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SPECIAL EDITION 5G - May-Jun 2020

What is 5G

- Understanding The Next-Gen Wireless System Set To Enable Our Connected Future
- 5G requires Data Centers, Fiber, Cell Towers and Small Cells

5G Collaboration

NI, Radisys and CommScope Collaborate on 28 Ghz 5G New Radio InterOperability Device Testing

Special Edition 5G

The next generation of wireless technology will offer new consumer and business applications, with near real-time connectivity.

Discover what you need to know about 5G in this Edition
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NI, Radisys and CommScope 5G Collaboration

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What Is 5G? Understanding The Next-Gen Wireless System Set To Enable Our Connected Future

CBINSIGHTS | Report dated: March 19, 2020 | https://www.cbinsights.com/

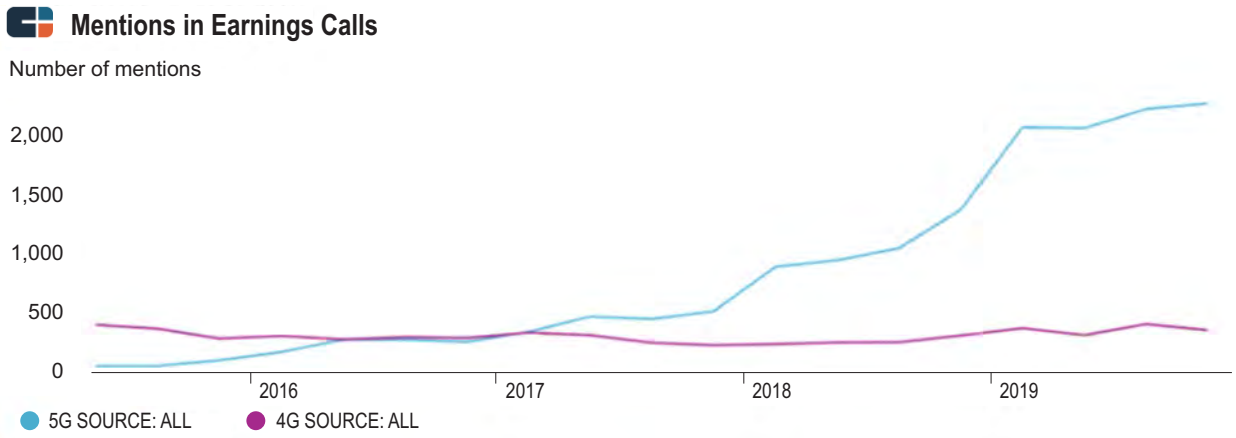
The next generation of wireless technology will offer new consumer and business applications, with near real-time connectivity.

In the last decade, 4G wireless technology has become the standard for many mobile consumers around the world.

From social media platforms like Snap and Instagram to transportation apps like Uber and Lyft, many companies have benefited tremendously from the reliable connectivity and speed provided by today's 4G systems.

While this fourth generation of wireless technology has paved the way for new mediums of mobile consumption, it does have limitations. Over the next decade, the rise of connected "internet of things" (IoT) devices will require networks to transmit massive sums of data in near real-time.

The next generation of wireless technology, known as 5G, will allow just that.
Early 5G deployment began at the end of 2018 when AT&T launched 5G wireless networks in 12 cities, but widespread implementation of the technology may take the better part of a decade.



Even so, corporates are increasingly focused on this technology: according to CB Insights' earnings transcript tool, 5G was mentioned over 2,000 times in earnings calls in each quarter of 2019.

Corporates like Nokia, Qualcomm, Ericsson, Broadcom, and Verizon have all discussed the implications of 5G, as well as plans for associated technology and service deployment.

We dive into the background of wireless technology, the introduction of 5G, and how the next generation of connectivity will come to be.

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History of wireless technology systems

Wireless communications have existed for over a century, but it wasn't until the late 1970s and early 1980s that they became a commercially viable consumer service. The first generation (1G) of wireless technology systems came with the introduction of cell phones. These devices and networks allowed for mobile voice calls, but nothing more.

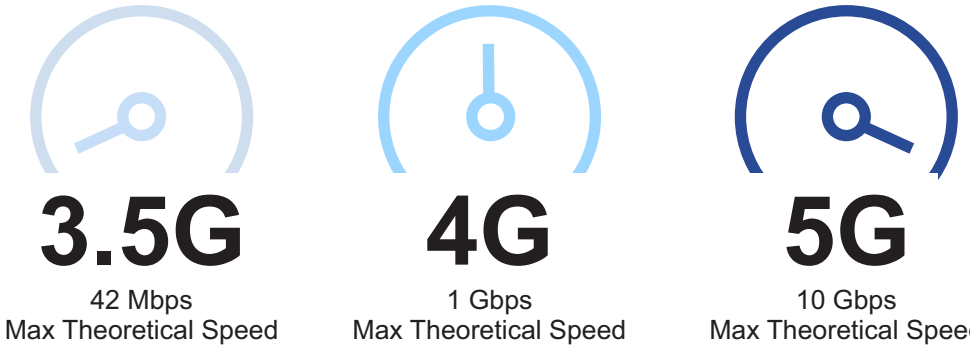
The second generation (2G) provided improvements to voice calling and introduced text messaging via SMS (and later media messaging via MMS), which ultimately helped the cellular industry to gain widespread adoption in the early 2000s. Later iterations of 2G introduced data transmission, but it wasn't until 1998 that 3G allowed for media-rich applications like mobile internet browsing and video calling. The most recent iterations of 3G are able to reach data speeds up to 4 Mbps. The most recent generation of wireless technology, known to consumers as 4G (now 4G LTE), is able to reach realworld speeds of between 10-50 Mbps, depending on the carrier.

These speeds allow for mobile online gaming, live stream HD-TV, group video conferencing, connected home solutions, and even emerging experiences like AR/VR.

That said, downloading or buffering is typically required at 4G speeds. For most consumers, this is a small price to pay for mediarich wireless freedom. But for industries like transportation or healthcare, latency (the delay before data transfer) can have a direct impact on system outcomes. For example, 5G will enable near-instant communication between autonomous vehicles — communication that may prevent fatal accidents. 5G will have the biggest impact on these mission-critical systems while also providing the necessary infrastructure for tomorrow's connected technologies.

What is 5G wireless technology?

5G is the next (and fifth) generation of wireless technology systems. It will provide speeds faster than any previous generation, comparable to those delivered via fiber-optic cables. Early testing of this technology shows real-world speeds of 700-3000 Mbps (3 Gbps), which consumers may experience once 5G becomes commercially available. Movies that took minutes to download with 4G will take seconds with 5G.



While smartphones and other mobile devices are the obvious use cases for 5G, there are many other applications for the technology. The internet of things (IoT), for example, will benefit tremendously from the speed and bandwidth provided by 5G, especially as the industry grows: Gartner estimates that over 20B IoT units will be installed by 2020, while IoT-related spending will reach nearly $3T. Autonomous vehicles, robotic surgery, and critical infrastructure monitoring are just a few of the potential applications of 5G-enabled IoT.

Industries being disrupted by 5G

5G's quantum leap in connectivity creates tremendous opportunity for numerous industries, but also sets the stage for large-scale disruption. Industries such as healthcare, manufacturing, and auto are already adopting technologies and becoming more connected. Once 5G becomes widespread, the effect on these industries could be transformative for 3 main reasons:

1. 5G devices are **lower latency**, enabling faster transmission of larger data streams
2. 5G devices are **more reliable**, enabling better transmission of data in extreme conditions
3. 5G is **more flexible** than Wi-Fi and can support a wider range of devices, sensors, and wearables

We dive into several industries that could see a drastic impact from 5G technology below.

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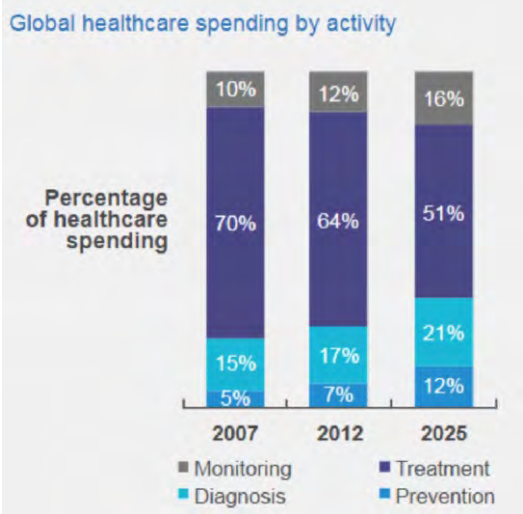
HEALTHCARE

In an attempt to reduce costs and improve overall health, western medicine is shifting towards preventative care.

5G offers enormous opportunity for expansion of both preventative and monitoring practices via wearable devices. Such devices are already being used to track everything from sleep to blood glucose levels to physical activity, among other things.

5G's faster speeds and greater network reliability will allow for the development of more complex devices, including those implanted directly into a human body rather than worn externally.
Microscopic cameras equipped with 5G will be able to provide realtime video streaming in and out of patients' bodies, setting the groundwork for more remote diagnoses and other more complex telehealth practices. Today, for example, recovering stroke patients for whom repeated hospital visits are a burden often suffer from a lack of home monitoring and care. New kinds of wearables that track patients around their daily lives — not possible today with 4G — could allow for such patients to get more personalized monitoring and telemedicine-based care without having to visit a hospital.



Source: Principal Global

Telemedicine is projected to grow to an $86B market by 2025, according to CB Insights' Industry Analysts Consensus market sizing tool.

In the field of robotic surgery, 5G has the potential to dramatically expand the ability of doctors to bring critical and specialized care services to patients worldwide.

Robotic surgery is feasible today, especially in dense urban areas with access to fast broadband internet, but doctors generally have to be located in the same operating theater as the patient for it to work. By allowing for low latency and jitter-free communication over long distances, 5G could enable operations to take place from anywhere in the world. In January 2019, a team in China tested 5G remote surgery for the first time, removing an animal's liver in the province of Fujian.
In the US, Rush University System for Health plans to be among the first healthcare organizations to trial 5G connectivity in its hospitals, in partnership with AT&T.

MANUFACTURING

The manufacturing industry has already started adopting artificial intelligence and IoT technologies to increase efficiency, improve data collection, and build better predictive analytics.

With 5G, manufacturers gain a faster, more reliable means of collecting and transmitting that data, as well as a broader range of sensors and devices they can integrate into their factories and workflows.

One major potential improvement with 5G will be augmented reality for manufacturing. Ericsson began testing augmented reality troubleshooting in its Tallinn, Estonia factory in January 2018. With an AR app, technicians can observe a part that needs maintenance and pull up the relevant schematics and instructions within their field of vision, drastically shortening the time it takes to complete the repair.

Ericsson has also partnered with MTU Aero Engines, an airplane engine manufacturer, and Germany's Fraunhofer Institute for Production Technology to test 5G tech. Ericsson says that this initiative could lead to savings of around 27M euros for a single factory.

A major benefit of 5G technology is the ability to run multiple dedicated networks on the same infrastructure to customize speed, coverage, security — also known as slicing. Even though the ability to run separate networks already exists, slicing could make it easier to tailor them to manufacturing processes and improve adaptability, like accommodating increased volumes of production.

The popularity of the technology is such that two-thirds of industrial companies are ready to deploy it within 2 years of availability, according to a 2019 report by digital transformation consultancy Capgemini.

A technician repairs a circuit board using an augmented realityoverlay at Ericsson's Tallinn factory.
(Source: Ericsson)

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While the higher latency of 4G and lower reliability of Wi-Fi make such technology limited today, 5G's ability to transmit low latency video at a high resolution could potentially make it much more broadly usable. Other industrial use cases for 5G (according to AT&T) include:

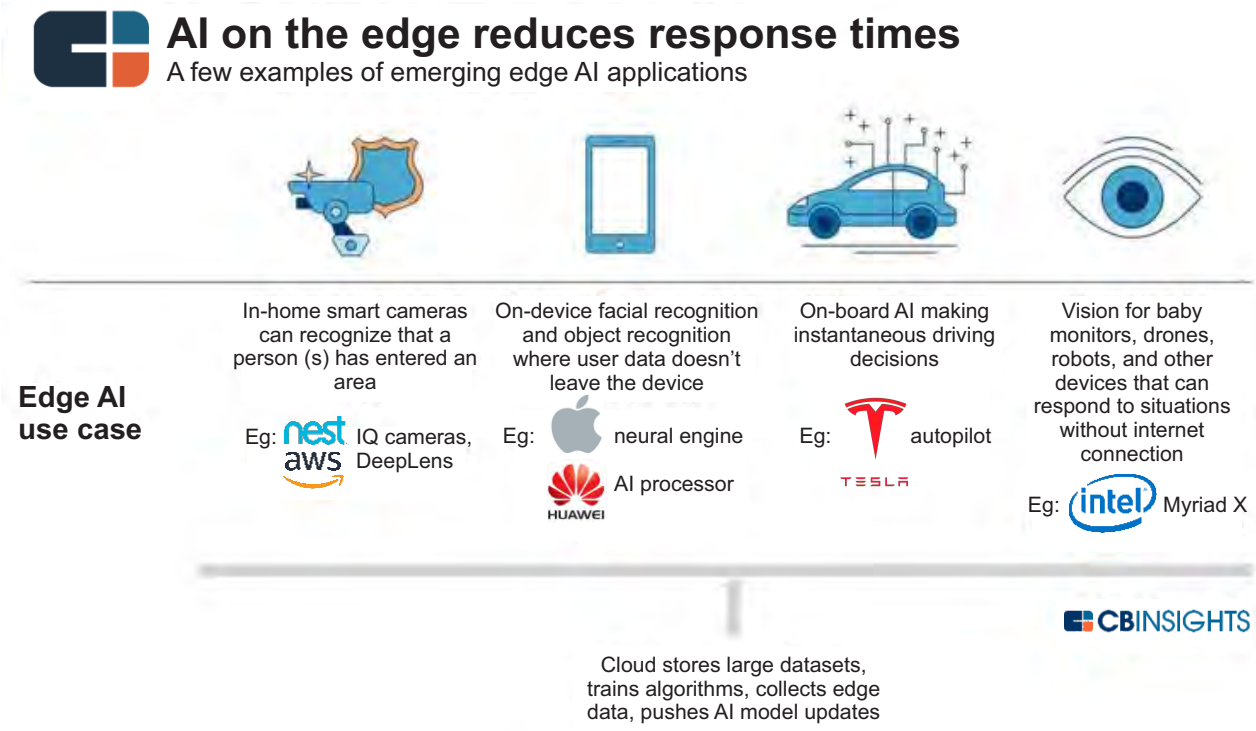
- Continuously monitoring equipment performance
- Robotic visual recognition that autonomously performs quality assurance on products
- Enabling predictive analytics to tell when a part is going to fail

AUTOMOTIVE

Tesla, Google, and others have been racing for years to build the first viable autonomous vehicle capable of navigating any environment without the input of a human driver.

Their primary approach to the problem thus far uses onboard computers and radar to scan the environment around the vehicle, and decide a car's next movement based on the information.

Other companies, including Qualcomm, Ericsson, Huawei, and Nokia, are looking to 5G and edge computing as a potential solution to the problems faced by autonomous vehicles.



Their consortium, the 5G Automotive Association (5GAA), began work on "cellular-vehicle-to-everything" or C-V2X technology in 2016. Rather than cars determining individually how to act, in the C-V2X system, driverless vehicles communicate with one another and with parts of the physical environment like traffic lights and construction signs in order to coordinate movements safely and efficiently.

The system is in a testing phase today, but researchers believe 5G could help enable truly autonomous driving in the future. The number of automotive 5G connections is expected to reach 96M by 2027, according to telecoms consultancy Analysys Mason.

5G availability would mean a greater density of sensors in the environment and faster data transmission from centralized servers to those sensors and vehicles — and as a result, faster improvement via machine learning algorithms.

The average autonomous car of the future could produce as much as 2M gigabytes of data per week, and moving all of that data to the cloud or a regional server isn't feasible today with Wi-Fi or 4G.

RETAIL

Over the last several years, retailers have invested millions in smart technologies to help customers shop more efficiently and check out faster, while collecting more data on the customer experience.

From in-store analytics to visual recognition-driven shelf monitoring, all depend on or benefit from the ability to transmit large amounts of data and access high-throughput connections, which is why 5G technology stands to have such a large impact on the way retailers operate.

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Current "smart shelves" incorporating RFID technology, for example, can tell a business owner the ratio of item pick-ups to sales and display dynamic prices. With 5G technology, shelves equipped with sensors could determine low stock on a product, ping a distribution center to restock its inventory, and dynamically monitor the progress of that shipment.

The amount of data needed to move over the mobile network is too great for existing infrastructure, according to AT&T.

Today, companies like Sephora use virtual try-on technology to help in-store customers see what a particular makeup would look like on them before they buy, but the product is constricted by data streaming limits. 5G technology eliminates such limits — we could one day try on our clothes in augmented reality with such accuracy that it would be hard to tell apart from reality.

5G also has the potential to create entirely new types of shopping experiences that would be unthinkable with today's technology: an augmented reality application on your smartphone, for example, that triggers when you enter a store and guides you directly to the shelf where you can find your items of choice. The physical groundwork for these kinds of experiences is already occurring with cashier-less retail (e.g. Amazon Go).

Improvements in connectivity as a result of 5G technology could increase retail revenue by $12B annually by 2021, according to Adobe Digital Insights.

ENTERTAINMENT

Media giants such as Fox and Warner Brothers have already begun to explore the use of 5G technology. 5G channels will be able to offer live streaming of unparalleled quality. Amazon and Dis Network are already in negotiations to jointly build and support a 5G network.

Download speeds will also decrease dramatically over 5G, making movie, game, and TV downloads possible in seconds rather than minutes. This could propel a shift away from streaming and towards mobile downloads, as downloaded media can be accessed and enjoyed with or without connectivity.

Better mobile connectivity is projected to propel global mobile media revenue to $420B annually by 2028, according to a 2018 Intel/Ovum report.

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5G could have an even more transformative effect on augmented reality (AR) and virtual reality (VR). VR and AR applications have a higher field of view, resolution, and frame rate than conventional media, and as such require a significantly higher level of bandwidth and lower level of latency in order to transmit a consistent experience to the viewer.

Your typical 4G connection has about 60ms of latency, far too slow for the VR experience, which can become disorienting and jarring even at 15ms. 5G, on the other hand, promises a latency of between 1-4 milliseconds.

Faster connectivity through 5G will also be revolutionary for the e-sports and gaming industry, where quick response times can often determine a player's success. Mobile 5G gaming revenue is expected to be worth $100B by 2028, according to the Intel/Ovum report.

ENERGY

With high speeds and low latency, 5G could help enable more cost effective energy transmission.

Faster connection speeds could result in energy grids being more efficiently managed, which, in turn, could lead to less downtime. For example, in the event of a power outage, 5G-driven smart power grids could quickly provide insights into the problem using data and sensors. The tech could also lead to a more stable supply of energy, as suppliers would be equipped to make better-informed decisions about distribution of power based on vast amounts of data and smart sensors.

5G could allow for more efficient transmission and management of energy.

A version of this type of smart grid can be seen in Hawaii, where a system built in collaboration with Verizon analyzes outages and monitors meters. Verizon anticipates this grid to become more efficient as it continues the rollout of its 5G network in the US in the coming months.

Better connectivity could also have upsides on the consumption end. Streetlights connected with 5G technology and equipped with sensors could switch off if there aren't any people or vehicles on the road, thus saving energy. This approach could lead to savings of up to $1B annually in the US, according to a report from Accenture.

With 5G allowing better connectivity between devices, more homes will likely become equipped with smart meters. These meters will be able to provide insight on energy consumption of different home appliances and devices, giving home owners more information to manage their energy use.

Verizon believes that the energy industry will be a key demonstration of 5G's potential, with the company stating that the sector will be one of the "most significant test cases" for 5G technology.

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AGRICULTURE

5G will offer farmers the opportunity to get faster, more accurate information in the field — which could help to increase outputs like crop yield and make it easier to prevent common crop and wildlife illnesses.

Companies such as SlantRange are already providing drone services for farmers to gain insight into their crops. With 5G connectivity, such services could operate with much more accuracy. Autonomous tractors, for example, may eventually use 5G to pair with drones to guide their work, like identifying which parts of a field needs fertilizer.

Precision farming is expected to see major improvements with 5G technology. For resource-intensive crops, factors such as soil health need to be monitored to help increase yield. Syncing a precision farming process using current 4G LTE networks can take about 30-60 seconds. With 5G, this process can be brought down to less than one second, according to John Deere Technology Innovation Center.

FINANCIAL SERVICES

With the growth of mobile banking and fintech, financial services has been moving towards greater personalization and ease of access for the last decade.

But 5G has the potential to accelerate that transition and transform banking into a more ubiquitous and instantaneous process.

For example, mobile payments could happen much faster and more reliably as multiple processes could be executed in parallel. 5G could also allow mobile apps to keep less data on devices — instead quickly recalling it from the cloud — resulting in lighter and more responsive apps.

Some observers are betting on 5G to bring better banking to areas where physical branches aren't present. AT&T, for example, is reportedly developing mobile branches for banks in the US, which will be connected using 5G technology. These mobile branches are envisioned as serving scenarios like music festivals, pop-up shops, and remote areas with low banking needs.

The banking sector's efforts towards providing greater personalization in services will also likely get a boost from 5G. For example, increased data collection that enables sharper artificial intelligence capabilities could provide insights that allow banks to deliver highly tailored services to customers.

SUPPLY CHAIN MANAGEMENT

By making digital communication more ubiquitous, 5G tech has the potential to transform nearly every part of the supply chain. In a warehouse, for example, 5G-connected devices coupled with sensors would allow quicker communication, collection of a larger amount of data, and faster responses to breakdowns.

One application of 5G tech in supply chains is tracking and tracing packaging or parts in real time. Faster internet speeds, connected sensors, and more bandwidth could make it possible for companies to continuously monitor the condition of individual packages being shipped.

This ability to better track individual packages could also streamline insurance claims for damaged shipments. With 5Genabled sensors attached to packages, it would be easier to monitor their status — including variables like temperature, moisture, and location — information that would help stakeholders identify where things went wrong and claim insurance accordingly.

Autonomous delivery, which is already being tested by companies like DHL, is another area that could receive a boost from 5G connectivity. As a larger number of devices will be able to latch on to the same network, it will allow companies to deploy more connected autonomous vehicles in dense areas.

Four drivers paving the way for 5G

Below, we identify 4 primary drivers that will bring widespread 5G adoption to reality, and highlight how they will contribute to the deployment and use of 5G systems.

FIBER-OPTIC INFRASTRUCTURE

While sometimes perceived as competing technologies, fiber-optic networks and wireless networks often work in tandem. In the case of 5G, fiber is required to reach the multi-Gbps speeds promoted by wireless carriers.

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Fiber-optic cables are faster than coaxial copper cables

	Fiber-Optic Cables	Coaxial Copper Cables
Cable Types		
Typical Bandwidth	More than 1 GB/s	Up to 1 GB/s
Benefits	Immune to electromagnetic and radio frequency interference	Inexpensive
Limitations	Expensive	Affected by electromagnetic and radio frequency interference

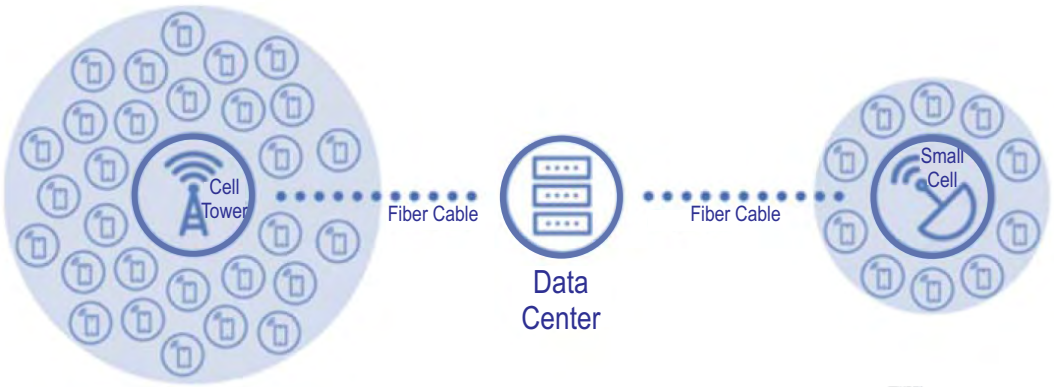
Source: cbinsights.com

CB INSIGHTS

Data travels through wires the majority of the time, with wireless antennas typically completing the last few miles of delivery. In this way, fiber functions as the nervous system to the mobile network.

Connecting data centers to cellular antennas (cell towers or small cells) with fiber will allow for the near real-time speeds expected from 5G. Fiber-optic infrastructure is prevalent today and used by current 4G systems, but more will be required to support widespread 5G.

Fiber-optic cables are necessary for 5G speeds



Source: cbinsights.com

CB INSIGHTS

Wireless service providers are leveraging different strategies to scale their 5G networks. For example, Verizon is looking to own its fiber backhaul (underlying connective infrastructure).

The company has worked with specialty glass manufacturer Corning and fiber provider Prysmian to design and install fiber optic cables for 5G.

In April 2017, Verizon announced a three-year purchase agreement with Corning to buy 12.4M miles of optical fiber each year for the next three years.

T-Mobile, on the other hand, leases "dark fiber" (unused or underutilized fiber) to support its small cells deployment. While the company may not own the fiber, it can provide 5G services sooner as much of the leased backhaul is already installed.

Both providers aim to further roll out 5G services in 2020. T-Mobile turned on its 5G network in the US in late 2019 and Verizon is planning to invest around $18B in infrastructure including fiber optic cables to expand services like 5G.

Most of these 5G deployments will probably look to support urban centers before expanding to rural areas. However, areas already infused with pervasive fiber — urban or rural — are likely candidates for early 5G deployments.

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SMALL CELL DEPLOYMENT

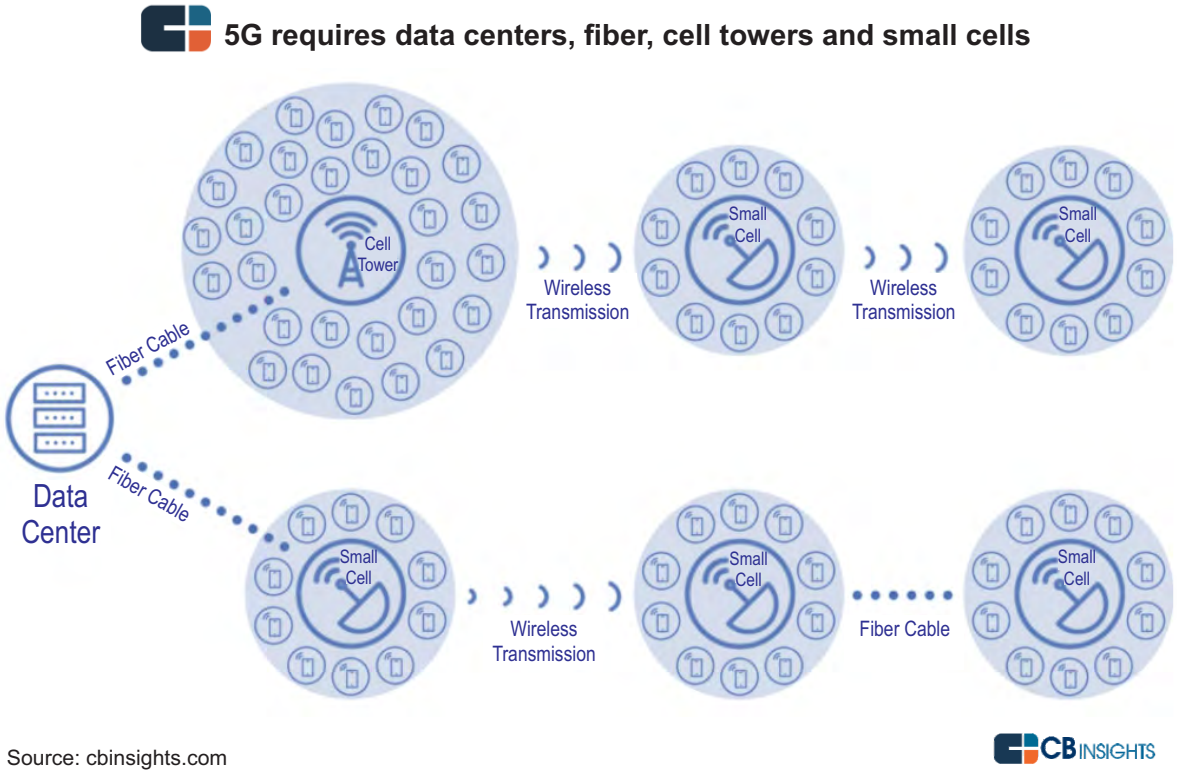
Much of today's wireless data is delivered through macrocells, known more commonly as cell towers. They provide the foundation for wireless connectivity and can serve thousands of mobile users within a radius of up to 40 miles.

While macrocells continue to serve the telecom industry well, they're difficult to deploy and maintain. The costs of regulatory approval, construction, power, and maintenance make traditional macrocell towers a necessary burden for wireless connectivity.

Small cells (or microcells) are growing contributors to wireless connectivity, supporting the wireless systems of the present and future. They serve fewer mobile users but are much easier to install and maintain. They're also cheaper, more energy efficient, and require less red tape than macrocells.

Small cells communicate wirelessly with macrocell towers, other small cells, and individual mobile devices. Certain small cells connect directly to fiber cables while others provide support to wireless mesh networks that improve wireless coverage.

In rural areas, small cells can help extend coverage; in densely populated areas, they can strengthen capacity.



Some of the newest small-cell technology is hidden in plain sight. In Los Angeles, small cells have been deployed as part of smart streetlights to strengthen 4G networks.

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In deploying these small cells, LA has also installed some of the necessary infrastructure required for tomorrow's 5G networks.

5G will work best at short, unobstructed distances. A number of small cells will be required to serve the same area that a single macrocell can cover — though the small cells will provide much faster speeds.

T-Mobile has already installed 15K small cells, with plans to deploy another 25K in the near future. These cells support the rollout of the company's 5G services in 30 cities, including Los Angeles, New York, and Dallas.

In October 2018, the FCC announced a new set of guidelines that restrict the ability of states and local communities to charge carriers for deploying small cells colocated with public infrastructure, a step expected to speed up the rollout of small cell technology across the country.

In addition to the successes with small cell deployment, there have been a string of complications.

Wireless carriers are beginning to realize that small cells will have to comply with a host of new regulations and meet certain demands from local residents who are concerned about the pervasive new technology.

Sprint paid an $11.6M fine for failing to secure appropriate permits. AT&T received pushback due to the "needlessly messy" design of certain small cells, and the city of Santa Rosa, CA, suspended Verizon's deployment for similar reasons.

The city of Hillsborough, California charged AT&T $60,000 in application fees for 16 nodes. It rejected the applications.

Some of these roadblocks led to the FCC's decision to reduce states and localities' ability to charge carriers for small cell deployment.

Small cell deployments are still in their early stages. That said, many carriers started offering their first 5G services in 2019. Mobile users should expect major carriers to offer 5G services in the largest US cities by the early 2020s.

HIGH-FREQUENCY SPECTRUM AVAILABILITY

In addition to fiber infrastructure and small cell deployment, 5G speeds also require radio waves with extremely high frequencies. These frequencies need line-of-sight within a small radius to successfully communicate.

In other words, increasing demand for wireless coverage, speed, and consumption requires the use of new bands within the radio wave spectrum. A band is a specific frequency range on the radio wave spectrum. They range from low (3-30 kHz) frequencies to extremely high (30-300 GHz) frequencies.

For context, AM radio uses the medium frequency band (300 kHz-3 MHz), leveraging the specific frequencies between 500 and 1700 kHz (or 1.7 MHZ).

Wi-Fi and Bluetooth, on the other hand, use the ultra-high frequency band (330 MHz-3 GHz), leveraging the specific frequency of 2.4 GHz. Many mobile devices are designed to communicate on both the 2.4 GHz and 5 GHz frequencies for Wi-Fi.

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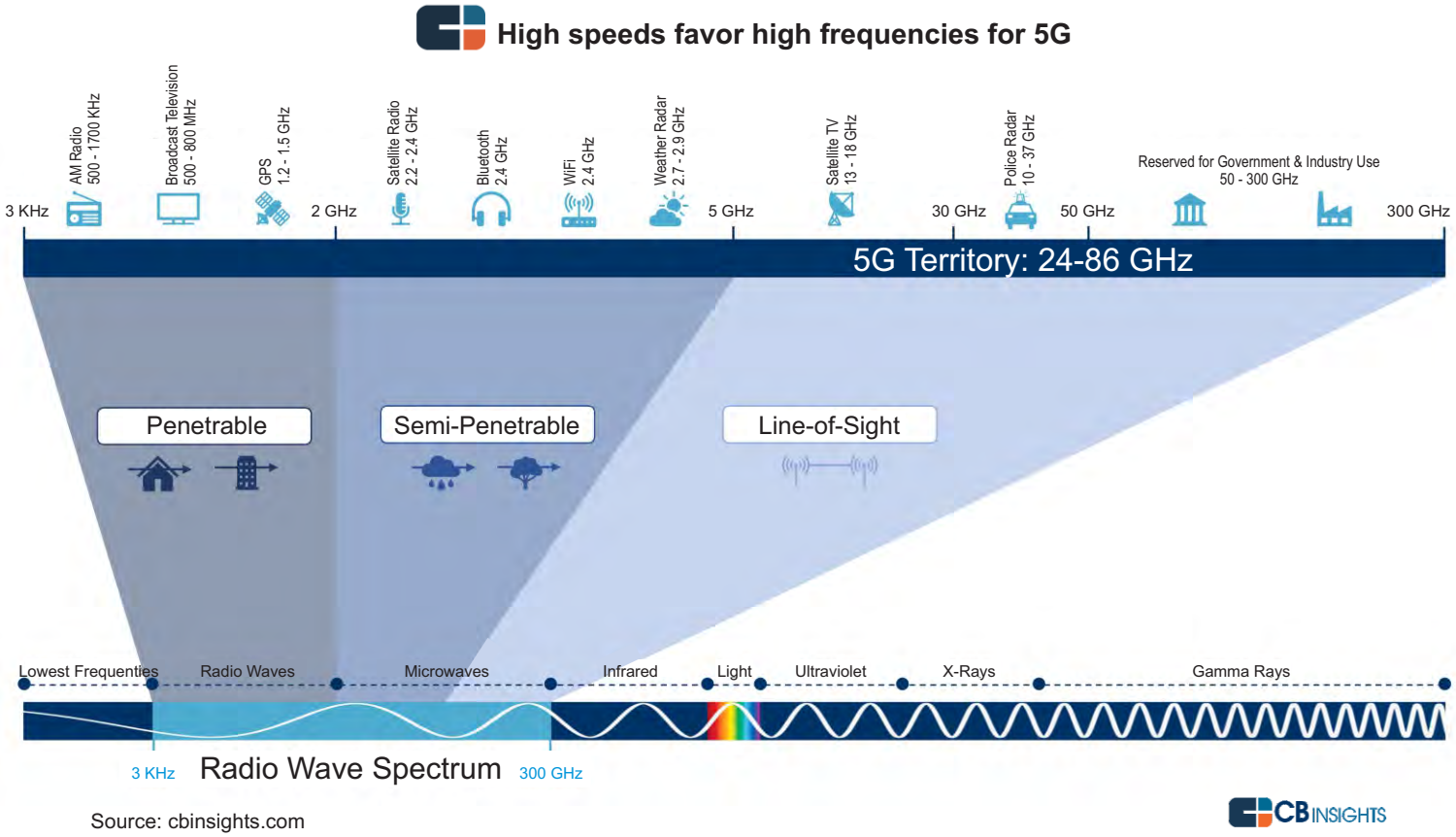

While higher frequencies allow for faster data transmission, they're unable to pass through certain structures. For example, satellite TV, which typically uses frequencies between 13-18 GHz, requires a direct line-of-sight to prevent disruptions. Heavy rainfall or an overgrown tree could impact viewing quality.

For most 5G networks, the super high (3-30 GHz) and extremely high (30-300 GHz) bands will be used to deliver the Gbps speeds promised by wireless carriers. Frequencies between 24 GHz and 86 GHz will be particularly popular.

The FCC began auctioning off the rights for the 28 GHz 5G band in November 2018 to a total of 40 telecoms, wireless carriers, and other entities.

Verizon did not take place in the auction because it already owns a license for part of the 28 GHz band, which it obtained through the acquisition of XO Communications.

By mid-December, total bids in the auction had reached more than $688M. The agency has never distributed this volume of spectrum at auction previously, and is doing so now since "wireless carriers have been talking up the need for speed and bandwidth for an internet of everything, 5G world," according to the FCC.

The FCC began auctioning more of the 5G spectrum in early 2019, and it is planning two additional auctions in the second half of 2020.

Certain spectrum will be allocated for shared access. With the use of a Spectrum Access System (SAS), carriers can dynamically access shared frequencies based on availability. This will allow carriers to scale bandwidth up and down based on network demand.

It will also provide spectrum access to smaller commercial users that don't license dedicated spectrum of their own. SAS providers like Federated Wireless ensure secure, interference-free bandwidth using proprietary software.

Shared or licensed outright, these higher frequencies will require small cells to be arranged in a way where they maintain line-ofsight between mobile users or other small cells. While an abundance of small cells will help to maintain 5G coverage, another wireless configuration called "fixed wireless" will help deliver wireless coverage indoors.

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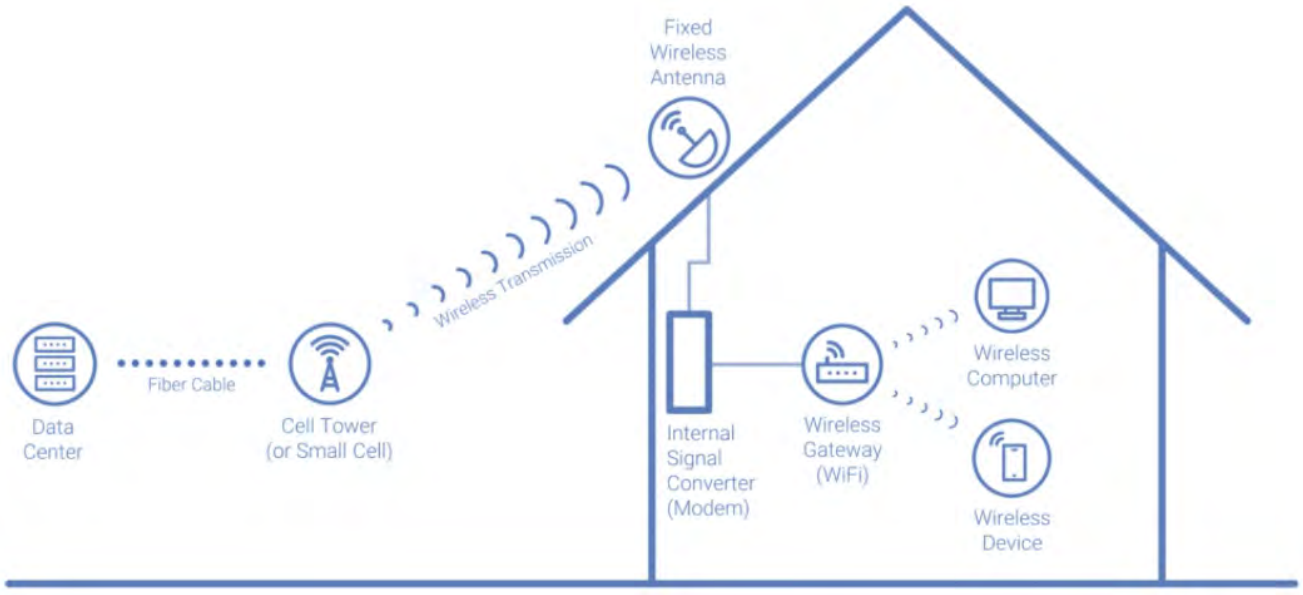
BRINGING 5G INDOORS WITH FIXED WIRELESS

Though the high frequencies of 5G require a direct line-of-sight, "fixed wireless" will allow for cellular coverage within buildings and homes, without the use of cables or lines.

Fixed wireless antennas are placed on top of homes and buildings to communicate with nearby small cells or macrocell towers. While these fixed wireless antennas must maintain line-of-sight with the nearby cells, they are able to extend cellular coverage into homes and buildings.

These antennas may be connected by fiber to internal picocells or femtocells, which are used to relay wireless coverage to a small number of mobile users indoors. The wireless signal can also be converted to conventional Wi-Fi with the use of specially designed modems and wifi routers.

5G may also provide stationary internet with fixed wireless



Source: cbinsights.com

CB INSIGHTS

The ability to convert a cellular signal to Wi-Fi may enable wireless carriers to compete with traditional ISPs like Comcast and Time Warner.

Verizon, which already provides internet access to homes and businesses, rolled out fixed 5G wireless services in a handful of cities in 2018. These services will provide an alternative to internet access delivered via fiber while maintaining comparable speeds.

The company is partnering with Samsung for its fixed wireless 5G routers, which will convert wireless 5G signals and enable Wi-Fi compatibility.

While Verizon plans to offer fixed 5G wireless access before any of its mobile 5G services, the infrastructure will help to support both mediums.

In September 2018, Verizon unveiled its first service offering in this space, named "Verizon 5G Home." The service became available for residents of Houston, Indianapolis, LA, and Sacramento, with advertised speeds between 300 Mbps and 1 Gbps: slower than initially promised by the company. While the telecoms company had planned to expand the deployment of fixed 5G for homes in 2019, it pushed back the date to mid-2020 to give time to get equipment that was powerful enough to support the network.

AT&T, while initially skeptical of the fixed wireless opportunity, announced in September 2018 that it would begin to rollout a fixed wireless service by late 2019.

Both companies are working with Samsung for the delivery of critical infrastructure for their 5G launches. On the other end of the spectrum, companies like Google may start to build a mobile 5G network using the number of fixed wireless assets installed as part of its growing Webpass business (acquired in 2016).

Ultimately, fixed wireless is early in its progression to extend mobile 5G service into buildings beyond line-of-sight or to provide internet access to homes and businesses.

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BARRIERS TO 5G ADOPTION

Even as 5G services become more common, the tech still has hurdles to overcome.

One major obstacle is that network providers will need to install a lot of new, and expensive, infrastructure.

Another challenge is range. 5G often relies on high frequency waves to gain its speed advantages over 4G, but this also entails shorter wavelengths — reducing the distance that 5G can carry a useful signal. With 5G signals tending to travel relatively short distances, network providers will need to deploy more antennas and base stations to ensure broad coverage.

All this additional infrastructure will lead to high upfront costs for network providers. Network providers globally are expected to spend $88B per year by 2023 on 5G network deployment, according to a report by Heavy Reading.

There are also some security and privacy concerns around 5G deployment. Alongside fears that compromised 5G infrastructure could create the potential for espionage, the new networks may create opportunities for vulnerabilities as underlying processes are more thoroughly scrutinized.

For example, security researchers found shortcomings in 2018 in a 5G security protocol known as Authentication and Key Agreement (AKA) that in some cases could be used to steal sensitive information. As 5G evolves and is rolled out more extensively, other vulnerabilities may emerge.

What's next for 5G

As numerous wireless carriers plan to offer 5G service in the capitalize on this shift to higher radio wave frequencies:

- Qualcomm unveiled new Snapdragon 5G-enabled chipsets late last year, which are intended to power high-end smartphones in 2020.
- Verizon launched its first 5G broadband internet networks in 4 cities during late 2018 and now plans to offer 5G in 60 US cities by the end of 2020.
- AT&T rolled out 5G mobile hotspots in a dozen cities in 2018 and plans to begin deploying standalone 5G, which does not use any functions from 4G LTE, in 2020.
- Sprint launched 5G in four US cities in the May 2019 and has now expanded its 5G network in to 9 cities.

Companies like Zayo are helping to lay the necessary fiber to support these 5G networks, while others like Siklu are providing fixed wireless antennas and small cells. Manufacturers of 5G devices also play one of the more important roles in 5G adoption: device manufacturers need growing coverage, while wireless networks need a growing number of compatible devices.

It is likely that the new technology will affect device design. Some prototypes currently exist, but it may take some time before manufacturers can properly — and aesthetically — integrate new 5G antennas into mobile devices. But with so many companies working to make the technology a reality, consumers should expect to see a range of 5G-enabled devices in the near future. Once carriers activate 5G in a minimum viable number of cities, compatible phones will soon follow.

While 5G service may be start to become more broadly available in the coming year, 4G will still remain the default service in areas outside of a select few densely populated cities. Widespread 5G coverage could take over a decade — and as for the broader industrial applications of 5G, estimates suggest that adoption will take off in the early 2020s.

Photo Sources: Brick Phone, Macrocell Towers, Smart StreetLight,Qualcomm 5G Phone Prototype

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This report was created with data from CB Insights' emerging technology insights platform, which offers clarity into emerging tech and new business strategies through tools like:

- *Earnings Transcripts Search Engine & Analytics to get an information edge on competitors' and incumbents' strategies*
- *Patent Analytics to see where innovation is happening next*
- *Company Mosaic Scores to evaluate startup health, based on our National Science Foundation-backed algorithm*
- *Business Relationships to quickly see a company's competitors, partners, and more*
- *Market Sizing Tools to visualize market growth and spot the next big opportunity*

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NI, Radisys and CommScope Collaborate on 28 Ghz 5G New Radio InterOperability Device Testing

LORI MESECKE | PR | https://hub.radisys.com/press-release/pr-nicommscoperadisys-28ghz5g

AUSTIN, Texas – April 24, 2019 – NI (Nasdaq: NATI), the provider of platform-based systems that help engineers and scientists solve the world's greatest engineering challenges; Radisys®, a global leader of open telecom solutions; and CommScope (NASDAQ: COMM), a global leader in infrastructure solutions for communications networks, today announced that they have collaborated to demonstrate a 28 GHz 5G New Radio (NR) network at the Brooklyn 5G Summit 2019. This first public demonstration of the three companies' collaboration shows a 28 GHz base station or gNodeB built from a CommScope remote radio unit (RRU) running software developed by Radisys that communicates with an NI Test UE.

Commercial rollout of sub-6 GHz 5G networks has begun, and mmWave technology continues to be developed even as this rollout is underway. Research and development teams around the globe have been tackling the challenges that mmWave presents, and early versions of 28 GHz equipment are emerging. An important step in delivering this technology to market is helping to ensure that network equipment (gNodeB) and user equipment (UE) work together properly (commonly referred to as InterOperability Device Testing, IoDT) and that the technology can be used in a variety of scenarios from inside a lab to outdoor field trials.

This demo showcases a 3GPP Release 15 non-standalone mmWave network created using equipment from multiple vendors. The above-6 GHz NI Test UE runs a physical layer designed by NI on NI's mmWave Transceiver System and a mmWave software defined radio (SDR) with an upper layer stack provided by Radisys. The 5G NR Software Suite by Radisys enables the NI Test UE in mmWave frequency spectrum for non-standalone and standalone modes of operation. The gNodeB is built with a physical layer running on an Intel FlexRAN, an upper layer protocol stack provided by Radisys and a remote radio unit (RRU), or antenna, from CommScope. A commercial LTE small cell is used as the LTE anchor. Combined, this system can make a live 5G NR mmWave call between the NI Test UE and the commercial 5G base station, made up of a CommScope RRU, Intel FlexRAN and Radisys protocol stack.

"We're pleased to work with industry leaders NI and CommScope to power this important demonstration that showcases the industry's first multivendor RAN ecosystem based on O-RAN compliant specifications, especially the F1 interface for CU – DU disaggregation enabling mmWave 5G deployments for cases beyond just fixed wireless backhaul," said Neeraj Patel, vice president and general manager of Software and Services at Radisys. "In addition to delivering a scalable Open RAN solution, Radisys also provided integration, test and validation services for end-to-end operationalization of the complete system from the UE to the gNB to the core network. We're excited about the possibilities that 5G offers to our customers, and we're committed to accelerating commercialization of these successful trials."

Farid Firouzbakht, CommScope senior vice president of RF products, said, "Our integrated antenna enables the full capabilities of 5G mmWave spectrum bands while offering maximum flexibility within an open RAN environment. As a contributing member to the ORAN organization, we endorse the benefits of an open baseband interface for enabling more innovation in the wireless marketplace."

James Kimery, NI director of marketing for wireless research, said, "This demonstration validates NI's hardware and software mmWave SDR platform by involving commercial vendors CommScope and Radisys. This is one of the first end-to-end mmWave systems developed, and it clearly demonstrates multivendor interoperability that is critical to the wider 5G ecosystem."

About NI

NI (www.ni.com) develops high-performance automated test and automated measurement systems to help you solve your engineering challenges now and into the future. Our open, software-defined platform uses modular hardware and an expansive ecosystem to help you turn powerful possibilities into real solutions.
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About Radisys

Radisys, a global leader in open telecom solutions, enables service providers to drive disruption with new open architecture business models. Radisys' innovative disaggregated and virtualized enabling technology solutions leverage open reference architectures and standards, combined with open software and hardware to power business transformation for the telecom industry, while its world-class services organization delivers systems integration expertise necessary to solve communications and content providers' complex deployment challenges.
For more information, visit www.Radisys.com

About CommScope

CommScope (NASDAQ: COMM) and the recently acquired ARRIS and Ruckus Networks are redefining tomorrow by shaping the future of wired and wireless communications. Our combined global team of employees, innovators and technologists have empowered customers in all regions of the world to anticipate what's next and push the boundaries of what's possible. Discover more at www.commscope.com.