



# 5G: It Will Be Here Before You Know It

## Introduction

Activity regarding the next generation of wireless, 5G, is building significant momentum. Several tier one carriers have already announced pre-standard trials and there are projections that 5G will be widely available by as early as 2020 – just 3 ½ short years away.

There are applications for both fixed and mobile broadband in 5G, with the fixed wireless broadband option expected to arrive first. The arrival of 5G creates a variety of implications for wireline and wireless providers alike, including backhaul opportunities, competitive factors, and spectrum management.

This whitepaper provides an overview of 5G, outlining its current state, its spectrum roadmap, and its emerging applications.

## 5G Today

To understand 5G today, you have to separate the marketing term 5G from the technology term 5G. While there has been significant discussion and announcements regarding 5G and its capabilities, the actual technology and the standards it will follow have yet to be determined. There is ongoing 5G technology and standards work from global organizations, including the ITU, GSMA, and 3GPP, among others, to formally define the technology and its capabilities. True 5G standards aren't expected to emerge until at least 2020.

But that hasn't stopped a wide ranging amount of 5G public relations activity from both large tier 1 carriers and the vendors who serve them. There is an ongoing 'press release war' of sorts between carriers and vendors, announcing their pending 5G plans and capabilities. Because most of this early 5G activity is pre-standard, it can really be characterized as 4.5G activity, where carriers and vendors are taking pre-5G standard equipment and applications, and applying them on existing 4G networks and infrastructure.

These announced activities include the potential for the industry to see pre-5G standard applications brought to market, perhaps as early as 2017. Verizon has been the most active with these early 5G proclamations, stating their intention to bring a pre-5G standard wireless service to market, that will be a fixed wireless solution for broadband access. <sup>1</sup>

"Having reached several key milestones such as 5G radio specifications, entering full system, broader pre-commercial market trials, and Verizon's continued collaboration with carriers and vendors, Verizon continues to drive the 5G ecosystem toward rapid

commercial deployment," wrote Verizon in a recent 5G progress report.

## 5G Spectrum

In July of 2016, the FCC adopted an order that outlines and defines 5G spectrum allocation for the U.S. This 5G spectrum band plan allocates a significant amount of spectrum, 11 GHz, across several bands for 5G use in the U.S. Additionally, the spectrum bands will be broken into high capacity blocks of 200 MHz.

The FCC identified the following spectrum bands for 5G use:

- The 28 GHz band (between 27.5-28.35 GHz) to be licensed on a county basis
- The 37 GHz band (between 37-38.5 GHz) to include shared access in the 37.37.6 band, and with licenses issued on a PEA basis for an "exclusively licensed" portion of the band
- The 39 GHz band (between 38.6-40 GHz) to be licensed on a PEA basis
- An unlicensed band between 64-71 GHz

This is the initial band plan, but it is by no means final. The FCC reserves the right to add additional spectrum bands to its 5G spectrum plan in the future.

This initial 5G spectrum is concentrated in the so called millimeter wave (mmWave) band. This spectrum is characterized as high bandwidth, high capacity spectrum, but with short range. These characteristics will require specific wireless engineering tactics to achieve acceptable performance, chief among them is densification of the network.

Because mmWave has short range, 5G networks will require more infrastructure than previous 4G and 3G wireless technologies. That will mean fiber rich backhaul connected to not just towers, but significant quantities of small cells and distributed antenna systems (DAS).

## 5G Network Goals

There are many 5G network goals, but the priorities include the ability to provide much higher bandwidth, much lower latency, congestion avoidance, and support for emerging IoT applications.

Higher bandwidth goals include wireless multi-gigabit access, or 100x faster speeds than what 4G typically provides on average today. Early use cases of 5G

are focused on fixed wireless applications, and with gigabit capable speeds, 5G is being eyed as a potential alternative to FTTH.

IoT applications have significant implications for 5G. The number of devices requiring network connectivity will number in the tens of billions worldwide, and many of them will need mission critical low latency characteristics. Connected and autonomous cars are one example, where low latency could literally mean the difference between life and death. 5G aims to provide 1 millisecond or less of network latency.

Because of its high power, low range characteristics, early 5G networks will look and act more like a super Wi-Fi network, providing very high bandwidth low latency connectivity in short range, than a traditional mobile network. 5G mobile applications will come later, as the 5G interface is applied to lower spectrum bands.

## 5G MIMO

5G will leverage multiple input, multiple output technology, where multiple antennas are used on both transmit and receive functions. These multiple antennas enable the use of multiple signals, reducing transmit and receive errors created by things like multipath wave propagation. MIMO offers higher bandwidth transmission and lower error rates.

Today's wireless networks utilize 4x4 and even 8x8 MIMO options. The introduction of 5G will bring 16x16, 64x64, and even 128x128 MIMO capabilities. When combined with a smaller cell serving radius, MIMO will help enable the significant improvement in bandwidth capabilities that 5G provides.

## 5G Applications

Beyond better wireless broadband capability and capacity, there are specific applications that 5G will help enable and many of them are focused on the interconnection of billions of devices that will bring 'smarts' to our daily activities. These IoT applications include smart cities/communities, smart vehicles, smart homes, and smart farms, to name a few.

### Smart Cities

By interconnecting millions of sensors throughout a city with a low latency high-capacity wireless network, cities can become smart and everyday life will be impacted. Traffic flows can be better monitored and re-routed in real time, reducing congestion and pollution. A city's electrical grid can be better managed and power can be applied where and when it makes the most sense, conserving electricity and lowering costs. Industry verticals like healthcare and manufacturing

can be monitored in real time allowing the proper resources to be applied wherever and whenever necessary. We're already beginning to see early use cases for smart cities, including the smart grid.

One example of the efficiencies that a smart city can enable is smarter refuse collection. In today's world, dump and refuse collection trucks traverse a city on pre-determined routes to collect refuse, regardless of whether there is refuse to be collected. But in a smart city, 5G connected sensors could determine if refuse collection is necessary and route trucks in real time, only to the necessary collection points. Instead of driving all over the city and wasting resources, trucks will only go where they are needed.

### Smart Vehicles

Perhaps the most recognized application today for 5G is smart vehicles. Much of that awareness focuses on self-driving or autonomous cars, where a human driver may be optional. But smart vehicles goes well beyond just driverless cars.

It includes vehicle-to-vehicle communication, fleet management, and robotic deliveries to name a few. With vehicle-to-vehicle communication, 5G connectivity will enable vehicles to talk with each other and share data, all without human intervention. Vehicles can share traffic and route information and can avoid accidents. If any given vehicle can automatically sense when the brakes of the vehicle ahead of it (even two or more cars ahead of it) are being applied, particularly abruptly, it can react itself. The impact of accident avoidance could be tremendous, saving lives and property.

Smart vehicle applications include trucks and fleets, in addition to passenger cars. Real-time routing of fleets and more efficient maintenance, thanks to sensors, will help fleet operators better apply their resources and lower costs. In addition to talking with each other, smart vehicles will talk to roads and highway infrastructure, helping ease the flow of traffic and avoid back-ups. Better traffic flow and fewer accidents will cut down on emissions and provide for 'greener' cities.

Smart cities and smart vehicle applications may also include autonomous drones and robots for deliveries. Rather than a package being delivered by a truck to a home or business, a drone could do the same and even enter the premise and deliver the package right to the kitchen table. This application could add great efficiency to deliveries, further removing vehicles from the road.

### Smart Homes

We are already seeing smart home applications coming into the mainstream, with wireless cameras for

security and monitoring and other networked applications taking hold. The introduction of 5G will only accelerate this momentum. More networked applications will proliferate and home automation will be built into everyday life, without human intervention.

An early look at this is Amazon's DASH program, where a simple connected button/sensor can be used to order everyday items. For example, a laundry detergent sensor button can currently be placed next to the washing machine in a home. When you need laundry detergent, you just press the button, and it is delivered to your home the next day, or even within the same day. Moving forward, that process will not need human intervention. The washing machine will order the laundry detergent on its own.

### Smart Agriculture

Smart farming applications are already in play and the introduction of 5G will make them smarter and wider in use. Sensors will proliferate all across the farm, including within livestock, to provide real time monitoring of the entire farming business cycle. This will add additional automation to the agricultural vertical, making farms much more efficient and hopefully, more profitable.

Applications like precision farming for better yields, and automated monitoring of livestock health for better animal well-being and economic vitality of herds and flocks will proliferate. The use of agribots, or micro robots, can tend to crops, managing fertilizing, weeding, and harvesting. Drones will be able survey fields for weed control and soil variations.

### Last Mile Broadband

An early emerging application for 5G is last mile broadband. The vast improvement in wireless broadband capability that 5G brings, makes it appealing for certain broadband connectivity into the home and business. 5G can deliver gigabit type speeds, and the ability to use it for 'last mile' or more like 'last 1,500 feet' options has significant appeal to broadband operators. Using 5G may allow broadband operators to use wireless for the 'drop' into the home, rather than fiber or coax. That significantly reduces cost for broadband upgrades and overbuilds. Several larger carriers including Verizon have outlined fixed wireless plans for 5G, with some examples coming as early as 2017.

AT&T also just introduced their AirGig technology, which is a wireless-powerline hybrid technology that uses electric powerlines to distribute broadband to a wireless access point. The electric powerlines act as waveguides, delivering broadband signals to 5G access points, which then beam broadband wirelessly into homes. AT&T promises multi-gigabit capabilities for this emerging technology, but commercial trials are a couple years off.

## Rural 5G Opportunities

Beyond the wireless broadband opportunity for wireless carriers, 5G presents many opportunities for wireline as well. The most obvious is leveraging fiber networks for backhaul. This is an attractive business today, but will only get better with 5G.

The network densification required by 5G will mean many more sites will need fiber backhaul, and it's not just traditional wireless towers. Hundreds of sites, including the use of small cells and DAS sites, will be needed to cover a 5G area that may have only needed 20 to 30 towers in a 4G environment. These sites will more likely than not require optical wavelength services over traditional Ethernet, due to low latency requirements.

These low latency requirements may drive additional rural carrier opportunities including increased demand for edge computing in the form of localized small scale data centers. One millisecond or less response times generally means servers for these applications need to be within 150 miles, traveling over fiber. That may drive demand for more edge computing infrastructure in rural markets.

## Conclusions

While there are still many technical and standards issues to resolve with regards to 5G, the technology is already impacting the market. By most accounts, we won't see full scale commercial introduction of 5G until 2020, but we will soon begin to see 4.5G momentum as early as 2017. Larger carriers and vendors are implementing 5G roadmaps that have implications for the entire broadband industry.

The technology of multi-gigabit wireless connectivity, with very low latency will enable many 5G applications. They include IoT driven smart cities, smart vehicles, smart homes, and smart agriculture to name a few. 5G is also driving a fixed wireless renaissance of sorts, highlighting last mile broadband applications which will emerge before mobile 5G applications.

There are many opportunities enabled by 5G and wireline and wireless carriers alike will need to evaluate them. That applies to rural carriers as well, where fiber backhaul infrastructure and edge computing look like early contenders.

Finley Engineering will be monitoring 5G closely and is prepared to assist clients with their 5G roadmap planning and implementation.

1 Verizon is first U.S. carrier to complete 5G radio specifications: pre-commercial trials continue full steam ahead, <http://www.verizon.com/about/news/verizon-first-us-carrier-complete-5g-radio-specifications-pre-commercial-trials-continue-full>



**About the author:**

Steve Senne has been a critical part of Finley Engineering's success since 1988, and is currently Finley's Chief Technology Officer. Working in both the Minnesota and Iowa offices, Senne has been responsible for feasibility studies, central office switching equipment, project management, and supervision of the installations and acceptance testing services for independent telephone companies. He has managed numerous independent telephone company projects across Iowa, including Next Generation Softswitch, VoIP, and IPTV video deployments.

Contact Steve Senne for more information at [s.senne@fecinc.com](mailto:s.senne@fecinc.com) or 515-334-5003.