White Paper

VIAVI Solutions

Validating Open RAN Equipment Interoperability and Performance

How Battelle's RavenStar broadband SDR with Massive MIMO underwent compliance testing via the VALOR Lab-as-a-Service

VALOR is funded by the U.S. NTIA Public Wireless Supply Chain Innovation Fund (PWSCIF)

In partnership with

BATTELLE

Executive Summary

The rapid evolution of Open RAN technology is transforming the telecommunications landscape and enabling open, interoperable, and standardized components to be used as part of the network infrastructure.

This disaggregation brings many benefits, but also presents significant challenges in interoperability, conformance, and performance validation. As traditional in-house testing facilities are prohibitively expensive, access for smaller vendors and startups has been limited.

Lab-as-a-Service and Test-as-a-Service models offer a cost-effective, flexible alternative not only for startups and smaller organizations that often lack the budget, staff and expertise to test their products, but also for network operators that have a strategic need for the testing but would not have the continuous need for the lab assets nor have the expertise to build and operate it.

In this case study, we highlight how Battelle validates its RavenStar™ technology, a software-defined radio platform with massive MIMO capabilities and advanced beamforming for use across the FR1 band.

Through VALOR, Battelle successfully conducted comprehensive O-RAN WG-4 conformance testing and demonstrated that the RavenStar radio platform's real-world performance aligned with Battelle's theoretical throughput calculations, achieving a remarkable 98% accuracy. Using VALOR's hybrid Lab-as-a-Service model, Battelle has both validated the RavenStar SDR technology capabilities and reduced the risk for operators when adding the new Open RAN equipment to the network.

VALOR™

The VIAVI Lab-as-a-Service for Open RAN (VALOR™) lab, which is funded by the National Telecommunications and Information Administration (NTIA) Public Wireless Supply Chain Innovation Fund (PSWCIF) provides an on-demand, pay-as-you-go approach to standardized testing, offering new entrants a cost-effective pathway to certification without significant investment in hardware and software.

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Introduction

The Challenge of Open RAN Validation

By enabling the use of open, interoperable and standardized components, Open RAN is widening the telecom ecosystem to a rapidly increasing number of vendors. This includes smaller, fast-moving startups, non-profits, academic research facilities and a plethora of mid-sized organizations, with competition predicted to accelerate innovation.

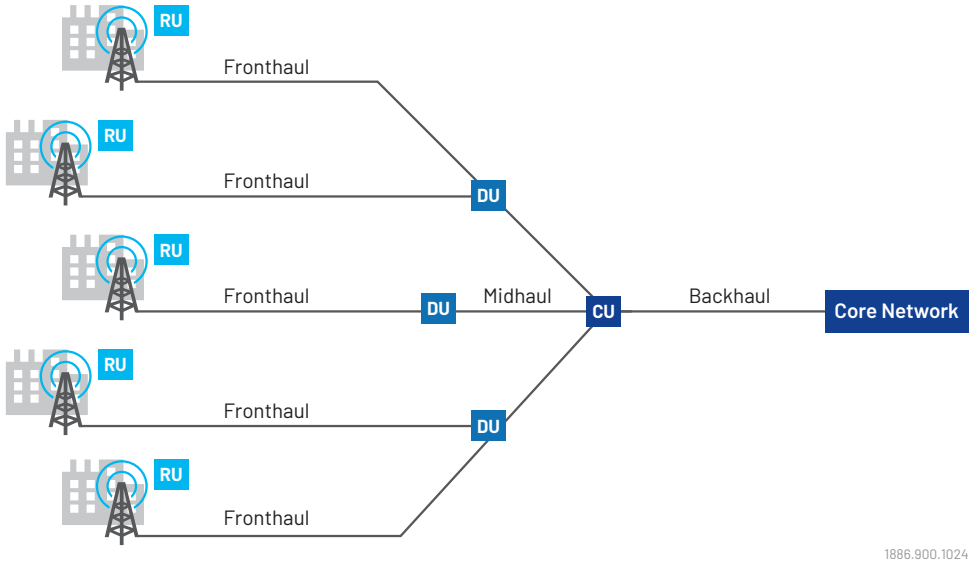

Figure 1. Open RAN divides the radio-access infrastructure into multiple standardized modules and interfaces, with radio, distributed and centralized units (RU, DU and CU).

While its disaggregated architecture can bring benefits such as flexibility, it also creates challenges in interoperability, conformance, and performance validation. To adopt these systems, operators require assurance that new components will integrate seamlessly into multi-vendor environments and maintain performance consistency and security.

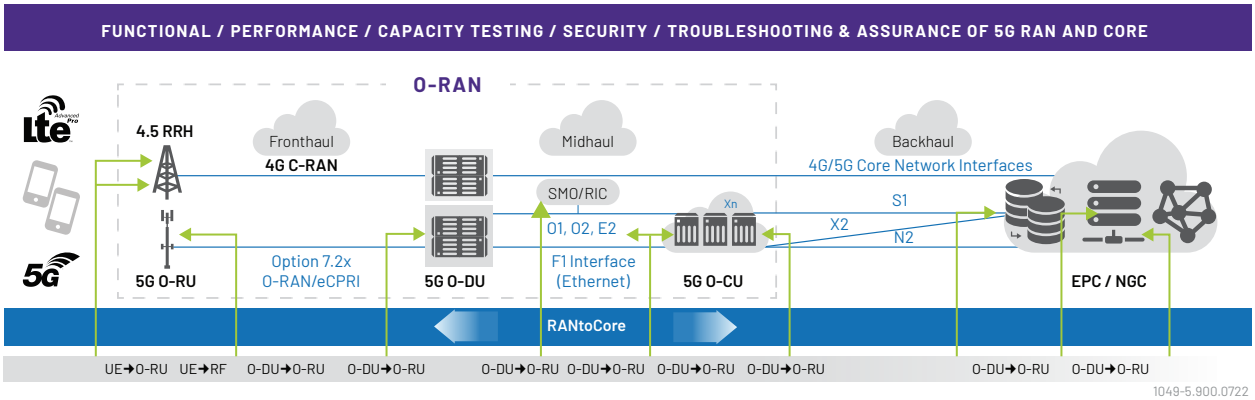

Figure 2. Testing and validation of various Open RAN components

Ironically, given a key aim is to open the market, one crucial factor has limited entry to (mostly) the larger, already well-established players: the cost of testing to ensure interoperability standards were met. Creating the in-house lab facilities needed for this is out of reach for all bar those with the deepest pockets.

Commercial and OTIC (Open Testing and Integration Centers) test labs do exist for system verification, but their numbers are limited, and testing is constrained to just a few geographies. As such there are gaps in the test services available to smaller companies.

VALOR Lab-as-a-Service Model

All this has led to the creation of VIAVI's VALOR Lab, the industry's first Lab-as-as-Service offering, which was funded by the National Telecommunications and Information Administration (NTIA) Public Wireless Supply Chain Innovation Fund. The lab officially opened on October 7, 2024 in Chandler, Arizona.

Figure 3. The VIAVI VALOR Lab in Chandler, AZ

VALOR uses a highly automated, on-demand and pay-as-you-go approach to standardized testing. It simplifies the development and deployment of Open RAN technologies and in doing so, offers new entrants and start-ups a pathway to certification without the need for significant investment in hardware and software.

In February, Battelle's RavenStar SDR Platform became the first product to be validated for O-RAN and 3GPP test specification through VALOR.

Battelle RavenStar SDR Platform

Battelle is one of the United States' leading applied science and technology research organizations, and since its foundation in 1929, it has become the world's largest nonprofit research and technology centers.

The company has a strong background in military and communications technology, particularly in areas related to national defense and security, and its research and development activities also span a wide range of fields, including infrastructure, environment, health, government and various commercial industries.

Its RavenStar software defined radio (SDR) platform, developed as a collaboration between its commercial and government work, is among the industry's first broadband massive MIMO (8T8R to 64T64R) digitally steered radio units (RU). The RU enables capacity to be added quickly, for example in urban areas, sports arenas or shopping malls, and the compact form factor and energy efficient design seamlessly integrates into an operator's network.

Figure 4. Battelle RavenStar SDR Platform

Such multichannel capabilities would normally only be achievable with higher cost, vastly more complex multi-element arrays. Battelle's Open RAN approach simplifies the system and significantly improves power consumption (and therefore operational cost) when adding network capacity.

Its beamforming functionality also enables it to dynamically adjust energy distribution across elements to shape and steer the beam, optimizing signal direction for improved performance, such as enhancing 5G communication by directing energy towards a specific user.

Battelle undertook its first preliminary outdoor testing of the O-RU in December 2023, and initial results were previewed in the run up to MWC 2024. These results prompted EverythingRF to say its performance milestone brought "confidence that it will revolutionize the front end of telecom infrastructure in the next few years".

Current solution has multiple antennas to support the different frequency bands.

RavenStar™ has a single unit per sector that supports all frequency bands. The technology has multiple beams per sector that can result in **4x capacity improvement over existing**.

Open RAN Testing and Validation

Conformance testing for Open RAN equipment is undertaken at Open Testing and Integration Centers (OTICs) approved by the O-RAN Alliance, with requirements and conformance specifications set out. It is also possible to validate complete Open RAN solutions, which can also be tested for end-to-end functionality.

Approved equipment needs to be validated under large-scale real-world and under stress conditions. However, before formal compliance testing is run, the equipment developers should test their equipment for performance, interoperability and security. This should also take place repeatedly throughout the development process,

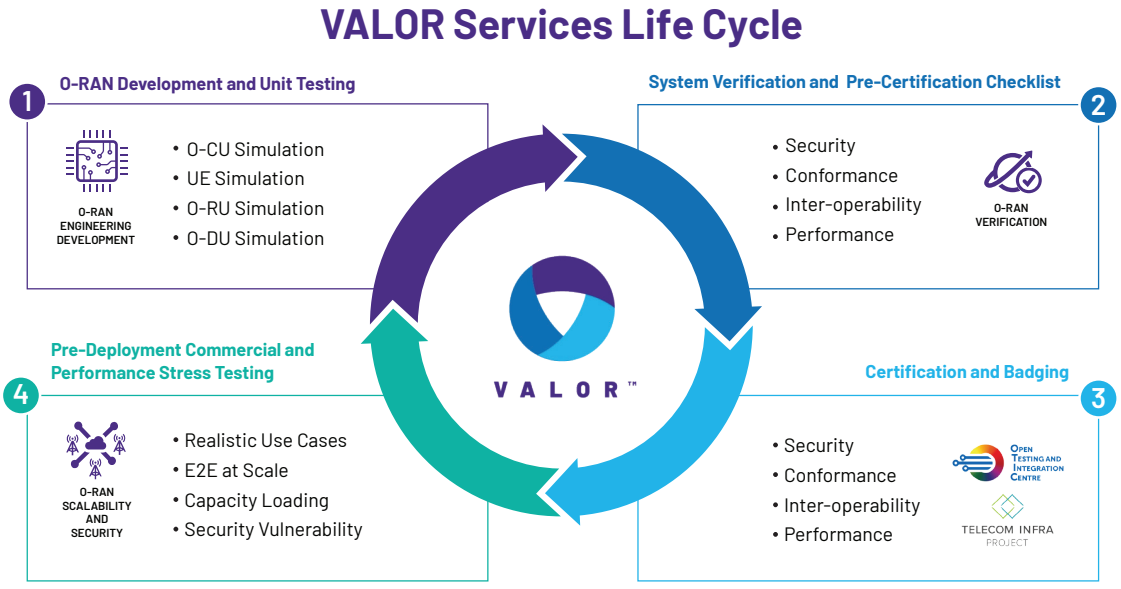

Figure 5. Equipment-test requirements extend throughout the product lifecycle

The Lab-as-a-Service Concept

The emergence of Lab-as-a-Service (LaaS) facilities is helping to address testing availability and cost, offering cloud-based environments for preliminary testing to extensive multi-cell load and stress testing that have been previously inaccessible to smaller vendors.

VALOR uses a hybrid LaaS model, with physical lab and cloud-based infrastructure to support flexible deployment with scalable carrier-grade testing – from functionality to high-capacity stress tests – as well as conformance and performance testing for the O-RU, O-DU (Open Distributed Unit), and O-CU (Open Centralized Unit).

Underpinning VALOR is VIAVI's Automation Management and Orchestration System (VAMOS), which is integrated with the NITRO® Wireless portfolio. This enables the automation of test campaigns, cases, and executions using a cloud-based platform.

To simplify the validation process and use resources across team and lab locations efficiently, VALOR uses workspaces and configurations that can be customized according to requirements, with shared tool testbeds and individual sandboxes available. Additionally, analytics and reporting provided by the platform enable enhanced test-resource utilization, and boost test accuracy.

Access to subsystem testing for conformance, performance and interoperability is given, as well as end-to-end testing with core emulation and RIC tests for validation and training of rApps and xApps.

500 test cases are being developed, each compliant with O-RAN WG4 (Working Group 4), WG5, WG11 and/or TIFG (Test and Integration Focus Group) specifications as well those from 3GPP.

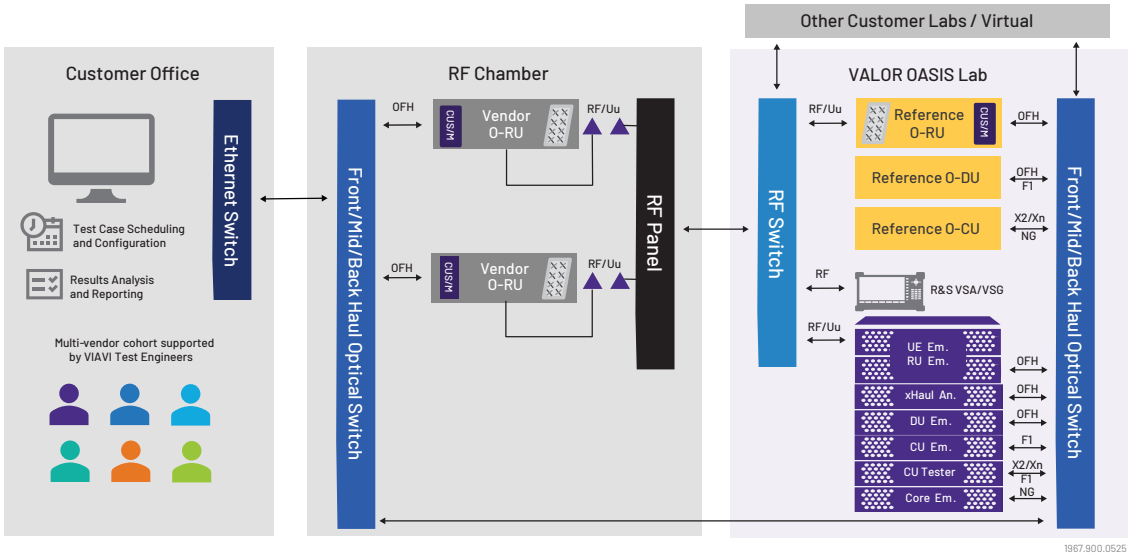

Figure 6. The VALOR testing process

The service also offers beamforming over-the-air (OTA) performance testing services, with a large 25' x 35' anechoic chamber launched in April 2025, and vulnerability testing such as denial of service (DoS), fuzzing, open fronthaul (OFH) interface testing, port scanning and O-CLOUD security.

RavenStar SDR Platform Testing and Results

Each company and product being testing with a LaaS facility needs a bespoke combination of these services. In the case of the RavenStar SDR platform, the validation specifically targeted the O-RAN WG-4 conformance testing, which evaluates the functionality and performance of the fronthaul interface, ensuring smooth data transmission between the O-RU and the O-DU according to the Working Group 4 specifications.

In particular, the WG-4 testing seeks to validate time and frequency synchronization, as well as the use of the Precision Time Protocol (PTP). Additionally, protocol compliance testing for the fronthaul interface is undertaken, including message formatting, error handling and adherence to protocol state machines; error correction and recovery; simulated stress performance at the O-RU's limits of traffic load and environmental conditions; and security testing for denial of service and unauthorized access attacks.

For this, performance testing was undertaken on the O-RU itself, as well as end-to-end testing with user equipment (UE) to validate the throughput bandwidth between the RavenStar SDR platform and the UE.

It should be noted that the RavenStar SDR platform underwent a first-of-its-kind testing to be done on a standalone RU and, even with the higher layers involved with the RU, DU and CU, it was possible to achieve the throughput measurements on standalone RU.

This testing allowed Battelle to quantify how well the equipment matched their initial modeling and theoretical throughput calculations, which were undertaken prior to its validation from VALOR. This demonstrated the results matched to within 98% of Battelle's calculated theoretical throughput.

For example, for one layer that was tested using higher-order modulation (256-QAM), which enables higher transmission rates, VALOR was able to demonstrate it receiving 44 Mbps, versus Battelle's theoretical throughput of 45 Mbps.

Proven Performance and Future Impact

The success of Battelle's RavenStar SDR platform highlights the effectiveness of VALOR and the Lab-as-a-Service concept in providing robust, scalable testing environments that are available to a far wider pool of Open RAN system developers than has previously been the case.

Reports are already showing the potential that Open RAN has to disrupt the market, with a March 2025 analysis by LightReading noting the "growing number of smaller radio vendors" that are entering the market to leverage Open RAN trend and to take a bite out of the market for 5G equipment. This naturally leads to questions of interoperability for any network operator.

Crucially, undertaking VALOR testing provides confidence to potential wireless carrier customers, be they an operator or private network provider, that the Open RAN standards have been met and that the network will not be hit by interoperability, performance or security issues as a result.

Following the testing, and having demonstrated compliance, Battelle has shown the RavenStar SDR platform can be integrated easily and seamlessly into wireless networks without affecting performance consistency.

VALOR's third-party verification also eliminates potential bias and ensures thorough testing, thereby enhancing trust and accelerating market adoption.

For further information on VIAVI's VALOR Lab-as-a-Service please visit:
viavisolutions.com/en-us/valor

For further information on Battelle's RavenStar™ SDR platform please visit:
battelle.org/markets/industry/communications/ravenstar

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