5G Bootcamp
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Preparing for 5G Deployment

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Design for Evolution: Building 5G equipment that helps operators succeed today—and meet tomorrow's challenges.

Manufacturing wireless infrastructure equipment has never been a game for the faint-hearted. But the so-called 5G revolution has made the game even tougher, riskier, and more confusing for the designers who must define and create products in a market where the technology—and their customers' deployment plans—are still in a state of rapid evolution.

With so many factors in play, designing products that can satisfy wireless operators' requirements involves keeping a close eye on the state of the technology, the state of the market, and how those factors are shaping their ever-evolving deployment strategies. Hopefully, this snapshot of the industry, and the dominant issues we've extracted from it, will provide a little guidance on the features and capabilities your products must have in order to earn a place in carriers' 5G deployment plans.

Basic Realities

Despite the hype and FUD surrounding it, 5G is real, with a surprising number of carriers already starting to tool up their networks for some form of 5G service. Pay close attention to "some form of 5G," though. If the operators remain true to form, their initial efforts will resemble what they did during an earlier "wireless revolution" in the mid-1990s, when they deployed the first Personal Communication Service (PCS) networks.

Back then, the U.S. government was conned into auctioning off large chunks of spectrum in the 1850- to 1990-MHz band to carriers who promised that the networks they'd roll out would support the PCS standard's full suite of advanced digital features, which included paging (i.e. messaging) and wireless data/internet services. Instead, nearly all North American carriers simply used their newly acquired bandwidth to expand their still-emerging 2G digital cellular services. In doing so, they denied their customers the advanced capabilities PCS could have provided until the emergence of 3G cellular.

History rarely repeats itself, but it frequently rhymes. And that certainly appears to be the case with PCS and 5G, observes Dave Burstein, a noted authority on telecom technology and EiC of *Fast Net News.* His recent report on the state of 5G shows that, while 2019 has been the year it became a market reality, nearly all carriers deploying it are much more focused on using the technology's new capabilities to expand the capacity of their networks. This instead of offering their customers advanced features or significant improvements in speed and quality of service—at least for the next three to five years.

One significant example is that although 5G is intended to operate in three frequency bands, virtually all initial deployments outside North America are in the so-called mid-band region, residing at 3.1 to 3.55 GHz and 3.7 to 4.2 GHz. Their decision is primarily due to the mid-band spectrum's propagation characteristics, which are quite similar to the 2305- to 2320-MHz and 2345- to 2360-MHz bands they currently use for the majority of their 4G services.[1] This isn't true in the U.S., where most deployments are at 28 or 39 GHz, except for T-Mobile2 and Korea, which is running some trials at 28 GHz.

Burstein says it's likely that, for most of the world, the 5X to 15X gains in capacity that 5G's deeper modulation schemes, MIMO beamforming, and other technologies will give the mid-band channels will delay most serious efforts to deal with the much shorter range, complex fading issues, and other technical challenges required to tap the enormous capacity (at least 3X of mid-band) available in the millimeter-wave bands (27.5 to 28.35 GHz and 37 to 40 GHz) for several years.

Building for the Future

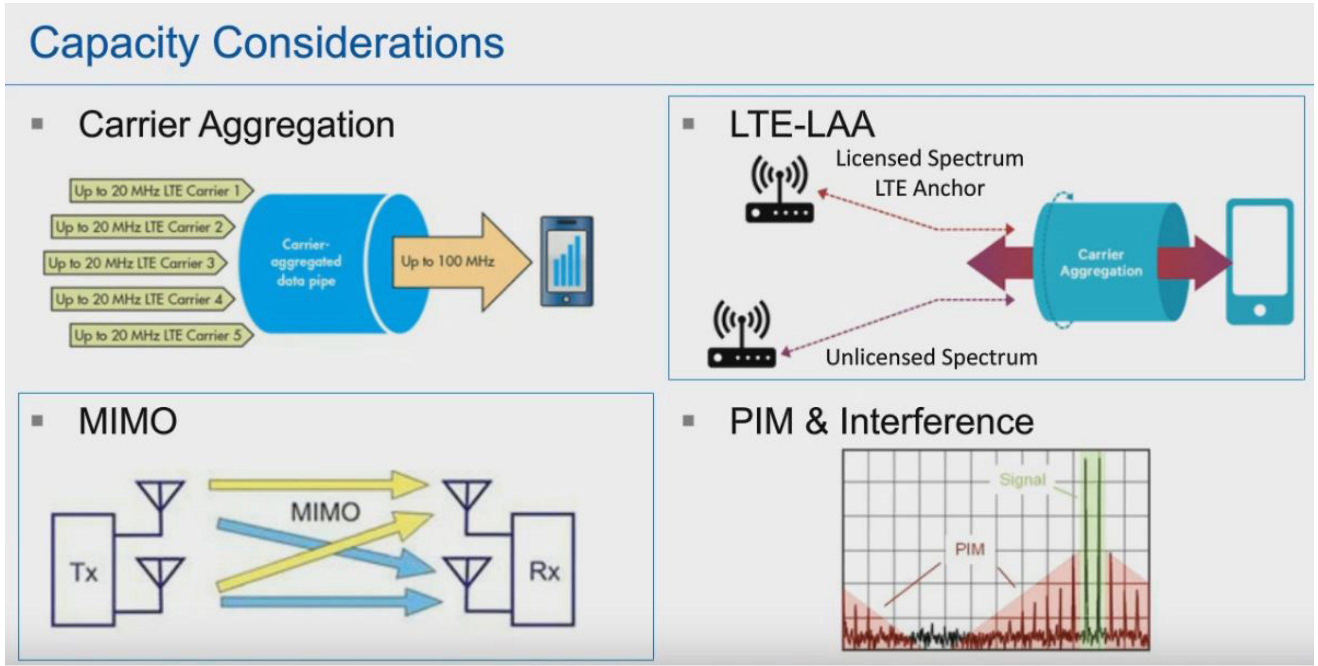
Wireless carriers' aversion to risk and attention to their immediate needs will no doubt have an impact. Specifically, with the exception of Asia, the first wave of 5G deployments will involve overlaying their current coverage by upgrading existing macro and small cell sites that deliver service at new frequencies.

This will delay the network upgrades needed to support things like the sub-10-ms latencies required for VR applications, indoor-friendly low-band services (600 to 700 MHz), and urban canyon-friendly MIMO-based beamforming. However, they also understand that the investments they make today must contain the seeds for tomorrow's networks. Nevertheless, they're buying equipment for today's upgrades that they believe will help them avoid painful "forklift upgrades" as their service offerings and overage strategies evolve.

To get a sense of the capabilities considered essential by carriers for smooth initial 5G deployments and cost-effective evolution over the next decade, let's look at some of the top-of-mind issues that Fast Net News identified during their conversations with over a dozen CEOs and CTOs of several leading wireless carriers:

Support Network Densification

Most carriers will be able to deploy 5G service with their existing fleet of cells and microcells. But, to realize the full potential of 5G, they will eventually need to “densify” their works. This involves dotting their territories with more access points that shorten link lengths and reduce the number of subscribers per cell. This will enable them to deliver the 500-Mb/s to 1-Gb/s download speeds they’ve promised without fear of congestion.



1. These are common densification strategies that will be employed by 5G. (Courtesy of Microlab)

According to Luke Getto, Director of Product Management at Microlab, this will involve a multi-pronged effort “that will be accomplished in space, time and frequency”[5] *(Fig. 1)*. Translated into English, Getto’s strategy involves dotting the landscape with 5G-capable small cells that can make the most of whatever spectrum they’ve got, using technologies such as:

Beamforming using MIMO techniques to create tightly focused, steerable spot beams that extend range, enable frequency reuse within a cell, and reduce interference caused by passive intermodulation (PIM) and other sources.

Channel aggregation techniques that create a single high-capacity “virtual band” from three, four, or five different licensed and/or unlicensed bands. License assisted access (LTE-LAA), for example, uses a combination of licensed and unlicensed bands (CBRS and Wi-Fi). Products that support channel aggregation must be prepared to offer options for frequency coverage from 350 to

5925 MHz to handle TETRA, commercial wireless, CBRS, LTE-LAA, and future 5G bands.

Distributed radio area networks (D-RANs) that use a single active node to drive a network of passive distribution points to lower the cost and increase the quality of coverage of indoor and heavily obstructed outdoor areas. D-RANs are frequently used in public spaces as shared infrastructure; therefore, the products you design should be able to be used as a neutral host and be multi-band capable.

Application	Frequency Requirement (Network/Air*)	Phase Requirement
LTE - FDD	16ppb / 50ppb	---
LTE - TDD	16ppb / 50ppb	+/1.5uS
LTE - MBMS	16ppb / 50ppb	+/-1uS
LTE - MBSFN	16ppb / 50ppb	+/500nS
LTE - Advanced	16ppb / 50ppb	+/500nS
OTDOA for e911	---	+/100nS
5G (MIMO & Tx Diversity at each Carrier Frequency)	Not yet ratified	+/-65ns

Tighter requirements

3GPP TS 36.104 V13.1.0 section 6.5.3.1

*Network = backhaul/fronthaul, Air = Antenna to UE (RF)

2. Shown are timing-precision requirements for wireless networks. (Courtesy of Microlab)

Prepare to Live on the Edge When Carriers Declare War on Latency

Virtually all of today's common business and consumer applications and run perfectly fine with the 45-ms delay typical for 4G LTE systems. It will be a while before the lower 30-ms latency that first-generation 5G networks can deliver becomes important. But this will change over the next decade as applications like streaming virtual reality (VR) become common and begin to push 5G systems to tighten up even further.

Streaming VR, for example, produces disorientation and nausea in most users if there's more than a 20-ms delay between a user's input and the change they see in their display. And if several companies' ambitious plans to use 5G as the network for cloud-based factory-automation systems become a reality, they may require latencies of 10 ms or less to keep 3D printers, robots, and material-handling equipment running safely and efficiently.

While India's Reliance Jio, Japanese carrier Rakuten, and China Telecom conduct aggressive trials involving many hundreds and even thousands of costly edge servers, most carriers are conducting much more modest trials—or even putting off any edge play for another year or two. But whenever latency becomes an issue in your market, Fast Net Future expects carriers will tighten up their networks using several strategies. These include "edge networks," which move servers away from the core and distribute them closer to the customer, often within telco networks.

Numerous designs for edge networks sprinkle servers at different points within the system. Level 2 edge networks that place servers one to three hops from the base station have already been shown to reduce latency in today's 5G networks from ~30 ms to around 15 ms.

As one would expect, 5G's lower latency also means that all network elements must be more tightly synchronized. In fact, supporting 5G's high data rates and lower end-to-end delays requires nearly a 10X improvement in timing precision over LTE-Advanced networks *(Fig. 2)*.

This means that to be ready to play well with edge-network architectures, you need to make sure that your products can work with a wider range of backhaul technologies and timing protocols. This includes the IEEE 1588 Precision Time Protocol (PTP)7 and the 3GPP protocol over wired, fiber, and wireless media.

Prepare for Fixed Wireless

5G's ability to deliver bucketloads of bandwidth to mobile subscribers has attracted the attention of telcos, wireless carriers, and disruptive startups. It serves a great tool for delivering connectivity to homes, businesses, and other customers who are either out of reach of their existing networks, or to customers in the market for an alternative to the duopoly that exists in most parts of the country. While it's unlikely that 5G will ever displace wired broadband, it will constitute a significant part of the market within the foreseeable future. *Wireless One News* predicts that 20%+ of U.S. customers will be getting their data via a 5G network by 2023.[8]

To capture business in this market, your products will need to support massive MIMO for precision beamsteering on the front end and compatibility with both wired and wireless backhaul on the back end. There's also the matter of PON connections for regions where FTTN infrastructures are already built out. It's early days for the fixed wireless market, so it's tough to say for certain whether there will be any demand for products capable of providing a shared infrastructure for multiple carriers, but that should probably be a lower priority for your development team.

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