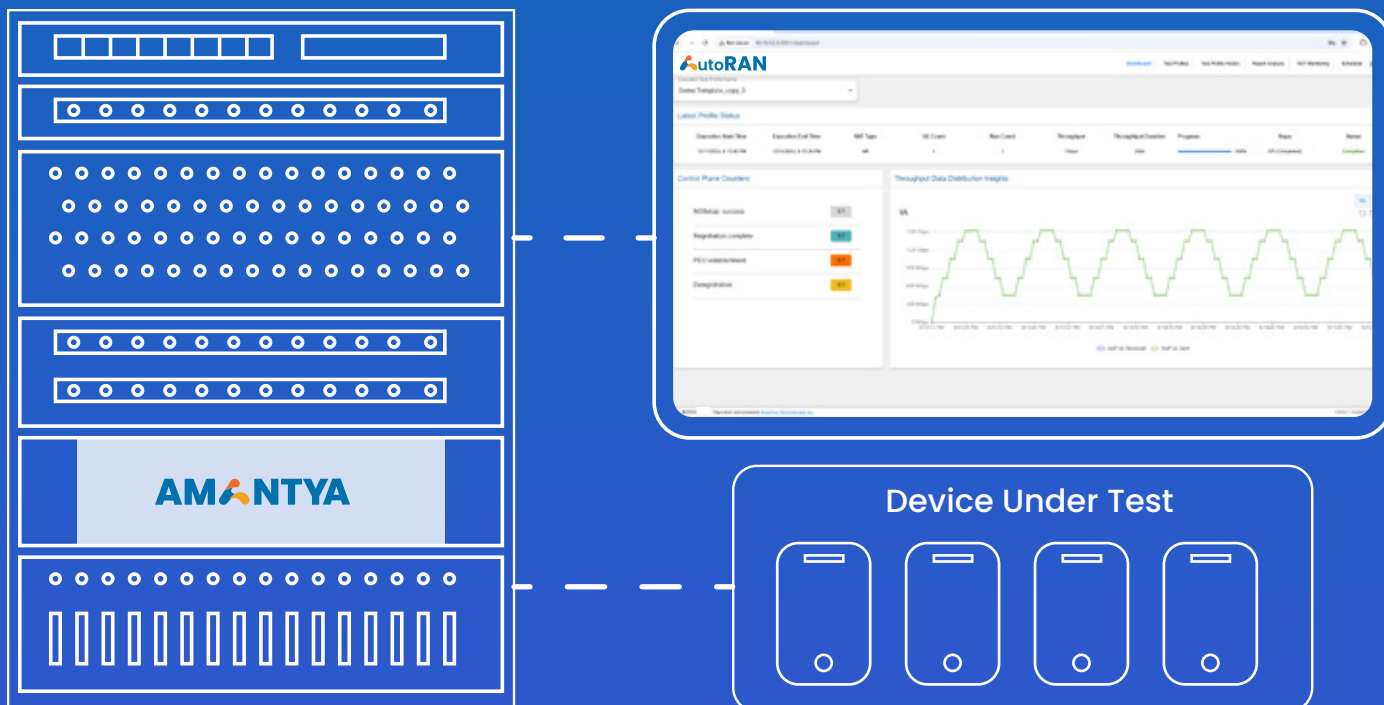


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1. Executive Summary



The telecom landscape is undergoing a major shift with the rise of 5G Standalone, Open RAN, and Non-Terrestrial Networks. These technologies promise flexibility and scalability but also introduce complexity in validating network performance, especially when it comes to real-world conditions.

While traditional test environments, centered on simulators and protocol conformance, are still necessary, they fall short in capturing live device behavior, unpredictable mobility, and true user experience.

Amantya Technologies' AutoRAN offers a smarter approach. By adding real-device validation, AI capabilities, and automation to existing test setups, it enables faster releases, better field readiness, and more confidence in deployment. This whitepaper explains how AutoRAN enhances traditional RAN testing for next-generation networks.

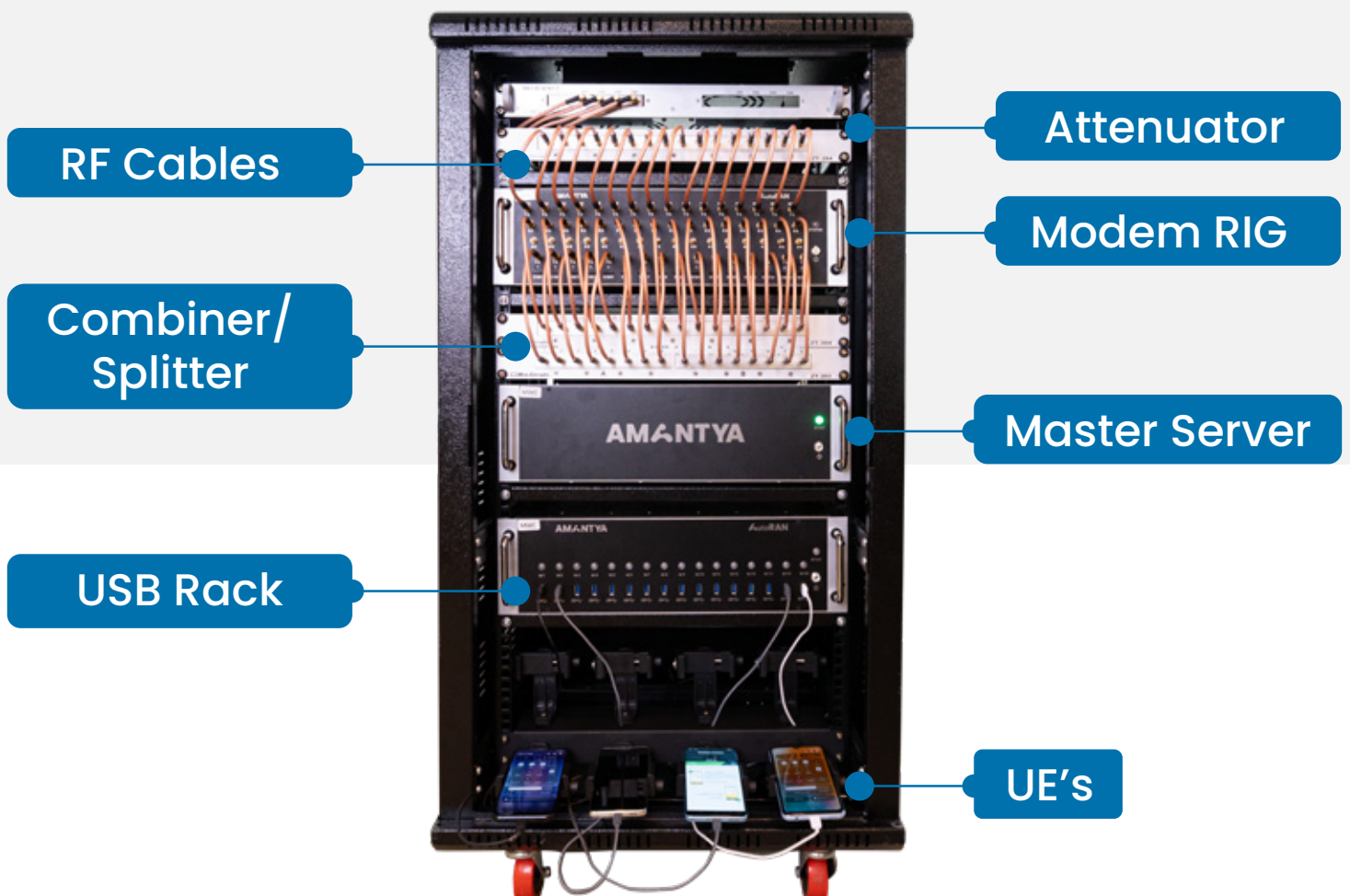
2. Introduction

As 5G networks mature and Open RAN and NTN enter mainstream adoption, the way we test Radio Access Networks must evolve. Engineers are now working in environments with disaggregated architectures, rapid release cycles, and a wide variety of UEs – including IoT, NB-IoT, and satellite-enabled devices.

Legacy lab-based tools like simulators and traffic generators were built for predictable, closed systems. But today's networks are dynamic, distributed, and device-diverse. Issues such as dropped VoNR calls, mobility failures, or degraded QoE often don't surface until after rollout – when they're harder and costlier to fix.

This whitepaper introduces the rationale for incorporating real-device testing, AI-based diagnostics, and CI/CD-driven automation into the RAN testing lifecycle, highlighting how a hybrid approach can address the growing lab-to-field gap.

AutoRAN Hardware Setup



3. The Evolving Landscape of RAN Testing



3.1. The New RAN Reality

From Open RAN and virtualized networks to NTN and AI-native cores, today's telecom infrastructure is more disaggregated and dynamic than ever.



Disaggregated Components: Open RAN (DU, CU, and RU) and virtualized RAN (vRAN) components sourced from multiple vendors.



Device Diversity: Android/iOS, NB-IoT, NTN, and modems in the same network.



Advanced Features: Ultra-reliable low-latency comms (URLLC), slicing, beamforming, and real-time IoT.

These advancements necessitate comprehensive testing strategies that address interoperability, performance, and user experience across varied scenarios.

3.2. A Shifting Market, A New Testing Mandate

With global 5G subscriptions expected to exceed 5.9 billion by 2027 (Ericsson Mobility Report), ensuring robust and field-ready RAN infrastructure is critical. Yet, a 2024 Heavy Reading survey found that 68% of mobile operators face gNB deployment delays due to post-deployment issues – many rooted in limited lab-only testing.

The RAN ecosystem is evolving rapidly:

- » The 5G device testing market is projected to grow from \$1.63B (2024) to \$2.57B (2029) at a 9.8% CAGR, driven by:
 - 30B+ IoT devices by 2025, increasing device diversity and interoperability demands
 - Network slicing and edge computing, requiring precise latency and QoS validation
 - NTN, which introduce latency, Doppler, and coverage-edge challenges

Meanwhile, network architectures are becoming more disaggregated:

- » Open RAN (O-RAN) is set to grow from \$3.18B (2025) to \$38.7B (2034) (CAGR 32.1%), with strong growth in:
 - Asia-Pacific: \$555.4M (2024) → \$3.48B (2030)
 - India: \$162.1M (2024) → \$1.19B (2030)
- » Private wireless RAN grew 40% in 2023, now a \$800M market
- » Traditional RAN still holds 43% market share, but vRAN adoption is accelerating for cloud-native scalability

Together, these shifts expose the limitations of simulator-only testing. As the RAN landscape grows more complex and dynamic, validation strategies must evolve – blending scale, authenticity, and automation to ensure true readiness for deployment.

3.3. What Today's RAN Demands from Testing



These market and architectural shifts are fundamentally reshaping how RAN systems must be validated. They introduce new layers of fragmentation and diversity across radio stacks, vendors, and deployment models:

- » Multi-vendor Open RAN components demand robust interoperability testing across disaggregated interfaces.
- » Virtualized RAN nodes vary in behavior depending on the underlying cloud or edge infrastructure.
- » Non-Terrestrial Networks (NTNs) introduce entirely new performance dynamics, including Doppler shifts, high latency, and intermittent coverage – challenges that traditional simulators struggle to emulate.

In short: RAN is becoming more open, more virtualized, and more real-time – and your test infrastructure needs to evolve to match.

4. Limitations of Traditional Test Stacks

Traditional RAN testing tools – such as simulators, traffic generators, and protocol analyzers – have long been essential in lab environments. They provide scalable, repeatable, and controlled setups for early-stage validation, conformance testing, and stress simulations. However, as networks evolve to include Open RAN, NTN, and highly diverse user equipment (UE), these tools face significant limitations.

Key Limitations:



Lack of Real-World Accuracy

Simulators struggle to replicate live network conditions, such as unpredictable interference, congestion, and environmental variability that impact actual performance.



Missed Device-Specific Behaviors

Chipset and OS variations lead to unique device responses, which simulators can't reproduce. Real smartphones may behave differently based on firmware versions, app ecosystems, or manufacturer-specific implementations.



Inability to Capture Mobility Edge Cases

Simulated handovers often fail to emulate real-world transitions involving Doppler shifts, signal fades, or mid-call bearer switches – especially critical in NTN or high-speed mobility scenarios.



QoE Blind Spots

Simulators cannot emulate subjective user experience metrics like voice clarity in VoNR, video buffering under load, or app responsiveness. They also can't provide real-time Mean Opinion Score (MOS) or true latency impacts.



Limited Adaptability to Emerging Architectures

As networks shift to disaggregated, multi-vendor O-RAN and dynamic features like slicing, traditional test tools lack the flexibility to validate interactions across varied vendor stacks or deployment modes (SA/NSA, public/private, cloud/edge).

Simulators and protocol-based tools are indispensable for validating compliance and repeatable protocol flows. However, they are not sufficient alone for ensuring production readiness. They must be augmented with real-device testing and intelligent analysis to capture the full complexity of today's and tomorrow's network environments.

5. How AutoRAN Enhances, Not Replaces, Your Existing RAN Testing Infrastructure



5.1. Real User Equipment

AutoRAN addresses the realism gap by integrating actual smartphones, modems, and NTN-enabled devices into automated test workflows. This capability reveals issues only observable in the field:

Real World Scenarios	AutoRAN Advantage
VoNR calls failure under high load	Validated using live VoNR-capable smartphones
Multi-RAT handover instability	Real-time inter/intra RAT transition testing with real UEs
Throughput inconsistencies in mobility	Testing under live mobility and Doppler-influenced scenarios
App-level signaling issues	Captured via real device app behavior and QoS validation
Public-private mobility transitions	Testing under live mobility and Doppler-influenced scenarios
NTN/Doppler conditions	Field testing with Doppler shift and variable latency effects
OS and chipset-specific signaling behavior	Exposed using real Android/iOS device diversity
Network slicing and QoE validation	Tested using real traffic and AI-based MOS scoring

By blending actual UE behavior into test loops, AutoRAN ensures 4G/5G/ORAN/NTN nodes are field-ready, not just lab-passed.

5.2. AI-Driven Intelligence for Smarter RAN Testing

Capturing real-world behavior is only half the story. To truly accelerate network readiness, those insights must be rapidly interpreted and translated into action – and that’s where AutoRAN’s AI engine adds transformative value.

While traditional test stacks generate large volumes of protocol logs, they often lack automation in parsing, correlating, and prioritizing issues. AutoRAN closes this gap by delivering deep, AI-driven log intelligence:

- » **Smart Multi-Layer Log Analysis**

Ingests PCAP, DLF, NGAP, X2AP, and FIAP logs from real and simulated UEs. AI correlates issues across layers and domains in real time, speeding up root cause analysis.

- » **AI-Based Anomaly Detection**

Continuously learns from test data to flag regressions, pattern deviations, and critical anomalies – before they affect performance.

- » **Intent-Based Test Case Generation**

Uses AI models to auto-generate relevant test scenarios aligned with network goals and historical outcomes.

- » **AI-Enabled QoE Scoring (MOS)**

Converts technical logs into user-centric metrics through AI-driven Mean Opinion Score estimation for voice, video, and data.

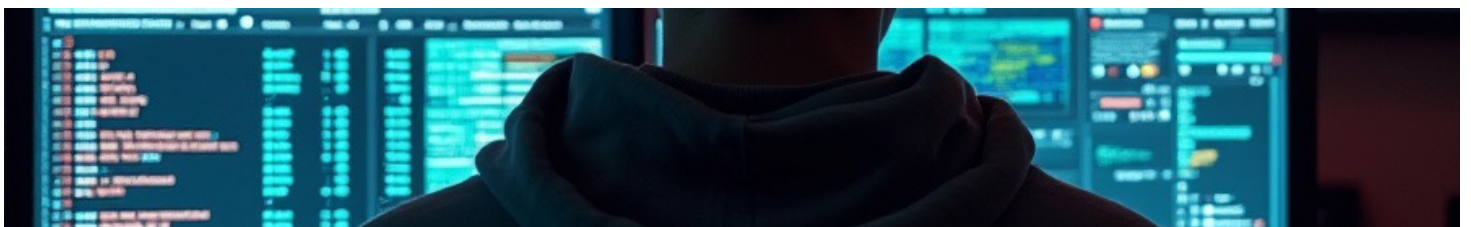
- » **Predictive Performance Insights**

Identifies early signs of degradation – like jitter buildup or signaling delays, enabling proactive optimization.

- » **Cross-Campaign Comparison**

Applies AI to compare test outcomes across releases, highlighting regressions and performance drifts with minimal manual input.

By combining real-device validation with intelligent automation, AutoRAN transforms RAN testing from reactive to predictive – ensuring next-gen networks are field-ready, faster.



5.3. AutoRAN Architecture: Purpose-Built for Dynamic RAN Environments

AutoRAN is designed to extend traditional testing by enabling scalable, real-world, and automation-ready RAN validation. Its core features support the complexity of modern networks – Open RAN, vRAN, private 5G, and NTN – without disrupting existing workflows.

- » **AI-Powered:** Intent-based test case generation, real-time log correlation, anomaly detection, and MOS-based QoE scoring across layers.
- » **Real-Device Scale:** Run parallel tests with 64–256 real UEs, including smartphones, modems, and NTN-capable devices.
- » **RF Control:** Integrated digital attenuation (0.25 dB steps, up to 95 dB) for precise signal path emulation.
- » **Advanced RAN Testing:** Validates VoNR, slicing, bearer management, public-private mobility, with seamless integration.
- » **ORAN & Multi-Vendor Support:** Interoperability testing across disaggregated DU/CU/RU components.
- » **NTN & Doppler Scenarios:** Emulates satellite-like latency and mobility conditions.
- » **CI/CD Integration:** RESTful APIs for DevOps workflows and automated regression cycles.
- » **Traffic Emulation:** Realistic app-layer load generation across TCP, UDP, RTP, and other protocols.

These capabilities make AutoRAN a robust last-mile validator – bridging the gap between controlled lab simulations and the unpredictable realities of live network deployments to ensure true production-readiness.

6. AutoRAN: The Missing Layer in End-to-End RAN Testing

AutoRAN is not here to replace traditional simulators. It’s designed to complement them. While simulators excel at scale and protocol conformance, they fall short in modeling real-world device behavior, QoE impact, and field conditions. As a strategic enabler, AutoRAN brings that missing realism and intelligence – enabling hybrid workflows that are both standards-compliant and deployment-ready.

Simulator + AutoRAN: A Hybrid Approach

Capability	Simulators	AutoRAN
Protocol Conformance	Validates 3GPP compliance with synthetic UEs	Verifies with real-device protocol behavior
Load & Stress Testing	Emulates massive UE scale	Adds realism with device-specific behavior under load
Real-World Device Behavior	Cannot replicate chipset/OS nuances	Captures real UE quirks and firmware-specific issues
Application-Layer Traffic	Limited or synthetic traffic patterns	Generates live app signaling and data traffic flows
Mobility & Handover Scenarios	Basic scripted transitions	Tests live handover, Doppler shift, and mid-call transitions
QoE and User-Centric Metrics	No voice/video quality feedback	AI-based MOS scoring, app performance insights
Support for NTN & High-Latency Scenarios	Difficult to emulate Doppler and delay dynamics	Validates latency, Doppler, and real NTN conditions
Network Slicing & Public-Private Handover	Limited or abstracted slicing flows	Supports real slicing, QoS, and public-private handover
Log Analysis	Manual or static rule-based	AI-driven log correlation and root cause analysis
CI/CD & DevOps	Scripted but rigid	API-ready, CI-integrated, automation friendly

Capability	Simulators	AutoRAN
Parallel Test Execution	Siloed scenarios	Supports simulator + real-device co-execution
Test Suite Flexibility	Limited scenario control	Modular, user-defined test flows for targeted validation

This coexistence model gives RAN teams the best of both worlds: scale and control from simulators, combined with realism and intelligence from AutoRAN. As networks become more diverse and distributed, this hybrid approach ensures you’re not just testing for lab success – but for live deployment success.



7. Conclusion: Complement, Don't Compromise

RAN testing must evolve. Simulators offer scale and control, but real-world readiness demands more - authentic device behavior, automation, and AI-driven insight.

As Open RAN, vRAN, NTN, and private 5G grow, lab-only validation falls short. AutoRAN bridges that gap - complementing traditional tools with the realism and intelligence needed for today's networks.

With AutoRAN, teams can:

- » Catch what simulators miss
- » Automate repetitive tests at scale
- » Use AI to accelerate root cause analysis
- » Validate QoE experience early and continuously

In a live, user-driven world, testing with real UEs isn't optional - it's essential. AutoRAN makes sure your network performs where it matters most: in the field.



8. Glossary

Term	Definition
3GPP	3rd Generation Partnership Project – the global standards body for cellular technologies including 4G, 5G, and beyond.
AI (Artificial Intelligence)	Use of machine learning and advanced algorithms to analyze data, correlate events, and predict patterns for smarter decision-making
CI/CD	Continuous Integration/Continuous Deployment – automated pipelines used in software development for faster delivery and testing cycles.
DLF, NGAP, X2AP, FIAP	Signaling interfaces used in RAN testing and log analysis (e.g., NGAP: Next Generation Application Protocol, FIAP: FI Application Protocol).
gNB	Next-generation Node B – the base station for 5G networks, equivalent to eNB in 4G.
IoT	Internet of Things – a network of interconnected physical devices that communicate and exchange data.
gNB	Next-generation Node B – the base station for 5G networks, equivalent to eNB in 4G.
MOS (Mean Opinion Score)	A metric used to evaluate the perceived quality of voice/video services.
NTN	Non-Terrestrial Network – includes satellite, aerial, and high-altitude platforms for telecom connectivity beyond terrestrial coverage.
O-RAN/Open RAN	Open Radio Access Network – a disaggregated RAN architecture promoting interoperability among multi-vendor hardware and software.
QoE	Quality of Experience – a user-centric measure of performance encompassing responsiveness, reliability, and satisfaction.
QoS	Quality of Service – performance guarantees at the network level, including latency, jitter, and packet loss.
RAN	Radio Access Network – the portion of a mobile network that connects user devices to the core network.

Term	Definition
SA/NSA	Standalone/Non-Standalone – two modes of 5G deployment. SA uses a native 5G core, NSA uses existing 4G infrastructure.
UE	User Equipment – devices like smartphones, modems, or IoT terminals that connect to the mobile network.
VoNR	Voice over New Radio – 5G-native voice service over standalone 5G networks.
vRAN	Virtualized RAN – a software-based implementation of RAN functions that runs on commercial off-the-shelf (COTS) hardware.

9. References

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For more information on AutoRAN and how it can enhance your testing infrastructure, visit Amantya Technologies.

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