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Overcoming T&M, Assurance Challenges in 5G Networks

A Heavy Reading white paper produced for Spirent & VIAVI



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INTRODUCTION

It's impossible to miss the hype surrounding the applications and services that 5G networks will enable: Tactile Internet, autonomous cars and virtual/augmented reality are just a few. The promise of fast speeds, vast coverage density and seemingly endless traffic capacity make 5G much more than just another iteration of cellular technology.

But as operators tout the coming ability to provide such services, the reality is that 5G networks dictate new specifications for throughput, reliability, latency and network robustness. The always-on connectivity required for many of the applications and services promised on 5G networks have technical requirements that far exceed those found on existing mobile networks, including data rate, latency, reliability, device and network energy efficiency, traffic volume density, mobility and connection density. Multiple factors are further spotlighting the need for test, measurement and service assurance of 5G networks:

- 5G timelines have accelerated without an associated lengthening or increase in the cycles of testing for those networks. This problem is evident even in 3GPP specifications themselves. 3GPP released 5G New Radio (NR) specs for non-standalone (NSA) operation of 5G and Long Term Evolution (LTE) in December 2017, as well as specs for standalone (SA) operation of 5G in June 2018. Nevertheless, gaps exist in the test specifications. For instance, in RAN4 and RAN5, core specifications need to be finalized to define performance requirements and test procedures, a process that could take up to nine months. While the industry pushes to bring timelines forward, the fact is that more time is needed to complete the specs and test the network.
- Revenue concerns are being driven by several factors. Operators are still in their 4G spend cycles, and 4G networks are still evolving. Indeed, in some countries, new 4G networks are still being built. Successful 5G is dependent upon 4G, especially for the use of the 4G core with 5G NR. Furthermore, 5G introduces technical challenges from testing devices, base stations and radio access networks (RAN), and operators must work closely with test and measurement (T&M) vendors to develop practical, economic testing methods to address those challenges.
- 5G is being touted as the technology that is all things to all users, all the time. As such, the network aims to simultaneously support multiple industry verticals and use cases with competing network quality and performance requirements. This creates vastly different service assurance requirements than for other network deployments.

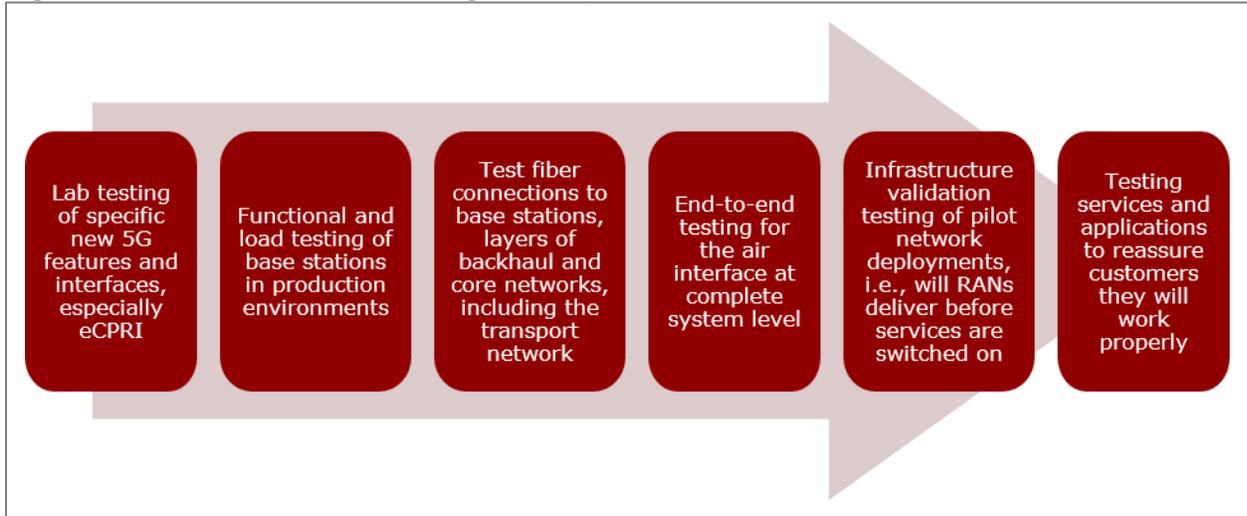
This white paper examines the extensive differences in how 5G networks are designed, as well as the types of applications and services that are slated to run across those networks, drives the need for operators to incorporate T&M and assurance now and throughout subsequent stages of 5G deployment.

5G'S UNIQUE T&M, ASSURANCE CHALLENGES

As mobile operators prepare to launch 5G, their intent is threefold: to obtain the highest possible capacity; to develop diverse new services and applications for new and existing customers, in order to extend their long-term business viability; and to ensure that the quality of the network is unimpeachable. The overarching goal of that intent is to replace eroding revenue, create long-term capex and opex stability and finally sever reliance upon legacy business models that have eroded shareholder value and customer satisfaction for years.

T&M and assurance play a critical role to enabling operators to achieve those goals. As shown in **Figure 1**, there are several areas in which testing will take place throughout the 5G ecosystem over the next 12 months.

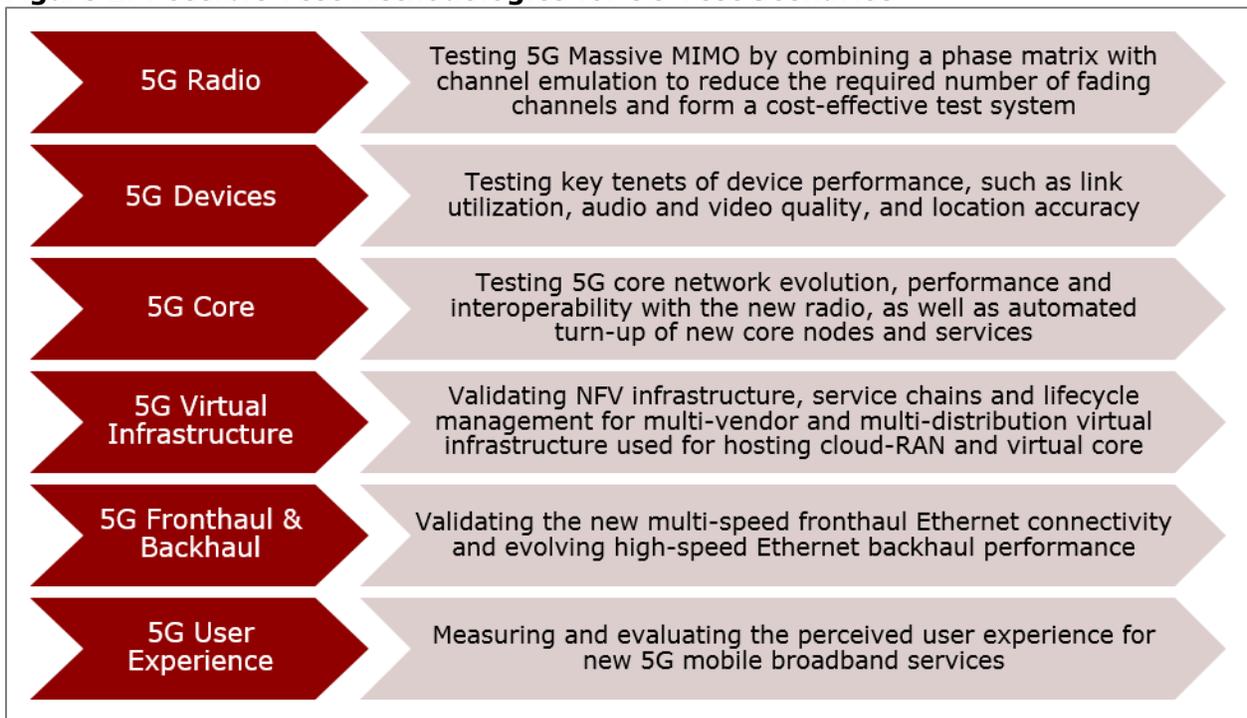
Figure 1: Focus Areas of Testing for 5G, 2018-2019



Source: Heavy Reading

5G networks initially will be deployed in NSA mode on a host LTE network using enhanced 4G core that eventually will migrate to a 5G core operating in SA mode. **Figure 2** shows possible test methodologies for several 5G test scenarios.

Figure 2: Possible Test Methodologies for 5G Test Scenarios



Source: Spirent

These first 5G networks are being built now by high-profile operators and likely will be operational in late 2018 and 2019. These networks will utilize 4G evolved packet core (EPC) for session management, mobility, authentication, authorization and accounting (AAA), as well as LTE radio for over-the-air (OTA) signaling. Within a contiguous 5G coverage zone, local-area mobility will be handled by 5G RAN; in later phases, the 5G core network will control both 4G and 5G radio access and might include fixed access, as well.

5G NR

In the search for more data bandwidth, 5G NR enters the 15 GHz frequency range, a higher and shorter range than current 3G and 4G cellular frequencies, which top out at around 2.6 GHz. Additionally, 5G requires associated adaptive antenna system (AAS) technologies and increases overall spectral efficiency in the form of beamforming and massive multiple input/multiple output (MIMO), which further impacts testing. In the past, most radio functionality could be evaluated independent of antenna systems; however, AAS makes it impossible to separate radio performance from antenna performance. Moreover, antenna arrays used with the radios makes it impossible to conduct tests of each antenna port, so radio performance must now be performed in an OTA test environment.

Massive MIMO

Massive MIMO in 5G can have more than 256 array elements that require a large number of radio channels. The addition of beamforming means the array elements that serve the device can dynamically change. As such, traditional conducted, or cable, testing is not always viable or cost effective. This is driving a desire to minimize hardware resources to test 5G NR in lab environments and utilize a combined strategy for both cable testing and OTA testing that solves the challenges brought about massive MIMO and beamforming.

Beamforming

Beamforming creates a catch-22 for engineers, who need to conduct static tests on devices and antennas. They have to discover how many points are necessary to obtain an accurate measurement, but they can't choose so many that the test becomes inefficient or cost-prohibitive. The general rule to follow for an operator to achieve cost-effective beamforming testing is 30 beams per base station. If the massive MIMO array only forms two beams, the business case doesn't work. Operators are learning that 3D beamforming is one of the most difficult 5G technologies to get right, which has serious implications on how testing is done.

mmWave

While testing for frequency range 1 (FR1) of 3GPP is more established because of its similarities to LTE, testing for frequency range 2 (FR2), which includes millimeter wave (mmWave) bands, is a challenge because it can only be demonstrated using OTA testing and specialist chambers. These devices have higher levels of integration with antenna arrays coupled more closely to the radio frequency (RF) components, making it impossible to use a cable connection to test the antennas and the RF separately. Furthermore, beamforming, identification and tracking can only be tested over the air. Operators also will have to take into account the fact that mmWave is more susceptible to propagation and interference from within and outside of the network.

MEC

The ability to deliver processing-intensive services via the low latency of 5G networks is a major attraction for operators, and the theoretical ability to do so is possible through multi-access edge computing (MEC). Deploying assets at the edge enables operators to deliver ultra-low latency (ULL), high bandwidth, distributed, dynamic control and user plane, as well as providing the ability to host third-party applications closer to the end user. However, the network performance required for MEC depends upon enhanced timing requirements, including new hardware for the core radio access network (C-RAN) domain and new synchronization technologies and standards.

THE IMPACT OF VIRTUALIZATION

As operators implement 5G networks, they increasingly will rely upon virtualized network functions (VNFs). Meanwhile, they will need to integrate solutions that can validate interoperability of virtual, hybrid and physical resources. As 5G networks mature, it's important to note that the new 5G core networks rely upon service-based architecture (SBA), which isn't supported in 4G. SBA supports services related to network slicing and MEC, and its key features include formal control and user plane separation (CUPS).

Virtualization of Radio

A successful 5G cloud RAN will flex and adapt based on usage and coverage to provide expanded network location choices for baseband processing. The ideal business case for 5G depends upon a large number of urban small cell sites from which baseband is distributed from lower levels that are hosted on the physical radio tower heads and in edge cloud data centers. Ultimately, the need is to reduce cost by removing as much of the costly and complex processing to a shared, centralized and cloud hosted environment as possible. The challenge is that cloud-hosted radio (baseband) processing needs unique capabilities around time-sensitive networking, acceleration and availability that current public cloud architectures cannot deliver.

Virtualization of Core

But radio network tests are not the only challenge. Testing also is necessary for fiber to base station sites and the layers of the backhaul and core networks, including the transport network, which will result in an evolution of core network testing over the next several years. The interworking between 5G NR and the 4G EPC will predominate initially, followed by NSA network products and production testing of 5G RAN and core.

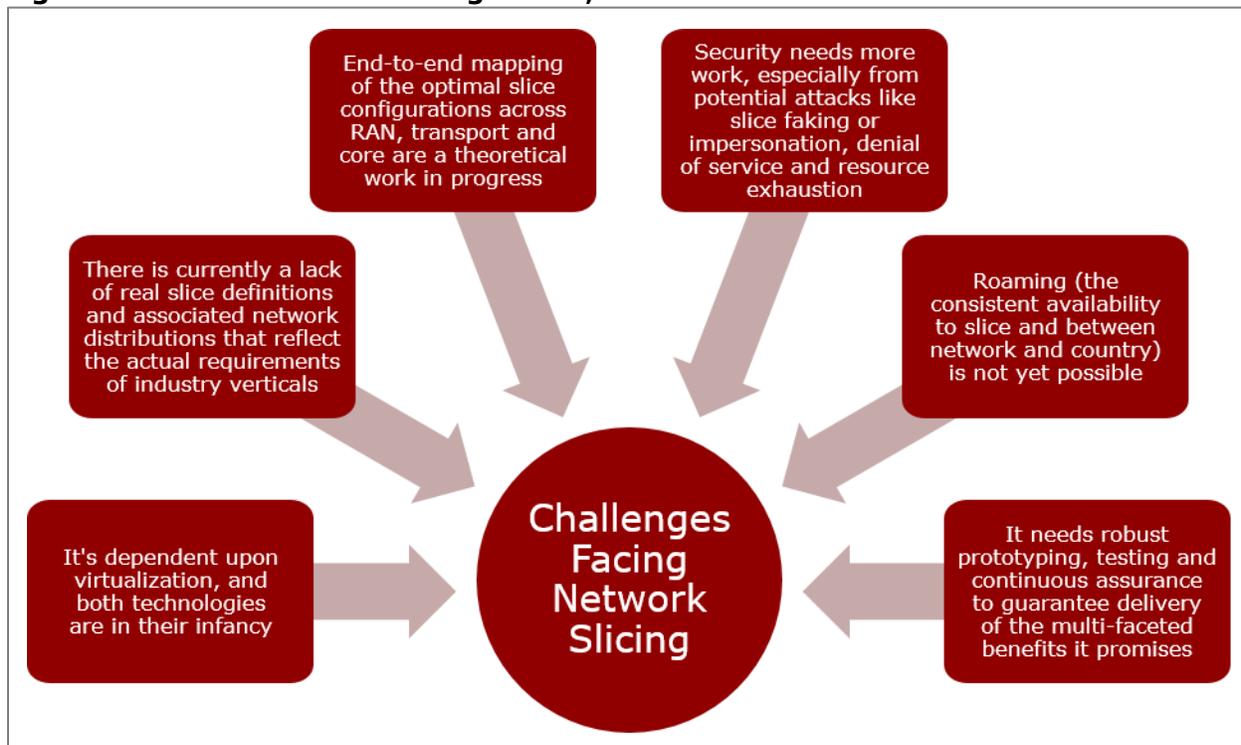
Control & User Plane Separation (CUPS)

CUPS has the ability to distribute the user plane at the edge data center, while the control-plane functions remain centralized, allowing for GTP traffic from the RAN to be terminated at the edge and then routed according to service type. In some cases, the application itself will reside at the same edge cloud location, removing the need for backhaul to the central data center and enabling low-latency services. There's a need for exploratory testing of CUPS to determine its suitability for these deployments, as well as to ascertain whether it will support the topologies that will help meet specific industry network slices.

Network Slicing

For advanced services such as network slicing, 5G core will be necessary. And while network slicing isn't solely a 5G attribute, it will become more important as operators design their 5G networks. End-to-end testing of slices is not straightforward, as each slice has its own performance requirements. Services based on one network slice will have different service-level agreements (SLAs) than those using another slice. In fact, network slicing faces several challenges, as seen in **Figure 3**.

Figure 3: Focus Areas of Testing for 5G, 2018-2019



Source: Heavy Reading

PREPARING FOR AUTOMATION

The key to successfully testing and assuring all 5G network elements will, in the long run, depend in large part on automation. The impetus to automate should gain more widespread acceptance as operators reap benefits from initial network virtualization efforts. Nevertheless, it will become increasingly difficult to test 5G networks that support new service types composed of multiple network slices without automated solutions.

Service Agility

The processes for launching new 5G services needs to evolve toward the speed of web-scale service providers such as Amazon and Facebook. It's not unusual today for communications service providers to take months to launch a new service, while web-scale providers exploit cloud-native architectures and agile development cultures to release new services

and iterations of services within hours. Because 5G's architectural foundation is built on virtualization, it gives communications service providers the opportunity to build agility into development and operational models and adopt web-scale principles to become digital service providers. This requires the adoption of a DevOps culture in which automation is utilized across the lifecycle with all vendors to embrace the principles of cloud-native architectures.

DevOps

A DevOps approach can generally be considered the collaboration of development and operations functions throughout the development and fulfillment of a network service. The key of DevOps is to maintain dynamic network services with high customer quality of experience (QoE). Development and operations teams need a unified and automated set of tool chains, methodologies and metrics that enable them to adopt streamlined DevOps continuous testing practices to improve efficiency, enable more releases and, thus, faster time to market, as well as the ability to better utilize resources and proactively address quality issues. DevOps continuous testing ultimately should be automated across the end-to-end service lifecycle through network validation, service testing and operational assurance workflows.

Service Assurance

Service assurance needs to be tightly integrated with services themselves, as probes will be implemented as VNFs with the service, rather than standing alone as a function of the network. Problems can be solved with automated root-cause analysis, service impact can be assessed in real time, and remediation is automatically initiated to counter the impact to customers. When the root cause is equipment failure or insufficient hardware resources, a ticket is automatically created to engage the support staff to replace/repair the defective component or initiate the request to add hardware resources. Dynamic SLA management also is needed to monitor SLAs in real time, even as the service evolves and changes.

Service Orchestration

The goal for service orchestration is to see it completely automated, from the point a customer requests a new service via a self-service portal to the service actually being provisioned, used and monitored for quality. Automating the provisioning and testing of services on demand and programmatically interacting with the network infrastructure with no human intervention also is a realistic goal. In terms of service orchestration, there may be a human element, depending upon the service complexity at the user request or approval of changes; however, that may only be until the system trains, uses cognitive intelligence to learn what appropriate actions were taken and what data needs to be correlated and analyzed to approve requests.

Analytics

Real-time, complex analytics ensure that SLAs are met and monitor the infrastructure for faults, congestion, anomalies and service impacts, as well as provide a detailed and correlated view of activities across the network, including services, applications and devices. It transforms network and test data into proactive insights, providing end-to-end quality and performance visibility that enables closed-loop actions, such as automated troubleshooting to enable zero-touch problem resolution, rapid fault isolation and reduced mean time to repair (MTTR).

REVENUE GENERATION & SERVICE CREATION

Ultimately, operators should view the incorporation of T&M and assurance in their 5G networks as a way to generate revenue and create services, as shown in **Figure 4**.

Figure 4: Revenue & Service Creation Opportunities in 5G

Opportunity	Benefit
T&M and assurance virtualization	Reduction in capex and opex by delivering new savings and efficiencies across 5G networks
T&M of C-RAN	Simplifies radio equipment, makes operation easier, lowers the cost of maintenance, provides economies of scale as a shared resource
Service assurance of Ethernet-based fronthaul	Assures network delivers relevant high-speed, low-latency and accurate synchronization, while simplifying and accelerating the turn-up of new cell sites
Lifecycle service approach to services, from initial design through operations	Faster development cycles, enhanced service agility, reduced operational costs, new revenue and services
Active testing of network	Generates small amounts of synthetic traffic, emulating certain parts of the network, and actively monitors the performance and SLAs of services; ideal for 24/7 continuous monitoring, troubleshooting, service turn-up and verification; simultaneously validates new services in the lab, at turn-up and continuously monitors SLAs in the operational network to find issues before customers are impacted
E2E analytics	Insight on the network, subscribers, connected machines, services and applications to drive new revenue opportunities and monetize the network
Automation	Automated business processes that build on artificial intelligence and machine learning techniques that are app-aware for efficiency and service velocity
Network slice assurance	Dynamically validate new slices in the lab and at turn-up and continuously monitor slice performance in the operational network to guarantee SLAs
Security auditing services	Continuously test and audit 5G enterprise environments to preemptively identify vulnerabilities and prioritize risk mitigation
User experience evaluation	Evaluate user experience of 5G services on end-user devices to ensure competitive differentiation and QoE performance
Lab as a service (LaaS)	Upgrade 5G labs and testbeds with emulation and automated test solutions so industry verticals accelerate innovation

Source: Heavy Reading

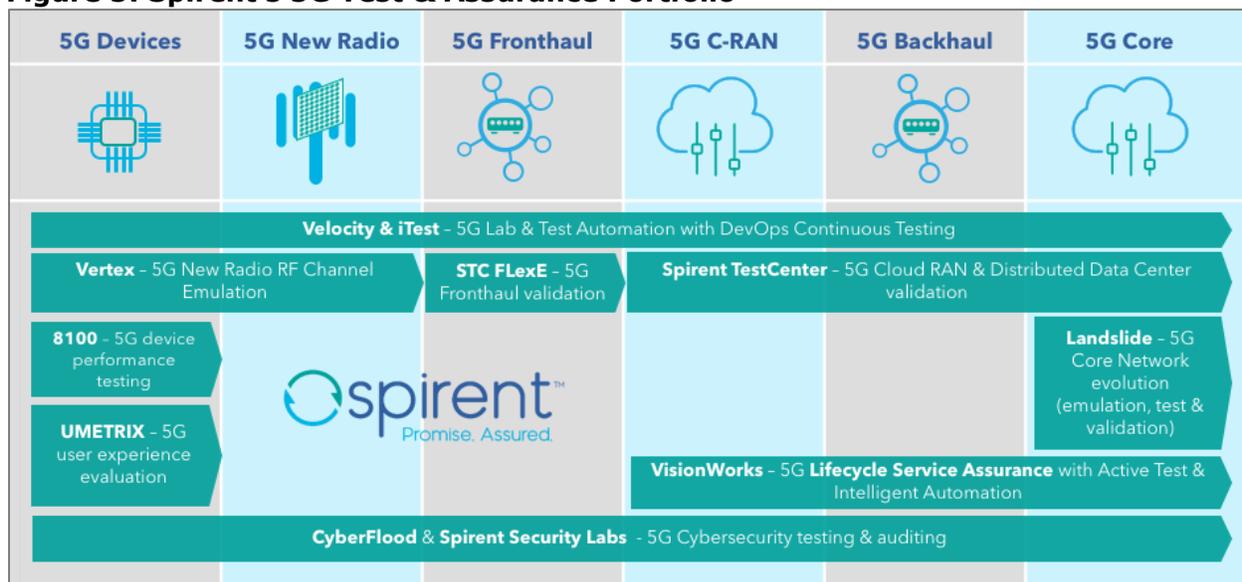
Spirent

Spirent is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers and enterprise networks. It helps bring clarity to increasingly complex technological and business challenges. Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled.

With a broad set of 5G test and assurance solutions, Spirent enables its customers to deliver on their 5G promises by:

- Simplifying 5G by reducing the complexity and economics of testing and validating 5G networks through test automation, emulation and new 5G test methodologies
- Accelerating 5G innovation and time to market of new services through DevOps continuous testing and cybersecurity
- Assuring 5G operationally delivers the new revenues, savings and experiences that have been promised

Figure 5: Spirent's 5G Test & Assurance Portfolio



Source: Spirent

VIAVI

VIAVI works with the world's top communication providers and other leading organizations to deliver contextually-aware visibility and intelligence needed to plan, test, enable, assure and optimize autonomous 5G networks with speed and success. Its expertise is applied to:

- **Technology verification and validation:** Solutions are designed to scale and provide continuity from manufacturing to field deployments, minimizing construction time and ensuring high-quality network performance.
- **Deploy, activate and scale:** Domain-focused solutions span devices, radio, *ad hoc* network clusters, RAN, transport, core and services for verticals to deliver essential visibility and actionable insights for 5G end-to-end programmable and dynamic networks.
- **Assurance and analytics:** Solutions support cognitive functions and end-to-end network slices by providing orchestrated, real-time network and contextual awareness across all key domains.
- **Optimization:** Continuous monitoring and feedback for the dynamic network, with general and deployment-specific key performance indicators (KPIs), such as use case-specific QoE and quality of service (QoS).

Figure 6: VIAVI's End-to-End 5G Testing Portfolio



Source: VIAVI

CONCLUSION

There is little question that 5G eventually will result in tremendous benefits for network operators, enabling them to provide enhanced services over automated networks to an expanded customer base.

For the promise of 5G to happen as quickly and seamlessly as possible, it's imperative for operators to incorporate test, measurement and service assurance solutions as they transition from 4G to 5G and throughout the entire lifecycle of 5G development and deployment.

Furthermore, the evolution of T&M and assurance methods is vital for operators on the road to 5G. Automating networks will be achieved as operators incorporate virtualization, and it's imperative for operators to ensure their virtualization and automation plans include T&M and assurance solutions.