

Bringing Field Testing Into the 5G Lab System Verification Life Cycle

Overview

5G is revolutionizing the connected world, bringing broadband capacity, gigabit speeds, ultra-reliability, low latency, and massive machine type communication. Overall, there is an expectation that 5G will be an innovation platform that fosters an environment where new services become possible and can be brought to market quickly. This will empower service providers to take advantage of market opportunities and dynamically meet changing consumer and business needs. However, deploying and supporting 5G's complex technology and network architecture will not be a trivial exercise. 5G is causing major changes across the entire network, from the highly flexible RAN architecture and 3D beamforming active antennas to software-defined network components, with stringent timing and latency requirements. Mission-critical applications will demand a network which cannot fail and ensuring network quality will be at the core of deployment. Time-to-market and network quality will depend on the rigor of test and measurement during the complete life cycle of the network; performing comprehensive verification during the lab validation stage will ensure a smooth and efficient deployment and launch of the network.

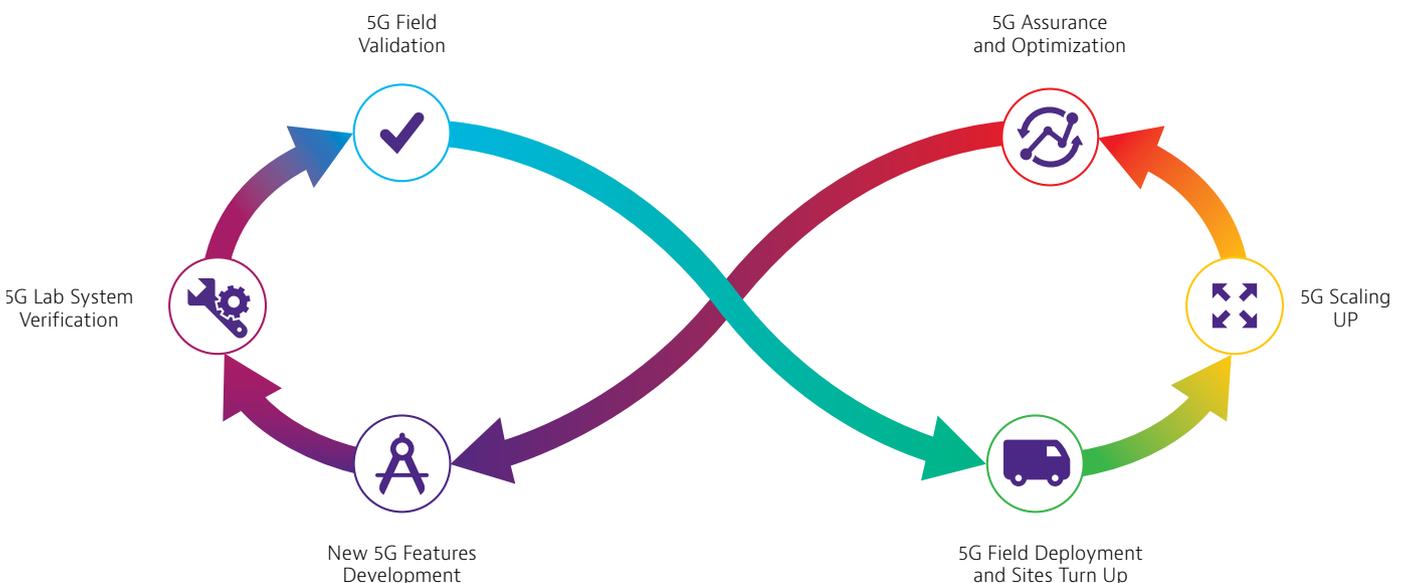


Figure 1: 5G Lab-to-Field Validation Cycle

Recent advances in 3D beamforming, along with the introduction of mmWaves and Massive MIMO active antenna mean that testing and optimizing overall system performance of 5G base stations in the lab is becoming more complex and challenging. Base station manufacturers are challenged to faithfully and extensively test and verify the integrated 5G new architecture in the lab. Bringing field testing experiences and extending the lab configuration and testing tools to account for real-life field scenarios not only accelerates the time to market, but provides a differentiated value when operators are choosing which unit and vendor to use for their 5G roll out along with how these should be deployed and configured. The same benefit can be realized by 5G service providers for integrating field trial testing with lab testing to efficiently plan an optimized roll out while guaranteeing the best network quality for the first adopters.

VIAVI, with its breadth of lab and field testing and optimization solutions, has been working closely with network equipment manufacturers (NEMs) and service providers (SPs) to help them streamline the complex process of validating new technologies in the lab and in the field and to efficiently deploy and turn up new technologies without negatively impacting their current customers, while enabling SPs to offer new services and enhancements on time to increase their top line.

In this short paper, we will discuss some of the use cases where VIAVI wireless lab testing solutions (TM500 and TeraVM) are integrated with best-of-breed field test and optimization solutions to improve overall lab to field delivery while automating the entire lab-to-field verification process.

Executive Summary

5G is revolutionizing the telecom industry, enabling innovation and new industry verticals with high margin revenue opportunities. However, the network evolution needed to realize these gains comes with major challenges. VIAVI is uniquely positioned to offer solutions to these challenges while enabling higher visibility and optimization of the new 5G revenue streams.

The introduction of 5G new radio (NR) with 3D beamforming antennas and massive MIMO is resulting in additional complexity for system performance testing and optimizing algorithms in the lab while verifying radio performance in the field.

VIAVI is the industry leader in both lab and field test and measurement, and is best positioned to deliver the most comprehensive lab-to-field test solution. VIAVI integrated 5G lab and field test and verification solution will reduce such complexity and enable better time to market with higher quality and test coverage. These solutions help the 5G network equipment manufacturer (NEM) mimic real-life field issues.

The solutions also help mobile service providers in field trials and initial 5G deployments to capture issues in the lab before rolling out to the field.

The new VIAVI Lab to Field testing and verification solution is helping leading 5G NEMs deliver higher quality 5G elements and ensure smooth network roll out.

As the 5G network evolves and expands over time, VIAVI 5G integrated solutions offer future proof implementations that protect current and future investments.

Validating RAN Performance in the Lab Environment

Validating new technology in the lab or field is always a daunting task, but with VIAVI TM500, coupled with TeraVM, NEMs can run a set of core test cases in the lab to assess the performance of network features within a loaded network environment. TM500 can also test the quality of experience of subscribers with real-world behavior under complex test scenarios including HetNet, C-RAN, small cell deployment, and FDD/TDD convergence.

In a 5G environment, downlink validation requires the ability to validate active antenna beam configuration as well as channel performance and quality. Without such visibility, lab testing will take longer and will result in many hours of root cause and triage analysis. VIAVI CellAdvisor 5G is the industry's most innovative and comprehensive field-portable solution for validating all aspects of 5G cell site deployment, maintenance, and management both in the lab and in the field, and is uniquely capable of providing this enhanced visibility during lab testing.

To achieve 5G throughput and enhanced cell performance using beamforming, user equipment (UE) should be able to perform beam tracking and switching. CellAdvisor 5G's beamforming analyzer function can analyze the entire 5G carrier in both FR1 and FR2, and can provide an accurate characterization of the active antenna beams to quickly troubleshoot and identify the root cause of poor RF performance.

By combining the power of TM500 and CellAdvisor 5G, NEMs and service providers can quickly identify any downlink (DL) anomalies such as variability in next Generation Node B (gNB) behavior, DL channel power, degraded DL modulation quality, beamforming performance or any antenna and cable issues in the lab. This allows them to perform comprehensive system verification in the most efficient and timely manner and reduce unnecessary manual root cause analysis steps.

With CellAdvisor 5G, engineers in the lab can quickly check the RF link before TM500 test execution, to ensure the test environment is clean and the gNB is radiating on the correct carrier with the desired numerology and with the correct identities at a sufficient power. They can also monitor in real time the DL RF link performance, which will allow them to adjust the test parameters and the RF environment to ensure the test was done in a true controlled environment.

With the help of CellAdvisor 5G, the following DL configuration and performance indicators can be monitored

- g/eNB channel bandwidth
- Channel center frequency
- Correct cell IDs
- Modulation quality
- Received power
- Active antenna beam performance
- Channel stability

Integrating CellAdvisor 5G DL beam analyzer and carrier analyzer function into the TM500 lab solution allows customers to further reduce verification cycle time by analyzing the relationship between xRAN performance and system anomalies in the lab. The integrated solution offers the following benefits:

- Enhanced visibility into lab verification
- Active antenna beam design and performance in labs
- Efficient management of factors affecting RF link performance and hence TM500 test results
- Result aggregation with unified dashboard identifying selected KPIs for TM500 and CellAdvisor 5G.

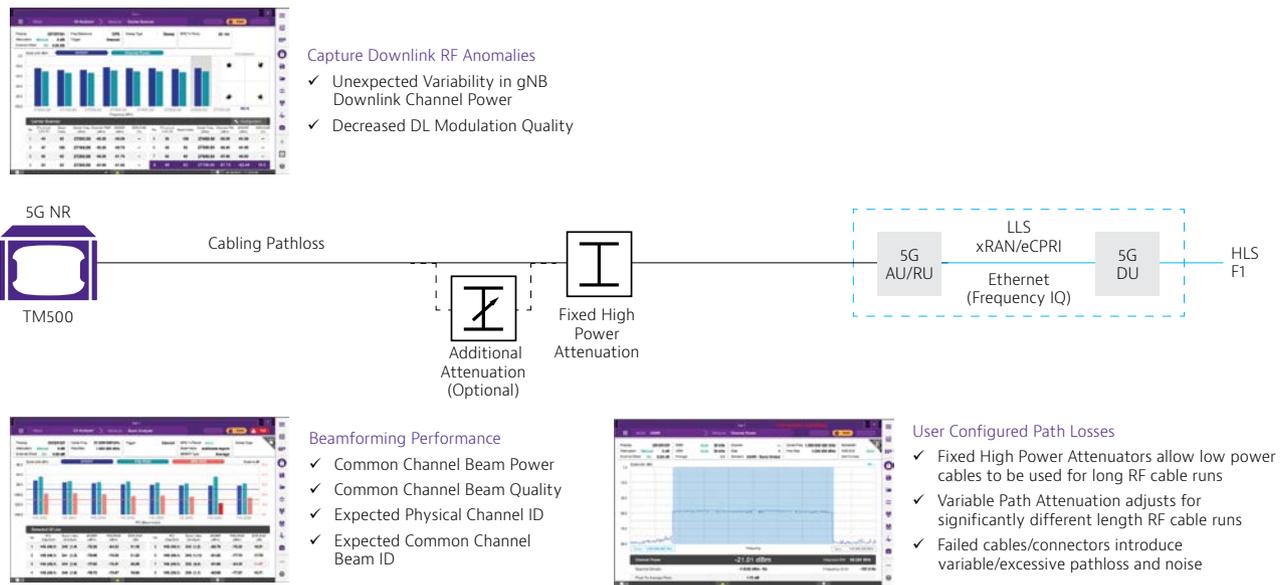


Figure 2: TM500 and CellAdvisor5G Lab to Field Solution

CellAdvisor 5G can also be used in controlled field trials as well as early campaign based trials to measure and record field beamforming characteristics, quality, and impairments. These results can be stored in the cloud for further analysis and integration with the lab test system to automate the creation of new lab test cases and configurations that mimic closely real-life field scenarios.

Isolating Fronthaul, Midhaul and Backhaul Issues

The need to manage the costs and complexity of 5G deployments demands the ability to host those network functions that can be centralized at aggregation points away from the network edge. There is also a need to place radios at sites with limited power and real estate. These needs contribute to the resulting new 5G architectural options, including the midhaul higher layer split (HLS) connecting the Central Unit (CU) with the Distributed Unit (DU) together with the fronthaul lower layer split (LLS) connecting the lower layer split Central Unit (LLS-CU) with the Radio Unit (RU). Coupled with these economic and logistical pressures is the fact that 5G networks will demand extreme bandwidth, and for certain use cases, such as remote surgeries, connected cars and mission critical applications, ultra-Reliable Low Latency Communication (URLCC) will be key. These conflicting needs must be balanced, and a network design must utilize the characteristics of the available real estate, power and fiber transport, while meeting low latency and other performance objectives. This means that the performance of the fronthaul, midhaul, and backhaul in the network must be measured and understood, and their impact on the system operation and performance along with impact on application KPIs characterized.

Therefore, methodical testing of the impact of the LLS and HLS in the lab is instrumental for capturing 5G RAN behavior in case of impairments on these links, and for characterizing the latency and time synchronization parameters to ensure an optimized 5G roll out in the field. These procedures and test cases in the lab can also be used by service providers and their deployment teams to certify these links during turn up and commissioning.

The exacting requirements for timing stability, synchronization and capacity on fronthaul links are addressed by the evolved Common Public Radio Interface (eCPRI) specification and the Open-RAN (O-RAN) Alliance. The latter is driving the decomposition of the RAN elements into components with specified interfaces, thus fostering flexibility and innovation. This move towards opening, specifying and standardizing interfaces has implications for 5G testing and verification, both in the lab and in the field.

Generally, the ethernet connection (eCPRI) in the lab environment between the Radio Unit (RU) and Central Unit (CU)/Distributed Unit (DU) is validated before starting a TM500 UE profile test execution. However, decoupling the dependencies between these UE profiles' performance and the timing stability, synchronization and capacity of the LLS link before and during the TM500 test execution, reduces the time to verify and understand the test results and errors. Different application mixes, especially mission critical applications, will require engineers to continuously monitor the link between the RU and CU to ensure that the radio and application performance is not negatively impacted due to packet/frame loss and relatively large delays.

VIAVI T-BERD/MTS-5800 field-test instrument provides engineers with an easy to use solution to measure and validate gNB/eNB connectivity and timing synchronization. With T-BERD 5800 engineers can quickly validate performance by analyzing the eCPRI link between the RU and the DU/CU to ensure correct configuration and sufficient performance of the xRAN user-plane, control-plane, sync-plane and management-plane. Engineers can run RFC 2544 or Y.1564 to validate end-to-end configuration at either the Ethernet or IP level (depending on the transport network specifics) to ensure that the key performance objectives such as throughput, latency, packet jitter, and frame loss are met. Engineers can select either RFC 2544 or Y.1564 to test a single service or select Y.1564 to test multiple classes of service. By analyzing the eCPRI link engineers can identify any problems with eCPRI and real-time control data packets (message type #2), allowing them to characterize service/network quality problems in an efficient manner.

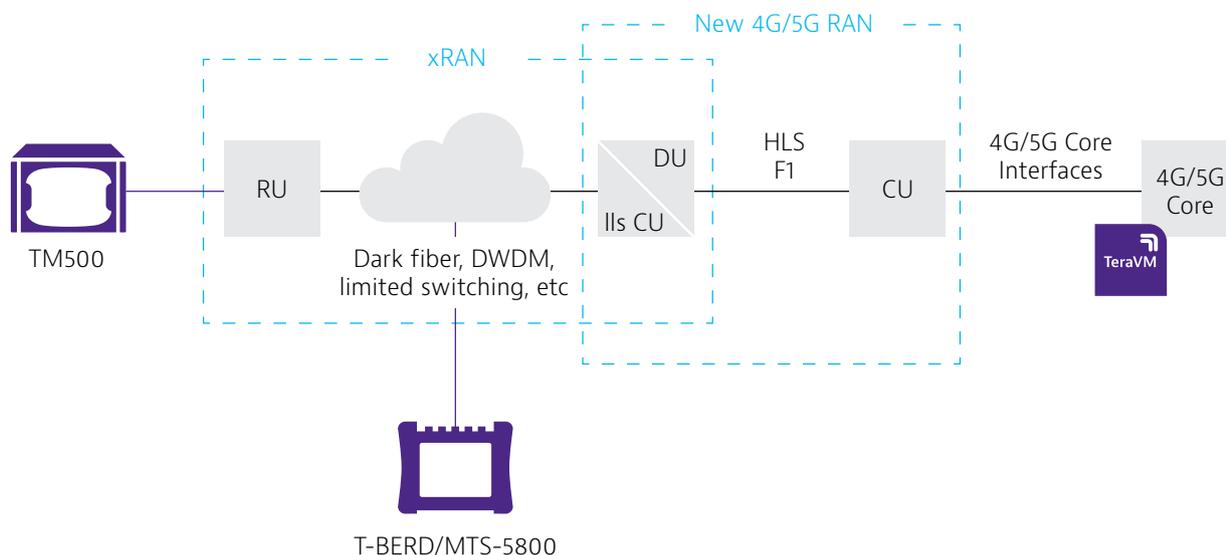


Figure 3: T-BERD/MTS-5800 and TM500 xRAN troubleshooting

By integrating T-BERD/MTS-5800 xRAN workflow with TM500, engineers in the lab can use the T-BERD /MTS-5800 dashboard available on the TM500 to detect if any packets are delayed or lost (user-, control-, management- or sync-plane) and flag errors quickly. T-BERD/MTS-5800 will decode xRAN and will autonomously stream analyzed test results to TM500 for long term capture and deferred analysis. The integrated solution will provide a more comprehensive view captured by both TM500 and T-BERD/MTS-5800 to help engineers study lab system performance in a more efficient manner, reducing the cycle time required to characterize and understand the relationship between xRAN performance and system failure.

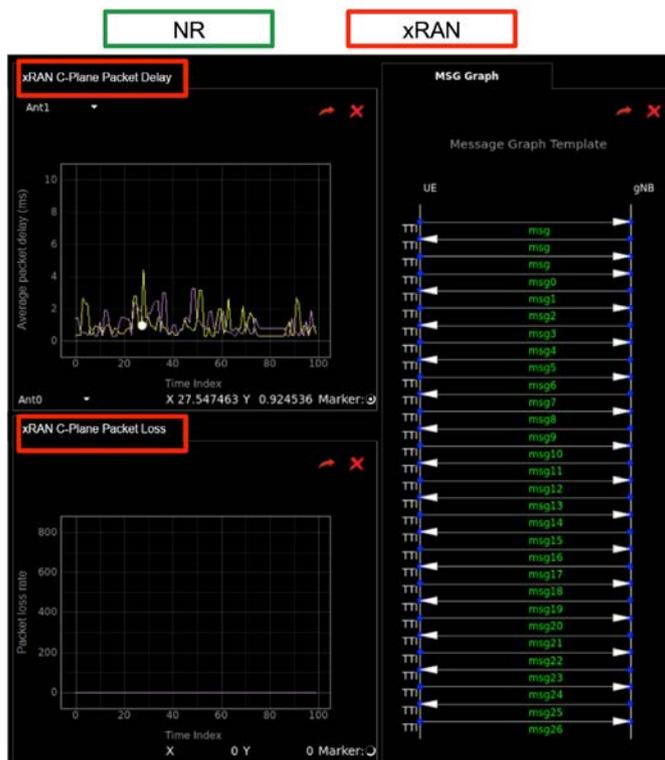


Figure 4: TM500 Lab to Field Dashboard showing packet loss and delay

Troubleshooting Dual Connectivity

The 3GPP specifications for 5G first standardized a Non-Standalone (NSA) architecture and the first 5G networks deployed are expected to use this architecture, which means that the early 5G networks will be supported by existing 4G infrastructure. Thus, 5G-enabled devices will connect to 5G frequencies for data throughput but will still use 4G for aspects such as system access and mobility. Dual connectivity capable UEs will have to identify as such in the attach procedure and if the functionality is supported then interoperability between the eNB and gNB will work. As both eNB and gNB will be usually collocated, it can potentially create RF environment challenges. Ensuring that there are no RF challenges in the lab and field environment is the key for validating 5G performance.

Using CellAdvisor 5G to validate the RF environment while running the TM500 test cases can help check RF interoperability issues and can reduce overall verification time.

By combining the power of TM500 and CellAdvisor 5G, NEMs and service providers can quickly identify any RF anomalies and can make adjustments to the link budget between 4G eNB/5G gNB and TM500. Future integration of CellAdvisor 5G will include streaming field RF information to the TM500 dashboard to further automate the process and reduce verification time in the lab.

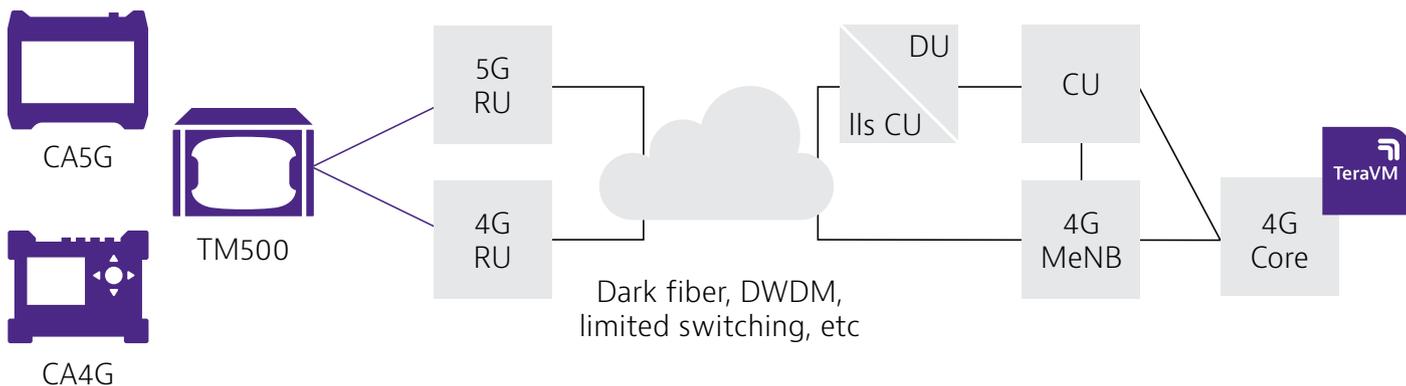


Figure 5: Architecture Option 3 -NSA dual connectivity test case



Figure 6: NSA dual connectivity TM500 dashboard

Conclusion

As 5G evolves from lab to field deployment, it is essential that service providers and NEMs have the confidence to validate all user scenarios in the lab in a timely and cost-efficient manner. 5G networks are more complex, driven by applications with different and more stringent demands on RF, latency and reliability. Having the right solutions in the lab will ensure a quick and smooth commercial network deployment with fewer field outages and customer complaints. VIAVI TM500 and point solutions can help NEMs deliver on that objective. The VIAVI Lab to Field solution is the most comprehensive solution for NEMs and service providers to quickly perform a complete network verification in the lab for an expedited and smooth field deployment.



VIAVI is an active participant in global 5G standards bodies, associations, and alliances



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