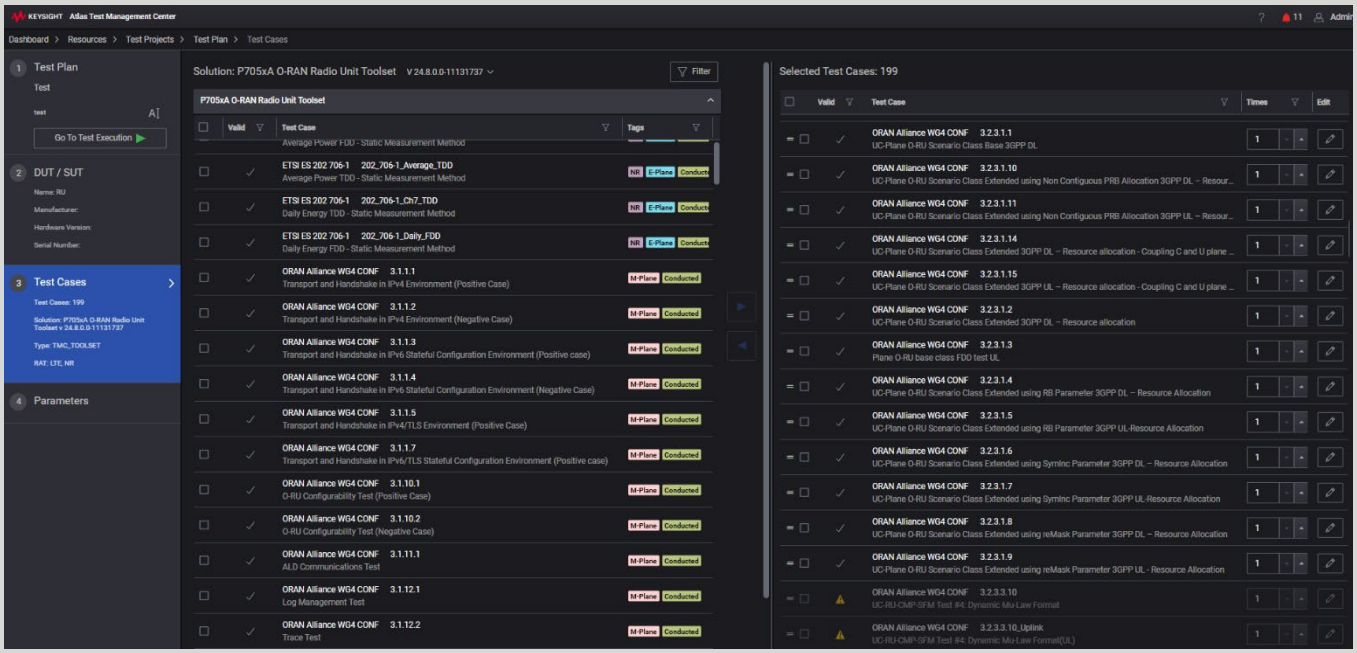

Keysight Open RAN Automated Compliance Test Cases

Streamline Open RAN Components Compliance Validation

KEYSIGHT

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Introduction

Keysight Open RAN Automated Compliance Test Cases

Keysight **Open RAN Automated Compliance Test cases are available as** an integrated software and hardware solutions for conformance, interoperability, energy efficiency and end to end testing against O-RAN products, systems, and solutions according to the test specifications below:

- O-RAN WG4 (Fronthaul Working Group) Conformance Test Specification
- O-RAN WG4 Fronthaul Interoperability Test Specification
- O-RAN WG5 Open F1/W1/E1/X2/Xn Interface Working Group Interoperability Test Specification
- O-RAN Test and Integration Focus Group End-to-end Test Specification
- O-RAN WG11 (Security Work Group) O-RAN Security Test Specifications
- O-RAN WG2 (Non-RT RIC and A1 interface WG) A1 interface: Test Specification
- O-RAN WG3 E2 Interface Test Specification
- 3GPP TS 33.117 Catalogue of general security assurance requirements
- ETSI TS 103 786 Dynamic energy performance measurement method of 5G Base Station (BS)
- ETSI ES 202 706-1 Metrics and measurement method for energy efficiency of wireless access network equipment; Part 1: Power consumption - static measurement method

Figure 1 illustrates the coverage of Keysight Open RAN solutions portfolio, where compliance test cases provide out-of-the-box, standardized automated testing approach.

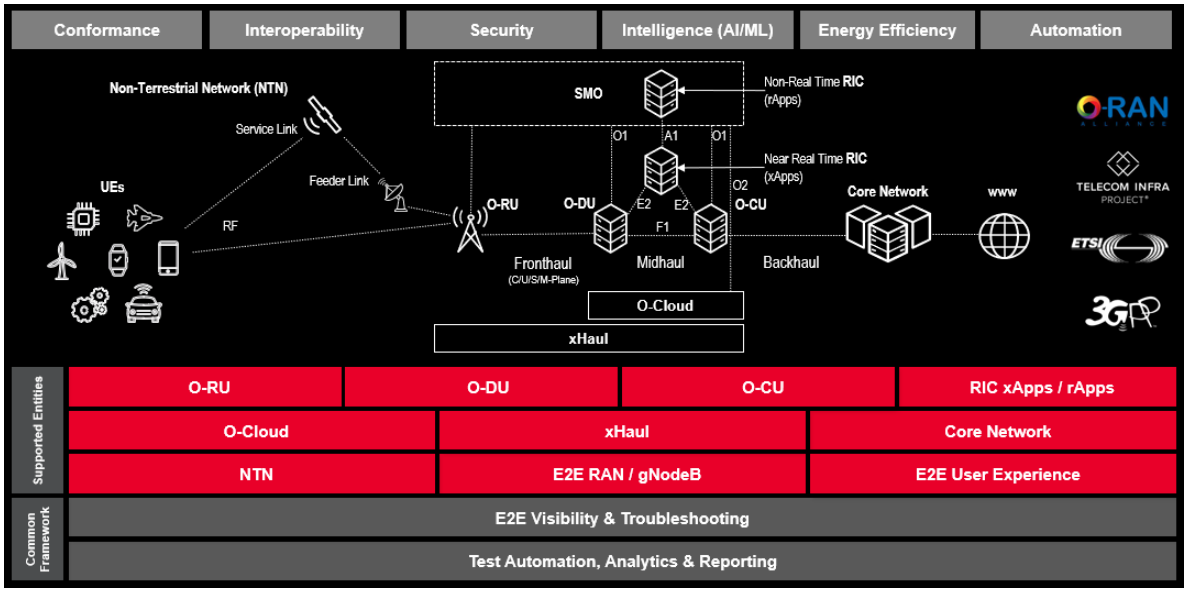

Figure 1. Keysight Open RAN solutions portfolio coverage.

Open RAN compliance testing is crucial for several reasons:

- **Conformance to standards:** Ensure that products meet O-RAN specifications for consistency and reliability.
- **Interoperability:** Verifies seamless operation of components for a flexible, vendor-neutral network.
- **Security:** Include checks to ensure product security and network protection.
- **Performance and functionality:** Validate end-to-end functionality and performance for deployment standards.
- **Efficiency in deployment:** Streamlines deployment by reducing repetitive testing, saving time and resources.

Open RAN Compliance Testing - Why Automation?

It is recommended that Open RAN compliance test cases be executed automatically. Below you can find several benefits brought by automation:

- **Efficiency and speed:** Automated tests run continuously and quickly, reducing compliance check time.
- **Accuracy and consistency:** Ensures consistent and accurate tests, minimizing human error.
- **Scalability:** Automated systems scale easily to meet growing compliance demands.
- **Real-time monitoring:** Tools provide real-time monitoring and alerts for proactive issue resolution.
- **Cost-effectiveness:** Initial setup costs are offset by reduced manual labor and continuous monitoring.
- **Comprehensive coverage:** Automated testing covers a wide range of scenarios and edge cases.

By integrating automation into compliance strategies, organizations can better navigate the complexities of regulatory demands, maintain a secure posture, and ensure that their software products consistently meet required standards.

Keysight Open RAN and Mobile Core Compliance Test Solution(s)

Atlas TMC and Analytics

Atlas Test Management Center (Atlas-TMC) streamlines the full testing workflow and integrates all the required features to cover different automation use cases, on an intuitive interface. It is designed to be the single test manager for creating and executing test campaigns, managing DUT profiles, and analyzing test results across Keysight's wireless solutions portfolio.

- **Browser-based test manager:** the Atlas-TMC is a web application that can be accessed via a web browser enabling quick access and easy test setup.
- **Multi-user access:** users can work simultaneously to create and set up test campaigns, queue tests and analyze/troubleshoot the results. No need to contend for access.
- **Manage multiple test systems with a single test manager:** the Atlas-TMC enables the management of multiple test systems and their unique use cases within one test manager framework.
- **Queue test campaigns:** TMC optimizes the test process by allowing users to queue test campaigns, compared to the conventional one-test campaign at a time method.
- **Integrated analytics and reporting:** Users can analyze the test results, download log files, and generate reports directly from Atlas TMC. One application for end-to-end test workflow.

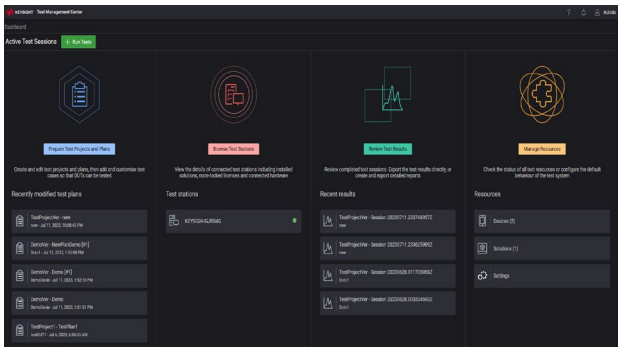

Figure 2. Atlas TMC – Main user interface

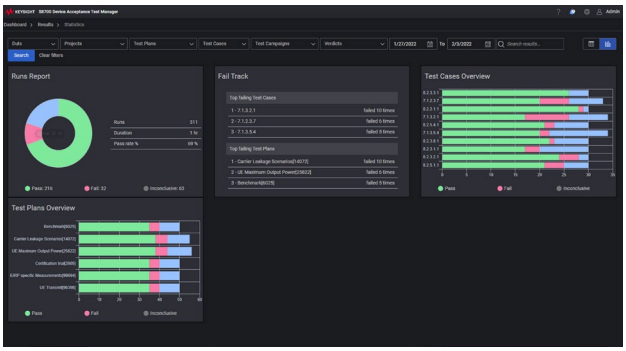

Figure 3. Atlas TMC – Test Result Dashboard

Atlas TMC Analytics can be used to automatically benchmark and evaluate the performance of Open RAN deployment by seamlessly integrating with Atlas TMC and analyzing the test result from test plan execution.

Objective, consistent, and seamless performance comparison

- Access to historical records automatically imported from Atlas TMC for trending and analytics.
- Cost-effective benchmarking of Open RAN components and base station.
- Capability to easily engage in in-depth troubleshooting to resolve network issues and to identify configuration changes between test runs.
- Consistency of test result benchmarking and comparison across network equipment.
- Single performance score across multiple test cases and KPIs reinforcing objective and seamless performance comparison.

Figure 4. Keysight Atlas TMC Analytics

Keysight Open RAN Compliance Test Cases with Atlas Test Management Center

Common Test Setup

Figure 5 below shows the common test setup for Keysight Open RAN Automated Compliance test solutions using Atlas TMC.

Various Keysight test instruments need to be connected to DUT/SUT according to the test cases. Multiple test solutions can be installed and controlled through Atlas-TMC for users to create and configure their test projects and test plans. Users can log in to Atlas-TMC via a browser to manage test sessions.

During test campaigns, Atlas-TMC orchestrates the test instruments through the Test Automation Platform (TAP) to perform specific test procedures according to the specifications. After execution, Atlas TMC generates standard test reports with pass/fail verdicts, and Atlas TMC Analytics provides further insights into the test results.

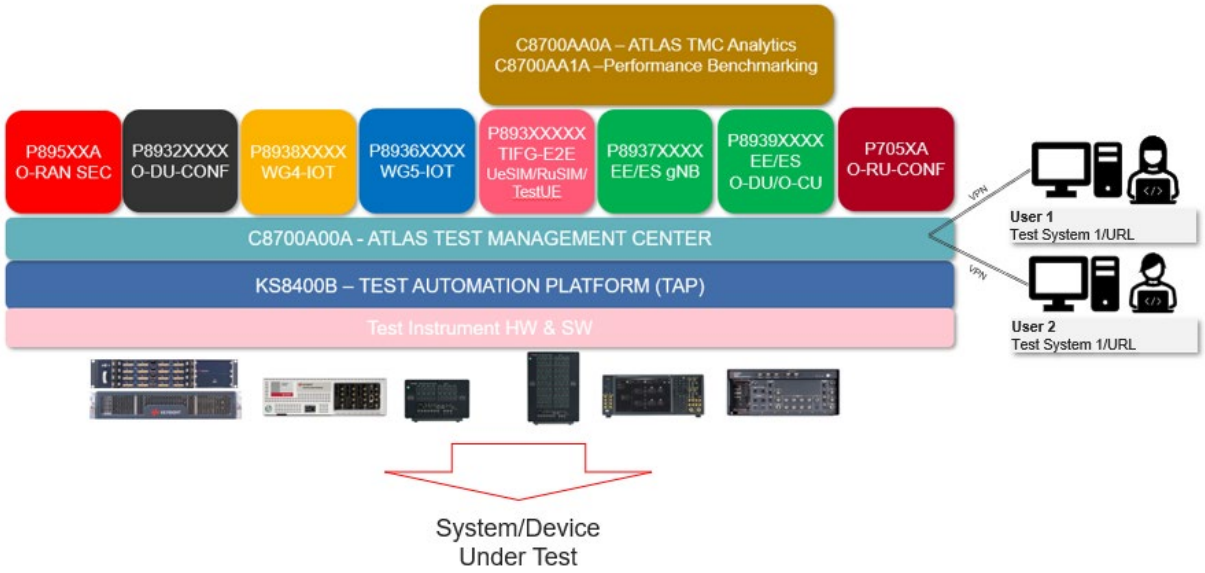

Figure 5. Common test setup for Keysight Open RAN Automated Compliance test solution(s)

WG4 O-RU Conformance Test Cases

Highlights

- Integrated solution for O-RAN WG4 Conformance, functional & performance testing against O-RU
- Comprehensive support for O-RAN fronthaul Control, User, Sync and Management (CUSM) Plane Testing and OTIC O-RU Certification purpose
- FR1, FR2 (mmWave) | FDD, TDD | Category A and B
- Massive MIMO beam forming (BF) and non-BF
- O-RAN standard test report

Test instruments

- VSA/VSG for non-Massive and Massive MIMO BF, as well as 3GPP RF Performance testing respectively – VXT2, MTRX,VXG/PXA
- O-DU emulator software and platform for CUSM testing

Extensible to support

- **Air interface and fronthaul troubleshooting and analytics** to avoid / resolve challenges with finger pointing during testing.
- **Live-to-Lab** – introduce live network impairments (packet loss, jitter, delay) to lab testing enabling conformance, interoperability, and end to end testing can be performed under real-world network conditions.
- **Security testing** – 3GPP SCAS and O-RAN ALLIANCE WG11 test specifications
- **Energy consumption, efficiency, and savings** – automated energy consumption and efficiency measurements for Massive and non-MIMO O-RUs based on standards references.

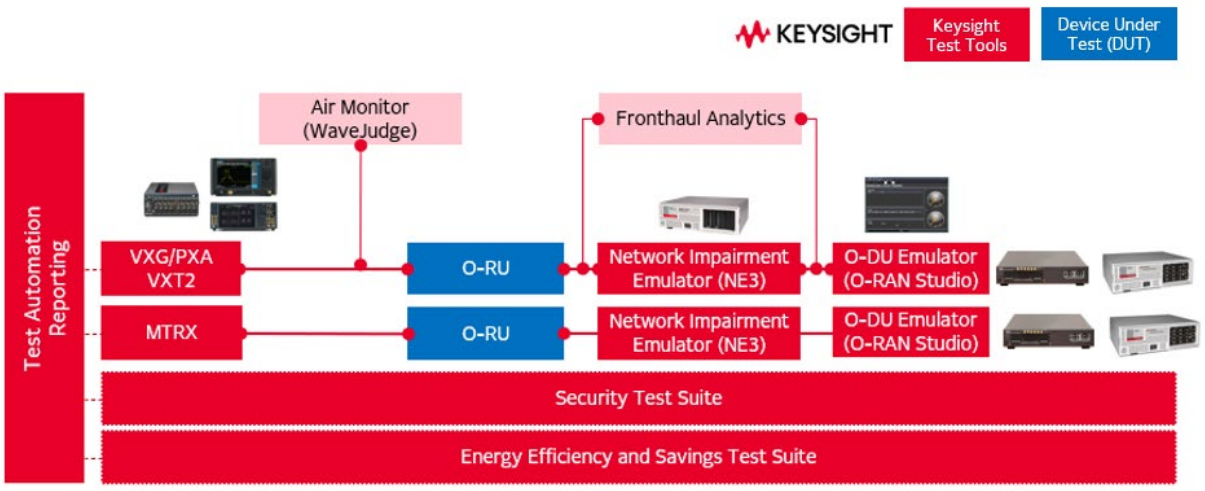

Figure 6. Test Setup for O-RU Conformance test cases

WG4 O-DU Conformance Test Cases

Solution highlights

- Integrated solution for O-RAN WG4 Conformance, functional & performance testing against standalone O-DU or combined O-DU/O-CU
- Comprehensive support for O-RAN fronthaul Control, User, Sync and Management (CUSM) Plane Testing and OTIC O-DU Certification purpose
- NSA.SA | FR1, FR2 (mmWave) | FDD, TDD | Category A and B
- Massive and Multi-Users MIMO testing with mobility support
- O-RAN standard test report

Test instruments

- O-RU Emulator with embedded multi-UEs emulation capabilities – RuSIM
- O-CU Emulator to support standalone O-DU conformance/subsystem testing – CuSIM
- Core Emulator to support combined O-DU + O-CU conformance/subsystem testing – CoreSIM
- Time Sync Analyzer to support O-DU clock measurement– TSA
- GNSS Emulator – MXG or EXG

Extensible to support

- Fronthaul troubleshooting and analytics to avoid / resolve challenges with finger pointing during testing.
- Live-to-Lab – introduce live network impairments (packet loss, jitter, delay) to lab testing enabling conformance, interoperability, and end to end testing can be performed under real-world network conditions.
- Security testing – 3GPP SCAS and O-RAN ALLIANCE WG11 test specifications
- Energy Consumption, Efficiency, and Savings – automated energy consumption and efficiency measurements for O-DU based on standards references.
- E2/O1 interface testing with RIC simulation – RICSIM provides E2 and O1 termination with support for selected procedures to exercise Global and Functional E2AP support and selected O1 Job Controls on eNB/gNB/CU/DU under test

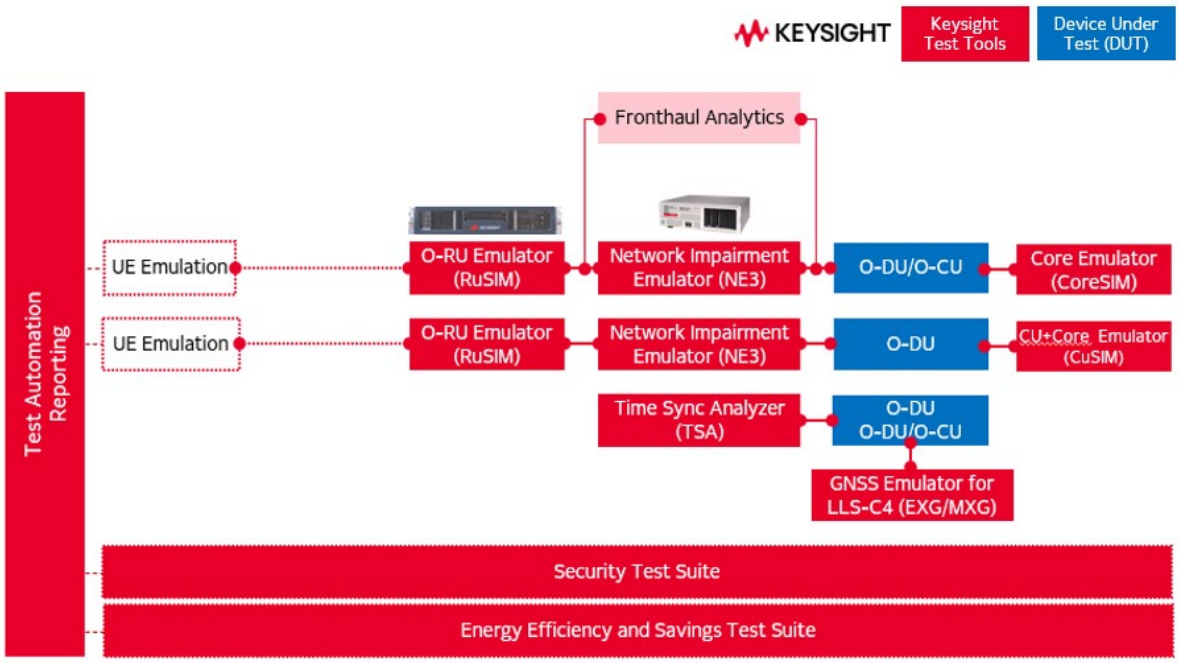

Figure 7. Test Setup for O-DU Conformance test cases

WG4 Fronthaul Interoperability test cases

Solution highlights

- O-RAN WG4 IOT test for O-RU and O-DU pair
- Comprehensive support for O-RAN fronthaul Control, User, Sync and Management (CUSM) Plane and delay management testing
- O-RAN standard test report

Test instruments

- Multi-UEs Emulator – UeSIM
- O-CU Emulator to support standalone O-DU testing – CuSIM
- Core Emulator to support combined O-DU + O-CU testing – CoreSIM
- Network Impairment Emulator to support network impairments to be added for fronthaul IOT testing – NE3
- Signal Analyzer and VSA for S-Plane Performance test cases – VXT2
- Time Sync Analyzer to support S-Plane T-GM functions– TSA
- O-RAN Analytics to support monitoring and troubleshooting on fronthaul interface – Open RAN Studio

Extensible to support

- **Live-to-Lab** – introduce live network impairments (packet loss, jitter, delay) to lab testing enabling interoperability testing to be performed under real-world network conditions – NE3
- Standard reference clock input/output with impairments over clock quality – Time Sync Analyzer
- **Massive MIMO and MU-MIMO validation** – enabling performance testing and optimization of MU-MIMO implementation with large number of emulated UEs sessions with full mobility support – Beam MIMO Detect

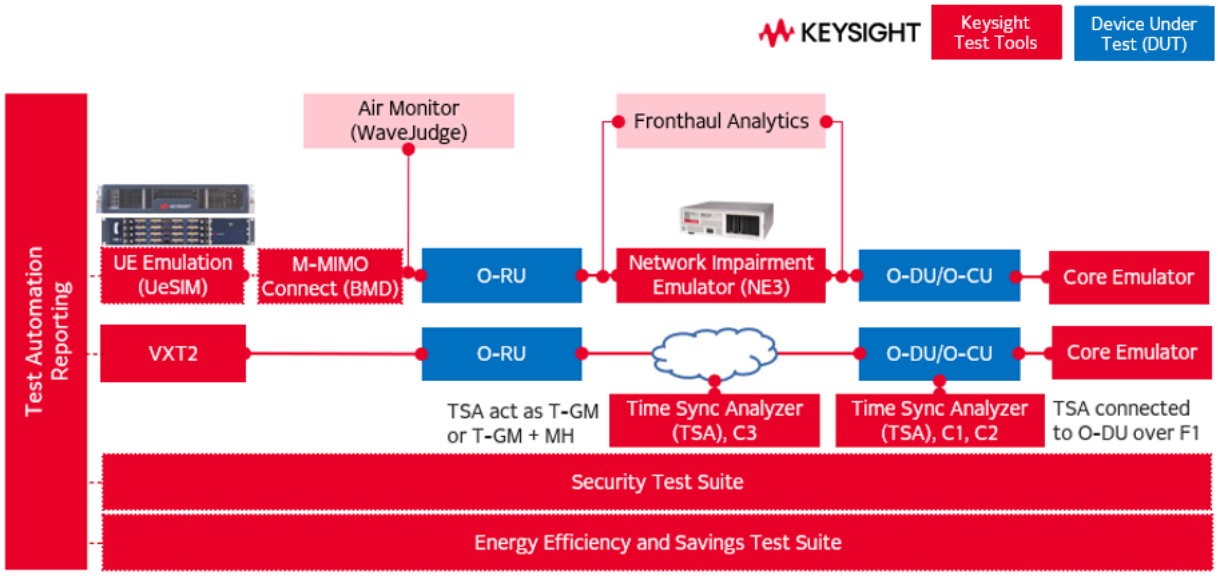

Figure 8. Test Setup for WG4 Fronthaul Interoperability test cases

WG5 Open Interface Interoperability Test Cases

Solution highlights

- O-RAN WG5 IOT test for network elements communicating over F1, X2 and Xn interfaces
- Emulate each and every network node to wrap-around the network element pair under test
- Additional network impairment emulator and protocol analyzer for interoperability validation
- Supports Standalone (SA), Non-Standalone (NSA) | Split, Non-Split | EN-DC, NR-DC test scenarios
- O-RAN standard test report

Test instruments

- UE Emulator with application traffic generator – UeSIM
- O-RU Emulator with embedded multi-UEs emulation capabilities – RuSIM
- Core Emulator with application traffic generator– CoreSIM
- Network Impairment Emulator – NE3

Extensible to support

- Live-to-Lab – introduce live network impairments (packet loss, jitter, delay) to lab testing enabling interoperability testing to be performed under real-world network conditions – NE3

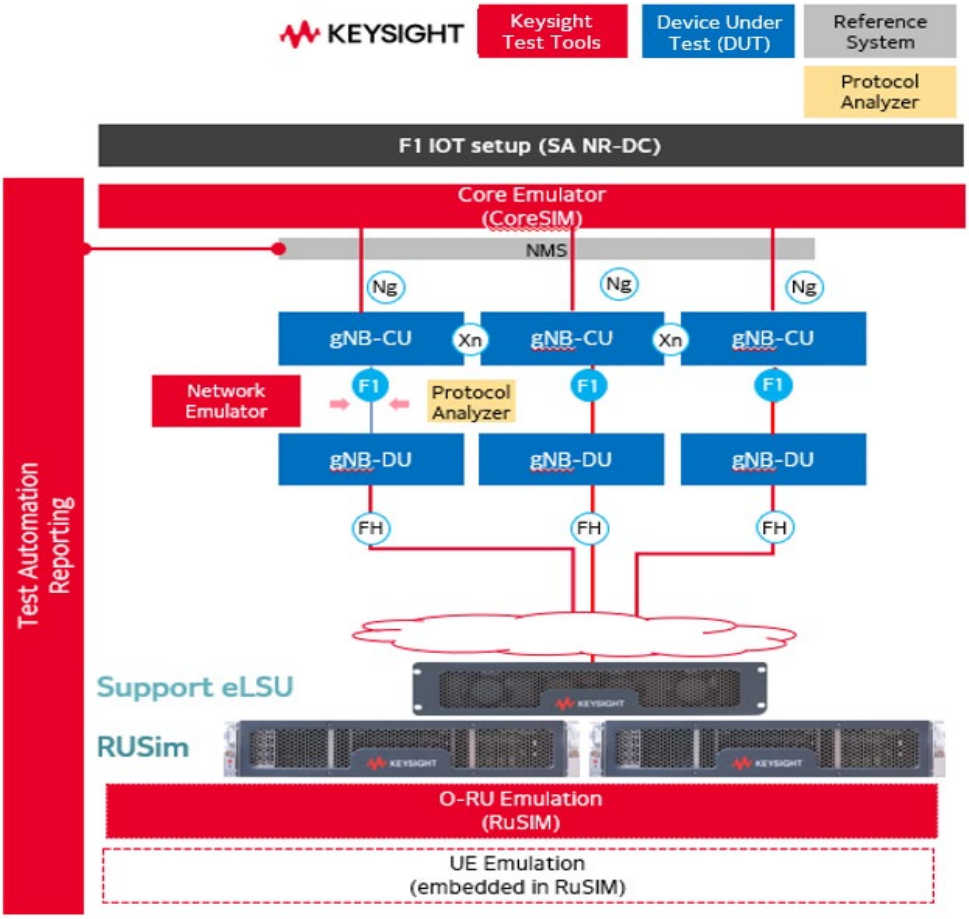

Figure 9. Test Setup for WG5 IOT F1 test cases

O-RAN Security Test Cases

Solution highlights

- **Keysight 5G and O-RAN Security test suite consists of Keysight's state of the art test solutions** widely adopted by leading operators, vendors, and system integrators supporting functional, performance and deployment readiness with real world test scenarios.
  - **Stateful emulation of UEs, O-RAN and Core network functions** following 3GPP and O-RAN standards for 5G, 5G-Advanced and pre-6G research.
  - **Stateful and non-Stateful emulation of Security attacks, scans, and audits** for RAN, O-RAN and Core network functions as well as Cloud and xHaul networks, taking advantage of Keysight's global knowledge and Application and Threat Intelligence (ATI) databases constantly updated by a dedicated team of Keysight security experts.
- **Complete Security Test and Troubleshooting Solution** used to verify that the 5G and O-RAN system service availability and performance were not degraded by simulated attacks.
  - Extensive Security Test solution portfolio with best-of-breed techniques
  - Evaluation of user experience under various types of attacks
  - 3GPP SCAS test suites support
  - O-RAN WG11 and TIFG E2E (Chapter 7) Security test suites support
  - Security assessment framework for easy open source/customer/commercial tool(s) integration
- **Integrated test automation and reporting framework** is essential to ensure that the O-RAN system under test can be fully characterized, test and validated with dynamic joint orchestration of multi-UEs and O-RAN network functions emulation and the security attacks, scan, and audit modules.
- Supports **simulating real world threat attacks scenarios** and performing extensive scan and audit functions required for commercial networks deployment readiness testing from the functional, performance and DevSecOps perspectives.
- Minimum learning curve and no extensive security/security test knowledge required.

Test instruments

- UE Emulator with Application Traffic Generator – UeSIM
- O-RU Emulator with embedded multi-UEs emulation capabilities – RuSIM
- Core Emulator with application traffic generator– CoreSIM
- DDoS Attacker Module
- Random Fuzzer Module
- Time Sync Analyzer
- Network Emulation and Impairment

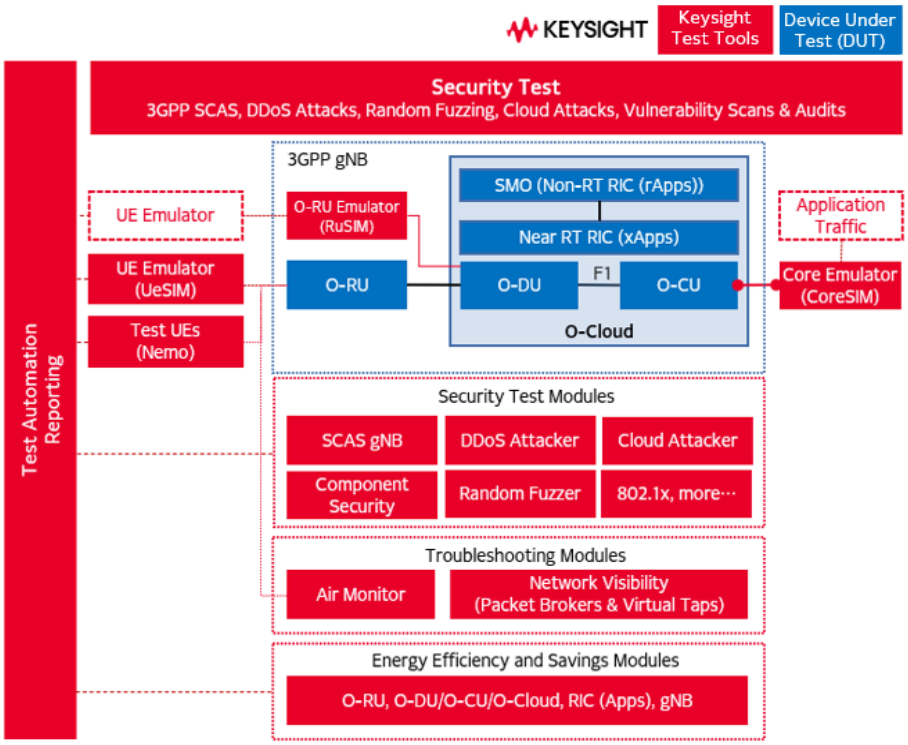

Figure 10. Test Setup for O-RAN Security test cases

ETSI O-RU Energy Efficiency and Saving Test Cases

Solution highlights

- Characterizing energy consumption of O-RU leveraging ETSI standards references
- Characterizing and evaluating energy saving gain of O-RU with different energy saving mechanisms
- Correlate energy consumption with different load level
- Measurement of power consumption under massive MIMO conditions
- ETSI standard test report
- 5GNR and LTE RAT support
- Multi Band and Multi Carrier Radio support
- Fronthaul M-Plane conformance test cases for Energy Saving features

Test instruments

- O-DU emulator software and platform to put O-RU under different load level– TSA or S5040A
- Power Meter for RF power measurement over air-interface
- Power Supply/Analyzer for power consumption measurement

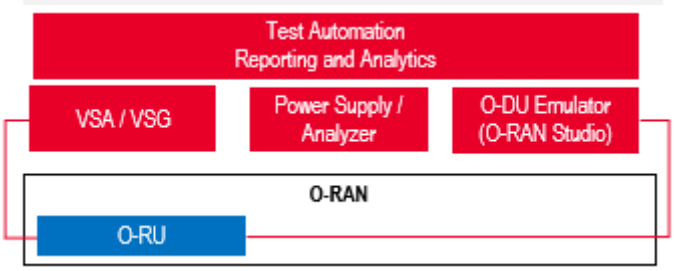

Figure 11. Test Setup for O-RU Energy Efficiency and saving test cases

ETSI O-DU/O-CU and gNB/eNB Energy Efficiency and Saving Test Cases

Solution highlights

- Characterizing energy consumption of O-DU/O-CU/O-Cloud and gNB/eNB leveraging ETSI standards references
- Characterizing and benchmarking energy saving gain of O-DU/O-CU/O-Cloud and gNB/eNB with different energy saving mechanisms
- Correlate energy consumption with traffic amount and user experience
- Support platform APIs such as Redfish to retrieve power consumption and other KPIs from DUT
- Support Power Management APIs to adjust P-State, C-State, etc during test execution
- ETSI standard test report

Test instruments

- UE Emulator to put gNB under different load level and measurement user experience – UeSIM
- O-RU Emulator with embedded multi-UEs emulation capabilities to put vRAN under different load level and measurement user experience – RuSIM
- Core Emulator with application traffic generator – CoreSIM
- Power Supply/Analyzer for power consumption measurement

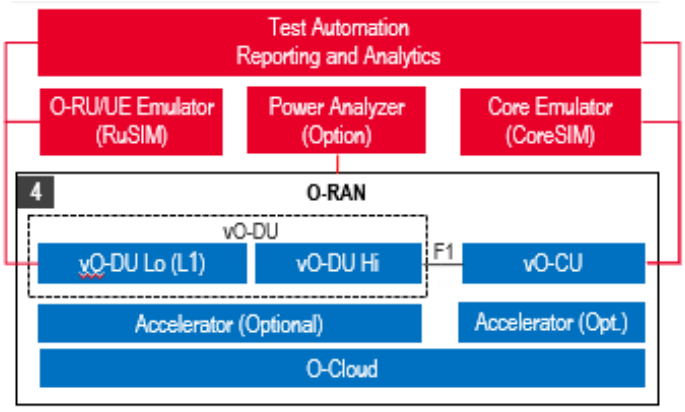

Figure 12. Test Setup for O-DU/O-CU/O-Cloud Energy Efficiency and saving test cases

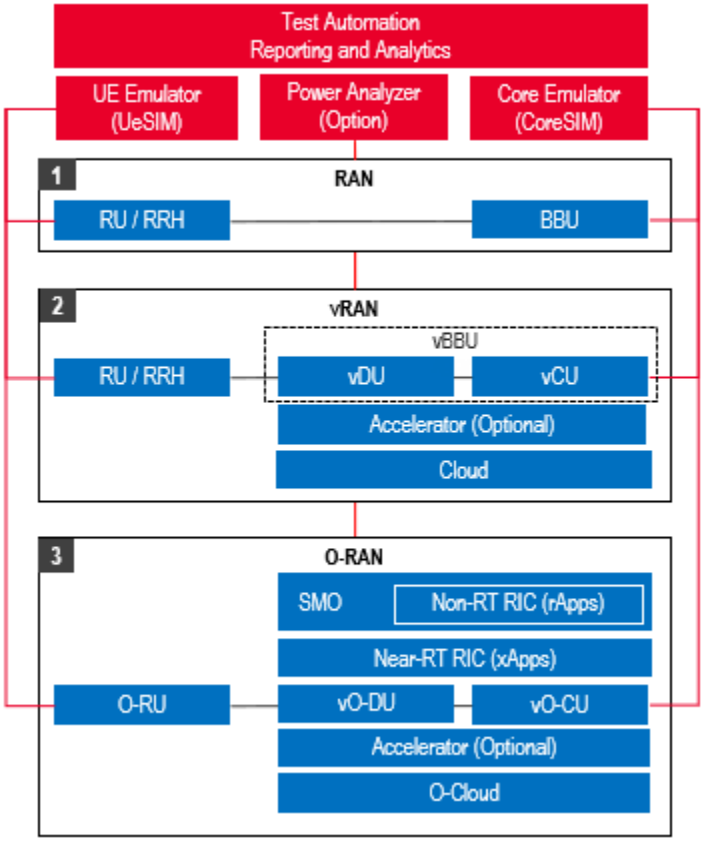

Figure 13. Test Setup for eNB/gNB Energy Efficiency and saving test cases

TIFG E2E Test Cases using Emulated UEs

Solution highlights

- Validate the end-to-end system functionality, performance, and key features of the RAN or O-RAN system as a black box
- Emulate UEs over RF interface or Emulate UEs embedded in RU over Fronthaul interface
- Support test cases in O-RAN TIFG E2E test specification with measurement of required KPIs
  - Functional
  - Performance
  - Service (Data, Video Streaming, VoNR/VoLTE, ViNR/ViLTE)
  - Load and Stress
  - RIC enabled use cases
- NSA | SA | LTE Test scenarios
- O-RAN standard test report
- User can also design and define their own E2E test cases with this solution.

Test instruments

- Multi-UE Emulator over RF with application traffic generator – UESIM
- Multi-UE Emulator over Fronthaul with application traffic generator – RuSIM
- Core Emulator with application traffic generator– CoreSIM
- Network Impairment Emulator to add latency on fronthaul and midhaul – NE3

Extensible to support

- Live-to-Lab – introduce live network impairments (packet loss, jitter, delay) to lab testing enabling interoperability testing to be performed under real-world network conditions – NE3
- Massive MIMO and MU-MIMO validation – enabling performance testing and optimization of MU-MIMO implementation with large number of emulated UEs sessions with full mobility support – Beam MIMO Detect BMD
- Energy consumption, efficiency, and savings – automated energy consumption and efficiency measurements for E2E RAN and O-RAN system based on standards references.
- Advanced Mobility with embedded 3GPP fast fading and high-speed train channel models
- E2/O1 interface testing with RIC simulation – RICSIM provides E2 and O1 termination with support for selected procedures to exercise Global and Functional E2AP support and selected O1 Job Controls on eNB/gNB/CU/DU under test

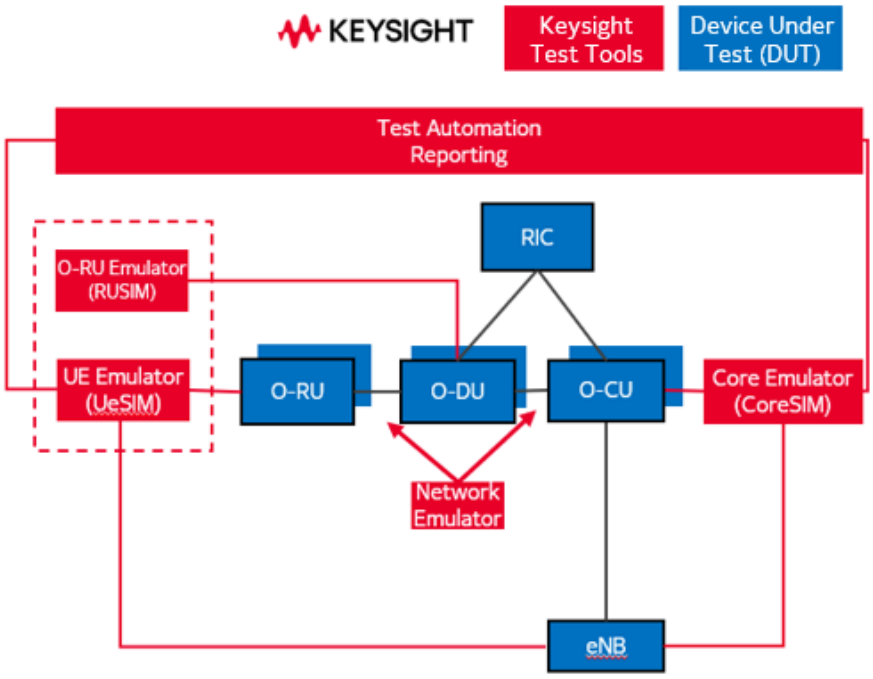

Figure 14. Test Setup for TIFG E2E test cases using UeSIM/RuSIM

TIFG E2E Test Cases using Real UEs

Solution highlights

- Validate the end-to-end system functionality, performance, and key features of the RAN or O-RAN system as a black box
- Using Nemo Outdoor based Test UE for test scenario and traffic generation
- Support test cases in O-RAN TIFG E2E test specification with measurement of required KPIs
  - Functional
  - Performance
  - Service (Data, Video Streaming, VoNR/VoLTE, ViNR/ViLTE)
- NSA | SA | LTE Test scenarios

Test instruments

- Test UE running Nemo Outdoor
- Network Impairment Emulator to add latency on fronthaul and midhaul – NE3
- Core Emulator or Real Core
- Programmable attenuator (3rd party – Check user manual for supported models)
- Shield Box (3rd Party)

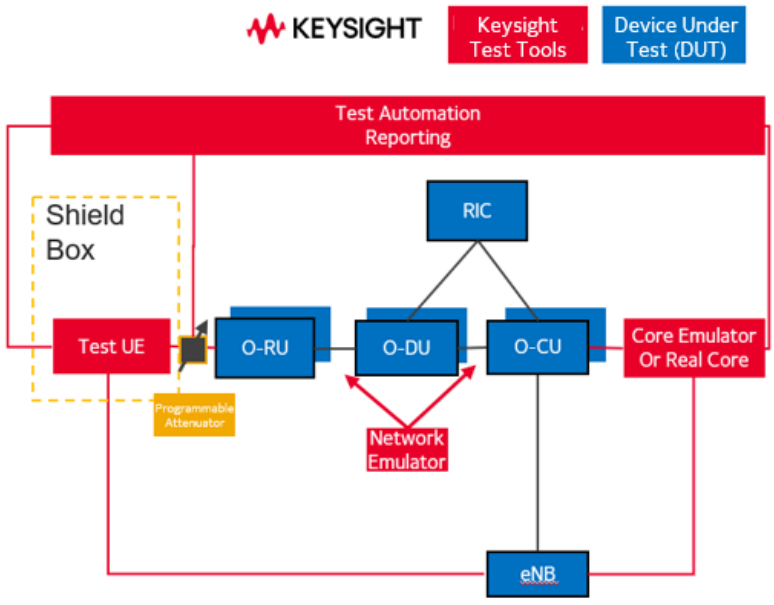

Figure 15. Test Setup for TIFG E2E test cases using Real UE.

Other Keysight Open RAN and Mobile Core Compliance Test Solutions

WG2 and WG3 RIC Conformance Test Cases

Solution highlights

O-RAN Working Group 2 A1 Interface Test Specification (O-RAN.WG2.A1TS-R003-v03.00)

- Keysight O-RAN Conformance Tool provides simulation of the Near Real-Time RIC for testing the Non-Real-Time RIC. A1TS Chapter 5.2 and 5.3 tests include these categories:
  - Conformance test cases for A1-P Consumer
  - Conformance test cases for A1-EI Producer
- Keysight O-RAN Conformance Tool provides simulation of the Non-Real-Time RIC for testing the Near Real-Time RIC. A1TS Chapter 6.2 and 6.3 tests include these categories:
  - Conformance Test Cases for A1-P Producer
  - Conformance Test Cases for A1-EI Consumer

O-RAN Working Group 3 E2 Interface Test Specification (O-RAN.WG3.E2TS-R003v02.00)

- Keysight O-RAN Conformance Tool provides simulation of the O-RAN Node for testing the Near Realtime RIC. E2TS Chapter 5.2 tests include these categories:
  - E2AP Global Procedures
  - E2AP Functional Procedures including E2SM-KPM and -NI
  - Support for defined Positive and Negative test cases
- Keysight O-RAN Conformance Tool provides simulation of the Near Real-Time RIC for testing the E2-compliant O-RAN Node. E2TS Chapter 6.2 tests include these categories:
  - E2AP Global Procedures
  - E2AP Functional Procedures
  - Support for defined Positive and Negative test cases

Test instruments

- P8828S RICtest — RAN Intelligent Controller Test Solutions

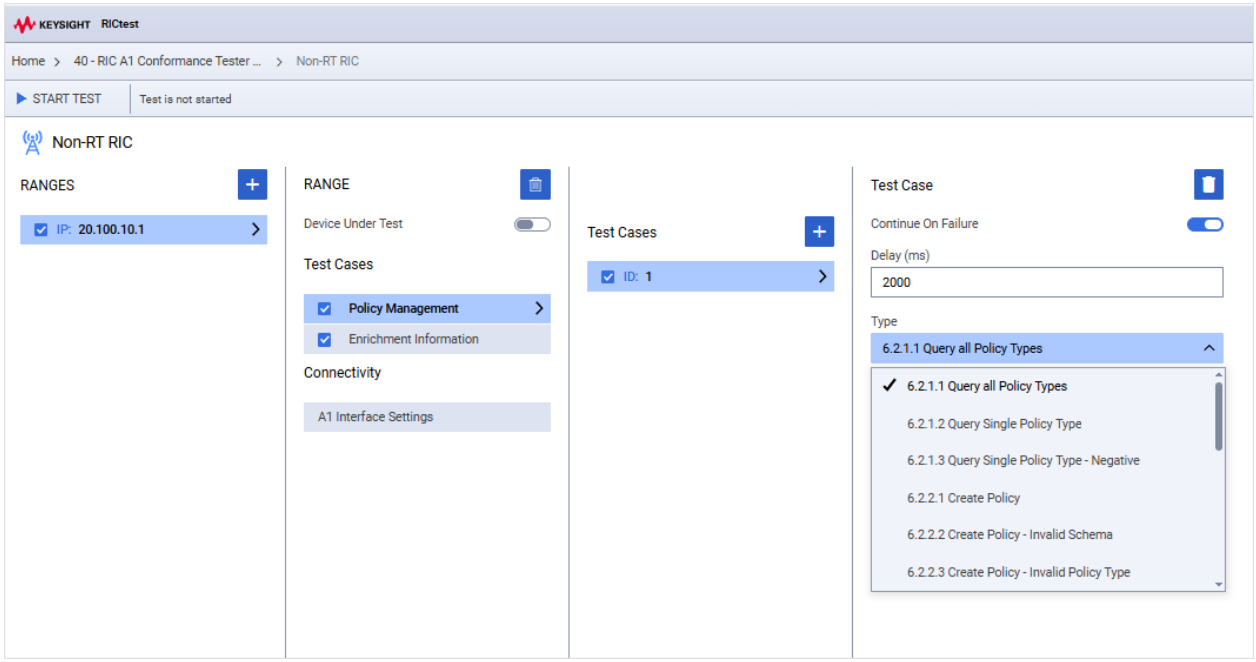

Figure 16. Example view from RICtest – RIC A1 Conformance Tester

Figure 17. RICtest solution user interface.

3GPP SCAS Mobile Core Security Test Cases

Solution highlights

- Keysight 3GPP Mobile Core Security Test Case suite enables users to validate mobile core network resilience against the security threats covering test scenarios according to following specifications:
  - 3GPP SCAS 33.117
  - 3GPP SCAS 33.512 (AMF)
  - 3GPP SCAS 33.513 (UPF)
  - 3GPP SCAS 33.514 (UDM)
  - 3GPP SCAS 33.515 (SMF)
  - 3GPP SCAS 33.517 (SEPP)
  - 3GPP SCAS 33.512 (NRF)
- In addition to SCAS test suits, Keysight provides multiple other options to validate mobile core network resilience against the security threats:
  - Service Based Interface (SBI) Fuzzing
  - Control Plane Impairment with ability to modify on the fly any procedure or message on SCTP/NAS, HTTP/2 or PFCP based interfaces
  - User Plane Impairment/ Network Emulation with ability to modify or drop User Plane packets (Uplink or Downlink)
  - Roaming Security
  - Malware generated from simulated UEs

Test instruments

- Keysight Atlas Test Management Center
- Keysight Pathwave Test Automation Center
- Keysight LoadCore solution

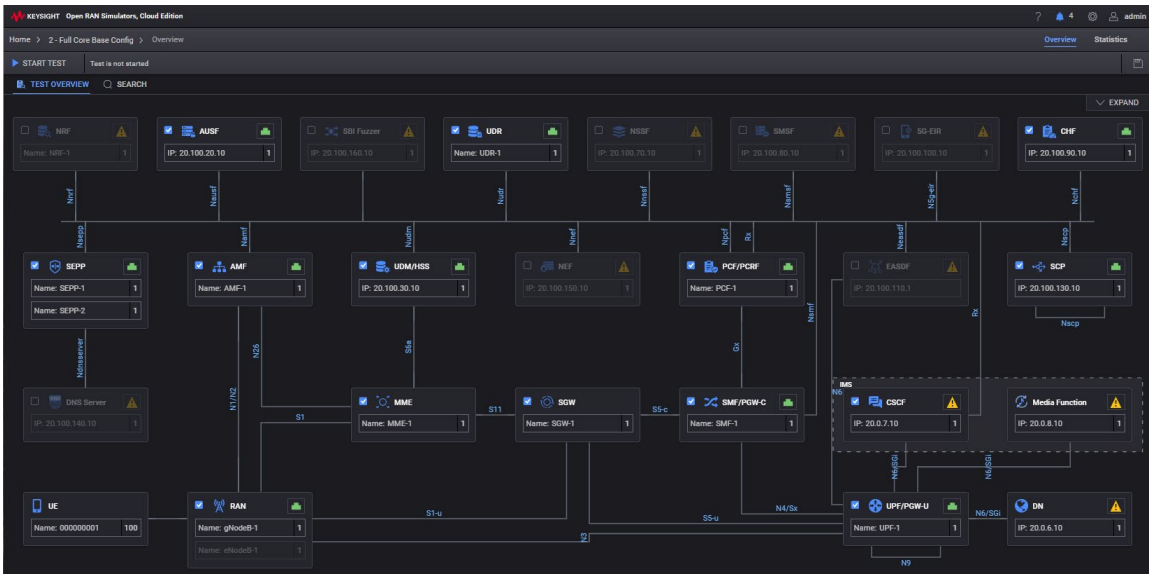

Figure 18. Keysight Loadcore Solution

3GPP RF Pre-Conformance Test Cases for O-RU and gNodeB

Highlights

- Integrated solution for RF Conformance test against O-RU and gNodeB according to 3GPP 38.141 chapter 6 & 7
- Automated Testing using PathWave KS8400 Test Automation Platform.
- Scalable Platform ready for new 3GPP releases.
- Chapter 4 Declarations automatically create Test Configurations for each Test Case.
- Customizable Customer Test Cases enable testing beyond 3GPP requirements for DVT.
- Automation platform performs thousands of measurements as needed for each test case, (eg: TRP, ALCR, Intermodulation, Frequency, Beam Declarations, Polarization, etc…)
- System Calibration test steps.
- Interfaces to control gNB and antenna positioner.
- Same test setup as WG4 O-RU Conformance test when testing against O-RU.

Test instruments

- For 3GPP RF Pre-Conformance test against O-RU
  - DU emulator software and platform to stimulate O-RU into Tx/Rx test mode – TSA or S5040A
- RF Instruments
  - Option 1:
    - Multi Transceiver RF Test Sets – MTRX for mMIMO capable O-RU and gNodeB
  - Option 2:
    - X-Series RF Vector Signal Analyzer for Tx test and X-Series RF Vector Generator for Rx test.
  - Option 3:
    - S9101A-BK1 5G Multi-Band Vector Transceiver TR1 with Blocker.

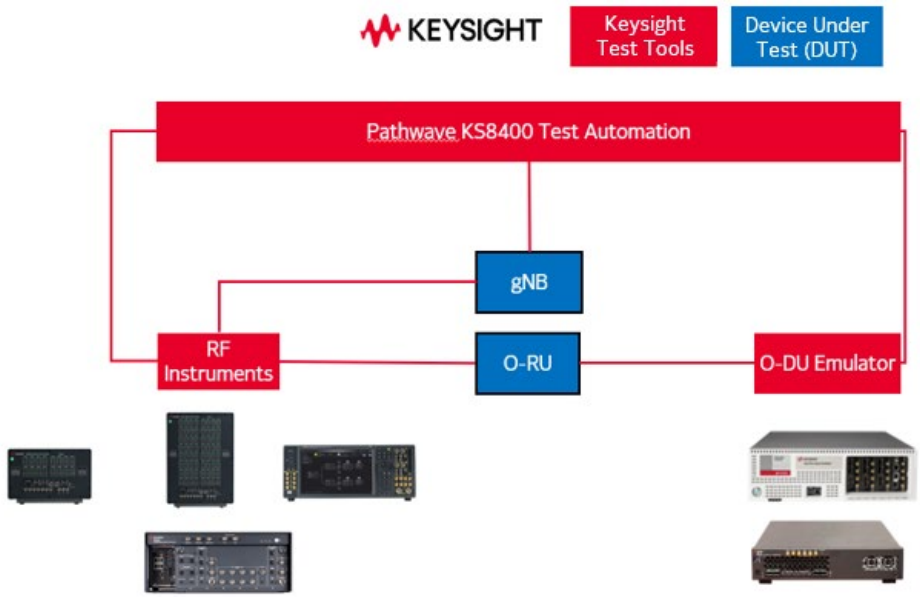

Figure 17. Test Setup for 3GPP RF pre-conformance test cases for O-RU and gNodeB.

Summary

Keysight Open RAN Automated Compliance Test Solution is an integrated software and hardware solution intended for conformance, interoperability, energy efficiency and end to end testing against O-RAN products, systems, and solutions according to various industry standards. By leveraging Keysight automation platforms such as Atlas Test Management Center & Analytics, the solutions can make sure test cases can be executed efficiently, and test results are produced with accuracy, repeatability and consistency.

Looking for More Information?

For more insights on Keysight Open RAN Test Solutions, check the following links:

- For more information about test automation platform, check out Atlas Test Management Center
- For O-RU Conformance test, check out Perform O-RAN radio unit conformance testing
- For 3GPP Base Station RF Conformance test, check out P7000A base station measurement automation solution
- For O-RU Energy Efficiency test, check out measure the energy efficiency of an O-RU
- For O-RU Energy Efficiency test, check out measure the energy efficiency of O-DU/O-CU
- For more RAN & Core test solutions, check out Keysight Radio Access and Core Network Test