

S6221A AI RAN Simulation Toolset

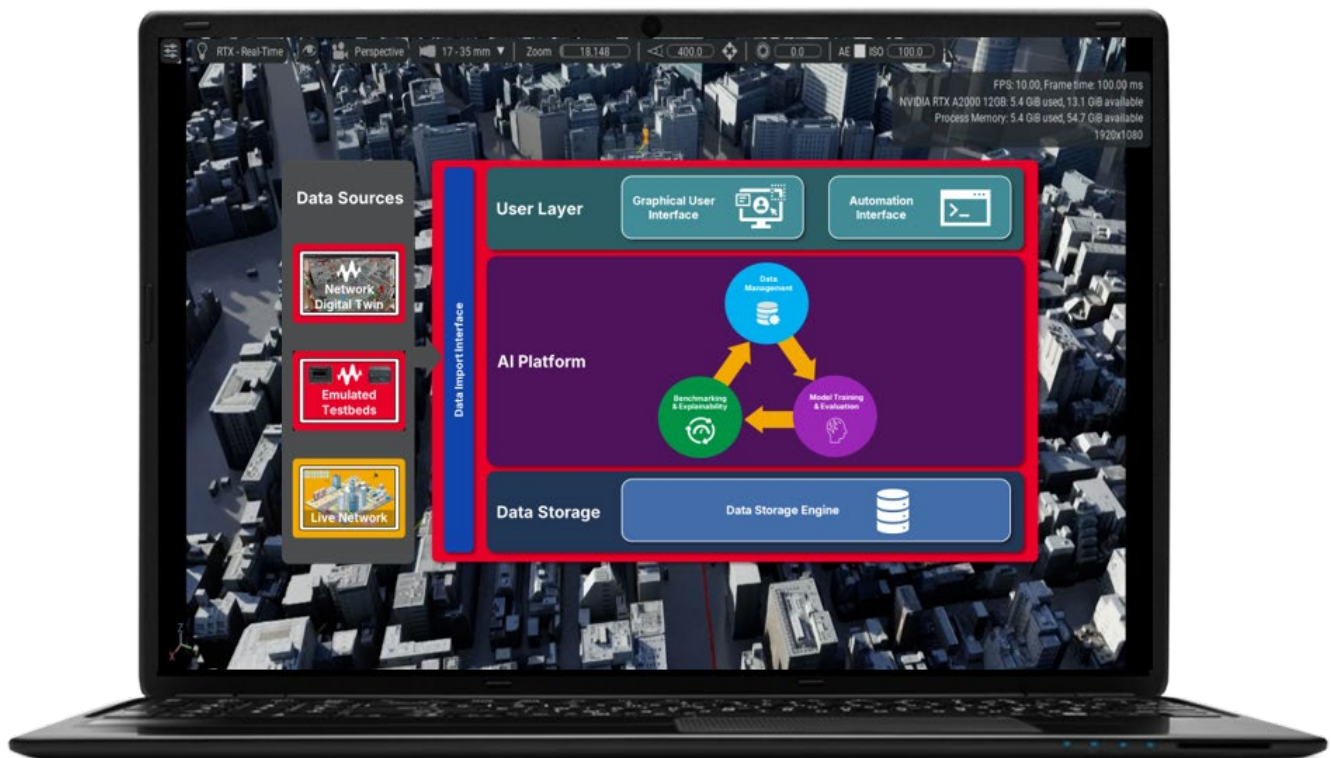
Solutions for Testing AI Enhanced RAN

Introduction

Wireless networks are rapidly evolving from static, hardware-driven architectures toward intelligent, software-defined systems capable of self-optimization. As modern networks introduce massive connectivity, diverse service requirements, and complex radio environments, traditional rule-based management becomes insufficient. This has driven the shift toward AI-native network architectures, where data-driven intelligence is embedded throughout the network stack — paving the way for AI RAN (Artificial Intelligence–driven Radio Access Network), the next generation of radio access networks that leverage AI to enhance efficiency, adaptability, and performance.

Keysight AI RAN Simulation Toolset provides unified solutions for telecom innovators to:

- **Create realistic, high-scale and high-fidelity network models** to simulate complex RAN scenarios.
- **Generate structured datasets containing large volumes of high-quality and trustworthy data** for AI model training, testing, and benchmarking.
- **Benchmark the performance of AI models** to ensure performance targets are achieved and continuously improved.
- **Provide actionable performance metrics and KPIs** to guide optimization and validation of AI model performance.



What is AI RAN?

AI RAN refers to the integration of artificial intelligence and machine learning techniques into the RAN (Radio Access Network) to optimize wireless network performance, resource management, and energy efficiency. In an AI-enabled RAN, AI models analyze real-time network data to enable autonomous decisions—such as dynamic beamforming, interference management, and traffic prediction—improving throughput, latency, and overall user experience. This approach represents a key evolution toward more adaptive, self-optimizing 5G and 6G networks.

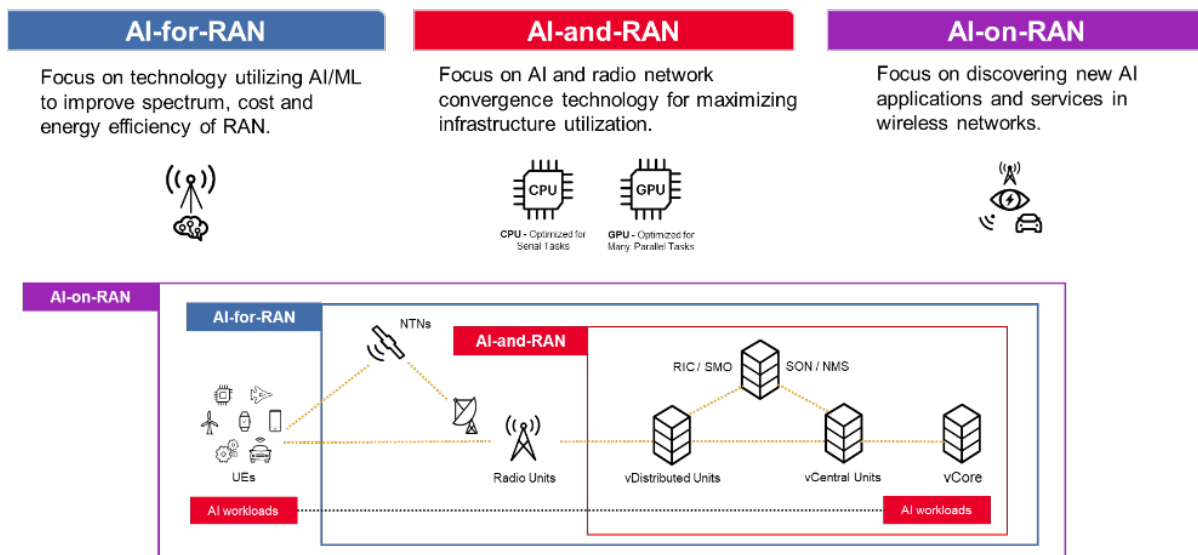


Figure 1. Three key use case categories defined by AI-RAN Alliance.

AI RAN Workflow and Testing Challenges

The AI RAN workflow, as illustrated in figure 2, follows a continuous cycle linking **data management**, **model training and evaluation**, and **benchmarking and explainability**. It begins with **data management**, where diverse network data sources are collected, curated, and prepared for analysis. This data feeds into the **model training and evaluation** phase, where AI models are designed, trained, and tested to address specific RAN optimization tasks such as scheduling, beamforming, or anomaly detection.

The resulting models are then subjected to **benchmarking and explainability**, where their performance, reliability, and interpretability are validated through deployment in lab, digital twin, or live environments. Insights from this phase feed back into data management, enabling continuous improvement of AI models and ensuring that the AI RAN system evolves dynamically with real-world network conditions.

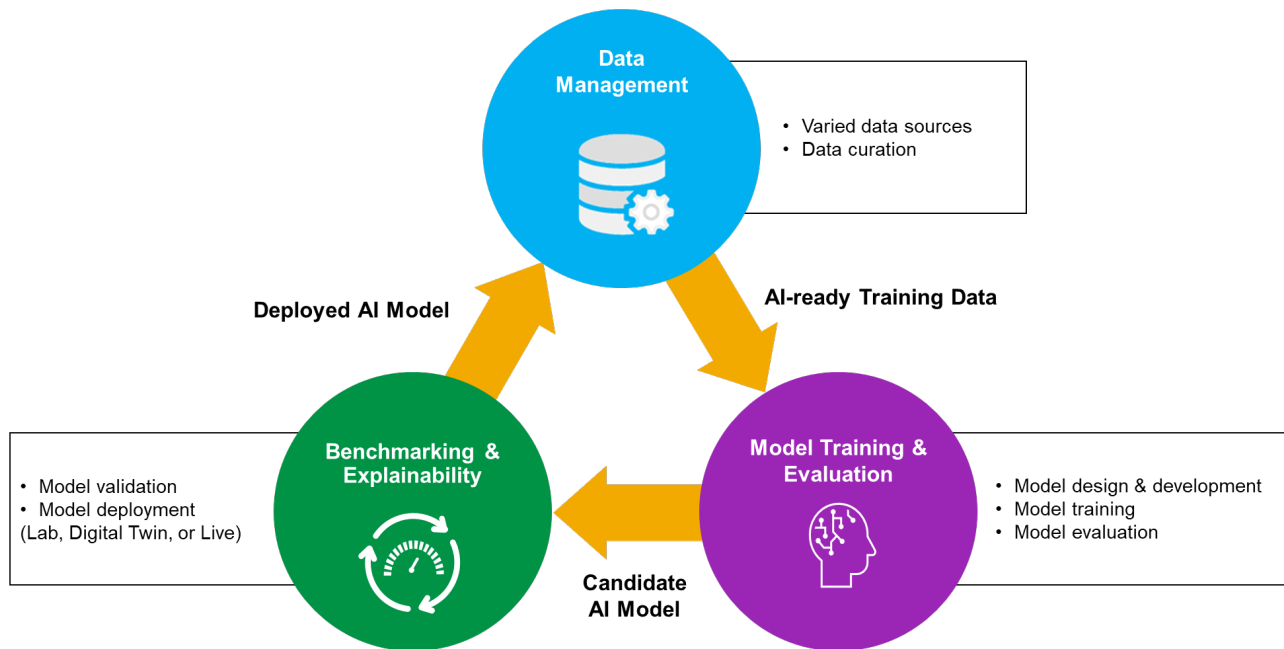


Figure 2. Continuous cycle of AI RAN Workflow.

Key challenges in developing and validating **AI RAN** solutions revolve around data quality, scalability, and performance validation, as shown in figure 3.

- First, generating **high-quality and curated datasets** is critical to ensure reliable AI model training and validation across diverse, high-fidelity RAN scenarios.
- Second, the use of **Network Digital Twin environments** addresses challenges in simulating large-scale, realistic network conditions for benchmarking and inferencing without impacting live networks.
- Finally, **validating AI algorithm performance improvements** requires robust testing frameworks capable of measuring real-world impact, providing explainability, and proving generalization across varying network conditions — ensuring that AI-driven enhancements truly translate to better RAN efficiency and user experience.

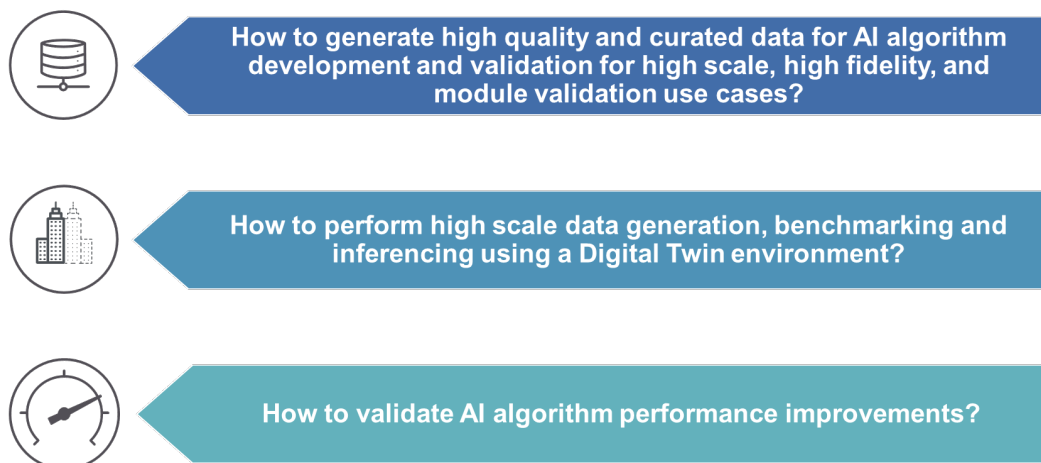


Figure 3. Key challenges for AI RAN development and testing.

Keysight AI RAN Simulation Toolset

Keysight AI RAN Simulation Toolset consists of following key components:

- **Data sources:** Network Digital Twins, Emulated Testbeds and Live Network
- **AI Platform:** Dataset management, AI model management, AI model and RAN KPI benchmarking, and data storage

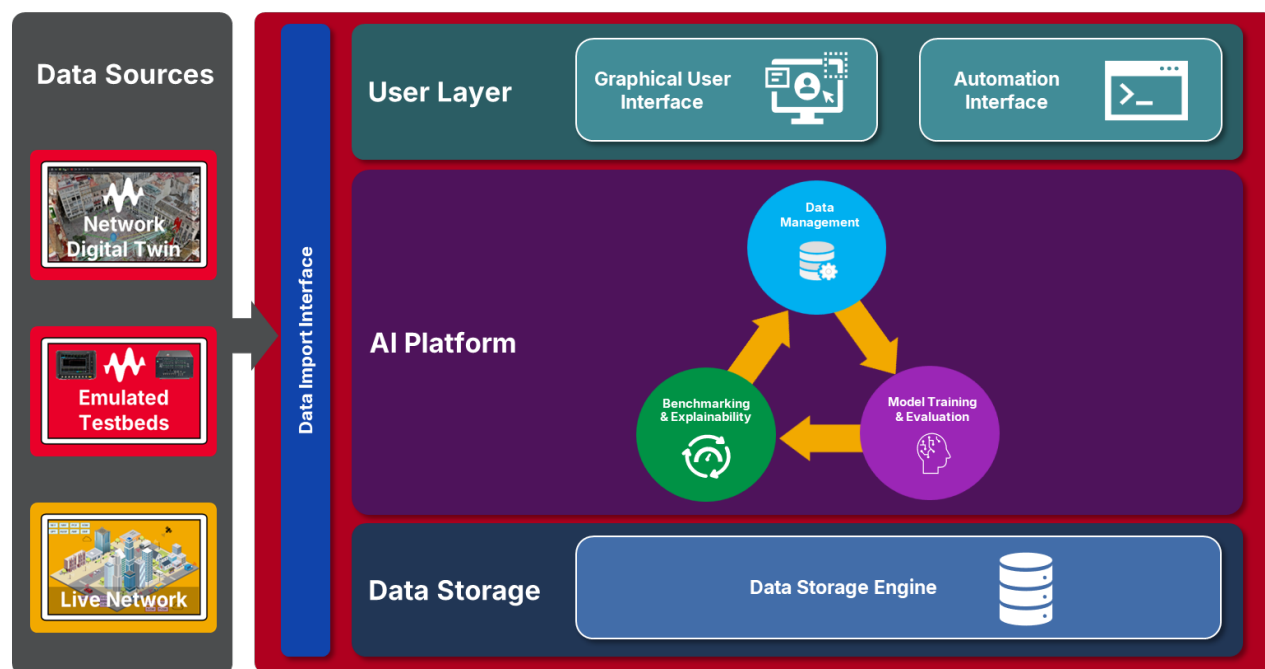


Figure 4. Keysight AI RAN Simulation Toolset components.

Generate High-Quality, Trustworthy Synthetic Datasets

With Keysight S6221A AI RAN Simulation Toolset, users can rely on synthetic data created by Keysight to complement live network data.

With following concrete steps user can generate realistic, synthetic data as needed to train an AI model.

- Generate synthetic data for the dataset using Network Digital Twin. Network Digital Twin enables fast configuration for UE's and Base stations into simulated environment.

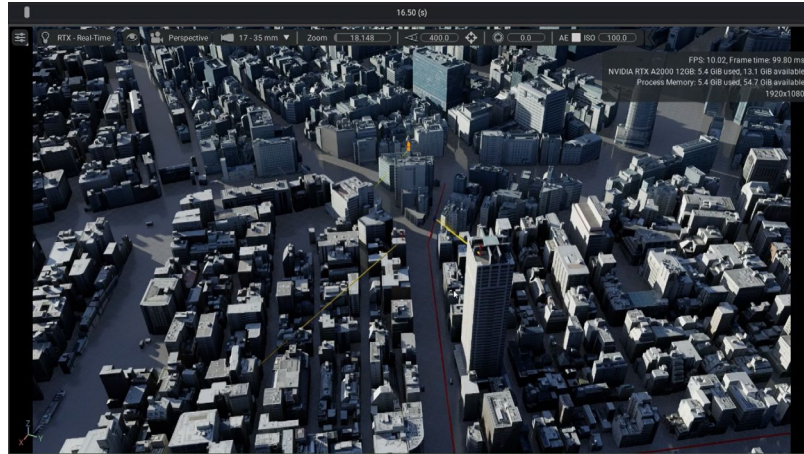


Figure 5. Network Digital Twin with High Level of Detail 3D Mapping

- Manage tagged datasets in AI Development Platform. Ingress network KPI baselines and training datasets.

Dataset Name	Data Source	Type	Created On	Modified On	Created By	Tags
nexus-dataset-1	File Import	Virtual	11/14/2023, 08:31 AM	12/05/2023, 09:10 AM		nexus
nexus-transformation-1	File Import	Virtual	11/06/2023, 04:29 AM	11/06/2023, 07:43 AM		nexus
nexus-data-entry-new	File Import	Virtual	11/06/2023, 02:14 AM	11/06/2023, 02:17 AM		nexus
nexus-energy-efficiency	File Import	Virtual	10/06/2023, 02:52 AM	10/06/2023, 02:52 AM		nexus
nexus-transformation	File Import	Virtual	10/05/2023, 02:58 AM	10/05/2023, 03:19 AM		nexus
nexus-new	File Import	Virtual	10/17/2023, 09:42 AM	10/17/2023, 09:49 AM		nexus
cell_induced_nexus_energy_efficiency_journal_standardized...	File Import	Virtual	10/16/2023, 08:40 AM	11/13/2023, 10:11 PM		nexus, nexus-dataset-1
nexus-dataset-test	File Import	Virtual	10/16/2023, 08:40 AM	10/16/2023, 07:40 AM		nexus
nexus-test-1	File Import	Virtual	10/06/2023, 08:42 AM	10/06/2023, 08:42 AM		nexus
nexus-test	File Import	Virtual	10/03/2023, 09:10 AM	10/03/2023, 09:10 AM		nexus

Figure 6. New project creation in AI Development Platform

- Use data augmentation strategies to create new datasets from seed data, volumizing your training sets.

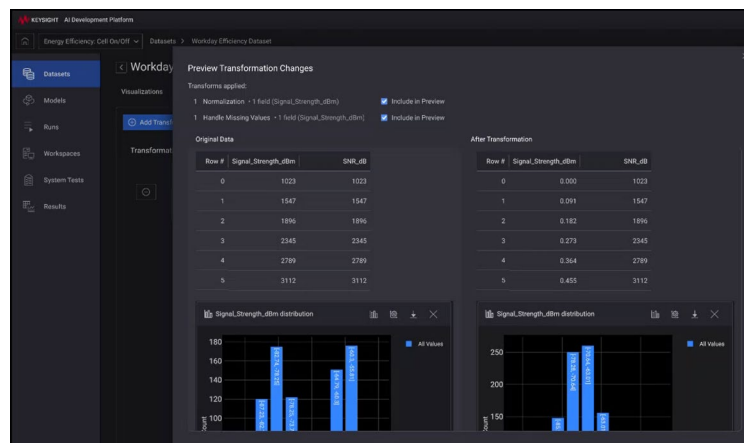


Figure 7. Dataset augmentation and validation.

- Explore and analyze with “big data” visualizations that help uncover trends, correlations, and anomalies in large datasets that would be hard to detect through raw numbers. Outliers, missing values, and skewed distributions become obvious when visualized, helping ensure higher quality training data.

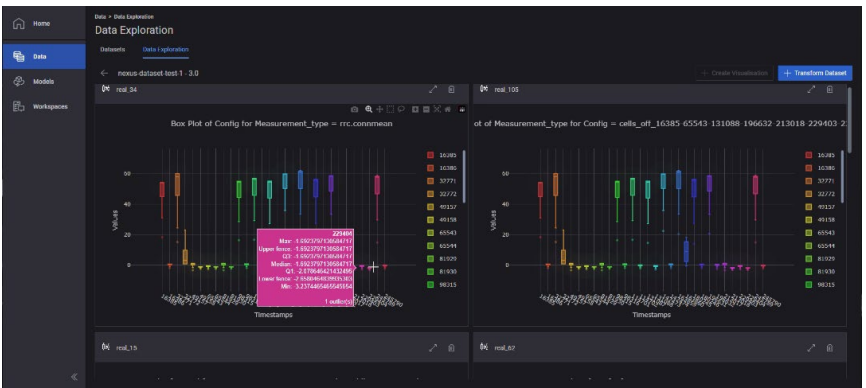
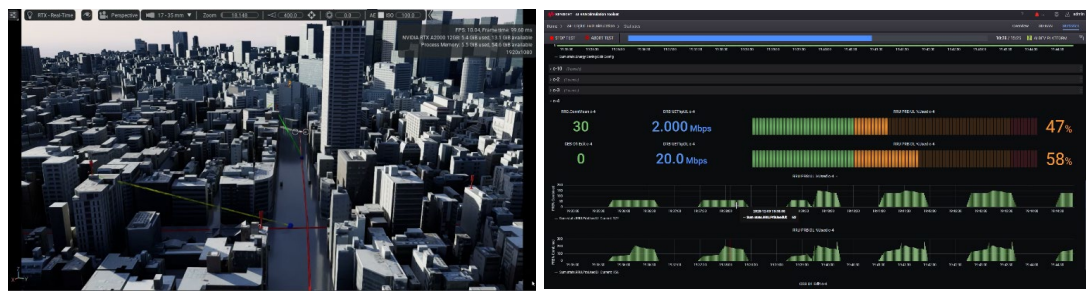


Figure 8. Data visualization to reveal insights across training sets.

- Validate model performance in lab environment using Network Digital Twin.



Figures 9 & 10. Monitor real-time KPI's with UE mobility during Lab Validation.

- Benchmark Use Case results and verify candidate AI models' KPI improvements against a baseline. Add any supported KPI in the dataset for comparison on-the-fly, with user-selectable KPI charting.

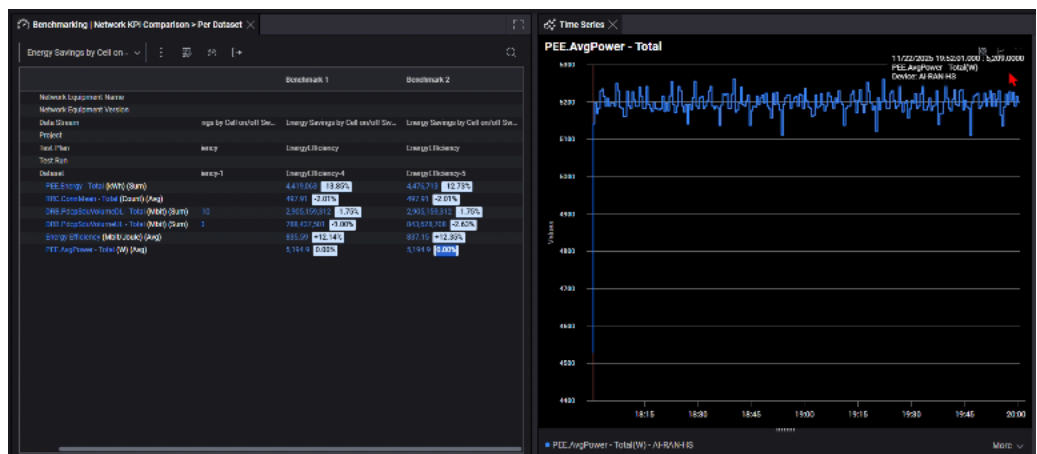


Figure 11. Verify candidate AI models' energy efficiency against the baseline.

Who Benefits from this Solution?

- Network equipment manufacturers (NEM)
- Mobile network operators
- Chipset / Device makers

Solution Components

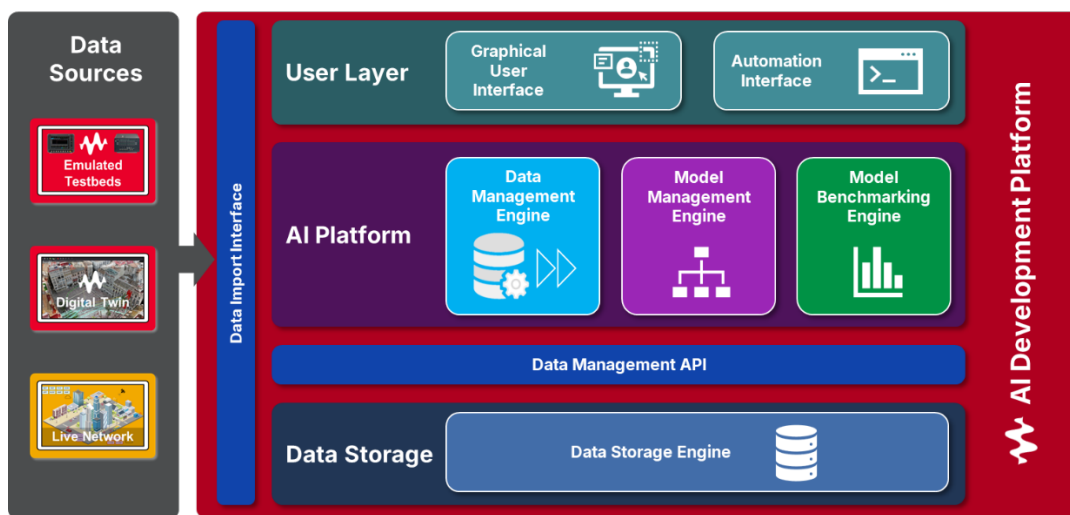


Figure 12. S6221A AI RAN Simulation Toolset solution components

Data Sources

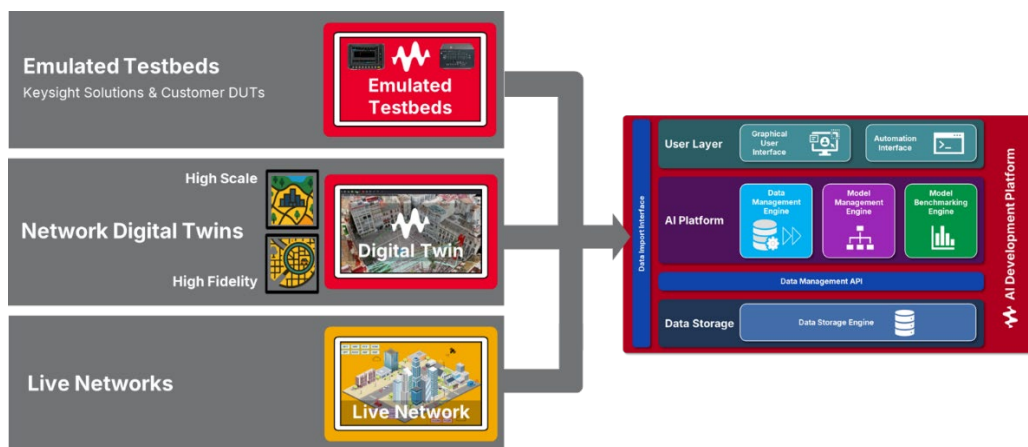


Figure 14. Sources for dataset generation

Data Source - Network Digital Twin



Network Digital Twin enables real-time simulation and analytics across all network layers — from PHY and MAC to applications and planning — accelerating AI-driven optimization, deployment, and troubleshooting of next-generation wireless systems.

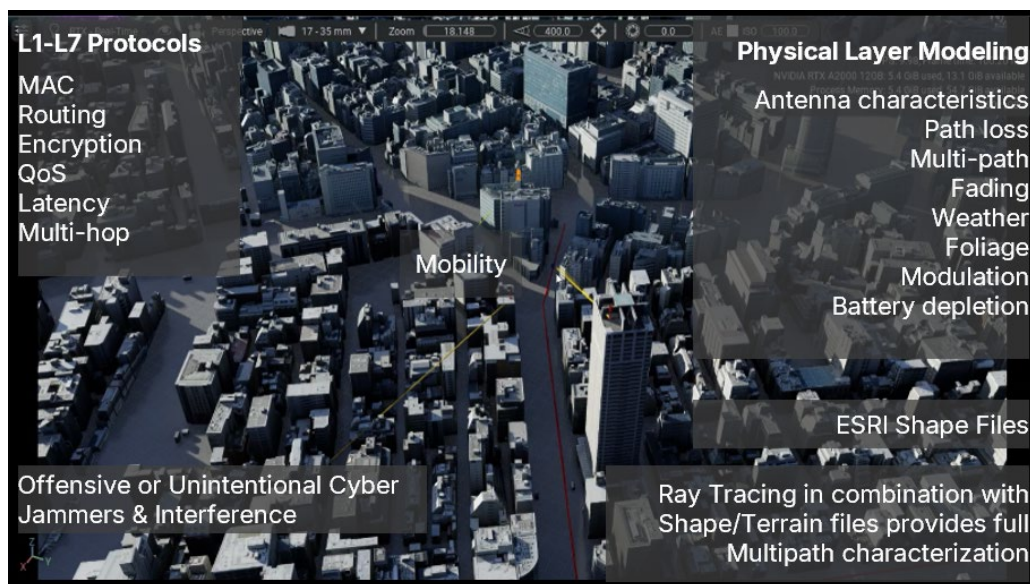


Figure 15. Network Digital Twin as data source

Keysight Network Digital Twin provides:

- High-Scale & High-Fidelity use cases
- Coverage across L1-L7 protocols
- Link-level, system-level, and network-level RF scenario simulations
- 3D site-specific deterministic channel modeling from Channel Studio RaySim
 - Realistic RF propagation with terrain and vegetation effects
 - Accurate building geometry and automatic RF material parametrization

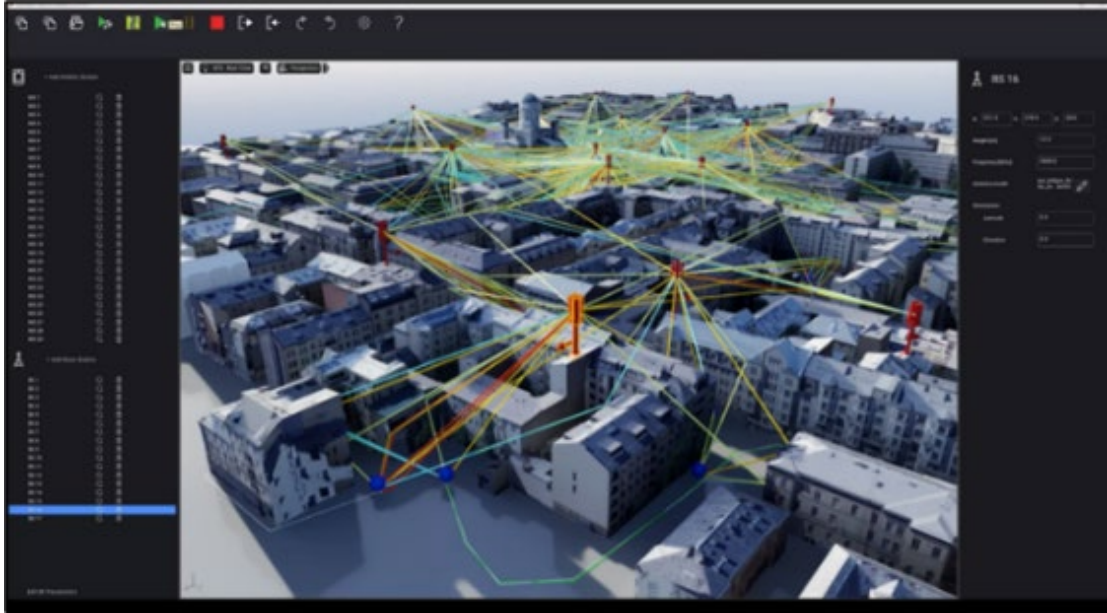


Figure 16. Realistic RF channel modeling with Channel Studio RaySim

Data Source - Emulated Testbeds

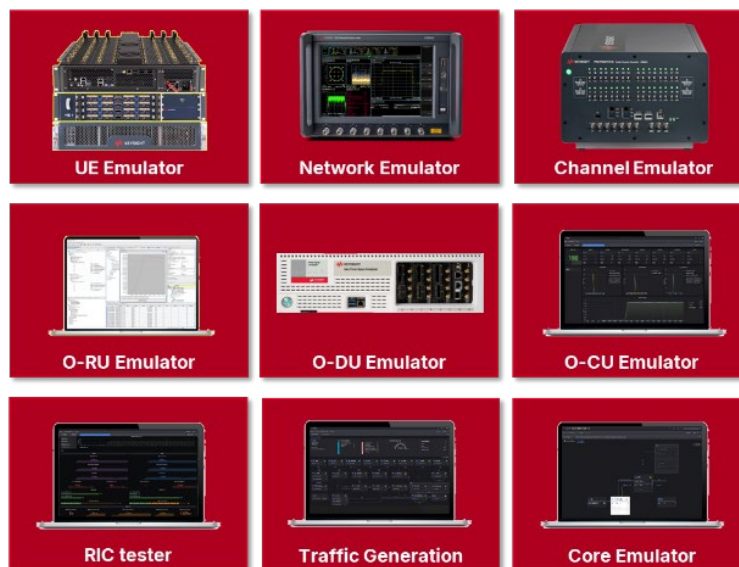


Figure 17. Emulated testbeds as data source

Keysight Provides widest range of emulator platforms and testbeds:

- Enable generation of realistic synthetic source data
- Configurable to generate data for a wide range of use cases and scenarios
- Support the latest features, from 3GPP, O-RAN Alliance etc.

Data Source - Live Network



Figure 18. Live network as data source

Keysight AI RAN Simulation Toolset supports ingestion of live network configurations (cell, node, band, etc.) and subscriber geolocation paths in conjunction with its Network Digital Twin.

Live Network as data sources include:

- Multi-format, any production level configuration or operational measurement captures
- Any information captured from a real device either in the production or lab

Live Network requires processing of raw data to create training data.

AI Development Platform

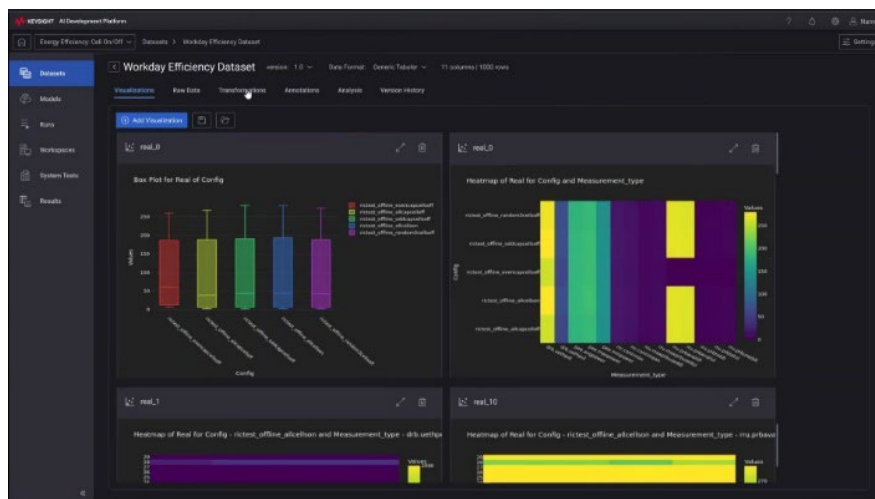


Figure 19. AI Development Platform

AI Development Platform provides user friendly interface and engine for AI data management, model management, and model benchmarking to evaluate and enhance user AI enhanced network. Below are some highlights of the AI Development Platform features.

- Transform source data to produce high-quality output datasets with Data Management
- Store models and datasets locally within your network with model management and versioning
- AI and RAN evaluation to ensure performance improvement with Benchmarking Engine
- Raw data, configuration data, curated datasets, AI models with metadata, benchmarking results (figures x & x) and automation scripts storage in Data Storage Engine.

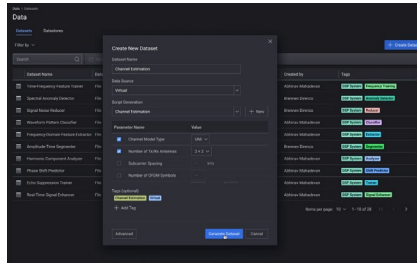


Figure 20. Model management

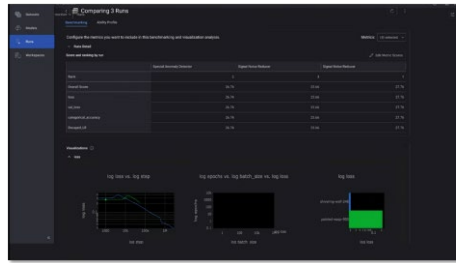


Figure 21. AI model benchmarking

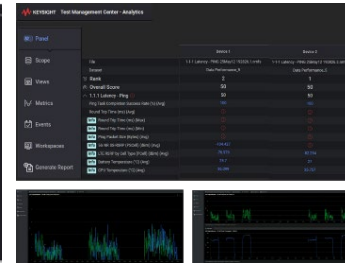


Figure 22. RAN performance benchmarking

AI RAN Key Use Cases

Use Case Categories

Picture below outlines three critical approaches to validating AI models and systems in network environments: High Scale, High Fidelity, and Module Validation.

- **High Scale validation** ensures that the system operates correctly and efficiently under extreme conditions, such as nationwide deployment, requiring vast amounts of data, traffic, and network elements.
- **High Fidelity** focuses on testing complex algorithms in near-real-world scenarios, like dense urban areas with intricate channel conditions, demanding highly granular data that mirrors actual network behavior at the bit or symbol level.
- **Module Validation** targets individual algorithm components before full system integration, using real-time data from emulators and user devices to verify performance on a smaller scale, such as a single link in a hardware testbed.

Together, these layers of validation provide a comprehensive framework for ensuring robust, scalable, and accurate AI deployment in network systems.

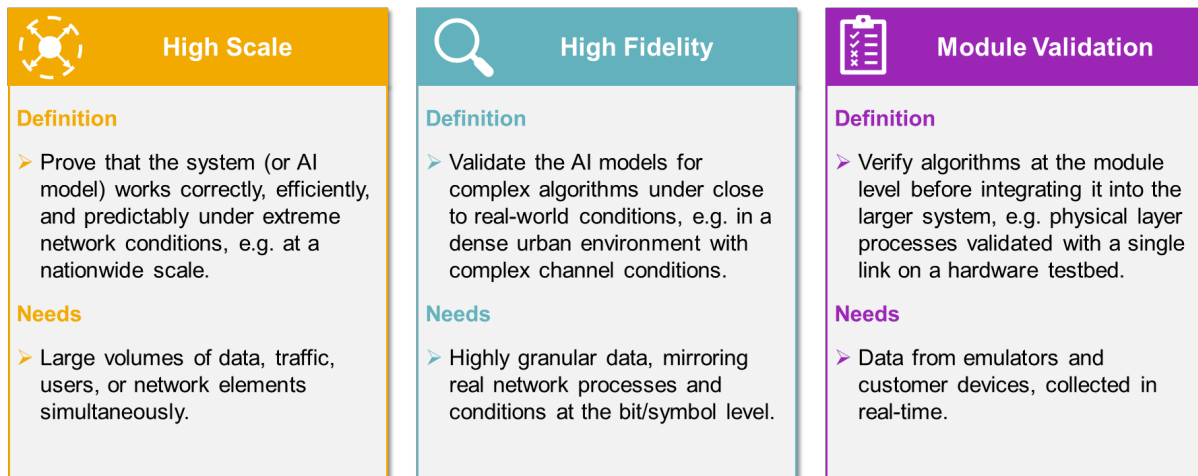


Figure 23. AI RAN use case categories

Use Case Example - Energy Efficiency: Cell On/Off Switching rApp

This use case focuses on training and optimizing the **ES-rApp AI model** to reduce energy consumption in multi-city radio access networks. The workflow involves:

- **Data Source:** Collecting large-scale network data, including QoS, energy metrics, and traffic patterns across diverse geographies.
- **Data Management:** Enhancing datasets with data cleaning, normalization, and data augmentation, and introducing data behavior variations for new datasets.
- **Model Development & Benchmarking:** Evaluating AI performance post-training for accuracy and latency, then scoring based on energy efficiency improvements while maintaining coverage and QoS.
- **System Configuration:** Using curated and synthetic data on an AI development platform to train the ES-rApp model, integrated via O-RAN architecture.

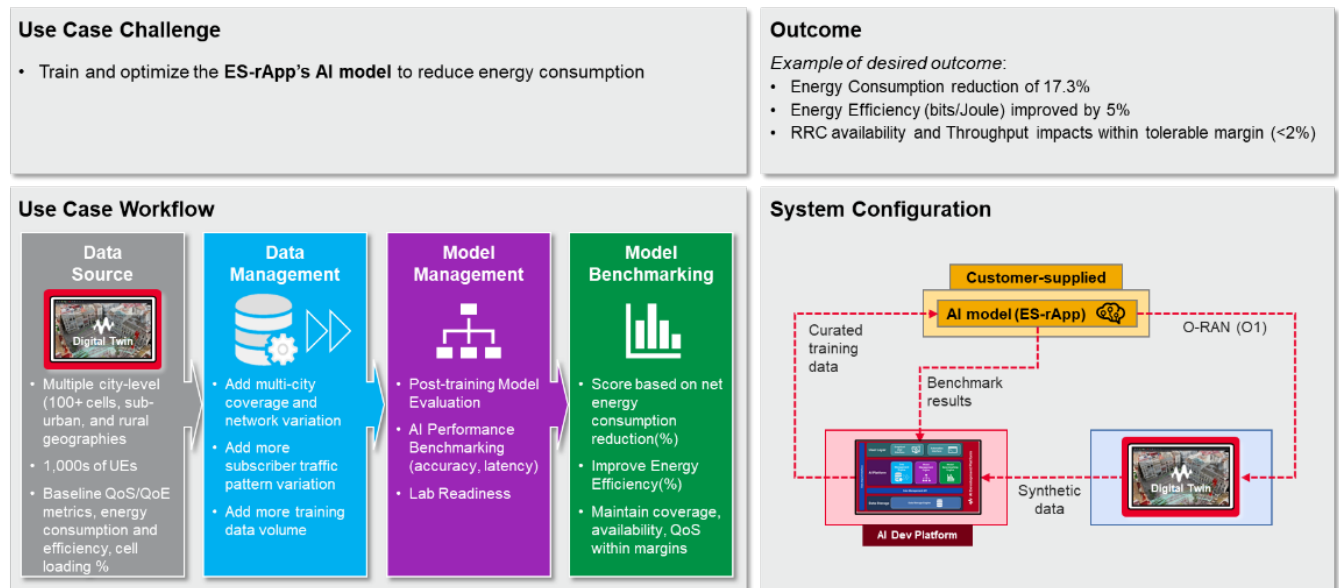


Figure 24. Use case example of improving energy efficiency

Conclusion

Keysight AI RAN Simulation Toolset streamlines the development and test process of AI enhance RAN.

- Comprehensive coverage** of the entire AI RAN workflow
- Unique ability to **generate and curate realistic datasets** for AI model training, from multiple input data sources
- Tightly **integrated with Keysight's Digital Twin solution**, for synthetic data generation and AI model validation
- Benchmark the performance** of AI models in isolation and validates/assesses their performance in a full system context
- Supports a **wide range of use cases**, across high scale, high fidelity, and module validation scenarios

Further Resources

- S6221A AI RAN Simulation Toolset
- Radio Access and Core Network Test
- Building Smarter Networks: AI / ML for Anomaly Detection in Open RAN

Related Solutions

- P8800S UeSIM RAN Testing Toolset
- P8822S RuSIM – UE / O-RU Emulation Over the O-RAN Fronthaul
- P8827S CuSIM – O-DU Midhaul Solutions
- P8826S DuSIM – O-CU Midhaul Solutions
- P8828S RICtest – RAN Intelligent Controller Test Solutions
- P8850S CoreSIM – Core Simulation RAN Solutions
- P8900S LoadCore – Core Network Solutions
- F9860000A Channel Studio RaySim
- PROPSIM Channel Emulator Platforms
- E7515B UXM 5G Wireless Test Platform

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