

An aerial night view of a city with a digital network overlay. The city lights are visible, and the sky is a mix of purple and red. The network overlay consists of vertical lines with glowing dots at the top, connected by horizontal lines, creating a grid-like structure. The dots are in various colors, including blue, red, and white.

# Accelerating Open RAN Innovations

**Keysight Technologies**

# Keysight Open RAN Leadership



# Keysight Leadership in Open RAN Consortia

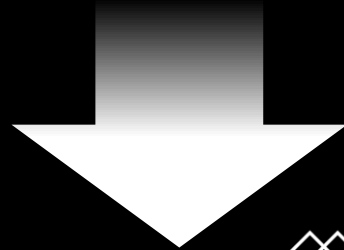
## Keysight Open RAN Leadership

### Keysight #1 T&M Contributor in O-RAN ALLIANCE

Leads and Drives Contributions to Advance Open RAN Standardization



Contribution & Commitment



### O-RAN ALLIANCE: Open RAN Specifications for Open Interfaces

1. **Active member** since its inception in 2018
2. **Co-chairs a committee (MVP-C)** that drives O-RAN specification priorities
3. **Leads (5 rapporteur/co-rapporteurs) and contributes to 12 working groups** to all major technical and test specifications
4. **Enables Open Testing & Integration Centers (OTICs)** by facilitating the addition of new OTICs to the O-RAN ALLIANCE. OTICs are crucial for validating Open RAN components and functionalities.
5. **Support & Participation to O-RAN PlugFests** and showcasing solutions and collaborates with other members to accelerate the deployment of Open RAN technologies.

### TIP: Open RAN Blueprints and Products

1. **Active member since 2017**
2. **Co-chairs Test and Integration (T&I) project group**
3. **Leads and contributes to various projects** including test automation within TIP's OpenCellular project

# Open RAN Testing Handbook in Collaboration with Vodafone

## Keysight Open RAN Leadership

**Vodafone** and **Keysight Technologies** have published a comprehensive handbook to aid vendors when they are testing new Open Radio Access Network (RAN) software and hardware.

**The handbook** is designed to make it easier for network operators and vendors of all sizes to navigate a path through the testing maze with the goal of developing a product for commercial deployment.

**The Handbook** lists the testing requirements for any Open RAN piece of software or hardware that a vendor brings to Vodafone's test labs.

**Vodafone and Keysight publish handbook to navigate the Open RAN testing maze**



### Press release:

[Vodafone and Keysight publish handbook to navigate the Open RAN testing maze, Aug 2023](#)

# MWC Barcelona 2024 – Keysight Demonstrations

## OPEN RAN – ENERGY SAVINGS OPTIMIZATION ~25%

MAVENIR

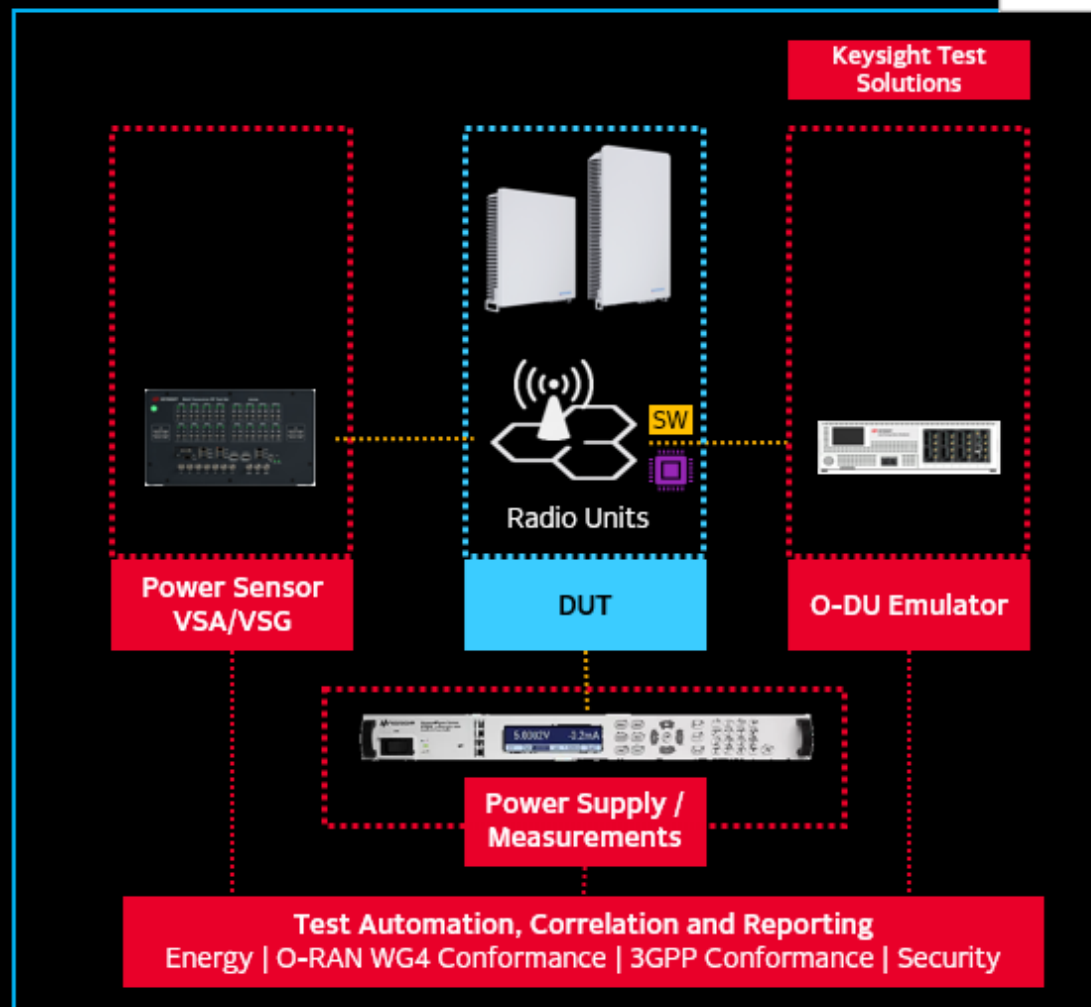
### Massive MIMO O-RU Energy Savings - Mavenir

#### Solution Highlights

1. **Industry 1<sup>st</sup> and Proven integrated portfolio** supporting automated RAN and Open RAN energy lab and field testing and benchmarking – **O-RU (this demo)**, O-DU/O-CU/O-Cloud, RIC (xApps, rApps), gNB
2. Keysight O-RU Energy Plane Test Suite
  - a) Industry proven with Massive and Non-Massive MIMO RUs
  - b) Automated test and report using ETSI ES 202 706-1 Power consumption - static measurement method
  - c) Advanced Sleep Mode Characterization and Optimization
  - d) Correlation of energy savings gain with signal quality
  - e) Same test setup for 3GPP and O-RAN WG4 fronthaul conformance testing

#### Demonstration Highlights

1. **DUT – Mavenir Open Beam Commercial Massive MIMO O-RU (32TRX)** supporting **advanced sleep mode** (micro DTX – switching on/off power amplifier on a per symbol basis)
2. **Demonstrated 25% energy savings gain** with only minimal variation in RF Performance



# Samsung, Verizon & Keysight Advance Commercial Open RAN with Extensive Conformance and Interoperability Testing

## Keysight Open RAN Leadership

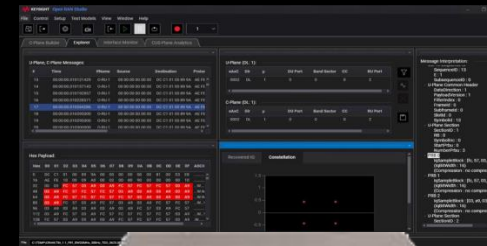
Testing across portfolio of radios illustrates **Samsung's virtualized Open RAN** leadership and advancements with its **Massive MIMO** radios.

**For the series of tests** carried out in Samsung's Dallas, Texas lab, the companies used Samsung's market-leading radios compliant with O-RAN specifications.

**The test included** multiple Samsung radios including CAT-A radios 4T4R supporting 700/850 MHz and AWS/PCS bands, CAT-B 64T64R Massive MIMO C-Band radios, and the 16T16R C-band and CBRS dual-band radio.

### Press release:

[Samsung, Verizon and Keysight Advance Commercial Open RAN with Extensive Conformance and Interoperability Testing - Samsung US Newsroom, Dec 2024](#)



# Partnering with 5G NTN Industry Leaders

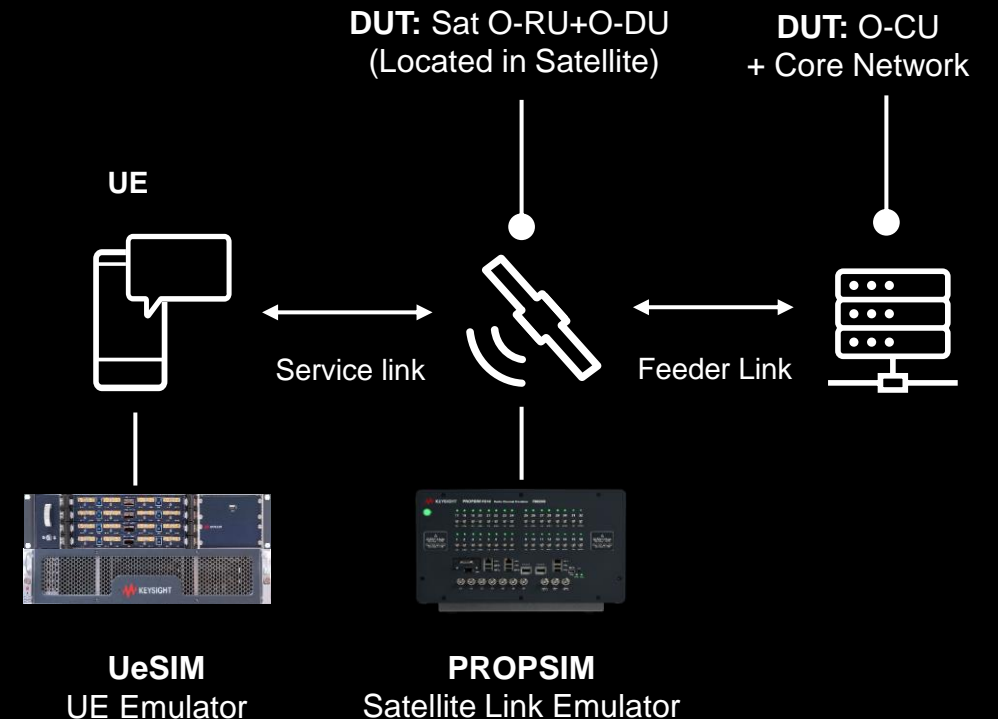
## Keysight Open RAN Leadership

### Strategic Collaboration with Lockheed Martin (LMCO)

- Lockheed Martin regenerative 5G NTN HBS-Space system
- 5G NTN capable UE Simulator - **UeSIM**
  - Used for validating Lockheed Martin's 5G NTN base station
- Keysight Channel Emulator - **PROPSIM**
  - Running satellite link with Doppler and delay consistent with real low earth orbit (LEO) satellite

### Test System Operation

- LMCO Real 5G Base Station - Developed over past 3 years
  - Full 5G NR Radio Access Network (RAN) stack, RAN Intelligent Controller (RIC) and 5G Stand Alone (SA) Core
  - Running on space-qualified hardware that will fly on the TacSat
  - Can be structured with a split architecture, further enhancing network implementation options
    - Control Unit (O-CU) on the ground
    - Distributed Unit (DU) on the satellite



Source:

[Lockheed Martin Prepares First 5G.MIL® Payload for Orbit](#)

# Collaboration

## Keysight Open RAN Leadership

- Keysight collaborating with multiple key customers in Open RAN industry
- Keysight holds leadership position in standards development within O-RAN ALLIANCE
- Participated in all organized O-RAN PlugFests since 2019



[Global OTIC Summit, Singapore, Aug 2024](#)

O-RAN Collaboration	Press Release
Foxconn Industrial Internet (Fii)	<a href="#">Keysight Enables Fii to Earn Outdoor Open Radio Unit Certificate of Conformance</a>
Vodafone, Wind River, Intel, Radisys	<a href="#">Vodafone, Wind River, Intel, Keysight Technologies and Radisys test 'green' Open RAN network</a>
Capgemini	<a href="#">Keysight and Capgemini Validate 5G New Radio RAN Solution for Non-Terrestrial Networks</a>
ritt7Layers	<a href="#">Keysight Enables ritt7Layers as Newest O-RAN ALLIANCE OTIC</a>
Intel	<a href="#">Keysight Enables Open RAN Massive MIMO Innovation</a>
Verizon & Samsung	<a href="#">Samsung, Verizon and Keysight Advance Commercial Open RAN with Extensive Conformance and Interoperability Testing</a>
Vodafone	<a href="#">Vodafone and Keysight publish handbook to navigate the Open RAN testing maze</a>
UK Government	<a href="#">Keysight Awarded Two Open Networks Ecosystem Competition Grants from UK Government</a>
Metanoia	<a href="#">Keysight and Metanoia Validate 5G Low Physical Layer Open Radio Unit</a>
O-RAN ALLIANCE	<a href="#">Keysight Accelerates Open RAN by Co-Organizing First Global OTIC Summit</a>
Qualcomm	<a href="#">Keysight Supports Verification of Open RAN Radio Units Powered by Qualcomm</a>
Astella	<a href="#">Keysight Validates Astella 5G Open RAN mmWave Small Cell Base Station</a>
CableLabs	<a href="#">Keysight O-RAN Solutions Added to CableLabs' 5G Lab for Support of 2023 5G Challenge</a>
Singapore University of Technology and Design	<a href="#">Keysight and SUTD Sign Memorandum of Understanding for Open RAN and 6G Technology</a>
Pegatron	<a href="#">Keysight Enables First O-RAN E2E System Integration Badge for Pegatron</a>
MICAS	<a href="#">Keysight Enables MICAS to Obtain One of the First O-RAN Certifications   Keysight</a>

### O-RAN PlugFest Press Releases

- [Keysight Enables 20 Open RAN Solution Demonstrations for AI, Sustainability, Interoperability and Test Automation at O-RAN ALLIANCE Fall 2023 Global PlugFest](#)
- [Keysight Demonstrates Open RAN Deployment Readiness Testing Leadership at Spring 2023 PlugFest](#)
- [Keysight Showcased Industry First Demonstrations at O-RAN Global PlugFest Fall 2022](#)
- [Keysight's Participation in O-RAN Global PlugFest Spring 2022](#)



# Keysight RAN Sustainability (Energy Plane) Test Solutions

## COMPREHENSIVE SOLUTIONS

Industry 1st integrated portfolio supporting automated RAN energy lab and field testing and benchmarking

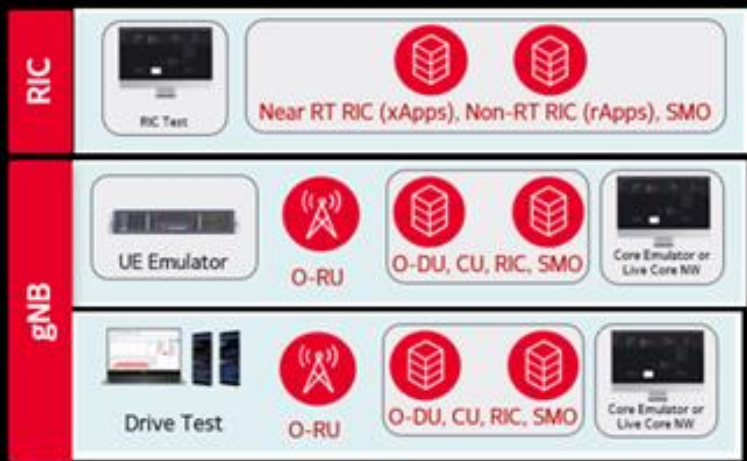
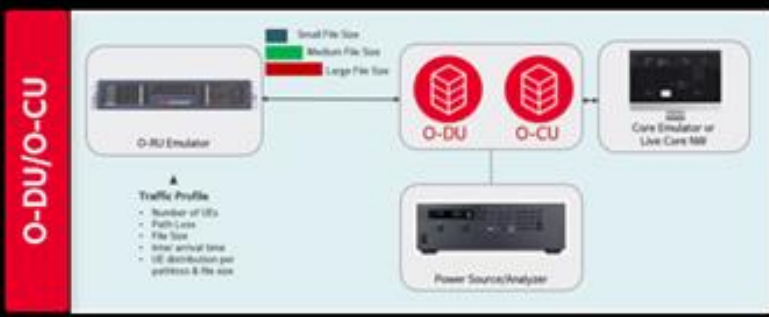
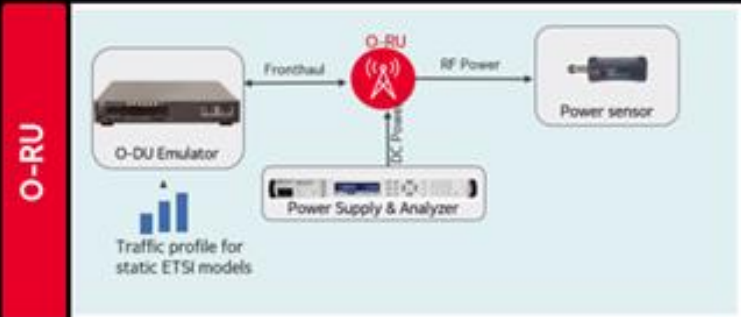
**Test Automation and Reporting**

- **Single Pane of Glass** across all Test Suites
- **Automated** energy test, correlation and reports

**Energy Test and Measurements Solutions for Lab and Field**

- Energy Meters / Power Supplies
- Emulators (UE, RU, DU)
- Test UEs (for outdoors)

### Test Automation and Reporting



Public references - O-RU with Rakuten Mobile, NEC, Analog Devices, LITEON, Auray OTIC, ... | O-DU/O-CU/Cloud with Vodafone, DTAG, SK Telecom, Intel, WindRiver, Radisys, Nokia, ... | RIC AI/ML with Juniper Networks, Capgemini, ... | gNB field with xxx operator and vendors

Keysight RAN Sustainability Testing Solutions have been developed through co-innovations with Industry Partners since 2022

# Why Keysight?

## Keysight Open RAN Leadership

Trusted Industry Advisor

Recognized T&M Leader

Technical Standards Influence

Local & Global Expertise

Seamless Automation & Analytics Platform

Only End-to-End Workflow Solutions Provider



# Open RAN Test Challenges and Solutions



# Some of the Key Test & Development Challenges with Open RAN Networks

Use links to navigate to the sections

## Open RAN Test Challenges and Solutions



- [Streamlining Open RAN Integration & Deployments](#): How can we maximize ROI and ensure seamless integration in multi-vendor, cloudified Open RAN deployments?



- [Efficient Development, Testing & Certification](#): How can we streamline testing and certification process through the whole Open RAN development lifecycle?



- [Optimizing Energy Efficiency](#): How can we achieve energy efficiency at both the subcomponent and E2E levels in Open RAN deployments?



- [MIMO/mMIMO Performance](#): How can we unlock maximum performance across Open RAN components and the entire network?



- [RIC Performance and AI/ML](#): How can we guarantee RIC performance and optimal behavior of AI/ML algorithms?



- [Securing Open RAN](#): How can we ensure the security of Open RAN components and the entire network?



- [5G NTN and Open RAN Integration](#): How can we validate gNB capability to handle doppler and delay pre-compensation channel characteristics in NTN integration?



- [E2E Network Visibility & Monitoring](#): How can we gain visibility and troubleshoot the entire network from user equipment to web services?

# Streamlining Open RAN Integration & Deployments

## Open RAN Test Challenges and Solutions

**Open RAN and cloudification** presents a significant opportunity for network component providers to innovate, but also introduces challenges in securing interoperability and integration across the entire network (E2E), at the same time securing efficient resource management.

**Keysight Open RAN test solutions portfolio** enables

- Tools for complete Open RAN components development
- Conformance, interoperability and E2E testing in cloudified environment

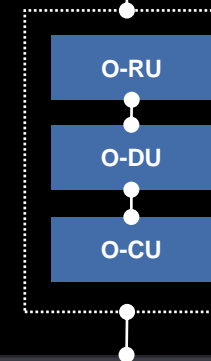
**Customer benefits from**

- Complete E2E test solution offering from a **single provider** streamlines the development process.
- Scalable test solutions cater to all needs, from **cost-effective options to full-scale systems**.
- Keysight close collaboration with **key industry consortia and customers** ensures our solutions meet your needs.

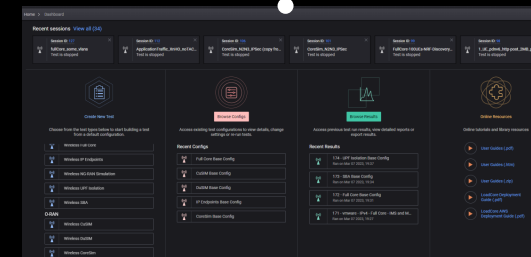
## Configuration Example: O-RAN E2E RAN Badging



**UeSIM**  
UE Emulator



**E2E RAN**  
System Under Test



**CoreSIM**  
Core Emulator



### Press Release:

[Samsung, Verizon and Keysight Advance Commercial Open RAN with Extensive Conformance and Interoperability Testing](#)

# Efficient Development Testing & Certification Process

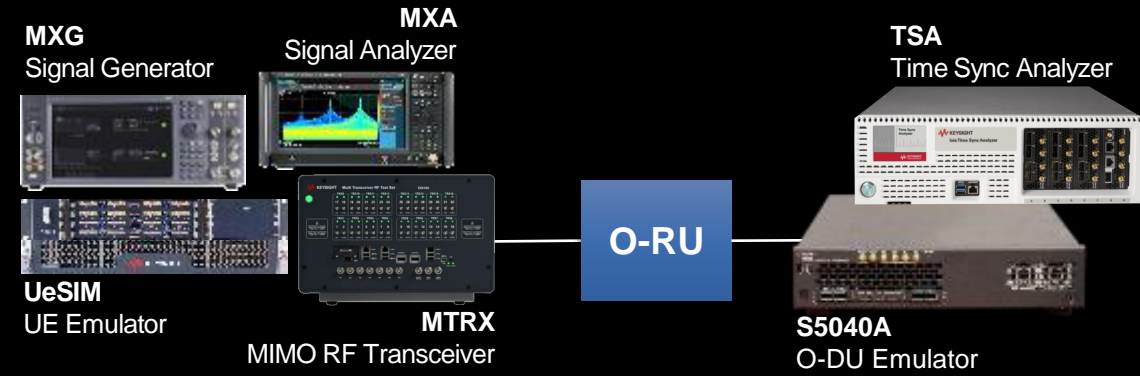
## Open RAN Test Challenges and Solutions

Testing complete Open RAN Network is a complex task introduced by wide range of use cases for development, interoperability and certification. Manual testing through the test process is time consuming and error prone.

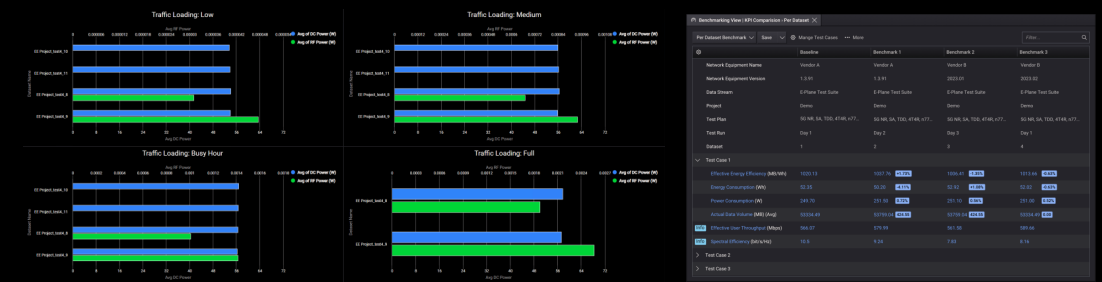
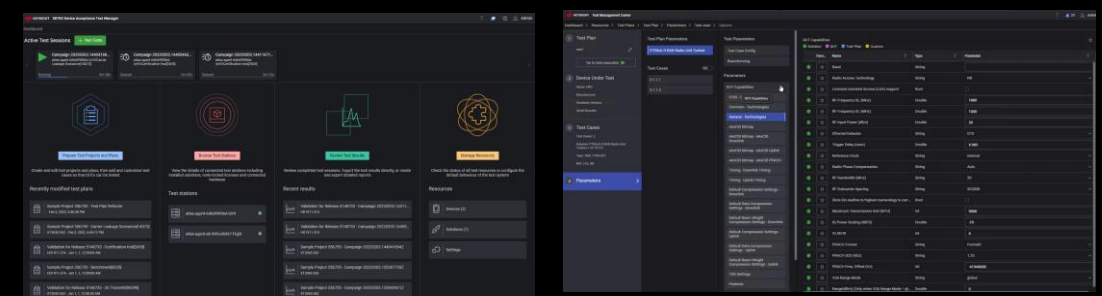
Keysight Atlas Test Management Center (TMC) enables complete test automation across Keysight's Open RAN test solutions portfolio.

- Automated, Out-of-the-Box test packages enables smooth use for 3GPP, O-RAN interoperability and certification tests
- Seamless integration into a CI/CD/CT pipelines
- ML / AI driven analytics and data insights
- Energy efficiency, O-RAN TIFG and customized test reporting
- Simultaneous user access to enable efficient usage across teams

Keysight Test Automation Platform speeds up and improves the quality and accuracy of the tests, at the same time enabling faster time-to-market for customers, resulting in increased ROI.



### Atlas Test Management Center (TMC)



### Atlas Test Management Center (TMC) Test Case Automation, Analytics and Reporting

# Optimizing Energy Efficiency

## Open RAN Test Challenges and Solutions

Ensuring energy efficiency (EE) across all components and the entire network (E2E) is critical for operators aiming to reduce carbon footprint and operational expenses (OPEX) in their multi-vendor Open RAN and traditional RAN deployments.

“On average, the network accounts for 90% of energy use for an operator, with the Radio Access Network (RAN) representing more than 80% of this, based on our latest energy benchmarking study. Energy has stubbornly remained at 20-40% of overall OPEX.” Source: [GSMA](#)

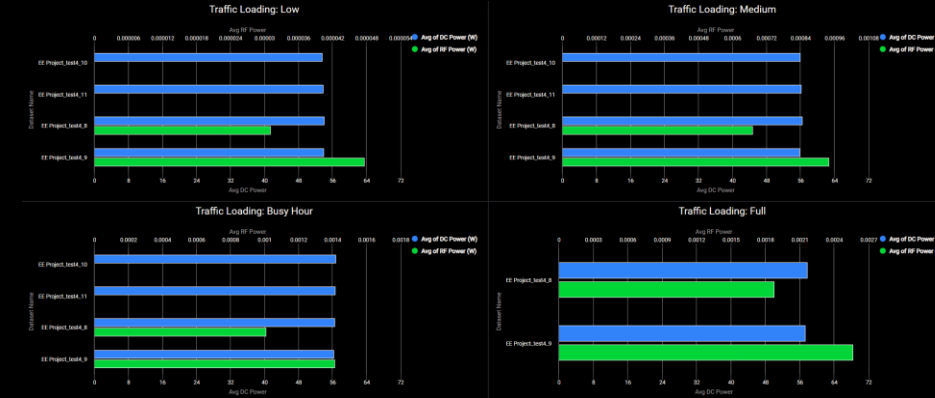
Keysight leads the way with **industry-proven test solutions for EE evaluation and benchmarking**. These solutions empowers customers to conduct measurements at Open RAN subsystem and E2E levels, according to ETSI specifications and customized test scenarios. By leveraging Keysight’s EE solutions, customer can reduce energy costs and minimize carbon footprint.

### Use Cases:

- [How to Measure the Energy Efficiency of an O-RU](#)
- [How to Measure the Energy Efficiency of an O-DU/O-CU](#)
- [How to Evaluate gNodeB Energy Performance](#)

### Press Release:

[Vodafone, Wind River, Intel, Keysight Technologies and Radisys test ‘green’ Open RAN network](#)



EE Measurements according to ETSI Traffic Profiles

Per Dataset Benchmark	Baseline	Benchmark 1	Benchmark 2	Benchmark 3
Network Equipment Name	Vendor A	Vendor A	Vendor B	Vendor B
Network Equipment Version	1.3.91	1.3.91	2023.01	2023.02
Data Stream	E-Plane Test Suite	E-Plane Test Suite	E-Plane Test Suite	E-Plane Test Suite
Project	Demo	Demo	Demo	Demo
Test Plan	5G NR, SA, TDD, 4T4R, n77...	5G NR, SA, TDD, 4T4R, n77...	5G NR, SA, TDD, 4T4R, n77...	5G NR, SA, TDD, 4T4R, n77...
Test Run	Day 1	Day 2	Day 3	Day 1
Dataset	1	2	3	4
Test Case 1				
Effective Energy Efficiency (MB/Wh)	1020.13	1037.76 <b>+1.7%</b>	1006.41 <b>-1.2%</b>	1013.66 <b>-0.4%</b>
Energy Consumption (Wh)	52.35	50.20 <b>-4.1%</b>	52.92 <b>+1.0%</b>	52.02 <b>-0.4%</b>
Power Consumption (W)	249.70	251.30 <b>0.7%</b>	251.10 <b>0.5%</b>	251.00 <b>0.1%</b>
Actual Data Volume (MB) (Avg)	53334.49	53759.04 <b>0.8%</b>	53759.04 <b>0.8%</b>	53334.49 <b>0%</b>
Effective User Throughput (Mbps)	666.07	679.99	661.38	589.66
Spectral Efficiency (bit/s/Hz)	10.5	9.24	7.83	8.16
Test Case 2				
Test Case 3				

Vendor EE Benchmarking

# Securing MIMO/mMIMO Performance of Open RAN Networks

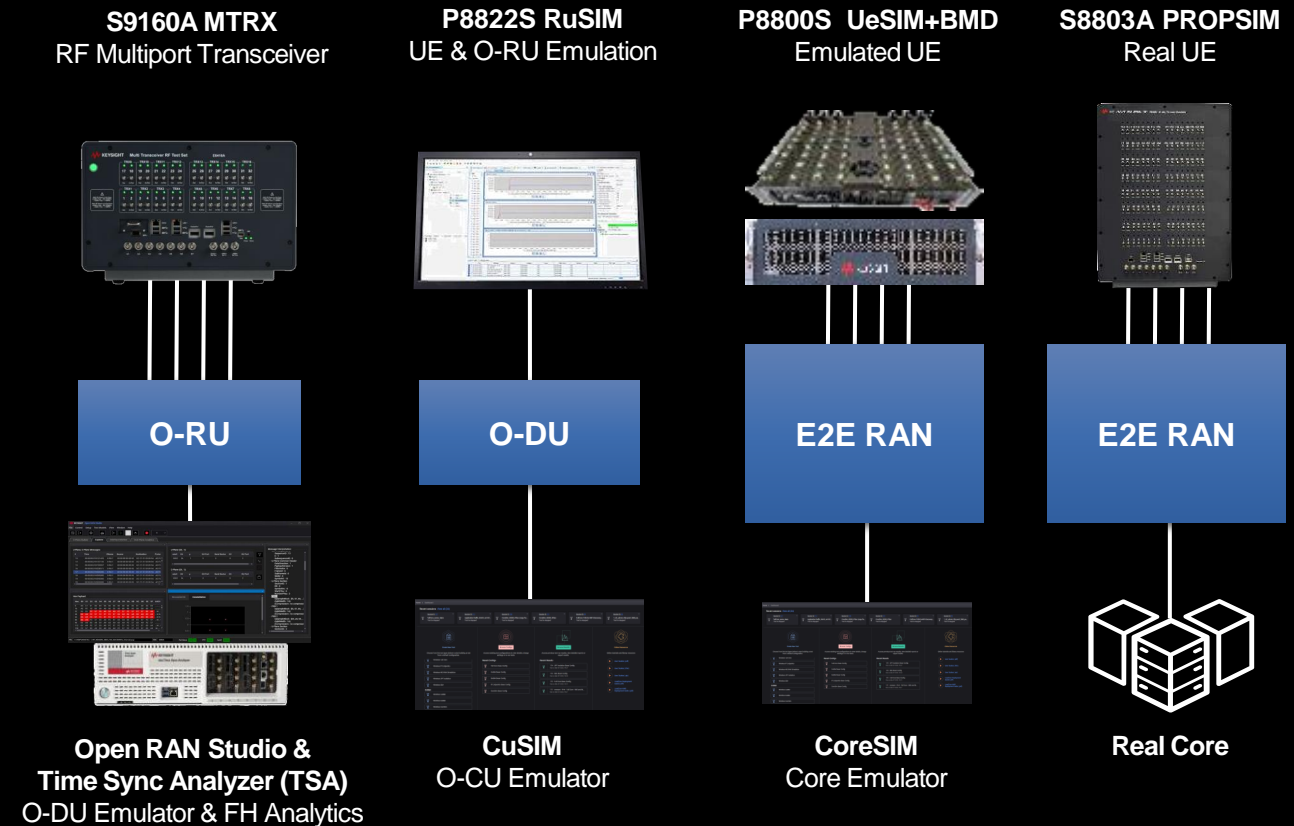
## Open RAN Test Challenges and Solutions

Capacity and performance is expected to increase dramatically with modern networks and MIMO and mMIMO plays key role to achieve the targets. In Open RAN networks, MIMO capability is disaggregated in different network functions which generates challenges to implement MIMO effectively and needs advanced tools for testing.

**Keysight O-RAN test solutions** provides comprehensive coverage to ensure MIMO and mMIMO performance of the network components:

- O-RU isolated testing
- O-DU isolated testing
- E2E RAN Testing with Emulated and Real UE's

**For customers** Keysight provides wrap-around test solution to ensure MIMO & mMIMO performance with isolated O-RU and O-DU as well as with E2E RAN network, in both lab and field.



**Press Release:**

[Keysight Enables Open RAN Massive MIMO Innovation](#)



# Guarantee RIC and AI/ML Performance in Open RAN Networks

## Open RAN Test Challenges and Solutions

**Real-Time Intelligent Controller (RIC)** functionality and performance rely heavily on data received through E2 and A1 interfaces. AI/ML algorithms within xApps and rApps needs to be efficient to meet the set performance expectations.

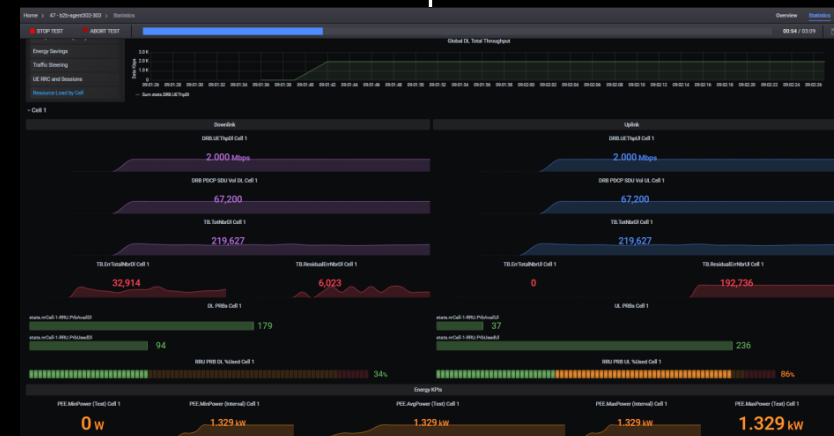
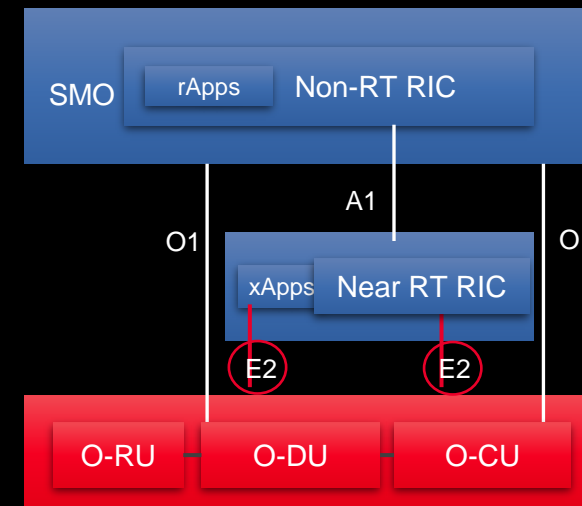
**Keysight O-RAN test solutions** enables testing of all RIC interfaces from functionality, interoperability and performance perspective. Both RIC and E2E test solutions helps to evaluate the performance of the AI/ML algorithms.

**For customers** Keysight O-RAN test solutions offers comprehensive coverage for RIC and AI/ML performance testing to evaluate RIC and E2E network performance expectations are met.

### Solution Demo:

<https://www.keysight.com/sg/en/library/demos/demo/near-real-time-ric-testing-with-keysight-s-rictest.html>

## Configuration Example: Validate E2 Interface (Functional & Load)



RICtest  
E2 Node Emulation



# Ensure the Security of Open RAN Interfaces and the Entire Network

## Open RAN Test Challenges and Solutions

**Disaggregation of Open RAN** exposes more potential entry points for attackers in the network. Multi-vendor integration and complexity of cloud infrastructure introduces their own aspect of security challenges.

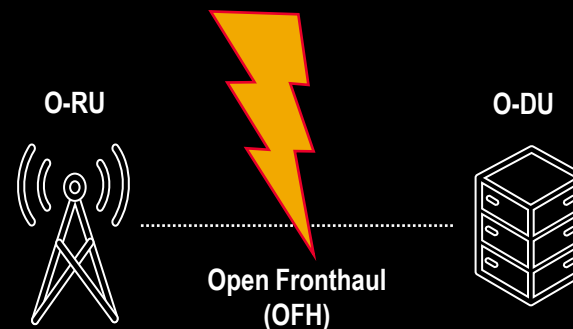
**Keysight Security Test Suite** provides

- Comprehensive coverage for security test scenarios defined by O-RAN ALLIANCE and 3GPP
- Vulnerability assessment and penetration testing for O-RAN components, interfaces and system.
- Extensive scan and audit functions.

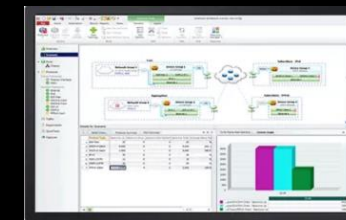
**With Keysight Security Test Solution** user can be assured to be covered for the needs for security testing aspects and ensure Open RAN network availability and performance under security attacks.

**Security Scenario Example:** DDoS attack targeting Open Fronthaul Interface

**Attackers Goal:** Overwhelm OFH interface with flood of malicious traffic to cause service outage for subscribers.



**Solution:** Keysight E2E RAN Security Test Solution helps to create real-world scenarios to find vulnerabilities and ensure Open Fronthaul functionality and performance under security attacks.



**IxNetwork**  
E2E RAN Security (FH) Tests

# 5G NTN and Open RAN Integration

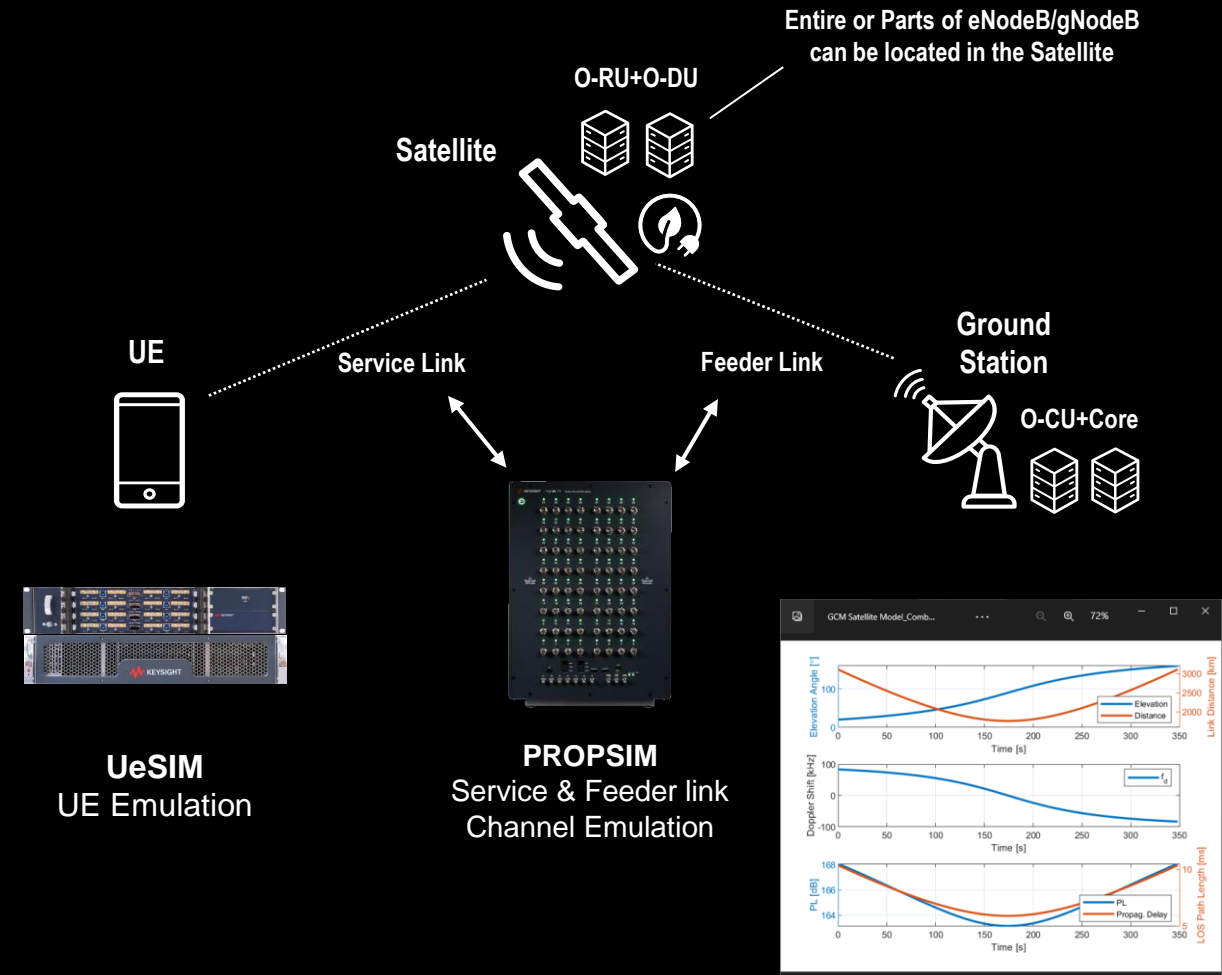
## Open RAN Test Challenges and Solutions

**Open RAN** provides the flexibility for the operator to innovate and effectively build the NTN network where Open RAN components can be dis-aggregated between satellite and ground. NTN networks brings the doppler and delay pre-compensation challenges for Open RAN components to handle.

**Keysight Test Solutions** provides the capabilities to ensure **Open RAN performance in NTN use case**

- Channel simulation on both Service and Feeder links
- Doppler & Delay Pre-Compensation
- Channel emulation for different UE ground locations
- Energy Efficiency & Optimization

**With Keysight NTN Test Solution** customer can be assured to be covered for the test requirements and ensure that network with Open RAN components can handle the challenges set by NTN networks.



### Press Releases:

[Keysight and Capgemini Validate 5G New Radio RAN Solution for Non-Terrestrial Networks](#)

See more about Keysight NTN test solutions from [Keysight.com](https://www.keysight.com)

# Open RAN E2E Visibility & Troubleshooting

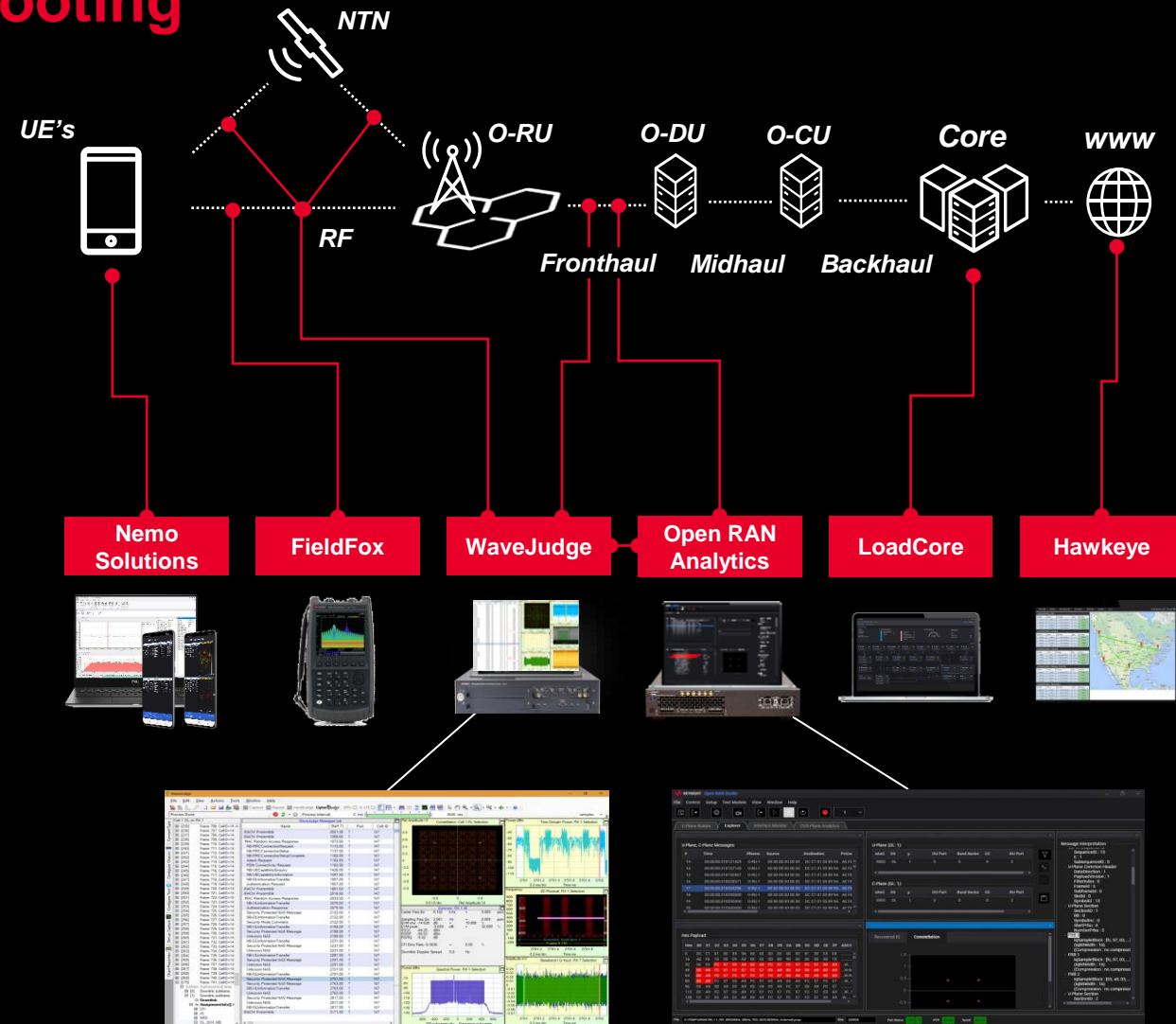
## Open RAN Test Challenges and Solutions

**Complete O-RAN Network** introduces various interfaces. In case of error or performance gap it is crucial to be able to gain detailed visibility from the interface and correlate data for efficient troubleshooting.

**Keysight** provides tools to gain visibility not only for each O-RAN interface, but also visibility from UE and core network perspective. Detailed analytics from RF and Fronthaul interface, with correlation, troubleshooting time can be reduced into fraction of the time used traditionally.

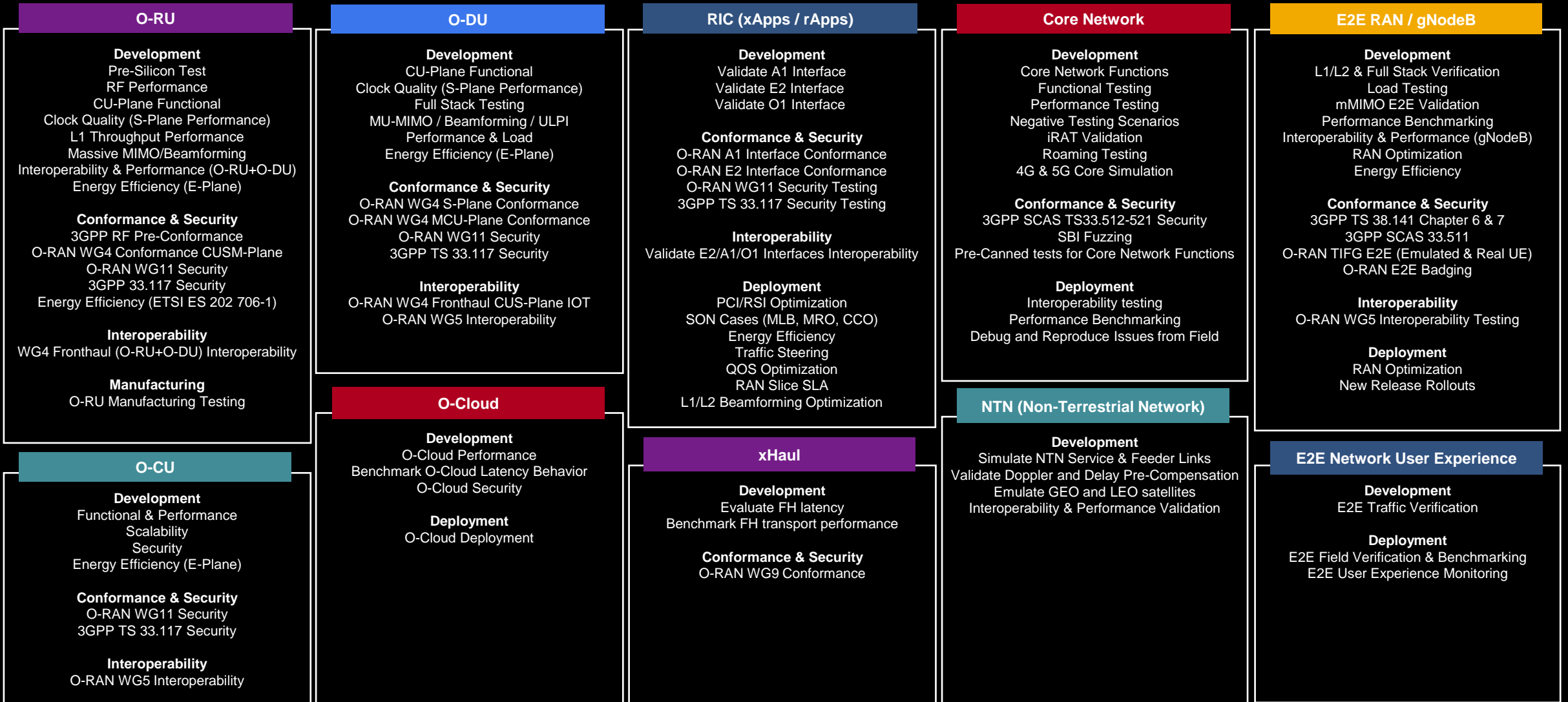
**Keysight Visibility & Troubleshooting Solutions** provides the tools to speed up the troubleshooting of the issues dramatically and speeds up the development process.

Learn more about Keysight network visibility solutions:  
<https://www.keysight.com/zz/en/products/network-visibility.html>



Detailed RF and Fronthaul Analytics

# Scalability to Overcome Open RAN Use Case Test Challenges



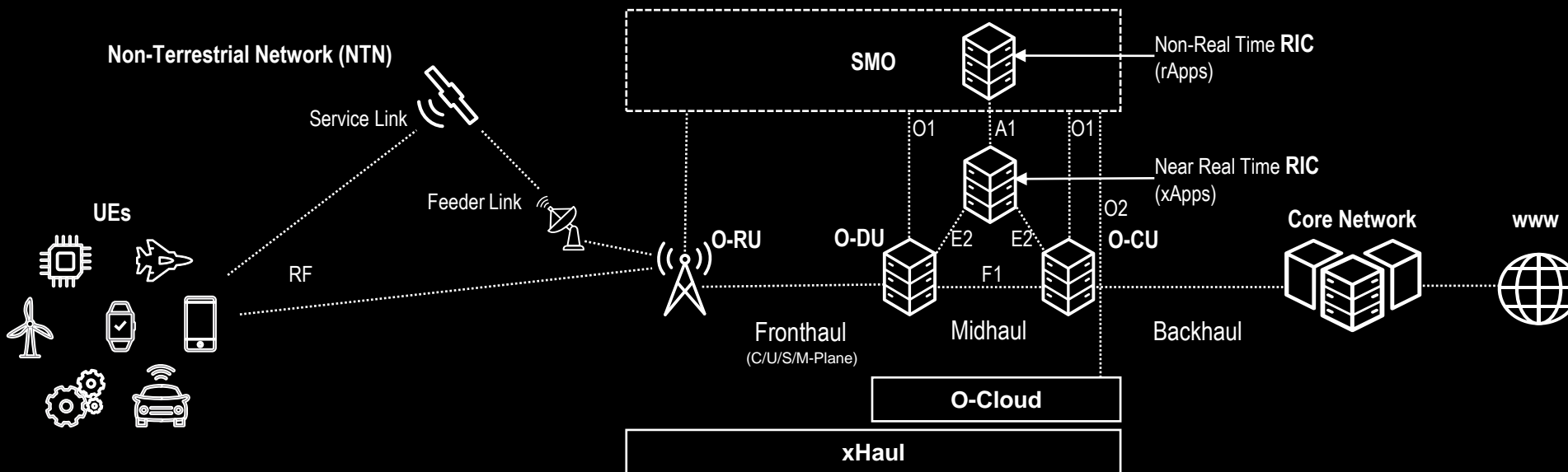
# Keysight Open RAN Test Solutions Portfolio

## High Level Introduction

# Keysight Solution Coverage for Open RAN Testing

Navigate Keysight's Solutions by Clicking the Blocks Below

- Conformance
- Interoperability
- Security
- Intelligence (AI/ML)
- Energy Efficiency
- Automation



Supported Entities	O-RU	O-DU	O-CU	RIC xApps / rApps
	O-Cloud	xHaul		Core Network
	NTN	E2E RAN / gNodeB		E2E User Experience
Common Framework	E2E Visibility & Troubleshooting			
	Test Automation, Analytics & Reporting			

# O-RU Testing

## Solution Highlights

### Wrap-around Test Solution for O-RU Testing

- C/U/S/M -plane test support in Single Solution
- Support from **Pre-Silicon** to **Manufacturing Testing**
- RF & L1 Throughput Performance
- MIMO & Massive MIMO Beamforming / ULPI
  - O-RU up to 64T64R
- 3GPP & O-RAN Conformance & Security
- O-RAN WG4 Interoperability (O-RU+O-DU)
- Energy Efficiency (E-Plane)
- RF & Fronthaul Analytics and Troubleshooting
- Test Automation & Reporting with **Atlas Test Management Center**

Use Cases:

[How to Perform O-RAN Radio Unit Conformance Testing](#)

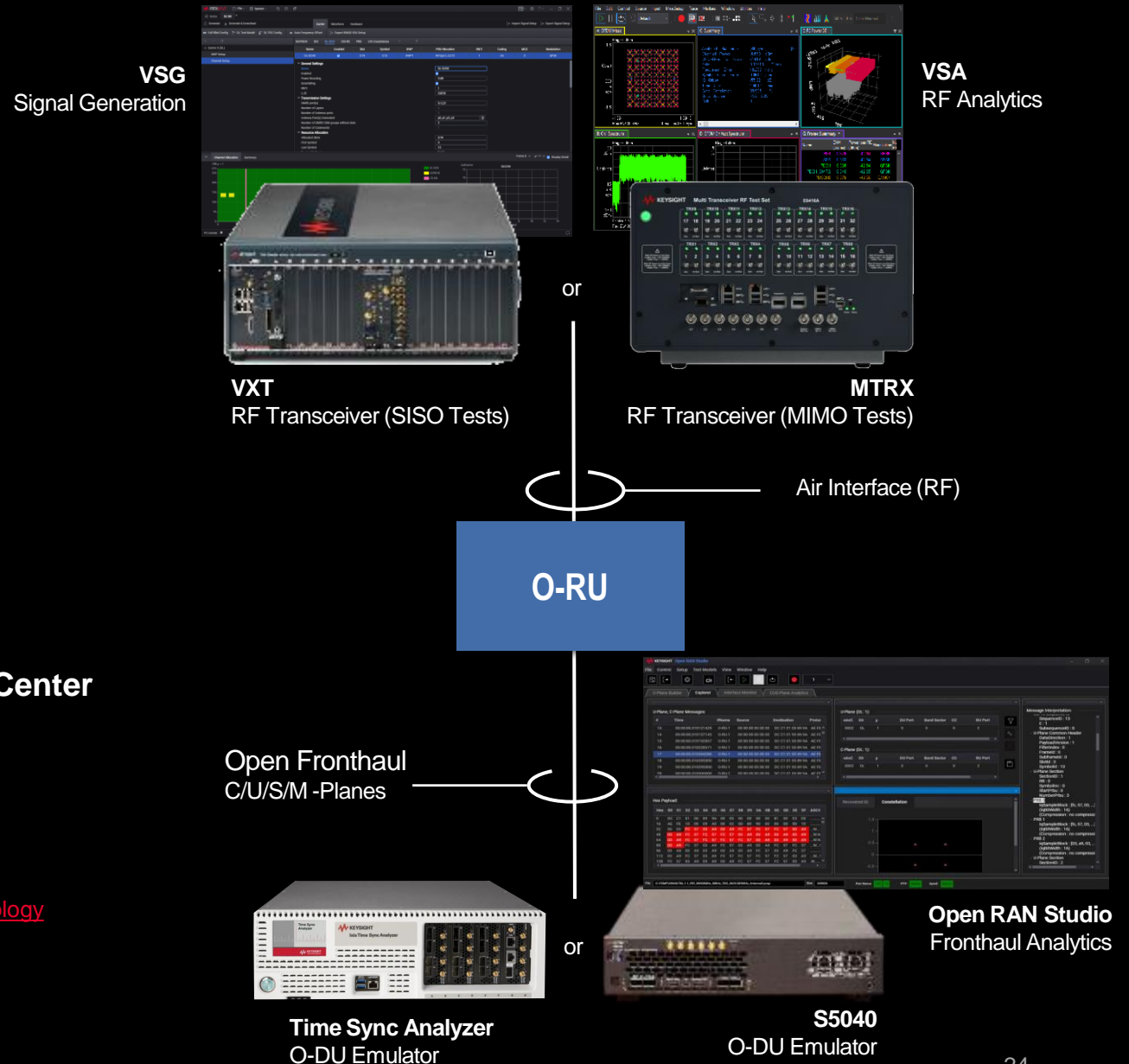
Press Releases:

[Keysight and SUTD Sign Memorandum of Understanding for Open RAN and 6G Technology](#)

[Keysight Supports Verification of Open RAN Radio Units Powered by Qualcomm](#)

[Keysight and Metanoia Validate 5G Low Physical Layer Open Radio Unit](#)

### Configuration Example for RF Performance Testing





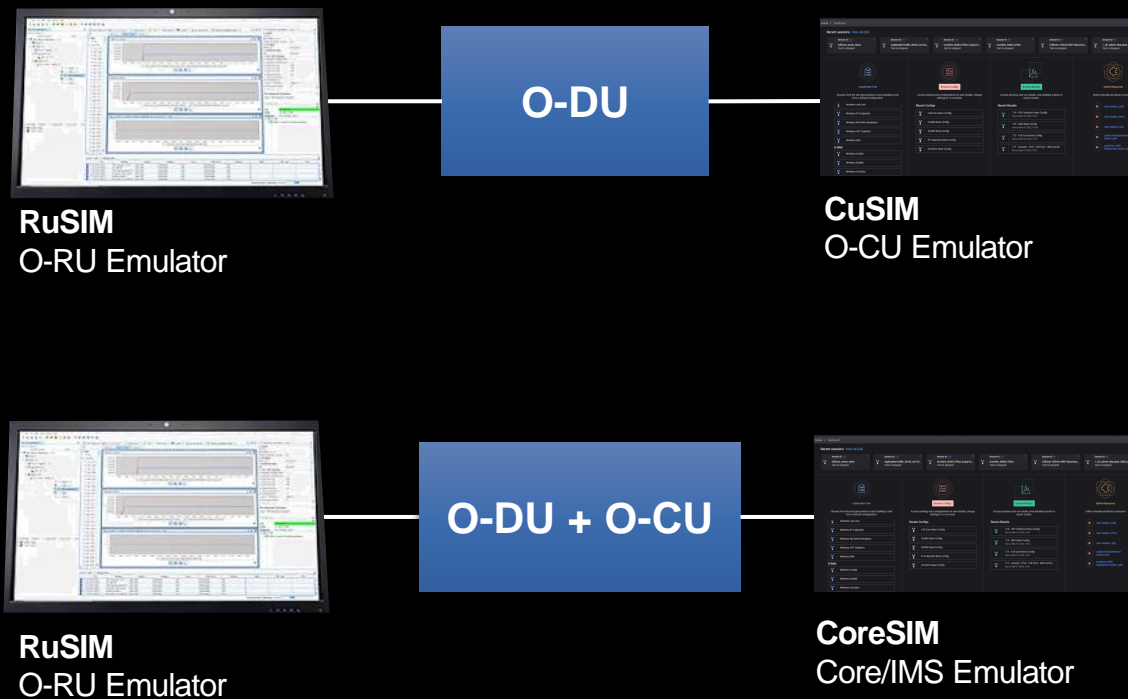
# O-DU Testing

## Solution Highlights

### Wrap-around Test Solution for O-DU

- Support both standalone O-DU & combined O-CU/O-DU
- O-RU, O-CU and Core Emulation
- Performance, Functional & Load Testing
- Full Stack C/U/S/M -plane test using Single Solution
- MU-MIMO, Beamforming & ULPI
- O-RAN WG4 Conformance
- O-RAN WG4 & WG5 Interoperability
- 3GPP & O-RAN Security
- Energy Efficiency (E-Plane)
- Test Automation & Reporting with **Atlas Test Management Center**

### Configuration Examples for Full Stack & mMIMO Verification



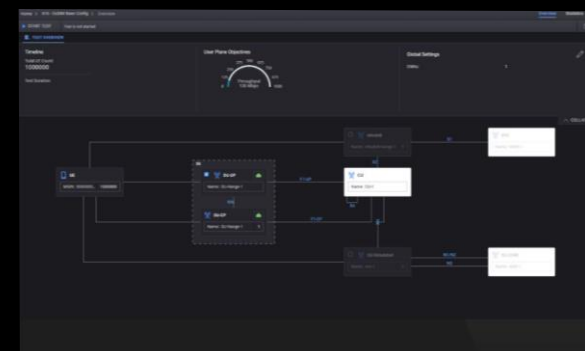
# O-CU Testing

## Solution Highlights

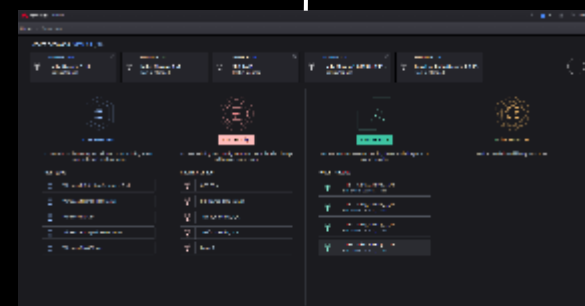
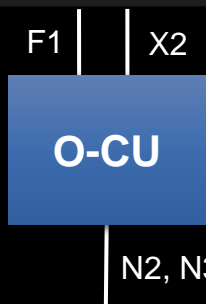
### Wrap-around Test Solution for O-CU

- Virtualized solution and easy to scale
- Functional, Performance & Load Testing
- Highly scalable to hundreds of O-DUs and thousands of UEs with 10s Gb of throughput
- Support for Standalone (F1) and Non-Standalone (X2/F1)
- 3GPP and O-RAN ALLIANCE WG11 test specifications
- O-RAN WG5 Interoperability (O-CU+O-DU)
- Energy Efficiency (E-Plane)
- Test Automation & Reporting with **Atlas Test Management Center**

## Configuration Example for O-CU Functional & Performance Testing



DuSIM  
O-DU Emulator



CoreSIM  
Core Emulator

# RIC, xApps, rApps and AI/ML Testing

## Solution Highlights

### Test RIC Protocol and Platform at any scale

- Emulate a High Number of UEs, Cells, E2 nodes cost effectively
- A1, O1 and E2 Interface Validation
- E2 and O1 scale and performance at Production volumes
- O-RAN WG2 and WG3 Conformance & Interoperability
- O-RAN WG11 and 3GPP TS 33.117 Security Testing

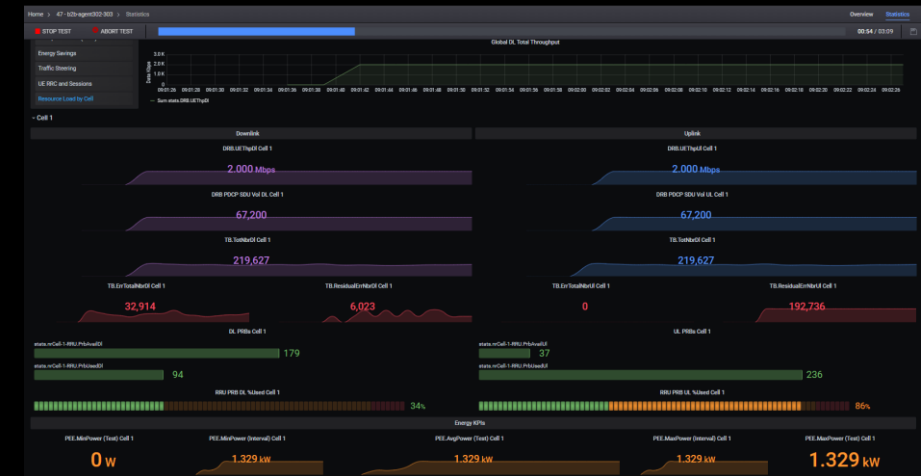
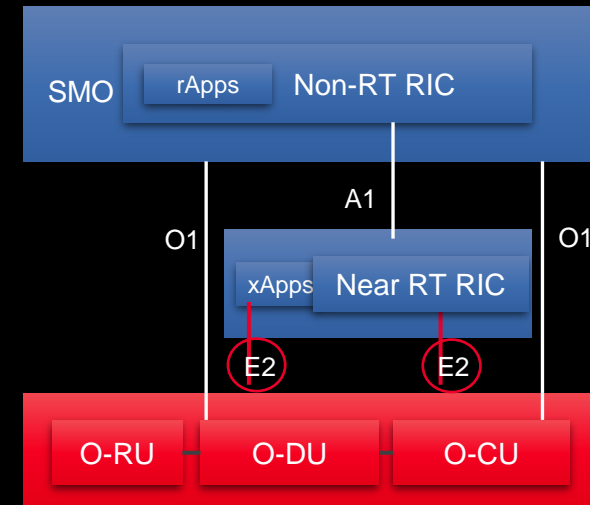
### Validate RIC, xApps, and rApps vertical integration in pre-deployment

- PCI/RSI Optimization, SON Cases (MLB, MRO, CCO)
- Traffic Steering & QOS Optimization
- RAN Slice SLA
- Energy Efficiency
- L1/L2 Beamforming Optimization & Massive MIMO use cases

### AI/ML Test Enablement

- Accelerated Data Set Generation for Offline Training
- Comparative Performance Assessment of Results Sets

## Configuration Example for E2 Interface Validation



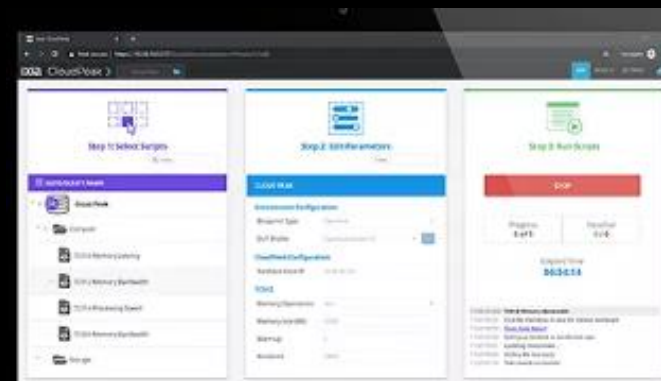
RICtest (e.g. Resource Load by Cell)

# O-Cloud Testing

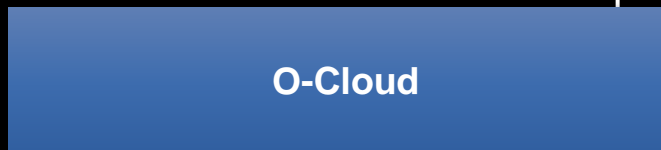
## Solution Highlights

### Single Solution to Cover All O-Cloud Test Use Case Scenarios

- Validate O-Cloud Performance
- Benchmark O-Cloud Latency Behavior
- Test O-Cloud Security
- TIFG E2E Security Test Scenarios
- O-Cloud Deployment
- Test Automation & Reporting with **Atlas Test Management Center**



**Cloud Peak**  
(Virtual Cloud Infrastructure Validation)

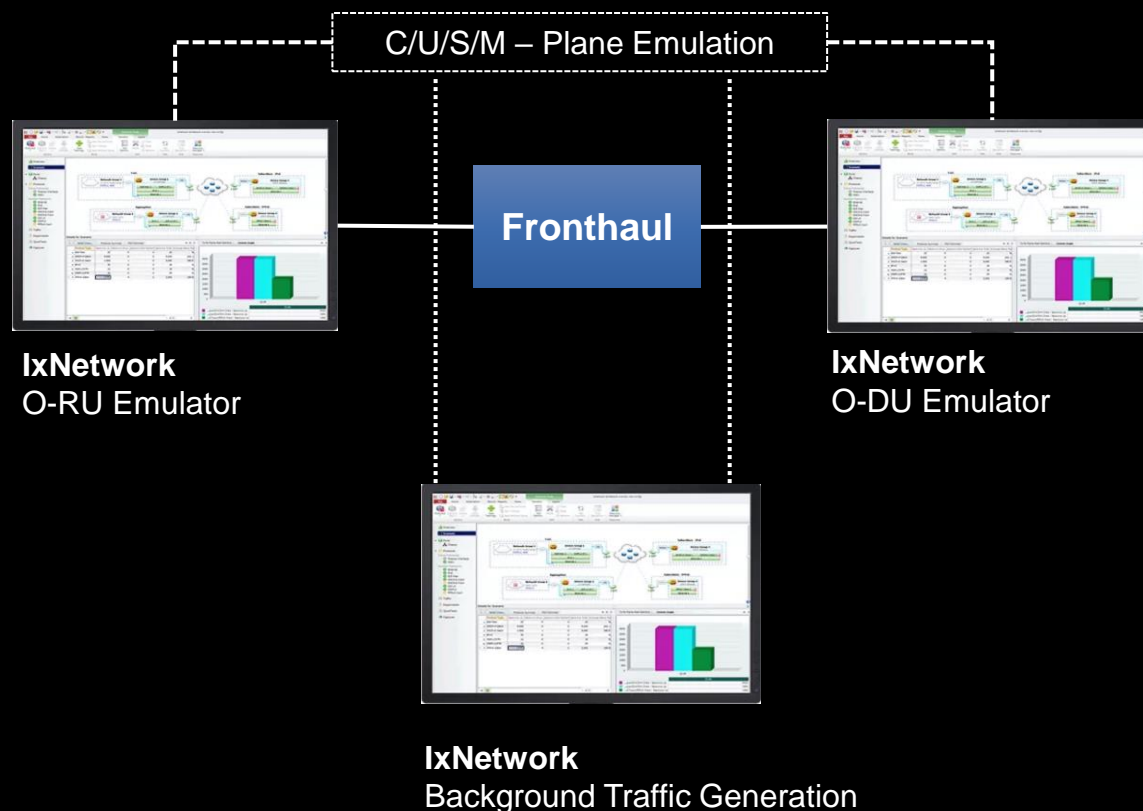


# xHaul Testing

## Solution Highlights

### Wrap-Around Test Solution to Cover xHaul Test Requirements

- Validate ORAN fronthaul Transport with realistic O-RU – O-DU eCPRI traffic
- Optimize Latency and Benchmark Transport Performance at Scale
- Test Transport Slicing and Differentiated 5G Services
- Validate Synchronization in Fronthaul Network and Measure Relative Time Error Between Multiple O-RUs
- Assess Compliance as per O-RAN ALLIANCE WG9 Conformance Test Specification
- Completely Virtualized Solution
- Test Automation & Reporting with **Atlas Test Management Center**

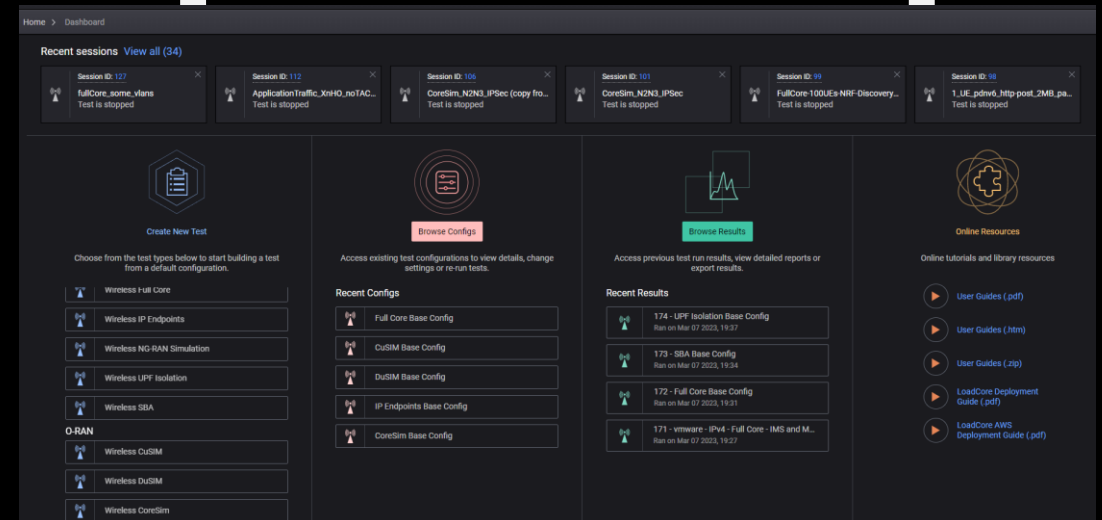
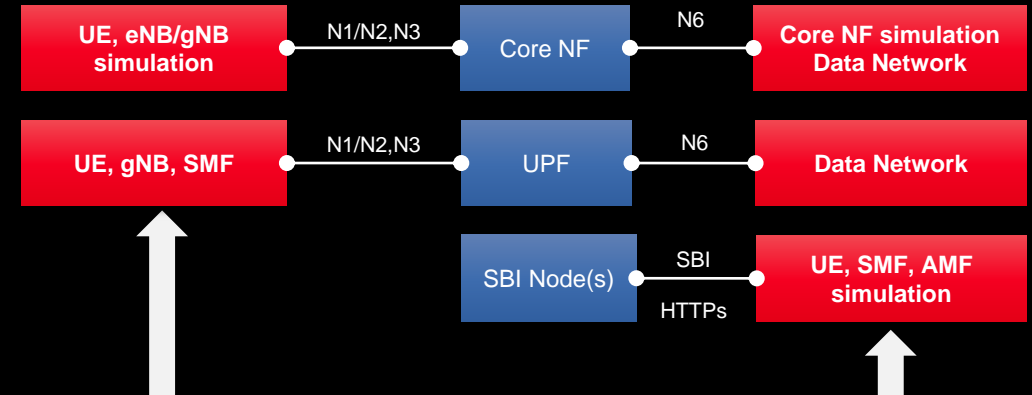


# Core Network Testing

## Solution Highlights

### Comprehensive Test Solution for Core Network Testing

- Functional & Performance Testing for Core Network Functions
- Security testing
- 3GPP Conformance testing
- Negative Testing Scenarios
- iRAT Validation
- Interoperability Testing
- Performance Benchmarking
- Troubleshooting and Analysis
- **Complete Test Automation with Atlas Test Management Center**



**LoadCore**  
UE traffic generator & Network Function Emulator

# Non-Terrestrial Network (NTN) Testing

## Solution Highlights

### Comprehensive Solution for NB-NTN & NR-NTN Testing

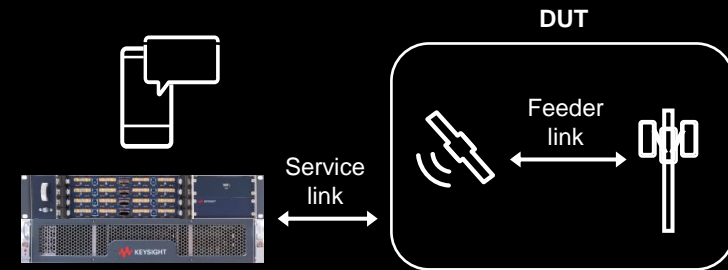
- Validate Open RAN by simulating service and feeder links with realistic NTN signal conditions
- Reception and decoding of MIB/SIBs in the presence of variable delay
- Doppler and delay pre-compensation applied for UL path of service link (SLUL)
- Validation of Doppler and delay pre-compensation applied for DL path by gNodeB
- Emulate Various Types of Satellites GEO, MEO and LEO
- Future proof with 3GPP Releases 17 & 18 compatibility including Ka band support

#### Press Release:

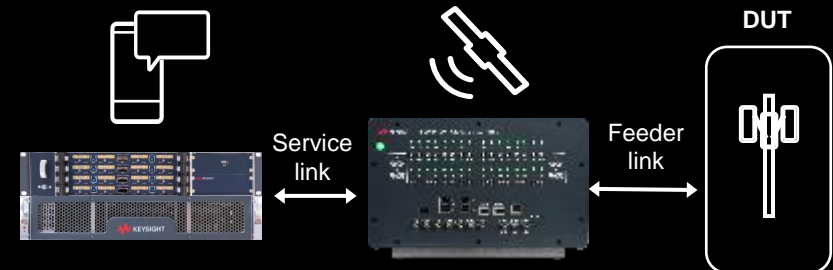
[Keysight and Capgemini Validate 5G New Radio RAN Solution for Non-Terrestrial Networks](#)

Learn more about Keysight NTN test solutions from [Keysight.com](https://www.keysight.com)

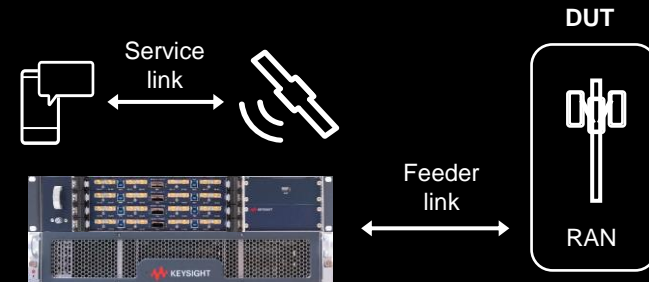
### Simulate Service link with UeSIM



### Simulate Service + Feeder link with PROPSIM



### Simulate Service + Feeder link with UeSIM internal CE



# E2E RAN / gNodeB Testing

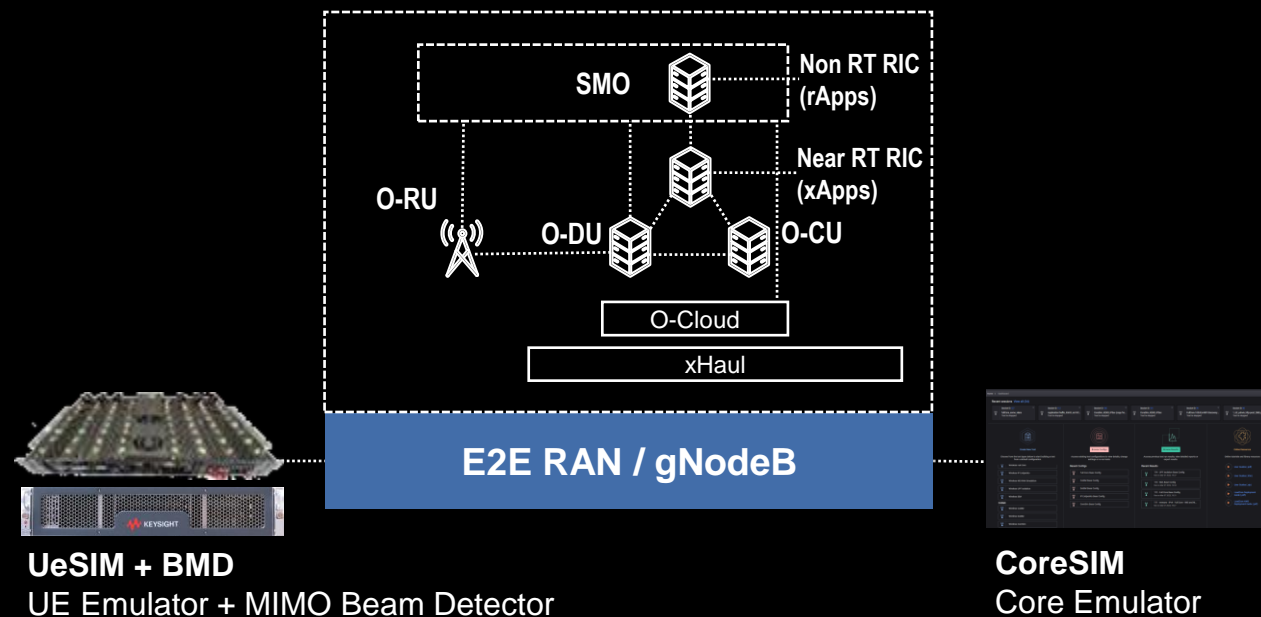
## Solution Highlights

Comprehensive coverage for end-to-end RAN and gNodeB testing, from development to deployment

- From Physical layer L1/L2 to full stack verification & performance benchmarking
- MU-MIMO, Beamforming & ULPI testing
- Conformance tests according to 3GPP and O-RAN (TIFG) specifications
- RAN optimization
- O-RAN E2E Badging
- Energy efficiency and security testing
- Complete Test Automation with **Atlas Test Management Center**



## Configuration Example for mMIMO E2E Validation



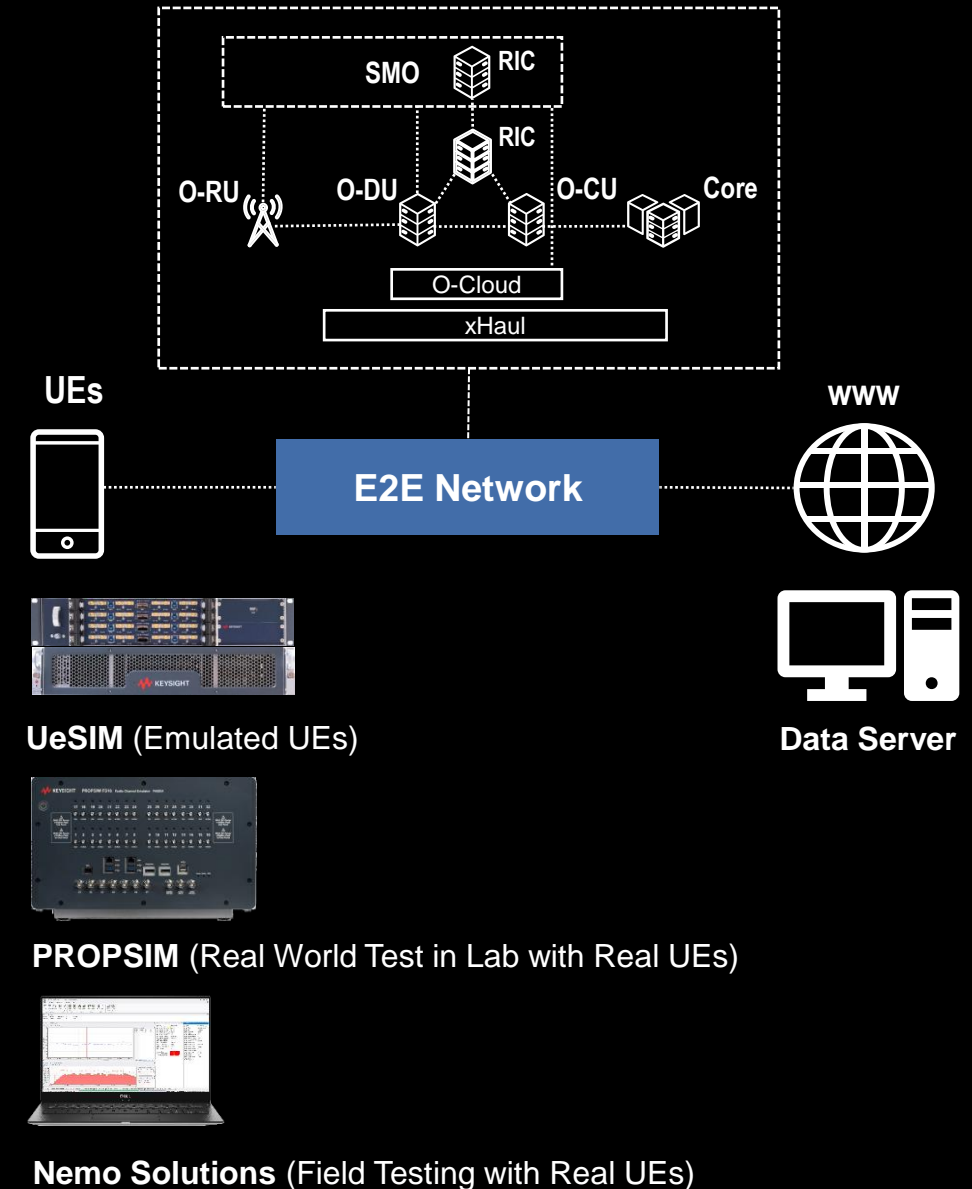


# E2E Network User Experience Testing

## Solution Highlights

Keysight Open RAN test suite enables to secure E2E Network Performance with comprehensive solution offering.

- Perform O-RAN Network **E2E Traffic & Performance Verification**
- Perform E2E Testing by Emulating from **Single to Thousands of UEs**
- Perform E2E **MIMO and Massive MIMO Beamform Test** with Real World 3D RF Channel Conditions in Lab using Real UEs
- Ensure Network **E2E Performance in Field Conditions** using Real UEs (Drive & Walk Tests & Monitoring)
- Complete Test Automation and Test Results Reporting with **Atlas Test Management Center**

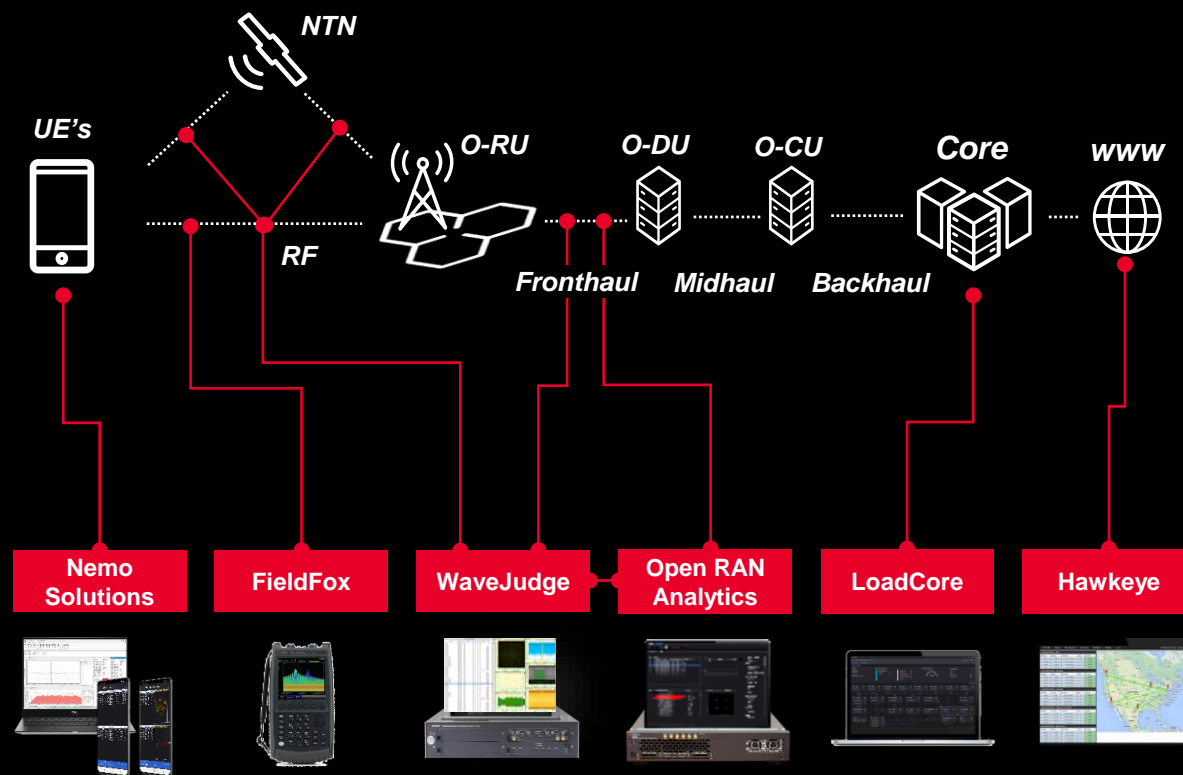


# O-RAN E2E Visibility & Troubleshooting

## Solution Highlights

Keysight provides full E2E visibility and troubleshooting capability across the whole E2E Open RAN network.

- **Nemo Solutions**
  - Test, optimize & monitor network performance and QoE with Nemo Solutions using real test UE's and applications. In lab and field.
- **FieldFox**
  - Identifying interference and optimize network performance in the field with handheld sized FieldFox RF & Spectrum analyzer.
- **WaveJudge 3GPP & O-RAN Protocol Analyzer**
  - Passively capture RF Air interface and Real-Time decode the signal (SW+HW required). Analyse IQ/PCAP captured from eCPRI Fronthaul interface and decode both 3GPP and O-RAN protocols (SW only solution – PCAP/IQ source required).
- **Open RAN Analytics**
  - Capture and decode Fronthaul O-RAN signaling and troubleshoot C/U/S/M –plane issues. Troubleshoot captures further with WaveJudge Protocol Analyzer.
- **LoadCore**
  - Simulate UE behavior to validate core network functionality and gain visibility for core network troubleshooting.
- **Hawkeye**
  - Validate performance of the E2E network and monitor real-time KPI's.



See more Keysight network visibility & troubleshooting solutions from [Keysight.com](https://www.keysight.com)

# Energy Efficiency and Savings

## Solution Highlights

Keysight provides integrated portfolio supporting automated RAN energy lab and field testing and benchmarking using Keysight's innovations:

- **Test scenarios** defined according to **ETSI specifications** also allowing customized test case creation.
- **Industry proven solution** to test and optimize various Open RAN components **energy savings and efficiency**
  - [O-RU](#)
  - [O-DU/O-CU](#)
  - RIC (xApps, rApps)
  - [E2E RAN in Lab](#)
  - E2E RAN in Field
- Complete Test Automation and Test Results Reporting with **Atlas Test Management Center**

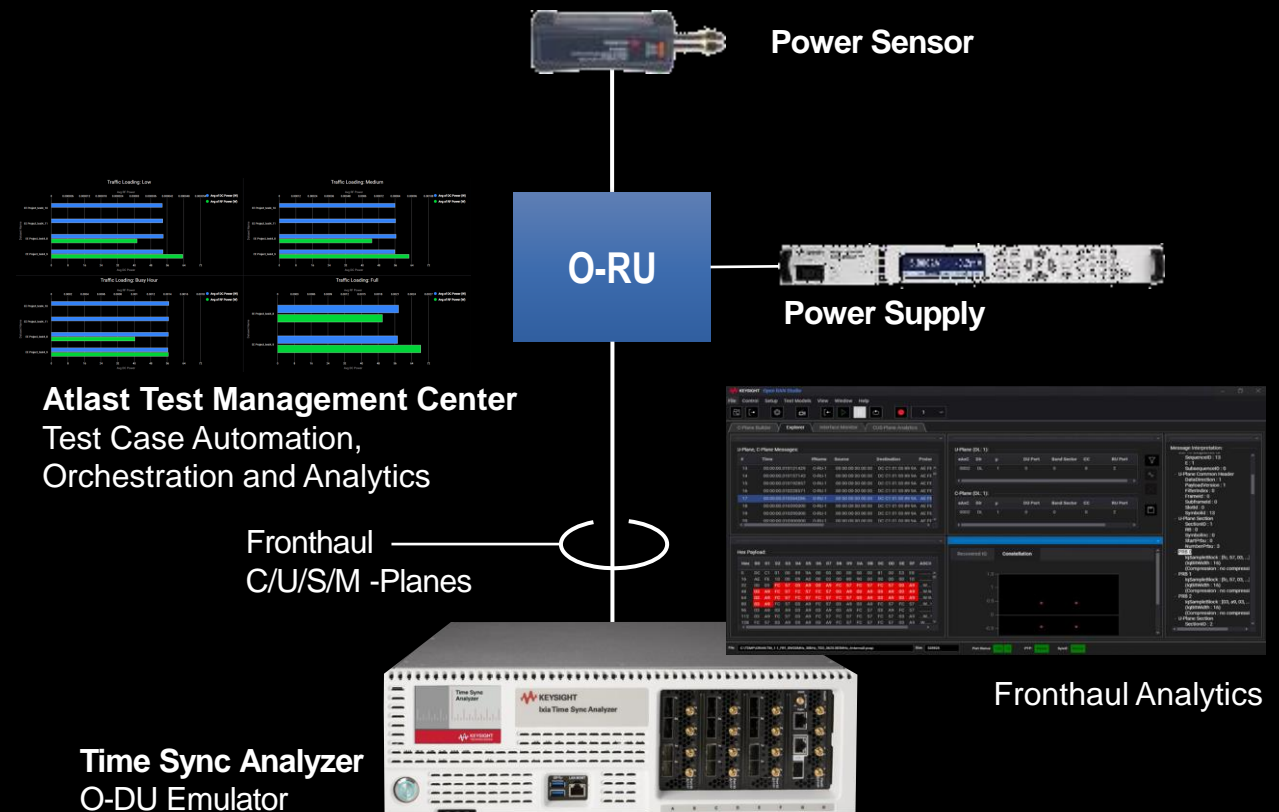
Technical overview of E-plane test suites:

<https://www.keysight.com/sq/en/assets/3123-1397/technical-overviews/Energy-Plane-E-Plane-Test-Suites-for-RAN-vRAN-O-RAN.pdf>

Press Release:

[Vodafone, Wind River, Intel, Keysight Technologies and Radisys test 'green' Open RAN network](#)

## Test Configuration Example: O-RU Energy Efficiency



# Security Testing

## Solution Highlights

**Keysight Security Test Suite** provides full coverage for security test scenarios defined by O-RAN ALLIANCE and 3GPP.

- **O-RAN WG11 Security Tests**
- **3GPP TS 33.117 Security Tests** covering all O-RAN Components
- **3GPP TS 33.511 SCAS (Security Assurance Spec) Security Tests**
- **Complete Test Automation and Test Results Reporting** with Atlas Test Management Center



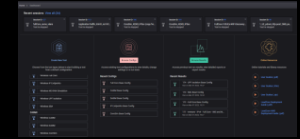
**UeSIM**  
UE emulation and U-Plane Traffic Generation



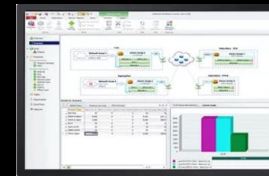
**RuSIM**  
O-RU Emulator



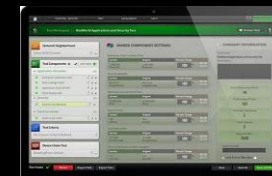
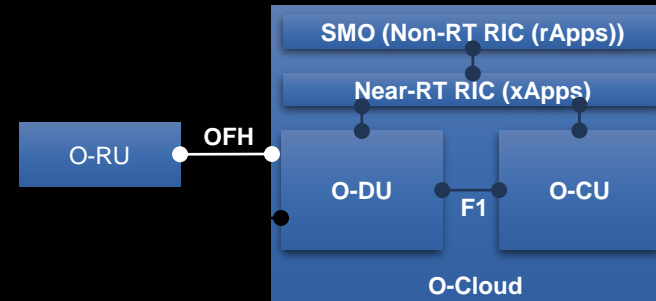
**Network Emulator 3**  
Random Network Fuzzer



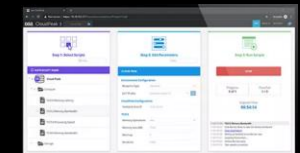
**CoreSIM**  
Core Emulator



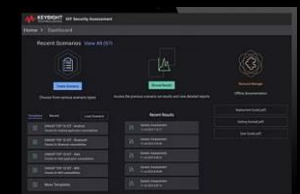
**IxNetwork**  
E2E RAN Security (OFH) Tests



**BreakingPoint Software**  
3GPP Security Tests



**CloudPeak**  
Cloud Security Tests



**IoT Security Assessment**  
O-RAN WG11 & 3GPP Security Tests

**Atlas Test Management Center (TMC)**  
Automation, Analytics & Reporting

# Conformance Testing

## Solution Highlights

Keysight O-RAN Test Suite provides complete test coverage for Conformance Test Scenarios Defined by **O-RAN ALLIANCE** and **3GPP**.

- O-RU 3GPP RF Pre-Conformance
- O-RU & O-DU O-RAN WG4 Conformance (CUSM-Plane)
- O-RAN A1 & E2 Interface covering RIC Conformance Tests
- O-RAN WG9 Conformance Tests covering xHaul
- **E2E RAN (gNB) Conformance**
  - 3GPP TS 38.141 Chapter 6 & 7 Conformance
  - O-RAN TIFG E2E (Emulated & Real UE)
- Complete Test Automation by **Atlas Test Management Center**

### Press Releases:

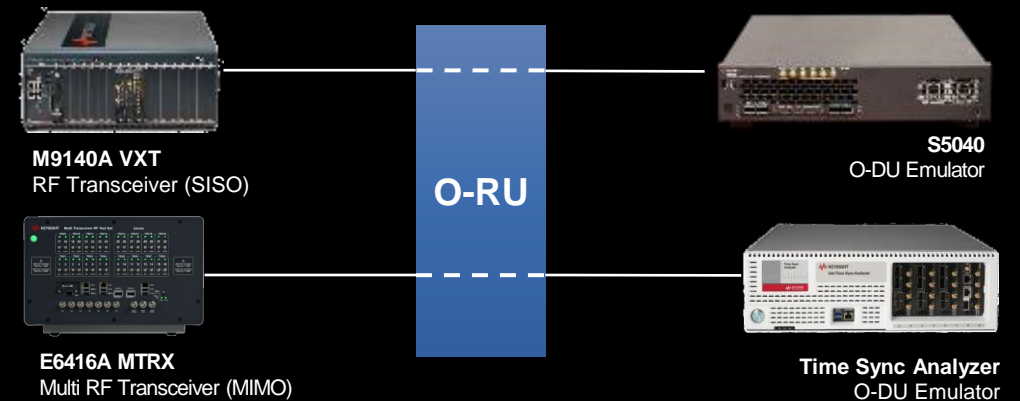
[Samsung, Verizon and Keysight Advance Commercial Open RAN with Extensive Conformance and Interoperability Testing](#)

[Keysight Enables Fii to Earn Outdoor Open Radio Unit Certificate of Conformance](#)

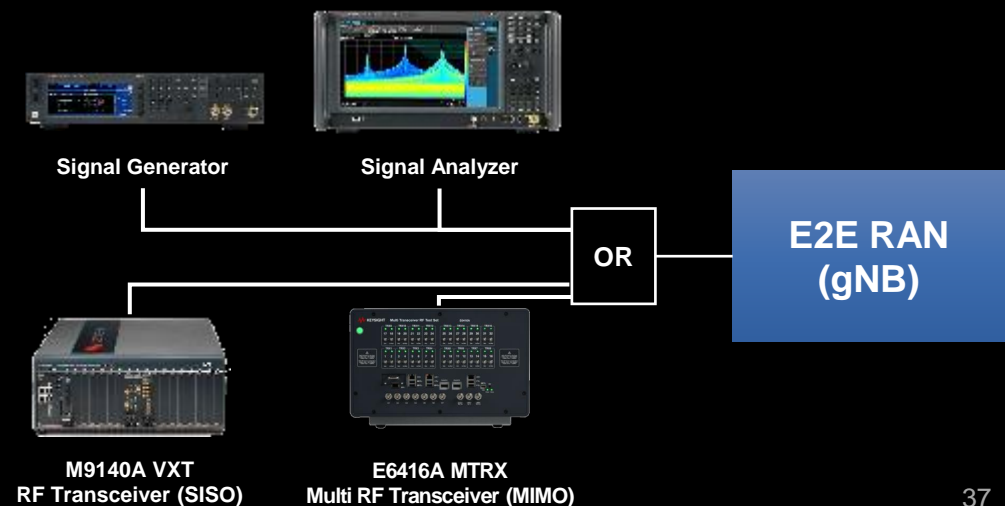


## Configuration Examples of O-RU WG4 & E2E RAN Conformance

### O-RU WG4 Conformance



### E2E RAN (gNB) 3GPP Conformance



# Interoperability Testing

## Solution Highlights

**Keysight O-RAN Test Suite** provides complete test coverage for interoperability test scenarios defined by O-RAN ALLIANCE

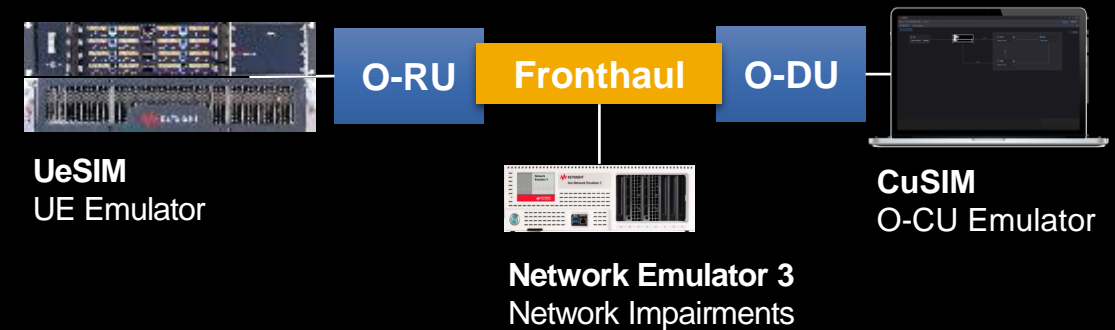
- **O-RAN WG4 Test Scenarios** for Fronthaul (O-RU+O-DU) Interoperability
- **O-RAN WG5 Test Scenarios** for F1 Interface (O-DU+O-CU) Interoperability
- **O-RAN Test Scenarios for A1 (WG2) & E2 (WG3) Interface** Interoperability Testing (RIC)
- **O-RAN WG5 Test Scenarios for E2E RAN / gNodeB Xn & X2 Interface** Interoperability Testing
- Complete Test Automation with **Atlas Test Management Center**



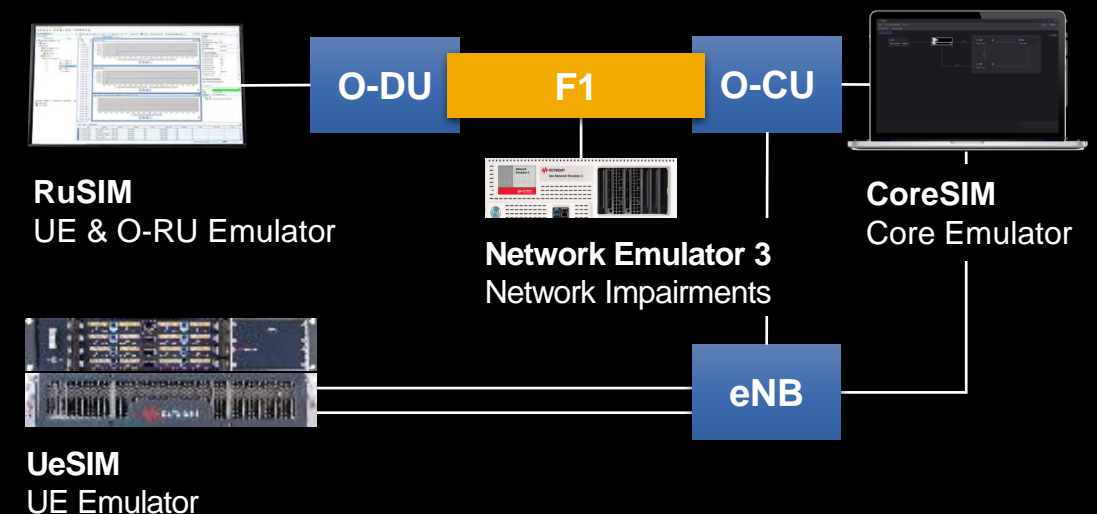
Press Release: [Samsung, Verizon and Keysight Advance Commercial Open RAN with Extensive Conformance and Interoperability Testing](#)

## Test Configuration Examples: O-RAN WG4 & WG5 Interoperability

### O-RU WG4 Interoperability



### O-DU WG5 Interoperability

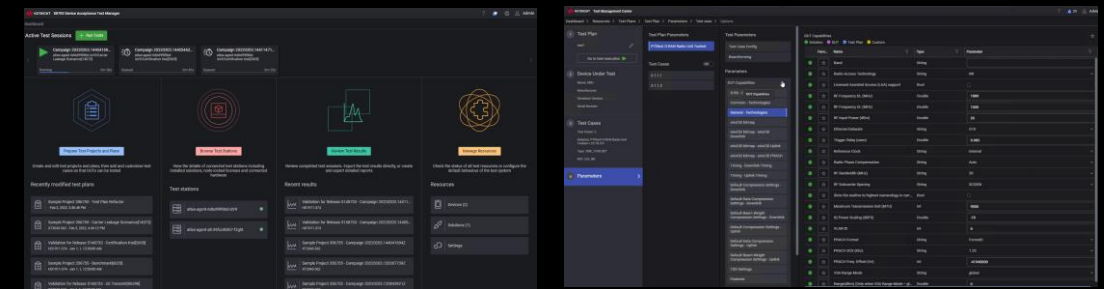
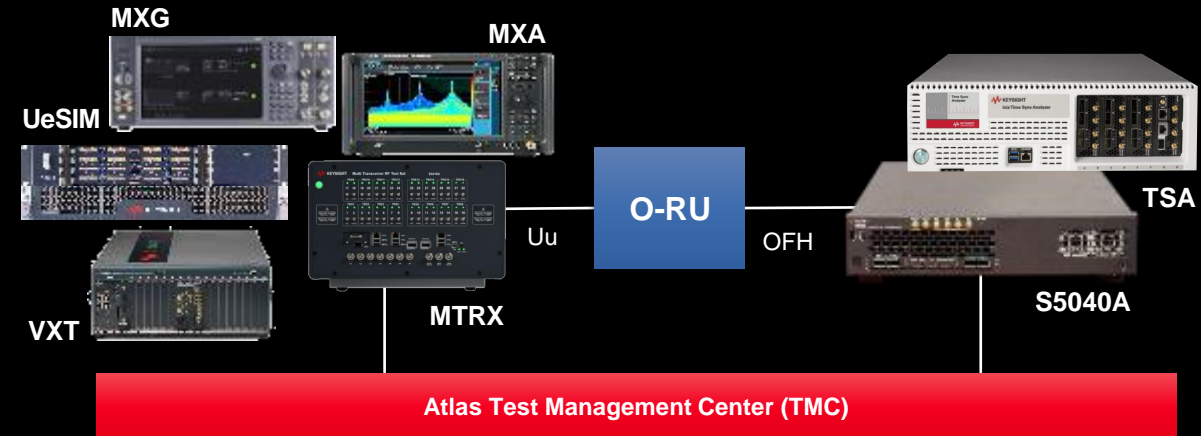


# Test Automation, Analytics & Reporting

## Solution Highlights

Test Manager across Keysight's Open RAN test solutions portfolio

- Out-of-the-Box Test Case Packages
- Enables CI / CD / CT workflows
- **ML/AI Driven Analytics and Data Insights**
  - Discover patterns and associations in the data to make better test decisions
  - Anomaly detection to minimize manual effort invested to analyze and debug failures
  - Detecting probable root cause for Low Throughput issues using data clustering
  - Parameter outlier detection to flag incorrectly set parameters during the test execution
- Simultaneous user access to enable efficient usage across teams



Atlas Test Management Center (TMC)  
Test Case Automation, Orchestration and Analytics

## Key Takeaways

Keysight delivers comprehensive E2E test solutions to customers for wrap-around Open RAN testing covering the most challenging test scenarios

Keysight provides deep domain expertise as a leader in the O-RAN ALLIANCE and TIP consortia by actively engaging in and leading multiple working groups and initiatives

# Thank You

Find out more:

[www.keysight.com/find/ORAN](http://www.keysight.com/find/ORAN)



