June 2020

ITI's 5G Essentials for Global Policymakers

ITI's 5G Essentials for Global Policymakers provides a helpful and necessary context on the issues ITI and its member companies believe to be of importance to those seeking to better understand the recommendations set forth in our 5G Policy Principles.

As the premier technology trade association with a presence across the globe, ITI represents the full spectrum of technology companies, including those contributing to nearly every facet of 5G, from the equipment at the core to the applications that will run on top of 5G networks.

1 What is 5G?

Simply put, 5G is the next generation of network technology. 5G can utilize existing 4G network infrastructure in some cases, although it is an enormous shift away from legacy telecommunications systems to an information technology-based infrastructure. 5G will bring new equipment and software, and spectrum – such as small cells, software-defined networks, and very high frequency spectrum. Although 5G can build off of existing infrastructure, it is not only an incremental improvement over previous network technology. While 5G deployment is in the early stages, it is already being deployed in public and private settings.

Some of the key commonly understood features that characterize 5G are:

- **Massive connectivity:** Radio Access Network (RAN) will be able to support 100x more connected devices. 4G networks support approximately ten thousand devices per square mile, while 5G should support about 100x this number = one million devices per square mile.
- **Ultra low-latency:** The amount of time it takes for data to be transmitted from its source to the destination point on the network is less than 1 millisecond, which is 400 times faster than the blink of an eye. Low latency results in 5G being significantly faster than 4G and is important for time sensitive applications and services such as high-definition streaming video, smart vehicles, precision manufacturing, and critical services and infrastructure control.
- **Extreme mobility:** 5G will allow the ability to maintain connection without interruption or loss of quality while moving at high rates of speed.
- **Increased capacity:** By utilizing higher spectrum frequency, 5G will be able to carry more data. It is expected to support 100 times the amount of data traffic as compared to 4G.

5G by the Numbers

5G will have a tremendous economic impact and effect on data. The implications of these numbers are significant not only because 5G will power the next wave of data-driven innovations, but also because of implications for individual privacy, national security, technological leadership, and economic competitiveness.

Economic Impact:

$13.2 T Globally, 5G technology is expected to enable $13.2 trillion in economic output by 2035.[1]

$275 B In the United States alone, 5G is expected to generate up to $275 billion in infrastructure investment, thus creating approximately three million new jobs and boosting GDP by $500 billion annually.[2]

Data:

38 EB /month in 2019 to **160 EB** /month in 2025 5G networks will enable increased speeds and staggering amounts of data – mobile traffic is expected to grow by a factor of 4 from 38 exabytes in 2019 to 160 exabytes per month in 2025 (exabyte = one billion gigabytes).[3]

[1] https://www.qualcomm.com/media/documents/files/ihs-5g-economic-impact-study-2019.pdf
[2] https://www.accenture.com/_acnmedia/pdf-82/accenture-strategy-accelerating-future-economic-value-2018-pov.pdf
[3] https://www.ericsson.com/en/mobility-report/reports/november-2019/mobile-data-traffic-outlook

2 The Importance of Spectrum to Deployment

Spectrum is the collection of airwaves that wireless signals travel over, the invisible medium that connects with the broader network. The amount of spectrum available is perhaps the most important factor that determines how much bandwidth or throughput 5G systems can support. Licensed, unlicensed, and shared licensed spectrum play important roles in enabling the full value of the 5G innovation platform.

- **Licensed spectrum** is where a user pays a fee for the exclusive right to operate on an assigned frequency. Spectrum rights are managed by governments, often a designated regulatory agency with information and communications technology (ICT) expertise
- **Unlicensed spectrum** is swaths of the airwaves where any user can transmit under certain power limits.
- **Shared spectrum** allows multiple categories of users to safely use the same frequency bands. Often this takes the form of tiered users, where certain users have primary access and other users can operate so long as they did not cause interference. Sharing may also take place on a temporal or geographic basis.

The current generation of fixed and mobile networks relies primarily on the lower range of radio frequencies under 3 GHz, referred to as low-band spectrum. For the first time ever, we are seeing a type of network technology that can operate over a much broader range of radio frequencies to include high-bands. Spectrum in low-, mid-, and high-bands is needed for 5G, though there has been specific focus globally on making more high- and mid-band spectrum available.

- **Low-band** (e.g. < ~1 GHz) spectrum, due to its propagation characteristics, is able to travel farther so carriers use this spectrum to cover larger geographical areas without signal interruption.
- **Mid-band** (e.g. 3.5 GHz) is considered the "sweet spot" of spectrum, offering a combination of both coverage and capacity.
- **High-band** (e.g. mmWave) spectrum offers wider bandwidth, which carries more data faster, providing higher data rates. Signals do not travel as far as lower spectrum, so 5G deployment in these bands is using a denser network of small cells operating at lower power than traditional macro cells.

3 How Standards Enable 5G Development and Rollout

Standards are essential to 5G deployment in that they facilitate interoperability of devices and solutions. For example, the fundamental promise of 5G for mobile applications is that any mobile device can speak to any other mobile device over any network, which will help to realize the economic benefits of 5G. In addition to interoperability, cybersecurity of 5G networks is also supported by industry-developed standards and guidelines. Those 5G specifications and guidelines are being driven and developed by a variety of standards development organizations with participation from thousands of experts from industry, government, academia, and research organizations.

Given the breadth and complexity of the work, it is important that companies are able to choose the most appropriate body in which to participate to advance their work. There are a wide variety of standards development organizations and consortia, each with their own procedures to develop standards and specifications. Market forces enable companies to coalesce around the "right" standards bodies for the right work. An illustrative, but by no means exhaustive, list of bodies engaged in 5G standards, guidelines, and specifications development is below:

- **3GPP:** By and large, the focal point of development for 5G specifications and standards is the Third Generation Partnership Project (3GPP), a consortium made up of seven of the regional telecommunications standards development bodies. 3GPP has hundreds of technical specifications under development for mobile wireless communications, including the air interface/radio access (5G New Radio), the 5G core, and the IoT, among others. 3GPP is also developing standards for networks to interconnect collaborate with one another. For example, 3GPP's non-public network support is intended to allow private networks optimized for a specific purpose (e.g., an automated manufacturing facility) to co-exist with public carrier networks.
- **GSMA:** GSMA is an industry association representing the interests of mobile operators worldwide, including more than 750 operators and almost 400 companies in the broader mobile ecosystem. GSMA has published hundreds of security guidelines, recommendations and requirements over the years regarding best practices in mobile security that support real-world deployments related to security of devices, networks, interconnect protocols, and services. GSMA's Fraud and Security Group is particularly active, working on 5G security in the context of other interdependent topics such as IoT and roaming.
- **International Telecommunications Union (ITU):** The ITU is in the process of developing ITU-R Recommendations for the terrestrial components of the IMT-2020 radio interface(s) based upon specifications from external, industry-led standards developments organizations.
- **O-RAN Alliance:** The O-RAN Alliance is working to build specifications and standards for 5G networks, focused on open and interoperable interfaces for radio access networks.
- **Internet Engineering Taskforce (IETF):** IETF covers specifications related to 5G non-radio network segments.
- **Institute for Electrical and Electronics Engineers (IEEE):** IEEE is involved in the creation of many standards, including WiFi and WiMAX standards, as well as other machine communications standards that will change with 5G.

4 Emerging ICT Technologies

There are a host of other technologies that are helping to drive the development and deployment of 5G networks, including network slicing and virtualization. Below are some key technologies explained:

- **Massive MIMO (Multiple Input/Multiple Output):** A wireless technology that uses multiple transmitters and receivers in a minimum 16X16 array to transfer multiple data signals over the same radio channel. This results in higher capacity, greater spectral efficiency, and faster speeds.
- **Network Slicing:** Unlike some earlier wireless technologies, 5G networks have sufficient capacity such that they can be segregated into individual channels utilizing the same physical infrastructure. This so-called "slicing" allows operators to optimize the network for different use-cases, making networks more agile, flexible, and able to address different customer needs.
- **Network Functions Virtualization (NFV):** Virtualization separates the network functions from hardware on a network and allows them to be managed through virtual machines, including through cloud-based solutions. This presents an opportunity for software applications to be run on widely available hardware, allowing 5G networks more flexibility than previous generations.
- **Software Defined Networking (SDN):** In previous generations of network technology, routers and switches controlled and forwarded data transmissions on the network. SDN separates the control function from the forwarding function, with a greater emphasis on consolidating this control function into a single network controller that can communicate and direct the entire network. Similar to virtualization, SDN offers significantly more flexibility and facilitates automation in the network.
- **Spectrum-Sharing:** Modern systems for avoiding harmful interference among co-users are freeing up new spectrum bands for 5G uses (e.g. the Citizens Broadband Radio Service in the U.S. and shared spectrum bands in the UK and Germany). This approach is especially useful when existing spectrum bands have incumbent users that are difficult to relocate.
- **Edge Computing:** Edge computing moves the data compute, storage, and processing functions closer to the IoT endpoint and/or end-user, which improves efficiency of processing and latency. 5G will harness edge computing in a way that previous generations of network technology did not, helping to meet performance requirements.

5 The Importance of Security in 5G

Security is fundamental to successfully deploying and using 5G. The future will be filled with exciting new applications and services that will run on top of 5G, but an increasingly connected world will also increase security risks, ranging from an accelerating and evolving cybersecurity threat landscape to concerns regarding sophisticated adversaries exploiting supply chain vulnerabilities. Given this increased interconnectedness, emerging threats can pose a danger to the 5G ecosystem more widely if not adequately planned for and managed. The good news is that 5G networks and standards are being designed with security in mind from the outset, and 5G networks will include several security enhancements that will enable business and government enterprises to confidently deploy new applications and IoT services to harness the full value of 5G. While investments in 5G infrastructure and the accompanying digital transformation are well under way, consumers, businesses, and governments should prioritize security during the transition and seek to leverage the security enhancements available for the first time in 5G.

Industry around the world is actively working to secure mobile networks, including 5G. This includes investing time and resources into developing cybersecurity technologies and services to secure 5G networks and the applications and services running over them, helping to educate business leaders on the importance of cybersecurity investments, sharing operational threat information on threats traversing mobile networks so that relevant parties can take action, and participating in the development of relevant global 5G security standards and reference documents. Industry and government are also collaborating via public-private partnerships to ensure that we arrive at the desired policy outcome of more secure 5G networks, including operational partnerships to share information on threats to 5G, and partnerships to further supply chain risk management best practices and solutions. No one organization in the private or public sectors can see all supply chain or cyber security threats so it is imperative that both sides work together to fully understand and assess the full range of potential security threats in order to develop and implement appropriate mitigations.

6 5G Will Power Data Driven Innovations

The increased speed, capacity, and functionality of 5G networks will help to enable the next generation of data-enabled innovations such as the internet of things (IoT) and artificial intelligence (AI).

6 5G Will Power Data Driven Innovations *(continued)*

Specific Use Cases Envisioned for 5G:

Agriculture

5G can enable new precision agriculture capabilities, allowing farm equipment to stream data back and forth in real-time. Specific examples of this include: leveraging sensors to communicate soil nutrition levels and report on current and predicted weather patterns; allowing for improved crop management and livestock analysis; directing autonomous vehicles to perform field tasks, such as harvesting; and bringing in-field expert advice to communicate with individuals working in remote farming areas.

Manufacturing

Currently, manufacturers rely primarily on fixed-line networks to support critical applications, but 5G could allow for lower costs, higher flexibility, and low latency performance for factory floor productions and alterations. By combining the data generated from 5G-connected sensors with machine learning algorithms, companies could monitor equipment in real-time and predict with greater accuracy which machines are about to fail, reducing the likelihood of costly downtime.

Healthcare

5G can help expand the possibilities for telemedicine as well as applications in hospital settings, allowing patients to be treated sooner and access a broader range of specialists. The availability of remote patient monitoring can improve health care delivery and enhance preventative care. The increased bandwidth of 5G can transport large data files like medical imagery and 5G's lower latency allows real-time high-quality video, enabling the use of augmented reality (AR) and virtual reality (VR) in surgical procedures.

Retail

From small grocery stores to large hotel chains, retailers of all sizes could leverage 5G technology to improve their operational efficiency. For example, by using IoT-embedded sensors, a store would have a real-time view of its stock and could seamlessly communicate to the supply chain to send a new shipment when a particular product is low. 5G will also enable retailers to use technologies such as personalized digital signage, interactive mobile apps, and virtual reality to both ease and enhance the overall customer experience.

6 5G Will Power Data Driven Innovations *(continued)*

Specific Use Cases Envisioned for 5G ***(continued):***

Smart Cities and Communities

The deployment of smart cities is reliant on the connection of multiple low-power digital devices to help power homes, offices, and communities through the IoT. Due to the high volume of data that must be collected and maintained to support this level of real-time connectivity, smart cities need the higher speed and larger capacity offered by 5G. Examples of smart city use cases include: smart traffic management and public transit systems (e.g., reducing rider wait time and optimizing bus inventory), smart grids and energy systems (e.g., enhancing demand-side management to help reduce electricity peaks and reduce costs), smart outdoor lighting (e.g., automatically dimming public lighting when no vehicles or pedestrians are present), and smart homes (e.g., controlling indoor lighting, entertainment systems, and appliances).

Public Safety

5G can help optimize public safety by allowing real-time access to mission critical information, improving connectivity, and ensuring reliable communication. 5G specifications will ensure that communications to or between first responders are prioritized in times of emergency, will help to provide first responders a high degree of situational awareness, and will ultimately lead to improved safety of responders and better outcomes all around.

Education

5G in education, particularly in underserved areas, can dramatically change the nature of education through enhanced learning technologies, including the use of AR/VR tools, which rely on 5G, resulting in closing persistent achievement gaps.

7 Common Misperceptions About 5G, Explained

MYTH: 5G is less secure than other generations of network technology.

FACT: 5G considers security at the outset, instead of as an afterthought. As a result, 5G has the potential to be more secure than previous generations of network technology. While the increased reliance by a wide swath of industries and critical infrastructure providers on 5G, coupled with the proliferation of connected devices enabled by 5G will result in more entry points into the network and the potential for increased cybersecurity challenges, the numerous security enhancements built in to 5G networks will help secure communications as well as the IoT and other innovations 5G helps enable.

Standards development bodies are working on 5G security standards. For example, 5G specifications will ensure that data integrity is achieved at every layer of the network, improved authentication measures are employed, and privacy enhancements are introduced. New industry reference documents are guiding operators on how to automatically detect and block threats and mitigate security risks. It will be imperative for operators to leverage standards and best practices, invest in state-of-the-art security technologies, and keep current on network security updates and good cyber hygiene. In addition, 5G will benefit from many technology evolutions already used in other industries, such as virtualization and micro-segmentation that are being deployed in large enterprise data centers and public cloud providers. 5G has the opportunity to benefit from the knowledge gained in the security developments in these adjacent markets.

MYTH: 5G is only about increasing download speeds.

FACT: 5G is about much more than just increasing download speeds – it is also about greater connectivity, lower latency, capacity, and network performance, all of which will usher in a new era of devices, applications, and services available to consumers and businesses alike. For example, we expect to see 5G-enabled applications across numerous sectors, including in manufacturing, agriculture, healthcare, and transportation. This will generate tremendous economic impact. Consumers will see improved video streaming, greater home automation, and new applications around augmented reality. Because an exponential amount of data will be sent between all parties at much faster speeds, appropriate spectrum must be quickly and efficiently allocated and security must be built in from the beginning.

MYTH: 5G standards are nearly finished.

FACT: 5G standards, as with most other technical standards, are and will remain under continuous development in 3GPP and a number of other standards bodies including O-RAN Alliance, IEEE, IETF, ISO, ITU and ETSI, and these standards will continue to change as the technology evolves. For example, 3GPP issues technical specifications in "Releases," whereby a core set of features are "frozen" and subsequent functionality can be added on in future Releases. It is important to note that 3GPP technical specifications are backwards and forwards compatible, ensuring that a system can continue to perform without interruption as network technology evolves.

7 Common Misperceptions About 5G, Explained *(continued)*

MYTH: China is taking over 3GPP and other standards development bodies and will therefore wield undue influence in the deployment of 5G networks.

FACT: As 5G is deployed and 3GPP continues to develop the technical specifications that will govern this next generation of network technology, some have raised concerns that China is "flooding" the system, putting forward large numbers of contributions and sending increased numbers of participants to meetings. However, the quantity of contributions is not an accurate way to measure or predict influence; what really matters is the quality and substance of a technical contribution and which ones are accepted for inclusion in the specifications. Additionally, few contributions put forth by one company go through the process without modification. 3GPP is a consensus-based, collaborative organization, with rules and processes in place to ensure that no company or country has undue influence or is able to micromanage an agenda. There is no empirical evidence of undue influence by any actor on 5G standards both in the distribution of leadership positions and in accepted contributions of leading 5G specifications. Firms participating in 3GPP do have influence based on the technical merit of their contributions, but there is no evidence that Chinese firms have disproportionate, meaningful influence at 3GPP or other SDOs.

MYTH: Only U.S.-based manufacturers produce safe/secure equipment.

FACT: Equipment security is not solely determined by country of origin. Security is a continuum, not an end state. While country-of-origin is one risk factor to be considered, it is not the sole and dispositive factor. For instance, the U.S. Department of Homeland Security ICT Supply Chain Task Force recently undertook a supplier threat assessment and country-of-origin was identified as one threat out of over one hundred potential factors to take into consideration.

MYTH: The primary security risk in 5G networks is associated with hardware.

FACT: While hardware is certainly one area that could present a risk in the network, security solutions will need to focus on all aspects of the end-to-end system.

Cyberattacks on mobile network infrastructure (3G, 4G, and now 5G) and their users continue to grow, along with increased network capacity and speed. Criminals consistently introduce and update new attack tools, using automation and exploit toolkits, to attack mobile operators' network infrastructure, applications, and services, and the operators' customers/end-users (consumers and enterprises). As 5G will support an increased amount of connected devices, the attack surface also increases. The risk and potential damage are relevant not only to the telecom sector, but to all sectors to which it is closely interconnected and interdependent including energy, finance, healthcare, transportation, IT, government, manufacturing, and retail. That said, governments should consider risks beyond those associated with hardware.

7 Common Misperceptions About 5G, Explained *(continued)*

MYTH: There is no need for an edge if your radio access network is connected by fiber to the core.

FACT: The 5G network design has been specifically architected to flatten the hierarchical design of previous generations of mobile network and push compute, storage and connectivity as close as possible to the service delivery point, also known as the edge of the network. It is the network edge where use cases that involve the need for ultra-reliable low-latency are enabled. The close proximity of the edge to the running service, for example, Robotic Surgery, creates the low latency capability between the Robot (UE) and the Service that is attached to the Robot. Thus, an edge is a vital part of the 5G network.