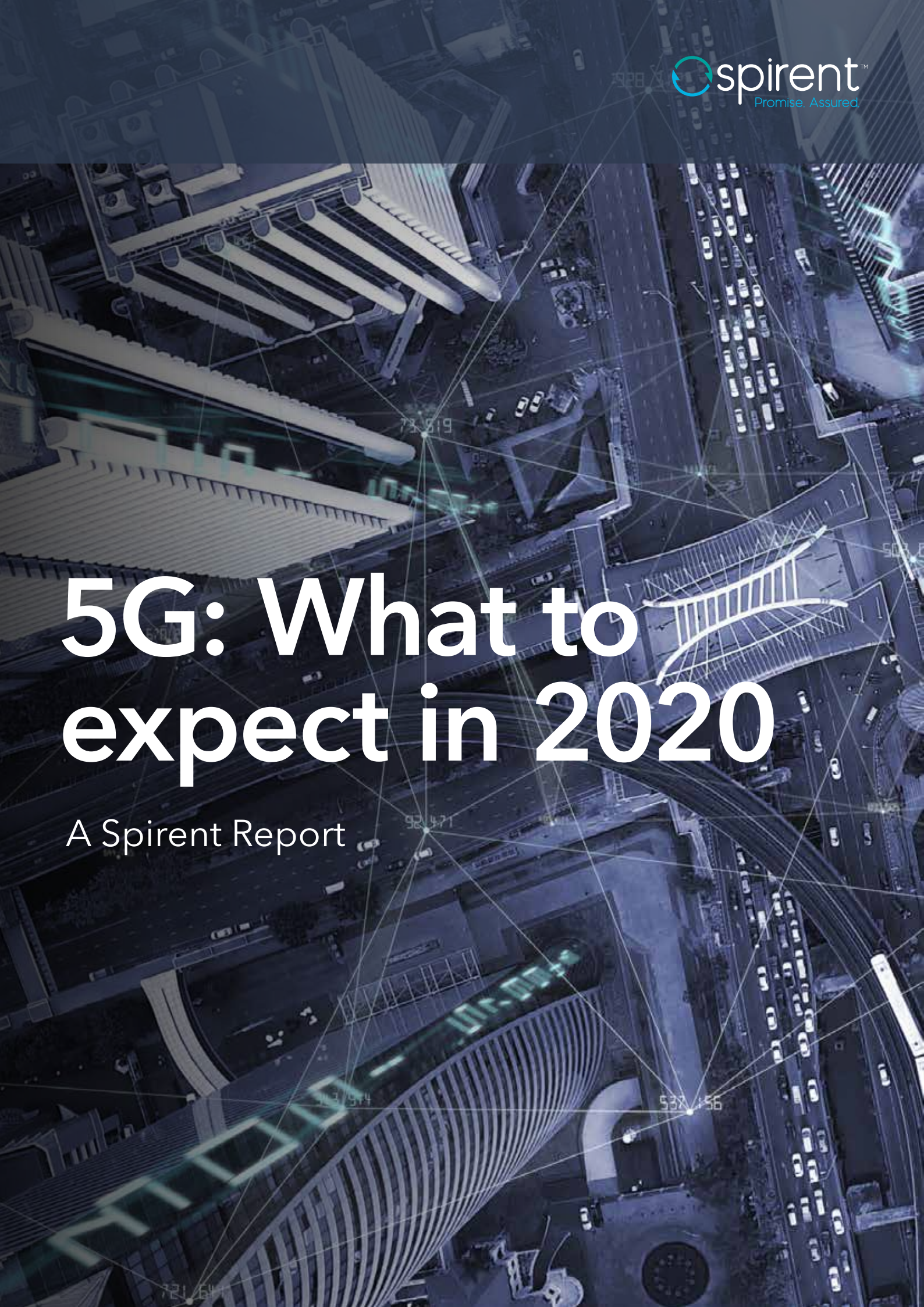
spirent
Promise. Assured.
5G: What to expect in 2020
A Spirent Report

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Seeing 5G With 2020 Vision

Every mobile ecosystem participant has a stake in 5G's success. Rollouts are well underway, but there is still considerable work to be done, opportunity abound and lessons to learn on the journey to success.

Spirent's expansive work with wireless operators, network equipment manufacturers and device makers globally gives the company a unique vantage point from which to triangulate the information, demands and trends that reveal what to expect on the road ahead.

This report summarizes insights from Spirent's global 5G deals, providing a behind-the-scenes view of what's gone right so far, where challenges exist and how past experiences can help predict what comes next.

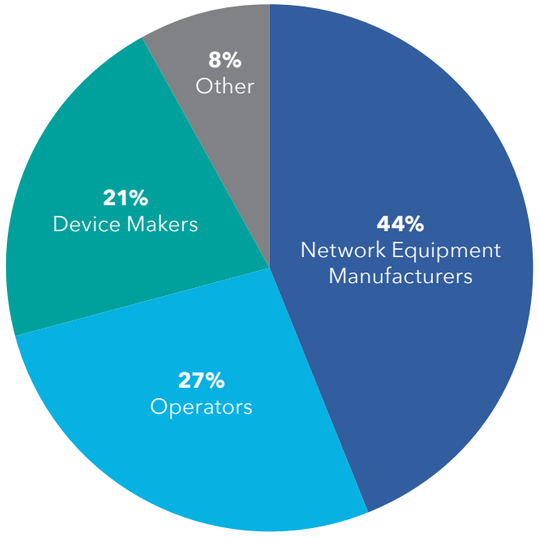
2020 will be 5G's biggest year yet. Read on for our view of what's in store.

Spirent 5G Deals Snapshot

A view of the global work shaping our market outlook

Across hundreds of deals throughout 2019, we gained privileged insight into exactly what is making the 5G market tick–where investment is strongest, where new trends are hottest and how far along our customers are on their 5G journeys. Following is a snapshot of Spirent 5G deals to date, which tell a compelling story about 5G's global advancement and what to expect in the year to come.

It is the infrastructure providers that typically lead early market investment so it is no surprise that work within this segment comprises nearly half of Spirent's overall 5G work. Over the past year, we've seen these providers prepare commercial releases of 3GPP standardized 5G equipment and accelerate early development of future capabilities as they gear up for the next 3GPP Release 16 in mid 2020.



CUSTOMER ENGAGEMENT

The high percentage of operator customer engagements reflects the market acceleration of commercial network launches as the focus turns to testing, and pushing prototype and trial boundaries to determine 5G's limits (or lack thereof). Recently, we've seen an uptick in deals driven by service assurance needs with the realization that perceived performance of fledgling 5G networks will be critical for commercial success.

We saw the device maker testing market accelerate over the past year as manufacturers rushed the launch of first-gen smartphones and user equipment. At the same time, chipset manufacturers continued to innovate towards new system on chip (SoC) designs to solve many of the early teething problems discovered in the field. The complexity that exists in the device market, which is covered in this report, remains heightened by the lack of worldwide conformance on available spectrum and frequency ranges.

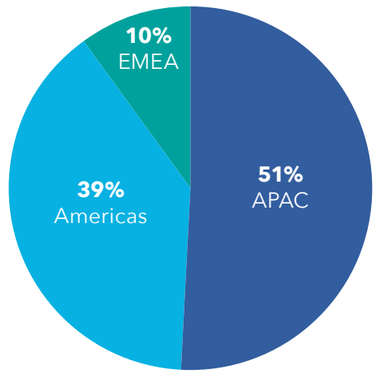
5G work in the APAC market comprised just over half of engagements. North America followed as all tier-one operators launched some flavor of 5G and major networking vendors continued to support the preparation of underpinning transport networks to address new capacity requirements, disaggregation and shifts in distribution. While EMEA adoption was slightly slower in momentum due to spectrum auctions, we did see an interestingly large uptick in research and innovation led by government and academia as a number of institutions began to explore 5G's longer-term value as part of their digital economies.

With transport networks poised to bear the brunt of 5G's data deluge, testing and validation in this area has been imperative as operators prepare for the commercial rollout of new 5G sites and an eventual evolution to distributed data center architectures.

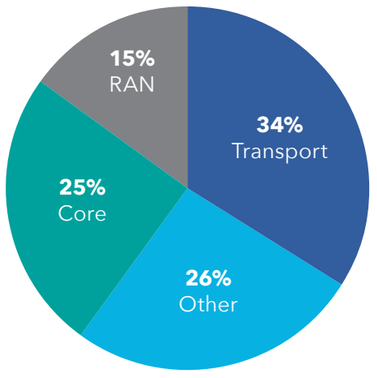
The importance of core testing was evident as major network equipment manufacturers and operators accelerated 5G Standalone (SA) timetables. This strategy shift was driven by a number of factors, including inability to achieve market differentiation with 5G Non-Standalone (NSA), NSA's early performance constraints and a desire to more rapidly engage with new non-consumer customer types.

5G RAN testing continued unabated as the complexity of New Radio and features challenged the industry. This complexity shows no sign of diminishing as new capabilities and technology advancements unfold.

Work toward automation began to see early investment to accelerate time-to-launch test and validation cycles, and address ongoing multi-vendor software delivery challenges requiring interoperability across development and operation domains. The move towards fully-automated DevOp pipelines will enable a new era of agile delivery of 5G services.



GEOGRAPHIC BREAKDOWN



5G INVESTMENT ACTIVITY FOCUS

Hindsight 2020: A Look Back For A View Of The Road Ahead

by Stephen Douglas, Head of 5G

If hindsight is 2020, we will eventually look back at 2019 as the year mobile finally found its way on 5G. For all the bluster, conjecture, planning and optimism, nothing really beats finally getting into the lab to test or actually going live in the network to truly see where you stand. Perhaps the least surprising part about this critical phase of the journey was discovering how much further we need to go before our industry realizes all of the many promises it has collectively made on behalf of 5G. But as they say, knowledge is power and what was learned last year will set the course for the strategies, investments and deployments that 2020 will bring.

The start of 2019 saw the first incarnations of 5G Non-Standalone (NSA) deployed amid what was frankly a bit of a rush. By the end of the year, there was clearly a worldwide shift in thinking with the realization among most tier-one operators that it was imperative to get the 5G core network ready for primetime by early 2020. So what happened in between?

Next-gen networks demonstrated promise but didn't woo consumers

In 2019, a sizable market didn't develop for the 5G experiences that early NSA networks were delivering. Early 5G rollouts had difficulty consistently delivering demonstrably different experiences versus what was already available on 4G. Instead of seeing much-hyped 10Gbps speeds, it was not uncommon for networks to instead register an average sustained speed of just 0.2-0.3Gbps for mid-bands and 1.1-1.5Gbps for high-bands (mmWave). These lower speeds were primarily due to the fact that the 5G radio technology is still in its infancy and lacked optimization mostly around beam management, utilization and efficient use of 5G radio channels.

Perhaps the least surprising part about this critical phase of the journey was discovering how much further we need to go before our industry realizes all of the many promises it has collectively made on behalf of 5G.

In North America, multiple carriers are supporting low-band and high-band. The use of low-bands helps support national coverage while parts of that network operate on mmWave frequencies, presenting new challenges when validating that users will have the experiences they expect across multiple frequencies and device orientations. For instance, the change in physical orientation of the device when connecting to mmWave beams is a challenge, requiring significant testing at various angles, heights and rotations.

In cases where 5G did deliver anticipated speeds, feature sets and apps were not optimized to take advantage of the speed and bandwidth, meaning consumers couldn't really discern a major difference. For the first time, the mobile industry was ahead of the capacity curve, but as we've seen time and again, it won't be long until it is filled by a new breed of data-hungry services and applications.

5G devices showed positive sales trends but were still finding their footing

5G phone sales were off to a slow start in the beginning of 2019[1] but by the end of the year, nearly 19 million had shipped, according to some estimates.[2] While still a small portion of overall smartphone sales, this was a positive sign for initial 5G interest.

Still, looking across the entire 5G device market, there were some important lessons learned from the roughly 200 5G-enabled smartphones, dongles, early IIoT modules and customer premise equipment that launched during the year.[3] Lessons that will impact devices we see hit the market in 2020.

Under ideal circumstances, 5G smartphones showed the power of next-gen networks but had trouble in real world testing. In some cases, new chipsets and the need for as many as three times the number of antennas as previous generation phones created overheating issues that resulted in radio link failures.

In others, 5G devices were registering higher latencies in real network testing versus their 4G counterparts. This was caused by 4G and 5G interoperation issues in NSA networks. When handsets attempted to switch up to 5G from 4G, it took considerable time due to the number of signalling messages that had to be sent, and ended up being highly noticeable to consumers. Once the switchover was complete, the experience could be great, but that transition has to happen seamlessly. Simply configuring devices to stay on 5G isn't a viable option due to coverage issues and up to ten times faster battery drain.

Take all this into account and consider the typical price tags north of $900[4] for first generation handsets that are only compatible with 5G NSA and it was evident that 5G devices, while successful in turning some heads, were not yet ready for mass adoption.

New revenues didn't arrive fast enough

One major goal of 5G was market differentiation that would lead to increased upsell or acquisition opportunity. Operators conceded that for all the effort getting 5G sped to market, the revenues just weren't yet there to support what was being delivered. Price wars began breaking out early in the U.S. In certain large APAC markets, discounting was already taking place. South Korea saw an uptick in ARPU, though this gain was offset by large subsidies for 5G handsets.[5]

These harsh realities only further exposed that operators needed to get to 5G Standalone faster than previously thought to capture broader revenue opportunities.

1. https://www.globaldata.com/global-adoption-of-5g-from-2020-driven-by-arrival-of-5g-mobile-handsets-in-2019-says-globaldata/
2. https://www.wsj.com/articles/samsung-posts-lower-profit-anticipates-end-of-chip-slump-11580347060
3. https://gsacom.com/paper/5g-device-ecosystem-december-2019/?utm=devicereports5g
4. https://www.cnet.com/news/cheaper-5g-phones-on-horizon-but-probably-wont-be-good/
5. https://www.telecomlead.com/smart-phone/5g-smartphones-accounted-for-2-of-the-market-in-q3-2019-92891

"Take Me To 5G Standalone... And Step On It!"

We are confident that 2020 will see operators work out many of the kinks that plagued 5G NSA networks last year. As the broader 5G market lifts, these networks will continue to serve an important component of demand. Tier-one operators may not roll them out nationally, but will identify areas where hybrid approaches make sense, even to help them finally retire 3G to reclaim spectrum. We do expect that tier-two providers will use NSA nationally to add additional capacity and bandwidth that will continue to support 4G and 5G consumer offerings.

That said, we know the desire to quickly mitigate 5G device issues for broader market appeal, consistently deliver low latencies, high throughput and blazing fast speeds, and create more market-differentiating services is pointing more operators in the direction of 5G SA. Recognition that opportunities in non-consumer markets like enterprise, industrial manufacturing, healthcare, automotive and agriculture depend on 5G SA is what's accelerating timetables.

This is the backdrop of the urgent 5G testing and assurance work Spirent is being asked to support for operators, network equipment manufacturers and device makers. Across hundreds of deals, we are seeing a range of trends unfolding in key areas explored in this report:

Transport:

The radio tends to get all the attention in 5G discussions, but the underpinning transport networks that support next-gen mobile are a major focus for our customers and a major driver of our work with NEMs. This is being driven by:

- **Densification of networks.** The high volume of small cells that will be required in urban and city environments will be 200-300% more than what is needed today, demanding substantial fiber deployments.
- **Need to feed the bandwidth beast.** Once 5G networks are fulfilling heavy demand, data consumption will be off the charts and networks need to be prepped for this. In places like Korea, there is already double to triple data consumption versus 4G[6].
- **Networks need an edge.** As edge computing architectures are planned, the network is being disaggregated, with more components and functions hosted at varying edge locations. These edge sites must deliver reliability and high performance, and transport networks are a major part of assuring them.

Assurance:

In previous network generations, service assurance was only evaluated once customer experience issues started to appear. This was typically months or even years after deployment. But the stakes are too high for 5G to wait and there is a strategy shift underway:

- **Assurance is a moving target.** As networks evolve to 5G SA, new capabilities like network slicing create new challenges for how quality is assured and compressed deployment timeframes leave little room for error.
- **Assurance and deployments now go hand in hand.** For the first time, we're seeing operators deploy service assurance alongside the earliest stages of their next-gen network rollouts.
- **No room for "best effort".** As enterprise and industrial customers become a target focus, the ability to meet stringent SLAs and uptime requirements will be table stakes.

As networks evolve to 5G SA, new capabilities like network slicing create new challenges for how quality is assured and compressed deployment timeframes leave little room for error.

Connected Devices:

2019 was the year the 5G device ecosystem truly lept from the pages of press releases and booth demos, and into hands, homes, the road, sky and beyond. It now comprises a rapidly expanding universe that spans handheld devices, IoT, medical devices, autonomous cars, high-speed trains, sensors, drones and more. In 2019 alone, we saw over 47 5G devices become commercially available, with 199 announced 5G devices in development from 76 vendors, with 16 form factors[7]. In our testing work with operators and device makers, a number of realities crystalized:

- **Networks aren't always device friendly.** Device performance cannot be uncoupled from the networks that support them and as device makers contend with incomplete standards sets, and a wide range of new radio, frequency and spectrum demands, they are simply not optimized for user experiences.
- **Expectations are sky-high.** After all the buzz and hype, 5G devices were heavily anticipated and thrust into the spotlight at launch. While there were certainly promising results, technical hiccups demanded expectations be reset as the reality of a necessary journey to success became evident.
- **5G devices aren't ready to go it alone.** For the foreseeable future, devices will need to support both 5G and 4G, necessitating new engineering feats that put device makers in unchartered territory.

6. https://www.strategyanalytics.com/strategy-analytics/blogs/service-providers/mobile-operators/service-providers/2019/08/01/5g-data-use-surges-in-south-korea
7. https://gsacom.com/paper/5g-device-ecosystem-december-2019/?utm=devicereports5g

Transport

Prepping the network to meet unprecedented demand

5G discussions typically focus on what's happening in the air, but it's the transport networks that will ultimately bear the heaviest burden of new 5G services. Network slicing, IoT, autonomous vehicles –take your pick. Each arrives with 5G performance requirements that typically need to be addressed by the same network architecture. All these ultra-fast speed, ultra-low latency, massive capacity and high reliability requirements demand a herculean effort to support.

Assuring the performance of 5G requires the complex transmission of video, data and voice from the core network to end devices. 5G services will not work as expected if the underlying transport network can't provide connectivity that meets the requirements of each service.

As discussed earlier in this report, 5G networks are highly-distributed, denser than any previous generation and will have to bear unprecedented loads. Operators and network equipment vendors are being challenged to meet the significant 5G performance demands on the transport network, which are more challenging because of 5G's high performance requirements, dynamic services and flexible architecture.

An added complexity is that not all transport standards have been finalized and new, competing standards are being proposed. With global markets eyeing more near-term commercial deployments, the crunch is on.

Putting Transport to the Test

Much must be done to prep transport networks for 5G. Network equipment manufacturers are fast-tracking product development while operators evaluate 5G standards and the vendors best prepared to meet their next-gen architecture vision.

As a result, Spirent is seeing a sizable uptick in demand for solutions to test transport networks. In fact, today it comprises well over one-third of our business—more than 5G infrastructure or application testing. Given the complexity involved and the high stakes at hand, NEMs are requesting urgent assistance with transport testing as they expedite offerings that must be ready for full-scale deployment in just 12-24 months.

Because transport technologies are being developed at the same time standards are being defined, Spirent is in a unique position to contribute testing insights, solve challenges and offer solutions to the new 5G standards as they are being created. Particularly, testing assistance is being requested in areas that span functionality, scalability and interoperability. While industry players are working in parallel, overall stability and a clear direction forward remain elusive.

Further adding to the complexity are requests to create test solutions not just for existing and evolving standards, but new technologies for delivering 5G transport, such as slicing packet network testing.

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Transport Testing Takeaways

Lessons learned following extensive testing

With transport-focused engagements comprising nearly half of Spirent's 5G work, we are actively engaged with a range of customers globally. Following are key takeaways from these engagements based on our efforts in the field over the past year:

- We can report with confidence that both vendors and operators are deeply engaged in projects to validate equipment and detailed strategies against new standards with plans for early interoperability testing. In particular, operators are leveraging end-to-end test solutions capable of emulating billions of devices to stress-test the transport infrastructure, since it is not feasible to do this on a live network.
- Operators are building out data centers to support Cloud RAN and NFV, as well as network slicing test capabilities to help ensure the diverse bandwidth, latency, security and time synchronization required by 5G applications. This includes network slicing transport standards testing and validation for mission-critical 5G applications, as well as fronthaul and backhaul protocol testing. This work is being done to help operators prepare the transport network and data center architecture for mass market deployments.
- In 2020, the industry must put more focus on higher speeds (100/400G), throughput testing and network emulation to overcome interoperability and scalability challenges, and help address competing 5G standards.
- As networks prepared for 5G, the levels of synchronization accuracy required to enable new 5G distributed fronhaul applications increased exponentially. The associated standards are evolving to support these next-generation accuracy requirements for PTP (Precision Time Protocol) and SynchE (Synchronous Ethernet). Our own test equipment already supports transport equipment manufacturers as they seek to accelerate validation of 5G equipment with the highest accuracy testing to sub nano-second.

Transport 2020: A look ahead and what to expect

Open initiatives to play an outsized role

A major industry shift is underway as an increasing number of top-tier operators begin to embrace open and virtual network infrastructure, including for radio. In late 2019, Vodafone went as far as to announce that it is putting its entire European footprint, which spans 100,000 mobile sites, up for a redesign based on open radio access network (ORAN) technology.[8] The significance of this cannot be understated as the move has the potential to shake up the infrastructure market as we know it.

2019 saw strong interest by manufacturers and operators in highly scalable, open interfaces such as eCPRI and ORAN for 5G fronthaul, as well as SDN and network slicing for 5G transport. In 2020, all of these will need to be tested to ensure they will meet performance, scalability, interoperability and high availability expectations.

As a result, we anticipate eCPRI and cRAN fronthaul protocols will become critically important. For backhaul, we expect EVPN and Segment Routing, especially SRv6 adoption, to further increase, truly powering 5G network services and transport. We see SPN (Slicing Packet Network) playing a major role in enabling network slicing to meet the most demanding requirements of 5G applications.

However, these advancements won't happen overnight. We will see 5G initially deployed in dense urban centers. Upgrades will be implemented gradually: radio tower upgrades to 5G, followed by fronthaul network upgrades, backhaul network upgrades, then cloud edge upgrades.

8. https://www.lightreading.com/mobile/5g/vodafone-eyes-open-ran-overhaul-at-100k-sites-may-swap-existing-suppliers-for-5g/d/d-id/755605

2019 saw strong interest by manufacturers and operators in highly scalable, open interfaces such as eCPRI and ORAN for 5G fronthaul, as well as SDN and network slicing for 5G transport.

Assurance & Automation

Preparing the 5G network to meet outsized expectations

The race to expand 5G deployments and the NFV infrastructure that supports them is shifting more of the network to the cloud. Functions that used to sit in well-defined network locations are now being virtualized and deployed in any number of locations –from centralized data centers to the customer premises.

In previous network generations, operators were happy to put off assurance strategies until problems started showing up in the network. But too much is riding on 5G to follow the same timelines, especially with lucrative enterprise revenues on the table. Of course, testing every last aspect of configurations in advance of deployment would delay rollouts given the complexity of these live, dynamic networks. Network slices, in particular, will change so often that manual troubleshooting won't be able to keep up.

This means that while many aspects of networks must be assured prior to deployment, automated assurance technology that remains active in the live network is not a luxury, but a necessity.

Trends driving assurance investments

As 2019 wrapped, operators and network equipment manufacturers were knee-deep in verifying VNF functionality and performance in the lab, as well as making sure emergency and other services will work properly. Also high on the priority list was testing how well 5G VNFs interoperate with existing technologies like 4G and WiFi .

For the 5G NSA operational network, service providers are in the early stages of assuring services, validating the NSA network's operational performance and ensuring the NSA network co-exists properly with LTE networks.

With an onslaught of new and modified network slices, new devices and frequent software updates, the 5G network is changing continually. It is changing so fast that the changes can't be validated using traditional manual methods. An active assurance framework can automate the validation and management of all these dynamic changes. The new active assurance playbook sees operators evaluating service performance at turnup, checking critical services and links that have variable or no usage, seeing end-to-end views, and isolating problems anywhere in the network. This active assurance approach emulates real network functions, devices and users, constantly testing networks to uncover issues by injecting highly realistic, synthetic traffic into the network.

Spirent is seeing customers embrace end-to-end, automated assurance to meet customer expectations for quality experiences. They are specifically focusing on network slicing, service quality monitoring, change management and fault isolation.

Assurance and automation takeaways

A state of play as deployments designed to preserve network performance and experiences begin

Spirent is actively engaged with a range of customers globally that are shoring up assurance strategies, uncovering a number of challenges, revelations and opportunities along the way. Key takeaways from our work over the past year have included:

- Network equipment manufacturers are having difficulty keeping up with service provider timetables.
- In testing, one of our operator customers was seeing 5G network performance of only 300-400 Mbps and latency around 30-40ms in some early deployments–frankly, not all that much better than 4G. Assurance processes helped to uncover this issue, which was isolated and resolved before launch, validating accelerated assurance timetables.
- Top operators are discussing a variety of network slicing strategies, ranging from a limited set of network slices to launching upwards of hundreds of network slices in the coming years, with as many as even one per subscriber. As noted earlier, we know that manual assurance techniques won't be fast or economical enough to support that kind of scale.
- Operators are using active assurance to enable the faster turn-up times that are a critical step in delivering agile networks to compete with the web-scale providers and demonstrate the benefits of 5G to enterprise customers. They are seeing seven to ten times faster turn-up of new network functions, an ability to validate performance of all configurations and significant reduction in manual efforts.

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Assurance & Automation 2020: A look ahead and what to expect

On the road to premium user experiences

Based on our work in 2019 and current engagements with operators and network equipment providers around assurance and automation strategies, we expect 2020 to bring:

- The first implementation of the 5G NWDF (Network Analytics Discovery Function), enabling advanced network-based machine learning, and future artificial intelligence-based services and capabilities, including zero-touch self-healing.
- Growth in 5G edge cloud distributions to deliver different customer or business case requirements, such as lower latency, reduced transport costs and localized data privacy. Edge-based service assurance will become critical in realizing these benefits.
- The edge itself will change with new entrants offering micro neutral hosting environments for multi-tenancy. In this scenario, SLA assurance will become critical, with the evolution of functionality moving operators ever closer to the delivery of trusted, mission-critical enterprise service assurance where SLAs can be guaranteed and actively validated. This is a prerequisite for servicing mission-critical 5G verticals like fintech and Industry 4.0.
- Cloud and NFV infrastructure ownership will continue to evolve to a hybrid model. Already in 2019, we saw service providers start to work with web-scale cloud providers in addition to building their own cloud environments. This trend will continue in 2020, creating new operational challenges in managing and assuring services distributed across different host data centers and cloud infrastructures.

Growth in 5G edge cloud distributions to deliver different customer or business case requirements, such as lower latency, reduced transport costs and localized data privacy.

- Active security assurance will become a priority as the first 5G SA networks are deployed. With 5G NSA, security needed to mainly focus on the traditional touch-points of the radio and transport network. However, with 5G SA, a new level of security risk and complexity is added with the cloudification of the core and the disaggregation and separation of the signaling plane. Active testing for security will become as critical as proactively monitoring performance.

Connected Devices

A view from the frontlines of 5G user experiences

5G devices aim to benefit from 5G's speed, throughput and (eventually) coverage density, powering new experiences and industries. To do this, they must deftly harness New Spectrum, New Radio (NR) and New Architecture, each bringing its own advantages and complexities. 5G is forcing operators to make rapid deployment decisions based on frequency availability, core SW readiness and budget, and even location requirements for emergency calls.

It's impossible to decouple device production strategy from radio, frequency and spectrum realities because they are so intertwined, and in 2019, played a role in some of the challenges we saw emerge on the device side.

For instance, some 5G deployments will focus on Frequency Range 1 (Sub 7.125GHz) while others will use Frequency Range 2 (mmWave). Some architectures will be SA and others NSA. There are decisions to make about whether voice and emergency calling will use VoLTE or VoNR, and when to move from 4G Assisted-GNSS positioning to newer 5G positioning technologies. The sheer plethora of options and lack of agreed-upon standards harkens back to the 3G era, when phones that worked across continents were hard to find—and even harder to test and assure.

In short, this will not be a clean, seamless device transition, if for no other reason than the devices already delivered or in-flight are being produced based on bets about where the industry is likely to go, but not necessarily where it will end up.

Connected Device Testing Takeaways

Our 5G device testing over the past year has revealed a number of invaluable insights and takeaways as the industry seeks to understand what comes next for this burgeoning market.

5G Device Realities Tuning User Expectations

When considering how consumers may perceive 5G, it is important to remember that they are essentially spoiled by the maturity of LTE. When they see the LTE icon on a handset, they know they have an LTE data connection. Things have not been as clear with 5G depending on the device or which operator's network it runs over. This has somewhat blurred consumer understanding of what actually constitutes 5G and what kind of performance to expect. Further complicating things is the fact that orientation matters. In our tests, it is not at all unusual to get different readings depending on how the phone is being held or how it's angled in the hand. Serving in-building coverage needs is a different animal entirely than delivering for someone out on the street with a direct line of sight to a cell. The result? Testing processes can be arduous, accounting for all of 5G's needs, plus those of 4G where the device is still likely to be used most. There are also field device-to-tower interoperability tests to consider. It's no wonder that so much is being learned in the field versus the lab.

Then there's the content devices are consuming. We know 5G will bring data-hungry applications. But it is the range of appetites it must serve that our device maker customers are focused on as they consider how to prepare for demand and ensure the experiences they deliver live up to the hype:

- **Video** and measurement of how end users are perceiving quality is a constantly moving target as evolving formats like 4K and HDR drive bitrates upward.
- **Autonomous vehicles** require billions of miles of testing, focused in part on understanding how network outages, signal loss, cell handovers or even security attacks may impact performance.
- **IoT devices** like those found in smart cities or on factory floors aren't as sensitive to speed or throughput as they are reliability and quality of service as they aim to power automation.
- **Augmented and virtual reality applications** represent the ultra latency-sensitive application, demanding strict thresholds to be met lest the experience fall painfully short.

In response, we are seeing a multitude of device-infrastructure network combinations, all of which will have to be tested. An example of this is Spirent's work with a leading research institute and industry consortium focusing on the future of 5G Cellular V2X. This early prototyping and research is critical to identifying complex and costly issues, such as the optimal position for locating antennas on vehicles. It could impact the speed of progress in the next phases of research and testing, when the official 3GPP R16 standards, including the first 5G NR-V2X (phase 3) features, are released later this year.

> In our tests, it is not at all unusual to get different readings depending on how the phone is being held or how it's angled in the hand.

The bottom line from our early device field testing is that the rush to bring 5G devices to market has meant first-generation smartphones are very much still in their infancy:

- Certain tested devices lack support of key 3GPP R15 features critical for optimal 5G performance, such as RRC connections that are kept active.
- Others are having thermal and overheating issues, leading to a large amount of radio link failures that impact performance and cause devices to fail to maintain 5G connections.
- We've also seen some 5G NSA implementations impacting user-perceived latency by 3X due to "up-switching" as devices move from LTE up to 5G to establish the data bearer.

These are all challenges that can be solved, but for now, they are the reality for any 5G device, the operators that support them and the end users whose experiences are colored by them.

Then There's The Radio

As noted earlier, to understand device trends, challenges and opportunities requires a close look at the radios that serve them.

While typical LTE setups typically max out at 2x2, 4x2, or maybe 4x4 MIMO (four antennas at the base station and four in the handset, with 16 radio channels to consider), 5G employs Massive MIMO, meaning antennas can reach up to 8x8 (64 elements) and even beyond. In the lab, that's 256 channels to measure (and in FDD, it's double that). In mmWave, the doppler effects are higher. Cellular V2X introduces new velocity and topology issues. And WiFi 6, while not strictly 5G, adds yet more factors of sophistication. Devices are sensitive to all of these variables.

In 2019, our initial testing of the first commercial implementations of the 5G New Radio (in all bands) made it evident that the radio was not yet optimized nor was it exploiting all of the capabilities defined within the standards. This is one reason initial deployments are delivering an average sustained speed of 0.2-0.3Gbps for mid-bands and 1.1-1.5Gbps for high-bands (mmWave) instead of much-hyped 10Gbps speeds. The delay in the new 5G Core and SA implementation also impacts deployment. The lack of radio optimization was mostly seen around beam management and utilization and the inefficient use of the 5G radio channels.

Location Matters

We talked before about challenges related to the angle at which a phone is held or whether a device is in-building or within direct line of site to a cell. The 5G signal also introduces interference effects onto the GPS signal, which must be considered. Additionally, it introduces new technologies, such as Z-axis location information (where the device is located vertically—on which floor of a building, for example). In short, these variables all further compound the reliability challenges faced. And in matters of location, it's not just the user experience on the line, but safety. After all, until these kinks can be worked out, location for emergency calling will remain in 4G mode for some time, meaning Standalone 5G devices will also remain a ways off.

Connected Devices 2020: A look ahead and what to expect

It's early days for devices, but 2020 will see substantial advancement

2019 saw the introduction of a handful of 5G consumer devices. For 2020, device and chipset manufacturers are getting into full swing incorporating 5G into many new smartphone models. Operators, meanwhile, are evaluating OEM devices, gearing up for 5G location services, and evaluating the field performance of new 5G network deployments.

Over the next year, we anticipate:

- As operators grapple with 5G rollouts, and the new technical challenges they introduce (particularly in millimeter wave networks), test repeatability will prove a challenge.
- With early 5G devices showing power consumption issues, managing the simultaneous use and handoffs between 4G and 5G radios will be a priority for device manufacturers.
- Device manufacturers will work to resolve interference effects on their satellite location system receivers due to combined 4G and 5G signals in single-chip modems.
- Device location accuracy will improve for all users as improvements enabled by 5G are rolled into devices to support FCC-mandated emergency calling location accuracy.
- As beamforming-capable base stations start to become more common, devices will begin to support new technologies such as beam-to-beam handovers.
- Devices may need different versions for particular markets, especially when it comes to incorporating millimeter radio support. It is likely that in these early days, consumers will not have the same device portability that they have come to expect with LTE.
- The proliferation of video services, both for mobile users and for home cord-cutters, will expose more differences between the quality of video from various services, given their differing distribution networks and player algorithms.
- Military organizations around the world will accelerate research into applications of 5G NR and devices, especially in the area of smart-base connectivity.

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Emerging Trends

Exploring the next steps of next-gen networks

For all the lessons learned about 5G, there is still considerable exploration on the horizon. Just like we saw with Non-Standalone deployments, there are those lessons that won't be learned until testing and rollouts begin. In a few key areas, this work is starting in earnest, signaling near-term advancements that will continue to expand and support 5G capabilities.

Security

There are two prevailing schools of thought when it comes to the role of security in 5G networks. The first sees 5G as a Pandora's box representing a massive security risk as software, network disaggregation, higher volumes of devices and cell sites, an influx of new vendors and open source trends exponentially increase attack surfaces. The second sees 5G as potentially more secure than any previous network given that the underlying architecture is capable of incorporating a number of advanced security mechanisms. For instance, network slicing strategies could include slices that are built to be more secure, act as treatment centers in the event of an attack or simply as honeypots to capture traffic in the network.

The early security test work we're doing on behalf of customers has focused on research and trials, and requirements for commercial launch. As most operators kick off 5G deployments with NSA commercial launches, transport network security (especially for New Radio) has been a dominant focus, along with security gateway and firewall performance, and IoT device security certification. The latter is part of an ongoing evolution to 5G using Narrowband IoT (NB-IoT) and LTE-M. With 5G SA coming in 2020, the focus is moving towards 5G New Core security, especially control plane signalling and functional disaggregation, network slicing security and edge cloud security.

Edge Computing

Edge computing moves processing power closer to where it's consumed to improve the performance of latency-sensitive, data hungry applications and devices. In the past year, Spirent has seen increased demand for researching, testing and benchmarking how and what type of virtual infrastructure at the edge is required to meet the needs of disaggregation, hosting and low latency. This included testing the level of performance cloud service providers could deliver from various points within the network. Our work also covered research and testing around how to virtualize and disaggregate the RAN while still meeting performance and reliability requirements, and testing the 5G new core with its cloud-native and service-based architecture. And importantly, testing of the inter and intra-transport networks (e.g., multi-speed, Ethernet, precision timing and synchronization, new Ethernet-based fronthaul, transport network slicing and SDN). Based on the state of testing taking place right now, we expect 2020 to be the year of edge deployments.

Integrated Access Backhaul

In North America, Spirent is seeing an increasing number of operators exploring the potential of integrated access backhaul. The concept is that radio can be inverted. So rather than pointing the signal at consumer handsets, it is used as a backhaul device between base stations with the aim to reduce the need for fiber at every cell site. Gaining the ability to build cell sites that rely on mmWave to deliver transport and relay messages allows creation of mesh networks comprising cell sites that are supported by one central site equipped with fiber to handle backhaul to more distant locations. This reduces fiber requirements by as much as 20-25%, limiting demand to as few as one fiber hookup per ten cell sites. Trials are already underway and real advancement will depend on standards expected later this year in release 16, but it is an opportunity to track closely with one tier-one operator we're working with estimating that 20% of their 5G networks could eventually be serviced by IAB. In the meantime, we will be helping to validate the opportunity with robust testing that includes line of sight distances, latency increases, and throughput degradation due to relaying and multiple hops.

Mobile Video

5G will increase choice around how video is consumed as it continues to dominate network traffic. The increased bandwidth and capacity will eventually enable new service provider entrants, further disrupting video delivery markets already grappling with the realities of cord cutting. Some mobile operators are already positioning for this opportunity that will ultimately require delivery of ultra-high quality content. Mobile gaming, which is primarily driven by video with the added requirement of low latency, is also expected to be a focus for providers. In fact, it is likely we'll see wireless operators prioritize services built around gaming versus TV. The difference now versus previous attempts is a broader ecosystem more ready to do business and, of course, networks that will be supercharged by 5G.

But 5G's robust capabilities won't immediately have all the answers when it comes to assuring QoS and providing an overall bulletproof service, a high bar set long ago by cable operators. Early Quality of Experience (QoE) testing for these types of services is already underway, validating new features that are expected to improve QoS mechanisms versus LTE networks. The ability to map services to a flow will let operators shape how traffic is handled. For example, mobile gaming and live video could be assigned to a delay-critical guaranteed bitrate flow while streaming non-live video might be assigned a delay-tolerant guaranteed bitrate flow. Network slicing will offer further QoS granularity and robustness. Of course, consumers won't care about all of that. They'll simply want to know that when they switch providers, they are receiving the same or better service than before.

Test as a Service

Just as 5G's distributed, virtualized architecture has transformed the network to be more software-oriented so, too, has it changed the test dynamic. Instead of a physical approach focused on specific tests of well-defined network hardware, 5G testing requires a continuous integration software model. This model emulates parts of the network to enable automated, customized end-to-end testing across the lifecycle, from development to validation to service rollout, followed by assurance and differentiated service quality assessments in the live network. The associated costs, extended time tables and need for continuous development of customized tests is creating demand for a Test as a Service (TaaS) model that introduces more flexibility and collaboration into the process. TaaS removes a major component of the testing burden that operators have traditionally taken on themselves and shifts it to experienced testing vendors better positioned to optimize the process and react quickly to new demands. As mission-critical services begin to launch on 5G and go-to-market time tables continue to accelerate, TaaS will emerge as an ace up the sleeve of operators determined to move swiftly and safely.

5G Near-Term Use Cases

5G's earliest revenues will hinge on use cases that can capitalize on the capabilities of the networks being rushed to market. Based on our close work with operators, network equipment manufacturers and device makers, and our understanding of the opportunities they are pursuing, we expect the following 5G use cases to break through in 2020.

Mobile Gaming

Gaming has been an early 5G use case standout globally, but especially in APAC and North America. Companies and developers in this space understand the benefit and value of access to higher bandwidth and lower latencies. AR and VR experiences are driving need, whether to serve hundreds or thousands of people that show up at one location at a time for massive multiplayer events or simply mimicking real-world moments in the isolated confines of virtual reality.

Industrial IoT

Factories will not be revolutionized overnight, but advanced planning is underway on how to bring 5G into a brownfield factory today to achieve better agility and visibility in terms of process management. Densification is a requirement here as well given the need to deploy high volumes of cellular IoT devices in a way that capitalizes on high throughput and low latency. It will take years to get to autonomous factories and the future here is dependent on pending industry standards releases. But make no mistake, the race is on. Network equipment manufacturers and operators we're working with are heavily focused on this market, and building out sales and services offerings that will support near-term increased activity.

As systems are trained to recognize a workplace injury, a theft in progress or a rare disease threatening a live crop, video as a sensor will emerge as a killer use case.

Video As A Sensor

Smart video monitoring is poised to revolutionize industries that span security, factories, cities, public safety and agriculture, to name a few. The extra bandwidth that 5G can deliver will support advanced video systems for monitoring of streets, farms, warehouse floors and more, with precision high-quality video feeding into AI-driven analysis algorithms. As systems are trained to recognize a workplace injury, a theft in progress or a rare disease threatening a live crop, video as a sensor will emerge as a killer use case.

Green Industries

The telecoms industry understands 5G's potential environmental impacts and is taking a leadership role in driving sustainability targets extending out the next many years. A growing number of operators are contributing to an industry-wide, climate action roadmap. While it is critical for the industry to lead by example, the reality is that it contributes less than two percent to global emissions with less than 80 percent of worldwide emissions attributed to the energy, agriculture, industry and transportation sectors. In fact, these are all areas where 5G and IoT can bring considerable change, accelerating green outcomes. For industry 4.0 and smart factories, efficiencies can be realized across energy-hungry activities like system maintenance, supply chains and precision manufacturing. In cities, it can reduce carbon emissions with smart traffic and building management. For agriculture deployments, 5G can optimize land sustainability, reduce waste, protect habitats and enable new forms of carbon sequestration through smart irrigation and precision farming solutions.

5G Long-Term Use Cases

Automotive & Transport Systems

Automotive is already a proven 4G LTE use case with an evolution to 5G expected by 2024. Ultra-low latency and higher throughput is what will support advanced driver assistance systems that will ultimately take us to full autonomy and support for complex vehicle-to-vehicle communications. These game-changing capabilities are expected to reduce accidents via collision avoidance systems, lower fuel consumption via advanced driving capabilities and reduce congestion through cooperative systems. Vehicles could even become public small cells, extending network coverage through mesh and relay network architectures.

Energy “Self” Efficient Networks

Energy efficiency will become an equal partner in the equation of optimizing networks for performance, quality and service as CSPs look to address their environmental and sustainability targets. AI and automation will be used to enable 5G Self Efficient Networks dynamically implementing holistic network-wide changes to continually provide optimal efficiency and performance.

Ultra-low latency and higher throughput is what will support advanced driver assistance systems that will ultimately take us to full autonomy and support for complex vehicle-to-vehicle communications.

“Micro” Private/ Public MNOs

The number of private networks will grow rapidly across industry, offices, hotels, public venues, rural locations and utilities. Some of these locations will be user-specific and remain private, but a growing percentage will enable new business models by becoming neutral host environments offering wholesale access or roaming.

Augmented Reality

As 5G grows to nationwide coverage, a new world of deeply integrated, highly social and personal AR experiences will let users see the world their way. The disaggregated edge cloud environment of 5G will allow AR applications to offload intensive processing to the edge, enabling AR glasses to become smaller, more appealing, efficient and cheaper. Over the next decade, we will begin to see the world and the information that powers it in completely new ways.

6G

This decade will be defined by the commercialization of 5G, but 6G looms on the horizon for 2030. 6G’s killer use cases (quantum computing, haptic perception?) are still anyone’s best guess, but we know that the path will be eased greatly from the hard knocks learned by 5G and the best ways to exploit cloud and AI orchestrated environments that will be ubiquitous.

Safely Accelerating The Journey To 5G

Spirent has supported hundreds of 5G-driven engagements with operators, network equipment manufacturers and device makers. A driving theme of this work has been our focus on helping customers move as quickly as possible in pursuit of new opportunity. When compared to previous generations, 5G is dynamic, near-real-time and high-performance, introducing fundamental change in how testing, validation, assurance and security must be addressed.

Spirent is a world leader in 5G test, assurance, analytics and security, with end-to-end expertise and solutions that address the challenges of 5G, from lab to live network testing and assurance. Our solutions are trusted by customers around the globe to help accelerate their journey to 5G with agility and safety, and to ensure 5G services ultimately live up to end user expectations.

When our customers make promises to their customers, Spirent is here to assure them.

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

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