

5G Technology

Amplifying the Next Big Thing- Prepare to Be Amazed

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Issue

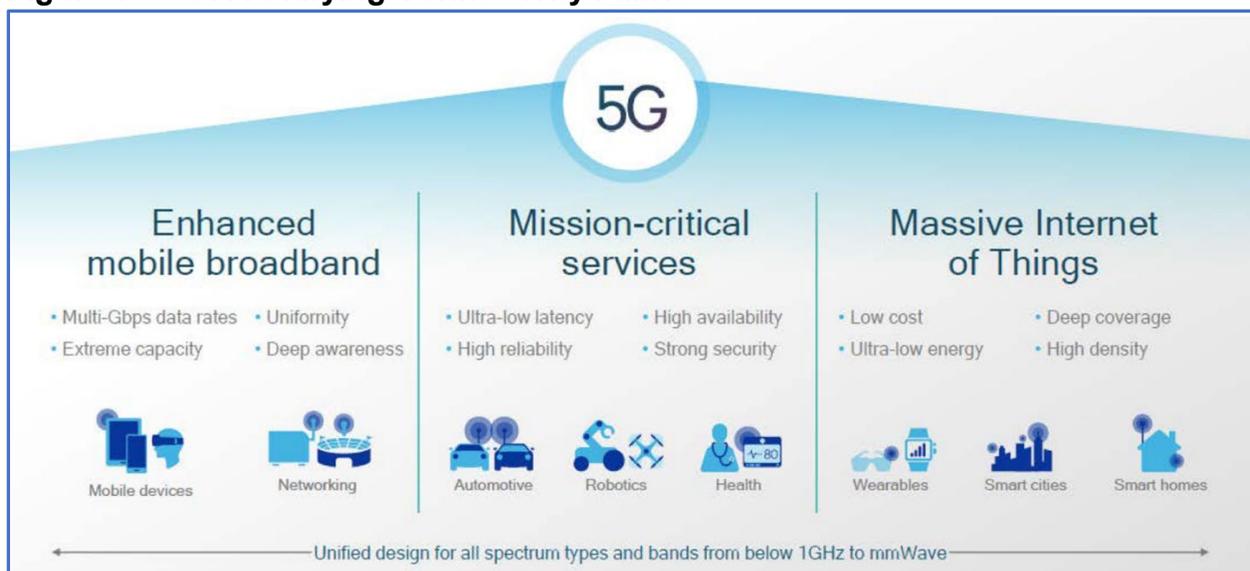
As technological advances continue to accelerate, one of the most common questions presented is, “What is the next big thing?” Every cycle in the electronics industry has been driven by a major technology, market or economic force ranging from consumer electronics, various generations of personal computers, and wireless/mobile communications to global economic booms and busts. Excitement is building in anticipation of the “next big thing.” What will it be? The answer is that the next major industry cycle will be driven by a triad of technologies that will form a “Technology Triumvirate” that will impact nearly every aspect of our life including globalization, economic growth, connectivity and sustainability.

The three technological forces that will shape the future could be compared to key strengths of a world-class athlete:

- **The Cloud:** The brain fueled by collective, global intelligence
- **Internet of Things (IoT):** The senses magnified by multi-dimensional, comprehensive measurements and muscles acting with athletic precision and coordination
- **5G Wireless Communications:** The nervous system powered by an efficient, reliable network of systems that radiate across personal, local, wide-area and global environments

The focus of this analysis is the rapidly advancing 5G wireless communications technology that will fuel revolutionary changes that will sweep the world and deliver resilient growth opportunities for prepared participants in the electronics value chain.

Figure 1 – 5G: A Unifying Connectivity Fabric



Source – Qualcomm

In an eloquent description of the expected global impact of 5G, Qualcomm proclaims on its website, “5G mobile technology will, like electricity or the automobile, benefit entire economies and benefit entire societies. This is because the global 5G standard (5G New Radio) will advance mobile from largely a set of technologies connecting people-to-people and people-to-information to a unified connectivity fabric connecting people to everything.” In a word, what Qualcomm is describing is a “revolution.” Just as previous revolutions such as the “Industrial Revolution” have changed the world, the technology revolution enabled by 5G technology will have powerful impact on every aspect of the global economy and daily life.

In January 2017 IHS published the results of a study evaluating the potential global economic impact of 5G. This study was sponsored by Qualcomm and some of the key results posted on its website include:

- In 2035, when 5G’s full economic benefit should be realized across the globe, a broad range of industries – from retail to education, transportation to entertainment, and everything in between – could produce up to **\$12.3 trillion** worth of goods and services enabled by 5G mobile technology.
 - That is nearly equivalent to US consumer spending in 2016 and more than the combined spending by consumers in China, Japan, Germany, the United Kingdom, and France in 2016.
 - In a study published by IHS on the 50th anniversary of Moore’s Law in 2015, it estimated the global economic boost enabled by advances in semiconductor technology over the previous 20 years was \$11 trillion.
- The 5G mobile value chain alone could generate up to **\$3.5 trillion** in revenue in 2035 and support up to **22 million jobs**.
 - This figure is larger than the value of today’s entire mobile value chain. It is approximately the combined revenue of the top 13 companies on the 2016 Fortune Global 1000
- Over time, the total contribution of 5G to Real Global GDP growth is expected to reach **\$3.0 trillion**, equivalent to a country the size of India.
 - India currently ranks as the seventh largest economy in the world.
 - By comparison, an IHS study estimated the direct contribution to Real Global GDP between 1995 and 2015 by the semiconductor industry achieving progress aligned with Moore’s Law was \$3.0 trillion.

In a report released by Ovum titled, “5G Economics of Entertainment Report” it is forecast that over the next decade (2019 to 2028) “media and entertainment companies will be competing to win a share of a near **\$3 trillion** cumulative wireless revenue opportunity. Experiences enabled by 5G networks will account for nearly half of this revenue opportunity (close to **\$1.3 trillion**.)” Some of the highlights from the forecasts presented in the report are:

- As early as 2025, 57 percent of global wireless media revenues will be generated by using the super-high-bandwidth capabilities of 5G networks and the devices that run on 5G.
- 5G will accelerate content consumption, including mobile media, mobile advertising, home broadband and TV, and improve experiences across a broad range of new immersive and interactive technologies – unleashing the full potential of augmented reality (AR), virtual reality (VR) and new media.
- Average monthly traffic per 5G subscriber will grow from 11.7GB in 2019 to 84.4GB per month in 2028, at which point video will account for 90 percent of all 5G traffic.

- AR and VR experiences will generate **\$140 billion** in cumulative revenues (2021-2028)
- Immersive and new media applications – applications and capabilities that are currently nonexistent – are forecast to generate more than **\$67 billion** annually by 2028 or the value of the entire current global mobile media market – video, music and games – in 2017.

Jonathan Wood, general manager of Business Development & Partnerships, 5G Next Generation and Standards at Intel proclaims, “5G will inevitably shake up the media and entertainment landscape. It will be a major competitive asset if companies adapt. If not, they risk failure or even extinction. This wave of 5G transformation will not be the purview of any singular industry, and now is certainly the time for all business decision-makers to ask: Is your business 5G-ready?”

The rapidly approaching technology tsunami will begin to reshape the electronics industry landscape as it grows in strength over the period of 2020 to 2022. Participants who are prepared for this new wave of opportunity will experience a thrilling ride while those who lag behind risk being crushed by the changes that are coming. The exciting news for hardware and electronics components designers is that 5G will entail the redesign of almost every type of electronics hardware. The combination of 5G, Cloud and IoT will result in new hardware, software and communications architectures and open doors of opportunity for all participants in the electronics value chain.

Analysis

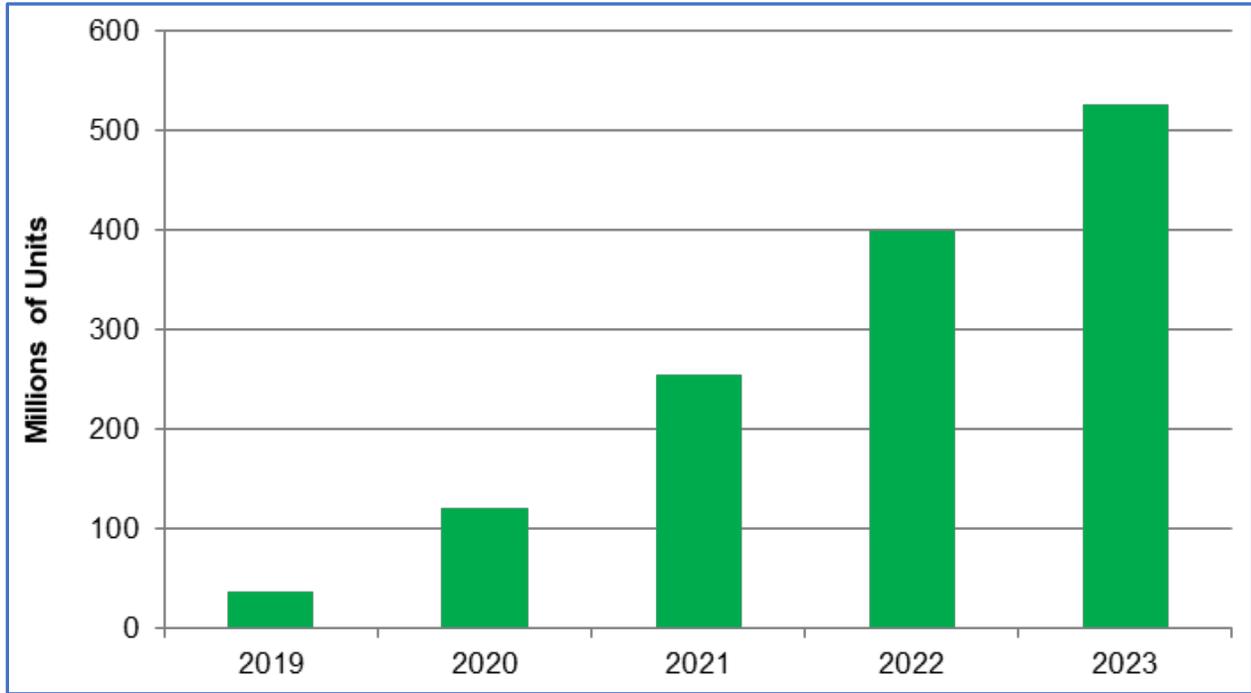
The high-profile and high-volume smartphone market will be the first to experience a boost from 5G technology. The enhanced mobile broadband capabilities of 5G have already triggered a race to market among handset OEMs and wireless service providers. By January of 2019, over 30 commercial 5G mobile devices have been scheduled for debut in the new year according to a press release by Qualcomm. Out of this group, ten OEMs have introduced smartphones for shipment in 2019 as of the end of July 2019. Other major players such as Apple are expected to launch products by 2020. (Apple’s next iPhone XII is expected to be 5G capable.)

- Huawei Mate X and Mate 20 X 5G
- LG V50 ThinQ
- Moto 5G phones - Motorola's Moto Z3 has a 5G Moto Mod
- OnePlus 7 Pro 5G
- Oppo Reno 5G
- Samsung S10 5G and Galaxy Fold
- Sony Xperia 5G phone
- Vivo 5G phone
- Xiaomi Mi Mix 3 5G
- ZTE Axon 10 Pro 5G

The growth in shipments of 5G handsets is forecast to significantly outpace the ramp in 4G/LTE handset shipments in the years following their introduction. Figure 2 presents a forecast from IHS Markit for 5G handset shipments. Figure 3 compares the forecast of 5G shipments to actual

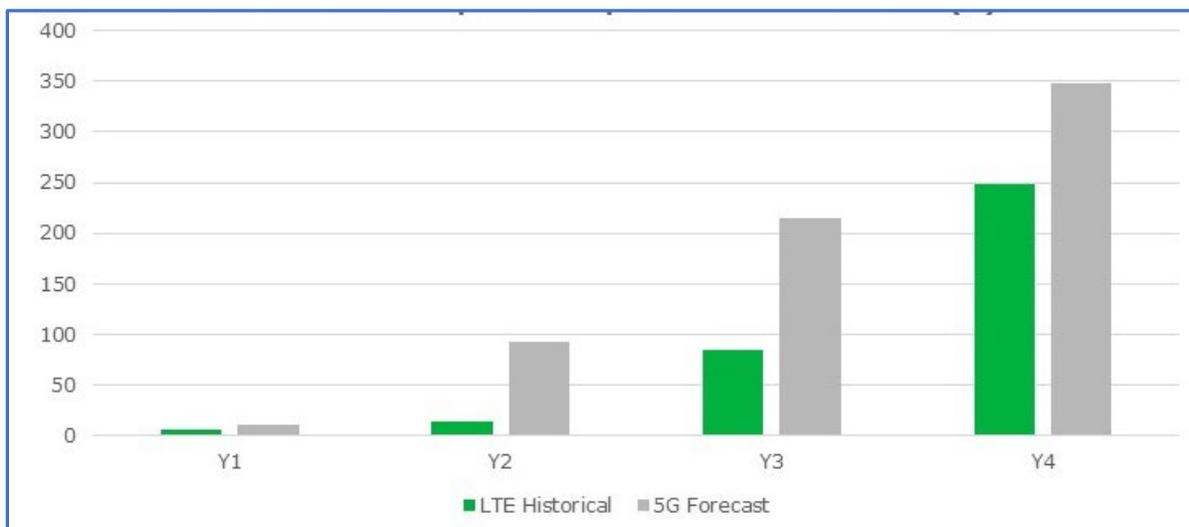
LTE shipments. 5G handset shipments will be the main driver of 5G connections in the early phases of development in 5G markets as presented in Figure 4.

Figure 2 – 5G Mobile Handset Forecast



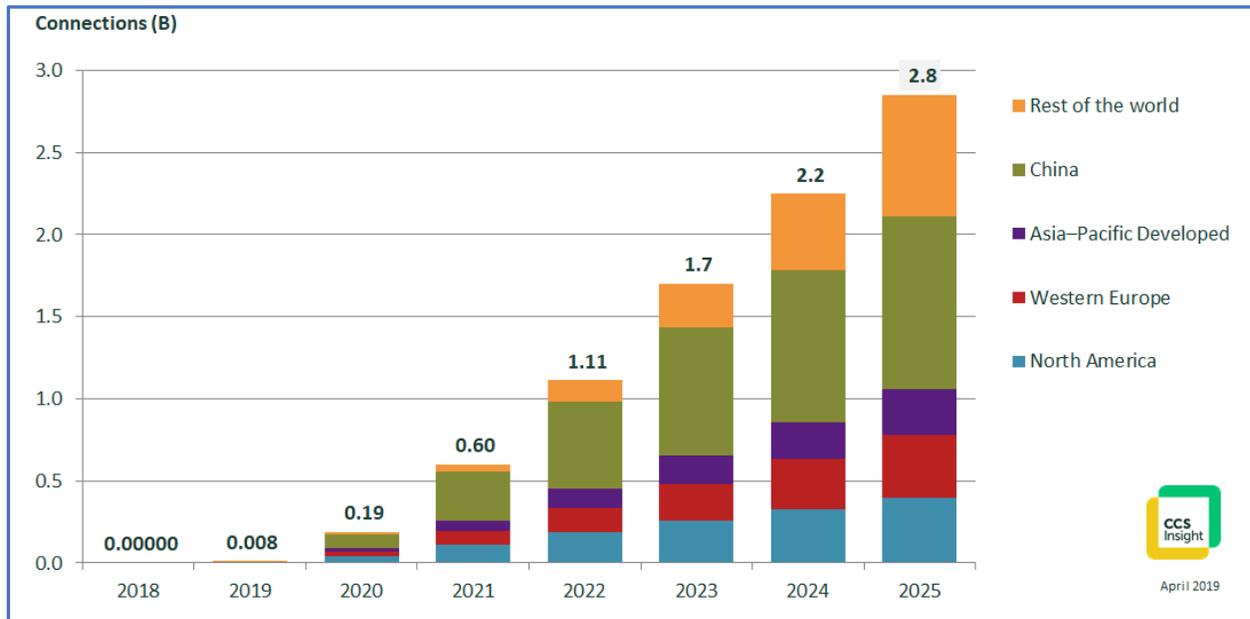
Source – IHS Markit Design Forecast Tool – Mobile Handsets

Figure 3 – Forecast 5G Shipments Compared to Historical LTE Shipments (Millions of Units)



Source – IHS Markit

Figure 4 – Forecast of Worldwide 5G Connections



Source – CCS Insight

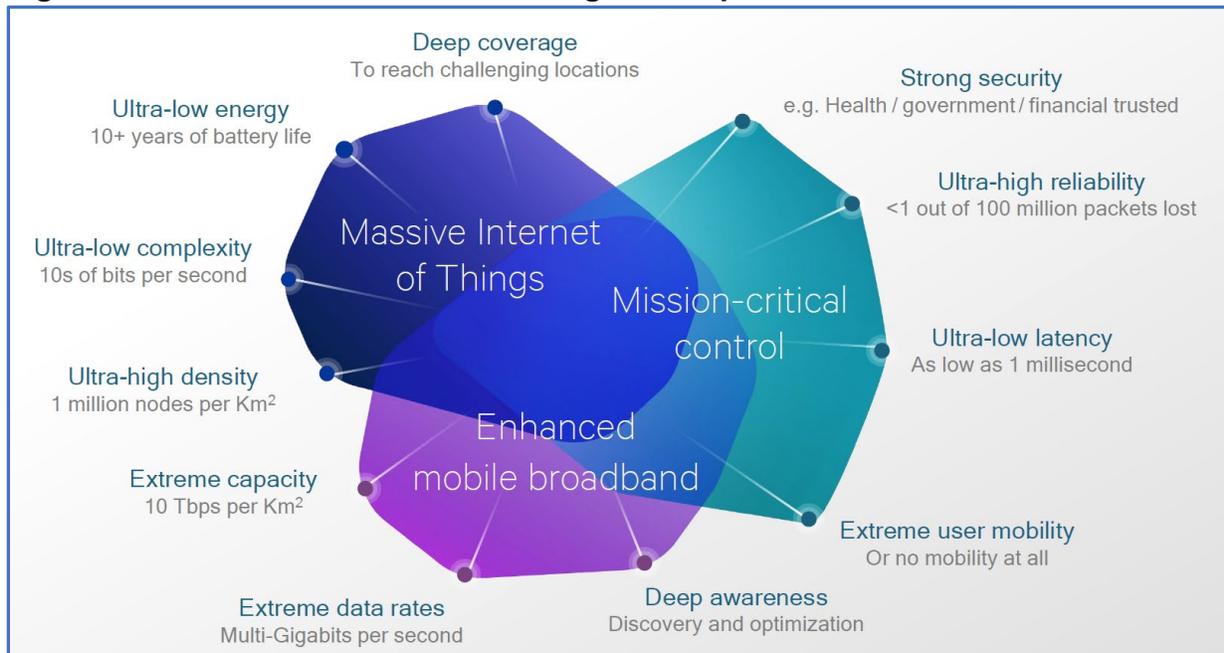
According to a survey by IHS Markit, ultra-low latency (ULL) is the chief technical driver for 5G for mobile operators (82%), followed by decreased cost per bit (76%), and increased network capacity (71%). Enhanced mobile broadband (eMBB) was the highest-rated 5G use case driver in the IHS Markit survey, followed by real-time gaming. As real-time gaming requires a super-fast network with low latency, it cannot occur in the absence of eMBB; the same applies to high-definition (HD) and ultra-high-definition (UHD) video services and tactile low-latency touch and steer. Respondents expect fixed-wireless access (FWA) to be ready for commercial deployment first.

The sections below provide a brief description of new opportunities enabled by 5G: Markets, Participants, Technologies, and Components.

New Markets

Mobile handsets are just the beginning of markets that will be reshaped by 5G technology. The exciting aspect of 5G is that it is much more than a standard that only supports higher data rates and lower latency. It is a comprehensive and robust standard that supports a wide range of needs/opportunities. It has been called a “network of networks.” Figure 5 illustrates the wide range of benefits that 5G delivers which can be leveraged in almost every imaginable application and environment. This provides a platform for the development of a wide range of applications and markets.

Figure 5 – Scalable to an Extreme Range of Requirements



Source – Qualcomm

The list below provides a sense of the diverse applications of 5G technology:

Enhanced Mobile Broadband:

- 3D/UHD Video Telepresence
- Tactile Internet
- UHD Video Streaming
- Demanding Conditions/Venues
- Broadband “Fiber” to the Home
- Virtual Reality

Massive Internet of Things:

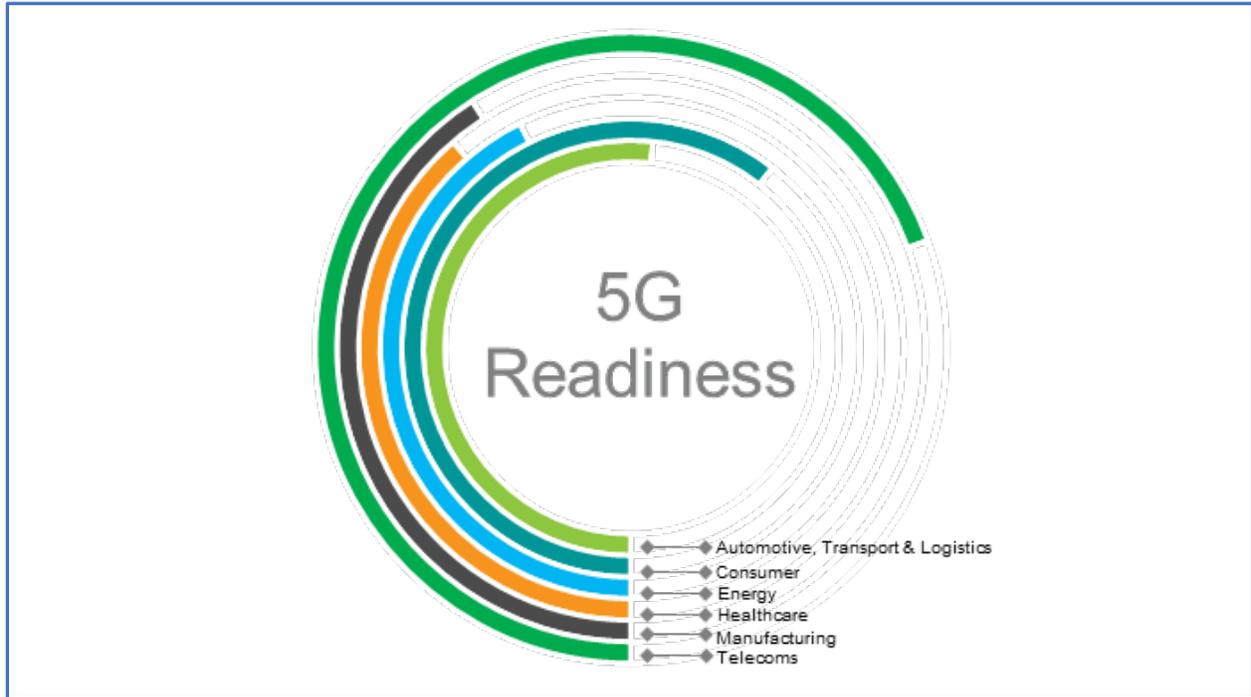
- Smart Cities
- Smart Homes
- Utility Metering
- Wearables/Fitness
- Remote Sensors/Actuators
- Object/Asset Tracking

Mission-Critical Control Services:

- Autonomous Vehicles
- Robotics
- Energy/Smart Grid
- Industrial Automation (Industrial 4.0)
- Aviation
- Medical

Varying levels of progress have been reached in establishing a foundation for development of 5G technology for various applications. Figure 6 presents an assessment by IHS of the relative progress in major areas. Clearly, telecom has advanced the farthest to reach an early commercial phase. However, all segments will see opportunities develop over the coming two to five years.

Figure 6 – 5G Readiness Scores by Industry



Source – IHS Markit Digital Orbit

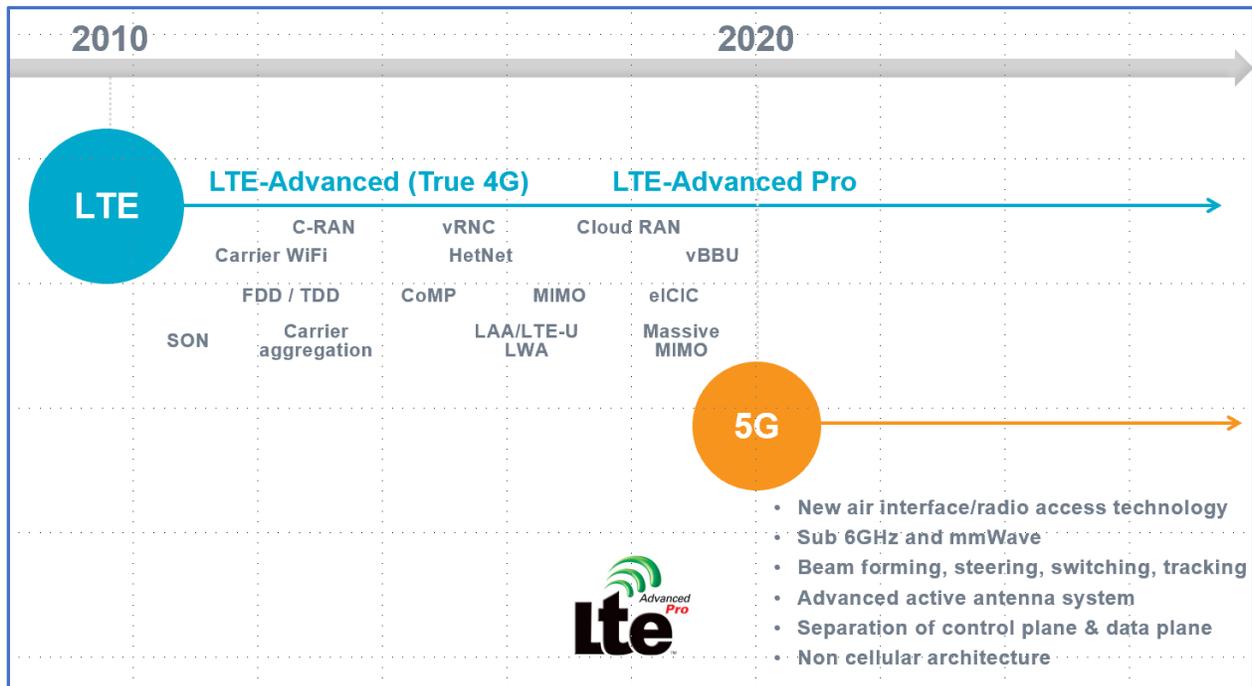
New Participants

The use of 5G technology in IoT applications will attract an increasing number of OEMs, service providers, businesses and consumers to adopt 5G in their products and services. However, the expertise needed to successfully implement 5G will take time to expand from a fairly concentrated core of experts. The more advanced technologies and architectures associated with 5G will create a need for expert support of OEMs and businesses who do not possess the in-house talent needed to access the benefits of 5G. This will create opportunities for a diverse set of companies to partner with companies in need of support. Potential support and strengthened business relationships could come from chipset suppliers, full-service distributors, design houses, ODMs, Manufacturer Representatives, etc. Power and positioning along the electronics components supply chain will flex as companies engage in new or expanded relationships in the adoption and implementation of 5G.

New Technologies

In addition to building on technologies developed for previous generations of wireless communication, 5G requires a significant leap in new technology development. Figure 7 provides a helpful illustration of technologies associated with the implementation of LTE and the new technologies required for 5G.

Figure 7 – 4G and 5G Technology Developments



Source – IHS Markit

According to Qualcomm, one of the most advanced developers of 5G, 5G is bringing a wide range of technology inventions in both the 5G NR (New Radio) air interface design as well as the 5G NextGen core network. In a summary description of 5G, Qualcomm notes that the new 5G NR air interface introduces many foundational wireless inventions. They identify the five most important areas of 5G technology development:

1. Scalable OFDM (orthogonal frequency-division multiplexing) numerology with 2n scaling of subcarrier spacing
2. Flexible, dynamic, self-contained TDD (time division duplex) subframe design
3. Advanced, flexible LDPC (low-density parity-check) channel coding
4. Advanced massive MIMO (multiple-in, multiple-out) antenna technologies
5. Advanced spectrum sharing techniques

According to a survey by IHS Markit, the most challenging network development item on the 5G agenda is radio. 53% of operator respondents said radio is the area of the network that will require the biggest development effort to make 5G happen, followed by transport (24%) and management (14%). With regard to radio challenges, 5G will be introduced in higher frequency bands with many operators expected to deploy their 5G systems in the mmWave (millimeter wave) frequency band. As the available amount of RF spectrum becomes saturated in high-

density environments, new spectrum efficiency methods must be taken into consideration. Massive MIMO technology uses multiple antennas to transmit carrier signals simultaneously, performing both input and output functions within the same spectrum allocation. Beamforming, which is a technique used to focus radio interfaces into a beam for directional signal transmission and reception, will enhance overall RF spectrum efficiency.

New (and More) Components

To understand the type, cost and number of components needed to implement 5G it is helpful to look at data from a teardown analysis of an actual 5G handset. One of the earliest 5G handsets was introduced by Motorola – the Moto Z3/5G Mod combo. The 5G Mod connects to the Z3, a 4G handset that can be customized with “mods.” In this case, the “mod” adds high-speed mmWave 5G capability to the handset. Table 1 presents a summary of the costs associated with the Z3 smartphone and the added costs of the 5G Mod. It also presents the top 10 components in each section based on cost.

Table 1 – Teardown Summary of Moto Z3 and 5G Moto Mod

	Motorola - Moto Z3 Smartphone	Motorola - Moto 5G Mod
Direct Material Costs (Components)	\$224.59	\$275.20
Conversion Costs (Assembly/Insertion/Test)	\$7.32	\$8.23
Total Cost (Direct Materials/Manufacturing)	\$231.91	\$283.44
Top 10 Component Cost Drivers (Percentage of Direct Material Costs)	\$167.56 75%	\$227.60 83%
Top 10 Components	<ul style="list-style-type: none"> Apps / Baseband Processor - \$38.41 SDRAM - \$24.20 Enclosure, Main - \$24.18 6.01" Diagonal, AMOLED - \$22.00 Primary Camera - \$20.40 10-Layer, FR4/RCF HDI - \$13.86 Flash, UFS NAND - \$13.26 RF Transceiver - \$4.86 Battery Pack, Li-Polymer - \$4.01 Power Management IC - \$2.38 	<ul style="list-style-type: none"> mmWave Antenna Modules - \$75.19 Apps / Baseband Processor - \$50.51 Baseband Processor - \$39.99 SDRAM - \$23.00 10-Layer, FR4/RCF HDI - \$15.64 RF Transceiver - \$7.71 Flash, UFS NAND - \$7.24 Battery Pack, Li-Polymer - \$2.87 Transmit Module, PAM - \$2.78 Transmit Module, PAM - \$2.67

Source – IHS Markit

While this is a first-generation product with opportunities for design optimization and streamlining, it is instructive to highlight a few key points. First, the radio in the 5G handset jumps up to the top of the list in terms of cost. Just the mmWave antenna modules roughly double the cost of the top cost item in the 4G section, the Apps/Baseband processor. Certainly, this cost will come down with time. However, there are other significant costs associated with other RF components such as the transceiver and multiple transmit modules. The baseband processors themselves also command a significant premium in this early version.

In addition, the 5G radio will require a significant jump in the number of components to support multiple antennas and RF paths. This will mean a leap in component demand for support components such as MLCCs. The 4G generation of handsets already placed heavy demands on the supply of key components such as MLCCs. This demand will increase substantially as 5G markets grow.

One final observation, hardware cost reduction will be essential to enable growth of the 5G market. Given that the radio will become a significant cost driver in the future, system and network designers will need to look at opportunities to offload other cost elements from the handset itself. Given the high-speed, low-latency benefits of 5G, it will make sense to shift many of the applications processing and storage functions to the cloud. This means shifting compute power away from the handset to Edge and Data Center platforms. It should be expected that 5G will drive important architectural design changes across the wireless ecosystem moving forward.

New Opportunities and Challenges

We are just beginning to grasp the opportunities and challenges associated with the rise of 5G. Figure 8 presents key findings from a survey conducted by Qualcomm. Thrilling opportunities await those prepared for the 5G future. However, there is no time to spare as companies prepare for the challenges that must be addressed to successfully launch into this future.

Figure 8 – 5G: A Platform for Innovation



Source – Qualcomm

Action

- ❖ Companies must determine whether they should begin investing in design capabilities to support 5G product development or develop partnerships with others that can provide timely and intimate support for product development. This action must be taken in a very timely way as the demand will ramp quickly and the talent pool will be stressed.
- ❖ Roadmaps should be developed for the introduction and growth of new 5G enabled products and markets. These will be essential for planning the resource investments required for these new opportunities.
- ❖ The pressure placed on component supply due to demand created by 5G should be analyzed. Priority for critical component supply will likely go to top smartphone OEMs with the high-volume production they will generate in the early stages. Other OEMs and distributors need to work with their suppliers to establish relationships and make investments needed to ensure adequate component supply as their market opportunities begin to grow.
- ❖ The “big picture” must be kept in view as 5G will reshape the electronics components landscape with shifting demands in other areas such as IoT, Edge, Cloud, Data Centers, etc. The changes stimulated by 5G will need to be addressed as system and network architectures change the demand profile for components.
- ❖ Attention must be paid to new semiconductor technologies associated with 5G. Heat and power are critical issues for 5G products. New material and process technologies are being developed to solve these challenges. As always, monitoring inventions and developments of semiconductor technology is important.
- ❖ Take advantage of the opportunity to hear Francis Sideco, IHS Markit Vice President, speak on, “The Promise and Potential of 5G: Evolution or Revolution.” Register now for this premiere industry event to be held October 20-22, 2019 at Loews Chicago O’Hare Hotel.