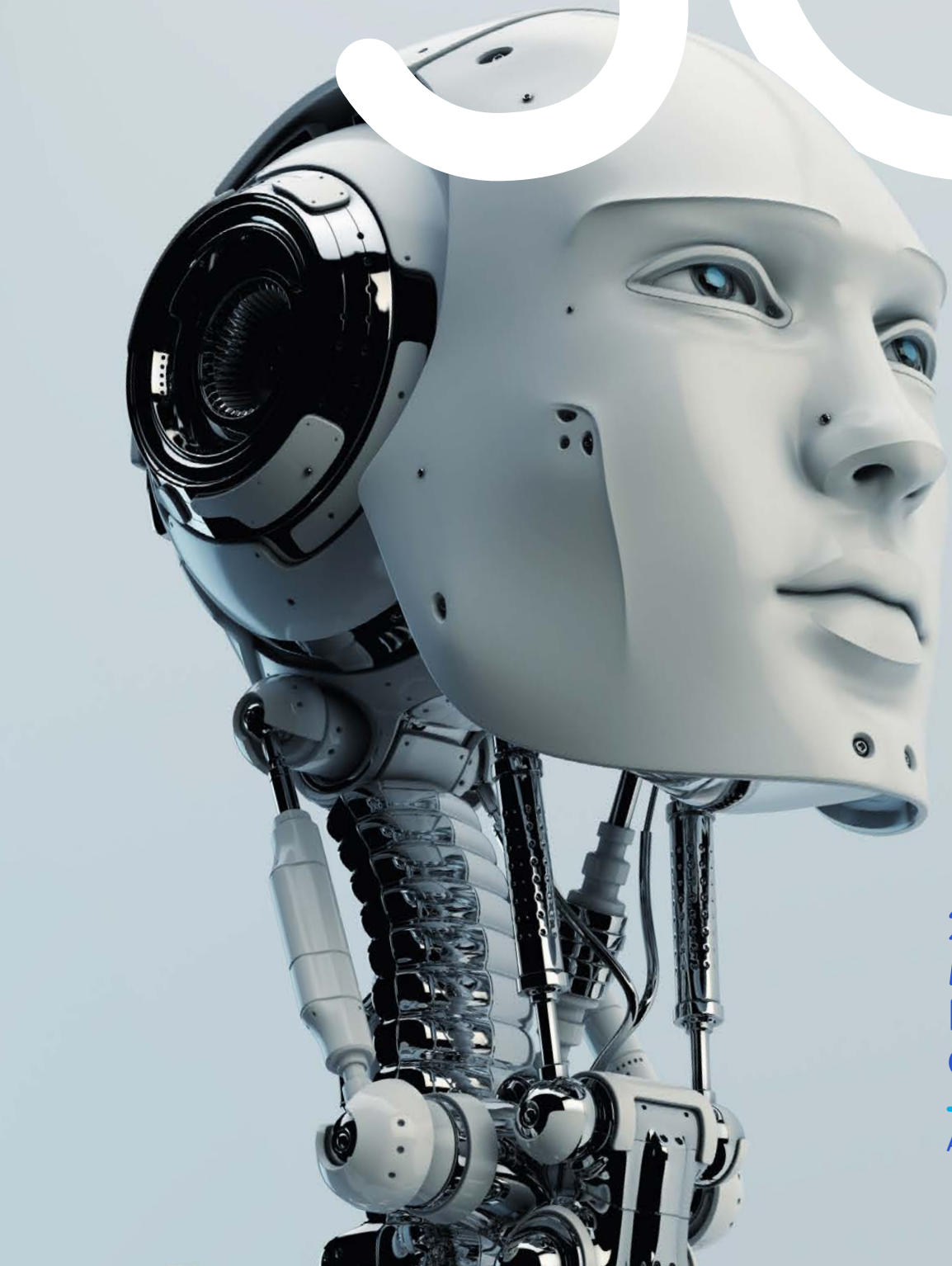
Spirent™

5G



2023: Market Drivers, Insights, and Considerations

A Spirent Report

We No Longer Need A Crystal Ball To See 5G's Bright Future

In 2020, we published our first annual 5G Report to share our next-gen network deployment predictions. More than three years on, our industry has both feet planted firmly in a vision we once could only see with a crystal ball.

We have collectively learned much during this time.

We learned that 5G is the network generation where service provider paths diverge, demanding customized strategies for success.

We learned that 5G is not a "build it and they will come" proposition. Every day, this ecosystem goes to work determined to prove the value of what can be delivered to consumers, enterprises, and the world.

We learned that despite what is said about telecom moving slowly, we can adapt quickly and thrive in the face of adversity.

We learned that we'll need to keep up this pace if we are to seize on the opportunities before us.

HELPING OUR CUSTOMERS CONFIDENTLY RACE TO REVENUE.

That is where our focus has been: helping our customers become more agile and efficient so they can confidently race forward in pursuit of new 5G revenues, even as they face excessive technical complexity and fierce competition.

For all the progress our industry has made, 5G remains in its infancy with plenty of roadway ahead. Less than 35% of service providers have deployed any flavor of 5G. Less than 5% have deployed on a true 5G core network.

5G is harder, more expansive, and has more riding on it—literally and figuratively—than any previous generation network.

It's no surprise then that even with today's macroeconomic headwinds more than $175B will be spent globally on infrastructure between 2023 and 2025 to support everything these deployments comprise—from cloud and core to private wireless networks, Open RAN, and beyond.

We will also see investments to counter inflationary and energy pressures with heightened focus on solutions and technologies to improve productivity, capital efficiency and power management.

The 5G opportunity won't be left solely to traditional players. It's attracting investment and competition from tech leaders outside of telecom, leading to a much larger field of vendors.

2,600 5G ENGAGEMENTS AND COUNTING.

Testing in the lab remains important, but is no longer sufficient on its own. 5G has made it clear that testing is not something that is done just once—it must continue in the live network.

A continuous integration and deployment approach to software development with integrated, automated test represents the path forward for any service provider eager to succeed in 5G. It's the only way to get both the agility and cost efficiency today's competitve market demands.

With 2,600 5G engagements under our belt now, it's safe to say that this requirement has become well-recognized by all participants.

There is also continued recognition that in contrast to previous years, service providers cannot take this journey alone.

Our business has fully evolved to become consultative wherever it is needed. We are trusted partners, not product vendors. We address all phases of the technology lifecycle. We are alleviating the burdens of complexity and filling expertise gaps to keep 5G surging forward.

We are proud to play this critical supporting role and grateful for the trust our customers have put in us.

As we continue this journey together, we proudly present our fourth annual 5G Market Drivers, Insights, and Considerations report.

The race is on and we're right alongside you. Let's toss the crystal ball in the back seat—we're in the thick of it now.

I'm excited to see how far we can continue to go together.

Eric

ERIC UPDYKE
CEO, Executive Director

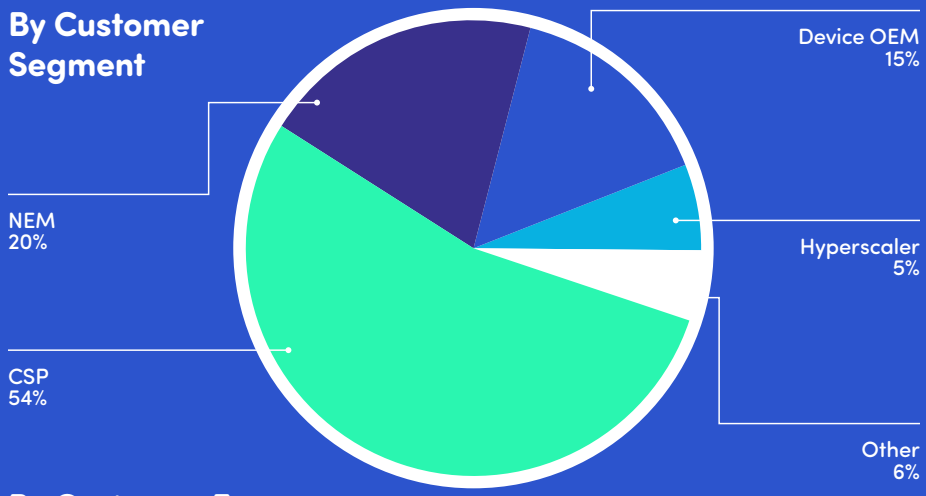
What's Inside

2022 By The Numbers

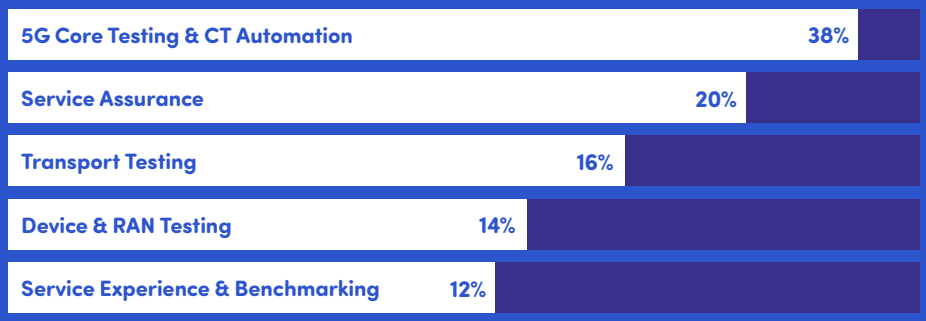
2,600
Total Spirent 5G Engagements To Date

800+
New Spirent 5G Engagements In 2022

By Customer Segment



By Customer Focus



Key Insights

>30 CSPs engaged in **5G Core** validation/launch testing

5G VoNR getting ready for prime time with MOS scores beating VoLTE

FWA range and competitive speeds double within 12 months

Mobile gaming success zeroes in on KPIs that relate to user perception

Edge (MEC) performance with cloud providers demonstrates latencies less than 20ms

Automating labs and lifecycle testing processes unlocks agility and substantial **energy savings**

NTN (LEO) testing highlights focus on direct-to-phone

Destination Revenue

5G network strategies are evolving to be more diverse than any previous generation.

Region, regulation, government ambitions, and competition all play a role. What do deployments have in common? The investments are as massive as the stakes.

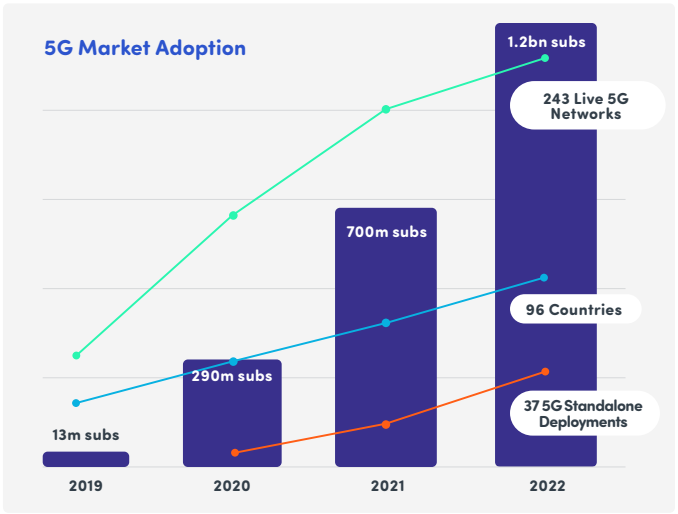
In 5G networks, nothing can be left to chance. It is not an option to leave revenue on the table, especially in today's uncertain macroeconomic environment where capital efficiency must be countered with new growth initiatives.

This is the backdrop of the relentless race to revenue playing out across 5G rollouts. It has fundamentally changed how operators go to market, what they need to know before they get there, and the steps they take to stay on course to revenue.

Read on to explore the diverse paths being taken by operators and the new roles testing is playing in the revenue chase.

5G Revenue Journeys Get Real

Manuel Zepeda
Spirent's EVP of Global Sales and Services, on the many paths to 5G profitability.



Source: Spirent analysis of public data

Can A Number Paint A Thousand Words?

I believe it can, and for 5G there is one metric that captures the moment: ***adoption***.

The numbers tell us 5G is no longer a journey reserved for the privileged. It has rolled out in 96 countries serving more than 1.2 billion people.

For our part, we've now embarked on 2,600 5G engagements with customers. 800 took place this year alone with over 180 unique customers, the majority (54%) comprising service providers. They run the gamut from testing the 5G waters all the way to the holy grail—5G Standalone (SA) core deployments.

Nearly half of our 2022 5G projects with service providers focused on cloud and core network challenges, especially the need to integrate expanding supplier bases. Around 40% of our work was based on assuring the network performance and service experience. This means making sure networks perform as expected and also deliver a competitive experience. One constant extends across all of our 5G projects — a keen and growing interest in automation for enhanced agility and cost efficiency.

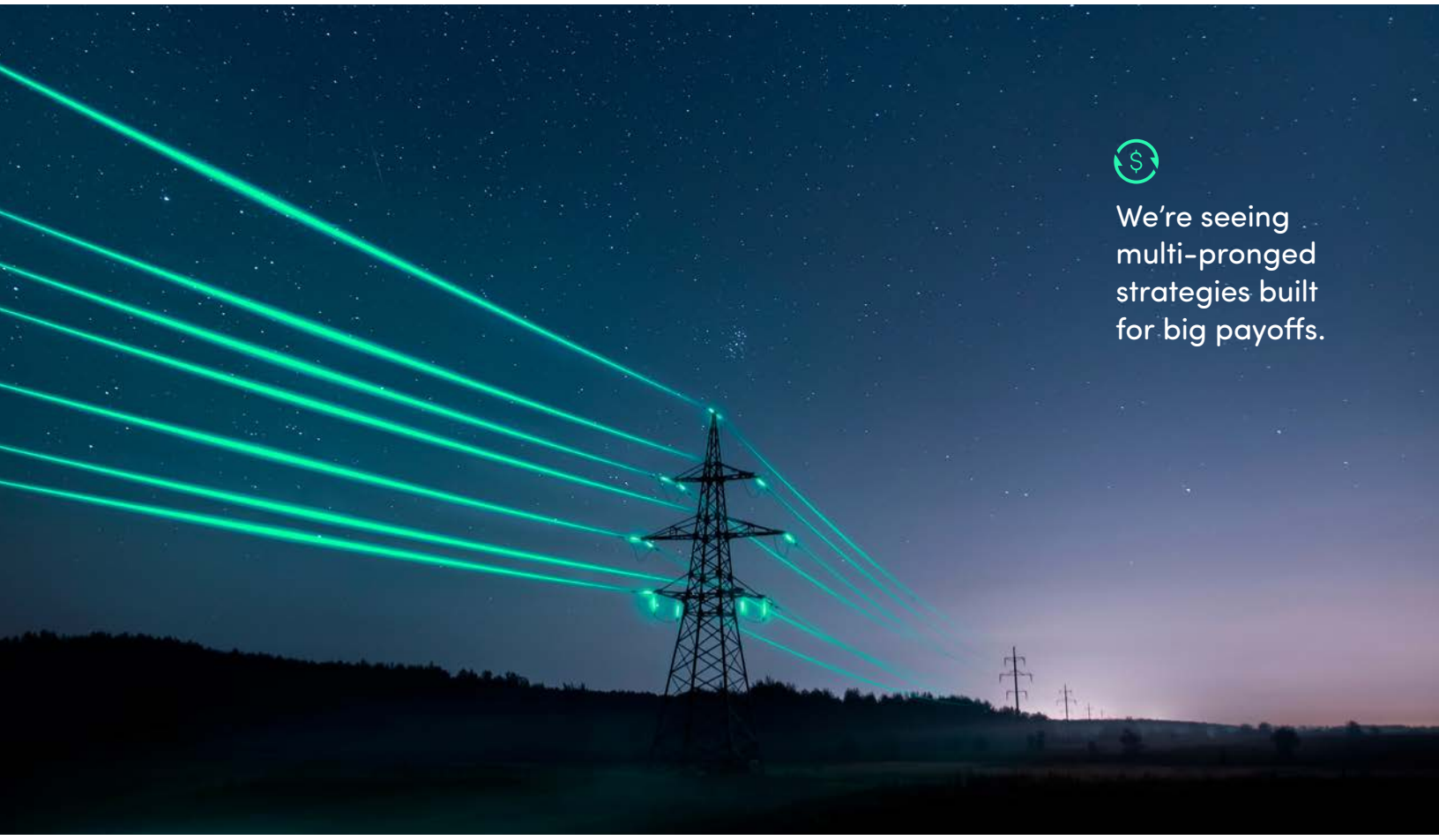
As 5G proliferates, an industry skill set shortage across cloud, security, and automation endures. Our managed services engagements were up 15% year-over-year as a result.

A Look Under The Hood Reveals Networks Ready To Earn

Real revenue requires scale.

That is the driving force behind our network testing which this year saw over 30 mobile service providers engaged in validation testing of the 5G core and supporting cloud infrastructure. This is a significant number that further underscores market readiness to pursue a range of 5G business cases.

Service providers are coping with a volume and velocity of challenges they've not previously seen. Will my multi-vendor system work? Can my network functions perform in the cloud? Does edge deliver on its promised value? Is my new network secure? Will my processes and network scale to meet new demands?



Top Testing Routes To Reliable Revenue And Capital Efficiency

Service providers are embarking upon multiple testing routes—sometimes in parallel—to get to desired revenue and capital efficiency destinations. Along each route, key test and assurance milestones must be passed to ensure they reach the final destination ahead of competitors.

Tier 1 U.S. Service Provider
250,000
Proactive health checks across the live network every day

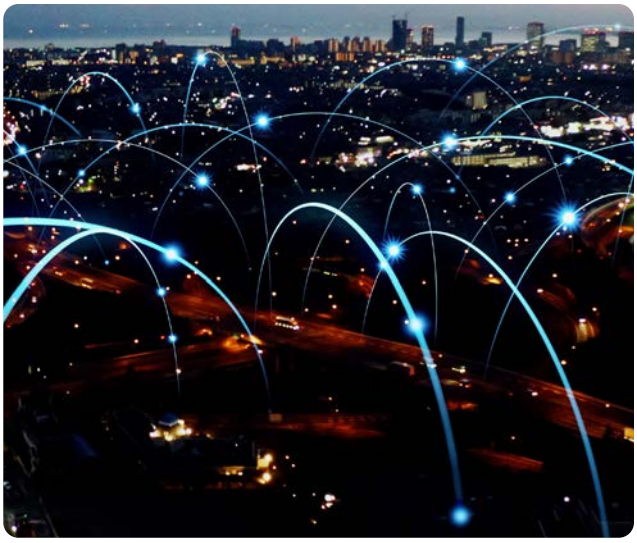
Tier 1 U.S. Service Provider
>120
National metro markets benchmarked for MEC quality and performance

Global Service Provider
40%
Energy savings from automating lab utilization + power management

Tier 1 European Service Provider
3x
Faster test + assurance process for 5G private networks

A Global View: 5G Looks Different Depending On Where In The World You're Standing

We continue to see splintering strategies from one region to the next. Market pressures, government ambitions, enterprise adoption readiness, and revenue paths all play a role. Let's explore Spirent's 5G engagements by region.



The Americas

The Americas is Spirent's most dominant region for 5G.

What's driving demand: A dominant focus on service assurance and evolution to 5G Standalone via 5G core introductions, with more attention paid to the service experience and competitive benchmarking.

- Network needs are changing. As more 5G Standalone rolls out, ensuring end-user devices are properly supported is a priority.
- There are new apps in the mix: Voice over New Radio (VoNR), 5G assisted GPS (AGPS), and adaptive bitrate (ABR) streaming to name a few.

Customer Spotlight: A major U.S. service provider preparing for 5G core deployments was struggling to support operational trouble tickets across multiple legacy core networks and not only couldn't add resources — it needed to reduce resources in coming years. The provider collaborated with Spirent to implement an active assurance solution that proactively performs over 250k health checks each day, automating critical aspects of the troubleshooting process and delivering the efficiencies needed to support the coming 5G core.

Out of this world and into outer space: A sudden uptick in testing for Low Earth Orbit (LEO) satellites sees the Americas leading the charge on direct-to-handset connectivity.

Top Focus Areas: Americas

31%	**Core** (Standalone)
31%	**Service Assurance**
17%	**Field Testing & Benchmarking**

Top Focus Areas:
EMEA

64% **Core** (Standalone)

11% **RAN & Device Testing**

8% **Transport Testing**

EMEA

EMEA continued reacceleration of 5G following pandemic-induced delays and a ban on high-risk vendors.

What's driving demand: A focus on the 5G core, including multi-vendor interoperability, cloud validation, and lifecycle automation (from lab to live) as mobile service providers explore paths to agility and efficiency.

- Service assurance saw a lift as national competition stiffened.
- Automated private network offerings also saw an increase with continuous testing embedded into enterprise solutions.
- 5G radio network testing extended towards research for both military and future railway mobile communication systems (FRMCS).

Customer Spotlight: A leading UK service provider used Spirent Test as a Service to overcome a skills shortage, streamline continuous integration and deployment (CI/CD) workflows with active tests, and meet aggressive multi-vendor, Standalone cloud-native validation timelines.

Securing the supply chain: Government and ecosystem partners are testing new ways to boost 5G security, resilience, and performance, while stimulating vendor diversity and closing digital skills gaps.

APAC

The 5G core was a shining star across APAC, including Japan, Singapore, Indonesia, Australia, and India.

What's driving demand: The 5G Standalone core is powering industry use cases like manufacturing, energy, and agritech, and at least one country's efforts to seize market leadership and avoid costly, multi-phase deployments. Testing across 5G transport fronthaul to lay a foundation for high-capacity edge networks, and 5G core and cloud validation to shore up continuous test (CT) automation and private network bids also stood out, with 5G RAN M-MIMO and 3D beamforming testing expanding.

Customer Spotlight: An Indian service provider's live network validation lab used Spirent's Test as a Service managed solution to quickly deploy 5G Standalone core and cloud, integrating automated testing with CI/CD processes and avoiding a costly and time-consuming investment in lab infrastructure, workflows and skill sets.

Government gets into the 5G2B game: Lacking early revenue in the consumer market, governments and research institutes are developing innovation networks and app developer ecosystems in search of promising business cases.

Top Focus Areas:
APAC

35% **Transport Testing**

30% **Core** (Standalone)

24% **RAN & Device Testing**

Unlocking Turnkey Validation: Introducing Innovation Labs And Customer Experience Centers

Complexity is coming at our customers from every direction. Performance, security, and automation are the new currency of 5G competency. A confluence of factors has resulted in a skill set shortage on these fronts. With critical skills in short supply, deploying a new 5G validation lab — including developing and automating testing workflows, finding and training staff, and investing in lab infrastructure — can be a time-consuming and expensive endeavor.

This has given rise to customer, industry, and vendor initiatives that span managed services and hosted labs. Spirent is meeting customers on each of these fronts, including via the 5G Open Innovation Lab and our own customer experience centers.

Spirent Customer Experience Centers

If it's next-generation tech, we've got it and can help test and validate it. We are deploying Spirent-hosted 5G validation labs around the world, including San Diego in the United States, Dorset in the United Kingdom, and Beijing in China.

At these centers, customers gain access to hosted infrastructure as a managed service with predefined use cases for 4G/5G core and Open RAN validation, SD-WAN/SASE validation and MEF certification, Wi-Fi 6/6E performance, high-speed Ethernet performance with impairment, and cloud and virtualized infrastructure cybersecurity. These labs are available remotely 24/7 with full automation, shaving months and years off the time it may take to build similar facilities and train staff to operate them.

5G Open Innovation Lab

This collaborative industry effort is developing an ecosystem comprising various industries and equipment manufacturers in pursuit of 5G use cases. Proofs of concept field labs are establishing "future ready" environments for product testing, deployment, and growth across healthcare, manufacturing, transport, agriculture, and more. Spirent has joined with an expanding set of global tech leaders as a corporate partner, with early activity focusing on establishing a field lab for smart farming.

Revving Up Revenue Possibilities

The most promising 5G network applications, services, and use cases primed for profit:

FIXED WIRELESS ACCESS

FWA range and competitive speeds doubled in just 12 months with throughputs reaching upwards of 900Mbps on mmWave and ranges beyond 2km.

MOBILE GAMING

Mobile gaming success zeroed in on KPIs that relate to user perception and acceptable tolerances.

EDGE COMPUTING

Multi-access edge computing (MEC) performance with cloud providers demonstrated <20ms latencies but guaranteeing consistency is a work in progress.

VoNR ON STANDALONE

VoNR on 5G Standalone is getting ready for prime time with MOS scores beating VoLTE, demonstrating the potential for immersive collaboration services.

PRIVATE NETWORKS

Stakeholders recognize the need for a simple set of understandable SLAs, performance and site acceptance metrics that will drive enterprise IT/OT/security team investments.

5G Trends We're Watching Most Closely

Stephen Douglas, Spirent's head of 5G strategy, puts a spotlight on where 5G is showing the most progress and promise–and where there's still work to be done.

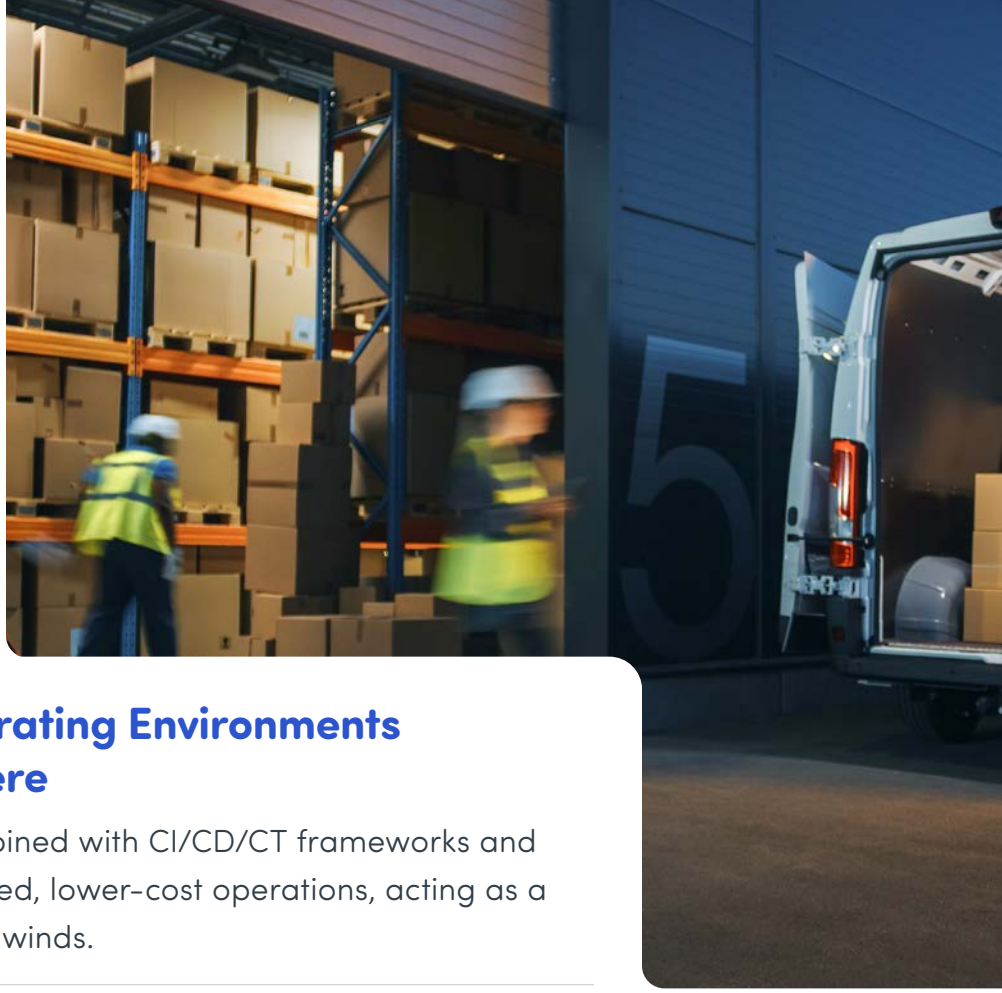
5G is finding its groove and not a moment too soon.

There is pressure to produce revenue growth. An eye on restraining and even lowering costs where possible. Impatience for delivery on promises. Most importantly, there is substantial progress on a number of fronts.

While en masse 5G Standalone deployments are still one to two years out, we now have evidence these deployments can deliver on proven use cases, generate increased profits and take network capabilities to new heights.

Let's take a look at where 5G stands and what to expect as another critical year kicks off.

1



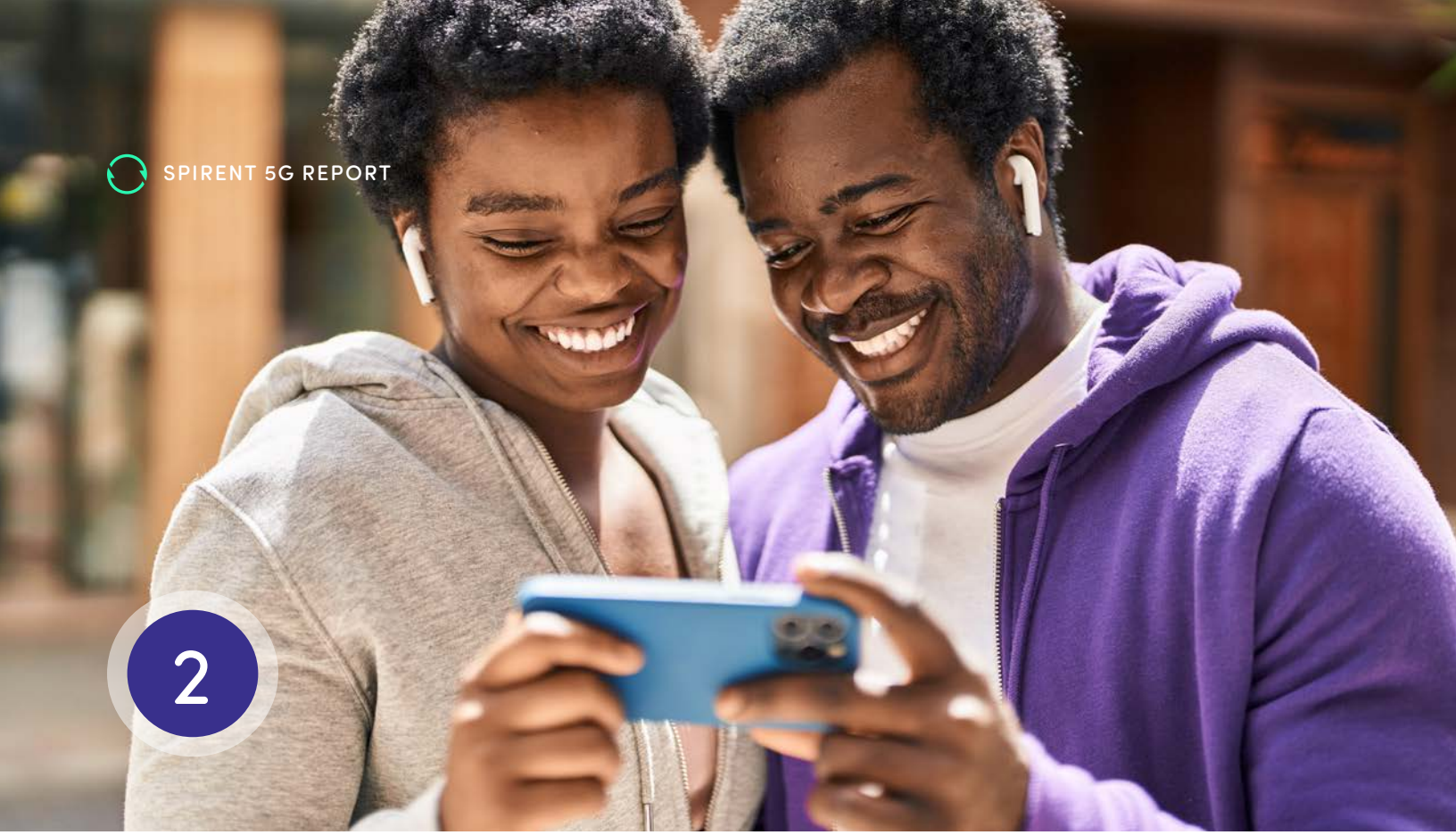
Simpler, Lower-Cost Operating Environments For Automation Everywhere

Network lifecycle automation combined with CI/CD/CT frameworks and tooling provide a path to streamlined, lower-cost operations, acting as a hedge against 5G complexity headwinds.

Breaking Down Bottlenecks

Expect to see more common labs and federated testing environments that bridge silos, aid agility, and reduce costs.

- Service providers and hyperscalers are chasing DevOps lab-to-live capabilities for process automation, from design through staging, and deployment through operation.
- An initial focus on continuous testing is evolving towards continuous monitoring and continuous security.
- Automation efforts are beginning in the 5G core but will eventually evolve to Open RAN and private 5G capabilities.
- There is a growing realization that monitoring and security can't just be point or point-in-time solutions.
- A DevOps lab-to-live approach is on display with leaders like DISH Network, which aims to ease supplier testing burdens.
- 2023 will see an evolution toward continuous testing and monitoring lifecycles that serve as a foundation for autonomous networks.



2

Video-Rich Experiences To Invigorate Revenues

Revenue growth has been hard to come by as premium devices weigh on plan profits and consumers see little service differentiation to excite them.

A Silver Lining

Fixed wireless access (FWA) continues to gain momentum globally as the business case improves. Revenues won't be earth-shattering, but it's a start.

Then there's ***edge computing.***

- Use cases are still in their infancy but our testing suggests performance wrinkles are being ironed out.
- Now the trick is to make sure SLAs can be guaranteed and managed.

What We're Watching

Video, video, video. We expect a heightened focus on uplink and HD video. Think live broadcast, remote monitoring, security, and surveillance, and a whole lot of gaming. There is also progress being made toward voice over new radio (VoNR), which can unlock premium collaboration services — our early testing is already validating superior voice quality.

But there's still that pesky legacy network thwarting full-on service transformation.

- Until 5G Standalone and VoNR are implemented, voice will be delivered over 5G Non-Standalone networks using VoLTE via EPS fallback.
- So subscribers get pushed back to 4G networks, impacting users with 5G data sessions running in the background, which means a poorer experience for data and video-centric apps.

Once this hurdle is overcome, major incremental revenue improvements are within reach. Early metaverse applications as well as services that combine voice with next-gen experiences like VR, enhanced collaboration, and gaming will lead the way.

5G Core On The Way, But Commercial Deployments Will Be Gradual

Sustained mobile service provider testing and continued RFPs for 5G Standalone vendor selection points to a strong future with 18-24 month timelines for a large percentage of rollouts.

Headwinds Remain Strong

Cloud-native complexity, multi-vendor network function integration, assuring high-performance services over disaggregated stacks, security risks, and spectrum portfolio migrations demand multi-phase testing. This work comprises a significant portion of our 5G business.

It's a control thing.

- Many service providers prefer a multi-vendor 5G core but most initial Standalone deployments favor single-vendor for risk mitigation and simplicity. The early stages are all about learning.
- A large percentage of service providers also prefer their own telco cloud environments. It's about performance and control, and besides, public cloud isn't necessarily cheap.

100+ 5G Core Deployments Expected By 2024

Until then, progress will happen steadily behind the scenes.

- Roaming across 5G networks and multiple countries is a growing testing focus.
- RFPs around network data and analytics functions (NWDAF) are increasing.
- Network autonomy and early AIOps implementations are becoming a priority, with a focus toward access traffic steering, switching, and splitting function (ATSSS) for 5G/Wi-Fi convergence being driven by enterprise demand.

Cloud partnerships will grow. Initial tie-ups built around edge and OSS/BSS-oriented applications will eventually expand to include some core functions, such as for private network offerings and data plane functions.

4

Two Clouds, Two Different Purposes

With some exceptions, service provider cloud strategies are gravitating towards telco cloud for network functions and public cloud for IT workloads and edge computing.

Where Is The Edge?

It depends on whether it can add value to regional cloud deployments.

- ***Gaming*** demand will necessitate zone locations across geographies. You'll also find them in places like ***sporting events, stadiums, and popular public locations***, driving gradual edge adoption.
- ***But who will pay?*** For specific use cases like autonomous vehicles and roadside infrastructure requiring map applications, telemetry, road condition alerts, and video offload, are service provider or government departments on the hook for funding? A similar calculus will play out in other industries. Maybe neutral hosts will become a new norm.

Public Cloud Use Case Clarity Is Coming Into Focus

- Expect to see edge locations prioritized for ***private network deployments*** in a bid to serve data sovereignty and privacy needs.
- 2022 was about building private network ecosystems; 2023 will be about actually building private networks.

A New Balancing Act Awaits

Mobile network operators already have cloud partnerships. Their enterprise customers do too.

- The call for multi-cloud support is growing louder: mobile network operators need to be all clouds to all customers.
- They'll need to support cloud-native functions and applications that can be hosted and moved across different environments. There is also a desire to avoid lock-in and remain free from any single cloud provider's grasp.

5

Private Networks Prep For A Productive Year

Early progress rolling out private mobile networks is promising, but now the hard work begins to seal the deal on adoption.

Slow Going But A Market Is Materializing

There were over 520 private mobile networks commercially deployed between 2021 and 2022, incorporating 5G, CBRS and LTE.

- Large enterprises favor dedicated private 5G networks for control, privacy, and performance.
- SMBs bring less complex use cases and are more open to public mobile networks for cost efficiency.

Where is Adoption Happening?

Ports for shipping and logistics, manufacturing, and major transport hubs. Common use cases are emerging:

- Better visualization for enterprise assets where large sensor networks feed analytics
- High-definition video monitoring and surveillance where corresponding actions are automated

A good start but challenges hold back maturity, meaning 2023's focus will be breaking down barriers to:

- Simplify management with as-a-service Opex models that remove design, build, operate, and management headaches, especially in hybrid connectivity environments
- Embrace network automation and 5G/Wi-Fi convergence to cut costs and alleviate initial 5G price burdens.
- Solve security hangups to build enterprise confidence, especially with SMBs evaluating public network slices
- Justify the business case based on solutions rather than technology to power profitable use cases

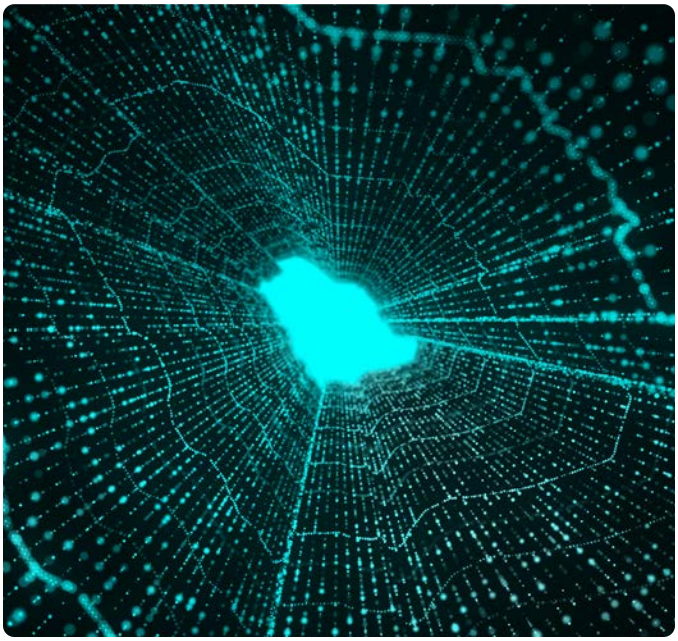
Also Look Out For

Developer ecosystems and industry-specific app stores that give enterprises a clear, user-friendly path to deployment.

6

Automation An Ace Up The Sleeve For Sustainability

Telecom energy efficiency initiatives are finding firm footing with concrete strategies for containing carbon footprints of next-gen networks.



The Backdrop

5G brings larger network densification, bigger antenna arrays, and outsized energy demands. Some equipment runs around the clock but is only needed 30% of the time.

Telecom thinks it has the cure for all the excess carbon it produces.

- New radio sleep mode capabilities, liquid cooling advancements versus air conditioning, and increased reliance on renewables like solar could be transformational.
- Automation in R&D labs and data centers can cut energy utilization 40% by powering down unused equipment, balancing resource utilization, and consolidating facilities.

This isn't pie in the sky stuff. In fact, it's viewed as low-hanging fruit.

Going Further

2023 aims to up the sustainability ante with more accurate approaches to metering, measuring, and reporting energy utilization.

- There are still challenges to manage on this front, but enterprise customers are demanding progress, so telecom will have to deliver.
- Expect service providers to demand the same from their supply chains—this is an ecosystem-wide responsibility.

Homework For Open RAN Before It Reaches Full Potential

Spirent estimates a 10x complexity increase for Open RAN testing and system integration, threatening market adoption.

What's So Hard?

Technology maturity, performance and feature gaps, plug and play interoperability headaches, chipset cost challenges, and energy efficiency headwinds, threaten to dim an otherwise bright future.

- This is the moment collaborative test environments powered by automation have prepared for and they stand ready (and proven) to take on this formidable challenge.
- But there will be no overnight success stories—there is hard work to be done.

Meanwhile, the clock is ticking…

- Service providers are putting stakes in the sand with ambitious timelines for progress.
- DISH Network is targeting 70% Open RAN-powered coverage in the U.S. by this year. Vodafone is pursuing 30% for its European networks by 2030. Telefónica says 50% of new sites will be Open RAN by 2025.

Others will be more cautious, waiting to see how peers perform. Expect these players to prioritize ***virtual RAN deployments*** with an eye on cost savings.

Open RAN will also find a home in more ***private networks*** during the next 18-24 months, especially for small cell indoor/outdoor applications.

8

Non-Terrestrial Network's Star Shines Brighter

NTNs and especially Low Earth Orbit (LEO) satellites took several giant leaps for mankind during 2022.

Connectivity For Good

As satellite prices fall so do barriers to entry for reaching underserved communities, supporting emergency services, and enhancing network resilience.

- The race to space is on, as a once small ecosystem begins to look more like an expansive constellation.
- Service providers are assessing business cases, partnerships are being established, and big investments are being made—the most recognized brands in cloud and telecom are on board.

Dialing The Future

Over the next 18-24 months, we expect momentum toward LEOs for direct-to-phone services and positioning, navigation, and timing (PNT) resilience through relay and direct services.

- First, challenges need to be solved around spectrum alignment, 3GPP Release 17 support, and handset compatibility.
- Technology performance caused by large signaling delays, interference, doppler shifts, and handovers also need to be addressed.

Regardless, we anticipate NTNs have only one direction to go and that's up.

9

Market Demanding Wi-Fi And 5G Convergence

Enterprise appetites for Wi-Fi aren't going anywhere, so if 5G wants to be part of the picture, seamless convergence is an imperative.

2022 Saw Big Wi-Fi 6 Uptake

Driven by superior performance capabilities across bandwidth, speed, channel subdivision, control, and quality. It has been a virtual no-brainer for enterprises given backwards compatibility and a familiar workflow.

- The same can't be said for Wi-Fi 6E which is challenged by lack of premium device support and worldwide spectrum allocations.

The bottom line is enterprises want to see convergence and so it will be.

- Telecom must demonstrate 5G and Wi-Fi can deliver enhanced flexibility, seamless connectivity, and differentiated, competitive services.

10

5G Investments And Next Steps Vary By Region

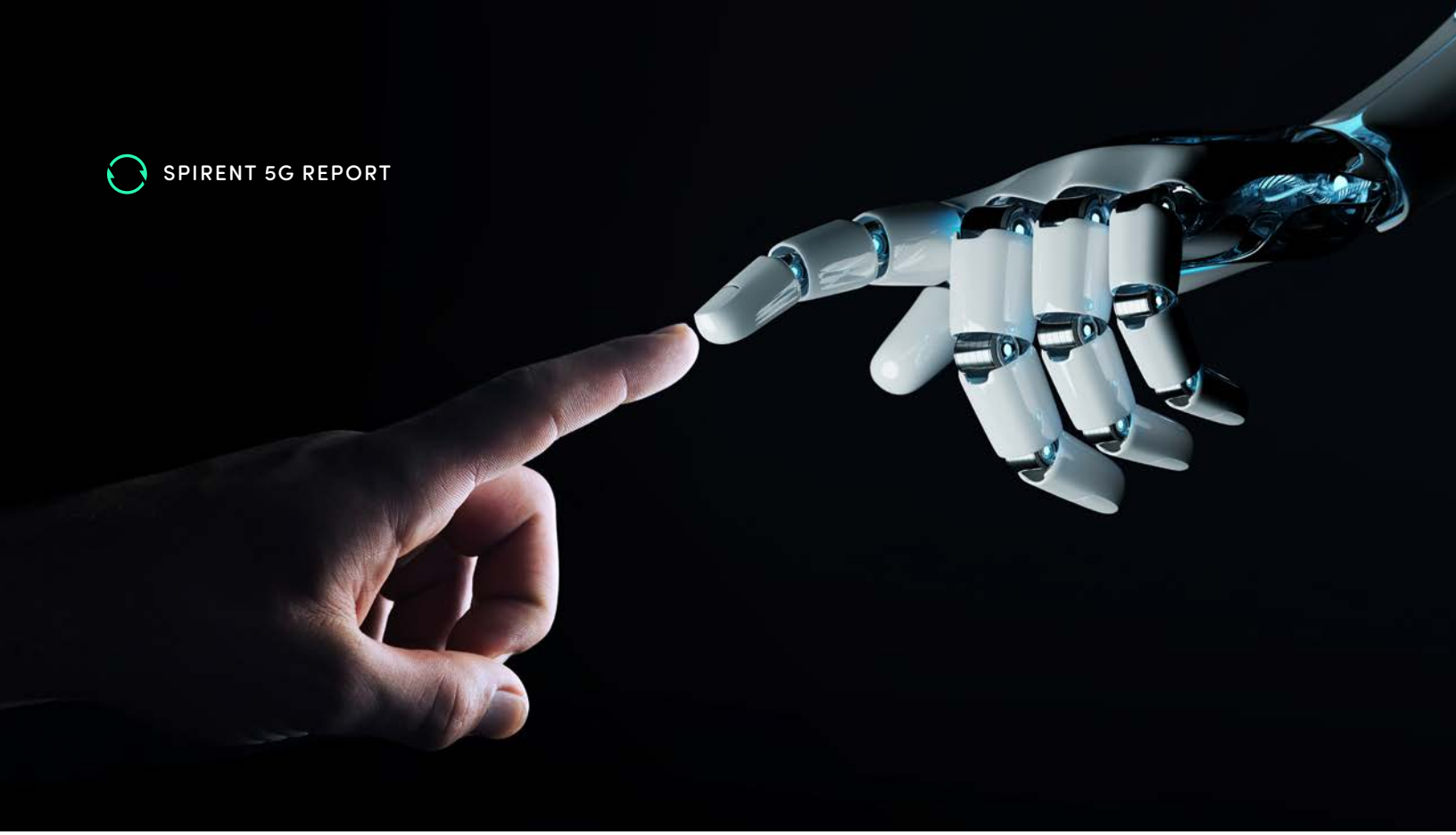
Paths are diverging as service providers globally move to the next phase of buildouts or face the realities of slow adoption.

5G Looks Different Depending On Where You Stand

- North America is focused on midband rollouts for national coverage in 2022.
- China buildouts plateaued following consecutive years of intense focus.
- 5G rollouts in Europe reaccelerated but lagged other regions with slow adoption driving investment hesitancy.

So Where Does 5G Go From Here?

- In 2023, we expect North American 5G spend to shift to niche areas of outdoor and indoor densification, 5G core, edge, and FWA.
- China will home in on 5G business services in industries like manufacturing, energy, and transportation.
- Expect India 5G Standalone rollouts to surge as Non-Standalone is bypassed entirely with networks deployed in more than 200 cities.



Spirent's View Of The Market

2,600

5G engagements have afforded us a unique, broad-based view of the industry's global 5G pursuit

We see a number of prevailing themes

- There is no single path to revenue that most service providers will follow. Instead, providers will pursue a variety of new 5G service offers aimed at incremental growth combined with targeted efficiency programs.
- Collaborative ecosystems are growing to accelerate innovation, de-risk investments, and lower the costs of validating new service concepts.
- The introduction of the 5G core and the move to Standalone is challenging but critical to realize new revenues and efficiencies.
- 5G and macroeconomics are triggering digital transformation programs as service providers embrace network lifecycle automation (DevOps, AIOps) with test and assurance methodologies at the heart.
- Energy efficiency is becoming a greater priority and market differentiator.

The industry is racing to generate 5G revenues to justify massive investment and bring new services to market. Operators are trailblazing, seeking the best paths to revenue based on business goals and regional realities.

SPIRENT'S VIEW OF THE MARKET

5G Revenue Opportunities On The Horizon

As one of the first successful 5G revenue opportunities, ***Fixed Wireless Access (FWA)*** rollouts continued at a strong pace in 2022 as they provide more flexible and farther reaching broadband connectivity for remote workers.

The growing momentum and successful deployments of ***5G Standalone and 5G core*** bode well for unlocking 5G revenues. They are critical enablers for a new class of high-performing services:

- Audio and video services on the same network with Voice over New Radio (VoNR)
- Automatic handovers between 5G and Wi-Fi networks
- Low latency needed for gaming by disaggregation to the edge
- Private networks

Private wireless networks are getting increased attention for the potential to use the 5G core to open a variety of vertical markets to service providers. We are seeing particular interest in use cases related to visualization and automation, such as:

- Creating sensor networks to visualize assets on the factory floor or for logistics
- Using automation to remotely control assets, monitor with high-definition video and use inspection robots

SPIRENT'S VIEW OF THE MARKET

Business Case Reflections

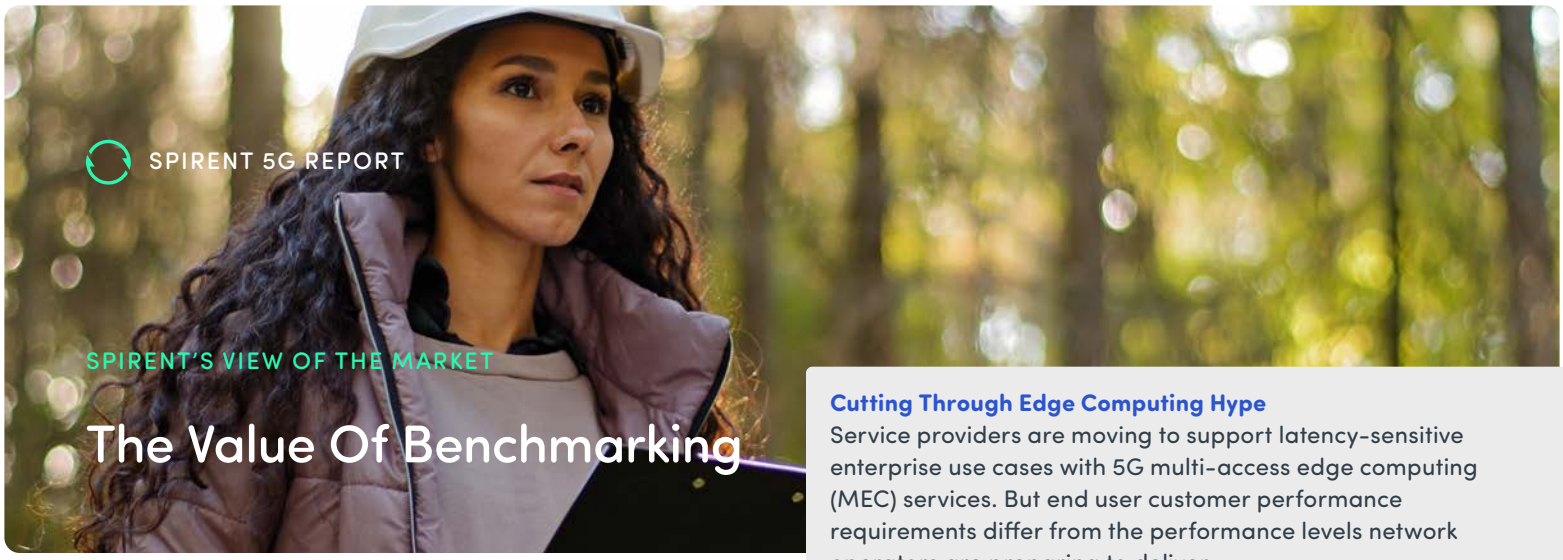
The industry's progress has provided better insights into 5G business cases.

Private wireless networks. Enterprises want solutions that are simple and easy to deploy. They strongly prefer turnkey managed services, working with one company that designs, builds, operates, and manages the solution for them. Recurring operational expenses are preferred over capital outlays. These factors change how providers will monetize services. For now, single use cases are not adequate for a business case. Instead, multiple use cases must be stacked. Enterprises are not convinced 5G will provide all the answers to the performance, flexibility, and security they need. Creative service providers are using test results to demonstrate the cost benefit of solutions and then using those same tests to monitor actual SLAs.

Partner collaborations. Service providers are recognizing they don't have time to reinvent the wheel. Business cases require strong partnerships to fill missing skill gaps and speed time to market. They are partnering with hyperscalers for cloud and using test as a service offerings instead of building proprietary test labs and hiring new talent.

Customer Spotlight: Telefónica is developing a new generation of private 5G products providing dedicated 5G connectivity, edge compute, and vertical-specific value-added services. Telefónica and Spirent have implemented a highly-scalable, cloud-native automated process to manage the systematic testing, update, and deployment of the private network products. Spirent's continuous test platform streamlines these workflows, allowing Telefónica to cost-effectively manage the lifecycle of their private 5G solutions.

Open RAN. While Open RAN is generating cautious optimism around vendor diversification, flexibility, and low costs, clarity is lacking on its revenue potential. Early areas of exploration include services that require small cell densification, such as mobile gaming in urban locations. However, lack of support for massive MIMO, and plug-and-play interoperability challenges may delay network deployments, narrowing Open RAN's market opportunity window in the short term.



SPIRENT'S VIEW OF THE MARKET

The Value Of Benchmarking

Cutting Through Edge Computing Hype
Service providers are moving to support latency-sensitive enterprise use cases with 5G multi-access edge computing (MEC) services. But end user customer performance requirements differ from the performance levels network operators are preparing to deliver.

Traditionally, benchmarking data has been used to compare a company's service or product to its competitors.

Given the many vendor elements involved in delivering services, benchmarking is taking on a more critical role with 5G. It is being used to measure the quality of experience and end-to-end performance actually being delivered by the many vendor functions involved in providing the service.

Benchmarking is also playing an important role in network optimization. It captures data sets required to tune the network, and guarantee performance and customer experience.

Benchmarking will be essential for private networks and nascent edge services. For private networks, bespoke radio environments will need throughput optimization and identification of areas without mobile coverage, as well as signal and noise interference that could impact performance. Edge services will also rely on comprehensive evaluation of edge vs. public cloud latency to drive network optimization efforts and ensure differentiated levels of service.

Service providers are moving to support latency-sensitive enterprise use cases with 5G multi-access edge computing (MEC) services. But end user customer performance requirements differ from the performance levels network operators are preparing to deliver.

To illuminate the divide, Spirent and STL Partners engaged in real-world edge network testing and more than 150 interviews with prospective edge customers.

We found that:

- Edge application demand and supply sides are disconnected in terms of what latency will be required, when it will be required, and for which use cases.
- Enterprise users overwhelmingly prioritize latency consistency to support edge applications they plan to deploy.
- Measured latency of real-world MEC services fluctuated significantly, by time and across regions, and lacked symmetry between the uplink and downlink.
- Mean observed MEC latency supports several 3GPP R16 edge use cases, but performance optimization will be required for use cases requiring consistent latency.
- Support for a broader set of 3GPP R16 edge use cases will require additional MEC performance optimization to further lower uplink and downlink latency levels and improve consistency.
- Numerous factors beyond the choice of network architecture can impact latency, highlighting the need for rigorous acceptance testing and benchmarking during and after deployment.
- Continuous latency benchmarking can help prioritize and optimize network efficiency by identifying and isolating what is impacting latency inside and outside the network.

The detailed results are in our Cutting Through the Edge Computing Hype report.

SPIRENT'S VIEW OF THE MARKET

Ecosystems Are Being Created Out Of Necessity

In 2022 service providers turned the corner on willingness to collaborate.

Driven by the rapid pace of technology innovation, the need to fill skill gaps, and the disaggregated 5G network, a hesitancy to embrace "outsiders" has turned into a true desire to team for success—increasingly, this is not a choice but a reality.

The intersecting trends of an expanding set of vendors and the need for neutral, collaboration environments are stimulating the creation of ecosystems today. A growing realization that validation costs will surge without tighter ecosystem coordination is adding even more urgency to this push.

SPIRENT'S VIEW OF THE MARKET

Diverse Vendors Are Multiplying And Engaged

The disaggregated 5G core and cloudification of the network have opened the door to the first real opportunity for vendor diversification in the heart of the network. Now, vendors can choose to deploy only a piece of the core network. This has potential cost benefits for service providers, which have more choices and therefore more financial leverage as hardware becomes commoditized.

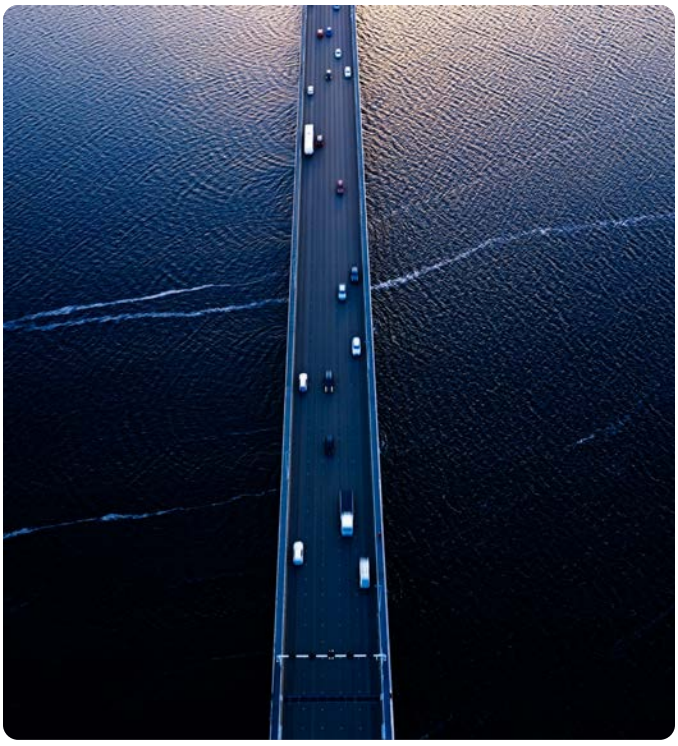
Meanwhile, hyperscalers with expertise in IT, cloud, virtualization, and scale are heavily engaged and bring capabilities that have not yet been in the service provider mainstream.

The enthusiasm around Open RAN is bringing the multi-vendor, plug-and-play model to the radio network as well.

In space, the non-terrestrial networks are getting a boost from 5G NTN connectivity standards and a host of LEO satellite providers are in play.

This growing corral of vendors is great news for the industry, and service providers are working with multiple providers to move quickly and take advantage of existing capabilities. They recognize that they can't be experts in everything, especially vertical markets such as automotive or private networks. Where they lack expertise, or for functions outside primary domains, they are outsourcing to managed services companies.

This diverse set of players does bring new challenges: security, standards interpretation, and feature parity among them.



SPIRENT'S VIEW OF THE MARKET

Collaborative, Neutral Playing Fields Are Needed, For All To Use

With a large influx of vendors, many of them new, service providers are asking how to ensure the combination will perform well (and fairly) together.

The industry is recognizing the need for playing fields where all can play. Vendors have proprietary labs, but what's being sought are common R&D and testing environments that enable multi-vendor collaboration and integration. Such collaborative labs need the flexibility to test interoperability, functionality, and scalability. And they must be able to emulate the real world.

Speed is essential, so there is movement to consolidate labs within service providers and federate between service providers and vendors. To minimize retesting, the same test configurations would be used as a service or solution moves through the lab-to-live lifecycle. Where not feasible to consolidate, labs are being federated so that, at least, the testing is aligned with the common playing field.

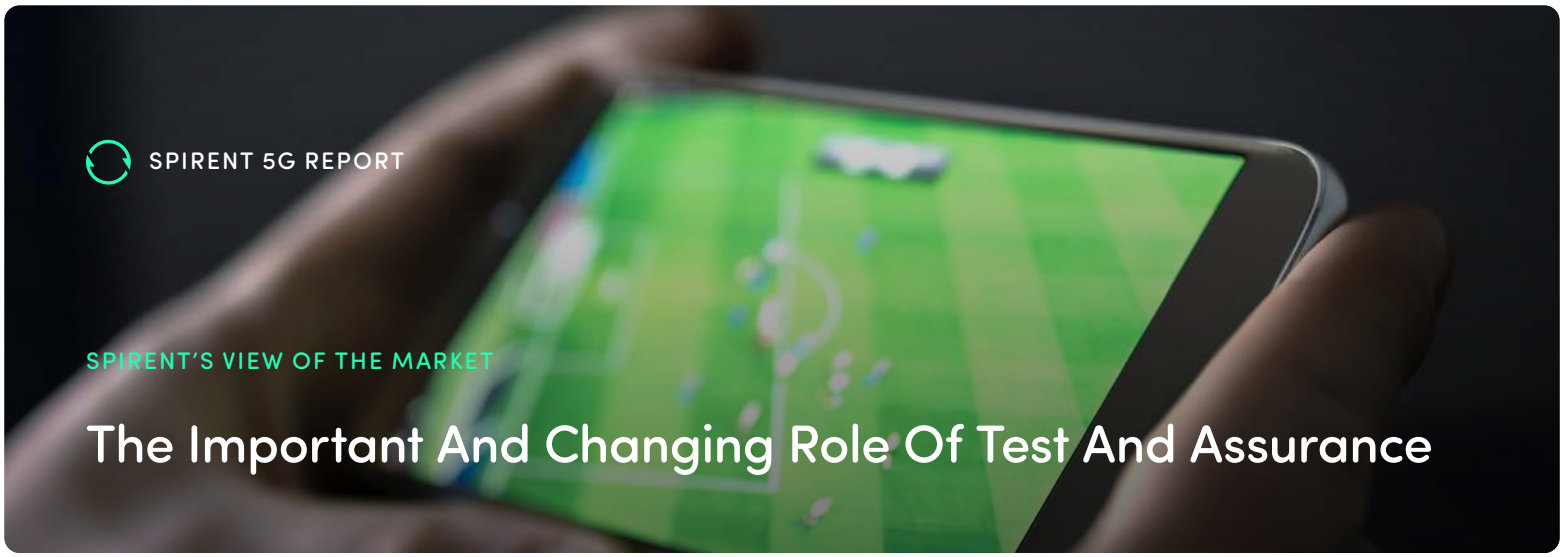
There is also a question of governance by a neutral party, with neutral test scripts that don't favor one vendor over another. Service providers are looking to Spirent to provide that common environment because of its objectivity, skill sets, and test as a service capabilities.

Customer Spotlight

A national telecom lab established by a top European economy has a mandate to improve supply chain diversity, intending to grow the ecosystem by enabling vendors and service providers to test 5G and Open RAN interoperability, performance, and security. In pursuit of that mission, Spirent's 5G core network emulation and validation platform is being implemented into their lab environment.

Customer Spotlight

A large UK service provider planned a major vendor migration that included transitioning to an in-house cloud-native platform for the core network. The provider didn't have all the skills needed to perform pre-production validation of a new telco cloud across multiple vendors. Spirent's Test as a Service was selected to help manage key aspects of the validation workflow and ensure the new network exceeds performance and capacity capabilities of the legacy network.



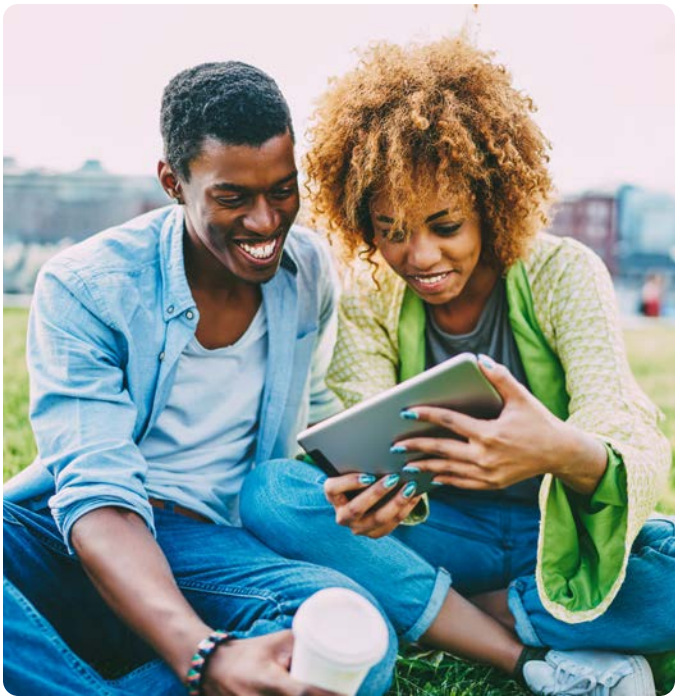
SPIRENT'S VIEW OF THE MARKET

The Important And Changing Role Of Test And Assurance

The many new use cases enabled by 5G require real-time, dynamic networks that deliver high-performing, dynamic, and personalized services with stringent quality expectations. Some services may demand low latency and generate large volumes of video data.

In this environment, service providers need to:

1. Ensure they have the capacities required by new use cases (e.g., uplink and downlink)
2. React proactively to find and isolate faults that can impact monetization
3. Perform rapid optimization to preserve service-level monetization guarantees
4. Make continuous configuration changes to, e.g., modify a network slice or recable a factory
5. Monitor and validate the network continuously to ensure performance, experience, and security quality



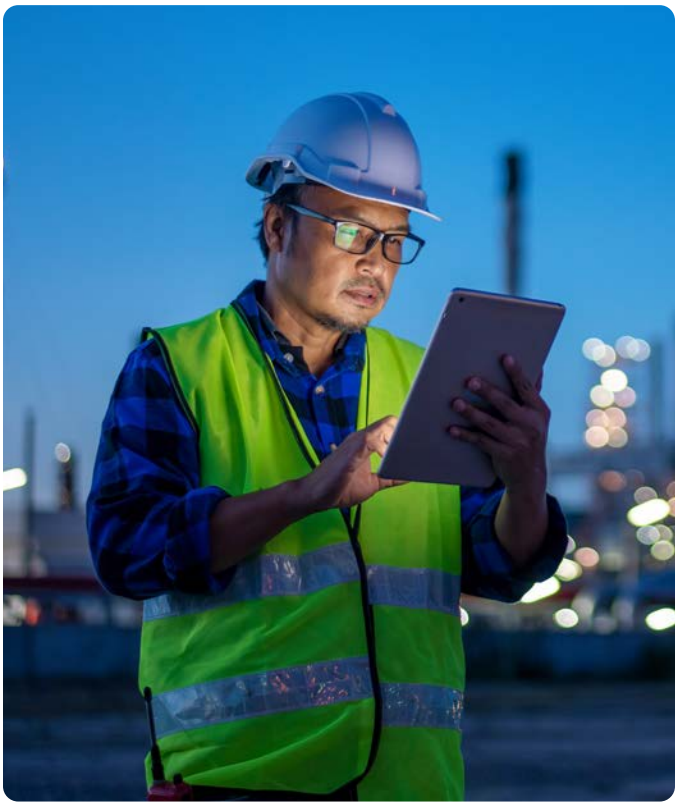
To accomplish this, service providers must be fast and flexible. They are incorporating DevOps CI/CD/CT processes to manage the continuous software updates coming from multiple stacks, vendors, and cloud environments. It is a step toward self-healing, autonomous networks.

SPIRENT 5G REPORT

SPIRENT'S VIEW OF THE MARKET

The Impact On Test And Assurance

Just as the network and services are becoming more agile, test and assurance methodologies must evolve to become more responsive and proactive. The time from development to live deployment needs to be rapid for new equipment and services, as well as for continuous software updates. Manual workflows must be automated wherever possible to lower costs and improve customer experiences.

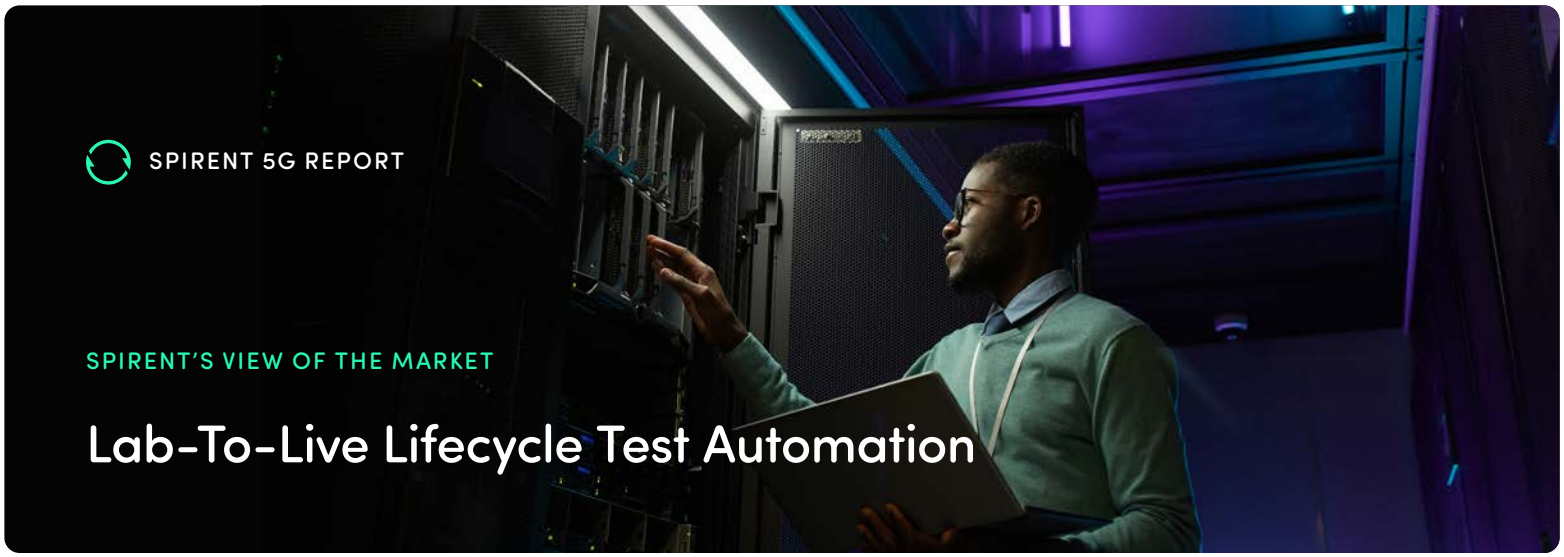


Traditional manual, passive approaches to test and assurance don't provide the agility or scalability required to validate and assure real-time, dynamic services and networks. They are no longer economical.

In the initial testing of Standalone 5G core and VoNR, service providers are finding that the increased complexity of 5G requires 10 times more testing than 4G.

Test needs to undergo a transformation for 5G. For example:

- Rapid and proactive root cause analysis and problem resolution are critical to service monetization.
- The perceived user experience, end-to-end, is essential to measure and then compare to current values. Perceivable processes like call setup times, but also MOS scores for voice services like VoNR and gaming, need to be measured.
- Relevant network KPIs like deterministic latency and video quality for guaranteed SLAs need to be developed and tested. Research is needed to determine what is acceptable for people and for machines, what the tolerances are, and when to trigger alarms.



SPIRENT'S VIEW OF THE MARKET

Lab-To-Live Lifecycle Test Automation

The paradigm shift that service providers are pursuing to unlock revenue potential with test and assurance incorporates automation across the lab-to-live test lifecycle, from development, to deployment, to operations. The entire process needs to be simple, seamless, and automated to create the operational agility and cost-efficiency live environments demand.

Automation makes it possible to:

- ***Accelerate development*** by streamlining testing of multi-vendor performance, interoperability, scalability, and resilience under real-world conditions
- ***Simplify and lower the cost of rollouts*** by easily validating multi-vendor releases when they are about to go commercially live, and smoothly integrating those tests into vendor CI/CD processes
- ***Make operations agile*** with automatic, continuous live environment monitoring to proactively assess performance, rapidly isolate issues, and revalidate efficacy

Service providers are pursuing end-to-end automated testing across the full lab-to-live process to dramatically reduce the time it takes to perform multiple silo processes, reduce overhead from replicated tests, help providers quickly test vendor changes before they go live, and ensure dynamic networks continue to perform as expected.

Customer Spotlight: A major U.S. service provider is using Spirent's Test as a Service lab validation and benchmarking services for field testing, as well as active assurance for continuous monitoring of the live 5G Standalone core network. Spirent provides full lab-to-live testing, with automation and consistency across the lifecycle that enables them to migrate to a more agile and efficient CI/CD/CT model.

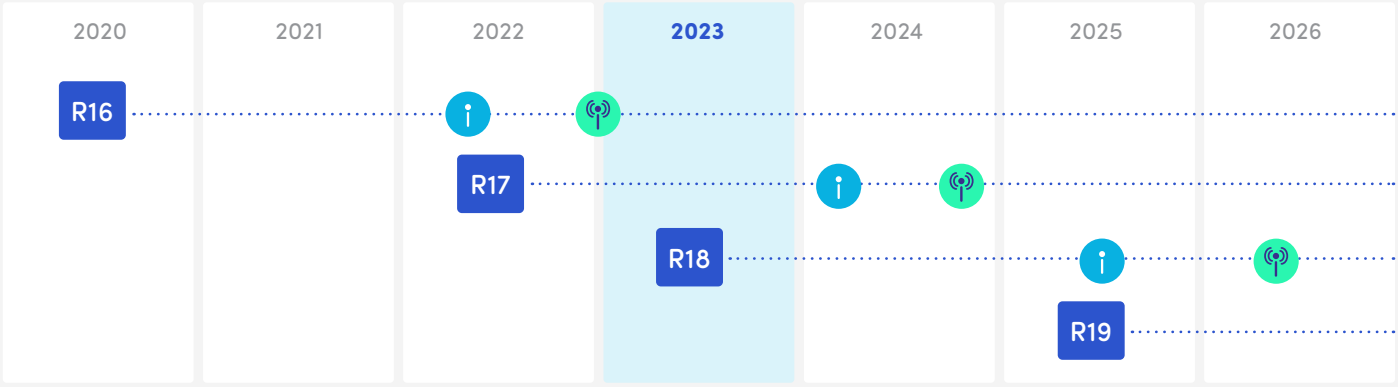
Fundamental to automation and efficiency are:

- A test automation pipeline with shared test software, libraries, methodologies, and test agents that are used seamlessly across each lifecycle stage
- Lab automation, consolidation, and federation that use the same test resources, thereby eliminating repetitive tests
- Continuous active monitoring in the live network to safely validate updates, measure performance, isolate faults, and revalidate efficacy after network changes

Customer Spotlight: An existing suite of lab and field test tools was causing deployment delays for a Tier 1 U.S. service provider, making it difficult to recreate network problems and resolve performance discrepancies across functional teams. Today, the provider is breaking down silos by implementing Spirent's automated test and assurance solution across lab and live network domains to validate new deployments, perform continuous active monitoring, and accelerate troubleshooting. Benefits include 60% faster releases with significantly lower validation and troubleshooting costs.

Roadmap To 5G Revenue

Each 3GPP release delivers new features that enable or enhance support for new revenue-generating applications and services. This roadmap highlights the key contributions of current and planned 3GPP releases for a set of promising new 5G revenue streams. After a release is finalized, equipment typically becomes available within 18-24 months. Initial network deployments begin 6-12 months after equipment availability and may continue for several years.



	R16	R17	R18	R19
XR (AR/VR, Gaming)	• NR URLLC	• NR Extended Reality (XR) • NR QoE	• XR Conversational Services • XR + Media Services • KQIs For Service Experience	• Localized Mobile Metaverse Services
Enterprise + Private Networks	• 5G Core Support for NPNs • NR-Based Access to Unlicensed Spectrum • 5G Wi-Fi Convergence (ATSSS)	• Non-Public Networks Enhancements • RAN Slicing • ATSSS Enhancements • Edge Computing in 5GC	• Enhanced Support For Non-Public Networks Phase 2	• Integrated Sensing + Communication
Industrial Automation	• NR Industrial IoT	• Industrial IoT/URLLC Enhancements • NR Over 52.6 For IoT		• Network of Service Robots with Ambient Intelligence
Voice Over 5G	• VoNR (SRVCC)		• Immersive Voice + Audio (EVS Codec Extension)	
Location Based Services	• NR Positioning Support (3-1 Meters)	• NR Positioning Enhancements (<1 Meters)	• Ranging Based Services + Sidelink Positioning	
IoT	• NB-IoT • eMTC	• Low Complexity NR Devices (RedCap)	• RedCap Phase 2 • Personal IoT Networks	• Ambient Power-Enabled IoT
NTN		• NR + IoT Over NTN (Transparent)	• NR + IoT Over NTN Coverage Enhancements (Regenerative)	• Satellite Access (Phase 3)
Automotive	• 5G V2X with NR Sidelink	• NR Sidelink Relay • Enhanced V2X Services	• V2X Enhancements	

Automate Your Journey to 5G Revenue

Spirent helps make sure its customers are not just market-ready but monetization-ready. In every engagement, speed is the currency that rules followed closely by cost-efficiency. Most critically, we exist to help our customers move as fast as they can in pursuit of new revenue.

Winning In The 5G Revenue Race

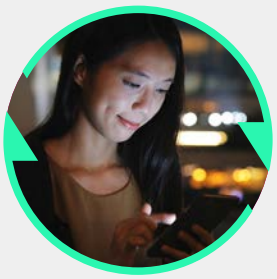
To accelerate the race to new 5G revenue, service providers must discover the new applications and services customers are willing to buy at a premium, and deliver competitive performance levels. Success hinges on a balancing act requiring 5G service providers to cut costs, reduce risk, simplify complexity, accelerate time to market, differentiate offerings, become more agile, and collaborate with an expanding ecosystem.

Our 5G automated test solutions transform the innovation lifecycle so customers can rapidly validate new concepts, and continuously and confidently assure network and service performance, from development, to deployment, to operation. This work collapses silos, better manages complicated processes, and assures performance. The result of our wide-ranging engagements with service providers is faster monetization, lower costs, and more secure, better performing networks.

- Spirent's automated testing, and Lab and Test as a Service managed solutions, let our customers validate new services and deploy them faster. If they don't have the right expertise in house, we can manage everything for them.
- Our automated test frameworks and packages support collaboration among vendors and across organizations with ownership of the development-to-deployment lifecycle.
- Our managed services and security solutions balance the increased risks of a collaborative environment.

Whether a new service, network slice, or anything in between, we assure the delivery will delight subscribers to help customers lock in revenues and avoid SLA penalties. We offer validation testing for labs and pre-production environments, active testing in the operational network, and vendor-neutral performance benchmarking for competitive analysis.

Spirent plays an important role in how customers unlock new revenue streams. Our success depends on customers trusting our expertise and technical capabilities to guide them forward. It requires us to never lose sight of the partner they need us to be as they embark on the most challenging telecom journey ever.



About Spirent

Spirent Communications plc. (LSE: SPT) is the leading global provider of automated test and assurance solutions for networks, cybersecurity, and positioning. The company provides innovative products, services, and managed solutions that address the test, assurance, and automation challenges of a new generation of technologies, including 5G, edge computing, cloud, autonomous vehicles, and beyond. From the lab to the real world, Spirent helps companies deliver on their promise to their customers of a new generation of connected devices and technologies. For more information visit: www.spirent.com.

Americas 1-800-SPIRENT
+1-800-774-7368 | sales@spirent.com

Europe and the Middle East
+44 (0) 1293 767979 | emeainfo@spirent.com

Asia and the Pacific
+86-10-8518-2539 | salesasia@spirent.com

About Spirent Communications
Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics, and security, serving developers, service providers, and enterprise networks.

We help 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.

For more information, visit: www.spirent.com

Rev A | 2/2023