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5G TECHNOLOGY, U.S.- CHINA RACE, AND THE COMPETITION FOR
DOMINANCE

By

Rhodes Michael Walker

A thesis submitted to the faculty of The University of Mississippi in partial fulfillment of
the requirements of the Sally McDonnell Barksdale Honors College.

Oxford, MS

May 2021

Approved By

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ABSTRACT

5G Technology, U.S.- China Race, and the Competition for Dominance

By: Rhodes Michael Walker

Under the Direction of Dr. Mark Chen

For much of the 21st century, the United States and China have been competing to determine which world superpower will have the upper-hand for decades to come. The creation of 5G networks has raised new questions which are imperative to understanding the outlook for the competition between the United States and China for global dominance. This thesis sought to answer the question: Why would implementing the first 5G networks be the key to global dominance for the next decade or longer? In addressing this question, this thesis discusses the current state of 5G networks in China, the U.S., and Europe and puts the 5G technology and networks in the context of U.S.-China race and competition for dominance. This thesis projects that China will implement 5G technology before the United States, which will give China advantages in the economic, cyber, and political sectors and could very well give China the advantages in U.S.-China race and competition for dominance in the foreseeable future. A deeper understanding of the importance of 5G networks would have significant policy and security implications for the U.S. Data for this research were compiled from primary and secondary sources through archive research as the methodology.

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Research Questions

Primary:

- How will implementing the first 5G networks be the key to world dominance for the next decade or longer?

Secondary:

- Who will win the race for the first 5G networks between the United States and China?
- What are the security risks of 5G networks?
- What industries will 5G change, and how will these industries affect the country that implements 5G networks first?
- How will implementing the first 5G networks allow the United States or China to be the world superpower for the next 20 years?
- How does the U.S.-Chinese relationship affect the race for 5G network implementation?
- What are possible Chinese goals for 5G networks?
- How will the race for 5G networks impact policy decisions in the U.S., China, and Europe?

Methodology

The main method of research used in this work was the qualitative analysis of primary and secondary sources. Much of my research, which was used predominantly in Chapters 2 through 6, was collected through scholarly works, journal articles, cyber-related articles, podcasts, news reports, and relevant social media content. These pieces provided specific information about 5G networks, the companies creating these networks, and the competition between the United States and China. Most of these pieces were written within the past two years because of the constant changing nature of the 5G landscape and changing relations between the United States and China. The data and research analyzed was then used to assess the impact that 5G networks and technology will have on the world as well as project the future winner of the race for 5G between the United States and China.

I selected the sources utilized in this work by researching 5G articles across the internet to find relevant and trustworthy sources and authors to best assess the impacts 5G will have on the world and whether the United States or China will implement the first functioning 5G networks. Research for this thesis was collected until March 1, 2021, so that the thesis could be as accurate as possible while not taking away from the core of the research question.

Chapter 1: Introduction

In 2021, 5G networks are commonly discussed. Whether on TV or a bill-board, people in the United States have seen or heard about 5G in some capacity. However, many people know 5G as a technology that will increase the speed of their phones, but they do not know the true capabilities that 5G networks and the untapped potential of this technology.

Wireless and computation technology advances quickly. As a result, approximately once a decade, cellular carriers, chipset makers, and technology companies come together to announce new wireless standards that take advantage of those innovations. 5G, as the name suggests, is the fifth generation of wireless standards. Most people in the United States with a smartphone are using 4G (also called Long Term Evolution or LTE) and 3G. As you might expect, 5G standards require operators to meet higher capabilities.¹ However, unlike previous generations, 5G will not completely replace 4G networks. Rather, it will compliment 4G, improving upon and adding further advancements to the fourth-generation technology.² While this new technology promises advancements for the future, it also will be the key in determining global dominance for the foreseeable future.

In April 2019, President Trump announced, “The race for 5G is on, and America

¹ Skorup, Brent. *5G Basics and Public Policy*. Mercatus Center at George Mason University, Feb. 2019, www.thriveed.org/wp-content/uploads/2019/03/skorup_-_policy_brief_-_5g_basics_and_public_policy_-_v1_0.pdf.

² Skorup, Brent. *5G Basics and Public Policy*. Mercatus Center at George Mason University, Feb. 2019, www.thriveed.org/wp-content/uploads/2019/03/skorup_-_policy_brief_-_5g_basics_and_public_policy_-_v1_0.pdf.

must win.”³ One year later on March 23, 2020, President Trump signed the Secure 5G and Beyond Act of 2020 which details the President’s plan “to take control and develop an implementation plan and security strategy for US 5G and other next generation telecommunications systems and infrastructure.”⁴ This is a large step for the United States, who has largely tried to let companies compete for the creation of the popular, and somewhat misrepresented 5G network. However, the Chinese company Huawei holds the largest share of the 5G market and is ahead of most companies in the world. Due to this, the United States has felt increased pressure to become more of a player in the so called “Race for 5G” to attempt to block Huawei’s efforts to be far-ahead in technological advancement and 5G implementation.

The goal of this thesis is to assess why 5G technology is the key to winning the race between the United States and China for world dominance. Throughout this paper, I will seek to explore the ways in which the U.S.- China “race for 5G” will impact these countries on both a policy level and security level. I will also address the key factors which play into the race to 5G, with the most notable of these being the economic and cyber-based advantages that come with the first full implementation of this technology. I will explain how 5G technology will impact the future of the world through allowing the creation of more advanced infrastructure and the integration of data into all sectors of life with the Internet of Things. I will argue that China will win the race for 5G dominance because of unified Chinese country goals, government funding by the CCP, and Huawei’s

³ Slayton, Rebecca. “Analysis | Trump Says 'America Must Win' the 5G Race. Here's What You Need to Know.” *The Washington Post*, WP Company, 18 Apr. 2019, www.washingtonpost.com/politics/2019/04/18/trump-says-america-must-win-g-race-heres-what-you-need-know/.

⁴ Osman, Jim. “Trump's 5G China Security Deadline Will Force Nokia M&A.” *Forbes*, Forbes Magazine, 24 Apr. 2020, www.forbes.com/sites/jimosman/2020/04/23/donald-trump-5g-us-china-security-nokia-merger-google/#2d5d177b1b27.

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ability to grow more rapidly than their main competitors of Qualcomm and Ericsson. The review of the literature will provide background and lay the foundation for explaining how China will be the first country to fully implement 5G networks. In short, I will argue that 5G networks are the key to being the world superpower for the foreseeable future.

Prior to addressing these questions, it is vital that one understands the origins of 5G networks, the state of 5G networks in China as well as the U.S. and Europe, and the relations between the United States and China. Understanding these fundamental principles provides the knowledge necessary to make accurate analytical predictions. It also gives insight into the possible affects that 5G technological implementation will have on the relations between the United States and China as well as their competition for dominance.

Chapter 2: History of 5G

I. What is 5G

Fifth-Generation wireless, better known as, 5G is the newest generation of cellular technology, which will provide “greater data speeds, lower latency (better responsiveness), and the possibility to simultaneously connect to more devices.”⁵ 5G is “engineered to greatly increase the speed and responsiveness of wireless networks.”⁶ 5G networks will allow data transmitted over broadband connections to travel “at multigigabit speeds, with potential peak speeds as high as 20 gigabits per second by some estimates. These speeds exceed wireline network speeds and offer latency of 1 millisecond or lower, which is useful for applications that require real-time feedback. 5G will enable a sharp increase in the amount of data transmitted over wireless systems due to more available bandwidth and advanced antenna technology.”⁷ In comparison to previous generations such as 4G and 4GLTE, 5G “is 20x faster than LTE-Advanced, which has a peak download speed of 1,000 Mbps. 5G latency (defined as the time to establish a connection) is estimated to be 10 to 20 milliseconds, compared to 4G's average latency of 40 ms. The maximum traffic capacity of 5G is roughly 100x greater

⁵ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

⁶ Gillis, Alexander S., and Kate Gerwig. “What Is 5G? Everything You Need to Know About 5G Technology.” *SearchNetworking*, TechTarget, 8 Jan. 2020, searchnetworking.techtarget.com/definition/5G.

⁷ Gillis, Alexander S., and Kate Gerwig. “What Is 5G? Everything You Need to Know About 5G Technology.” *SearchNetworking*, TechTarget, 8 Jan. 2020, searchnetworking.techtarget.com/definition/5G.

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than a typical 4G network.”⁸ For example, on a normal 4G network to download a movie to a mobile device will take around 2 minutes, however when operating on a 5G network this process will take only 2-3 seconds.

The most significant upgrade provided by 5G networks is the access to IoT or the “Internet of Things.” The IoT “encompasses everything connected to the internet, but it is increasingly being used to define objects that are able to “talk” to each other. More simply explained, the IoT is made up of devices – from simple sensors to smartphones and wearables – connected together.”⁹ IoT allows devices on closed private internet connections to communicate with others thus bringing those networks together. It gives the opportunity for devices to communicate not only within close silos but across different networking types and creates a much more connected world.”¹⁰ The number of IoT devices is greatly increasing each year due to the increasing number of microchips and data that are incorporated into everyday products we use. “The number of IoT devices is projected to grow from seven billion in 2018 to 22 billion by 2025. Market researcher Gartner predicts that by 2020, there will be 26 times more connected things than people, while globally, every second, another 127 devices are connected to the internet.”¹¹

5G will make advancements in IoT because it will allow products to become more connected than ever before which will give companies and people countless amounts of data to make products and life more efficient. With the 5G high-speed networks, devices

⁸ Tech Terms. “5G.” *5G Definition*, 18 May 2020, techterms.com/definition/5g.

⁹ Burgess, Matt. “What Is the Internet of Things? WIRED Explains.” *WIRED UK*, WIRED UK, 17 Nov. 2020, www.wired.co.uk/article/internet-of-things-what-is-explained-iot.

¹⁰ Burgess, Matt. “What Is the Internet of Things? WIRED Explains.” *WIRED UK*, WIRED UK, 17 Nov. 2020, www.wired.co.uk/article/internet-of-things-what-is-explained-iot.

¹¹ Kenworthy, Randal. “Council Post: The 5G And IoT Revolution Is Coming: Here’s What To Expect.” *Forbes*, Forbes Magazine, 18 Nov. 2019, www.forbes.com/sites/forbestechcouncil/2019/11/18/the-5g-iot-revolution-is-coming-heres-what-to-expect/?sh=1591ecc36abf.

will be able to communicate fast than ever before. “The exponential increase in connectivity 5G delivers makes it a technological paradigm shift akin to the transition from typewriters to computers, because it enables a single-use device (e.g. a pressure sensor in a pipeline) to conduct digitally automated services (e.g. detecting a leak and sending a notification to a regulator, triggering an alert to a third-party contractor for repair).”¹²

With the implementation of 5G, it will also be possible to transmit data in real time. This means that 100 billion mobile devices around the world would be accessible at the same time. In other words, a connection density of approximately one million devices per square kilometer. At the same time, the new technology will bring an increase in the relative movement speed. This means that connection quality will be much more stable up to a speed of 500 kilometers per hour, thus will bring about enormous benefits, especially for rail travelers. Regardless of smartphones, increasing amounts of data are inevitable in other areas of application. The numbers do not just sound huge, they are huge. For these reasons and many others, 5G IoT will become the new key technology of connectivity.¹³ The advancements that will come as a result of this new cellular technology will include “robotics and automation, virtual and augmented reality, and artificial intelligence and machine learning – transforming the scene of smart devices and applications, and the entire operation of digital societies, very likely in ways unimagined today.”¹⁴ It is examples such as these that make 5G so important; the

¹² Kenworthy, Randal. “Council Post: The 5G And IoT Revolution Is Coming: Here's What To Expect.” *Forbes*, Forbes Magazine, 18 Nov. 2019, www.forbes.com/sites/forbestechcouncil/2019/11/18/the-5g-iot-revolution-is-coming-heres-what-to-expect/?sh=1591ecc36abf.

¹³ Emnify . “What Is 5G IoT and How Will It Change Connectivity?” *IoT & M2M Connectivity Management Platform*, 10 Dec. 2020, www.emnify.com/en/resources/what-is-5g-iot-and-how-will-it-change-connectivity.

¹⁴ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

vastness of these networks and their integration into the innerworkings of human life will make 5G implementation crucial to any country seeking global dominance. While many would think of these advancements as positives, there are also many downsides that I will discuss in depth in this paper. These downsides include evolving security threats such as broader levels on which to attack meaning there will be an exponential rise in potential targets and subsequent attacks of 5G networks.¹⁵

II. Where did 5G start?

For this paper, it is important to first put into context the “generational networks” that have been created in the past 40 years and how these networks changed the world. Moreover, framing these networks and their beginnings will further show the impact that 5G networks will have on the future of the world, and more specifically, why 5G will define which country dominates the world for the next decade or longer.

Since the invention of cellular technology almost 40 years ago, each generation of technology has brought with it an evolved difference from the previous generation. “1G was analog cellular. 2G technologies, such as CDMA, GSM, and TDMA, were the first generation of digital cellular technologies. 3G technologies, such as EVDO, HSPA, and UMTS, brought speeds from 200kbps to a few megabits per second. 4G technologies, such as WiMAX and LTE, were the next incompatible leap forward, and they are now scaling up to hundreds of megabits and even gigabit-level speeds.”¹⁶ In order to explain how the world came from bulky phones that were carried in bags to new, sleek phones

¹⁵ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

¹⁶ Segan, Sascha. “What Is 5G?” *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

which contain more advanced technology than the first space shuttle, I will provide a brief overview of each generation of cellular technology.

First generation cellular or “1G” was launched in Tokyo, Japan in 1979 by Nittpon Telegraph and Telephone (NTT). By 1984, 1G covered the entirety of Japan. However, it was not until 1983 that the US approved 1G, and the first none-landline phones were sold across America as well as Britain and Canada.¹⁷ While 1G was cutting edge technology, it did have flaws such as little coverage areas and poor sound quality on the large majority of calls. A big security concern which come about with the invention of the first “mobile” phones was the lack of secure networks. Without secure networks, people could listen in on conversations by using radio scanners. Despite this, by the year 1990, Motorola had 20 million global users.¹⁸

The widespread success of 1G led to the creation of the second generation of mobile network better known as “2G.” 2G was launched in Finland in 1991. The main upgrades from 1G to 2G were the encryption of phone calls as well a drastic improvement in phone call quality. However, the biggest impact of 2G was the creation of text messages and picture messages which allowed people to communicate without talking on the phone. This new digital future of 2G led to massive increases in users all over the world. Because of buyer demand, companies invested in new infrastructure such as cell towers which led to increased speeds and connectivity.¹⁹

¹⁷ BrainBridge . “From 1G to 5G: A Brief History of the Evolution of Mobile Standards.” *From 1G to 5G: A Brief History of the Evolution of Mobile Standards / My Brainbridge*, 2020, www.brainbridge.be/news/from-1g-to-5g-a-brief-history-of-the-evolution-of-mobile-standards#:~:text=On%20December%2018%20South,was%20made%20back%20in%201973.

¹⁸ BrainBridge . “From 1G to 5G: A Brief History of the Evolution of Mobile Standards.” *From 1G to 5G: A Brief History of the Evolution of Mobile Standards / My Brainbridge*, 2020, www.brainbridge.be/news/from-1g-to-5g-a-brief-history-of-the-evolution-of-mobile-standards#:~:text=On%20December%2018%20South,was%20made%20back%20in%201973.

¹⁹ BrainBridge . “From 1G to 5G: A Brief History of the Evolution of Mobile Standards.” *From 1G to 5G: A Brief History of the Evolution of Mobile Standards / My Brainbridge*, 2020, www.brainbridge.be/news/from-1g-to-5g-a-brief-history-of-the-evolution-of-mobile-standards#:~:text=On%20December%2018%20South,was%20made%20back%20in%201973.

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3G was launched by Japanese company NTT and was formulated around increased speed and standardized networks across the country so that international roaming could be made possible on cell phones. 3G increased connectivity speeds, which was 4 times faster than 2G, led to new technology like video calls and video streaming on devices. The most popular phone in the 3G era launched in 2002, the Blackberry. However, in late 2007 at the end of 3G, Apple launched the iPhone which led to the need for increased technology across the board.²⁰

4G was first deployed in Sweden and Norway in 2009 and became known as 4G LTE Standard. 4G offered fast mobile web access which allowed users access to HD video streaming, faster message services, Facetime calls, and increased mobile games. 4G had large popularity due to users having to buy 4G specific phones compared to phones that could easily switch from cellular generations in the past.²¹ 4G networks featured networks that were up to 500 times faster than 3G.²² 4G can support up to 2 Gbps and is slowly continuing to improve in speeds to this day.

The invention of 4G led creators to look ahead to the next generation of cellular networks: 5G. 5G was initially launched by South Korea in March 2019. The fifth-generation network was rolled out by three South Korean telecom providers.²³ 5G brings three new aspects to the table: bigger channels (to speed up data), lower latency (to be

evolution-of-mobile-standards#:~:text=On%20December%201%2C%202018%2C%20South,was%20made%20back%20in%201973.

²⁰ BrainBridge . "From 1G to 5G: A Brief History of the Evolution of Mobile Standards." *From 1G to 5G: A Brief History of the Evolution of Mobile Standards / My Brainbridge*, 2020, www.brainbridge.be/news/from-1g-to-5g-a-brief-history-of-the-evolution-of-mobile-

standards#:~:text=On%20December%201%2C%202018%2C%20South,was%20made%20back%20in%201973.

²¹ BrainBridge . "From 1G to 5G: A Brief History of the Evolution of Mobile Standards." *From 1G to 5G: A Brief History of the Evolution of Mobile Standards / My Brainbridge*, 2020, www.brainbridge.be/news/from-1g-to-5g-a-brief-history-of-the-evolution-of-mobile-

standards#:~:text=On%20December%201%2C%202018%2C%20South,was%20made%20back%20in%201973.

²² Gillis, Alexander S., and Kate Gerwig. "What Is 5G? Everything You Need to Know About 5G Technology." *SearchNetworking*, TechTarget, 8 Jan. 2020, searchnetworking.techtarget.com/definition/5G.

²³ Galazzo, Richard. "Timeline from 1G to 5G: A Brief History on Cell Phones." *CENGN*, 24 Feb. 2021, www.cengn.ca/timeline-from-1g-to-5g-a-brief-history-on-cell-phones/.

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more responsive), and the ability to connect a lot more devices at once (for sensors and smart devices).²⁴ However, 5G networks are very much still a work in progress as many countries do not have the necessary capabilities and cell towers to effectively run 5G devices at their full force.

While generations 1-4 provided their own new networks and new cellular devices, 5G does not because it is not a network. 5G is not inherently separate from 4G. 5G phones all need 4G's networks and coverage. Initially, all 5G networks used 4G to establish their connections, something called "non-standalone." Now, "standalone" networks are being created, but there's no standard for voice calls over 5G yet. Therefore, every time you want to make a phone call, your phone has to fall back to 4G. Part of the 5G specifications also allows 5G phones to combine 5G and 4G channels invisibly and seamlessly to the user." That symbiosis between 4G and 5G has caused AT&T to get a little overenthusiastic about its 4G network. "The carrier has started to call its 4G network "5G Evolution," because it sees improving 4G as a major step to 5G. AT&T is right to see it as an evolution, but the phrasing confuses less-informed consumers, making them think 5G Evolution is 5G, when it isn't."²⁵ This means in part that while the US carriers will turn off their 2G and 3G networks in the next few years, 4G has many years ahead of it as part of the 5G equation.

In summation, "1G, the first generation of telecom networks (1979), lets us talk to each other and be mobile. 2G digital networks (1991) let us send messages and travel (with roaming services) 2.5G and 2.75G brought some improvement to data services (GPRS and EDGE). 3G (1998) brought a better mobile internet experience (with limited

²⁴ Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

²⁵ Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

success). 3.5G brought a truly mobile internet experience, unleashing the mobile apps eco-system. 4G (2008) networks brought all-IP services (Voice and Data), a fast-broadband internet experience, with unified networks architectures and protocols. 4G LTE (for Long Term Evolution), starting in 2009, doubled data speeds. 5G networks will expand broadband wireless services beyond mobile internet to IoT and critical communications segments,” by allowing the creation of new industries and technologically advanced infrastructure.²⁶

III. Improvement on Current Technology

The advancements in generational networks, as discussed in the previous section shows that 5G will provide many upgrades to the previous generations of wireless networks. These advancements will include some basic upgrades such as increased data speed on cell phones to advancements that are more complicated such as the Internet of Things (IoT). “5G for consumers means not just faster mobile internet, but mainly internet connectivity in many more objects than what you see today. The car and the house are two examples of the big IoT revolution coming ahead, supported by 5G networks.”²⁷ This section will provide an overview of the advancements that 5G will bring forth the both for the users of 5G products and the producers of these products. These advancements will be in the fields of smart devices, consumer products, industrial production, health care, and IoT connectivity. These advancements further display the

²⁶ Thales Group . “Introducing 5G Technology and Networks (Speed, Use Cases and Rollout).” *What Is 5G? A Helpful Illustrated Q&A (2021)*, Thales Group , 4 Feb. 2021, www.thalesgroup.com/en/markets/digital-identity-and-security/mobile/inspired/5G.

²⁷ Thales Group . “Introducing 5G Technology and Networks (Speed, Use Cases and Rollout).” *What Is 5G? A Helpful Illustrated Q&A (2021)*, Thales Group , 4 Feb. 2021, www.thalesgroup.com/en/markets/digital-identity-and-security/mobile/inspired/5G.

importance of 5G for countries and companies seeking to stay relevant in both global relations and business for generations to come.

The first advancement that will be noticeable around the globe is the utilization of 5G transmitter signals compared to 4G cell towers. While 4G LTE provides the foundation for 5G networks, they utilize “large, high-power cell towers to radiate signals over longer distances.” In contrast, 5G signals will be “transmitted through large numbers of small cell stations located in places like light poles or building roofs.”²⁸ The use of smaller cell stations instead of larger cell towers is called network densification. Cell phone carriers are already building hundreds of thousands of these “small cell” carriers all across the globe to supplement their 4G towers. The reason that 5G networks will use smaller stations located on preexisting or new places is due to an effort by companies to relieve network congestion that is often experienced when using 4G towers. “Sharing a 4G tower with everyone in your neighborhood means that sometimes networks falter and YouTube videos, games, or video chats stutter. 5G will first be deployed in urban neighborhoods to relieve areas with the most intense network congestion.”²⁹

Another advancement that has been widely discussed is the major increase in speed that will occur in fully-functioning 5G networks compared to 4G LTE. “5G download speeds can currently reach upwards of 1,000 megabits per second (Mbps) or even up to 2.1 Gbps. To visualize this, a user could start a YouTube video in 1080p quality on a 5G device without it buffering. Downloading an app or an episode of a Netflix show, which may currently take up to a few minutes, can be completed in just a few seconds.

²⁸ Gillis, Alexander S., and Kate Gerwig. “What Is 5G? Everything You Need to Know About 5G Technology.” *SearchNetworking*, TechTarget, 8 Jan. 2020, searchnetworking.techtarget.com/definition/5G.

²⁹ Skorup, Brent. *5G Basics and Public Policy*. Mercatus Center at George Mason University, Feb. 2019, www.thriveed.org/wp-content/uploads/2019/03/skorup_-_policy_brief_-_5g_basics_and_public_policy_-_v1_0.pdf.

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Wirelessly streaming video in 4K also becomes much more viable.”³⁰ These new speeds, while an advancement unto themselves, will lead to further advancements that will integrate technology more into our daily lives and every application that we touch.

5G is much more than just fast downloads; its unique combination of high-speed connectivity, very low latency, and ubiquitous coverage will support smart vehicles and transport infrastructure such as connected cars, trucks, and buses, where a split-second delay could mean the difference between a smooth flow of traffic and a 4-way crash at an intersection.³¹ 4G created a massive market for smartphone apps and the use of phones other than calling or texting such as mobile gaming, video watching, and ride sharing.³² 5G improvements means more services and, with that, high-speed services. An example of a service is “Aira makes “smart glasses” for blind people. These glasses require wireless reliability and real-time responsiveness. A camera in the glasses streams video via a wireless connection to a distant human assistant who verbally helps the customer navigate airports, restaurants, and other public places.”³³

5G networks will allow these advancements through the use of the IoT that was briefly discussed in this paper. Current devices which come to mind for many people include Alexa or Google home, but this will soon expand into many more home devices, wearable devices, and others. 5G will also bring about advancements in the business sector as companies will be able to use more artificial intelligence and advanced technology within their businesses. “Carriers and chip companies designed 5G standards

³⁰ Gillis, Alexander S., and Kate Gerwig. “What Is 5G? Everything You Need to Know About 5G Technology.” *SearchNetworking*, TechTarget, 8 Jan. 2020, searchnetworking.techtarget.com/definition/5G.

³¹ Collela, Paolo. *5G And IoT: Ushering in a New Era*, 2021, www.ericsson.com/en/about-us/company-facts/ericsson-worldwide/india/authored-articles/5g-and-iot-ushering-in-a-new-era .

³² Skorup, Brent. *5G Basics and Public Policy*. Mercatus Center at George Mason University, Feb. 2019, www.thriveed.org/wp-content/uploads/2019/03/skorup_-_policy_brief_-_5g_basics_and_public_policy_-_v1_0.pdf.

³³ Skorup, Brent. *5G Basics and Public Policy*. Mercatus Center at George Mason University, Feb. 2019, www.thriveed.org/wp-content/uploads/2019/03/skorup_-_policy_brief_-_5g_basics_and_public_policy_-_v1_0.pdf.

with enterprise and industry customers as a priority. Some enterprise services that might benefit from 5G include commercial drones (inspections, medicine delivery, Amazon deliveries, search and-rescue, etc.), air taxis and flying cars, remote control of autonomous vehicles, and warehouse floor robots.³⁴ 5G will enable us to control devices remotely where real-time network performance is critical, such as remote control of heavy machinery in hazardous environments, thereby improving worker safety, and even remote surgery. For example, a significant majority of healthcare executives surveyed (73%) expect next-generation mobile networks (5G) to allow them to implement new services and products that will improve quality of life for the general public. 5G promises to make remote medical care a reality—and to be a change agent for the future of the industry.³⁵

With 5G, the continuous data exchange between machines, systems, robots and people will become an integral part of industrial production. The number of connected devices and parts will increase enormously. For example, the control units of industrial robots are addressed in real time – and error probabilities are ultimately reducible to a minimum. For example, the driverless courier service would therefore be able to always pick up the materials on time at the loading and unloading points of the machines. There are numerous examples in the industry to show how 5G can be used to optimize operational processes. The new technologies give rise to opportunities and ideas that nobody had thought of, because they were not technically possible before.³⁶ These ideas

³⁴ Skorup, Brent. *5G Basics and Public Policy*. Mercatus Center at George Mason University, Feb. 2019, www.thriveed.org/wp-content/uploads/2019/03/skorup_-_policy_brief_-5g_basics_and_public_policy_-_v1_0.pdf.

³⁵ Collela, Paolo. *5G And IoT: Ushering in a New Era*, 2021, www.ericsson.com/en/about-us/company-facts/ericsson-worldwide/india/authored-articles/5g-and-iot-ushering-in-a-new-era.

³⁶ Emnify . “What Is 5G IoT and How Will It Change Connectivity?” *IoT & M2M Connectivity Management Platform*, 10 Dec. 2020, www.emnify.com/en/resources/what-is-5g-iot-and-how-will-it-change-connectivity.

and opportunities are also adapting to other economic sectors, regardless of industry. For example, agriculture with so-called smart farming. Thanks to digital use, data and insights regarding animal health, where weeds or pests are, or what the moisture in the soil is like are all possible. Such intelligent networks will multiply and mature in the future. With 5G IoT connectivity, smart farming creates something that conventional agriculture has not yet been able to do: It creates a greater degree of ecology while increasing efficiency in food production.³⁷

More in depth, the IoT is going to be an integral part of almost everything that we buy within the next 10 years. It is evident that 5G is going to spur innovation across all industries and provides platforms for many emerging technologies. Connectivity is the heart of the 5G movement. With connectivity, the world will be a more efficient place. Operators have excelled in connecting phones, tablets, and other devices, but connecting and managing growing numbers of cars, meters, machinery sensors and consumer electronics profitably will require innovative business models.³⁸ The IoT has the potential to provide users with smart services, while raising security and privacy questions and offering new challenges to standardization and governance bodies. The 5G technology can significantly expand IoT beyond what is possible with existing technologies. The 5G wireless network will enable IoT devices to interact with smart environment to a new level through intelligent sensors connected. The 5G wireless network can also significantly enlarge the scope and scale of IoT by providing the fastest communication

³⁷ Emnify . “What Is 5G IoT and How Will It Change Connectivity?” *IoT & M2M Connectivity Management Platform*, 10 Dec. 2020, www.emnify.com/en/resources/what-is-5g-iot-and-how-will-it-change-connectivity.

³⁸ Collela, Paolo. *5G And IoT: Ushering in a New Era*, 2021, www.ericsson.com/en/about-us/company-facts/ericsson-worldwide/india/authored-articles/5g-and-iot-ushering-in-a-new-era .

and capacity.³⁹ It is the full integration of technology and the IoT into all sectors that is causing companies and consumers to wonder who is making this technology and who could have possible control of this new vast amount of data when 5G networks reach their full capabilities.

³⁹ Li, Shancang, et al. "5G Internet of Things: A Survey." *Journal of Industrial Information Integration*, 20 Jan. 2018, doi:<https://doi.org/10.1016/j.jii.2018.01.005>.

Chapter 3: China and 5G

This section will focus on China's rise to technological power since the early 1990's. More specifically, it will focus on the rise of Huawei into the global spotlight for telecommunications companies.

Beginning over a decade ago with the 2006 long-term national innovation strategy, the People's Republic of China has been determined to become "a digital technology superpower."⁴⁰ This strategy included, "setting goals of technological indigenous innovation and untying itself from the West."⁴¹ When referring to the West, this mainly meant the need to use U.S. based products for everyday life. To remove itself from Western technology, China backed the effort to create "firm government guidance and control, with focused government investment into technology research and development. By restricting Western companies' access to the Chinese market, Chinese industry has been able to benefit from the economies of scale in its home market, largely unchallenged by foreign competitors. Government subsidy and direct financing has boosted Chinese companies' competitive position on the global market, both in terms of technological advance and affordable prices. Over recent years, Chinese capital has acquired numerous Western technology and infrastructure companies, which is leaving European and US regulators increasingly concerned."⁴²

⁴⁰ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

⁴¹ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

⁴² Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

In recent years, China has turned its attention towards the introduction and implementation of 5G networks into their society, which would then allow its domestic companies to sell these products to the world. In 2020, Chinese operators accelerated the deployment of 5G networks across the country and now operate more than 700,000 5G sites nationwide. New implementations are expected to occur later this year, to further expand 5G coverage in urban and rural areas of the country.⁴³ “China plans to achieve full urban/rural coverage of the 5G network by 2025. It will build the world’s largest 5G network. Operators are expected to deploy nearly 1 million base stations in China in 2021, to continue to expand 5G coverage. China is in a leading position in the global 5G field. Its successful practice will provide valuable reference for the development of global 5G.”⁴⁴

One of the reasons China has been able to deploy 5G networks and stations across the country is because “of focused government industrial policy and accompanying funding instruments.”⁴⁵ Meaning, the government has increased state funding and incentives for their domestic companies.

Through these efforts, Chinese companies have increased their number of patents, made large technological advancements compared to other companies, and increased the capabilities to compete with and take over Western companies’ foothold in the world technological market. These Chinese efforts for 5G dominance have been funneled through one company: Huawei.

⁴³ Tomás, Juan Pedro. “Chinese Telcos Expected to Deploy 1 Million 5G SA Base Stations This Year.” *RCR Wireless News*, 8 Feb. 2021, www.rcrwireless.com/20210205/5g/chinese-telcos-expected-deploy-1-million-5g-sa-base-stations-this-year.

⁴⁴ Tomás, Juan Pedro. “Chinese Telcos Expected to Deploy 1 Million 5G SA Base Stations This Year.” *RCR Wireless News*, 8 Feb. 2021, www.rcrwireless.com/20210205/5g/chinese-telcos-expected-deploy-1-million-5g-sa-base-stations-this-year.

⁴⁵ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

I. Huawei

“Huawei Technologies Co Ltd is a Chinese company founded by former military officer Ren Zhengfei in 1987 in Shenzhen. It began by selling switching equipment to direct phone traffic through rural China but now produces smart devices, cloud services and telecommunications equipment.”⁴⁶ However, the size and ability of the company greatly changed when it was granted a government contract in 1993. “That contract gave the company an important boost over its rivals. A year later, Ren managed to secure another form of protection from the state. He met with Jiang Zemin, the Communist Party general secretary, and told him that a country without a domestic telecom switch industry was like a country without a military. “Well said,” Jiang replied, according to Ren’s account of the meeting.”⁴⁷

By 1996, under Ren’s prodding, “the Chinese government shifted its industrial policy to favor domestic telecommunications companies, keeping foreign competitors out.”⁴⁸ It was because of this meeting that Ren was able to give Huawei a portion of the telecommunications market. Starting in 1997, Huawei entered the Global System of Mobile communications (GSM) network, making equipment for 2G and 3G mobile systems.”⁴⁹ The increased Chinese focus on domestic telecom companies has allowed Huawei the access and ability to grow without competition that American companies face and become a telecom giant. Since entering the market in 1997, Huawei has become a

⁴⁶ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

⁴⁷ Johnson, Keith, and Elias Groll. “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁴⁸ Johnson, Keith, and Elias Groll. “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁴⁹ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

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telecom giant because of the “billions of dollars in support from the Chinese government, last year posting more than \$107 billion in revenue from operations in some 170 countries. More important, Huawei has, by most accounts, taken the lead in the race to develop one of the modern world’s most important technologies: fifth-generation mobile telephony. Unlike its various predecessors, which simply offered consumers the ability to send texts, then to surf the web on their phones, and finally to stream video, 5G promises to revolutionize the entire global economy.”⁵⁰

While the US was dominating the early 4G markets in the late 2000’s, Huawei made the decision that it was going to focus its efforts on 5G in order to create this new network before the United States. Huawei did this the same way that it started: funding and research/development. “The US wrote 4G,” says Charles Clancy, vice president for intelligence programs at MITRE, a nonprofit that manages US research projects. “In the meantime, through government subsidies and cybertheft of competitors’ intellectual property, Huawei became the global leader while nobody was watching,” says Clancy, who has studied 5G security. “They slowly took control of the standards groups, and China wrote 5G.”⁵¹ The reason that Huawei has been able to ‘write 5G’ is because of government funding, a cost advantage over their competitors, patents, and the ability to create every piece of hardware that is used in the development of their phones.

China has long been accused of providing state funding for its companies and organizations to have better standing within the international markets compared to countries with completely free markets. The Chinese government, however, often says

⁵⁰ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁵¹ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

that their markets are free, while it has largely been speculated that they are run by the CCP. While China continues to claim it does not provide funding for their organizations, recent reports counter this claim made by the CCP. In 2019, the CIA reportedly told members of the Five-Eyes Intelligence alliance that Huawei has received funding from “the People’s Liberation Army, China’s National Security Commission and a third branch of the Chinese state intelligence network.”⁵² Continuing with the article, “only the most senior U.K. officials are believed to have seen the intelligence, which the CIA awarded a strong but not cast-iron classification of certainty. The Chinese ministry of state security — its principal security and espionage organization — had approved government funding for Huawei.”⁵³

Huawei has most likely used government funding throughout its history. While they say they have no ties to the Chinese government many documents have linked the telecom giant to multiple Chinese owned banks for large investments. “Huawei appears to have benefited from state support not available to the company’s Western rivals such as Qualcomm or Ericsson, though the exact nature of that aid is difficult to quantify, as is the broader relationship of any private Chinese firm to the government.”⁵⁴ While the number of subsidies is not known, it is claimed that Huawei receives massive funding from the Chinese government. “Analysis by The Wall Street Journal puts the figure at \$75 billion. Huawei disputes this but will not specify the amount itself.”⁵⁵ Huawei does

⁵² Fisher, Lucy. “CIA Warning over Huawei.” *News / The Times*, The Times, 20 Apr. 2019, www.thetimes.co.uk/article/cia-warning-over-huawei-rz6xc8kzk.

⁵³ Fisher, Lucy. “CIA Warning over Huawei.” *News / The Times*, The Times, 20 Apr. 2019, www.thetimes.co.uk/article/cia-warning-over-huawei-rz6xc8kzk.

⁵⁴ Johnson, Keith, and Elias Groll. “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁵⁵ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

not have to specify the amount because the company is privately held through complex employee ownership. This ownership may show that the company is indeed funded by the Chinese government as US researchers say “it is owned by a holding company that is 99 percent owned by an entity called a “trade union committee” and 1 percent owned by Ren. The researchers have found that if the ownership stake claimed by the trade union committee is genuine, and if the trade union and its committee function as trade unions generally function in China, then Huawei may be deemed effectively state-owned.”⁵⁶ Further investigation has also shown that “Huawei may have received a massive \$30 billion line of credit from the China Development Bank, among other well-timed financing. State-backed finance was crucial in Huawei’s growth,” said Matthew Schrader, a China analyst at the Alliance for Securing Democracy at the German Marshall Fund. It helped Huawei sew up the domestic market, which in turn enabled it to expand overseas by offering deep discounts.”⁵⁷ This funding has given Huawei a cost advantage in comparison to western products.

This cost advantage makes Huawei products more affordable while being just as technologically advanced. “Huawei’s affordable pricing is more likely an outcome of China’s domestic policy than its fundamental technological superiority over competitors. Preferential treatment of domestic providers means that the latter ‘control 75 percent of the [Chinese] market, giving them unbeatable economies of scale’.”⁵⁸ Because of this cost advantage, more Europeans are turning to Huawei to use their products due to the

⁵⁶ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

⁵⁷ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁵⁸ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

expensive nature of American-made smart phones. “Europe is a market, with a sizable lower middle class which isn’t able to afford an iPhone — especially not when such a device becomes obsolete so quickly.” He continues to say, “There is a huge market remaining for cheaper, lower-end smartphones.”⁵⁹ Once Huawei was able to see the demand that exists in Europe, they started exponentially increasing their share of the market. “In 2015, only about 2 percent of smartphones sold in Europe were Huawei devices; now Huawei sells nearly a quarter of the smartphones in Europe.”⁶⁰ This cost advantage is also true for Huawei’s infrastructure. “Huawei is about 30 percent cheaper than its rivals. Critics say massive Chinese state subsidies are allowing the company to undercut and kill rivals, leaving the world depending on Chinese equipment for its critical infrastructure.”⁶¹ With this cost advantage, more countries are likely to choose Huawei to build their cellular networks compared to more expensive companies such as Nokia and Ericsson. Recently, Huawei has been contracted to build over 39 5G networks around the world, with dozens of other countries close to signing on.⁶² This is especially true in Europe.

Huawei has “a baked-in 5G advantage in Europe, because it helped build out extensive 4G networks.”⁶³ For example, in Britain, “Huawei is allowed to supply 35% of

⁵⁹ Burdeau, Cain. “Europe Becomes a Battleground Over Huawei and 5G.” *Courthouse News Service*, 12 Feb. 2020, www.courthousenews.com/europe-becomes-a-battleground-over-huawei-and-5g/.

⁶⁰ Burdeau, Cain. “Europe Becomes a Battleground Over Huawei and 5G.” *Courthouse News Service*, 12 Feb. 2020, www.courthousenews.com/europe-becomes-a-battleground-over-huawei-and-5g/.

⁶¹ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

⁶² Johnson, Keith, and Elias Groll. “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁶³ Feng, Emily, and Amy Cheng. “China’s Tech Giant Huawei Spans Much Of The Globe Despite U.S. Efforts To Ban It.” *NPR*, NPR, 24 Oct. 2019, www.npr.org/2019/10/24/759902041/chinas-tech-giant-huawei-spans-much-of-the-globe-despite-u-s-efforts-to-ban-it.

what it categorizes as periphery infrastructure, such as masts and antennae.”⁶⁴ However, Ren says that Huawei’s goal is not global dominance in the infrastructure of smartphones, but with operations in 170 countries and the fact that “Huawei recorded total revenues of \$US87 billion – up 24% on the same period in 2018,” it begs the question, what are they after? Ren says, “Huawei wants to be the world's leading supplier of the equipment that runs 5G networks enabling super-fast mobile broadband speeds.”⁶⁵ This mission seems to be funded by the Chinese goal of dominance over the world, which they are attempting to get to through 5G networks.

To become the world’s leading supplier in 5G related equipment, Huawei has been stockpiling patents and creating technology at a rate that other countries have not. “Huawei has more 5G-related patents than any other firm, according to IPlytics, a German-based company that tracks intellectual property development. That means other companies will have to pay Huawei to use key bits of 5G technology.”⁶⁶ However, Huawei is not in this so-called “patent race” alone. Along with Huawei and other Chinese telecom companies, China is taking active role in securing “core” patents and rights for 5G essential property rights. China currently holds an estimated 10 percent of the ‘5G-essential’ industrial property rights in radio access solutions; of these, Huawei has the most patents, followed by ZTE.”⁶⁷ By securing patents, Huawei is giving themselves the

⁶⁴ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

⁶⁵ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

⁶⁶ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁶⁷ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

leading role in shaping the future of 5G by making companies ask and pay Huawei to use these patents or patented products. Huawei's leading role in shaping the most important new technology standard will likely pay dividends in terms of billions of dollars in license fees. Additionally, it could give the Chinese firm an advantage as countries around the world scramble to build 5G networks. "In the developing world, China is internationalizing Chinese technology standards."⁶⁸ By making the world come through Huawei for use of such patents, it allows China to continue to attempt to assert their dominance on a world technological stage.

To receive these patents and IP rights to technology, Huawei has had to build technology and technological networks which it has done faster than its competitors. Huawei also does something that no other technology company has done with 5G; it makes and designs every component of their 5G technology, including their 5G smartphones.⁶⁹ Because of these advances which set them apart, Huawei is currently the only company that can produce 'at scale and cost all the elements of a 5G network, with its closest competitors Nokia and Ericsson not yet able to offer a viable alternative. Huawei's ambition is to dominate the market for 5G wireless communications, and it has established cooperation with telecommunications companies in a number of countries in Europe and worldwide."⁷⁰ By making each part or component of their 5G products and networks, Huawei can control how fast or how vast they want to expand and implement their 5G networks around the world. Additionally, by creating every component Huawei

⁶⁸ Johnson, Keith, and Elias Groll . "The Improbable Rise of Huawei." *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁶⁹ Johnson, Keith, and Elias Groll . "The Improbable Rise of Huawei." *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁷⁰ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

has an economic advantage over each of their competitors who do not make every piece of technology.

Huawei is able to make these components because of their extensive patents and rights, which has allowed them to produce not just 5G infrastructure, but also every part of their smartphones. They now produce the second most smartphones in the world behind South Korea's Samsung. "By designing chipsets and the handsets they talk to, experts argue, Huawei may have an edge in getting 5G products to market more quickly."⁷¹ By being able to make their phones faster, Huawei has been able to get their products to market faster as "the company is now estimated to supply 30% of the world's mobile technology market, double the reach of its nearest rivals, Nokia and Ericsson."⁷² While some would argue that producing all parts of a phone or infrastructure could break down advancements and speed, Huawei has managed to continually average high 5G speeds. It employs 194,000 staff worldwide, 60,000 of them based in Shenzhen. Huawei says 45 percent of its staff work on researching and developing new technologies."⁷³ This statistic is also back up by field-testing and research. "We have field-tested its 5G technology in lower frequencies (good for coverage) and higher frequencies (better for high data speeds). Earlier this year, it debuted its own, in-house-designed chipset and devices that will make 5G a reality."⁷⁴

⁷¹ Johnson, Keith, and Elias Groll . "The Improbable Rise of Huawei." *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁷² Bourke, Latika. "Why Are Huawei and 5G Such a Big Deal around the World?" *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

⁷³ Bourke, Latika. "Why Are Huawei and 5G Such a Big Deal around the World?" *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

⁷⁴ Johnson, Keith, and Elias Groll . "The Improbable Rise of Huawei." *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

Huawei is writing 5G. Studies have shown that with their advancements and lower costs, Huawei is in control of the 5G race. “5G will be, simply put, the central nervous system of the 21st-century economy—and if Huawei continues its rise, then Beijing, not Washington, could be best placed to dominate it.”⁷⁵ This can be shown by the number of 5G subscribers that will be in the world by the end of 2021 as “global 5G mobile subscriptions are expected to reach 220 million by the end of this year, with China accounting for almost 80% of the total, Ericsson said in a report last month. North America is expected to have 4%.”⁷⁶ By accounting for 80 percent of 5G subscriptions around the world, China is making its case for 5G dominance.

Others have said that Huawei is building their market dominance with 5G and will be a telecom company to be dealt with for the foreseeable future. “5G is totally different than the internet. It's like a global nervous system. Huawei is the leading company in 5G. They will be around in 10, 20, 50 years—you cannot say that about the US tech companies. In the internet era, the US produced a few trillion-dollar companies. Because of 5G, China will have 10 or more trillion-dollar companies. Huawei and China now have the lead.”⁷⁷

Some have even seen Huawei being the company that the United States and others should be worried about for years to come. “From the year 2001 to the present—three administrations—not enough attention has been paid to Huawei and their technological advancements,” says Reed Hundt, a former Federal Communications Commission chair

⁷⁵ Johnson, Keith, and Elias Groll. “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁷⁶ Mukherjee, Supantha, and Isla Binnie. “Analysis: Europe Plots Catch-up in Global 5G Race to Drive COVID-19 Recovery.” *Reuters*, Thomson Reuters, 28 Dec. 2020, www.reuters.com/article/us-europe-5g-analysis/analysis-europe-plots-catch-up-in-global-5g-race-to-drive-covid-19-recovery-idUSKBN2920WJ.

⁷⁷ Levy, Steven. “Huawei, 5G, and the Man Who Conquered Noise.” *Wired*, Conde Nast, 2020, www.wired.com/story/huawei-5g-polar-codes-data-breakthrough/.

during the Clinton administration. Hundt is one of a number of current and former officials alarmed that the United States has no equivalent to Huawei—that is, a major telecommunications company that both develops next-generation technology and builds it into equipment. “In Europe, they have an Ericsson. In Japan, they have companies. And in China, they have not just Huawei but also ZTE. But Huawei is the one that covers the whole range of products.” All of this made Huawei's 5G standards bid an alarming prospect. “Huawei's IP and standards are the wedge they intend to use to pry open the Western computing world,” Hundt says.”⁷⁸ With Huawei, China will assert its self as the dominant country in the world, at least technologically and economically, for years to come.

Huawei is the Chinese leader, and disputed world leader in current 5G telecommunications and networks. While many authors have spoken about the concerns with Huawei leading the way for 5G, some analysts are worried about the implications this could have in relation to China. “While Huawei stands in the limelight due to its advanced 5G capacity, the issue is not just about Huawei: many states are likewise concerned about other Chinese communications and video surveillance technology manufacturers – primarily ZTE, but also Hytera Communications Corporation, Hangzhou Hikvision, and Dahua Technology, all of whose technology has been banned from use in government networks under US law.”⁷⁹ These implications and security concerns listed, among others, will be discussed and analyzed more in depth later in the paper, but one

⁷⁸ Levy, Steven. “Huawei, 5G, and the Man Who Conquered Noise.” *Wired*, Conde Nast, 2020, www.wired.com/story/huawei-5g-polar-codes-data-breakthrough/.

⁷⁹ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

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thing is clear from the research: “No one knows the future. But Huawei and China now have a hand in controlling it.”⁸⁰

⁸⁰ Levy, Steven. “Huawei, 5G, and the Man Who Conquered Noise.” *Wired*, Conde Nast, 2020, www.wired.com/story/huawei-5g-polar-codes-data-breakthrough/.

Chapter 4: United States and 5G

While the Chinese 5G network implementation is being funneled through Huawei and their research and development team, the American companies are working to research and develop their own 5G networks and technology free of government funding.

This section will detail the common misconceptions surrounding 5G networks especially when it involves the 5G capabilities of US-based cellular networks such as Verizon, AT&T, T-Mobile, and Sprint. This section will also discuss the 5G capabilities of Qualcomm, an American company which currently stands as Huawei's main competitor for 5G infrastructure.

I. Misconception of 5G in the United States

With the rollout of 5G upon us, many US companies are claiming to have the fastest 5G in America. This statement of "Nationwide 5G" has been claimed by all the major cellular providers on billboards, tv commercials, and internet ads. Yet, as they all make this claim, none of them are really telling the truth. Better put, they are hiding the real truth from their customers. Many have done testing on the 5G capabilities of these companies, and their findings are very consistent: 5G, currently, is not faster than 4G for the most part; and if it is faster, it does not have the capabilities that the true 5G networks will have.⁸¹ One study, which went to 26 different cities that have 5G on all three major US carriers, and they found "that AT&T's and T-Mobile's 5G feels a lot like 4G, and while Verizon's 5G feels radically different, it has very little coverage."⁸² This is because the supposed "5G" that is being released is, for the most part, rebranded 4GLTE or enhanced 4G networks, that do not have the full capabilities of a functioning 5G network.

⁸¹ Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

⁸² Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

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For example, Verizon has fast, high-band 5G in parts of 35 cities, with online coverage maps. T-Mobile currently has a slow nationwide low-band 5G network that covers most of the country; mid-band in five cities, and high-band in seven cities. AT&T has slow low-band across most of the country and high-band in 35 cities, which it doesn't give maps for and is unnecessarily confusing about the coverage of. It calls the low-band "5G" and the high-band "5G+."⁸³ To make this clearer, we do have 5G technology in the United States, but we don't have the 5G experience; meaning we do not currently have the capabilities and networks in place to see real improvements in 5G over 4G.⁸⁴

The truth is, "5G is still being developed, and commercial rollout in a limited fashion won't begin in earnest until next year; the first true 5G networks, which will deliver all the whiz-bang features the technology promises, probably won't arrive until 2025 at the earliest."⁸⁵ 5G itself is not a "magic bullet" as many think it is, it's wrong to assume 5G will immediately make everything faster. If I get a 5G phone right now, even if I live in a 5G network, I'm unlikely to notice much of a change. That is because 5G is really an enabling technology, and for 5G to have a big impact, it requires multiple 'complementary technologies' to come along with it, which are not in place yet."⁸⁶ While the earliest "5G experience" will not begin until 2025, many US customers believe that their phones are using 5G technology. In fact, "one in three Americans think they already have 5G, according to one study from 2019. The results showed that 47% of AT&T subscribers who own iPhones think their device is 5G-capable. AT&T's misleading 5G Evolution logo (5GE) to describe service that's really just advanced LTE, probably aided

⁸³ Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

⁸⁴ Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

⁸⁵ Johnson, Keith, and Elias Groll. "The Improbable Rise of Huawei." *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

⁸⁶ Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

that confusion.”⁸⁷ As mentioned above, AT&T is the biggest culprit of misleading its customers with commercials and even signals on devices showing that their phones are on 5G when in big cities such as Atlanta. However, “5GE is just a rebranding of AT&T's Gb 4G LTE network. AT&T argues that the speeds are close enough to 5G, but it is technically not 5G.”⁸⁸ The G stands for generation, typically signaling a compatibility break with former hardware. 5GE does not follow this trend and is technically not 5G. This marketing strategy may mislead individuals who do not know 5GE is not actually 5G.

It is important to note that while many 5G networks do not have the full capabilities and will not have full capabilities, a study was conducted to find the 5G speeds that companies have and their effectiveness in cities. “ootMetrics” praised T-Mobile/Sprint for having the largest 5G footprint and best availability across the country, however Verizon did have the fastest overall speeds, even though these speeds were in such small areas. This finding is shown in Figure 7. Meanwhile, Opensignal declares T-Mobile/Sprint to have the best 5G network at the moment thanks to top download and upload speeds. Verizon has the better video experience over 5G.⁸⁹ Another study done by Ookla, which relies on crowd-sourced testing, gives the crown to AT&T for fastest 5G network as of the end of 2020, after Verizon's average speed tumbled thanks to the introduction of slower nationwide coverage.⁹⁰

II. Qualcomm

⁸⁷ Staff, Tom's Guide. “When Is 5G Coming to You? The Definitive Guide to the 5G Network Rollout.” *Tom's Guide*, Tom's Guide, 4 Feb. 2021, www.tomsguide.com/special-report/when-is-5g-coming-to-you-the-definitive-guide-to-the-5g-network-rollout.

⁸⁸ Gillis, Alexander S., and Kate Gerwig. “What Is 5G? Everything You Need to Know About 5G Technology.” *SearchNetworking*, TechTarget, 8 Jan. 2020, searchnetworking.techtarget.com/definition/5G.

⁸⁹ Staff, Tom's Guide. “When Is 5G Coming to You? The Definitive Guide to the 5G Network Rollout.” *Tom's Guide*, Tom's Guide, 4 Feb. 2021, www.tomsguide.com/special-report/when-is-5g-coming-to-you-the-definitive-guide-to-the-5g-network-rollout.

⁹⁰ Staff, Tom's Guide. “When Is 5G Coming to You? The Definitive Guide to the 5G Network Rollout.” *Tom's Guide*, Tom's Guide, 4 Feb. 2021, www.tomsguide.com/special-report/when-is-5g-coming-to-you-the-definitive-guide-to-the-5g-network-rollout.

Before providing information on Qualcomm, it is important to note that they are different than the telecom companies listed above such as Verizon, AT&T, Sprint, and T-Mobile. While these companies are cellular servers, Qualcomm focus on the research and development of network technology.

Here is an easy way to look at it: generational networks are composed of different layers. The first layer is the foundational layer. In this layer, network technology is created. The next layer is where hardware is built, and the third layer is full of sectors such as smartphones where companies give cell-phone access to customers.⁹¹ Qualcomm competes on the foundational layer. “There are different players on this network side including Huawei, who also competes in other sectors as well, like smartphones. “The top 10 companies cover roughly 80 – 90 percent of this sector.”⁹² Qualcomm is number one and Huawei is a close second place.”⁹³ There are also more competitors including Ericsson, Nokia and a few hundred others worldwide. Based on the network technology standard, hardware is built such as chipsets, handsets like smartphones and tablets, and base stations. These are the three separate hardware pillars which sit on top of the foundation. In the third layer, carrier services ride on top of these hardware pillars. These are what AT&T Mobility, Verizon Wireless, T-Mobile and Sprint sell to the marketplace in the United States.⁹⁴ Moreover, all of these layers build upon each other to create the last section which is what people commonly refer to as, 5G - “The finished product which

⁹¹ Kagan, Jeff. “Kagan: Why Qualcomm Is Important to USA in 5G Race.” *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.

⁹² Kagan, Jeff. “Kagan: Why Qualcomm Is Important to USA in 5G Race.” *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.

⁹³ Kagan, Jeff. “Kagan: Why Qualcomm Is Important to USA in 5G Race.” *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.

⁹⁴ Kagan, Jeff. “Kagan: Why Qualcomm Is Important to USA in 5G Race.” *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.

is a combination of three different levels. So, as you can see, there are many slices to this pie.”⁹⁵

It is important to mention this because it is upon this foundational layer that the race for 5G implementation, and subsequently global technological dominance is being fought on. While US commercials can mislead individuals to think their networks matter most, it is the foundational technology and equipment that will decide who wins the race for 5G. This is why Qualcomm is the most important company for the United States in their race against China for 5G implementation. Realistically, it is the United States’ only domestic company that can compete with Huawei to create and implement 5G technology around the world.

Qualcomm thrives in the world of technological advancement, information rights, and most importantly patents. While Huawei has the most 5G patents in the world, Qualcomm actually has what is referred to as the most 5G core, important patents. China realized the value of patents early in 5G development, which is why Huawei has been making claims for patents regarding 5G technology and networks. Research shows that Huawei’s patents, while vast, are more focused on quantity than quality. One article says, “if you were to do a patent comparison between Huawei and Qualcomm, you shouldn’t just count patents but also assess the strength and value of those patents. Huawei may have more, but Qualcomm, by nature of its business, should have better handset patents due to the company’s tighter focus.”⁹⁶

⁹⁵ Kagan, Jeff. “Kagan: Why Qualcomm Is Important to USA in 5G Race.” *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.

⁹⁶ Enderle, Rob. “Qualcomm vs. Huawei: Is This a Battle Between Companies or Countries?” *ITbusinessedge*, IT Business Edge, 9 Mar. 2019, www.itbusinessedge.com/blogs/unfiltered-opinion/qualcomm-vs.-huawei-is-this-a-battle-between-companies-or-countries.html.

The difference in these patents is best explained as the difference between protecting your own product versus protecting a product that has to be implemented in all 5G networks. One study on patents says, “Qualcomm licenses and makes a considerable amount of income from those licenses, which forces a different kind of rigor when it comes to patent creation than Huawei, where the patents are mostly defensive or protective to assure Huawei isn’t adversely damaged by patent litigation or doesn’t lose an edge due to a competitor stealing its IP. While Huawei is bigger than Qualcomm, it is contained within its own product set, while Qualcomm’s technology extends across the entire vendor ecosystem worldwide.”⁹⁷ What this means in relation to future of the world of 5G is that Qualcomm has the ability to drive industry advancements like 5G better than their Chinese competitors can. For example, Qualcomm was the first to launch a commercial 5G chipset while Huawei could have the first 5G phone on the market. Qualcomm has done the initial investment on the ground level more than other companies, giving it the greatest assets for 5G advancements.

Not all patents are created equal. Some are based on past technology. Some are simply not as important as other patents. “Therefore, if the company with less patents creates a better industry with better products and better user experience, then they are obviously the industry leader, no matter how many patents they hold. The reverse can also be true for companies with the most patents. If a patent is not core to the network, and is even outdated, it is quite often peripheral.”⁹⁸ In other words, it’s good for the number count, but not important as a leadership builder. Yet, that’s not the way it’s

⁹⁷ Enderle, Rob. “Qualcomm vs. Huawei: Is This a Battle Between Companies or Countries?” *Itbusinessedge*, IT Business Edge , 9 Mar. 2019, www.itbusinessedge.com/blogs/unfiltered-opinion/qualcomm-vs.-huawei-is-this-a-battle-between-companies-or-countries.html.

⁹⁸ Kagan, Jeff. “Kagan: Why Qualcomm Is Important to USA in 5G Race.” *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.

positioned in the marketplace with marketing and public relations. “That’s why it’s important to understand the quality of a patent than the mere quantity of patents a company holds.”⁹⁹

Because of these advancements and ownership of core patents, Qualcomm has been identified “as a national treasure by the U.S. administration.”¹⁰⁰ Due to their importance to 5G development, the US has protected Qualcomm from moves that could hurt it such as “an Apple-orchestrated hostile takeover of the company by Broadcom last year.”¹⁰¹ The reason that U.S. leadership is backing Qualcomm is due to the U.S. wanting to be a part of, if not leading, the development of 5G and its global standards.¹⁰² Qualcomm research and development states that, “Just a few companies shoulder the burden of research and development for the entire world because of the high-risk investment and tremendous engineering expertise required. Among them, only Qualcomm is an American company. The ground-breaking inventions and ideas of these R&D innovators are vetted via a consensus-based process to ensure 5G standards reflect the best technologies available. The process is highly collaborative, yet also highly competitive. That is because whoever leads in defining the 5G technical standards has the greatest control over future products and infrastructure.”¹⁰³ Qualcomm is important to the future of American technology because of its technological advancements as well as its

⁹⁹ Kagan, Jeff. “Kagan: Why Qualcomm Is Important to USA in 5G Race.” *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.

¹⁰⁰ Enderle, Rob. “Qualcomm vs. Huawei: Is This a Battle Between Companies or Countries?” *Itbusinessedge*, IT Business Edge , 9 Mar. 2019, www.itbusinessedge.com/blogs/unfiltered-opinion/qualcomm-vs.-huawei-is-this-a-battle-between-companies-or-countries.html.

¹⁰¹ Enderle, Rob. “Qualcomm vs. Huawei: Is This a Battle Between Companies or Countries?” *Itbusinessedge*, IT Business Edge , 9 Mar. 2019, www.itbusinessedge.com/blogs/unfiltered-opinion/qualcomm-vs.-huawei-is-this-a-battle-between-companies-or-countries.html.

¹⁰² Qualcomm. “The Race to 5G: Setting the Pace for What's Next.” *CSRWire*, Qualcomm, 19 Dec. 2020, www.csrwire.com/press_releases/709566-race-5g-setting-pace-whats-next.

¹⁰³ Qualcomm. “The Race to 5G: Setting the Pace for What's Next.” *CSRWire*, Qualcomm, 19 Dec. 2020, www.csrwire.com/press_releases/709566-race-5g-setting-pace-whats-next.

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leadership in the US technology industry. The Department of Defense and Department of Energy both agree with this, and they support Qualcomm and its R&D “claiming national security is at risk with Huawei being one of the main competitors of 5G technology.”¹⁰⁴

¹⁰⁴ Enderle, Rob. “Qualcomm vs. Huawei: Is This a Battle Between Companies or Countries?” *Itbusinessedge*, IT Business Edge , 9 Mar. 2019, www.itbusinessedge.com/blogs/unfiltered-opinion/qualcomm-vs.-huawei-is-this-a-battle-between-companies-or-countries.html.

Chapter 5: Europe and 5G

While the focus of this paper is the Chinese and U.S. 5G networks, it is important to mention the European networks, companies, and infrastructure that is important in the United States-Chinese race for 5G dominance.

Europe is caught at the cross roads of the 5G battle between the United States and China. The EU is being pressured by its foreign policies and domestic policies because of this cross road between the two countries. Research has found that the EU has to protect its interest and think about these questions: “how to balance the EU between China and the United States, encourage free trade but also stand up to China’s practice of subsidizing companies like Huawei, figure out how to build up its own independence and sovereignty while not enraging far-superior superpowers, and needing 5G technology to bolster their economies while protecting themselves from cyberwarfare and ensure its citizens’ human rights and data are protected.”¹⁰⁵ It is this crossroad that makes it is important to mention Europe as an integral battleground for 5G dominance between the United States and China. To create dominance in a sector, a country would need a region outside of their own country to be on their side. In the case of 5G, the U.S. and China are competing for Europe.

¹⁰⁵ Burdeau, Cain. “Europe Becomes a Battleground Over Huawei and 5G.” *Courthouse News Service*, 12 Feb. 2020, www.courthousenews.com/europe-becomes-a-battleground-over-huawei-and-5g/.

I. European Union Action in 5G Race

While considering the questions stated above, EU countries have taken different approaches to 5G networks between the U.S. and China. Even close U.S. allies such as Britain and Germany are still deciding which companies will participate in building their 5G networks and are unlikely to ban Huawei altogether. “The reason is simple: for many European countries that already use Huawei equipment in their 4G networks, it would be costly to switch horses in midstream.”¹⁰⁶ Telecom operators had been planning to use their existing 4G infrastructure as the cheapest and fastest way to start the upgrade to 5G, “which will be able to transmit data as much as 20 times faster than current networks.”¹⁰⁷ However, countries have decided that despite being costly, the need to switch technological providers is real. These countries are turning to Europe’s biggest technology companies: Ericsson and Nokia. Nokia and Ericsson have profited handsomely from this shift away from Huawei, winning deals from former Huawei customers.¹⁰⁸

II. Ericsson

Companies and countries are choosing Ericsson because of their European location and advancements similar to or better than Huawei’s advancements. “Wireless carriers want Ericsson’s concentrated wireless technology, telecom executives say, because it enables fast connections and allows them to serve more customers using existing cellular towers. Building new towers is unattractive because it is a bureaucratic

¹⁰⁶ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

¹⁰⁷ Mukherjee, Supantha, and Isla Binnie. “Analysis: Europe Plots Catch-up in Global 5G Race to Drive COVID-19 Recovery.” *Reuters*, Thomson Reuters, 28 Dec. 2020, www.reuters.com/article/us-europe-5g-analysis/analysis-europe-plots-catch-up-in-global-5g-race-to-drive-covid-19-recovery-idUSKBN2920WJ.

¹⁰⁸ Mukherjee, Supantha, and Isla Binnie. “Analysis: Europe Plots Catch-up in Global 5G Race to Drive COVID-19 Recovery.” *Reuters*, Thomson Reuters, 28 Dec. 2020, www.reuters.com/article/us-europe-5g-analysis/analysis-europe-plots-catch-up-in-global-5g-race-to-drive-covid-19-recovery-idUSKBN2920WJ.

process that can cost tens of thousands of dollars. Ericsson and Huawei sold 5G equipment with this feature last year, but Nokia didn't because of delays developing computer chips for its hardware.”¹⁰⁹ It is the speed of Ericsson and delays of Nokia that continues to set Ericsson apart in the European market. Recently, Ericsson “notched a victory this spring when it joined Huawei in winning 5G contracts to supply all three major wireless carriers in China, the world's second-biggest telecom-equipment market after the U.S. Nokia lost out on the significant Chinese bids.”¹¹⁰ Ericsson also supplies the 3 major U.S. phone carriers with equipment.¹¹¹ It is the reach of Ericsson combined with sanctions by the United States against Huawei that has allowed Ericsson to gain a greater foothold in the race for 5G.

It is important to ask the question of why European countries are choosing their own companies over U.S. companies. Researchers show this is because of the importance of 5G and the security risks it can present if put in the wrong hands. The German Foreign Minister states, “5G is the nervous system of our digital society and economy. If we make decisions about security risks today based on cost, we will pay for those decisions very dearly in the future.” There is another factor influencing this debate: many Europeans lost trust in U.S. tech companies and the U.S. government after the stunning revelations of Edward Snowden. “Now we are in the realm of trust relationships,” the

¹⁰⁹ Woo , Stu. “Ericsson Emerges as 5G Leader After U.S. Bruises Huawei.” <https://www.bangkokpost.com>, Bangkok Post , 4 June 2020, www.bangkokpost.com/business/1929056/ericsson-emerges-as-5g-leader-after-u-s-bruises-huawei#:~:text=Ericsson's%20share%20rose%20from%2026.2,from%2027.5%25%20to%2030.7%25.&text=The%20big%20question%20for%20wireless,carriers%20have%20come%20to%20expect.

¹¹⁰ Woo , Stu. “Ericsson Emerges as 5G Leader After U.S. Bruises Huawei.” <https://www.bangkokpost.com>, Bangkok Post , 4 June 2020, www.bangkokpost.com/business/1929056/ericsson-emerges-as-5g-leader-after-u-s-bruises-huawei#:~:text=Ericsson's%20share%20rose%20from%2026.2,from%2027.5%25%20to%2030.7%25.&text=The%20big%20question%20for%20wireless,carriers%20have%20come%20to%20expect.

¹¹¹ Woo , Stu. “Ericsson Emerges as 5G Leader After U.S. Bruises Huawei.” <https://www.bangkokpost.com>, Bangkok Post , 4 June 2020, www.bangkokpost.com/business/1929056/ericsson-emerges-as-5g-leader-after-u-s-bruises-huawei#:~:text=Ericsson's%20share%20rose%20from%2026.2,from%2027.5%25%20to%2030.7%25.&text=The%20big%20question%20for%20wireless,carriers%20have%20come%20to%20expect.

Minister said. “Europe had its fair share of trust relations with the U.S. in 2013 after the Snowden revelations.”¹¹² It is these trust issues with the U.S. that has allowed Ericsson to swoop into the previously Huawei saturated European market and increase their influence around the world. Because of Ericsson’s increased hold of the market, they are predicting increased European 5G coverage around the continent. Ericsson forecasts Europe’s 5G coverage should “grow from around 1% of mobile subscriptions across the continent in 2020, to 55% in western countries and 27% in central and eastern states over the next five years, underpinning a longed-for economic recovery.”¹¹³ Because of this, the mobile operators must pay companies like Ericsson, Nokia, Qualcomm, and Huawei billions of dollars for the 5G equipment.

EU companies are pouring money into Nokia and Ericsson instead of Huawei, which has allowed the United States to gain closer to China in the race for 5G implementation. With Europe splintered over which companies to let design and implement their 5G infrastructures, the Chinese lead in the race for 5G has lessened substantially, making room for U.S. advancement.

¹¹² Burdeau, Cain. “Europe Becomes a Battleground Over Huawei and 5G.” *Courthouse News Service*, 12 Feb. 2020, www.courthousenews.com/europe-becomes-a-battleground-over-huawei-and-5g/.

¹¹³ Mukherjee, Supantha, and Isla Binnie. “Analysis: Europe Plots Catch-up in Global 5G Race to Drive COVID-19 Recovery.” *Reuters*, Thomson Reuters, 28 Dec. 2020, www.reuters.com/article/us-europe-5g-analysis/analysis-europe-plots-catch-up-in-global-5g-race-to-drive-covid-19-recovery-idUSKBN2920WJ.

Chapter 6: The Context of 5G Competition: U.S.-China Relationship

For this research and subsequent analysis, it is important to put into perspective the rivalry between the United States and China. This chapter will discuss where this rivalry began as well as its current state. The first section of this chapter will focus on the beginning of the current Chinese regime starting in 1949, and the beginning of the relationship between the United States and China. Then, the second section will discuss the current state of the United States and Chinese relations in relation to their pursuit of future world dominance.

I. U.S.-China Relationship in Historical Perspective

For twenty years (1949-1969), the United States tried to disrupt, destabilize, and weaken China's communist government. Washington believed that China was an aggressive, expansionist power that threatened the security of its noncommunist neighbors. The United States constructed an off-shore line of military alliances along China's eastern and southern borders. These included the U.S. alliances with Japan, South Korea, and the Nationalist government on Taiwan. The United States maintained military bases and, in some cases, stationed significant numbers of troops in many of these countries, especially Japan and South Korea. During these years, the United States also became involved in the war in Vietnam.¹¹⁴

¹¹⁴ Columbia University. "U.S.-China Relations Since 1949: Asia for Educators: Columbia University." *U.S.-China Relations Since 1949 | Asia for Educators | Columbia University*, Columbia University, 2021, afe.easia.columbia.edu/special/china_1950_us_china.htm.

Washington encouraged its allies to refrain entering into diplomatic relations with Beijing. The United States prohibited Americans from visiting China. The United States cut off trade and orchestrated an international embargo of Chinese goods.¹¹⁵ By being even tougher on China than on its main communist rival, the Soviet Union, the United States pursued a so-called "wedge strategy." This strategy aimed to encourage a split between the two communist allies. It was successful, because such a split did occur, becoming evident in around 1960 and worsening thereafter.¹¹⁶

The strategic adjustments that US and China made with President Nixon's visit to China in 1972 eventually resulted in the establishment of diplomatic relationship between US and China in 1979 and the start of China's economic reform in 1979 that led to China's rise today need to be briefly described here.

After the Cold War, the United States started becoming more open to China and having relations with China. In October of 2000, President Clinton signs the U.S. – China Relations Act “granting Beijing permanent normal trade relations with the United States and paving the way for China to join the World Trade Organization in 2001. Between 1980 and 2004, U.S.-China trade rises from \$5 billion to \$231 billion. In 2006, China surpasses Mexico as the United States' second-biggest trade partner, after Canada.”¹¹⁷

¹¹⁵ Columbia University. “U.S.-China Relations Since 1949: Asia for Educators: Columbia University.” *U.S.-China Relations Since 1949 | Asia for Educators | Columbia University*, Columbia University, 2021, afe.easia.columbia.edu/special/china_1950_us_china.htm.

¹¹⁶ Columbia University. “U.S.-China Relations Since 1949: Asia for Educators: Columbia University.” *U.S.-China Relations Since 1949 | Asia for Educators | Columbia University*, Columbia University, 2021, afe.easia.columbia.edu/special/china_1950_us_china.htm.

¹¹⁷ Council On Foreign Relations. Timeline: U.S. relations with CHINA 1949–2021, <https://www.cfr.org/timeline/us-relations-china>

While the current relations with China are not as much focused on military dominance or a military presence in the region, the current U.S.-Chinese relations are still very rocky today as the administrations in each country disagree on many things. Currently, the United States still has a tariff on the \$370 billion of Chinese goods; this has not changed under the current Biden administration. These tariffs have not only hurt the Chinese economy, but also the economy of the United States. These tariffs seem to be a ploy to give the United States economic leverage over the Chinese.¹¹⁸

Another factor in the U.S.- China competition is the deterioration of Hong Kong's freedoms in 2020; a move which damaged China's relations with not just the United States, but most of the West. With the U.S. in particular, Beijing's move to tighten restrictions around Hong Kong has led to a worsening of U.S.-China relations. "In fact, the Trump administration has sanctioned Chinese and Hong Kong officials and ordered an end to Hong Kong's special trade status. Beijing nevertheless felt compelled to act because of the embarrassing instability created by millions of democratic protesters in its prize special administrative region."¹¹⁹

Another factor in the U.S.-China competition is the perception of China as the culprit of the pandemic and disruptions to global supply chains which have led some U.S. politicians to demand a decoupling from China. Conspiracy theories about the origins of the outbreak, which were encouraged by disinformation and misinformation efforts from both sides, exacerbated mistrust between the two nations.

¹¹⁸ Economy, Elizabeth, et al. "How 2020 Shaped U.S.-China Relations." *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

¹¹⁹ Economy, Elizabeth, et al. "How 2020 Shaped U.S.-China Relations." *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

At the same time, the pandemic has led to a significant increase in the proportion of American people with a negative view of China: an October Pew Research Center survey found that 73 percent of Americans view China negatively, the highest level since 2005.¹²⁰ In China, the government's ability to rapidly contain the virus's spread, in conjunction with the U.S.-China diplomatic row, has solidified nationalism and anti-Americanism. "Trump's deliberate usage of the phrase "China virus" struck a raw nerve and elicited a nationalist backlash, leading to the expulsion of American journalists in China. Also, Chinese state media outlets have portrayed the United States as a diminishing and hostile power throughout the past few months. Washington's perceived failure in global health leadership and bullying of Beijing have convinced even liberal-minded elites in China that the country should move to reduce the risks associated with interdependence with the United States."¹²¹ This has led to Chinese public's views toward the United States being significantly more negative than they were a year earlier just as the United States public views of China are significantly more negative.

By instituting this mistrust in each other, both through policies and everyday media, the U.S. and China have further emphasized their need to be the global superpower, and this dominance, as previously explained and continually discussed through this paper, will be based on which country can implement the first fully functioning, effective 5G infrastructure and technology.

II. Competition in Technology and Security Concerns against Huawei

¹²⁰ Economy, Elizabeth, et al. "How 2020 Shaped U.S.-China Relations." *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

¹²¹ Economy, Elizabeth, et al. "How 2020 Shaped U.S.-China Relations." *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

The current state of relations between the United States and China revolves around the competition that the United States and China have to position themselves in a way that ensures technological dominance. Each country is attempting to lessen the impact that the other country will have on its markets and global presence by cutting the other out of certain sectors, instituting tariffs, and threatening more substantial actions.

Beijing is trying to insulate itself from Washington's pressure against them. In recent months, it announced a strategy to maintain economic growth and reduce its reliance on foreign markets and technology.¹²² The domestic chip industry is an especially important area of focus, with the government spending billions of dollars to support research and development, encouraging small firms to enter the sector and exploring open-source technologies that could be beyond the reach of American export control laws. In addition, the Chinese leadership is asserting more political control over the technology sector: it issued new guidelines to increase the influence of the CCP within firms; blocked the IPO of Ant Group, one of the world's highest valued financial technology companies; and unveiled new anti-monopoly regulations that limit the influence of the biggest companies.¹²³

This year saw significant escalation in the technology competition between the United States and China. "In May, the U.S. Commerce Department tightened the noose on Huawei, cutting the telecommunications manufacturer off from critical semiconductor

¹²² Economy, Elizabeth, et al. "How 2020 Shaped U.S.-China Relations." *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

¹²³ Economy, Elizabeth, et al. "How 2020 Shaped U.S.-China Relations." *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

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suppliers and expanding restrictions on U.S. technology.”¹²⁴ These measures handed a severe blow to the company’s 5G business, and, as a result, several European countries announced restrictions on Huawei’s participation in their telecommunication networks. In addition, the Trump administration moved to ban the Chinese-owned apps TikTok and WeChat for national security reasons, which would mark the first time the United States widely blocks foreign information technology. While these restrictions have so far been halted by the courts, the Trump administration announced its intention to limit Chinese telecom carriers and cloud service providers as well as restrict Chinese developers’ access to American mobile application stores.

Within the race for 5G dominance, countries are starting to evaluate the potential improvements that this new technology will offer such as faster download speeds, connected devices, and improved, more efficient businesses and companies. While looking at the improvements, countries are also starting to assess the potential concerns with 5G networks specifically with Huawei’s 5G networks and infrastructure they are creating. The United States and their allies are starting to consider the potential security concerns that could occur with Huawei as the leader of the race for 5G technology. These concerns are related to: the Chinese intelligence law, infrastructure concerns, and the relative unknown nature of 5G networks and their security.

The first major concern has been related to the Chinese National Intelligence Law of 2016, in which the People’s Republic of China requires all Chinese companies and citizens “to support, aid, and cooperate in national intelligence work, and guard the secrecy of any national intelligence work that they are aware of. The law claims that the

¹²⁴ Economy, Elizabeth, et al. “How 2020 Shaped U.S.-China Relations.” *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

state shall protect individuals and organizations that support, cooperate with, and collaborate in national intelligence work.”¹²⁵ In the same way, the 2014 Counterintelligence Law states that organizations and individuals have an obligation to “provide information, facilities, or other assistance, and states the relevant organizations and individuals ‘must not refuse’ cooperation.”¹²⁶ One author found that these two acts (2014 and 2016) leave little assurance regarding proper judicial or public oversight to constrain the introduction of backdoors, “should the state deem this necessary for its broad notion of maintaining state security.”¹²⁷ Meaning, that the Chinese government could take steps to control or watch 5G networks if a Chinese manufacturer had control of the industry.

Researchers agree that the Chinese government could implement such backdoor’s as a means of espionage against the U.S. and its allies. “Australian and US spy agencies have assessed that under 5G, there can be no difference between the core and the edge, meaning the entire network is considered "critical infrastructure" and must be protected accordingly.”¹²⁸ One analyst writes that the United States and Australia share similar concerns with Huawei, he has found that Britain’s Cyber Security Centre thinks different. However, within this organization, Huawei has established the Huawei Cyber Security Evaluation center, which is funded by Huawei and has members of Huawei on its board, to monitor risks posed by using Huawei equipment. The Huawei board found “that while

¹²⁵ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

¹²⁶ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

¹²⁷ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

¹²⁸ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

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more computing will be pushed out of the centralized hubs or core, that computing can still be protected.”¹²⁹ Meaning, that Britain does not think Huawei could comprise their core infrastructure and technology. This evaluation that Huawei cannot affect the core of Britain 5G networks can be called into question due to the source of this evaluation being Huawei, who is also the company in question for security risks.

The concerns regarding Huawei’s 5G networks extend into the IoT or “Internet of Things.” With 5G, most devices around the world are going to be connected with each other and the internet. While this will bring fast speeds and change the way the world communicates, research points that controlling the technology at the heart of 5G networks could give Huawei the capacity to spy on or disrupt communications if China needed them to.¹³⁰ The researcher continues to say that the concern is that as more things become connected to the internet like fridges, cars, and fire alarms; state sponsored hackers could use these devices to infiltrate people’s networks in America or other American allies. One example of this is hackers could possibly shut down the infrastructure of a city or municipality.¹³¹ Another analyst agrees with this research by saying, “the significance of fundamental infrastructure to the functioning of society makes the deployment of communications infrastructure a strategic decision not merely for the telecommunications operator, but for the nation, particularly as 5G is expected to lead to a massive growth of IoT-enabled services, ‘upgrading’ not merely the degree but

¹²⁹ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

¹³⁰ Bowler, Tim. “Huawei: Why Is It Being Banned from the UK’s 5G Network?” *BBC News*, BBC, 14 July 2020, www.bbc.com/news/newsbeat-47041341.

¹³¹ Bowler, Tim. “Huawei: Why Is It Being Banned from the UK’s 5G Network?” *BBC News*, BBC, 14 July 2020, www.bbc.com/news/newsbeat-47041341.

the very character of contemporary societies' digital dependency.”¹³² He continues to say that a potential cyber incident could have major impacts on national security and national interest.

These infrastructure concerns stated above are pointed at Britain, currently, because of the infrastructure that Huawei has already built in the UK. Britain had to weigh the security concerns presented by its allies against the costs and time needed to take Huawei completely out of their 5G network implementation. The Culture Secretary Oliver Dowden said it would be delayed by two to three years and with added costs of up to £2bn.¹³³ Given the cost and difficulty of replacing core infrastructure due to the architectural changes required and limited spectrum availability, supplier side risks must be weighed in a comprehensive manner and before making any decisions.¹³⁴

Because of Huawei's involvement with some of its closest allies, Washington has already started preparing for the security risks that could arise with 5G infrastructure that is created by Huawei. U.S. officials are worried that this infrastructure could be subverted for espionage, allowing Chinese intelligence agencies access to huge volumes of data.¹³⁵ For years, the United States intel agencies have capitalized on the role of U.S. companies in global telecom networks to gather crucial intelligence. Because of the U.S. dominance in the intelligence sphere, the reason the United States is so worried about Huawei is because it could allow China to replace them as “the world's premier intelligence power and perhaps even deny it access to the networks that make global commerce and the

¹³² Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

¹³³ Bowler, Tim. “Huawei: Why Is It Being Banned from the UK's 5G Network?” *BBC News*, BBC, 14 July 2020, www.bbc.com/news/newsbeat-47041341.

¹³⁴ Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.

¹³⁵ Johnson, Keith, and Elias Groll. “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

projection of military power possible.”¹³⁶ It is this need for intelligence dominance that is furthering the United States attempts to foil Chinese plans to implement the first fully functioning 5G networks.

While the U.S. has these security concerns, they also do not know the full extent of these concerns with the technology because the technology is so new and is still in the process of being implemented around the world. Graham Webster, a technology commentator says, “Part of the honest dilemma is people don't know precisely what the risks will look like, but the Huawei question has jumped to the front of that discussion before the broader security assurance programs are really through.”¹³⁷ In 2019, Sue Gordon, the deputy director of national intelligence, reiterated this point by saying, “U.S. intelligence officials are already beginning to prepare for a world in which Huawei dominates next-generation telecommunications networks. We are going to have to figure out a way in a 5G world that we're able to manage the risks in a diverse network that includes technology that we can't trust. You have to presume a dirty network.”¹³⁸

These security concerns have presented the United States with different options of how to deal with the security threat of China has the world 5G leader, but there is no doubt that a security threat exists, says Dan Coats, the director of national intelligence. He warns, “foreign production of advanced communication networks “will challenge

¹³⁶ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

¹³⁷ Feng, Emily, and Amy Cheng. “China's Tech Giant Huawei Spans Much Of The Globe Despite U.S. Efforts To Ban It.” *NPR*, NPR, 24 Oct. 2019, www.npr.org/2019/10/24/759902041/chinas-tech-giant-huawei-spans-much-of-the-globe-despite-u-s-efforts-to-ban-it.

¹³⁸ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

U.S. competitiveness and data security,” and as American data increasingly flows across those networks, that will increase “the risk of foreign access and denial of service.”¹³⁹

III Sanctions against Huawei

It is because of these concerns that China will have the first 5G networks, that the United States has acted against Huawei as a means of protecting their national interest. Tim Ruhling, a 5G technology researcher says, “5G is turning more into a geopolitical battleground between the United States and China.”¹⁴⁰ Because of this political battleground, the United States has banned Huawei among other Chinese telecommunications companies from their cellular networks and infrastructure. In addition to the U.S., allies such as Australia, New Zealand, Japan, Taiwan, and other countries have banned Huawei and other Chinese companies like ZTE from their networks. However, “some nations have balked at U.S.-led efforts to keep Huawei and other Chinese firms out of the picture. Argentina, Brazil, Russia, the Philippines, and Thailand, all welcome China’s 5G tech.”¹⁴¹

The United States is seeking a global ban of Huawei’s 5G equipment, however policy researchers do not believe this will happen. Many countries are resisting the pressure of the United States because of the price of Huawei and feeling that they can mitigate the risks of these networks.¹⁴² The reason the United States is pressing so strongly for a ban of Huawei networks is because of the intelligence sharing alliance called the Five Eyes

¹³⁹ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

¹⁴⁰ Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/

¹⁴¹ Feng, Emily, and Amy Cheng. “China's Tech Giant Huawei Spans Much Of The Globe Despite U.S. Efforts To Ban It.” *NPR*, NPR, 24 Oct. 2019, www.npr.org/2019/10/24/759902041/chinas-tech-giant-huawei-spans-much-of-the-globe-despite-u-s-efforts-to-ban-it.

¹⁴² Feng, Emily, and Amy Cheng. “China's Tech Giant Huawei Spans Much Of The Globe Despite U.S. Efforts To Ban It.” *NPR*, NPR, 24 Oct. 2019, www.npr.org/2019/10/24/759902041/chinas-tech-giant-huawei-spans-much-of-the-globe-despite-u-s-efforts-to-ban-it.

that it is a member of. The U.S. says it will not send intelligence over networks that could be compromised or hijacked by Chinese intelligence agencies. “Washington believes that through 5G, Huawei could easily build in access points known as "back doors" that would allow it to take control of 5G networks to either hack them, take them down or take over mobile-connected devices to perform hostile actions. Such secret back doors could be installed into the equipment over time, allowing Beijing to penetrate networks.”¹⁴³ Australia, who has also banned Huawei believes that this ban should not be for backdoors, but denial of service. Meaning that systems used in daily life could be taken offline.¹⁴⁴

While Huawei has not built infrastructure in most of the United States allied countries, the largest country who this ban affects is the United Kingdom. In January 2020, the U.K. agreed to allow Huawei to help build 35 percent of the country's 5G infrastructure despite U.S. concerns that the company poses a risk to surveillance and intelligence theft.¹⁴⁵ However, after much pressure from the United States, the UK agreed to ban Huawei from its networks and infrastructure in July 2020. This move “banned the use of new Huawei 5G network equipment by the end of 2020 and remove existing Huawei network components by 2027.”¹⁴⁶ It will also ban UK mobile providers from buying new Huawei 5G equipment after the end of this year and they will have to remove

¹⁴³ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

¹⁴⁴ Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.

¹⁴⁵ Conklin, Audrey. “When Will the US Have 5G Technology?” *Fox Business*, Fox Business, 4 Feb. 2020, www.foxbusiness.com/technology/us-5g-technology-mobile-arrival.

¹⁴⁶ Keane, Sean. “Huawei Ban Timeline: Chinese Company May Start Making Electric Vehicles This Year.” *CNET*, 2 Mar. 2021, www.cnet.com/news/huawei-ban-full-timeline-us-sanctions-china-5g-electric-vehicles/.

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all of its 5G kit from their networks by 2027.¹⁴⁷ This was a step toward achieving the United States desire for 5G dominance because it is taking Huawei systems out of countries and discouraging its use.

Because of these bans, either being enforced or encouraged by the United States, countries are turning their eyes towards the United States for different 5G options that would be as advanced and relatively price similar to Huawei and their Chinese-based counterparts. The U.K is leading this charge as Tobias Ellwood, chair of the House of Commons Defense Select Committee, said the Five Eyes — an intelligence alliance between Australia, Canada, New Zealand, the U.K. and the U.S. — should develop its own Huawei rival. “What I think we need to recognize is that if we do allow Huawei in temporarily, we need to quickly create an alternative, which doesn’t exist at the moment. So, you look at Cisco, Ericsson, Nokia, you need to get these companies together with some international state funding to create our own 5G capability.”¹⁴⁸ Others share this sentiment, but not the same concern for viable options. “Huawei is at the center of a very complex issue in terms of cybersecurity, and the U.S. is trying to formulate a strategy that is like Huawei. But there are a bevy of very large, successful, strong alternatives to Huawei. I have no concerns about the availability of best-of-grade, leading-edge, 5G tech for America.”¹⁴⁹ With these alternatives, the U.S. and its allies are hoping to slow-down if not stop, Huawei’s ascent into the first company to fully implement 5G networks.

¹⁴⁷ Bowler, Tim. “Huawei: Why Is It Being Banned from the UK’s 5G Network?” *BBC News*, BBC, 14 July 2020, www.bbc.com/news/newsbeat-47041341.

¹⁴⁸ Kharpal, Arjun. “Huawei Says US Push to Create a 5G Rival ‘Would Be a Challenge.’” *CNBC*, CNBC, 21 Feb. 2020, www.cnbc.com/2020/02/21/huawei-says-us-push-to-create-a-5g-rival-would-be-a-challenge.html.

¹⁴⁹ Conklin, Audrey. “When Will the US Have 5G Technology?” *Fox Business*, Fox Business, 4 Feb. 2020, www.foxbusiness.com/technology/us-5g-technology-mobile-arrival.

Along with these options, some U.S. lawmakers have made suggestion on how the United States can gain traction in the race for 5G dominance. These include suggestions from Marco Rubio and former Attorney General William Barr. These suggestions call for the government to back an open source 5G architecture. The result, they claim, would allow new players to enter the networking equipment game for specific components rather than competing with Huawei in the entire architecture.”¹⁵⁰ Rubio, leading a group of bipartisan lawmakers, “introduced a bill earlier this year “providing over \$1 billion to invest in Western-based alternatives to Chinese equipment providers Huawei and ZTE.”¹⁵¹

Another idea, suggested by former U.S. Attorney General William Barr, is for the government to do both. “Putting our large market and financial muscle behind one or both of these firms, would make it a far more formidable competitor and eliminate concerns over ... their staying power,” Barr said.¹⁵² This option was quickly shut down by American lawmakers due to the United States being a capitalist society. Meanwhile, Larry Kudlow, the White House’s economic advisor, said in an interview with the Wall Street Journal that the “big-picture concept is to have all of the US 5G architecture and infrastructure done by American firms, principally.” He added that Ericsson and Nokia could also be a part of this movement.¹⁵³ While the United States has yet to present a viable option, Huawei is continuing to allocate its business elsewhere. “This year, it announced expanding research centers in Switzerland and \$3.1 billion worth of

¹⁵⁰ Kharpal, Arjun. “Huawei Says US Push to Create a 5G Rival 'Would Be a Challenge'.” *CNBC*, CNBC, 21 Feb. 2020, www.cnbc.com/2020/02/21/huawei-says-us-push-to-create-a-5g-rival-would-be-a-challenge.html.

¹⁵¹ Kharpal, Arjun. “Huawei Says US Push to Create a 5G Rival 'Would Be a Challenge'.” *CNBC*, CNBC, 21 Feb. 2020, www.cnbc.com/2020/02/21/huawei-says-us-push-to-create-a-5g-rival-would-be-a-challenge.html.

¹⁵² Kharpal, Arjun. “Huawei Says US Push to Create a 5G Rival 'Would Be a Challenge'.” *CNBC*, CNBC, 21 Feb. 2020, www.cnbc.com/2020/02/21/huawei-says-us-push-to-create-a-5g-rival-would-be-a-challenge.html.

¹⁵³ Kharpal, Arjun. “Huawei Says US Push to Create a 5G Rival 'Would Be a Challenge'.” *CNBC*, CNBC, 21 Feb. 2020, www.cnbc.com/2020/02/21/huawei-says-us-push-to-create-a-5g-rival-would-be-a-challenge.html.

investment in Italy over the next three years. Italy promptly dropped proposed emergency legislation to ban Huawei from its 5G networks two days later.”¹⁵⁴ Feng believes that while the United States and its allies ban Huawei and do not produce a viable alternative, it will not stop Huawei from pursuing business and investment in every other country around the world.

This belief by Feng is one that is often being overlooked by U.S. policymakers, but one that I believe one of the most important beliefs that people need to focus on when looking at 5G networks and the U.S.- China race for dominance with these networks and the world. The United States can ban Huawei networks to slow down China in the race for 5G, but it does not mean that the United States will start to gain ground on China any faster, especially in a race that is more of a marathon than a sprint.

¹⁵⁴ Feng, Emily, and Amy Cheng. “China's Tech Giant Huawei Spans Much Of The Globe Despite U.S. Efforts To Ban It.” *NPR*, NPR, 24 Oct. 2019, www.npr.org/2019/10/24/759902041/chinas-tech-giant-huawei-spans-much-of-the-globe-despite-u-s-efforts-to-ban-it.

Chapter 7: Assessments and Projections

Focusing on the assessment of 5G networks and their importance in the competition for technological dominance between the United States and China, this chapter discusses the importance of controlling the first developed 5G networks and 5G networks for future countries seeking global technological dominance in the world, projects China winning the race for the first fully implemented 5G networks, and analyzes the potential security risks to the U.S. as China is on its way to achieve 5G dominance.

I. The Importance of 5G Networks for Dominance

Although 5G will take time to be fully integrated into society, the importance of 5G networks are centered around the revolutionization of industries, the invention of new technologies, and the integration into everyday society and products. 5G networks are the building blocks for the future. Similar to the ways in which 4G technology changed the world as well as the technology we interact with, 5G will have a similar, yet exponentially bigger, impact on the world. By creating the first 5G fully implemented 5G networks, a company will have an advantage with creating and determining technology until other companies implement the same tech.

5G is set to revolutionize industries by allowing same-second response to events or interactions. This will occur because of the latency that 5G will have in the future. As discussed in chapter 2, this latency will allow for instant control over objects. Such control will allow industries to become more efficient and use more artificial intelligence or robots for greater accuracy in their results. This will impact industries such as construction due to dealing with large equipment, the medical field due to medical use for

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increased efficiency in robots and machinery used in procedures, and the shipping industry which handle crates or large amounts of product. Another industry that will be revolutionized is smart phones. With new technology, cellular devices will have increased capabilities and advancements which allow them to instantaneously interact with each other. 5G will allow smartphones to have large speed increases, as compared to current 4G networks. 5G will also revolutionize current industries because of the Internet of Things (IoT) which will allow more devices to be connected to each other. By being connected, these products will be able to interact with each other in real time. This real time connection will also revolutionize self-driving cars, a concept which will become much more prevalent with 5G networks. In theory, 5G will allow self-driving cars to interact and communicate with one another in order to decide the best routes or roads to take on a journey.

Along with revolutionizing current industries, 5G networks will allow for the creation of many new technologies and industries, with one of these industries being the invention of smart city. These smart cities will allow household products and the infrastructure of the city to interact and assess what is needed at certain times. In regards to infrastructure, it will allow cities to run more efficiently and self-diagnosis itself before problems occur allowing for cities to operate more efficiently for all. Each part of a smart city will be connected, from the water systems to the power stations. Another technology that will become more integrated into society is artificial intelligence (AI). With 5G, AI will become more integrated into the products that we use and the ways that we go about our lives.

As discussed early in this section, 5G will be implemented and integrated into all daily products. This is due to the IoT and increased latency that is experienced with the 5G networks. The combination of these two will allow household products to become more intelligence and interact with each other to make humans' lives easier. This could be used in anything from the light bulbs installed in houses or the toasters and ovens in a kitchen. All of these products will become more efficient and make life easier for the people using them.

II. The Importance of Winning the Race for 5G Between the United States and China

While 5G is an important technology for the entire world, winning the race to create the first fully developed 5G program is the key to world dominance for a number of reasons such as controlling large amounts of data, implementing advanced technology, controlling advanced 5G networks, and creating political advantage.

In this section of the analysis, it is important to note that when the author uses the term “winning the race to 5G” or the “race for 5G”, it is referring to the full or almost full implementation of 5G networks into society. This implementation goes beyond basic cell phone coverage in some areas, and refers instead to vast coverage and use throughout a country. “Winning the race for 5G” refers to a company having the first fully implemented foundational networks and infrastructure. This does not refer to companies that only provide consumers with 5G networks, as these companies need the infrastructure and technology that other countries create.

The first reason that winning the race for 5G is so important is due to the large amounts of data that will be transmitted through 5G networks. With more aspects of people's lives being connected to tech in the next 10 years, there will be vast amounts of

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data that will be collected by the companies which control 5G networks. Companies can use this data or sell it to other companies, so that they can tailor their products to specific users. Alternatively, the controlling telecom company can use data itself to enhance the 5G experience for individual users. Another dark reason for wanting to control data is the possible control of internet networks and controlling what people are able to see across networks. While this is unlikely to happen, controlling 5G could allow a company to use user data to spy on users or, as previously mentioned, sell their data to harmful groups.

The second reason that winning the race for 5G is important is due to the competitive advantage gained by implementing advanced technology and infrastructure before competitors can. Not only will this give the winning company an economic boost over other competitors, but it could also allow for the further creation and invention of newer technologies and capabilities that other companies or countries do not have. By implementing 5G technologies first, companies will have an advantage over their competitors both in security and infrastructure. Additionally, by implementing these networks first, a company would have control over the 5G market before any other competitors, which gives them a greater chance at securing governmental contracts around the world and also smaller corporate contracts. These contracts matter because of the potential financial gains that can be made as well as the long-term effects that securing governmental contracts could have on a company.

The third and most important that winning the race for 5G matters is due to the political stakes that surround 5G networks and their implementation into society. Similar to the ways in which Russia and the United States fought over world dominance in the mid to late 20th century with nuclear weapons and military strength, the U.S. and China

are fighting today over world dominance with network influence and strength. Across the news networks, the race for 5G between the United States and China has been at the forefront. While technically the race for 5G is between technology companies, the US and China have made it a battle between countries for technological power for the foreseeable future. Political advantage matters so much because of the economic and technological impacts that 5G will have on the future. The United States' lead in 4G technology allowed for a major increase of United States GDP, and 5G promises exponential increases in economic gains for whichever country can controls the network.

Another reason that 5G is so important politically is due to the societal impacts that 5G networks could have on countries and their influence around the world. If a company within a country has developed the most 5G networks around the world, this country is more than likely going to have greater influence over countries or areas in which their networks are located. The country that creates the first fully capable networks will have this influence because countries will want to align with the country that has the first technological capabilities; giving whichever country wins, a head start economically and politically.

III. The Winner of the Race for 5G Networks: China

While the “winner” of the race for 5G between the United States and China has yet to be determined due to 5G networks being implemented over a long period of time, I project that China will win the race for 5G. To date, Huawei has the most functional and advanced 5G networks and their infrastructure will likely be in place before any of the American companies. The research that I conducted suggests that much like the U.S. had the advantage over Europe terms of technology with the last generation (4G), China will

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likely have a similar advantage over the U.S. with 5G. Huawei's ability as a vendor to sell products on all layers of the 5G market, their significant backing from the Chinese government, the growing size of their Chinese market as compared to the small size and market of Qualcomm makes them the most likely victor in this race. This assessment is partially based on the inference that Huawei receives funding from the Chinese government. While this is not confirmed, the research and investigation conducted by many companies shows evidence that it is extremely likely that the Chinese government helps Huawei with their research, development, and implementation.

Huawei is a company unlike any other because they operate on all levels of 5G technology and 5G equipment. Huawei is an end-to-end infrastructure vendor for 5G. Meaning, they create the infrastructure needed for 5G networks, such as base stations and towers, while also creating smartphones that are able to operate on the networks. This advantage allows Huawei to make certain features in their smartphones that are enhanced by Huawei 5G towers. This feature could be costly to other competing companies such as Apple because no other company has the ability or infrastructure to make the technology on top of producing the phones that will be on the markets. While this type of overall domination of every area of the 5G arena is still in the future, Huawei has the inside track to make the most advanced networks as well as good, reliable, cheap smartphones for these networks. This type of domination would be hard to break once controlled in a growing market such as 5G.

Another reason I project that Huawei will win the race to 5G is because of the significant resources and funding that China has put into 5G research and development over the past decade. As discussed in Chapter 3, the Chinese government has put billions

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of dollars into the research and development of 5G so that a Chinese company would be the leader in the upcoming technology. As the recipient of this government investment, Huawei has had the advantage of receiving government funding while still having competition from other companies within China. Huawei has access to China's population as well as almost unlimited resources to create the best networks possible. They currently have the largest research and development budget among Chinese companies which has allowed them to use almost half of their employees for R&D. Huawei is using this budget to invest in more 5G base stations, which it currently leads to world in, as well as produce the second most smartphones in the world. Support from the CCP has made this possible, so that Huawei can help China accomplish their goal of global technological dominance.

The next reason that I project will help Huawei continue to be the world leader of 5G is the growing population of China and the subsequent growing consumer population that comes with it. China is currently expected to have three times the U.S. market by 2030 and because of this, Huawei can be the leader in 5G by focusing on domestic strength and some international development. Even with U.S. sanctions against the company, Huawei has been able to continue to grow due to its increasing population. While they may not always produce the most smartphones, Huawei's ability to design and implement infrastructure will make them the superior company in what will be the biggest tech market in the world.

The final reason that I project Huawei to win the race to 5G is the size and reach of their company compared to competing companies, namely Ericsson and Qualcomm. As stated earlier in this section, most companies operate on only one level of the 5G market

whether that be the selling of smartphones like AT&T and Verizon, or companies that make infrastructure and technology like Qualcomm and Ericsson. Huawei has the unique advantage of operating on all levels on the market due to its size and funding. In contrast, U.S. companies only have the capacity to compete at one level because they lack government funding for research. Another problem with U.S. companies is that they are competing against each other in 5G markets. For example, Apple is constantly trying to cripple Qualcomm because Qualcomm and Apple are technology rivals. Companies in China, on the other hand, do compete but they also are working on lifting up technology for the country of China as a whole, not just each individual company. China realizes that this is a battle between countries, not between companies, so they attempt to help all their domestic companies build the best possible networks.

IV. Chinese Country Goals for 5G Networks

With the assumption that Huawei will have the first fully functional and implemented networks, meaning China will win the race for 5G implementation, it is important to assess how 5G networks and 5G dominance will help further or accomplish the Chinese Communist Party (CCP's) goal of becoming the world superpower over the U.S.

China's goal has been and continues to be to become a, if not the, superpower in the world. This has led China to extreme economic gains in the past twenty years which boosted their status as a world leader drastically since opening their borders for trade. If Huawei establishes the first 5G networks, I project they will be the world leader for the next decade or until 6G technology is implemented. This assessment is based upon the importance of 5G for economic development, China's emphasis on country over individual person or company, and China realizing the importance of cyber capabilities over a standard military.

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China is on pace to pass the United States as the world's biggest economy by the year 2028. As the world's biggest economy, China would have trade influence over a majority of countries around the world as well as be a place that businesses want to move to and invest in. 5G will help China achieve this economic dominance because of the new industries that will be invented because of 5G. If Huawei implements the 5G systems first, China will be able to establish new industries and revolutionized current industries before other countries as discussed in section 1 of this chapter. This would allow to China to bring in more capital due to the investment and influx of business seeking these advanced capabilities.

China also places a big emphasis on country goals over company goals. This is because of China's one-party state and the ability of the CCP to rally their citizens around the idea of China first. China has taken a very similar path with 5G networks by giving companies the resources that they need to create and implement 5G networks. This is different than the United States as many American companies are more focused on competition amongst each other and having the highest profit margins. These values, while still important to Huawei and other Chinese companies, do not take precedence over their emphasis on the China dream which is China being the greatest country in the world. This emphasis can be seen with their new policy: dual circulation. This particular term focuses on the reorientation of the economy towards internal consumption without closing off from the outside world, has in reality been government policy for years, albeit now with renewed intent. The 14th five-year plan, released on October 29, 2020, has dual circulation at its core. The logic is sound: The capital-intensive model that has powered

China to the economic forefront in recent decades is running its course.¹⁵⁵ This new model will increase China's reliance on their own 5G companies like Huawei which will increase Huawei's profits and in turn increase China's influence around the world.

5G is also important to China's country goals because of their increased awareness and resources dedicated to technology and cyber capabilities. The world has quickly changed from its view on warfare in 1980's to now. Today, a hacker can do more damage than a bomb in terms of crippling a country's infrastructure. I believe that China has realized that the future of the world is not in nuclear weapons or the size of a military, but rather the size of networks, tech capabilities, and partners around the globe. This realization has led to China to put their resources into companies like Huawei, so that Chinese technology can be in place around the world.

In 1994, Ren Zhengfei told Jiang Zemin, the Communist Party Secretary, that a country without a domestic telecom switch industry was like a country without a military.¹⁵⁶ In the same way, this still proves true, if not truer, today than it did in 1994. China has taken extreme steps to make sure that Huawei is the world leader in 5G technology and its implementation because China understands the importance that 5G networks will have on the future. In 1994, not having domestic generational networks was like not having a military. Now, without generational networks, it would not be possible to be a world superpower.

V. Future Security Implications of Chinese 5G Networks

¹⁵⁵ Tang, F. "What is China's dual Circulation economic strategy and Why is it important?" *China Macro Economy* 4 March 2021, <https://www.scmp.com/economy/china-economy/article/3110184/what-chinas-dual-circulation-economic-strategy-and-why-it>

¹⁵⁶ Johnson, Keith, and Elias Groll . "The Improbable Rise of Huawei." *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

In order to fully assess the impact that 5G networks will have on the future, it is important to assess the likely security implications of Chinese 5G networks and 5G networks as whole. This assessment is the product of the qualitative research done for this paper, and this assessment assumes that these security implications are mainly dealing with Chinese companies and networks. However, this assessment will also discuss 5G security risks as they pertain to the whole network, not just a specific country. The likely security risks that will be associated with Chinese 5G networks are: military and intelligence advancements, data breaches, risk of critical infrastructure failure, and the overall control of data. While this section is mainly assessing the likely security implications, it is important to note that these networks will not be fully implemented for some time, and therefore a full assessment of the security implications is difficult to project since the technology has not been fully realized yet.

The first security risk is the control of data that Huawei or China could have as a result of implementing the first 5G networks. If a country controls the networks, it has the capability to control what users of the network see and how they interact with each other. This occurred during the rise of 4G networks. In the mid 2000s, the United States was using devices to spy on individuals that they deemed as a risk to the United States. This resulted in the mass surveillance of U.S. citizens until made known to the public by whistleblower Edward Snowden. These 5G capabilities could allow China to track and limit what people who use Huawei networks see on their devices. China already does this to an extent to their own citizens, so it is possible they would the same thing to foreigners that could be enemies of the state.

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If Huawei wins the race for 5G and has a fully implemented 5G network before the United States, China will have the capability to improve their military and intelligence systems before the United States can. This assessment is based on the increased capabilities of artificial intelligence and the IoT with 5G technology. The increases in these capabilities could allow the Chinese military and intelligence branches to create and implement new advanced weaponry, tracking, and communications that the United States would not have the capacity to stop because their 5G networks would not yet be fully realized. 5G could allow the Chinese intelligence community to be the most sophisticated and advanced intelligence community in the world if their networks are online first.

Another security implication that will come as a result of China winning the race to 5G is the possible implementation of backdoors in Huawei's system. These backdoors, as previously discussed in Chapter 6, could result in data breaches of users on Huawei systems. While Huawei has stated that their system is fully secure, the Chinese Intelligence laws of 2014 and 2016 could force Huawei to implement these backdoors into the system without informing the public. These backdoors could allow Chinese intelligence agents or hackers to access user data or anything that uses 5G. This is a major security risk because of the increased technological footprint that 5G will allow for. Simply put, 5G will connect everything in the world, therefore, if everything is connected, this could result in catastrophic events if hackers or an intelligence agency got into the networks with an intent of causing problems. The critical infrastructure of cities or countries, for example, is at risk. Some experts warn that if a country uses Huawei's systems, it is at risk of allowing the Chinese government to have access to — and

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potentially even control over — its internet network, leaving it exposed to crippling cyberattacks, industrial espionage and widespread surveillance.

Chapter 8: Policy Implications and Responses

Based on the qualitative research conducted by the author, this chapter discusses the policy implications of likely Chinese dominance of 5G networks domestically and around the globe and policy and technological responses by the United States and Europe to Chinese dominance in the future of 5G by mainly focusing on the possible scenarios in which China and the United States both try to assert 5G dominance in the European region.

I. United States Policy Responses to China

Assuming that the United States will continue imposing bans or tariffs on China because of trade disputes involving 5G related materials, this section discusses current and possible United States governmental policy responses to China and the Chinese companies that produce, implement, and sell 5G equipment, infrastructure and products, highlights the problems with targeting China, and speculates on the possible policy responses that the new executive administration in the United States could take.

The United States has been targeting Huawei for well over a year. Because of the relationship that Huawei has with the Chinese government and allegations that Huawei will use their networks to support Chinese intelligence, as stated in Chapter 6. I assess that it is highly likely that the United States will continue to impose a ban of Huawei equipment in in the United States due to the security risks surrounding Huawei unlikely to change in the eyes of the intelligence community. The United States will continue to target Huawei with bans because they view Huawei as an extension of the Chinese government. When targeting Huawei, the United States has treated Huawei and their

development of 5G technology as an intelligence agency more than as a standalone company in China. This assessment is based on the Chinese Intelligence Laws of 2014 and 2016, as outlined in Chapter 5, which could force Huawei to give the Chinese government access to their networks and the data of all users on their 5G networks. In a survey conducted by the Harvard Business Review, there was less consensus on the politically thornier issue of tech restrictions, such as those imposed on Huawei. While 61% of institutions saw a partial or total lifting of the restrictions, 39% expected the measures to remain in place.¹⁵⁷ National security concerns combined with an increasingly hawkish attitude towards China in both Congress and the American public at large could make softening the U.S. stance in this area unpalatable without significant concessions from Beijing on issues of corporate governance. Another reason that the United States will continue this ban of Huawei equipment is because of the current stance of President Biden, as President Biden has taken similar stances to former president Trump in that he is emphasizing security for the United States and its citizens.

The United States has another possible policy option to lift the tariffs that were imposed on China by former President Trump. In a survey of 67 international institutions carried out recently by the Harvard Business Review, close to 80% of respondents saw Biden either partially or completely removing Trump's import tariffs. The economic incentives to do so are clear: prices paid by U.S. consumers would fall, and in exchange, China would likely improve market access for American exports.¹⁵⁸ I believe this policy

¹⁵⁷ Reynolds, Oliver, and Arne Pohlman. "What Will the U.S.-China Relationship Look Like in the Biden Era?" *Harvard Business Review*, 7 Jan. 2021, hbr.org/2021/01/what-will-the-u-s-china-relationship-look-like-in-the-biden-era.

¹⁵⁸ Reynolds, Oliver, and Arne Pohlman. "What Will the U.S.-China Relationship Look Like in the Biden Era?" *Harvard Business Review*, 7 Jan. 2021, hbr.org/2021/01/what-will-the-u-s-china-relationship-look-like-in-the-biden-era.

option to be unlikely even with the economic incentives to lift the tariffs because lifting the tariffs could be seen as a sign of the United States softening its stance on China amidst their government's decision to silence citizens in Hong Kong and limit media for Chinese citizens.

As the United States continues to take policy action against China and their 5G companies, it is important to assess possible technological responses that the United States government or companies will have to take to further their own 5G infrastructure and networks. It is important to note that while the U.S. has companies that are well-known such as AT&T, Verizon, and T-Mobile, these companies do not matter in the race for 5G. The race for 5G is based on *5G infrastructure*, not the ability to make 5G phones or have the most users on a data network. While Huawei does have its own “network” or users, it creates and implements the technology for 5G. Companies such as U.S. telecommunications carriers do not make their own technology or infrastructure. Instead, they simply give consumers network capabilities. With this in mind, this section focuses on companies that create and build infrastructure for 5G as well as companies that have 5G patents.

For the United States to win the race for 5G, the United States would need to encourage their companies to continue to create 5G technology and networks that equate to that of the Huawei. Based on the research done, there are only two companies that could potentially beat Huawei in the race to 5G: Qualcomm and Ericsson. Qualcomm, a U.S. based company, owns what are referred to as the most “core patents” for 5G technology meaning they own, not the most overall, but the greatest number of the

important patents. Ericsson, a European-based company, provides 5G technology for parts of Europe as well as companies around the world. Both of these companies are very important in the 5G race; however, they do not currently have the size and ability that Huawei has in China.

A possible response for the U.S. and others could be to work together with subsidies from Western countries to create and implement 5G technology. This technological response would encourage companies to work together to create advanced networks that rival Chinese networks. If companies like Qualcomm and Ericsson worked together, they could set a price that is comparable, if not equivalent, to that of Huawei. In turn, this would encourage countries to invest in their networks instead of Huawei.

Another option could be for the United States to invest in one of these companies. As theorized by Marco Rubio and other policymakers, if the United States invested in Qualcomm or Ericsson, it would give these companies the resources needed to stay on-par with Huawei's research and development department. These two companies need more investment because they do not have the resources or capacity to keep up with Huawei because it is backed by all of China. If it is serious about wanting to win the race for 5G the United States, would need to provide major subsidies, loans, or backing for a company like Ericsson or Qualcomm to create 5G networks at the pace of Huawei. Note, this analysis is not claiming that the Huawei networks are better; instead, this analysis is saying that no other companies have the capabilities that Huawei does to implement their networks. This particular option is highly unlikely because the United States does not want to be seen as trying to control the economy. If the United States were to invest in or control a technology company, it could have negative impacts on competition within the

U.S. markets and could lead to policies that are skewed towards the company they would invest in.

II. Future European Responses to U.S. Pressure and Chinese Pressure

While Europe is not the focus of this paper, it is important to assess likely European responses to American governmental action and the subsequent counteraction of the Chinese government. As Europe is caught in the middle of this race for 5G dominance, it is important to assess the likelihood of Europe picking a side or continuing to be split between the East and the West. This assessment will focus on the ways in which China could pressure Europe as well as the ways in which the United States could convince more European countries to ban Huawei technologies. European countries are split on what to do in regards to the United States and China, and more specifically, the U.S. stance on Huawei. Some countries have already banned and will continue to ban Huawei; however, some countries are looking at Huawei's low-price points and are not willing to pass up the economic advantage that choosing Huawei could have, regardless of security risk.

China is very involved in Europe's economic growth because of trade deals and China's increased presence in the region. With the threat of European countries backing out of deals due to Huawei security concerns, it is likely that China will retaliate with economic threats. In fact, this has already happened in Germany. In December, China's ambassador to Berlin threatened to torpedo German car sales in China. Beijing also directed similar warnings at France.¹⁵⁹ These threats will impact European decision regarding whether to move away from Huawei technology and infrastructure as it could

¹⁵⁹ Bellamy, Daniel. "EU Insists European Companies Could Replace Huawei in 5G Network." *Euronews*, 25 July 2020, www.euronews.com/2020/07/25/eu-insists-european-companies-could-replace-huawei-in-5g-network.

create serious economic issues. China is also influencing European countries against switching away by arguing that the United States has similar technology intelligence laws at China. China argues the U.S. mass surveillance as stated by Edward Snowden, revealed to the public makes the US as trustworthy as them.

On the other hand, the United States will likely continue to put pressure on European countries to ban Huawei products similar to what they have done with Britain as mentioned in Chapter 5. To accomplish this goal, the United States could put pressure on the EU by expediting trade agreement negotiations.¹⁶⁰ These negotiations could help economic growth and assure European countries that the United States will care for them and provide them with the help needed if they exclude Huawei from their networks. The U.S. may be able to use his approach effectively since it is the largest export destination for the EU and their goods, receiving almost twice as much as China.¹⁶¹ This would allow the United States to reason with, not intimidate the EU. The United States could also apply pressure on the EU by focusing on their shared values of democracy. Historically in Europe, Huawei has relied on large-scale lobbying campaign to convince Europeans that it is a trustworthy vendor. Huawei's campaign highlights the shared values it has with Europe, such as saying that voting for Huawei 5G is voting for European values.¹⁶² However, the United States can use this campaign to its advantage due by pointing out that Huawei's 5G technologies' an integral part of China's campaign to suppress and

¹⁶⁰ Bowler, Tim. "Huawei: Why Is It Being Banned from the UK's 5G Network?" *BBC News*, BBC, 14 July 2020, www.bbc.com/news/newsbeat-47041341.

¹⁶¹ Bellamy, Daniel. "EU Insists European Companies Could Replace Huawei in 5G Network." *Euronews*, 25 July 2020, www.euronews.com/2020/07/25/eu-insists-european-companies-could-replace-huawei-in-5g-network.

¹⁶² Feng, Emily, and Amy Cheng. "China's Tech Giant Huawei Spans Much Of The Globe Despite U.S. Efforts To Ban It." *NPR*, NPR, 24 Oct. 2019, www.npr.org/2019/10/24/759902041/chinas-tech-giant-huawei-spans-much-of-the-globe-despite-u-s-efforts-to-ban-it.

isolate Uighurs in Xinjiang, counter protesters in Hong Kong, and thereby exert greater control over the daily lives of all Chinese. The United States could argue that buying into Huawei subsidizes these actions—which go against the core values of the EU itself.¹⁶³ This course of action would exert pressure on the EU, not by force, but by using the values of the EU and pointing out sound reasons as to why the EU should be weary of Huawei.

¹⁶³ Fisher, Lucy. “CIA Warning over Huawei.” *News / The Times*, The Times, 20 Apr. 2019, www.thetimes.co.uk/article/cia-warning-over-huawei-rz6xc8kzk.

Chapter 9: Conclusion and Outlook

5G is the key to being the global superpower for the future because of the technological advancements and advantages that come with creating this technology. Areas such as cellular devices, transportation, and cities infrastructure will be reimaged and revolutionized because of 5G networks. These advancements will give China economic and political leverage as well as the ability to control and implement data and technological standards. These advancements will allow the Chinese economy to grow to the largest in the world as well as become a haven for new industries that will be created with 5G networks.

It is likely that Huawei will implement the first fully functioning 5G network; meaning China will win the race for 5G dominance. Huawei will be able to implement fully functioning 5G technology first because of China's unified country goals, government funding, and the ability to grow with a size and scale greater than their main competitors, Ericsson and Qualcomm. For Ericsson or Qualcomm to implement full 5G capabilities before Huawei, they would need government backing which the United States and their allies are not currently willing to provide.

Even though the U.S. is likely to continue banning Huawei and its closest allies, this will only slow down Huawei's expansion, not speed up American or European companies' development of competitive 5G technology. Therefore, the U.S. is still going to have to wait for viable options comparable to the size and capabilities of Huawei 5G. The longer the U.S. waits, the more advantages China and Huawei will have over the United States. Companies such as Qualcomm and Ericsson do not possess the scale or government backing that Huawei does. The U.S. will continue doing everything to stop

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Huawei, however the problem is that the U.S. is not doing anything to further their own advancements. This is not the most effective strategy. As is commonly said, your defense is only the best offense until it's time to score. The United States has been doing everything defensively, but they have no offensive weapons (5G capabilities) that are comparable to those of Huawei.

It is important to note that eventually the United States will have to log-on or access Huawei built networks because of how vast 5G is. While this is not the same as having Huawei built networks across America, the United States will have to face the security concerns associated with utilizing Huawei's systems whether in the next two years or further down the road.

If the United States and its allies continue to ban Huawei products, this could lead to the new age cold war with technology at the center instead of nuclear weapons. Over the next decade, the Chinese networks could become the favorite of non-democratic countries around the world. If this happens, it could lead to a new age Berlin Wall built around networks where a highly controlled internet is run by the Chinese companies, while the Western internet is built around a Western companies 5G infrastructure. While this may seem extreme, neither China or the U.S. is likely to back down to the other or compromise in terms of technology.

While 5G technologies are currently being created, implemented, and turned on around the world, one thing is certain: Huawei is the leader in implementing this technology. It will take time to see if this lead grows even further, but the race for 5G dominance is on and China is in the lead.

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5G technology development in the context of the U.S.-China race and competition for dominance has significant economic, technological, political and security implications for both the U.S. and China. This thesis provides an overview of the 5G technology and its development, discusses these implications, and highlights the possible prospect of China winning the 5G technology race and U.S. policy responses so far. The race in progress requires close attention for many reasons and purposes, and policy responses and results would demand careful evaluations. This subject certainly merits further investigation and study.

List of References

- Collela, Paolo. *5G And IoT: Ushering in a New Era*, 2021, www.ericsson.com/en/about-us/company-facts/ericsson-worldwide/india/authored-articles/5g-and-iot-ushering-in-a-new-era .
- Bellamy, Daniel. “EU Insists European Companies Could Replace Huawei in 5G Network.” *Euronews*, 25 July 2020, www.euronews.com/2020/07/25/eu-insists-european-companies-could-replace-huawei-in-5g-network.
- Bourke, Latika. “Why Are Huawei and 5G Such a Big Deal around the World?” *The Sydney Morning Herald*, The Sydney Morning Herald, 14 Feb. 2020, www.smh.com.au/world/europe/why-are-huawei-and-5g-such-a-big-deal-around-the-world-20200131-p53wf0.html.
- Bowler, Tim. “Huawei: Why Is It Being Banned from the UK's 5G Network?” *BBC News*, BBC, 14 July 2020, www.bbc.com/news/newsbeat-47041341.
- BrainBridge . “From 1G to 5G: A Brief History of the Evolution of Mobile Standards.” *From 1G to 5G: A Brief History of the Evolution of Mobile Standards | My Brainbridge*, 2020, www.brainbridge.be/news/from-1g-to-5g-a-brief-history-of-the-evolution-of-mobile-standards#:~:text=On%20December%201%2C%202018%2C%20South,was%20made%20back%20in%201973.
- Burdeau, Cain. “Europe Becomes a Battleground Over Huawei and 5G.” *Courthouse News Service*, 12 Feb. 2020, www.courthousenews.com/europe-becomes-a-battleground-over-huawei-and-5g/.
- Burgess, Matt. “What Is the Internet of Things? WIRED Explains.” *WIRED UK*, WIRED UK, 17 Nov. 2020, www.wired.co.uk/article/internet-of-things-what-is-explained-iot.
- Columbia University. “U.S.-China Relations Since 1949: Asia for Educators: Columbia University.” *U.S.-China Relations Since 1949 | Asia for Educators | Columbia University*, Columbia University, 2021, afe.easia.columbia.edu/special/china_1950_us_china.htm.
- Conklin, Audrey. “When Will the US Have 5G Technology?” *Fox Business*, Fox Business, 4 Feb. 2020, www.foxbusiness.com/technology/us-5g-technology-mobile-arrival.
- Contreras, Samuel. “5G Coverage Map: Every US City with AT&T, Verizon & T-Mobile 5G.” *Android Central*, Android Central, 25 Feb. 2021, www.androidcentral.com/heres-every-us-city-5g-coverage-right-now.

5G Technology, U.S.- China Race, and the Competition for Dominance

Council On Foreign Relations. Timeline: U.S. relations with CHINA 1949–2021, <https://www.cfr.org/timeline/us-relations-china>

Economy, Elizabeth, et al. “How 2020 Shaped U.S.-China Relations.” *Council on Foreign Relations*, Council on Foreign Relations, www.cfr.org/article/how-2020-shaped-us-china-relations.

Emnify . “What Is 5G IoT and How Will It Change Connectivity?” *IoT & M2M Connectivity Management Platform*, 10 Dec. 2020, www.emnify.com/en/resources/what-is-5g-iot-and-how-will-it-change-connectivity.

Enderle, Rob. “Qualcomm vs. Huawei: Is This a Battle Between Companies or Countries?” *Itbusinessedge*, IT Business Edge , 9 Mar. 2019, www.itbusinessedge.com/blogs/unfiltered-opinion/qualcomm-vs.-huawei-is-this-a-battle-between-companies-or-countries.html.

Feng, Emily, and Amy Cheng. “China's Tech Giant Huawei Spans Much Of The Globe Despite U.S. Efforts To Ban It.” *NPR*, NPR, 24 Oct. 2019, www.npr.org/2019/10/24/759902041/chinas-tech-giant-huawei-spans-much-of-the-globe-despite-u-s-efforts-to-ban-it.

Fisher, Lucy. “CIA Warning over Huawei.” *News / The Times*, The Times, 20 Apr. 2019, www.thetimes.co.uk/article/cia-warning-over-huawei-rz6xc8kzk.

Fisher, Tim. “When Is 5G Coming to the US? (Updated for 2021).” *Lifewire*, 1 Mar. 2021, www.lifewire.com/5g-availability-us-4155914.

Fowler, Bree. “Is There a 5G Cellular Network Near You?” *Consumer Reports*, Consumer Reports , 10 Mar. 2021, www.consumerreports.org/cell-phone-service-providers/is-there-a-5g-network-near-you/.

Galazzo, Richard. “Timeline from 1G to 5G: A Brief History on Cell Phones.” *CENGN*, 24 Feb. 2021, www.cengn.ca/timeline-from-1g-to-5g-a-brief-history-on-cell-phones/.

Gillis, Alexander S., and Kate Gerwig. “What Is 5G? Everything You Need to Know About 5G Technology.” *SearchNetworking*, TechTarget, 8 Jan. 2020, searchnetworking.techtarget.com/definition/5G.

Johnson, Keith, and Elias Groll . “The Improbable Rise of Huawei.” *Foreign Policy*, 3 Apr. 2019, foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/.

5G Technology, U.S.- China Race, and the Competition for Dominance

- Kagan, Jeff. "Kagan: Why Qualcomm Is Important to USA in 5G Race." *RCR Wireless News*, 9 Dec. 2019, www.rcrwireless.com/20191209/analyst-angle/kagan-qualcomm-5g-race.
- Kaska, Kadri, et al. *Huawei, 5G and China as a Security Threat*, 28 Mar. 2019, www.ccdcoe.org/uploads/2019/03/CCDCOE-Huawei-2019-03-28-FINAL.pdf.
- Keane, Sean. "Huawei Ban Timeline: Chinese Company May Start Making Electric Vehicles This Year." *CNET*, 2 Mar. 2021, www.cnet.com/news/huawei-ban-full-timeline-us-sanctions-china-5g-electric-vehicles/.
- Kenworthy, Randal. "Council Post: The 5G And IoT Revolution Is Coming: Here's What To Expect." *Forbes*, Forbes Magazine, 18 Nov. 2019, www.forbes.com/sites/forbestechcouncil/2019/11/18/the-5g-iot-revolution-is-coming-heres-what-to-expect/?sh=1591ecc36abf.
- Kharpal, Arjun. "Huawei Says US Push to Create a 5G Rival 'Would Be a Challenge'." *CNBC*, CNBC, 21 Feb. 2020, www.cnbc.com/2020/02/21/huawei-says-us-push-to-create-a-5g-rival-would-be-a-challenge.html.
- Levy, Steven. "Huawei, 5G, and the Man Who Conquered Noise." *Wired*, Conde Nast, 2020, www.wired.com/story/huawei-5g-polar-codes-data-breakthrough/.
- Li, Shancang, et al. "5G Internet of Things: A Survey." *Journal of Industrial Information Integration*, 20 Jan. 2018, doi:<https://doi.org/10.1016/j.jii.2018.01.005>.
- Mukherjee, Supantha, and Isla Binnie. "Analysis: Europe Plots Catch-up in Global 5G Race to Drive COVID-19 Recovery." *Reuters*, Thomson Reuters, 28 Dec. 2020, www.reuters.com/article/us-europe-5g-analysis/analysis-europe-plots-catch-up-in-global-5g-race-to-drive-covid-19-recovery-idUSKBN2920WJ.
- Osman, Jim. "Trump's 5G China Security Deadline Will Force Nokia M&A." *Forbes*, Forbes Magazine, 24 Apr. 2020, www.forbes.com/sites/jimosman/2020/04/23/donald-trump-5g-us-china-security-nokia-merger-google/#2d5d177b1b27.
- Qualcomm. "The Race to 5G: Setting the Pace for What's Next." *CSRWire*, Qualcomm, 19 Dec. 2020, www.csrwire.com/press_releases/709566-race-5g-setting-pace-whats-next.
- Reynolds, Oliver, and Arne Pohlman. "What Will the U.S.-China Relationship Look Like in the Biden Era?" *Harvard Business Review*, 7 Jan. 2021, hbr.org/2021/01/what-will-the-u-s-china-relationship-look-like-in-the-biden-era.
- Segan, Sascha. "What Is 5G?" *PCMag*, PCMag, 25 Feb. 2021, www.pcmag.com/news/what-is-5g.

5G Technology, U.S.- China Race, and the Competition for Dominance

Skorup, Brent. *5G Basics and Public Policy*. Mercatus Center at George Mason University, Feb. 2019, www.thriveed.org/wp-content/uploads/2019/03/skorup_-_policy_brief_-_5g_basics_and_public_policy_-_v1_0.pdf.

Slayton, Rebecca. “Analysis | Trump Says 'America Must Win' the 5G Race. Here's What You Need to Know.” *The Washington Post*, WP Company, 18 Apr. 2019, www.washingtonpost.com/politics/2019/04/18/trump-says-america-must-win-g-race-heres-what-you-need-know/.

Staff, Tom's Guide. “When Is 5G Coming to You? The Definitive Guide to the 5G Network Rollout.” *Tom's Guide*, Tom's Guide, 4 Feb. 2021, www.tomsguide.com/special-report/when-is-5g-coming-to-you-the-definitive-guide-to-the-5g-network-rollout.

Tang, F. “What is China's dual Circulation economic strategy and Why is it important?” *China Macro Economy* 4 March 2021, <https://www.scmp.com/economy/china-economy/article/3110184/what-chinas-dual-circulation-economic-strategy-and-why-it>

Tech Terms. “5G.” *5G Definition*, 18 May 2020, techterms.com/definition/5g.

Thales Group . “Introducing 5G Technology and Networks (Speed, Use Cases and Rollout).” *What Is 5G? A Helpful Illustrated Q&A (2021)*, Thales Group , 4 Feb. 2021, www.thalesgroup.com/en/markets/digital-identity-and-security/mobile/inspired/5G.

Tomás, Juan Pedro. “Chinese Telcos Expected to Deploy 1 Million 5G SA Base Stations This Year.” *RCR Wireless News*, 8 Feb. 2021, www.rcrwireless.com/20210205/5g/chinese-telcos-expected-deploy-1-million-5g-sa-base-stations-this-year.

Woo, Stu. “Ericsson Emerges as 5G Leader After U.S. Bruises Huawei.” <https://www.bangkokpost.com>, Bangkok Post , 4 June 2020, www.bangkokpost.com/business/1929056/ericsson-emerges-as-5g-leader-after-u-s-bruises-huawei#:~:text=Ericsson's%20share%20rose%20from%2026.2,from%2027.5%25%20to%2030.7%25.&text=The%20big%20question%20for%20wireless,carriers%20have%20come%20to%20expect.