APPENDIX A: DECLARATION OF JOHN LEGERE
Chief Executive Officer, T-Mobile US, Inc.

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Chief Executive Officer, T-Mobile US, Inc.

I. BIOGRAPHICAL INFORMATION

1. My name is John J. Legere. I have been Chief Executive Officer of T-Mobile US, Inc. since September of 2012. I have a long history in the telecommunications industry, having previously spent nearly 18 years at AT&T, several years as an executive at Dell, and then more than a decade at Asia Global Crossing and Global Crossing, where I was CEO. I received a B.B.A. from the University of Massachusetts, an M.S., as an Alfred P. Sloan fellow, from the Massachusetts Institute of Technology Sloan School of Management, and an M.B.A. from Fairleigh Dickinson University. I also completed Harvard Business School's Program for Management Development.

2. As CEO of T-Mobile, I have been responsible for all aspects of the proposed merger with Sprint, including review and approval of the proposed business plan for the merged company. Upon approval of the merger and its consummation, I will serve as the CEO of New T-Mobile.

3. I hereby make this declaration.

II. SUMMARY

4. T-Mobile's track record as the Un-carrier speaks for itself. Only six years ago, wireless customers dealt with onerous service agreements, unnecessary termination fees, and penalties for over-usage, just to name a few ridiculous restrictions that consumers simply accepted and lived with. Today, thanks to T-Mobile's consumer-first approach, U.S. wireless customers have true freedom to choose the plans and options that work best for them. The Un-carrier approach developed under my leadership has forced dramatic change in the wireless industry, and we have no plans to stop changing the market. In our view, being pro-consumer

and pro-competition means lower prices, more value, better service, and more choices for consumers in every corner of the country.

5. I am proud that T-Mobile puts our customers first. There's no doubt our Un-carrier strategy has been great for consumers across the entire industry. We pursued this approach for very real and significant business reasons—we need to attract, sign up and retain customers in order to be successful. We have intentionally differentiated ourselves from our competitors in new and exciting ways and, as a result, customers have come to T-Mobile, embraced our blazing fast network, and stayed with T-Mobile. Our customer satisfaction has leapt up, our churn numbers have gone down and we have shown that being the Un-carrier is a successful business strategy for us and a win for U.S. consumers.

6. From my first day at T-Mobile, I realized that if we were truly going to put the customer first, we needed to dramatically improve our network. On my arrival in September of 2012, T-Mobile had not yet begun deploying 4G LTE technology. We had no LTE. We were behind all of the competitors in the market and our network was uncompetitive. We were hemorrhaging over two million customers a year, the financial position of the company was strained, and the implications of not investing in new mobile technologies was painfully obvious. If I was going to effectively execute my strategy, it was abundantly clear that we would not only have to build out the network capability that would put us on even footing with the competition, but we really needed to build and operate a network that was second-to-none. Many thought that impossible; but through a combination of sheer determination, a financial foundation with an ability to raise capital, and a highly skilled team with a clear mission to build the best and fastest network in the country, I believed it was possible. As we sit here today, that has been accomplished and now we face an even greater opportunity and challenge with the advent of 5G.

7. A significant part of what helped us achieve a best in class network was our acquisition of MetroPCS just five years ago. Since then, we have added over one million total customers every single quarter for the past five years—that's 20 quarters. Along with the launch of Un-carrier, this acquisition was a watershed event that allowed us to grow, add scale, directly access the capital markets and have a bigger impact in the U.S. marketplace. Despite skeptics at the time, we more than doubled MetroPCS distribution across the country, increased the number of MetroPCS FTEs by 50 percent, achieved our run-rate synergy targets one year earlier than planned, and beat our NPV synergy targets by more than 40 percent—all while doubling the number of customers in 4½ years. We migrated the MetroPCS customers and network seamlessly, painlessly, and quickly to the benefit of consumers. Our ability to effectively execute on this acquisition sets the stage for similar consumer benefits to come from our merger with Sprint.

8. Our proposed merger with Sprint will provide New T-Mobile with the added scale and assets to supercharge the Un-carrier model, taking it to new levels and increasing our ability to compete with and win customers from the largest wireless players: AT&T, Verizon, and the large well-capitalized companies—like Comcast—now competing in the wireless industry. We're going to hit the ground running by building the first and best nationwide 5G network as quickly as possible, bringing unprecedented capacity gains for consumers, jumpstarting even more advanced innovation, and forcing our competitors to invest more to keep up with us.

9. When I say "hit the ground running," I am not just talking about big markets and big cities. We are going to go aggressively into parts of the United States that other wireless carriers shy away from. This includes rural America, where we are finally going to create real choices for consumers. We will deliver improved broadband, higher quality service, and boots

on the ground to serve towns and communities that have long been neglected. This will include 600 new retail stores to serve rural areas and small towns—communities that need them most.

10. The transaction will also enable us to expand our Un-carrier strategy into new industries and markets, making it possible for New T-Mobile to bring innovative service offerings, lower prices, and increased competition to in-home broadband, video and entertainment, as well as to the enterprise segment of wireless—areas where real competition is generally lacking today. Plus, New T-Mobile's broad and deep nationwide 5G network will help to propel the U.S. forward in global technology leadership, allowing the country to be a first in 5G technology and innovation.

11. I have read that opponents of our transaction suggest that, once we complete our merger, T-Mobile and I will start to raise prices, stop innovating, and basically start to act like the big boys in our industry. Nothing could be further from the truth. That's not the way I operate, that is not how my management team operates—and it is definitely not the path to success for New T-Mobile.

III. THE BIRTH OF UN-CARRIER

12. When I took over as CEO of T-Mobile in 2012, one of the things that was clear to me about the wireless industry was that people hated it. They hated being locked into contracts. They hated being gouged by extra fees for things they didn't understand or couldn't fully control, such as data and roaming. They hated the high or hidden costs associated with monthly fees and device upgrades. Honestly, other than the mobility that wireless service allowed, there was almost nothing about the industry that consumers liked.

13. At the time, T-Mobile was struggling. The business was stagnant—people were trying hard, but not gaining any ground. Frankly, they were losing ground. The company was just a smaller version of the market leaders. To me, it was clear that the best way to succeed was

to do things as differently as possible from the existing carriers. In fact, we had to do the complete opposite: we had to become the Un-carrier. So, I laid out a plan to reinvent T-Mobile, drive our business forward, and differentiate ourselves from the other guys—putting consumers first. I framed our strategy in a "manifesto," which I closed by saying "We are T-Mobile. The Un-carrier. And we will be un-relenting." We have been unrelenting, and consumers have taken notice.

14. In the manifesto, I explained that "consumers don't need another AT&T. What consumers need is a company to stop acting like AT&T. They don't need another wireless carrier that's modeled itself after a utility company—they need a wireless carrier with a recognizable pulse that their customers can feel in the palm of their hand. A wireless company kept alive and nimble with the belief of being a better carrier, not simply another carrier." It was this philosophy that was the start of the strategy we named Un-carrier.

15. As the Un-carrier, our goal is to make the whole industry better for consumers forever. We listen to customers, solve their pain points, and we give more to customers without asking more from them. We got rid of long-term service contracts and replaced them with a transparent pricing model—freeing 180 million customers from service contracts in the process. We made it easier to upgrade to a new smartphone and eliminated charges for global roaming, which often led to giant bills for our competitors' customers. Since then, customers have been free to upgrade when they want, not when they are told and more than three hundred times more data has been consumed internationally than before we started. We offered to reimburse customers for competitors' early termination fees and equipment loans if they wanted to switch to T-Mobile. We made it easy to call free over Wi-Fi networks. As streaming video became more popular, we created Binge On, which allowed customers to watch YouTube, Netflix, and

other video without hitting their data buckets. In addition, it was T-Mobile that ushered in the era of Unlimited data amounts by forcing AT&T and Verizon to do something they said they never would do, offer Unlimited plans! And along the way, we kept investing in our network to continually give customers a better experience.

16. The Un-carrier changed the wireless market not just for our own customers, but for customers in the whole U.S. wireless industry. Every time we make a move that the other guys follow—that is success for us and for U.S. consumers. As T-Mobile began to stand out in the market, other carriers had no choice but to follow suit and tried to copy our pioneering initiatives, particularly in abandoning long-term, restrictive service contracts and making it easier for customers to switch wireless providers without being shackled by unnecessary contract terms. Customers have recognized and responded to our disruption and our value. Over the last five years, T-Mobile has had 20 consecutive quarters with more than 1 million net adds. In addition to our steady customer growth, customers are also staying with T-Mobile longer. Our postpaid churn rate was a record low 1.07 percent in the first quarter of 2018—half of what it was 5 years ago. And, T-Mobile recently earned the highest score ever recorded in J.D. Power's 2018 U.S. Wireless Customer Care Study. This track record will only improve when we have the combined assets to truly compete with some of the largest players in the industry.

17. Since I took over as CEO, I have been devoted to the Un-carrier. I'm not afraid to mix it up and go after our competitors. In fact, I once commented that I saw more honesty on a Match.com ad than on one competitor's coverage maps. I spend a lot of time on my phone and my tablet echoing this sentiment, but I also tweet about our company and listen to customers, without a filter. If someone complains about T-Mobile, I personally try to address their issues. I'll tweet him or her my e-mail address and make sure we follow up. When I'm not tweeting or

in meetings, I spend time in our call centers, listening to our employees talk about what is working and what is not. This brand is my life—I wear magenta T-Mobile gear 24 hours a day, seven days a week. I truly believe in our company, our people and our Un-carrier approach.

18. My employees are also proud brand ambassadors both on and off the job. When we combined with MetroPCS in May of 2013 and became a public company, I believed deeply in the mission that I was on and believed that to be successful it would take the support of every single person in the company. After all, my frontline employees touch millions of customers every day and each of these interactions is a "moment of truth". To address the importance of this we have made every single employee an owner of T-Mobile and each year each employee receives an additional grant of equity in the company. Over the past five years, we have made more than 330,000 unique stock awards to employees resulting in nearly 62 million units awarded. I deeply believe that the pride of ownership makes a real difference in the way we serve our customers: we listen more carefully, we take the extra step and are always looking to improve and do better. Ownership is a philosophy that I believe makes a difference and I intend to continue with this approach.

IV. NEW T-MOBLE WILL CONTINUE THE PRO-CONSUMER UN-CARRIER APPROACH

19. While we have moved from number four to number three in terms of wireless subscribers, we have not been able to make much of a dent in the about two-thirds market share held by the two leading carriers, AT&T and Verizon. They are much larger than T-Mobile and more diversified so they have a better cost structure. The stubbornness of Verizon and AT&T's combined share is incredibly irritating to me since we think we offer customers better options and some of AT&T and Verizon's policies are just dumb—you know my feelings on this if you read my Twitter account. But scale and a top quality 5G network for the future are critical assets

to our ability to truly compete on a broader scale with everyone in this market—that is why this transaction is so important to our business, and to American consumers.

20. Scale and a leading 5G network will become even more important since we aren't just running up against traditional wireless carriers anymore. When it comes to new entrants like cable companies and others, I've been somewhat dismissive. In fact, I once referred to Comcast and Charter's wireless businesses as "irrelevant, and . . . irrelevant squared." But the truth of the matter is that the numbers are starting to show everyone that they are making progress. In the first quarter of 2018, Comcast added more postpaid phone customers than AT&T and Verizon combined. Some estimates have Comcast and Charter adding five million customers in the next two years. And the net present value of their wireless business has been estimated at $20 billion. So, these companies clearly are striving to be major players in the wireless market, they have the assets to drive forward and they are truly investing together to grow their wireless businesses. Now even DISH has begun to build out its own wireless network and put its considerable spectrum assets into use.

21. On top of new, well-capitalized companies expanding into wireless, the nature and structure of the market is also changing. Whether or not you believe it, AT&T is the largest MVPD in the U.S. right now. With its purchase of DIRECTV and acquisition of Time Warner, AT&T has become a content behemoth, leveraging its traditional wireline and wireless businesses to offer consumers a bundle of services that meet their needs. Verizon has followed suit, not only acquiring content, but also entering agreements to deliver certain content over its wireless network to meet consumer demand for mobility. And with the existing infrastructure that companies like Comcast, Charter, and DISH already have in place, they are well positioned to deliver an attractive bundle of services as the transition to innovative 5G networks occurs. So

there is an adjacent and converging industry game that's going on, with players that have deep pockets, built-in customer bases, and the ability to bundle. It's not just wireless. It's not just cable. It's connecting people with content, which is a space we definitely want to play in.

22. The proposed transaction with Sprint will give us the scale and network we need to compete with these larger and more diversified competitors. Make no mistake—even after the transaction, we will still be the little guy among these giants. We won't have an existing cable or fixed broadband base of customers to cross-sell or other services to cross-subsidize our network costs. That means we will still need to offer more value to consumers to get their attention, keep them as customers and be successful.

23. New T-Mobile will take our Un-carrier strategy into the 5G world and beyond. As CEO, my plan is to put that same disruptive, pro-consumer strategy into overdrive to benefit our combined business. We are committing nearly $40 billion to bring this company into the 5G era over the first 3 years, with the majority of this investment focused on the rapid enhancement of the network, in order to retain our existing customer base, attract new customers, and benefit from being first to deliver transformative 5G services across the country. That's why we plan to expand T-Mobile's unique customer service model to Sprint while we subsequently deliver better coverage, reliability, and speed. And that's why we will keep prices low for consumers, who are vital to our ability to build out 5G infrastructure across the country. When it comes to changing how the wireless industry operates, we're only getting started.

24. To be clear, we aren't merging to be like AT&T and Verizon. As T-Mobile learned prior to my arrival, trying to act like those bigger, more diversified companies is not a recipe for success in this business. Rather, we need to take their customers. The network synergies resulting from our proposed transaction and the capacity we will have on the New T-

Mobile network create an opportunity for us to take market share from the marketplace leaders—but taking advantage of that opportunity requires us to be agile, innovative and aggressive to give consumers great pricing and additional value. Not to operate like the AT&Ts and Verizons of the world. No. This merger is about being able to go toe-to-toe with them and all comers to provide aggressive, disruptive competition that is anything but the 'status quo'—well into the future.

25. Combining T-Mobile and Sprint will also allow us to extend the Un-carrier model into new areas. New T-Mobile's nationwide 5G network will allow us to enter new markets and segments, like truly giving businesses and enterprises new options and delivering on real consumer IoT capabilities. We will have the ability to deliver true in-home wireless broadband alternatives, and video solutions to compete with both traditional and non-traditional offers. We will be able to expand the choices and create competition for rural consumers and for businesses of all sizes. New T-Mobile will give customers the ability to say goodbye to their traditional ISPs and MVPDs with the first wireless-only bundle for TV and home broadband. We'll deliver unmatched 4K-quality video to all markets via our nationwide 5G network and allow customers to choose TV packages that actually meet their needs. We've already taken the first step by adding Layer3 TV to our family, but this merger will give us the scale in network, costs, and financial resources to really disrupt the video market for consumers.

26. We are serious about the potential to grow, disrupt and deliver new solutions and alternatives to consumers from one end of the country to the other. Only our Un-carrier strategy can get us there. Being a maverick is in my DNA and T-Mobile's DNA. Everyone at T-Mobile has put too much blood, sweat, and tears into this brand and philosophy to abandon our Un-carrier ways. It matters to us, it matters to consumers and it works for shareholders. We fully

understand that being successful in the evolving telecommunications marketplace requires that New T-Mobile continue being an aggressive disruptor that challenges the *status quo*. If we changed, we'd run the risk of losing the confidence of our customers, losing our position of brand strength in the marketplace—and it could even cost us paying customers. These people came to us because we offered something different from the other guys. They would abandon us—and I wouldn't blame them!—if we started acting like AT&T, Verizon, or a cable company. As we build out our 5G network and expand into new services, we will need to grow our customer base. That means keeping the customers we've fought hard to win and attracting new customers with great quality and more innovative offerings. Only the Un-carrier can actually make that a reality.

27. The telecommunications marketplace is changing in wondrous ways and it is sometimes difficult to predict the future. But there are two things you can count on—T-Mobile won't stop being a maverick, and I won't stop wearing magenta.

28. I declare under penalty of perjury that the foregoing is true and correct. Executed on June 18, 2018.

John J. Legere
Chief Executive Officer
T-Mobile US, Inc.

APPENDIX B: DECLARATION OF NEVILLE R. RAY
Executive Vice President and Chief Technology Officer, T-Mobile US, Inc.

DECLARATION OF NEVILLE R. RAY
Executive Vice President and Chief Technology Officer, T-Mobile US, Inc.

I. BIOGRAPHICAL INFORMATION

1. My name is Neville R. Ray. I serve in the T-Mobile US, Inc. ("T-Mobile") technology organization in the capacity of Executive Vice President and Chief Technology Officer. I joined T-Mobile (then VoiceStream) in April 2000 and since December 2010 have served as its Chief Technology Officer, responsible for the national management and development of the T-Mobile wireless network and the company's IT services and operations.

2. I have more than 30 years of experience in the design, deployment and operational management of wireless networks in the United States and worldwide. Prior to joining T-Mobile, I served as Network Vice President for Pacific Bell Mobile Services. I currently serve on the Board of Directors of Next Generation Mobile Networks Alliance, a mobile telecommunications association of mobile operators, vendors, manufacturers and research institutes. I also serve as the Chairperson of the 5G Americas, the industry trade association and voice of 5G and LTE for the Americas. I have also served as a member of the National Telecommunications and Information Administration's Commerce Spectrum Management Advisory Committee and the Federal Communications Commission's Communications Security, Reliability and Interoperability Council. I am an honors graduate of The City University of London and a member of the Institute of Electrical and Electronic Engineers and the Institution of Civil Engineers.

3. I hereby make this declaration.

II. SUMMARY

4. The proposed transaction will allow New T-Mobile to create a broad and deep nationwide 5G and LTE wireless network faster and more efficiently than either company could

on its own. The combination will allow New T-Mobile to increase network density, deploy complementary spectrum resources across that dense network, and enhance spectral efficiency by faster spectrum refarming to 5G which will multiply the overall network capacity of the standalone networks and deliver world-class speed and user experiences to consumers. Existing Sprint customers will be rapidly migrated to the New T-Mobile network (which will be anchored on the existing T-Mobile system) over an approximately three-year period. Absent this transaction, T-Mobile would be unable to match the throughput and capacity needed to deploy a fully capable 5G network as quickly or as cost efficiently as New T-Mobile.

III. T-MOBILE'S CURRENT NETWORK

5. T-Mobile is currently the third-largest wireless provider in the United States, serving approximately 72.6 million customers under the T-Mobile and MetroPCS brands. T-Mobile's wireless network currently supports voice and data services predominantly using LTE technology. There are some legacy subscribers that rely upon UMTS/HSPA technology for a small amount of voice and data traffic. At the end of 2017, T-Mobile had approximately 61,000 macro cell sites and 18,000 small cells and distributed antenna systems ("DAS").[1] The majority of these cell site locations are leased from third-party tower companies such as American Tower Company, Crown Castle, and SBA.

6. Our network utilizes licensed spectrum in the 600 MHz, 700 MHz, 1900 MHz (PCS), and 1700/2100 MHz (AWS) bands and will extend to the millimeter wave spectrum bands (28 and 39 GHz) in the future.[2] We hold approximately 30 megahertz of 600 MHz spectrum nationally, which we are in the process of deploying while working with television

[1] T-Mobile SEC 10-k filing at 7 (found here: http://investor.t-mobile.com/Cache/392104903.pdf).

[2] T-Mobile also uses some unlicensed spectrum in the 5 GHz band using the Licensed Assisted Access 3GPP standard technology to supplement its existing licensed network

broadcasters to clear the spectrum, some of whom will remain in the band until 2020.[3] This spectrum provides an excellent coverage layer for the T-Mobile network, along with the approximately 10 megahertz of 700 MHz spectrum that we have already deployed in many markets for LTE. In the mid-band range, we have access to approximately 30 megahertz of PCS spectrum and 40 megahertz of AWS spectrum where we support our legacy UMTS/HSPA users in a small portion of the AWS and PCS band (spectrum band used varies by market but does not exceed 10 megahertz on average) and the rest of the spectrum is used to support LTE services, including VoLTE for voice services. Finally, we have some millimeter wave band spectrum rights (from 100 to over 800 megahertz) in certain urban markets that we will deploy for 5G services in the upcoming years. As of April 2018, we had approximately [redacted] subscriber devices on our PCS network, [redacted] subscriber devices on our AWS network, and [redacted] subscriber devices on our 700 MHz network.

7. We use two network equipment vendors to support our cell site radio equipment infrastructure, Nokia and Ericsson. However, we restrict our use of vendors so that we only use one vendor's equipment at a site and, to drive further efficiencies into the network, generally rely upon a single vendor within an operating market. Our two-vendor strategy creates competition on pricing and drives cost efficiencies, despite the use of only one vendor within a given market. In addition, we have found that this dual sourcing allows the wireless network to operate more consistently and ensures that all equipment features will be supported and synchronized.

8. In the past several years, we have aggressively expanded the network spend and coverage footprint to compete with other national wireless providers and established a track record of quickly deploying spectrum resources. Initially, in 2014, we purchased 700 MHz

[3] All spectrum holdings discussed below are based on national averages.

spectrum from Verizon for about $3.35 billion in cash and spectrum assets and deployed this spectrum (along with some additional 700 MHz spectrum acquired from secondary markets) to cover 185 million POPs (out of a possible 190 million POPs) by the end of 2015. We have continued to both purchase and deploy additional 700 MHz spectrum which now covers 272M POPs. In 2017, we purchased approximately 30 megahertz of 600 MHz spectrum nationally for roughly $8 billion in the Federal Communications Commission's incentive auction process. Within two months of license grant, we had deployed this 600 MHz spectrum in some markets.[4] By the end of 2017, we had deployed in nearly 600 cities and towns, and continue to rapidly extend this coverage—now to more than 900 cities and towns.[5] We currently plan to spend approximately $25.9 billion in network CapEx between 2018 and 2022 to continue this forward progress, with a focus on completing our 600 MHz build (which will include radios that are capable of supporting both LTE and 5G), densifying our existing network, and increasing in-building and rural coverage to our existing subscriber base. By the end of 2021, we will have approximately [redacted] macro cell sites and [redacted] small cells, with approximately [redacted] of these sites utilizing 5G technology. While these investments have vastly improved our network over time, we will face increasing challenges in meeting the capacity demands of our customers as we transition to 5G.

IV. 5G WILL PROVIDE INNUMERABLE BENEFITS FOR AMERICAN CONSUMERS.

9. Over the years I have been involved in the wireless marketplace, it has been characterized by rapid technological shifts. To put this into context, in the slightly more than 30

[4] *T-Mobile Lights Up World's First 600 MHz LTE Network at Breakneck Pace* (Aug. 16, 2017), https://newsroom.t-mobile.com/news-and-blogs/cheyenne-600-mhz.htm.

[5] *T-Mobile 600 MHz Extended Range LTE Now Live in 900+ Cities and Towns, Coming to Puerto Rico* (June 6, 2018), https://www.t-mobile.com/content/t-mobile/corporate/news/articles/2018/06/extended-range-lte-puerto-rico.html.

years since wireless providers initiated service in the United States, the wireless industry has already deployed four generations of technology, with the next generation on the imminent horizon.[6] 5G and its affiliated air interface standard which was recently approved will expand the capabilities of wireless systems dramatically, unleashing even more uses for mobile wireless than the previous generations.[7] Service providers and manufacturers are developing plans and laying the groundwork for deploying this new technology.[8] These new advanced networks will surpass the performance capabilities of today's networks bringing advanced telecommunications services to consumers and enterprise customers.

10. Each generational transition in wireless technology (*e.g.*, 3G to 4G) has led to a dramatic increase in wireless data consumption. As can be seen in the figure below, the transition from 2G to 3G technology resulted in a 21X increase in gigabytes consumed by a subscriber per month while the 3G to 4G change led to a 7.6X increase.[9]

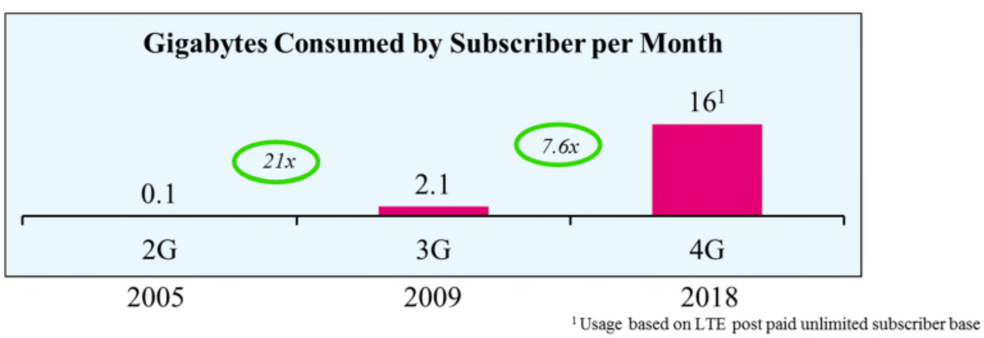

Figure 1: Increase in Subscriber Data Consumption

11. Given the transformational changes that 5G will bring, I anticipate this pattern to continue—and at a greater pace due to an expected tsunami of new data-intensive use cases

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[6] *See, e.g.*, Thomas K. Sawanobori, *The Next Generation of Wireless: 5G Leadership in the U.S.*, CTIA (2016), https://www.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf.

[7] *See, e.g.*, Georg Mayer, *3GPP system standards heading into the 5G*, 3GPP (June 13, 2017). http://www.3gpp.org/news-events/3gpp-news/1614-sa_5g.

[8] *See, e.g.*, Juan Pedro Tomás, *5G trials in the U.S*, RCR WIRELESS NEWS (Feb. 16, 2017). https://www.rcrwireless.com/20170216/carriers/5g-trials-u-s.

[9] These values are based on average consumption on T-Mobile's postpaid network.

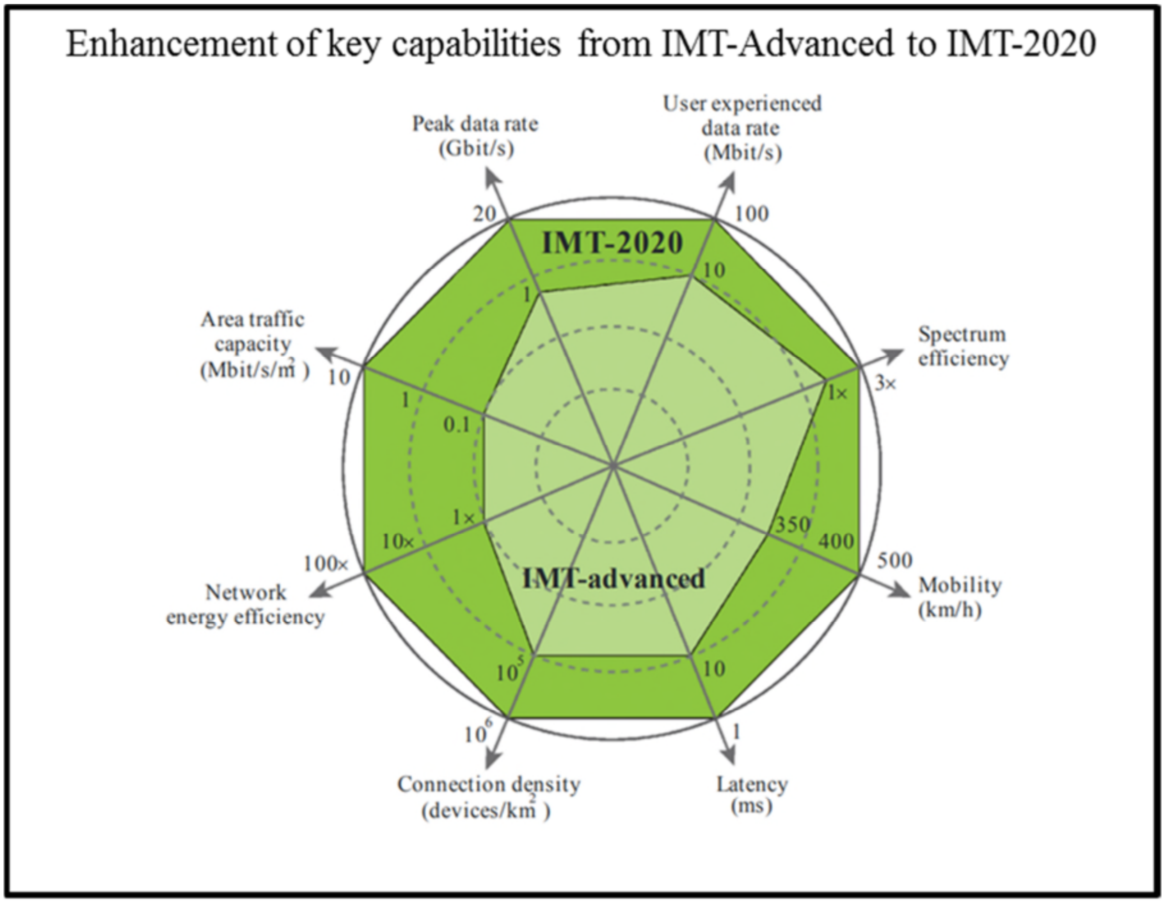
enabled by 5G. 5G promises to bring myriad benefits to users and provide for a multitude of new applications and use cases beyond what can be supported by today's most advanced 4G networks and provide a richer user experience, increased engagement time, and new and innovative methods of consumption. These noticeable upgrades over 4G (*e.g.*, IMT-Advanced or LTE) include superior capacity, faster data rates, and much lower latency. Further, 5G will offer enhancements in energy efficiency leading to longer battery life and the capability to connect a much greater number of devices. More specifically, 5G could potentially offer:[10]

- A tenfold increase in connection density from approximately 100,000 connections per square kilometer to 1,000,000 connections per square kilometer;
- A tenfold improvement in latency;
- A tenfold improvement in the typical user experienced data rate from 10 Mbps to 100 Mbps (or more);
- A twentyfold increase in peak downlink data rates;
- A tenfold improvement in network energy efficiency;
- Three times greater spectral efficiency; and
- Longer battery life (up to 10 years for some IoT devices).[11]

12. The figure below graphically demonstrates the transformative changes expected from new 5G (*e.g.*, IMT-2020) networks as compared to LTE (IMT-Advanced).

[10] *See* Recommendation ITU-R M.2083-0 (09/2015), IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond, https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf.

[11] 5G Systems: Enabling The Transformation of Industry and Society, ERICSSON (Jan. 2017), https://www.ericsson.com/en/white-papers/5g-systems--enabling-the-transformation-of-industry-and-society/white-paper--5g-systems--enabling-the-transformation-of-industry-and-society.



Source: ITU Recommendation ITU-R M.2083-0

Figure 2: 5G Network Improvements

13. The improvements inherent in 5G will usher in a new wave of applications and spawn new business opportunities and customer benefits. It will not only be an evolution of mobile broadband networks, it is also envisioned to enable new unique network and service capabilities. The connectivity increase supported by 5G networks will be essential to support fiber-like data speeds, low latency for real-time interactivity, more consistent performance and user experience, and massive capacity for unlimited data (for things like 4K video streaming, online gaming and other capacity hungry applications) that cannot be served across a substantial number of users by 4G. The new 5G ecosystem will enable new forms of mobile media and entertainment—no longer will consumers be required to subscribe to multiple network providers

to watch television and movie content wherever and whenever they want. Subscribers will be able to develop and share rich user-generated content, regardless of file size or location. Congested environments, such as sporting events, concerts, and large enterprises, will no longer be constrained. Commuters will have high-speed data available—allowing video streaming of state-of-the-art 4K content and the ability to download any file nearly instantaneously while traveling on public transit. And novel and innovative new applications such as virtual and augmented reality, connected vehicles and highways, real-time translation, and drone control/monitoring could dramatically reshape the way consumers engage and enjoy new content and experiences.[12]

14. These are not the only examples. 5G will also provide the ability to connect a massive number of Internet of Things ("IoT") devices and sensors to monitor, among other things, the electric grid to instantly detect surges and outages so that repair crews can be immediately deployed to where they are needed; industrial processes to create more efficiencies within factories and notify maintenance crews before a machine fails; or biometric data to alert doctors when a patient's diagnostic readings are approaching critical levels so that action can be taken before larger issues develop.[13]

15. All these new 5G applications will dramatically accelerate the increase in capacity demands on the wireless network. As I describe in more detail below, New T-Mobile, using the combination of the complementary spectrum and network assets of T-Mobile and Sprint will unlock the potential in both the existing and future use cases envisioned for 5G and provide the capacity needed to carry the oncoming wave of data consumption and user engagement that will

[12] *See* McKinsey & Company, McKinsey Global Institute. *The Internet of Things: Mapping the Value Beyond the Hype* (June 2015). Available at: https://goo.gl/HtAZRF.

[13] *Id*.

be unleashed. T-Mobile alone, given its network assets and capacity, will not otherwise be able to keep up with the explosive growth in new use cases and associated data requirements.

V. ON A STANDALONE BASIS, T-MOBILE CANNOT BUILD A COMPARABLE 5G NETWORK TO NEW T-MOBILE

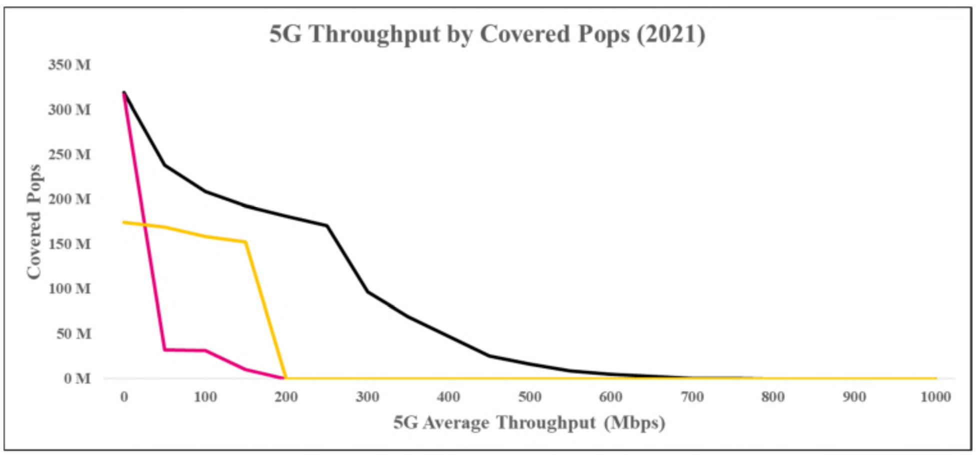
16. We are building 5G in 30 markets in 2018 and preparing for the launch of a 5G network in 2019 to remain competitive with other wireless providers in the United States. As a precursor to offering 5G service, we are installing 600 MHz equipment at our cell sites that is upgradeable to 5G. On average, we have procured licenses for over 30 megahertz of 600 MHz spectrum nationwide (some markets have even more 600 MHz spectrum licensed to T-Mobile; some have slightly less). In the past year and a half, we have been aggressively deploying these new spectrum holdings to supplement our coverage for the LTE network. However, we have reserved [redacted] megahertz of 600 MHz spectrum (more in some markets, depending on the amount of available spectrum in the particular market) for future 5G services. Additionally, we will use up to [redacted] megahertz of millimeter wave spectrum licensed in a number of key major markets (and in one market up to 850 megahertz) to supplement the 600 MHz spectrum for 5G operations.

17. We have publicly announced that we will commence building the T-Mobile 5G network in 30 cities, including New York, Los Angeles, Dallas, and Las Vegas, during 2018. Because 5G-capable devices are not yet available, we do not anticipate offering 5G mobile services until sometime in the first half of 2019. This network build will include approximately [redacted] cell sites and will provide an average throughput of 25 Mbps,[14] a peak throughput of 900 Mbps, and maximum offered traffic of [redacted] per month by 2021. These numbers will

[14] Average data rate is not equivalent to the actual user experience. The user experience will be affected by a number of variable factors, including received signal strength, location of the mobile device and base station, and whether the device is in motion, among others.

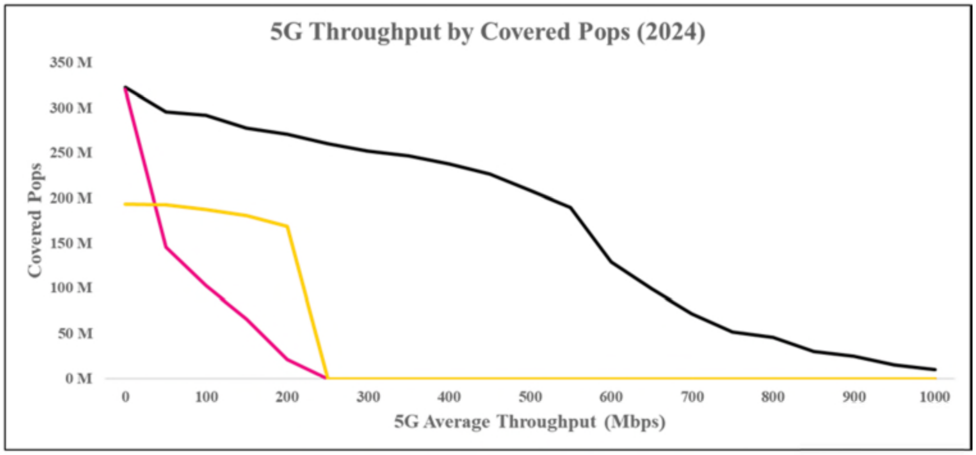
increase to [redacted] 5G sites, an average throughput of 76 Mbps, a peak throughput of 2700 Mbps, and maximum offered traffic of [redacted] per month in 2024.

18. On a standalone basis, we will deploy a nationwide 5G network, but will lack the bandwidth to deliver upon the full data rate and capacity gains possible for 5G. Our lack of access to significant amounts of available mid-band spectrum that is not encumbered with LTE subscribers (as well as a lack of large amounts of high-band spectrum nationally) will significantly limit our ability to provide a nationwide 5G system that can handle the most demanding high capacity 5G applications. This is depicted graphically in the figures below:



2021	T-Mobile	Sprint	New T-Mobile
Pops with > 100 Mbps	31.5 M	159.3 M	208.8 M
Pops with > 150 Mbps	10.8 M	153.1 M	193.4 M
Pops with > 300 Mbps			96.5 M
Pops with > 500 Mbps			16.2 M

Figure 3: 5G Speed vs. Covered Population Distribution



2024	T-Mobile	Sprint	New T-Mobile
Pops with > 100 Mbps	102.8 M	187.8 M	292.3 M
Pops with > 150 Mbps	66.6 M	181.4 M	278.1 M
Pops with > 300 Mbps			252.4 M
Pops with > 500 Mbps			208.7 M

Figure 4: 5G Speed vs. Covered Population Distribution

19. Based on the output of our engineering modeling,[15] by 2021 only 31.5 million covered POPs on the T-Mobile standalone 5G network will receive average data rates above 100 Mbps, only 10.8 million covered POPs will receive average data rates above 150 Mbps, and no covered POPs will receive average data rates above 300 Mbps. In contrast, New T-Mobile's 5G network will deliver average data rates above 100 Mbps to 208.8 million covered POPs, average data rates above 150 Mbps to 193.4 million covered POPs, average data rates above 300 Mbps to 96.5 million covered POPs, and average data rates above 500 Mbps to 16.2 million covered POPs.

20. The differences between the networks will continue in 2024. 102.8 million covered POPs on the T-Mobile standalone 5G network will receive average data rates above 100 Mbps, only 66.6 million covered POPs will receive average data rates above 150 Mbps, and there still will not be any covered POPs receiving data rates above 300 Mbps. In contrast, New T-Mobile's 5G network will deliver average data rates above 100 Mbps to 292.3 million covered

[15] The modeling is discussed in paragraph 25 below in more detail.

POPs, average data rates above 150 Mbps to 278.1 million covered POPs, average data rates above 300 Mbps to 252.4 million covered POPs, and average data rates above 500 Mbps to 208.7 million covered POPs.

VI. THE TRANSACTION WILL ALLOW NEW T-MOBILE TO DEPLOY NATIONWIDE 5G SERVICES FASTER AND WITH LESS COST, WHILE SIMULTANEOUSLY ENHANCING LTE SERVICES

21. As discussed above, 5G represents a major advance for the wireless industry in terms of performance, efficiency, service flexibility, and latency. The increased performance that 5G offers in terms of average and peak throughput, capacity, and latency will directly translate to a superior end-user experience meaning more value for consumers' money. In light of consumers' ever increasing data usage and the 5G economy emerging quickly, to compete in broadband services, a deep and broad 5G network is imperative in this highly competitive environment. Therefore, it is unsurprising that the two largest wireless providers (AT&T and Verizon) have vigorously asserted that they will lead in the development and deployment of 5G services.

22. For a successful 5G network, the key pillars are access to spectrum, cell sites, and spectral efficiency. When combined together, these three factors deliver the capacity needed to deliver the throughput and services that consumers expect from their wireless service. As new technologies like 5G are introduced, T-Mobile must continue to provide our existing customers using LTE with the same or better quality of service they are accustomed to, while simultaneously setting aside spectrum resources to allow for the development of new technology. The merger will give New T-Mobile the spectrum and infrastructure resources to expedite its deployment of a superior 5G network than either company could do on a standalone basis, while improving the existing service quality for T-Mobile and Sprint customers.

23. Driving the benefits of the merger is the ability to enhance the network capacity available to existing T-Mobile and Sprint customers. The combination of the two companies does not simply double the network capabilities, but instead provides a multiplicative effect for the overall capacity of the New T-Mobile network. A basic formula for determining wireless network capacity is:

$$\textit{Number of cell sites} \times \textit{Spectrum (MHz)Deployed Per Site} \times \textit{Spectral Efficiency} = \textit{Capacity}$$

24. Unpacking these variables, if we are able to: (1) access more cell sites, (2) utilize more spectrum across those sites, and (3) achieve higher spectral efficiencies from faster refarming of spectrum from LTE to 5G, the overall capacity of the new network will improve extensively. As described in detail below, combining T-Mobile and Sprint and anchoring upon the T-Mobile cell site infrastructure will allow New T-Mobile to employ more sites faster than either company could on a standalone basis. Additionally, New T-Mobile will have low-, mid-, and high-band spectrum resources to apply to each cell site as needed, increasing the amount of spectrum deployed per site dramatically. Finally, the transaction will enable much faster deployment of 5G over more spectrum—5G has substantially better spectral efficiency as compared to LTE. In sum, New T-Mobile will have the depth and breadth of network to deliver incredible amounts of capacity to consumers that could not be matched by the standalone companies.

25. In the ordinary course, we utilize an engineering model that predicts when our network may face congestion (relying upon busy hour calculations that occur when the network load is the highest). When congestion is predicted, we evaluate all potential methods to resolve it, including adding more cell sites to enable greater spectrum reuse to increase capacity,

supplying additional spectrum resources, or improving spectral efficiency. With the combination of T-Mobile and Sprint, New T-Mobile will have more resources at its disposal and more flexibility to use the best method available for reducing congestion and providing additional capacity where it is needed. I discuss each of these factors in detail below.

A. The Merger Will Lead to Immediate Availability of Additional Cell Sites for New T-Mobile

26. A primary challenge to deploying a wireless network is obtaining access to sufficient cell site locations to deploy spectrum resources in the most effective and complete manner. Below, I discuss the process for adding new cell sites and the benefits that New T-Mobile will enjoy by being able to effectively start using retained Sprint sites in addition to T-Mobile's anchor sites to augment capacity for the combined company.

27. On a standalone basis, we (as well as other wireless providers) rely heavily upon independent tower companies such as American Tower and Crown Castle for tower space. Tower companies will either commission a tower for an individual lessee or will build infrastructure with sufficient space for multiple tenants. The wireless company enters into a lease agreement with the tower companies for space and power infrastructure, but the individual wireless providers are responsible for providing the relevant radio equipment, power supply (in some instances), and backhaul.

28. Each of these individual components has varying associated costs. Cell site space leases generally require payments per square inch of leased space on a site. We will also generally enter into lease agreements with backhaul providers that are based on the volume of traffic transported from the cell site. As the data traffic from a particular site will vary by cell site and by market, these backhaul contracts are optimized accordingly. Moreover, there are generally discounts provided as part of backhaul leases based on volume (discounts for greater

traffic). Similarly, the radio equipment that we must self-provision has costs, and minimizing the number of radios to support the wireless communications traffic is desirable to the extent possible, as the radio access network ("RAN") accounts for approximately 80 percent of the total network costs. By combining spectrum resources into contiguous blocks that can be managed by a single radio (instead of multiple radios), costs for radio equipment are reduced.

29. In addition to the costs associated with the various leases to support individual cell sites, there are also substantial logistical barriers to cell site access. If T-Mobile requires a cell site in a particular location, but no tower companies have an existing structure or space on an existing tower, there will be a need for new construction. New construction requires a number of time-consuming and costly steps. Initially, obtaining local zoning approvals can take as long as 18 months for a new cell site. And, as part of that process, there are costs associated with obtaining the new tower permits that are typically borne by T-Mobile. Finally, there will be a need to confirm the availability of backhaul for the site and, in some cases, the need to bring new backhaul (fiber or Ethernet) to the site, which can also cause delays and add costs.

30. These cell site challenges are mitigated by the transaction as it will allow the combined company to immediately engage in "cell splits" to densify the network infrastructure and reuse spectrum more intensely. A cell split replaces a single cell site with multiple cell sites in the same coverage footprint. The effect is to multiply the capacity available to the network (if the same amount of spectrum is used in each new cell site as on the original single cell) by the number of new cell sites. However, in the New T-Mobile context, not only will there be multiple new cell sites in a coverage area, each of those cell sites as well as T-Mobile's anchor sites will also have additional spectrum resources deployed on them, further multiplying the capacity gains for the network. Importantly, New T-Mobile, in spite of adding density to its network, will also

create significant cost-saving synergies related to on-site expenses in comparison to the combined site spend of T-Mobile and Sprint in the standalone world.

31. Normally, a wireless provider seeking a cell split would need to work with a tower company to obtain access to a new site. However, New T-Mobile will implement cell splitting by anchoring on the existing T-Mobile cell site infrastructure and augmenting the density of deployed cell sites by retaining approximately 11,000 cell sites from Sprint (the retained cell sites will be selected to optimize coverage and capacity for the New T-Mobile network). In many instances, this will obviate the need to work with the tower companies for new site leases. So long as New T-Mobile can replace existing antennas and radio equipment at existing T-Mobile and Sprint cell sites with new equipment (in most cases, improved equipment that can handle more spectrum bands and more capacity) without increasing the amount of physical space or mass (weight of the equipment) used at a site, it may only incur limited new lease payments and may be able to avoid new zoning approvals. The ability to nearly immediately create cell splits in this fashion, in many cases without incurring substantial new costs or delays, will allow New T-Mobile to more rapidly deploy a wider and deeper network while simultaneously reducing the cost of adding incremental capacity.

32. In light of the challenges in obtaining new cell sites, cell splitting in this fashion would be infeasible without the transaction. To match the modeled throughput performance of New T-Mobile, our standalone network would require as many as approximately 162,400 cell splits by 2024. At the end of 2017, we only had slightly more than 61,000 macro cell sites, so matching the available capacity of New T-Mobile would require more than double the existing number of macro cell sites in the next several years. From an operational perspective, it would be impossible to obtain this many site leases and/or construct any needed new sites in this short

period of time. Moreover, even if it were feasible, the costs associated with such an effort would be economically unviable. Deploying more than double the number of macro cell sites would also more than double the operational expenditures needed to support the network along with substantial increases in the costs to provide backhaul from these sites. The capital expenditures to enter into this many new tower leases or payments to construct new sites would also be impractical.

B. The Spectrum Depth of the Combined Company Allows More Spectrum To Be Deployed Per Cell Site

33. New T-Mobile will be able to leverage Sprint's and T-Mobile's complementary spectrum and sites to provide immediate enhanced LTE benefits, while deploying and transitioning to a 5G network. Deploying a robust 5G experience requires spectrum across multiple frequency bands and the infrastructure to support such spectrum use. Sprint's and T-Mobile's combined spectrum assets span the low-, mid-, and high-bands. Combining their existing infrastructure will enable New T-Mobile to deploy denser and more capable enhanced LTE and 5G networks than either company could on a standalone basis.

34. While we are rolling out a 5G network supported by spectrum in the 600 MHz and limited millimeter wave bands, including the Sprint spectrum and infrastructure assets will allow New T-Mobile to more rapidly create a truly nationwide 5G network that will have the depth and breadth to help the U.S. lead the world and continue its success as an innovation pool for start-ups and other businesses in the coming 5G era. As discussed above, our 5G network build is focused on the 600 MHz spectrum band, supplemented by limited spectrum holdings in the millimeter wave bands (covering 100 million people in most major metropolitan areas). New T-Mobile will build upon this T-Mobile plan, by adding the 2.5 GHz spectrum (and other mid-

band spectrum as available as it is refarmed from LTE) held by Sprint, along with additional cell sites that will be retained and used for the New T-Mobile network.

35. The ability of New T-Mobile to more quickly deliver a deeper 5G network and user experience than standalone T-Mobile is driven in part by the complementary spectrum assets of T-Mobile and Sprint. A full range of spectrum for 5G is important to guarantee a robust 5G network. Low-band spectrum (below 1 GHz) allows for broader coverage, both in-building and in rural areas. Spectrum below 1 GHz can support cell site operating radii of up to 18 miles, allowing for broad coverage without the need for as much capital expenditure, especially in rural markets.

36. Mid-band spectrum (from 1 to 6 GHz) provides high capacity with some reduction in coverage capabilities as compared to sub-1 GHz spectrum bands. Because there is more spectrum in the mid band, there is more capacity that can be delivered from a single cell site, and it is well-suited for urban and suburban markets where consumer demand for more capacity is highest. Because the propagation in the mid-band is more limited (operating radii of approximately up to 4 miles around cell sites) the band is not optimized for rural area coverage, as it requires more capital expenditures to cover those geographies.

37. High-band spectrum (above 20 GHz) is best utilized in dense urban markets where there are extreme capacity demands, need for low latency, and surging use of high-speed data applications. High-band spectrum cell operating radii are significantly less than one-half of one mile, making use of this spectrum only economical in very densely populated areas. The positive attributes of high-band spectrum are that it has large bandwidths available, enables the use of very small antennas, and can be readily reused within a market area. These features

enable high-band spectrum to deliver much higher data rates and lower latency than mid-band or low-band spectrum.

38. New T-Mobile will leverage the variety of spectrum at its disposal to deploy greater quantities (more spectrum per cell site) more densely (to more cell sites throughout the network). While standalone T-Mobile will have similar coverage, New T-Mobile will be able to deploy a capacity layer of 2.5 GHz spectrum to provide much higher 5G data rates to consumers. Moreover, the combined company will be able to deploy more spectrum in more cell sites, providing a much more consistent signal strength throughout the coverage area than T-Mobile could on a standalone basis. Signal strength is one of the best approximations of the actual user experience—the stronger and more consistent the signal strength, the more likely the consumer will have a steady and robust data and voice connection. For this reason, signal strength is directly related to the actual data rates delivered to a customer.

39. This ability to provide a more consistent signal translates to greater 5G coverage reliability for New T-Mobile. As can be seen in the table below, New T-Mobile will greatly improve the coverage footprint for Sprint overall (nearly 145 million more covered POPs in 2021; 130 million more in 2024),[16] as well as for Sprint's PCS and 2.5 GHz coverage (66.2 million more covered POPs in 2021; 88.2 million more in 2024). Moreover, nearly 2 million more POPs will be covered by New T-Mobile than standalone T-Mobile in 2021, and 1.1 million more in 2024.

[16] Because the low-band coverage overlaps the mid-band coverage, the 145 million difference in covered POPs is calculated as the difference of New T-Mobile's total covered POPs in 2021 (319.6 million) minus Sprint's total covered POPs in 2021 (174.7 million). Similarly, the 130 million difference in covered POPs in 2024 is the difference between New T-Mobile 600 MHz coverage and Sprint's total covered POPs.

		T-Mobile	Sprint	New T-Mobile
	Network Coverage Footprint	Covered Pops (Millions)	Covered Pops (Millions)	Covered Pops (Millions)
Year 2021	Mid-band (PCS & 2.5GHz)	74.6 (77% uncovered)	174.7 (47% uncovered)	240.9 (26% uncovered)
	Low-band (600)	317.9 (2.9% uncovered)	0 (100% uncovered)	319.6 (2.4% uncovered)
Year 2024	Mid-band (PCS & 2.5GHz)	173.2 (47% uncovered)	194.0 (41% uncovered)	282.2 (14% uncovered)
	Low-band (600)	323.0 (1.4% uncovered)	0 (100% uncovered)	324.1 (1.0% uncovered)

Table 1: 5G Coverage Comparisons

40. Without access to the 2.5 GHz spectrum provided by the transaction, we would be forced to redeploy our PCS and AWS spectrum from existing LTE services to 5G—further constraining our LTE capacity and bandwidth during the critical transitional period from 4G to 5G. Repurposing existing spectrum away from LTE and other legacy services is very difficult and requires careful coordination, which can be greatly helped if the operator has a broad and deep spectrum portfolio. Refarming of spectrum resources is accomplished by repurposing frequency assets that have historically been allocated to a preceding technology (*e.g.*, LTE) to accommodate a new technology (*e.g.*, 5G). Refarming depends upon two critical factors: (1) new technology device penetration levels and (2) service continuity (the need to continue to support existing customers with legacy devices). Based on past experiences with device penetration, we have estimated that New T-Mobile will be able to drive 5G capable device penetration rates up by 10 percent, year over year (*e.g.*, if standalone T-Mobile would have 50 percent of customers with 5G devices, New T-Mobile would have 55 percent). This more rapid transition to new 5G devices will enable New T-Mobile to refarm more spectrum from LTE to

5G in a much more expeditious fashion. Moreover, this will leave much fewer New T-Mobile customers on the LTE network—easing LTE demand and ensuring that the user experience for remaining LTE customers will not suffer during the 5G spectrum refarming process. The refarming process is depicted in the figure below.

[redacted]

Table 2: Spectrum Holdings and Refarming Plan

41. Absent the merger, we would begin to migrate some of our PCS spectrum in 2021 to 5G, while maintaining [redacted] of our AWS and the remaining PCS spectrum to support existing LTE services. This would deliver only shared portions of [redacted] of mid-band spectrum for 5G by 2021, and we would not be able to increase that amount of spectrum until 2023. Similarly, we would only be dedicating [redacted] of 600 MHz spectrum in 2020 and some of our AWS spectrum in 2021 for 5G services and would not be able to increase that

amount until 2024 at the earliest. In sum, on a standalone basis, we would have only [redacted] of spectrum dedicated to 5G and [redacted] of spectrum split between LTE and 5G in 2021, and only [redacted] of spectrum dedicated to 5G and [redacted] of spectrum split between LTE and 5G by 2024, and limited amounts of millimeter wave spectrum in select markets.[17]

42. In contrast, by 2021, New T-Mobile will have [redacted] of mid-band 2.5 GHz spectrum and [redacted] of 600 MHz spectrum dedicated for 5G services, and [redacted] of AWS and PCS spectrum split between LTE and 5G. Moreover, by 2024, the combined company will have [redacted] of mid-band spectrum and [redacted] of low-band spectrum dedicated for 5G services and [redacted] of AWS spectrum split between LTE and 5G. In total, New T-Mobile will have [redacted] dedicated for 5G in 2021 and [redacted] dedicated for 5G in 2024. In short, New T-Mobile's broader spectrum portfolio will allow it to devote substantial spectrum resources to 5G immediately while also enhancing the coverage and capabilities of the existing LTE network, as discussed in Section E below in more detail.

C. Expedited Deployment of 5G Will Deliver Spectral Efficiency Gains

43. The ability to rapidly migrate consumers from LTE to 5G provides immediate efficiency benefits because 5G has much better spectral efficiency. An increase in spectral efficiency translates to a proportional increase in the number of users supported at the same load per user—or, for the same number of users, an increase in throughput available to each user. 5G delivers spectral efficiency improvements due to four main factors: (1) lean carrier design; (2)

[17] Spectrum that is split between LTE and PCS means that in some markets, the spectrum is used for LTE services and in some markets it is used for 5G.

high bandwidth utilization; (3) improved massive MIMO and beamforming; and (4) inter-cell coordination.

44. ***Lean Carrier Design.*** The 5G New Radio ("NR") standard is designed to operate with lower control signaling overhead, which translates to increased mobile system capacity. Lean carrier design also translates into energy efficiency as control signals are only transmitted when needed. In 5G NR, the control signaling has a duty cycle that is designed to be 100 times lower than LTE.[18] This reduced control signal overhead frees up more capacity to carry customer traffic and reduces inter-cell interference to neighboring cells, which increases the overall system capacity.

45. ***High Bandwidth Utilization.*** The LTE radio standard requires a static 90 percent occupied bandwidth utilization requirement. This means that if there is a 30 megahertz LTE radio channel, only 27 megahertz can be used for radio communications. In contrast, the 5G NR standard does not have a static 90 percent bandwidth utilization requirement. This enables 5G NR to deliver more capacity in the same bandwidth as compared to LTE. For 5G NR channel bandwidths greater than or equal to 20 megahertz, the bandwidth utilization can vary between 95 and 98 percent depending on the carrier bandwidth and subcarrier spacing.[19] Therefore, that same 30 megahertz channel would not have a full 3 megahertz reserved for a guard band, but instead would have only 0.6 to 1.5 megahertz of spectrum reserved for guard bands. For larger blocks of contiguous spectrum beyond 20 megahertz,[20] these spectrum blocks will typically be able to have even higher bandwidth utilization because the guard band represents a smaller percentage of the overall carrier bandwidth.

[18] Control signaling duty cycle in 5G NR will be as low as 0.5% versus 50% for LTE.

[19] *See* 3GPP TS 38.101-1 (which dictates the bandwidth utilization requirement for 5G NR).

[20] Spectrum blocks smaller than 20 megahertz with the same subcarrier spacing as LTE have bandwidth utilization rates of 90 to 95 percent.

46. Additionally, larger contiguous spectrum blocks will allow for gains in statistical multiplexing. As the size of a radio channel increases, the available routes for communication traffic to flow increases more than proportionally due to the uneven nature of the traffic load. The Commission has previously found that a single 20 x 20 megahertz LTE carrier can carry 20 percent more traffic due to this factor than could two 10 x 10 megahertz carriers.[21] Depending on the type of data traffic and the system load, the overall trunking efficiency gain can vary between 7 and 40 percent.[22]

47. ***Massive MIMO ("mMIMO") and Beamforming.*** mMIMO technology uses a larger number of elements (greater than or equal to 16) to focus and direct radio wave energy using beamforming to a given user, delivering faster speeds and higher capacity.[23] MIMO combined with beamforming techniques allow the radio energy to be focused where needed as a user moves and therefore reduce the interference within the system—leading to gains in capacity and network efficiency. For frequencies below 6 GHz, MIMO will help to improve spectral efficiencies. However, for spectrum bands above 6 GHz, MIMO and beamforming are required or mobile communications will not be achievable. When applied to high-band spectrum (like millimeter wave spectrum bands), mMIMO and beamforming will boost the coverage and reduce inter-site interference, which will lead to better performance and higher capacity. Implementation of mMIMO in the 5G NR standard improves upon MIMO technologies in LTE in several ways. First, improved feedback via Channel State Information (CSI) in 5G NR

[21] *See* The Broadband Availability Gap: OBI Technical Paper, Chapter 4 at 73 (rel. April 2010), https://transition.fcc.gov/national-broadband-plan/broadband-availability-gap-paper.pdf.

[22] Impact of Spectrum Aggregation Technology and Frequency on Cellular Network Performance, IEEE Dyspan, 2015.

[23] Beamforming is a signal processing technique that allows the radio signal to be directed between two points. Beamforming is used both at the transmitting and receiving ends of the communication path and helps improve the robustness of the radio signal.

translates into improved interference measurements with better link adaptation. This enables higher multiuser MIMO system gains. Next, mMIMO as standardized in 5G NR also has an optimized MIMO codebook. This change enables the support of a larger number of antenna elements, which creates improvement in system capacity due to reduced inter-cell interference and more focused beamforming.

48. ***Inter-Cell Coordination.*** Inter-cell coordination allows for coordination of cell edge signal transmissions to reduce interference within the network. This in turn provides improvements in coverage, cell edge throughput, and spectral efficiency. The 5G NR standard is designed as a beam-based technology, which makes it better suited to utilize cell edge coordination. Inter-cell coordination will capitalize on the native spatial domain system platform of 5G NR that provides improvements in system performance much greater than can be achieved with LTE.

49. Each of these improvements contributes to the significant spectral efficiency improvements shown in the table below for 5G. Greater efficiency gains will be provided in the high-band spectrum because this spectrum has smaller wavelengths. Smaller wavelengths mean that antennas that are optimized for that frequency can be smaller—meaning that more antenna elements can be placed in a given area or form factor. More antennas will typically improve coverage and capacity in the network.

Average Spectral Efficiency (bps/Cell)				Percentage Increase
Spectrum	**Antennas**	**LTE**	**5G**	
Low band	4x2 MIMO	2.1	2.5	19%
Mid band	4x4 MIMO	2.5	3.8	52%
mmWave	mMIMO	N/A	7	N/A

Table 3: Spectral Efficiency Comparison[24]

50. As can be seen, low-band spectrum will achieve a 19 percent improvement in average spectral efficiency (2.1 bps/Hz to 2.5 bps/Hz) and mid-band spectrum will achieve a 52 percent improvement in average spectral efficiency (2.5 bps/Hz to 3.8 bps/Hz) moving from LTE to 5G. New T-Mobile's ability to rapidly migrate spectrum and users to 5G will allow it to capitalize on these significant improvements in spectral efficiency.

D. The Combined Company Will Provide Unmatched 5G Data Rates and Capacity Faster and on a Much Wider and Deeper Basis

51. When multiplying the effects of the benefits contributed by the increased number of cell sites, the amount of low-band and mid-band spectrum available per cell site, and the spectral efficiency gains, the performance benefits of this combination are dramatic. My technical team has performed extensive technical throughput modeling of the standalone and combined networks and these models project, based on our ordinary course traffic modeling, that the New T-Mobile 5G network will be substantially faster than either standalone network. The figure below summarizes the comparison between New T-Mobile and the standalone 5G networks by 2024.

[24] The spectral efficiency improvements are derived from equipment vendor simulations, internal T-Mobile analysis, and ITU requirements.

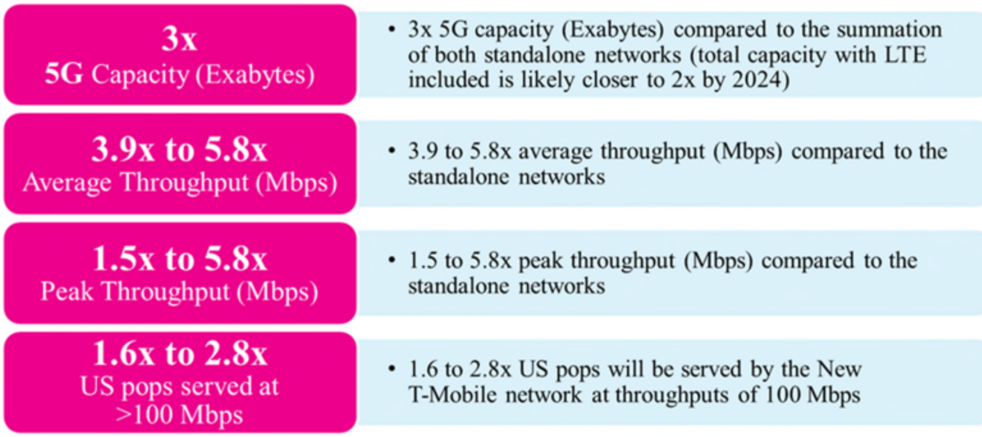


Figure 5: New T-Mobile Network Comparison to Standalones (2024)

52. By combining the spectrum resources of T-Mobile and Sprint, New T-Mobile will be uniquely positioned to roll out a 5G network that can provide both coverage and capacity throughout the country, including in rural markets. New T-Mobile will be able to deploy a multi-faceted 5G network that provides the full array of features and improvements envisioned by the new 5G standard throughout the country in terms of improved data rates, capacity, latency, and device density that will meet the consumer demand for new 5G services.

53. As the tables below demonstrate, the dramatic improvements in average and peak data rates for New T-Mobile as compared to the standalone networks will drive substantial benefits to subscribers. New T-Mobile will be able to deliver data rates that will compete with wired connections and greatly exceed current wireless data rates. These improvements will allow the combined company to enable the wide variety of new 5G applications and use cases described above in Section III.C.2.

Entity	Average 5G Data Rates (Mbps)	Peak 5G Data Rates (Mbps)
T-Mobile	25	900
Sprint	55	300
New T-Mobile	149	1500

Table 4: Average and Peak Data Rate Comparisons (Year 2021)

Entity	Average 5G Data Rates (Mbps)	Peak 5G Data Rates (Mbps)
T-Mobile	76	2700
Sprint	113	700
New T-Mobile	444	4100

Table 5: Average and Peak Data Rate Comparisons (Year 2024)

54. In a similar manner, the overall capacity on New T-Mobile's 5G network will greatly exceed the combined capacity of the two standalone companies. As noted above in more detail, these capacity gains are driven by the greater number of cell sites, more available spectrum, and improvement in spectral efficiency that are not achievable for T-Mobile and Sprint on their own. While the offered capacity numbers for the combined network have been developed using a robust set of assumptions and associated calculations, we also know that the offered capacity of the network today is materially greater than what is consumed by our customers. The reasons for this difference include:

- **Advance Planning –** Network capacity is created in advance of future demand materializing, with the typical planning assuming being 18 months ahead of demand;
- **Traffic Distribution** - Traffic not manifesting itself uniformly relative to the deployed resources, resulting in some sites being more loaded than others;
- **Non-uniform Capacity –** Supply not always sized up to meet the demand – in lightly loaded sites or sites built for coverage, all spectrum that the radio access hardware supports is deployed regardless of the actual demand;

- **Increments of Deployed Radio and Spectrum Ahead of Consumption –** this translates to speed benefits until the capacity is consumed and speeds drop;
- **Coverage –** Some sites built for coverage and have only sporadic demand;
- **Stochastic and Random Nature of Traffic –** temporal changes in traffic patterns result in need to over-index supplied capacity in some cases; and
- **Busy Hour Effect –** Need to dimension for the busy hour of the network, resulting in lower capacity utilization during non-busy hours.

55. For the years of 2016 and 2017, our network carried traffic is [redacted] percent of the offered traffic and is [redacted] percent for standalone Sprint.[25] While we believe that we will be able to deliver greater efficiency in the 5G network, we have made a conservative assumption that the efficiency of today's network will be the same in future years. This is conservative for several reasons:

- **Topology –** New T-Mobile will continue to improve precision in how it deploys cell sites and the overall network alignment with customer generated traffic;
- **User-behavior** - we believe that higher bandwidth applications such as 4K video will be heavily consumed in lower mobility environments. (Mobility based consumption is less efficient than static consumption because of error correction overhead necessary to support mobility);
- **5G Technology –** we believe that enhanced 5G network functionality, such as beamforming, will provide more precise delivery of required traffic and thereby enhance efficiency; and
- **New Use Cases –** increasing the monthly consumption per user.

56. The unpredictability of wireless data traffic provides further reason that the ratio of carried to offered traffic is likely to be higher in the New T-Mobile network relative to the stand-alone networks. Averaging stochastic demand over the combined usage of Sprint and T-Mobile subscribers rather than over each user base individually has the effect of smoothing out the distribution of traffic and thereby increasing the "effective" capacity of the network.

[25] Saw Decl. at ¶7.

57. The tables below demonstrate the estimated gains in available capacity (both offered and carried):

Entity	2021 5G Monthly Capacity (Exabytes)	2024 5G Monthly Capacity (Exabytes)
T-Mobile	[redacted]	[redacted]
Sprint	[redacted]	[redacted]
New T-Mobile	6.8	20.3

Table 6: 5G Monthly Offered Capacity (in addition to LTE)

Entity	2021 5G Monthly Carried Capacity (Exabytes)	2024 5G Monthly Carried Capacity (Exabytes)
T-Mobile	[redacted]	[redacted]
Sprint	[redacted]	[redacted]
New T-Mobile	[redacted]	[redacted]

Table 7: 5G Monthly Carried Capacity Per Month (in addition to LTE)

Entity	2021 LTE Available Capacity (Exabytes)	2024 LTE Available Capacity (Exabytes)
T-Mobile	[redacted]	[redacted]
Sprint	[redacted]	[redacted]
New T-Mobile	[redacted]	[redacted]

Table 8: LTE Available Capacity Per Month

Entity	2021 LTE Carried Capacity (Exabytes)	2024 LTE Carried Capacity (Exabytes)
T-Mobile	[redacted]	[redacted]
Sprint	[redacted]	[redacted]
New T-Mobile	[redacted]	[redacted]

Table 9: LTE Monthly Carried Capacity Per Month

58. To derive the carried capacity, we applied the [redacted] percent factor to the offered capacity values we have calculated for T-Mobile and New T-Mobile. This factor for Sprint is [redacted] percent based on calculated values from 2016 and 2017. New T-Mobile will deliver more than twice the carried 5G capacity of T-Mobile and Sprint in 2021 ([redacted] exabytes versus [redacted] exabytes for the combined standalone companies) and more than three times the carried 5G capacity by 2024 ([redacted] exabytes versus [redacted] exabytes).

59. Finally, New T-Mobile will produce much more densified LTE and 5G cell site networks that will provide greater service benefits to consumers. The table below highlights the sites deployed by the standalone entities as well as the broader infrastructure that will be possible with New T-Mobile.

[redacted]

Table 10: 5G Site and Spectrum Comparison (Year 2021-2024)

60. This increased site density for New T-Mobile will provide a more consistent signal strength throughout the 5G network and a more consistent user experience, as discussed in detail in Section VI .B above.

E. The Transaction Will Maintain Existing LTE Services Even as 5G Services Are Deployed

61. Importantly, the existing LTE network will also be maintained during the transition to 5G. To deploy a 5G network, New T-Mobile will be required to balance the existing spectrum and infrastructure resources necessary to maintain the LTE network for existing subscribers with the need for the same spectrum assets for 5G. Specifically, the combined company will need to optimize the use of the existing LTE spectrum resources (AWS, PCS, 600 MHz, 700 MHz, and 800 MHz) to provide enhanced LTE. As part of the transition

process to 5G, Sprint's 2.5 GHz LTE subscribers will be moved to New T-Mobile's AWS spectrum rapidly, which will free up the 2.5 GHz spectrum for 5G more quickly.

62. Our network modeling projections demonstrate that there will be no negative effects on LTE performance throughput during the refarming process to 5G. At the same time, the Sprint and T-Mobile PCS and AWS spectrum will provide a dense LTE layer in combination with the Sprint 800 MHz and 2.5 GHz and T-Mobile 600 and 700 MHz spectrum assets and allow for 5G to be deployed without degrading the LTE experience. New T-Mobile's enhanced LTE network would be able to maintain LTE average data rates without any network congestion and without a need for any additional costs for cell splits. In contrast, both standalone companies would have high levels of congestion absent additional cell splits or other network investments. In addition, there will be no increase in LTE congestion during the 5G refarming process. For a mature LTE network, congestion levels of 2 percent are regarded as the threshold for triggering investments to mitigate negative customer experiences. New T-Mobile will not approach this level of congestion for the LTE network.

VII. RAPID CUSTOMER MIGRATION WILL RESULT IN NUMEROUS CONSUMER BENEFITS.

63. We plan an aggressive technology migration program for the combined company that will allow for a smooth and rapid expansion of capacity and enable customers to quickly experience the benefits of the transaction. Importantly, New T-Mobile will not be integrating the T-Mobile and Sprint networks; the combination will be accomplished through a network and customer migration. This migration plan involves: (1) accommodating Sprint's existing LTE customers on the existing T-Mobile network as rapidly as possible after closing and (2) utilizing the freed up spectrum resources for 5G as soon as practical thereafter.

64. Sprint customers who (1) have handsets compatible with T-Mobile's network (nearly 20 million devices or half of the branded customer base) or (2) upgrade to T-Mobile-compatible handsets will gain access to New T-Mobile's nationwide network, improved coverage quality, higher performing devices,[26] access to LTE VoLTE capabilities,[27] and a broader choice of handsets. Importantly, improved coverage quality will be enabled for existing Sprint customers as they migrate to the combined network because T-Mobile's network is broader and denser in terms of macro cell sites relative to the Sprint network. The coverage quality benefit of the retained Sprint capacity sites is additive and will further improve coverage satisfaction for both T-Mobile and migrating Sprint customers simultaneously.

65. We have engaged in extensive traffic modeling using our regular course traffic model and determined that during the transition, Sprint customers can be supported on the New T-Mobile network. The ability to support these customers will be enhanced through the use of Sprint macro cells retained by New T-Mobile for the purpose of providing capacity relief. New T-Mobile will aggressively migrate Sprint customers onto the existing T-Mobile network to improve the LTE functionality for all consumers and to increase the spectrum resources available for 5G. I expect that Sprint customers are likely to be completely migrated within three years. By undertaking this rapid migration, New T-Mobile will drive synergies to our existing LTE network and free up valuable spectrum for 5G use in a more rapid fashion than either company could accomplish on its own.

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[26] Sprint's existing voice services are provided using CDMA technology. CDMA does not allow a voice and data connection at the same time – so a Sprint customer on the CDMA network must choose between these services.

[27] While Sprint will begin deploying VoLTE in 2018, our experience is that this effort may take some time to roll out throughout the network. T-Mobile already has VoLTE available on its network and the nearly 20 million Sprint devices that are capable through a software update to use the New T-Mobile network will be able to rapidly have access to VoLTE and HD Voice capabilities.

66. Additionally, a built-in LTE feature known as Multi-Operator Core Network ("MOCN") will allow us to unify the T-Mobile and Sprint radio access networks ("RANs") almost immediately and allow Sprint existing customers with compatible devices to seamlessly access the best of both networks during integration.[28] MOCN allows for a seamless migration to a virtual single core network by routing all services to the "home" network – which in this case will be the existing T-Mobile core. As Sprint customers are migrated off of the Sprint core, we will remove this requirement and collapse to a single New T-Mobile core network.

67. MOCN works by configuring a base station to transmit more than one network identity. MOCN can be defined on a site by site basis and is highly flexible. In idle mode, the phone decides which base station it camps-on to achieve attached status. In that status, the phone can transition to active mode to communicate with the network and be paged by the network. When a phone transitions to active mode (to make a call, receive a call or communicate data) the network manages the connection performance and hand offs. When a phone scans, it scans for bands that it remembers as being "home" and looks for a signal that has its home network code broadcasted.

68. If the signal can be decoded and the mobile phone finds a home, then it camps on that cell and starts to de-code the available system information. The phone then registers on the network and enters attached status. In some rare cases, the signal cannot be decoded because it is interfered with, and the phone will start to scan other bands for valid home signals. Phones get to choose their own towers according to policy burned into the device and SIM card. If a phone finds multiple signals from multiple sites and finds that they are all home, then the phone selects and camps on the one with the highest signal quality. In the case where a base station is

[28] MOCN is defined in the 3GPP standards TS 23.251 and TR 22.951.

operating MOCN for Sprint, for example, Sprint phones will see a home signal at the same time that T-Mobile phones will also see home.

69. As a result, legacy Sprint subscribers with compatible devices can access the T-Mobile network. This flexibility to access both networks has the potential to benefit all customers, not just those with compatible devices. This is because when some customers migrate to the network with the higher signal quality, capacity is freed up for the network with lower signal quality.

70. Our existing subscribers should have minimal disruptions during the transition to New T-Mobile. As part of the transition process, the Sprint PCS spectrum will be used for LTE services and most existing T-Mobile devices are compatible with that spectrum band (69 million devices as of April 2018). Therefore, there is no need for a change in handsets. Additionally, New T-Mobile in the first few years after closing will continue to utilize some of its 2.5 GHz spectrum for LTE services. As of April 2018, approximately 26.6 million T-Mobile devices were compatible with the 2.5 GHz spectrum for LTE and will be able to take advantage of the existing Sprint 2.5 GHz spectrum holdings. Moreover, T-Mobile subscribers who upgrade handsets during this time will obtain devices that are also able to use the 2.5 GHz spectrum—bringing improvements to data speeds and capacity for LTE services.

71. I am confident this migration process will be successful based on our experience in migrating MetroPCS customers to the T-Mobile network. Following our transaction to acquire MetroPCS, we projected that the entire migration of approximately 9 million MetroPCS subscribers, utilizing a market-by-market transition, would be completed in 24 months. In reality, we fully completed this process within 26 months after the deal closed, and with the majority of markets completed well ahead of schedule. Further, the MetroPCS customers were

using an incompatible technology (CDMA) that required handset changes for all existing subscribers to access the T-Mobile network. Despite this, we radically expanded: (1) coverage for MetroPCS customers (and retained more MetroPCS cell sites than our original target to increase capacity); (2) retail doors; and (3) dealers. Through this process, 70 percent of MetroPCS subscribers migrated to HSPA+ or LTE within 15 months and this enabled a more accelerated refarm of the MetroPCS spectrum to LTE (from CDMA). And, importantly we utilized the MOCN technique described above to combine the two RANs on Day One without any adverse effect to MetroPCS subscribers. All these efforts allowed us to realize the synergies we estimated a year ahead of schedule and, in reality, achieve 40 percent higher synergies than planned.

72. We expect to utilize a similar approach for migrating Sprint customers. By migrating Sprint customers to the New T-Mobile network, we will provide a similar expansion in coverage for these subscribers as well as increased voice performance. The two companies both have spectrum assets in the PCS band which will greatly aid the integration of Sprint's existing customers onto our new network. A substantial portion of the Sprint customer base (approximately 20 million or nearly one-half of the branded customer base) can have their existing devices updated through over-the-air software to allow almost immediate access to the New T-Mobile network. Further, we integrated the sites retained from MetroPCS much in the same way we will do here with the retained sites from Sprint and T-Mobile, on a market-by-market basis. Finally, the success of the MetroPCS integration provides a good indication of what will occur in the New T-Mobile migration plan—the cost savings were ahead of schedule, the synergies achieved were better than expected, and the MetroPCS customer base doubled in the 4.5 year period since the transaction. As we will utilize many of the same tools and team for

the migration of the Sprint customer base, I am confident we will again deliver on the cost savings, synergies, and timing for this proposed transaction.

VIII. NEW T-MOBILE WILL ENABLE NEW AND IMPROVED BROADBAND SERVICES TO RURAL AMERICA.

73. From a network perspective, I believe that New T-Mobile will generate significantly improved and expanded services to currently unserved and underserved portions of America. The combined network, built with the 600 MHz band as the foundational coverage layer and the 2.5 GHz band as the primary capacity layer, will have the spectrum available to provide competitive broadband data rates throughout the country. In addition, the breadth of the new cell site infrastructure, with approximately 84,000 macro cell sites blanketing the country, will allow New T-Mobile to provide reliable signal strength levels to more areas than either standalone company. The data throughput improvements will be felt by underserved consumers in rural areas.

74. The improvement in rural coverage for New T-Mobile is substantial. By 2024, our network modeling indicates that New T-Mobile will provide service to 59.4 million outdoor rural POPs out of 62 million available rural POPs. New T-Mobile's network also will provide service to 31 million indoor rural POPs by 2024. New T-Mobile's increase in coverage is due largely to the enhanced signal strength that will be enabled by the combined spectrum portfolios of T-Mobile and Sprint as well as the increased cell site density of New T-Mobile.

75. By 2024, New T-Mobile will provide wireless service with download speeds of 10 Mbps or greater to 45.9 million POPs over 2 million square miles of rural America, delivering service meeting the FCC's baseline download speed for wireless broadband to 74 percent of rural POPs in the United States.

76. In addition to bringing new, quality mobile services to rural areas, the complementary spectrum assets of T-Mobile and Sprint will allow 5G deployment to deliver higher speeds and additional capacity on a wide-scale basis for fixed services. As a result, New T-Mobile will provide rural America with a true in-home, high-speed wireless alternative to existing fiber and cable offerings. By 2024, New T-Mobile will deliver fixed broadband service meeting the FCC's speed definition for broadband of 25/3 Mbps to a total of 52.2 million rural POPs over 2.4 million square miles, reaching over 84 percent of rural POPs in the country.[29]

77. These service improvements and New T-Mobile's targeted efforts to obtain new subscribers will allow the combined company to expand services more broadly into rural communities, as it will be able to spread the costs of expansion across an increased customer base. Moreover, New T-Mobile's increased scale will enable it to obtain better pricing for infrastructure and may allow more bang for the buck to purchase equipment that T-Mobile would not otherwise be able to as a standalone company

78. I have reviewed the technical statements and findings in the Public Interest Statement and agree with the methodology and conclusions reached in that document.

[29] For fixed in-home services, the subscriber will utilize a fixed access point, similar to what is used by many consumers to transmit Wi-Fi signals in their house, that will have better gain and power available than would a mobile device. Therefore, coverage to these areas will be better than would be the case for mobile services.

79. I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct. Executed on June 18, 2018.

Neville R. Ray
Executive Vice President and Chief
Technology Officer
T-Mobile US, Inc.

APPENDIX C: DECLARATION OF G. MICHAEL SIEVERT
President and Chief Operating Officer, T-Mobile US, Inc.

DECLARATION OF G. MICHAEL SIEVERT
President and Chief Operating Officer, T-Mobile US, Inc.

I. INTRODUCTION

1. My name is G. Michael Sievert and I am the President and Chief Operating Officer for T-Mobile US, Inc. I have been with T-Mobile since 2012. Together with T-Mobile's Chief Executive Officer John Legere, I was directly involved in the acquisition of MetroPCS and the development of T-Mobile's Un-carrier business plan. Prior to joining T-Mobile, I had over two decades of experience at several Fortune 500 companies and as an entrepreneur. I received a Bachelor of Science in Economics degree from the Wharton School of the University of Pennsylvania, where I graduated magna cum laude.

2. In my capacity as T-Mobile President and COO, I have been engaged in the evaluation of T-Mobile's proposed merger with Sprint Corporation, and the discussions concerning the business plans for the merged entity, New T-Mobile. I will be President and Chief Operating Officer for New T-Mobile.

3. I have reviewed the Public Interest Statement being filed with the applications for transfers of control being submitted to the FCC for approval of the license transfers attendant to the merger. In support of the Public Interest Statement, I am providing information with respect to (1) T-Mobile's disruptive DNA and its competitive position; (2) the merger synergies and plan to invest nearly $40 billion in New T-Mobile's 5G network and related capital projects; (3) plans to use the massive capacity gains, lower costs, and other synergies from the 5G Network to deliver value and capture wireless broadband market share; and (4) New T-Mobile's plans for expanded or new service offerings made possible by the merger.

II. T-MOBILE'S DISRUPTIVE DNA AND ITS COMPETITIVE POSITION

4. In recent years, T-Mobile has achieved a remarkable level of success. There have been two key contributors to our progress over the past five years. They are the launch of our disruptive and successful Un-carrier approach to customers and our merger with MetroPCS in 2013 that provided critical additional scale and resources. With the benefits of both brands, we have improved our competitive market position and gained market share. That momentum, plus T-Mobile's Un-carrier obsession with customer service, has enabled T-Mobile to charge ahead and force its competitors to lower prices and offer more benefits to customers. In doing so, T-Mobile has built its brand on the ability to identify and relieve consumer pain points in the wireless marketplace.

5. It is in T-Mobile's DNA to act disruptively in the marketplace. Our Un-carrier manifesto puts the consumer first. It is also good business as it distinguishes T-Mobile in the marketplace and attracts customers.

6. Despite our recent success, however, T-Mobile continues to face significant challenges in competing against substantially larger nationwide carriers with superior scale and spectrum advantages for 5G. In this declaration, I review the challenges facing T-Mobile due to its smaller size, subscriber share, and spectrum resources. I also discuss how the proposed transaction with Sprint helps address those issues, allowing New T-Mobile to be a more effective competitor against current market leaders and other emerging competition.

7. The transaction will allow New T-Mobile to supercharge its disruptive ways by giving the company the scale and assets to take the Un-carrier model to new levels, and to increase our ability to compete with and take customers from AT&T, Verizon, and the well-

situated media and Internet companies that T-Mobile competes with in the rapidly converging wireless broadband and content delivery industries.

8. For many years, AT&T and Verizon have dominated the mobile wireless market. Although both T-Mobile and Sprint have competed aggressively and seen success in recent years, the combined market share of AT&T and Verizon has not significantly decreased over the past five years. T-Mobile's current share of the wireless market is far less than either of Verizon or AT&T, which together hold about two thirds of the market. AT&T and Verizon service revenues are about twice those of T-Mobile. And T-Mobile's total consolidated revenues, EBITDA, net income, and cash flows remain just a fraction of those financials at the much larger AT&T or Verizon. In other words, although T-Mobile and Sprint have been aggressively attacking AT&T and Verizon for the past five years, the two leading companies of the past decade are still the two leading companies—with approximately two thirds of the market and greater than 80 percent of the EBITDA, net income, and cash flows from operations in this market.

9. Because of their greater size, AT&T and Verizon can also realize scale efficiencies that are unavailable to T-Mobile, Sprint, and any other smaller competitor. Most importantly, AT&T and Verizon Wireless have higher asset utilization measured by the number of customers supported per unit of fixed cost network (*e.g.,* cell towers). T-Mobile must instead allocate the largely fixed costs of its network over a significantly smaller subscriber base compared to AT&T or Verizon, so T-Mobile's costs-per-subscriber are substantially higher. Greater scale also provides Verizon and AT&T an increased ability to acquire diverse assets and invest in new lines of business. For example, both AT&T and Verizon have recently sought to acquire content companies and companies with valuable mmWave spectrum holdings. The latter

acquisitions provide AT&T and Verizon with a further advantage: they now hold more mmWave spectrum than any other mobile wireless provider, which amounts to a head start in the race to 5G. Armed with valuable spectrum holdings and financial and other advantages, AT&T and Verizon will be uniquely positioned to outbid T-Mobile and other competitors for new spectrum licenses with 5G applications that the FCC will eventually put to auction. AT&T and Verizon have been able to consolidate spectrum resources and, without a large and well-resourced challenger, they will remain unchecked and able to further distance themselves from any meaningful competition in the 5G era. In sum, AT&T and Verizon have been able to take advantage of these and other scale efficiencies which impact bottom lines, and therefore, competitiveness. New T-Mobile will be able to achieve similar scale efficiencies, thereby closing that competitive gap.

10. As a standalone company, T-Mobile would not independently have the type of spectrum resources that would enable it to launch a robust and deep 5G network during the next few years—the critical early years of the 5G innovation cycle. T-Mobile now has a thin layer of (600 MHz) spectrum that it can use to deploy a nationwide 5G network. However, this spectrum has limited capacity compared to other bands being considered for 5G deployments, and it is best suited for providing coverage over large areas. T-Mobile also faces competitive pressure from other sources, including big cable providers. Cable's recent entry into the wireless marketplace should not be underestimated: like AT&T and Verizon, they have extensive high-speed broadband networks and the scale and resources to adapt those networks to support next generation communications, access to a large customer base, and the ability to offer attractive, high-value bundled services. Comcast already signed on 577,000 wireless subscribers in its inaugural year, and Charter is launching its service this summer. In addition, DISH just

announced that its planned narrowband IoT network will serve as the first step to deploying a full-fledged 5G network.

11. While its Un-carrier ethos and unlimited data plans have earned T-Mobile its customer-friendly reputation and improved market position, T-Mobile continues to face significant competitive challenges in the wireless marketplace, and more challenges can be expected in the 5G era. In particular, as customer demand for mobile data continues to grow and more subscribers seek unlimited data plans, T-Mobile's current standalone network will likely struggle to meet these demands. Without the proposed transaction, T-Mobile's ability to continue exerting competitive pressure on Verizon and AT&T is likely to plateau because of its smaller subscriber share, revenue base, and longer-term spectrum constraints.

III. THE TRANSACTION WILL GENERATE SYNERGIES TO FUND AN INVESTMENT OF NEARLY $40 BILLION INTO BUILDING A 5G NETWORK AND DEPLOYING NEW SERVICES

12. Our merger with Sprint will create an estimated $43.6 billion in total net present value cost synergies, and New T-Mobile will use those synergies to fund an investment of nearly $40 billion to build a 5G network (and fund related capital projects) by 2024 that has [redacted] times the capacity of T-Mobile's standalone 5G network in 2024. New T-Mobile will use that capacity and the resulting lower marginal costs per customer to deliver lower prices and to accommodate increased customer data usage at the same or lower prices. Our goal for the merger is to be the first, fastest, and best in the 5G race and to capture market share with the Un-carrier combination of value and quality.

13. In our financial analysis, there are three principal sources of merger-related synergies (*i.e.* net present value ("NPV") cost savings). First, there are the network synergies gained by eliminating the massive and inefficient duplication of T-Mobile's and Sprint's existing networks. These synergies consist of (1) synergies from decommissioning duplicative or

otherwise unneeded network sites, and (2) reduced capital expenditures resulting from the scale benefits of combined network assets. Together, network synergies amount to $25.7 billion in NPV cost savings. Second, there are sales, service and marketing cost-related synergies. These synergies consist of: store consolidations (partly offset by store expansions); consolidating advertising and marketing assets; increased equipment purchasing power and efficiency savings; and improved repair and logistics practices. Together sales, service and marketing synergies amount to $11.2 billion. Finally, there are back office synergies from I.T. and billing improvements and other general and administrative synergies. Together, these synergies amount to about $6.1 billion.

14. As explained in the declaration of T-Mobile's Chief Technology Officer Neville Ray, Sprint's customer base will be rapidly migrated to New T-Mobile's expanded network.[1] Upon completion, this will permit New T-Mobile promptly to decommission duplicative cell sites and backhaul, achieving significant cost savings. New T-Mobile is expected to be able to eliminate approximately 35,000 redundant Sprint cell base station sites, generating substantial cost savings from elimination of leases, backhaul, utilities, upgrades, maintenance, and other recurring site-related expenses. The decommissioning of these cell sites and the ability to avoid building roughly 20,000 macro sites and 40,000 small cells through the network integration will result in projected run-rate synergies of approximately [redacted] by 2024. Meanwhile, those sites that are retained will provide added network capacity during the transition and help defer spectrum congestion in urban areas and ensure Sprint customers migrating to the New T-Mobile network have the same or better coverage everywhere. New T-Mobile will save further by eliminating future individual network builds and upgrades.

[1] Declaration of Neville Ray, Executive Vice President and Chief Technology Officer, T-Mobile US, Inc., at ¶¶63-72 ("Ray Decl.").

15. The merger synergies will free up financial resources that can be invested back in new network technology, innovation, and operations. Specifically, New T-Mobile plans to invest nearly $40 billion within three years to build (and fund related capital projects) a world-leading, nationwide 5G network with more capacity than any network in existence today, or currently planned for the future. New T-Mobile's business plan calls for capital expenditures of $14 billion in 2019, $12.3 billion in 2020 and $13.3 billion in 2021. The investments, of course, are focused on building and deploying the 5G network. However, they also include added investments for development of new services, the IoT business and $500 million for the expanded push into video. This investment is about three times the combined investment that T-Mobile would have made on its own.

16. Our plan is to invest nearly $40 billion in building a world-leading 5G nationwide network and business model, which involves expanding our retail footprint and entering into new business sectors, such as in home broadband Internet distribution and cable television service. This investment and expansion is expected to translate into more jobs, especially in rural areas. New T-Mobile plans to bring on board new employees to build the network, provide customer care, and support marketplace initiatives in in-home broadband, video, IoT and enterprise services.

17. We also plan to make a significant economic investment in the future of rural America as a result of the transaction. New T-Mobile will continue the long history of T-Mobile and Sprint partnering with rural carriers to further wireless deployments in rural areas. Specifically, we plan to extend an offer to become the Preferred Roaming Partner for rural carriers, providing long-term roaming access to our new network at industry-leading terms. This will include a roaming program that offers carriers with existing roaming rates with either T-

Mobile or Sprint to determine which rates will govern their relationship with New T-Mobile after the transaction closes. New T-Mobile will cooperate with rural partners on their 5G roll-out, including providing technical assistance and advice on 5G deployments. In addition to roaming, New T-Mobile expects to open 600 or more new stores—at least 500 dealer stores and 100 corporate stores—to serve small towns and rural areas, directly resulting in approximately 5,000 new retail jobs. New T-Mobile also expects to create approximately 1,800 new jobs dedicated to transitioning the T-Mobile and Sprint networks in rural areas and expanding rural coverage. It also anticipates needing to add approximately 1,000 new jobs to take advantage of New T-Mobile's enhanced competitiveness in the enterprise sector.

18. New T-Mobile also expects to substantially increase its domestic customer care workforce to ensure it maintains T-Mobile's industry-leading standard of customer care. For example, we anticipate opening up to five new technologically advanced Customer Experience Centers in small towns and rural communities to implement the company's innovative "Team of Experts" customer care and business model, directly resulting in approximately 5,600 new jobs. Employees will benefit from significant management preparation experience and qualify for college tuition reimbursement. In total, New T-Mobile expects to create over 12,000 new jobs to serve small towns and rural communities as a direct result of the transaction.

19. Indeed, our plan calls for the merger to be jobs positive from Day One. Within a year of closing, New T-Mobile is expected to employ 3,600 more direct internal employees than the two standalone companies would have absent the merger.[2] Under our plan, New T-Mobile's number of direct internal jobs will continue to increase—relative to what the standalone companies' combined employee base would have been every year for the foreseeable future. As

[2] "Direct internal" employees are on-payroll jobs (*e.g.*, a badge-carrying employee who would receive a W-2 from the New T-Mobile). "Direct external" employees are jobs that perform a core function of the New T-Mobile, but are outsourced to a dealer or contractor.

described in the table below, the incremental job increases relative to the standalone companies' baselines are, or will be, at or above the combined employer baselines:

	2019	2020	2021	2022	2023	2024
Direct Internal Incremental Jobs	3,625	3,755	5,045	5,010	8,115	11,060

In addition, the incremental increases for the combined direct internal and external employees will be 9,600 more jobs relative to the standalone companies' baselines for 2021.[3]

20. These estimates are conservative and likely understate the merger's effects on company employment. T-Mobile has a track record of significant job creation in connection with mergers. In 2013, T-Mobile acquired MetroPCS, then the fifth-largest mobile provider in the United States. At the time, T-Mobile conservatively projected that MetroPCS would employ roughly the same number of people after the merger. But, since the date of closing, MetroPCS has expanded into multiple new markets and more than tripled the number of employees and contractors who support the MetroPCS brand.

IV. NEW T-MOBILE'S NATIONWIDE 5G NETWORK CREATES MASSIVE CAPACITY AND LOWER COSTS THAT SUPERCHARGE THE UN-CARRIER REVOLUTION

21. The result of the planned investment will be to create the largest, most robust 5G network in the United States with greatly expanded capacity. The massive capacity expansion will result from New T-Mobile deploying the unique combined spectrum portfolios of both T-Mobile and Sprint across New T-Mobile's combined sites and accelerating the use of spectrum for 5G. Rather than simply adding the capacity of the two networks, the combination of two companies will increase capacity by a factor of four, as compared to the standalone companies.

[3] These projections were developed using a model that starts with a detailed assessment of the New T-Mobile business plan, which incorporates an analysis of internal as well as contractor and dealer employment across the full range of employment functions, including engineering; retail; back-office and other administrative functions; customer care; enterprise support; and infrastructure installation, operations, repair and maintenance.

In other words, the merger will double capacity compared to the combination of what the standalone firms would do on their own. As New T-Mobile expands its capacity, this will greatly reduce the cost of delivering each gigabyte of data to customers—capacity will double and the cost of delivering data will plummet. We will compete aggressively with lower prices to take market share from Verizon and AT&T, allowing more customers to enjoy the benefits of our increased capacity. More than 20 years of history in this industry shows that when providers increase capacity, consumers use the capacity and prices go down. We at New T-Mobile will deliver greater capacity at a lower price, to the benefit of our customers and to the benefit of competition.

22. By combining with Sprint, T-Mobile will be able to advance its Un-carrier strategy in several key ways. First, the combined spectrum assets acquired through the proposed transaction will allow New T-Mobile to deploy a broad, deep nationwide layer of 5G years before AT&T and Verizon could do, which is something neither Sprint nor T-Mobile could otherwise achieve alone. By enhancing and diversifying T-Mobile's spectrum and selected network assets, the transaction will not only provide customers with improved network coverage (including enhanced in-building coverage) and capacity, but also allow New T-Mobile to more efficiently use its spectrum.[4] The strength of New T-Mobile's 5G data network will allow it to continue to ambitiously pursue customers looking for smartphone plans or other data-intensive service offerings and enhance its ability to submit competitive bids for enterprise customers. In particular, the enhanced 4G LTE and emerging 5G capabilities will inure to the benefit of New T-Mobile in the eyes of consumers.

[4] *See* Ray Decl. at ¶4.

23. New T-Mobile's 5G speeds and unprecedented capacity will benefit consumers by enabling new use cases and will have the potential to revolutionize the wireless user experience and existing consumer and business applications; supercharge a wide range of commercial growth areas, particularly through the Internet of Things ("IoT"); and push connectivity to new consumer and business horizons. Indeed, the New T-Mobile 5G network will also provide fertile ground for cycles of innovation out of which new services and products for consumers and businesses will grow.

24. The combined company will help T-Mobile's efforts to become the value leader in the U.S. market. New T-Mobile can capitalize on both companies' proven abilities to develop attractive and competitive service offerings and achieve stronger penetration in specific customer demographics in an effective manner, including areas that were previously underserved by the nation's largest wireless carriers. New T-Mobile will also continue the Lifeline services currently provided by T-Mobile and Sprint. Moreover, adding Sprint's unique spectrum holdings and key assets to T-Mobile's existing network will enable New T-Mobile to offer enhanced products and services that will drive further competition—and therefore benefits—for consumers.

25. Because New T-Mobile's combined network will have massive speed and capacity improvements without having to pass on additional costs to consumers, the proposed transaction will serve to affirm New T-Mobile as a value leader in the rapidly converging wireless marketplace. In true Un-carrier fashion, we will engage in continued maverick challenges that are sure to evoke competitive responses from AT&T, Verizon, and all other competitors in the mobile wireless market. By combining T-Mobile and Sprint, the transaction will ultimately benefit all wireless consumers by increasing wireless market competition overall.

26. We are planning to spend nearly $40 billion building a superior network experience and product offers, in order to retain our existing customer base, attract new customers and benefit from being the first to deliver transformative 5G services nationwide. Once we go down this road there is no turning back from the Un-carrier path of delivering value and quality to our customers. If we broke faith by raising rates, cutting back benefits and acting like the other guys, we would lose our base and destroy our future. We would have spent billions in capex to build a beautiful network, only to be left with tons of idle capacity and billions of dollars in unrecovered investment. It would be economically irrational and contrary to shareholder interests for New T-Mobile to raise prices and/or restrict output as a result of this merger. Our success was and will be centered around delivering more to consumers for less.

V. THE MERGER WILL ENABLE NEW T-MOBILE TO COMPETE IN NEW AND EXPANDED SERVICES IN WAYS NOT POSSIBLE ON A STANDALONE BASIS

27. New T-Mobile's 5G network will offer speeds and unprecedented capacity that will benefit consumers by enabling otherwise impossible uses. It will have the potential to revolutionize the wireless user experience and existing consumer and business applications; supercharge a wide range of commercial growth areas, particularly through the IoT; and push connectivity to new consumer and business horizons. The New T-Mobile 5G network will also provide the fertile soil for cycles of innovation out of which will grow new services and products for consumers and businesses. We will provide much-needed competition in key market segments that today lack competitive pressures and/or are known for low customer satisfaction, like in-home broadband; video distribution; and enterprise services.

28. ***Internet of Things.*** 5G technology is expected to accelerate the development and deployment of consumer and commercial IoT systems, with massive growth projected across verticals like connected homes and workplaces, connected healthcare, connected cities, and

connected vehicles. What's more, every major competitor in the wireless market has identified IoT as a central component of their 5G strategy; there is no doubt that 5G networks will prompt tremendous advancements in IoT. As such, the more quickly 5G networks can be built and deployed, the faster these networks will be able to capture IoT's potential and maximize the benefits flowing to consumers, businesses, and the broader economy.

29. T-Mobile currently offers a range of basic consumer IoT products, with a focus on smart and connected home devices (*e.g*., home security devices, lighting, speakers), basic connected car solutions (*e.g.,* SyncUp Drive), wearable devices (*e.g.,* smart watches), and mobile hotspots. However, New T-Mobile's 5G network will enable it to turbocharge existing IoT product lines, attract more customers, and facilitate innovation in terms of new consumer IoT products.

30. The New T-Mobile 5G network will also create opportunities for commercial IoT applications, with a focus on "smart mobility" and "smart community" applications. We also expect to invest in private wireless networks, distributed computing, telehealth, and backup connectivity. Through emerging commercial IoT applications, New T-Mobile's 5G network and associated capabilities will enable it to spark and accelerate new parts of the value chain.

31. "Smart mobility" means using New T-Mobile's 5G network to provide IoT solutions that will help Americans transport themselves, and/or their goods, in a faster, safer, more efficient, and more cost-effective manner. For New T-Mobile, this translates into leveraging its new 5G network to provide reliable high-speed and low-latency connectivity for autonomous and connected vehicles, in order to compete for a share of the growing vehicular connectivity market. Smart mobility also means using the 5G network's superior nationwide coverage to offer better asset tracking services and, because of the network's vast capacity, to

provide these services at a lower cost to the consumer. Finally, smart mobility means improved connectivity for IoT fleet management services to enable business customers to optimize their commercial vehicle fleets by tracking fuel consumption, trip and route efficiency, driver behavior, and other critical factors.

32. "Smart communities" mean using New T-Mobile's 5G network to provide IoT solutions that will help connect, manage, and optimize community infrastructure. New T-Mobile's IoT solutions can be good for business while making our communities safer, healthier, more efficient, and generally nicer places to live, visit and work. This translates into partnering with cities around the nation to provide products targeted to their needs, such as lighting optimization, traffic management, utilities, and public safety. Smart communities also mean providing solutions on a smaller scale, for smart campuses and even smart buildings. New T-Mobile's 5G network will enable IoT solutions for smart building and campus needs ranging from energy efficiency and climate control to security and elevators.

33. New T-Mobile's 5G network will also provide IoT solutions for numerous and diverse other applications for which its unique balance of high speed, high capacity, low latency and coverage will be particularly well-suited. Some of these applications include private networks, connected manufacturing and agriculture, supply chain logistics, transportation, telehealth, and backup connectivity. Others have not yet been identified, but will be spurred by the availability of a broad and deep 5G network such as the one made possible by the transaction.

34. While both Sprint and T-Mobile hold valuable spectrum assets, neither company's assets would be sufficient to independently roll out competitive 5G IoT capabilities in the near term, during the crucial formative years of the new IoT marketplace. By combining

our complementary assets and spectrum, we will supercharge the Internet of Things and bring the Un-carrier approach of enhanced customer value to this segment.

35. ***In-Home Broadband Competition.*** In-home broadband today is not a competitive market segment, and a significant percentage of Americans lack a competitive choice of residential broadband service. The merger enables New T-Mobile to offer an attractive high-speed in-home broadband option in some areas in direct competition with existing incumbent wired broadband services. The merger also increases the attractiveness of New T-Mobile's mobile wireless service as a substitute for existing incumbent in-home broadband. New T-Mobile's 5G network will provide speeds sufficient to support HD and 4K video streaming to tomorrow's handsets, tablets, desktops and other in-home and mobile screens. Furthermore, the 5G network's improved performance will allow New T-Mobile to deliver cost-effective in-home broadband services without compromising the quality of its core wireless service offerings. New T-Mobile's supercharged 5G network will, for all practical purposes, close the speed differential that currently exists between mobile and in-home broadband, and make the company a strong competitor to other in-home broadband providers for millions of households across the country.

36. *New Direct Competition*. New T-Mobile will be a direct competitor in the in-home broadband market. The New T-Mobile 5G network will provide data rates in excess of 100 Mbps to two-thirds of the U.S. population by 2021. These speeds are fast enough to enable New T-Mobile to compete successfully with landline broadband services in these areas. New T-Mobile will have an opportunity to expand its subscriber base through competitive equipment, service packages and products that will serve as a substitute for traditional, subscription-based—and often costly—fixed in-home broadband. New T-Mobile will attack the opportunity to serve

this market and provide consumers with an alternative choice for their in-home broadband service and a better value.

37. By 2024, New T-Mobile is expected to provide in-home broadband service to 9.5 million households nationwide, equating to approximately 7 percent market penetration, and making New T-Mobile potentially the fourth largest Internet service provider in the U.S. by subscribership. Of particular importance, T-Mobile estimates that 20-25 percent of these new subscribers for in-home broadband service will be located in rural areas. These estimates for service penetration and network capacity assume that the average monthly mobile subscriber data consumption would increase eight-fold from today's 9.8 GB to approximately 80 GB by 2024, and that the capacity needed for providing in-home broadband, including high quality video services, would be approximately 500 GB per month/household. New T-Mobile's 5G network will be able to handle capacity increases of this magnitude for millions of customers, but the standalone T-Mobile and Sprint 5G networks could not.

38. *Mobile Substitution for In-Home Broadband*. In addition, New T-Mobile will cause more people to use mobile service as a substitute for in-home broadband, eliminating their need for in-home broadband entirely. New T-Mobile's broad and deep mobile 5G network will provide network performance that will meet or exceed the in-home needs of many consumers. With unlimited plans and New T-Mobile's lower prices, substituting mobile wireless service for in-home broadband will provide many consumers with an economical option of using their mobile service as their only broadband subscription, instead of paying for separate mobile wireless and in-home broadband subscriptions. This solution enables consumers to avoid paying for both in-home and mobile broadband and allow them to save the significant amount of money that would otherwise be spent on in-home service. Today, 19 percent of households could

eliminate their home broadband subscription entirely by using tethering on a T-Mobile two-line plan. By 2024, we estimate this number would be 15-20 points higher, meaning that 35-40 percent of households could completely eliminate their home broadband subscription and rely on New T-Mobile for all their broadband needs. This option of having only one Internet service, a viable mobile service that can meet all of your connection needs, rendering in-home broadband unneeded, provides the most benefit to lower-income households who may not be able to afford both. And further, this ability to substitute mobile service for in-home broadband, created by the enhanced capacity of the New T-Mobile network, would become even more important and accelerated in the event of an economic downturn.

39. The transaction thus will enable in-home and mobile broadband options that are beyond the currently planned 5G capabilities of T-Mobile or Sprint as standalone companies. The transaction will, therefore, alter the fundamental dynamics that have left millions of customers with few choices for in-home broadband services, resulting in slow speeds and high prices.

40. ***Video Services.*** As with in-home broadband services, New T-Mobile sees video services as offering an opportunity to both deepen relationships with its existing wireless base and open up a fruitful new avenue through which the company can generate revenue as the technology industry converges. As consumers increasingly want content available on mobile devices, they have warmed to the idea of getting television service from non-traditional providers. New T-Mobile will leverage the benefits of scale in network, costs, and financial resources to disrupt television viewing by offering best-in-market TV packages that will allow customers to break-up with their ISPs with the first 5G wireless-only bundle for TV and home Internet. This is something that standalone T-Mobile would not likely be in a position to

provide. T-Mobile's recent acquisition of Layer3 puts it in a strong position to generate more revenue and attract subscribers, particularly when combined with the expanded network capabilities of New T-Mobile.

41. In the near term, the customer and retail scale created by the transaction will enable T-Mobile to more rapidly expand the current Layer3 model than possible without the transaction. This scale should allow the company to acquire content at lower rates and on better terms than T-Mobile and Layer3 can do on their own. Layer3 estimates that its content acquisition costs will decrease by [redacted] percent as a direct result of the transaction and the increased customer scale, allowing the company to price its service offerings to provide more affordable options for consumers. The competitive imperative will demand that Layer3 pass these cost savings on to consumers through lower prices and more flexible rate offerings.

42. New T-Mobile's 5G network will allow us to offer the nation's first 5G-delivered in-home and mobile video services. This will include high-quality video content—including HD and 4K—to in-home and mobile locations in markets across much of the country. The merged company will create a multi-billion dollar business that is more than double the size of their standalone ambitions, due to the combined network and financial resources. The merger produces a quantifiable opportunity for New T-Mobile and resulting benefits for many more consumers than otherwise possible.

43. ***Enterprise Services.*** Finally, T-Mobile is not a significant competitive factor in the enterprise segment of the market today. It has only a very small share of the business market segment (including small businesses), and only a 4 percent share of the large enterprise and government portion of the segment. Historically, T-Mobile has been focused on the consumer segment of the market and has been limited in the enterprise segment because the old T-Mobile

network generally failed to meet the technical requirements demanded by enterprise and government clients. On its own, T-Mobile does not have the scale, network, or resources to compete optimally in the enterprise segment, which is currently dominated by AT&T and Verizon, which together have almost three-quarters of the enterprise segment. New T-Mobile will have the ability to use its 5G network to offer an attractive alternative in the enterprise segment by providing superior quality traditional data and voice products, as well as advanced IP-based services and Ethernet-related products, to large, medium, and small businesses; federal, state, and local governments; and wholesale customers. The New T-Mobile will compete with both traditional wireless and wireline providers in the business segment, bringing significant competition to many customers to an extent not likely for standalone T-Mobile.

44. New T-Mobile's superior 5G network will unlock these opportunities, as it will be able to meet or exceed enterprise customer technical and operational requirements and surpass the performance of many competitor networks, whether wireless or wired. Additionally, the network's increased capacity and lower costs per unit will address the specific challenges we face as a standalone company and enable us to compete on pricing in the enterprise market segment by providing greater value to enterprise customers and exerting pricing pressure in a market segment dominated by AT&T and Verizon. New T-Mobile's unmatched network will also allow it to expand and diversify its voice and data offerings and develop innovative enterprise solutions. Furthermore, New T-Mobile will be able to use its more robust resources to expand its enterprise sales force and offer a broader portfolio of products. As noted above, these advantages will cause New T-Mobile to immediately invest in adding approximately 1,000 new jobs in the first year or two after the transaction closes, to bring much more meaningful competition to today's established players.

45. Last, but not least, enterprise customers are likely to be early experimenters and participants in IoT adoption, and would thereby provide meaningful points of early entry into IoT business lines. An expanded suite of enterprise IoT solutions, facilitated by the combined talent at both Sprint and T-Mobile, will allow New T-Mobile to quickly jumpstart these IoT business segments.

46. I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct. Executed on June 18, 2018.

G. Michael Sievert
President and Chief Operating Officer
T-Mobile US, Inc.

APPENDIX D: DECLARATION OF PETER EWENS
Executive Vice President, Corporate Strategy, T-Mobile US, Inc.

DECLARATION OF PETER EWENS
Executive Vice President, Corporate Strategy, T-Mobile US, Inc.

I. INTRODUCTION

1. My name is Peter Ewens and I currently serve as the Executive Vice President, Corporate Strategy for T-Mobile US, Inc. ("T-Mobile"). I have been at T-Mobile since 2008. I hold undergraduate and graduate degrees in engineering from the University of Toronto, and I earned a master's of science in management from MIT's Sloan School of Management.

2. In this declaration, I discuss some of the financial bases for the proposed merger of T-Mobile and Sprint Corporation. In so doing, I also discuss the competitive pressures that the combined company will be able to exert on the mobile market in the 5G era, as well as the competitive pressures that will shape how New T-Mobile offers services in the future. I follow that with a discussion of the near term strategic issues that will face New T-Mobile, and why engaging in aggressive competition to attract new customers is the only reasonable strategy for the company and its shareholders.

II. THE CORE VALUE PROPOSITION OF THE MERGER IS TO CONTINUE T-MOBILE'S MAVERICK, CONSUMER-FIRST STRATEGY

3. At its core, this merger is about realizing synergies and achieving the scale and resources, including both spectrum and sites, to create the nation's leading 5G network. By constructing a better, faster 5G network earlier than either company could do on its own—and addressing the challenges T-Mobile and Sprint each face today with their standalone networks—New T-Mobile's network capabilities and capacity will lead to better service and lower prices for customers. Specifically, this deep and broad 5G network will allow New T-Mobile to continue T-Mobile's proven pro-consumer "Un-carrier" strategy, which is fundamentally built around defying industry norms set by our entrenched competitors and delivering more value and satisfaction to consumers. The network will also remedy T-Mobile's network capacity

constraints and expand Sprint's network service and coverage. The New T-Mobile will also use the added capacity and capabilities of its network to proactively compete in adjacent industries, bringing Un-carrier disruption to in-home broadband and other markets. And, the merger will position New T-Mobile to create real mobile broadband and wireless competition for many rural Americans for the first time and new competition for enterprise customers.

4. I believe this merger is critical to continue, and supercharge, the competitive disruption and benefits of T-Mobile's revolutionary Un-carrier movement. While there are many aspects of the Un-carrier movement that everyone can identify—no service contract (service plans without lock-in service contracts); Binge On (video streaming without data charges); Simple Global (allowing the use of data abroad without extra charges); Music Freedom (music streaming without data charges); and T-Mobile ONE (elimination of tiered data plans in favor of unlimited)—one of the most important tenets of being the Un-carrier is continuing to deliver more value and more data, year over year, without increasing plan rates. A prime example of this strategy in action was T-Mobile's leadership in driving unlimited rate plans. As it became apparent that HSPA+ (and later 4GLTE) network upgrades would drive huge increases in capacity, T-Mobile moved to make Unlimited data its core offer—eventually forcing AT&T and Verizon to make unlimited rate plans broadly available.

5. And T-Mobile continues to drive the industry to provide more value in unlimited plans. Measured by revenue yield per GB on average, for the past several years T-Mobile has given its subscribers 37 percent more data each year per dollar spent on their wireless plans while at the same time lowering their package prices (a data dividend),[1] thereby passing on the benefits of capacity upgrades the company makes to its network at no added cost to subscribers.

[1] Based on T-Mobile branded phone customers from 2013-2017.

This benefit extends to all customers. Unlimited plan subscribers, of course, benefit from reduced costs and predictable, flexible contracts. Cost-conscious customers benefit because, according to T-Mobile's data, value customers continue to use their data plans extensively, even when they exceed usage limits on metered plans and their traffic is slowed after that. For example, on average, value subscribers on our unlimited plans use [redacted] GB/mo., more than the [redacted] GB/mo. used by other unlimited customers (a blended average of over [redacted] GB/mo.)—the highest in the US wireless industry. Decreased data costs (and other initiatives to help customers manage data costs, such as Binge On and Music Freedom) are especially impactful and tangible to cost-conscious customers, since many such users' smartphones are their exclusive access to the Internet. Because all customers should be able to take advantage of newer, more data-intensive applications and products without going broke, accommodating greater use without raising rates is a practice T-Mobile would ideally like to continue, especially with compound annual data growth that we estimate at greater than 30 percent. But, T-Mobile does not have the capacity, resources, or capital to sustain that added annual data dividend indefinitely.[2]

6. Network capacity is directly linked with T-Mobile's ability to execute Un-carrier initiatives. The most obvious example of this was T-Mobile's decision to eliminate tiered rate plans and make all rate plans unlimited. In order to make that work from a capacity perspective, T-Mobile had to adopt certain limiting conditions to ensure that capacity on the network could be managed. Principally, T-Mobile lowers network priority in rare times and places of congestion for customers who use over 50GB in a month to ensure a small minority of customers don't degrade service for the vast majority. Over time, as T-Mobile has built out capacity, it has been able to increase the thresholds—for example, in 2017 this threshold was increased from 32GB to

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[2] *See* Declaration of Neville Ray, Executive Vice President and Chief Technology Officer, T-Mobile US, Inc., at ¶41 ("Ray Decl.").

50GB, but our ability to continue these advances is tied to how much "offered capacity" the network has. Having more capacity will continue to allow New T-Mobile to develop and implement Un-carrier initiatives that offer better value to subscribers.

7. With the proposed merger and the added capacity that it would create, I believe New T-Mobile will be able to continue as a maverick and supercharge the Un-carrier revolution. As I have done for other new lines of businesses and major acquisitions, I developed a financial plan for New T-Mobile. Using inputs from the network engineers who are simulating the 5G network roll-out and 4G LTE enhancements, my team and I have modeled and estimated how the transaction, and the deployment of that new network, will impact key performance factors—including projected average revenue per user ("ARPU"), share of gross adds ("SOGA"), and churn rates, as well as the costs of network deployment and revenues from services—to predict what the business will look like in 2024 and beyond. Based on that work, I believe this merger will produce an estimated $43.6 billion in total net present value cost synergies, mainly reflecting reductions from the avoided duplication of network costs like sites and backhaul, and non-network costs like retail and advertising. Importantly, many of the non-network cost synergies, such as retail and advertising savings and integration savings from combining and de-duplicating information technology systems, will start to accrue in the first year after close, lowering our cost structure even before full deployment of the 5G network. I expect the network cost synergies to begin in 2020 and ramp up through 2023.

8. Moreover, as shown in Figure 1, the financial model projects passing scale benefits on to customers in the form of an over 6 percent reduction in ARPU, going from [redacted] to [redacted] by 2024, for a network that will be significantly faster, higher capacity, and lower latency. By contrast, the financial model of T-Mobile standalone projects flat ARPU over time.

Put otherwise, the model demonstrates that with this merger, New T-Mobile will continue T-Mobile's Un-carrier strategy of passing savings through to customers.

[redacted]

Figure 1: Voice ARPU for New T-Mobile

The reduction in ARPU includes one very substantial benefit to Sprint subscribers immediately, which is that New T-Mobile will guarantee each customer a rate plan that is equal or better than the plans they currently enjoy with Sprint. Because T-Mobile's network has greater coverage and industry-leading speeds, and because approximately 20 million Sprint customers' phones are already compatible with T-Mobile's network, Sprint customers will receive more value for less money shortly after close and with minimal disruption as we enable their phones to access the T-Mobile network. At the same time, T-Mobile customers will benefit from the superior network services that New T-Mobile can offer (*e.g.*, increased network capacity, throughput, and service). Also, New T-Mobile will extend the Un-contract rate promise to those plans, which is the strongest industry commitment by a national carrier to maintaining customer value in existence today, by continuing to honor the terms of the original Sprint plans. A strategy of providing increased value immediately after the merger will maintain New T-Mobile's status as the Un-carrier and will signal to the public and to our investors that the Un-carrier strategy will continue post-merger.

9. I should also emphasize that T-Mobile is well aware that we owe our recent success to our commitment to the Un-carrier movement. The Un-carrier movement is indelibly associated with T-Mobile and its brand by consumers and investors, so New T-Mobile's branding will be dependent upon New T-Mobile remaining a maverick. New T-Mobile will maintain the T-Mobile philosophy of placing a high value on its pro-customer reputation as its brand, and the reputations of the leadership team, most notably John Legere, are inextricably intertwined with the company's commitment to shake up industry conventions in favor of the customer.

10. Management, and T-Mobile broadly, recognize that customers come to T-Mobile (and stay with T-Mobile) because of our commitment to low costs, superior value, simple plans, and innovation. The Un-carrier movement is one of T-Mobile's core assets. Actions that consumers view as reneging on the consumer-centric tenets of T-Mobile's brand promise will greatly diminish the value of the Un-carrier brand. Most notably, the company would be punished by subscribers (and ultimately by shareholders) if it started acting like the "other guys," abandoned its steady drumbeat of pro-consumer enhancements, or walked back from the Un-contract rate promise. To be sure, even a small misstep in an era when consumer activism is amplified through social media could have grave consequences. Simply put, squandering such a successful Un-carrier business strategy for small incremental profits would be a financial and business disaster for the long-term success of New T-Mobile.

III. THE MERGER WILL ALLOW NEW T-MOBILE TO TAKE ADVANTAGE OF THE UPRECEDENTED OPPORTUNITIES 5G OFFERS AND REVOLUTIONIZE THE MOBILE MARKET

11. The merger will give New T-Mobile the capabilities and incentives to implement a superior 5G network faster than either company—or any current wireless company—could do alone, and incentivize other wireless and broadband companies to compete more aggressively.

Currently, no standalone company has the resources or incentives deploy 5G across low, medium and high bands, which is necessary to create a robust nationwide 5G offer. Both Verizon and AT&T have approached 5G tentatively—announcing plans for limited services, like Verizon's fixed broadband replacement, or announcing planned deployment only in selective areas. Both Sprint and T-Mobile have announced 5G implementation, but our plans are severely limited by our access to spectrum and relative lack of scale. Thus, while the ingredients for massive 5G deployment exist, the current market is not structured to allow for the massive investments necessary to fully deploy 5G.

12. The merger creates efficiencies that allow New T-Mobile to go all-in on 5G, which will fundamentally change the market going forward. New T-Mobile is committed to a nearly $40 billion investment over the next three years to bring the company into the 5G era, including integrating the networks using 5G compatible equipment. During this time, it is in New T-Mobile's financial interest to attract new customers to spread out the sunk network integration costs. Without the merger, though, the 5G world will be very different. 5G will require vast network investments. While AT&T and Verizon have the capital resources and are capable of making this investment, they are not currently compelled to do so because neither T-Mobile nor Sprint has the capabilities to make that jump. Absent the merger, and absent a credible threat of a more capable and broad 5G network, Verizon and AT&T will be able to defer true 5G and hold to their more limited deployment plans.

13. From a business perspective, the New T-Mobile 5G network will be vastly superior to the planned 5G networks of either Verizon or AT&T. Both Verizon and AT&T have very large holdings in the millimeter wave spectrum bands. They have, accordingly, announced 5G networks that capitalize on that advantage, while downplaying the broader potential of 5G.

As one article put it, "If you're in one of the cities selected by [AT&T or Verizon], you will be able to buy a wireless device later this year with roughly the same speed as a wired broadband connection," but "AT&T's 'mobile' 5G devices will be battery-powered and portable pucks; [and] Verizon's "fixed" 5G devices will be wall-powered and designed to be left in a home or small business;" "[i]n each case, existing computers, tablets, and phones will likely use Wi-Fi to access the 5G cellular connection."[3] The key takeaways here are that AT&T and Verizon will be deploying 5G in limited cities and will be deploying services that more resemble fixed broadband replacement. New T-Mobile, in contrast, will focus its 5G deployment on ubiquitous mobile broadband.

14. Because the New T-Mobile investment in infrastructure will leverage the existing spectrum and sites of both T-Mobile and Sprint, New T-Mobile's network will not only have massive added capacity, that capacity will come at a lower cost. This ability to create more from our network investment gives the New T-Mobile a lot of headroom to create rate plans with high data thresholds and consumer value at low prices in order to maximize the use of the network. This increased ability to monetize added capacity dovetails with New T-Mobile's plan to provide a combination of greater value and lower cost for conventional data services—including its data dividend. Our demand forecasts for the next six years indicate that consumers are likely to continue growing their demand by over 30 percent per year. With the New T-Mobile we will be able to continue offering subscribers more data each year without increasing prices. Without this merger we will not be able to sustain those rates of data growth without severely degrading network performance. Our plan to gain share by giving more for less money is vital to our

[3] Jeremy Horwitz, *After fuzzy announcements, AT&T and Verizon now have clear 5G roadmaps for 2018*, VENTURE BEAT (Feb. 1, 2018), https://venturebeat.com/2018/02/01/after-fuzzy-announcements-att-and-verizon-now-have-clear-5g-roadmaps-for-2018/.

financial interest—as explained above, the vast majority of our network investment is a sunk cost, and the more subscribers we have that we can spread that cost over, the better off we are.

15. The 5G era will also be accompanied by other disruptions that we will be positioned to take advantage of. The market will be disrupted by new technology and new platforms—companies like Verizon, AT&T, Comcast, Charter, and DISH will be scrambling to design and offer new service packages. Each of these companies, and others, will emphasize their unique combination of assets—whether speed, capacity, or video content— and try to find mixes that appeal to different customer segments. In addition to the fact that firms' positions across different geographic areas will vary with respect to latency, capacity and speed as a result of differing mixes of spectrum assets and investment, 5G offerings will have more axes of competition upon which to price. We expect to see a broad variety of plans and experimentation around usage thresholds, the resolution of delivered content, bundling, connection characteristics (*e.g.*, latency, guaranteed bandwidth), and pricing. We intend to drive that competition in a continuation of our Un-carrier strategy by using our tremendous capacity to create high-value packages at low prices. We believe we can continue to drive competition, win market share, and force other competitors to improve their proposition to customers by being competitively aggressive at this unique inflection point in broadband development.

16. We understand that in industries like these, regulators are concerned that fewer competitors will lead to either intentional or unintentional coordination. However, given the market positioning explained above, there is no threat that the merger would reduce our incentives to delay capital investment. Network quality is the most significant factor underlying consumer choice of mobile provider, and T-Mobile has spent years attempting to address our longstanding issues with network inferiority, and customer perceptions of network inferiority—

issues we still struggle with today. We see no incentive to delay network investment and quality improvements, but rather an opportunity to be had through aggressive network implementation.

17. Moreover, the idea of acting in concert with other carriers to delay network investment seems implausible in today's mobile broadband market. First, to come to a common understanding, each company must know exactly where other competitors are making network investments. We may learn from press statements how much a competitor intends to spend on its network, but we have no understanding of how that money is apportioned across network elements; how investment in different areas will impact performance; how the investment is geographically distributed; or how cost-effective the spending is at creating capacity (especially given the variations in core assets different players bring to the table in different areas). Thus, sporadic and limited disclosures of generalized spending levels, without all of the information discussed above, simply does not give us enough information to plan our network capacity based on what are competitors are doing. And, the competitors in today's market have widely varying incentives given the ability of different players to package services with other content or other capabilities. With limited measures of the impact of investment and without a common competitive baseline of service, there is no ability to create the framework for a common understanding, nor is there an ability to police such an understanding. Second, if someone defected and invested more than they should, there is no way to undo the investment—other participants would simply have to catch up.

18. For New T-Mobile, there are also company-specific factors that militate against a tacit agreement on delaying investment. First, the risk of being caught flat (*i.e.*, finding out after the fact that AT&T and Verizon were offering more capacity) would be more devastating for a company like New T-Mobile because it would take time to catch up and we would severely risk

our Un-carrier promise of offering more for less. Second, at least for the first few years, New T-Mobile will have to invest to merge the networks and get Sprint customers off their network to achieve the cost savings. With technology advances, it is now no more expensive to use radios that operate across 80 MHz, as opposed to ones that operate across 20 MHz, so New T-Mobile has unique, and very clear, incentives to invest and change its cost structure going forward.

19. Our entire brand value, competitive history, and corporate culture rests on forcing change for the good of consumers. Far from discouraging investment, this merger provides the industry with the necessary incentives to force change. With the merger, we believe that New T-Mobile can rapidly deploy a better, faster network and that we can force change in an amplified way benefitting both the public and our shareholders. Settling into some common understanding based on today's market shares make zero sense.

IV. SUCCESS IN THE 5G ERA REQUIRES NEW T-MOBILE TO AGGRESSIVELY COMPETE BEFORE 5G ARRIVES

20. The 5G network will require T-Mobile to have a strong base of customers ready to adopt the new technology. New T-Mobile cannot afford to wait and rely on a giant influx of subscribers when it opens its 5G network—migration to 5G will be continuous, and there is no unique point in time where a large portion of the market's subscribers will collectively reconsider their choice of carrier and make decisions going forward. Because change will be continuous, to maximize the value of its planned investment, New T-Mobile wants the broadest base of subscribers possible during the entire course of the transition. For that to happen, New T-Mobile has to continue competing day in and day out, even before the 5G network is launched.

21. The reason New T-Mobile is incentivized to maximize its customer base for the 5G transition is that T-Mobile has found that those most likely to adopt new value-added services, like the potential offerings enabled by 5G technology (*e.g.*, home broadband

replacement or substitution, or new consumer-oriented IoT offerings), are existing customers. Convincing a customer who is already happy with network quality and value to adopt a new offering will always be easier than attracting a customer from another provider who is likely to fear the unknown. Thus, to maximize the value of the revenue opportunities of new 5G services, New T-Mobile must have the largest subscriber base possible upon initiating new 5G services.

22. To maximize the customer base at the 5G launch, New T-Mobile will have to incrementally add subscribers—starting the day after the merger is completed. T-Mobile has found that the cost per gross add (“CPGA”), which reflects incentives, promotions, sales commissions, and other costs, rises with every new subscriber. In other words, the CPGA of the marginal net additional customer rises. As a result, it is less costly to add 1,000 subscribers in one quarter and another 1,000 subscribers in the following quarter, than to add 2,000 subscribers in the same quarter. In turn, this means T-Mobile cannot simply forego growth today and expect to make up that growth at some arbitrary date in the future once the 5G network is deemed “complete.” We need to start now, immediately after the merger.

23. Having scale, both nationally and locally, is an advantage in attracting new subscribers. One of the key elements in attracting new subscribers is word-of-mouth, as well as the general customer perceptions that arise from having a broader customer base. The first individual to get T-Mobile service in a group of peers is a risk-taker, since they have no one to corroborate advertising claims with real-world performance. But with every new T-Mobile subscriber in that peer group, the risk is less and less, because the advertising message is anecdotally reinforced by trusted sources. A similar effect also exists with respect to retail presence in a market—the number of retail stores in a market, and the number of times potential customers see those stores, reinforces the perception that the provider has a committed presence

in the market, which also legitimizes their advertising message. Thus, scale matters, both for attracting new subscribers and, in the future, for creating the revenues that allow continued capital investment.

24. That need to maintain the perception of high network quality provides strong incentives for us to maximize the quality of our LTE network even as we prepare to roll out 5G. T-Mobile also must compete now for future gain because improvements to the 4G LTE network will benefit the future 5G consumer. The 5G network won't come all in one day. The 4G LTE network will continue to be an important part of the 5G experience for some time, and therefore T-Mobile must maintain a high-quality 4G LTE experience in order to ensure a high-quality 5G experience. And, as handset migration will take some time, we know that a bad network experience for any set of customers would be detrimental to the brand image that we are trying to build. That is why we are committed to not leaving any customer behind during the migration.

25. Our MetroPCS experience shows that this makes business sense. Following that acquisition, we were able to quickly improve the MetroPCS subscribers' experience by providing them with access to the faster T-Mobile network and industry leading customer care. We have continued to extend to those subscribers the benefits received by other T-Mobile subscribers, like increased data based on network capacity. Tangible evidence of the success of the transition is that churn for MetroPCS subscribers went from 3.45 percent in 2013 before the subscriber transition to 2.95 percent in 2016 after the subscriber transition to the T-Mobile network was complete. That experience also demonstrated our customer-first philosophy in other ways—post-merger, T-Mobile kept more than its original target of MetroPCS sites so that it would have more capacity, which ultimately was a benefit passed on to subscribers without increasing rates.

26. In addition, T-Mobile must contend with the competitive results of our policy to increase the ease with which customers switch carriers. T-Mobile first got rid of contracts. Then it offered to pay off early termination fees. T-Mobile also offered "all inclusive" rates to reduce fears that advertised rates would not be the billed price and "test drive" programs to alleviate fears of network quality or coverage. All of these moves, and our competitors' copying of them, have made it easier for subscribers to be lured away.

27. It should also be noted that I would expect that all our competitors will seize on the merger as a time to even more aggressively court Sprint customers, and even existing T-Mobile customers. In fact, I recently saw one of our competitors saying that they were going to "make the most" of our transition period.[4] Because every lost subscriber costs more to replace tomorrow, New T-Mobile will have clear motives to use merger efficiencies to allow it to create further competitive inducements for existing and potential customers by delivering more value for less money. Not only will the merger efficiencies allow New T-Mobile to compete aggressively in areas where it already has a solid foothold, but they will also enhance its ability to compete in areas where it has a lower customer share and where greater SOGA growth is possible, such as rural areas and with enterprise customers. In both cases, New T-Mobile will be a more aggressive competitor.

28. The same competitive incentives, and network benefits, also exist relative to maintaining existing, and attracting new, mobile virtual network operators ("MVNOs"). At a most fundamental level, MVNOs typically have long-term contracts at wholesale prices and provide sufficient capacity to permit the MVNO to expand successfully. T-Mobile has historically had a good relationship with its MVNO partners and found that MVNOs have

[4] Todd Bishop, *Verizon CEO brushes off T-Mobile's Sprint merger: 'We don't care, is the answer to that'*, GEEKWIRE (May 2, 2018), https://www.geekwire.com/2018/verizon-ceo-brushes-off-t-mobiles-sprint-merger-dont-care-answer/.

marketing and distribution advantages in attracting and reaching customers from particular segments. In an environment where New T-Mobile will have significant added network capacity, it has no incentives to impair the ability of existing MVNOs to put subscribers on New T-Mobile's network. New T-Mobile, in fact, has every incentive to encourage new MVNOs that can offer unique value propositions or better reach particular customer segments. And, from the MVNOs' perspective, the benefits that New T-Mobile's 5G network provides are benefits they can provide to their subscribers as well. MVNOs utilizing the New T-Mobile network stand to gain competitive advantage with the enhanced speed, capacity and coverage of the new network, and T-Mobile in turn would gain from the wholesale revenue they provide back.

29. I declare under penalty of perjury that the foregoing is true and correct. Executed on June 18, 2018.

Peter Ewens
Executive Vice President, Corporate Strategy
T-Mobile US, Inc.

APPENDIX E: DECLARATION OF JOHN C. SAW
Chief Technology Officer, Sprint Corporation

DECLARATION OF JOHN C. SAW
Chief Technology Officer, Sprint Corporation

I. BIOGRAPHICAL INFORMATION

1. My name is John C. Saw. I am Chief Technology Officer for Sprint Corporation. In this role, I am responsible for technology development, network planning, engineering, deployment and service assurance of the Sprint network.

2. I have more than 30 years of technology development and engineering experience in the wireless industry. Prior to becoming Chief Technology Officer of Sprint in 2015, I served as Sprint's Chief Network Officer from 2014 to 2015, and I served as Senior Vice President Technical Architecture at Sprint from 2013 to 2014. Before Sprint's acquisition of Clearwire Corp., I was Chief Technology Officer of Clearwire Corp. and its predecessor companies since 2008. Between 2009-2010, I led the Clearwire team in building the first 4G network in North America based on WiMax technology, covering more than 130 million people. Prior to my position at Clearwire, I was Senior Vice President & General Manager of Fixed Wireless Access at Netro Corp. (now SR Telecom) after Netro's acquisition of AT&T Wireless' broadband wireless group in 2002. From 1997-2002, I was Chief Engineer and VP of Engineering at AT&T Wireless, and was instrumental in the development and rollout of AT&T Wireless' Digital Broadband wireless service. In April 2017, I was appointed to the Broadband Deployment Advisory Committee by Federal Communications Commission (FCC) Chairman Ajit Pai. Also, I currently serve on the advisory board to the Global TDD LTE Initiative (GTI), an international consortium. I hold a PhD in electrical engineering from McMaster University, Canada.

3. I hereby make this declaration.

II. SUMMARY

4. The proposed combination of T-Mobile and Sprint presents the opportunity to create a world-class 5G network that will have performance characteristics that are far superior to what either Sprint or T-Mobile could offer on its own. Sprint and T-Mobile hold extremely complementary network assets that can be combined to unlock tremendous benefits to network performance and user experiences. Compared to Sprint's standalone network trajectory, the combined company will have dramatically improved coverage, throughput, and capacity, as well as a superior scale and cost position. Sprint's network faces challenges arising from a number of factors, including: the limited number of cell sites with 2.5 GHz spectrum, the spectrum that is responsible for carrying the majority of our data traffic; a lack of sufficient low-band spectrum that prevents the company from providing ubiquitous coverage and consistency of network experience; and a lack of scale required to justify capital investment necessary to build a nationwide network. The transaction will result in a much stronger network that will deliver substantial benefits to customers and allow the combined company to lead in 5G.

III. SPRINT'S CURRENT NETWORK

5. Sprint's network supports voice services on 3G technology and data services on 4G LTE and 3G EVDO technologies. Today, Sprint's network consists of [redacted] macro cell sites, [redacted] enhanced small cells called "mini macros," [redacted] strand mounts (small cells that attach to cable company fiber strands), and approximately [redacted] "MagicBox" femtocells designed to be used inside the end customer premises.

6. Sprint does not own the macro cell sites in its network. Rather, Sprint leases space on macro cell sites from third-party tower companies, including American Tower

Company, Crown Castle, and SBA, at substantial expense. These tower companies charge Sprint to lease space on their towers based on the amount of space and weight required to hang the radio equipment.

7. Sprint's network utilizes spectrum in the 800 MHz (ESMR), 1.9 GHz (PCS), and 2.5 GHz (BRS/EBS) bands. With some exceptions along the U.S.-Mexico and U.S.-Canada borders and other smaller markets, Sprint holds approximately 14 MHz of 800 MHz spectrum nationally, which it uses to support 3G voice services on CDMA, as well as 4G LTE data services. Sprint is limited, however, to a single 5 x 5 MHz 4G LTE carrier in the 800 MHz band, leaving a mere 2 x 2 MHz to support some of our voice and 3G data traffic in this band. Our competitors each have a far greater amount of low-band spectrum available for 4G LTE data services, which has allowed them to provide better 4G LTE coverage. In addition, Sprint has not yet deployed VoLTE, but plans to do so in 2018. Until VoLTE is deployed, voice traffic will continue to be served on our 3G CDMA network in the 800 MHz and 1.9 GHz bands. Sprint holds the rights to an average of about 160 MHz of 2.5 GHz spectrum in the top 100 markets in the United States. 2.5 GHz spectrum serves as the source of most of our current 4G LTE capacity in our network. This large amount of contiguous spectrum can provide substantial capacity and throughput where it is deployed, including by supporting two-channel and three-channel carrier aggregation.[1] Today, Sprint has deployed 4G LTE on 2.5 GHz spectrum across [redacted] macro sites. Nearly every 2.5 GHz site uses either 40 MHz of spectrum with two-channel carrier aggregation or 60 MHz of spectrum with three-channel carrier aggregation.

[1] Carrier aggregation involves combining channels of spectrum to create a broader path for the transmission of data. On Sprint's network, two-channel carrier aggregation involves aggregating two 20 MHz channels of 2.5 GHz spectrum for a total of 40 MHz, while three-channel carrier aggregation involves aggregating three 20 MHz channels of 2.5 GHz spectrum for a total of 60 MHz.

While Sprint's 2.5 GHz spectrum can deliver high data speeds and support substantial capacity, it is limited in its propagation characteristics and ability to penetrate buildings compared to lower-band spectrum, such as T-Mobile's 600 and 700 MHz bands. Sprint also holds an average of 40 MHz of 1.9 GHz PCS spectrum nationwide. In addition to supporting voice and 3G data, this spectrum is also used to support 4G LTE in areas where 2.5 GHz is unavailable because it has not been deployed or because the end user's device cannot obtain a sufficiently strong signal to connect to 2.5 GHz. While available network capacity and utilization may vary across geographic areas, depending on factors such as network configuration, spectrum deployment, subscriber load, and usage, at the network-wide level, Sprint's aggregate carried traffic or delivered tonnage averaged across 2016 and 2017 was approximately [redacted] of its total available capacity.

8. Sprint uses a variety of network equipment vendors to support its radio access network. In particular, Sprint uses network equipment from Nokia, Ericsson, and Samsung. Because Sprint rolled out different layers of its LTE network at different times and across different spectrum holdings, in many regions it relies on multiple radio access network equipment vendors in the same geography. This has led to some challenges in aligning feature roadmaps in the same market between vendors and higher operational and optimization complexities than if Sprint had a single equipment vendor in these regions.

9. Because we lack the scale of our larger competitors, we do not have as many subscribers over which to spread out our network costs, particularly compared to AT&T and Verizon. Part of our network strategy involves seeking out lower-cost solutions that can deliver a high quality network experience. In 2015, Sprint faced significant financial challenges and adopted plans to substantially reduce our costs in order to improve our financial trajectory and

operational efficiency. As part of these cost reduction efforts, Sprint adopted plans to utilize alternative network investments that presented the potential to save on capital expenditure compared to traditional network strategies utilizing traditional macro sites on towers. Our alternative network solutions plan was designed to reduce our network costs by limiting reliance on high-cost traditional macro cell sites in favor of monopoles, which are macro cells hung on low-profile poles rather than towers, and enhanced small cells called mini macros to densify our footprint.

10. Sprint's plan to rely on these alternative network designs met a number of challenges that prevented the company from realizing the anticipated cost benefits. These challenges also delayed improvements to our network. In particular, the company faced substantial hurdles surrounding the implementation of monopoles due to zoning and regulatory approval requirements and resistance from localities that prevented the execution of the strategy. In 2015, Sprint anticipated that it would deploy about [redacted] monopoles under this plan, but as of late 2017, we were not able to deploy any. These challenges resulted in the cancelation of the monopole strategy. Sprint expected to save about [redacted] in operating expense by moving macro sites from towers to monopoles, but had to write off over [redacted] due to abandoned monopole sites. We also faced substantial challenges in deploying mini macros at the pace and scale we originally anticipated, due in large part to vendor problems and challenges accessing municipal infrastructure at reasonable rates and timeframes. These setbacks prevented Sprint from meaningfully improving its overall network coverage and quality during this timeframe, leading us to reconsider our network plan.

11. Today, Sprint is pursuing a network strategy that relies on a more traditional macro cell site-oriented approach that is supplemented by mini macros, strand mounts, and

MagicBox indoor femtocells. Sprint currently plans to spend approximately $5-6 billion in network capital expenditure per year between 2018 and 2020. We are focusing on densification and optimization of our 4G LTE footprint in metropolitan and suburban areas to improve network experience, building out new cell sites to expand coverage, and deploying massive MIMO equipment that will deliver 4G LTE capacity and launch 5G in our top markets. By 2021, we plan to have [redacted] macro cell sites, and [redacted] small cells in our network.

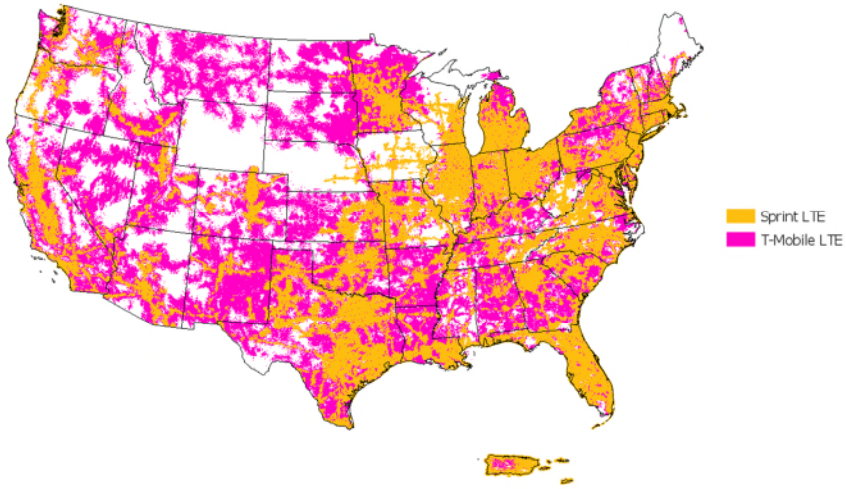
12. While Sprint holds attractive spectrum assets, our current network faces significant challenges. With only [redacted] current macro cell sites, Sprint has much less cell site density than Verizon, AT&T, or T-Mobile, which each have thousands more macro sites than we do (ranging from about 12,000 additional sites to over 20,000 additional sites). At a national level, Sprint's network footprint covers less geography and fewer POPs than that of Verizon, AT&T, or T-Mobile. The Sprint 4G LTE network covers about 302 million POPs, compared to about 322 million POPs for Verizon,[2] 317 million POPs for AT&T,[3] and 322 million POPs for T-Mobile[4] (based on the public statements and announcements of those carriers). The charts below illustrate that Sprint's 4G LTE network also does not cover nearly as much of the U.S. geography as is covered by these other networks.[5]

[2] Better Matters, Verizon, https://www.verizonwireless.com/featured/better-matters/ (last visited Jun. 11, 2018).

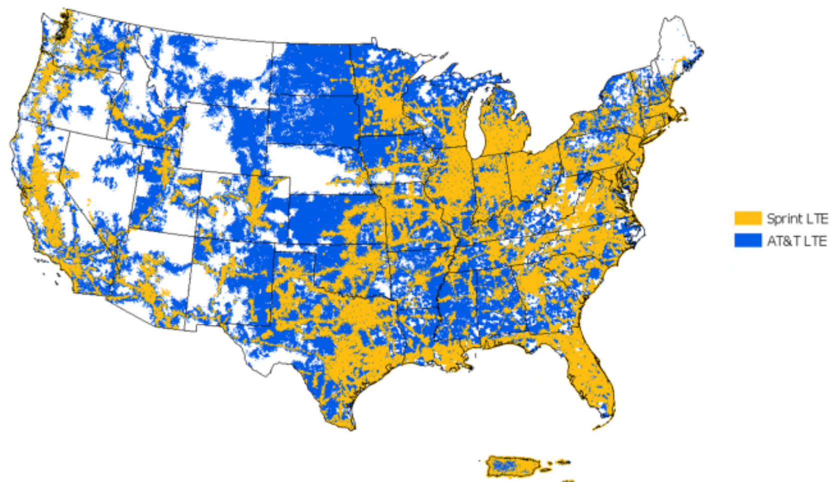
[3] Network, AT&T, https://www.att.com/offers/network.html (last visited Jun. 11, 2018).

[4] T-Mobile, Investor Factbook Q1 2018, at 6, *http://investor.t-mobile.com/Cache/1001236272.PDF*.

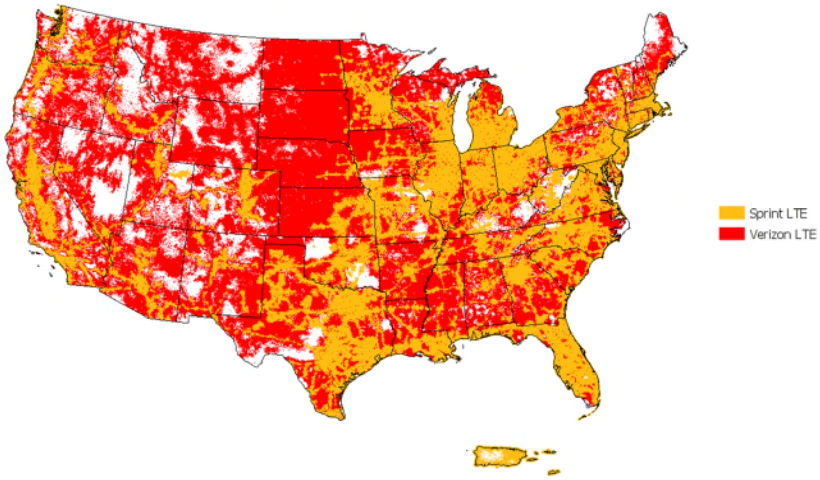
[5] The maps were generated using Mosaik data.



Sprint Coverage (Yellow) Versus T-Mobile (Magenta)



Sprint Coverage (Yellow) Versus AT&T (Blue)

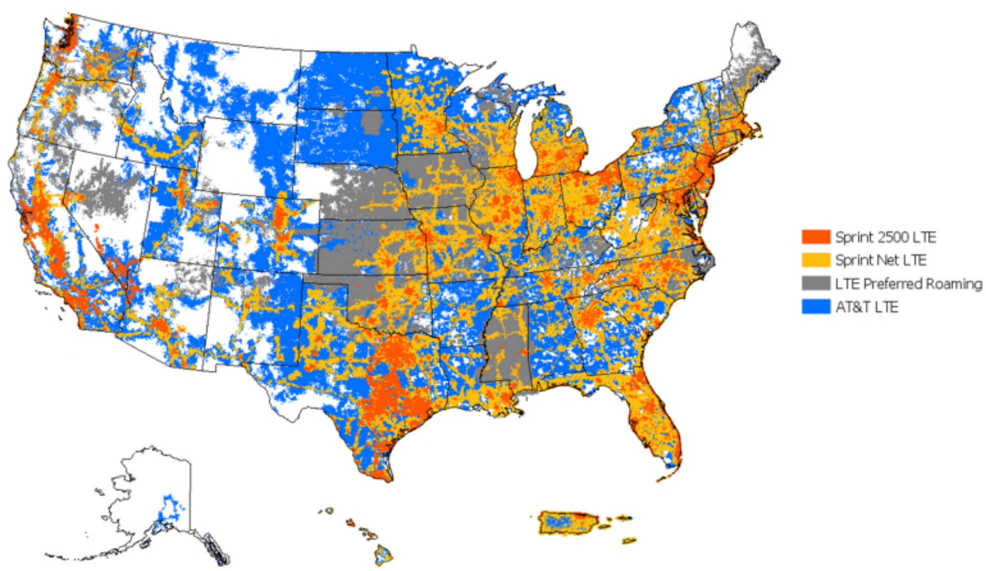


Sprint Coverage (Yellow) Versus Verizon (Red)

13. While Sprint's 4G LTE network covers about 302 million POPs, only about 208 million POPs are covered by Sprint's 2.5 GHz spectrum, which is the spectrum that provides Sprint's best data speeds. However, 2.5 GHz in-building coverage on our macro cell sites is lower and covers only about 133 million POPs because the 2.5 GHz spectrum does not penetrate buildings as well as lower-band spectrum.

14. Because our network covers fewer POPs and less geography than our competitors, we must rely on roaming arrangements to provide services outside of our network footprint, particularly in rural areas. Today, our largest roaming partner is [redacted] from whom we purchase voice roaming and 3G data roaming, but no LTE data roaming. We also have data roaming agreements with [redacted], as well as a variety of rural carriers. As of the date of the proposed transaction, we entered into a 4G LTE data roaming agreement with T-Mobile. Roaming arrangements provide customers service coverage in areas where they cannot access Sprint's network, but the subscriber network experience is typically inferior to what a customer

would receive on its home network for a variety of reasons, including the necessity to control Sprint's roaming expenses. This often results in substantially lower performance than average Sprint 4G LTE speeds within its footprint. For example, Sprint subscribers roaming on [redacted] do not have access to 4G LTE and experience data speeds of only 64 kbps, and Sprint subscribers roaming on [redacted] experience data speeds of only 256 kbps. To illustrate the geographical limits of Sprint's network footprint coverage, the chart below overlays Sprint's total 4G LTE coverage (yellow), our more geographically limited 2.5 GHz footprint (orange), our preferred roaming partner coverage (gray), and AT&T's LTE coverage (blue).[6]



Overlay of Sprint LTE, 2.5 GHz, Preferred Roaming, and AT&T LTE

15. Historically, Sprint's network performance has lagged other carriers in certain key metrics. For example, in 2017, several third parties that measure network performance, including Ookla and OpenSignal, ranked Sprint behind Verizon, AT&T, and T-Mobile in

[6] The map was generated using Mosaik data.

national LTE data download speed. A significant challenge for Sprint has been to create sufficient network density in our 2.5 GHz layer to offer a consistent high-speed 4G LTE user experience. Where we have sufficient 2.5 GHz coverage and density, we offer a very fast network and high quality user experience. However, because of the propagation characteristics of 2.5 GHz spectrum, as subscribers move around our network footprint, they often do not experience continuous coverage on our 2.5 GHz spectrum. When subscribers drop off of the 2.5 GHz spectrum, they experience much worse data speeds on our fallback 4G LTE layers on 1.9 GHz and 800 MHz, which have much less spectrum depth than the 2.5 GHz layer. This lack of a consistent and ubiquitous high-speed user experience across our network is a key reason for negative perceptions surrounding the Sprint network and network-related subscriber churn. Sprint has been working to densify and upgrade our network, but we will continue to face challenges. Because Sprint has limited subscriber scale and creating ubiquitous coverage with 2.5 GHz spectrum would be expensive and require extremely high cell site density, building a truly nationwide 2.5 GHz layer in terms of geographic coverage would not be economical or practical.

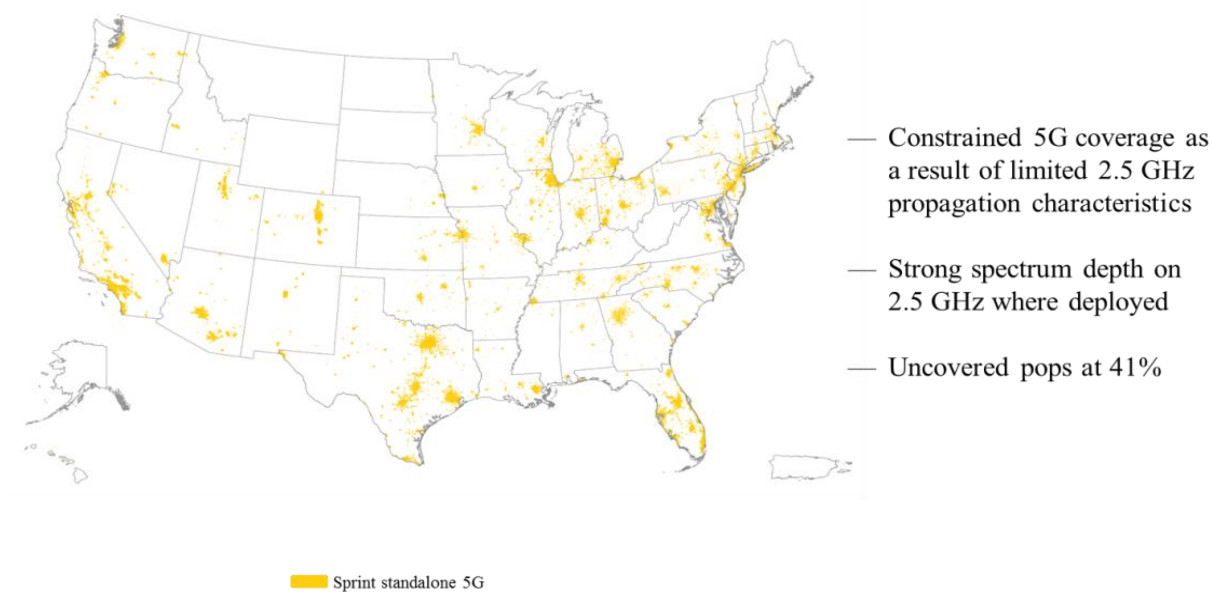
16. In recent years, Sprint has faced financial challenges and has pursued efforts to substantially reduce its costs, including network-related costs. The company also faces higher levels of subscriber churn, lower subscriber scale, and lower share of wireless industry EBITDA compared to other carriers, particularly AT&T and Verizon. Because of these factors, among others, Sprint has been unable to invest in its network at the same level of its competitors, resulting in a smaller footprint and lower site density, thereby impacting customer experience.

IV. SPRINT'S 5G PLANS

17. Sprint will launch 5G services in the first half of 2019 on its 2.5 GHz spectrum. We do not have plans to utilize our 800 MHz or 1.9 GHz spectrum for 5G at this time, largely because we must maintain our 4G LTE and 3G CDMA networks which utilize our 800 MHz and 1.9 GHz spectrum bands for the foreseeable future as 5G is gradually rolled out. Sprint's 5G services will initially be rolled out in nine metropolitan areas: Atlanta-Athens, Chicago, Dallas-Fort Worth, Houston, Kansas City, Los Angeles, New York City, Phoenix, and Washington D.C. Sprint's current board-approved network plan covers 2018 through 2022 and includes building out [redacted] 5G sites, with over [redacted] sites to be deployed in 2018, growing to [redacted] sites in 2019, and reaching [redacted] sites in 2020. These [redacted] 5G sites will cover approximately 150 million POPs. Thus, Sprint's initial 5G deployment plan will not be national in scope, but rather, will focus on population-dense metropolitan areas. For the foreseeable future, Sprint will not be equipped to offer ubiquitous nationwide 5G coverage.

18. The network model developed by T-Mobile to compare the combined company's anticipated 5G performance with that of each standalone network extends beyond our multiyear board-approved network plan and assumes that Sprint would continue to deploy more 5G sites over time beyond the [redacted] sites noted above, increasing to [redacted] in 2021, [redacted] in 2022, and [redacted] in 2023. These are realistic assumptions because if Sprint is able to successfully deploy [redacted] 5G sites by 2020, it is likely that the company would continue to roll out additional 5G sites if it is within our budget to do so. [redacted] massive MIMO sites would cover nearly 200 million POPs, allowing 5G services to cover areas that make up a large portion of the national U.S. population, but this would not equate to ubiquitous nationwide 5G coverage. Given Sprint's current network footprint, subscriber scale, the propagation characteristics of 2.5 GHz,

and lower population density outside of major cities and suburban areas covered by Sprint's network, it would not make business sense to build substantially more than [redacted] MIMO sites as a standalone company. The map below was generated from the network model developed by T-Mobile to compare the standalone networks to the combined company's network and shows estimated 5G coverage for Sprint in 2024.



Sprint Standalone Projected 5G Coverage in 2024

19. Sprint has been testing 5G "New Radio" (NR) equipment with vendors including Ericsson, Nokia, and Samsung. We have also been working with leading device OEMs on 5G-capable devices and currently have commitments from several top tier device manufacturers, with their first 5G devices expected to be available in the first half of 2019.

20. Sprint will deploy 5G NR radios utilizing massive MIMO technology. Massive MIMO is a next generation technology that incorporates multiple antenna elements on one radio in order to strengthen signals, provide greater capacity, and utilize beam forming, a technique which allows for greater precision in how data is directed and transmitted across the network.

Our massive MIMO equipment will allow us to provide large amounts of capacity in high-traffic locations, and deliver 4G LTE and 5G both separately and simultaneously on one radio. MIMO stands for "multiple input / multiple output" technology and has been in use in the industry for years. MIMO utilizes multiple antenna elements on one radio to improve performance. Our current 2.5 GHz radios deployed today use eight transmit and eight receive antenna elements (generally referred to as "8T8R"). In contrast, our massive MIMO radios will have a total of 128 antenna elements. Massive MIMO offers up to ten times more capacity per radio than traditional radios. Sprint's massive MIMO will allow for "split mode" deployments in which a single radio can transmit and receive over multiple protocols at once. Sprint's initial deployments of massive MIMO for 5G will utilize 64 transmit and 64 receive antenna elements (64T64R) in split mode to support both LTE and 5G NR simultaneously.

21. Split mode is possible on the Sprint network because we have deep spectrum holdings in 2.5 GHz, and a portion of the spectrum can be dedicated to each of 4G LTE and 5G. Thus, as 5G is deployed, a massive MIMO site can dedicate certain antenna elements to 4G LTE and certain antenna elements to 5G, including providing two simultaneous 32T32R sets of antenna elements dedicated to each of 4G LTE and 5G. These radios are cost-effective because they can be used to simultaneously enhance 4G LTE and deploy 5G and are software-upgradeable to 5G without additional tower climbs. In addition, Sprint can alter the proportion of spectrum dedicated to 4G LTE versus 5G through software.

22. Upon initial deployment of massive MIMO, Sprint will dedicate all deployed 2.5 GHz spectrum to 4G LTE on these sites prior to launching 5G. As we roll out 5G, we will initially deploy [redacted] MHz of 2.5 GHz spectrum for 4G LTE and up to [redacted] MHz for 5G in 2019. Over time, we will allocate more spectrum to 5G, but we would likely reserve [redacted] MHz of 2.5

GHz spectrum for 4G LTE through 2022 and reserve [redacted] MHz of spectrum for 4G LTE in 2023-2024. Thereafter, we would continue to move more spectrum to 5G, but would likely need to maintain some 2.5 GHz spectrum for 4G LTE for the foreseeable future. In markets where we have not deployed 5G, we will continue to use available 2.5 GHz spectrum for 4G LTE only.

23. While Sprint expects its 5G plans to deliver markedly better network performance in the areas where is it deployed, Sprint faces limitations in terms of what it can achieve as a standalone company compared to the combined company. Sprint's biggest challenge in deploying 5G is the same as its biggest challenge in deploying 4G LTE. Because we will rely on 2.5 GHz spectrum to carry most data-intensive traffic, we will not have a robust 5G coverage layer in all areas across the country. 2.5 GHz spectrum can provide enormous capacity and throughput where it is deployed, but it has much poorer propagation characteristics than low-band spectrum. Signals on 2.5 GHz spectrum cannot travel as far from a cell site or penetrate buildings as well as low-band spectrum. Therefore, subscribers are more likely to experience coverage gaps and a less consistent data experience than a similar network of cell sites built with low-band spectrum. 2.5 GHz spectrum must be built out very densely if it is to provide wide areas of coverage and consistent user experience. However, building out 2.5 GHz densely enough to support a ubiquitous nationwide 5G network would be very challenging, expensive, and impractical for us as a standalone company, particularly in lower-population and rural areas outside of major metropolitan areas. Without sufficient customer scale or population density to justify investment, 2.5 GHz cannot adequately serve alone as a ubiquitous coverage layer in a nationwide 5G network.

24. For the foreseeable future, Sprint will not have 5G service on low-band spectrum because its 800 MHz spectrum will continue to support 3G voice and 4G LTE, and Sprint's 800

MHz holdings are extremely limited and therefore not substantial enough to support 4G LTE while simultaneously harvesting spectrum for 5G. Where a 2.5 GHz signal for 5G/4G is not available, users will drop down onto our 1.9 GHz or 800 MHz 4G LTE network. The performance gap between the 5G experience and this fallback 4G LTE network, which does not benefit from multiple 20 MHz-wide carrier aggregation or the same spectrum depth as our current 2.5 GHz 4G LTE layer will be substantial. Our customers in this situation may see about a 10x drop in speed. Thus, while our 5G network will provide a greatly improved user experience compared to the 4G LTE services we currently offer, the network experience will not be consistent across our footprint.

IV. THE TRANSACTION WILL CREATE A DRAMATICALLY IMPROVED NETWORK AND ACCELERATE 5G DEPLOYMENT

25. The combination of Sprint's and T-Mobile's network assets will allow the combined company to offer a much stronger 5G offering in terms of coverage, capacity, and throughput than either company could achieve on its own. The key driver of the enhanced performance of the combined network is combining complementary spectrum of the companies and deploying them in a dense network. A network that can utilize each of low-band, mid-band, and high-band spectrum can unlock much more value and performance on 5G technology than a network that is limited to only mid-band spectrum (2.5 GHz), in the case of Sprint, or to only low-band (600 MHz) and high-band (mmWave) in the case of T-Mobile.

26. Sprint's 2.5 GHz spectrum provides an excellent capacity layer to support high data speed and large amounts of traffic, but does not provide a suitable coverage layer that will ensure the ubiquity of a 5G signal. T-Mobile's 600 MHz spectrum lacks the capacity advantages

of 2.5 GHz but it can provide a strong ubiquitous coverage layer over a wide area. In addition, T-Mobile's high-band mmWave spectrum holdings will also provide additional capacity in areas of very high demand and increased throughput, but will have much worse propagation characteristics than mid-band or low-band spectrum, limiting its coverage area. Thus, the combined company will have highly complementary spectrum assets that can deliver both nationwide coverage and enormous capacity and throughput that will unlock a network experience that is superior to what either company could provide alone.

27. Under the integration plan, the combined company's network will be anchored on the existing T-Mobile network of cell sites. This approach will allow the combined company to take advantage of T-Mobile's much denser cell site network and supplement the network with Sprint macro cell sites in areas where it would be advantageous to have additional capacity or density of coverage to provide a better network experience. The current network integration plan calls for integrating about 11,000 Sprint macro sites into the combined network.

28. Anchoring off of T-Mobile's network provides an efficient way to integrate the networks because radios utilizing Sprint's spectrum bands can be added to existing T-Mobile cell sites, which already form a denser network than Sprint's current network. In addition, adding Sprint radios to T-Mobile cell sites can be achieved at a lower cost per site and on a faster timeframe than what Sprint could achieve by building out new macro sites to match the same footprint as T-Mobile. This is because network equipment can generally be added to existing sites at significantly lower costs and faster timeframe than permitting and constructing completely new sites.

29. Integrating Sprint's and T-Mobile's complementary network assets will also allow the combined company to dedicate more spectrum to 5G on a faster timeline than Sprint or

T-Mobile could do on its own. Because Sprint subscribers will be able to utilize T-Mobile's strong 4G LTE network upon closing, there will be less need to dedicate 2.5 GHz spectrum to 4G LTE. While Sprint has enough 2.5 GHz spectrum to run 5G and 4G LTE networks in split mode, there is substantial opportunity cost in not dedicating the entirety of available 2.5 GHz to 5G. If Sprint could dedicate the entirety of the 2.5 GHz spectrum band to 5G, we would be able to roll out 5G in a standalone mode and deliver significantly lower latency versus today's LTE network. This is because the 5G airlink interface in standalone mode (i.e. 5G NR SA mode) will have a much lower latency than 4G LTE. In addition, utilizing all of Sprint's available 2.5 GHz spectrum for 5G would provide much greater capacity and throughput to the network than using only a portion of the spectrum while simultaneously supporting 4G LTE. Under our current 5G plans, for the foreseeable future, Sprint will not be able to launch 5G with standalone mode on the 2.5 GHz band, but rather will support LTE alongside 5G. However, the network plan for New T-Mobile allows for dedicating all available 2.5 GHz spectrum to 5G by 2022.

30. The network integration plan also contemplates installing 2.5 GHz 5G on many T-Mobile sites, resulting in over [redacted] cell sites with 5G on 2.5 GHz spectrum. Thus, the combined company will deploy 5G on 2.5 GHz in more places than Sprint would on its own. The new company will benefit from a much larger subscriber base and bigger 5G coverage footprint, making building out a denser 2.5 GHz 5G network more economical than it would be for Sprint to do on its own.

31. A critical benefit of the transaction for Sprint subscribers will be the dramatic increase in 5G coverage, owing to the new company's 600 MHz spectrum. On its own, Sprint would not be able to attain ubiquitous nationwide 5G coverage because of the lack of sufficient low-band spectrum nationwide. T-Mobile's 600 MHz spectrum will provide a very broad 5G

layer that will allow customers to continue to receive a 5G signal when they have moved outside of the coverage area for 2.5 GHz spectrum. This means that Sprint's subscribers will have access to wireless services in many more areas, including in rural areas, where Sprint currently has a very limited footprint. The limitations of Sprint's current coverage compared to other carriers is particularly stark in rural areas where it is difficult to justify incremental network investment due to limited population density and challenges associated with building out 2.5 GHz spectrum. The combined network will provide substantially better 5G and 4G coverage than what Sprint could provide on its own.

32. In addition to better coverage, the ability for the combined company to utilize complementary low-, mid-, and high-band spectrum and deploy more spectrum on more sites will improve signal strength and provide a much more consistent data experience than subscribers would experience on Sprint's standalone network. Simply put, more subscribers will experience high data speeds with greater frequency because the combined network will be much denser than Sprint's standalone network and more 5G spectrum will be available. It would be infeasible as a matter of cost and operational practicality for Sprint to build a 2.5 GHz network with the same capacity, coverage, and quality characteristics of the combined network.

33. Sprint subscribers will begin to realize network benefits of the transaction almost immediately upon closing. Approximately 20 million Sprint subscribers will be able to access the T-Mobile network as of day one of the integration because they already have handsets that are compatible with T-Mobile spectrum. These customers use devices that can connect to T-Mobile's PCS and AWS spectrum bands. In addition, recent phone models such as the Samsung Galaxy S9 may be able to connect to T-Mobile's 600 MHz spectrum band. Thus, many Sprint customers will be able to very quickly utilize both the Sprint and T-Mobile networks, providing

enhanced coverage and better user experience. The ability of many Sprint subscribers to utilize the T-Mobile network will also facilitate faster harvesting of 2.5 GHz spectrum for 5G because these subscribers will enjoy a robust 4G LTE experience on T-Mobile's network.

34. Sprint and T-Mobile have entered into a roaming agreement that allows for customers with compatible devices to roam on T-Mobile's network. However, the roaming agreement is quite limited in scope compared to the full integration of the networks. The agreement limits the amount of traffic Sprint can put onto the T-Mobile network based on congestion and also limits the number of simultaneous Sprint users that can access the T-Mobile network. In addition, the roaming agreement includes LTE data only (no voice or 5G) and prevents Sprint from using T-Mobile's [redacted] in many areas because the agreement only allows Sprint to roam on [redacted]. While the agreement does cover the [redacted] is limited so far and there are not many devices in the Sprint customer base today that can access it. Thus, the roaming agreement will not provide the coverage benefits associated with fully accessing T-Mobile's currently deployed low-band spectrum and will not improve Sprint's 5G offering. The benefits of combining the networks will provide a much more cohesive and seamless user experience and will create a truly nationwide 5G network with performance that Sprint could not achieve on its own.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct. Executed on June 18, 2018.

Signed: ____________________
Chief Technology Officer
Sprint Corporation

APPENDIX F: DECLARATION OF BRANDON "DOW" DRAPER
Chief Commercial Officer, Sprint Corporation

DECLARATION OF DOW DRAPER
Chief Commercial Officer, Sprint Corporation

I. BIOGRAPHICAL INFORMATION

1. My name is Brandon "Dow" Draper. I am Chief Commercial Officer for Sprint Corporation. In this role, I am responsible for commercial strategy, including marketing and sales for the Sprint, Boost Mobile and Virgin Mobile brands.

2. I have more than 13 years of business and financial planning experience in the wireless industry. Prior to becoming Sprint's Chief Commercial Officer in 2017, I served as President of Sprint Prepaid Group, which included brands such as Boost Mobile, Virgin Mobile and Sprint Prepaid from 2013 to 2016. As President of the Sprint Prepaid Group, I expanded the contract-free business and implemented marketing strategies to keep the company's prepaid brands value-driven and competitive. In late 2014, I also assumed responsibility for managing business development for Sprint's Wholesale segment. Before joining Sprint in 2013, I served in several management roles at Clearwire Corp. I was Senior Vice President (SVP) and General Manager of Retail at Clearwire from 2011 to 2013, and I was Vice President for Product Development and Innovation from 2009 to 2011. Before Clearwire, I held various positions at Alltel Wireless, including SVP of Device and Data Services and SVP of Financial Planning and Analysis. There, I played an integral role in the sale of Alltel to TPG Capital and Goldman Sachs for $25 billion. I have also held executive positions at Western Wireless and McKinsey & Company. While at McKinsey, I was involved in strategy and marketing engagements for various industries, including software, automotive, commercial aviation and telecommunications. I hold a BS in Business from the University of Colorado at Boulder and an MBA from the Kenan-Flagler Business School at the University of North Carolina at Chapel Hill.

II. THE EVOLUTION OF SPRINT'S STANDALONE BUSINESS

3. Just a few years ago, Sprint was in dire financial straits. It lagged behind other carriers in deploying 4G LTE and was forced to invest many billions of dollars on its network just to try to catch up with competitors who were well ahead in the next generation wireless network capabilities. Sprint was losing subscribers and not generating the cash needed to support vital capital investments without incurring billions in new debt. In short, Sprint's path was unsustainable.

4. Under Marcelo Claure's leadership, however, Sprint has become a more stable company financially than it has been in a very long time. In 2017, we became net income positive for the first time in 11 years and achieved positive metrics across several other financial performance measures such as operating revenue, EBITDA growth, and free cash flow. Through a series of difficult but necessary transformations and workforce reductions, Sprint has taken out billions of dollars in costs and adopted aggressive measures to attract and retain subscribers. The aggressive promotions we have undertaken in an attempt to gain scale have pressured our ability to invest in the network (and have not generated the desired growth we need to get to a scale that supports increased network investments). This financial stability has thus been achieved, in part, through shrinking the size of the company and reducing our network investment to historically low levels.

5. Indeed, the financial stabilization we have achieved is just that: stabilization. To move forward from here, Sprint needs to invest more in its network. Sprint has plans to invest $5-6 billion per year over the next three years in massive MIMO, small cells, tower upgrades, and new towers to increase our deployment of 2.5 GHz spectrum and to roll out 5G services in several major urban centers beginning in 2019. But, as we ramp up our capital spending in FY18, we expect significant pressure on free cash flow, and even with this accelerated

investment we still are unable to spend at parity (Network Capex per subscriber) with Verizon and AT&T, much less “catch up” from previous underinvestment. And, as we put more investment into our network it inevitably means that we must be less aggressive in the pricing and promotions we offer in the marketplace. Moreover, as a standalone company, even with this investment Sprint will not be able to come close to matching the capabilities of New T-Mobile to compete and win in the marketplace.

6. As a standalone company with the worst scale among major carriers, in order to sustain the company, we will now need to be much more focused with our investments, which will necessarily be more regionally focused. Efforts to attract and retain customers will be tempered by our need to preserve cash flow required to support the massive investments we still need to improve the quality of our 4G LTE network while also beginning to roll out 5G. As a result, we will be a far less aggressive competitor and our financial plan absent this transaction reflects steadily increasing ARPU for Sprint each year for the foreseeable future.

III. EVEN WITH INCREASED INVESTMENT, SPRINT’S NETWORK CHALLENGES WILL LIMIT ITS POTENTIAL

7. Sprint continues to work to improve its network to meet the needs of its customers, and we have steadily been improving our network, with more investment to come. But alone, Sprint faces severe challenges arising from our lack of scale, our legacy-CDMA technology, and our limited ability to materially improve our network coverage, including in less-densely populated suburban, exurban, and rural areas, and in-building network coverage except in urban areas where we have our most dense network coverage. Standalone Sprint will never be able to achieve the kind of network coverage, capacity, and performance that would be unlocked by the combination of Sprint and T-Mobile’s complementary assets and scale. This

combination enables New T-Mobile to offer unmatched coverage, capacity, and quality, both for LTE and for 5G, bringing compelling value propositions to wireless customers.

8. One significant limitation is Sprint's continued reliance on CDMA technology. Handset manufacturers are making fewer and fewer CDMA-compatible phones. And as a result, Sprint customers are limited to only a fraction of handset devices as compared to SIM technology-based carriers. This same issue also limits Sprint's ability to win customers who do not want to part with their current handset (e.g., Bring Your Own Device or "BYOD" promotions), since only those with CDMA-compatible handsets can bring them onto the Sprint network.

9. A more fundamental limitation is Sprint's limited portfolio of low- and mid-band spectrum. While Sprint has low- and mid-band spectrum, it has only thin layers that pose significant capacity challenges and impede network performance and quality. Customers whose activities bring them into areas with good coverage by Sprint's 2.5 GHz spectrum experience a high-quality network with a lot of capacity. However, this spectrum does not propagate as far as low band spectrum and has relative weaknesses at delivering a good signal inside buildings where Sprint does not have an adequately dense network. The poor in-building propagation of our spectrum is a particularly significant disadvantage as most consumption of wireless data occurs indoors.

10. Because of Sprint's limited low-band spectrum resources, and lack of scale to support more dense deployment of 2.5 GHz spectrum in less-populated areas, like exurbs and rural America, Sprint will continue to be unable to offer a robust network alternative to Verizon and AT&T for the 60 million wireless customers in these areas.

11. At a national level, Sprint's network footprint covers less geography and fewer POPs than Verizon and AT&T, and it will continue to do so into the future. Sprint's current LTE network covers around 302 million POPs, but only 208 million POPs are covered by Sprint's 2.5 GHz spectrum that provides high capacity and competitive data speeds. These numbers are even lower when accounting for in-building coverage, where only 133 million POPs have 2.5 GHz spectrum coverage.

12. Because of the limited reach of Sprint's own network, we must rely on roaming arrangements to provide services outside our network footprint. These roaming agreements are extremely expensive and often lead to a poor customer experience as Sprint must reduce throughput in order to afford offering a nationwide network to its customers, which is often a requirement of consumers considering any wireless provider.

13. While Sprint has worked hard and has considerably improved its network, the reality is that Verizon and AT&T are still considered the gold standards for network quality. Historically, Sprint has scored poorly in measurements of customer satisfaction, and its network and data performance metrics have significantly lagged behind those of Verizon and AT&T. For example, in 2017, several third parties that measure network performance, including OOKLA and OpenSignal ranked Sprint behind Verizon and AT&T in nearly all performance-related categories in major national markets, including metrics particularly relevant to the consumer experience such as data download speed.

14. This lack of coverage and lack of a consistent, high-speed user experience in many places where Sprint does offer coverage leads to Sprint having the highest network-related churn among major carriers. In 2017, Sprint's postpaid phone churn rate was 1.60%, around twice that of AT&T's and Verizon's rates, which were 0.86% and 0.78%, respectively. These

numbers indicate customer dissatisfaction with the Sprint network, and Sprint has recognized that a major driver of its comparably higher churn is related to customers' network quality of experience.

15. Sprint has a plan to deploy 5G network technology and intends to offer a mobile 5G service beginning next year. Sprint may lead the market with a truly mobile 5G offering, but its plan anticipates a limited 5G build over time that will lack broad coverage, both due to limitations on Sprint's 2.5 GHz spectrum and Sprint's financial capabilities. These constraints mean that the maximum 5G deployment covers just 50M PoPs by mid-2019, 130M by mid-2020, and 150M by 2020. Further complicating our 5G competitiveness is the fact that tower prioritization for Massive MIMO deployment is largely driven by capacity demands on our existing 4G LTE network. This means that while our network may cover 150 million PoPs with a 5G signal in 2020, it will not be contiguous everywhere and our actual "marketable" 5G footprint will be much smaller.

IV. SPRINT'S AGGRESSIVE PRICING AND PROMOTIONS HAVE NOT PROVEN EFFECTIVE AT ACHIEVING PROFITABLE SUBSCRIBER GROWTH

16. With its limited financial resources, Sprint has prioritized its investment over the last three years in promotional discounts and has underinvested in the network. This strategy was not successful in improving the scale of the business and cannot continue.

17. Sprint principally targeted its advertising and promotional campaigns at Verizon and AT&T. Those carriers are the obvious targets because between them they have almost 190 million customers, or around 70% of U.S. subscribers. Even with churn rates under 1%, when applied against their huge customer base, AT&T and Verizon represent the largest sources of opportunities to gain new subscribers that are seeking to switch wireless providers.

18. Sprint's recent efforts to win subscribers from Verizon and AT&T have been aggressive, but they have not been effective. Sprint's recent marketing efforts have targeted Verizon in particular. Sprint developed marketing campaigns featuring Paul Marcarelli, Verizon's former "Can you hear me now?" spokesman and launched a marketing campaign targeting Verizon customers. In Sprint's "Paul Switched" campaign, Sprint benchmarked its network and pricing against Verizon's pricing.

19. Sprint also launched a campaign aimed at Verizon customers offering 12 months of free "Sprint Unlimited" service, including unlimited talk, text messaging, 4G LTE data, HD streaming video, and 10 gigabytes of data per line for mobile hot spot access each month. Sprint has continuously promoted prices that saved Verizon customers hundreds of dollars a year (e.g., even promotions offering 50% off Verizon prices), yet Verizon customers who port in to Sprint tend to port back to Verizon at a significantly higher rate than Sprint's other competitors. Thus, the savings through price discounting has not been enough to offset either real or perceived network differences. The net results show in almost every month of 2017 and 2018 Sprint lost more customers to Verizon than it gained from Verizon.

20. The results against Verizon are disappointing, but the story is not significantly different when comparing against AT&T. Although we have largely stabilized our customer losses, we have not driven sustained growth in our subscriber base or lowered churn—and as a result we have actually lost market share—over the same period that we have been using these aggressive customer acquisition strategies. Sprint continues to have the highest churn among the major carriers and is the only carrier with a rising churn rate. Most disappointing, even with our very aggressive promotional pricing, Sprint survey data show that we are consistently ranked last in customer perception of which wireless competitor provides the "best value."

V. SPRINT FACES MANY CHALLENGES AS A STANDALONE COMPANY THAT LIMIT ITS ABILITY TO BE AN AGGRESSIVE NATIONWIDE COMPETITOR

21. To improve our ability to attract and maintain subscribers, we must improve the perception of our network. But we are limited here as well. Paralleling other cost-saving initiatives, the amount Sprint spent advertising products and services has declined over the past three years as a part of its overall necessary cost reduction efforts, from $679 million in 2015, and $561 million in 2016, to just $494 million in 2017. This pales in comparison with our principal rivals. Over the last three years, while Sprint was spending $1,734 million on advertising to promote our products and combat negative customer perceptions about our network quality, Verizon spent twice as much ($3,130 million), often focusing on the superiority of its network. During that same period the other major carriers outspent Sprint by an average of around $500 million: AT&T spent $2,308 million; and T-Mobile spent $2,103 million. Sprint lacks the scale and financial resources to advertise anywhere near as extensively as those carriers—so even were Sprint to succeed in improving its network, it would face an uphill battle to shift customer perceptions about network quality.

VI. THE GAP BETWEEN SPRINT AND AT&T AND VERIZON WILL WIDEN WITHOUT THE TRANSACTION

22. Sprint is currently in the fourth year of our five-year "Sprint Now" plan to address our commercial challenges by cutting costs while simultaneously working to improve our network. Despite significant success in reforming our cost structure and ongoing efforts to improve our network, Sprint's ability to challenge AT&T and Verizon as a standalone firm will continue to be constrained by our lack of scale and distribution, network quality, high churn, and limitations on Sprint's ability to make simultaneous investments in its network, brand, and

customer promotions. A huge and increasingly insurmountable gap remains between Sprint and both AT&T and Verizon.

23. AT&T and Verizon continue to account for the vast majority of mobile wireless subscribers. Verizon and AT&T maintain shares of mobile wireless service revenues of about 37% and 33%, respectively, compared to less than 14% for Sprint. AT&T and Verizon also continue to account for the majority of EBITDA, free cash flow, and revenue. In 2017, AT&T and Verizon accounted for approximately 80% of adjusted wireless EBITDA, and each of Verizon and AT&T had EBITDA nearly twice that of the combined EBITDA of Sprint and T-Mobile.

24. Despite the stabilization of Sprint's finances over the past few years, Sprint's ability to drive competition is limited, and faces even greater challenges absent the combination with T-Mobile. Sprint's service revenue has been declining for at least the last five years, falling around 25% from 2013 to 2018. And while net adds have nominally increased, the number of net adds without the "free lines" from Sprint promotions has decreased, and the net number of accounts has decreased as well.

25. AT&T and Verizon also have much larger distribution networks, which serve to drive customer acquisition and retention (through branding, convenience, and improved customer service experiences) for AT&T and Verizon. For example, Verizon currently has around 6,500 Verizon-branded stores for distribution and AT&T has around 5,000, compared to Sprint's 3,700 stores. Not only has Sprint fallen behind in retail distribution, but for new stores it has opened – the payback on that investment is exceedingly long (if it's even positive), driven by low customer addition and retention rates. This reality makes it infeasible for Sprint to invest

what it would need to in order to open sufficient stores to meaningfully close the distribution gap with AT&T and Verizon.

26. All of this translates into the ability for AT&T and Verizon to reinvest significantly higher levels of capital back into their networks, their distribution and marketing, and their brands. In 2017, Verizon and AT&T each invested about four times more in their networks than Sprint.

27. Sprint has committed to continue to increase the capital investment in its network. However, its CapEx per subscriber, $62 in 2017, is still significantly behind that of AT&T ($102) and Verizon ($90) and in no manner addresses the prior years of deficient spending. Sprint will not be able to close the coverage, breadth, and performance gap with AT&T and Verizon without the ability to match or exceed their network spending.

28. More importantly, Sprint cannot continue to invest unless it begins to generate incremental free-cash flow from its business, another area where AT&T and Verizon have massive advantages. Sprint's current net debt is approximately $32 billion. Sprint is not only leveraged higher than AT&T and Verizon, but is the most highly leveraged company in the S&P 500. And though Sprint's transformative cost reductions have yielded positive free cash flow for the first time in many years that result was achieved only during a period of suppressed spending on network capital during 2016-17. In short, even with Sprint's business transformation and improved cost structure, Sprint's debt burden and lack of scale and profitability mean that we do not have the capacity to simultaneously increase investment in the network and continue aggressive promotional activity.

29. As a result, our standalone plan does not position Sprint to become a more effective competitor against Verizon and AT&T on a nationwide basis. Our 5G investments will

necessarily be narrowly focused geographically, and we will need to earn returns sufficient to pay back that spending. Unlike New T-Mobile, which will unlock compelling new capacity and capabilities to challenge Verizon and AT&T aggressively nationwide (in urban, exurban, and rural areas), that is simply a path that is not available to Sprint on a standalone basis.

30. A combination with T-Mobile will allow the combined firm to immediately become a more effective competitor in LTE, and to develop a superior 5G network. The combined company will have the highest quality network and the scale, resources, and access to capital necessary to continue to disrupt the market by aggressively competing with AT&T and Verizon and offering wireless customers even better value for their money.

VII. COMPETITION FOR ENTERPRISE AND GOVERNMENT CUSTOMERS

31. Largely due to the network quality and network quality perception issues facing Sprint described above, Sprint has been unable to meaningfully compete for the roughly 40 million customers who contract for wireless services through their employer. This enterprise segment represents about $180 billion in annual revenues and is dominated by AT&T and Verizon. Sprint estimates that it has low single digit share of the total wireless enterprise business.

32. Enterprise and government customers make sophisticated, informed judgments and are highly sensitive to network quality and security characteristics. As such, Sprint is significantly disadvantaged in competing for these contracts due to customer concerns about the quality and geographic coverage of Sprint's network. For enterprise and government customers, as with so many others, there are only two network choices for them today: AT&T and Verizon.

33. Whereas Sprint, along with T-Mobile, individually have been unable to overcome these limitations to meet the demands of enterprise and government customers or meaningfully compete with AT&T and Verizon, New T-Mobile will be able to provide real competition to

AT&T and Verizon in these segments for the first time. By offering an improved LTE network and the best 5G network, and with the subscriber scale to invest more in its business than either predecessor company can alone, New T-Mobile will be able to provide these customers with the services they require and give consumers a viable third competitive option.

VIII. COMPETITION OUTSIDE OF TRADITIONAL WIRELESS SERVICES, INCLUDING IN-HOME BROADBAND, VIDEO DISTRIBUTION AND IoT

34. Traditional industry lines are blurring as wireless providers begin to provide subscribers with proprietary content and traditional content providers like cable companies are moving to offer their subscribers wireless telephony. As the industry converges around it, Sprint generally lacks the scale, infrastructure, and financial resources to join the competitive fray with traditional cable providers and Multichannel Video Programming Distributors (MVPD) in these segments.

35. Wireless broadband service is trending towards more direct competition with fixed wireline broadband, both through wireless in-home broadband "replacement" options, and the "substitution" of mobile for in-home broadband altogether. However, Sprint currently cannot offer the speed or capacity necessary to compete with wireline broadband and has no current plans to launch in-home fixed wireless broadband services. Sprint can target limited use cases, or cases of extremely limited geography, but generally lacks the scale or resources necessary to deploy the type of network necessary to provide true in-home broadband replacement or a mobile wireless substitute that could support the highest quality video and other key applications customers demand.

36. Sprint has had limited success bolstering its value proposition by combining its traditional services with compelling video content. As a standalone company, Sprint does not have the size or scale to independently expand its offerings to compete with AT&T and Verizon

who have the ability to both vertically integrate into content channels and form numerous strategic alliances with content providers. For example, Verizon has pushed aggressively into content and digital media, including strategic acquisitions of AOL and Yahoo and partnerships with Vice, Viacom, ESPN, CBS Sports, and the NFL. AT&T, for its part, acquired DIRECTV, and its proposed merger with Time Warner would only further increase its content integration.

37. Sprint has had some one-off video partnerships, such as its agreement with Hulu to provide Sprint customers with access to Hulu's library of movies and television shows on their mobile devices. However, these partnerships have not driven meaningful share to Sprint or shifted customer perception of the company's offerings. Sprint has no current plans to move more significantly into offering video content.

38. Sprint has expanded its IoT offerings, including the appointment of Ivo Rook to lead a business segment focused on IoT solutions in September 2017. However, Sprint still has a low share in the emerging IoT segment as compared to other wireless carriers, particularly Verizon and AT&T, and has struggled to launch competitive IoT products in part due to its lack of sufficient low-band spectrum as well as OEMs resistance to support CDMA-based products. Because of its spectrum limitations, standalone Sprint will struggle to offer the kinds of massive IoT deployments contemplated in the 5G era.

39. The combined spectrum depth, coverage and scale of Sprint and T-Mobile will enable the new company to more effectively compete in these areas and drive competition in key segments outside of wireless services, including the ability to offer a more a competitive broadband replacement to customers and to compete against cable, satellite and other pay television and content providers with new and innovative video distribution models, and a more competitive and robust IoT offering supported by a vastly superior 5G network.

*   *   *

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct. Executed on June 15, 2018.

Signed: ______________________
Chief Commercial Officer
Sprint Corporation

APPENDIX G: DECLARATION OF DAVID S. EVANS, Ph.D
Founder, Market Platform Dynamics

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EXECUTIVE SUMMARY

1. T-Mobile's merger with Sprint (the "Transaction") will result in the faster deployment of a more robust 5G network, which will provoke an industry-wide increase in wireless network capacity. This dynamic competition among the carriers will cause a substantial decline in the price per gigabyte (GB) of cellular data for mobile subscribers, dramatically improve network quality, and spur the development of new wireless applications.

2. During the last three decades, cellular carriers have invested in successive generations of cellular technologies. Dynamic competition has pushed each carrier to match and surpass the deployment of more capacious and better performing networks, because failing to do so would risk losing substantial numbers of customers. The history of the deployment of 3G and 4G networks in the United States shows that carriers compete with each other to deploy new technology. Generally, one carrier makes the first move to the new technology, inducing other carriers to follow. The carriers then compete to finish robust, nationwide deployments of the new technology. Cellular carriers that fall behind face competitive disadvantages. Knowing this, carriers have made substantial investments over time to try to match and surpass each other.

3. Quantitative and qualitative evidence shows that each wave of technology has resulted in massive economic benefits. For mobile subscribers, those benefits came from vast increases in the supply of cellular data, which have translated into greater consumption of online content and services, exponential declines in the price per GB of cellular data, and faster and more reliable networks. Critically, investments in network capacity and performance have determined the contours of the packages that the carriers offer to subscribers, including fees and data limits. Cellular carriers prominently feature network quality indicators that result

and data limits. Cellular carriers prominently feature network quality indicators that result from these investments, such as average data speeds, in their marketing. In addition, network performance improvements have induced the development of new apps and app features that improve the breadth and quality of Internet-based services obtained and thereby increase value for mobile subscribers. This dynamic competition among the carriers has been the main driver of industry supply, prices, and quality.

4. The cellular industry is now at an inflection point for next generation 5G cellular technology. Previous generations have focused primarily on mobile phone applications. As with previous generations of cellular technology, 5G will provide immense benefits for mobile phone subscribers through vastly higher data speeds, faster response times, and more network capacity than 4G LTE networks. But 5G will also reach far more broadly into the economy. The real-time, always-on, high-capacity, and highly reliable connections enabled by 5G will make it a critical input for new and innovative products and services used by consumers, enterprises, and governments.

5. Given the impact of the Transaction on the deployment of 5G networks across the industry, the two-year time period often considered in merger review is too short to evaluate the Transaction's competitive effects and its effects on the public interest. The pace of the transition to 5G and the strength of the 5G networks deployed are the main determinants of the Transaction's effects on consumers. Sound economic principles therefore favor considering the effects of this Transaction over the time period covering the industry's transition to 5G networks. It is appropriate to focus on the evolution of prices, output, and network quality over a longer time period.

6. My analysis is predicated on projections, prepared by T-Mobile, of the cellular networks that New T-Mobile and each of the stand-alone companies would deploy, based on profit-maximizing behavior and engineering considerations. The record evidence shows that the stand-alone companies would deploy weaker versions of 5G networks than New T-Mobile, given their individual network investment and spectrum limitations. The Transaction will result in substantial reductions in fixed and marginal costs of 5G deployment, flowing from combining complementary spectrum assets and cell sites and taking advantage of considerable infrastructure synergies. As a result of these efficiencies, New T-Mobile will consequently be able to deploy a much stronger 5G network sooner. On a non-quality-adjusted basis, by 2024, New T-Mobile will have almost twice the network capacity as the stand-alone companies combined. New T-Mobile would have, by 2024, a national total capacity of 23.7 exabytes (EB) per month (EB/month) compared with [redacted] EB/month for the two stand-alone companies combined ([redacted] EB/month for T-Mobile and [redacted] EB/month for Sprint).[1] The quality-adjusted capacity of New T-Mobile would be even greater because of the substantial improvements in network performance.

7. As has been the case with each prior deployment of a new generation cellular technology, the increased capacity and performance of New T-Mobile's network will pressure the other wireless companies, namely AT&T and Verizon, to accelerate and strengthen their own 5G network deployments. As a result, industry-wide prices to consumers will go down more quickly. I calculate that, under plausible assumptions, by 2024, the price per GB of data

[1] I use the term "national total capacity" to refer to offered traffic. This is the calculated maximum carried traffic that the network could deliver if that traffic were uniformly distributed in time and space relative to the deployment of resources. Carried traffic is the actual amount of data consumed by users provided over the network.

would be substantially lower with the Transaction than without it – in the range of around 41 percent to 65 percent – as a result of this dynamic competition over network capacity and quality. If the Transaction did not provoke a competitive response by AT&T and Verizon, I estimate that the price/GB of data would fall by 14.0 percent and cellular data output would expand by 16.2 percent just as a result of New T-Mobile providing more capacity than the combination of the standalone companies. Given the improvements in performance and the new app development enabled by 5G technology described above, quality-adjusted price/GB would decline even more. These estimates assume that average revenue per user/unit (ARPU) remains the same between 2017 and 2024, which is consistent with T-Mobile business plans.[2] These estimates are based on the impact of the Transaction on dynamic competition and do not consider its impact on static competition.

8. In addition, the Transaction is likely to accelerate the provision of new 5G-based products. For instance, 5G will enable more households to drop fixed broadband subscriptions and become cellular-only customers, giving millions of consumers who today depend on only one broadband supplier additional options for purchasing broadband services. The Transaction will therefore disrupt cable incumbents and bundled video services in ways the stand-alone companies cannot do today.

[2] The New T-Mobile business plan projects that ARPU will decline through 2024.

I. Introduction and Overview of Declaration

9. My name is David S. Evans, and I am an economist. This Introduction summarizes my qualifications, my assignment, and the organization of this declaration.

A. Qualifications

10. I am the founder of Market Platform Dynamics, based in Boston. I am also the Executive Director of the Jevons Institute for Competition Law and Economics and Visiting Professor at the University College London. I have BA, MA, and Ph.D. degrees in economics, all from the University of Chicago. As an economist, I specialize in the field of industrial organization, which concerns the behavior of firms and their interactions, and in antitrust economics, which is the portion of industrial organization that concerns the analysis of business practices that could limit competition and harm consumers. I have authored six major books, including two award winners, and more than 100 scholarly articles, which have been widely read and cited.[3] My curriculum vitae is attached as Appendix I.

11. I have conducted research, published, or submitted testimony on industries that are relevant to the proposed merger (the Transaction) of T-Mobile and Sprint (the Applicants), including the mobile phone industry, Internet-based industries, and the fixed broadband industry. Several of my books, co-authored with Richard Schmalensee, present economic analyses of the dynamics of competition and innovation in the mobile phone industry,[4] and I

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[3] As of May 2018, I ranked among the top 2 percent of published economists according to quality-weighted citations by IDEAS/RePec, which tracks publications and citations by economists worldwide. Many of my publications and citation rankings are available at http://ideas.repec.org/e/pev9.html. I have posted most of my publications on the Social Science Research Network since 2000. As of May 2018, based on those publications I ranked number 13 out of the top 8,000 economists based on cumulative total downloads. My SSRN publications are available at http://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=268756.

[4] DAVID S. EVANS ET AL., INVISIBLE ENGINES: HOW SOFTWARE PLATFORMS DRIVE INNOVATION AND TRANSFORM INDUSTRIES CH. 7 (2006); DAVID S. EVANS & RICHARD SCHMALENSEE, CATALYST CODE: THE STRATEGIES

have published articles on various aspects of the smartphone ecosystem.[5] A significant portion of my research, writing, teaching, and consulting in the last 20 years has concerned Internet-based businesses. My recent book, with Richard Schmalensee, *Matchmakers: The New Economics of Multisided Platforms*, describes the economics and business strategies for many Internet-based businesses.[6]

12. I have previously submitted declarations to the Federal Communications Commission (FCC) in the proposed merger of Comcast Corporation and Time Warner Cable, Inc. (on behalf of Netflix). I made presentations to the FCC staff and participated in the Economist Roundtable organized by the FCC in that transaction review proceeding.[7] I also submitted declarations and made presentations to the FCC staff concerning the merger of Charter and Time Warner Cable (on behalf of INCOMPASS).[8]

BEHIND THE WORLD'S MOST DYNAMIC COMPANIES CH. 3, 8 (2007); DAVID S. EVANS & RICHARD SCHMALENSEE, MATCHMAKERS: THE NEW ECONOMICS OF MULTISIDED PLATFORMS, CH. 3, 7 (2016).

[5] David S. Evans & Alexis Pirchio, *An Empirical Examination of Why Mobile Money Schemes Ignite in Some Developing Countries but Flounder in Most*, 13 REV. NETWORK ECON. 397 (2014); Hemant Bhargava, David S. Evans & Deepa Mani, *The Move to Smart Mobile and Its Implications for Antitrust Analysis of Online Markets*, 16 UC DAVIS BUS. L.J. 157 (2016).

[6] DAVID S. EVANS & RICHARD SCHMALENSEE, MATCHMAKERS: THE NEW ECONOMICS OF MULTISIDED PLATFORMS, CH. 3, 7 (2016).

[7] David S. Evans, *Economic Analysis of the Impact of the Comcast-Time Warner Cable Transaction on Internet Access to Online Video Distributors* (Aug. 25, 2014) (submitted with Netflix, Inc., Petition to Deny, MB Docket No. 14-57); David S. Evans, *Economic Analysis of the Impact of the Comcast-Time Warner Cable Transaction on Internet Access to Online Video Distributors: Response to Opposition to Petitions to Deny and Response to Comments* (Dec. 23, 2014) (submitted with Netflix, Inc., Petition to Deny, MB Docket No. 14-57), https://www.competitionpolicyinternational.com/assets/Evans-Reply-Declaration-December-23-2014.pdf; Fed. Commc'ns Comm'n, Proposed Comcast-Time Warner Cable-Charter Transaction Economic Analysis Workshop, MB Docket No. 14- 57 (Jan. 30, 2015).

[8] David S. Evans, *Economic Analysis of the Impact of the Proposed Merger of Charter, Time Warner Cable, and Bright House Networks on Video Programming Prices and Broadband Entry and Competition* (Jan. 15, 2016) (submitted with INCOMPAS, Petition to Deny, MB Docket No. 15-149), https://ecfsapi.fcc.gov/file/60001406054.pdf (submitted with INCOMPAS, Petition to Deny, MB Docket No. 15-149).

13. I have testified, or submitted testimony, on antitrust matters to courts and regulatory authorities in the United States as well as Australia, Brazil, China, the European Union, Germany, Singapore, South Korea, and Thailand. In the United States, I have testified before federal courts, administrative law courts for the Federal Trade Commission and the Securities and Exchange Commission, and submitted amicus briefs to the U.S. Supreme Court. I have also testified before the European General Court and the Supreme People's Court of China. In addition, I have testified before several committees of the U.S. Congress, including the Senate Banking Committee, the House Financial Services Committee, and the House Oversight Committee, and the U.K.'s House of Lords.

B. Assignment and Documents Reviewed

14. Counsel for the Applicants asked me to address three related topics.

a. Evaluate the likely benefits of the deployment of 5G technologies in the United States to consumers, enterprises, governments, and the economy in light of historical evidence concerning the deployment of previous generations of technology, as well as the currently envisioned uses of 5G technologies and mobile industry economics.

b. Evaluate the role of dynamic competition between carriers for developing and deploying new cellular technologies that increase data speeds, reduce latency, increase spectral efficiency, and thereby increase the capacity of networks to process Internet-based data.

c. Evaluate the impact of the Transaction on the overall diffusion of 5G cellular networks in the United States, the development of 5G applications, and the resulting merger-specific consequences of the Transaction for consumers, enterprises, governments, and the economy as a result of dynamic competition.

My assignment focuses on dynamic competition and its role in the deployment of new cellular networks. I have not conducted a unilateral effects analysis that considers the loss of one competitor on prices through static competition.

15. I, or staff under my direction, have reviewed a variety of documents from the Applicants, government agencies, mobile industry participants, and standards development organizations, as well as company-specific documents and data, Securities and Exchange Commission filings, public press, websites, and other information to carry out this assignment.[9] For part of my analysis, I have relied on my knowledge of the mobile phone and Internet-based industries. I have also relied on the declaration of T-Mobile's Chief Technical Officer Neville Ray, who explains that the Transaction will enable the merged entity to roll out a substantially stronger 5G network sooner than the Applicants could do on their own. In addition, I have reviewed the Declarations of John Legere, Chief Executive Officer of T-Mobile, and of Peter Ewens, T-Mobile's Executive Vice President of Corporate Strategy, Michael Sievert, T-Mobile's President and Chief Operating Officer, John Saw, Sprint's Chief Technology Officer, and Brandon Dow Draper, Sprint's Chief Commercial Officer, who describe the Applicants' stand-alone businesses and business strategy for New T-Mobile, as well as the documents cited in those declarations.

16. The opinions expressed in this declaration are based on information available to me at this time. My work in this matter is ongoing and I reserve the right to revise or supplement my

[9] Appendix II contains a summary of the documents that I have relied upon.

opinion if any additional information makes that appropriate, or to correct any inadvertent errors. Appendix II provides a list of materials relied upon.

C. Organization of Declaration

17. This declaration consists of four sections in addition to this Introduction. Section II reports my economic analysis of how the deployment of successive generations of cellular technologies has contributed to innovation, and provided substantial benefits for consumers, in the mobile phone ecosystem in the United States over the last three decades. Section III presents my economic analysis of the likely benefits of 5G technologies to consumers, enterprises, governments, and the economy overall. Section IV reports my economic analysis of competition among the cellular carriers to deploy new generations of cellular technologies and the effects of that competition on consumers. Section V presents my economic analysis of the impact of the Transaction on the deployment of 5G technologies by the merged entity and by its main competitors, as well as the consequent impact on consumers, enterprises, governments, and the economy overall.

II. Deployment of Cellular Technologies by Carriers in the United States, from 1G through 4G LTE Enabled the Smartphone Revolution and the Mobile App Ecosystem

18. The history of investment in network technology demonstrates that "if you build it, they will come." The U.S. carriers engineered vast increases in capacity with each new generation, and demand soon soaked up that supply, which translated into lower prices for consumers.[10] This dynamic has important implications for the Transaction because, as discussed further below, it will result in a substantial increase in industry-wide network capacity.

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[10] *See infra* Section II.C.

19. The economic history provides strong empirical evidence that the deployment of 5G cellular networks will result in new uses – some envisioned, others unimaginable – that will create massive increases in value for consumers and drive down the costs of access to those benefits. This section describes that economic history and shows that it led to enormous increases in consumer value.

A. The Development and Deployment of Improved Cellular Technologies Came Through Successive Generations

20. Consumers are able to use vast amounts of data over cellular networks today as a result of Standards Development Organizations (SDO), working with technology innovators, developing and specifying next generation cellular technologies, and cellular carriers and handset makers that together deploy those technologies.

1. Improvements in Cellular Technologies Have Resulted in More Capacity, Faster Speeds, and Improved Responses

21. The mobile phone revolution – that began with devices that untethered consumers from landline phones and much later from desktop computers – resulted from the carriers' improvements, and deployment, of cellular technology families. These technologies lowered the costs of providing capacity, which enabled the carriers to make investments in network expansion, which in turn allowed carriers to provide more capacity for voice and data at lower prices.

22. The first innovations involved "1G technologies," which made it possible to make analog phone calls wirelessly. However, there was a natural limit to the number of voice calls

that cellular networks could carry because a dedicated amount of spectrum was required for each call.[11]

23. Carriers solved that problem with a switch to digital 2G technologies that made it possible to carry many more voice calls over spectrum.[12] This enabled carriers to offer cheaper cellular plans, which in turn led to the mass adoption of mobile phones in the United States.[13] 2G technologies also made it possible to move data over cellular networks and to provide limited mobile connectivity to the Internet.

24. Each new technology development since 2G has improved the mobile broadband experience. Three dimensions have proved important.

25. The first – *spectral efficiency* – concerns the amount of data that cellular carriers can move through a given amount of spectrum,[14] which is a scarce and expensive resource. Consumers benefit from greater spectral efficiency because if carriers can provide data more efficiently they can pass those savings on through lower prices – and they have done so.[15] Consumers also benefit from reliability and performance. If the carriers do not have enough

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[11] *See, e.g.*, QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 7-9 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf; *see also* ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 5-6 (2011).

[12] *See, e.g.*, QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 11 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf; *see also*, ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 6 (2011).

[13] Malik Saadi, *Analyst Angle: The Hidden Value of 5G Innovation and its Impact on Economic Growth and Consumers' Lifestyles*, RCR WIRELESS (Jan. 4, 2018), https://www.rcrwireless.com/20180103/opinion/analyst-angle-the-hidden-value-of-5g-innovation-and-its-impact-on-economic-growth-and-consumers-lifestyles.

[14] *See, e.g.*, Ron Hranac, *Spectral Efficiency*, COMM. TECH. (Oct. 2012), http://www.scte.org/TechnicalColumns/12-10-01%20spectral%20effieciency.pdf.

[15] Malik Saadi, *Analyst Angle: The Hidden Value of 5G Innovation and its Impact on Economic Growth and Consumers' Lifestyles*, RCR WIRELESS (Jan. 4, 2018), https://www.rcrwireless.com/20180103/opinion/analyst-angle-the-hidden-value-of-5g-innovation-and-its-impact-on-economic-growth-and-consumers-lifestyles.

capacity for the demands for data, then the networks become congested, which degrades performance.

26. The second – *data speeds* – refers to the number of megabits of data that consumers obtain per second (Mbps).[16] Faster cellular data speeds enable consumers to access and use more data faster. For example, those faster data speeds allow consumers to, for example, download photos more quickly or have higher resolution live chats. Increased data speeds are a byproduct of improved spectral efficiency and result from the capability to move more data over a given bandwidth of spectrum.[17]

27. The third – *latency* – concerns how long it takes, in milliseconds (ms), to send a request to and receive a response from a server in the cloud for an app or website.[18] Lower latency means faster response times, which means apps and websites respond more quickly.[19]

28. Table 1 reports, beginning with 2G, the improvements in various speed and efficiency metrics achieved by each technology generation.

[16] Richard N. Clarke, *Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics*, 38 TELECOMM. POL'Y 693, 694 (2014).

[17] Martha DeGrasse, *Verizon Wireless Outlines Strategies for Spectral Efficiency and More Bandwidth*, RCR WIRELESS (Sept. 21, 2017), https://www.rcrwireless.com/20170921/carriers/verizon-spectrum-tag4-tag99.

[18] Dan Meyer, *T-Mobile and Verizon Tops in Low Latency and Why it Matters*, RCR WIRELESS (Aug. 24, 2016), https://www.rcrwireless.com/20160824/carriers/t-mobile-verizon-tops-low-latency-matters-tag2.

[19] Joseph Hanlon, *These LTE Speeds Will Make You Cry*, CNET (Oct. 3, 2012), https://www.cnet.com/news/these-lte-speeds-will-make-you-cry.

Table 1
Comparison of Mobile Technologies in the United States

Standard	System	Peak Data Rates	Target User Plane Latency
2G	GSM	9.6 kbps	600-700 ms
	GPRS	107 kbps	600-700 ms
	EDGE	384 kbps	150-400 ms
	cdmaOne (IS-95B)	115 kbps	>600 ms
3G	WCDMA	384-2048 kbps	100-200 ms
	HSPA	3.6-14.4 Mbps (DL) / 2.3-5 Mbps (UL)	70-90 ms
	HSPA+	28-42 Mbps (DL) / 11.5 Mbps (UL)	10-40 ms
	CDMA2000	307 kbps	500-600 ms
	EV-DO	2.4-4.9 Mbps (DL) / 800-1800 kbps (UL)	50-200 ms
4G	LTE	150 Mbps (DL) / 75 Mbps (UL)	5-15 ms in Rel. 8
	LTE-Advanced	3 Gbps (DL) / 1.5 Gbps (UL)	

Note: I refer to all versions of LTE and WiMAX as "4G" technologies because even the initial versions of those technologies represented dramatic advances in performance from technologies used in the prior generation of cellular technologies, WCDMA and CDMA2000. I use "3G" to refer to WCDMA and CDMA2000, including the subsequent evolution of those technologies. It should be noted that there were major improvements in performance in those standards over time, especially from the improvements to WCDMA in HSPA+, which is described as "4G" by some carriers.

Source: ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 7, 12, 21, 23 (2011); PATRICK XAVIER, LICENSING OF THIRD GENERATION (3G) MOBILE: BRIEFING PAPER 10 (2001), https://www.itu.int/osg/spu/ni/3G/workshop/Briefing_paper.PDF; T. Blajic *et al.*, *Latency Improvements in 3G Long Term Evolution*, MIPRO'07, at 1 (2007), https://pdfs.semanticscholar.org/ed86/78a5572928049d23d4aa9bb7398b8d16b7b1.pdf; Jeanette Wannstrom, *LTE-Advanced*, 3GPP (June 2013), http://www.3gpp.org/technologies/keywords-acronyms/97-lte-advanced.

29. These limits provide a general indication of the rate of improvements in cellular technologies. Table 2 shows improvements based on average realized speed and latency levels for subscribers, which are lower than the theoretical rate of improvements. Each generation has resulted in a multiple of performance relative to the previous generation, leading to exponential improvements.

Table 2
Typical Mobile Broadband Performance Observed on T-Mobile's U.S. Network, by Technology Standard

Speed Metric/Comparison	**4G LTE**	**3G HSPA+**	**3G HSPA**	**2G**
Download Speed (Mbps)	7–40	2–6	0.4–0.7	0.04–0.2
Times Faster than 2G	196X	33X	5X	N/A
Upload Speed (Mbps)	4–20	0.5–1.8	0.1–0.25	0.02–0.08
Times Faster than 2G	240X	23X	4X	N/A
Latency (ms)	30–55	60–180	100–450	400–900
Improvement over 2G	15X	5X	2X	N/A

Note: Higher values for download and upload speeds and lower values for latency are associated with better performance. Performance comparisons are made by comparing the midpoint of the respective ranges. For example, the midpoint of 4G LTE download speed is 23.5 Mbps and the midpoint of 2G download speed is 0.12 Mbps. The ratio of the 4G LTE midpoint to the 2G midpoint, or 23.5/0.12, is 196 which means that 4G LTE is 196 times faster than 2G.

Source: T-Mobile, *Broadband Facts*, https://www.t-mobile.com/content/dam/tmo/en-g/pdf/T-Mobile-Broadband-Disclosure-Label.pdf (last visited June 3, 2018).

30. Table 3 reports the evolution of downlink spectral efficiency across the various standards.

Table 3
Evolution of Downlink Spectral Efficiency

Wireless Technology Standard	Downlink Spectral Efficiency (bps/Hz)	How Many Times More Efficient LTE Rel. 10 Is Compared to Older Standard
EDGE (2G)	0.09	29.7
WCDMA (3G)	0.24	11.1
HSDPA Rel. 5 (3G)	0.48	5.6
HSPA Rel. 6 (3G)	0.72	3.7
HSPA Rel. 7 (3G)	1.29	2.1
LTE Rel. 8 (4G)	1.50	1.8
LTE Rel. 10 (4G)	2.67	N/A

Note: The comparison of spectral efficiency is based on the ratio of the spectral efficiency of 4G LTE (Rel. 10) to that of earlier standards. For example, the relative spectral efficiency of 4G LTE compared to 2G EDGE = 2.67 / 0.09 = 29.7 times more efficient.

Source: REAL WIRELESS LTD., REPORT FOR OFCOM: 4G CAPACITY GAINS, 6 fig. A-1, 9 fig. A-6 (Jan. 27, 2011), https://www.ofcom.org.uk/__data/assets/pdf_file/0038/74999/4gcapacitygainsfinalreporta1.pdf. This research was conducted by realWireless and commissioned by Ofcom. Ofcom referred to the report as its research. *4G set to deliver capacity gains of more than 200% over 3G*, OFCOM (May 12, 2011), https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2011/4g-set-to-deliver-capacity-gains-of-more-than-200-over-3g.

2. The Adoption of Cellular Technologies Faces a Chicken and Egg Problem

31. Different, and complementary, products and services must work together for end users and application developers to use cellular technology.[20] Cellular networks have to incorporate the technology to make it available to subscribers, and handset makers have to incorporate the technology in their phones. Other providers, such as chipmakers, radio equipment vendors, and operating system providers, have to provide inputs.

32. There is a chicken and egg problem in the deployment of new cellular technologies. Handset makers would not incorporate new technology in their handsets, which are typically

[20] FED. COMMC'NS COMM'N, OPENNESS IN THE MOBILE BROADBAND ECOSYSTEM 1 (Aug. 20, 2013), https://transition.fcc.gov/cgb/oiac/Mobile-Broadband-Ecosystem.pdf.

replaced every couple of years, unless there are enough customers to support the cost of doing so. Cellular carriers would not invest in upgrading their networks if they were not confident that they could provide their customers with handsets that could use it. In practice, this chicken and egg problem is resolved because the providers of these complementary products have consistent expectations that the other providers will incorporate the new standard.[21] They all expect that others will make investments in the improved technology, thereby resulting in a virtuous cycle of better performance and increased functionality.

33. Cellular carriers play a critical role. They induce handset makers and others in the supply chain to develop the necessary inputs by making substantial capital investments to deploy new technologies. Their ability to do so depends on (1) the availability of spectrum (which, in the United States, is determined by the FCC), and (2) their ability to purchase the necessary spectrum. Once one carrier makes the first move to start deploying a new technology, competing carriers follow because otherwise they will have inferior technology and lose subscribers.[22] Once handset makers anticipate there is going to be enough demand in the relevant time period – on a global basis – they incorporate the new technology.

3. Carriers Have Deployed Each Successive Generation of Cellular Technologies Throughout the United States

34. The availability of improved technologies to consumers, and therefore to app developers, depends on when cellular carriers start deploying those technologies. Consumers need a mobile device that incorporates that technology.

[21] FED. COMMC'NS COMM'N, OPENNESS IN THE MOBILE BROADBAND ECOSYSTEM 1 (Aug. 20, 2013), https://transition.fcc.gov/cgb/oiac/Mobile-Broadband-Ecosystem.pdf.

[22] *See infra* Sections IV.C V.B.1.

35. Many U.S. consumers get their devices from their carriers, which have historically subsidized the sale of the handsets in return for a multi-year commitment to a subscriber.[23] As defined by GSMA, a "connection" for a particular technology refers to a handset[24] that has that technology and a subscription to a cellular network that has that technology. Coverage refers to the percent of the population that has access to a cellular network with a particular generation of technology in a geographic area.[25] Table 4 reports the evolution of connections for 1G, 2G, 3G, and 4G technologies and coverage for 3G and 4G technology; data on 1G and 2G coverage are not available.

[23] Aaron Pressman, *The Death of the $199 iPhone Marks A New Era For Wireless*, FORTUNE (Jan. 11, 2017), http://fortune.com/2017/01/11/death-of-the-199-iphone-wireless-subsidy/.

[24] According to GSMA, connections are defined as "total unique SIM cards (or phone numbers, where SIM cards are not used), excluding machine-to-machine (M2M) connections that have been registered on the mobile network at the end of the period. M2M connections enable mobile data transmission between two or more machines via cellular M2M (2G, 3G, 4G or 5G) technology. Cellular M2M excludes computing devices in consumer electronics such as e-readers, smartphones, dongles and tablets. Connections differ from subscribers such that a unique subscriber can have multiple connections." GSMA INTELLIGENCE.

[25] "Coverage" refers to the percent of the population that has access to a cellular network with a particular generation of technology in a geographic area. One or more carriers may provide coverage in a given geographic area. For the purposes of this declaration, I calculate coverage based on the weighted average, across all carriers, of the population that has coverage. That approach, therefore, places greater weight on the deployment of coverage by carriers that have more subscribers. This weighted average accounts for sources of differentiation and therefore better reflects the choices available to a typical consumer than whether they have access to at least one carrier.

Table 4
Evolution in Cellular Technology Coverage and Connections in the United States
2000 – 2017

Year	3G Coverage	4G Coverage*	Total Connections	% of Connections with Fastest Speed at 1G	2G	3G	4G LTE	4G WiMAX
2000	0%	0%	111,376,633	27%	73%	0%	0%	0%
2001	0%	0%	114,983,475	18%	82%	0%	0%	0%
2002	0%	0%	132,403,375	9%	91%	0%	0%	0%
2003	1%	0%	150,349,110	5%	95%	0%	0%	0%
2004	11%	0%	169,816,604	3%	96%	0%	0%	0%
2005	23%	0%	194,232,359	2%	96%	2%	0%	0%
2006	34%	0%	217,777,896	1%	93%	6%	0%	0%
2007	46%	0%	239,004,363	0%	87%	13%	0%	0%
2008	58%	0%	254,613,333	0%	72%	28%	0%	0%
2009	69%	0%	269,009,535	0%	61%	39%	0%	0%
2010	75%	3%	286,685,960	0%	47%	52%	0%	1%
2011	82%	21%	307,540,802	0%	33%	63%	1%	3%
2012	87%	42%	317,892,998	0%	27%	63%	7%	3%
2013	92%	71%	314,873,792	0%	19%	58%	21%	2%
2014	95%	87%	320,603,042	0%	15%	47%	38%	0%
2015	96%	93%	335,203,291	0%	13%	37%	51%	0%
2016	97%	95%	346,066,386	0%	11%	30%	60%	0%
2017	97%	95%	341,671,692	0%	9%	24%	67%	0%

Note: * 4G includes LTE, which was the main technology used, as well as WiMAX, which was a 4G technology used mainly by Sprint for a short period of time.

Source: Exhibits 2 and 3.

B. Each Drastic Improvement in Cellular Technologies Has Unleashed a Torrent of Downstream Innovation and Created Massive Consumer Benefits

36. Each generation of technology has corresponded to an inflection point, or discontinuity, in the mobile ecosystem evolution. In each case, there has been a substantial leap in performance, a reduction in prices, and new use cases. Indeed, each generation has brought

massive increases in consumer value. The superlative "massive," is not hyperbolic, and is backed by quantitative and qualitative evidence.

1. 1G Technologies Created the Modern Cellular Telephone Industry

37. The modern cellular phone industry began with 1G in the early 1980s when the FCC allocated spectrum that supported the deployment of geographically separated cell towers.[26] Each cell covered a small area so that different areas could use the same frequency.[27] With the spectrum allocated to two carriers in each area, there were hundreds of voice channels available in each cell area.[28] Voice was carried using analog methods like the traditional landline.[29]

38. Although each channel could handle only one analog phone call at a time,[30] the vast increase in the available channels increased the supply, and lowered the cost, of providing mobile service. Early mobile phones were bulky, voice quality was imperfect, and the battery life was short.[31] And yet, for consumers at the time, these phones were smaller, cheaper, and better than what they had been able to get before.[32] Between 1985 and 1988 the number of mobile subscribers jumped from 340,000 to 2.1 million.[33]

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[26] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 3 (2011).

[27] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 3 (2011).

[28] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 3, 5-6 (2011).

[29] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 3, 6 (2011).

[30] QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 7-9 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf.

[31] *See, e.g.*, Chris Ziegler, *2G, 3G, 4G, And Everything In Between: An Engadget Wireless Primer*, ENGADGET (Jan. 17, 2011), https://www.engadget.com/2011/01/17/2g-3g-4g-and-everything-in-between-an-engadget-wireless-prim/; Lopa J. Vora, *Evolution of Mobile Generation Technology: 1G to 5G and Review of Upcoming Wireless Technology 5G*, 22 INT'L J. MOD. TRENDS ENGINEERING & RES. 281-82 (Mar. 2015), https://www.researchgate.net/publication/317032541_Comparison_between_Cellular_Generations.

[32] Calvin Sims, *All About/Cellular Telephones; A Gadget That May Soon Become the Latest Necessity*, N.Y. TIMES (Jan. 28, 1990), https://www.nytimes.com/1990/01/28/business/all-about-cellular-telephones-a-gadget-that-may-soon-become-the-latest-necessity.html ("Once gadgets of the rich and powerful, cellular telephones are moving

2. 2G Cellular Networks Made Mobile Phones Available to the Masses for Calls, SMS, Email, and Some Data

39. Mainstream consumption using 1G resulted in cell networks with severe capacity constraints. There was a natural limit on how many mobile calls a network could handle and therefore on the number of subscribers that the network could reasonably accommodate.[34] For example, in areas like Los Angeles, 1G customers making calls during rush hour often received "system not available" light responses on their phones, with networks in other large cities like New York, San Francisco, Chicago, and Washington, D.C. nearing their limits.[35] Digital technology was "expected to provide three times the capacity of the current analog system at a lower cost per call."[36]

40. In the 1980s, technology innovators and SDOs had begun working on developing digital technologies that would increase network capacity. The European Telecommunications Standards Institute (ETSI) developed the GSM technology and released the final specification

into the mainstream. Still primarily business tools, the phones are increasingly showing up in the cars, handbags and pockets of the elderly, housewives, outdoor enthusiasts and others who need instant communications.").

[33] Calvin Sims, *Cellular Phone Growth Starts Investor Rush*, N.Y. TIMES (June 23, 1989), https://www.nytimes.com/1989/06/23/business/cellular-phone-growth-starts-investor-rush.html.

[34] QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 9 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf.

[35] Calvin Sims, *All About/Cellular Telephones; A Gadget That May Soon Become the Latest Necessity*, N.Y. TIMES (Jan. 28, 1990), https://www.nytimes.com/1990/01/28/business/all-about-cellular-telephones-a-gadget-that-may-soon-become-the-latest-necessity.html. In 1989, CTIA noted that: "By 1991, the major cities will have so many cellular subscribers that we won't be able to engineer analog systems to maintain the current level of quality . . . We will have no choice but to switch our systems to digital technology, otherwise some customers won't be able to get on the network, and that will have a negative impact on our growth." Calvin Sims, *Meeting Mobile Phone Demand*, N.Y. TIMES (July 19, 1989), https://www.nytimes.com/1989/07/19/business/meeting-mobile-phone-demand.html.

[36] Calvin Sims, *Meeting Mobile Phone Demand*, N.Y. TIMES (July 19, 1989), https://www.nytimes.com/1989/07/19/business/meeting-mobile-phone-demand.html.

in 1990.[37] The Telecommunications Industry Association (TIA) adopted the CDMA standard (IS-95) in 1993, which saw the release of a revised version called cdmaOne in 1995.[38]

41. These 2G technologies increased the capacity of the cellular networks, improved voice quality, and provided early support for data applications. Compared to the analog system, cdmaOne provided 14 times the voice capacity and GSM provided 3 times the capacity.[39] 2G could also transmit data at a rate of 9.6 kbps at first.[40] That improved substantially with the introduction of GPRS and EDGE for the GSM standard, as shown in Table 1 above.

42. In 1996, AT&T got "a jump on the competitors" when it began deploying its 2G digital network, but other carriers quickly responded.[41] By 2001, 82 percent of mobile connections were 2G.[42] Carriers could offer even cheaper packages due to more network capacity. By 1998, the average bill for mobile service had dropped below $40 per month.[43] The number of mobile subscribes reached almost 77 million in 1999, with more than 37,500 people signing up

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[37] The initial 3G specification was released in 1987. ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 7 (2011); Sophia Antipolis, *Why Were the Founders Of GSM In Cyprus This Week? 20 Years and 2.3 Billion Users Has A Lot To Do With It*, ETSI (Mar. 16, 2007), http://www.etsi.org/component/content/article/9-news-events/news/194-news-release-16th-march-2007.

[38] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 9 (2011); QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 18 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf.

[39] QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 18 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf.

[40] Patrick Xavier, LICENSING OF THIRD GENERATION (3G) MOBILE: BRIEFING PAPER 12 (2001), https://www.itu.int/osg/spu/ni/3G/workshop/Briefing_paper.PDF.

[41] Jube Shiver Jr., *AT&T Makes Big Move in Digital Race*, LA TIMES (Oct. 3, 1996), http://articles.latimes.com/1996-10-03/business/fi-49967_1_digital-pcs

[42] *See* Exhibit 2.

[43] Vivian S. Toy, *Teen-Agers and Cell Phones: A Match Made in Gab Heaven*, N.Y. TIMES (Aug. 2, 1999), https://www.nytimes.com/1999/08/02/nyregion/teen-agers-and-cell-phones-a-match-made-in-gab-heaven.html. Note that the average bill of $40 per month is not necessarily inconsistent with the ARPU amount of $47.23 determined by CTIA, which clearly notes that ARPU is not the equivalent to the average revenue per bill because multiple devices can be associated with one bill. ROBERT F. ROCHE & KATHRYN MALARKEY, CTIA'S WIRELESS INDUSTRY REPORT INDICES REPORT: YEAR-END 2016 RESULTS 53 (May 2017).

for wireless phone service each day.[44] Scale economies in manufacturing handsets also drove handset prices down. Other technological improvements enabled handset manufacturers to make much smaller phones with better battery life.[45]

43. This was a remarkable change for U.S. consumers. People could make phone calls conveniently and cheaply wherever they were. In 2000, around 38 percent of the total U.S. population were wireless users, increasing to around 83 percent in 2007.[46] As shown in Figure 1 below, the volume of minutes of use for voice calls grew by more than 8 times over this same time period.[47] People started making the switch from landlines to mobile phones.[48]

[44] Catherine Greenman, *Too Many Phones, Too Little Service*, N.Y. TIMES (Aug. 19, 1999), https://www.nytimes.com/1999/08/19/technology/too-many-phones-too-little-service.html.

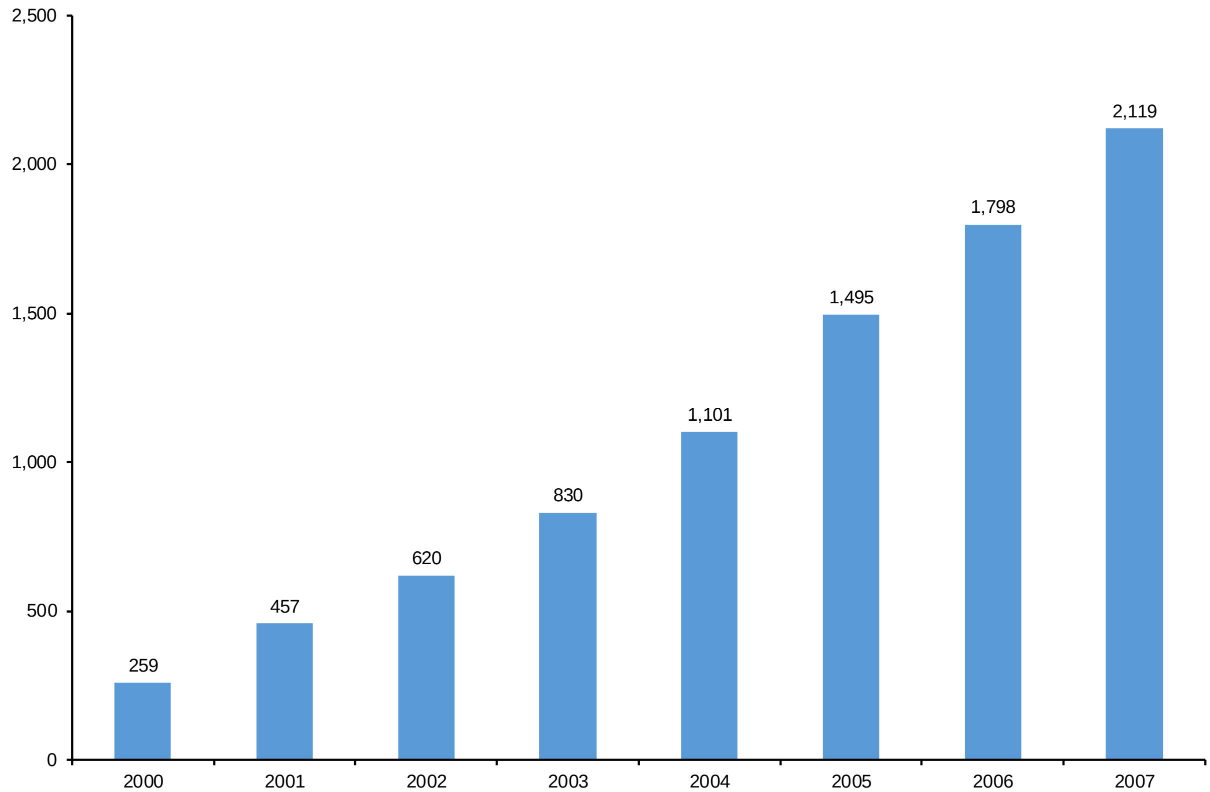
[45] For example, the Ericsson CF 788, offered in the United States in 1998, was 4 inches tall and weighed 4.7 ounces. As one reporter noted: "Besides being small enough to slip easily into a purse or shirt pocket, the phone -- which bears a striking resemblance to Captain Kirk's retro-futuristic flip-top communicator -- can accept short E-mail messages. It will probably cost around $200 and will also have voice mail, phone-to-phone text messaging and caller ID." Michel Marriott, *News Watch; An Even Smaller Phone With Even More Stuff*, N.Y. TIMES (May 14, 1998), https://www.nytimes.com/1998/05/14/technology/news-watch-an-even-smaller-phone-with-even-more-stuff.html.

[46] The U.S. population, including the United States and its territories, is determined by the U.S. Census Bureau. ROBERT F. ROCHE & KATHRYN MALARKEY, CTIA'S WIRELESS INDUSTRY REPORT INDICES REPORT: YEAR-END 2016 RESULTS 27-28 tbl. 8 (May 2017).

[47] *See* Exhibit 1.

[48] In fact, at the end of 2003, around 4 percent of U.S. households were "wireless-only households." ROBERT F. ROCHE & KATHRYN MALARKEY, CTIA'S WIRELESS INDUSTRY REPORT INDICES REPORT: YEAR-END 2016 RESULTS 32 chart 13 (May 2017).

Figure 1
Voice Traffic on U.S. Mobile Networks
(Billions of Minutes of Use)



Source: Exhibit 1.

44. 2G technologies made it possible for people to send Short Messaging Service (SMS) based text messages. By 2008 Americans had sent more than one trillion SMS messages.[49] Table 5 shows the increase in the number of SMS messages through 2011 (when it peaked

[49] ROBERT F. ROCHE & KATHRYN MALARKEY, CTIA'S WIRELESS INDUSTRY REPORT INDICES REPORT: YEAR-END 2016 RESULTS 100 (May 2017); *No Text Please, We're American*, THE ECONOMIST (Apr. 3, 2003), https://www.economist.com/node/1683713; Amanda Lenhart, *Teens, Smartphones & Texting*, PEW RES. CTR (Mar. 19, 2012), http://www.pewinternet.org/2012/03/19/teens-smartphones-texting/.

before being displaced by Multimedia Messaging Service (MMS) messages using 3G technology).[50]

Table 5
Annualized Text/SMS Messages
(Millions)

Year	Text/SMS
2005	81,208
2006	158,649
2007	362,550
2008	1,005,144
2009	1,563,091
2010	2,051,679
2011	2,303,524
Source: Exhibit 1.	

45. 2G technologies also provided data services for email on phones. Blackberry became a sudden success on the strength of email service using 2G.[51] In addition, 2G technologies provided Internet connectivity. That made the killer app of the time – downloadable ringtones – possible.[52] At the same time, handset manufacturers were, once again, able to offer smaller and lighter mobile phones with added features.[53]

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[50] MMS is a mobile service allowing users to send multimedia messages (i.e., images, videos, and sound files) to other users, while SMS service allows users to send and receive text messages. *MMS*, TECHTERMS.COM, https://techterms.com/definition/mms (last updated Aug. 25, 2011).

[51] Phil Goldstein, *BlackBerry 5810 Kickstarted the Mobile Work Era*, BIZTECH (Nov. 11, 2016), https://biztechmagazine.com/article/2016/11/blackberry-5810-kickstarted-mobile-work-era.

[52] *Mobile Ringtones Sound Web Alert*, CNN.COM (Apr. 23, 2001), http://edition.cnn.com/2001/TECH/ptech/04/23/tunes/index.html; Paul Trueman, *Ring Tones*, THE GUARDIAN (Feb. 28, 2001), https://www.theguardian.com/technology/2001/mar/01/internetnews.onlinesupplement3; Breeanna Hare, *Whatever Happened to the Ringtone?* CNN.COM (May 16, 2013), https://www.cnn.com/2013/05/09/tech/mobile/ringtones-phones-decline/index.html. Customizable ringtones became a phenomenon, as younger customers began to interact with the large variety of new features that accompanied the rise of mobile technologies. Vivian S. Toy, *Teen-Agers and Cell Phones: A Match Made in Gab*

46. Ultimately, 2G ignited the mobile revolution for the benefit of millions of U.S. consumers.[54]

3. 3G Cellular Networks Brought Fast Reliable Internet Access to Smartphones

47. If technology innovators, SDOs, and cellular carrier networks had stopped at 2G, we would not have today's app ecosystem, and smartphones would not have evolved into the primary method consumers use to access the Internet.

48. Even advanced 2G technologies, such as EDGE, were too slow for Internet access.[55] The EDGE 2.5 network typically had download speeds between 80 kbps to 120 kbps, compared to average DSL speeds of around 3 Mbps at the end of 2007, and had a latency of 150 ms, resulting in Web download speeds of 10 to 15 seconds.[56] The New York Times reported that it took nearly a minute to access the New York Times' home page, over a minute and a half to

Heaven, N.Y. TIMES (Aug. 2, 1999), https://www.nytimes.com/1999/08/02/nyregion/teen-agers-and-cell-phones-a-match-made-in-gab-heaven.html.

[53] Michel Marriott, *News Watch: An Even Smaller Phone With Even More Stuff*, N.Y. TIMES (May 14, 1998), https://www.nytimes.com/1998/05/14/technology/news-watch-an-even-smaller-phone-with-even-more-stuff.html. *See also* QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 12 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf.

[54] QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES 6, 10, 12, 18 (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf.

[55] The very first iPhone could only work on AT&T's EDGE (2.5G) network. Apple chose to rely upon AT&T's EDGE technology, even though faster networks were available, due to the wider coverage the EDGE network provided. AT&T's CEO stated that "[i]f you want to sell these devices in a variety of places, Edge is the only opportunity you have." Moreover, Apple's CEO explained that the 3G chip sets were "power-hungry," so choosing not to use them helped the iPhone's battery life. John Markoff, *Chiefs Defend Slow Network for the iPhone*, N.Y. TIMES (June 29, 2007), https://www.nytimes.com/2007/06/29/technology/29phone.html.

[56] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 9 (2011); Om Malik, *DSL Getting Faster – Just Not in the U.S.*, GIGAOM (Nov. 29, 2007), https://gigaom.com/2007/11/29/dsl-getting-faster-just-not-in-the-us/; ERICSSON, THE EVOLUTION OF EDGE 9 (Feb. 2007), http://www.iwpc.org/Workshop_Folders/08_03_GSM_EDGE_Extensions/3107_The_evolution_of_EDGE_A.pdf.

launch the Amazon.com home page, and two minutes to launch Yahoo's homepage.[57] Moreover, 2G networks would have been overwhelmed if consumers had bought 2G smartphones in droves and used them for Internet access.[58]

49. Cellular carriers started to build 3G networks in the United States in 2002.[59] By 2008, when consumers were first able to purchase 3G versions of the iPhone (the iPhone 3G was released in July 2008) and Android (October 2008), 58 percent of the U.S. population lived in areas with a 3G network.[60]

50. The massive leap in performance turned the new phones into Internet-access devices. When Steve Jobs announced the iPhone 3G he said:

> 3G [is] 2.8 times faster [than 2.5G EDGE.] But it's even more remarkable when you take a look at this next to WiFi. You can see that the 3G speeds are actually approaching WiFi . . . .[61]

An Apple iPhone 3G commercial claimed:

> After you experience the wide screen iPod, the real Internet at 3G speed, and email that looks like this, it would be easy to forget that it's also a pretty amazing phone.[62]

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[57] David Pogue, *The iPhone Matches Most of Its Hype*, N.Y. TIMES (June 27, 2007), http://www.nytimes.com/2007/06/27/technology/circuits/27pogue.html.

[58] *Exploring 2G, 3G, 4G Technology*, GEOTAB (Nov. 26, 2012), https://www.geotab.com/blog/exploring-2g-3g-4g-technology/.

[59] EV-DO was the first true 3G technology deployed in the United States, with the prior CDMA2000 technology marketed as 3G but did not meet the full 3G standard requirements. *See Verizon Launches First U.S. '3G' Network*, CNN (Jan. 28, 2002), http://edition.cnn.com/2002/TECH/ptech/01/28/verizon.3g/; Press Release, Verizon Wireless, Verizon Wireless Announces Roll Out of National 3G Network (Jan. 8, 2004), http://www.verizon.com/about/news/vzw/2004/01/pr2004-01-07; ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 11-12 (2011); *see also* Exhibit 2.

[60] Press Release, Apple Inc., Apple Introduces the New iPhone 3G, (June 9, 2008), https://www.apple.com/newsroom/2008/06/09Apple-Introduces-the-New-iPhone-3G/; Nancy Gohring, *T-Mobile, Google and HTC Introduce First Android Phone*, MACWORLD (Sept. 23, 2008), https://www.macworld.com/article/1135695/android_g1.html; *see also* Exhibit 3.

[61] Video of Apple's 2008 Worldwide Developers Conference is available on YouTube. Mr. Jobs' discussion of 3G begins at the 1:26:48 timestamp. *See* EverySteveJobsVideo, *Steve Jobs introduces iPhone 3G & MobileMe - WWDC (2008)*, YOUTUBE (Dec. 21, 2012), https://youtu.be/Zk97Tu3PY6I?t=1h26m48s.

51. In marketing its first Android phone, Verizon emphasized the multi-tasking and voice search capabilities of the Motorola Droid, and the access to thousands of Android Market apps.[63] Sprint emphasized the combination of the Android platform and apps, with the high-speed connectivity of its 3G network.[64]

52. By 2009, 80 percent of the smartphones sold in the United States were 3G, and by 2010 over 95 percent of all smartphones sold in the United States were 3G (or 4G).[65] The installed base of mobile phones that could use a 3G network (because they had a 3G handset with a 3G network subscription) grew explosively, as shown in Figure 2. It increased from 9 percent of all connections in Q1 2007 to 48 percent all connections in Q1 2010.

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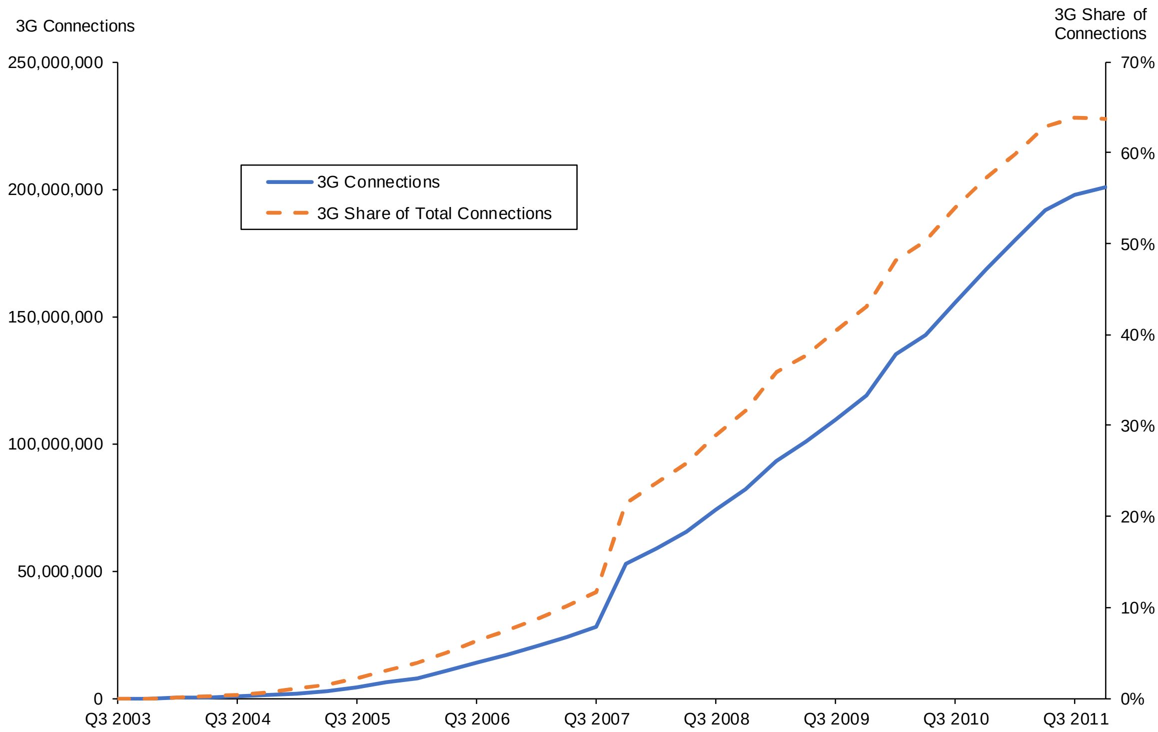
[62] Apple iPhone 3G television commercial is available on YouTube. *See* Lawrence Kan, *Apple iPhone 3G Commercial-Hong Kong(English)*, YOUTUBE (Aug. 21, 2008), https://www.youtube.com/watch?v=rxS7nQNjyrE.

[63] Verizon Commc'n Inc., Annual Report (Form 10-K), at 8 (Feb. 26, 2010); *Android's early days*, ANDROID CENTRAL (Oct. 28, 2015), https://www.androidcentral.com/androids-early-days.

[64] Press Release, Sprint, Sprint to Launch Its First Android Device (Sept. 3, 2009), https://community.sprint.com/t5/Sprint-News-Archives/Sprint-to-Launch-Its-First-Android-Device/ba-p/935115. The New York Times noted: "Data speed is the main advantage to a 3G phone and wireless service. EV-DO . . . can transfer data as fast as some DSL connections. This makes it possible to stream videos or even movies to the phone, or to quickly download photos and Web pages. The handset can also be used as a serviceable laptop modem on the road." J.D Biersdorfer, *The Perks of a Faster Phone*, N.Y. TIMES (Dec. 6, 2007), https://www.nytimes.com/2007/12/06/technology/personaltech/06askk-002.html?rref=collection%2Ftimestopic%2FMobile%20Phones.

[65] IDC, QUARTERLY MOBILE PHONE TRACKER: 2017 Q4 HISTORICAL RELEASE (May 11, 2018).

Figure 2
Growth of 3G in the United States
Q3 2003 – Q4 2011



Source: GSMA INTELLIGENCE.

53. 3G technology, combined with modern smartphones, created the FCC's "virtuous cycle":

> The mobile broadband ecosystem is built on a seemingly 'virtuous cycle,' where networks that are fast, reliable, and widely available encourage the creation of mobile devices that connect to these networks, which spurs innovation in compelling applications and content, which in turn motivate more users to adopt the technology, spurring further investment in the underlying networks.[66]

The value of the smartphone to consumers and developers came from the fact that subscribers could use them for Internet access anywhere, anytime. Uber, for example, was useful to drivers and riders only if they could quickly and reliably access the service when they were on the

[66] FED. COMMC'NS COMM'N, OPENNESS IN THE MOBILE BROADBAND ECOSYSTEM 1 (Aug. 20, 2013), https://transition.fcc.gov/cgb/oiac/Mobile-Broadband-Ecosystem.pdf.

move.[67] Google Search and Google Maps became much more valuable to people because they could do things like check prices and get directions when they were out and about.

54. To see how the virtuous cycle set off the smartphone revolution consider the five years between the launch of the 2G version of the iPhone in 2007 and the launch of the 4G version in 2012.[68] Table 6 shows the total number of mobile phones that had a 3G or better connection, the total number of apps available in the primary app stores, and total cellular data consumed. Following the introduction of the iPhone and Android smartphones, there was a rapid uptake of 3G, app development grew explosively, and the amount of cellular data consumed by subscribers skyrocketed. While correlation does not prove causation, the facts on the ground make the causal links clear.

[67] Chris Price, *Digital Technology Drives Uber to Global Success*, THE TELEGRAPH (Jan. 27, 2015), https://www.telegraph.co.uk/sponsored/technology/4g-mobile/engaging-customers/11366554/digital-technology-uber.html.

[68] This period includes some 4G connections for Android devices in 2011 and 2012 but is mainly dominated by 3G. Todd Haselton, *Here's Every iPhone Released, In Order, And What Changed Along The Way*, CNBC (June 29, 2017), https://www.cnbc.com/2017/06/29/every-iphone-released-in-order.html.

Table 6
Apps and Mobile Data Use
2007 – 2012

Year	Mobile Connections 3G or Better	iOS Apps	Google Play Apps	Mobile Data (PB)
2007	13%	0	0	
2008	28%	3,000	<2,300	
2009	39%	100,000	16,000	
2010	53%	300,000	100,000	388
2011	67%	500,000	400,000	867
2012	73%	700,000	700,000	1,468

Note: App counts are based on apps available in their respective stores. A petabyte (PB) is equivalent to one million gigabytes (GBs) or 1 billion megabytes (MBs). CTIA began reporting mobile data in 2010.

Source: Exhibits 1, 2, and 4.

55. 3G cellular networks were not the only ingredients for the smartphone revolution but they were essential ones. Andy Rubin, who co-founded Android, noted 3G data networks transformed smartphones into powerful connected computers and were a main driver shifting the technology industry's focus towards smartphone development.[69]

4. 4G LTE Delivered More Capacity for Faster and Better Mobile Broadband Experiences

56. While 3G technology was much faster than 2G technology, it was not nearly as fast as cable or fiber broadband for providing Internet access and video content. Average 3G download speeds around 2010 were only approximately a quarter of average home broadband

[69] Ryan Kim, *Apple, Google, Palm Rule Smartphones*, SFGATE (June 15, 2009), https://www.sfgate.com/news/article/Apple-Google-Palm-rule-smart-phones-3227347.php.

speeds, which are a reasonable proxy for home Wi-Fi speeds.[70] Typical 3G speeds were even slower as compared with the speeds for a typical cable customer.[71]

57. Even at these slower speeds, however, the demand for consuming data over cellular networks exploded. To help alleviate congestion on its 3G network Verizon, for example, offered a promotion to encourage consumers to upgrade to an LTE device and data plan.[72] In 2011, after monthly data usage for smartphone users had doubled from 2008 to 2009 and again from 2009 to 2010, Cisco projected a 10-fold increase in monthly smartphone data traffic by 2015.[73] It seemed hard to believe, but that is roughly what happened.

58. Recognizing the need to develop faster and better mobile broadband with greater data capacity, SDOs working with technology innovators designed and specified LTE technology.[74] 3GPP set design goals for LTE that would offer peak download and upload data rates that were an order of magnitude better than 3G systems, average user data rates 2 to 4 times better than HSPA, a 2 to 4 times improvement in spectral efficiency, and a target round-trip latency for

[70] The FCC reported that the average residential fixed broadband download speed was 4.1 Mbps based on a sample of U.S. households from January through June 2009. The median residential fixed broadband download speed was 3.1 Mbps. FED. COMMC'NS COMM'N, CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN 21 (March 16, 2010), https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf. 3G networks offered download speeds that typically ranged from 0.4 to 1.8 Mbps around this time. Mark Sullivan, *AT&T roars back in 3G wireless performance test*, COMPUTERWORLD (Feb. 25, 2010), https://www.computerworld.com/article/2520067/mobile-wireless/at-t-roars-back-in-3g-wireless-performance-test.html; Dong Ngo, *Home Networking Explained, Part 4: Wi-Fi vs. Internet*, CNET (Sept. 3, 2016), https://www.cnet.com/how-to/home-networking-explained-part-4-wi-fi-vs-internet/.

[71] During this time, the FCC reported median actual download speeds for fiber and cable between 5 Mbps and 6 Mbps. FED. COMMC'NS COMM'N, CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN 21 (Mar. 16, 2010), https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf.

[72] Chris Velazco, *Verizon's New LTE Promotion Meant To Benefit iPhone Users Too*, TECHCRUNCH (Nov. 10, 2011), https://techcrunch.com/2011/11/10/verizons-new-lte-promotion-meant-to-benefit-iphone-users-too/ ("The deal is also meant to reduce congestion on the company's 3G EV-DO network . . . .").

[73] David Goldman, *You're Using More Smartphone Data Than You Think*, CNN MONEY (Feb. 8, 2011), http://money.cnn.com/2011/02/08/technology/smartphone_data_usage/index.htm.

[74] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 26 (2011).

LTE radio network as low as 10 ms (compared to 20 to 40ms in many DSL systems).[75] LTE was also designed to be deployed across a wide range of spectrum, with the expectation that many LTE networks would re-farm spectrum that was previously used for 2G or 3G networks.[76]

59. Major cellular carriers in the United States started deploying 4G LTE networks beginning with Verizon in December 2010, followed by AT&T in September 2011, Sprint in July 2012, and T-Mobile in March 2013.[77] Android 4G LTE phones were available in 2011 and Apple introduced a 4G LTE version of the iPhone in September 2012.[78] By 2015, more than 90 percent of the U.S. population had access to 4G LTE coverage in their local areas, and 4G LTE accounted for 51 percent of total connections.[79] The average cost to a smartphone subscriber of using a gigabyte of data plummeted from $38.75 in 2011 to $10.84 in 2015.[80]

[75] ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 26 (2011).

[76] LTE operators could deploy LTE networks using 900MHz, 1800MHz, 700MHz, and 2.6GHz. ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE 26 (2011).

[77] Press Release, Verizon Wireless, Verizon Wireless Launches The World's Largest 4G LTE Wireless Network On Dec. 5 (Dec. 1, 2010), http://www.verizon.com/about/news/vzw/2010/12/pr2010-11-30a; Jessica Dolcourt, *AT&T Launching LTE on Sept. 18, At Long Last*, CNET.COM (Sept. 15, 2011), https://www.cnet.com/news/at-t-launching-lte-on-sept-18-at-long-last/; Press Release, Sprint, Sprint 4G LTE Launch Extends to 15 Cities Throughout Portions of Georgia, Kansas, Missouri and Texas (July 16, 2012), http://newsroom.sprint.com/sprint-4g-lte-launch-extends-to-15-cities-throughout-portions-of-georgia-kansas-missouri-and-texas.htm; Press Release, T-Mobile Inc., T-Mobile Makes Bold "Un-carrier" Moves (Mar. 26, 2013) https://newsroom.t-mobile.com/news-and-blogs/t-mobile-makes-bold-un-carrier-moves.htm.

[78] Brad Reed, *Metropcs Snags First LTE Android Phone*, NETWORK WORLD (Feb. 9, 2011), https://www.networkworld.com/article/2199740/smartphones/metropcs-snags-first-lte-android-phone.html; Mark Milian, *Verizon To Debut 3rd Android Phone With 4G Thursday*, CNN (May 25, 2011), http://www.cnn.com/2011/TECH/mobile/05/25/lg.revolution/index.html; Press Release, Apple, Inc., Apple Introduces iPhone 5 (Sept. 12, 2012), https://www.apple.com/newsroom/2012/09/12Apple-Introduces-iPhone-5/.

[79] *See supra* Table 4.

[80] *See infra* Table 8; Exhibit 5A.

60. The switch to 4G LTE produced a rapid acceleration of the virtuous cycle described by the FCC and transformed the mobile ecosystem. Consumers flocked to 4G LTE.[81] Carriers offered attractive packages that enabled consumers to get the new 4G LTE handsets and a 4G LTE subscription. For example, in 2011 Verizon offered a promotion providing customers with "twice the data [for the] same low price" when they purchased a new 4G LTE smartphone and data plan.[82]

61. With faster, more responsive phones, and lower data prices consumer demand for using smartphones to access the Internet surged even more. In December 2014, an executive at comScore underscored the impact of 4G on app use:

> [T]he main driver behind the shift to apps is wider adoption by consumers of 4G wireless data connectivity . . . says Andrew Lipsman, vice president of marketing and insights at comScore. "Prior to 4G, browsing the web or using apps on your smartphone was slow and clunky, and consumers generally used apps only when necessary; the average consumer was not sitting on their couch or on the go heavily using mobile apps," Lipsman says. "In the last two years, though, smartphones have become the primary platform consumers use to consume content and shop, and 4G connectivity is a big part of this movement to mobile devices and apps."[83]

Cellular data consumption increased from 388 petabytes (PBs) in 2010 to 9,650 PBs in 2015.[84]

62. 4G smartphones enabled consumers to start to use apps, in particular data-intensive video apps.[85] A Cisco study found that mobile video comprised 60 percent of total mobile data

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[81] In 2017, 67 percent of connections were 4G LTE connections, compared to 7 percent in 2012. *See supra* Table 4.

[82] Chris Velazco, *Verizon's New LTE Promotion Meant To Benefit iPhone Users Too*, TECH CRUNCH (Nov. 10, 2011), https://techcrunch.com/2011/11/10/verizons-new-lte-promotion-meant-to-benefit-iphone-users-too/ ("[t]he deal is also meant to reduce congestion on the company's 3G EV-DO network").

[83] Bill Siwicki, *Mobile Apps Dominate Time Consumers Spend Online*, INTERNET RETAILER (Dec. 10, 2014) https://www.digitalcommerce360.com/2014/12/10/mobile-apps-dominate-time-consumers-spend-online/.

[84] *See, e.g.*, Exhibit 1.

traffic in 2016.[86] The increase in data was not just because consumers were using existing apps. Rather, developers created new apps, and incorporated new features into existing apps, that relied on faster, better, and cheaper cellular networks.[87] Facebook, for example, rolled out Facebook Live functionality, which allowed users to stream video to other users.[88]

63. As a result of the explosion in apps, new features, and the greater use of mobile devices, the average amount of time a U.S. adult spent online on their smartphones increased from 20 hours per month in 2010 to almost 79 hours per month in 2017.[89]

64. The increase in smartphone use was dependent on 4G LTE technology. 3G networks could not have accommodated it. In 2017, for example, T-Mobile carried [redacted] EBs of consumer data on its network, of which approximately [redacted] percent was carried through its 4G LTE

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[85] An October 2015 post on Google's company website stated: "Thanks to increasing smartphone penetration and the roll-out of 4G, digital video consumption is escalating through the roof – since March 2014 the number of daily YouTube watchers has grown 40% year over year. These people are seeking entertainment, information and inspiration while out and about, seated at their desks or relaxing at home...." Mark Howe, *Digital Video Upfronts: Putting YouTube On The Modern-Day Media Plan*, THINK WITH GOOGLE (Oct. 2015), https://www.thinkwithgoogle.com/intl/en-gb/consumer-insights/digital-video-upfronts-putting-youtube/.

[86] CISCO, CISCO VISUAL NETWORKING INDEX: GLOBAL MOBILE DATA TRAFFIC FORECAST UPDATE 2016–2021, at 2 (2017), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.pdf.

[87] In 2016, Apple's App Store had more than 2 million apps available. *See* Jordan Golson, *Apple's App Store Now Has over 2 Million Apps*, THE VERGE (June 13, 2016), https://www.theverge.com/2016/6/13/11922926/apple-apps-2-million-wwdc-2016.

[88] Facebook Live was available to all users by April 2016. Michelle Castillo, *Mark Zuckerberg Put Employees On 'Lockdown' For Two Months to Launch Facebook Live*, CNBC (Mar. 6, 2017), https://www.cnbc.com/2017/03/06/zuckerberg-put-employees-on-lockdown-to-launch-facebook-live-wsj.html

[89] The 2017 hours were calculated by taking the average of the App/Web on a Smartphone monthly hours spent by adults for Q1 2017 and Q2 2017. Data for 2010 was not available. The 2010 hours were estimated using the compound quarterly growth rate based on growth from Q4 2011 to Q4 2012. That 3.3 percent growth rate was then applied to the Q4 2011 minutes per day to determine monthly hours for each quarter in 2010. The average of those quarterly monthly amounts is 20 hours per month. NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q1 2017, at 20 tbl. 4A (2017), http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/total-audience-report-q1-2017.pdf; NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q2 2017, at 20 tbl. 4A (2017), http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/total-audience-report-q2-2017.pdf; NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q4 2013, at 9 ex. 1, 11 tbl. 3 (2014); NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q1 2014, at 8 ex. 1 (2014); NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q2 2014, at 8 ex. 1 (2014); NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q3 2014, at 10 ex. 1 (2014).

network.[90] Executives at T-Mobile have informed me that if the spectrum they had allocated to LTE in 2017 were instead allocated to 3G, that spectrum would have been able to handle a maximum of roughly [redacted] EBs, approximately [redacted] percent, of the traffic actually carried on the 4G LTE network that year.[91] In addition to only being able to carry a fraction of the [redacted] EBs, 3G would have provided an inferior customer experience resulting in lower downlink data speeds, higher latency and slower uplink data speeds.[92] Similarly, in April 2018 Sprint carried [redacted] PB of 4G tonnage, which is [redacted] times more than its maximum 3G tonnage of [redacted] PB in August 2014.[93] Sprint estimates that [redacted] PB of 4G tonnage per month could be supported on its 3G network using maximum spectrum; however, this represents only [redacted] percent of its April 2018 current 4G demand.[94]

65. The level of cellular data, and the performance of the network connection, translates directly into the apps that people enjoy.

C. The Deployment of New Generations of Technology Dramatically Increased the Supply, and Reduced the Price, of Mobile Data

66. The deployment of 3G and 4G LTE technologies resulted in a vast expansion in the capacity of cellular networks to provide cellular data to mobile subscribers. They used that capacity to increase the supply of cellular data massively, as shown above, and to reduce the

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[90] "T-Mobile Usage Data, Chart Data – Annual Worksheet," *T-Mobile* (Apr. 24, 2018).

[91] "T-Mobile Usage Data, Chart Data – Annual Worksheet," *T-Mobile* (Apr. 24, 2018).

[92] T-Mobile further informed me it is not clear that the core 3G network structure would have been able to support [redacted] EBs of traffic, technologically.

[93] According to Sprint, 3G monthly tonnage hit a maximum of [redacted] PB in August 2014, and April 2018 4G tonnage was [redacted] PB. I understand this analysis considered the amount of spectrum used when 3G was at its peak compared to the maximum available 3G spectrum. Sprint further noted that 4G data speeds and overall experience is superior to a 3G data experience. Sprint internal data.

[94] Comparing Sprint's monthly estimate of [redacted] PBs of 4G tonnage that could be supported on its 3G network using maximum spectrum, with its April 2018 4G demand of [redacted] PB, results in a ratio of [redacted] Sprint internal data.

price of cellular data dramatically, as I show here. The details of the calculations are reported in Appendix A.

67. To estimate mobile data prices, I have focused on smartphone users. I have allocated revenue to cellular data, versus voice calls, based on the fraction of the time subscribers spend using their smartphones to consume data rather than make voice calls.[95] The advantage of this method is that it correlates with how people use smartphones and can adjust for the changing use of smartphones for consuming data rather than making voice calls.[96]

68. I have used Nielsen data to calculate the amount of time adult smartphone users spent online from 2010 to 2017. I used CTIA data to calculate the number of voice minutes for mobile users and the share of mobile phone connections that are smartphone (as opposed to feature phones, tablets, laptops, etc.) – the smartphone penetration rate – to calculate the number of voice minutes spent on smartphones. Table 7 reports the results of these calculations. It shows that the percentage of time on smartphones spent online increased from 35 percent in 2010 to 73 percent in 2017.

[95] It is not possible to obtain reliable estimates of the price of cellular data from the package fees charged by cellular carriers, particularly over time, because voice calls and Internet access are typically bundled together in complex ways.

[96] Sprint and T-Mobile calculate allocations of voice and data revenue in the normal course of business. Their allocations for 2017 are consistent with the result of my method based on time-allocation. Both companies indicated that most consumers are moving to unlimited data plans and for these customers the allocation between voice and data are in the range of 80-90 percent data and 10-20 percent voice. Both companies expect the data portion to increase over time and eventually comprise almost all of the allocated revenue.

Table 7
Amount of Time on Smartphone Spent Online
2010 – 2017

Year	Mobile Data Minutes on Smartphone (Billions)	Voice Minutes on Smartphone (Billions)	Percent of Time on Smartphone Spent Online
2010	336.5	635.7	35%
2011	615.0	871.5	41%
2012	937.7	1,177.1	44%
2013	1,580.8	1,517.2	51%
2014	2,405.5	1,631.4	60%
2015	2,949.8	1,996.6	60%
2016	4,754.5	2,126.1	69%
2017	5,830.6	2,126.1	73%
Source: Exhibit 5B.			

69. Using data from GSMA Intelligence, I determined the portion of mobile recurring revenues attributable to smartphones. First, I applied the smartphone penetration rate and the percent of time on smartphone spent online to mobile recurring revenue to determine smartphone mobile data revenue. I then used data from CTIA and Cisco to calculate the mobile data traffic attributable to smartphones. The first two columns of Table 8 below report the results of these calculations.

70. It is possible to restate smartphone revenue and traffic numbers on a per user basis. To do so, I calculated the portion of ARPU allocated to data (Data ARPU) and mobile data traffic per smartphone user, measured in GB per month.[97] The third and fourth columns of Table 8

[97] According to the FCC, various measures of ARPU, which stands for average revenue per user or unit, are frequently used as a "proxy for price, particularly in industries with multiple pricing plans and complex rate structures." Estimates of industry-wide ARPU reported by the FCC for the years 2010 to 2016 range between approximately $50 and $35. FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TWENTIETH REPORT, WT Docket No. 17-69, at 5, 41-42, (Sept. 27, 2017).

report the results of these calculations. The last column of Table 8 reports the average price per GB of smartphone mobile data for U.S. smartphone users based on the ratio of smartphone mobile data revenue to smartphone mobile data traffic – or equivalently, based on the ratio of Data ARPU and smartphone mobile data traffic per smartphone user.

71. The results show that the price per GB of mobile data plummeted from $49.07 per GB in 2010, to $6.23 in 2017 – a total decline of 87 percent and an annual decline of 26 percent. Over that same period, the consumption of mobile data per smartphone subscriber increased by 1,633 percent from 0.3 GBs to 5.2 GBs per smartphone user per month, for an annual increase of 50 percent.

Table 8
Average Price per GB of Mobile Data for U.S. Smartphone Users
2010 – 2017

Year	Smartphone Mobile Data Revenue ($ Millions)	Smartphone Mobile Data Traffic (PB)	Data ARPU	Data Traffic per Smartphone User (GB/Month)	Price per GB of Smartphone Mobile Data
2010	$13,778.4	281	$17.01	0.3	$49.07
2011	$26,032.8	672	$20.06	0.5	$38.75
2012	$39,197.1	1,277	$21.71	0.7	$30.70
2013	$58,646.5	2,310	$25.85	1.0	$25.39
2014	$77,853.4	4,884	$29.67	1.9	$15.94
2015	$83,026.4	7,661	$27.89	2.6	$10.84
2016	$99,006.0	12,262	$30.71	3.8	$8.07
2017	$105,321.5	16,901	$32.19	5.2	$6.23

Source: Exhibit 5A.

D. Consumers Derive Substantial Benefits from Today's Mobile Ecosystem

72. Today's mobile ecosystem and its associated consumer benefits were unimaginable when the first 1G cellular network was deployed 35 years ago. By 2017, the smartphone had become the primary method that U.S. consumers use to access the Internet. In 2017 84.5 percent of adults in the United States (around 208 million adults) had smartphones, almost all of which could be used on 3G or 4G cellular networks.[98] During Q2 2017, the average adult in the United States spent 63 percent of their total time online using smartphones, compared to 22 percent with computers and 15 percent with tablets.[99] This development has resulted in consumers shifting generally from personal computers (PCs) to smartphones and has put competitive pressure on the PC industry.[100]

73. Precise quantification of the value on the online content and services made possible by the successive deployment of cellular technologies is difficult because so much of it is not sold in traditional markets. Rather, many of the most ubiquitous online platforms and services, such

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[98] The Nielsen Total Audience Reports in Q1 and Q2 2017 estimate that 84 percent and 85 percent of adults, respectively, in the United States used app/web on a smartphone, for an average of 84.5 percent. Nielsen also reports adult smartphone users of 207.9 million in Q1 2017 and 207.7 million in Q2 2017, for an average of 208 million. NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q1 2017, at 16 tbl. 2A, 18 tbl. 3A (2017), http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/total-audience-report-q1-2017.pdf; NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q2 2017, at 16 tbl. 2A, 18 tbl. 3A (2017), http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/total-audience-report-q2-2017.pdf; *see also* Exhibit 2.

[99] NIELSON CO., THE NIELSEN TOTAL AUDIENCE REPORT Q2 2017, at 13 exhibit 1 (2017), http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/total-audience-report-q2-2017.pdf. Similarly, estimates from comScore indicate that the share of online time accounted for by smartphones was 59 percent during December 2016. COMSCORE, CROSS-PLATFORM FUTURE IN FOCUS U.S. 2017, at 5 (2017), https://www.comscore.com/Insights/Presentations-and-Whitepapers/2017/2017-US-Cross-Platform-Future-in-Focus.

[100] For example, a report by comScore found that in 2016 growth in digital media consumption was driven all by use of smartphones, while digital media consumed on PCs (desktops and laptops) and tablets declined. Additionally, the report found that an increasing share of online retail spending is done using smartphones (although total dollars spent in retail spending using PCs increased as well). COMSCORE, CROSS-PLATFORM FUTURE IN FOCUS U.S. 2017, at 5, 60, 62 (2017), https://www.comscore.com/Insights/Presentations-and-Whitepapers/2017/2017-US-Cross-Platform-Future-in-Focus.

as YouTube, give people valuable content and get consumer time, attention, and data in return. They then take that time, attention, and data and use it to sell marketers advertising that these platforms intersperse in the content, thereby grabbing some people's attention for these marketers.[101]

74. People plainly value the content and services they get from these platforms because, of course, they would not spend their scarce time on them if they did not. In 2017 American adults spent 197 billion hours using their smartphones online to consume content and services.[102] The content and services they consumed were obviously worth a tremendous amount to them to spend this much time, even if some of it involved multitasking.[103]

75. Brynjolfsson *et al.* have used discrete choice experiments to estimate consumer surplus just from the Facebook social network, which accounted for about 14 percent of the time people spent on their smartphones in March 2016.[104] They conducted surveys of U.S. consumers in which they measured consumers' willingness to accept (WTA) compensation for giving up Facebook for a month. This measures the amount of consumer surplus from

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[101] *See, e.g.*, David S. Evans, *Attention Rivalry Among Online Platforms*, 9 J. COMPETITION L. & ECON. 313 (2013); David S. Evans, *The Economics of Attention Markets* (SSRN Working Paper No. 3044858, 2017), https://ssrn.com/abstract=3044858; Kevin Murphy & Ignacio Palacios-Huerta, *A Theory of Bundling Advertisements in Media Markets* (NBER Working Paper No. 22994, 2016), http://www.nber.org/papers/w22994.

[102] The annual time spent online on their smartphones is calculated by taking the average of the monthly time U.S. adults spent on the on app/web on a smartphone times the average number of users of app/web on a smartphone. The cited figure represents the expected yearly usage given data for Q1 2017 and Q2 2017. NIELSEN HOLDINGS, THE NIELSEN TOTAL AUDIENCE REPORT: Q1 2017, at 16 tbl. 2A, 20 tbl. 4A (July 12, 2017), http://www.nielsen.com/us/en/insights/reports/2017/the-nielsen-total-audience-report-q1-2017.html; NIELSEN HOLDINGS, THE NIELSEN TOTAL AUDIENCE REPORT: Q2 2017, at 16 tbl. 2A, 20 tbl. 4A (Nov. 16, 2017), http://www.nielsen.com/us/en/insights/reports/2017/the-nielsen-total-audience-q2-2017.html.

[103] David S. Evans, *The Economics of Attention Markets* (SSRN Working Paper No. 3044858, 2017), https://ssrn.com/abstract=3044858.

[104] Erik Brynjolfsson et al., *Using Massive Online Choice Experiments to Measure Changes in Well-being* (NBER Working Paper No. 24514, 2018), http://www.nber.org/papers/w24514; David S. Evans, *Mobile Advertising: Economics, Evolution, and Policy*, at 15 tbl. 1 (SSRN Working Paper No. 2786123, 2016), https://ssrn.com/abstract=2786123.

Facebook.[105] The median WTA was $37.76 a month in 2017. comScore estimated there were 176.6 million Facebook monthly active mobile users in the United States in June 2017.[106] Applying Brynjolfsson *et al.*'s $37.76 a month valuation of Facebook to this user base yields around $80 billion a year.[107] Facebook earned 91 percent of its advertising income from mobile use in Q1 2018, which suggests that most of its traffic is coming from mobile devices.[108]

76. These figures confirm the obvious. Smartphones have become part of most people's daily lives and investments in cellular networks, most importantly 3G and 4G networks, were instrumental in leading to this result.

E. U.S. Carrier Investments in Successive Generations of Technology Have Helped Position the United States as a Global Leader in the Smartphone Ecosystem

77. The deployment of cellular networks in the United States, including 4G LTE, where the United States was ahead of most large developed countries,[109] created a massive base of U.S. consumers available to any entrepreneur who wanted to find use cases for new technology.

[105] To ensure that people gave reliable answers, respondents were told they would be entered into a lottery and if selected they would actually be paid the agreed-upon WTA figure to stop using Facebook for a month; the researchers developed monitoring tools to make sure people did not access their Facebook accounts.

[106] IAB, DIGITAL TRENDS: CONSUMER USAGE OF DIGITAL AND ITS INFLUENCE ON AD REVENUE 22 (2017), https://www.iab.com/wp-content/uploads/2017/12/Digital-Trends-Consumer-Usage-of-Digital-and-its-Influence-on-Ad-Revenue.pdf.

[107] Erik Brynjolfsson et al., *Using Massive Online Choice Experiments to Measure Changes in Well-being* (NBER Working Paper No. 24514, 2018), http://www.nber.org/papers/w24514. For example, $37.76 x 12 x 176.6 million = $80 billion.

[108] Press Release, Facebook, Inc., Facebook Reports First Quarter 2018 Results (April 25, 2018), https://investor.fb.com/investor-news/press-release-details/2018/Facebook-Reports-First-Quarter-2018-Results/default.aspx.

[109] Kevin Fitchard, *How The First Countries To Adopt LTE Are Faring In The 4G Race*, OPENSIGNAL (Oct. 7, 2015), https://opensignal.com/blog/2015/10/07/how-the-first-countries-to-adopt-lte-are-faring-in-the-4g-race/; RECON ANALYTICS, HOW AMERICA'S 4G LEADERSHIP PROPELLED THE U.S ECONOMY (2018), https://api.ctia.org/wp-content/uploads/2018/04/Recon-Analytics_How-Americas-4G-Leadership-Propelled-US-Economy_2018.pdf.

U.S.-based companies and entrepreneurs seized this opportunity. They developed, introduced, and perfected their products and services in the U.S. market and then rolled them out around the world. They have made U.S. companies, at least outside of China, the leading providers for the smartphone ecosystem. Apple, Facebook, Google, and Uber are examples.

78. Apple, based in Cupertino, California, launched the iPhone in the United States in June 2007 in an exclusive distribution deal with AT&T.[110] As we saw above, the iPhone depended critically on the availability of 3G cellular network that had largely been built out by 2008, as well as subsequent 4G LTE networks.[111] Apple evolved from a niche company in 2007 (starting with a market cap of $72.0 billion at the beginning of the year, and ending with a market cap of $173 billion by the end of the year, six months after the iPhone's launch) to the world's most valuable publicly traded company with a market cap of $931.5 billion on June 1, 2018.[112]

79. Facebook, based in Menlo Park, California, decided to become a mobile-first company in 2012.[113] It launched revamped, native iPhone and Android apps that year and bought

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[110] David Pierce, *The Wired Guide to the iPhone*, WIRED (Feb. 1, 2018), https://www.wired.com/story/guide-iphone/; MG Siegler, *The Long Complicated Tale of AT&T's Exclusive (And Elusive) iPhone Agreement*, TECHCRUNCH (May 10, 2010), https://techcrunch.com/2010/05/10/apple-att-iphone-agreement/.

[111] In 2008, Verizon's 3G network covered around 82 percent of the U.S. population, while AT&T covered 73 percent, Sprint covered 62 percent, and T-Mobile covered 30 percent. *See* Exhibit 6.

[112] Press Release, Apple Inc., Apple Reinvents the Phone with iPhone (Jan. 9, 2007), https://www.apple.com/newsroom/2007/01/09Apple-Reinvents-the-Phone-with-iPhone/; Ari Levy, *Amazon Just Passed Alphabet to Become the World's Second Most Valuable Company*, CNBC (Mar. 20, 2018), https://www.cnbc.com/2018/03/20/amazon-just-passed-alphabet-to-become-the-worlds-second-most-valuable-company.html; Bloomberg data.

[113] Alistair Barr, *Facebook's Zuckerberg Says Mobile First Priority*, REUTERS (May 11, 2012), https://www.reuters.com/article/net-us-facebook-roadshow/facebooks-zuckerberg-says-mobile-first-priority-idUSBRE84A18520120512.

Instagram.[114] As of 2012, 47 percent of its advertising revenues, were from the United States and Canada.[115] The growing base of 3G and 4G LTE cellular network subscribers helped drive its growth. For example, in 2012 Facebook estimated that 11 percent of its total advertising revenue came from mobile products; in 2017, that figure grew to 88 percent.[116] As of June 1, 2018, Facebook's market cap was $561.7 billion, making it the seventh-largest publicly traded company in the world, driven mainly by the success of its mobile advertising business.[117]

80. Google, based in Mountain View, California, has become primarily a mobile company, with more searches performed on mobile devices than computers,[118] more than half of YouTube views on mobile,[119] and around half of its advertising revenue coming from mobile.[120] As of June 1, 2018, Alphabet, Google's parent company, had a market cap of

[114] Ellis Hamburger, *Facebook For iOS Goes Native Waves Goodbye To HTML 5*, THE VERGE (Aug. 23, 2012), https://www.theverge.com/2012/8/23/3262782/facebook-for-ios-native-app; Josh Constine, *Facebook Speeds Up Android App By Ditching HTML5 And Rebuilding It Natively Just Like The iOS Version*, TECHCRUNCH (Dec. 13, 2012), https://techcrunch.com/2012/12/13/facebook-android-faster/; Evelyn M. Rusli, *Facebook Buys Instagram for $1 Billion*, N.Y. TIMES (Apr. 9, 2012), https://dealbook.nytimes.com/2012/04/09/facebook-buys-instagram-for-1-billion/.

[115] This figure is calculated as $631 million in revenue in the United States and Canada divided by $1,329 million in revenue worldwide. Facebook Inc., Annual Report (Form 10-K), at 40 (Feb. 1, 2013).

[116] Facebook Inc., Annual Report (Form 10-K), at 41 (Feb. 1, 2013); Facebook Inc., Annual Report (Form 10-K), at 43 (Feb. 1, 2018).

[117] Ari Levy, *Amazon Just Passed Alphabet to Become the World's Second Most Valuable Company*, CNBC (March 20, 2018), https://www.cnbc.com/2018/03/20/amazon-just-passed-alphabet-to-become-the-worlds-second-most-valuable-company.html.

[118] A 2016 report from Hitwise estimated that mobile search is approximately 58 percent of all search queries in the Unites States. While this figure appears to reflect the broader search market, not just Google searches, it also suggests the importance of mobile search. Jerry Dischler, *Building for the Next Moment*, GOOGLE INSIDE ADWORDS BLOG (May 5, 2015), https://adwords.googleblog.com/2015/05/building-for-next-moment.html; Greg Sterling, *Report: Nearly 60 Percent of Searches Now From Mobile Devices*, SEARCH ENGINE LAND (Aug. 3, 2016), https://searchengineland.com/report-nearly-60-percent-searches-now-mobile-devices-255025.

[119] *YouTube for Press*, YOUTUBE.COM, https://www.youtube.com/intl/en-GB/yt/about/press/ (last visited June 4, 2018).

[120] The 47 percent share of advertising revenue from mobile is calculated by dividing total advertising revenue in 2016 by net mobile advertising revenue in 2016. In addition, Google expects mobile to continue to take a larger share. *Google's Ad Revenue From 2001 To 2017*, STATISTA (Feb. 2018), https://www.statista.com/statistics/266249/advertising-revenue-of-google/; *Worldwide Net Mobile Advertising*

$782.5 billion making it the third largest publicly traded firm in the world, with almost all of its revenue coming from Google.[121]

81. Uber, based in San Francisco, California, is now the global leader on local transportation services, with a market value of around $72 billion.[122] It launched its service in San Francisco in 2010, beginning with iPhone apps that ran on AT&T's cellular network.[123] It rolled out to five U.S. cities before branching out overseas.[124]

82. The bottom line is that the deployment of successive generations of cellular technology created a critical mass of wireless users in the United States and thereby contributed to the U.S. lead in the smartphone ecosystem. This provides an important economic lesson for the deployment of 5G cellular networks in the United States.

Revenues Of Google From 2014 To 2018, STATISTA (Oct. 2016), https://www.statista.com/statistics/539477/google-mobile-ad-revenues-worldwide/; Alphabet Inc., Annual Report (Form 10-K), at 8 (Feb. 5, 2018).

[121] Ari Levy, *Amazon Just Passed Alphabet to Become the World's Second Most Valuable Company*, CNBC (Mar. 20, 2018), https://www.cnbc.com/2018/03/20/amazon-just-passed-alphabet-to-become-the-worlds-second-most-valuable-company.html; Alphabet, Annual Report (Form 10-K), at 28 (Feb. 6, 2018); Bloomberg data.

[122] Uber is not a publicly traded company, so valuations vary. In February 2018, Uber was valued at $72 billion. Theodore Schleifer, *Uber's Latest Valuation: $72 Billion*, RECODE (Feb. 9, 2018), https://www.recode.net/2018/2/9/16996834/uber-latest-valuation-72-billion-waymo-lawsuit-settlement.

[123] *The History of Uber*, UBER NEWSROOM, https://www.uber.com/newsroom/history/ (last visited June 3, 2018); Yasmin Hyder, *Uber's Evolution from San Francisco to International Disruption*, SOUMYASEN.COM (Feb. 7, 2014), http://soumyasen.com/IDSC6050/Case15/Group15_index.html; M.G. Siegler, *The Long, Complicated Tale of AT&T's Exclusive (And Elusive) iPhone Agreement*, TECHCRUNCH (May 10, 2010), https://techcrunch.com/2010/05/10/apple-att-iphone-agreement/.

[124] Avery Hartmans & Nathan McAlone, *The Story of How Travis Kalanick Built Uber into the Most Feared and Valuable Startup in the World*, BUS. INSIDER (Aug. 1, 2016), http://www.businessinsider.com/ubers-history; Eric Eldon, *How Uber is Launching in Its Newest City, Washington, DC*, TECHCRUNCH (Dec. 15, 2011), https://techcrunch.com/2011/12/15/uberdc/.

III. 5G Technologies, the Development of Applications, and the Impact on Consumers and the Economy

83. U.S. smartphone mobile data traffic grew with a compound annual growth rate (CAGR) of about 80 percent between 2010 and 2017.[125] Industry observers project that demand will continue to grow at a rapid clip as consumer use of data-intensive apps increases and they migrate from using desktop to mobile devices.[126] Eventually carriers will face a physical limit – dictated by scarce spectrum and spectral efficiency – on the amount of data traffic they will be able to handle over 4G LTE networks.[127] Of course, this is the same problem that cellular carriers faced as 1G, 2G, and 3G networks matured.

84. Because of this dynamic, SDOs began work on 5G technologies around 2013,[128] and 3GPP is scheduled to release the full 5G specification by the end of 2019.[129] 5G technology is expected to improve traffic capacity by 4 times over the most advanced LTE technologies.[130] The deployment of 5G networks is therefore expected to enable carriers to keep up with

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[125] As shown in Table 8 above, smartphone mobile data traffic on U.S. cellular networks grew from 281 PBs in 2010 to 16,901 PBs in 2017.

[126] *See e.g.*, CISCO, CISCO VISUAL NETWORKING INDEX: GLOBAL MOBILE DATA TRAFFIC FORECAST UPDATE 2016-2021, at 5, 22 (Feb. 7, 2017), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html; *see also*, ERICSSON, ERICSSON MOBILITY REPORT 12 (Nov. 2017), https://www.ericsson.com/en/mobility-report/reports/november-2017/mobile-data-traffic-growth-outlook.

[127] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, 62-63 (June 27, 2011); FED. COMMC'NS COMM'N, MOBILE BROADBAND: BENEFITS OF ADDITIONAL SPECTRUM 14-15 (Oct. 2010), https://transition.fcc.gov/national-broadband-plan/mobile-broadband-paper.pdf.

[128] *See, e.g.*, Milon Gupta, Editorial, *Dear Readers*, EURESCOM MESSAGE, Spring 2014, at 3, https://www.eurescom.eu/fileadmin/documents/message/Eurescom-message-01-2014-web.pdf.

[129] 3GPP is working on the specification which is being informed by related initiatives by the International Telecommunications Union and the 5G Technical Forum. For a summary of the standardization initiatives, *see* CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 32 (Oct. 2017); *Release 16*, 3GPP, http://www.3gpp.org/release-16 (last visited June 3, 2018); ITU, IMT VISION – FRAMEWORK AND OVERALL OBJECTIVES OF THE FUTURE DEVELOPMENT FOR IMT FOR 2020 AND BEYOND 4-5 (Sept. 2015), https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf.

[130] Based on 5G expected average data rate (>100 Mbps) compared to 4G LTE average data rate (~25 Mbps). CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017).

growing demand from consumer use of existing app features, such as video streaming. It will also enable them to meet demand for the new app features that will arise endogenously in response to the development of 5G technologies.

85. The planned 5G technologies, however, are not just the next stop on the mobile phone journey. Once deployed, these technologies will provide even faster, almost real-time, always-on, and highly reliable connections to an almost unlimited number of access points.[131] 5G networks could thereby unleash a torrent of innovation for consumers, businesses, and governments. While industry participants have started to discuss applications, the history of the prior deployment of 3G and 4G technologies shows that the most important innovations may be ones that are unimaginable today.[132] But there is a consensus that critical new applications cannot happen without 5G technology and cellular networks with vastly more capacity and far superior performance.[133]

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[131] Radio Commc'n Study Grps. Working Party 5D, *Minimum Requirements Related to Technical Performance for IMT-2020 Radio Interface(s)* 6-9 (Int'l Telecomm. Union, Document No. ITU-R SG05 Contribution 40, 2017), https://www.itu.int/md/R15-SG05-C-0040/en; THOMAS K. SAWANOBORI, CTIA, 5G THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. 7 (Feb. 9, 2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf.

[132] *See, e.g.*, "Road to 5G – TMUS Board of Directors Meeting," ***T-Mobile***, Sept. 7-8, 2016, at 9-11; "Understanding the Ins and Outs of the 5G Use Cases," *Signals Ahead*, Dec. 8, 2015, at 5.

[133] *See, e.g.*, HUSAIN M. ABDUL AZIZ ET AL., SYNTHESIS STUDY ON TRANSITIONS IN SIGNAL INFRASTRUCTURE AND CONTROL ALGORITHMS FOR CONNECTED AND AUTOMATED TRANSPORTATION 8-9 (June 2017), https://info.ornl.gov/sites/publications/files/Pub75211.pdf; Don Butler, *Why We're Working with Qualcomm to Ensure Everything in Cities Speaks the Same Language*, MEDIUM (Jan. 9, 2018), https://medium.com/cityoftomorrow/why-were-working-with-qualcomm-to-ensure-everything-in-cities-speaks-the-same-language-98e0cc1bff18; ANTONIO ORSINO ET AL., IEEE, FACTORIES OF THE FUTURE ENABLED BY 5G TECHNOLOGY 2-3 (2018), https://5g.ieee.org/images/files/pdf/applications/Factories-of-the-Future-Enabled-by-5G-Technology_030518.pdf; KAREN CAMPBELL ET AL., IHS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 22-24 (2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; THOMAS K. SAWANOBORI, CTIA, 5G THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. 7 (Feb. 9, 2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf. JAMES FAUCETTE ET AL., MORGAN STANLEY, LEARNING TO RIDE A 5G CYCLE 12 (Oct. 15, 2017).

A. 5G Technologies Are a Gigantic Leap Forward From 4G LTE

86. In the previous section, I compared 2G, 3G, and 4G LTE technologies based on data speeds, latency, and spectral efficiency. These are the main elements that determine the price, quantity, and quality of data-based services that consumers obtain from carriers.[134] Three other dimensions are relevant for evaluating the likely value of 5G to consumers:

a. *Connection density* measures the number of active users per square kilometer, a feature important for the Internet of Things (IoT).[135]

b. *Mobility* measures the ability to be connected to a device as it is moving through space, a feature important for possible applications such as drones.

c. The *block error rate* (BLER) measures the percent of blocks of data that are transmitted in error, which is relevant for applications with stringent reliability requirements, such as industrial control, traffic safety, and medical applications like remote surgery.

87. Table 9 summarizes these key performance metrics for 4G and 5G targets. Specifically:

a. 5G *data speeds* are expected to be greater than 100 Mbps on average with theoretical speeds greater than 10,000 Mbps.[136] By comparison, the average download speed for wired broadband internet access service (BIAS) providers in

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[134] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TWENTIETH REPORT, WT Docket No. 17-69, at 35, 64 (Sept. 27, 2017).

[135] Lee Rainie & Janna Anderson, *The Internet of Things Connectivity Binge: What Are the Implications?* PEW RESEARCH CENTER (June 6, 2017), http://www.pewinternet.org/2017/06/06/the-internet-of-things-connectivity-binge-what-are-the-implications/.

[136] CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017).

the United States was about 64 Mbps in 2017.[137] The expected average speed for 5G is four times the average for 4G.[138]

b. *Latency* is expected to drop to around 1 ms down from about 50 ms for 4G.[139]

c. *Connection density* is expected to be much higher with 5G, supporting more than 100,000 active users per square kilometer compared with approximately 2,000 for LTE.[140]

d. *Mobility* will increase to more than 500 km/h from no more than 350 km/h for 4G.[141]

e. Variants of 5G networks are expected to have a *BLER* of 10^{-5} compared with 10^{-2} for 4G.[142]

88. 5G is also expected to provide enhanced spectral efficiency over LTE.[143] In addition, while 4G LTE primarily uses lower bands of spectrum that can deliver wide-area coverage at the expense of limited bandwidth, 5G is being designed to support all spectrum bands. That

[137] Ookla, United States Fixed Speeds, SpeedTest.net (Sept. 7, 2017), http://www.speedtest.net/reports/united-states/#fixed.

[138] CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017).

[139] CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017).

[140] CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017).

[141] CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017).

[142] Mehdi Bennis et al., Ultra-Reliable and Low-Latency Wireless Communication: Tail, Risk and Scale, at 2 (Jan. 8, 2018), https://arxiv.org/pdf/1801.01270.pdf.

[143] Sebastian Anthony, *5G Specs Announced: 20Gbps Download, 1Ms Latency, 1M Devices Per Square Kkm*, ARS TECHNICA (Feb. 24, 2014), https://arstechnica.com/information-technology/2017/02/5g-imt-2020-specs/; *see also*, 5G AMERICAS, WIRELESS TECHNOLOGY EVOLUTION TOWARDS 5G: 3GPP RELEASE 13 TO 15 AND BEYOND 138 (Feb. 2017), http://www.5gamericas.org/files/3214/8833/1313/3GPP_Rel_13_15_Final_to_Upload_2.28.17_AB.pdf.

will provide greater capacity by extending use of mid-band spectrum and expanding into millimeter wave (mmWave) bands beyond 24 GHz.[144]

Table 9
Key Performance Indicators: 5G v. 4G

Performance Indicator	5G Target	4G
Data Rate	>100 Mbps (Avg.) >10,000 Mbps (Peak)	~25 Mbps (Avg.) 150 Mbps (Peak)
Latency	~1 ms	~50 ms 10 ms for 2-way RAN
Spectral Efficiency	Enhanced over 4G	1X
Connection Density	>100,000 users/km^2	~2,000 users/km^2
Spectrum Bands	Supports all	Limited support
Mobility	>500 km/h	350 km/h
BLER	10^{-9}-10^{-5}	10^{-2}
Source: CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017); Mehdi Bennis et al., Ultra-Reliable and Low-Latency Wireless Communication: Tail, Risk and Scale 2 (Jan. 8, 2018) (unpublished draft), https://arxiv.org/pdf/1801.01270.pdf; Consumer Tech. Ass'n, *The Promise of 5G* (Aug. 22, 2017), https://www.cta.tech/News/i3/Articles/2017/July-August/The-Promise-of-5G.aspx.		

89. Modern cellular technologies, beginning with 3G, are general-purpose technologies that provide critical inputs into downstream innovation.[145] By giving every point in physical space access to an ultra-fast, essentially real-time, and highly reliable data connection, 5G could have an enormous impact on productivity growth, and increase the United States' economic welfare,

[144] QUALCOMM & NOKIA, MAKING 5G A REALITY: ADDRESSING THE STRONG MOBILE BROADBAND DEMAND IN 2019 & BEYOND 9, 10 (Sept. 2017), https://www.qualcomm.com/system/files/document/files/whitepaper_-_making_5g_a_reality_-_addressing_the_strong_mobile_broadban.pdf.

[145] Timothy F. Bresnahan & Manuel Trajtenberg, *General Purpose Technologies 'Engines of Growth?'* 1 (Nat'l Bureau of Econ. Research, Working Paper No. 4148, 1992), http://www.nber.org/papers/w4148.pdf.

in much the same way that electricity, and the electric power grid, did during the 20th century.[146] The deployment of 5G technologies, however, faces the chicken and egg problem discussed earlier, in which innovators cannot use 5G to create new products and services until it is deployed.

90. In the last section, I will show that the Transaction will accelerate the deployment of 5G through dynamic competition, and deliver benefits faster, because it will result in the more rapid deployment of a stronger 5G network by New T-Mobile and induce AT&T and Verizon to accelerate and strengthen their own 5G deployments.

B. The Deployment of 5G Technologies Will Benefit Cellular Subscribers Through Lower Data Prices, Improved Quality, and More Applications

91. The subscribers of cellular networks will be among the first beneficiaries of 5G technologies. The data shows that the deployment of 5G technologies will produce a substantial drop in the price per GB of data and a vast increase in the amount of data consumed. This decline in price, and increase in output, will occur for 5G, as it has for 2G, 3G, and 4G, for three interrelated reasons.

92. First, cellular carriers will again be able to provide more data at a lower cost. As one measure of the potential capacity gains of 5G, the ITU has set a goal for area traffic capacity of 10 Mbps per square meter in the IMT-2020 objectives that 5G technologies were developed to meet, which is 100 times as great as the goal for IMT-Advanced (*i.e.*, LTE).[147] Cellular

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[146] ROBERT J. GORDON, THE RISE AND FALL OF AMERICAN GROWTH: THE U.S. STANDARD OF LIVING SINCE THE CIVIL WAR 16-17 (2017).

[147] INT'L TELECOMM. UNION, IMT VISION – FRAMEWORK AND OVERALL OBJECTIVES OF THE FUTURE DEVELOPMENT OF IMT FOR 2020 AND BEYOND 14 (Sept. 2015), https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf.

carriers will be able to provide that data at a cost per GB that is 10 times lower than the cost per GB for current 4G networks, based on estimates from Ericsson.[148] With more capacity and lower costs, carriers would have stronger incentives to offer consumers more data at lower prices per GB. Historically, lower prices per GB have produced lower priced packages and increased the amount of data that subscribers consume given the package price.

93. Second, consumer demand for the increased capacity would result from natural increases in the demand for using smartphones for online data functions. For example, Ericsson estimated that the average North American smartphone would use 7.1 GBs of data per month by the end of 2017, and usage was expected to grow to 48.0 GBs per month by 2023 – with 5G accounting for 37 percent of all mobile subscriptions in North America.[149] Ericsson also noted that total North American smartphone user monthly data usage was approximately 2,201 PBs in 2017 and would grow by a factor of 8.5 to 18,720 PBs in 2023. Consumer demand would increase with the deployment of 5G because using apps and browsing the Web would be faster and better given improvements in data speeds and reductions in latency – just as with the deployment of 4G LTE technologies.

94. Third, substantial improvements in 5G data speed, latency, and reliability will cause developers to create more app features or new apps, including some that we cannot imagine

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[148] ERICSSON, THE 5G CONSUMER BUSINESS CASE: AN ECONOMIC STUDY OF ENHANCED MOBILE BROADBAND (2018), https://www.ericsson.com/assets/local/narratives/networks/documents/gfmc-18000020-rev-a-uen.pdf.

[149] ERICSSON, ERICSSON MOBILITY REPORT 8, 12 (Nov. 2017), https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-november-2017.pdf.

today.[150] Again, that is what happened following the deployment of 3G and 4G LTE technologies.

95. Therefore, based on the historical data, and the technical features of 5G technology, I would expect that the deployment of 5G cellular networks will result in a massive increase in the quantity of cellular data, a dramatic drop in the price per GB of data, and substantial improvements in the consumer experience. When and how quickly that happens largely depends on when cellular carriers deploy 5G networks across the United States and the provision of 5G handsets.

C. The Deployment of 5G Technology Will Increase Competition for Fixed Broadband

96. The deployment of 5G technologies will provide consumers with competitive alternatives to fixed broadband. That will benefit some mobile subscribers either directly through their monthly plan, for example by getting Wi-Fi hotspots, or through additional home broadband services from fixed wireless broadband. The availability of 5G networks will also create competitive pressure on the fixed broadband providers and thereby result in a decline in prices, and improvement in quality, for consumers of fixed broadband.

1. American Households Have Limited Choices of Fixed Broadband Internet Access Providers

97. Households require high-speed broadband – download speeds of at least 25 Mbps and upload speeds of at least 3 Mbps[151] – to use high-quality voice, data, graphics, and video

[150] As illustrated above in Table 9, 5G is expected to have 4x the data rates, up to 50x lower latency, and 1,000x better BLER rates as compared to 4G.

[151] In its 2015 Broadband Progress Report, the FCC concluded that in order for a service to qualify as having “advanced telecommunications capability,” it would need download speeds of at least 25 Mbps and upload speeds of at least 3 Mbps. This was a change from its previous benchmark of 4 Mbps downloads and 1 Mbps uploads.

applications.[152] The FCC has found that most U.S. customers have access to only a small number of high-speed wired BIAS providers that supply adequate Internet speeds.[153] Wired BIAS providers include cable companies, telecommunication companies, and, in limited areas, overbuilders.[154] Because laying cable is expensive, and often requires governmental approvals, these wired BIAS providers are usually available only in particular neighborhoods and only to households where wired BIAS providers have extended their networks very close to the home.[155] As the FCC has recognized, these dynamics impact the available competitive choices to consumers.[156]

For a discussion of the rationale for this benchmark, see FED. COMMC'NS COMM'N, 2015 BROADBAND PROGRESS REPORT AND NOTICE OF INQUIRY ON IMMEDIATE ACTION TO ACCELERATE DEPLOYMENT, GN Docket No. 14-126, ¶¶ 19-62 (Feb. 4, 2015), https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-10A1.pdf. This benchmark threshold remains the same through the current FCC Broadband Progress Report. *See* FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket N. 15-191, ¶ 19 (Jan. 29, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf.

[152] "When given the choice, households predominantly use high-speed broadband providers which indicates that slower-speed providers do not impose significant competitive constraints. DSL, satellite, fixed wireless, and other wireline technologies (excluding cable, fiber, and AT&T's hybrid U-Verse technology) accounted for just 15.7 percent of broadband connections as of June 30, 2016, compared to the 84.3 percent for cable, fiber-to-the-premises, and AT&T's hybrid U-Verse technology. This 15.7 percent is only modestly larger than the 7 percent of the U.S. population which lacks access to any provider of high-speed broadband." David S. Evans, *Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and Edge Providers* (SSRN, Working Paper No. 3029006, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3029006%20.

[153] *Applications of Charter Communications, Inc., Time Warner Cable Inc., and Advance/Newhouse Partnership for Consent to Assign or Transfer Control of Licenses and Authorizations*, Memorandum Opinion and Order, 31 FCC Rcd. 6327 (2016)(Charter-Time Warner Order); FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket N. 15-191, ¶ 86 (Jan. 29, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf.

[154] In this context, an overbuilder is a cable company, telco, or fiber provider that offers broadband service to households already served by incumbent cable and telco providers. For example, an overbuilder like RCN is a company that offers wired BIAS via coaxial cable to households in areas already served by an incumbent cable provider. *Overbuilder*, PC MAGAZINE, https://www.pcmag.com/encyclopedia/term/67769/overbuilder (last visited June 10, 2018).

[155] David S. Evans, *Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and EDGE Providers*, 9 (SSRN, Working Paper No. 3029006, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3029006%20.

[156] FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket N. 15-191, ¶¶ 85-86 (Jan. 29, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf.

98. Table 10 shows the percentage of the population who have access to various numbers of high-speed wired BIAS providers as of June 30, 2016. About 7.0 percent of the population did not have any access to a high-speed wired BIAS provider. Of those who have at least one option, the average person had two high-speed wired BIAS provider choices. The most common situation, accounting for 40.8 percent of people, was two high-speed wired BIAS choices. Of people who had at least one high-speed wired BIAS provider, about 31.9 percent only have one alternative and 75.8 percent have one or two. These figures are generally consistent with findings the FCC has reached using earlier and similar data.[157]

[157] FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket N. 15-191, ¶ 86 (Jan. 29, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf; *Preserving the Open Internet*, GN Docket No. 09-191, Report & Order, 25 FCC Rcd. 17905, ¶ 32 (Dec. 23, 2010), https://apps.fcc.gov/edocs_public/attachmatch/FCC-10-201A1_Rcd.pdf; David S. Evans, *Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and EDGE Providers*, 10-11 (SSRN, Working Paper No. 3029006, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3029006%20.

Table 10
Subscribers and Shares for the Largest Wired BIAS Providers
June 30, 2016

Number of High-Speed Wired BIAS Providers in Census Block	Share of Population	Share of Population with at Least One High-Speed Wired BIAS Provider
0	7.0%	-
1	29.7%	31.9%
2	40.8%	43.8%
3	19.0%	20.4%
4	3.1%	3.3%
5	0.4%	0.5%
6+	0.1%	0.1%
Weighted Average Number of Providers	1.83	1.97

Source: FCC, Fixed Broadband Deployment Data from FCC Form 477: Data as of June 30, 2016 (v2), https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477 (last visited June 3, 2018); U.S. Census Bureau; *see also*, David S. Evans, *Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and EDGE Providers*, Table 2 (SSRN, Working Paper No. 3029006, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3029006%20.

99. The typical household only has access to one cable company and one telecommunications provider. The cable companies generally offer fast broadband with download speeds of 150 Mbps or more. The telecommunications companies provide fiber optic cable with similar speeds in some areas and DSL with relatively low download speeds, about 20 Mbps, in others.[158]

[158] David S. Evans, *Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and EDGE Providers*, 11 (SSRN, Working Paper No. 3029006, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3029006%20.

100. The competitive situation is substantially worse in rural areas.[159] The FCC found that 39 percent of rural Americans had no high-speed BIAS provider, 48 percent had one high-speed BIAS provider, and only 13 percent of had more than one BIAS provider.[160] In another study, the FCC found that high-speed BIAS was available to only 69.3 percent of rural Americans in 2016 compared to 97.9 percent of urban Americans.[161] These rural areas account for 19.3 percent of the U.S. population and 97 percent of the landmass of the country.[162] Rural households often have to turn to satellite and DSL providers for broadband but cannot purchase high broadband speeds from these providers.[163] For example, the FCC reported median download speeds of 50 Mbps for cable, compared with approximately 10 Mbps for DSL and Satellite broadband.[164]

2. 5G Technologies Can Increase Cord-Cutting Competition

101. Today, consumers cannot obtain high-speed cellular broadband service that can provide a direct substitute for high-speed wired broadband service. Cellular carriers lack the capacity to handle the large volumes of data that cable subscribers use.[165] Even when cellular carriers

[159] FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket N. 15-191, ¶ 119 (Jan. 29, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf.

[160] FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket N. 15-191, ¶ 86 (Jan. 29, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf.

[161] FED. COMMC'NS COMM'N, 2018 BROADBAND DEPLOYMENT REPORT, GN Docket No. 17-199, ¶ 57 tbl. 4 (Feb. 2, 2018), https://docs.fcc.gov/public/attachments/FCC-18-10A1.pdf

[162] Press Release, U.S. Census Bureau, New Census Data Show Differences Between Urban and Rural Populations (December 8, 2016), https://www.census.gov/newsroom/press-releases/2016/cb16-210.html.

[163] *See, e.g.*, Jennifer Levitz & Valerie Bauerlein, *Rural America is Stranded in the Dial-Up Age*, WALL STREET JOURNAL (June 15, 2017), https://www.wsj.com/articles/rural-america-is-stranded-in-the-dial-up-age-1497535841.

[164] FED. COMMC'NS COMM'N, 2016 MEASURING BROADBAND AMERICA FIXED BROADBAND REPORT 32 (Dec. 1, 2016), https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-report-2016.

[165] Larry Thompson et al., *Comparing Wired and Wireless Broadband 86-92*, BBCMag.com (May 2015), http://www.bbcmag.com/2015mags/May_June/BBC_May15_ComparingWiredandWireless.pdf.

offer unlimited data plans they limit the data rate or video quality consumers who try to use their cellular plan to consume extreme amounts of data by, for example, downloading a high-definition movie.[166] Every carrier has instituted a data usage threshold whereby heavy users will have their traffic deprioritized during periods of network congestion. The thresholds are well below typical levels used for streaming video via home broadband.[167] No carrier offers unlimited data plans for mobile 4G LTE hotspots which prevents consumers from using their mobile plans affordably to connect televisions and other devices to the Internet. Even zero-rating programs limit users to poorer video quality: while T-Mobile allows users to access a variety of video services without counting the data against their monthly usage through its

[166] As of April 27, 2018, the four major U.S. carriers offered unlimited talk, texting, and data plans; however, when data usage exceeds a certain threshold (AT&T 22 GB, Verizon 22 GB, Sprint 23 GB, and T-Mobile 50 GB), the carriers may limit the user's data rates. Patrick Holland, *Verizon, T-Mobile, AT&T and Sprint Unlimited Plans Compared*, CNET (Apr. 27, 2018), https://www.cnet.com/news/how-does-verizon-unlimited-plan-stack-up-against-the-others/; Jerry Hildenbrand, *When Do Carriers Start Throttling You and What Can You Do About It?*, ANDROIDCENTRAL (Dec. 27, 2017), https://www.androidcentral.com/when-do-carriers-start-throttling-you-and-what-you-can-do-about-it; Wired Staff, *Verizon's Unlimited Data Plan Has Changed. Here's How It Compares to Other Carriers*, WIRED (Aug. 22, 2017), https://www.wired.com/2017/08/verizons-unlimited-data-plan-back-heres-compares-carriers/; *How To Stop Video Throttling on Unlimited Data Plans (and stream in 4k)*, VPN UNIVERSITY: TUTORIAL, https://www.vpnuniversity.com/tutorial/how-to-stop-video-throttling-on-unlimited-data-plans-and-stream-in-4k (last updated Sept. 13, 2017).

[167] At present, these thresholds are: AT&T 22 GB, Verizon 22 GB, Sprint 23 GB, and T-Mobile 50 GB. Patrick Holland, *Verizon, T-Mobile, AT&T and Sprint Unlimited Plans Compared*, CNET (Apr. 27, 2018), https://www.cnet.com/news/how-does-verizon-unlimited-plan-stack-up-against-the-others/; Jerry Hildenbrand, *When Do Carriers Start Throttling You and What Can You Do About It?*, ANDROIDCENTRAL (Dec. 27, 2017), https://www.androidcentral.com/when-do-carriers-start-throttling-you-and-what-you-can-do-about-it; Wired Staff, *Verizon's Unlimited Data Plan Has Changed. Here's How It Compares to Other Carriers*, WIRED (Aug. 22, 2017), https://www.wired.com/2017/08/verizons-unlimited-data-plan-back-heres-compares-carriers/; *How To Stop Video Throttling on Unlimited Data Plans (and stream in 4k)*, VPN UNIVERSITY: TUTORIAL, https://www.vpnuniversity.com/tutorial/how-to-stop-video-throttling-on-unlimited-data-plans-and-stream-in-4k (last updated Sept. 13, 2017). Streaming HD video from Netflix requires approximately 3 Gbps per hour, and the average Netflix user watches 34 hours of content (requiring up to 102 GB) per month. *How Can I Control How Much Data Netflix Uses?*, NETFLIX.COM: HELP CENTER, https://help.netflix.com/en/node/87 (last visited June 3, 2018); Joan E. Solsman, *Netflix Is Hijacking 1 Billion Hours Of Our Lives Each Week*, CNET (Apr. 17, 2017), https://www.cnet.com/news/netflix-billion-hours-a-week-adam-sandler/; Rani Molla, *Netflix Now Has Nearly 118 Million Streaming Subscribers Globally*, RECODE (Jan. 22, 2018), https://www.recode.net/2018/1/22/16920150/netflix-q4-2017-earnings-subscribers.

Binge On program, it limits data users to sub-HD video resolutions of 480p or 720p.[168] Binge On had a significant effect on the T-Mobile network: an Ericsson study of T-Mobile's network found that the program generated an immediate 12 percent reduction in traffic load.[169]

102. Nevertheless, given the high price of high-speed broadband, and consumer dissatisfaction with cable providers, a growing number of consumers use only cellular wireless. The U.S. Department of Commerce found that "the proportion of online households that relied exclusively on mobile service at home doubled between 2013 and 2015, from 10 percent to 20 percent."[170] This is particularly true for younger customers. One report found that 39 percent of Americans as a whole said they "usually connect to the Internet at home" using mobile devices, but 55 percent of millennials and 60 percent of respondents ages 18 to 24 said that they did so.[171]

103. The increased availability of unlimited data plans and bundled streaming services has increased the appeal of using cellular instead of fixed broadband. Research firm Parks Associates expects this trend to continue with 10 percent of U.S. broadband households likely to cancel their fixed broadband services in favor of mobile data services over the 12-month period following the survey.[172] For younger consumers, 15 percent of 25-to-34-year-old

[168] *Binge On*, T-MOBILE SUPPORT, https://support.t-mobile.com/docs/DOC-24291?icid=WMM_TM_Q118BINGEO_ZJPCJ73EKJW12494 (last visited June 10, 2018); *see also Letter to Customers: T-Mobile's CEO on Binge On*, T-MOBILE (undated), https://www.t-mobile.com/brand/binge-on-letter?icid=WMM_TM_Q118BINGEO_XSHPG7BA32B12493.

[169] ERICSSON, RADIO NETWORK EVOLUTION STUDY 2016-2021, at 12 (Q4 2016).

[170] Giulia McHenry, *Evolving Technologies Change the Nature of Internet Use*, NTIA (Apr. 19, 2016), https://www.ntia.doc.gov/blog/2016/evolving-technologies-change-nature-internet-use.

[171] *Wired, Wireless or Both? Americans Rethink Their Internet Connections*, REPORT LINKER (Mar. 9, 2017), https://www.reportlinker.com/insight/internet-connections.html.

[172] *10% of U.S. Broadband Households Likely to Cancel Their Fixed Broadband Internet Service Over Next 12 Months*, PARKS ASSOCIATES (Feb. 23, 2017), http://www.parksassociates.com/blog/article/pr-02232017.

households are likely to cancel fixed broadband services over the 12-month period.[173] eMarketer estimated that 12.3 percent of U.S. Internet users relied solely on mobile devices in 2015, a figure that was expected to grow to 14.9 percent in 2017 and 18.3 percent by 2021.[174]

104. Despite these trends, mobile broadband is not currently a close substitute for fixed broadband. Consumers who only use mobile broadband generally do not stream as much long-form content, such as from Netflix and Amazon, or engage in other data-intensive activities. Consider consumers on AT&T's and Verizon's unlimited plans both of which limit data to 22 GBs per month.[175] In comparison, streaming standard definition (SD) video on Netflix requires approximately 0.7 GBs of data per hour while high definition (HD) video requires up to 3 GBs per hour.[176] The average Netflix user watches approximately 34 hours of content per month[177] – approximately 23.8 GBs to 102 GBs worth of streaming data depending on the quality. Therefore, the average Netflix user under AT&T's and Verizon's unlimited plans would reach their limits every month, using only Netflix and not accounting for the other applications and use cases for cellular technology. Therefore, consumers appear to substitute cellular broadband

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[173] *10% of U.S. Broadband Households Likely to Cancel Their Fixed Broadband Internet Service Over Next 12 Months*, PARKS ASSOCIATES (Feb. 23, 2017), http://www.parksassociates.com/blog/article/pr-02232017.

[174] *eMarketer Releases Updated Estimates for US Digital Users*, EMARKETER (Feb. 20, 2017), https://www.emarketer.com/Article/eMarketer-Releases-Updated-Estimates-US-Digital-Users/1015275. Values are calculated from data presented in the source (i.e., 12.3% = 32.1 mobile-only U.S. Internet users in 2015 / 260.8 million total U.S. Internet users in 2015; 18.3% = 52.3 mobile-only U.S. Internet users in 2021 / 286.5 million total U.S. Internet users in 2021).

[175] Patrick Holland, *Verizon, T-Mobile, AT&T and Sprint Unlimited Plans Compared*, CNET (Apr. 27, 2018), https://www.cnet.com/news/how-does-verizon-unlimited-plan-stack-up-against-the-others/.

[176] *How Can I Control How Much Data Netflix Uses?*, NETFLIX.COM: HELP CENTER, https://help.netflix.com/en/node/87 (last visited June 3, 2018).

[177] 340 Hours per Month = (1.0 B Weekly Hours ÷ 117 MM Subscribers) × 4 Weeks per Month. Joan E. Solsman, *Netflix is Hijacking 1 Billion Hours of Our Lives Each Week*, CNET (Apr. 17, 2017), https://www.cnet.com/news/netflix-billion-hours-a-week-adam-sandler/; Rani Molla, *Netflix Now Has Nearly 118 Million Streaming Subscribers Globally,* RECODE (Jan. 22, 2018), https://www.recode.net/2018/1/22/16920150/netflix-q4-2017-earnings-subscribers.

for fixed broadband because of the very high prices and poor service they encounter or because they do not have a material demand for data-intensive video content.[178]

105. 5G technologies are expected to provide a much closer substitute to high-speed BIAS because they will give carriers the capacity to handle customer demand for large amounts of data; carriers will provide data speeds and latency that are generally consistent with or exceed what consumers can get with Wi-Fi networks attached to fixed broadband;[179] and they will charge prices per GB that will make it affordable to use mobile rather than fixed broadband.

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[178] T-Mobile is an outlier, having brought its Un-carrier strategy to video to a certain limited extent through its Binge On feature, which allows customers with a qualifying data plan to stream unlimited video from streaming services such YouTube, Netflix, Hulu, HBO, Sling, ESPN, SHOWTIME, Starz, and more. However, video content subject to Binge On was limited to sub-HD quality (either 480p or 720p). *See supra* note 168 and associated text. The T-Mobile ONE plan, introduced in 2016, provided unlimited data but also capped video content at DVD quality (480p or 720p) unless the customer purchased an HD add-on for an additional $25 per month. *T-Mobile, Hello Un-carrier 12 … R.I.P Data Plans: T-Mobile Goes All In on Unlimited*, T-MOBILE (Aug. 18, 2016), https://newsroom.t-mobile.com/news-and-blogs/rip-data-plans.htm; *Binge On*, T-MOBILE SUPPORT, https://support.t-mobile.com/docs/DOC-24291?icid=WMM_TM_Q118BINGEO_ZJPCJ73EKJW12494 (last visited June 10, 2018).

[179] As discussed in Section III.A., 5G average data rates are expected to be greater than 100 Mbps with peak data rates greater than 10,000 Mbps. The current generation of Wi-Fi (802.11ac) was released in 2013 and is expected to be superseded by Wi-Fi (802.11ax) in 2019. Wi-Fi (802.11ax) is expected to have a theoretical data rate of 9,072 Mbps – less than 5G's peak rate. According to Qorvo – a U.S. based developer and manufacturer of cellular radio frequency and Wi-Fi (including 802.11ac and 802.11ax) components with annual revenues of approximately $3.0B in 2018 fiscal year – the expected "typical" Wi-Fi (802.11ax) data rate is expected to be 1,730 Mbps while data rates in an apartment complex are expected to be 290 Mbps. Actual throughput for Wi-Fi depends on a variety of factors including: user activity level, distances to the access point, average packet size on the link, number of users per access point, and number of access points and clients on the same channel and within interference range. Furthermore, since Wi-Fi networks "do not talk to each other," and every network independently "optimizes" its own settings, there is the potential of network interferences occurring. This is typical of Wi-Fi networks in which "there are no bandwidth guarantees," "no guarantees on the latency of the first wireless hop," and such networks "do not offer sufficient performance with respect to real-time and reliability requirements." In contrast, 5G is expected to provide ultra-low latency and ultra-high reliability. *See* CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017); Boris Bellalta, ***IEEE 802.11ax: High-efficiency WLANS***, IEEE WIRELESS COMMS. 38 (Mar. 2, 2016), https://ieeexplore.ieee.org/document/7422404/; CEES LINKS, QORVO, WI-FI DATA RATES, CHANNELS AND CAPACITY 2 (Dec. 2017), https://www.qorvo.com/resources/d/qorvo-wifi-data-rates-channels-capacity-white-paper; *see also, 802.11ac Wave 2 FAQ*, CISCO.COM: SOLUTIONS, https://www.cisco.com/c/en/us/solutions/collateral/enterprise-networks/802-11ac-solution/q-and-a-c67-734152.html (last updated Jan. 16, 2018); Qorvo, Inc., Annual Report (Form 10-K), at 4-6, 13 (May 21, 2018); CHIH-PING LI ET AL., 5G ULTRA-RELIABLE AND LOW-LATENCY SYSTEMS DESIGN (July 2017), https://ieeexplore.ieee.org/document/7980747; Ilya Grigorik, *WiFi*, HIGH PERFORMANCE BROWSER NETWORKING, https://hpbn.co/wifi/ (last visited June 3, 2018); ANDREAS FROTZSCHER ET AL, REQUIREMENTS AND CURRENT

106. Deloitte, for example, has concluded that "5G may be the first to realistically challenge fixed-line networks for even some of the most data-intensive applications."[180] Ovum stated that 5G improvements in spectrum capacity and faster speeds "will make it easier for 5G to compete directly against fiber and other very-high-speed broadband access networks."[181]

3. 5G Technologies Can Provide Fixed Wireless Access Solutions That Will Provide Direct Competition to Broadband, Particularly in Rural Areas

107. Fixed wireless access (FWA) refers to the provision of broadband service to consumers in fixed locations via wireless technology.[182] Customers receive signals from wireless transmitters via antennas attached to the subscribers' premises.[183] FWA networks offer consumer advantages over the use of mobile hotspots because a FWA network can be optimized for high throughput applications like streaming video.

108. FWA provides several economic benefits relative to wired BIAS. First, since service is transmitted wirelessly to consumers' premises, FWA providers avoid costly "last mile"

SOLUTIONS OF WIRELESS COMMUNICATION IN INDUSTRIAL AUTOMATION, (June 2014), https://ieeexplore.ieee.org/document/6881174/.

[180] PREETA M. BANERJEE ET AL., DELOITTE, A NETWORK OF NETWORKS: HOW WILL CARRIERS HANDLE THE EVOLUTION OF 5G? 2-3 (2017), https://www2.deloitte.com/content/dam/insights/us/articles/3795_network-of-networks/DUP_Network-of-networks.pdf.

[181] DARYL SCHOOLAR, OVUM, 5G FIXED WIRELESS ACCESS 4 (2016), http://images.samsung.com/is/content/samsung/p5/global/business/networks/insights/white-paper/5g-fixed-wireless-access/global-networks-insight-whitepaper_5g-fixed-wireless-access-0.pdf.

[182] Kim Laraqui et al., *5G and Fixed Wireless Access*, ERICSSON TECH. REV, Dec. 16, 2016, at 4, https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2016/etr-5g-and-fixed-wireless-access.pdf; CARMEL GROUP, READY FOR TAKEOFF: BROADBAND WIRELESS ACCESS PROVIDERS PREPARE TO SOAR WITH FIXED WIRELESS 5, 7 (2017), https://carmelgroup.com/wp-content/uploads/2017/12/TCG_2017_BWA_Full_Report.pdf.

[183] CARMEL GROUP, READY FOR TAKEOFF: BROADBAND WIRELESS ACCESS PROVIDERS PREPARE TO SOAR WITH FIXED WIRELESS 7 (2017), https://carmelgroup.com/wp-content/uploads/2017/12/TCG_2017_BWA_Full_Report.pdf.

installations, subsequent repairs, and upgrades of wired BIAS installations.[184] Compared to FWA, the estimated capital expenditure per residential subscriber is about 4.5 times greater for cable and 7 times greater for fiber.[185] Second, via wireless backhaul (the use of wireless technologies to transfer data from an end user to an Internet backbone provider) FWA can provide broadband service to underserved rural areas.[186]

109. Due to its speed, capacity, and low latency, 5G technology will make it possible for cellular carriers to offer FWA services at a quality that rivals wired BIAS.[187] In markets

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[184] Kim Laraqui et al., *5G and Fixed Wireless Access*, ERICSSON TECH. REV, Dec. 16, 2016, at 3, https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2016/etr-5g-and-fixed-wireless-access.pdf.

[185] CARMEL GROUP, READY FOR TAKEOFF: BROADBAND WIRELESS ACCESS PROVIDERS PREPARE TO SOAR WITH FIXED WIRELESS 12 (2017), https://carmelgroup.com/wp-content/uploads/2017/12/TCG_2017_BWA_Full_Report.pdf.

[186] CARMEL GROUP, READY FOR TAKEOFF: BROADBAND WIRELESS ACCESS PROVIDERS PREPARE TO SOAR WITH FIXED WIRELESS 8, 12 (2017), https://carmelgroup.com/wp-content/uploads/2017/12/TCG_2017_BWA_Full_Report.pdf.

[187] There are three categories of fixed broadband: fiber to the home (FTTH), DSL, and cable modem. *See* CISCO, ZETTABYTE ERA: TRENDS AND ANALYSIS 19 (June 2017), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.pdf. FTTH currently provides data rates of approximately 1 Gbps. However, this type of connection only covers 25 percent of the United States. and is relatively expensive to deploy compared to DSL and cable modem. Cable modem and DLS currently cover 89 percent and 90 percent (respectively) of the United States, but cable modem has a commanding share of the total U.S. broadband market at 64.5 percent of the broadband subscribers as of Q1 2018. Cable modem also typically offers higher bandwidth than DSL. *See* Tyler Cooper, *DSL vs Cable vs Fiber*, BROADBAND NOW (Jan. 23, 2018), https://broadbandnow.com/report/dsl-vs-cable-vs-fiber. The current standard used for cable modems is Full Duplex DOCSIS 3.1, which was released in 2017 and allows for potential downstream / upstream data rates of 10 Gbps. The prior generation (DOCSIS 3.1) was launched in 2013 and offered the same potential downstream data rate of 10 Gbps but a lower upstream data rate of 1 Gbps to 2 Gbps. *See Full Duplex DOCSIS 3.1*, CABLELABS.COM, https://www.cablelabs.com/full-duplex-docsis/ (last visited June 3, 2018). As mentioned above, these data rates are the same as 5G's expected peak rates of greater than 10 Gbps. While the idea of DOCSIS 4.0 was announced in May 2018, and could push cable broadband speeds up to 30 Gbps to 60 Gbps, development efforts towards this next generation standard are nascent and the technology is not expected to deploy until the "late 2020s." *See* Karl Bode, *Industry Already Hyping DOCSIS 4.0 or 'DOCSIS dot Next'*, DSL REPORTS (May 24, 2018), http://www.dslreports.com/shownews/Industry-Already-Hyping-DOCSIS-40-or-DOCSIS-dot-Next-141884. According to Cisco, the North American average fixed broadband data rate is expected to reach 51.0 Mbps in 2018 and grow to 74.2 Mbps by 2021. *See* CISCO, ZETTABYTE ERA: TRENDS AND ANALYSIS 19 (June 2017), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.pdf. While these figures likely include older generation technologies with lower data rates, they provide a relative benchmark as to the actual and expected data rates received by fixed wired consumers – especially considering that DOCSIS 3.1 was launched in 2013. As discussed *infra* in Section III.A, the average data rate for 5G is expected to be greater than 100 Mbps. While Full Duplex DOCSIS 3.1 latency requirements

without a wired broadband provider, 5G FWA solutions can expand the number of consumers with access to high-speed broadband, while in markets with limited broadband options, 5G FWA will create significant local competition for wireline broadband and satellite.[188]

110. FWA enabled by 5G will be particularly beneficial to consumers in rural areas, who as discussed above, are often served only by lower-performing DSL and satellite service providers. The 5G standard is expected to incorporate a range of spectrum bands, including low and mid frequencies, which have a relatively longer reach than mmWave spectrum, and could be utilized by 5G-enabled FWA to more easily connect people in rural and remote areas.[189] Accordingly, FWA will be able to provide the benefits of 5G to rural consumers that wired BIAS providers have deemed too costly to reach.[190]

111. Several wireless service providers have conducted 5G FWA trials in rural settings. For example, in 2017, U.S. Cellular conducted a 5G FWA trial using 28 GHz spectrum with

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are not readily available, DOCSIS 3.1 was developed to have latency rates of 10 ms. DSL latency is typically higher than cable modem and fiber latency tests reported by the FCC indicate rates of just over 10 ms in 2016. *See* FED. COMMC'NS COMM'N, 2016 MEASURING BROADBAND AMERICA FIXED BROADBAND REPORT 46-47, (Dec. 1, 2016), https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-report-2016; Tyler Cooper, *DSL vs Cable vs Fiber*, BROADBAND NOW (Jan. 23, 2018), https://broadbandnow.com/report/dsl-vs-cable-vs-fiber. These latency rates are all higher than 5G's expected latency rate of ~1 ms. *See* CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017); Sarah Barry James, *Fixed Wireless to Shine in 2018 Thanks to 5G, Cost Savings – S&P Global*, RISE BROADBAND (Apr. 9, 2018), https://www.risebroadband.com/2018/04/fixed-wireless-shine-2018-thanks-5g-cost-savings-sp-global.

[188] Kendra Chamberlain, *Measuring the 5G Opportunity* 19, FIERCE WIRELESS (2017) (ebook), https://info.mavenir.com/hubfs/eBooks/5G:%20A%20Look%20at%20the%20Business%20Models.pdf. ("Once carriers are able to deliver up to gigabit speeds with fixed 5G, they will be in a good position to compete head to head with wireline service providers, and particularly the cable companies that have come to dominate the fixed broadband market in the U.S.").

[189] Kim Laraqui et al., *5G and Fixed Wireless Access*, ERICSSON TECH. REV, Dec. 16, 2016, at 9-10 https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2016/etr-5g-and-fixed-wireless-access.pdf.

[190] JAMES FAUCETTE ET AL., MORGAN STANLEY, LEARNING TO RIDE A 5G CYCLE 23 (Oct. 15, 2017); KAREN CAMPBELL ET AL., IHS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 22 (2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf.

Ericsson in rural and suburban environments in Madison, Wisconsin. In addition to achieving throughput speeds of 8.5 Gbps, the trials included tests of AR/VR, advanced beamforming, and massive MIMO.[191] As another example, C Spire conducted a 5G FWA test in February 2018 in Mississippi using 3.65 GHz spectrum and states that it is "continuing to conduct 5G technology trials using high-band mmWave spectrum in the 28 GHz and 60 GHz ranges."[192]

112. In urban areas, the provision of 5G FWA would also increase competition with wired broadband service providers.[193] Ericsson has stated that "[i]t is also increasingly evident that 5G FWA will be able to offer very attractive services that can compete with high-capacity fixed solutions."[194]

113. FWA service providers would be able to provide a satisfactory broadband product to consumers that do not already purchase multichannel video programming (MVPD) packages.

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[191] U.S. Cellular has commented that there are difficulties transmitting using mmWave without a dense network and that they therefore prefer LTE. *See* Press Release, Ericsson, U.S. Cellular Expands 5G Test With Ericsson to 28GHz (Oct. 24, 2017), https://www.prnewswire.com/news-releases/us-cellular-expands-5g-tests-with-ericsson-to-28ghz-300542076.html. However, 5G mmWave relies on high frequency spectrum bands above 24 GHz. *See 5G mmWave: The Next Frontier in Mobile Broadband*, QUALCOMM.COM, https://www.qualcomm.com/invention/technologies/5g-nr/mmwave (last visited June 3, 2018). Both T-Mobile and Sprint own low-band airwaves – for example, T-Mobile invested more than $1 billion on 700 MHz A Block licenses and $8 billion on 600 MHz licenses in the FCC's incentive auction while Sprint currently owns 800 MHz and 1900 MHz spectrum. It is currently anticipated that New T-Mobile will be relying on these low band frequencies of spectrum for their 5G deployment to rural areas. *See* Colin Gibbs, *T-Mobile/Sprint Merger Would 'Significantly Improve' Ability to Compete in Rural Markets: Mosaik*, FIERCEWIRELESS (Oct. 2, 2017), https://www.fiercewireless.com/wireless/t-mobile-sprint-merger-would-significantly-improve-ability-to-compete-rural-markets-mosaik. Mid-band spectrum requires higher capital expenditures to achieve coverage because it does not propagate as far from the cell site. High-band spectrum has an even lower operational radius around the cell site and is economical to deploy only in very densely populated areas. Declaration of Neville Ray, ¶¶ 36-37.

[192] Press Release, C-Spire, C Spire Tests Leading Edge 5G Technology for First Time in Mississippi Today (Feb. 20, 2018), https://www.cspire.com/company_info/about/news_detail.jsp?entryId=29600005.

[193] "What are People Talking About When They Talk about 5G?," *T-Mobile*, Feb. 18, 2018, at 1.

[194] *See* Kim Laraqui et al., *5G and Fixed Wireless Access*, ERICSSON TECH. REV, Dec. 16, 2016, at 4, https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2016/etr-5g-and-fixed-wireless-access.pdf. *See also* KAREN CAMPBELL ET AL., IHS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 22 (2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; CARMEL GROUP, READY FOR TAKEOFF: BROADBAND WIRELESS ACCESS PROVIDERS PREPARE TO SOAR WITH FIXED WIRELESS 16 (2017), https://carmelgroup.com/wp-content/uploads/2017/12/TCG_2017_BWA_Full_Report.pdf.

However, for wider-scale adoption FWA providers would need to bundle MVPD packages. Fixed BIAS providers, such as Google Fiber and other overbuilders, have faced challenges in doing so in the past because they lack the scale to negotiate lower prices with content providers. FWA providers are likely to be in a better position over the next 5-10 years for several reasons.

114. First, they could deploy FWA solutions more cheaply than fixed BIAS providers and therefore achieve scale more quickly. Second, with the development of OTT providers, it is likely that over the relevant time period more MVPD-type services will move to over the top thereby providing options for consumers. That is consistent with the trend reported above concerning the increase in the percent of households without traditional MVPD service.[195] Third, the carriers will be in a better position to compete as MVPDs. T-Mobile, for example, acquired the TV service provider Layer3 TV (Layer3),[196] an MVPD that currently offers customers in several cities access to 275 HD channels at a monthly price starting at $75.[197] T-Mobile plans to use its acquisition of Layer3 to offer an OTT "disruptive new TV service" by late 2018.[198]

D. 5G Will Enable Many New Applications Across the Economy

115. The deployment of 5G technologies will continue the long arc of improved connectivity and expansion of the app-based economy. This new generation of cellular technology is

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[195] "Industry Context," *T-Mobile*, Dec. 2017, at 16.

[196] Press Release, T-Mobile, T-Mobile Closes Layer3 TV Acquisition, Prepares to Take on Cable & Satellite TV (Jan. 23, 2018), https://newsroom.t-mobile.com/news-and-blogs/uncarrier-tv-close.htm.

[197] Currently, Layer3 provides content over a leased fiber optic network instead of the public internet. *See* Todd Spangler, *T-Mobile Jumps Into Internet TV Arena With Layer3 TV Acquisition*, VARIETY (Dec. 13, 2017), https://variety.com/2017/digital/news/t-mobile-wireless-tv-layer3-tv-acquisition-1202639000/.

[198] Jeff Baumgartner, *T-Mobile Paid $325 Million for Layer3 TV*, MULTICHANNEL NEWS (Feb. 8, 2018), https://www.multichannel.com/news/t-mobile-paid-325-million-layer3-tv-418030.

designed to power new applications throughout the economy by transforming industries and creating new ones.

116. As explained above, connection density in 5G allows it to support 100,000 connections per km^2.[199] This enables an expansion of IoT to include access points in vehicles, homes, factories, drones, throughout cities, on farms, and elsewhere. Moreover, 5G real-time connectivity from extremely low latency enables applications that require an almost instantaneous response such as vehicular safety and factory automation. These billions of devices spread through the economy will generate massive data traffic as will data-intensive applications such as connected cars – all of which 5G cellular networks are designed to accommodate.[200]

117. We cannot be certain about how 5G will specifically drive technological change across the economy over time. Some of the applications being discussed today may not gain traction, while others not contemplated will. But the economics of general purpose technologies, and historical data, enable us to predict with confidence that 5G will have a significant procompetitive effect for consumers and the economy.

118. I have surveyed applications currently under development and examined how they could drive technological change, productivity improvements, and consumer benefits across several important economic sectors. Table 11 summarizes current anticipations. The breadth and scope of these applications are consistent with the view that 5G technologies will have a far broader and more substantial impact on the economy than previous generations.

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[199] CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK 12 (Oct. 2017).

[200] *Internet of Things (IoT) Connected Devices Installed Base Worldwide from 2015 to 2025 (in billions),* Statista, https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/ (last visited June 10, 2018).

Table 11
Exemplary List of 5G Enabled Applications

Application	**Description**	**Benefits**	**5G Essentiality**	**Who is Investing**	**Impacted Sectors**
Connected Vehicles	Vehicles connecting with other devices and the network	- Reduced fatalities - Reduced traffic - Enhanced user experience	- Low latency - High reliability - High bandwidth - Increased connections	*e.g.*, Ford, Intel, Samsung	*e.g.*, Personal transport, trucking
Autonomous Vehicles	Self-driving vehicles	- Reduced fatalities - Reduced traffic - Enhanced user experience	- Low latency - High reliability - High bandwidth - Increased connections	*e.g.*, Ford, Intel, Samsung	*e.g.*, Personal transport, trucking
Augmented Reality & Virtual Reality	AR: transparent displays with digital overlays upon the physical world. VR: user experience confined to a digital environment	- Enhanced user experience - Enhanced training - Enhanced education - Cost savings - Increased product demand	- Low latency - High bandwidth	*e.g.*, Facebook, HTC, Intel	*e.g.*, Gaming, sports, retail, education
Drones	Unmanned aerial vehicles	- Military applications - Disaster relief - Infrastructure inspection - Delivery (goods) - Delivery (Internet) - Monitoring crops	- Low latency - High reliability - High bandwidth	*e.g.*, Facebook, Amazon, Intel	*e.g.*, Military, municipalities, disaster relief, retail, agriculture, transportation
Factory Automation	Discrete manufacturing where products are assembled, tested, or packed	- Enhanced flexibility - Shorter lead times - Cost savings	- Low latency - High reliability	*e.g.*, General Electric, Intel, Honeywell, Ericsson	Manufacturing

Application	**Description**	**Benefits**	**5G Essentiality**	**Who is Investing**	**Impacted Sectors**
Smart Agriculture	Adoption of information and communications technologies to enhance, monitor, or automate agricultural operations	- Higher crop yield - Water conservation - Cost savings	- Low latency - High reliability - High bandwidth	*e.g.*, John Deere, Qualcomm, Ericsson	Agriculture
Smart Cities	Cities that use interconnected sensing devices that can communicate with one another (*e.g.*, vehicles, traffic lights, libraries, *etc*.)	- Enhanced quality of service - Enhanced transportation - Improved security - Cost savings	- Low latency - High reliability - Increased connections - Low power requirement	*e.g.*, AT&T, Cisco, Deloitte, Ericsson, General Electric, IBM, Intel, Qualcomm, Samsung	Municipalities
Telehealth-care	Health-related applications that rely on information and communication technologies	- Point of care testing - Real-time monitoring - Remote surgery - Cost savings	- Low latency - High reliability - Low power requirement	*e.g.*, Ericsson	Healthcare
Energy & Utility	Traditional grid with communication and information control technologies (i.e., "Smart Grids")	- Real-time diagnostics - Reduced down-time - Smart lighting - Cost savings	- Low latency - High reliability - Increased connections - Low power requirement	U.S. cities have begun adopting smart grids (e.g., Austin, TX; San Diego, CA; Washington, D.C.	Municipalities
Asset Tracking	Tracking and monitoring the distribution of assets	- Reducing lost shipments - Enhanced inventory management - Cost savings	- Increased connections - Low power requirement	*e.g.*, Qualcomm, DHL, Ericsson	*e.g.*, Shipping and logistic, manufacturing
Source: Exhibit 7.					

To provide an understanding of 5G's role in this technological change, Appendix B describes current plans for deploying 5G for transportation, manufacturing and government.

E. The Creation of 5G Value Depends on When and How Quickly Carriers Deploy 5G Networks

119. Realizing the benefits of 5G technology depends on the timing of investments in and wide-scale deployment of strong 5G cellular networks in the United States. The sooner cellular carriers invest in and launch robust 5G networks, and the more rapidly they deploy them, the sooner app developers will innovate and end users will invest in the companion 5G devices.

IV. Competition Among Cellular Carriers to Improve and Invest in Networks Has Been the Main Driver of Quality-Adjusted Prices and Consumer Surplus in the U.S. Cellular Industry

120. The capital investments by cellular carriers in new generations of technology have driven the massive expansion in output and dramatic reduction in price for the consumer. The timing and intensity of these investments has resulted from dynamic competition among the carriers. The prior level of investment by a carrier determines the capacity and performance of its networks and therefore, the packages that it can offer. Carriers must react rapidly to their rivals' investments in network capacity and quality. If they do not, they cannot make competitive offerings, will incur customer churn, and will lose share.

121. Given that the U.S. cellular industry is at an inflection point between technology generations,[201] the impact of this Transaction on quantity and prices that consumers pay for cellular data will largely depend on how it affects the deployment of 5G networks. To help make that assessment, I have conducted an empirical investigation into the economic history of the dynamics of competition among cellular carriers, the results of which are reported in this

[201] *See supra* Section III.

section. I have focused on the period from 2000 to 2017, which is when cellular carriers competed to deploy 3G and 4G LTE networks.[202]

122. This section is organized as follows. Part A presents qualitative evidence that demonstrates network quality is a critical component of competition for customers and that network investments are the means by which carriers improve quality. Part B documents the investments made by the four major cellular carriers and shows that these investments resulted in industry-wide increases in data output and declines in data prices per GB. Part C presents a detailed analysis of the competitive responses among carriers to invest in the next generation of technology and the role of first-movers in setting off the race to deploy the next generation. Part D shows that this dynamic investment competition is the main determinant of changes in industry output and prices.

A. Investments in Network Capacity and Performance Have Been the Main Way that Carriers Have Competed with Each Other for Subscribers Because These Investments Determine What Packages and Service Levels Carriers Can Offer to Subscribers

123. Customers care about the quality of cellular carriers' networks when they choose among carriers. For example, a 2015 T-Mobile presentation on network capacity noted that for consumers the "[n]etwork [was] the #1 reason for choosing a carrier" over other factors such as price, devices, or customer focus.[203] In fact, in 2015, Consumer Intelligence Research Partners (CIRP) released an analysis of consumer behavior for U.S. mobile phone carriers that found customers change carriers based on either actual experience or perceived attributes related to

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[202] *See supra* Section II.C.

[203] "Network Discussion – Capacity: TMUS Board of Directors," *T-Mobile*, Sept. 24-25, 2015, at 6.

network quality.[204] CIRP found that network-motivated switching accounted for almost 40 percent of Sprint and T-Mobile departing customers.[205] McKinsey also found that network quality is a key concern for customers, and a differentiator among carriers.[206]

124. The carriers recognize that a poor network quality can have a significant negative competitive impact. A 2015 T-Mobile presentation on network capacity reported that [redacted] of T-Mobile subscribers who had switched from Verizon "view their experience with T-Mobile as worse than their previous carrier" putting them "at risk of round-tripping" and returning to Verizon.[207] A June 2016 T-Mobile board presentation highlighted that "[n]etwork reliability [was] impacting consideration" of T-Mobile by consumers and that T-Mobile's "reliability perception" among the switcher pool was [redacted] lower than Verizon's.[208] The presentation also stated that "[redacted] [d]o not choose T-Mobile due to network concerns and limited distribution & network reach."[209] Thus, T-Mobile views its ability to successfully compete contingent on its own investments and quality *and* how investments and quality compare with rivals.

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[204] Michael R. Levin, *Why Do Consumers Switch Mobile Phone Carriers?*, HUFFINGTON POST (Dec. 6, 2017), https://www.huffingtonpost.com/michael-r-levin/why-do-consumers-switch-m_b_6525492.html.

[205] Michael R. Levin, *Why Do Consumers Switch Mobile Phone Carriers?*, HUFFINGTON POST (Dec. 6, 2017), https://www.huffingtonpost.com/michael-r-levin/why-do-consumers-switch-m_b_6525492.html.

[206] Fan Guo, et al., *Everywhere, All the Time, Really Fast: The Importance of Network Quality*, MCKINSEY & COMPANY (Feb. 2015), https://www.mckinsey.com/practice-clients/tmt/everywhere-all-the-time-really-fast-the-importance-of-network-quality.

[207] "Network Discussion – Capacity: TMUS Board of Directors," *T-Mobile*, Sept. 24-25, 2015, at 7.

[208] "T-Mobile US, Inc. 9-7-16 Board Meeting Materials," *T-Mobile*, Sept. 7, 2016, at 122.

[209] "T-Mobile US, Inc. 9-7-16 Board Meeting Materials," *T-Mobile*, Sept. 7, 2016, at 122.

125. Relative difference in network quality is one of the primary reasons that customers switch between carriers.[210] A 2017 Sprint customer exit survey revealed that network quality is a main reason for Sprint's "consistently higher churn" compared to other carriers.[211] A T-Mobile presentation on switching trends drawn from 2016 Nielsen data shows that data network quality was the number two reason that likely switchers want to leave their current provider for each of the four major carriers; price or taking advantage of promotions was the number one reason.[212] T-Mobile, in a February 2018 press release, attributed improvements in subscribers' churn rates in part to "increased customer satisfaction and loyalty from ongoing improvements to network quality."[213]

126. Given the importance that consumers attribute to network quality, every carrier has recognized that the quality of its network is fundamental to its ability to compete. Verizon has stated that it is operating in "an environment where quality of connection matters more now than ever before."[214] AT&T has stated that "[c]ritical to the equation of building premier wireless assets is competitiveness in network quality characterized by breadth and depth of coverage and depth of capacity."[215] T-Mobile has referred to its network as "the foundation of

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[210] This is increasingly true as the consumer market reaches saturation and overall industry growth slows. "Industry Context," ***T-Mobile***, Dec. 2017, at 5; "Project Nations Discussion Materials," ***T-Mobile***, Sept. 21, 2017, at 5.

[211] "Managing Network Quality of Experience (QoE) from a Commercial Perspective: Methodology and Initial Results," ***Sprint***, Sept. 8, 2017, at 4.

[212] "T-Mobile U.S. Inc., Q4 2016 Switching Summary Report," ***T-Mobile***, 2017, at 17.

[213] Press Release, T-Mobile, T-Mobile Reports Record Financial Results Across the Board for FY 2017, Issues Strong Guidance for 2018 and Beyond (Feb. 8, 2018), https://newsroom.t-mobile.com/news-and-blogs/tmus-q4-2017-earnings.htm.

[214] Verizon Commc'ns, Inc., *Verizon Communications (VZ) on Q1 2018 Results - Earnings Call Transcript* , SEEKING ALPHA (Apr. 24, 2018), https://seekingalpha.com/article/4165238-verizon-communications-vz-q1-2018-results-earnings-call-transcript.

[215] AT&T Inc., *Edited Transcript AT&T Inc. 2012 Analyst Conference*, FED COMMC'NS COMM'N (Nov. 7, 2012), https://ecfsapi.fcc.gov/file/7022113687.pdf.

[its] competitive formula."[216] Sprint has stated that "network quality is obviously central to providing a great customer experience"[217] and "to be truly a great company, [it has] to have a great product, [which is the] network."[218]

127. The importance of network quality to competition among carriers is also evident from their advertising. For example, in 2013 AT&T and T-Mobile engaged in an advertising war on network performance.[219] T-Mobile CEO John Legere called AT&T's network "crap" at a trade show, and AT&T responded by publishing an ad in the New York Times, the Wall Street Journal, and USA Today criticizing T-Mobile's network performance:[220]

[216] T-Mobile, *T-Mobile US's (TMUS) CEO John Legere on Q2 2014 Results - Earnings Call Transcript*, SEEKING ALPHA (July 31, 2014), https://seekingalpha.com/article/2365125-t-mobile-uss-tmus-ceo-john-legere-on-q2-2014-results-earnings-call-transcript?part=single.

[217] Sprint, *Sprint Nextel Corporation Q3 2008 (Qtr End 09/30/08) Earnings Call Transcript*, SEEKING ALPHA (Nov. 7, 2008), https://seekingalpha.com/article/104773-sprint-nextel-corporation-q3-2008-qtr-end-09-30-08-earnings-call-transcript.

[218] Sprint, *Sprint Corporation's (S) CEO Michel Combes on Q4 2017 Results - Earnings Call Transcript*, SEEKING ALPHA (May 2, 2018), https://seekingalpha.com/article/4168931-sprint-corporations-s-ceo-michel-combes-q4-2017-results-earnings-call-transcript?part=single.

[219] *AT&T Goes After T-Mobile with Attack Ads*, ADAGE (Mar. 1, 2013), http://adage.com/article/digital/t-t-mobile-attack-ads/240112/.

[220] *AT&T Goes After T-Mobile with Attack Ads*, ADAGE (Mar. 1, 2013), http://adage.com/article/digital/t-t-mobile-attack-ads/240112/.

T-Mobile launched an ad campaign defending its network against AT&T the following week:[221]

[221] Elyse Betters, *Here's T-Mobile's Awesome Response to AT&T's Attack Ads*, 9TO5MAC (Mar. 6, 2013), https://9to5mac.com/2013/03/06/heres-t-mobiles-awesome-response-to-atts-attack-ads/.

128. As another example of back-and-forth marketing claims about relative network quality, Verizon in 2015 ran a commercial showing colorful balls rolling down four ramps representing its wins against rivals in a RootMetrics network quality study.[222] T-Mobile and Sprint responded with parodies of this ad, which emphasized how they have closed the gap in network quality.[223] The emphasis on comparing quality against Verizon in particular may indicate that

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[222] *Verizon – A Better Network as Explained by Colorful Balls 12 2015*, YOUTUBE (Mar. 13, 2016), https://www.youtube.com/watch?v=qEY1r8doHj8.

[223] Sprint responded with a parody ad that claimed its new LTE Plus network delivered faster download speeds than its competitors. Verizon responded with an ad claiming that the study referenced in Sprint's ad studied only a few metro areas and that Verizon's network was "consistently fast everywhere." Sprint CTO John Shaw issued a blog post in January 2016 comparing the different network speed metrics that carriers had used in their advertising. He notes that in the RootMetrics tests that formed the basis of Verizon's ball and ramp ads, the difference between the winner (often Verizon) and the other carriers would often be indistinguishable for consumers. Like Sprint, T-Mobile released a parody of Verizon's ad, which noted that T-Mobile's LTE network covered nearly as many people as Verizon's (with T-Mobile having doubled its coverage in the previous year) and that T-Mobile had improved its LTE service to reach twice as far and perform four times better in buildings. The ad concluded with the claim that T-Mobile had the country's fastest 4G LTE network. *Sprint Commercial Verizon Balls Parody*, YOUTUBE, (Jan. 30, 2016), https://www.youtube.com/watch?v=5VeBk3FX7LI; *Verizon… Ricky Gervais A Better Network … commercial 2016*, YOUTUBE, (Mar. 30, 2016), https://www.youtube.com/watch?v=XqVtJBeSJ6s; John Saw, *Sprint's New LTE Plus Network Delivers the*

Verizon's early and sustained investments in 4G technologies – described below – created, at a minimum, the perception of a lasting network quality advantage.

129. The FCC repeatedly has recognized the importance of network quality to competition among carriers. In its 2011 Report, the FCC observed that "network quality is a critical factor for many mobile consumers."[224] Along similar lines, in its 2015 Report the FCC stated that "[o]ne critical way in which mobile wireless service providers differentiate themselves is through the coverage and speed of their mobile broadband networks."[225]

130. Consequently, cellular carriers must continually invest in network performance.[226] As the FCC has explained. wireless "[s]ervice providers may make such strategic capital expenditure (CAPEX) decisions to differentiate their service offerings from those of their rivals by becoming the first to deploy a particular upgrade or new network technology."[227]

Fastest LTE Download Speeds, SPRINT (Jan. 25, 2016), http://newsroom.sprint.com/sprints-new-lte-plus-network-delivers-the-fastest-lte-download-speeds.htm; *T-Mobile | Verizon's Secret | Network Ad*, YOUTUBE, (Jan. 24, 2016), https://www.youtube.com/watch?v=gYBaslSJaR8.

[224] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, ¶ 222 (June 27, 2011), https://docs.fcc.gov/public/attachments/FCC-11-103A1.pdf.

[225] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – EIGHTEENTH REPORT, WT Docket No. 15-125, ¶ 109 (Dec. 23, 2015), https://docs.fcc.gov/public/attachments/DA-15-1487A1_Rcd.pdf.

[226] *See, e.g.*, *Wireless Telecommunications Carriers – US Market Research Report*, IBISWORLD (Nov. 2017), https://www.ibisworld.com/industry-trends/market-research-reports/information/broadcasting-telecommunications/wireless-telecommunications-carriers.html.

[227] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – NINETEENTH REPORT, WT Docket No. 16-137, ¶ 23 (Sept. 23, 2016), https://docs.fcc.gov/public/attachments/DA-16-1061A1_Rcd.pdf; *see also* FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – EIGHTEENTH REPORT, WT Docket No. 15-125, ¶ 115 (Dec. 23, 2015), https://docs.fcc.gov/public/attachments/DA-15-1487A1_Rcd.pdf; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, ¶ 104 (June 27, 2011), https://docs.fcc.gov/public/attachments/FCC-11-103A1.pdf; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – THIRTEENTH REPORT, WT Docket No. 08-27, ¶ 159 (Jan. 16, 2009),

131. Carriers have routinely emphasized the importance of continued investment to maintain high network quality. Verizon stated on its Q4 2017 earnings call it has "always been focused on keeping [its] network the gold standard and investing in the business for growth."[228] In its 2017 annual report, AT&T stated its belief that in the "capital-intensive" wireless industry, its "ability to continue to invest aggressively in our network gives [it] a competitive advantage."[229] Similarly, a 2017 T-Mobile market overview presentation noted that "significant [capital expenditure] was required to maintain network quality."[230]

132. Package fees also are a key determinant of competition among carriers. Carriers charge monthly subscription fees for packages that enable subscribers to consume data and make cellular phone calls. Competition among carriers has resulted in subscribers getting packages that enable them to consume more data and make more phone calls at given package costs.[231]

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https://docs.fcc.gov/public/attachments/DA-09-54A1.pdf ("Network investment remains a centerpiece of providers' efforts to improve their customers' wireless service experience."); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, ¶ 131 (Sept. 29, 2006), https://docs.fcc.gov/public/attachments/FCC-06-142A1.pdf ("By increasing network coverage and call handling capacity and improving network performance and capabilities, carriers' investments in network deployment and upgrades have the potential to result in service quality improvements that are perceptible to consumers, such as better voice quality, higher call-completion rates, fewer dropped calls and deadzones, additional calling features, more rapid data transmission, and advanced data applications.").

[228] Verizon Commc'ns Inc., *Verizon Communications (VZ) CEO Lowell McAdam on Q4 2017 Results - Earnings Call Transcript*, at 4, SEEKING ALPHA (Jan. 23, 2018), https://seekingalpha.com/article/4139417-verizon-communications-vz-ceo-lowell-mcadam-q4-2017-results-earnings-call-transcript?part=single; *see also* Julie Creswell, *Ivan Seidenberg, CEO of Verizon, Vows to Overpower the Cable Guys by Plowing Billions into a '90s-style Broadband Buildout. But Will He Really? Or Is the Most Powerful Man in Telecom Pulling a Megabluff?* FORTUNE, (May 31, 2004), http://archive.fortune.com/magazines/fortune/fortune_archive/2004/05/31/370724/index.htm (In 2004 Verizon's CFO noted: "When we told analysts we were going to spend $4 billion a year in capex . . . for our wireless group, they were merciless. . . . Well, not a one of them bothers me anymore about the capital budget there. The quality of the network was the strategic advantage, and it needed the investment.").

[229] AT&T Inc., 2017 Annual Report (Form 10-K), at 11 (Feb. 12, 2018), http://www.attproxy.com/~/media/Files/A/ATT-Proxy/documents/2017-letter-to-shareholders.pdf.

[230] "2017 US Market Overview: Challenges and Opportunities," *T-Mobile*, 2017, at 8.

[231] The package fees therefore do not correspond to well-defined prices. Comparisons of package fees across carriers or over time do not provide relevant economic evidence. Any comparison of fees would need to account

133. Significantly, the packages that cellular carriers can offer consumers largely depend on prior network investment. If a carrier had not invested in additional capacity it cannot compete as well with carriers who had done so. A carrier that failed to invest would have to ration demand by charging higher data fees, limiting subscribers' data rates, or living with the disadvantageous competitive consequences of having a congested network. Therefore, the package competition among carriers, including the fees they charge for packages with particular features, is largely determined by these past network investment decisions.

B. Cellular Carriers Have Made Substantial Investments in Their Networks Which Resulted in Expanded Capacity and Greater Performance for the Cellular Industry

134. To compete on the dimensions described above, carriers continually make substantial investments to improve and expand their networks, enhancing speed, coverage and other dimensions of network service.[232] Carrier investment follows a cyclical pattern as "[i]ncreases in CAPEX are closely correlated with periods in which there are mobile wireless network deployments and upgrades."[233] A carrier's capital expenditures typically spike as it rolls out a new generation of cellular technology, but carriers also make large investments in incremental

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for variations in the composition of the bundles which include the quantity of data consumed, and the performance of the network in terms of speeds, latency, coverage, reliability, and other metrics important to subscribers. Comparisons over would also need to account for improvements in the breadth and quality of apps which determines the value of the data that consumers get.

[232] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, ¶ 181-182, 215-16 (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf.

[233] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, ¶ 215-16 (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf.

improvements to expand coverage or provide other intermediate upgrades within a generation.[234]

135. U.S. cellular carriers have invested $475 billion in networks since 1994.[235] I have examined their investments (as measured by their capital expenditures) in network capacity and performance from 2002 to 2017, during which they were investing in the deployment of faster 2G networks, then deploying 3G, and later 4G networks.[236] Figure 3 shows the carriers capital expenditures over the 2002 to 2017 time period.

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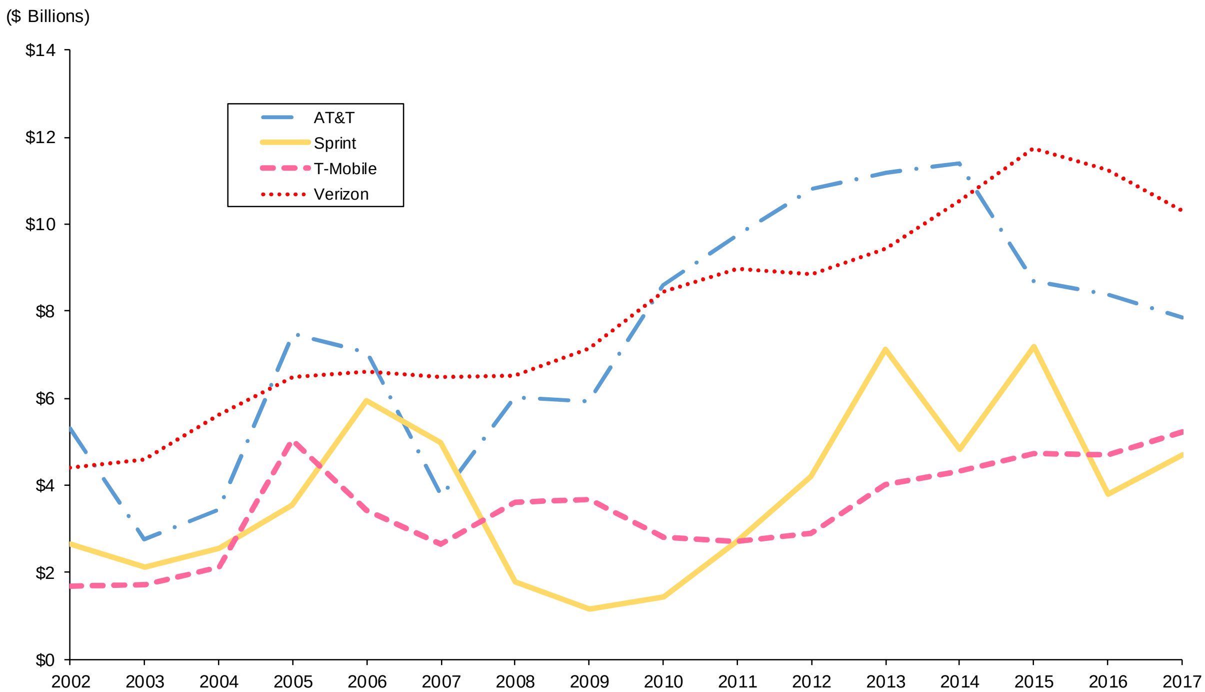
[234] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, ¶ 215-16 (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf.

[235] CTIA, WIRELESS SNAPSHOT 2017: MORE DEVICES, MORE SMARTPHONES, AND MORE APPLICATIONS CONTRIBUTE TO OUR MOBILE-FIRST LIVES (2017), https://api.ctia.org/docs/default-source/default-document-library/ctia-wireless-snapshot.pdf.

[236] *See infra* Tables 12 - 15.

Figure 3
U.S. Mobile Carrier Capital Expenditures



Source: Exhibits 8 and 9.

136. Tables 12 to 15 summarize the major investment initiatives and associated capital expenditures of Verizon, AT&T, Sprint, and T-Mobile (including the carriers they acquired over this time period) from 2002, when they were improving their 2G networks and beginning to invest in their 3G networks, until 2017.

Table 12
Verizon Wireless Capital Expenditures and Investment Activity
($ Millions)

Year	Amount	Main Investment Initiatives
2002	$4,414	First to launch CDMA 1xRTT (3G)[1] network in three markets in January. Full deployment during the year.
2003	$4,590	Launch EV-DO (3G) network in two cities.
2004	$5,633	Deploy EV-DO network, covering 30 major metropolitan areas by year end.
2005	$6,484	Expand EV-DO network deployment, covering 150 million people by year end.
2006	$6,618	Deploy EV-DO Rev. A (upgraded EV-DO) network.
2007	$6,503	Upgrade entire EV-DO network to EV-DO Rev. A.
2008	$6,510	Expand EV-DO Rev. A network coverage.
2009	$7,152	Expand EV-DO Rev. A network coverage.
2010	$8,438	Deploy first LTE network in the United States in December, covering 38 metropolitan areas and 60 airports.
2011	$8,973	Expand LTE network.
2012	$8,857	Expand LTE network, covering 200 million people in January 2012.
2013	$9,425	Expand LTE network, covering 273 million people in January 2013. Increase LTE capacity with AWC spectrum augmentation.
2014	$10,515	Expand LTE network, covering 305 million people by May. Increase LTE capacity with AWC spectrum augmentation.
2015	$11,725	LTE network AWC spectrum augmentation completed in over 400 markets.
2016	$11,240	Build out fiber assets to support densification of LTE network and position for 5G deployment.
2017	$10,310	Build out fiber assets to support densification of LTE network and position for 5G deployment.

Note:
[1] At the time, 1xRTT was considered “3G.” In hindsight it would be classified as 2.5G.

Source: Exhibit 10.

Table 13
AT&T Wireless Capital Expenditures and Investment Activity
($ Millions)

Year	Amount	Main Investment Initiatives
2002	$5,302	Expand GSM/GPRS (2G) network to cover 63 percent of the U.S. population.
2003	$2,774	Deploy EDGE (2G) network.
2004	$3,449	Launch WCDMA (3G) network in four major U.S. cities. Expand EDGE network.
2005	$7,475	Launch WCDMA network with HSDPA (3G) in 16 cities (post AT&T/Cingular merger).
2006	$7,039	Expand HSDPA network to more than 160 markets, including most of the top 100 major cities in the United States by year end.
2007	$3,745	Expand WCDMA/HSDPA.
2008	$6,021	Deploy HSPA (3G) network.
2009	$5,924	Deploy HSPA network to over 350 major metropolitan areas. Upgrade network to HSPA 7.2 (3G).
2010	$8,593	Upgrade network to HSPA+ (3G).
2011	$9,764	Launch LTE (4G) network in five U.S. cities.
2012	$10,795	Expand LTE network, reaching 103 markets in November.
2013	$11,191	Expand LTE network to 209 markets.
2014	$11,383	Expand LTE network to 400 markets and 280 million people. Introduce carrier aggregation technology (4G) in Chicago to increase network capacity.
2015	$8,697	Expand carrier aggregation technology to other major markets.
2016	$8,384	Expand fiber infrastructure and 5G trials.
2017	$7,870	Expand fiber infrastructure and 5G trials.

Source: Exhibit 11.

Table 14
Sprint Wireless Capital Expenditures and Investment Activity
($ Millions)

Year	Amount	Main Investment Initiatives
2002	$2,640	First nationwide deployment of CDMA 1xRTT (3G)[1] by August. Invest in capacity-enhancing technologies.
2003	$2,123	Deploy 1xRTT across entire network footprint.
2004	$2,559	Prepare for EV-DO (3G) network launch, instead of waiting for 1xEV-DV (more advanced than EV-DO technology).
2005	$3,545	Deploy EV-DO network, covering half of the U.S. population.
2006	$5,944	Launch EV-DO Rev. A (upgraded EV-DO) network in San Diego in October. Invest in iDEN (2G) and CDMA (2G) networks. Prepare for WiMAX (4G) network.
2007	$4,988	Expand EV-DO Rev. A network (reaching most of its footprint by October). Improve CDMA and iDEN networks.
2008	$1,789	Launch WiMAX network in Baltimore.
2009	$1,161	Expand WiMAX network.
2010	$1,455	Expand WiMAX network.
2011	$2,702	Expand WiMAX network, covering 132 million people in 71 markets. Announce plans to develop LTE (4G) network in October.
2012	$4,199	Final expansion of WiMAX network. Develop and launch LTE network in 15 cities, covering 49 markets by year end.
2013	$7,136	Expand LTE network, covering over 200 million people by December. Improve speed and performance of LTE network.
2014	$4,828	Improve speed and performance of LTE network.
2015	$7,193	Expand LTE network, covering 280 million people by October. Deploy carrier aggregation network technology, called "LTE Plus" (4G), in 77 major markets.
2016	$3,798	Expand LTE Plus network, covering 300 million people by June.
2017	$4,692	Improve LTE network speed and capacity. Test Massive MIMO technology, use to improve 4G and support 5G.

Note:
[1] At the time, 1xRTT was considered "3G." In hindsight it would be classified as 2.5G.

Source: Exhibit 12.

Table 15
T-Mobile Wireless Capital Expenditures and Investment Activity
($ Millions)

Year	Amount	Main Investment Initiatives
2002	$1,700	Expand and improve GSM (2G) network.
2003	$1,734	Improve quality and capacity in GSM/GPRS (2G) networks.
2004	$2,138	Improve quality and capacity in GSM/GPRS networks.
2005	$5,045	Build cell sites and expand geographic coverage.
2006	$3,444	Build 3G-enabled cell sites.[1]
2007	$2,667	Build 3G-enabled cell sites, deploy over 8,000 UMTS (3G)-capable cell sites by year end.
2008	$3,603	Build 3G-enabled cell sites. Deploy 3G network in 13 major cities by September.
2009	$3,687	Expand 3G network, covering 200 million people by year end.
2010	$2,819	Deploy HSPA 7.2 (3G) across entire network. Deploy HSPA+ (3G)[2] to 200 million people by year end.
2011	$2,729	Build HSPA+ network. [3]
2012	$2,901	Modernize network for LTE (4G) launch.
2013	$4,025	Launch LTE network in seven markets in March, covering 200 million people by October.
2014	$4,317	Modernize and deploy LTE on network.
2015	$4,724	Modernize and deploy LTE on network.
2016	$4,702	Construct, expand, and upgrade LTE network infrastructure.
2017	$5,237	Construct, expand, and upgrade LTE network infrastructure.

Note:
[1] In 2006 T-Mobile purchased AWS-1 spectrum licenses in the FCC's 2006 auction, planning to use the spectrum to deploy its 3G network. However, T-Mobile did not receive full access to the spectrum until mid-2008, delaying its 3G launch.
[2] At the time, T-Mobile marketed HSPA+ as "4G."
[3] T-Mobile reportedly focused on HSPA+, rather than developing LTE, due to spectrum constraints. When T-Mobile's proposed merger with AT&T fell through in late 2011, T-Mobile received AWS spectrum licenses which allowed for the deployment of its LTE network.

Source: Exhibit 13.

137. As described above and summarized in Table 16, these investments led to the dramatic expansion in network capacity and decline in the price per GB of data.

Table 16
U.S. Wireless Network Investments, Smartphone Data Traffic and Price per GB

Year	Capital Expenditures ($ Billions) Annual	Capital Expenditures ($ Billions) Cumulative	Smartphone Mobile Data Traffic (PB)	Price per GB of Smartphone Mobile Data
2010	$23.192	$23.192	281	$49.07
2011	$26.516	$49.708	672	$38.75
2012	$28.975	$78.683	1,277	$30.70
2013	$32.964	$111.648	2,310	$25.39
2014	$31.720	$143.367	4,884	$15.94
2015	$32.919	$176.286	7,661	$10.84
2016	$28.570	$204.856	12,262	$8.07
2017	$28.579	$233.435	16,901	$6.23
Source: Table 8; Exhibits 5A and 9.				

138. These investments also determined the ability of carriers to compete for subscribers. For instance, when AT&T deployed its 2.5G EDGE network in 2003, its CEO at the time stated, "[w]e have broken the speed barrier and we believe we have a distinct advantage in attracting and retaining customers."[237] In a 2009 comment to the FCC, AT&T explained that continued investment within a generation would deliver consumer-benefitting network quality improvements:

> [D]emand for wireless broadband is so great and competition so fierce that competitors cannot wait for the roll out of these next generation networks to offer customers even better services. Consequently, carriers are also investing billions of dollars to upgrade existing network technologies to provide more reliable and faster service. For example, AT&T is continuing to invest in its existing wireless broadband network, by devoting more spectrum to its 3G network and by upgrading to HSPA 7.2 technology . . .[238]

[237] Joris Evers, *AT&T Wireless Lives on the EDGE*, PC WORLD (Nov. 18, 2003), https://www.pcworld.com/article/113530/article.html.

[238] FED. COMMC'NS COMM'N, COMMENTS OF AT&T INC. IN THE MATTER OF WIRELESS TELECOMMUNICATIONS BUREAU SEEKS COMMENT ON COMMERCIAL MOBILE RADIO SERVICES MARKET COMPETITION, WT Docket No. 09-66, 34 (June 15, 2009), https://ecfsapi.fcc.gov/file/6520221081.pdf.

Discussing Verizon's LTE rollout on its Q1 2011 earnings call, Verizon's CFO commented, "we have positioned ourselves on the leading edge of a whole new phase of Wireless market development."[239]

139. The effects of a failure to invest also demonstrate its importance for competition. Sprint initially deployed a 4G network using WiMAX technology, but was forced to abandon WiMAX as the industry consolidated around superior LTE technology.[240] The course correction had a material impact on the performance of Sprint's existing network. A June 2012 speed test conducted by PC World found that Sprint had slower download and upload speeds than Verizon and AT&T for both its 3G and 4G (then WiMAX) service.[241]

140. Internal documents from the Applicants also emphasize that network investments are essential to remain competitive. A 2013 presentation discussing the need for T-Mobile to increase its investments notes that "T-Mobile has effectively kept capex investment levels flat" while "Verizon and AT&T pulsed capex investments with introduction of new technologies (3G, 4G) or the introduction of iPhone."[242] The document observes that "Verizon & AT&T LTE deployments [are] 12-36 months ahead of TMUS & deeper investment [from T-Mobile is]

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[239] Verizon Commc'ns, Inc., *Verizon Communications Management Discusses Q1 2011 Results - Earnings Call Transcript*, SEEKING ALPHA (Apr. 21, 2011), https://seekingalpha.com/article/264793-verizon-communications-management-discusses-q1-2011-results-earnings-call-transcript.

[240] *See, e.g.*, Sascha Segan, *WiMAX vs. LTE: Should You Switch?*, PC MAGAZINE (May 16, 2012), https://www.pcmag.com/article2/0,2817,2403490,00.asp.

[241] Sascha Segan et al., *Fastest Mobile Networks 2012*, PC MAGAZINE (June 18, 2012), https://www.pcmag.com/article2/0,2817,2405597,00.asp. Commenting on the results, PC World noted that Sprint seemed to "have virtually stopped developing its existing 3G and 4G networks while looking for a way to make the transition from its outdated WiMax 4G technology to LTE." Mark Sullivan, *3G and 4G Wireless Speed Showdown: Which Networks Are Fastest*, PC WORLD (Apr. 16, 2012), https://www.pcworld.com/article/253808/3g_and_4g_wireless_speed_showdown_which_networks_are_fastest_.html.

[242] "Recommended Plan: Capex Deep Dive," *T-Mobile*, Jul 29, 2013, at 2.

required for market relevance."[243] In 2015, T-Mobile noted that "[n]etwork modernization" was a "key strategic program to revitalize the [company's] US business in 2012", and that these "[i]nvestment[s] addressed [T-Mobile's] challenged position in US marketplace."[244] Also, in a 2015 presentation, T-Mobile acknowledged that absent network investment, "[d]emand management, via both network tools and data plan design/pricing" could be used to limit network use.[245] T-Mobile further noted that investment in its network is required to maintain a competitive customer experience.[246]

141. In a 2016 report, T-Mobile notes:

> Although network modernization has substantially advanced our network capabilities, we remain at a competitive network disadvantage. Our level of capital investment, both in infrastructure and spectrum, is a fraction of competitors' investment, even when normalized for spectrum type, customer scale, usage, and coverage. As demand continues to rapidly increase, we face [redacted][247]

A February 2016 T-Mobile board presentation recommended participating in a spectrum auction because "[n]ationwide low-band spectrum is critical to eliminating network experience as a dis-qualifier for customers considering T-Mobile."[248] Similarly, a September 2016 Board presentation noted that T-Mobile's "growing customer base and continued increase in data

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[243] "Recommended Plan: Capex Deep Dive," ***T-Mobile***, Jul. 29, 2013 at 2.

[244] "Network Modernization enabled re-farm of existing spectrum assets to build capacity and migrate to LTE, enabled by AT&T break-up spectrum," ***T-Mobile***, Apr. 22, 2015, at 1.

[245] "Capacity Evolution Study – Executive Summary," ***T-Mobile,*** Apr. 2015, at 3.

[246] In addition to network investments, spectrum and demand management were other criteria identified to maintain a competitive customer experience. "Capacity Evolution Study – Executive Summary," ***T-Mobile,*** Apr. 2015, at 7.

[247] Email from Cynthia Damlan to Dave Mayo et al., "4Q15 ERA – Inadequate Network Investment in Capacity & Coverage [Review Needed]," Nov. 8, 2016.

[248] "2-11-16 Board Meeting Materials," ***T-Mobile,*** Feb. 11, 2016, at 57.

utilization [is] driving capacity investment" and that coverage improvements and expansion into new markets were the reasons for accelerated low-band spectrum deployment.[249]

142. Carriers also are keenly aware of the relationship between improvements in network quality and the prices that they can offer to consumers. Sprint's Executive Chairman recently characterized network capacity as "the main driver of pricing."[250] In other words, the mobile data service plans a carrier can offer to consumers depend on how well that carrier's network quality investments have positioned it to meet the subscribers' usage demands.

143. The history of unlimited data plans in the smartphone era provides a clear illustration. AT&T, Verizon, T-Mobile, and Sprint each introduced unlimited data plans as smartphones were introduced in the mid-2000s.[251] However, by July 2011, AT&T, Verizon, and T-Mobile had eliminated their unlimited data plans and reverted to tiered usage plans.[252] Sprint remained the only major cellular carrier to offer an unlimited plan, describing the practice as its "distinctive differentiator."[253] The switch from unlimited to usage-based data plans has been

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[249] "T-Mobile US, Inc. 9-7-15 Board Meeting Materials," *T-Mobile*, Sept. 6, 2016, at 79.

[250] Sprint, *Sprint Corporation's (S) CEO Michel Combes on Q4 2017 Results - Earnings Call Transcript*, SEEKING ALPHA (May 2, 2018), https://seekingalpha.com/article/4168931-sprint-corporations-s-ceo-michel-combes-q4-2017-results-earnings-call-transcript?part=single.

[251] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 45-47 (Sept. 29, 2006).

[252] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, at 63 (Jun. 27, 2011), https://docs.fcc.gov/public/attachments/FCC-11-103A1.pdf; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, at 98-101, 104-105 (Mar. 21, 2013). https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf; Josh Sanburn, *Why Verizon Dropped Its Unlimited Data Plan (And What You Can Do About It)*, TIME (June 23 2011), http://business.time.com/2011/06/23/why-verizon-dropped-its-unlimited-data-plan/.

[253] Roger Cheng, *Sprint Confirms Unlimited Data Plan for Next iPhone*, CNET (Apr. 25, 2012), https://www.cnet.com/news/sprint-confirms-unlimited-data-plan-for-next-iphone/.

interpreted as a way to encourage high-data usage consumers to curb their demand for network capacity and thereby discourage them from "clogging" the network.[254]

144. In March 2014, after it rapidly deployed LTE service and increased capacity, T-Mobile launched a plan with unlimited 4G LTE data for $80 for a single line (previous 4G plans had unlimited 2G data but capped 4G LTE data).[255] In August 2016, T-Mobile announced that it would eliminate plans with data tiers or caps and place all new subscribers on the T-Mobile ONE plan, which provided unlimited talk, text, and 4G LTE data for $70 per month for a single line.[256]

145. T-Mobile explicitly tied its ability to offer unlimited data to all subscribers to the network investments that it had made in its LTE network. In a blog post the month after the announcement of the T-Mobile ONE plan, CTO Neville Ray stated that T-Mobile had launched the most LTE Advanced technologies in the industry and that "T-Mobile's network was built . . . for massive amounts of data."[257] Mr. Ray also announced that T-Mobile had recently deployed two LTE Advanced technologies (4X4 MIMO and 256 QAM) in a large portion of its

[254] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, at 63 (June 27, 2011), https://docs.fcc.gov/public/attachments/FCC-11-103A1.pdf.

[255] *T-Mobile's Simple Choice*, T-MOBILE, http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MjI0MDIxfENoaWxkSUQ9LTF8VHlwZT0z&t=1 (last visited June 8, 2018).

[256] Video would typically stream at 480p, and subscribers would be deprioritized behind other traffic during periods of heavy network congestion after using 26GB of data in a month. *T-Mobile, Hello Un-carrier 12 … R.I.P Data Plans: T-Mobile Goes All In on Unlimited*, T-MOBILE NEWSROOM (Aug. 18, 2016), https://newsroom.t-mobile.com/news-and-blogs/rip-data-plans.htm; Roger Cheng, *T-Mobile Really, Really Wants You on its Unlimited Data Plan*, CNET (Jan. 5, 2017), https://www.cnet.com/news/t-mobile-uncarrier-next-13-really-really-wants-you-on-its-unlimited-data-plan-ces-2017.

[257] *LTE Advanced is So 2014. We're Already on to the Next Big Thing. Verizon is Now 50% faster … and Still Slower Than T-Mobile!*, T-MOBILE BLOG (Sept. 6, 2016), https://newsroom.t-mobile.com/news-and-blogs/lte-advanced.htm.

network and that it was the first carrier to launch these technologies to provide faster data speeds.[258]

146. AT&T and Verizon responded quickly. Verizon reintroduced an unlimited plan in February 2017, offering unlimited voice, text, and data for $80 with limitations on subscribers' data rates after 22GB each month.[259] Verizon's plan offered unlimited HD video streaming.[260] In a video announcement of the plan, Verizon's president stated: "Our network investment and innovation have put us in a great position to meet customers' increasing demand in the growing market for wireless broadband and data."[261] Verizon's chief network officer, then provided an extensive description of the hardware and software investments that Verizon had made in its 4G LTE network,[262] with Verizon's president concluding "[w]e've built our network so we can manage all the activity customers undertake. Everything we've done is to provide the best experience on the best network – and we've built it for the future, not just for today."[263]

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[258] *LTE Advanced is So 2014. We're Already on to the Next Big Thing. Verizon is Now 50% Faster … And Still Slower Than T-Mobile!*, T-MOBILE BLOG (Sept. 6, 2016), https://newsroom.t-mobile.com/news-and-blogs/lte-advanced.htm.

[259] Brian Fung, *Verizon is Launching a New Unlimited Data Plan. Here Are the Details*, THE WASHINGTON POST (Feb. 13, 2017), https://www.washingtonpost.com/news/the-switch/wp/2017/02/13/verizon-is-launching-a-new-unlimited-data-plan-here-are-the-details/?utm_term=.af67f78dd94e.

[260] Brian Fung, *Verizon is Launching a New Unlimited Data Plan. Here Are the Details*, THE WASHINGTON POST (Feb. 13, 2017), https://www.washingtonpost.com/news/the-switch/wp/2017/02/13/verizon-is-launching-a-new-unlimited-data-plan-here-are-the-details/?utm_term=.af67f78dd94e.

[261] Verizon, *Not Just Unlimited, Verizon Unlimited*, YOUTUBE at 1:04 (Feb. 12, 2017) https://www.youtube.com/watch?v=YacWu0bi690.

[262] Verizon, *Not Just Unlimited, Verizon Unlimited*, YOUTUBE at 1:45 - 3:00 (Feb. 12, 2017) https://www.youtube.com/watch?v=YacWu0bi690.

[263] Verizon, *Not Just Unlimited, Verizon Unlimited*, YOUTUBE at 3:03 (Feb. 12, 2017) https://www.youtube.com/watch?v=YacWu0bi690.

147. Also in February 2017, AT&T launched the AT&T Unlimited Plus and AT&T Unlimited Choice plans.[264] The Unlimited Plus plan offered customers unlimited data, talk, and text with DIRECTV for $115 a month for a single line, and the Unlimited Choice plan offered customers unlimited talk, text, and data with a maximum speed of 3 Mbps at $60 a month for a single line.[265] Under both plans, AT&T could slow the connections of subscribers that used more than 22 GB in a month in times of network congestion.[266]

148. Thus, by spring 2017, Verizon, AT&T, and T-Mobile each offered unlimited data plans to their customers. However, T-Mobile suggested in an April 2017 press release that these plans were not created equal because other carriers' networks weren't "built to handle" unlimited data plans.[267] Notably, both Verizon's and AT&T's plans imposed lower thresholds for limiting data use than T-Mobile's. In a press release, T-Mobile showed that T-Mobile's download speeds had remained relatively steady while rivals' speeds had dropped sharply after introducing their unlimited 4G LTE plans.[268]

[264] Press Release, AT&T, AT&T Brings New Unlimited Wireless and Entertainment Deals to Market, AT&T (Feb. 27, 2017), http://about.att.com/story/att_brings_new_unlimited_wireless_and_entertainment_deals_to_market.html.

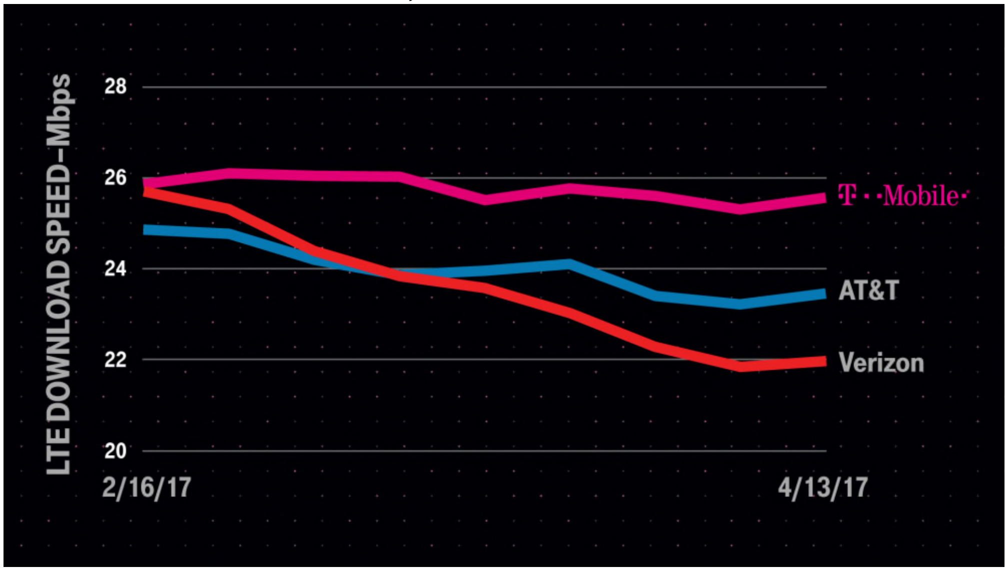
[265] Press Release, AT&T, AT&T Brings New Unlimited Wireless and Entertainment Deals to Market, AT&T (Feb. 27, 2017), http://about.att.com/story/att_brings_new_unlimited_wireless_and_entertainment_deals_to_market.html.

[266] Press Release, AT&T, AT&T Brings New Unlimited Wireless and Entertainment Deals to Market, AT&T (Feb. 27, 2017), http://about.att.com/story/att_brings_new_unlimited_wireless_and_entertainment_deals_to_market.html.

[267] According to T-Mobile's CEO, "Watching what the carriers' new unlimited plans are doing to their networks is like watching a train wreck in slow motion – emphasis on slow … This is what happens when you unleash unlimited data on a network that wasn't built to handle it. T-Mobile's network was built for unlimited, so customers can experience the Galaxy S8 as it was intended – insanely-fast and without limits." *As Unlimited Data Takes Center Stage, T-Mobile Widens Speed Gap Between the Network Built for Unlimited … and Everyone Else*, T-MOBILE BLOG (Apr. 21, 2017), https://newsroom.t-mobile.com/news-and-blogs/tmobile-widens-lte-speed-gap-over-verizon-att-unlimited-plans.htm.

[268] *As Unlimited Data Takes Center Stage, T-Mobile Widens Speed Gap Between the Network Built for Unlimited … and Everyone Else*, T-MOBILE BLOG (Apr. 21, 2017), https://newsroom.t-mobile.com/news-and-blogs/tmobile-widens-lte-speed-gap-over-verizon-att-unlimited-plans.htm.

Figure 4
According to T-Mobile
LTE Download Speed Comparison
T-Mobile, AT&T and Verizon[269]



C. The History of the Dynamics of Investment Competition Shows that Cellular Carriers React to Each Other's Investment Decisions Because They Will Fall Behind and Lose Customers If They Do Not

149. Carrier investments that improve network quality beyond what rivals can offer rapidly create an advantage in competition to attract subscribers. Anticipation of this first-mover advantage leads carriers to quickly react to investments made by rivals with network investments of their own. Carriers that cannot match the network quality of their rivals will lose customers, making it harder for them to invest in the network upgrades needed to compete effectively and leading them to fall further behind.

150. The qualitative evidence presented below documents the initial and reactive investments that carriers made in deploying their 3G and 4G networks, including improved standards and

269 *As Unlimited Data Takes Center Stage, T-Mobile Widens Speed Gap Between the Network Built for Unlimited … and Everyone Else*, T-MOBILE BLOG (Apr. 21, 2017), https://newsroom.t-mobile.com/news-and-blogs/tmobile-widens-lte-speed-gap-over-verizon-att-unlimited-plans.htm.

technologies within generations. Adopting a new generation of cellular technology and phasing out an old one is not an instantaneous event; a carrier will continue to operate previous generation networks – even further upgrading and expanding them – for many years as the new technologies are deployed and adopted by consumers. For those reasons, investment competition late in one generation often influences investment competition in the next. The discussion of 3G investments and deployments below therefore begins with the launch of late generation 2G networks, and the discussion of 4G investments and deployments notes the impact of upgrades to late generation 3G networks.

1. Investment in 3G Drove Dynamic Competition Among U.S. Cellular Carriers in the 2000s

151. To understand investment competition in 3G technologies, it is helpful to begin with the deployment of the 2.5G CDMA2000 1xRTT and EDGE technologies, both of which offered significant advantages over earlier 2G technologies, and both of which were marketed as "3G." Sprint and Verizon deployed 1xRTT and continued to deploy CDMA-family technologies (CDMA2000 EV-DO Rev. 0, EV-DO Rev. A, EV-DO Rev. B) as they moved to true 3G networks. AT&T, Cingular Wireless, and T-Mobile (then known as VoiceStream) deployed EDGE and later GSM-family 3G technologies (WCDMA, HSPA).

152. In the early 2000s, Verizon and Sprint (the two U.S. CDMA carriers) were competing neck-and-neck in network technology. In January 2002, Sprint announced that it would be the first carrier to roll out "3G" 1xRTT that summer.[270] Verizon unexpectedly "beat Sprint PCS to

[270] ComputerWire, *Sprint CEO Promises Mid Year 3G US Roll Out*, THE REGISTER (Jan. 14, 2002), https://www.theregister.co.uk/2002/01/14/sprint_ceo_promises_mid_year/.

[the] 3G throne"[271] by launching the nation's first 1xRTT wireless network the same month in three locations.[272] Sprint fulfilled its original promise, providing the first *nationwide* 1xRTT service (which both carriers marketed as "3G") by August 2002.[273]

153. In October 2003, Verizon launched the first wide-area broadband 3G network, using upgraded EV-DO technology to power its BroadbandAccess service in Washington, D.C. and San Diego.[274] Three months later, in January 2004, Verizon announced their decision to expand EV-DO nationally.[275] Rather than deploying EV-DO itself, Sprint initially planned to wait until 1xEV-DV, a technology superior to EV-DO, was ready for commercial deployment (at the time expected in 2005).[276] However, EV-DO provided Verizon with a noticeable quality advantage: in December 2004, a review of BroadbandAccess stated that "[s]peed-wise, Verizon's EV-DO connectivity lived up to its promises."[277]

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[271] Margo McCall, *Verizon Steals 1X Crown*, WIRELESS WEEK (May 27, 2002), https://www.highbeam.com/doc/1G1-87206619.html.

[272] *Verizon Launches First U.S. '3G' Network*, CNN (Jan. 28, 2002), http://edition.cnn.com/2002/TECH/ptech/01/28/verizon.3g/; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – SEVENTH REPORT, WT Docket No. 02-179, at 59-61 (July 3, 2002).

[273] Bob Brewin, *Sprint PCS Launches Nationwide 3G Network*, COMPUTERWORLD (Aug. 8, 2002), https://www.computerworld.com/article/2577108/mobile-wireless/sprint-pcs-launches-nationwide-3g-network.html; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379, at 38-39 (July 14, 2003); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – SEVENTH REPORT, WT Docket No. 02-179, at 59-61 (July 3, 2002).

[274] Press Release, Verizon Wireless, Verizon Wireless Announces Roll Out of National 3G Network (Jan. 8, 2004), http://www.verizon.com/about/news/vzw/2004/01/pr2004-01-07.

[275] Verizon Commc'ns Inc., *Q4 2003 Verizon Earnings Conference Call and Investor Conference* (Jan. 29, 2004).

[276] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379, 38-39 (July 14, 2003).

[277] Gary Krakow, *High-speed wireless network lives up to claims*, NBC NEWS (Dec. 16, 2004), http://www.nbcnews.com/id/6722931/ns/technology_and_science-wireless/t/high-speed-wireless-network-lives-claims/#.Wv34-q6nGpo.

154. "In response to competitive pressure from Verizon Wireless's deployment of EV-DO,"[278] Sprint changed course and announced plans to deploy EV-DO in the majority of top markets in 2005, with the technology being available in selected markets in the second half of 2004.[279] The FCC noted that "Sprint's change in strategy with regard to deployment of technologies on the CDMA migration path can be seen as a competitive response to Verizon's EV-DO offering, and thus provides a clear-cut example of intense non-price rivalry."[280]

155. Network upgrades among GSM-family operators lagged behind those spurred by competition between Verizon and Sprint in CDMA technologies. The first EDGE network was launched by Cingular in July 2003, more than a year after Verizon and Sprint deployed their 1xRTT networks.[281] AT&T followed closely behind, announcing the deployment of its own EDGE network in November.[282] In mid-2004, AT&T leapfrogged Cingular by launching its first 3G network using WCDMA technology in four major U.S. cities.[283] Cingular acquired AT&T in October 2004.[284]

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[278] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 52 (Sept. 29, 2006).

[279] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – NINTH REPORT, WT Docket No. 04-111, at 57-58 (Sept. 28, 2004).

[280] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TENTH REPORT, WT Docket No. 05-71, at 45-46 (Sept. 30, 2005).

[281] Keith Winstein, *A Tedious and Personal History of 3G*, GIZMODO (Aug. 21, 2010), https://gizmodo.com/5618307/a-tedious-and-personal-history-of-3g.

[282] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – NINTH REPORT, WT Docket No. 04-111, at 56 (Sept. 28, 2004); Dave Mock, *AT&T Wireless Pushes the EDGE*, THE MOTLEY FOOL (Nov. 19, 2003), https://www.fool.com/investing/general/2003/11/19/atampt-wireless-pushes-the-edge.aspx.

[283] Stephen Lawson, *AT&T Wireless Goes 3G*, PC WORLD (July 20, 2004), https://www.pcworld.com/article/116966/article.html.

[284] The two entities were not consolidated under one brand name until 2007 (when it decided to use the AT&T brand name for the combined company) nor were their cellular networks announced to be fully integrated until October 2006. Exhibit 8 provides a brief background on the history of these companies. Lloyd Vries, *From AT&T To Cingular And Back Again*, CBS (Jan. 12, 2007), https://www.cbsnews.com/news/from-att-to-cingular-

156. The combined AT&T/Cingular worked to close the gap with its CDMA-based competitors. When AT&T had initially launched its WCDMA network, an analyst had noted that the claimed speeds were slightly lower than Verizon's EV-DO technology.[285] AT&T replied that its new network could be upgraded "easily and cost-effectively" to use the HSDPA technology, which was then under development.[286] To compete with Verizon's EV-DO network, the combined AT&T/Cingular[287] carried out this investment in HSDPA, which offered speeds similar to or slightly faster than EV-DO.[288] AT&T/Cingular launched a WCDMA network with HSDPA in 16 cities across the United States in December 2005.[289] AT&T/Cingular rapidly expanded the network, reaching more than 160 markets by the end of 2006.[290]

157. During this period, analysts found that Verizon was mainly differentiated from its rivals by its superior network quality,[291] the result of early and outsized investment in its network. The FCC noted that both AT&T/Cingular's HSDPA deployment and Sprint's own EV-DO

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and-back-again/; Amol Sharma, *Cingular Finishes Absorbing Network of AT&T Wireless*, THE WALL STREET JOURNAL (Oct. 3, 2006), https://www.wsj.com/articles/SB115984186629680838.

[285] Stephen Lawson, *AT&T Wireless Goes 3G*, PC WORLD (July 20, 2004), https://www.pcworld.com/article/116966/article.html.

[286] Stephen Lawson, *AT&T Wireless Goes 3G*, PC WORLD (July 20, 2004), https://www.pcworld.com/article/116966/article.html.

[287] I refer to the merged company as AT&T/Cingular until the AT&T brand becomes the name for the combined company. Lloyd Vries, *From AT&T To Cingular And Back Again*, CBS (Jan. 12, 2007), https://www.cbsnews.com/news/from-att-to-cingular-and-back-again/.

[288] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 53 (Sept. 29, 2006).

[289] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 53 (Sept. 29, 2006).

[290] *Cingular 3G Coverage In More Than 160 Markets*, FIELD TECH. MAG. (Dec. 21, 2006), https://www.fieldtechnologiesonline.com/doc/cingular-3g-coverage-in-more-than-160-markets-0001.

[291] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TENTH REPORT, WT Docket No. 05-71, at 51 (Sept. 30, 2005).

deployment were competitive responses to Verizon's EV-DO network. In its 2006 Report on the state of the wireless industry in 2005 and 2006, the FCC noted: "[m]obile data competition intensified in the past year with two of the nation-wide carriers launching wireless broadband services to compete with Verizon Wireless's EV-DO offerings."[292]

158. Investment competition between the CDMA operators continued through the next intermediate standard. In October 2005, Verizon announced it was starting trials of EV-DO Rev. A.[293] Sprint responded quickly. In October 2006, Sprint launched EV-DO Rev. A in the San Diego market, which it said was the first market in the nation.[294] Verizon's deployment followed rapidly: by December 2006 its EV-DO Rev. A network, which covered about 200 million people.[295] By June 2007, both Sprint[296] and Verizon[297] had deployed EV-DO Rev. A to most of their EV-DO network footprint.

[292] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 62 (Sept. 29, 2006).

[293] Verizon Commc'ns Inc., *Q3 2005 Verizon Earnings Conference Call* (Oct. 27, 2005).

[294] Press Release, Sprint, Sprint Launches Nation's First EV-DO Revision A Mobile Broadband Network (Oct. 24, 2006), http://newsroom.sprint.com/sprint-launches-nations-first-ev-do-revision-a-mobile-broadband-network-1.htm; *cf. Sprint 'Powers Up' Wireless Coverage, Capacity To Its Nextel Network In Metro Detroit* (Oct. 12, 2006), http://newsroom.sprint.com/sprint-powers-up-wireless-coverage-capacity-to-its-nextel-network-in-metro-detroit.htm.

[295] Verizon Commc'n Inc., Annual Report (Form 10-K), at 5 (Mar. 1, 2007); *see also* Verizon Commc'n Inc., Annual Report (Form 10-K), at 8 (Feb. 28, 2008).

[296] Press Release, Sprint, America's Largest and Fastest Mobile Broadband Network Just Got Even Larger – Sprint Customers Can Do More, In More Places, And At Fast Speeds (June 19, 2007), http://newsroom.sprint.com/americas-largest-and-fastest-mobile-broadband-network-just-got-even-larger-sprint-customers-can-do-more-in-more-places-and-at-fast-speeds.htm; Sprint, Annual Report (Form 10-K), at 7-8 (Mar. 1. 2007).

[297] Press Release, Verizon Wireless, Verizon Wireless: 100 Percent of Wireless Broadband Network Now Enhanced with Faster Speeds (June 29, 2007), https://www.verizon.com/about/news/vzw/2007/06/pr2007-06-28h.

159. T-Mobile (ranked the fourth largest operator at the end of 2004,[298] considering AT&T/Cingular as a single company) was not a player in early 3G deployments. This is because it did not have sufficient spectrum for 3G deployment though it was prepared to buy the necessary capacity in the next auction.[299] T-Mobile did not announce any plans to deploy 3G until December 2005, when it said it would launch a 3G network by the end of 2006, or by 2007 at the latest.[300] In 2006 T-Mobile purchased AWS-1 spectrum licenses in the FCC's 2006 auction at a total cost of $4.18 billion, planning to use the spectrum to deploy its 3G network.[301] However, T-Mobile did not immediately receive full access to the spectrum because of government delays in transitioning law enforcement and homeland security functions to other frequencies.[302] T-Mobile did not launch 3G until May 2008, a full six years after Verizon.[303]

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[298] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TENTH REPORT, WT Docket No. 05-71, at 86 (Sept. 30, 2005).

[299] Carlo Longino, *T-Mobile Outlines 3G Catch-Up Plans*, TECH DIRT (Dec. 19, 2005), https://www.techdirt.com/articles/20051219/140625.shtml; "DT Network and Procurement Update," T-Mobile, Jan. 31, 2006, at 36 ("Sufficient spectrum required to ensure aggressive growth, service quality, and competitive product portfolio[;] UMTS technical requirements make it impossible to launch on existing PCS spectrum[;] TMUS lags competitors' spectrum positions, which have increased dramatically through consolidation and purchases"); id. at 37 ("Participate in Summer 2006 auction for nationwide AWS spectrum[;]Projected AWS 1700/2100 MHz spectrum purchase keeps TMUS competitive with the three other national wireless providers") (emphasis in original).

[300] Ed Oswald, *T-Mobile Plans for Growth, 3G in 2006*, BETA NEWS (Dec. 16, 2005), https://betanews.com/2005/12/16/t-mobile-plans-for-growth-3g-in-2006/.

[301] *T-Mobile USA Exceeds 25 Million Customer Milestone and Reports Fourth Quarter and 2006 Results*, BUSINESSWIRE (Mar. 1, 2007), https://www.businesswire.com/news/home/20070228006332/en/T-Mobile-USA-Exceeds-25-Million-Customer-Milestone; Press Release, T-Mobile, T-Mobile USA Secures Rights from FCC for Auctioned Spectrum (Nov. 30, 2006), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-usa-secures-rights-from-fcc-for-auctioned-spectrum.htm.

[302] *T-Mobile's 3G Delay Government Related*, PHONESCOOP (Sept. 24, 2007), http://www.phonescoop.com/articles/article.php?a=2419.

[303] Press Release, T-Mobile, T-Mobile USA Begins Commercial 3G Network Rollout (May 5, 2008), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-usa-begins-commercial-3g-network-rollout.htm; *Verizon Launches First U.S. '3G' Network*, CNN (Jan. 28, 2002), http://edition.cnn.com/2002/TECH/ptech/01/28/verizon.3g/; s*ee also*, Tables 12 and 15.

160. This delay resulted in T-Mobile falling behind as a competitor for an extended period of time. In February 2011, after T-Mobile reported that it had lost customers in the previous quarter, commentators sought to explain why it was the only carrier to do so. One reason offered was a "consumer perception that T-Mobile was late to 3G and [didn't] have as much coverage as other carriers."[304]

2. Investment in 4G LTE Drove Dynamic Competition Among U.S. Cellular Carriers in the 2010s

161. In January 2007, Sprint announced plans to deploy the first 4G network using WiMAX, a technology standard developed by IEEE that was not related to either the CDMA or the GSM families of cellular technology standards, before the end of the year.[305] At the time, WiMAX was the only 4G technology ready for commercial deployment.[306] Sprint announced a plan to partner with Clearwire to deploy the technology in July 2007,[307] and the companies launched the first WiMAX network in Baltimore in September 2008.[308] Sprint and Clearwire continued

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[304] Peter Pachal, *Why Is T-Mobile Losing Customers*, PC MAGAZINE (Feb. 25, 2011), https://www.pcmag.com/article2/0,2817,2380949,00.asp.

[305] Darren Murphy, *Sprint Announces Large Scale WiMAX Rollout, Starts With Chicago and D.C.*, ENGADGET (Jan. 9, 2007), https://www.engadget.com/2007/01/09/sprint-announces-large-scale-wimax-rollout-starts-with-chicago/.

[306] Mark Sullivan, *Sprint CEO Says WiMax Bet Paid Less Than Hoped*, PC WORLD (Dec. 7, 2010), https://www.pcworld.com/article/212878/Sprint_CEO_Says_WiMAX_bet_Paid_Less_Than_Hoped.html.

[307] Press Release, Sprint, Sprint Nextel and Clearwire to Partner to Accelerate and Expand the Deployment of the First Nationwide Mobile Broadband Network Using WiMAX Technology (July 19, 2007), http://newsroom.sprint.com/sprint-nextel-and-clearwire-to-partner-to-accelerate-and-expand-the-deployment-of-the-first-nationwide-mobile-broadband-network-using-wimax-technology.htm.

[308] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, at 129 (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf; Reuters Staff, *Sprint Launches Its First WiMax Market*, REUTERS (Sept. 29, 2008), https://www.reuters.com/article/sprint-wimax/sprint-launches-its-first-wimax-market-idUSN29381830200809 29.

to expand WiMAX service offerings through 2011, ultimately reaching 132 million people in 71 markets.[309]

162. According to an industry analyst, Sprint's decision to pursue the buildout of a WiMAX network "spur[red] the other guys [i.e., Verizon and AT&T] to get their act together and get LTE out in the field."[310] Verizon announced in November 2007 that it would deploy LTE as its 4G technology, with trials set to begin in 2008 but no indication of when a commercial launch would occur.[311] AT&T announced in April 2008 that it planned to use spectrum acquired at the March 2008 FCC spectrum auction to develop its own LTE network, but did not expect widespread commercial LTE deployment to occur before 2012.[312] After purchasing spectrum in the same auction, Verizon clarified that it planned to launch its LTE network in 2010.[313]

163. The press noted that, at the time, Verizon had an incentive to launch a 4G network as soon as possible to limit the first-mover advantage of Sprint's 4G WiMAX network and to beat AT&T to 4G.[314] Verizon's move away from CDMA towards LTE coincided with a stall in next generation CDMA technology. Verizon also faced competitive pressure from AT&T,

[309] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, at 129 (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf.

[310] Matt Hamblen, *WiMax vs. Long Term Evolution: Let the Battle Begin*, COMPUTER WORLD (May 14, 2008) https://www.computerworld.com/article/2535716/mobile-wireless/wimax-vs--long-term-evolution--let-the-battle-begin.html?page=3.

[311] Press Release, Verizon Wireless, Verizon Selects LTE as 4G Wireless Broadband Direction (Nov. 29, 2007), http://www.verizon.com/about/news/vzw/2007/11/pr2007-11-29.

[312] Matt Buchanan, *AT&T to Use 700MHz Spectrum for High-Speed 4G LTE Network*, GIZMODO (Apr. 3, 2008), https://gizmodo.com/375898/att-to-use-700mhz-spectrum-for-high-speed-4g-lte-network.

[313] Press Release, Verizon Wireless, Verizon Wireless Says Spectrum Additions From FCC's Auction 73 Will Further Company's Broadband Strategy (Apr. 4, 2008), http://www.verizon.com/about/news/vzw/2008/04/pr2008-04-04.

[314] Dan Frommer, *Verizon Wireless Testing 4G "LTE" Network Today*, BUSINESS INSIDER (Aug. 14, 2009), http://www.businessinsider.com/verizon-wireless-testing-4g-lte-network-today-2009-8.

pushing it to accelerate its LTE deployment. AT&T stated in 2010 that "Verizon has to hurry because Big Red's 3G network is more limited in speed than AT&T's."[315]

164. Verizon's early deployment may also have been aimed at better positioning to benefit from the unexpected explosion of smartphone-enabled apps. Within four months of the iPhone's exclusive release on AT&T's network, AT&T reported that it had activated 1.1 million iPhone users and that 40 percent of those users were new AT&T customers, suggesting that many subscribers switched to AT&T to access the iPhone.[316] Verizon did not just wait to get access to the iPhone, but rather made investments in its network which started to pay off, as Verizon became "the network of choice for phones that run on Google's Android platform,"[317] potentially enabling the creation of 4G Android devices that would outperform an iPhone limited to AT&T's 3G network.

165. AT&T, on the other hand, had a strong incentive to continue to upgrade its 3G network to keep pace with the data demands of iPhone users. In addition, because HSPA and LTE share a common technological base, AT&T's HSPA network upgrades would ultimately support an LTE rollout.[318] In September 2009, AT&T announced plans to improve major portions of its HSPA network with an HSPA 7.2 software upgrade, which would provide theoretical

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[315] Sascha Segan, *AT&T Hits Back on Verizon LTE Claims*, PC MAGAZINE (Oct. 7, 2010), https://www.pcmag.com/article2/0,2817,2370398,00.asp. At the time, Verizon used CDMA EV-DO Rev. A, which topped out at 3.1 Mbps, while AT&T was upgrading its HSPA network offering downloads at up to 84 Mbps.

[316] Laurie J. Flynn, *AT&T Profit Surges 41% With Help From iPhone*, N.Y. TIMES (Oct. 24, 2007), https://www.nytimes.com/2007/10/24/business/24phone.html.

[317] Fortune Editors, *Get Ready for Verizon's "Dream Phone,"* FORTUNE (Oct. 29, 2010), http://fortune.com/2010/10/29/get-ready-for-verizons-dream-phone/.

[318] Press Release, AT&T, AT&T to Deliver 3G Mobile Broadband Speed Boost (May 27, 2009), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=26835; Mike Jude, *AT&T 4G Network Architecture and the LTE Wars*, TECHTARGET (Feb. 2011), https://searchtelecom.techtarget.com/tip/ATT-4G-network-architecture-and-the-LTE-wars.

maximum download speeds of 7.2 Mbps.[319] AT&T completed the upgrade in 2010 and continued to deploy supporting infrastructure improvements into 2011.[320] In May 2010, AT&T announced plans to cover 250 million people with an upgrade to HSPA+,[321] which would provide theoretical maximum download speeds of 14.4 Mbps.[322] The HSPA+ upgrade path would potentially allow AT&T to reach theoretical maximum speeds of up to 84 Mbps on its 3G network.[323] As discussed above, Verizon's anticipation of these 3G network improvements from AT&T may also have played a role in its decision to aggressively roll out its 4G LTE network. In December 2010, as noted earlier, Verizon launched the country's first 4G LTE network in 38 major metropolitan areas and 60 commercial airports coast to coast.[324] This propelled Verizon ahead of AT&T.[325]

166. For its part, AT&T continued to accelerate its plans to launch a 4G LTE network. In December 2010, within days of Verizon's LTE network launch, AT&T's CEO stated that AT&T was planning an "aggressive ramp [up] of LTE to challenge Verizon's early 4G lead," claiming that AT&T would cover 70 million people across the United States by the end of

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[319] Press Release, AT&T, AT&T Upgrades 3G Technology at Cell Sites Across Nation (Jan. 5, 2010), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=30358.

[320] Press Release, AT&T, AT&T Upgrades 3G Technology at Cell Sites Across Nation (Jan. 5, 2010), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=30358.

[321] John Herrman, *AT&T's Super-fast HSPA+ Network Will Cover 250 Million People By the End of the Year*, GIZMODO (May 14, 2010), https://gizmodo.com/5539391/atts-super-fast-hspa%252B-network-will-cover-250-million-people-by-the-end-of-the-year.

[322] Sascha Segan, *AT&T Hits Back on Verizon LTE Claims*, PC MAGAZINE (Oct. 7, 2010), https://www.pcmag.com/article2/0,2817,2370398,00.asp.

[323] Sascha Segan, *AT&T Hits Back on Verizon LTE Claims*, PC MAGAZINE (Oct. 7, 2010), https://www.pcmag.com/article2/0,2817,2370398,00.asp.

[324] Matt Buchanan, *Verizon's 4G LTE Network Launches Dec. 5: How Fast, How Much and Where It's At*, GIZMODO (Dec. 1, 2010), https://gizmodo.com/5703350/verizons-4g-lte-wireless-network-launches-dec-5; Press Release, Verizon Wireless, Verizon Wireless Launches the World's Largest 4G LTE Wireless Network on Dec.5 (Dec. 1, 2010), http://www.verizon.com/about/news/vzw/2010/12/pr2010-11-30a.

[325] Mark Sullivan, *Consumer Reports AT&T Slam Points Squarely Toward Verizon iPhone*, PC WORLD (Dec. 6, 2010), https://www.pcworld.com/article/212670/Cr_att.html.

2011.[326] While acknowledging that AT&T's initial launch would come well behind Verizon's, AT&T's CEO claimed that AT&T's smoother upgrade path from HSPA+ would largely eliminate any network quality gaps in a "three to five year horizon."[327] Verizon, he explained, was "incentivised [sic] to move faster" because its CDMA architecture did not have an upgrade path to LTE.[328]

167. In January 2011, AT&T again accelerated its plans, announcing that it would launch its LTE network by the middle of the year.[329] According to commentary at the time: "AT&T's plan will likely accelerate its evolution to 4G and will drive competitive responses by the two other major U.S. 4G players: Verizon and Sprint. The near-term impact will likely be an increased deployment in LTE infrastructure and new 4G instruments."[330]

168. AT&T ultimately launched its LTE network in September 2011 in five U.S. cities and had covered 103 markets by November 2012.[331] Verizon and AT&T were described as racing against each other to compete over LTE coverage as well as the overall speed across their

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[326] Alan Burkitt-Gray, *AT&T Plans "Aggressive Ramp" of LTE to Challenge Verizon's Early 4G Lead*, GLOBAL TELECOMS BUSINESS (Nov./Dec. 2010), https://www.att.com/Common/about_us/downloads/leadership_spotlight/RLS_GTB_Nov-Dec2010.pdf.

[327] Alan Burkitt-Gray, *AT&T Plans "Aggressive Ramp" of LTE to Challenge Verizon's Early 4G Lead*, GLOBAL TELECOMS BUSINESS (Nov./Dec. 2010), https://www.att.com/Common/about_us/downloads/leadership_spotlight/RLS_GTB_Nov-Dec2010.pdf.

[328] Alan Burkitt-Gray, *AT&T Plans "Aggressive Ramp" of LTE to Challenge Verizon's Early 4G Lead*, GLOBAL TELECOMS BUSINESS (Nov./Dec. 2010), https://www.att.com/Common/about_us/downloads/leadership_spotlight/RLS_GTB_Nov-Dec2010.pdf.

[329] Eric Bangeman, *AT&T to Flip Switch on 4G LTE Network by Mid-2011*, ARS TECHNICA (Jan. 5, 2011), https://arstechnica.com/gadgets/2011/01/att-to-flip-switch-on-4g-lte-network-by-mid-2011/.

[330] Mike Jude, *AT&T 4G Network Architecture and the LTE Wars*, TECHTARGET (Feb. 2011), https://searchtelecom.techtarget.com/tip/ATT-4G-network-architecture-and-the-LTE-wars.

[331] According to GSMA Intelligence data, AT&T's 4G coverage (by population) was 24 percent in Q4 2011, increasing to 50 percent in Q4 2012. Exhibit 6; Jessica Dolcourt, *AT&T Launching LTE on Sept. 18, at Long Last*, CNET (Sept. 15, 2011), https://www.cnet.com/news/at-t-launching-lte-on-sept-18-at-long-last/; Robert Nelson, *AT&T 4G LTE Coverage was Doubled in 2012, is Now Available for More Than 150 Million People*, ANDROID AUTHORITY (Nov. 16, 2012), https://www.androidauthority.com/att-4g-lte-doubles-in-2012-132046/.

combined LTE and 3G networks. Around this time, an article stated that while Verizon was rapidly growing its LTE network, its EV-DO backup connection was slower than the AT&T 3G HSPA+ network that AT&T had continued to aggressively upgrade.[332]

169. While Sprint had been an early mover with its 4G WiMAX network in 2007-2008, the technology was not widely adopted by other carriers. That limited the number potential consumers for WiMAX phones and discouraged device manufacturers from offering them. The first successful WiMAX handset was not launched until June 2010. Subscribers had limited opportunities to realize the benefit of WiMAX before that handset became available and even after that, faced a limited choice of WiMAX compatible smartphones.[333] In October 2010, Sprint's board members resigned from Clearwire, which was viewed as a signal that the WiMAX technology would likely become a dead end.[334] In October 2011, Sprint conceded on WiMAX and announced its plans to deploy a LTE network by mid-2012 and complete the deployment by the end of 2013.[335] Sprint ultimately struggled to roll out its LTE network, and it was not substantially completed until mid-2014.[336]

[332] Scott Webster, *AT&T to Focus on LTE Network First, Then Compatible Phones*, CNET (Aug. 10, 2011), https://www.cnet.com/news/at-t-to-focus-on-lte-network-first-then-compatible-phones/.

[333] Sprint launched its HTC EVO 4G, a WiMAX phone, in June 2010. The EVO 4G was the first 4G-enabled phone. Reuters Staff, *Sprint Unveils HTC WiMax Phone EVO 4G*, REUTERS (Mar. 23, 2010), https://www.reuters.com/article/us-sprint-htc/sprint-unveils-htc-wimax-phone-evo-4g-idUSTRE62M5L120100324?type=technologyNews; Brian Barrett, *Sprint's HTC Evo, the First Ever 4G Phone: Meet the New Terrific*, GIZMODO (Mar. 23, 2010), https://gizmodo.com/5500343/sprints-htc-evo-the-first-ever-4g-phone-meet-the-new-terrific; *What does '4G' Really Mean, Anyway?,* NPR, (Jan. 14, 2012), https://www.npr.org/2011/01/14/132934022/what-does-4g-really-mean-anyway.

[334] Galen Gruman, *WiMax: Goodbye and Good Riddance*, INFOWORLD (Oct. 9, 2010), https://www.pcworld.com/article/207386/wimax_goodbye_and_good_riddance.html.

[335] Press Release, Sprint, Sprint Accelerates Deployment of Network Vision and Announces National Rollout of 4G LTE (Oct. 7, 2011), http://newsroom.sprint.com/sprint-accelerates-deployment-of-network-vision-and-announces-national-rollout-of-4g-lte.htm.

[336] Roger Cheng, *Why Sprint is Taking its Sweet Time With 4G LTE*, CNET (July 24, 2013), https://www.cnet.com/news/why-sprint-is-taking-its-sweet-time-with-4g-lte/; s*ee also Sprint Powers Ahead of*

170. T-Mobile continued to develop its 3G HSPA network as rivals pivoted to WiMAX and LTE, respectively. In early 2010, T-Mobile announced it had deployed HSPA 7.2 across its entire network – well ahead of AT&T, which planned to complete 90 percent of its deployment by the end of 2011.[337] T-Mobile's HSPA+ network upgrade (which it marketed as 4G), started in select cities in 2010, and by the end of 2010, its HSPA+ network covered 200 million people.[338] Indeed, the investment provided T-Mobile with a (short-lived) network quality advantage, with its "HSPA+ network . . . outperforming competing 3G wireless networks with speeds up to three times faster."[339] A March 2011 article considering T-Mobile's 4G outlook noted that in the short term its HSPA+ network would satisfy most customers but that "as time goes on, customers are going to be demanding greater and greater amounts of data capability on their smartphones, and T-Mobile's 4G network has a very low ceiling."[340] Similarly, in December 2011, CBS News commented that T-Mobile "doesn't have enough spectrum to make a transition on its own to 4G LTE technology" and that it has been "steadily losing

LTE Rollout, AGL MEDIA GROUP (Apr. 30, 2014), https://www.aglmediagroup.com/sprint-powers-ahead-with-lte-rollout/.

[337] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, at 76 (June 27, 2011); *AT&T to Make Faster 3G Technology Available in Six Major Cities This Year* (Sept. 9, 2009), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=27068.

[338] Press Release, T-Mobile, T-Mobile USA Reports Fourth Quarter 2010 Results (Feb. 25, 2011), https://www.businesswire.com/news/home/20110224007281/en/T-Mobile-USA-Reports-Fourth-Quarter-2010-Results; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, at 76 (June 27, 2011).

[339] *T-Mobile to Rollout the Nation's Fastest 3G Wireless Network with HSPA+ to More than 100 Metropolitan Areas in 2010*, FIELD TECHNOLOGIES ONLINE (Mar. 29, 2010), https://www.fieldtechnologiesonline.com/doc/t-mobile-to-rollout-the-nations-fastest-3g-0001.

[340] Seth Porges, *7 Implications of an AT&T/T-Mobile Merger*, POPULAR MECHANICS (Mar. 21, 2011), https://www.popularmechanics.com/technology/gadgets/a6753/7-implications-of-an-at-t-and-t-mobile-merger/.

customers."[341] In February 2012, after T-Mobile announced a plan to launch 4G LTE, CNET argued that "[t]he issue for T-Mobile is that it will be woefully behind on its LTE deployment by the time it gets started" and that after losing a total of 802,000 customers in the fourth quarter of 2011, "a return to growth on the contract side remain[ed] far from certain."[342]

171. Unlike AT&T, T-Mobile faced spectrum constraints that prevented it from beginning to deploy a 4G network in parallel.[343] But when its proposed merger with AT&T fell through in late 2011, T-Mobile received AWS spectrum licenses that would allow for the deployment of a 4G LTE network.[344] Once T-Mobile had the necessary spectrum assets, it invested heavily in catching up to its rivals' 4G network deployments. In February 2012, T-Mobile announced plans to invest a total of $4 billion in its 4G network in 2013.[345] In March 2013, T-Mobile launched its LTE service in seven markets, and by October 2013 T-Mobile's LTE network covered 200 million people.[346] T-Mobile's ability to quickly deploy a broad LTE network, once it had sufficient spectrum, resulted from its previous investments in HSPA+ coverage.[347]

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[341] *What the AT&T-T-Mobile Breakup Means for You*, CBS NEWS (Dec. 20, 2011), https://www.cbsnews.com/news/what-the-att-t-mobile-breakup-means-for-you/.

[342] Roger Cheng, *T-Mobile's Comeback Plan: Is it Enough*, CNET (Feb. 23, 2012), https://www.cnet.com/news/t-mobiles-comeback-plan-is-it-enough/.

[343] Marguerite Reardon, *T-Mobile Launches 4G LTE Network*, CNET (Mar. 26, 2013), https://www.cnet.com/news/t-mobile-launches-4g-lte-network/ ("T-Mobile's prior focus on HSPA+ was out of necessity. Unlike the other major carriers, T-Mobile has been severely spectrum-constrained. And it simply had no other spectrum to 'grow into' for its LTE service.").

[344] Press Release, T-Mobile, T-Mobile USA Reports Fourth Quarter 2011 Operating Results (Feb. 23, 2012), https://www.businesswire.com/news/home/20120222007005/en/T-Mobile-USA-Reports-Fourth-Quarter-2011-Operating.

[345] Press Release, T-Mobile, T-Mobile USA Reports Fourth Quarter 2011 Operating Results (Feb. 23, 2012), https://www.businesswire.com/news/home/20120222007005/en/T-Mobile-USA-Reports-Fourth-Quarter-2011-Operating.

[346] Neal Gompa, *T-Mobile USA Launched LTE Network with Breathtaking Speeds*, EXTREME TECH (Mar. 27, 2013), https://www.extremetech.com/electronics/151758-t-mobile-usa-launches-lte-network-with-breathtaking-speeds; T-Mobile, Annual Report (Form 10-K), at 4 (Feb. 25, 2014). T-Mobile also merged with MetroPCS in April 30, 2013. As stated in their first combined Form 10-K, the merger "aimed to provide [the combined firm]

172. Carriers continued to invest in improving the performance of their LTE networks to address the ever-increasing traffic from LTE-enabled devices.[348] Verizon, the first mover in 4G LTE, was described as having "the upper hand . . . at least in the major cities," while other mobile carriers were "play[ing] catch-up."[349]

173. For example, Verizon began to increase the capacity of its LTE network by augmenting it with AWS spectrum, first in major cities in June 2013, reaching over 400 markets by 2015.[350] T-Mobile started to use AWS spectrum for its LTE network in 40 of the top U.S. metro markets in November 2013 and, in 2014, acquired additional AWS and PCS spectrum licenses, primarily from Verizon, designated for 4G LTE.[351] T-Mobile's choice to deploy LTE on AWS also allowed it to align the spectrum bands used for its 3G and 4G networks with those used by AT&T, meaning that T-Mobile could use phones designed to work on AT&T's network, most

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with expanded scale, spectrum, and financial resources to compete aggressively with other, larger U.S. wireless carriers." *Id.*

[347] *See, e.g.*, "Key Beliefs – Foundational Assumptions – Alternatives and Recommendations," ***T-Mobile***, Aug. 20, 2010, at 4, 25.

[348] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SEVENTEENTH REPORT, WT Docket No. 13-135, at 30-31 (Dec. 18, 2014).

[349] Kevin Fitchard, *Verizon Quietly Unleashes its LTE Monster*, *Tripling 4G Capacity in Major Cities*, GIGAOM (Dec. 5, 2013), https://gigaom.com/2013/12/05/verizon-quietly-unleashes-its-lte-monster-tripling-4g-capacity-in-major-cities/.

[350] Kevin Fitchard, *The State of LTE in the U.S.: How the Carriers' 4G Networks Stack Up*, GIGAOM (Jan. 30, 2014), https://gigaom.com/2014/01/30/4g-vs-4g-comparing-lte-networks-in-the-us/; Press Release, Verizon Wireless, Verizon Wireless Celebrates Three Years (and Counting) of 4G LTE (Dec. 5, 2013), http://www.verizonwireless.com/news/article/2013/12/verizon-wireless-4g-lte-three-year-anniversary.html; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – EIGHTEENTH REPORT, WT Docket No. 14-125, at 75-76 (Dec. 23, 2015).

[351] This transaction had an aggregate fair value of $4.8 billion, and T-Mobile provided Verizon with cash and transferred certain AWS and PCS spectrum in exchange. Kevin Fitchard, ***T-Mobile*** *Doubles its LTE Speeds, Capacity in at Least 40 Major Cities*, GIGAOM (Nov. 5, 2013), https://gigaom.com/2013/11/05/t-mobile-doubles-its-lte-speeds-capacity-in-at-least-40-major-cities/; T-Mobile, Annual Report (Form 10-K), at 25 (Feb. 19, 2015).

notably the iPhone.[352] AT&T relied, instead, on a technology known as carrier aggregation to increase the capacity of its LTE network using its existing spectrum.[353] In March 2014, AT&T had introduced this technology in Chicago and by the start of 2015 had expanded it to New York, San Francisco, Dallas, and other major markets.[354] In October 2013, Sprint demonstrated a technique to make more efficient use of the large band of high-frequency spectrum it acquired from Clearwire and improve the speed and performance of its LTE service.[355] Sprint later combined the technique with other advancements to its LTE network to deliver "faster service with double the network capacity."[356]

D. Investment Competition Between the Cellular Carriers Is the Main Determinant of Output, Prices and Quality

174. To reiterate, investments in a carrier's network often produce significant effects on key network quality indicators within a matter of 12 to 18 months.[357] Because competition among

[352] *See, e.g.*, "Spectrum Re-Farm, UMTS1900 and LTE Deployment Strategy," *T-Mobile*, Jan. 5, 2011, at 4 (noting that T-Mobile's plan to use AWS for LTE and re-farm spectrum 1900 MHz spectrum for UMTS would allow it to "[a]lign spectrum use with North American operators.").

[353] Carrier aggregation increases capacity by merging transmissions across different spectrum bands. Mike Dano, *AT&T Edging into LTE Advanced Technologies for Capacity, Not Speed*, FIERCEWIRELESS (Feb. 26, 2014), https://www.fiercewireless.com/wireless/at-t-edging-into-lte-advanced-technologies-for-capacity-not-speed.

[354] Kevin Fitchard, *AT&T's New Souped-Up LTE Network is Live in Chicago, but You'll Have to Wait to Use it*, GIGAOM (Mar. 6, 2014), https://gigaom.com/2014/03/06/atts-new-souped-up-lte-network-is-live-in-chicago-but-youll-have-to-wait-to-use-it/; Sue Marek, *AT&T Expands Carrier Aggregation to NY, San Fran and More*, FIERCEWIRELESS (Jan. 22, 2015), https://www.fiercewireless.com/wireless/at-t-expands-carrier-aggregation-to-ny-san-fran-and-more.

[355] The technique allowed Sprint to combine different sets of frequencies in the 2.5 GHz band obtained from Clearwire and make them act as one block of spectrum. Stephen Lawson, *Sprint Taps Into its Spectrum for Fast LTE, with Room to Grow*, PC WORLD (Oct. 31, 2013), https://www.pcworld.com/article/2059780/sprint-taps-into-its-spectrum-for-fast-lte-with-room-to-grow.html.

[356] Phil Goldstein, *Sprint Unveils 'LTE Plus' Network Brand to Highlight Carrier Aggregation, Beamforming in 77Mmajor Markets*, FIERCEWIRELESS (Nov.18, 2015), https://www.fiercewireless.com/wireless/sprint-unveils-lte-plus-network-brand-to-highlight-carrier-aggregation-beamforming-77.

[357] "TMUS On-Network MB Forecast," T-*Mobile*, Aug. 2, 2011, at 12 ("Targeted 18 month planning horizon . . . . up to 6 [months] order processing, up to 6 [months] build, up to 6 [months] build ahead of reaching capacity"); Email from Aslam Khan to Leslie Koutroulis *et al.*, "RE: MOU and MB Forecast Discussion," July 25, 2013 ("[T]o determine 2018 budget, we need to look at 12 months in advance (preferably 18 months) of the capacity

carriers centers on network capacity and performance, and particularly on relative capacity and performance compared with rivals, carriers typically react quickly to rivals' investments by increasing their own investments.[358] A carrier's decision to invest in its network therefore tends to spur industry-wide improvements in network quality.[359]

175. The FCC has previously found increased investment competition to be a major favorable factor in telecommunications mergers. Cingular's October 2004 acquisition of AT&T made the combined company the largest wireless carrier in the United States.[360] The FCC's chairman explicitly connected the merger to its beneficial future effects on the data market which was in its infancy, at the time noting:

> [AT&T/]Cingular will emerge a stronger competitor with better coverage, improved customer service and a renewed commitment to innovation. This will not only be true in the voice market but also increasingly for data.[361]

176. Similarly, in approving the 2005 Sprint and Nextel merger, the FCC emphasized that further innovation and the deployment of advanced services would result from the

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needed to account for Engineering interval / Build ahead period. In other words we need to spend money in 2018 to support capacity augmentation required for 2019.").

[358] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, at 122-125, 145 (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf.

[359] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, at 145 (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf.

[360] *Cingular Agrees to Buy AT&T Wireless*, NBC (Feb. 17, 2004), http://www.nbcnews.com/id/4276272/ns/business-stocks_and_economy/t/cingular-agrees-buy-att-wireless/#.WxLzCq6nGpo.

[361] Statement of Michael K. Powell, FED. COMMC'NS COMM'N, Chairman, *Re: Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corporation, For Consent to Transfer of Control of Licenses and Authorizations*, WT Docket No. 04-70 (Oct. 22, 2004), https://apps.fcc.gov/edocs_public/attachmatch/DOC-253545A2.pdf; *see also* Statement of Kathleen Q. Abernathy, FED. COMMC'NS COMM'N, Comm'r, *Re: Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corporation For Consent to Transfer of Control of Licenses And Authorizations*, WT Docket No. 04-70 (Oct. 22, 2004), https://docs.fcc.gov/public/attachments/DOC-260394A2.pdf.

transaction.[362] The FCC concluded that the merger would lead to benefits, including "enhanced service quality and broader deployment of advanced wireless services."[363]

177. And increased investment competition increases network capacity and performance, thus having an immediate effect on the quality-adjusted prices of data by allowing greater numbers of subscribers to consume greater amounts of data.[364] In addition, once a critical mass of users with access to higher-quality network services develops, innovators create new apps that could not have been economically produced on the lower-quality pre-investment network. Investment competition therefore not only decreases quality-adjusted prices by driving data prices down, but also by improving the quality of data consumed.

V. The Transaction Will Accelerate and Strengthen the Deployment of 5G Networks, Lead to a Substantial Increase in Supply and Reduction in Price of Cellular Data, and Accelerate Delivery of Value from New 5G Products and Services

178. The economic history of this industry shows that dynamic competition over network investment, capacity and performance largely determines the wireless packages offered to consumers by carriers and is therefore the main determinant of industry output and prices. That

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[362] Press Release, FED. COMMC'NS COMM'N, FCC Consents to Sprint Corporation Acquisition of Nextel Communications Licenses and Authorizations (Aug. 3, 2005), https://www.fcc.gov/proceedings-actions/mergers-transactions/sprint-nextel.; Statement of Jonathan S. Adelstein, Comm'r, *In the Matter of Applications of Nextel Communications, Inc. and Sprint Corporation For Consent to Transfer of Control of Licenses and Authorizations*, WT Docket No. 05-63 (Aug. 3, 2005), https://www.fcc.gov/proceedings-actions/mergers-transactions/sprint-nextel.

[363] Press Release, FED. COMMC'NS COMM'N, FCC Consents to Sprint Corporation Acquisition of Nextel Communications Licenses and Authorizations (Aug. 3, 2005), https://www.fcc.gov/proceedings-actions/mergers-transactions/sprint-nextel. In a separate statement, Commissioner Jonathan Adelstein stated: "The infusion of capital into this market should significantly stimulate product and service offerings that ultimately will benefit both the commercial and educational segments of the 2.5 GHz industry." Statement of Jonathan S. Adelstein, FED. COMMC'NS COMM'N, Comm'r, *In the Matter of Applications of Nextel Communications, Inc. and Sprint Corporation For Consent to Transfer of Control of Licenses and Authorizations*, WT Docket No. 05-63 (Aug. 3, 2005), https://www.fcc.gov/proceedings-actions/mergers-transactions/sprint-nextel.

[364] *See supra* Table 16.

dynamic competition has come to center mainly on the provision of data to subscribers. Between 2010 and 2017, the amount of cellular data consumed by smartphone users increased by 80 percent per year, while the number of mobile call minutes increased by only 3 percent per year.[365] By 2017, smartphone users spent almost three times more minutes consuming cellular data than making voice calls.[366] Carriers compete on investments to improve their data networks and to market attractive data packages to consumers that focus on the quantity of data and the quality of network performance.

179. Given the preeminent importance of data to mobile subscribers, I focus on the Transaction's impact on the dynamic competition for providing cellular data to mobile subscribers. I have not, however, offered any opinion concerning the static unilateral effects of the Transaction resulting from the elimination of a competitor, nor have I conducted any analysis of the effect of the Transaction on static competition.

180. Neville Ray reports in his declaration that the Transaction will result in New T-Mobile having almost twice the capacity as the sum of the stand-alone companies, accelerate the development of 5G networks, and create a stronger 5G network than the stand-alone companies could achieve.[367] By enabling and accelerating the creation of a strong 5G network by New T-Mobile, the Transaction would force AT&T and Verizon to quicken and deepen their investments and thereby cause a substantial increase in the industry-wide supply of cellular data to mobile subscribers. That increase in the total supply of cellular data would put

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[365] *See* Exhibits 1 and 5A; *see also* FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TWENTIETH REPORT, WT Docket No. 17-69, Appendix I, Chart I (Sept. 27, 2017).

[366] *See* Exhibit 5B.

[367] Declaration of Neville Ray, § VI.

substantial downward pressure on the price/GB of data to mobile subscribers, consistent with the history of the industry. The Transaction would also result in a decline in quality-adjusted cellular data prices due to a dramatic improvement in network performance, and induce the development of new app features that would increase the value consumers get from a given amount of cellular data.

181. Given that the Transaction would take place during a critical inflection point for the deployment of the next generation of cellular technology, the two-year time period often considered in merger review is too short to evaluate the Transaction's competitive effects and its effects on the public interest. Sound economic principles favor considering the effects of this Transaction over the time period during which cellular carriers will transition to 5G networks. The pace of those transitions and the strength of the 5G networks deployed are the main determinants of the effect of the Transaction on mobile subscribers and its broader economic effects. To assess the impact on mobile subscribers, I focus on the effect of the Transaction on prices, output and quality in 2024, approximately 5 years after the anticipated launch of New T-Mobile in 2019. That time period is consistent with the time frame during which previous deployments of new cellular technologies diffused to a substantial portion of the population.

182. As a theoretical matter, a merger of cellular carriers could result in either an increase or a decrease in dynamic investment in network capacity and quality. To evaluate these possibilities requires a factual inquiry into the specifics of the Transaction, particularly its impact on the deployment of capacity and an empirical analysis of the dynamics of competition between carriers.

A. New T-Mobile Is Expected to Deploy a Network with Greater Capacity, Faster Speeds, and Lower Latency than the Two Stand-Alone Companies Would Offer

183. To analyze the Transaction's competitive effects, I have relied on analyses prepared by the Applicants concerning (a) the characteristics of the 5G networks New T-Mobile will deploy in 2024, assuming that the Applicants consummate the Transaction in Q1 2019, and (b) the networks that T-Mobile and Sprint would deploy if they continued as stand-alone enterprises.[368] These analyses are predicates for my analysis below that shows that the Transaction would result in a substantial increase in industry network capacity.

184. The Applicants have determined that the Transaction will result in a substantial decrease in both the fixed costs of deploying a strong national 5G cellular network as well as the marginal costs of improvements in the quality and capacity of that network.[369] As a result of these efficiencies, New T-Mobile will experience a substantial decline in the cost of investing in 5G technologies and a substantial increase in the coverage and performance that it can achieve for a given capital expenditure. That in turn would lead New T-Mobile to make the profit-maximizing decision to deploy a stronger 5G network covering a significantly larger portion of the population materially sooner than the stand-alone companies would. The Applicants' business plans reflect that. Given long-run profit-maximizing investment decisions, New T-Mobile would deploy a stronger national 5G network than the two stand-alone companies would, taken together, as of 2024.

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[368] Public Interest Statement, § III.A; Declaration of Neville Ray, §§ V-VI; Declaration of Michael Sievert, §§ III-IV; Declaration of Peter Ewens, § III; Declaration of John Saw, §§ IV-V; Declaration of Brandon Dow Draper, § III.

[369] Public Interest Statement, § III.A; Declaration of Neville Ray, § VI; Declaration of Michael Sievert, §§ III-IV; Declaration of Peter Ewens, §§ III -IV; Declaration of John Saw, § IV.

185. As previously referenced, the declarations of Neville Ray, Michael Sievert, John Saw, and Peter Ewens, as well as the companies' business plans, state that New T-Mobile would have substantially more data capacity, and better network performance, than Sprint and T-Mobile would have in 2024 as a result of having a larger and stronger 5G network.[370] Figure 5 summarizes the national total 5G and 4G LTE capacity for the stand-alone networks and New T-Mobile as reported by Mr. Ray.[371] As is normal with generational changes in technology, there is a gradual shift of capacity from one generation to the other.[372] This figure reflects the fact that the rate of diffusion of the 5G network coverage would be substantially higher for New T-Mobile than for the stand-alone companies.

[370] Declaration of Neville Ray, §§ V-VI; Declaration of Michael Sievert, §§ IV-V; Declaration of Peter Ewens, §§ III-IV; Declaration of John Saw, §§ III-IV.

[371] I use the term "national total capacity" to refer to offered traffic. This is the calculated maximum carried traffic that the network could deliver if that traffic were uniformly distributed in time and space relative to the deployment of resources. Carried traffic is the actual amount of data consumed by users provided over the network.

[372] *See supra* Table 4.

Figure 5
National Total LTE and 5G Capacity
for Stand-Alone Networks and New T-Mobile
2021-2024

[redacted]

186. Because the 4G LTE network offers substantially poorer capacity performance than the 5G network, it is not correct, as an economic matter, to simply sum up the two types of national capacity to determine national total capacity. To do so is like adding the output of Volkswagens and Ferraris, given the performance differences between 4G LTE and 5G. But to provide a general indication of the effect of the merger, I have summed the 4G LTE and 5G national total capacity figures. By 2024, New T-Mobile would have a national total capacity of 23.7 exabytes (EB) of data per month (EB/month) compared with [redacted] EB/month for the two combined ([redacted] EB/month for T-Mobile and [redacted] EB/month for Sprint).

187. The total non-quality-adjusted national total capacity of New T-Mobile would be [redacted] times the total non-quality-adjusted national total capacity of the combined stand-alone

companies. And given the superior performance of the 5G network, the quality-adjusted national total capacity of New T-Mobile would be much greater than 1.8 times that of the combined stand-alone companies. In 2024, 85.7 percent of the national total capacity of New T-Mobile would be 5G compared with 50.8 percent of the stand-alone companies.

188. The greater capacity of New T-Mobile's network would translate into faster data speeds with the Transaction than without it. By 2024, the average data speed available nationwide on New T-Mobile's 5G network would be 444 Mbps.[373, 374] The New T-Mobile average data speed would be 5.8 times faster than the 76 Mbps average data speed that T-Mobile would offer separately, and 3.9 times faster than the 113 Mbps average data speed Sprint would offer without the transaction.[375] As explained by Mr. Ray, more people would get higher data speeds. In 2024, New T-Mobile's 5G network will deliver average data rates above 100 Mbps to 292.3 million covered POPs, average data rates above 150 Mbps to 278.1 million covered POPs, average data rates above 300 Mbps to 252.4 million covered POPs, and average data rates above 500 Mbps to 208.7 million covered POPs.[376] In comparison, 102.8 million covered POPs on the T-Mobile stand-alone 5G network would receive average data rates above 100 Mbps, only 66.6 million covered POPs will receive average data rates above 150 Mbps, and the T-Mobile stand-alone 5G network would not offer 300 Mbps to any customers.[377] Similarly, 187.8 million covered POPs on the Sprint stand-alone 5G network would receive average data

[373] Declaration of Neville Ray, ¶ 53.

[374] Declaration of Neville Ray, ¶ 17 n.14 ("Average data rate is not equivalent to the actual user experience. The user experience will be affected by a number of variable factors, including received signal strength, location of the mobile device and base station, and whether the device is in motion, among others.").

[375] Declaration of Neville Ray, ¶ 53.

[376] Declaration of Neville Ray, ¶ 20.

[377] Declaration of Neville Ray, ¶ 20.

rates above 100 Mbps, 181.4 million covered POPs would receive average data rates above 150 Mbps, and no customers would receive 300 Mbps.[378]

189. The critical bottom line is that New T-Mobile's network would perform substantially better than the networks of the stand-alone companies on important dimensions, including 5G capacity, average data speed, peak data speed, and population served, as reported by Mr. Ray.[379]

B. The Empirical Evidence on Dynamic Competition Demonstrates that the Transaction Would Result in a Substantial Increase in the Industry Supply of Cellular Data and Put Substantial Downward Pressure on the Price of Cellular Data for Mobile Subscribers

190. With these estimates as a predicate, we can assess the impact of the Transaction on dynamic competition among cellular carriers to invest in network capacity and performance, and the implications of that investment for the nominal and quality-adjusted prices of cellular data. This part presents a qualitative assessment of the impact of the Transaction based on the empirical evidence on dynamic competition. The next part presents projections of the Transaction's impact on the supply of cellular data and the nominal price of cellular data that confirm the qualitative assessment, based on plausible assumptions, which I have confirmed with the Applicants' business teams.

[378] Declaration of Neville Ray, fig. 4.

[379] Specifically, I understand that New T-Mobile network would have 3x the 5G national total capacity in EB, 3.9x to 5.8x the average data speed (Mbps), 1.5x to 5.8x the peak data speed (Mbps), and 1.6x to 2.8x the U.S. POPs served at greater than 100 Mbps. Declaration of Neville Ray, fig. 5.

1. The Transaction Will Cause a Substantial Increase in Industry-wide National Total Capacity by Almost Doubling Sprint and T-Mobile's Combined Capacity and Inducing AT&T and Verizon to Increase Their National Total Capacity as a Result of Dynamic Competition

191. The Transaction will result in a substantial increase in industry-wide national total capacity by 2024 even if it does not accelerate AT&T and Verizon's investment decisions. The increase is equivalent to adding non-quality adjusted capacity almost equal to the combined national total capacity of T-Mobile and Sprint as stand-alone companies and an even greater multiple of quality-adjusted capacity. But the Transaction will have a much greater impact on industry-wide national total capacity because it will likely force AT&T and Verizon to accelerate and strengthen their deployment of 5G networks thereby increasing their national total capacities.[380]

a. The Transaction Will Accelerate the Deployment of Strong 5G Networks by Inducing AT&T and Verizon to Speed Up Their 5G Network Efforts

192. Cellular carriers in the United States try to match (and surpass) the breadth of each other's networks. In particular, AT&T and Verizon have made investments to ensure that they have the most technologically advanced networks with the best coverage. That said, the carriers have not deployed new technology at the same time or the same rate. Instead, the evidence shows that one carrier sometimes decides to invest in a new technology standard to get a jump on its competitors, and then the competitors make more investments in order to remain competitive.

[380] This conclusion and the subsequent ones concerning supply and prices follows from the Transaction resulting in New T-Mobile having substantially more national total capacity than the sum of the stand-alone companies. These conclusions would hold even if the Transaction resulted in less additional national total capacity than estimated by Mr. Ray so long as that increase is substantial. *See* Declaration of Neville Ray, § VI.

193. The major carriers have each announced plans to start to deploy 5G technology in limited and different ways in 2018. Verizon has announced that it will focus on residential 5G broadband initially, with launches in three to five markets later in 2018.[381] It will then deploy mobile 5G over its mmWave spectrum, the timing of which is contingent on when 5G devices are available.[382] The availability of 5G devices will depend on when carriers make commitments to deploy 5G networks thereby creating enough demand for new handsets. This slow deployment plan contrasts with the aggressive and speedy approach that Verizon took for deployment of its national 4G LTE network in December 2010.

194. For its part, AT&T says it will start with mobile 5G in 12 markets in late 2018.[383] AT&T is marketing its 5G rollout as an "evolution," but analysts have noted that it will really be comprised of an enhanced 4.5G LTE and only later deploy a mobile network that meets 5G NR standards.[384] This is similar to the strategy that T-Mobile took in the early 2010s. Rather than firmly committing to 4G LTE, T-Mobile made improvements based on early generations of technology.[385]

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[381] John O'Malley, *What it Means to Lead the Race to 5G*, VERIZON NEWSROOM (Apr. 25, 2018), http://www.verizon.com/about/news/what-it-means-lead-race-5g; Mike Dano, *Sprint Promises to Launch Nationwide Mobile 5G Network in First Half of 2019*, FIERCE WIRELESS (Feb. 2, 2018), https://www.fiercewireless.com/5g/sprint-promises-to-launch-nationwide-mobile-5g-network-first-half-2019-and-to-raise-unlimited.

[382] John O'Malley, *What it Means to Lead the Race to 5G*, VERIZON NEWSROOM (Apr. 25, 2018), http://www.verizon.com/about/news/what-it-means-lead-race-5g.

[383] Press Release, AT&T, AT&T to Launch Mobile 5G in 2018 (Jan. 4, 2018), http://about.att.com/story/att_to_launch_mobile_5g_in_2018.html; Press Release, AT&T, AT&T Builds on 5G Foundation in More Than 100 New Markets (Apr. 20, 2018), http://about.att.com/story/att_builds_on_5g_foundation_in_more_than_100_new_markets.html.

[384] Jeremy Horowitz, *AT&T Plans 12-City Mobile 5G Network By Year's End as Verizon, Sprint, and T-Mobile Bicker Over 'Real 5G' Plans*, VENTURE BEAT (Jan. 4, 2018), https://venturebeat.com/2018/01/04/att-plans-12-city-mobile-5g-network-by-years-end-as-verizon-sprint-and-t-mobile-bicker-over-real-5g-plans/.

[385] *See, e.g.*, "TMUS Mobile Broadband Review," *T-Mobile*, Mar. 15, 2010, at 10-14.

195. Neither Sprint nor T-Mobile have the spectrum resources, or scale as stand-alone companies, to deploy high-quality 5G networks with national coverage in the near future.[386] T-Mobile has announced its intention to deploy a commercial 5G network by 2019 and provide nationwide coverage by 2020.[387] But as a stand-alone company, T-Mobile's 5G network would be limited to just [redacted] in most markets.[388] Even by 2024, T-Mobile would be [redacted], covering only 173.2 million POPs.[389] The 5G network deployed by stand-alone T-Mobile would therefore deliver only a fraction of the potential consumer benefits of 5G technology.[390] Sprint has publically announced its intention to launch a "nationwide" 5G network in the first half of 2019.[391] But because Sprint would rely on mid-band spectrum for 5G service it would not be able to provide robust geographic coverage.[392] As a stand-alone company, Sprint would provide 5G coverage for just 194.0 million POPs by 2024.[393]

196. The public data indicates that none of the carriers are on track to deploy a robust national 5G network quickly. Specifically, the data show that the carriers are not ready to

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[386] Declaration of Peter Ewens, ¶12.

[387] Roger Cheng, *T-Mobile Will Deploy Blazing 5G This Year, but You Can't Use It*, CNET (Feb. 27, 2018), https://www.cnet.com/news/t-mobile-will-deploy-blazing-5g-this-year-but-you-cant-use-it-yet/. This is consistent with internal documents. *See, e.g.*, "5G Device Technology Development," *T-Mobile*, Dec. 2017, at 2, 6 (noting that T-Mobile anticipates launching its 5G network in 2019).

[388] Declaration of Neville Ray, ¶ 16.

[389] Declaration of Neville Ray, tbl. 1.

[390] Declaration of Neville Ray, ¶¶ 16-18; Declaration of Michael Sievert, ¶ 10; Declaration of Peter Ewens, ¶ 12.

[391] Mike Dano, *Sprint Promises to Launch Nationwide Mobile 5G Network in First Half of 2019*, FIERCE WIRELESS (Feb. 2, 2018), https://www.fiercewireless.com/5g/sprint-promises-to-launch-nationwide-mobile-5g-network-first-half-2019-and-to-raise-unlimited. This is consistent with internal documents. *See, e.g.*, "5G Customer Demand Impact View," *Sprint*, 2015, at 3 ("5G Assumptions: March & Oct. 2019 – First 5G capable devices.").

[392] Declaration of John Saw, ¶ 23.

[393] Declaration of Neville Ray, tbl. 1.

deploy 5G networks with the same breadth and depth at which 4G LTE networks were deployed in the early 2010s. By the end of 2011, one year after Verizon announced that it had begun its national 4G LTE deployment in December 2010, 64 percent of the country's population had access to 4G LTE from Verizon and 24 percent from AT&T.[394] In 2015, five years after Verizon's announcement, 93 percent of the population had access to a 4G LTE carrier on a weighted average basis.[395] That is not the path the U.S. cellular industry is on right now.

197. Of course, this could change. But based on the history of investment competition by the U.S. carriers, this tepid adoption of the next generation of cellular technology will likely continue until a carrier makes a first move to accelerate deployment. As shown, the Transaction will cause New T-Mobile to deploy a stronger 5G network sooner because of the substantial efficiencies described above. It would therefore become the first mover among cellular carriers for 5G, which in turn is likely to cause AT&T or Verizon to respond more rapidly than they would without the merger. Just as Verizon's aggressive launch of 4G LTE networks was the catalyst that spurred the other carriers, New T-Mobile's aggressive launch would be the catalyst that would spur AT&T and Verizon along.

b. The Transaction Will Force AT&T and Verizon to Build Stronger 5G Networks

198. The Transaction would likely induce AT&T and Verizon not only to accelerate their deployment of 5G networks, but also to develop stronger networks than they would otherwise. To compete with New T-Mobile on packages in the future, both carriers will need to make the

[394] *See* Exhibit 6.

[395] *See* Exhibit 6.

investments needed to offer attractive data packages – for example, data usage is modulated by practices such as tethering allowances and bitrate constraints – and offer competitive network performance.

199. We saw that with the competition over 4G LTE. Five years after Verizon first launched its 4G LTE network all of the major carriers had rolled out national networks and many of their subscribers had shifted to 4G LTE handsets and data plans. As shown in Exhibit 6, Verizon's 4G LTE network covered 35 percent of the U.S. population in Q4 2010, when it first launched. Three years later, Verizon had expanded LTE coverage to 97 percent of the U.S. population. Over the same time period, AT&T, T-Mobile, and Sprint had made investments to deploy their own 4G LTE networks. By Q4 2013, their networks had reached substantial portions of the U.S. population, but they were still trailing behind Verizon's.[396] All four carriers kept investing in their networks and expanding coverage in subsequent years, with each covering over 90 percent of the U.S. population by Q3 2017.[397]

200. Importantly, Sprint and T-Mobile both lost significant ground, which they have been unable to fully recoup, because of delays in deploying 3G and 4G LTE networks. Sprint's share of mobile subscribers steadily declined from 23.0 percent in Q3 2006 to 12.0 percent in Q3 2017 – and the company remains challenged.[398] T-Mobile's share of mobile subscribers also bottomed out at 9.5 percent in Q4 2012 as it failed to keep up with AT&T's and Verizon's

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[396] *See supra* Section IV.C.2. By Q4 2013 AT&T's 4G LTE network covered 84 percent of the population, T-Mobile's network covered 62 percent of the population, and Sprint's network covered 62 percent of the population. Exhibit 6.

[397] *See* Exhibit 6.

[398] GSMA INTELLIGENCE.

3G and 4G networks.[399] As of Q1 2017, T-Mobile had increased its share to 19 percent but only after (1) merging with Metro PCS in 2013 (giving T-Mobile almost 9 million more subscribers) and (2) building out its own LTE network using AWS spectrum acquired from AT&T.[400] That additional scale and spectrum enabled T-Mobile to gain share through its "Un-carrier strategy" that gave consumers unlimited data plans and other benefits.[401]

201. While I, of course, do not have access to AT&T and Verizon's internal planning documents, based on their long-standing strategy of seeking to offer the highest quality network, their competitive behavior over many years strongly indicates that they will respond aggressively to New T-Mobile's 5G deployment.

c. The Loss of Sprint as a Stand-Alone Competitor Would Not Reduce New T-Mobile's Investment Incentives

202. Over the last 10 years, during the build-out and expansion of 4G networks, T-Mobile has primarily focused on AT&T and Verizon, not Sprint, when it determines how to invest in its network. A 2009 T-Mobile presentation pointedly does not mention Sprint, and notes that

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[399] GSMA INTELLIGENCE.

[400] *See* "TMUS 2014 – 2018 Preliminary Long Range Plan – Executive Summary," *T-Mobile*, Oct. 15, 2013, at 6 ("Branded prepaid SOGA is expected to increase from 19.3% in 2013 to 22.5% SOGA by 2015, driven largely by the expansion of the Metro brand."); *Wireless Subscriptions Market Share By Carrier in the U.S. from 1st Quarter 2011 to 4th Quarter 2017*, STATISTA (2018), https://www.statista.com/statistics/199359/market-share-of-wireless-carriers-in-the-us-by-subscriptions/; *see also* Chris Welch, *T-Mobile and MetroPCS Merger Finalized, Company to Begin Trading as 'T-Mobile US,'* THEVERGE (May 1, 2013), https://www.theverge.com/2013/5/1/4286622/t-mobile-us-metropcs-merger-complete-tmus. As of Q3 2017 T-Mobile's had dipped to 18.6 percent. GSMA INTELLIGENCE.

[401] *See* "Performance Review Un-carrier," *T-Mobile*, Sept. 21, 2015, at 10 ("Our Un-carrier strategy has turned around the trend of postpaid customer declines and over-delivered on business case expectations…Individual phase metrics are in line or exceeding business expectations"); "2016 PCAI Keynote," *T-Mobile*, June 2016, at 28; Press Release, T-Mobile, T-Mobile Celebrates 5 Years as a Public Company with Record-Low Churn, Industry-Leading Customer Growth, and Strong Profitability (May 1, 2018), https://www.t-mobile.com/news/q1-2018-earnings ("Our formula is simple. We listen to customers and look to fix what they hate about this industry. Fourteen Un-carrier moves and millions of satisfied customers is proof our formula is working. The Un-carrier has rid the industry of two-year service contracts and punitive data overages, and ushered in an era of Unlimited rate plans. Simply put, T-Mobile changed wireless for good.").

the company needed to "[g]ain scale to improve competitive positioning long term" in order to "compete with AT&T and Verizon on marketing, distribution, and network quality."[402] A 2016 report from Deutsche Telekom states that T-Mobile was reaching "near-national LTE coverage" and "materially narrow[ing] the coverage gap vs. AT&T and Verizon."[403] While the report includes an analysis of Sprint's performance, it is clear from the report that Deutsche Telekom did not consider Sprint as a point of comparison for network quality, and that remains the case today. A 2017 presentation on T-Mobile enterprise risks notes that the "ability [of AT&T and Verizon] to spend more on advertising and distribution channels and adjacent businesses such as content has an impact on [T-Mobile's] market position." It further states that as "Verizon/AT&T continue to scale and invest in new technologies and converging industries, the competitive landscape is becoming increasingly aggressive, forcing us and others to respond."[404]

203. The 2016 Deutsche Telekom report notes:

> Sprint is clearly the laggard. The company is about to embark on a significant network re-build that will see a densification of its network through the building of smaller cells – however we expect Sprint will face significant execution challenges in securing suitable sites and migrating the network over to this new structure without causing disruption to the customer experience. More importantly this strategy will not impact TMUS growth in rural areas – the next leg of growth for them.[405]

The report further concludes that:

> Sprint meanwhile continues to struggle through another network overhaul over the coming years, placing significant constraints on the business. While we

[402] "Project Velocity," *T-Mobile*, Jan. 23, 2009, at 10.

[403] DEUTSCHE TELEKOM, THE US JOB IS NOT EVEN HALF DONE 10 (Mar. 17, 2016).

[404] "T-Mobile US Enterprise Risk Assessment (EV)," *T-Mobile*, Q2 2017, at 5.

[405] DEUTSCHE TELEKOM, THE US JOB IS NOT EVEN HALF DONE 35 (Mar. 17, 2016).

> believe they will continue to be aggressive in promotional activity, we do not think they have the brand or network capable of attracting the more valuable customers (who will not churn away once a year). Those are the customers who truly add value to a company over the long term.[406]

204. T-Mobile's focus on AT&T and Verizon as leaders in network investment is also evident from its advertising. T-Mobile's advertisements frequently compare its network performance against AT&T's and Verizon's rather than Sprint's. T-Mobile has run advertising campaigns specifically aimed at demonstrating that it has closed the network quality gap with AT&T and Verizon.[407] There is no similar advertising campaign focused on Sprint. Similarly, when promoting its unlimited data offer, T-Mobile has noted performance issues with AT&T's and Verizon's networks; Sprint does not even bear mention.[408]

205. Therefore, while the empirical evidence indicates that the Transaction is likely to cause AT&T and Verizon to increase their investment in their networks, the evidence does not show that the Transaction would reduce New T-Mobile's incentives to invest by combining with Sprint. To the contrary, by sharply lowering the fixed and marginal cost of building out 5G networks for New T-Mobile, the Transaction is likely to intensify competition to build out 5G networks.

2. As a Result of Dynamic Competition to Build Network Capacity and Performance the Transaction Would Cause a Substantial Increase in Industry Supply of Cellular Data to Mobile Subscribers

206. The history of mobile packages and carrier behavior indicates that carriers generally increase the supply of cellular data in tandem with the increase in capacity from their past

[406] DEUTSCHE TELEKOM, THE US JOB IS NOT EVEN HALF DONE 42 (Mar. 17, 2016).

[407] *See supra* Section IV.A.

[408] *See supra* Section IV.B.

investments, particularly as their fixed and marginal costs of providing capacity decline. By investing in 4G LTE the carriers were able to increase the total supply of data to smartphone subscribers from 281 PBs in 2010 to 16,901 PBs in 2017.[409] During that same time period the number of GBs per smartphone user increased from 0.3 GB per month to 5.2 GB per month.[410] In other words, investments result in excess capacity given existing data limits and pricing, but then carriers increase data limits and lower pricing to encourage its use.

207. The industry's history also indicates that carriers construct packages and prices to encourage consumers to use capacity up to the limits dictated by maintaining an acceptable level of quality for users on a national basis.[411] The carriers have taken a number of steps that indicate that their networks are close to these limits. We saw earlier that, even after they deployed 4G LTE technology, the carriers dropped unlimited data plans to control congestion and maintain network performance.[412] Even after the carriers, prodded by T-Mobile's Un-carrier strategy, offered unlimited data plans they have had to reduce speeds to subscribers who use too much data.[413]

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[409] *See supra* Table 8; Exhibit 5A.

[410] *See* Exhibit 5A.

[411] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, at 63 (June 27, 2011), https://docs.fcc.gov/public/attachments/FCC-11-103A1.pdf; *As Unlimited Data Takes Center Stage, T-Mobile Widens Speed Gap Between the Network Built for Unlimited … and Everyone Else*, T-MOBILE BLOG (Apr. 21, 2017), https://newsroom.t-mobile.com/news-and-blogs/tmobile-widens-lte-speed-gap-over-verizon-att-unlimited-plans.htm.

[412] *See supra* Section IV.B; *see also* FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133, at 63 (June 27, 2011), https://docs.fcc.gov/public/attachments/FCC-11-103A1.pdf.

[413] According to T-Mobile, the industry has instituted certain practices to help manage the onslaught of user traffic caused by unlimited plans, including: (1) quality of service (QoS) on cell sites to manage localized congestion and the prioritization of voice and critical real time services while data is assigned to lower QoS Class Identifier (QCI) classes; (2) using QCI ranges to differentiate between brands; and (3) imposition of lower QCI classes on subscribers that have exceeded their monthly fair use limits.

208. AT&T and Verizon have both run into congestion issues as a result of matching T-Mobile's unlimited plans, which has forced them aggressively to limit data use. Verizon has scaled back its unlimited data plans, offering two consumer options: Go Unlimited at $75 for a single line per month, which reduces speeds any time the network is congested (regardless of monthly data usage) and caps video at 480p quality on smartphones; and Beyond Unlimited at $85 per month, which reduces speeds during periods of heavy congestion for users exceeding 22 GB in a month and caps video at 720p on smartphones.[414] AT&T and Verizon also do not offer unlimited mobile hotspots at 4G LTE speeds at any price.[415] T-Mobile offers unlimited mobile hotspot usage at 3G speeds as part of its standard package and 10 GB/line/month of 4G LTE mobile hotspot usage for an extra $10.[416]

209. Wireless carriers do not operate their cellular networks at their national total capacity because the customer experience would fall below acceptable levels.[417] I use the term "national practical capacity" for a network to refer to the amount of data that a cellular network provides to users as a proportion of its national total capacity, given the engineering and business

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[414] Colin Gibbs, *Verizon Overhauls 'Unlimited' Plan, Reverts to Video Throttling*, FIERCEWIRELESS (Aug. 22, 2017), https://www.fiercewireless.com/wireless/verizon-overhauls-unlimited-plan-intros-video-throttling.

[415] AT&T and Verizon offer a maximum of 15 GB of high-speed data for hotspot. After these limits data speeds are reduced substantially. T-Mobile's unlimited mobile hotspot plan is given lower priority than traditional mobile data. *Unlimited Data Plans*, AT&T, https://www.att.com/plans/unlimited-data-plans.html (last visited June 8, 2018); *The New Verizon Plan Unlimited FAQs*, VERIZON, https://www.verizonwireless.com/support/new-verizon-plan-unlimited-faqs/ (last visited June 8, 2018); *Policies: Open Internet*, T-MOBILE, https://www.t-mobile.com/responsibility/consumer-info/policies/internet-service (last visited June 8, 2018).

[416] T-Mobile as part of its international plan does offer an unlimited 4G LTE hotspot plan. *Smartphone Mobile HotSpot (Wi-Fi Sharing/Tethering)*, T-MOBILE, https://support.t-mobile.com/docs/DOC-2384 (last visited June 9, 2018).

[417] *See supra* Section IV.B; *As Unlimited Data Takes Center Stage, T-Mobile Widens Speed Gap Between the Network Built for Unlimited … and Everyone Else*, T-MOBILE BLOG (Apr. 21, 2017), https://newsroom.t-mobile.com/news-and-blogs/tmobile-widens-lte-speed-gap-over-verizon-att-unlimited-plans.htm.

practicalities of running the network.[418] National practical capacity is highly correlated with national total capacity. Therefore, an increase in national total capacity for a network will result in a proportional increase in its national practical capacity. Moreover, because carriers generally operate close to the limits of national practical capacity, the increase in carried traffic for subscribers for a network also increases proportionately with its national total capacity.

210. Since the Transaction would increase industry-wide national total capacity, it will also increase industry-wide practical capacity and industry-wide supply of cellular data to consumers. Over time, carriers will allocate some of their national practical capacity for new 5G use cases, rather than part of the packages that mobile subscribers receive. My understanding from T-Mobile executives is that they will devote most of the network national total capacity to mobile subscribers in 2024. They will allocate the bulk of the additional national total capacity to the provision of fixed wireless access broadband services, with data consumption from new 5G products ramping up after that.[419]

3. The Transaction Would Place Significant Downward Pressure on the Price of Cellular Data for Mobile Subscribers

211. As discussed, the history of dynamic competition among cellular carriers shows that the deployment of new generations of technology puts substantial downward pressure on prices. The new technologies result in dramatic reductions in the costs to deploying more capacious

[418] Based on my conversations with the engineering team at T-Mobile, the amount of capacity that could be made available on average, nationally, depends on a number of business and engineering factors, including but not limited to: (i) historical and continued decision to offer packages on a national basis; (ii) commitment to providing users with a national cellular network of sufficient quality to continue to attract customers; (iii) sales and marketing practices; (iv) advance planning for future increases in demand (by leaving enough headroom in capacity to ensure that a carrier can accommodate expected future demand); (v) the fact that a carrier deploys all available spectrum that the deployed radio infrastructure supports rather than deploying it on an as-needed basis; and (vi) planning for unexpected and irregular spikes in demand (e.g., potential streaming of an NBA Finals game in the home cities of the teams).

[419] Declaration of Neville Ray, ¶¶ 40-42.

national networks and in the marginal cost of providing cellular data to mobile subscribers. The price per GB of data declined by approximately 26 percent a year between 2010 (at the beginning of the 4G LTE rollout) and 2017 (by which time all major carriers had achieved essentially nationwide 4G LTE coverage).[420]

212. The transition to 5G will have the same effect as previous technologies given its design, which will drive the cost per bit down substantially. As cellular carriers transition to 5G, they would lower prices substantially in light of the marginal cost reductions and their long-standing practice of designing their networks.[421]

213. The Transaction would accelerate this decline in price because it would enable New T-Mobile to deploy a more robust network with greater capacity than the sum of what the two companies could do on a stand-alone basis, and force AT&T and Verizon to increase their supply of cellular data.[422]

4. Transaction Will Improve Quality by Improving Performance and Increasing the Supply of Apps and Features

214. The Transaction will increase the quality of the data connection that mobile subscribers receive through improved data speeds, lower latency, and greater coverage. It will also increase the value of the data itself by inducing the supply of new app features and apps. As a result, it will also accelerate the reduction in the *quality-adjusted* price of data.

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[420] As shown in Exhibit 3, by 2017, 4G networks covered 95 percent of the United States on a weighted average basis. Exhibits 3 and 5A.

[421] Each carrier is making long-run profit maximizing decisions to build capacity in light of forecasts of demand. The history of competition provides evidence on how these decisions play out dynamically in light of generational changes in technology that drive costs down.

[422] I discuss possible offsetting effects from changes in static price competition below.

a. The Transaction Will Reduce the Quality-Adjusted Price as a Result of Enhancing the Subscriber Experience in Consuming Online Content and Services

215. Consumer demand for data increased dramatically when cellular networks moved from 3G to 4G LTE technology.[423] That was because consumers had a far superior experience using apps and browsing the web with their mobile devices. Response times shortened, and data speeds increased. The quality-adjusted price therefore fell even more dramatically than the unadjusted price following the deployment of 4G LTE networks.

216. The same phenomenon will happen with 5G. Consumers will find that response times are almost instantaneous and that data-intensive apps will work better as a result of higher speeds. T-Mobile projects that New T-Mobile 5G subscribers will have much higher data speeds than the 5G subscribers of the stand-alone networks and a higher fraction of subscribers will have access to 5G.[424] I would expect that AT&T and Verizon 5G subscribers would also experience superior performance with the Transaction because AT&T and Verizon likely will be forced to invest more in improving their networks, for the reasons discussed earlier.

217. As a result, the Transaction would lead to a greater reduction in quality-adjusted prices than in unadjusted prices.

b. The Transaction Will Reduce the Quality-Adjusted Price and Increase Quality-Adjusted Output as a Result of Inducing the Supply of New App Features and Apps

218. The supply of data-intensive app features, and new apps, also increased following the deployment of 4G LTE networks. Because the consumer experience of using data-intensive

[423] *See supra* Section II.B.4.

[424] *See supra* Section V.A.

apps such as video streaming improved substantially, and the price/GB of using data-intensive apps declined dramatically, developers invested more resources in developing new app features, such as Facebook Live.[425] I would expect that the same supply response would occur as developers become confident that there will be a critical mass of 5G mobile subscribers.

219. By creating a critical mass of 5G mobile subscribers earlier, and providing them with stronger networks, the Transaction is likely to accelerate the development of 5G apps and app features. Consumers would therefore be able to obtain larger benefits from new apps and app features sooner with the Transaction than without it. Given that the Transaction will likely improve the quality of the data that mobile subscribers obtain using their cellular connections, the quality-adjusted output will increase, and quality-adjusted prices will decrease more than unadjusted prices.

C. The Transaction Would Result in 55 Percent Lower Cellular Data Prices and 120 More Cellular Data Supply in 2024 Under Plausible Assumptions Concerning Dynamic Competition Among Carriers

220. The history of dynamic competition shows that investment in network capacity and performance results in dramatic increases in the supply, and sharp decreases in the price, of cellular data.[426] In this section, I present my estimates of the quantitative magnitude of the impact of the Transaction on cellular industry data output and prices given the dynamic aspects of this industry and the upcoming generational change. The analytical framework demonstrates that, under a set of assumptions that are grounded in the experience of this industry and the analysis-based plans of the Applicants, the Transaction will lead to substantial increases in output and reductions in price per GB of wireless data paid by American consumers. My

[425] *See supra* Section II.B.4.

[426] *See supra* Section IV.D.

projections, of course, are not precise estimates,[427] and as noted earlier, I have not addressed the impact of the Transaction on the prices charged for specific wireless plans in a static competitive environment.

221. Given the central role played by network capacity in driving the cost of wireless data to consumers, the analysis begins with forecasts of industry-wide national practical capacity per subscriber per month with and without the Transaction. The forecasts are grounded in the Applicants' experience operating cellular networks and the economic evidence concerning dynamic competition in this industry. The relationship between capacity and the prices paid by consumers per GB of data flows directly from the observed pattern of price/GB equilibrating to reflect increases in national practical capacity based on the carriers' consistent practice of designing service packages that stimulate demand to make use of available network cellular data capacity. As a result of these practices, national practical capacity equals the carried traffic that mobile subscribers actually consume. My projections draw from the evidence that consumer demand for cellular data increases rapidly, in part from the endogenous supply response of app developers to create products and features that rely on greater capacity and faster data speeds. This greater consumer demand thereby absorbs the dramatically larger network capacities that result from investments.[428]

[427] The FCC (and the U.S. Department of Justice) could make more precise estimates by obtaining information from AT&T and Verizon concerning their deployment of 5G networks under the stand-alone and merged company scenarios, and in particular whether they plan to stand pat in response to the stronger 5G network that New T-Mobile will deploy.

[428] *See supra* Sections III.D and V.B.2.

1. The Transaction Would Result in New T-Mobile Supplying More Cellular Data to Subscribers by 2024 Based on the Historical Ratio of Carried to Offered Traffic

222. T-Mobile projects that New T-Mobile would have national total capacity of 23.7 EB per month, compared with only [redacted] EB per month for T-Mobile and [redacted] EB per month for Sprint as stand-alone companies in 2024.[429] Because of network performance requirements and the distribution of usage across the network over time and geography, these figures do not represent the amount of cellular data that is realistically available to be consumed by wireless customers.

223. T-Mobile reports that over the last two years, in which it provided as much national total capacity as possible given the engineering and business practicalities of running the network, it provided carried traffic – that is, the actual amount of data consumed by users provided over T-Mobile's network – that was [redacted] percent of the national total capacity on its 4G LTE network.[430] In other words, [redacted] percent of national total capacity resulted in national practical capacity for T-Mobile, and that national practical capacity was equal to the actual data consumed by users.

224. T-Mobile projects that its national practical capacity ratio will be higher for its 5G network than for its 4G LTE network because it will be able to more flexibly deploy capacity for new use cases.[431] For example, T-Mobile expects that it would support other 5G use cases,

[429] *See supra* Figure 5.

[430] I understand that the actual utilization in dense urban areas may be much higher than the national average, while the actual utilization of sites deployed to provide coverage in less densely populated (e.g., rural or ex-urban) areas may be much lower.

[431] T-Mobile expects that its national practical capacity will be higher for its 5G network than for its 4G LTE network because T-Mobile will be able to more flexibly deploy capacity for new use cases – especially considering IoT and the many opportunities for the consumption of underutilized network resources that will arise. The national practical capacity figure for T-Mobile's 4G LTE network is therefore a conservative estimate

including fixed wireless access, from the national total capacity that is not deployed as national practical capacity for mobile subscribers. That is because the 5G use cases such as fixed wireless access and IoT do not impose the same demands on national total capacity and therefore can be provided without degrading the quality of the experience for mobile subscribers. The [redacted] percent ratio of carried traffic to offered traffic for T-Mobile's 4G LTE network, which is consistent over time with the business' historical usage practices, is therefore a conservative estimate of the percent of national practical capacity and carried traffic for New T-Mobile's 5G network.[432]

225. I use T-Mobile rather than Sprint as a point of comparison for AT&T's and Verizon's network capacities in the stand-alone scenario because AT&T and Verizon would likely not view Sprint's capacity as a significant motivator to invest. Sprint's geographic footprint is far smaller and covers far fewer POPs than any other major carrier.[433] In addition, Sprint does not have the scale or financial resources to both expand network investment and continue spending on promotional prices and other incentives to lure customers from AT&T and Verizon.[434]

of what the figure will be for New T-Mobile's 5G network, but it is consistent over time with the business's historical usage practices.

[432] I investigated how results change if this ratio is changed to 30 percent or 50 percent in the calculations below concerning the impact of the Transaction on industry supply and price. Reducing the ratio to 30 percent reduces national practical capacity per subscriber and increases price per GB with and without the Transaction, with the change in these metrics proportional to the change in the ratio. Increasing the ratio to 50 percent increases national practical capacity per subscriber and reduces price per GB, proportionally with the change in the ratio. Because these changes occur with and without the Transaction, the percent increase in national practical capacity per subscriber due to the Transaction is unaffected by changing the ratio to 30 or 50 percent. Similarly the percent reduction in price per GB due to the Transaction is unaffected.

[433] *See* Declaration of John Saw, ¶ 12; Declaration of Brandon Dow Draper, ¶ 6.

[434] Declaration of Brandon Dow Draper, ¶ 22.

2. The Transaction Would Result in AT&T and Verizon Supplying More Cellular Data to Subscribers Based on Plausible Assumptions Concerning Their 5G Deployments with and Without the Transaction

226. I have considered a range of scenarios under which AT&T and Verizon would respond to the massive deployment of 5G capacity by New T-Mobile.

227. My base "with Transaction assumption" is that AT&T and Verizon will approximately match New T-Mobile in terms of performance and the amount of data they could offer subscribers so that they remain competitive with New T-Mobile. They could not offer competitive packages if they had materially less national practical capacity available per subscriber.[435] I report estimates based on alternatives to this base assumption below.

228. My base "without Transaction assumption" is that AT&T and Verizon would, for the reasons discussed above, and as they have stated publicly, invest slowly in 5G capacity and network performance.[436] To be conservative, however, I assume that AT&T and Verizon would build enough national total capacity to be able to offer as much as T-Mobile would as a stand-alone company. In the past, T-Mobile has competed aggressively with AT&T and Verizon and forced them to adopt unlimited plans.[437] Based on the dynamic competition described earlier, I would expect that AT&T and Verizon would try to ensure that they do not fall behind T-Mobile in network capabilities. I report estimates based on alternatives to this base assumption below.

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[435] It is possible that instead of matching national practical capacity they could compensate on other dimensions, such as bundling content which would then appear as a reduction in the quality-adjusted price. Therefore, one can think of the assumption of matching data per subscriber as covering the possibility that they either match or surpass data plans or provide some other compensating benefit.

[436] *See supra* Section V.B.1.a.

[437] *See supra* Section IV.B.

229. The competitive response from AT&T and Verizon to New T-Mobile would likely be stronger than to either stand-alone company. Verizon and AT&T have often ignored investments from T-Mobile and Sprint. For instance, Verizon has dismissed T-Mobile's investment in broadening rural coverage. In January 2018, a Verizon executive stated: "To me, [T-Mobile is] in a continual catch-up mode. To say they're on par with Verizon – we'll see what the third parties say."[438] Verizon did not purchase any 600 MHz spectrum, useful for expanding coverage in rural areas, in the FCC auction, and AT&T purchased less than $1 billion in licenses (which it later sold).[439] This is despite T-Mobile's 2015 announcement that it planned to purchase up to $10 billion in 600 MHz licenses.[440]

230. The history of unlimited data plans provides another example. In 2011 Verizon and AT&T discontinued their unlimited plans and transitioned to tiered data plans with overage charges, even though Sprint continued to offer an unlimited plan and T-Mobile continued to supply unlimited data at reduced 2G speeds rather than imposing overage charges.[441] However, when T-Mobile began providing unlimited 4G LTE data to all new subscribers in 2016, Verizon and then AT&T quickly followed.[442] The difference is that, in 2012, T-Mobile's 4G LTE deployment was in its infancy, while by 2016 it had made substantial investments and was able to provide data speeds that were superior to AT&T and Verizon. These examples show

[438] Monica Alleven, *Verizon not showing signs of worry that T-Mobile is catching up to it on LTE coverage*, FIERCEWIRELESS (Jan. 4, 2018), https://www.fiercewireless.com/wireless/verizon-not-showing-signs-worry-t-mobile-catching-up-to-it-lte-coverage.

[439] Mike Dano, *Editor's Corner—600 MHz incentive auction 'extravaganza' ends with a whimper*, FIERCEWIRELESS (Jan. 8, 2018), https://www.fiercewireless.com/wireless/editor-s-corner-600-mhz-incentive-auction-extravaganza-ends-a-whimper.

[440] Mike Dano, *T-Mobile CFO on 600 MHz incentive auction: 'Dynamics are positive,' carrier could have up to $10B to spend*, FIERCEWIRELESS (Sept. 30, 2015), https://www.fiercewireless.com/wireless/t-mobile-cfo-600-mhz-incentive-auction-dynamics-are-positive-carrier-could-have-up-to-10b.

[441] *See supra* Section IV.B.

[442] *See supra* Section IV.B.

that Verizon and AT&T give little attention to others' investments aimed at "catching up" but react more strongly to investments that challenge their long-standing claims of network superiority. The New T-Mobile's 5G network would surpass AT&T and Verizon and thus provoke a strong competitive response. Nevertheless, I use the conservative base assumptions in the quantifications discussed next.

231. For comparison I also consider a "no response assumption" scenario in which the Transaction does not change AT&T and Verizon's deployment of 5G networks as of 2024. I consider the scenario in which AT&T and Verizon provide the same data per subscriber as New T-Mobile would in 2024 with or without the Transaction. This assumption is very conservative given that AT&T and Verizon do not have plans to deploy a strong 5G network as rapidly as New T-Mobile would do so based on their public announcements.

3. The Transaction Would More than Double Industry-Wide Supply of Cellular Data Per Subscriber Given Base Assumptions on AT&T and Verizon 5G Deployments

232. To determine the impact of the Transaction on the industry-wide supply of cellular data per subscriber, I estimated the number of wireless smartphone customers who would be using three national networks (conservatively assuming that there is no new national entry) in order to allow me to convert total industry-wide practical capacity, and carried traffic, to an amount per subscriber. I have focused on smartphone users because they are the main consumers of cellular data.

233. I forecasted the total number of smartphone subscribers for 2024 as the product of projected 2024 total subscribers and the projected smartphone penetration rate. I projected the smartphone penetration rate to reach 90 percent up from its 2017 level of 80 percent. Based on the total connections data series from the GSMA, I projected the total number of subscribers to

grow at a compounded annual growth rate of 2.17 percent from its 2017 value.[443] This growth rate is equal to the average growth rate of connections in the GSMA data between 2014 and 2017. I then calculated the GB per subscriber of national practical capacity traffic for 2024 for New T-Mobile, T-Mobile, and Sprint under the assumption that subscriber shares are the same in 2024 as in Q3 2017.[444]

234. In 2024, I find that New T-Mobile could provide national practical capacity of [redacted] GB per month per smartphone subscriber, T-Mobile as a stand-alone company would provide [redacted] GB per month per smartphone subscriber, and Sprint as a stand-alone company would provide [redacted] GB per month per smartphone subscriber. Following the analysis above, I project that AT&T and Verizon would each offer [redacted] GB per month per smartphone subscriber in 2024 with the Transaction (like New T-Mobile) and [redacted] GB per month per smartphone subscriber without the Transaction (like T-Mobile as a stand-alone company).[445]

235. Based on these calculations I project that the Transaction would result in New T-Mobile, AT&T, and Verizon collectively supplying [redacted] EB per month of national practical capacity to smartphone subscribers, which would imply [redacted] GB per month per smartphone subscriber.[446] By way of comparison, Ericsson estimates that the growth in data traffic demand would result in 66 GB per North American smartphone subscriber in 2024.[447] Without the

[443] In the GSMA database, total connections are defined as total unique SIM cards (or phone numbers, where SIM cards are not used), excluding cellular M2M, that have been registered on the mobile network at the end of the period. GSMA INTELLIGENCE.

[444] *See* Exhibit 14B.

[445] *See* Exhibits 14B and 14C.

[446] *See* Exhibit 14A.

[447] Ericsson estimates that data traffic per smartphone subscriber will grow at a compounded annual rate of 37 percent from 7.1 GB per month per smartphone subscriber in 2017 to 48 GB per month per smartphone subscriber in 2023. Applying the same growth rate to the 2023 figure I obtain 66 GB per month per smartphone subscriber in

Transaction, I find that the four carriers would collectively provide substantially lower levels of national practical capacity – specifically [redacted] EB per month of national practical capacity for smartphone subscribers, which would imply [redacted] GB per smartphone subscriber. Industry output, as measured by national practical capacity, would therefore be 120.3 percent higher with the Transaction than without it.[448] That is, the Transaction would almost double the amount of industry supply by 2024 based on these assumptions. The multiple would be lower if AT&T and Verizon didn't expand their network capabilities to match New T-Mobile with the Transaction or if they expanded more aggressively without the Transaction.[449]

4. The Transaction Would Result in a More than 50 Percent Reduction in the Price per GB of Data for Smartphone Users.

236. With these projections in hand, I next estimate the impact of the Transaction on the price per GB of data that consumers would pay in 2024 given the base assumptions concerning AT&T and Verizon responses. I do not provide an opinion on the unilateral effects of the Transaction on the specific package fees charged by the carriers under conditions of static competition. Using an analysis based on dynamic competition, I have projected the price/GB under the assumption that the ARPU is the same in 2024 as it was in 2017, which assumption is consistent with T-Mobile's business plans.[450]

2024. ERICSSON, ERICSSON MOBILITY REPORT 31 (Nov. 2017), https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-november-2017.pdf.

[448] *See* Exhibit 14A.

[449] I have verified that increasing and decreasing the number of forecasted subscribers by 20 percent does not change the percent change in national practical capacity per smartphone subscriber due to the Transaction or the percent change in the price per GB due to the Transaction reported below. Changing the number of forecasted subscribers does affect the projected level of national practical capacity per smartphone subscriber and price per GB. As expected, increasing (decreasing) the number of subscribers reduces (raises) national practical capacity per subscriber and raises (reduces) the price per GB with and without the Transaction.

[450] The New T-Mobile business plan projects that ARPU will decline through 2024.

237. The cellular carriers would, as I show above, change their packages and fees to accommodate this increased supply of data, as they have done with previous massive increases in capacity resulting from generational changes in technology. Because I focus on cellular data prices, I allocate ARPU to data based on the percent of time that smartphone users spend using data. That percentage has increased over time reaching 73 percent in 2017.[451] Given the growth trend I assume that the percent of time spent using data will reach 90 percent by 2024, although the shift from voice calls to other means of communication and the increased use of data suggest that the percentage could well be higher. In 2024, Data ARPU – the portion of ARPU allocated to the provision of cellular data – is assumed equal to 90 percent of ARPU.

238. To calculate the price/GB I divide the estimated Data ARPU by the estimated GB/subscriber reported above. Table 17 summarizes the results.

Table 17
National Practical Capacity and
Price per GB With and Without the Transaction

	Without Transaction	**With Transaction**	**Percent Change Due to Transaction**
National Practical Capacity (EB/Month)	[redacted]	[redacted]	120.25%
National Practical Capacity per Smartphone Subscriber (GB/Month)	[redacted]	[redacted]	120.25%
Price per GB	[redacted]	[redacted]	-54.60%
Source: Exhibit 14A.			

[451] *See* Exhibit 5A. This estimate is consistent with allocations between voice and data revenue that Sprint and T-Mobile have calculated in the ordinary course of business. *See supra* note 96.

239. This analytical framework, and the projections they yield, strongly support my conclusions from the other record evidence that the investment in capacity sparked by the Transaction will yield huge benefits to consumers in terms of output expansion and lower price/GB. I find that the Transaction would result in a substantial drop in the price/GB – $[redacted] with the Transaction and $[redacted] without the Transaction.[452] I project that price/GB would be 54.6 percent lower with the Transaction than without it. In addition, given the improvements in performance and the introduction of new apps described above, the quality-adjusted price/GB would decline even more than the nominal price/GB for the reasons discussed above.

240. I have also considered the "no-response case" in which the Transaction does not provoke AT&T and Verizon to accelerate their investments in 5G networks. As discussed above, I consider the conservative case in which AT&T and Verizon, contrary to their current plans, would have a strong national 5G network in 2024 that provides the same data per subscriber as New T-Mobile regardless of whether the Transaction takes place. In this case, as a result of New T-Mobile having almost twice as much capacity as the stand-alone companies, the price/GB would be 14.0 percent lower with the Transaction than without the Transaction and national practical capacity per subscriber would be 16.2 percent higher.

5. The Finding that the Transaction Would Result in A Dramatic Decrease in Price Is Confirmed by Sensitivity Tests of Base Assumptions

241. I have considered the impact of changing the base assumptions. I consider scenarios in which, with the Transaction, AT&T and Verizon are more or less aggressive in matching New T-Mobile's practical capacity per subscriber – in particular, in which they match 80 percent,

[452] By way of comparison, if the rate of decline in the price/GB of data for 2010 to 2017 continued through 2024 the price/GB would fall to $[redacted]. *See* Exhibit 5A.

100 percent, and 120 percent of New T-Mobile's practical capacity per subscriber. I also consider scenarios in which, without the Transaction, AT&T and Verizon are more or less aggressive than T-Mobile as a stand-alone company – in particular, in which they build 80 percent, 100 percent, and 120 percent of T-Mobile's national practical capacity per subscriber.

242. For each of the nine resulting scenarios, Table 18 reports how much national practical capacity per subscriber would increase and how much the price/GB would decrease as a result of the Transaction (changes in the price/GB are reported in parentheses). The projections for these alternatives are consistent with the earlier result that the Transaction results in a substantial increase in cellular data supply and reduction in cellular data prices. The estimated price changes vary from a low of a 41 percent decrease when AT&T and Verizon are less aggressive with the Transaction and more aggressive without, to a high of 65 percent when they are more aggressive with the Transaction and less aggressive without, relative to the base assumptions.

Table 18
Sensitivities for the Percent Change
in National Practical Capacity per Smartphone Subscriber
and Price per GB Due to the Transaction

		Percent of New T-Mobile's National Practical Capacity per Smartphone Subscriber that AT&T and Verizon Match With the Transaction		
		80	**100**	**120**
Percent of New T-Mobile's National Practical Capacity per Smartphone Subscriber that AT&T and Verizon Match Without the Transaction	**80**	116.57% (-53.83%)	150.84% (-60.13%)	185.12% (-64.93%)
	100	90.16% (-47.41%)	120.25% (-54.60%)	150.34% (-60.05%)
	120	69.49% (-41.00%)	96.31% (-49.06%)	123.13% (-55.18%)

Note: Changes in price per GB are reported in parentheses.

Source: GSMA INTELLIGENCE; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TWENTIETH REPORT, WT Docket No. 17-69, at 15 (Sept. 27, 2017); Exhibits 5A, 14B and 14C.

243. I have also investigated how my analysis reflected in Table 17 would change if I were to use a ratio of national practical capacity to national total capacity of 31.5 percent for Sprint as a stand-alone company, rather than the 40.9 percent ratio used thus far.[453] The results for this scenario are reported in Table 19 below. In this scenario the changes in national practical capacity and price per GB with the Transaction are even more pronounced, confirming that my base approach is conservative.

[453] I also understand that as a result of the loss of subscribers, Sprint operates with excess national total capacity and its network would be able to sustain a higher amount of carried traffic than it currently does.

Table 19
National Practical Capacity and
Price per GB With and Without the Transaction
Using [redacted] Percent as the Ratio of National Practical Capacity
to National Total Capacity for Sprint Stand-alone

	Without Transaction	**With Transaction**	**Percent Change Due to Transaction**
National Practical Capacity (EB/Month)	[redacted]	[redacted]	131.87%
National Practical Capacity per Smartphone Subscriber (GB/Month)	[redacted]	[redacted]	131.87%
Price per GB	[redacted]	[redacted]	-56.87%
Source: GSMA INTELLIGENCE; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TWENTIETH REPORT, WT Docket No. 17-69, at 15 (Sept. 27, 2017); Exhibits 5A, 14A, 14B and 14C.			

244. As I indicated above, these estimates should be viewed as plausible projections of the order of magnitude of the impact of the Transaction, resulting from dynamic competition in light of substantial merger-specific efficiencies, rather than precise estimates of prices or supply. The projections support my conclusion that dynamic competition over network capacity and performance are primary drivers of industry supply and prices.[454] The Transaction will increase industry supply of cellular data and reduce the price of cellular data substantially under plausible assumptions.

[454] *See supra* Section IV.

D. The Transaction Would Accelerate the Development and Adoption of New 5G-Based Products and Services and Thereby Result in Substantial Increases in Consumer Surplus and Economic Efficiency

245. There are sound economic reasons to expect that the deployment of 5G networks in the United States will have more far-reaching effects on the economy than the deployment of previous technology generations. Personal mobile devices were the primary focus of 1G, 2G, 3G, and 4G technologies, whereas 5G is a far more powerful general-purpose technology. By providing pervasive, high-speed, and essentially real-time connections to billions of devices, 5G technologies can support innovation that will result in products and services that could benefit all sectors of the economy.

246. U.S. consumers, enterprises, and governments will benefit from these new products and services. The Transaction would accelerate the deployment of strong 5G networks and thereby quicken the development and adoption of these new products and services. Developers of 5G products and services would have stronger 5G networks available to them sooner to support the wide-scale deployment of 5G connections in areas such as transportation (cars, drones, and trucks), enterprise (factories and other IoT applications), government (smart cities and transportation infrastructure), and consumer products (fixed wireless access, smart home devices, and AR/VR headsets).[455] They would also have a larger mass of customers who could use these new products and services – and the applications we cannot imagine – sooner, which would stimulate the development of 5G-applications.

247. By accelerating the deployment and adoption of 5G technologies the Transaction could result in a dramatic increase in economic value. I present a simple example to illustrate this

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[455] *See supra* Section III.D.

point and then discuss the applicability of the illustration to the Transaction. Consider a new general-purpose technology (New GPT) that is introduced in Year 1 and diffuses through the economy over subsequent years. New GPT would generate $100 billion of additional value each year reaching $500 billion in its fifth year of deployment and $1 trillion in its tenth year of deployment.

248. Now consider the impact of a delay. Table 20 compares the evolution of value for New GPT when it is introduced in the calendar year 2020 compared with 2022, as of 2018. The table also reports the difference in economic value between the series based on its introduction in 2020 and introduction in 2022, as well as the present discounted value of cumulative losses. Accelerating the introduction of New GPT by two years results in a present value of $1.9 trillion over 10 years without discounting; using a conservative discount rate of 2 percent the present discounted value of the cumulative benefit would be around $1.7 trillion.[456]

[456] If the growth was based on increments of $50 billion a year reaching $500 billion after 10 years, the cost of a two-year delay would be $950 billion undiscounted and $833 billion discounted.

Table 20
Evolution of New GPT Value Based on Introduction Date
($ Billions)

Year	Value of GPT Introduced in 2020	Value of GPT Introduced in 2022	Absolute Difference	Difference Using a 2% Discount Rate
2020	$100	$0	$100	$96
2021	$200	$0	$200	$188
2022	$300	$100	$200	$185
2023	$400	$200	$200	$181
2024	$500	$300	$200	$178
2025	$600	$400	$200	$174
2026	$700	$500	$200	$171
2027	$800	$600	$200	$167
2028	$900	$700	$200	$164
2029	$1,000	$800	$200	$161
Total	$5,500	$3,600	$1,900	$1,665

249. This example, while highly stylized, provides insights into the potential impact of the Transaction on the broader economy under the predicate that it will result in a stronger 5G network sooner and further encourage competitive responses from AT&T and Verizon. It is widely acknowledged that 5G will spur innovation throughout the economy. A number of organizations have estimated the economic impact of 5G. For example, a 2017 IHS Markit report calculates that 5G would enable more than $12 trillion in worldwide economic activity (in 2016 U.S. dollars) spanning across 16 different industries over the next 20 years.[457] With

[457] KAREN CAMPBELL ET AL., IHS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 4, 17 (2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf.

respect to the United States, Accenture estimates that 5G wireless technology is expected to boost annual GDP by approximately $500 billion.[458]

250. Case studies of particular applications also find that 5G will generate substantial economic value. Accenture reports that "5G technology will help unleash the next wave of Smart Grid features and efficiency" and in the "U.S., Smart Grid benefits are estimated to be as high as $2 trillion dollars over 20 years."[459] Ericsson's study of manufacturing processes at a select company concludes that introducing real-time monitoring, real-time control, and automation enabled by very low, stable, and predictable latency provided by 5G could translate to €360 million in annual savings.[460]

251. Finally, there is a general understanding regarding the potential of 5G and its ability to enable increased productivity improvement. For example, the U.S. Assistant Secretary of Commerce for Communications and Information stated that: "5G will greatly expand the capabilities of wireless networks, allowing for powerful broadband applications and nearly universal connectivity of people and machines. It will open the door for advanced IoT and Smart Cities applications, faster and more reliable health care and public safety services, and increased productivity in almost every industry, from farming to advanced manufacturing."[461]

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[458] MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES: HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 1 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf.

[459] MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES: HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 7 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf.

[460] ERICSSON CONSUMER & INDUS. LAB, BRINGING 5G BUSINESS VALUE TO INDUSTRY 4-6 (2018), https://www.ericsson.com/assets/local/networked-society/consumerlab/reports/2018/bringing-5g-business-value-to-industry.pdf.

[461] David J. Redl, Assistant Sec'y of Comm. for Commc'ns & Info., U.S. Dep't of Comm., Remarks at the BIS 2018 Annual Conference on Export Controls and Policy (May 14, 2018), https://www.ntia.doc.gov/speechtestimony/2018/remarks-assistant-secretary-redl-bis-2018-annual-conference-

252. These studies are based on assumptions concerning the development of 5G-based products and the demand for them. While one should not put much confidence in any single estimate, there is a consensus, based on serious studies, that the economic impact of 5G will be substantial. Given these studies, together with the estimates of the value of 3G and 4G technology reported earlier, the assumption that 5G could generate incremental economic surplus, for consumers, enterprises, and governments, of $1 trillion 10 years after launch is plausible, particularly if this sum also includes the benefits to mobile subscribers through lower prices and superior performance.

253. The Transaction will bring these benefits to the U.S. economy sooner than would occur in the absence of the Transaction, based on the plans put forward by the Applicants. For example, 5G will account for more than [redacted] percent of New T-Mobile's national total capacity by 2022.[462] In contrast, by 2024, 5G would account for around [redacted] percent of national total capacity for T-Mobile's stand-alone network and [redacted] percent for Sprint's stand-alone network.[463] And this substantial acceleration of the deployment of New T-Mobile's 5G network will, in turn, induce AT&T and Verizon to ramp up their efforts and build stronger competitive 5G networks sooner.

export-controls-and; *see also* FROST & SULLIVAN & PRINCIPAL GLOB. INV'RS, 5G: THE FOUNDATION FOR A HYPER-CONNECTED WORLD 5, 7, 9 (2017), https://go.frost.com/tt-HyperConnectedWorld; MICHAEL MANDEL, PROGRESSIVE POL'Y INST., LONG-TERM U.S. PRODUCTIVITY GROWTH AND MOBILE BROADBAND: THE ROAD AHEAD 6 (2016), http://www.progressivepolicy.org/wp-content/uploads/2016/03/2016.03-Mandel_Long-term-US-Productivity-Growth-and-Mobile-Broadband_The-Road-Ahead.pdf; Austl. Gov't Bureau of Commc'ns & Arts Res., *Impacts of 5G on Productivity and Economic Growth* 2 (April 2018) (working paper), https://www.communications.gov.au/file/35551/download?token=0MlSFttv.

[462] "Lakes Capacity Update," *T-Mobile*, June 9, 2018, at 4, 6.

[463] *See supra* Figure 5.

E. The Transaction Will Increase Competition for Home Broadband and Thereby Benefit Fixed Broadband Subscribers

254. The Transaction will also accelerate the deployment of 5G networks that could provide a closer substitute for cable, DSL, and satellite broadband. As I showed earlier, many households have only one or two choices for obtaining high-speed broadband at home. Because of the high prices and poor service, some households have decided to just use cellular. That solution is imperfect today because people cannot obtain plans that allow them to affordably stream as much video content on their connected televisions and other devices as they can with fixed broadband solutions.[464]

255. Carriers with strong 5G networks will be able to provide packages that can compete with fixed broadband because they will have far more capacity, making unlimited data hotspots at affordable prices feasible. In addition, carriers will be able to develop more sophisticated FWA solutions that would provide even closer substitutes for fixed broadband.

256. T-Mobile has represented to the FCC that it plans to promote competitive alternatives to fixed broadband and that it would deploy these competitive alternatives more broadly, and sooner, than T-Mobile or Sprint would as stand-alone companies. The Transaction would therefore increase the number of high-speed broadband competitors in many local ISP markets from one to two or from two to three. In many rural areas there are currently no high-speed broadband alternatives, so the Transaction would introduce a high-speed alternative to DSL and satellite.[465] Therefore, the Transaction would more rapidly put greater downward pressure on

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[464] *See supra* Section III.C.

[465] *See* FED. COMMC'NS COMM'N, 2018 BROADBAND DEPLOYMENT REPORT, GN Docket No. 17-1999, ¶ 50 (Feb. 2, 2018), https://docs.fcc.gov/public/attachments/FCC-18-10A1.pdf; FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket No. 15-191, ¶ 86 (Jan. 29, 2016), https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2016-broadband-progress-report; *Applications of Charter*

prices for cable, DSL, and satellite and in some local markets, particularly rural ones, provide consumers with additional higher-quality alternatives.

257. In short, the Transaction will likely provide households in many parts of the country with more high-speed broadband providers at a faster rate than they would have in the absence of the Transaction. That will put a downward pressure on fixed broadband prices and therefore benefit consumers who do not choose to switch to cellular-based home broadband service.

F. The Transaction Will Place U.S. App Developers and Others in a Stronger Position to Compete Globally By Accelerating Adoption of 5G Networks and Creating Critical Mass of U.S. Customers for Whom to Create Apps

258. American companies like Apple and Facebook succeeded in their home markets because U.S. cellular networks deployed 3G and 4G technology that created a critical mass of customers for smartphones and mobile apps. Their experience and scale in the United States had payoffs in expanding globally.[466] It is possible that the successful American mobile companies could have started elsewhere, but the advantage of the United States is that it is a large market that is well-understood by U.S.-based firms. This history provides insights into the importance of developing 5G networks in the United States.

259. Successful developers of 5G applications will need national markets that have a critical mass of potential customers who could use those applications. American companies such as

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Communications, Inc., Time Warner Cable Inc., and Advance/Newhouse Partnership for Consent to Assign or Transfer Control of Licenses and Authorizations, Memorandum Opinion and Order, 31 FCC Rcd. 6327, ¶ 50 (2016) (Charter-Time Warner Order); David S. Evans, *Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and Edge Providers*, 9-10 (SSRN, Working Paper No. 3029006, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3029006%20.

[466] *See supra* Section II.E.

General Motors, which is investing in connected and autonomous vehicles,[467] would benefit from developing 5G products for the domestic market. By proving and scaling these products here, they gain competitive advantages in entering global markets.

260. By accelerating and strengthening the deployment of 5G networks in the United States, the Transaction would give American companies competitive advantages. They would likely develop 5G solutions sooner since they would have a larger base of potential customers in this country. They would also have the ability to refine and scale their technologies sooner, based on the large U.S. market.

[467] David Welch, *GM Adds SoftBank as Ally in Self-Driving Race Against Google*, BLOOMBERG (May 31, 2018), https://www.bloomberg.com/news/articles/2018-05-31/gm-s-cruise-unit-draws-2-25-billion-investment-by-softbank-fund; Kevin Fitchard, *A Peek Into GM's Connected Car Future*, FORTUNE (Mar. 27, 2015), http://fortune.com/2015/03/27/a-peek-into-gms-connected-car-future/.

261. I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct. Executed on June 18, 2018.

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David S. Evans, Ph.D.
Founder
Market Platform Dynamics

Appendix A
Calculation of the Average Price per GB of Mobile Data for U.S. Smartphone Users

I. Average Price per GB of Mobile Data for U.S. Smartphone Users as a Function of Smartphone Mobile Data Revenue and Mobile Data Traffic

1. Because mobile carriers offer complex bundles of voice and internet services it is not possible to obtain a stand-alone price for data. Using the approach described below, I calculate the price per GB of mobile data by allocating revenue to data used by smartphone users (Smartphone Mobile Data Revenue) and dividing that amount by the mobile data delivered to smartphone users (Smartphone Mobile Data Traffic):

$$p = \frac{Smartphone\ Mobile\ Data\ Revenue}{Smartphone\ Mobile\ Data\ Traffic}.$$

2. I focus on smartphone users since most mobile users now have smartphones, these devices account for the majority of mobile data traffic, and I have the relevant data for the allocation method I describe below. To determine Smartphone Mobile Data Revenue, I allocate carrier recurring revenues to data based on the fraction of smartphone connections as a share of all connections (Smartphone Penetration Rate), and the fraction of time subscribers spend using their smartphones to consume data rather than make voice calls (Percent of Time on Smartphone Spent Online). This method correlates with how people use smartphones and can adjust for the changing use of smartphones for consuming data rather than making voice calls over time. Specifically, I calculate Smartphone Mobile Data Revenue as

$$Smartphone\ Mobile\ Data\ Revenue = Recurring\ Revenue * Smartphone\ Penetration\ Rate * Percent\ of\ Time\ on\ Smartphone\ Spent\ Online.$$

3. I calculate each component of Smartphone Mobile Data Revenue over the period between 2010 and 2017. I use Recurring Revenue from GSMA Intelligence.[1] To calculate the Smartphone Penetration Rate, I divide Smartphone Connections by Total Connections (excluding machine-to-machine connections) from GSMA Intelligence.[2] I calculate the Percent of Time on Smartphone Spent Online as

$$Percent\ of\ Time\ on\ Smartphone\ Spent\ Online = \frac{Data\ Minutes\ on\ Smartphone}{Data\ Minutes\ on\ Smartphone + Voice\ Minutes\ on\ Smartphone}.$$

4. I calculate annual Data Minutes on Smartphone using data that Nielsen collects on the average number of minutes per month spent by adults using smartphones for app/web.[3] I multiply this metric by the average number of adult smartphone users in each year, multiplied by 12. I calculate the average number of adult smartphone users in each year using data from

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[1] According to GSMA, Recurring Revenue includes "recurring (service) revenue generated in the period, including revenue generated from the use of the network (voice, messaging, data, VAS), but excluding non-recurring revenue such as handset or equipment sales." GSMA INTELLIGENCE.

[2] According to GSMA, connections are defined as "total unique SIM cards (or phone numbers, where SIM cards are not used), excluding cellular [machine-to-machine ('M2M') connections], that have been registered on the mobile network at the end of the period. Connections differ from subscribers such that a unique subscriber can have multiple connections." M2M connections enable "mobile data transmission between two or more machines via cellular M2M (2G, 3G, 4G or 5G) technology. Cellular M2M excludes computing devices in consumer electronics such as e-readers, smartphones, dongles and tablets." Smartphone connections are defined as "unique SIM cards (or phone numbers, where SIM cards are not used) that have been registered on the mobile network and are used in a smartphone device at the end of the period. It refers to a smartphone connections installed base but does not represent the number of smartphone devices sold or shipped. A smartphone is defined as a mobile handset enabling advanced access to internet-based services with computer-like functions." GSMA INTELLIGENCE.

[3] *See* Exhibit 5B.

Nielsen and GSMA Intelligence.[4] The Data Minutes data from Nielsen includes time spent on a smartphone online using a mobile connection as well as the time spent online using a Wi-Fi connection. I use data from P3 and OpenSignal to estimate the share of smartphone time that is mobile.[5] I calculate Voice Minutes on Smartphone as Total Minutes of Use from CTIA multiplied by the share of mobile phone connections that are smartphones (as opposed to feature phones, tablet, laptops, etc.), which I calculate based on data from CTIA.[6] CTIA provides these figures for the years 2010 through 2016; I project Total Minutes of Use for 2017 and the smartphone share of mobile phone connections to be equal to the 2016 figure.

5. To calculate Smartphone Mobile Data Traffic, I use data from CTIA and Cisco. CTIA provides estimates of mobile data traffic for the years 2010 through 2016.[7] I project 2017 Mobile Data Traffic by applying to CTIA's 2016 estimate the mobile data traffic growth rate for North America from 2016 to 2017 provided by Cisco (38% YoY).[8] I then calculate Smartphone Mobile Data Traffic by multiplying CTIA's estimates of Mobile Data traffic by the share of mobile data traffic from smartphones. I compute this share using data from CTIA.[9]

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[4] *See* Exhibit 5B.

[5] *See* Exhibit 5B.

[6] *See* Exhibit 5B.

[7] ROBERT F. ROCHE & KATHRYN MALARKEY, CTIA'S WIRELESS INDUSTRY REPORT INDICES REPORT: YEAR-END 2016 RESULTS Appendix B 4 (May 2017). *See also*, Exhibit 1.

[8] *See* Exhibit 5A. CISCO, NORTH AMERICAN VNI ACTUAL AND PROJECTED MOBILE TRAFFIC VOLUME (June 2017).

[9] *See* Exhibit 5B.

II. Expression of Average Price per GB of Mobile Data for U.S. Smartphone Users as a Function of Data ARPU and Mobile Data Traffic per Smartphone User

6. I calculate the average price per GB of mobile data as the ratio of Smartphone Mobile Data Revenue, calculated above, and Smartphone Mobile Traffic and reformulate numbers to a per user basis:

$$p = \frac{Recurring\ Revenue}{Smartphone\ Mobile\ Data\ Traffic} * \frac{Smartphone\ Connections}{Total\ Connections}$$

$$* \ Percent\ of\ Time\ on\ Smartphone\ Spent\ Online$$

$$= \frac{Recurring\ Revenue/Total\ Connections/12}{Smartphone\ Mobile\ Data\ Traffic/Smartphone\ Connections\ /12}$$

$$* \ Percent\ of\ Time\ on\ Smartphone\ Spent\ Online$$

$$= \frac{ARPU}{Smartphone\ Mobile\ Data\ Traffic\ per\ Smartphone\ User}$$

$$* \ Percent\ of\ Time\ on\ Smartphone\ Spent\ Online$$

$$= \frac{Data\ ARPU}{Smartphone\ Mobile\ Data\ Traffic\ per\ Smartphone\ User}.$$

Appendix B
5G Technologies Are Expected to Provide Substantial Increased Economic Benefits for Transportation, Manufacturing and Cities – A Few Key Cases

I. 5G for Transportation Will Reduce Vehicular Accidents and Traffic Congestion

1. There were an estimated 269.7 million registered vehicles in the United States in 2017.[1] Drivers in cars, trucks, minivans, buses, and SUVs put on 3.2 trillion miles in 2016.[2] The average American spent 293 hours driving in 2016, for a total of around 79,000 hours,[3] and that does not include the time they spent as passengers in cars.[4] These vehicles also include short-haul and long-haul trucking, which are central to the distribution of goods for businesses and consumers. Trucks moved around 71 percent of the nation's freight based on weight, and the industry earned $739 billion in gross revenue from trucking in 2016.[5]

2. Unfortunately, in 2017 alone, around 40,000 people died and another 4.6 million were seriously injured in motor vehicle accidents.[6] The National Safety Council estimated that motor vehicle deaths, injury, and property damage amounted to around $414 billion in 2017.[7]

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[1] *United States Vehicle Ownership Data, Automobile Statistics and Trends*, HEDGES & CO., https://hedgescompany.com/automotive-market-research-statistics/auto-mailing-lists-and-marketing (last visited June 3, 2018).

[2] Press Release, U.S. Dep't of Transp., 3.2 Trillion Miles Driven on U.S. Roads In 2016 (Feb. 21, 2017), https://www.fhwa.dot.gov/pressroom/fhwa1704.cfm; David Schaper, *Record Number Of Miles Driven In U.S. Last Year*, NPR (Feb. 21, 2017), https://www.npr.org/sections/thetwo-way/2017/02/21/516512439/record-number-of-miles-driven-in-u-s-last-year.

[3] This assumes that the average American spent the same amount of time driving in 2016 as 2017.

[4] Tamra Johnson, *Americans Spend an Average of 17,600 Minutes Driving Each Year*, AAA (Sept. 8, 2018), https://newsroom.aaa.com/2016/09/americans-spend-average-17600-minutes-driving-year/.

[5] *Reports, Trends & Statistics*, AMERICAN TRUCKING ASSOCIATION, http://www.trucking.org/News_and_Information_Reports_Industry_Data.aspx (last visited June 3, 2018).

[6] *Motor Vehicle Deaths in U.S. Again Top 40,000*, INSURANCE JOURNAL (Feb. 16, 2018), https://www.insurancejournal.com/news/national/2018/02/16/480956.htm.

3. These vehicles already generate large volumes of data. A recent article noted that "[v]ehicles today have about 40 microprocessors and dozens of sensors that collect telematics and driver behavior data."[8] Car manufacturers use these computer systems to make cars safer (e.g., braking systems) and easier to use (e.g., parking-assist technologies).

4. Technology providers and car manufacturers have efforts underway to connect these vehicles to the cloud and to develop applications to improve performance and provide services. Recent efforts are focused on mobility, navigation, communication, and infotainment that can be supported with 4G LTE technologies.[9] Two broad automotive categories related these enhanced capabilities include "connected vehicles" and "autonomous vehicles."[10]

5. The term "connected vehicles" refers to vehicles that can connect with other devices (including other vehicles, devices embedded in roadways or other infrastructure, and personal devices) and with cloud-based services that support applications.[11] The term "autonomous vehicles" refers to vehicles that are powered by applications that provide autonomous vehicle

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[7] NAT'L SAFETY COUNCIL, NSC MOTOR VEHICLE FATALITY ESTIMATES 1 (2017), https://www.nsc.org/Portals/0/Documents/NewsDocuments/2018/December_2017.pdf.

[8] As above, assumes that the average American spent the same amount of time driving in 2016 as 2017. *Connected Cars Will Send 25 Gigabytes of Data to the Cloud Every Hour*, QUARTZ, https://qz.com/344466/connected-cars-will-send-25-gigabytes-of-data-to-the-cloud-every-hour/ (last visited June 3, 2018). *See also*, Steve Mertil, *How Cars Have Become Rolling Computers*, THE GLOBE & MAIL (May 16, 2018), https://www.theglobeandmail.com/globe-drive/how-cars-have-become-rolling-computers/article29008154/.

[9] Tara Seals, *Ford to Build 4G LTE Into All Vehicles By 2020*, FIERCE WIRELESS (Mar. 16, 2018), https://www.fiercewireless.com/ford-to-build-4g-lte-into-all-vehicles-by-2020.

[10] *Connected and Automated Vehicles*, CENTER FOR ADVANCED AUTOMOTIVE TECHNOLOGY, http://autocaat.org/Technologies/Automated_and_Connected_Vehicles/ (last visited June 9, 2018).

[11] Cellular Vehicular to Everything (C-V2X) – which was developed by 3GPP – will help achieve connected driving and was designed to operate in two modes: (1) Device-to-device: This is Vehicle-to-Vehicle (V2V), Vehicle-to-(Roadway) Infrastructure (V2I) and Vehicle-to-Pedestrian (V2P) direct communication without necessarily relying on network involvement for scheduling, and (2) Device-to-network: This is Vehicle-to-Network (V2N) communication which uses the traditional cellular links to enable cloud services to be part of the end-to-end solution by means of network slicing architecture for vertical industries. Apostolos Papathanassiou & Alexey Khoryaev, *Cellular V2X as the Essential Enabler of Superior Global Connected Transportation Services*, 1 IEEE 5G TECH FOCUS 2 (2017), https://5g.ieee.org/tech-focus/june-2017/cellular-v2x.

control (e.g., driverless cars), cooperative collision avoidance (e.g., multiple vehicles coordinate movements to avoid collision), and vulnerable road user discovery (e.g., identification of pedestrians, motorcyclists and cyclists).[12]

6. Technology providers and car manufacturers are currently developing connected and autonomous vehicle applications to improve vehicular safety and performance. For example, in January 2018, Ford and Qualcomm announced their collaboration to develop Cellular Vehicular to Everything (C-V2X) technologies to "improve vehicle safety, traffic efficiency, and support for autonomous driving."[13] In May 2018, General Motors (GM) announced that, following SoftBank's investment of $2.25 billion into GM's Cruise autonomous car segment, GM would invest a further $1.1 billion into Cruise with the intention of "making a business out of self-driving cars."[14] That same day Alphabet also announced that its Waymo subsidiary – which has been working on driverless technology since 2009 – was expanding its partnership with Fiat Chrysler Automotive NV by adding 62,000 minivans to its fleet of self-driving vehicles.[15] Intel has developed and launched its "GO™ Automotive 5G Platform" to help enable automakers to develop and test use cases, such as "sensor data uploads from the vehicle

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[12] *The Internet of Things*, ERICSSON 5 (2016); QUICHEN WANG AND CHRIS PHILLIPS, COOPERATIVE COLLISION AVOIDANCE FOR MULTI-VEHICLE SYSTEMS USING REINFORCEMENT LEARNING 1 (2013), https://ieeexplore.ieee.org/document/6669888/; JOSE ANAYA ET AL., VULNERABLE ROAD USERS DETECTION USING V2X COMMUNICATIONS 1 (2015), https://ieeexplore.ieee.org/document/7313118/.

[13] Press Release, Qualcomm Inc., Qualcomm and Ford Collaborate on C-V2X Global Initiative to Improve Vehicle Safety, Traffic Efficiency and Support for Autonomous Driving (Jan. 9, 2018), https://www.qualcomm.com/news/releases/2018/01/09/qualcomm-and-ford-collaborate-c-v2x-global-initiative-improve-vehicle.

[14] Press Release, Qualcomm Inc., Qualcomm and Ford Collaborate on C-V2X Global Initiative to Improve Vehicle Safety, Traffic Efficiency and Support for Autonomous Driving (Jan. 9, 2018), https://www.qualcomm.com/news/releases/2018/01/09/qualcomm-and-ford-collaborate-c-v2x-global-initiative-improve-vehicle.

[15] Mark Bergen & Gabrielle Coppola, *Waymo Expands Chrysler Self-Driving Fleet 100-Fold to 62,000*, BLOOMBERG (May 31, 2018), https://www.bloomberg.com/news/articles/2018-05-31/waymo-adds-62-000-chrysler-minivans-to-self-driving-fleet.

for machine learning, high-definition map downloads in real time, and over-the-air firmware and software updates."[16] To be deployed on a large-scale basis, these applications require 5G or another technology with similar performance characteristics.[17]

7. The applications under development are primarily focused on improving vehicular safety, reducing traffic congestion, and improving the driver experience. The U.S. Department of Transportation (USDOT) has observed that deploying just two of the applications under development could yield substantial safety benefits:

> 1,083 lives . . . is the approximate number of lives that could be saved annually by deploying just two [Intersection Movement Assist (IMA) and Left Turn Assist (LTA)] of the many connected vehicle safety applications being developed by the USDOT. . . . NHTSA estimates that a connected vehicle safety application that helps drivers safely negotiate intersections could help prevent 41 to 55 percent of intersection crashes. Another connected vehicle safety application that helps drivers take left turns at intersections could help prevent 36 to 62 percent of left-turn crashes, according to NHTSA. In addition to the lives saved, just these two applications [IMA and LTM] alone could prevent up to 592,000 crashes and 270,000 injuries each year.[18]

The Center for Transportation Research has predicted that by 2030 to 2035 vehicle-to-vehicle connections could reduce accidents by 76 percent.[19] These benefits arise because the

[16] *Intel News Fact Sheet: The 5G - Autonomous Driving Connection*, INTEL NEWSROOM (Jan. 2017), https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2017/01/why-5G-for-ad-fact-sheet.pdf.

[17] Bijan Khosravi, *Autonomous Cars Won't Work - Until We Have 5G*, FORBES (Mar. 25, 2018), https://www.forbes.com/sites/bijankhosravi/2018/03/25/autonomous-cars-wont-work-until-we-have-5g/#227263c6437e.

[18] *Connected Vehicle Basic Facts*, U.S. DEP'T OF TRANSP., https://www.its.dot.gov/cv_basics/cv_basics_facts.htm#fact3 (last visited June 3, 2018)*; see also*, *Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application*, U.S. DEP'T OF TRANSP., (Aug. 2014), https://www.nhtsa.gov/staticfiles/rulemaking/pdf/V2V/Readiness-of-V2V-Technology-for-Application-812014.

[19] This research was limited to north central Texas. JAMES KUHR ET AL., TRAVEL MODELING IN AN ERA OF CONNECTED AND AUTOMATED TRANSPORTATION SYSTEMS: AN INVESTIGATION IN THE DALLAS-FORT WORTH AREA 25 (2017), http://www.caee.utexas.edu/prof/bhat/REPORTS/DSTOP_122.pdf.

applications can foresee issues, such as impending collisions with another vehicle or a pedestrian and rectify them in real time.

8. Connected and autonomous car applications would also reduce traffic congestion by capitalizing on data generated from vehicle-to-vehicle connections and from vehicle-to-roadway device connections. Traffic congestion imposes substantial costs on American consumers through wasted time and fuel consumption. According to INRIX Research (referenced by The Economist), congestion cost U.S. drivers approximately $305 billion in 2017 – an average of $1,445 per driver.[20]

9. USDOT recognized that technology and innovation will play a critical role in improving mobility and reducing traffic congestion, which will in turn improve the economy and increase utility for the average U.S. citizen:

> Intelligent transportation technologies like [V2V and V2I] have the capacity to create safer vehicles and roadways by enhancing crash avoidance capabilities; enhance mobility by exploring methods and strategies that increase system efficiency and improve individual mobility; and better manage traffic flow and reduce congestion. Each of these improvements enables infrastructure to operate more efficiently, to better support future economic growth and to improve the lives of everyday Americans.[21]

10. Connected vehicles that can interface with its surrounding infrastructure may lead to material decreases in traffic congestion. For example, Carnegie Mellon University found that a test of smart traffic lights in Pittsburgh resulted in a 40 percent reduction in vehicle wait time, a

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[20] *The Hidden Cost of Congestion*, THE ECONOMIST (Feb. 28, 2018) (citing *INRIX 2017 Global Traffic Scorecard*, INRIX RESEARCH 18, 40 (Feb. 2018)), https://www.economist.com/graphic-detail/2018/02/28/the-hidden-cost-of-congestion*; see also*, Press Release, Texas A&M Transp. Inst., Traffic Gridlock Sets New Records for Traveler Misery (Aug. 26, 2015), https://mobility.tamu.edu/ums/media-information/press-release/.

[21] *Improving America's Transportation Infrastructure: The Road Forward: Hearing Before the S. Comm. on Env't and Pub. Work* (May 17, 2017) (statement of Elaine L. Chao, Sec'y of Transp.), https://www.transportation.gov/content/improving-americas-transportation-infrastructure-road-forward.

26 percent faster commute, and a 21 percent decrease in vehicle emissions.[22] While this test was not operating over a 5G network, smart traffic-management systems operating over a 5G network could increase the flow of traffic by changing traffic signals based on real-time traffic patterns monitored by cameras and sensors connected to a shared network throughout a city.[23]

11. 5G is necessary to deploy the variety of safety, performance, and infotainment applications contemplated for connected cars on a wide-scale basis. Some of the envisioned applications, particularly for safety, have to work in essentially real-time and be highly reliable.[24] This requires the low latency and low block-error rate only made possible by 5G.[25] The country also would need to have a massive number of connected devices – in vehicles but also in the road system – to optimize vehicular safety and minimize congestion.[26] Current cellular networks using 4G LTE technology cannot handle the density of connections required

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[22] Dylan Miller & Jonathan Hadad, *How 5G Could Start a Transportation Revolution in Smart Cities*, IBIS WORLD (April 6, 2018), https://www.ibisworld.com/media/2018/04/06/how-5g-could-start-a-transportation-revolution-in-smart-cities/.

[23] Dylan Miller & Jonathan Hadad, *How 5G Could Start a Transportation Revolution in Smart Cities*, IBIS WORLD (April 6, 2018), https://www.ibisworld.com/media/2018/04/06/how-5g-could-start-a-transportation-revolution-in-smart-cities/.

[24] *See* HUSAIN M. ABDUL AZIZ ET AL., SYNTHESIS STUDY ON TRANSITIONS IN SIGNAL INFRASTRUCTURE AND CONTROL ALGORITHMS FOR CONNECTED AND AUTOMATED TRANSPORTATION 8-10 (June 2017), https://info.ornl.gov/sites/publications/files/Pub75211.pdf.

[25] *See* HUSAIN M. ABDUL AZIZ ET AL., SYNTHESIS STUDY ON TRANSITIONS IN SIGNAL INFRASTRUCTURE AND CONTROL ALGORITHMS FOR CONNECTED AND AUTOMATED TRANSPORTATION 8-10 (June 2017), https://info.ornl.gov/sites/publications/files/Pub75211.pdf; James Kuhr et al., *Travel Modeling in an Era of Connected and Automated Transportation Systems: An Investigation in the Dallas-Fort Worth Area* 17-18 (Ctr. for Trans. Research, Report No. D-STOP/2017/122, Feb. 2017), http://www.caee.utexas.edu/prof/bhat/REPORTS/DSTOP_122.pdf; IEEE, IEEE 5G AND BEYOND TECHNOLOGY ROADMAP WHITE PAPER 10 (Oct. 2017), https://5g.ieee.org/images/files/pdf/ieee-5g-roadmap-white-paper.pdf.

[26] IEEE, IEEE 5G AND BEYOND TECHNOLOGY ROADMAP WHITE PAPER 10, 26 (Oct. 2017), https://5g.ieee.org/images/files/pdf/ieee-5g-roadmap-white-paper.pdf; *A Study on 5G V2X Deployment*, 5G-PPP AUTO. WORKING GROUP 5 (Feb. 2018), https://5g-ppp.eu/wp-content/uploads/2018/02/5G-PPP-Automotive-WG-White-Paper_Feb.2018.pdf.

for connected and autonomous vehicle applications to work.[27] Finally, these types of applications will also rely on the large bandwidth 5G is expected to deliver.[28]

II. 5G Will Increase Manufacturing Productivity

12. Manufacturing contributed $2.24 trillion, about 11.6 percent, to GDP in 2017.[29] Developers are working on using 5G technologies to improve factory automation. Each step of the manufacturing process involves the use of many sensors and actuators. According to IEEE, these components are increasingly using wireless connections to avoid wear and reduce the cost of running wires to difficult locations.[30]

13. This movement towards deploying information and communication-related technologies in manufacturing processes has been termed "Industry 4.0." Boston Consulting Group (BCG) described Industry 4.0 as a process that makes it possible to gather and analyze data across machines, which would enable "faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs."[31] BCG identified nine technologies that are

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[27] *See, e.g.*, Heejung Yu, et al., *What is 5G? Emerging 5G Mobile Services and Network Requirements*, 9 SUSTAINABILITY Volume 9, Issue 10 (Oct. 15, 2017), http://www.mdpi.com/2071-1050/9/10/1848/htm; *The 5G-Autonomous Driving Connection*, INTEL (May 2017), https://newsroom.intel.com/wp-content/uploads/sites/11/2017/05/why-5G-for-ad-fact-sheet.pdf; *Things You Can Do Today to Build a '5G Ready Network'*, CASA SYSTEMS, http://www.casa-systems.com/assets/Casa-Opinion-Paper-5G-Ready-Network.pdf; *The Road to 5G: Drivers, Applications, Requirements and Technical Development*, GSA 8 (Nov. 2015), http://www.huawei.com/minisite/5g/img/GSA_the_Road_to_5G.pdf; Oliver Rist, *For Truly Connected Cars, We Need to Wait for 5G*, PC MAGAZINE (Jan. 9, 2018), https://www.pcmag.com/news/358436/for-truly-connected-cars-we-need-to-wait-for-5g.

[28] IEEE, IEEE 5G AND BEYOND TECHNOLOGY ROADMAP WHITE PAPER 10 (Oct. 2017), https://5g.ieee.org/images/files/pdf/ieee-5g-roadmap-white-paper.pdf.

[29] *Industry Data*, U.S. DEP'T OF COMMERCE, BUREAU OF ECON., (April 19, 2018), https://bea.gov/iTable/iTable.cfm?reqid=51&step=51&isuri=1&5114=a&5102=1#reqid=51&step=51&isuri=1&5114=a&5102=1.

[30] ANTONIO ORSINO ET AL., IEEE, FACTORIES OF THE FUTURE ENABLED BY 5G TECHNOLOGY (2018), https://5g.ieee.org/images/files/pdf/applications/Factories-of-the-Future-Enabled-by-5G-Technology_030518.pdf.

[31] *Embracing Industry 4.0-and Rediscovering Growth*, BCG: OPERATIONS, https://www.bcg.com/en-us/capabilities/operations/embracing-industry-4.0-rediscovering-growth.aspx (last visited June 3, 2018).

the "building blocks" of Industry 4.0: autonomous robots, the cloud, the industrial IoT, cyber security, augmented reality, big data and analytics, additive manufacturing, simulation, and horizontal and vertical system integration.[32] These technologies are intended to help enable real-time responses, allow for real-time decision making, leverage real-time data, and achieve reaction times from the cloud in milliseconds to increase deployment of machine data and functionality to the cloud.[33]

14. IEEE has found that "[t]he major challenge for wireless communication systems [in industrial automation] are high requirements regarding latency, synchronism, and reliability for closed-loop control applications in factory automation."[34] Current wireless technologies, such as WiFi, "do not offer sufficient performance with respect to real-time and reliability requirements" for these applications.[35] In particular, "just as there are no bandwidth guarantees when on WiFi, similarly, there are no guarantees on the latency of the first wireless hop."[36] The presence of multiple competing WiFi access points and devices could lead to latencies as

[32] *Embracing Industry 4.0-and Rediscovering Growth*, BCG: OPERATIONS, https://www.bcg.com/en-us/capabilities/operations/embracing-industry-4.0-rediscovering-growth.aspx (last visited June 3, 2018).

[33] *Embracing Industry 4.0-and Rediscovering Growth*, BCG: OPERATIONS, https://www.bcg.com/en-us/capabilities/operations/embracing-industry-4.0-rediscovering-growth.aspx (last visited June 3, 2018).

[34] ANTONIO ORSINO ET AL., IEEE, FACTORIES OF THE FUTURE ENABLED BY 5G TECHNOLOGY (2018), https://5g.ieee.org/images/files/pdf/applications/Factories-of-the-Future-Enabled-by-5G-Technology_030518.pdf.

[35] ANTONIO ORSINO ET AL., IEEE, FACTORIES OF THE FUTURE ENABLED BY 5G TECHNOLOGY (2018), https://5g.ieee.org/images/files/pdf/applications/Factories-of-the-Future-Enabled-by-5G-Technology_030518.pdf.

[36] Ilya Grigorik, *WiFi*, HIGH PERFORMANCE BROWSER NETWORKING, https://hpbn.co/wifi/ (last visited June 3, 2018). The author Ilya Girgorik is a web performance engineer at Google and co-chair of the W3C Web Performance Working Group.

high as hundreds of milliseconds.[37] Thus, "[i]f your application is latency sensitive, then you may need to think carefully about adapting its behavior when running over a WiFi network."[38]

15. Ericsson, one of the leading developers of forthcoming 5G equipment,[39] has observed that low latency 5G networks will enable industries to upgrade to a digital platform because "[g]uaranteed real-time communication between humans, robots, factory logistics and products is a fundamental prerequisite of the Industry 4.0 concept."[40] Expanding the use of wireless technologies in manufacturing will also depend on other capabilities of 5G technology, including "standardized networking capabilities, built-in security, guaranteed grades of service, as well as distributed cloud and network slicing concepts."[41] In sum, "5G is a perfect tool for advanced industries that want to take advantage of digital transformation."[42]

16. 5G Americas further highlighted that 5G technology can enable the transformation to industrial automation (i.e., Industry 4.0) by supporting advances in mass connectivity, cloud computing, big analytics, and intelligent automation.[43] Notable aspects of the transformation

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[37] Ilya Grigorik, *WiFi*, HIGH PERFORMANCE BROWSER NETWORKING, https://hpbn.co/wifi/ (last visited June 3, 2018).

[38] Ilya Grigorik, *WiFi*, HIGH PERFORMANCE BROWSER NETWORKING, https://hpbn.co/wifi/ (last visited June 3, 2018).

[39] Scott Bicheno, *Ericsson and the Middle East are Leading the 5G Race*, TELECOMS (Feb. 21, 2018), http://telecoms.com/487902/ericsson-and-the-middle-east-are-leading-the-5g-race/.

[40] Roberto Sabella et al., *5G and Industrial Application*, 96 ERICSSON TECH. REV. 41 (2018), https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2018/etr_magazine_2018_01.pdf.

[41] Roberto Sabella et al., *5G and Industrial Application*, 96 ERICSSON TECH. REV. 41 (2018), https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2018/etr_magazine_2018_01.pdf.

[42] Roberto Sabella et al., *5G and Industrial Application*, 96 ERICSSON TECH. REV. 41 (2018), https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2018/etr_magazine_2018_01.pdf.

[43] 5G AMERICAS, 5G SERVICES & USE CASES 12 (2017), http://www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf.

include:[44] (a) industrial process automation,[45] (b) automated production lines,[46] (c) inventory and supply chain optimization,[47] (d) inter- and intra-enterprise communication,[48] and (e) remote-human IoT.[49]

17. Productivity is widely recognized as an essential component of long-term economic growth and development.[50] While U.S. productivity experienced growth after 1995, there was a marked deceleration since 2004 – with over half of the overall decline resulting from the manufacturing sector.[51] According to the U.S. Bureau of Labor Statistics, productivity growth

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[44] 5G AMERICAS, 5G SERVICES & USE CASES 12-13 (2017), http://www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf.

[45] *Industrial Process Automation* involves processes that can be spread over a large area and use a large number of sensors/actuators to monitor/control complex interconnected processes and that high availability and reliability is required to ensure both the seamless production and ability to adapt processes in real-time.

[46] *Automated Production Lines* involves various types of devices such as sensors, robots, and actuators in a production line which requires low latency and high reliability to achieve a high degree of productivity.

[47] *Inventory and Supply Chain Optimization* involves leveraging a large number of sensors/platforms to automate inventory and supply chain management decisions which can be enabled through 5G technologies related to mass connections, end-to-end operation of broad coverage areas, offering advantages over the RFID technologies that are currently used

[48] *Inter- and Intra-Enterprise Communication* involves communications that require secure connectivity and real-time coordination between different nodes within and between enterprises.

[49] *Remote-Human IoT* involves utilizing augmented and virtual reality which can provide remote human guidance (e.g., remote control of instruments, robots, and others) for applications such as conducting measurements, handling of hazardous material, digging, teleoperating industry vehicles which require high-speed, low latency, and reliable connectivity

[50] *See, e.g.*, Martin Neil Baily & Nicholas Montalbano, *Why is U.S. Productivity Growth So Slow* 1 (The Brookings Inst. Hutchins Ctr. On Fiscal and Monetary Pol'y, Working Paper No. 22, 2016), https://www.brookings.edu/wp-content/uploads/2016/09/wp22_baily-montalbano_final4.pdf; James Bullard, *Higher GDP Growth in the Long Run Requires Higher Productivity Growth*, FEDERAL RESERVE BANK OF ST. LOUIS: REGIONAL ECONOMIST (Oct. 2016), https://www.stlouisfed.org/publications/regional-economist/october-2016/higher-gdp-growth-in-the-long-run-requires-higher-productivity-growth; JAMES MANYIKA ET. AL., MCKINSEY GLOB. INST., THE PRODUCTIVITY PUZZLE: A CLOSER LOOK AT THE UNITED STATES 1 (2017), https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Employment%20and%20Growth/New%20insights%20into%20the%20slowdown%20in%20US%20productivity%20growth/MGI-The-productivity-puzzle-Discussion-paper.ashx.

[51] Martin Neil Baily & Nicholas Montalbano, *Why is U.S. Productivity Growth So Slow* 15 (The Brookings Inst. Hutchins Ctr. On Fiscal and Monetary Pol'y, Working Paper No. 22, 2016), https://www.brookings.edu/wp-content/uploads/2016/09/wp22_baily-montalbano_final4.pdf.

in U.S. manufacturing declined from 4.3 percent a year between 2000 and 2007, to 0.7 percent a year between 2007 and 2017.[52]

18. Although there is no consensus as to the cause of this decline,[53] 5G technologies have the potential to increase productivity growth.[54] The current trend in the manufacturing industry, as noted above, is to deploy information- and communications-related technologies to gain greater flexibility and more efficient processes in order to manufacture higher-quality products at lower costs, making 5G crucial toward enabling industries to make the upgrade to a digital platform.[55] Indeed, the importance of 5G toward enabling productivity improvement – specifically in physical industries – is widely recognized.[56] According to BCG, two-thirds of

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[52] U.S. Bureau of Lab. Stat., *Productivity Change in the Manufacturing Sector 1987-2017*, LABOR PRODUCTIVITY AND COSTS, https://www.bls.gov/lpc/prodybar.htm (last modified May 3, 2018).

[53] *See, e.g.*, JAMES MANYIKA ET. AL., MCKINSEY GLOB. INST., THE PRODUCTIVITY PUZZLE: A CLOSER LOOK AT THE UNITED STATES 2 (2017), https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Employment%20and%20Growth/New%20insights%20into%20the%20slowdown%20in%20US%20productivity%20growth/MGI-The-productivity-puzzle-Discussion-paper.ashx (McKinsey reported that there are various possible explanations but most fall under the following three (non-exclusive) categories: (1) productivity is increasingly difficult to measure and therefore current estimates have failed to capture actual productivity growth; (2) shortage of demand and investment (secular stagnation) is constraining growth; and (3) technological innovation is either not as transformative as it historically was or there's a delayed response between the impact of new technologies and the realized productivity benefits). *See also*, Martin Neil Baily & Nicholas Montalbano, *Why is U.S. Productivity Growth So Slow* 15 (The Brookings Inst. Hutchins Ctr. On Fiscal and Monetary Pol'y, Working Paper No. 22, 2016), https://www.brookings.edu/wp-content/uploads/2016/09/wp22_baily-montalbano_final4.pdf.

[54] *See, e.g.,* Soumik Roy, *5G in 5 Minutes for Manufacturers*, TECHWIRE ASIA (Mar. 12, 2018), http://techwireasia.com/2018/03/5g-5-minutes-manufacturers/; *5G for Manufacturing*, ERICSSON.COM, https://www.ericsson.com/en/networks/trending/insights-and-reports/5g-for-manufacturing (last visited June 3, 2018).

[55] *Embracing Industry 4.0-and Rediscovering Growth*, BCG: OPERATIONS, https://www.bcg.com/en-us/capabilities/operations/embracing-industry-4.0-rediscovering-growth.aspx (last visited June 3, 2018).

[56] *See, e.g.*, David J. Redl, Assistant Sec'y Nat'l Telecomm. & Info. Admin., U.S. Dep't Comm., Remarks at the BIS 2018 Annual Conference on Export Controls and Policy (May 14, 2018), https://www.ntia.doc.gov/speechtestimony/2018/remarks-assistant-secretary-redl-bis-2018-annual-conference-export-controls-and; FROST & SULLIVAN & PRINCIPAL GLOB. INV'RS, 5G: THE FOUNDATION FOR A HYPER-CONNECTED WORLD 5, 7, 9 (2017), https://go.frost.com/tt-HyperConnectedWorld; MICHAEL MANDEL, PROGRESSIVE POL'Y INST., LONG-TERM U.S. PRODUCTIVITY GROWTH AND MOBILE BROADBAND: THE ROAD AHEAD 6 (2016), http://www.progressivepolicy.org/wp-content/uploads/2016/03/2016.03-Mandel_Long-term-US-Productivity-Growth-and-Mobile-Broadband_The-Road-Ahead.pdf; Austl. Gov't Bureau of Commc'ns & Arts

the 315 U.S. companies with revenues of more than $50 million that it surveyed associated Industry 4.0 with the opportunity of achieving "increased productivity" and "cost reduction."[57]

19. BCG has also analyzed the potential impact Industry 4.0 could have on the German economy, concluding that the country's manufacturing sectors would see an increase in productivity of approximately €90 billion to €150 billion over a 5 to 10 year period – resulting in productivity gains of 5 percent to 8 percent including materials costs.[58] An Ericsson study related of the milling processes of bladed disks, which are important components of turbines, concluded that 5G-enabled real-time monitoring, real-time control, and automated factories could translate to €360 million in annual savings globally.[59] These savings would result from very low, stable, and predictable latency.[60] The Australian Bureau of Communications and Arts Research also found that 5G would have a positive effect on productivity growth across the Australian economy, estimating that 5G would add up to $2,000 in GDP per capita within a

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Res., *Impacts of 5G on Productivity and Economic Growth* 2 (April 2018) (working paper), https://www.communications.gov.au/file/35551/download?token=0MlSFttv.

[57] Markus Lorenz et al., *Time to Accelerate in the Race Toward Industry 4.0*, BCG (May 19, 2016), https://www.bcg.com/en-us/publications/2016/lean-manufacturing-operations-time-accelerate-race-toward-industry-4.aspx.

[58] Philipp Gerbert et al., *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries*, BCG (April 9, 2015), https://www.bcg.com/en-us/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx.

[59] ERICSSON CONSUMER & INDUS. LAB, BRINGING 5G BUSINESS VALUE TO INDUSTRY 4-6 (2018), https://www.ericsson.com/assets/local/networked-society/consumerlab/reports/2018/bringing-5g-business-value-to-industry.pdf.

[60] ERICSSON CONSUMER & INDUS. LAB, BRINGING 5G BUSINESS VALUE TO INDUSTRY 4-6 (2018), https://www.ericsson.com/assets/local/networked-society/consumerlab/reports/2018/bringing-5g-business-value-to-industry.pdf.

decade of rollout.[61] It estimated that, globally, 5G may stimulate over $12 trillion in economic activity, over $3.4 trillion of which will be in manufacturing.[62]

20. I am not endorsing any of these numbers, which obviously require a degree of speculation. But these figures emphasize that serious analysts expect that 5G will have an economically substantial impact on the manufacturing sector.

III. 5G Will Enable Governments to Develop Smart Cities and Smart Infrastructure

21. Smart Cities encompass a variety of technology applications that include lighting, security, energy and utilities, physical infrastructure environmental monitoring, and transportation and mobility.[63] They offer a range of benefits including enhanced livability, cost savings, and increased safety and security, and they can promote economic growth.[64] One benefit of a smart city is the ability for devices to communicate to help manage traffic congestion – through a connection between smart traffic lights and a connected vehicle for example. Efficient transportation within a city would help taxi drivers, for example, to reduce gas expenses and increase the frequency of pickups, while also increasing the efficiency of couriers and local delivery services.[65]

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[61] *5G Should Boost Productivity and Economic Growth*, FIRST5000 (Apr. 14, 2018), http://www.first5000.com.au/blog/5g-should-boost-productivity-and-economic-growth/.

[62] Austl. Gov't Bureau of Commc'ns & Arts Res., *Impacts of 5G on Productivity and Economic Growth* 6-7, Fig. 2 (Apr. 2018) (working paper), https://www.communications.gov.au/file/35551/download?token=0MlSFttv.

[63] KAREN CAMPBELL ET AL., IHS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 23 (2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf.

[64] DOMINIQUE BONTE, ROLE OF SMART CITIES FOR ECONOMIC DEVELOPMENT 1 (ABI Research 2018), https://www.chordant.io/white_papers/abi-research-role-of-smart-cities-for-economic-development?submit_success=true.

[65] "Dylan Miller & Jonathan Hadad, *How 5G Could Start a Transportation Revolution in Smart Cities*, IBISWORLD ANALYST INSIGHTS (Apr. 6, 2018), https://www.ibisworld.com/media/2018/04/06/how-5g-could-start-a-transportation-revolution-in-smart-cities/.

22. Smart Grid systems, which are an important element of Smart Cities, can monitor, protect, and optimize operations within the system by way of its interconnected elements (e.g., from central and distributed generators, to industrial users and building automation systems, to energy storage installations, and to end-use consumers and their thermostats, electric vehicles, appliances, and other household devices).[66] Many cities have already begun investing in Smart Grid systems.[67] According to Accenture, 5G would allow these systems and devices to more accurately monitor and better support energy needs, reduce energy costs, and potentially reduce downtime.[68] For example, "[i]n the event of power failure, smart grid technology [utilizing 5G would enable] precise, real-time diagnosis, down to the specific pole or transformer affected by an outage, which speeds up repairs and reduces downtime."[69]

23. CTIA indicated that Smart Grid modernization investments could total as much as $1.3 trillion over a 15 year period in the United States.[70] Moreover, an Ericsson survey illustrated that 75 percent of corporate stakeholders within the energy and utilities sector intended to invest in 5G technologies to realize the "operational efficienc[ies]" expected to be provided by

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[66] ELEC. POWER RES. INST., ESTIMATING THE COSTS AND BENEFITS OF THE SMART GRID 21 (2011), https://www.smartgrid.gov/files/Estimating_Costs_Benefits_Smart_Grid_Preliminary_Estimate_In_201103.pdf.

[67] These cities include Austin, TX; Boulder, CO; Fort Collins, CO; Maui, HI; Sacramento, CA; San Diego, CA; Tempe, AZ; Washington, DC, and Worcester, MA. Alex Kingsbury, *10 Cities Adopting Smart Grid Technology*, U.S. NEWS, https://www.usnews.com/news/energy/slideshows/10-cities-adopting-smart-grid-technology?onepage (last visited June 3, 2018).

[68] MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES, HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 7 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf.

[69] MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES, HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 7 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf.

[70] CTIA, THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. 9 (2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf.

5G.[71] According to Accenture: "5G technology will help unleash the next wave of Smart Grid features and efficiency. Across the United States, Smart Grid benefits are estimated to be as high as $2 trillion dollars over 20 years."[72]

24. There are many other 5G-enabled applications that could benefit citizens of a Smart City including, waste management, public health, public safety, and tourism.[73] Depending on the application, 5G's technological improvements – such as enhanced mobile broadband, massive IoT, low power consumption, enhanced mobility, low latency, and high reliability – may all be utilized within a Smart City.

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[71] ERICSSON, THE INDUSTRY IMPACT OF 5G 4 (2018), https://www.ericsson.com/assets/local/narratives/networks/documents/report-bnew-18000486-rev-a-uen.pdf.

[72] MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES, HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 7 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf.

[73] NARENDRA MANGRA & ALIREZA GHASEMPOUR, IEEE, SMART CITIES: CONNECTED ECOSYSTEM OF ECOSYSTEMS 2-3, https://5g.ieee.org/images/files/pdf/applications/Smart-Cities_030518.pdf; MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES, HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 7 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf.

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Curriculum Vitae

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Professional Summary

My academic work has focused on industrial organization, including antitrust economics, with a particular expertise in multisided platforms, digital economy, information technology, and payment systems. I have authored 8 books, including two award winners, and more than 100 articles in these areas. I have developed and taught courses related to antitrust economics, primarily for graduate students, judges and officials, and practitioners, and have authored handbook chapters on various antitrust subjects.

My expert work has focused on competition policy and regulation. I have served as a testifying or consulting expert on many significant antitrust matters in the United States, European Union, and China. I have also made submissions to, and appearances before, competition and regulatory authorities with respect to mergers and investigations in those and other jurisdictions. I have worked on litigation matters for defendants and plaintiffs, on mergers for merging parties and intervenors, and for and in opposition to competition authorities.

Representative Matters

Federal Trade Commission v. 1-800 Contacts. Testimony on behalf of the FTC concerning the competitive effects of agreements between 1-800 Contacts and other online sellers of contact lenses that restricted certain forms of search advertising. Expert report and trial testimony on the economics of search engines and search advertising, market definition, and competitive effects. (April 2017).

Comcast's Proposed Acquisition of Time Warner Cable. On behalf of Netflix, submitted multiple declarations to the Federal Communications Commission in opposition to the merger and made appearances before the Federal Communications Commissions and U.S. Department of Justice. (July 2014-April 2015).

Qihoo 360 v. Tencent. Written testimony in support of Tencent before the Supreme People's Court, People's Republic of China, concerning Qihoo 360's market definition and abuse of dominance claims against Tencent. This was the first antitrust matter decided under the Anti-Monopoly Law by the Supreme Court of China. (September 2013)

Federal Reserve Board Debit Card Interchange Fees and Routing Rulemaking Procedure. Written submissions on behalf of a group of financial institutions concerning the Federal Reserve Board's preliminary proposed rules concerning debit interchange fees. (January – June 2011).

European Commission v. Microsoft. Oral testimony and written submissions before the Grand Chamber, European Court of First Instance (now the European General Court) on behalf of Microsoft concerning economic aspects of the European Commission's Decision that Microsoft had abused its dominant position with respect to media players and server interoperability. Made several appearnances of various topics over five days. (April 2006).

Professional Positions

Market Platform Dynamics (2004-present)
　　Founder

Global Economics Group (2011-present)
　　Chairman

University College London (2004-present)
　　Executive Director, Jevons Institute for Competition Law and Economics
　　Visiting Professor in the Faculty of Laws

University of Chicago Law School (2006-2016)
　　Lecturer

LECG, LLC (2004-2011)
　　Vice Chairman, LECG Europe
　　Head, Global Competition Policy Practice
　　Member of the Boards of Directors of various subsidiaries

NERA Economic Consulting (1988-2004)
　　Senior Vice President
　　Member of the Management Committee
　　Member of the Board of Directors

Fordham University (1983-1995)
Professor of Law, Fordham University Law School (1985-1995)
Associate Professor of Economics (1983-1989) (tenured as of 1988)

Charles River Associates (1975-1979)
Senior Consultant

Education

Ph.D., MA Economics, University of Chicago, 1983

B.A. Economics, University of Chicago, 1975 (completed first year of graduate program)

Teaching and Editorships

Teaching

University College London: "Multisided Plaforms: Business Economics & Competition Policy," intensive course taught annually since 2014; "Digital Economy: Economics, Antitrust & Regulation," intensive course taught annually since 2016 at University College London; "The Role of Economics in Competition Law and Economics", annual course taught 2005-2011.

University of Chicago, "EC Competition Law and Economics," quartly seminar course taught 2006-2016.

Competition Policy International, "Antitrust Economics," 32 lecture online course, offered in 2013-2014.

Training for Judges and Officials

Training courses on antitrust law and economics for Chinese Supreme Court and High Court Judges, sponsored by Ministry of Industy and Information Technology, 2013-15; lectures on market definition, tying, platforms, dynamic competition and innovation, and antitrust of online industries.

Faculty, Training courses on antitrust law and economics for European Judges, sponsored by University College London and University of Touslouse, 2009-2010; lectures on basic economics and antitrust and intellectual property.

Editorships

Managing Editor, *Competition Policy International,* 2004-present

Publisher, Antitrust Chronicle, 2008-present

Editorial Board, *Review of Network Economics,* 2004-2015

Honors and Rankings

Gold Medal Winner, Economics, 2017 Axiom Business Books Awards, for *Matchmakers: The New Economics of Multisided Platforms* (with R. Schmalensee)

Winner of the Business, Management & Accounting category in the 2006 Professional/Scholarly Publishing Annual Awards presented by the Association of American Publishers, Inc. for *Invisible Engines: How Software Platforms Drive Innovation and Transform Industries* (with R. Schmalensee).

Top 2% of economists, IDEAS, based on average rank score (May 2017)

Ranked 12th most downloaded economist and 15th most downloaded law professor, Social Science Research Network; ranked 243 out of 8000 economists and 16 out of 3000 law professors based on quality weighted citations (May 2017).

Appearances in Competition and Regulatory Matters

Trial Testimony

In the Matter of 1-800 Contacts, Before the Federal Trade Commission, Office of Administrative Law Judges, Docket No. 9372. Testified in support of the Federal Trade Commission, concerning the competitive effects of agreements between 1-800 Contacts and other online sellers of contact lenses that restricted certain forms of search advertising. (April 2017).

In the Matter of the Application of Securities Industry and Financial Markets Association For Review of Actions Taken by Self-Regulatory Organizations Administrative Proceeding File No. 3-15350. Testified in support of the Securities Industry and Financial Markets Association (SIFMA), concerning whether securities exchanges face significant competitive constraints in setting their fees for depth-of-book data products. (April 2015).

Qihoo 360 v. Tencent. Written testimony in support of Tencent before the Supreme People's Court, People's Republic of China, concerning Qihoo 360's market definition and abuse of dominance claims against Tencent. (Written testimony filed for September 2013 trial). Also testified before the Guangdong High Court. (Written submission, April 2012)

Presidential Emergency Board No. 243, National Mediation Board, Case Nos. A-13569, A-13570, A-13572, A-13573, A-13574, A-13575, and A-13592. Testified in support of the National Railway Labor Conference concerning wages, benefits, and work rules for railroad workers. (October 2012).

Case T-201/04, *Microsoft v. Commission of the European Communities*. Testified in support of Microsoft before the Grand Chamber, Court of the First Instance of the European Union concerning the Commission's determination that Microsoft had abused its dominant position by refusing to license certain information regarding its operating system and by tying a media player to its Windows operating system. (April 2006).

Case T-201/04, *Microsoft v. Commission of the European Communities*. Testified before the President, Court of the First Instance of the European Union in support of Microsoft's application for a suspension of remedies during its appeal of a Commission decision. (October 2004).

Case T-201/04, *Microsoft v. Commission of the European Communities*. Testified before Hearing Officer of the European Commision concerning the Commission's determination that Microsoft had abused its dominant position by refusing to license certain information regarding its operating system and by tying a media player to its Windows operating system. (October 2003).

Deposition Testimony

In the Matter of 1-800 Contacts, Before the Federal Trade Commission, Office of Administrative Law Judges, Docket No. 9372. Testified for the Federal Trade Commission, concerning the competitive effects of agreements between 1-800 Contacts and other online sellers of contact lenses that restricted certain forms of search advertising. (March 2017).

MarchBanks Truck Service, Inc., et al. v. Comdata Network, Inc., et al., Case No. 07-1078-JKG. Testified for defendant concerning allegations of anticompetitive behavior with respect to Comdata's agreements with certain truck stop chains. (August 2013).

Meredith Corporation et al. v. SESAC, Case No. 09 Civ. 9177 (PAE). Testified for defendant concerning allegations of anticompetitive behavior with respect to the blanket licensing of local television music performance rights. (May 2013).

Other Significant Antitrust Matters

Comcast Time Warner Cable Transaction, MB Docket No. 14-57, Federal Communications Commission, Economists Roundtable, January 2015, as well as several presentations to FCC senior staff and officials.

U.S. v. Visa et al. concerning alleged exclusionary rules and duality and *U.S. v. Visa et al.* concerning alleged tying of credit and debit cards. On behalf of Visa, lead consulting economics team and worked with testifying experts.

U.S. v. Microsoft concerning alleged monopolization. On behalf of Microsoft, lead consulting economics team, including recruiting and working with testifying experts, for the 1998-1999 original trial and the 2002 trial concerning remedies.

U.S. v. AT&T concerning alleged monopolization. On behalf of the U.S. Department of Justice, lead consulting economics team, and worked with testifying expert, on rebuttal economics testimony.

Amicus Briefs

Brief of Amici Curiae of David S. Evans and Richard Schmalensee in Support of Respondents, *State of Ohio, et al., v. American Express Company, et al.* U.S. Supreme Court, 2018.

Brief of Amici Curiae of David S Evans and Richard Schmalensee in Support of Appellants-Cross Appellees, *US Airways v. Sabre Holdings Corp.*, 2nd Circut, 2017.

Brief of Amici Curiae Economists in Support of Petitioners, *Bell Atlantic v. Twombly,* U.S. Supreme Court, 2007 (Principal Author and Signatory).

Brief of Amici Curiae Economists in Support of Petitioners, *Leegin Creative Leather Products, Inc. v. PSKS, Inc.,* U.S. Supreme Court, 2007 (Contributor and Signatory)

Appearances And Submissions Before Competition and Regulatory Authorities

Australian Competition and Consumer Commission
Federal Cartel Office, Germany
Competition Commission of Singapore
Directorate General for Competition, European Commission
Korean Fair Trade Commission
Ministry of Commerce, People's Republic of China
National Development and Reform Commission, People's Republic of China
U.K. Competition and Market Authority
U.S. Federal Reserve Board
U.S. Department of Justice
U.S. Federal Communications Commission
U.S. Federal Trade Commission
U.S. Securities and Exchange Commission

Publications

Books

Matchmakers: The New Economics of Multisided Platforms (Cambridge, MA: Harvard Business School Press, 2016). Published or pending translations in Chinese, French, Japanese, Korean, Russian, Spanish, Vietnamese. Gold Medal Winner, Economics, 2017 Axiom Business Book Awards.

Platform Economics: Essays on Multi-Sided Businesses, (Boston, Competition Policy International, 2011), with R. Schmalensee, M. Noel, H. Chang, and D. Garcia-Swartz. (Published in Chinese in 2016 by Economic Science Press.)

Interchange Fees: The Economics and Regulation of What Merchants Pay for Cards, (Boston, Competition Policy International, 2011), with R. Schmalensee, R. Litan, D. Garcia-Swartz, H. Chang, M. Weichert, A. Mateus.

Trustbusters: Competition Authorities Speak Out (Boston: Competition Policy International, 2009), co-editor with F. Jenny.

Catalyst Code: The Strategies of the World's Most Dynamic Companies (Massachusetts: Harvard Business School Press, 2007), with R. Schmalensee. Translated into Chinese, Korean, Polish, and Russian.

Invisible Engines: How Software Platforms Drive Innovation and Transform Industries, (Massachusetts: MIT Press, 2006), with A. Hagiu and R. Schmalensee. Translated into Chinese and Korean.Winner of the Business, Management & Accounting category in the 2006 Professional/Scholarly Publishing Annual Awards presented by the Association of American Publishers, Inc.

Paying with Plastic: The Digital Revolution in Buying and Borrowing (Massachusetts: MIT Press, first edition 1999, second edition 2005), with R. Schmalensee. Translated into Chinese.

Microsoft, Antitrust and the New Economy: Selected Essays (New York: Kluwer Academic Publishers, 2002), editor.

The Economics of Small Businesses: Their Role and Regulation in the U.S. Economy (New York: Holmes and Meier, 1986), with W. Brock.

Breaking Up Bell: Essays on Industrial Organization and Regulation (New York: Elsevier, 1983), editor and co-author of eight of ten chapters.

Articles, Book Chapters, and Working Papers

(Note: links to most of my publications since 2001 appear on my SSRN Home page and links to most of my publications before 2001 appear on my IDEAS Home page.)

"Multi-Sided Platforms," *New Palgrave Dictionary of Economics Online*, 2017 (with R. Schmalensee) (forthcoming).

"The Economics of Attention Markets," Working Paper, 2017.

"Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and Edge Providers," Working Paper, 2017.

"Network Effects: March to the Evidence, Not to the Slogans," *Antitrust Chronicle*, September 2017 (with R. Schmalensee).

"Why the Dynamics of Competition for Online Platforms Leads to Sleepless Nights, But Not Sleepy Monopolies," Working Paper, 2017.

"The Emerging High-Court Jurisprudence on the Antitrust Analysis of Multisided Platforms," *Antitrust Chronicle*, February 2017.

"The Businesses That Platforms Are Actually Disrupting," *Harvard Business Review*, September 21, 2016 (with R. Schmalensee).

"Mobile Advertising: Economics, Evolution, and Policy," *Antitrust Chronicle,* June 2016.

"A Deep Look Inside Apple Pay's Matchmaker Economics," *Harvard Business Review*, June 17, 2016 (with R. Schmalensee).

"The Best Retailers Combine Bricks and Clicks," *Harvard Business Review*, May 30, 2016 (with R. Schmalensee).

"What Platforms Do Differently than Traditional Businesses," *Harvard Business Review*, May 11, 2016 (with R. Schmalensee).

"Why Winner-Takes-All Thinking Doesn't Apply to the Platform Economy," *Harvard Business Review*, May 4, 2016 (with R. Schmalensee).

"Some of the Most Successful Platforms Are Ones You've Never Heard Of," *Harvard Business Review*, March 28, 2016 (with R. Schmalensee).

"How We Learned (Almost) Everything That's Wrong with U.S. Census Data," *Harvard Business Review*, March 11, 2016 (with R. Schmalensee).

"Multisided Platforms, Dynamic Competition and the Assessment of Market Power for Internet-based Firms," *Competition Policy International*, Spring 2016.

"The Move to Smart Mobile and Its Implications for Antitrust Analysis of Online Market," *UC Davis Business Law Journal*, 2016 (with Hemant Bhargava and Deepa Mani).

"An Empirical Examination of Why Mobile Money Schemes Ignite in Some Developing Countries but Flounder in Most," *Review of Network Economics*, 2015.

"The Impact of the U.S. Debit Card Interchange Fee Caps on Consumer Welfare: An Event Study Analysis," (with H. Chang and S. Joyce), *Journal of Competition Law and Economics*, 2015.

"The Antitrust Analysis of Multi-Sided Platform Businesses," (with R. Schmalensee), in *Oxford Handbook on International Antitrust Economics*, R. Blair and D. Sokol, eds., Oxford: Oxford University Press, 2015.

"Assessing Unfair Pricing Under China's Anti-Monopoly Law for Innovation-Intensive Industries," University of Chicago Coase-Sandor Institute for Law & Economics Research Paper No. 678. *Competition Policy International*, Spring 2014. Chinese version published in the NDRC Price Journal (with V. Zhang and X. Zhang).

"Economic Aspects of Bitcoin and Other Decentralized Public-Ledger Currency Platforms," University of Chicago Coase-Sandor Institute for Law and Economics Research Paper No. 685, May 2014.

"The Antitrust Analysis of Rules and Standards for Software Platforms," *Competition Policy International*, Autumn 2014.

"Market Definition Analysis in Latin America with Applications to Internet-Based Industries," (with E. Mariscal), Working Paper (University of Chicago Law School and Centro de Investigacion y Docencia Economica), 2013.

"Paying with Cash: A Multi-Country Analysis of the Past and Future Use of Cash for Payments by Consumers," (with K. Webster, G. Colgan, and S. Murray), Working Paper (University of Chicago Law School and Market Platform Dynamics), 2013.

"Payments Innovation and the Use of Cash," (with K. Webster, G. Colgan, and S. Murray), Working Paper (University of Chicago Law School and Market Platform Dynamics), 2013.

"The Consensus Among Economists on Multisided Platforms and Its Implications for Excluding Evidence that Ignores It," *Antitrust Chronicle*, 2013, 6(1).

"Analzying Competition among Internet Players: Qihoo 360 v. Tencent," (with V. Y. Zhang and H. Chang), *Antitrust Chronicle*, 2013, 5(1).

"Attention Rivalry among Online Platforms", *Electronics Intellectual Property, MIIT China*, 2013, 9, 30-41(in Chinese).

"Attention Rivalry among Online Platforms and Its Implications for Antitrust Analysis," *Journal of Competition Law and Economics,* 2013, 9(2), 313-357.

"Economics of Vertical Restraints for Multi-Sided Platforms," *Competition Policy International*, 2013, 9(1).

"The Role of Keyword Advertising in Competition among Rival Brands," (with Elisa Mariscal). *Antitrust Chronicle*, 2012, 12(1).

"Will the Wheatley Recommendations Fix LIBOR?" (with R.M. Abrantes-Metz). *Antitrust Chronicle*, 2012, 11(2).

"Governing Bad Behavior by Users of Multi-Sided Platforms," *Berkeley Technology Law Journal*, 2012, 27(2).

"Replacing the LIBOR with a Transparent and Reliable Index of Interbank Borrowing: Comments on the Wheatley Review of LIBOR Initial Discussion Paper," (with R.M. Abrantes-Metz), University of Chicago Institute for Law and Economics Olin Research Paper No. 620, 2012.

"Two-Sided Market Definition," in *Market Definition in Antitrust: Theory and Case Studies*, 2012.

"Why Come Platform Businesses Face Many Frivolous Antitrust Complaints and What to Do About It," *Competition Policy International*, 2012, 8(2).

"Lightening Up on Market Definition," in *Research Handbook on the Economics of Antitrust Law*, E. Elhauge, ed., New York: Edward Elgar, 2012.

"Payments Innovation and Interchange Fees Regulation: How Inverting the Merchant-Pays Business Model Would Affect the Extent and Direction of Innovation," Working Paper (University of Chicago Law School), 2011.

"How Changes in Payment Card Interchange Fees Affect Consumers Fees and Merchant Prices: An Economic Analysis with Applications to the European Union," with A.M. Mateus, Working Paper (University of Chicago Law School and New University of Lisbon), 2011.

"Economic Analysis of Claims in Support of the 'Durbin Amendment' to Regulation Debit Card Interchange Fees," with H.H. Chang and M.M. Weichert, Working Paper (University of Chicago Law School, Global Economics Group, and Market Platform Dynamics), 2011.

"The Antitrust Economics of Free." *Competition Policy International*, 2011, 7(1).

"Conversations with Jon Leibowitz and Joaquin Almunia," (with Jon Leibowitz and Joaquin Almunia). *Competition Policy International*, 2011, 7(1).

"The Economic Principles for Establishing Reasonable Regulation of Debit-Card Interchange Fees that Could Improve Consumer Welfare," (with R.E. Litan and R. Schmalensee), Working Paper (University of Chicago Law School, AEI-Brookings Joint Center for Regulatory Studies, and MIT), 2011.

"The Regulation of Interchange Fees by the U.S. Federal Reserve Board: A Primer on Economic Principles, II," *Antitrust Chronicle*, 2011, 12(2).

"AT&T/T-Mobile: Does Efficiency Really Count?" (with H. Chang & R. Schmalensee) *Antitrust Chronicle*, 2011, 10(2).

"Net Neutrality Regulation and the Evolution of the Internet Economy," *Antitrust Chronicle*, 2011, 8(2).

"A Presentation on Assessment of Market Power and Dominance," *Antitrust Chronicle*, 2011, 6(1).

"Economic Analysis of the Effects of the Federal Reserve Board's Proposed Debit Card Interchange Fee Regulations on Consumers and Small Businesses," (with R.E. Litan and R. Schmalensee), Working Paper (University of Chicago Law School, AEI-Brookings Joint Center for Regulatory Studies, and MIT), 2011.

"Essays on the Economics of Two-Sided Markets: Economics, Antitrust and Strategy," Working Paper (University of Chicago Law School), 2010.

"Failure to Launch: Critical Mass in Platform Businesses," (with Richard Schmalensee). *Review of Network Economics*, 2010, 9(4).

"The Effect of the Consumer Financial Protection Act of 2009 on Consumer Credit," *Loyola Consumer Law Review*, 2010, 22(3).

"The Web Economy, Two-Sided Markets, and Competition Policy," Working Paper (University of Chicago Law School), 2010.

"Why Now is Not the Time to Revamp Consumer Financial Protection," Working Paper (University of Chicago Law School), 2010.

"The New Consensus on Class Certification: What it means for the Use of Economic and Statistical Evidence in Meeting the Requirements of Rule 23," *Antitrust Chronicle*, 2010, 1(1).

"A Response to Professor Levitin on the Effect of the Consumer Financial Protection Agency Act of 2009 on Consumer Credit," (with J.D. Weight), George Mason Law and Economics Research Paper No. 09-56, 2009.

"The Middle Way on Applying Antitrust to Information Technology," *Antitrust Chronicle*, 2009, 11(2).

"How the Consumer Financial Protection Agency Act of 2009 Would Change the Law and Regulation of Consumer Financial Products," (with J. Wright), *Bloomberg Law Reports: Risk and Compliance*, 2009, 2(10).

"The Online Advertising Industry: Economics, Evolution, and Privacy," *Journal of Economic Perspectives*, 2009, 23(3), 37-60.

"Why Different Jurisdictions Do Not (and Should Not) Adopt the Same Antitrust Rules," *Chicago Journal of International Law*, 2009, 10, 161.

"Innovation in Payments," (with R. Schmalensee), in *Moving Money: The Future of Consumer Payments*, M. Baily and R. Litan, eds., DC: Brookings Institution Press, 2009.

"How Catalysts Ignite: The Economics of Platform-Based Start-Ups," in *Platforms, Markets and Innovation*, A. Gawer, ed., Cheltenham, UK and Northampton, MA, US: Edward Elgar, 2009.

"The Microsoft Judgment and its Implications for Competition Policy towards Dominant Firms in Europe," (with C. Ahlborn), *Antitrust Law Journal*, 2009, 75(3), 887.

"Trustbusting Goes Global," in *Trustbusters: Competition Policy Authorities Speak Out*, D, Evans and F. Jenny, eds., Boston: Competition Policy International, 2009.

"What You Need to Know About Twombly: The Use and Misuse of Economic and Statistical Evidence in Pleadings," *Antitrust Chronicle*, 2009, 7(2).

The Economics of Market Coordination for the Check-Clearing System in the Late 19th Century United States (October 1, 2007). Explorations in Economic History, Vol. 45, pp. 445-461, 2008. (with H. Chang, M. Danilevsky, and D. Garcia-Swartz).

"Markets with Two-Sided Platforms," (with R. Schmalensee), in *Issues in Competition Law and Policy*, Vol. 1, American Bar Association, August 2008.

"Antitrust Issues Raised by the Emerging Global Internet Economy," *Northwestern University Law Review*, 2008, 102(4), 285-306.

"Competition and Regulatory Policy for Multi-sided Platforms with Applications to the Web Economy," *Concurrences*, 2008, 2, 57-62.

"The Lawful Acquisition and Exercise of Monopoly Power and its Implications for the Objectives of Antitrust," (with K. Hylton), *Competition Policy International*, 2008, 4(2).

"The Analysis of Mergers that Involve Multisided Platform Businesses," (with M. Noel), *Journal of Competition Law and Economics*, 2008, 4(3).

"The Economics of the Online Advertising Industry," *Review of Network Economics*, 2008, 7(3).

"The Economics of Market Coordination for the Pre-Fed Check-Clearing System: A Peek into the Bloomington (IL) Node," (with H. Chang, M. Danilevsky, and D. Garcia–Swartz), *Explorations in Economic History*, 2008, 45(4).

"The Role of Cost in Determining When Firms Offer Bundles and Ties," (with M. Salinger), *Journal of Industrial Economics*, 2008, 56(1).

"Economics and the Design of Competition Law," in *Issues in Competition Law and Policy*, W Collins, ed., Vol. 1, American Bar Association, August 2008.

"Has the Pendulum Swung Too Far?" (with H. Chang), *Regulation*, Winter 2007-2008. 30(4).

"Do Mobile Operators Have a Dominant Position in a Market for the Wholesale Termination of Calls from Fixed to Mobile?" *The Economics of Mobile Prices, Vodafone Policy Paper Series*, 2007, 7(4).

"Designing the Right Product Offerings," (with K. Webster), *Sloan Management Review*, Fall 2007.

"Pick Your Pricing," (with R. Schmalensee), *Chief Executive Magazine, Incorporated*, No. 227, Summer 2007.

"The Industrial Organization of Markets with Two-Sided Platforms," (with R. Schmalensee), *Competition Policy International*, 2007, 3(1).

"Defining Markets That Involve Multi-Sided Platform Businesses: An Empirical Framework with an Application to Google's Purchase of DoubleClick," (with M. Noel), Reg-Markets Center Working Paper No. 07-18, 2007.

"A Pragmatic Approach to Identifying and Analyzing Legitimate Tying Cases," (with A. Padilla and M. Salinger), in *European Competition Law Annual 2003: What is an Abuse of a Dominant Position?* Oxford: Hart Publishing, 2006.

"The Optimal Prosecution of Corporate Fraud: An Error Cost Analysis," (with H. Chang), Working Paper (LECG and eSapience), 2006.

"A Somber Anniversary: Terrorism Insurance Five Years after 9/11," (with D. Garcia-Schwartz and A. Layne-Farrar), Barbon Discussion Paper No. 06-02, 2006.

"Untying the Knot: The Case for Overruling Jefferson Parish," Working Paper (LECG), 2006.

"An Empirical Analysis of Bundling and Tying: Over-the-Counter Pain Relief and Cold Medicines," (with M. Salinger), in *Recent Developments in Antitrust: Theory and Evidence*, J. Choi, ed., Massachusetts: The MIT Press, 2006.

"The Economics of Software Platforms: An Application of Theory of Two-Sided Markets," (with A. Hagiu and R. Schmalensee), *Industrial Organization and the Digital Economy*, G. Illing and M. Peitz, eds., (Massachusetts: The MIT Press, July 2006).

"Tying: The Poster Child for Antitrust Modernization" in *Antitrust Policy and Vertical Restraints***,** R. Hahn, ed., DC: Brookings Institution Press, 2006.

"The Architecture of Product Offerings," (with Karen Webster), Working Paper (University of Chicago Law School and Market Platform Dynamics), 2006.

"Testimony on Tying for the DOJ/FTC Hearings on Single-Firm Conduct," *Antitrust Chronicle*, 2006, 11(1).

"The Law and Economics of Tying," (with C. Ahlborn, J. Padilla, and M. Salinger), *Antitrust Chronicle*, 2006, 11(1).

"Defining Antitrust Markets When Firms Operate Two-Sided Platforms," (with M. Noel), *Columbia Business Law Review*, 2005, 3.

"U.S. v. Microsoft: Did Consumers Win?" (with R. Schmalensee and A. Nichols), *Journal of Competition Law and Economics*, 2005, 1(3), 497-539.

"The Effect of Regulatory Intervention in Two-Sided Markets: An Assessment of Interchange-Fee Capping in Australia," (with H. Chang and D. Garcia-Swartz), *Review of Network Economics*, 2005, 4(4).

"Designing Antitrust Rules for Assessing Unilateral Practices: A Neo-Chicago Approach," (with A. Padilla), *University of Chicago Law Review,* 2005, 72(1), 73-98.

"Why Do Firms Bundle and Tie? Evidence from Competitive Markets and Implications for Tying Law," (with M. Salinger), Y*ale Journal on Regulation*, 2005, 22(1), 37-89.

"The Logic and Limits of the Exceptional Circumstances Test," (with C. Ahlborn and A. Padilla), *Magill and IMS Health, Fordham Journal of International Law*, 2005, 28(4), 1109-1156.

"Analyzing Market Definition and Power in Multi-sided Platforms Markets," (with M. Noel), Working Paper (University of Chicago Law School and University of California, San Diego), 2005.

"The Economics of Interchange Fees and Their Regulation: An Overview," MIT Sloan Working Paper No. 4548-05, May 2005.

"How Economists Can Help Courts Design Competition Rules – An EU and US Perspective," *World Competition: Law and Economics Review*, 2005, 28(1).

"2004: The Beginning of Change," *American Banker-Bond Buyer*, 2005, 17(12).

"The Economics of Interchange Fees and Their Regulation: An Overview," (with R. Schmalensee), MIT Sloan Working Paper No. 4548-05, 2005.

"Tying Under Article 82 EC and the Microsoft Decision: A Comment on Dolmans and Graf," (with A. Padilla), *World Competition: Law and Economics Review*, 2005, 28(1), 93-99.

"The Changing Role of Economics in Competition Policy Decisions by the European Commission during the Monti Years," (with C. Grave), *Competition Policy International*, 2005, 1(1).

"Excessive Prices: Using Economics to Define Administrable Legal Rules," (with A. Padilla), *Journal of Competition Law & Economics*, 2005, 1(1), 97-122.

"Curing Sinus Headaches and Tying Law: An Empirical Analysis of Bundling Decongestants and Pain Relievers," (with M. Salinger), CESifo Working Paper Series No. 1519, 2005.

"The Retailer Class Action Antitrust Case Against the Card Associations," (with H. Chang and R. Schmalensee), *The Payment Card Economics Review*, Winter 2004, Vol. 2.

"More Than Money: The Development of a Competitive Electronic Payments Industry in the United States," *The Payment Economics Review*, Winter 2004, Vol. 2.

"The Growth and Diffusion of Credit Cards in Society," *The Payment Economics Review*, Winter 2004, Vol. 2.

"The Role of Credit Cards in Providing Financing for Small Businesses," (with D. Blanchflower), *Payment Card Economics Review,* Winter 2004, Vol. 2.

"A Little Knowledge Can Be a Dangerous Thing: Price Controls in the Yellow Pages Industry," (with A. Oldale and E. Wang), *European Competition Law Review*, October 2004, 25(10), 607-610.

"A Survey of the Economic Role of Software Platforms in Computer-Based Industries," (with R. Schmalensee and A. Hagiu), CESifo Working Paper Series No. 1314, 2004.

"Software Patents and Open Source: The Battle Over Intellectual Property Rights," (with A. Layne-Farrar) *Virginia Journal of Law & Technology*, Summer 2004, 9(10).

"The Antitrust Economics of Tying: A Farewell to Per Se Illegality," (with C. Ahlborn and A. Padilla), *Antitrust Bulletin*, 2004, 49(1/2), 287-341.

"Competition, Cooperation and Upheaval: So-called co-opetition in payment cards is a work in progress-one affected by rapidly changing business relationships and punctuated by court decisions. How will this dance play out?" *American Banker-Bond Buyer*, 2004, 17(1).

"What's Yours Is Mine," *The Wall Street Journal*, February 2004, at A7.

"Will Retailers Stampeded to Drop Signature Debit?" *American Banker,* January 2004.

"Managing the Maze of Multisided Markets," *Strategy+Business*, Fall 2003.

"Regulators set bar high for foreign insurers," (with M. Ross), *South China Morning Post*, November 2003.

"Some Empirical Aspects of Multi-Sided Platform Industries," *Review of Network Economics*, 2003, 2(3).

"Demand-Side Efficiencies in Merger Control," (with A. Padilla), *World Competition Law and Economics Review*, 2003, 26(2).

"Has the Consumer Harm Standard Lost Its Teeth?" (with H. Chang and R. Schmalensee), in *High-Stakes Antitrust* **-** *The Last Hurrah?* R. Hahn, ed., Washington, DC: Brookings Institution Press, 2003.

"The Antitrust Economics of Multi-Sided Platform Markets," *Yale Journal on Regulation*, 2003, 20(2).

"Everything You Wanted to Know about Two-Sided Markets," (with P. Passell), *The Milken Institute Review*, Second Quarter 2003.

"Government Preferences for Promoting Open-Source Software: A Solution in Search of a Problem," (with B. Reddy), *Michigan Telecommunications and Technology Law Review*, 2003, 9(2).

"The Failure of E-Commerce Business: A Surprise or Not?" (with D. Garcia-Swartz and B. Martin-Keating), *European Business Organization Law Review*, 2002, 3.

"Tying in Platform Software: Reasons for a *Rule-of-Reason* Standard in European Competition Law," (with A. Padilla and M. Polo), *World Competition Law and Economics Review*, 2002, 25(4).

"Who Owns Ideas? The War Over Global Intellectual Property," *Foreign Affairs,* November/December 2002.

"The New Trustbusters—Brussels and Washington May Part Ways," *Foreign Affairs*, January/February 2002, 81(1).

"Class Certification, the Merits, and Expert Evidence," *George Mason Law Review*, 2002, 11(1).

"Class Certification and the Substantive Merits," (with R. Bone), *Duke Law Journal*, 2002, 51(4).

"Some Economic Aspects of Antitrust Analysis in Dynamically Competitive Industries," (with R. Schmalensee), in *Innovation Policy and the Economy,* Vol. 2, A. Jaffe, J. Lerner and S. Stern, eds., Cambridge, MA: MIT Press, 2002.

"The Rise and Fall of Leaders in Personal Computer Software," (with A. Nichols and B. Reddy), in *Microsoft, Antitrust and the New Economy: Selected Essays*, D. Evans, ed., Norwell, MA: Kluwer Academic Publishers, 2002.

"Why Does Microsoft Charge So Little for Windows," (with A. Nichols and B. Reddy), in *Microsoft, Antitrust and the New Economy: Selected Essays*, D. Evans, ed., Norwell, MA: Kluwer Academic Publishers, 2002.

"Dodging the Consumer Harm Inquiry: A Brief Survey of Recent Government Antitrust Cases," *St. John's Law Review*, 2001, 75(3).

"Is Free Software the Wave of the Future?" *The Milken Institute Review*, Fourth Quarter 2001.

"Industry Regulation Through Antitrust: The Clinton Legacy and the Bush Future," *Regulation*, Fall 2001.

"Clinton's Brave New Business World," *Regulation*, Fall 2001, 24(3).

"The Problem of Interchange Fee Analysis: Case Without a Cause?" (with C. Ahlborn and H. Chang), *European Competition Law Review*, 2001, 22(8).

"An Analysis of the Government's Economic Case in *U.S. v. Microsoft*," (with A. Nichols and R. Schmalensee), *Antitrust Bulletin*, Summer 2001.

"A Monopolist Would Still Charge More for Windows: A Comment on Werden," and "A Monopolist Would Still Charge More for Windows: A Comment on Werden's Reply," (with B. Reddy, A. Nichols and R. Schmalensee), *Review of Industrial Organization*, 2001, 18(3).

"Competition Policy in the New Economy: Is European Competition Law Up to the Challenge?" (with C. Ahlborn and A. Padilla), *European Competition Law Review*, May 2001, No. 5.

"An Analysis of the Government's Economic Case in *U.S. v. Microsoft*," in *Antitrust Bulletin*, with A. Nichols and R. Schmalensee, Summer 2001. Reprinted in *Microsoft, Antitrust and the New Economy: Selected Essays,* D. Evans, ed., Norwell, MA: Kluwer Academic Publishers, 2002.

"*U.S. v. Microsoft*, Remedy or Malady?" (with K. Elzinga and A. Nichols), *George Mason Law Review*, 2001, 9(3). Reprinted in *Microsoft, Antitrust and the New Economy: Selected Essays*, D. Evans, ed., Norwell, MA: Kluwer Academic Publishers, 2002.

"Antitrust and the New Economy," *Computer Industry Committee Newsletter*, Spring 2001.

"The Competitive Effects of the Collective Setting of Interchange Fees by Payment Card Systems," (with H. Chang), *The Antitrust Bulletin*, Fall 2000.

"Be Nice To Your Rivals: How the Government Is Selling an Antitrust Case without Consumer Harm in *U.S. v. Microsoft*," (with R. Schmalensee), in *Did Microsoft Harm Consumers? Two Opposing Views*, AEI-Brookings Joint Center for Regulatory Studies: Washington DC, May 2000.

"Consumers Lose if Leading Firms are Smashed for Competing," (with R. Schmalensee), in *Did Microsoft Harm Consumers? Two Opposing Views,* AEI-Brookings Joint Center for Regulatory Studies: Washington DC, May 2000.

"Economics for the Third Industrial Revolution," (with M. Leder), *Viewpoint, The Marsh & McLennan Companies Journal*, 1999, No. 1.

"All the Facts That Fit: Square Pegs and Round Holes in *U.S. v. Microsoft*," *Regulation*, November 1999, 22(4).

"Joint Ventures: *MountainWest,"* (with R. Schmalensee), in *The Antitrust Revolution*, 3rd edition, J. Kwoka and L. White, eds., New York: Oxford University Press, 1998.

"Some Economic Principles for Guiding Antitrust Policy Towards Joint Ventures," (with H. Chang and R. Schmalensee), *Columbia Business Law Review*, 1998, No. 2.

"A Guide to the Antitrust Economics of Networks," (with R. Schmalensee), *Antitrust*, Spring 1996.

"Some Economic Aspects of Standards in Network Industries and Their Relevance to Antitrust and Intellectual Property Law," (with B. Reddy), *Intellectual Property Antitrust*, *Practicing Law Institute*, July 1996, Vol. 1.

"Defining Relevant Antitrust Markets with Special Application to Intellectual Property," *Intellectual Property Antitrust, Practicing Law Institute*, July 1996, Vol. 1.

"A Tailored Approach to Diversity Planning," (with M. Oh), *HR Magazine*, 1996, 41(6).

"Market Definition in Antitrust and Patent-Infringement Litigation," *Practicing Law Institute*, July 1995, Vol. 1.

"Economic Aspects of Payment Card Systems and Antitrust Policy Toward Joint Ventures," (with R. Schmalensee), *Antitrust Law Journal*, Spring 1995.

"Retrospective Bias in the Displaced Worker Surveys," (with L. Leighton), *Journal of Human Resources*, Winter 1995.

"Industry Dynamics and Small Firms," in *Births and Start-up of Small Firms*, F. Cicogna, ed., Amsterdam: Kluwer Publishing Co., 1995.

"Common Statistical Fallacies in Pattern-and-Practice Employment Discrimination Cases," *American Employment Law Council*, October 1995.

"Entrepreneurship and Small Business Growth: A Case Study," (with Z. Acs), in *Advances in the Study of Entrepreneurship*, G. Libecap, ed., Greenwich, Ct.: JAI Press, 1993.

"An Economic Approach to the Mitigation of Damages in Age Discrimination Cases," *Advanced Employment Law and Litigation: ALI-ABA Course of Study Materials*, Vol. 2, Washington, DC: American Law Institute-American Bar Association Committee on Continuing Professional Education, 1992.

"Small Business Formation and Success by Unemployed Workers," (with L. Leighton), *Small Business Economics*, 1990.

"Trade Associations and the Exchange of Price and Nonprice Information," in *Annual Proceedings of the Fordham Corporate Law Institute: 1992 and EEC/U.S. Competition and Trade Law*, B. Hawk, ed., 1990.

"An Estimated Model of Entrepreneurial Choice Under Liquidity Constraints," (with B. Jovanovic), *Journal of Political Economy*, 1989, 97(4), 808-827. Reprinted in *Small Firms and Economic Growth,* International Library of Critical Writings in Economics, Z. Acs, ed., Cheltensham, UK: Edward Elgar Publishing, Ltd., 1995.

"Some Empirical Aspects of Entrepreneurship," (with L. Leighton), *American Economic Review*, 1989, 79(3), 519-535. Reprinted in *Entrepreneurship*, International Library of Critical Writings in Economics, M. Casson, ed., Hants, England: Edward Elgar Publishing Co., 1990.

"Why Do Smaller Firms Pay Less?" (with L. Leighton), *Journal of Human Resources*, 1989, 24(4), 299-318. Reprinted in *Small Firms and Economic Growth,* Z. Acs, ed., Cheltensham, UK: Edward Elgar Publishing, Ltd., 1995.

"Small Business Economics," (with W. Brock), *Small Business Economics*, 1989, 1(1), 7-20. Reprinted in *Small Firms and Economic Growth,* Z. Acs, ed., Cheltensham, UK: Edward Elgar Publishing, Ltd., 1995.

"Tests of Alternative Theories of Firm Growth," *Journal of Political Economy*, 1987, 95(4), 657-674. Reprinted in *Small Firms and Economic Growth*, Z. Acs, ed., Cheltensham, UK: Edward Elgar Publishing, Ltd., 1995.

"The Determinants of Changes in U.S. Self-Employment, 1968-1987," *Small Business Economics*, 1989, 1(2), 111-119.

"The Relationship Between Firm Growth, Size and Age: Estimates for 100 Manufacturing Industries," *Journal of Industrial Economics*, June 1987. Reprinted in *The Empirical Renaissance in Industrial Economics*, R. Schmalensee, ed., London: Basil Blackwell, 1988.

"Natural Monopoly and the Bell System: Response to Charnes, Cooper and Sueyoshi," (with J. Heckman), *Management Science*, 1988, 34(1), 27-38.

"Empirical Analysis of the Size Distribution of Farms: Discussion," *American Journal of Agricultural Economics*, 1987, 69(2), 484-485.

"The Differential Effect of Regulation Across Plant Size: Comment on Pashigian," *Journal of Law and Economics*, 1986, 29(1), 187-200.

"A Test for Subadditivity of the Cost Function with an Application to the Bell System," *American Economic Review*, with J. Heckman, September 1986, 76(4), 856-858.

"The Economics of Regulatory Tiering," (with W. Brock), *RAND Journal of Economics*, 1985, 16(3), 398-409. Reprinted in *Small Firms and Economic Growth*, Z. Acs, ed., Cheltensham, UK: Edward Elgar Publishing, Ltd., 1995.

"The Audience Revenue Relationship for Local Broadcast Stations," (with F. Fisher and J. McGowan), *Bell Journal of Economics*, 1980, 11(2), 694-708.

"Cross Country Prediction of Consumption Patterns," *Economic Letters*, 1979, 3(1), 85-88.

Document Relied Upon by David S. Evans

Public Interest Statement and Declarations

Public Interest Statement

Declaration of John Legere

Declaration of Brandon Dow Draper.

Declaration of John Saw.

Declaration of Michael Sievert.

Declaration of Neville Ray.

Declaration of Peter Ewens.

Applicant Documents

“2016 PCAI Keynote,” T-MOBILE (June 2016), [TMOPA_00240128].

“2017 US Market Overview: Challenges and Opportunities,” *T-Mobile*, 2017, [TMOPA_00229537].

“2-11-16 Board Meeting Materials,” *T-Mobile*, Feb. 11, 2016, [TMOPA_00602388].

“5G Device Technology Development,” T-Mobile U.S. Inc., Dec. 2017, [TMOPA_00777322_00000001].

“Capacity Evolution Study – Executive Summary,” *T-Mobile*, Apr. 2015, [TMOPA_00896687].

“Draft T-Mobile Presentation: Road to 5G – TMUS Board of Directors Meeting,” *T-Mobile*, Sept. 7-8, 2016, [TMOPA_00394587_00000003].

“DT Network and Procurement Update,” T-Mobile, Jan. 31, 2006, [TMOPA-00242248].

“Get Smart[er]: Understanding the Ins and Outs of the 5G Use Cases,” *Signals Ahead* (Dec. 8, 2015), [TMOPA_00449905_00000002].

“Network Modernization enabled re-farm of existing spectrum assets to build capacity and migrate to LTE, enabled by AT&T break-up spectrum,” *T-Mobile*, Apr. 22, 2015, [TMOPA_00243424].

“Performance Review Un-carrier,” T-MOBILE (Sept. 21, 2015), [TMOPA_01066456].

“Project Velocity,” T-MOBILE (Jan. 23, 2009), [TMOPA_00256103_ 00000001].

“Recommended Plan: Capex Deep Dive,” *T-Mobile*, Jul 29, 2013, [TMOPA_00529719].

“Spectrum Re-Farm, UMTS1900 and LTE Deployment Strategy,” *T-Mobile*, Jan. 5, 2011 [TMOPA_00574865]

“T-Mobile Presentation – Industry Context,” *T-Mobile*, Dec. 2017, [TMOPA_00006626_00000001].

“T-Mobile Presentation – Project Nations Discussion Materials,” *T-Mobile*, Sept. 21, 2017, [TMOPA_00007730_00000002].

“T-Mobile Presentation: Key Beliefs – Foundational Assumptions – Alternatives and Recommendations,” *T-Mobile*, [TMOPA_00243179].

“T-Mobile Presentation: T-Mobile U.S. Inc., Q4 2016 Switching Summary Report,” *T-Mobile*, 2017, [TMOPA_00007755_00000008].

“T-Mobile US Enterprise Risk Assessment (EV),” T-MOBILE (Q2 2017), [TMOPA_00008850_00000001].

“T-Mobile US, Inc. 9-7-16 Board Meeting Materials,” *T-Mobile*, Sept. 7, 2016, [TMOPA_00602400].

“T-Mobile Usage Data, Chart Data – Annual Worksheet,” *T-Mobile* (Apr. 24, 2018) [TMOPA_00162577_00000001].

"TMUS 2014 – 2018 Preliminary Long Range Plan – Executive Summary," T-MOBILE (Oct. 15, 2013), [TMOPA_00584756].

"TMUS Mobile Broadband Review," ***T-Mobile***, Mar. 15, 2010 [TMOPA_00972759_00000001].

"TMUS On-Network MB Forecast," T-*Mobile*, (Aug. 2, 2011) [TMOPA_00971259_00000001].

"What are People Talking About When They Talk about 5G?," ***T-Mobile***, Feb. 18, 2018, [TMOPA_00278941_00000001].

5G: The Road to the Next Evolution, CITI RESEARCH (Sept. 1, 2017) [TMOPA_00010531_00000001].

Email from Aslam Khan to Leslie Koutroulis *et al.*, "RE: MOU and MB Forecast Discussion," July 25, 2013 [TMOPA-00480478].

Email from Cynthia Damlan to Dave Mayo et al., "4Q15 ERA – Inadequate Network Investment in Capacity & Coverage [Review Needed]," Nov. 8, 2016 [TMOPA-00392314].

ERICSSON, RADIO NETWORK EVOLUTION STUDY 2016-2021, (Q4 2016) [TMOPA_00673504].

T-Mobile Presentation: Network Discussion – Capacity: TMUS Board of Directors," ***T-Mobile***, Sept. 24-25, 2015, [TMOPA_00903690_00000001.pptx].

"Sprint Presentation – Managing Network Quality of Experience (QoE) from a Commercial Perspective: Methodology and Initial Results," *Sprint*, Sept. 8, 2017.

Data

BLOOMBERG.

GSMA INTELLIGENCE.

IDC, QUARTERLY MOBILE PHONE TRACKER: 2017 Q4 HISTORICAL RELEASE (May 11, 2018).

SNL KAGAN (S&P GLOBAL INTELLIGENCE).

Bureau of Labor Statistics, CPI Inflation Calculator, https://www.bls.gov/data/inflation_calculator.htm (last visited June 3, 2018).

Full Duplex DOCSIS 3.1, CABLELABS.COM, https://www.cablelabs.com/full-duplex-docsis/ (last visited June 3, 2018).

SEC Filings

Alphabet Inc., Annual Report (Form 10-K) (Feb. 5, 2018).

AT&T Inc., Annual Report (Form 10-K) (Feb. 12, 2018).

AT&T Inc., Annual Report (Form 10-K) (Dec. 31, 2006).

AT&T Inc., Annual Report (Form 10-K) (Feb. 21, 2014).

AT&T Inc., Annual Report (Form 10-K) (Mar. 1, 2006).

AT&T Wireless Services, Inc., Annual Report (Form 10-K (Dec. 31, 2003).

Cingular Wireless LLC, Annual Report (Form 10-K) (Dec. 31, 2005).

Facebook Inc., Annual Report (Form 10-K) (Feb. 1, 2013).

Facebook Inc., Annual Report (Form 10-K) (Feb. 1, 2018).

Qorvo, Inc., Annual Report (Form 10-K) (May 21, 2018).

Sprint Corp., Annual Report (Form 10-K) (Mar. 11, 2005).

Sprint Nextel Corp., Annual Report (Form 10-K) (Mar. 1. 2007).

Sprint Nextel Corp., Annual Report (Form 10-K) (Feb. 28, 2013).

T-Mobile US, Inc., Annual Report (Form 10-K) (Feb.8, 2018).

T-Mobile US, Inc., Annual Report (Form 10-K) (Feb. 19, 2015).

T-Mobile US, Inc., Annual Report (Form 10-K) (Feb. 25, 2014).

T-Mobile USA, Inc., Annual Report (Form 10-K) (Mar. 10, 2003).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Mar. 14, 2006).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Feb. 27, 2014).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Feb. 24, 2012).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Feb. 26, 2013).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Feb. 24, 2009).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Feb. 23, 2018).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Mar. 14, 2003).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Mar. 12, 2004).

Verizon Comm'ns Inc., Annual Report (Form 10-K) (Mar. 14, 2005).

Verizon Commc'n Inc., Annual Report (Form 10-K) (Feb. 26, 2010).

Verizon Commc'n Inc., Annual Report (Form 10-K) (Feb. 28, 2008).

Verizon Commc'n Inc., Annual Report (Form 10-K) (Mar. 1, 2007).

Company and Industry Data

5G AMERICAS, 5G SERVICES & USE CASES 12, 13-15 (2017), http://www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf.

5G AMERICAS, WIRELESS TECHNOLOGY EVOLUTION TOWARDS 5G: 3GPP RELEASE 13 TO 15 AND BEYOND (Feb. 2017), http://www.5gamericas.org/files/3214/8833/1313/3GPP_Rel_13_15_Final_to_Upload_2.28.17_AB.pdf.

5G for manufacturing, ERICSSON.COM, https://www.ericsson.com/en/networks/trending/insights-and-reports/5g-for-manufacturing (last visited June 3, 2018).

5G Is Now, Part 1: 2018, the Year of 5G, SAMSUNG: INSIGHTS (February 27, 2018), http://www.samsung.com/global/business/networks/insights/news/5g-is-now-part-1-2018-the-year-of-5g.

802.11ac Wave 2 FAQ, CISCO.COM: SOLUTIONS, https://www.cisco.com/c/en/us/solutions/collateral/enterprise-networks/802-11ac-solution/q-and-a-c67-734152.html (last updated Jan. 16, 2018).

ANTONIO ORSINO ET AL., IEEE, FACTORIES OF THE FUTURE ENABLED BY 5G TECHNOLOGY (2018), https://5g.ieee.org/images/files/pdf/applications/Factories-of-the-Future-Enabled-by-5G-Technology_030518.pdf.

Apostolos Papathanassiou & Alexey Khoryaev, *Cellular V2X as the Essential Enabler of Superior Global Connected Transportation Services*, 1 IEEE 5G TECH FOCUS 2 (2017), https://5g.ieee.org/tech-focus/june-2017/cellular-v2x.

AT&T 4G LTE Reaches 400 Markets, Nearly 240M POPs, AT&T (Sept. 12, 2013), http://about.att.com/newsroom/att_4g_lte_reaches_400_markets_nearly_240m_pops.html.

AT&T Details 5G Evolution, AT&T (Jan. 4, 2017), http://about.att.com/story/att_details_5g_evolution.html.

AT&T Inc., *Edited Transcript AT&T Inc. 2012 Analyst Conference*, FED. COMMC'NS COMM'N, (Nov. 7, 2012), https://ecfsapi.fcc.gov/file/7022113687.pdf.

AT&T's 4G Evolution, AT&T, https://www.att.com/Common/about_us/pdf/lte_markets_1512.pdf (last visited June 8, 2018).

Binge On, T-MOBILE SUPPORT, https://support.t-mobile.com/docs/DOC-24291?icid=WMM_TM_Q118BINGEO_ZJPCJ73EKJW12494 (last visited June 10, 2018).

Boris Bellalta, *IEEE 802.11ax: High-efficiency WLANS*, IEEE WIRELESS COMMS. (Mar. 2, 2016), https://ieeexplore.ieee.org/document/7422404/.

CARLA CHIASSERINI & ANTHONY MAGNAN, IEEE, 5G FOR THE AUTOMOTIVE DOMAIN, https://5g.ieee.org/images/files/pdf/applications/5G-for-the-Automotive-Domain030518.pdf.

CARMEL GROUP, READY FOR TAKEOFF: BROADBAND WIRELESS ACCESS PROVIDERS PREPARE TO SOAR WITH FIXED WIRELESS 7 (2017), https://carmelgroup.com/wp-content/uploads/2017/12/TCG_2017_BWA_Full_Report.pdf.

CHIH-PING LI ET AL., 5G ULTRA-RELIABLE AND LOW-LATENCY SYSTEMS DESIGN (July 2017), https://ieeexplore.ieee.org/document/7980747.

CISCO, CISCO VISUAL NETWORKING INDEX: GLOBAL MOBILE DATA TRAFFIC FORECAST UPDATE 2016-2021 (Feb. 7, 2017), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html.

CISCO, NORTH AMERICAN VNI ACTUAL AND PROJECTED MOBILE TRAFFIC VOLUME (JUNE 2017).

CISCO, ZETTABYTE ERA: TRENDS AND ANALYSIS 19 (June 2017), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.pdf.

COMSCORE, CROSS-PLATFORM FUTURE IN FOCUS U.S. 2017, at 5, 60, 62 (2017), https://www.comscore.com/Insights/Presentations-and-Whitepapers/2017/2017-US-Cross-Platform-Future-in-Focus.

David J. Redl, Assistant Sec'y Nat'l Telecomm. & Info. Admin., U.S. Dep't Comm., Remarks at the BIS 2018 Annual Conference on Export Controls and Policy (May 14, 2018), https://www.ntia.doc.gov/speechtestimony/2018/remarks-assistant-secretary-redl-bis-2018-annual-conference-export-controls-and.

Ericsson and King's College London Demonstrate 5G Tactile Robotic Surgery, ERICSSON (June 28, 2016), https://www.ericsson.com/en/press-releases/2016/6/ericsson-and-kings-college-london-demonstrate-5g-tactile-robotic-surgery.

Ericsson and Qualcomm Push the Boundaries of IoT in Brazil, ERICSSON (Apr. 11, 2018), https://www.ericsson.com/en/news/2018/4/iot-collaboration-in-brazil.

ERICSSON CONSUMER & INDUS. LAB, BRINGING 5G BUSINESS VALUE TO INDUSTRY (2018), https://www.ericsson.com/assets/local/networked-society/consumerlab/reports/2018/bringing-5g-business-value-to-industry.pdf.

ERICSSON, 5G SYSTEMS 4 (January 2017), https://www.ericsson.com/assets/local/publications/white-papers/wp-5g-systems.pdf.

ERICSSON, ERICSSON MOBILITY REPORT 12 (Nov. 2017), https://www.ericsson.com/en/mobility-report/reports/november-2017/mobile-data-traffic-growth-outlook.

ERICSSON, THE 5G CONSUMER BUSINESS CASE: AN ECONOMIC STUDY OF ENHANCED MOBILE BROADBAND (2018), https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-november-2017.pdf.

ERICSSON, THE EVOLUTION OF EDGE (Feb. 2007), http://www.iwpc.org/Workshop_Folders/08_03_GSM_EDGE_Extensions/3107_The_evolution_of_EDGE_A.pdf.

ERICSSON, THE INDUSTRY IMPACT OF 5G (2018), https://www.ericsson.com/assets/local/narratives/networks/documents/report-bnew-18000486-rev-a-uen.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES–TWELFTH REPORT, WT Docket No. 07-71 (Feb. 4, 2008).

FED. COMMC'NS COMM'N, 2015 BROADBAND PROGRESS REPORT AND NOTICE OF INQUIRY ON IMMEDIATE ACTION TO ACCELERATE DEPLOYMENT, GN Docket No. 14-126 (Feb. 4, 2015), https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-10A1.pdf.

FED. COMMC'NS COMM'N , 2016 BROADBAND PROGRESS REPORT, GN Docket No. 15-191 (Jan. 29, 2016), https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2016-broadband-progress-report.

FED. COMMC'NS COMM'N, 2016 BROADBAND PROGRESS REPORT, GN Docket N. 15-191, ¶ 19 (Jan. 29, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf.

FED. COMMC'NS COMM'N, 2016 MEASURING BROADBAND AMERICA FIXED BROADBAND REPORT (Dec. 1, 2016), https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-report-2016.

FED. COMMC'NS COMM'N, 2018 BROADBAND DEPLOYMENT REPORT, GN Docket No. 17-199 (Feb. 2, 2018), https://docs.fcc.gov/public/attachments/FCC-18-10A1.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17 (Sept. 29, 2006), https://docs.fcc.gov/public/attachments/FCC-06-142A1.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – FIFTEENTH REPORT, WT Docket No. 10-133 (June 27, 2011), https://docs.fcc.gov/public/attachments/FCC-11-103A1.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – THIRTEENTH REPORT, WT Docket No. 08-27 (Jan. 16, 2009), https://docs.fcc.gov/public/attachments/DA-09-54A1.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – NINETEENTH REPORT, WT Docket No. 16-137, (Sept. 23, 2016), https://docs.fcc.gov/public/attachments/DA-16-1061A1_Rcd.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, (Mar. 21, 2013), https://docs.fcc.gov/public/attachments/FCC-13-34A1.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TWENTIETH REPORT, WT Docket No. 17-69 (Sep. 27, 2017), https://docs.fcc.gov/public/attachments/FCC-17-126A1_Rcd.pdf.

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379 (July 14, 2003).

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – SEVENTH REPORT, WT Docket No. 02-179 (July 3, 2002).

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – NINTH REPORT, WT Docket No. 04-111 (Sept. 28, 2004).

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TENTH REPORT, WT Docket No. 05-71 (Sept. 30, 2005).

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – FOURTEENTH REPORT, WT DOCKET NO. 09-66 (MAY 20, 2010).

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – SEVENTEENTH REPORT, WT Docket No. 13-135 (Dec. 18, 2014).

FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – EIGHTEENTH REPORT, WT Docket No. 14-125 (Dec. 23, 2015).

FED. COMMC'NS COMM'N, CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN (March 16, 2010), https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf.

FED. COMMC'NS COMM'N, COMMENTS OF AT&T INC. IN THE MATTER OF WIRELESS TELECOMMUNICATIONS BUREAU SEEKS COMMENT ON COMMERCIAL MOBILE RADIO SERVICES MARKET COMPETITION, WT Docket No. 09-66 (June 15, 2009), https://ecfsapi.fcc.gov/file/6520221081.pdf.

FED. COMMC'NS COMM'N, MOBILE BROADBAND: BENEFITS OF ADDITIONAL SPECTRUM (Oct. 2010), https://transition.fcc.gov/national-broadband-plan/mobile-broadband-paper.pdf.

FED. COMMC'NS COMM'N, OPENNESS IN THE MOBILE BROADBAND ECOSYSTEM (Aug. 20, 2013), https://transition.fcc.gov/cgb/oiac/Mobile-Broadband-Ecosystem.pdf.

FED. COMMC'NS COMM'N, Proposed Comcast-Time Warner Cable-Charter Transaction Economic Analysis Workshop, MB Docket No. 14- 57 (Jan. 30, 2015).

FED. COMMC'NS COMM'N, Fixed Broadband Deployment Data from FCC Form 477: Data as of June 30, 2016 (v2), https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477 (last visited June 3, 2018).

From Healthcare to Homecare –The Critical Role of 5G in Healthcare Transformation, ERICSSON CONSUMER LAB (June 2017), https://www.ericsson.com/assets/local/networked-society/consumerlab/reports/2017/healthcare-to-homecare_screen_aw2.pdf.

FROST & SULLIVAN & PRINCIPAL GLOB. INV'RS, 5G: THE FOUNDATION FOR A HYPER-CONNECTED WORLD (2017), https://go.frost.com/tt-HyperConnectedWorld.

Giulia McHenry, *Evolving Technologies Change the Nature of Internet Use*, NTIA (Apr. 19, 2016), https://www.ntia.doc.gov/blog/2016/evolving-technologies-change-nature-internet-use.

NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q1 2011 (2011).

NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q1 2014 (2014).

NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q2 2011 (2011).

NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q2 2014 (2014).

NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q3 2011 (2011).

NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q4 2011 (2012).

NIELSEN CO., THE NIELSEN CROSS-PLATFORM REPORT Q4 2013 (2014).

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q1 2015 (2015).

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q1 2016 (2016).

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q1 2017 (2017), http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/total-audience-report-q1-2017.pdf.

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q2 2015 (2015), http://www.nielsen.com/us/en/insights/reports/2015/the-total-audience-report-q2-2015.html.

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q2 2016 (2016).

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q2 2017 (2017), http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2017-reports/total-audience-report-q2-2017.pdf.

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q3 2014 (2014).

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q3 2016 (2016).

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q3 2015 (2015), http://www.nielsen.com/us/en/insights/reports/2015/the-total-audience-report-q3-2015.html.

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q4 2014 (2015).

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q4 2015 (2015), http://www.nielsen.com/us/en/insights/reports/2016/the-total-audience-report-q4-2015.html.

NIELSEN CO., THE NIELSEN TOTAL AUDIENCE REPORT Q4 2016 (2017).

Ookla, United States Fixed Speeds, SpeedTest.net (Sept. 7, 2017), http://www.speedtest.net/reports/united-states/#fixed.

Radio Commc'n Study Grps. Working Party 5D, *Minimum Requirements Related to Technical Performance for IMT-2020 Radio Interface(s)* (Int'l Telecomm. Union, Document No. ITU-R SG05 Contribution 40, 2017), https://www.itu.int/md/R15-SG05-C-0040/en.

REAL WIRELESS LTD., REPORT FOR OFCOM: 4G CAPACITY GAINS (Jan. 27, 2011), https://www.ofcom.org.uk/__data/assets/pdf_file/0038/74999/4gcapacitygainsfinalreporta1.pdf.

RECON ANALYTICS, HOW AMERICA'S 4G LEADERSHIP PROPELLED THE U.S ECONOMY (2018), https://api.ctia.org/wp-content/uploads/2018/04/Recon-Analytics_How-Americas-4G-Leadership-Propelled-US-Economy_2018.pdf.

Robert F. Roche & Kathryn Malarkey, CTIA's Wireless Industry Report Indices Report: Year-End 2016 Results (May 2017).

Ron Hranac, *Spectral Efficiency*, COMM. TECH. (Oct. 2012), http://www.scte.org/TechnicalColumns/12-10-01%20spectral%20effieciency.pdf.

RYSAVY RESEARCH, MOBILE BROADBAND EXPLOSION: THE 3GPP WIRELESS EVOLUTION (Aug. 2013), http://www.5gamericas.org/files/9414/0622/2731/4G_Americas_Mobile_Broadband_Explosion_August_2013_9_5_13_R1.pdf.

ITU, IMT VISION – FRAMEWORK AND OVERALL OBJECTIVES OF THE FUTURE DEVELOPMENT FOR IMT FOR 2020 AND BEYOND (Sept. 2015), https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf.

Sophia Antipolis, *Why Were the Founders Of GSM In Cyprus This Week? 20 Years and 2.3 Billion Users Has A Lot To Do With It*, ETSI (Mar. 16, 2007), http://www.etsi.org/component/content/article/9-news-events/news/194-news-release-16th-march-2007.

Statement of Jonathan S. Adelstein, FED. COMMC'NS COMM'N, Comm'r, *In the Matter of Applications of Nextel Communications, Inc. and Sprint Corporation For Consent to Transfer of Control of Licenses and Authorizations*, WT Docket No. 05-63 (Aug. 3, 2005), https://www.fcc.gov/proceedings-actions/mergers-transactions/sprint-nextel.

Statement of Kathleen Q. Abernathy, FED. COMMC'NS COMM'N, Comm'r, *Re: Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corporation For Consent to Transfer of Control of Licenses And Authorizations*, WT Docket No. 04-70 (Oct. 22, 2004), https://docs.fcc.gov/public/attachments/DOC-260394A2.pdf.

Statement of Michael K. Powell, FED. COMMC'NS COMM'N, Chairman, *Re: Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corporation, For Consent to Transfer of Control of Licenses and Authorizations*, WT Docket No. 04-70, et al. (Oct. 22, 2004), https://apps.fcc.gov/edocs_public/attachmatch/DOC-253545A2.pdf.

Other Research

10% of U.S. Broadband Households Likely to Cancel Their Fixed Broadband Internet Service Over Next 12 Months, PARKS ASSOCIATES (Feb. 23, 2017), http://www.parksassociates.com/blog/article/pr-02232017.

3GPP, *LTE*, http://www.3gpp.org/technologies/keywords-acronyms/98-lte (last visited June 3, 2018).

4G set to deliver capacity gains of more than 200% over 3G, OFCOM (May 12, 2011), https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2011/4g-set-to-deliver-capacity-gains-of-more-than-200-over-3g.

5G for Energy, GLOBAL 5G, https://www.global5g.org/verticals/5g-energy (last visited June 8, 2018).

5G FORUM, 5G SERVICE ROADMAP 2022 (March 2016), http://kani.or.kr/5g/whitepaper/5G%20Service%20Roadmap%202022.pdf.

5G mmWave: The Next Frontier in Mobile Broadband, QUALCOMM.COM, https://www.qualcomm.com/invention/technologies/5g-nr/mmwave (last visited June 3, 2018).

Aaron Pressman, *The Death of the $199 iPhone Marks A New Era For Wireless*, FORTUNE (Jan. 11, 2017), http://fortune.com/2017/01/11/death-of-the-199-iphone-wireless-subsidy/.

ACCENTURE, WINNING WITH THE INDUSTRIAL INTERNET OF THINGS (2015), https://www.accenture.com/t20160909T042713__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_11/Accenture-Industrial-Internet-of-Things-Positioning-Paper-Report-2015.pdf.

Alan Burkitt-Gray, *AT&T Plans 'Aggressive Ramp' of LTE to Challenge Verizon's Early 4G Lead*," GLOBAL TELECOMS BUSINESS (Nov./Dec. 2010), https://www.att.com/Common/about_us/downloads/leadership_spotlight/RLS_GTB_Nov-Dec2010.pdf.

Alex Kingsbury, *10 Cities Adopting Smart Grid Technology*, U.S. NEWS, (Feb. 19, 2010), https://www.usnews.com/news/energy/slideshows/10-cities-adopting-smart-grid-technology?onepage.

Alistair Barr, *Facebook's Zuckerberg Says Mobile First Priority*, REUTERS (May 11, 2012), https://www.reuters.com/article/net-us-facebook-roadshow/facebooks-zuckerberg-says-mobile-first-priority-idUSBRE84A18520120512.

Amanda Lenhart, *Teens, Smartphones & Texting*, PEW RES. CTR (Mar. 19, 2012), http://www.pewinternet.org/2012/03/19/teens-smartphones-texting/.

Amol Sharma, *Cingular Finishes Absorbing Network of AT&T Wireless*, THE WALL STREET JOURNAL (Oct. 3, 2006), https://www.wsj.com/articles/SB115984186629680838.

Android Market Hits the 400,000 Apps -Right Behind Apple's App Store, ANDROIDAUTHORITY (January 4, 2012), https://www.androidauthority.com/android-market-400-thousand-apps-41590/.

Android's early days, ANDROID CENTRAL (Oct. 28, 2015), https://www.androidcentral.com/androids-early-days.

Ari Levy, *Amazon Just Passed Alphabet to Become the World's Second Most Valuable Company*, CNBC (Mar. 20, 2018), https://www.cnbc.com/2018/03/20/amazon-just-passed-alphabet-to-become-the-worlds-second-most-valuable-company.html.

ARUNABHA GHOSH, ET AL., FUNDAMENTALS OF LTE (2011).

As Unlimited Data Takes Center Stage, T-Mobile Widens Speed Gap Between the Network Built for Unlimited … and Everyone Else, T-MOBILE BLOG (Apr. 21, 2017), https://newsroom.t-mobile.com/news-and-blogs/tmobile-widens-lte-speed-gap-over-verizon-att-unlimited-plans.htm.

Press Release, AT&T, *AT&T Builds on 5G Foundation in More Than 100 New Markets* (Apr. 20, 2018), http://about.att.com/story/att_builds_on_5g_foundation_in_more_than_100_new_markets.html.

AT&T Goes After T-Mobile with Attack Ads, ADAGE (Mar. 1, 2013), http://adage.com/article/digital/t-t-mobile-attack-ads/240112/.

AT&T to Make Faster 3G Technology Available in Six Major Cities This Year (Sept. 9, 2009), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=27068.

Avery Hartmans & Nathan McAlone, *The Story of How Travis Kalanick Built Uber into the Most Feared and Valuable Startup in the World*, BUS. INSIDER (Aug. 1, 2016), http://www.businessinsider.com/ubers-history.

Benoit Tournier, *IoT-Enabled Asset Tracking is Driving Business Innovation*, SIERRA WIRELESS (Sept. 27, 2017), https://www.sierrawireless.com/iot-blog/iot-blog/2017/09/iot_enabled_asset_tracking_is_driving_business_innovation/.

Bernie Arnason, *First Amazon Drone Delivery is Highlight of Coming IoT, 5G Future*, TELECOMPETITOR (Dec. 14, 2016), http://www.telecompetitor.com/first-amazon-drone-delivery-is-highlight-of-coming-iot-5g-future/.

Bijan Khosravi, *Facebook's New Focus On 5G and Golden Opportunity for Entrepreneurs*, FORBES (Apr. 30, 2018), https://www.forbes.com/sites/bijankhosravi/2018/04/30/todays-black-clouds-over-facebook-will-part-look-at-their-golden-ideas-in-5g/#45c1ec38313b.

Bill Siwicki, *Mobile Apps Dominate Time Consumers Spend Online*, INTERNET RETAILER (Dec. 10, 2014) https://www.digitalcommerce360.com/2014/12/10/mobile-apps-dominate-time-consumers-spend-online/.

Blajic et al., *Latency Improvements in 3G Long Term Evolution*, MIPRO'07 (2007), https://pdfs.semanticscholar.org/ed86/78a5572928049d23d4aa9bb7398b8d16b7b1.pdf.

Bob Brewin, *Sprint PCS Launches Nationwide 3G Network*, COMPUTERWORLD (Aug. 8, 2002), https://www.computerworld.com/article/2577108/mobile-wireless/sprint-pcs-launches-nationwide-3g-network.html.

Brad Reed, *MetroPCS Snags First LTE Android Phone*, NETWORK WORLD (Feb. 9, 2011), https://www.networkworld.com/article/2199740/smartphones/metropcs-snags-first-lte-android-phone.html.

Breeanna Hare, *Whatever Happened to the Ringtone?* CNN.COM (May 16, 2013), https://www.cnn.com/2013/05/09/tech/mobile/ringtones-phones-decline/index.html.

Brent Rose, *Sprint is Ditching 4G WiMax for 4G LTE: What it Means for You*, GIZMODO (Oct. 7, 2011), https://gizmodo.com/5847643/its-official-sprint-is-going-lte.

Brian Barrett, *Sprint's HTC Evo, the First Ever 4G Phone: Meet the New Terrific*, GIZMODO (Mar. 23, 2010), https://gizmodo.com/5500343/sprints-htc-evo-the-first-ever-4g-phone-meet-the-new-terrific.

Brian Fung, *Verizon Is Launching a New Unlimited Data Plan. Here Are the Details*, THE WASHINGTON POST (Feb. 13, 2017), https://www.washingtonpost.com/news/the-switch/wp/2017/02/13/verizon-is-launching-a-new-unlimited-data-plan-here-are-the-details/?utm_term=.af67f78dd94e.

Brian Krzanich, *Data Is the New Oil in the Future of Automated Driving*, INTEL (Nov. 15, 2016), https://newsroom.intel.com/editorials/krzanich-the-future-of-automated-driving/.

Brian Womack, *Google Says 700,000 Applications Available for Android*, BUSINESSWEEK(October 29, 2012) https://web.archive.org/web/20121101015738/http://www.businessweek.com/news/2012-10-29/google-says-700-000-applications-available-for-android-devices.

Calvin Sims, *All About/Cellular Telephones; A Gadget That May Soon Become the Latest Necessity*, N.Y. TIMES (Jan. 28, 1990), https://www.nytimes.com/1990/01/28/business/all-about-cellular-telephones-a-gadget-that-may-soon-become-the-latest-necessity.html.

Calvin Sims, *Cellular Phone Growth Starts Investor Rush*, N.Y. TIMES (June 23, 1989), https://www.nytimes.com/1989/06/23/business/cellular-phone-growth-starts-investor-rush.html.

Calvin Sims, *Meeting Mobile Phone Demand*, N.Y. TIMES (July 19, 1989), https://www.nytimes.com/1989/07/19/business/meeting-mobile-phone-demand.html.

Carlo Longino, *T-Mobile Outlines 3G Catch-Up Plans*, TECH DIRT (Dec. 19, 2005), https://www.techdirt.com/articles/20051219/140625.shtml.

Catherine Greenman, *Too Many Phones, Too Little Service*, N.Y. TIMES (Aug. 19, 1999), https://www.nytimes.com/1999/08/19/technology/too-many-phones-too-little-service.html.

CEES LINKS, QORVO, WI-FI DATA RATES, CHANNELS AND CAPACITY (Dec. 2017), https://www.qorvo.com/resources/d/qorvo-wifi-data-rates-channels-capacity-white-paper.

Sprint 'Powers Up' Wireless Coverage, Capacity To Its Nextel Network In Metro Detroit (Oct. 12, 2006), http://newsroom.sprint.com/sprint-powers-up-wireless-coverage-capacity-to-its-nextel-network-in-metro-detroit.htm.

Chris Price, *Digital Technology Drives Uber to Global Success*, THE TELEGRAPH (Jan. 27, 2015), https://www.telegraph.co.uk/sponsored/technology/4g-mobile/engaging-customers/11366554/digital-technology-uber.html.

Chris Velazco, *Verizon's New LTE Promotion Meant To Benefit iPhone Users Too*, TECHCRUNCH (Nov. 10, 2011), https://techcrunch.com/2011/11/10/verizons-new-lte-promotion-meant-to-benefit-iphone-users-too/.

Chris Welch, *T-Mobile and MetroPCS Merger Finalized, Company to Begin Trading as 'T-Mobile US,'* THEVERGE (May 1, 2013), https://www.theverge.com/2013/5/1/4286622/t-mobile-us-metropcs-merger-complete-tmus.

Chris Ziegler, *2G, 3G, 4G, And Everything In Between: An Engadget Wireless Primer*, ENGADGET (Jan. 17, 2011), https://www.engadget.com/2011/01/17/2g-3g-4g-and-everything-in-between-an-engadget-wireless-prim/.

Cingular 3G Coverage In More Than 160 Markets, FIELD TECH. MAG. (Dec. 21, 2006), https://www.fieldtechnologiesonline.com/doc/cingular-3g-coverage-in-more-than-160-markets-0001.

Cingular agrees to buy AT&T Wireless, NBC (February 17, 2004), http://www.nbcnews.com/id/4276272/ns/business-stocks_and_economy/t/cingular-agrees-buy-att-wireless/#.WxLzCq6nGpo.

Claire Reilly, *CES 2018 is Where You'll Start Caring About 5G*, CNET (Jan. 2, 2018), https://www.cnet.com/news/ces-2018-caring-about-5g-intel-iot-driverless-cars-vr/.

Colin Gibbs, *T-Mobile/Sprint Merger Would 'Significantly Improve' Ability to Compete in Rural Markets: Mosaik*, FIERCEWIRELESS (Oct. 2, 2017), https://www.fiercewireless.com/wireless/t-mobile-sprint-merger-would-significantly-improve-ability-to-compete-rural-markets-mosaik.

Colin Gibbs, *Verizon Overhauls 'Unlimited' Plan, Reverts to Video Throttling*, FIERCEWIRELESS (Aug. 22, 2017), https://www.fiercewireless.com/wireless/verizon-overhauls-unlimited-plan-intros-video-throttling.

ComputerWire, *Sprint CEO Promises Mid Year 3G US Roll Out*, THE REGISTER (Jan. 14, 2002), https://www.theregister.co.uk/2002/01/14/sprint_ceo_promises_mid_year/.

CONSUMER TECH. ASS'N, DEVELOPMENT AND DEPLOYMENT OF 5G NETWORK (Oct. 2017).

CONSUMER TECH. ASS'N, *The Promise of 5G* (Aug. 22, 2017), https://www.cta.tech/News/i3/Articles/2017/July-August/The-Promise-of-5G.aspx.

CTIA, WIRELESS SNAPSHOT 2017: MORE DEVICES, MORE SMARTPHONES, AND MORE APPLICATIONS CONTRIBUTE TO OUR MOBILE-FIRST LIVES (2017), https://api.ctia.org/docs/default-source/default-document-library/ctia-wireless-snapshot.pdf.

Dan Frommer, *Verizon Wireless Testing 4G 'LTE' Network Today*, BUSINESS INSIDER (Aug. 14, 2009), http://www.businessinsider.com/verizon-wireless-testing-4g-lte-network-today-2009-8.

Dan Meyer, *T-Mobile and Verizon Tops in Low Latency and Why it Matters*, RCR WIRELESS (Aug. 24, 2016), https://www.rcrwireless.com/20160824/carriers/t-mobile-verizon-tops-low-latency-matters-tag2.

Darrell Etherington, *iOS App Store Boasts 700K Apps, 90% Downloaded Every Month*, TECHCRUNCH (September 12, 2012), http://techcrunch.com/2012/09/12/ios-app-store-boasts-700k-apps-90-downloaded-every-month/.

Darren Murphy, *Sprint Announces Large Scale WiMAX Rollout, Starts With Chicago and D.C.*, ENGADGET (Jan. 9, 2007), https://www.engadget.com/2007/01/09/sprint-announces-large-scale-wimax-rollout-starts-with-chicago/.

DARYL SCHOOLAR, OVUM, 5G FIXED WIRELESS ACCESS (2016), http://images.samsung.com/is/content/samsung/p5/global/business/networks/insights/white-paper/5g-fixed-wireless-access/global-networks-insight-whitepaper_5g-fixed-wireless-access-0.pdf.

Dave Mock, *AT&T Wireless Pushes the EDGE*, THE MOTLEY FOOL (Nov. 19, 2003), https://www.fool.com/investing/general/2003/11/19/atampt-wireless-pushes-the-edge.aspx.

David Goldman, *You're Using More Smartphone Data Than You Think*, CNN MONEY (Feb. 8, 2011), http://money.cnn.com/2011/02/08/technology/smartphone_data_usage/index.htm.

DAVID J. TEECE, TUSHER CENTER FOR INTELLECTUAL CAPITAL, INSTITUTE FOR BUSINESS INNOVATION, HAAS SCHOOL OF BUSINESS, U.C. BERKELEY, 5G MOBILE: DISRUPTING THE AUTOMOTIVE SECTOR (2017).

David Pierce, *The Wired Guide to the iPhone*, WIRED (Feb. 1, 2018), https://www.wired.com/story/guide-iphone/.

David Pogue, *The iPhone Matches Most of Its Hype*, N.Y. TIMES (June 27, 2007), http://www.nytimes.com/2007/06/27/technology/circuits/27pogue.html.

David Welch, *GM Adds SoftBank as Ally in Self-Driving Race Against Google*, BLOOMBERG (May 31, 2018), https://www.bloomberg.com/news/articles/2018-05-31/gm-s-cruise-unit-draws-2-25-billion-investment-by-softbank-fund.

Don Butler, *Why We're Working with Qualcomm to Ensure Everything in Cities Speaks the Same Language*, MEDIUM (Jan. 9, 2018), https://medium.com/cityoftomorrow/why-were-working-with-qualcomm-to-ensure-everything-in-cities-speaks-the-same-language-98e0cc1bff18.

Dong Ngo, *Home Networking Explained, Part 4: Wi-Fi vs. Internet*, CNET (Sept. 3, 2016), https://www.cnet.com/how-to/home-networking-explained-part-4-wi-fi-vs-internet/.

Drones + 5G: The Sky's the Limit, QUALCOMM (Nov. 14, 2016), https://www.qualcomm.com/news/onq/2016/11/14/drones-5g-skys-limit.

Ed Oswald, *T-Mobile Plans for Growth, 3G in 2006*, BETA NEWS (Dec. 16, 2005), https://betanews.com/2005/12/16/t-mobile-plans-for-growth-3g-in-2006/.

Ellis Hamburger, *Facebook For iOS Goes Native Waves Goodbye To HTML 5*, THE VERGE (Aug. 23, 2012), https://www.theverge.com/2012/8/23/3262782/facebook-for-ios-native-app.

Elyse Betters, *Here's T-Mobile's Awesome Response to AT&T's Attack Ads*, 9TO5MAC (Mar. 6, 2013), https://9to5mac.com/2013/03/06/heres-t-mobiles-awesome-response-to-atts-attack-ads/.

eMarketer Releases Updated Estimates for US Digital Users, EMARKETER (Feb. 20, 2017), https://www.emarketer.com/Article/eMarketer-Releases-Updated-Estimates-US-Digital-Users/1015275.

Eric Bangeman, *AT&T to Flip Switch on 4G LTE Network by Mid-2011*, ARS TECHNICA (Jan. 5, 2011), https://arstechnica.com/gadgets/2011/01/att-to-flip-switch-on-4g-lte-network-by-mid-2011/.

Eric Eldon, *How Uber is Launching In Its Newest City, Washington, DC*, TECHCRUNCH (Dec. 15, 2011), https://techcrunch.com/2011/12/15/uberdc/.

Erik Brynjolfsson et al., *Using Massive Online Choice Experiments to Measure Changes in Well-being* (NBER Working Paper No. 24514, 2018), http://www.nber.org/papers/w24514.

Evaluating Market Consolidation in Mobile Communications (CESifo Working Paper, No. 6509, 2018), http://hdl.handle.net/10419/167495.

Evelyn M. Rusli, *Facebook Buys Instagram for $1 Billion*, NEW YORK TIMES (Apr. 9, 2012), https://dealbook.nytimes.com/2012/04/09/facebook-buys-instagram-for-1-billion/.

EverySteveJobsVideo, *Steve Jobs introduces iPhone 3G & MobileMe - WWDC (2008)*, YOUTUBE (Dec. 21, 2012), https://youtu.be/Zk97Tu3PY6I?t=1h26m48s.

Exploring 2G, 3G, 4G Technology, GEOTAB (Nov. 26, 2012), https://www.geotab.com/blog/exploring-2g-3g-4g-technology/.

Fan Guo, et al., *Everywhere, All the Time, Really Fast: The Importance of Network Quality*, MCKINSEY & COMPANY (Feb. 2015), https://www.mckinsey.com/practice-clients/tmt/everywhere-all-the-time-really-fast-the-importance-of-network-quality.

Fortune Editors, *Get Ready for Verizon's 'Dream Phone,'* FORTUNE (Oct. 29, 2010), http://fortune.com/2010/10/29/get-ready-for-verizons-dream-phone/.

Galen Gruman, *WiMax: Goodbye and Good Riddance*, INFOWORLD (Oct. 9, 2010), https://www.pcworld.com/article/207386/wimax_goodbye_and_good_riddance.html.

Garrett Mitchell, *Facebook's Internet-Delivering Drone Takes Flight*, USA TODAY(June 30, 2017), https://www.usatoday.com/story/tech/nation-now/2017/06/30/facebooks-internet-delivering-drone-takes-flight/444559001/.

Gary Krakow, *High-speed wireless network lives up to claims*, NBC NEWS (Dec. 16, 2004), http://www.nbcnews.com/id/6722931/ns/technology_and_science-wireless/t/high-speed-wireless-network-lives-claims/#.Wv34-q6nGpo.

Google: Actually, We Count Only 16,000 Apps In Android Market, TECHCRUNCH (December 16, 2009), https://techcrunch.com/2009/12/16/google-android-market/.

Greg Sterling, *Report: Nearly 60 Percent of Searches Now From Mobile Devices*, SEARCH ENGINE LAND (Aug. 3, 2016), https://searchengineland.com/report-nearly-60-percent-searches-now-mobile-devices-255025.

Heejung Yu, et al., *What is 5G? Emerging 5G Mobile Services and Network Requirements*, SUSTAINABILITY Volume 9, Issue 10 (Oct. 15, 2017), http://www.mdpi.com/2071-1050/9/10/1848/htm.

HSPA or LTE? That is the Question, RCR WIRELESS (May 9, 2014), https://www.rcrwireless.com/20140509/hetnet-news/hspa-lte.

IAB, DIGITAL TRENDS: CONSUMER USAGE OF DIGITAL AND ITS INFLUENCE ON AD REVENUE (2017), https://www.iab.com/wp-content/uploads/2017/12/Digital-Trends-Consumer-Usage-of-Digital-and-its-Influence-on-Ad-Revenue.pdf.

Intel 2018 MWC Booth Demonstrations, INTEL NEWSROOM (2018), https://newsroom.intel.com/wp-content/uploads/sites/11/2018/02/2018-mwc-demo-fact-sheet.

Intel and Ericsson Launch 5G Innovators Initiative With Honeywell, GE and the University of California Berkeley, INTEL (Feb. 21, 2017), https://newsroom.intel.com/news-releases/intel-ericsson-launch-5g-innovators-initiative-honeywell-ge-university-california-berkeley/.

Intel News Fact Sheet: The 5G - Autonomous Driving Connection, INTEL NEWSROOM (Jan. 2017), https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2017/01/why-5G-for-ad-fact-sheet.pdf.

Internet of Things (IoT) Connected Devices Installed Base Worldwide from 2015 to 2025 (in billions), Statista, https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/ (last visited June 10, 2018).

J.D Biersdorfer, *The Perks of a Faster Phone*, N.Y. TIMES (Dec. 6, 2007), https://www.nytimes.com/2007/12/06/technology/personaltech/06askk-002.html?rref=collection%2Ftimestopic%2FMobile%20Phones.

JAMES FAUCETTE ET AL., MORGAN STANLEY, LEARNING TO RIDE A 5G CYCLE (Oct. 15, 2017).

JAMES K. UHRETAL., TRAVEL MODELING IN AN ERA OF CONNECTED AND AUTOMATED TRANSPORTATION SYSTEMS: AN INVESTIGATION IN THE DALLAS-FORT WORTH AREA (2017), https://rosap.ntl.bts.gov/view/dot/32602.

Jason Snell, *Jobs speaks! The Complete Transcript*, MACWORLD (October 18, 2010), http://www.macworld.com/article/1154980/jobs_transcript.html.

Jeanette Wannstrom, *LTE-Advanced*, 3GPP (June 2013), http://www.3gpp.org/technologies/keywords-acronyms/97-lte-advanced.

Jeff Baumgartner, *T-Mobile Paid $325 Million for Layer3 TV*, MULTICHANNEL NEWS (Feb. 8, 2018), https://www.multichannel.com/news/t-mobile-paid-325-million-layer3-tv-418030.

Jennifer Levitz & Valerie Bauerlein, *Rural America is Stranded in the Dial-Up Age*, WALL STREET JOURNAL (June 15, 2017), https://www.wsj.com/articles/rural-america-is-stranded-in-the-dial-up-age-1497535841.

Jeremiah Owyang et al., *5G Enables the Next Generation of Intelligent Tech*, KALEIDO INSIGHTS (Feb. 27, 2018), http://www.kaleidoinsights.com/5g-enables-the-next-generation-of-intelligent-tech.

Jeremy Horowitz, *AT&T Plans 12-City Mobile 5G Network By Year's End as Verizon, Sprint, and T-Mobile Bicker Over 'Real 5G' Plans*, VENTURE BEAT (Jan. 4, 2018), https://venturebeat.com/2018/01/04/att-plans-12-city-mobile-5g-network-by-years-end-as-verizon-sprint-and-t-mobile-bicker-over-real-5g-plans/.

Jerry Dischler, *Building for the Next Moment*, GOOGLE INSIDE ADWORDS BLOG (May 5, 2015), https://adwords.googleblog.com/2015/05/building-for-next-moment.html.

Jerry Hildenbrand, *When Do Carriers Start Throttling You and What Can You Do About It?*, ANDROIDCENTRAL (Dec. 27, 2017), https://www.androidcentral.com/when-do-carriers-start-throttling-you-and-what-you-can-do-about-it.

Jessica Dolcourt, *AT&T launching LTE on Sept. 18, at Long Last*, CNET (Sept. 15, 2011), https://www.cnet.com/news/at-t-launching-lte-on-sept-18-at-long-last/.

Joan E. Solsman, *Netflix is Hijacking 1 Billion Hours of Our Lives Each Week*, CNET (Apr. 17, 2017), https://www.cnet.com/news/netflix-billion-hours-a-week-adam-sandler/.

John Herrman, *AT&T's Super-fast HSPA+ Network Will Cover 250 Million People By the End of the Year*, GIZMODO (May 14, 2010), https://gizmodo.com/5539391/atts-super-fast-hspa%252B-network-will-cover-250-million-people-by-the-end-of-the-year.

John Markoff, *Chiefs Defend Slow Network for the iPhone*, N.Y. TIMES (June 29, 2007), https://www.nytimes.com/2007/06/29/technology/29phone.html.

John Saw, *Celebrating and Accelerating: Sprint's 2017 Network Accomplishments and New Investment in 2018*, SPRINT (Dec. 21, 2017), http://newsroom.sprint.com/celebrating-and-accelerating.htm.

Jordan Golson, *Apple's App Store Now Has Over 2 Million Apps*, THE VERGE (June 13, 2016), https://www.theverge.com/2016/6/13/11922926/apple-apps-2-million-wwdc-2016.

Joris Evers, *AT&T Wireless Lives on the EDGE*, PC WORLD (Nov. 18, 2003), https://www.pcworld.com/article/113530/article.html.

Joseph Hanlon, *These LTE Speeds Will Make You Cry*, CNET (Oct. 3, 2012), https://www.cnet.com/news/these-lte-speeds-will-make-you-cry.

Josh Constine, *Facebook Speeds Up Android App By Ditching HTML5 And Rebuilding It Natively Just Like The iOS Version*, TECHCRUNCH (Dec. 13, 2012), https://techcrunch.com/2012/12/13/facebook-android-faster/.

Josh Sanburn, *Why Verizon Dropped Its Unlimited Data Plan (And What You Can Do About It)*, TIME (June 23 2011), http://business.time.com/2011/06/23/why-verizon-dropped-its-unlimited-data-plan/.

Jube Shiver Jr., *AT&T Makes Big Move in Digital Race*, LA TIMES (Oct. 3, 1996), http://articles.latimes.com/1996-10-03/business/fi-49967_1_digital-pcs.

Julie Creswell, Ivan Seidenberg, *CEO of Verizon, Vows to Overpower the Cable Guys by Plowing Billions into a '90s-style Broadband Buildout. But Will He Really? Or Is the Most Powerful Man in Telecom Pulling a Megabluff?* FORTUNE, (May 31, 2004), http://archive.fortune.com/magazines/fortune/fortune_archive/2004/05/31/370724/index.htm.

Kalyan Parbat, *How 5G Technology Can Play Crucial Role in Agricultural Growth and Smart Cities Initiative*, ECONOMIC TIMES (Apr. 7, 2018), https://economictimes.indiatimes.com/tech/internet/how-5g-technology-can-play-crucial-role-in-agricultural-growth-and-smart-cities-initiative/articleshow/63649045.cms.

KARIM TAGA ETAL.,ARTHUR D. LITTLE GLOB., 5G DEPLOYMENT MODELS ARE CRYSTALLIZING (JUNE 2017), http://www.adlittle.com/sites/default/files/viewpoints/adl_5g_deployment_models.pdf.

Keith Winstein, *A Tedious and Personal History of 3G*, GIZMODO (Aug. 21, 2010), https://gizmodo.com/5618307/a-tedious-and-personal-history-of-3g.

Kendra Chamberlain, *Measuring the 5G Opportunity* 19, FIERCE WIRELESS (2017) (ebook), https://info.mavenir.com/hubfs/eBooks/5G:%20A%20Look%20at%20the%20Business%20Models.pdf.

Kent German & Donald Bell, *Review: iPhone 3G Lives Up to the Hype*, CNN (July 15, 2008), http://www.cnn.com/2008/TECH/ptech/07/15/iphone.review/.

Kevin Fitchard, *A Peek Into GM's Connected Car Future*, FORTUNE (Mar. 27, 2015), http://fortune.com/2015/03/27/a-peek-into-gms-connected-car-future/.

Kevin Fitchard, *AT&T's New Souped-Up LTE Network is Live in Chicago, but You'll Have to Wait to Use it*, GIGAOM (Mar. 6, 2014), https://gigaom.com/2014/03/06/atts-new-souped-up-lte-network-is-live-in-chicago-but-youll-have-to-wait-to-use-it/.

Kevin Fitchard, *How The First Countries To Adopt LTE Are Faring In The 4G Race*, OPENSIGNAL (Oct. 7, 2015), https://opensignal.com/blog/2015/10/07/how-the-first-countries-to-adopt-lte-are-faring-in-the-4g-race/.

Kevin Fitchard, *The state of LTE in the U.S.: How the carriers' 4G networks stack up*, GIGAOM (Jan. 30, 2014), https://gigaom.com/2014/01/30/4g-vs-4g-comparing-lte-networks-in-the-us/.

Kevin Fitchard, *T-Mobile Doubles its LTE Speeds, Capacity in at Least 40 Major Cities*, GIGAOM (Nov. 5, 2013), https://gigaom.com/2013/11/05/t-mobile-doubles-its-lte-speeds-capacity-in-at-least-40-major-cities/.

Kevin Fitchard, *Verizon Quietly Unleashes its LTE Monster, Tripling 4G Capacity in Major Cities*, GIGAOM (Dec. 5, 2013), https://gigaom.com/2013/12/05/verizon-quietly-unleashes-its-lte-monster-tripling-4g-capacity-in-major-cities/.

Kevin Murphy & Ignacio Palacios-Huerta, *A Theory of Bundling Advertisements in Media Markets* (NBER Working Paper No. 22994, 2016), http://www.nber.org/papers/w22994.

Kim Laraqui et al., *5G and Fixed Wireless Access*, ERICSSON TECH. REV, Dec. 16, 2016, https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2016/etr-5g-and-fixed-wireless-access.pdf.

Kyle Gibb, *Android Market passes 100,000 'apps'*, ANDROID CENTRAL (October 26, 2010), https://www.androidcentral.com/android-market-surpasses-100000-apps.

Larry Thompson et al., *Comparing Wired and Wireless Broadband*, BBCMag.com (May 2015), http://www.bbcmag.com/2015mags/May_June/BBC_May15_ComparingWiredandWireless.pdf.

Laurie J. Flynn, *AT&T Profit Surges 41% With Help From iPhone*, N.Y. TIMES (Oct. 24, 2007), https://www.nytimes.com/2007/10/24/business/24phone.html.

Lawrence Kan, *Apple iPhone 3G Commercial-Hong Kong(English)*, YOUTUBE (Aug. 21, 2008), https://www.youtube.com/watch?v=rxS7nQNjyrE.

Lloyd Vries, *From AT&T To Cingular And Back Again*, CBS (Jan. 12, 2007), https://www.cbsnews.com/news/from-att-to-cingular-and-back-again/.

Lopa J. Vora, *Evolution of Mobile Generation Technology: 1G to 5G and Review of Upcoming Wireless Technology 5G*, INT'L J. MOD. TRENDS ENGINEERING & RES. (Mar. 2015), https://www.researchgate.net/publication/317032541_Comparison_between_Cellular_Generations.

M.G. Siegler, *The Long, Complicated Tale of AT&T's Exclusive (And Elusive) iPhone Agreement*, TECHCRUNCH (May 10, 2010), https://techcrunch.com/2010/05/10/apple-att-iphone-agreement/.

MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES: HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 7 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf.

Malik Saadi, *Analyst Angle: The Hidden Value of 5G Innovation and its Impact on Economic Growth and Consumers' Lifestyles*, RCR WIRELESS (Jan. 4, 2018), https://www.rcrwireless.com/20180103/opinion/analyst-angle-the-hidden-value-of-5g-innovation-and-its-impact-on-economic-growth-and-consumers-lifestyles.

Margaret Rouse, *Drone (Unmanned Aerial Vehicle, UAV)*, IOT AGENDA(Oct. 2016), https://internetofthingsagenda.techtarget.com/definition/drone.

Margo McCall, *Verizon Steals 1X Crown*, WIRELESS WEEK (May 27, 2002), https://www.highbeam.com/doc/1G1-87206619.html.

Marguerite Reardon, *Broken Connection for Sprint Nextel*, CNET (Jan. 29, 2007), https://www.cnet.com/news/broken-connection-for-sprint-nextel/.

Marguerite Reardon, *Sprint Officially Launches 4G LTE in 15 Cities*, CNET (July 16, 2012), https://www.cnet.com/news/sprint-officially-launches-4g-lte-in-15-cities/.

Marguerite Reardon, *T-Mobile Launches 4G LTE Network*, CNET (Mar. 26, 2013), https://www.cnet.com/news/t-mobile-launches-4g-lte-network/.

Mark Howe, *Digital Video Upfronts: Putting YouTube On The Modern-Day Media Plan*, THINK WITH GOOGLE (Oct. 2015), https://www.thinkwithgoogle.com/intl/en-gb/consumer-insights/digital-video-upfronts-putting-youtube/.

Mark Milian, *Verizon To Debut 3rd Android Phone With 4G Thursday*, CNN (May 25, 2011), http://www.cnn.com/2011/TECH/mobile/05/25/lg.revolution/index.html.

Mark Sullivan, *3G and 4G Wireless Speed Showdown: Which Networks Are Fastest*, PC WORLD (Apr. 16, 2012), https://www.pcworld.com/article/253808/3g_and_4g_wireless_speed_showdown_which_networks_are_fastest_.html.

Mark Sullivan, *AT&T roars back in 3G wireless performance test*, COMPUTERWORLD (Feb. 25, 2010), https://www.computerworld.com/article/2520067/mobile-wireless/at-t-roars-back-in-3g-wireless-performance-test.html.

Mark Sullivan, *Consumer Reports AT&T Slam Points Squarely Toward Verizon iPhone*, PC WORLD (Dec. 6, 2010), https://www.pcworld.com/article/212670/Cr_att.html.

Mark Sullivan, *Sprint CEO Says WiMax Bet Paid Less Than Hoped*, PC WORLD (Dec. 7, 2010), https://www.pcworld.com/article/212878/Sprint_CEO_Says_WiMAX_bet_Paid_Less_Than_Hoped.html.

Markus Lorenz et al., *Time to Accelerate in the Race Toward Industry 4.0*, BCG (May 19, 2016), https://www.bcg.com/en-us/publications/2016/lean-manufacturing-operations-time-accelerate-race-toward-industry-4.aspx.

Martha DeGrasse, *Verizon Wireless Outlines Strategies for Spectral Efficiency and More Bandwidth*, RCR WIRELESS (Sept. 21, 2017), https://www.rcrwireless.com/20170921/carriers/verizon-spectrum-tag4-tag99.

Matt Buchanan, *AT&T to Use 700MHz Spectrum for High-Speed 4G LTE Network*, GIZMODO (Apr. 3, 2008), https://gizmodo.com/375898/att-to-use-700mhz-spectrum-for-high-speed-4g-lte-network.

Matt Buchanan, *Verizon's 4G LTE Network Launches Dec. 5: How Fast, How Much and Where It's At*, GIZMODO (Dec. 1, 2010), https://gizmodo.com/5703350/verizons-4g-lte-wireless-network-launches-dec-5.

Matt Hamblen, *WiMax vs. Long Term Evolution: Let the Battle Begin*, COMPUTER WORLD (May 14, 2008) https://www.computerworld.com/article/2535716/mobile-wireless/wimax-vs--long-term-evolution--let-the-battle-begin.html?page=3.

Matthew Hutson, *Hurricanes Show Why Drones Are the Future of Disaster Relief*, NBC NEWS (Sept. 9, 2017), https://www.nbcnews.com/mach/science/hurricanes-show-why-drones-are-future-disaster-relief-ncna799961.

Michael Abrash, Photo Post, FACEBOOK (May 7, 2018) https://www.facebook.com/photo.php?fbid=2080525585560542&set=a.1633971423549296.1073741827.100008093611738&type=3&theater.

Michael R. Levin, *Why Do Consumers Switch Mobile Phone Carriers?*, HUFFINGTON POST (Dec. 6, 2017), https://www.huffingtonpost.com/michael-r-levin/why-do-consumers-switch-m_b_6525492.html.

Michael Reilly, *Facebook Enters the Race to Build 5G Networks*, MIT TECHNOLOGY REVIEW(Feb. 22, 2016), https://www.technologyreview.com/s/600875/facebook-enters-the-race-to-build-5g-networks.

Michel Marriott, *News Watch: An Even Smaller Phone With Even More Stuff*, N.Y. TIMES (May 14, 1998), https://www.nytimes.com/1998/05/14/technology/news-watch-an-even-smaller-phone-with-even-more-stuff.html.

Michelle Castillo, *Mark Zuckerberg Put Employees On 'Lockdown' For Two Months to Launch Facebook Live*, CNBC (Mar. 6, 2017), https://www.cnbc.com/2017/03/06/zuckerberg-put-employees-on-lockdown-to-launch-facebook-live-wsj.html.

Mike Dano, *AT&T Edging into LTE Advanced Technologies for Capacity, Not Speed*, FIERCEWIRELESS (Feb. 26, 2014), https://www.fiercewireless.com/wireless/at-t-edging-into-lte-advanced-technologies-for-capacity-not-speed.

Mike Dano, *Editor's Corner—600 MHz incentive auction 'extravaganza' ends with a whimper*, FIERCEWIRELESS (Jan. 8, 2018), https://www.fiercewireless.com/wireless/editor-s-corner-600-mhz-incentive-auction-extravaganza-ends-a-whimper.

Mike Dano, *Sprint Promises to Launch Nationwide Mobile 5G Network in First Half of 2019*, FIERCE WIRELESS (Feb. 2, 2018), https://www.fiercewireless.com/5g/sprint-promises-to-launch-nationwide-mobile-5g-network-first-half-2019-and-to-raise-unlimited.

Mike Dano, *T-Mobile CFO on 600 MHz incentive auction: 'Dynamics are positive,' carrier could have up to $10B to spend*, FIERCEWIRELESS (Sept. 30, 2015), https://www.fiercewireless.com/wireless/t-mobile-cfo-600-mhz-incentive-auction-dynamics-are-positive-carrier-could-have-up-to-10b.

Mike Dano, *Verizon: 5G Launch Will Feature Proprietary Equipment and a New OTT Video Service*, FIERCEWIRELESS (Apr. 24, 2018), https://www.fiercewireless.com/5g/verizon-5g-launch-will-feature-proprietary-equipment-and-a-new-ott-video-service.

Mike Jude, *AT&T 4G Network Architecture and the LTE Wars*, TECHTARGET (Feb. 2011), https://searchtelecom.techtarget.com/tip/ATT-4G-network-architecture-and-the-LTE-wars.

MMS, TECHTERMS.COM, https://techterms.com/definition/mms (last updated Aug. 25, 2011).

Mobile Fact Sheet, PEW RESEARCH CENTER (Feb. 5, 2018), http://www.pewinternet.org/fact-sheet/mobile/.

Mobile Ringtones Sound Web Alert, CNN.COM (Apr. 23, 2001), http://edition.cnn.com/2001/TECH/ptech/04/23/tunes/index.html.

Monica Alleven, *Verizon not showing signs of worry that T-Mobile is catching up to it on LTE coverage*, FIERCEWIRELESS (Jan. 4, 2018), https://www.fiercewireless.com/wireless/verizon-not-showing-signs-worry-t-mobile-catching-up-to-it-lte-coverage.

Motor Vehicle Deaths in U.S. Again Top 40,000, INSURANCE JOURNAL (Feb. 16, 2018), https://www.insurancejournal.com/news/national/2018/02/16/480956.htm.

Nancy Gohring, *T-Mobile, Google and HTC Introduce First Android Phone*, MACWORLD (Sept. 23, 2008), https://www.macworld.com/article/1135695/android_g1.html.

Natalie Gagliordi, *How 5G Will Impact the Future of Farming and John Deere's Digital Transformation*, ZDNET (Feb. 2, 2018), https://www.zdnet.com/article/how-5g-will-impact-the-future-of-farming-and-john-deeres-digital-transformation/.

Neal Gompa, *T-Mobile USA Launched LTE Network with Breathtaking Speeds*, EXTREME TECH (Mar. 27, 2013), https://www.extremetech.com/electronics/151758-t-mobile-usa-launches-lte-network-with-breathtaking-speeds.

NEXT GENERATION MOBILE NETWORKS, NGMN 5G WHITE PAPER 17 (2015).

No Text Please, We're American, THE ECONOMIST (Apr. 3, 2003), https://www.economist.com/node/1683713.

Oliver Rist, *For Truly Connected Cars, We Need to Wait for 5G*, PC MAGAZINE (Jan. 9, 2018), https://www.pcmag.com/news/358436/for-truly-connected-cars-we-need-to-wait-for-5g.

Om Malik, *DSL Getting Faster – Just Not in the U.S.*, GIGAOM (Nov. 29, 2007), https://gigaom.com/2007/11/29/dsl-getting-faster-just-not-in-the-us/.

Patrick Holland, *Verizon, T-Mobile, AT&T and Sprint Unlimited Plans Compared*, CNET (Apr. 27, 2018), https://www.cnet.com/news/how-does-verizon-unlimited-plan-stack-up-against-the-others/.

Patrick Xavier, LICENSING OF THIRD GENERATION (3G) MOBILE: BRIEFING PAPER 12 (2001), https://www.itu.int/osg/spu/ni/3G/workshop/Briefing_paper.PDF.

Paul Trueman, *Ring Tones*, THE GUARDIAN (Feb. 28, 2001), https://www.theguardian.com/technology/2001/mar/01/internetnews.onlinesupplement3.

Peter Marx, *GE Digital Sprints Towards 5G*, GE (2017), https://www.ge.com/digital/blog/ge-digital-sprints-towards-5g.

Peter Pachal, *Why Is T-Mobile Losing Customers*, PC MAGAZINE (Feb. 25, 2011), https://www.pcmag.com/article2/0,2817,2380949,00.asp.

Phil Goldstein, *BlackBerry 5810 Kickstarted the Mobile Work Era*, BIZTECH (Nov. 11, 2016), https://biztechmagazine.com/article/2016/11/blackberry-5810-kickstarted-mobile-work-era.

Phil Goldstein, *Sprint Unveils 'LTE Plus' Network Brand to Highlight Carrier Aggregation, Beamforming in 77 Major Markets*, FIERCEWIRELESS (Nov.18, 2015), https://www.fiercewireless.com/wireless/sprint-unveils-lte-plus-network-brand-to-highlight-carrier-aggregation-beamforming-77.

Phil Goldstein, *Sprint: HTC Evo launch breaks sales record*, FIERCE WIRELESS, (June 7, 2010), https://www.fiercewireless.com/wireless/sprint-htc-evo-launch-breaks-sales-record.

Philipp Gerbert et. al., *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries*, BCG (April 9, 2015), https://www.bcg.com/en-us/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx.

PREETA M. BANERJEE ET AL., DELOITTE, A NETWORK OF NETWORKS: HOW WILL CARRIERS HANDLE THE EVOLUTION OF 5G? 2-3 (2017), https://www2.deloitte.com/content/dam/insights/us/articles/3795_network-of-networks/DUP_Network-of-networks.pdf.

Press Release, Apple Inc., App Store Downloads Top 100 Million Worldwide (September 9, 2008), http://www.apple.com/pr/library/2008/09/09App-Store-Downloads-Top-100-Million-Worldwide.html.

Press Release, Apple Inc., Apple Announces Over 100,000 Apps Now Available on the App Store (November 4, 2009), http://www.apple.com/pr/library/2009/11/04Apple-Announces-Over-100-000-Apps-Now-Available-on-the-App-Store.html.

Press Release, Apple Inc., Apple Introduces the New iPhone 3G (June 9, 2008), https://www.apple.com/newsroom/2008/06/09Apple-Introduces-the-New-iPhone-3G/.

Press Release, Apple Inc., Apple Reinvents the Phone with iPhone (Jan. 9, 2007), https://www.apple.com/newsroom/2007/01/09Apple-Reinvents-the-Phone-with-iPhone/.

Press Release, Apple, Inc., Apple Introduces iPhone 5 (September 12, 2012), https://www.apple.com/newsroom/2012/09/12Apple-Introduces-iPhone-5/.

Press Release, AT&T, AT&T Announces Plans to Deliver Nation's Most Advanced Mobile Broadband Experience (Jan. 5, 2011), https://www.prnewswire.com/news-releases/att-announces-plans-to-deliver-nations-most-advanced-mobile-broadband-experience-112945969.html.

Press Release, AT&T, AT&T Brings New Unlimited Wireless and Entertainment Deals to Market (Feb. 27, 2017), http://about.att.com/story/att_brings_new_unlimited_wireless_and_entertainment_deals_to_market.html.

Press Release, AT&T, AT&T Builds on 5G Foundation in More Than 100 New Markets (Apr. 20, 2018), http://about.att.com/story/att_builds_on_5g_foundation_in_more_than_100_new_markets.html.

Press Release, AT&T, AT&T Expanding Fixed Wireless 5G Trials to Additional Markets (Aug. 30, 2017), http://about.att.com/story/att_expanding_fixed_wireless_5g_trials_to_additional_markets.html.

Press Release, AT&T, AT&T to Deliver 3G Mobile Broadband Speed Boost (May 27, 2009), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=26835.

Press Release, AT&T, AT&T to Launch Mobile 5G in 2018 (Jan. 4, 2018), http://about.att.com/story/att_to_launch_mobile_5g_in_2018.html.

Press Release, AT&T, AT&T Upgrades 3G Technology at Cell Sites Across Nation (Jan. 5, 2010), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=30358.

Press Release, C-Spire, C Spire Tests Leading Edge 5G Technology for First Time in Mississippi Today (Feb. 20, 2018), https://www.cspire.com/company_info/about/news_detail.jsp?entryId=29600005.

Press Release, Ericsson, U.S. Cellular Expands 5G Test With Ericsson to 28GHz (Oct. 24, 2017), https://www.prnewswire.com/news-releases/us-cellular-expands-5g-tests-with-ericsson-to-28ghz-300542076.html.

Press Release, Facebook, Inc., Facebook Reports First Quarter 2018 Results (April 25, 2018), https://investor.fb.com/investor-news/press-release-details/2018/Facebook-Reports-First-Quarter-2018-Results/default.aspx.

Press Release, FED. COMMC'NS COMM'N, FCC Consents to Sprint Corporation Acquisition of Nextel Communications Licenses and Authorizations (Aug. 3, 2005), https://www.fcc.gov/proceedings-actions/mergers-transactions/sprint-nextel.

Press Release, Qualcomm Inc., Qualcomm and Ford Collaborate on C-V2X Global Initiative to Improve Vehicle Safety, Traffic Efficiency and Support for Autonomous Driving (Jan. 9, 2018), https://www.qualcomm.com/news/releases/2018/01/09/qualcomm-and-ford-collaborate-c-v2x-global-initiative-improve-vehicle.

Press Release, Sprint Corp., Sprint 4G LTE Launch Extends to 15 Cities Throughout Portions of Georgia, Kansas, Missouri and Texas (July 16, 2012), http://newsroom.sprint.com/sprint-4g-lte-launch-extends-to-15-cities-throughout-portions-of-georgia-kansas-missouri-and-texas.htm.

Press Release, Sprint Corp., Sprint to Launch Its First Android Device (Sept. 3, 2009), https://community.sprint.com/t5/Sprint-News-Archives/Sprint-to-Launch-Its-First-Android-Device/ba-p/935115.

Press Release, Sprint Nextel, Sprint Accelerates Deployment of Network Vision and Announces National Rollout of 4G LTE (Oct. 7, 2011), http://newsroom.sprint.com/sprint-accelerates-deployment-of-network-vision-and-announces-national-rollout-of-4g-lte.htm.

Press Release, Sprint Nextel, Sprint Nextel and Clearwire to Partner to Accelerate and Expand the Deployment of the First Nationwide Mobile Broadband Network Using WiMAX Technology (July 19, 2007), http://newsroom.sprint.com/sprint-nextel-and-clearwire-to-partner-to-accelerate-and-expand-the-deployment-of-the-first-nationwide-mobile-broadband-network-using-wimax-technology.htm.

Press Release, Sprint, America's Largest and Fastest Mobile Broadband Network Just Got Even Larger – Sprint Customers Can Do More, In More Places, And At Fast Speeds (June 19, 2007), http://newsroom.sprint.com/americas-largest-and-fastest-mobile-broadband-network-just-got-even-larger-sprint-customers-can-do-more-in-more-places-and-at-fast-speeds.htm.

Press Release, Sprint, America's Largest and Fastest Mobile Broadband Network Just Got Even Larger –Sprint Customers Can Do More, In More Places, And At Fast Speeds (June 19, 2007), http://newsroom.sprint.com/americas-largest-and-fastest-mobile-broadband-network-just-got-even-larger-sprint-customers-can-do-more-in-more-places-and-at-fast-speeds.htm.

Press Release, Sprint, Sprint Launches Nation's First EV-DO Revision A Mobile Broadband Network (Oct. 24, 2006), http://newsroom.sprint.com/sprint-launches-nations-first-ev-do-revision-a-mobile-broadband-network-1.htm.

Press Release, T-Mobile, T-Mobile Celebrates 5 Years as a Public Company with Record-Low Churn, Industry-Leading Customer Growth, and Strong Profitability (May 1, 2018), https://www.t-mobile.com/news/q1-2018-earnings.

Press Release, T-Mobile Inc., T-Mobile Makes Bold 'Un-carrier' Moves (March 26, 2013) https://newsroom.t-mobile.com/news-and-blogs/t-mobile-makes-bold-un-carrier-moves.htm.

Press Release, T-Mobile, T-Mobile Celebrates 5 Years as a Public Company with Record-Low Churn, Industry-Leading Customer Growth, and Strong Profitability (May 1, 2018), https://www.t-mobile.com/news/q1-2018-earnings.

Press Release, T-Mobile, T-Mobile Closes Layer3 TV Acquisition, Prepares to Take on Cable & Satellite TV (Jan. 23, 2018), https://newsroom.t-mobile.com/news-and-blogs/uncarrier-tv-close.htm.

Press Release, T-Mobile, T-Mobile Reports Record Financial Results Across the Board for FY 2017, Issues Strong Guidance for 2018 and Beyond (Feb. 8, 2018), https://newsroom.t-mobile.com/news-and-blogs/tmus-q4-2017-earnings.htm.

Press Release, T-Mobile, T-Mobile USA Begins Commercial 3G Network Rollout (May 5, 2008), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-usa-begins-commercial-3g-network-rollout.htm.

Press Release, T-Mobile, T-Mobile USA Reports Fourth Quarter 2010 Results (Feb. 25, 2011), https://www.businesswire.com/news/home/20110224007281/en/T-Mobile-USA-Reports-Fourth-Quarter-2010-Results.

Press Release, T-Mobile, T-Mobile USA Reports Fourth Quarter 2011 Operating Results (Feb. 23, 2012), https://www.businesswire.com/news/home/20120222007005/en/T-Mobile-USA-Reports-Fourth-Quarter-2011-Operating.

Press Release, T-Mobile, T-Mobile USA Secures Rights from FCC for Auctioned Spectrum (Nov. 30, 2006), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-usa-secures-rights-from-fcc-for-auctioned-spectrum.htm.

Press Release, U.S. Census Bureau, New Census Data Show Differences Between Urban and Rural Populations (December 8, 2016), https://www.census.gov/newsroom/press-releases/2016/cb16-210.html

Press Release, Verizon Wireless, Verizon Selects LTE as 4G Wireless Broadband Direction (Nov. 29, 2007), http://www.verizon.com/about/news/vzw/2007/11/pr2007-11-29.

Press Release, Verizon Wireless, Verizon Wireless Announces Roll Out of National 3G Network (Jan. 8, 2004), http://www.verizon.com/about/news/vzw/2004/01/pr2004-01-07.

Press Release, Verizon Wireless, Verizon Wireless Celebrates Three Years (and Counting) of 4G LTE (Dec. 5, 2013), http://www.verizonwireless.com/news/article/2013/12/verizon-wireless-4g-lte-three-year-anniversary.html.

Press Release, Verizon Wireless, Verizon Wireless Launches The World's Largest 4G LTE Wireless Network On Dec. 5 (Dec. 1, 2010), http://www.verizon.com/about/news/vzw/2010/12/pr2010-11-30a.

Press Release, Verizon Wireless, Verizon Wireless Says Spectrum Additions From FCC's Auction 73 Will Further Company's Broadband Strategy (Apr. 4, 2008), http://www.verizon.com/about/news/vzw/2008/04/pr2008-04-04.

Press Release, Verizon Wireless, Verizon Wireless: 100 Percent of Wireless Broadband Network Now Enhanced with Faster Speeds (June 29, 2007), https://www.verizon.com/about/news/vzw/2007/06/pr2007-06-28h.

QUALCOMM & NOKIA, MAKING 5G A REALITY: ADDRESSING THE STRONG MOBILE BROADBAND DEMAND IN 2019 & BEYOND (Sept. 2017), https://www.qualcomm.com/system/files/document/files/whitepaper_-_making_5g_a_reality_-_addressing_the_strong_mobile_broadban.pdf.

QUALCOMM INC., THE EVOLUTION OF MOBILE TECHNOLOGIES (June 2014), https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf.

Raj Talluri, *Unleashing the Full Potential of 5G to Create a Massive Internet of Things*, NETWORK WORLD (Jan. 31, 2017), https://www.networkworld.com/article/3160851/internet-of-things/unleashing-the-full-potential-of-5g-to-create-a-massive-internet-of-things.html.

Rani Molla, *Netflix Now Has Nearly 118 Million Streaming Subscribers Globally*, RECODE (Jan. 22, 2018), https://www.recode.net/2018/1/22/16920150/netflix-q4-2017-earnings-subscribers.

Rebecca Hills-Duty, *HTC CEO: 5G Will Have A Big Impact On VR*, VR FOCUS(Mar. 6, 2018), https://www.vrfocus.com/2018/03/htc-ceo-5g-will-have-a-big-impact-on-vr/.

Reuters Staff, *Sprint Launches Its First WiMax Market*, REUTERS (Sept. 29, 2008), https://www.reuters.com/article/sprint-wimax/sprint-launches-its-first-wimax-market-idUSN2938183020080929.

Reuters Staff, *Sprint Unveils HTC WiMax Phone EVO 4G*, REUTERS (Mar. 23, 2010), https://www.reuters.com/article/us-sprint-htc/sprint-unveils-htc-wimax-phone-evo-4g-idUSTRE62M5L120100324?type=technologyNews.

Richard N. Clarke, *Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics*, 38 TELECOMM. POL'Y (2014).

ROBERT J. GORDON, THE RISE AND FALL OF AMERICAN GROWTH: THE U.S. STANDARD OF LIVING SINCE THE CIVIL WAR (2017).

Robert Nelson, *AT&T 4G LTE Coverage was Doubled in 2012, is Now Available for More Than 150 Million People*, ANDROID AUTHORITY (Nov. 16, 2012), https://www.androidauthority.com/att-4g-lte-doubles-in-2012-132046/.

Roger Cheng, *T-Mobile Will Deploy Blazing 5G This Year, but You Can't Use It*, CNET, February 27, 2018, https://www.cnet.com/news/t-mobile-will-deploy-blazing-5g-this-year-but-you-cant-use-it-yet/.

Roger Cheng, *Sprint Confirms Unlimited Data Plan for Next iPhone*, CNET (Apr. 25, 2012), https://www.cnet.com/news/sprint-confirms-unlimited-data-plan-for-next-iphone/.

Roger Cheng, *T-Mobile Really, Really Wants You on Its Unlimited Data Plan*, CNET (Jan. 5, 2017), https://www.cnet.com/news/t-mobile-uncarrier-next-13-really-really-wants-you-on-its-unlimited-data-plan-ces-2017.

Roger Cheng, *T-Mobile's Comeback Plan: Is It Enough*, CNET (Feb. 23, 2012), https://www.cnet.com/news/t-mobiles-comeback-plan-is-it-enough/.

Roger Cheng, *Why Sprint Is Taking Its Sweet Time With 4G LTE*, CNET (July 24, 2013), https://www.cnet.com/news/why-sprint-is-taking-its-sweet-time-with-4g-lte/.

Ryan Kim, *Apple, Google, Palm Rule Smartphones*, SFGATE (June 15, 2009), https://www.sfgate.com/news/article/Apple-Google-Palm-rule-smart-phones-3227347.php.

Sarah Barry James, *Fixed Wireless to Shine in 2018 Thanks to 5G, Cost Savings – S&P Global*, RISE BROADBAND (Apr. 9, 2018), https://www.risebroadband.com/2018/04/fixed-wireless-shine-2018-thanks-5g-cost-savings-sp-global.

Sarah Perez, *More Than 1 Billion iOS Apps Are Downloaded Each Month*, TECH CRUNCH (October 4, 2011), http://techcrunch.com/2011/10/04/more-than-1-billion-ios-apps-are-downloaded-per-month/.

Sascha Segan et al., *Fastest Mobile Networks 2012*, PC MAGAZINE (June 18, 2012), https://www.pcmag.com/article2/0,2817,2405597,00.asp.

Sascha Segan, *AT&T Hits Back on Verizon LTE Claims*, PC MAGAZINE (Oct. 7, 2010), https://www.pcmag.com/article2/0,2817,2370398,00.asp.

Sascha Segan, *WiMAX vs. LTE: Should You Switch?* PC MAGAZINE (May 16, 2012), https://www.pcmag.com/article2/0,2817,2403490,00.asp.

Scott Webster, *AT&T to Focus on LTE Network First, Then Compatible Phones*, CNET (Aug. 10, 2011) https://www.cnet.com/news/at-t-to-focus-on-lte-network-first-then-compatible-phones/.

Sebastian Anthony, *5G Specs Announced: 20Gbps Download, 1Ms Latency, 1M Devices Per Square Kkm*, ARS TECHNICA (Feb. 24, 2014), https://arstechnica.com/information-technology/2017/02/5g-imt-2020-specs/.

Seth Porges, *7 Implications of an AT&T/T-Mobile Merger*, POPULAR MECHANICS (Mar. 21, 2011), https://www.popularmechanics.com/technology/gadgets/a6753/7-implications-of-an-at-t-and-t-mobile-merger/.

Sharon Bass, *The Growth of Car Phones is Busy, Busy*, N.Y. TIMES (Dec. 11, 1988), https://www.nytimes.com/1988/12/11/nyregion/the-growth-of-car-phones-is-busy-busy.html.

Smart Farming IoT and 5G to Revolutionize Agriculture, LANNER (July 6, 2017), https://www.lanner-america.com/blog/smart-farming-iot-5g-agriculture/.

Sprint Commercial Verizon Balls Parody, YOUTUBE, (Jan. 30, 2016), https://www.youtube.com/watch?v=5VeBk3FX7LI.

Sprint Corp., *Sprint Corporation's (S) CEO Michel Combes on Q4 2017 Results - Earnings Call Transcript*, SEEKING ALPHA (May 2, 2018), https://seekingalpha.com/article/4168931-sprint-corporations-s-ceo-michel-combes-q4-2017-results-earnings-call-transcript?part=single.

Sprint Corp., *Sprint Nextel Corporation Q3 2008 (Qtr End 09/30/08) Earnings Call Transcript*, SEEKING ALPHA (Nov. 7, 2008), https://seekingalpha.com/article/104773-sprint-nextel-corporation-q3-2008-qtr-end-09-30-08-earnings-call-transcript.

Sprint LTE Plus Posts Strong Gains in Network Reliability, Beats T-Mobile and Pulls Within 1% of Verizon and AT&T, SPRINT (June 2, 2016), http://investors.sprint.com/news-and-events/press-releases/press-release-details/2016/Sprint-LTE-Plus-Posts-Strong-Gains-in-Network-Reliability-Beats-T-Mobile-and-Pulls-Within-1-of-Verizon-and-ATT/default.aspx.

Sprint Powers Ahead of LTE Rollout, AGL MEDIA GROUP (Apr. 30, 2014), https://www.aglmediagroup.com/sprint-powers-ahead-with-lte-rollout/.

Stephen Lawson, *Android Market Needs More Filters, T-Mobile Says*, PC WORLD (March 17, 2009), https://www.pcworld.com/article/161410/article.html.

Stephen Lawson, *AT&T Wireless Goes 3G*, PC WORLD (July 20, 2004), https://www.pcworld.com/article/116966/article.html.

Stephen Lawson, *Sprint Taps Into its Spectrum for Fast LTE, with Room to Grow*, PC WORLD (Oct. 31, 2013), https://www.pcworld.com/article/2059780/sprint-taps-into-its-spectrum-for-fast-lte-with-room-to-grow.html.

Sue Marek, *AT&T Expands Carrier Aggregation to NY, San Fran and More*, FIERCEWIRELESS (Jan. 22, 2015), https://www.fiercewireless.com/wireless/at-t-expands-carrier-aggregation-to-ny-san-fran-and-more.

Theodore Schleifer, *Uber's Latest Valuation: $72 Billion*, RECODE (Feb. 9, 2018), https://www.recode.net/2018/2/9/16996834/uber-latest-valuation-72-billion-waymo-lawsuit-settlement.

THOMAS K. SAWANOBORI, CTIA, 5G THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. (Feb. 9, 2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf.

Timothy F. Bresnahan & Manuel Trajtenberg, *General Purpose Technologies 'Engines of Growth?'* (Nat'l Bureau of Econ. Research, Working Paper No. 4148, 1992), http://www.nber.org/papers/w4148.pdf.

T-Mobile | Verizon's Secret | Network Ad, YOUTUBE, (Jan. 24, 2016), https://www.youtube.com/watch?v=gYBaslSJaR8.

T-Mobile to Rollout the Nation's Fastest 3G Wireless Network with HSPA+ to More than 100 Metropolitan Areas in 2010, FIELD TECHNOLOGIES ONLINE (Mar. 29, 2010), https://www.fieldtechnologiesonline.com/doc/t-mobile-to-rollout-the-nations-fastest-3g-0001.

T-Mobile U.S., *T-Mobile US's (TMUS) CEO John Legere on Q2 2014 Results - Earnings Call Transcript*, SEEKING ALPHA (July 31, 2014), https://seekingalpha.com/article/2365125-t-mobile-uss-tmus-ceo-john-legere-on-q2-2014-results-earnings-call-transcript?part=single.

T-Mobile USA Announces Commercial 3G Network Availability in 21 Markets By Mid-October, T-MOBILE (Sept. 18, 2008), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-usa-announces-commercial-3g-network-availability-in-21-markets-by-mid-october.htm.

T-Mobile USA Exceeds 25 Million Customer Milestone and Reports Fourth Quarter and 2006 Results, BUSINESSWIRE (Mar. 1, 2007), https://www.businesswire.com/news/home/20070228006332/en/T-Mobile-USA-Exceeds-25-Million-Customer-Milestone.

T-Mobile USA Reports Fourth Quarter 2011 Operating Results, BUSINESSWIRE (Feb. 23, 2012), available at https://www.businesswire.com/news/home/20120222007005/en/ T-Mobile-USA-Reports-Fourth-Quarter-2011-Operating.

T-Mobile USA Reports Fourth Quarter and Full Year 2004 Results, BUSINESSWIRE (Mar. 3, 2005), https://www.businesswire.com/news/home/20050302006002/en/T-Mobile-USA-Reports-Fourth-Quarter-Full-Year.

T-Mobile USA Reports Fourth Quarter and Full Year 2007 Results, BUSINESSWIRE (Feb. 28, 2008), https://www.businesswire.com/news/home/20080227006352/en/T-Mobile-USA-Reports-Fourth-Quarter-Full-Year.

T-Mobile USA Reports Fourth Quarter and Full Year 2009 Results, BUSINESSWIRE (Feb. 25, 2010), https://www.businesswire.com/news/home/ 20100224007058/en/T-Mobile-USA-Reports-Fourth-Quarter-Full-Year.

T-Mobile USA Reports Record Fourth Quarter and Full Year 2005 Results, BUSINESSWIRE (Mar. 2, 2006), https://www.businesswire.com/ news/home/20060301006225/en/T-Mobile-USA-Reports-Record-Fourth-Quarter-Full.

T-Mobile, Hello Un-carrier 12 … R.I.P Data Plans: T-Mobile Goes All In on Unlimited, T-MOBILE NEWSROOM (Aug. 18, 2016), https://newsroom.t-mobile.com/news-and-blogs/rip-data-plans.htm.

T-Mobile's Simple Choice, T-MOBILE, http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MjI0MDIxfENoaWxkSUQ9LTF8VHlwZT0z&t=1 (last visited June 8, 2018).

T-Mobile's 3G Delay Government Related, PHONESCOOP (Sept. 24, 2007), http://www.phonescoop.com/articles/article.php?a=2419.

Todd Haselton, *Here's Every iPhone Released, In Order, And What Changed Along The Way*, CNBC (June 29, 2017), https://www.cnbc.com/2017/06/29/every-iphone-released-in-order.html.

Todd Spangler, *T-Mobile Jumps Into Internet TV Arena With Layer3 TV Acquisition*, VARIETY (Dec. 13, 2017), https://variety.com/2017/digital/news/t-mobile-wireless-tv-layer3-tv-acquisition-1202639000/.

Trefis Team, *Verizon's LTE Advantage Is Paying Off Big Time*, FORBES (May 24, 2013), https://www.forbes.com/sites/ greatspeculations/2013/05/24/verizons-lte-advantage-is-paying-off-big-time/#471c37f779b3.

Tyler Cooper, *DSL vs Cable vs Fiber*, BROADBAND NOW (Jan. 23, 2018), https://broadbandnow.com/report/dsl-vs-cable-vs-fiber.

Verizon – A Better Network as Explained by Colorful Balls. 12 2015, YOUTUBE (Mar. 13, 2016), https://www.youtube.com/watch?v=qEY1r8doHj8.

Verizon Commc'ns Inc., *Verizon Communications (VZ) CEO Lowell McAdam on Q4 2017 Results - Earnings Call Transcript*, SEEKING ALPHA (Jan. 23, 2018), https://seekingalpha.com/article/4139417-verizon-communications-vz-ceo-lowell-mcadam-q4-2017-results-earnings-call-transcript?part=single.

Verizon Commc'ns, Inc., *Verizon Communications (VZ) on Q1 2018 Results - Earnings Call Transcript*, SEEKING ALPHA (Apr. 24, 2018), https://seekingalpha.com/article/4165238-verizon-communications-vz-q1-2018-results-earnings-call-transcript.

Verizon Commc'ns, Inc., *Verizon Communications Management Discusses Q1 2011 Results - Earnings Call Transcript*, SEEKING ALPHA (Apr. 21, 2011), https://seekingalpha.com/article/264793-verizon-communications-management-discusses-q1-2011-results-earnings-call-transcript.

Verizon Launches First U.S. '3G' Network, CNN (Jan. 28, 2002), http://edition.cnn.com/2002/TECH/ptech/01/28/verizon.3g/.

Verizon, *Not Just Unlimited, Verizon Unlimited*, YOUTUBE (Feb. 12, 2017) https://www.youtube.com/watch?v=YacWu0bi690.

Verizon… Ricky Gervais A Better Network … commercial 2016, YOUTUBE, (Mar. 30, 2016), https://www.youtube.com/watch?v=XqVtJBeSJ6s.

Vivian S. Toy, *Teen-Agers and Cell Phones: A Match Made in Gab Heaven*, N.Y. TIMES (Aug. 2, 1999), https://www.nytimes.com/1999/08/02/nyregion/teen-agers-and-cell-phones-a-match-made-in-gab-heaven.html.

Washington Bytes, *The Dawn Of 5G: Will Wireless Kill the Broadband Star?*, FORBES (Sept. 22, 2017), https://www.forbes.com/sites/washingtonbytes/2017/09/22/the-dawn-of-5g-will-wireless-kill-the-broadband-star/#5ad21475fd7f.

What does '4G' Really Mean, Anyway?, NPR, (Jan. 14, 2012), https://www.npr.org/2011/01/14/132934022/what-does-4g-really-mean-anyway.

What is Telehealth? How is Telehealth Different from Telemedicine? HEATHIT.GOV (Sept. 22, 2017), https://www.healthit.gov/faq/what-telehealth-how-telehealth-different-telemedicine.

What the AT&T-T-Mobile Breakup Means for You, CBS NEWS (Dec. 20, 2011), https://www.cbsnews.com/news/what-the-att-t-mobile-breakup-means-for-you/.

Wired Staff, *Verizon's Unlimited Data Plan Has Changed. Here's How It Compares to Other Carriers*, WIRED (Aug. 22, 2017), https://www.wired.com/2017/08/verizons-unlimited-data-plan-back-heres-compares-carriers/.

Wired, Wireless or Both? Americans Rethink Their Internet Connections, REPORT LINKER (Mar. 9, 2017), https://www.reportlinker.com/insight/internet-connections.html.

Yasmin Hyder, *Uber's Evolution from San Francisco to International Disruption*, SOUMYASEN.COM (Feb. 7, 2014), http://soumyasen.com/IDSC6050/Case15/Group15_index.html.

YouTube for Press, YOUTUBE.COM, https://www.youtube.com/intl/en-GB/yt/about/press/ (last visited June 4, 2018).

Google's Ad Revenue from 2001 to 2017, STATISTA (Feb. 2018), https://www.statista.com/statistics/266249/advertising-revenue-of-google/.

HUSAIN M. ABDUL AZIZ ET AL., SYNTHESIS STUDY ON TRANSITIONS IN SIGNAL INFRASTRUCTURE AND CONTROL ALGORITHMS FOR CONNECTED AND AUTOMATED TRANSPORTATION (June 2017), https://info.ornl.gov/sites/publications/files/Pub75211.pdf.

Internet of Medical Things, ARANCA (2016), https://www.aranca.com/assets/uploads/resources/special-reports/Internet-of-Medical-Things-IoMT_Aranca-Special-Report.pdf.

JAMES MANYIKA ET. AL., MCKINSEY& CO. THE INTERNET OF THINGS: MAPPING THE VALUE BEYOND THE HYPE (2015), https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/The-Internet-of-things-Mapping-the-value-beyond-the-hype.ashx.

John Blyler, *Top 5 RF Technologies for 5G in the IoT*, MICROWAVES & RF (July 28, 2017), http://www.mwrf.com/systems/top-5-rf-technologies-5g-iot.

John O'Malley, *What it Means to Lead the Race to 5G*, VERIZON NEWSROOM (Apr. 25, 2018), http://www.verizon.com/about/news/what-it-means-lead-race-5g.

John Saw, *Sprint's New LTE Plus Network Delivers the Fastest LTE Download Speeds*, SPRINT (Jan. 25, 2016), http://newsroom.sprint.com/sprints-new-lte-plus-network-delivers-the-fastest-lte-download-speeds.htm.

KAREN CAMPBELL ET AL., IHS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf.

Karl Bode, *Industry Already Hyping DOCSIS 4.0 or 'DOCSIS dot Next'*, DSL REPORTS (May 24, 2018), http://www.dslreports.com/shownews/Industry-Already-Hyping-DOCSIS-40-or-DOCSIS-dot-Next-141884.

Krishna Rao, *The Path to 5G for Health Care*, IEEE, https://5g.ieee.org/images/files/pdf/applications/5G--Health-Care030518.pdf.

Lee Rainie and Janna Anderson, *The Internet of Things Connectivity Binge: What Are the Implications?* PEW RESEARCH CENTER (June 6, 2017), http://www.pewinternet.org/2017/06/06/the-internet-of-things-connectivity-binge-what-are-the-implications/.

Letter to Customers: T-Mobile's CEO on Binge On, T-MOBILE (undated), https://www.t-mobile.com/brand/binge-on-letter?icid=WMM_TM_Q118BINGEO_XSHPG7BA32B12493.

LTE Advanced is So 2014. We're Already on to the Next Big Thing. Verizon is Now 50% faster … and Still Slower Than T-Mobile!, T-MOBILE BLOG (Sept. 6, 2016), https://newsroom.t-mobile.com/news-and-blogs/lte-advanced.htm.

Mehdi Bennis et al., Ultra-Reliable and Low-Latency Wireless Communication: Tail, Risk and Scale (Jan. 8, 2018), https://arxiv.org/pdf/1801.01270.pdf.

MICHAEL MANDEL, PROGRESSIVE POL'Y INST., LONG-TERM U.S. PRODUCTIVITY GROWTH AND MOBILE BROADBAND: THE ROAD AHEAD (2016), http://www.progressivepolicy.org/wp-content/uploads/2016/03/2016.03-Mandel_Long-term-US-Productivity-Growth-and-Mobile-Broadband_The-Road-Ahead.pdf.

Milon Gupta, Editorial, *Dear Readers*, EURESCOM MESSAGE, Spring 2014, https://www.eurescom.eu/fileadmin/documents/message/Eurescom-message-01-2014-web.pdf.

NARENDRA MANGRA & ALIREZA GHASEMPOUR, IEEE, SMART CITIES: CONNECTED ECOSYSTEM OF ECOSYSTEMS, https://5g.ieee.org/images/files/pdf/applications/Smart-Cities_030518.pdf.

Policies: Open Internet, T-MOBILE, https://www.t-mobile.com/responsibility/consumer-info/policies/internet-service (last visited June 8, 2018).

Smartphone Mobile HotSpot (Wi-Fi Sharing/Tethering), T-MOBILE, https://support.t-mobile.com/docs/DOC-2384 (last visited June 9, 2018).

The New Verizon Plan Unlimited FAQs, VERIZON, https://www.verizonwireless.com/support/new-verizon-plan-unlimited-faqs/ (last visited June 8, 2018).

T-Mobile International Reports Fourth Quarter and Full Year 2003 Results for T-Mobile USA, T-MOBILE (Mar. 10, 2004), https://www.t-mobile.com/Cms/Files/Published/0000BDF20016F5DD010312E2BDE4AE9B/0000BDF20016F5DF010980E90F08FE00/file/2003_Q4.pdf.

T-Mobile, *Broadband Facts*, https://www.t-mobile.com/content/dam/tmo/en-g/pdf/T-Mobile-Broadband-Disclosure-Label.pdf (last visited June 3, 2018).

Unlimited Data Plans, AT&T, https://www.att.com/plans/unlimited-data-plans.html (last visited June 8, 2018).

Verizon Commc'ns Inc., *Q2 2016 Verizon Earnings Call* (July 26, 2016), https://www.verizon.com/about/investors/quarterly-reports/2q-2016-quarter-earnings-conference-call-webcast.

Verizon Commc'ns Inc., *Q3 2005 Verizon Earnings Conference Call* (Oct. 27, 2005).

Verizon Commc'ns Inc., *Q4 2003 Verizon Earnings Conference Call and Investor Conference* (Jan. 29, 2004).

Wireless Subscriptions Market Share By Carrier in the U.S. from 1st Quarter 2011 to 4th Quarter 2017, STATISTA (2018), https://www.statista.com/statistics/199359/market-share-of-wireless-carriers-in-the-us-by-subscriptions/.

Wireless Telecommunications Carriers – US Market Research Report, IBISWORLD (Nov. 2017), https://www.ibisworld.com/industry-trends/market-research-reports/information/broadcasting-telecommunications/wireless-telecommunications-carriers.html.

Worldwide Net Mobile Advertising Revenues Of Google From 2014 To 2018, STATISTA (Oct. 2016), https://www.statista.com/statistics/539477/google-mobile-ad-revenues-worldwide/.

YOSEF GETA CHEW ET AL., JOINT CTR. FOR POLITICAL AND ECON. STUDIES, 5G, SMART CITIES & COMMUNITIES OF COLOR 3, 9-10 (2017).

DEUTSCHE TELEKOM, THE US JOB IS NOT EVEN HALF DONE 10 (Mar. 17, 2016).

How Can I Control How Much Data Netflix Uses? NETFLIX.COM: HELP CENTER, https://help.netflix.com/en/node/87 (last visited June 3, 2018).

Ilya Grigorik, *WiFi*, HIGH PERFORMANCE BROWSER NETWORKING, https://hpbn.co/wifi/ (last visited June 3, 2018).

Release 16, 3GPP, http://www.3gpp.org/release-16 (last visited June 3, 2018).

The History of Uber, UBER NEWSROOM, https://www.uber.com/newsroom/history/ (last visited June 3, 2018).

UNIVERSITY: TUTORIAL, https://www.vpnuniversity.com/tutorial/how-to-stop-video-throttling-on-unlimited-data-plans-and-stream-in-4k (last updated Sept. 13, 2017).

Visual Networking Index: Forecast and Methodology, 2016-2021CISCO 4-7, 17, https://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/#~Country.

Select Publications and Prior Testimony

David S. Evans, *Economic Analysis of the Impact of the Comcast-Time Warner Cable Transaction on Internet Access to Online Video Distributors* (Aug. 25, 2014) (submitted with Netflix, Inc., Petition to Deny, MB Docket No. 14-57).

David S. Evans, *Economic Analysis of the Impact of the Comcast-Time Warner Cable Transaction on Internet Access to Online Video Distributors: Response to Opposition to Petitions to Deny and Response to Comments* (Dec. 23, 2014) (submitted with Netflix, Inc., Petition to Deny, MB Docket No. 14-57), https://www.competitionpolicyinternational.com/assets/Evans-Reply-Declaration-December-23-2014.pdf.

David S. Evans, *Economic Analysis of the Impact of the Proposed Merger of Charter, Time Warner Cable, and Bright House Networks on Video Programming Prices and Broadband Entry and Competition* (Jan. 15, 2016) (submitted with INCOMPAS, Petition to Deny, MB Docket No. 15-149), https://ecfsapi.fcc.gov/file/60001406054.pdf.

Applications of Charter Communications, Inc., Time Warner Cable Inc., and Advance/Newhouse Partnership for Consent to Assign or Transfer Control of Licenses and Authorizations, Memorandum Opinion and Order, 31 FCC Rcd. 6327, (2016) (Charter-Time Warner Order).

David S. Evans & Alexis Pirchio, *An Empirical Examination of Why Mobile Money Schemes Ignite in Some Developing Countries but Flounder in Most*, REV. NETWORK ECON. 397 (2014).

DAVID S. EVANS & RICHARD SCHMALENSEE, CATALYST CODE: THE STRATEGIES BEHIND THE WORLD'S MOST DYNAMIC COMPANIES (2007).

DAVID S. EVANS & RICHARD SCHMALENSEE, MATCHMAKERS: THE NEW ECONOMICS OF MULTISIDED PLATFORMS (2016).

DAVID S. EVANS ET AL., INVISIBLE ENGINES: HOW SOFTWARE PLATFORMS DRIVE INNOVATION AND TRANSFORM INDUSTRIES (2006).

David S. Evans, *Attention Rivalry Among Online Platforms*, J. COMPETITION L. & ECON. 313 (2013).

David S. Evans, *Economic Findings Concerning the State of Competition for Wired Broadband Provision to U.S. Households and Edge Providers* (SSRN, Working Paper No. 3029006, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3029006%20.

David S. Evans, *The Economics of Attention Markets* (SSRN Working Paper No. 3044858, 2017), https://ssrn.com/abstract=3044858.

Hemant Bhargava, David S. Evans & Deepa Mani, *The Move to Smart Mobile and Its Implications for Antitrust Analysis of Online Markets*, UC DAVIS BUS. L.J. 157 (2016).

All other materials cited in the declaration, exhibits, and appendices.

Exhibit 1
Select U.S. Wireless Usage Metrics
2000 – 2016
(Millions)

Year	Voice Minutes of Use	Text and SMS Messages	MMS Messages	Mobile Data Traffic (MBs)[1]
2000	258,855			
2001	456,964			
2002	619,734			
2003	829,877			
2004	1,101,292			
2005	1,495,447	81,208	1,133	
2006	1,798,362	158,649	2,727	
2007	2,118,646	362,550	6,100	
2008	2,202,878	1,005,144	14,933	
2009	2,275,271	1,563,091	34,534	
2010	2,241,323	2,051,679	56,621	388,010
2011	2,295,515	2,303,524	52,816	866,820
2012	2,299,917	2,189,966	74,471	1,468,003
2013	2,618,182	1,910,200	96,125	3,229,758
2014	2,454,930	1,921,122	151,989	6,112,344
2015	2,881,019	1,889,029	218,474	9,649,866
2016	2,751,005	1,660,919	277,865	13,719,038

Note:
[1] There was a data anomaly for mobile data traffic in 2014. To determine the corrected value for 2014, the mobile data traffic growth rate for North America from 2013 to 2014 provided by Cisco (89% YoY) was applied to the 2013 mobile data traffic value.

Source: Robert F. Roche & Kathryn Malarkey, CTIA's Wireless Industry Report Indices Report: Year-End 2016 Results 90-91, 100, 102, Appendix B 4 (May 2017); Cisco, North American VNI Actual and Projected Mobile Traffic Volume (June 2017).

Exhibit 2
U.S. Wireless Connections by Standard
2000 – 2017

	Number of Connections[1]						Percentage of Total Connections[2]					
Year	1G	2G	3G	4G WiMAX	4G LTE	Total	1G	2G	3G	4G WiMAX	4G LTE	Total
2000	29,925,996	81,450,637	0	0	0	111,376,633	27%	73%	0%	0%	0%	100%
2001	21,139,590	93,843,885	0	0	0	114,983,475	18%	82%	0%	0%	0%	100%
2002	12,306,809	120,096,566	0	0	0	132,403,375	9%	91%	0%	0%	0%	100%
2003	8,025,873	142,320,681	2,556	0	0	150,349,110	5%	95%	0%	0%	0%	100%
2004	5,570,490	163,652,924	590,816	0	0	169,816,604	3%	96%	0%	0%	0%	100%
2005	3,642,513	186,804,123	3,882,526	0	0	194,232,359	2%	96%	2%	0%	0%	100%
2006	2,038,080	203,428,819	12,413,170	0	0	217,777,896	1%	93%	6%	0%	0%	100%
2007	844,530	206,986,760	31,315,496	0	0	239,004,363	0%	87%	13%	0%	0%	100%
2008	136,901	184,244,600	70,186,566	118,750	0	254,613,333	0%	72%	28%	0%	0%	100%
2009	0	162,759,742	105,683,543	566,250	0	269,009,535	0%	61%	39%	0%	0%	100%
2010	0	133,758,787	150,446,402	2,441,250	39,522	286,685,960	0%	47%	52%	1%	0%	100%
2011	0	102,987,418	192,597,001	8,427,000	3,529,384	307,540,802	0%	33%	63%	3%	1%	100%
2012	0	86,489,052	199,002,854	10,507,000	21,894,092	317,892,998	0%	27%	63%	3%	7%	100%
2013	0	60,215,332	182,131,449	5,236,854	67,290,158	314,873,792	0%	19%	58%	2%	21%	100%
2014	0	48,867,203	149,965,041	913,281	120,857,518	320,603,042	0%	15%	47%	0%	38%	100%
2015	0	42,668,827	122,450,777	244,384	169,839,303	335,203,291	0%	13%	37%	0%	51%	100%
2016	0	36,742,315	102,964,394	0	206,359,678	346,066,386	0%	11%	30%	0%	60%	100%
2017	0	30,085,480	82,804,618	0	228,781,595	341,671,692	0%	9%	24%	0%	67%	100%

Note:
[1] Annual connection figures are calculated as the quarterly average for each year. Totals for various standards do not sum to total connections for 2004 to 2008. Connections exclude cellular M2M. Years for which no connections data for a given generation are available are set to have zero connections of that generation.
[2] Percentages may not add to 100 percent due to rounding.

Source: GSMA INTELLIGENCE.

Exhibit 3
U.S. Wireless Network Coverage by Standard
2000 – 2017

Year	3G Coverage	4G Coverage
2000	0%	0%
2001	0%	0%
2002	0%	0%
2003	1%	0%
2004	11%	0%
2005	23%	0%
2006	34%	0%
2007	46%	0%
2008	58%	0%
2009	69%	0%
2010	75%	3%
2011	82%	21%
2012	87%	42%
2013	92%	71%
2014	95%	87%
2015	96%	93%
2016	97%	95%
2017	97%	95%

Note:
[1] Yearly coverage figures are a simple average of quarterly figures within each year.
[2] To calculate quarterly coverage, each carrier's reported coverage for a given standard is weighted by its number of total connections (excluding M2M). The weighted coverage for each carrier is then summed and divided by the total number of connections reported across all carriers, regardless of standard (excluding M2M). For a given standard, carriers for which coverage data are never observed are set to have zero coverage. Carriers for which coverage data are observed in some but not all quarters are set to have zero coverage wherever no coverage data are observed. When there is connections data but no coverage data for a carrier in a quarter, that carrier's total connections are excluded from both the numerator and denominator in calculating the quarterly coverage.

Source: GSMA Intelligence.

Exhibit 4
App Usage Metrics: iOS and Google Play
2007 – 2012

Year	iOS Apps[1]	Google Play Apps[2]
2007	0	0
2008	3,000	<2,300
2009	100,000	16,000
2010	300,000	100,000
2011	500,000	400,000
2012	700,000	700,000

Note: App counts are based on apps available in their respective stores.

Source:
[1] Press Release, Apple Inc., App Store Downloads Top 100 Million Worldwide (September 9, 2008), http://www.apple.com/pr/library/2008/09/09App-Store-Downloads-Top-100-Million-Worldwide.html ; Press Release, Apple Inc., Apple Announces Over 100,000 Apps Now Available on the App Store (November 4, 2009), http://www.apple.com/pr/library/2009/11/04Apple-Announces-Over-100-000-Apps-Now-Available-on-the-App-Store.html; Jason Snell, *Jobs speaks! The Complete Transcript*, MACWORLD (October 18, 2010), http://www.macworld.com/article/1154980/jobs_transcript.html; Sarah Perez, *More Than 1 Billion iOS Apps Are Downloaded Each Month*, TECH CRUNCH (October 4, 2011), http://techcrunch.com/2011/10/04/more-than-1-billion-ios-apps-are-downloaded-per-month/; Darrell Etherington, *iOS App Store Boasts 700K Apps, 90% Downloaded Every Month*, TECH CRUNCH (September 12, 2012), http://techcrunch.com/2012/09/12/ios-app-store-boasts-700k-apps-90-downloaded-every-month/.
[2] Stephen Lawson, *Android Market Needs More Filters, T-Mobile Says*, PC WORLD (March 17, 2009), https://www.pcworld.com/article/161410/article.html; *Google: Actually, We Count Only 16,000 Apps In Android Market*, TECH CRUNCH (December 16, 2009), https://techcrunch.com/2009/12/16/google-android-market/; Kyle Gibb, *Android Market passes 100,000 'apps'*, ANDROID CENTRAL (October 26, 2010), https://www.androidcentral.com/android-market-surpasses-100000-apps ; *Android Market Hits the 400,000 Apps - Right Behind Apple's App Store*, ANDROID AUTHORITY (January 4, 2012), https://www.androidauthority.com/android-market-400-thousand-apps-41590/; Brian Womack, *Google Says 700,000 Applications Available for Android*, BUSINESSWEEK (October 29, 2012) https://web.archive.org/web/20121101015738/http://www.businessweek.com/news/2012-10-29/google-says-700-000-applications-available-for-android-devices.

Exhibit 5A
Average Price per GB of Mobile Data for U.S. Smartphone Users
2010 – 2017

Year	Recurring Revenue[1]	Total Connections[2]	Implied ARPU[3]	Smartphone Penetration Rate[4]	Percent of Time on Smartphone Spent Online[4]	Data ARPU[5]	Smartphone Mobile Data Revenue[6]	Smartphone Mobile Data Traffic (GB)[7]	Data Traffic per Smartphone User (GB/Month)[8]	Price per GB of Smartphone Mobile Data[9]
2010	$169,081,283,235	286,685,960	$49.15	24%	35%	$17.01	$13,778,419,819	280,807,096	0.3	$49.07
2011	$178,928,267,305	307,540,802	$48.48	35%	41%	$20.06	$26,032,767,989	671,860,709	0.5	$38.75
2012	$186,774,957,432	317,892,998	$48.96	47%	44%	$21.71	$39,197,106,381	1,276,802,822	0.7	$30.70
2013	$191,404,289,935	314,873,792	$50.66	60%	51%	$25.85	$58,646,512,534	2,309,826,745	1.0	$25.39
2014	$191,582,530,968	320,603,042	$49.80	68%	60%	$29.67	$77,853,373,851	4,883,854,899	1.9	$15.94
2015	$188,113,295,085	335,203,291	$46.77	74%	60%	$27.89	$83,026,416,797	7,660,693,405	2.6	$10.84
2016	$184,548,078,406	346,066,386	$44.44	78%	69%	$30.71	$99,006,032,913	12,261,634,369	3.8	$8.07
2017	$180,122,115,512	341,671,692	$43.93	80%	73%	$32.19	$105,321,517,563	16,900,555,699	5.2	$6.23

Note:
[1] Calculated as the sum of quarterly figures. Q4 2017 data are not available, so 2017 recurring revenue is calculated as the sum of recurring revenue for the first three quarters, plus the average recurring revenue from the first three quarters.
[2] Calculated as the average of quarterly figures. Connections exclude machine-to-machine connections. Q4 2017 data are not available.
[3] Calculated as Recurring Revenue divided by Total Connections, divided by 12.
[4] See Exhibit 5B.
[5] Calculated as Implied ARPU multiplied by Percent of Time on Smartphone Spent Online.
[6] Calculated as Recurring Revenue multiplied by Smartphone Penetration Rate, multiplied by Percent of Time on Smartphone Spent Online.
[7] CTIA reports the average data consumed per smartphone and the total number of smartphone devices on U.S. cellular networks. I estimate smartphones' share of mobile data traffic by dividing smartphone mobile data traffic by total mobile data traffic. 2017 data are not available, so smartphones' share of mobile data traffic in 2017 is set equal to smartphones' share of mobile data traffic in 2016. I multiply smartphones' share of mobile data traffic by total mobile data traffic to estimate smartphone mobile data traffic. There was a data anomaly for mobile data traffic in 2014. To determine the corrected value for 2014, the mobile data traffic growth rate for North America from 2013 to 2014 provided by Cisco (89% YoY) was applied to the 2013 mobile data traffic value. 2017 data are not available, so the mobile data traffic growth rate for North America from 2016 to 2017 provided by Cisco (38% YoY) was applied to the 2016 mobile data traffic value.
[8] Calculated as Smartphone Mobile Data Traffic divided by Total Connections, divided by Smartphone Penetration Rate, divided by 12.
[9] Calculated as Smartphone Mobile Data Revenue divided by Smartphone Mobile Data Traffic.

Source: GSMA INTELLIGENCE; ROBERT F. ROCHE & KATHRYN MALARKEY, CTIA'S WIRELESS INDUSTRY REPORT INDICES REPORT: YEAR-END 2016 RESULTS 10, 90-91, APPENDIX B 4 (May 2017); CISCO, NORTH AMERICAN VNI ACTUAL AND PROJECTED MOBILE TRAFFIC VOLUME (JUNE 2017); NIELSEN CROSS-PLATFORM REPORTS, Q4 2013 – Q2 2014; NIELSEN TOTAL AUDIENCE REPORTS, Q3 2014 – Q2 2017; Mike Dano, *How much cellular and Wi-Fi data are smartphone users consuming, and with which apps? The Verizon, AT&T, T-Mobile and Sprint breakdown*, FIERCEWIRELESS (Sep. 16, 2016), https://www.fiercewireless.com/wireless/how-much-cellular-and-wi-fi-data-are-smartphone-users-consuming-and-which-apps-verizon-at; Mike Dano, *How much cellular and Wi-Fi data are smartphone users consuming, and with which apps? The Verizon, AT&T, T-Mobile and Sprint Q4 2016 breakdown*, FIERCEWIRELESS (Jan. 24, 2017), https://www.fiercewireless.com/wireless/how-much-cellular-and-wi-fi-data-are-smartphone-users-consuming-and-which-apps-verizon-0; Mike Dano, *How much cellular and Wi-Fi data are smartphone users consuming, and with which apps? The Verizon, AT&T, T-Mobile and Sprint Q1 2017 breakdown*, FIERCEWIRELESS (Apr. 26, 2017), https://www.fiercewireless.com/wireless/how-much-cellular-and-wi-fi-data-are-smartphone-users-consuming-and-which-apps-verizon-1; *Global State of Mobile Networks (August 2016)*, OPENSIGNAL (Aug. 2016), https://opensignal.com/reports/2016/08/global-state-of-the-mobile-network; *Global State of Mobile Networks (February 2017)*, OPENSIGNAL (Feb. 2017), https://opensignal.com/reports/2017/02/global-state-of-the-mobile-network.

Exhibit 5B
Derivation of Smartphone Penetration Rate and Percent of Time on Smartphone Spent Online
2010 – 2017

Year	Total Connections[1]	Smartphone Connections[1]	Smartphone Penetration Rate[2]	Voice Minutes[3]	Total Time Spent Online Using Smartphones[4]	Mobile Data Minutes on Smartphone[5]	Smartphones' Share of Mobile Phone Connections[6]	Voice Minutes on Smartphone[7]	Percent of Time on Smartphone Spent Online[8]
2010	286,685,960	67,492,418	24%	2,241,323,210,924	681,805,837,022	336,541,639,292	28%	635,720,765,280	35%
2011	307,540,802	108,156,944	35%	2,295,514,719,942	1,245,864,454,257	614,962,857,465	38%	871,517,452,995	41%
2012	317,892,998	150,457,977	47%	2,299,916,848,471	1,899,692,917,886	937,694,771,768	51%	1,177,061,821,440	44%
2013	314,873,792	189,074,096	60%	2,618,182,348,182	3,202,476,558,750	1,580,753,129,927	58%	1,517,158,645,470	51%
2014	320,603,042	218,641,219	68%	2,454,929,682,914	4,873,312,653,000	2,405,483,408,863	66%	1,631,390,971,393	60%
2015	335,203,291	248,082,848	74%	2,881,018,798,415	5,976,141,140,250	2,949,843,235,082	69%	1,996,572,297,990	60%
2016	346,066,386	268,679,875	78%	2,751,005,432,743	9,632,282,814,000	4,754,526,981,618	77%	2,126,145,791,677	69%
2017	341,671,692	272,634,441	80%	2,751,005,432,743	11,812,378,275,000	5,830,629,385,584	77%	2,126,145,791,677	73%

Note:
[1] Calculated as the average of quarterly figures. Connections exclude machine-to-machine connections. Q4 2017 data are not available.
[2] Calculated as Smartphone Connections divided by Total Connections.
[3] 2017 data are not available, so voice minutes in 2017 are set equal to voice minutes in 2016.
[4] Annual data minutes on smartphones are calculated based on the average number of minutes per month spent by adults using smartphones for app/web, multiplied by the average number of adult users in each year, multiplied by 12. For each year, monthly minutes per adult user equal the simple average of monthly minutes per adult user in each quarter. For Q4 2011 to Q3 2012, monthly minutes per adult user are equal to the daily minutes per adult user figures reported by Nielsen multiplied by 30. Prior to Q4 2011, quarterly figures are calculated using the compound quarterly growth rate between Q4 2011 and Q4 2012 (3.3 percent). Starting in 2016, Nielsen stopped capping the time counted per session at 30 minutes even if actual time was longer. This was implemented in Q1 2016 for iPhones and Q3 2016 for Android devices (Nielsen Total Audience Reports, Q1 2016 – Q3 2016). The number of adult smartphone users for a given year is calculated as the simple average of adult smartphone users in each quarter. Quarterly smartphone user data are not available from Nielsen before Q4 2012. To calculate quarterly smartphone users prior to Q4 2012, the quarterly number of smartphone connections from GSMA Intelligence is divided by 1.4, which is the average ratio of smartphone connections from GSMA Intelligence to smartphone users from Nielsen between Q4 2012 and Q3 2013. Because quarterly smartphone user data for Q3 and Q4 2017 are not available from Nielsen, the 2017 average is calculated based on Q1 and Q2 2017 data from Nielsen.
[5] P3 estimates the share of smartphone time on a cellular connection, reported at the wireless-carrier level. I compute a country-wide average by weighting the wireless carriers' cellular share by their share of smartphone connections based on data from GSMA Intelligence. July 2016 data are not available for AT&T, so the share of smartphone time on a cellular connection in July 2016 is set equal to the share of smartphone time on a cellular connection in June 2016. OpenSignal also estimates the share of smartphone time on a cellular connection. The August 2016 estimate covers 5/1/16–7/23/16 and the February 2017 estimate covers 11/1/16–1/31/17. I take the average of P3's and OpenSignal's estimates of the percentage of smartphone time spent on a cellular connection over their respective samples and assume the percentage was constant over time. I apply this percentage to Total Time Spent Online Using Smartphones to estimate Mobile Data Minutes on Smartphone.
[6] CTIA reports the total number of connections, the number of smartphone connections, and the number of non-mobile phone connections. I compute mobile phone connections by subtracting non-mobile phone connections from total connections. I compute smartphones' share of mobile phone connections as smartphone connections divided by mobile phone connections. 2017 data are not available, so smartphones' share of mobile phone connections in 2017 is set equal to smartphones' share of mobile phone connections in 2016.
[7] Calculated as Voice Minutes multiplied by Smartphones' Share of Mobile Phone Connections.
[8] Calculated as Mobile Data Minutes on Smartphone divided by the sum of Mobile Data Minutes on Smartphone and Voice Minutes on Smartphone.

Source: GSMA Intelligence; Robert F. Roche & Kathryn Malarkey, CTIA's Wireless Industry Report Indices Report: Year-End 2016 Results 10, 90-91, Appendix B 4 (May 2017); Nielsen Cross-Platform Reports, Q4 2013 – Q2 2014; Nielsen Total Audience Reports, Q3 2014 – Q2 2017; Mike Dano, *How much cellular and Wi-Fi data are smartphone users consuming, and with which apps? The Verizon, AT&T, T-Mobile and Sprint breakdown*, FierceWireless (Sep. 16, 2016), https://www.fiercewireless.com/wireless/how-much-cellular-and-wi-fi-data-are-smartphone-users-consuming-and-which-apps-verizon-at; Mike Dano, *How much cellular and Wi-Fi data are smartphone users consuming, and with which apps? The Verizon, AT&T, T-Mobile and Sprint Q4 2016 breakdown*, FierceWireless (Jan. 24, 2017), https://www.fiercewireless.com/wireless/how-much-cellular-and-wi-fi-data-are-smartphone-users-consuming-and-which-apps-verizon-0; Mike Dano, *How much cellular and Wi-Fi data are smartphone users consuming, and with which apps? The Verizon, AT&T, T-Mobile and Sprint Q1 2017 breakdown*, FierceWireless (Apr. 26, 2017), https://www.fiercewireless.com/wireless/how-much-cellular-and-wi-fi-data-are-smartphone-users-consuming-and-which-apps-verizon-1; *Global State of Mobile Networks (August 2016)*, OpenSignal (Aug. 2016), https://opensignal.com/reports/2016/08/global-state-of-the-mobile-network; *Global State of Mobile Networks (February 2017)*, OpenSignal (Feb. 2017), https://opensignal.com/reports/2017/02/global-state-of-the-mobile-network.

Exhibit 6
U.S. Wireless Carrier Network Coverage by Standard
(Percentage of the U.S. Population)
Q4 2003 – Q3 2017

	3G Coverage[1]				4G Coverage[2]			
Quarter	**Verizon**	**AT&T**	**Sprint**	**T-Mobile**	**Verizon**	**AT&T**	**Sprint**	**T-Mobile**
Q4 2003	25%							
Q3 2004	32%	25%						
Q4 2004	35%	27%						
Q3 2005	42%	35%	25%					
Q4 2005	45%	37%	27%					
Q4 2006	58%	48%	37%					
Q4 2007	72%	62%	48%					
Q2 2008	74%	69%	54%	25%				
Q4 2008	82%	73%	62%	30%				
Q4 2009	88%	79%	73%	39%				
Q4 2010	95%	85%	79%	51%	35%			
Q3 2011	99%	90%	83%	62%	56%	20%		
Q4 2011	99%	91%	85%	66%	64%	24%		
Q3 2012	99%	97%	90%	73%	80%	42%	20%	
Q4 2012	99%	98%	91%	74%	89%	50%	28%	
Q1 2013	99%	99%	93%	76%	92%	60%	37%	20%
Q4 2013	99%	99%	98%	80%	97%	84%	62%	62%
Q4 2014	99%	99%	99%	86%	98%	93%	86%	79%
Q4 2015	99%	99%	99%	93%	99%	97%	88%	91%
Q4 2016	99%	99%	99%	99%	98%	98%	93%	95%
Q3 2017	99%	99%	99%	99%	99%	97%	95%	93%

Note:
[1] 3G mobile coverage, expressed as a percentage of the total market population, at the end of the period. 3G includes the following technologies: CDMA2000 1xEV-DO; CDMA2000 1xEV-DO Rev. A; CDMA2000 1xEV-DO Rev. B; TD-SCDMA; WCDMA; WCDMA HSPA; and WCDMA HSPA +.
[2] 4G mobile coverage, expressed as a percentage of the total market population, at the end of the period. 4G includes the following technologies: AXGP; LTE; LTE Advanced; TD-LTE; TD-LTE Advanced; and WiMAX.

Source: GSMA INTELLIGENCE.

Exhibit 7
Exemplary List of 5G Enabled Applications

#	Application	Description	Benefits	5G Essentiality	Who is Investing	Impacted Sectors
[1]	Connected Vehicles	Vehicles connecting with other devices and the network	- Reduced fatalities - Reduced traffic - Enhanced user experience	- Low latency - High reliability - High bandwidth - Increased connections	*e.g.* , Ford, Intel, Samsung	*e.g.* , Personal transport, trucking
[2]	Autonomous Vehicles	Self-driving vehicles	- Reduced fatalities - Reduced traffic - Enhanced user experience	- Low latency - High reliability - High bandwidth - Increased connections	*e.g.* , Ford, Intel, Samsung	*e.g.* , Personal transport, trucking
[3]	Augmented Reality & Virtual Reality	AR: transparent displays with digital overlays upon the physical world VR: user experience confined to a digital environment	- Enhanced user experience - Enhanced training - Enhanced education - Cost savings - Increased product demand	- Low latency - High bandwidth	*e.g.* , Facebook, HTC, Intel	*e.g.* , Gaming, sports, retail, education
[4]	Drones	Unmanned aerial vehicles	- Military applications - Disaster relief - Infrastructure inspection - Delivery (goods) - Delivery (Internet) - Monitoring crops	- Low latency - High reliability - High bandwidth	*e.g.* , Facebook, Amazon, Intel	*e.g.* , Military, municipalities, disaster relief, retail, agriculture, transportation
[5]	Factory Automation	Discrete manufacturing where products are assembled, tested, or packed	- Enhanced flexibility - Shorter lead times - Cost savings	- Low latency - High reliability	*e.g.* , General Electric, Intel, Honeywell, Ericsson	Manufacturing
[6]	Smart Agriculture	Adoption of information and communications technologies to enhance, monitor, or automate agricultural operations	- Higher crop yield - Water conservation - Cost savings	- Low latency - High reliability - High bandwidth	*e.g.* , John Deere, Qualcomm, Ericsson	Agriculture
[7]	Smart Cities	Cities that use interconnected sensing devices that can communicate with one another (*e.g.,* vehicles, traffic lights, libraries, *etc.*)	- Enhanced quality of service - Enhanced transportation - Improved security - Cost savings	- Low latency - High reliability - Increased connections - Low power requirement	*e.g.* , AT&T, Cisco, Deloitte, Ericsson, General Electric, IBM, Intel, Qualcomm, Samsung	Municipalities

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Exhibit 7
Exemplary List of 5G Enabled Applications

#	Application	Description	Benefits	5G Essentiality	Who is Investing	Impacted Sectors
[8]	Telehealth-care	Health-related applications that rely on information and communication technologies	- Point of care testing - Real-time monitoring - Remote surgery - Cost savings	- Low latency - High reliability - Low power requirement	*e.g.* , Ericsson	Healthcare
[9]	Energy & Utility	Traditional grid with communication and information control technologies (i.e. "Smart Grid")	- Real-time diagnostics - Reduced down-time - Smart lighting - Cost savings	- Low latency - High reliability - Increased connections - Low power requirement	U.S. cities have begun adopting smart grids (*e.g.* , Austin, TX; San Diego, CA; Washington, D.C.)	Municipalities
[10]	Asset Tracking	Tracking and monitoring the distribution of assets	- Reducing lost shipments - Enhanced inventory management - Cost savings	- Increased connections - Low power requirement	*e.g.* , Qualcomm, DHL, Ericsson	*e.g.* , Shipping and logistics, manufacturing

Source:
[1] Apostolos Papathanassiou & Alexey Khoryaev, *Cellular V2X as the Essential Enabler of Superior Global Connected Transportation Services*, IEEE TECH FOCUS (June 2017), https://5g.ieee.org/tech-focus/june-2017/cellular-v2x ; JAMES KUHR ET AL., TRAVEL MODELING IN AN ERA OF CONNECTED AND AUTOMATED TRANSPORTATION SYSTEMS: AN INVESTIGATION IN THE DALLAS-FORT WORTH AREA 17-18, 25 (2017), https://rosap.ntl.bts.gov/view/dot/32602; THOMAS K. SAWANOBORI, CTIA, 5G THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. 8, 10-11(Feb. 9, 2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf; HUSAIN M. ABDUL AZIZ ET AL., SYNTHESIS STUDY ON TRANSITIONS IN SIGNAL INFRASTRUCTURE AND CONTROL ALGORITHMS FOR CONNECTED AND AUTOMATED TRANSPORTATION 6-9 (June 2017), https://info.ornl.gov/sites/publications/files/Pub75211.pdf; Oliver Rist, *For Truly Connected Cars, We Need to Wait for 5G*, PC MAGAZINE (January 9, 2018), https://www.pcmag.com/news/358436/for-truly-connected-cars-we-need-to-wait-for-5g; Don Butler, *Why We're Working with Qualcomm to Ensure Everything in Cities Speaks the Same Language*, MEDIUM (Jan. 9, 2018), https://medium.com/cityoftomorrow/why-were-working-with-qualcomm-to-ensure-everything-in-cities-speaks-the-same-language-98e0cc1bff18; *Intel News Fact Sheet: The 5G - Autonomous Driving Connection*, INTEL NEWSROOM (Jan. 2017), https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2017/01/why-5G-for-ad-fact-sheet.pdf; *5G Is Now, Part 1: 2018, the Year of 5G*, SAMSUNG: INSIGHTS (February 27, 2018), http://www.samsung.com/global/business/networks/insights/news/5g-is-now-part-1-2018-the-year-of-5g.

[2] *Intel News Fact Sheet: The 5G - Autonomous Driving Connection*, INTEL NEWSROOM (Jan. 2017), https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2017/01/why-5G-for-ad-fact-sheet.pdf; Brian Krzanich, *Data is the New Oil in the Future of Automated Driving*, INTEL (Nov. 15, 2016), https://newsroom.intel.com/editorials/krzanich-the-future-of-automated-driving/; JAMES KUHR ET AL., TRAVEL MODELING IN AN ERA OF CONNECTED AND AUTOMATED TRANSPORTATION SYSTEMS: AN INVESTIGATION IN THE DALLAS-FORT WORTH AREA 4-5, 17-18, 25 (2017), https://rosap.ntl.bts.gov/view/dot/32602; CARLA CHIASSERINI & ANTHONY MAGNAN, IEEE, 5G FOR THE AUTOMOTIVE DOMAIN, https://5g.ieee.org/images/files/pdf/applications/5G-for-the-Automotive-Domain030518.pdf; KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 25 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; DAVID J. TEECE, TUSHER CENTER FOR INTELLECTUAL CAPITAL, INSTITUTE FOR BUSINESS INNOVATION, HAAS SCHOOL OF BUSINESS, U.C. BERKELEY, 5G MOBILE: DISRUPTING THE AUTOMOTIVE SECTOR (2017); HUSAIN M. ABDUL AZIZ ET AL., SYNTHESIS STUDY ON TRANSITIONS IN SIGNAL INFRASTRUCTURE AND CONTROL ALGORITHMS FOR CONNECTED AND AUTOMATED TRANSPORTATION 8-9 (June 2017), https://info.ornl.gov/sites/publications/files/Pub75211.pdf; JAMES FAUCETTE ET AL., MORGAN STANLEY, LEARNING TO RIDE A 5G CYCLE 12 (Oct. 15, 2017); 5G AMERICAS, 5G SERVICES & USE CASES 13-15 (2017), http://www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf; Don Butler, *Why We're Working with Qualcomm to Ensure Everything in Cities Speaks the Same Language*, MEDIUM (Jan. 9, 2018), https://medium.com/cityoftomorrow/why-were-working-with-qualcomm-to-ensure-everything-in-cities-speaks-the-same-language-98e0cc1bff18; *5G Is Now, Part 1: 2018, the Year of 5G*, SAMSUNG: INSIGHTS (February 27, 2018), http://www.samsung.com/global/business/networks/insights/news/5g-is-now-part-1-2018-the-year-of-5g.

[3] THOMAS K. SAWANOBORI, CTIA, 5G THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. 12 (Feb. 9, 2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf; KARIM TAGA ET AL., ARTHUR D. LITTLE GLOB., 5G DEPLOYMENT MODELS ARE CRYSTALLIZING 8-9 (June 2017), http://www.adlittle.com/sites/default/files/viewpoints/adl_5g_deployment_models.pdf; KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 12, 22 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; ERICSSON, 5G SYSTEMS 4 (January 2017), https://www.ericsson.com/assets/local/publications/white-papers/wp-5g-systems.pdf; JAMES FAUCETTE ET AL., MORGAN STANLEY, LEARNING TO RIDE A 5G CYCLE 12 (Oct. 15, 2017); Bijan Khosravi, *Facebook's New Focus On 5G and Golden Opportunity for Entrepreneurs*, FORBES (Apr. 30, 2018), https://www.forbes.com/sites/bijankhosravi/2018/04/30/todays-black-clouds-over-facebook-will-part-look-at-their-golden-ideas-in-5g/#45c1ec38313b; Michael Abrash, Photo Post, FACEBOOK (May 7, 2018) https://www.facebook.com/photo.php?fbid=2080525585560542&set=a.1633971423549296.1073741827.100008093611738&type=3&theater; Michael Reilly, *Facebook Enters the Race to Build 5G Networks*, MIT TECHNOLOGY REVIEW (Feb. 22, 2016), https://www.technologyreview.com/s/600875/facebook-enters-the-race-to-build-5g-networks; Rebecca Hills-Duty, *HTC CEO: 5G Will Have A Big Impact On VR*, VR FOCUS (Mar. 6, 2018), https://www.vrfocus.com/2018/03/htc-ceo-5g-will-have-a-big-impact-on-vr/; *Intel 2018 MWC Booth Demonstrations*, INTEL NEWSROOM (2018), https://newsroom.intel.com/wp-content/uploads/sites/11/2018/02/2018-mwc-demo-fact-sheet.

[4] Margaret Rouse, *Drone (Unmanned Aerial Vehicle, UAV)*, IOT AGENDA (Oct. 2016), https://internetofthingsagenda.techtarget.com/definition/drone; 5G FORUM, 5G SERVICE ROADMAP 2022, at 21, 48-50 (March 2016), http://kani.or.kr/5g/whitepaper/5G%20Service%20Roadmap%202022.pdf; *Drones + 5G: The Sky's the Limit*, QUALCOMM (Nov. 14, 2016), https://www.qualcomm.com/news/onq/2016/11/14/drones-5g-skys-limit; Matthew Hutson, *Hurricanes Show Why Drones Are the Future of Disaster Relief*, NBC NEWS (Sept. 9, 2017), https://www.nbcnews.com/mach/science/hurricanes-show-why-drones-are-future-disaster-relief-ncna799961; KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 17, 25 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; Raj Talluri, *Unleashing the Full Potential of 5G to Create a Massive Internet of Things*, NETWORK WORLD (Jan. 31, 2017), https://www.networkworld.com/article/3160851/internet-of-things/unleashing-the-full-potential-of-5g-to-create-a-massive-internet-of-things.html; Garrett Mitchell, *Facebook's Internet-Delivering Drone Takes Flight*, USA TODAY (June 30, 2017), https://www.usatoday.com/story/tech/nation-now/2017/06/30/facebooks-internet-delivering-drone-takes-flight/444559001/; Bernie Arnason, *First Amazon Drone Delivery is Highlight of Coming IoT, 5G Future*, TELECOMPETITOR (Dec. 14, 2016), http://www.telecompetitor.com/first-amazon-drone-delivery-is-highlight-of-coming-iot-5g-future/; *Intel 2018 MWC Booth Demonstrations*, INTEL NEWSROOM (2018), https://newsroom.intel.com/wp-content/uploads/sites/11/2018/02/2018-mwc-demo-fact-sheet.

[5] ANTONIO ORSINO ET AL., IEEE, FACTORIES OF THE FUTURE ENABLED BY 5G TECHNOLOGY (2018), https://5g.ieee.org/images/files/pdf/applications/Factories-of-the-Future-Enabled-by-5G-Technology_030518.pdf; KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 25-26 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; INDUSTRIAL AUTOMATION ENABLED BY ROBOTICS, MACHINE INTELLIGENCE, AND 5G, ERICSSON TECH. REVIEW 40-49 (2018); 5G AMERICAS, 5G SERVICES & USE CASES 12-13 (2017), http://www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf; *5G for manufacturing*, ERICSSON.COM, https://www.ericsson.com/en/networks/trending/insights-and-reports/5g-for-manufacturing (last visited June 3, 2018); ACCENTURE, WINNING WITH THE INDUSTRIAL INTERNET OF THINGS 2-3 (2015), https://www.accenture.com/t20160909T042713__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_11/Accenture-Industrial-Internet-of-Things-Positioning-Paper-Report-2015.pdf; ERICSSON, 5G SYSTEMS 3-4 (January 2017), https://www.ericsson.com/assets/local/publications/white-papers/wp-5g-systems.pdf; Peter Marx, *GE Digital Sprints Towards 5G*, GE (2017), https://www.ge.com/digital/blog/ge-digital-sprints-towards-5g; *Intel and Ericsson Launch 5G Innovators Initiative With Honeywell, GE and the University of California Berkeley*, INTEL (Feb. 21, 2017), https://newsroom.intel.com/news-releases/intel-ericsson-launch-5g-innovators-initiative-honeywell-ge-university-california-berkeley/.

[6] *Smart Farming IoT and 5G to Revolutionize Agriculture*, LANNER (July 6, 2017), https://www.lanner-america.com/blog/smart-farming-iot-5g-agriculture/; Natalie Gagliordi, *How 5G Will Impact the Future of Farming and John Deere's Digital Transformation*, ZDNET (Feb. 2, 2018), https://www.zdnet.com/article/how-5g-will-impact-the-future-of-farming-and-john-deeres-digital-transformation/; THOMAS K. SAWANOBORI, CTIA, 5G THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. 9 (Feb. 9, 2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf; JAMES MANYIKA ET. AL., MCKINSEY & CO., THE INTERNET OF THINGS: MAPPING THE VALUE BEYOND THE HYPE (2015), https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/ McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/T he-Internet-of-things-Mapping-the-value-beyond-the-hype.ashx; ERICSSON, THE INDUSTRY IMPACT OF 5G 7 (2018), https://www.ericsson.com/assets/local/narratives/networks/documents/report-bnew-18000486-rev-a-uen.pdf; KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 23 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; Claire Reilly, *CES 2018 is Where You'll Start Caring About 5G*, CNET (Jan. 2, 2018), https://www.cnet.com/news/ces-2018-caring-about-5g-intel-iot-driverless-cars-vr/; *Ericsson and Qualcomm Push the Boundaries of IoT in Brazil*, ERICSSON (Apr. 11, 2018), https://www.ericsson.com/en/news/2018/4/iot-collaboration-in-brazil; Kalyan Parbat,*How 5G Technology Can Play Crucial Role in Agricultural Growth and Smart Cities Initiative*, ECONOMIC TIMES (Apr. 7, 2018), https://economictimes.indiatimes.com/tech/internet/how-5g-technology-can-play-crucial-role-in-agricultural-growth-and-smart-cities-initiative/articleshow/63649045.cms.

[7] YOSEF GETACHEW ET AL., JOINT CTR. FOR POLITICAL AND ECON. STUDIES, 5G, SMART CITIES & COMMUNITIES OF COLOR 3, 9-10 (2017); MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf; KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 23-24 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; THOMAS K. SAWANOBORI, CTIA, 5G THE NEXT GENERATION OF WIRELESS: 5G LEADERSHIP IN THE U.S. 7-8 (Feb. 9, 2016), https://api.ctia.org/docs/default-source/default-document-library/5g_white-paper_web2.pdf; ERICSSON, 5G SYSTEMS 4 (January 2017), https://www.ericsson.com/assets/local/publications/white-papers/wp-5g-systems.pdf; NARENDRA MANGRA & ALIREZA GHASEMPOUR, IEEE, SMART CITIES: CONNECTED ECOSYSTEM OF ECOSYSTEMS 2-3, https://5g.ieee.org/images/files/pdf/applications/Smart-Cities_030518.pdf; *5G Is Now, Part 1: 2018, the Year of 5G*, SAMSUNG: INSIGHTS (February 27, 2018), http://www.samsung.com/global/business/networks/insights/news/5g-is-now-part-1-2018-the-year-of-5g; Claire Reilly, *CES 2018 is Where You'll Start Caring About 5G*, CNET (Jan. 2, 2018), https://www.cnet.com/news/ces-2018-caring-about-5g-intel-iot-driverless-cars-vr/.

[8] *What is Telehealth? How is Telehealth Different from Telemedicine?* HEATHIT.GOV (Sept. 22, 2017), https://www.healthit.gov/faq/what-telehealth-how-telehealth-different-telemedicine; Krishna Rao, *The Path to 5G for Health Care*, IEEE, https://5g.ieee.org/images/files/pdf/applications/5G--Health-Care030518.pdf; DARRELL M. WEST, CTR. FOR TECH. INNOVATION AT BROOKINGS, HOW 5G TECHNOLOGY ENABLES THE HEALTH INTERNET OF THINGS 6-11 (2016); *Internet of Medical Things*, ARANCA (2016), https://www.aranca.com/assets/uploads/resources/special-reports/Internet-of-Medical-Things-IoMT_Aranca-Special-Report.pdf; *Internet of Things*, *ERICSSON* (2016), https://www.ericsson.com/en/internet-of-things; NEXT GENERATION MOBILE NETWORKS, NGMN 5G WHITE PAPER 17 (2015); *From Healthcare to Homecare – The Critical Role of 5G in Healthcare Transformation*, ERICSSON CONSUMER LAB (June 2017), https://www.ericsson.com/assets/local/networked-society/consumerlab/reports/2017/healthcare-to-homecare_screen_aw2.pdf; JAMES FAUCETTE ET AL., MORGAN STANLEY, LEARNING TO RIDE A 5G CYCLE 12 (Oct. 15, 2017); 5G AMERICAS, 5G SERVICES & USE CASES 13-15 (2017), http://www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf; KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 26 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; *Ericsson and King's College London Demonstrate 5G Tactile Robotic Surgery*, ERICSSON (June 28, 2016), https://www.ericsson.com/en/press-releases/2016/6/ericsson-and-kings-college-london-demonstrate-5g-tactile-robotic-surgery.

[9] *5G for Energy*, GLOBAL 5G, https://www.global5g.org/verticals/5g-energy (last visited June 8, 2018); *Internet of Things*, ERICSSON (2016), https://www.ericsson.com/en/internet-of-things; MAJED AL AMINE ET AL., ACCENTURE, SMART CITIES HOW 5G CAN HELP MUNICIPALITIES BECOME VIBRANT SMART CITIES 6-7 (2017), https://www.accenture.com/t20170222T202102__w__/us-en/_acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf; 5G FORUM, 5G SERVICE ROADMAP 2022, at 39 (March 2016), http://kani.or.kr/5g/whitepaper/5G%20Service%20Roadmap%202022.pdf; ERICSSON, THE INDUSTRY IMPACT OF 5G 6 (2018), https://www.ericsson.com/assets/local/narratives/networks/documents/report-bnew-18000486-rev-a-uen.pdf; Alex Kingsbury, *10 Cities Adopting Smart Grid Technology*, U.S. NEWS (Feb. 19, 2010), https://www.usnews.com/news/energy/slideshows/10-cities-adopting-smart-grid-technology?onepage.

[10] KAREN CAMPBELL ET AL., HIS, THE 5G ECONOMY: HOW 5G TECHNOLOGY WILL CONTRIBUTE TO THE GLOBAL ECONOMY 23 (Jan. 2017), https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf; Benoit Tournier, *IoT-Enabled Asset Tracking is Driving Business Innovation*, SIERRA WIRELESS (Sept. 27, 2017), https://www.sierrawireless.com/iot-blog/iot-blog/2017/09/iot_enabled_asset_tracking_is_driving_business_innovation/; JAMES MACAULAY ET AL., DHL AND CISCO, INTERNET OF THINGS IN LOGISTICS 7-10, 14-25 (2015); Jeremiah Owyang et al., *5G Enables the Next Generation of Intelligent Tech*, KALEIDO INSIGHTS (Feb. 27, 2018), http://www.kaleidoinsights.com/5g-enables-the-next-generation-of-intelligent-tech; ERICSSON, 5G SYSTEMS 11 (January 2017), https://www.ericsson.com/assets/local/publications/white-papers/wp-5g-systems.pdf; John Blyler, *Top 5 RF Technologies for 5G in the IoT*, MICROWAVES&RF (July 28, 2017), http://www.mwrf.com/systems/top-5-rf-technologies-5g-iot; *Ericsson and Qualcomm Push the Boundaries of IoT in Brazil*, ERICSSON (Apr. 11, 2018), https://www.ericsson.com/en/news/2018/4/iot-collaboration-in-brazil.

Exhibit 8
U.S. Wireless Carrier Capital Expenditures
2002 – 2006
($000s)

Carrier	2002	2003	2004	2005	2006
AT&T[1]	$5,302,000	$2,774,000	$3,449,000	$7,475,000	$7,039,000
Sprint[2]	$2,640,000	$2,123,000	$2,559,000	$3,545,000	$5,944,000
T-Mobile[3]	$1,700,000	$1,734,000	$2,138,000	$5,045,000	$3,444,000
Verizon[4]	$4,414,000	$4,590,000	$5,633,000	$6,484,000	$6,618,000

Note:
[1] In 2001, AT&T Corp. spun off AT&T Wireless Services, Inc. In 2004, AT&T Wireless merged with Cingular Wireless LLC, with the combined company initially operating under the Cingular name. In late 2005, AT&T Corp. merged with SBC Communications Inc., which held a majority interest in the combined AT&T/Cingular wireless entity, and became AT&T Inc. In 2006, AT&T Inc. merged with BellSouth Corporation, which held a 40 percent interest in Cingular Wireless. The AT&T values for 2002 and 2003 reflect capital expenditures for AT&T Wireless, the values for 2004 and 2005 reflect capital expenditures for Cingular Wireless, and the value for 2006 reflects wireless capital expenditures for AT&T Inc.
Source: AT&T Wireless Services, Inc., Annual Report (Form 10-K), at 2, 18, 38 (Dec. 31, 2003); Cingular Wireless LLC, Annual Report (Form 10-K), at 36 (Dec. 31, 2005); AT&T Inc., Annual Report (Form 10-K), at 1, 56 (Dec. 31, 2006).

[2] Source: Sprint Corp., Annual Report (Form 10-K), at 34 (Mar. 11, 2005); Sprint Nextel Corp., Annual Report (Form 10-K), at 46, F-57 (Mar. 1, 2007).

[3] T-Mobile values are for the entire corporation, as wireless segment data was unavailable.
Source: T-Mobile USA, Inc., Annual Report (Form 10-K), at 38 (Mar. 10, 2003); *T-Mobile International Reports Fourth Quarter and Full Year 2003 Results for T-Mobile USA*, T-MOBILE (Mar. 10, 2004), https://www.t-mobile.com/Cms/Files/Published/0000BDF20016F5DD010312 E2BDE4AE9B/0000BDF200 16F5DF010980E90F08FE00/file/2003_Q4.pdf; *T-Mobile USA Reports Fourth Quarter and Full Year 2004 Results*, BUSINESSWIRE (Mar. 3, 2005), https://www.businesswire.com/news/home/20050302006002/en/T-Mobile-USA-Reports-Fourth-Quarter-Full-Year; *T-Mobile USA Reports Record Fourth Quarter and Full Year 2005 Results*, BUSINESSWIRE (Mar. 2, 2006), https://www.businesswire.com/ news/ home/20060301006225/en/T-Mobile-USA-Reports-Record-Fourth-Quarter-Full; *T-Mobile USA Exceeds 25 Million Customer Milestone and Reports Fourth Quarter and 2006 Results*, BUSINESSWIRE (Mar. 1, 2007), https://www.businesswire.com/news/home/20070228006332/en/T-Mobile-USA-Exceeds-25-Million-Customer-Milestone.

[4] Source: Verizon Comm'ns Inc., Annual Report (Form 10-K), at Exhibit 13 (Mar. 14, 2003); Verizon Comm'ns Inc., Annual Report (Form 10-K), at Exhibit 13, Note 17 (Mar. 12, 2004); Verizon Comm'ns Inc., Annual Report (Form 10-K), at p. 18, Exhibit 13 (Mar. 14, 2005); Verizon Comm'ns Inc., Annual Report (Form 10-K), at 19, Exhibit 13 (Mar. 14, 2006); Verizon Comm'ns Inc., Annual Report (Form 10-K), at 16, Exhibit 13 (Mar. 1, 2007).

Exhibit 9
U.S. Wireless Carrier Capital Expenditures
2007 – 2017
($000s)

Carrier	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
AT&T[1]	$3,745,000	$6,020,856	$5,924,415	$8,593,200	$9,764,000	$10,795,000	$11,191,000	$11,383,000	$8,697,230	$8,383,540	$7,870,230
Sprint	$4,988,000	$1,789,000	$1,161,000	$1,455,000	$2,702,000	$4,199,000	$7,136,000	$4,828,000	$7,193,000	$3,798,000	$4,692,000
T-Mobile	$2,667,000	$3,603,000	$3,687,000	$2,819,000	$2,729,000	$2,901,000	$4,025,000	$4,317,000	$4,724,000	$4,702,000	$5,237,000
Verizon	$6,503,000	$6,510,000	$7,152,000	$8,438,000	$8,973,000	$8,857,000	$9,425,000	$10,515,000	$11,725,000	$11,240,000	$10,310,000
Industry Total	$20,065,289	$20,587,855	$20,245,042	$23,192,211	$26,516,228	$28,974,850	$32,964,253	$31,719,515	$32,919,383	$28,569,540	$28,579,230

Note:
[1] AT&T capital expenditure data starting in Q3 2015 are based on SNL Kagan estimates as AT&T no longer reports this data separately for wireless.

Source: SNL Kagan (S&P Global Intelligence).

Exhibit 10
Verizon Wireless Capital Expenditures and Investment Activity
2002 – 2017
($ Millions)

Year	Amount[1]	Main Investment Initiatives[2]
2002	$4,414	First to launch CDMA 1xRTT (3G)[3] network in three markets in January. Full deployment during the year.
2003	$4,590	Launch EV-DO (3G) network in two cities.
2004	$5,633	Deploy EV-DO network, covering 30 major metropolitan areas by end of year.
2005	$6,484	Expand EV-DO network deployment, covering 150 million people by end of year.
2006	$6,618	Deploy EV-DO Rev. A (upgraded EV-DO) network.
2007	$6,503	Upgrade entire EV-DO network to EV-DO Rev. A.
2008	$6,510	Expand EV-DO Rev. A network coverage.
2009	$7,152	Expand EV-DO Rev. A network coverage.
2010	$8,438	Deploy first LTE network in the U.S. in December, covering 38 metropolitan areas and 60 airports.
2011	$8,973	Expand LTE network.
2012	$8,857	Expand LTE network, covering 200 million people in January 2012.
2013	$9,425	Expand LTE network, covering 273 million people in January 2013. Increase LTE capacity with AWC spectrum augmentation.
2014	$10,515	Expand LTE network, covering 305 million people by May. Increase LTE capacity with AWC spectrum augmentation.
2015	$11,725	LTE network AWC spectrum augmentation completed in over 400 markets.
2016	$11,240	Build out fiber assets to support densification of LTE network and position for 5G deployment.
2017	$10,310	Build out fiber assets to support densification of LTE network and position for 5G deployment.

Note:
[1] Exhibits 8 and 9.
[2] *Verizon Launches First U.S. '3G' Network*, CNN (Jan. 28, 2002), http://edition.cnn.com/2002/TECH/ptech/01/28/verizon.3g/; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379, at 44 (June 26, 2003); Press Release, Verizon Wireless, Verizon Wireless Announces Roll Out of National 3G Network (Jan. 8, 2004), http://www.verizon.com/about/news/vzw/2004/01/pr2004-01-07; *Q4 2003 Verizon Earnings Conference Call and Investor Conference - Final* (Jan. 29, 2004); Verizon Comm'ns Inc., Annual Report (Form 10-K), at Exhibit 13 (Mar. 14, 2006); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 51 (Sept. 26, 2006); Press Release, Verizon Wireless, Verizon Wireless: 100 Percent of Wireless Broadband Network Now Enhanced with Faster Speeds (June 29, 2007), https://www.verizon.com/about/news/vzw/2007/06/pr2007-06-28h; Verizon Comm'ns Inc., Annual Report (Form 10-K), at 4 (Feb. 24, 2009); Press Release, Verizon Wireless, Verizon Wireless Launches the World's Largest 4G LTE Wireless Network on Dec.5 (Dec. 1, 2010), http://www.verizon.com/about/news/vzw/2010/12/pr2010-11-30a; Verizon Comm'ns Inc., Annual Report (Form 10-K), at 3 (Feb. 24, 2012); Verizon Comm'ns Inc., Annual Report (Form 10-K), at 3 (Feb. 26, 2013); Trefis Team, *Verizon's LTE Advantage Is Paying Off Big Time*, FORBES (May 24, 2013), https://www.forbes.com/sites/ greatspeculations/2013/05/24/verizons-lte-advantage-is-paying-off-big-time/#471c37f779b3; Press Release, Verizon Wireless, Verizon Wireless Celebrates Three Years (and Counting) of 4G LTE (Dec. 5, 2013), http://www.verizonwireless.com/news/article/2013/12/verizon-wireless-4g-lte-three-year-anniversary.html; Verizon Comm'ns Inc., Annual Report (Form 10-K), at 2, 4 (Feb. 27, 2014); Kevin Fitchard, *The state of LTE in the U.S.: How the carriers' 4G networks stack up*, GIGAOM (Jan. 30, 2014), https://gigaom.com/2014/01/30/4g-vs-4g-comparing-lte-networks-in-the-us/; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – EIGHTEENTH REPORT, WT Docket No. 14-125, at 75-76 (Dec. 23, 2015); Verizon Comm'ns Inc., Annual Report (Form 10-K), at 90-91 (Feb. 23, 2018).
[3] At the time, 1xRTT was considered "3G." In hindsight it would be classified as 2.5G. *See* FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379, at 21-22 (June 26, 2003).

Exhibit 11
AT&T Wireless Capital Expenditures and Investment Activity
2002 – 2017
($ Millions)

Year	Amount[1]	Main Investment Initiatives[2]
2002	$5,302	Expand GSM/GPRS (2G) network to cover 63% of the U.S. population.
2003	$2,774	Deploy EDGE (2G) network.
2004	$3,449	Launch WCDMA (3G) network in four major U.S. cities. Expand EDGE network.
2005	$7,475	Launch WCDMA network with HSDPA (3G) in 16 cities (post AT&T/Cingular merger).
2006	$7,039	Expand HSDPA network to more than 160 markets, including most of the top 100 major cities in the U.S. by year end.
2007	$3,745	Expand WCDMA/HSDPA.
2008	$6,021	Deploy HSPA (3G) network.
2009	$5,924	Deploy HSPA network to over 350 major metropolitan areas. Upgrade network to HSPA 7.2 (3G).
2010	$8,593	Upgrade network to HSPA+ (3G).
2011	$9,764	Launch LTE (4G) network in five U.S. cities.
2012	$10,795	Expand LTE network, reaching 103 markets in November.
2013	$11,191	Expand LTE network to 209 markets.
2014	$11,383	Expand LTE network to 400 markets and 280 million people. Introduce carrier aggregation technology (4G) in Chicago to increase network capacity.
2015	$8,697	Expand carrier aggregation technology to other major markets.
2016	$8,384	Expand fiber infrastructure and 5G trials.
2017	$7,870	Expand fiber infrastructure and 5G trials.

Note:
[1] Exhibits 8 and 9.
[2] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379, at 37 (June 26, 2003); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – NINTH REPORT, WT Docket No. 04-111, at 56 (Sept. 9, 2004); AT&T Inc., Annual Report (Form 10-K), at Exhibit 13, 43 (Mar. 1, 2006); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 50 (Sept. 26, 2006); *Cingular 3G Coverage In More Than 160 Markets*, FIELD TECHNOLOGIES MAGAZINE (Dec. 21, 2006), https://www.fieldtechnologiesonline.com/doc/cingular-3g-coverage-in-more-than-160-markets-0001; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES
– TWELFTH REPORT, WT Docket No. 07-71, at 66-67 (January 28, 2008); Press Release, AT&T, AT&T Upgrades 3G Technology at Cell Sites Across Nation (Jan. 5, 2010), https://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=30358; Press Release, AT&T, AT&T Announces Plans to Deliver Nation's Most Advanced Mobile Broadband Experience (Jan. 5, 2011), https://www.prnewswire.com/news-releases/att-announces-plans-to-deliver-nations-most-advanced-mobile-broadband-experience-112945969.html; Jessica Dolcourt, *AT&T Launching LTE on Sept. 18, at Long Last*, CNET (Sept. 15, 2011), https://www.cnet.com/news/at-t-launching-lte-on-sept-18-at-long-last/; *AT&T's 4G Evolution*, AT&T, https://www.att.com/Common/about_us/pdf/lte_markets_1512.pdf (last visited June 8, 2018); Robert Nelson, *AT&T 4G LTE Coverage was Doubled in 2012, is Now Available for More Than 150 Million People*, ANDROID AUTHORITY (Nov. 16, 2012), https://www.androidauthority.com/att-4g-lte-doubles-in-2012-132046/; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – FOURTEENTH REPORT, WT Docket No. 09-66, at 70 (May 20, 2010); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, at 126-27 (March 21, 2013); Trefis Team, *Verizon's LTE Advantage Is Paying Off Big Time*, FORBES (May 24, 2013), https://www.forbes.com/sites/greatspeculations /2013/05/24/verizons-lte-advantage-is-paying-off-big-time/#471c37f779b3; *AT&T 4G LTE Reaches 400 Markets, Nearly 240M POPs*, AT&T (Sept. 12, 2013), http://about.att.com/newsroom/att_4g_lte_reaches_400_markets_nearly _240m_pops.html; AT&T Inc., Annual Report (Form 10-K), at 15 (Feb. 21, 2014); Mike Dano, *AT&T Edging into LTE Advanced Technologies for Capacity, Not Speed*, FIERCEWIRELESS (Feb. 26, 2014), https://www.fiercewireless.com/wireless/at-t-edging-into-lte-advanced-technologies-for-capacity-not-speed; Kevin Fitchard, *AT&T's New Souped-Up LTE Network is Live in Chicago, but You'll Have to Wait to Use it*, GIGAOM (Mar. 6, 2014), https://gigaom.com/2014/03/06/atts-new-souped-up-lte-network-is-live-in-chicago-but-youll-have-to-wait-to-use-it/; *HSPA or LTE? That is the Question*, RCR WIRELESS (May 9, 2014), https://www.rcrwireless.com/20140509/hetnet-news/hspa-lte; Sue Marek, *AT&T Expands Carrier Aggregation to NY, San Fran and More*, FIERCEWIRELESS (Jan. 22, 2015), https://www.fiercewireless.com/wireless/at-t-expands-carrier-aggregation-to-ny-san-fran-and-more; *AT&T Details 5G Evolution*, AT&T (Jan. 4, 2017), http://about.att.com/story/att_details_5g_evolution.html; Fed. Commc'ns Comm'n, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – TWENTIETH REPORT, WT Docket No. 17-69, at 65 (Sept. 27, 2017).

Exhibit 12
Sprint Wireless Capital Expenditures and Investment Activity
2002 – 2017
($ Millions)

Year	Amount[1]	Main Investment Initiatives[2]
2002	$2,640	First nationwide deployment of CDMA 1xRTT (3G)[3] by August. Invest in capacity-enhancing technologies.
2003	$2,123	Deploy 1xRTT across entire network footprint.
2004	$2,559	Prepare for EV-DO (3G) network launch, instead of waiting for 1xEV-DV (more advanced than EV-DO technology).
2005	$3,545	Deploy EV-DO network, covering half of the U.S. population.
2006	$5,944	Launch EV-DO Rev. A (upgraded EV-DO) network in San Diego in October. Invest in iDEN (2G) and CDMA (2G) networks. Prepare for WiMAX (4G) network.
2007	$4,988	Expand EV-DO Rev. A network (reaching most of its footprint by October). Improve CDMA and iDEN networks.
2008	$1,789	Launch WiMAX network in Baltimore.
2009	$1,161	Expand WiMAX network.
2010	$1,455	Expand WiMAX network.
2011	$2,702	Expand WiMAX network, covering 132 million people in 71 markets. Announce plans to develop LTE (4G) network in October.
2012	$4,199	Final expansion of WiMAX network. Develop and launch LTE network in 15 cities, covering 49 markets by end of year.
2013	$7,136	Expand LTE network, covering over 200 million people by December. Improve speed and performance of LTE network.
2014	$4,828	Improve speed and performance of LTE network.
2015	$7,193	Expand LTE network, covering 280 million people by October. Deploy carrier aggregation network technology, called "LTE Plus" (4G), in 77 major markets.
2016	$3,798	Expand LTE Plus network, covering 300 million people by June.
2017	$4,692	Improve LTE network speed and capacity. Test Massive MIMO technology, use to improve 4G and support 5G.

Note:
[1] Exhibits 8 and 9.
[2] Bob Brewin, *Sprint PCS Launches Nationwide 3G Network*, COMPUTERWORLD, (Aug. 8, 2002), https://www.computerworld.com/article/2577108/mobile-wireless/sprint-pcs-launches-nationwide-3g-network.html; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379, at 38-42 (June 26, 2003); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – NINTH REPORT, WT Docket No. 04-111, at 57-58 (Sept. 9, 2004); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – ELEVENTH REPORT, WT Docket No. 06-17, at 52 (Sept. 26, 2006); Press Release, Sprint, Sprint Launches Nation's First EV-DO Revision A Mobile Broadband Network (Oct. 24, 2006), http://newsroom.sprint.com/sprint-launches-nations-first-ev-do-revision-a-mobile-broadband-network-1.htm; Marguerite Reardon, *Broken Connection for Sprint Nextel*, CNET (Jan. 29, 2007), https://www.cnet.com/news/broken-connection-for-sprint-nextel/; Press Release, Sprint, America's Largest and Fastest Mobile Broadband Network Just Got Even Larger – Sprint Customers Can Do More, In More Places, And At Fast Speeds (June 19, 2007), http://newsroom.sprint.com/americas-largest-and-fastest-mobile-broadband-network-just-got-even-larger-sprint-customers-can-do-more-in-more-places-and-at-fast-speeds.htm; Reuters Staff, *Sprint Launches Its First WiMax Market*, REUTERS (Sept. 29, 2008), https://www.reuters.com/article/sprint-wimax/sprint-launches-its-first-wimax-market-idUSN2938183020080929; Press Release, Sprint Nextel, Sprint Accelerates Deployment of Network Vision and Announces National Rollout of 4G LTE (Oct. 7, 2011), http://newsroom.sprint.com/sprint-accelerates-deployment-of-network-vision-and-announces-national-rollout-of-4g-lte.htm; Brent Rose, *Sprint is Ditching 4G WiMax for 4G LTE: What it Means for You*, GIZMODO (Oct. 7, 2011), https://gizmodo.com/5847643/its-official-sprint-is-going-lte; Marguerite Reardon, *Sprint Officially Launches 4G LTE in 15 Cities*, CNET (July 16, 2012), https://www.cnet.com/news/sprint-officially-launches-4g-lte-in-15-cities/; Sprint Nextel Corp., Annual Report (Form 10-K), at 35 (Feb. 28, 2013); FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – SIXTEENTH REPORT, WT Docket No. 11-186, at 128-30 (March 21, 2013); Stephen Lawson, *Sprint Taps Into its Spectrum for Fast LTE, with Room to Grow*, PC WORLD (Oct. 31, 2013), https://www.pcworld.com/article/2059780/sprint-taps-into-its-spectrum-for-fast-lte-with-room-to-grow.html; Phil Goldstein, *Sprint Unveils 'LTE Plus' Network Brand to Highlight Carrier Aggregation, Beamforming in 77 Major Markets*, FIERCEWIRELESS (Nov.18, 2015), https://www.fiercewireless.com/wireless/sprint-unveils-lte-plus-network-brand-to-highlight-carrier-aggregation-beamforming-77; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES – EIGHTEENTH REPORT, WT Docket No. 14-125, at 76-77 (Dec. 23, 2015); *Sprint LTE Plus Posts Strong Gains in Network Reliability, Beats T-Mobile and Pulls Within 1% of Verizon and AT&T*, SPRINT (June 2, 2016), http://investors.sprint.com/news-and-events/press-releases/press-release-details/2016/Sprint-LTE-Plus-Posts-Strong-Gains-in-Network-Reliability-Beats-T-Mobile-and-Pulls-Within-1-of-Verizon-and-ATT/default.aspx; John Saw, *Celebrating and Accelerating: Sprint's 2017 Network Accomplishments and New Investment in 2018*, SPRINT (Dec. 21, 2017), http://newsroom.sprint.com/celebrating-and-accelerating.htm.
[3] At the time, 1xRTT was considered "3G." In hindsight it would be classified as 2.5G. *See* FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO COMMERCIAL MOBILE SERVICES – EIGHTH REPORT, WT Docket No. 02-379, at 21-22 (June 26, 2003).

Exhibit 13
T-Mobile Wireless Capital Expenditures and Investment Activity
2002 – 2017
($ Millions)

Year	Amount[1]	Main Investment Initiatives[2]
2002	$1,700	Expand and improve GSM (2G) network.
2003	$1,734	Improve quality and capacity in GSM/GPRS (2G) networks.
2004	$2,138	Improve quality and capacity in GSM/GPRS networks.
2005	$5,045	Build cell sites and expand geographic coverage.
2006	$3,444	Build 3G-enabled cell sites.[3]
2007	$2,667	Build 3G-enabled cell sites, deploy over 8,000 UMTS (3G)-capable cell sites by end of year.
2008	$3,603	Build 3G-enabled cell sites. Deploy 3G network in 13 major cities by September.
2009	$3,687	Expand 3G network, covering 200 million people by end of year.
2010	$2,819	Deploy HSPA 7.2 (3G) across entire network. Deploy HSPA+ (3G)[4] to 200 million people by end of year.
2011	$2,729	Build HSPA+ network.[5]
2012	$2,901	Modernize network for LTE (4G) launch.
2013	$4,025	Launch LTE network in seven markets in March, covering 200 million people by October.
2014	$4,317	Modernize and deploy LTE on network.
2015	$4,724	Modernize and deploy LTE on network.
2016	$4,702	Construct, expand, and upgrade LTE network infrastructure.
2017	$5,237	Construct, expand, and upgrade LTE network infrastructure.

Note:
[1] Exhibits 8 and 9.
[2] T-Mobile USA, Inc., Annual Report (Form 10-K), at F-17 (Mar. 10, 2003); *T-Mobile USA Reports Fourth Quarter and Full Year 2004 Results*, BUSINESS WIRE (Mar. 3, 2005), https://www.businesswire.com/news/home/20050302006002/en/T-Mobile-USA-Reports-Fourth-Quarter-Full-Year; *T-Mobile USA Reports Record Fourth Quarter and Full Year 2005 Results*, BUSINESS WIRE (Mar. 2, 2006), https://www.businesswire.com/news/home/20060301006225/en/T-Mobile-USA-Reports-Record-Fourth-Quarter-Full; *T-Mobile USA Exceeds 25 Million Customer Milestone and Reports Fourth Quarter and 2006 Results*, BUSINESSWIRE (Mar. 1, 2007), https://www.businesswire.com/news/home/20070228006332/en/T-Mobile-USA-Exceeds-25-Million-Customer-Milestone; *T-Mobile USA Reports Fourth Quarter and Full Year 2007 Results*, BUSINESS WIRE (Feb. 28, 2008), https://www.businesswire.com/news/home/20080227006352/en/T-Mobile-USA-Reports-Fourth-Quarter-Full-Year; *T-Mobile USA Announces Commercial 3G Network Availability in 21 Markets By Mid-October*, T-MOBILE (Sept. 18, 2008), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-usa-announces-commercial-3g-network-availability-in-21-markets-by-mid-october.htm; *T-Mobile USA Reports Fourth Quarter and Full Year 2009 Results*, BUSINESS WIRE (Feb. 25, 2010), https://www.businesswire.com/news/home/ 20100224007058/en/T-Mobile-USA-Reports-Fourth-Quarter-Full-Year; FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES — FIFTEENTH REPORT, WT Docket No. 10-133, at 76 (June 24, 2011); *T-Mobile USA Reports Fourth Quarter 2010 Results*, BUSINESS WIRE (Feb. 25, 2011), https://www.businesswire.com/news/home/20110224007281/en/T-Mobile-USA-Reports-Fourth-Quarter-2010-Results; *T-Mobile USA Reports Fourth Quarter 2011 Operating Results*, BUSINESS WIRE (Feb. 23, 2012), available at https://www.businesswire.com/news/home/20120222007005/en/ T-Mobile-USA-Reports-Fourth-Quarter-2011-Operating; Marguerite Reardon, *T-Mobile Launches 4G LTE Network*, CNET (Mar. 26, 2013), https://www.cnet.com/news/t-mobile-launches-4g-lte-network/; Neal Gompa, *T-Mobile USA Launched LTE Network with Breathtaking Speeds*, EXTREME TECH (Mar. 27, 2013), https://www.extremetech.com/electronics/151758-t-mobile-usa-launches-lte-network-with-breathtaking-speeds; Kevin Fitchard, *T-Mobile doubles its LTE speeds, capacity in at least 40 major cities*, GIGAOM (Nov. 5, 2013), https://gigaom.com/2013/11/05/t-mobile-doubles-its-lte-speeds-capacity-in-at-least-40-major-cities/; T-Mobile US, Inc., Annual Report (Form 10-K), at 4 (Feb. 25, 2014); T-Mobile US Inc., Annual Report (Form 10-K), at p. 7 (Feb. 8, 2018).
[3] In 2006 T-Mobile purchased AWS-1 spectrum licenses in the FCC's 2006 auction, planning to use the spectrum to deploy its 3G network. However, T-Mobile did not receive full access to the spectrum until mid-2008, delaying its 3G launch. *See T-Mobile USA Exceeds 25 Million Customer Milestone and Reports Fourth Quarter and 2006 Results*, BUSINESSWIRE (Mar. 1, 2007), https://www.businesswire.com/news/home/20070228006332/en/T-Mobile-USA-Exceeds-25-Million-Customer-Milestone; *T-Mobile USA Announces Commercial 3G Network Availability in 21 Markets By Mid-October*, T-MOBILE (Sept. 18, 2008), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-usa-announces-commercial-3g-network-availability-in-21-markets-by-mid-october.htm; *T-Mobile's 3G Delay Government Related*, PHONESCOOP, (Sept. 24, 2007), http://www.phonescoop.com/articles/article.php?a=2419.
[4] At the time, T-Mobile marketed HSPA+ as "4G." *See* FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES — FIFTEENTH REPORT, WT Docket No. 10-133, at 76 (June 24, 2011).
[5] T-Mobile reportedly focused on HSPA+, rather than developing LTE, due to spectrum constraints. When T-Mobile's proposed merger with AT&T fell through in late 2011, T-Mobile received AWS spectrum licenses which allowed for the deployment of its LTE network. *See T-Mobile USA Reports Fourth Quarter 2011 Operating Results*, BUSINESS WIRE (Feb. 23, 2012), available at https://www.businesswire.com/news/home/20120222007005/en/ T-Mobile-USA-Reports-Fourth-Quarter-2011-Operating; Marguerite Reardon, *T-Mobile Launches 4G LTE Network*, CNET (Mar. 26, 2013), https://www.cnet.com/news/t-mobile-launches-4g-lte-network/.

Exhibit 14A
National Practical Capacity and Price per GB of Mobile Data in 2024
With and Without the Transaction

	No Transaction	Transaction	Percent Change Due to Transaction
ARPU[1]	$43.93	$43.93	-
Total Subscribers[2]	397,209,827	397,209,827	-
Smartphone Penetration Rate	90%	90%	-
Smartphone Subscribers[3]	357,488,845	357,488,845	-
Percent of Time on Smartphone Spent Online	90%	90%	-
Data ARPU[4]	$39.54	$39.54	-
National Practical Capacity (EB/month)[5]	13.88	30.57	120.25%
National Practical Capacity per Smartphone Subscriber (GB/month)[6]	38.82	85.51	120.25%
Price per GB of Mobile Data[7]	$1.02	$0.46	-54.60%

Note:
[1] ARPU in 2024 is set equal to implied ARPU in 2017 (see Exhibit 5A).
[2] Calculated using 2017 total connections (excluding machine-to-machine connections) as the base value (see Exhibit 5A) and a compound annual growth rate of 2.17 percent, the average annual growth rate of total connections between 2014 and 2017. It is the average of the 2014-15 growth rate, the 2015-16 growth rate, and the 2016-17 growth rate.
[3] Calculated as Total Subscribers multiplied by the Smartphone Penetration Rate.
[4] Calculated as ARPU multiplied by the Percent of Time on Smartphone Spent Online.
[5] Without the Transaction, National Practical Capacity is calculated as the sum of National Practical Capacity for Verizon, AT&T, Sprint, and T-Mobile. With the Transaction, National Practical Capacity is calculated as the sum of National Practical Capacity for Verizon, AT&T, and New T-Mobile. National Practical Capacity for T-Mobile, Sprint, and New T-Mobile is calculated in Exhibit 14B. National Practical Capacity for Verizon and AT&T is calculated in Exhibit 14C.
[6] Calculated as National Practical Capacity divided by Smartphone Subscribers.
[7] Calculated as Data ARPU divided by National Practical Capacity per Smartphone Subscriber.

Source: GSMA INTELLIGENCE; Exhibit 5A; Exhibit 14B; Exhibit 14C.

Exhibit 14B
National Practical Capacity in 2024
T-Mobile, Sprint, and New T-Mobile

	No Transaction		Transaction
	T-Mobile	Sprint	New T-Mobile
Subscriber Share[1]	19.3%	12.4%	31.7%
Total Subscribers[2]	397,209,827	397,209,827	397,209,827
Smartphone Penetration Rate	90%	90%	90%
Smartphone Subscribers[3]	68,924,680	44,343,151	113,267,830
LTE National Total Capacity (EB/month)[4]	3.0	3.5	3.4
5G National Total Capacity (EB/Month)[5]	2.8	3.9	20.3
National Total Capacity (EB/Month)[6]	5.8	7.4	23.7
National Practical Capacity (EB/month)[7]	2.39	3.03	9.69
National Practical Capacity per Smartphone Subscriber (GB/month)[8]	34.65	68.25	85.51

Note:
[1] Based on connection share data from GSMA Intelligence. Shares are as of the third quarter of 2017. The sum of Verizon, AT&T, T-Mobile, and Sprint's share of connections as of the third quarter of 2017 was 96.4 percent, so each company's share is rescaled by multiplying it by 1.04. New T-Mobile's share of connections is calculated as the sum of T-Mobile and Sprint's rescaled shares of connections.
[2] Calculated using 2017 total connections (excluding machine-to-machine connections) as the base value (see Exhibit 5A) and a compound annual growth rate of 2.17 percent, the average annual growth rate of total connections between 2014 and 2017. It is the average of the 2014-15 growth rate, the 2015-16 growth rate, and the 2016-17 growth rate.
[3] Calculated as Total Subscribers multiplied by the Smartphone Penetration Rate and multiplied by the Subscriber Share.
[4] See Ray Declaration.
[5] See Ray Declaration.
[6] Calculated as the sum of LTE National Total Capacity and 5G National Total Capacity.
[7] National Practical Capacity = 0.409 x National Total Capacity. T-Mobile reports that 0.409 is the ratio of Carried Traffic to National Total Capacity for T-Mobile on its 4G LTE Network over the last two years, where Carried Traffic refers to the actual amount of data consumed by users provided over T-Mobile's network. See Section V.C.
[8] Calculated as National Practical Capacity divided by Smartphone Subscribers.

Source: GSMA INTELLIGENCE; Ray Declaration; Exhibit 5A.

Exhibit 14C
National Practical Capacity in 2024
Verizon and AT&T

	No Transaction		Transaction	
	AT&T	Verizon	AT&T	Verizon
Subscriber Share[1]	31.4%	36.9%	31.4%	36.9%
Total Subscribers[2]	397,209,827	397,209,827	397,209,827	397,209,827
Smartphone Penetration Rate	90%	90%	90%	90%
Smartphone Subscribers[3]	112,155,544	132,065,470	112,155,544	132,065,470
National Practical Capacity (EB/month)[4]	3.89	4.58	9.59	11.29
National Practical Capacity per Smartphone Subscriber (GB/month)[5]	34.65	34.65	85.51	85.51

Note:
[1] Based on connection share data from GSMA Intelligence. Shares are as of the third quarter of 2017. The sum of Verizon, AT&T, T-Mobile, and Sprint's share of connections as of the third quarter of 2017 was 96.4 percent, so each company's share is rescaled by multiplying it by 1.04.
[2] Calculated using 2017 total connections (excluding machine-to-machine connections) as the base value (see Exhibit 5A) and a compound annual growth rate of 2.17 percent, the average annual growth rate of total connections between 2014 and 2017. It is the average of the 2014-15 growth rate, the 2015-16 growth rate, and the 2016-17 growth rate.
[3] Calculated as Total Subscribers multiplied by the Smartphone Penetration Rate and multiplied by the Subscriber Share.
[4] Calculated as National Practical Capacity per Smartphone Subscriber multiplied by Smartphone Subscribers.
[5] Based on T-Mobile's National Practical Capacity per Smartphone Subscriber without the Transaction and based on New T-Mobile's National Practical Capacity per Smartphone Subscriber with the Transaction (see Exhibit 14B). Without the Transaction, Verizon and AT&T match 100% of T-Mobile National Practical Capacity per Smartphone Subscriber. With the Transaction, Verizon and AT&T match 100% of New T-Mobile National Practical Capacity per Smartphone Subscriber.

Source: GSMA Intelligence; Exhibit 5A; Exhibit 14B.

APPENDIX H: JOINT DECLARATION OF
PROFESSOR STEVEN C. SALOP AND DR. YIANIS SARAFIDIS
Charles River Associates
Coordinated Effects Analysis of the Proposed T-Mobile/Sprint Merger Transaction

Table of Contents

I. Overview and Executive Summary

1. Steven C. Salop is Professor of Economics and Law at the Georgetown University Law Center, and Senior Consultant at Charles River Associates. Yianis Sarafidis is Vice President at Charles River Associates. Professor Salop teaches antitrust law and economics, and has written numerous articles on various antitrust economics, policy, and law topics, including mergers, joint ventures and exclusionary conduct. Most recently, he submitted declarations to the Commission on the then-proposed Sirius/XM merger (on behalf of the parties), the proposed AT&T/T-Mobile merger (on behalf of Sprint), and the then-proposed Charter/Time Warner Cable/Bright House Networks merger (on behalf of Charter). Dr. Sarafidis has consulted on numerous merger investigations, including the proposed AT&T/T-Mobile merger (on behalf of Sprint) and the then-proposed Sirius/XM merger (on behalf of the parties). He has written articles on mergers, applied game theory, and behavioral economics, including game-theoretic articles that involve dynamic economic models. Before joining Charles River Associates, Dr. Sarafidis served on the faculties of INSEAD and Yale University. Each of us has received a Ph.D. degree from Yale University. Our Curricula Vitae are attached in Exhibit 1.

2. We have been asked by counsel for the parties to analyze whether the proposed merger between T-Mobile and Sprint likely will lead to an increased risk of anticompetitive coordinated effects. Our analysis indicates that the Federal Communications Commission ("Commission") would lack a credible basis on which to conclude that the merger increases the likelihood of successful coordination. The efficiency benefits of the merger and other market factors on balance will provide New T-Mobile ("Newco") with the incentive to maintain and reinforce its maverick image by continuing its procompetitive, disruptive market conduct.

3. In its ALLTEL Order, the Commission explained that:

> in markets where only a few firms account for most of the sales of a product, those firms may be able to exercise market power by either explicitly or tacitly coordinating their actions. Accordingly, one way in which a transaction may create or enhance market power or facilitate its exercise is by making such coordinated interaction among firms more likely, more successful, or more complete. Successful coordination depends on two key factors.

> The first is the ability to reach terms that are profitable for each of the firms involved, and the second is the ability to detect and punish deviations that would undermine the coordinated interaction.[1]

4. The Commission further explained that its analysis of coordinated interaction includes examination of market conditions such as "the availability of information about market conditions, the extent of firm and product homogeneity, and the presence of maverick providers in the market."[2]

5. The 2010 Horizontal Merger Guidelines ("Guidelines")[3] take a similar approach. The Guidelines state that the Agencies are likely to challenge a merger for coordinated effects "if the following three conditions are all met: (1) the merger would significantly increase concentration and lead to a moderately or highly concentrated market; (2) the market shows signs of vulnerability to coordinated conduct . . . ; and (3) the Agencies have a credible basis on which to conclude that the merger may enhance that vulnerability."[4]

6. The Guidelines go on to state a further concern that "[a]n acquisition eliminating a maverick firm . . . in a market vulnerable to coordinated conduct is likely to cause adverse coordinated effects,"[5] though they focus specifically on the scenario where "one of the merging firms has a strong incumbency position and the other merging firm threatens."[6]

7. It is difficult to imagine any reasonable observer characterizing either Sprint or T-Mobile has having a "strong incumbency position." Moreover, the Guidelines also explain that "incremental cost reductions may make coordination less likely or effective by enhancing the

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1 *Applications of Cellco Partnership d/b/a Verizon Wireless and Atlantis Holdings LLC For Consent to Transfer Control of Licenses, Authorizations, and Spectrum Manager and De Facto Transfer Leasing Arrangements and Petition for Declaratory Ruling that the Transaction is Consistent with Section 310(b)(4) of the Communications Act*, WT Docket No. 08-95, Memorandum Opinion and Order and Declaratory Ruling, 23 FCC Rcd. 17444, ¶ 88 (2008).

2 *Id.* ¶ 90.

3 U.S. Dep't of Justice and Fed. Trade Comm'n, *Horizontal Merger Guidelines* at 25 (2010) ("*Guidelines*"), http://www.justice.gov/atr/public/guidelines/hmg-2010.pdf.

4 *Id.* at 25.

5 *Id.* at 25.

6 *Id.* at 3.

incentive of a maverick to lower price or by creating a new maverick firm."[7] As discussed below, Newco anticipates having significantly lower marginal costs as a result of the merger, as well as increased capacity and improved network quality.

8. Using the traditional market definition of the Commission for mobile wireless mergers, the merger of Sprint and T-Mobile would satisfy the first coordinated effects condition of significantly increasing concentration in a "highly concentrated market," defined as a market with an HHI above 2,500.[8] However, reaching an overall conclusion about the likelihood of coordinated effects requires that all three conditions be satisfied. Evaluating these conditions requires more evidence and analysis. Some critics have argued that the merger would satisfy these conditions, simply because T-Mobile has been a maverick firm and there has not been any new entry in recent years by a nationwide fully facilities-based carrier.[9] However, relying on these observations to conclude that the merger would lead to an increased likelihood of coordination is too simplistic, particularly in light of the significant efficiency benefits that the parties have projected for the merger. A more complete coordinated effects analysis is needed.

9. Based on the totality of our understanding of the facts and our economic analysis, a conclusion that there will be higher risk of coordination after this merger cannot be supported. While some observers may assert that some market characteristics may suggest that the post-merger market is vulnerable or more vulnerable to coordination, key factors point significantly in the opposite direction.

10. A theory of harm from anticompetitive coordinated effects must define the dimensions on which the carriers would coordinate. Wireless carriers compete on network investments, prices,

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[7] *Id.* at 30.

[8] *Id.* at 19. We do not analyze market definition in this declaration. We understand that the Commission has traditionally viewed the relevant product market as "a combined market for 'mobile telephony/broadband services' comprised of mobile voice and data services, including mobile voice and data services provided over advanced broadband wireless networks (mobile broadband services)." *Application of AT&T Inc. and Qualcomm Incorporated For Consent To Assign Licenses and Authorizations*, WT Docket No. 11-18, Order, 26 FCC Rcd. 17589, 17603 (2011).

[9] *See* Gigi Sohn, *Promises Mean Little for Consumers in T-Mobile-Sprint Deal*, WIRED (May 10, 2018), https://www.wired.com/story/promises-mean-little-for-consumers-in-t-mobile-sprint-deal/; Meghan Keneally, *How the T-Mobile and Sprint merger could impact consumers*, ABC NEWS (Apr. 30, 2018), https://abcnews.go.com/Business/mobile-sprint-merger-impact-consumers/story?id=54826385; and Harold Feld, *Commentary: Where Are the Disruptors in the Wireless Industry?*, FORTUNE (May 1, 2018), http://fortune.com/2018/05/01/t-mobile-sprint-merger-wireless-antitrust/.

and various dimensions of quality and service offerings. Moreover, the emergence of 5G technology means that, in the short-term time frame after the merger is consummated, most traffic will be on 4G LTE networks with an increasing fraction of traffic migrating to 5G networks in near-future years. Therefore, there is no bright line when the technology switches from 4G to 5G. We understand that all tower radios deployed beginning in early 2019 will be software-upgradeable to 5G, the initial 5G rollout will be underway by 2019 if the merger is consummated by the end of 2018, and an increasing fraction of new handsets will be 5G-compatible starting in 2019.

11. In the following sections, we explain why the Commission would lack a credible basis to conclude that the merger will likely raise the risk of coordinated effects.[10] We separately analyze potential coordination in (i) network investment (including in 5G rollout), (ii) pricing and quality in the time frame when 5G technology and its large efficiencies become established, and (iii) pricing and quality during the short-term period after the merger is consummated, but before 5G technology and its efficiencies become well-established and while 4G LTE traffic is still predominant.

12. As 5G networks are rolled out by all the carriers, there are several reasons why it would be difficult for wireless carriers to successfully coordinate investment activities after the merger. Economic analysis of the facts explains why there is no credible basis to conclude that the merger on balance would enhance the vulnerability of the market to successful coordination.

- First, network investment cannot be easily or rapidly monitored. Even though network investment expenditures are public information, they are reported with a delay (e.g., when the previous quarter's financials are reported) and only at the national level. Therefore, deviations can go undetected, which undermines any attempted coordination.
- Second, as a result of substantial merger-induced efficiencies, Newco will have increased capacity, improved network quality, and reduced network and non-network marginal costs (relative to the standalone firms), which will provide an increased incentive to the merged firm to grow its market share, rather than to settle into coordinated interaction with AT&T and Verizon.

[10] This declaration summarizes our initial analysis. We may supplement it as our analysis is developed further.

- Third, unlike price changes that can be rescinded relatively quickly, network investments are essentially irreversible decisions because the investments do not depreciate very quickly. There also is a long-lead time for retaliatory investments by rivals, once defections are finally detected, which provides the defector with a significant first-mover advantage. As explained in the Guidelines, "[f]irms are also less likely to be deterred by whatever responses occur if competition in the relevant market is marked by leapfrogging technological innovation, so that responses by competitors leave the gains from successful innovation largely intact."[11]

13. There also is not a credible basis to conclude that the merger would increase the likelihood of coordination in pricing and quality after 5G technology becomes established. Such coordination would face severe impediments.

- First, the merger is expected to significantly expand the capacity of the merged firm, increase its network quality, and reduce its network and non-network marginal costs (relative to the standalone firms). These efficiency benefits will decrease the likelihood of coordination because they provide a significantly increased incentive to the merged firm to seek additional incremental subscribers, and hence an increased incentive to deviate from a hypothetical price coordination outcome.

- Second, we understand that Newco expects that it will roll out a 5G network that is superior to those of AT&T and Verizon, based on these carriers' own public statements. To the extent this will be the case, Newco will be rolling out a superior 5G network at the same time that its profitability will be lower than AT&T's and Verizon's. This asymmetry also would impose significant obstacles to reaching a common understanding or attempting and achieving accommodating price increases initiated by leaders.

- Third, as each carrier searches for the right competitive positioning given its new network properties, it is reasonable to expect that the carriers will continue to offer service packages that differ according to each carrier's unique mix of assets on numerous dimensions of competition, including: coverage, speed, handsets, throttling thresholds, zero rating content, the prices and components (i.e., triple-play and video content) of

[11] *Guidelines*, *supra* note 3, at 26.

bundled packages, as well as the basic service price. This product differentiation would hinder reaching and maintaining a common understanding.

- Furthermore, technological asymmetries between carriers across geographies and the emergence of competition from cable MVPDs will provide additional impediments to coordination taking hold.

14. There also is not a credible basis to conclude that the merger would increase the likelihood of coordination in the transitional time frame during which 4G LTE traffic is still predominant, but before all the 5G network efficiencies are achieved.

- First, T-Mobile has built its branding image by being a disruptive force in the industry, the so-called "Un-carrier." The new T-Mobile plans to maintain and reinforce this image with its maverick conduct, rather than to settle into coordinated interaction with AT&T and Verizon. T-Mobile executives have explained that any actions which could be interpreted by consumers as "reneging on the consumer-centric tenets of T-Mobile's brand promise will greatly diminish the value of the Un-carrier brand."[12] Settling into coordinated interaction with AT&T and Verizon likely would be interpreted by consumers as a departure from T-Mobile's expressed brand promise and would risk alienating its existing customer base who identify with the Un-carrier brand differentiation. Thus, deviating from its brand promise would impose short and longer term costs on T-Mobile.

- Second, these plans to maintain its maverick conduct and compete intensely in the short-term are consistent with Newco's economic incentives. Various industry characteristics such as word-of-mouth advertising, signaling effects, and switching costs make the demand facing a carrier dynamic; that is, more subscribers in the present lead to more subscribers in the future. Coupled with the fact that the merger is expected to significantly reduce the marginal cost of 5G network expansion and operations and increase 5G network quality over time (relative to the standalone firms), the presence of dynamic demand implies that Newco will have a significant incentive to begin to pass through these future cost reductions and future quality improvements starting right after

[12] Ewens Decl. ¶ 10.

the merger is consummated. In effect, the future cost and quality efficiencies reduce the opportunity cost of expanding output and lowering price even before actually realizing those efficiencies. Therefore, as a result of dynamic demand incentives and anticipated 5G efficiencies, Newco will have an increased incentive (relative to the standalone firms) to continue on the Un-carrier path it has created and behave like a maverick, not only in the future when the transition to 5G technology is well underway, but also in the short-term transitional time frame before the market migrates to a higher fraction of traffic on 5G.

- Third, while the full realization of the merger's network efficiencies will take a number of years, we understand that Newco expects that the merger will generate efficiencies in the short run as well. These efficiencies will reinforce Newco's incentive to behave like a disruptive maverick and seek additional incremental subscribers in this time frame, rather than to coordinate with AT&T and Verizon.

- Finally, while some market characteristics may be said to suggest that the post-merger market is vulnerable to coordination, key market factors point significantly in the opposite direction. These factors include product differentiation and complexity, including the bundling of various services and video content; market asymmetries, including asymmetric carrier vertical integration; infrequency of purchase from switching costs and consumer inertia; and competition from MVNOs and cable MVPDs.

15. The remainder of this declaration is organized as follows. Section II discusses two overarching themes that are central to the economic analysis of this declaration, namely T-Mobile's history as the industry maverick and the large merger-induced efficiencies that the parties are projecting. Section III analyzes the issues relating to coordination in 5G investment and price and quality in the time frame when traffic on the 5G network becomes the focus of competition. Section IV analyzes the issues relating to coordination in the short-term period of transition when 4G LTE traffic is still primary. Section V concludes.

II. T-Mobile's Maverick History and Merger Efficiencies

16. As summarized above, our analysis indicates that the Commission would not have a credible basis to conclude that the merger increases the likelihood of coordination. Our analysis is multi-faceted. However, two overarching themes are that T-Mobile has a long history as a maverick competitor and that the efficiency benefits of the merger will incentivize Newco to maintain and reinforce this maverick image with its post-merger competitive conduct.

17. These incentives are illustrated by T-Mobile's track record following its acquisition of MetroPCS in 2013. After the merger, T-Mobile used the additional spectrum to expand MetroPCS's footprint and significantly upgrade its LTE network overall.[13] It also continued its maverick behavior with its disruptive Un-carrier strategy. Thus, not only did T-Mobile carry out a successful merger integration that was able to deliver significant efficiency benefits, T-Mobile also did not abandon its maverick strategy but rather intensified it. New T-Mobile intends to replicate this strategy with this merger.[14]

A. T-Mobile's Maverick History

18. We understand that Newco intends to continue to engage in procompetitive market conduct to protect and reinforce T-Mobile's image as the disruptive Un-carrier.[15] This is illustrated by the ARPU projections in the Newco financial model, in comparison to the financial models of T-Mobile and Sprint as standalone firms.[16] The Newco model projects decreasing

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[13] Ray Decl. ¶ 71. *See also* Press Release, T-Mobile, *Migration of MetroPCS Customers to Nationwide 4G HSPA+ and LTE Network Ahead of Schedule* (June 14, 2013), https://newsroom.t-mobile.com/news-and-blogs/migration-of-metropcs-customers-to-nationwide-4g-hspa+-and-lte-network-ahead-of-schedule.htm ("This migration will provide customers of both brands deeper LTE deployment and faster network performance - delivering on the benefits of the combined company. . . . As customers leave the MetroPCS network, the freed up spectrum can then be added to the company's growing 4G LTE network. Deploying the company's spectrum on a single network provides a path to double its initial super-fast 4G LTE deployment (to 20+20 MHz of 4G LTE) in approximately 90 percent of the top 25 metro areas planned for 2014 and beyond."); Phil Goldstein, *T-Mobile to expand MetroPCS footprint by 100M POPs*, FIERCEWIRELESS (May 15, 2013), https://www.fiercewireless.com/wireless/t-mobile-to-expand-metropcs-footprint-by-100m-pops ("T-Mobile US plans to significantly expand the footprint where its MetroPCS brand offers service--by around 100 million POPs over the next six quarters.").

[14] Sievert Decl. ¶¶ 4, 7.

[15] Ewens Decl. ¶¶ 8-10.

[16] As noted by the Commission, ARPU measures "are frequently used as a proxy for price, particularly in industries with multiple pricing plans and complex rate structures." Federal Communications Commission,

ARPU over time.[17] By contrast the T-Mobile model projects flat ARPU,[18] while the Sprint model projects increasing ARPU.[19] As detailed below, Newco will have the incentive to continue its maverick conduct rather than follow a strategy of coordination.

19. T-Mobile has a long history of being a disruptive force in the wireless industry. This history can be traced back to T-Mobile putting to good use assets it acquired following the abandonment of its merger with AT&T in 2011, as well as conduct before that time.[20] As part of the breakup fee from the abandoned merger with AT&T, T-Mobile's parent company (Deutsche Telecom) obtained $3 billion in cash, a seven-year roaming agreement with AT&T, and a significant slice of wireless spectrum. T-Mobile used a portion of the cash to upgrade its network to facilitate LTE transmission, and used the newly acquired spectrum to deploy LTE service without disturbing the service experienced by its existing customers.[21]

20. T-Mobile went on to acquire MetroPCS in 2013. T-Mobile used the spectrum and towers it acquired from MetroPCS to significantly upgrade its LTE network without an adverse effect on MetroPCS customers.[22] Combined with the other efficiencies of the merger, T-Mobile expanded its maverick conduct.

21. At the same time that it was increasing the reach and quality of its physical network, T-Mobile launched what turned out to be a highly effective and enduring marketing campaign in

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Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993, Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services, 32 FCC Rcd. (Sept. 27, 2017) ¶ 6 [hereinafter *FCC 2017 Report*], https://docs.fcc.gov/public/attachments/FCC-17-126A1.pdf.

17 Ewens Decl. ¶ 8.

18 *Id*.

19 Draper Decl. ¶ 6.

20 T-Mobile was a disruptive competitor even before 2011. For example, T-Mobile in 2008 announced flat rate plans for unlimited calls in the United States, raising "investor concerns that a price war could break out." Sinead Carew, *Unlimited mobile plans spark price war concerns*, REUTERS (Feb. 19, 2008), https://www.reuters.com/article/wireless-pricing/unlimited-us-mobile-plans-spark-price-war-concerns-idUSN1926578920080219. In 2008, T-Mobile also was the first carrier to offer a mobile phone that used the Android operating system. *See* Press Release, T-Mobile, *T-Mobile Unveils the T-Mobile G-1 – the First Phone Powered by Android* (Sept. 22, 2008), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-unveils-the-t-mobile-g1-the-first-phone-powered-by-android.htm.

21 Phil Goldstein, *FCC approves AT&T's AWS spectrum transfer to T-Mobile*, FIERCEWIRELESS (Apr. 26, 2012), https://www.fiercewireless.com/wireless/fcc-approves-at-t-s-aws-spectrum-transfer-to-t-mobile.

22 Ray Decl. ¶ 71.

March 2013 that positioned T-Mobile as the industry-disrupting "Un-carrier." T-Mobile did not use the Un-carrier campaign as pure image advertising, but rather as a platform for rolling out a series of consumer-friendly initiatives designed to solve what T-Mobile CEO John Legere calls customer "pain points."[23] These initiatives have affected competition in the wireless market since, as AT&T and Verizon have responded to T-Mobile's disruptions.

22. The first Un-carrier initiative was T-Mobile's "Simple Choice" plan that eliminated service contracts (and allowed device installment purchases) for customers starting in March 2013, a change that reduced consumer switching costs for subscribers who later might leave T-Mobile. With Simple Choice, customers were given straightforward plans with simplified pricing that included unlimited voice and texting. One later initiative was "Carrier Freedom," with which T-Mobile reduced switching costs by paying off customers' early termination fees when they switched to T-Mobile from other carriers. Another was "Music Freedom," in which music streamed from particular services was not counted in the customers' monthly data consumption. This latter initiative was later expanded to include video as part of the "Binge On" initiative.

23. In August 2016, the "T-Mobile One" initiative expanded T-Mobile's unlimited talk, text and data offers to be its core offer, which eventually triggered AT&T and Verizon to expand availability of their previously restricted unlimited plan offers. The "Un-carrier Next" initiative launched in January 2017 further simplified T-Mobile's pricing structure and made its plans even more transparent. This included eliminating hidden taxes and fees from customer bills, which reduced the cost of evaluating T-Mobile's service plan, and thereby reduced search costs for potential new subscribers. T-Mobile also guaranteed customers the ability to keep their T-Mobile plan without worrying about it being changed without their permission.

24. As explained by Peter Ewens, T-Mobile will have the incentive to continue these types of disruptive initiatives after the merger.[24] Newco will maintain and reinforce T-Mobile's current reputation as the disruptive "Un-carrier" and send a clear signal to the market that the merger

[23] Legere Decl. ¶ 15.

[24] Ewens Decl. ¶¶ 8-10.

will not change its business strategy.[25] T-Mobile has explained that it places a high value on maintaining its pro-consumer reputation. As explained by Peter Ewens, "squandering such a successful Un-carrier business strategy for small incremental profits would be a financial and business disaster for the long-term success of New T-Mobile."[26]

B. The Efficiency Benefits of the T-Mobile / Sprint Merger

25. As explained in the declarations of the Chief Technology Officers of both Sprint and T-Mobile, the merger will generate network efficiencies which will allow Newco to offer a substantially superior network than either of the standalone firms. Relative to the standalone firms, Newco will have increased capacity, superior quality of experience, and reduced marginal cost of capacity expansion. Moreover, Newco will begin realizing these benefits soon after the merger is consummated and will realize increasing benefits as traffic transitions over time to 5G.

26. We understand that one set of efficiencies stems from Newco being able to combine the spectrum resources of Sprint and T-Mobile. This affords several benefits. First, in some cases it is possible to combine spectrum resources to cover the full range in contiguous blocks using fewer radios, thus lowering radio costs.[27] Second, larger contiguous spectrum blocks (made possible by combining spectrum resources from both companies) can increase throughput.[28] Third, by combining spectrum resources, Newco will have more flexibility (relative to the standalone firms) in allocating spectrum between the LTE and 5G networks, which will enable Newco to accelerate the deployment of a 5G network while maintaining the quality of the LTE network.[29] Moreover, because the 5G technology offers substantially higher spectral efficiency than the LTE technology, a faster transition to 5G also lowers the incremental cost for Newco to add capacity.[30]

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[25] *Id.* ¶ 8.

[26] *Id.* ¶ 10.

[27] Ray Decl. ¶ 28.

[28] *Id.* ¶ 46.

[29] *Id.* ¶¶ 41-42; Saw Decl. ¶ 29.

[30] That is, deploying additional spectrum or adding a cell site on a 5G network provides more incremental capacity for the same cost relative to LTE because of the higher spectral efficiency of 5G. *See* Ray Decl. ¶¶ 43-50.

27. We also understand that another set of efficiencies stems from Newco being able to combine the tower sites (and associated contracts) of Sprint and T-Mobile.[31] There are substantial cost and time savings from adding retained Sprint cell sites to the T-Mobile network rather than adding new sites.[32] In addition, the structure of contracts with tower companies and companies providing backhaul services makes it cheaper for a carrier to add equipment on a site on which the carrier already has equipment.[33]

28. Newco's ability to economically combine tower sites reduces the cost to Newco of "densifying" its network, relative to T-Mobile standalone. This lower cost in turn gives Newco the incentive to densify its network further by adding more sites. Moreover, this incentive is further reinforced by scale economy benefits stemming from offering more subscribers the network quality advantages of a denser network.[34] As a result of building a denser network, Newco will be able to deploy more spectrum on more sites, which increases the capacity of a network in a multiplicative fashion.[35]

29. These efficiencies give Newco the capability and incentive to provide a superior quality 5G network relative to the standalone companies. We understand that the Newco network will have better signal strength for subscribers because of its greater site density.[36] We also understand that it will also have the capacity to handle substantially more traffic than the combined standalone networks. For example, as discussed by Mr. Ray in his declaration, Newco is expected to have an average 5G data rate of about 149 Mbps in 2021. By comparison, the standalone network plans for T-Mobile and Sprint forecast average 5G data rate of 25 Mbps and 55 Mbps,

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31 *Id.* ¶¶ 26-31.

32 *Id.* ¶ 26-32; Saw Decl. ¶ 28.

33 Ray Decl. ¶ 28-29.

34 Saw Decl ¶ 30.

35 Ray Decl. ¶¶ 23-24. *See also* Federal Communications Commission, *The Public Safety Nationwide Interoperable Broadband Network: A New Model for Capacity, Performance and Cost*, FCC WHITE PAPER 5 (June 2010). ("To first approximation, the total capacity that a cellular architecture can provide to a given region can be described by the following equation:

Total capacity = (# of sites) * (# of sectors per site) * (Capacity/MHz) * (# of MHz of spectrum) / (Frequency Reuse Factor).").

36 Ray Decl. ¶¶ 38, 59-60; Saw Decl. ¶¶ 31-32.

respectively, in 2021. The corresponding figures in 2024 are 444 Mbps for Newco, versus 76 Mbps for T-Mobile and 113 Mbps for Sprint.[37]

30. A network with a higher data rate can accommodate more data traffic (i.e., more subscribers or more data per subscriber) without compromising the subscribers' quality of experience, can provide a superior quality of experience for the same amount of data traffic, or can result in a combination of both. This is analogous to adding more lanes on a highway; a larger highway can accommodate more cars at the same speed, can allow the previous number of cars to travel faster, or can result in a combination of both. Moreover, as discussed above, the faster transition to 5G (with its associated higher spectral efficiency) and Newco's ability to combine the spectrum and tower assets of both firms will result in lower marginal costs of capacity expansion.[38] And, despite its greater site density, we understand that Newco is projected to realize savings by reducing ongoing on-site expenses relative to the combined standalone plans.[39]

31. The combined resources of the T-Mobile and Sprint networks will also generate efficiencies in the immediate time frame after the merger is consummated. Newco intends to implement a multi-operator core network ("MOCN") soon after the merger closes.[40] We understand that this will allow customers with compatible phones to access sites and spectrum from both partners' networks, thus taking advantage of the best of both networks in terms of signal strength and capacity, and thereby raise quality.[41] It is also expected that Newco subscribers will benefit from Newco's lower incremental costs of adding capacity.[42] Moreover, soon after the merger is consummated Newco will also realize marginal cost reductions

[37] Ray Decl. ¶ 53. The superiority of the Newco network relative to the standalone networks is also reflected in projected 5G capacity. *Id.* ¶¶ 54-58.

[38] *Id.* ¶ 31; Saw Decl. ¶ 28.

[39] Sievert Decl. ¶ 14.

[40] Ray Decl. ¶¶ 66-68.

[41] These quality improvements are still in the process of being quantified. Currently, approximately 20 million Sprint customers have devices that can access spectrum on the T-Mobile network, while nearly 27 million T-Mobile users have devices that can access Sprint's 2.5 GHz spectrum. Those numbers will increase over time as consumers upgrade their handsets. *See Id.* ¶¶ 70, 72. Sprint customers without compatible devices will also potentially benefit from the MOCN as other customers migrate to the T-Mobile network, thus freeing up capacity on the Sprint network. *Id.* ¶ 69.

[42] Saw Decl. ¶ 28; Ray Decl. ¶ 31.

associated with dealer commissions, equipment, and other miscellaneous expenses, in addition to the network cost efficiencies.[43]

32. These efficiency benefits will increase Newco's incentives to continue and enhance its maverick conduct. In both the short-term transitional period after the merger is consummated and in the subsequent period as 5G technology becomes established, Newco will have the incentive to use its additional capacity, higher quality and lower marginal costs of expansion to gain subscribers and reinforce its reputation as a disruptive competitor. Newco will have more to gain by deviating from an attempted coordination strategy on price or network investments because of these efficiencies. It also will have less to fear from a breakdown in coordination. As recognized in the Guidelines, "incremental cost reductions may make coordination less likely or effective by enhancing the incentive of a maverick to lower price or by creating a new maverick firm."[44]

33. These incentives to continue its maverick strategy are reflected in Newco's financial plan that Mr. Ewens developed for the acquisition.[45] As noted earlier, the financial plans for the standalone companies assume increasing ARPU over time for Sprint and flat ARPU for T-Mobile. By contrast, Newco intends to gradually reduce ARPU by an overall 6 percent through 2024.[46] Newco also intends to maintain its "data dividend," whereby subscribers will be able to increase data usage every year without any price increases or quality degradation, a policy that Mr. Ewens states would be difficult to sustain absent the merger.[47] In addition, the rapid implementation of the MOCN shortly after the merger also will increase service quality for the current Sprint and T-Mobile subscribers.[48]

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43 Ewens Decl. ¶ 7.

44 *Guidelines*, *supra* note 3, at 30.

45 Ewens Decl. ¶ 8.

46 *Id.* ¶ 8.

47 *Id.* ¶ 14.

48 Ray Decl. ¶¶ 66-70.

III. Evaluating the Risk of Successful Coordination in Investment and Pricing and Quality After the Transition to 5G

34. Economic analysis does not provide a credible basis for finding that the merger will create a higher likelihood of coordinated effects occurring in either network investment, or in pricing and quality in the time period when 5G technology becomes established. A key factor reducing the likelihood of this coordination is the substantial efficiency benefits that the merger is expected to generate. As detailed above, these efficiencies will result in substantial increases in capacity, increases in network quality, and reductions in the marginal cost of expanding capacity (relative to the standalone firms).

35. The Guidelines raise the analytical question of whether a proposed merger might reduce competition by leading to coordinated interaction among the remaining competitors.[49] The Guidelines refer to three types of potential coordinated effects: (i) express agreements that would violate Section 1 of the Sherman Act; (ii) common (tacit) understandings;[50] and (iii) parallel accommodating conduct.[51] The Guidelines characterize common understandings as "not explicitly negotiated but . . . enforced by the detection and punishment of deviations that would undermine the coordinated interaction."[52] The Guidelines explain that parallel accommodating conduct "includes situations in which each rival's response to competitive moves made by others is individually rational, and not motivated by retaliation or deterrence nor intended to sustain an agreed-upon market outcome, but nevertheless emboldens price increases and weakens competitive incentives to reduce prices or offer customers better terms."[53]

36. Our economic analysis focuses on coordination through both common understandings and parallel accommodating conduct.[54] Regarding the latter, we focus on changes in strategic variables (e.g., price, quality, or investment) initiated by one leader firm that are followed by

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[49] *Guidelines*, *supra* note 3, at 24-27.

[50] The common understandings variant flows from Stigler's seminal article on detection and punishment. *See* George J. Stigler, *A Theory of Oligopoly*, 72 J. POL. ECON. 44 (1964).

[51] *Guidelines*, *supra* note 3, at 24.

[52] *Id.*

[53] *Id.* at 24-25.

[54] Economic analysis of the incentives for express price fixing agreement is similar to the analysis of common understandings.

others. This leadership conduct is more like a type of successful common understanding that is not undermined by defections by potential followers. This might be termed *coordinated* parallel accommodating conduct.[55]

A. Coordination in Network Investment

37. Attempting and succeeding with a coordination strategy to reduce network investments would not become more likely after the merger as a result of several impediments. These impediments to successful coordination would apply both to coordination through common understanding and coordinated parallel accommodating conduct. The impediments would decrease the likelihood of attempts to coordinate, as well as the likelihood that coordination will succeed if it were attempted.

38. First, a severe monitoring problem would be an impediment to coordination. Any attempted coordination strategy by the carriers to reduce network performance likely would involve a reduction in the carriers' network investment expenditures. This is because there are multiple dimensions to network investment, such as deploying spectrum, adding sites, or engaging in targeted interventions in specific neighborhoods and large buildings.[56] Moreover, these multiple dimensions vary across geography and are difficult to measure. However, carriers cannot easily monitor rivals' network investment expenditures or the impact of those expenditures on rivals' network capacity.[57] Some network investment expenditures are public information, but only at an aggregate, national level. They also are reported with a delay; for

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[55] Another interpretation of parallel accommodating conduct is the follow-on conduct by rivals to unilateral price increases. In technical economic terms, this refers to the adjustment process from the pre-merger Nash equilibrium to the post-merger one. We will not discuss this interpretation because analysis of unilateral price increases or decreases is beyond the scope of this declaration. For further general discussion, ***see*** Joseph Harrington, ***Evaluating Mergers for Coordinated Effects and the Role of 'Parallel Accommodating Conduct'***, 78 ANTITRUST L.J. 3 (2013); ***see also*** Eric Maskin & Jean Tirole, ***A Theory of Dynamic Oligopoly, II: Price Competition, Kinked Demand Curves, and Edgeworth Cycles***, 56 ECONOMETRICA 571 (1988).

[56] Sprint network "optimization" strategies include spectrum deployment, improved spectrum load balancing, and carrier aggregation technology deployment. Sprint network "densification" investments include the deployment of new cell sites. Sprint also developed a "localization" initiative in 2017, which aims to drive growth through focused investment in 10 initial markets. In 2017, Sprint launched the "Magic Box", a device designed to improve signal quality in and around customer buildings. ***See*** Monica Alleven, ***Sprint Introduces Magic Box, and It's not a Simple Repeater***, FIERCEWIRELESS (May 3, 2017), https://www.fiercewireless.com/wireless/sprint-introduces-magic-box-and-it-s-not-a-simple-repeater.

[57] Ewens Decl. ¶ 17.

example, completed capital expenditure from the previous quarter is observed after the fact when that quarter's financial statement is reported. Even after it is reported, the geographic areas where the spending is taking place and the impact of the expenditures on network capacity and quality are not public information. These can only be detected imperfectly through general business intelligence, monitoring of permits, and observation of tower climbs.[58] As a result, a common understanding or coordinated parallel accommodating conduct to reduce the level of investment would likely fail because the translation from dollars invested to network performance levels is difficult and cannot be easily or rapidly monitored.[59]

39. Second, as a result of substantial merger-induced efficiencies, Newco will have increased capacity, improved network quality, and reduced network and non-network marginal costs (relative to the standalone firms). These efficiencies will provide an increased incentive to the merged firm to grow its market share, rather than to settle into coordinated interaction with AT&T and Verizon.

40. Third, unlike price changes that can be rescinded relatively quickly, network investments are essentially irreversible decisions because the investments do not depreciate very quickly. There also is a long-lead time for investment by rivals. The combination of slow detection of defections and long lead time for retaliatory investments would allow the defector to obtain a long-lasting first-mover advantage. This means that the effectiveness of punishment would be reduced, which in turn reduces deterrence and undermines the stability of sustaining coordination.[60] As explained in the Guidelines, "[f]irms are also less likely to be deterred by whatever responses occur if competition in the relevant market is marked by leapfrogging technological innovation, so that responses by competitors leave the gains from successful innovation largely intact."[61]

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[58] *Id.*

[59] *Id.*

[60] *See* Kai-Uwe Kühn & John Van Reenen, *Capacity Constraints and Irreversible Investments: Defending Against Collective Dominance in UPM Kymmene/Norske Skog/Haindl*, CASES IN EUROPEAN COMPETITION POLICY: THE ECONOMIC ANALYSIS 383 (Bruce Lyons ed., 2009); *see also* Switgard Feuerstein & Hans Gersbach, *Is Capital a Collusion Device?*, 21 ECON. THEORY 133 (2003). Irreversible cost-reducing or quality-increasing investments also hinder price coordination. *See* Johannes Paha, *The Value of Collusion with Endogenous Capacity and Demand Uncertainty*, 65 J. IND. ECON. 623 (2017).

[61] *Guidelines*, *supra* note 3, at 26.

B. Coordination in Pricing and Quality

41. The risk of coordination in pricing and quality also is not likely to increase as 5G technology and its large efficiencies are rolled out.

42. First, as already discussed in the context of coordination in 5G investment, we understand that the merger will generate substantial efficiencies that will reduce the likelihood of coordination. For example, as discussed in Mr. Ray's declaration, Newco will have significant additional capacity in its 5G network, relative to the standalone firms.[62] Newco will have the incentive to use this additional capacity to gain subscribers (thus also reinforcing its reputation as a disruptive competitor), rather than settle into a coordinated effects outcome at a lower market share.[63] Newco would have more to gain by deviating than it would in the absence of these efficiencies. It also would have less to fear from a breakdown in coordination.

43. Second, we understand that Newco expects that its 5G network will be superior, not only relative to the standalone firms, but also relative to AT&T and Verizon, based on these two carriers' own public statements.[64] To the extent this is the case, Newco will be rolling out a superior 5G network at the same time that its profitability will be lower than AT&T's and Verizon's. This asymmetry between Newco's superior network quality and lower profitability will give Newco an incentive to grow its market share, rather than coordinate in a way that maintains the status quo. For example, if AT&T or Verizon were to attempt to initiate coordinated parallel accommodating conduct in the form of price increases, T-Mobile would have the incentive to forgo a parallel response, and instead to advertise the price differential in order to gain share and reinforce its reputation as a disruptive firm. This incentive would deter such coordinated parallel accommodating conduct.

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62 Ray Decl. ¶¶ 54-57.

63 It is the case that significant capacity by a potential "punisher" firm can make a market more vulnerable to coordination. But, here the significant capacity will be in the hands of Newco, which is more likely a defector than punisher.

64 Ewens Decl. ¶ 13; Sievert Decl. ¶¶ 15, 21. *See also* Jeremy Horwitz, *After fuzzy announcements, AT&T and Verizon now have clear 5G roadmaps for 2018*, VENTURE BEAT (Feb. 1, 2018), https://venturebeat.com/2018/02/01/after-fuzzy-announcements-att-and-verizon-now-have-clear-5g-roadmaps-for-2018/.

44. Third, the market will be further disrupted as new technology is introduced and the firms experiment to design and then offer new service packages. These packages will differ because each company will want to emphasize its own unique combination of assets.[65] This volatility and differentiation also will make it harder to reach a common understanding and deter defections or to implement successful coordinated parallel accommodating conduct. The carriers differ in their ownership of content and wireline assets. The competitors likely will offer differentiated service packages that involve differences in throttling thresholds and properties, zero rating content, and bundled packages, as well as prices, as they search for the right combination to fit their network properties and competitive positioning.[66] The firms also advertise their prices differently. While T-Mobile includes taxes and other fees arising from an Un-carrier initiative designed to create more clarity and simplicity in the monthly bill, other carriers do not. This product differentiation also will make it more difficult to reach a common understanding and deter defections.

45. Fourth, there will be further market disruption as the new technology is rolled out geographically. The firms' positions will differ across geographic areas in terms of speed, latency and coverage.[67] This means that the technological market structure in any particular geography also will not be stable over time. This type of disruptive environment will make it very difficult if not impossible to reach and enforce a common understanding, or facilitate coordinated parallel accommodating conduct, across the wide array of local areas.

46. Fifth, the presence and growth of cable MVPDs in wireless may complicate attempts to coordinate. While the cable MVPDs have low wireless shares today, they likely will be expanding their own wireless service over the period in which 5G develops and likely will become stronger competitors over time. Some analysts have estimated that cable companies could take over 35 million customers from incumbent wireless carriers or 13 percent of the U.S.

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65 Ewens Decl. ¶ 15.

66 *Id.*

67 *Id.*

wireless market;[68] others have predicted that cable will ultimately "win" in wireless, as they ultimately won in broadband.[69] These predictions are consistent with the fact that cable companies have important assets that can provide them with competitive advantages: large retail customer bases; the ability to offer triple-play and quad-play bundles; and ubiquitous hotspot availability (where a significant portion of data traffic occurs[70]). Moreover, they control backhaul and small cell sites, which will be very important for 5G technology,[71] as well as valuable video content.[72] Cable MVPDs also can build their own wireless networks.[73] Comcast already owns spectrum[74] and Charter has plans to eventually develop its own wireless mobile network relying on small cell LTE towers.[75]

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68 Colin Gibbs, *New Street: Cable companies could take 20% of the wireless market in 5 years*, FIERCEWIRELESS (June 27, 2016), https://www.fiercewireless.com/wireless/new-street-cable-companies-could-take-20-wireless-market-5-years.

69 Colin Gibbs, *MoffettNathanson: Cable's infrastructure will ultimately win in wireless*, FIERCEWIRELESS (Sept. 28, 2016), https://www.fiercewireless.com/wireless/moffettnathanson-cable-s-infrastructure-will-ultimately-win-wireless.

70 *See* Mike Dano, *Thanks to unlimited data, wireless users are increasingly eschewing Wi-Fi*, FIERCEWIRELESS (Apr. 19, 2018), https://www.fiercewireless.com/wireless/thanks-to-unlimited-data-wireless-users-are-increasingly-eschewing-wi-fi. According to this article, about half of data traffic occurs on Wi-Fi.

71 *See* Bernie Arnason, *Moffett: At the End of the Day, Cable Industry 5G May Prevail Over all Others*, TELECOMPETITOR (Apr. 19, 2017), http://www.telecompetitor.com/moffett-at-the-end-of-the-day-cable-industry-5g-may-prevail-over-all-others/ ("5G networks . . . will require dense wireline backhaul capacity and cable MSOs already have that in the ground.").

72 Comcast owns NBC Universal, *see* COMCAST, https://corporate.comcast.com/our-company/businesses/nbcuniversal (last visited May 22, 2018). Charter also owns various regional sports networks, *see Spectrum Sports*, SPECTRUM, https://www.spectrum.com/twc-bhn-sports.html (last visited May 22, 2018). (Charter Communications is the parent company to Spectrum).

73 *See* Walter Piecyk, *Will Comcast Use Its Fiber for a New Wireless Network?*, BTIG RESEARCH (Jan. 3, 2017), http://www.btigresearch.com/2017/01/03/will-comcast-use-its-fiber-for-a-new-wireless-network/ ("[I]nvestors should also start to consider the possibility that cable operators could build new wireless networks as an evolution of an MVNO strategy.") (registration necessary).

74 *See* Michelle Caffrey, *Comcast spends $1.2 billion net to purchase airwaves*, PHILADELPHIA BUSINESS JOURNAL (Apr. 14, 2017), https://www.bizjournals.com/philadelphia/news/2017/04/14/comcast-fcc-auction-airwaves-wireless-spectrum.html ("Comcast spent a total of $1.2 billion to purchase airwaves made available through an FCC auction after buying $1.7 billion in wireless spectrum.").

75 *See* Colin Gibbs, *Charter looks beyond MVNO model as it prepares to launch wireless next year*, FIERCEWIRELESS (Oct. 27, 2017), https://www.fiercewireless.com/wireless/charter-looks-beyond-mvno-model-as-it-prepares-to-launch-wireless-next-year ("Charter has outlined plans to pursue an "inside-out" strategy starting with a Wi-Fi-first MVNO, then expanding into developing its own mobile infrastructure using LTE small cells.").

IV. Evaluating the Risk of Successful Coordination in the Short-Term Transition Period

47. We next analyze the potential for successful coordination in the short-term transitional period following consummation of the merger. Our analysis indicates that the Commission would lack a credible basis on which to conclude that the merger increases the likelihood of successful coordination.

48. There is no bright line between the time periods when networks will rely primarily on 4G LTE versus 5G technology, since traffic will evolve gradually to 5G over time. We understand that all tower radios deployed starting in 2019 will be software-upgradeable to 5G technology,[76] the initial 5G rollout also will be underway by 2019 if the merger is consummated by the end of 2018, [77] and an increasing fraction of new handsets will be 5G compatible starting in 2019.[78] There also will be substitution among consumers from 4G to 5G handsets. We draw the distinction in time periods to highlight the interaction from dynamic demand and to address coordination issues that might be raised regarding this more immediate period. As explained below, the existence of dynamic demand and 5G efficiencies will affect competition earlier in time as well.

49. If the carriers anticipate that coordination would not succeed in investment or prices after the transition to 5G is well underway, it seems counterintuitive that they would attempt to coordinate for a couple of years during the transition. But, even putting this practical argument aside, there are several reasons that explain why coordination in the immediate transition period likely would not be attempted and likely would not succeed if it were attempted. These reasons explain why there is not a credible basis to conclude that the risk of successful coordinated conduct would increase.

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76 Ray Decl. ¶ 16. *See also, e.g.*, Linda Hardesty, *Ericsson Updates Existing Radios to 5G NR via Software*, SDXCENTRAL (Feb. 8, 2018), https://www.sdxcentral.com/articles/news/ericsson-updates-existing-radios-5g-nr-via-software/2018/02/; Marin, *5G FUTURE X : NOKIA HAS COMPLETED ITS PORTFOLIO OF 5G PRODUCTS*, NOKIAMOB (Jan. 30, 2018), http://nokiamob.net/2018/01/30/5g-future-x-nokia-has-completed-its-portfolio-of-5g-products/.

77 Ray Decl. ¶ 16.

78 *See, e.g.*, Jessica Dolcourt, *All the proof you need that 5G phones are coming in 2019*, CNET (Feb. 8, 2018), https://www.cnet.com/news/5g-phones-will-come-in-2019-heres-more-proof/.

50. As discussed in section II, T-Mobile has built its branding image by being a disruptive force in the industry, the so-called "Un-carrier." We understand that the new T-Mobile intends to maintain and reinforce this image with its post-merger competitive conduct.[79] As summarized by T-Mobile CEO John Legere, the merger will add scale and assets to "supercharge" the Un-carrier model.[80]

51. This strategy also is consistent with its economic incentives. Various industry characteristics — word-of-mouth advertising, signaling effects, the various sources of switching costs and subscriber stickiness, and rising marginal subscriber acquisition costs at a moment of time — make the demand facing a carrier dynamic, in the sense that more subscribers in the present lead to more subscribers in the future. When demand is dynamic, the expectation of near-future merger-induced efficiencies (such as those that Newco will realize with its 5G network) provides an incentive for the merged firm to invest more in building an increased subscriber base in advance. The anticipation of future cost and quality efficiencies reduces the opportunity cost of expanding output and lowering price even before actually realizing those efficiencies. This strategy will allow the merged firm to reduce the cost of subscriber acquisition. It also will allow Newco to build a strong starting position to create momentum as its 5G network and its efficiencies are rolled out in the next several years by taking advantage of word-of-mouth advertising and market signaling.

52. These incentives also will be reinforced by merger efficiencies that we understand that Newco expects to realize in the short run, which will lower its cost, increase its capacity and improve the quality of its LTE network and the subscriber experience – both soon after the merger is consummated and through the transition to 5G.

53. Important industry characteristics also do not support the view that the market will be vulnerable to coordination. These include product differentiation and complexity, infrequency of purchases by sticky consumers, market asymmetries (including asymmetric vertical integration among carriers), and the presence of MVNOs and cable MVPDs.

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[79] Ewens Decl. ¶¶ 8-10.

[80] Legere Decl. ¶ 8.

54. For all these reasons, there is not a credible basis to conclude that Newco will have the incentive to abandon its Un-carrier business strategy and coordinate with AT&T and Verizon in the immediate period following the merger, despite its increased share and the elimination of Sprint as a competitor.

A. Economic Analysis of Dynamic Demand and the Incentive for Immediate Price Reductions in Anticipation of Future Cost Savings

55. A wireless carrier's demand in a particular period depends upon the carrier's subscriber base in previous periods. In economics jargon, carrier demand is dynamic. When demand is dynamic, a firm that expects to have lower marginal costs in the future (and hence a higher margin) will have an incentive to reduce its prices in the present as well as in the future. This is because the lower marginal cost in the future reduces the opportunity cost of expansion in the present.

1. Dynamic Demand Price-Setting Incentives

56. When demand is dynamic, a firm has an incentive to set its price below its short-term profit-maximizing level. The profits earned on the higher future output demand more than offset the initial decrease in short-term profits. This strategy of setting a lower current price sometimes is referred to as "penetration pricing."[81] The low current price represents an investment in future demand.

57. Similarly, when demand is dynamic, a firm has an incentive to spend more on demand-enhancing investments (e.g., product quality improvements such as expanding the number of towers, advertising, retail presence[82]), as well as cost-reducing investments. This is because the increases in current sales resulting from these investments will have dynamic benefits by increasing profitable future sales as well.

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[81] *See, e.g.*, Martin Spann, Marc Fischer & Gerard J. Tellis, *Skimming or Penetration? Strategic Dynamic Pricing for New Products*, 34 MARKETING SCI. 235 (2015); Trichy Krishnan, Frank M. Bass & Dipak C. Jain, *Optimal Pricing Strategy for New Products*, 45 MGMT. SCI. 1650 (1999).

[82] An increased retail presence may be a demand-enhancing investment because it "reinforces the perception that the provider has a committed presence in the market." Ewens Decl. ¶ 23. It may also be a cost-reducing investment, to the extent that it decreases the cost per gross add.

58. A firm's incentive to reduce current prices (or increase demand-enhancing investments) will depend on future margins. The higher a carrier's expected future margins are, the greater its incentive will be to reduce current prices (or increase current investment) to attract a larger flow of current subscribers, who then will lead to more subscribers in the future. Importantly, this also means that a firm would have an incentive to pass through future cost reductions and future quality improvements in the present as well as in the future.

59. Applied here, Newco expects to have a better and lower cost 5G network in the future than the standalone firms.[83] Newco also will offer more value-added services such as home broadband replacement and new consumer-oriented IoT offerings its subscribers.[84] These factors will lead Newco to earn higher future margins than would the standalone firms. As a result, the merger enhances Newco's incentives to charge lower prices, not only after the transition to 5G technology is established, but also in the short-term time period after the merger is consummated, even aside from any efficiencies achieved in the immediate post-merger network and operations. This strategy will ensure that, when Newco's superior 5G network is completed, Newco will have a larger subscriber base which then will upgrade their service and subscribe for a longer average period of time.[85]

2. Newco's Reinforced Incentives for Maverick Behavior

60. This analysis of dynamic demand pricing incentives in the anticipation of future efficiencies also explains why coordination (whether common understanding or coordinated parallel accommodating conduct) is unlikely to be attempted (and unlikely to succeed if it is attempted) in the interim period soon after the merger is consummated. Even if there are fewer competitors, the presence of dynamic demand coupled with anticipation of future efficiencies will give Newco the incentive to behave like a maverick firm and deviate from any attempted coordination in order to win more subscribers in this time frame.

61. These incentives to behave like a maverick will be further reinforced by efficiencies that Newco expects to realize in the short term. Specifically, Newco expects reduced network and

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[83] *See supra* Section II.B.

[84] Ewens Decl. ¶ 21; *see also* Sievert Decl. ¶¶ 35-41.

[85] Ewens Decl. ¶ 21.

non-network marginal costs[86] and improved network quality[87] (relative to the standalone firms). These efficiencies will increase the incentives of the merged firm to continue to behave like a maverick and defect from any attempted coordinated strategy by AT&T or Verizon. For example, the additional capacity means that Newco will have the incentive to offer greater usage before needing to throttle speed, including (for example) by increasing tethering limits. Moreover, if AT&T and Verizon also do not develop sufficient additional capacity, they would be unable to quickly match Newco if it were to defect from some hypothetical coordinated outcome. For example, AT&T and Verizon suffered quality losses when they matched T-Mobile's unlimited data service plans.[88] Under these circumstances, coordinated strategies are unlikely to be attempted.

62. The Guidelines state that "[a]n acquisition eliminating a maverick firm . . . in a market vulnerable to coordinated conduct is likely to cause adverse coordinated effects."[89] But, the Guidelines specifically are concerned with the case where "one of the merging firms has a strong incumbency position and the other merging firm threatens."[90] This scenario does not apply here since neither Sprint nor T-Mobile could be reasonably characterized as having "a strong incumbency position." The concern in the Guidelines also would not apply here in light of the dynamic demand incentives coupled with the expected efficiency benefits, and Newco's resulting incentive to maintain and strengthen its Un-carrier branding. As stated in the Guidelines, "incremental cost reductions may make coordination less likely or effective by enhancing the incentive of a maverick to lower price or by creating a new maverick firm."[91]

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86 Ewens Decl. ¶ 7.

87 *See* discussion of MOCN in Ray Decl. ¶¶ 66-70.

88 *See* Colin Gibbs, *Editor's Corner—The Pros and Cons of Deprioritization in the Unlimited-Data Era*, FIERCEWIRELESS (Nov. 10, 2017), https://www.fiercewireless.com/wireless/editor-s-corner-pros-and-cons-de-prioritization-unlimited-data-era ("The launch of unlimited-data plans by Verizon and AT&T has resulted in slower network speeds for some of their subscribers."). As noted earlier, *supra* note 63, a merger that creates significant excess capacity of potential "punisher" firms can make the market more vulnerable to coordination. But that is not the situation here, where it is the maverick Newco that will gain excess capacity.

89 *Guidelines*, *supra* note 3, at 25.

90 *Id.* at 3.

91 *Id.* at 30. It is theoretically possible to construct economic models and identify empirical evidence that would suggest that efficiencies can increase the likelihood of coordination. However, because efficiencies generally reduce the likelihood of coordination by increasing the profitability of defection, and because they lead to beneficial unilateral effects, courts and Agencies likely would demand a heavy burden of proof on claims that

63. This analysis of Newco's continued incentives to engage in maverick behavior despite the reduction in the number of firms and Newco's larger market share undermines the basis for arguing that the merger will increase the vulnerability of the market to coordination.

64. This incentive for maverick behavior also is consistent with the intentions expressed by T-Mobile and with T-Mobile's history. When T-Mobile acquired MetroPCS in 2013, it did not attempt to coordinate. Instead, it significantly upgraded its LTE network, supporting its Un-carrier maverick strategy, which it has pursued ever since.

3. Sources of Dynamic Demand

65. There are several industry characteristics that contribute to making the demand for a carrier's service dynamic.

66. One reason for demand being dynamic stems from the fact that only a limited number of potential new subscribers are available in any period. This means that if a carrier wishes to achieve a higher subscriber share in the future, it needs to begin accumulating additional subscribers in advance. It also means that the marginal out-of-pocket or opportunity costs of attracting additional new subscribers in any given period will be rising with the number of new subscribers obtained in that period.[92] As explained by Peter Ewens with a simple numerical illustration, "it is less costly to add 1,000 subscribers in one quarter and another 1,000 subscribers in the following quarter, rather than add 2,000 subscribers in the same quarter."[93]

67. Another reason for dynamic demand is that a carrier's success in growing its subscriber base can create momentum and become self-reinforcing for a period of time, thus leading to more subscriber gains in a virtuous cycle. Subscribers are imperfectly informed about the relative network quality of each carrier (or, more generally, the desirability of each brand) and may look at the choices made by other consumers as a guide. This might involve direct word-of-mouth recommendations offered by acquaintances. Or, it might involve market signaling,

efficiencies will facilitate rather than hinder coordination in a particular matter. That proof is absent in this case.

92 The opportunity cost arises from the need to engage in more advertising or cost promotions to attract a larger flow of new subscribers.

93 Ewens Decl. ¶ 22.

whereby people treat a growing or large subscriber base of a carrier, or a low churn rate or a large number of retail stores, as signals that the carrier is a good buy.[94]

68. Yet another reason for dynamic demand is that wireless subscribers perceive costs of switching carriers, which leads their choices to be sticky. This is a natural phenomenon in this industry that persists for several reasons, despite T-Mobile's actions that have reduced certain switching costs. First, a subscriber's act of switching carriers has an opportunity cost in terms of the time the subscriber will have to spend on the phone or at a store to cancel the old plan and to subscribe to the new one. Second, some subscribers who own a previously purchased phone may be worried that switching carriers has a monetary cost associated with having to change phones. Third, if switching carriers is accompanied by switching phones, a subscriber may be worried about the opportunity cost of time (or possibly the risk) in porting information (e.g., contacts, photos, music) from the old phone to the new one. Fourth, there is imperfect information about product quality and associated search costs. The quality of a subscriber's wireless service depends on how and where the handset is used, which takes some time to learn about from experience. A disappointed subscriber will need to research alternative carriers' expected quality and price, which is a time-consuming process. Finally, psychological factors discussed in the behavioral economics literature no doubt also come into play in consumers delaying rational decisions because of perceived decision or switching costs.[95]

69. This stickiness in subscriber carrier choices is consistent with the low churn rates for postpaid subscribers. For example, in the fourth quarter of 2017, the postpaid phone churn rates of Verizon and AT&T were only 0.77 percent and 0.89 percent respectively.[96] Stated differently, the average expected subscriber duration with a specific carrier is about 10 years.[97] While it is

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[94] Ewens Decl. ¶ 23.

[95] *See, e.g.*, David Laibson, *Golden Eggs and Hyperbolic Discounting*, 112 Q.J. ECON. 443 (1997); *see also, e.g.*, George A. Akerlof, *Procrastination and Obedience*, 81 AM. ECON. REV. (PAPERS & PROC.) 1 (1991); Ted O'Donaghue & Matthew Rabin, *Choice and Procrastination*, 116 Q.J. ECON. 121 (2001). For a popular press account, *see* James Suroweicki, *Later*, THE NEW YORKER, Oct. 11, 2010, https://www.newyorker.com/magazine/2010/10/11/later.

[96] Verizon, *Verizon closes 2017 with strong wireless customer growth and retention, well-positioned in new markets*, https://www.verizon.com/about/news/verizon-closes-2017-strong-wireless-customer-growth-and-retention-well-positioned-new-markets; AT&T, *AT&T Reports Fourth-Quarter and Full-Year Results*, http://about.att.com/story/att_fourth_quarter_earnings_2017.html.

[97] This is calculated as (1 – 0.008)/0.008 = 124 months, or about 10 years.

theoretically possible that subscribers continuously re-evaluate and reaffirm their carrier choice relative to the alternatives available in the market, it is more likely that subscribers only evaluate periodically and take into account the perceived costs of switching when they do.

70. For all these reasons, demand is dynamic. A carrier that attracts more incremental subscribers in the present (e.g., from a price decrease) will be likely to have more subscribers in the future too, *ceteris paribus*. By cutting prices in advance and taking advantage of word-of-mouth advertising and market signaling, this dynamic demand pricing and promotion strategy will allow the merged firm to reduce the cost of subscriber acquisition and build a strong starting position to create momentum as its 5G network and its efficiencies are rolled out in the next several years.[98]

B. Coordination Checklist Factors

71. In the previous section, we explained why dynamic demand incentives coupled with anticipated 5G efficiencies, as well as more immediate 4G efficiencies, will reduce the likelihood of coordinated effects and incentivize Newco to continue with its maverick behavior. In this section, we will analyze other market factors that affect the vulnerability to successful coordination. Antitrust practitioners sometimes refer to informal "checklists" of factors that could be used to help gauge coordinated effects concerns. These checklists involve factors that may make a market more or less vulnerable to coordination. Changes in these factors that result from the merger also are relevant to evaluating whether the merger would increase or decrease the likelihood of successful coordination and attempts to coordinate.

72. Just as deeper coordinated effects analysis explains why Newco will have an increased incentive for disruptive maverick conduct, it also explains that key checklist factors help to neutralize any concerns that the post-merger market will become more vulnerable to coordination. The checklist factors include product differentiation and market complexity, market asymmetries, the infrequency of purchases flowing from switching costs, and competition from MVNOs and cable MVPDs.

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98 For an illustration of how momentum effects induce players to expend resources early in a race, *see* Nicolas deRoos & Yianis Sarafidis, *Momentum in Dynamic Contests*, 70 ECON. MODELLING 401 (2018).

1. Product Differentiation, Complexity and Transparency

73. The Guidelines explain that a market is more vulnerable to coordinated conduct if the "terms offered to customers are relatively transparent."[99] The Guidelines go on to say that "[p]rice transparency can be greater for relatively homogeneous products."[100] Nominal prices and the terms of the wireless plans are public. However, wireless service quality and the offered service packages are differentiated and complex. Quality of service also has several dimensions (e.g., coverage, speed, latency) that can differ according to where and when a device is used within the subscriber's service area. Service plans also involve multiple dimensions that differ among carriers, including price differences in the number of lines, streaming speeds, throttling thresholds, zero rating content, international roaming, bundled packages, as well as plan prices.

74. For example, a recent CNET article compared unlimited plans from Verizon, T-Mobile, AT&T, and Sprint.[101] The article showed the price differentials across the plans for single line and multiple line subscribers.[102] The article also indicated differences across plans in terms of throttled data speeds at varying thresholds, whether streaming was standard definition or high definition, limits on mobile hotspot data, and whether the data speed was 3G or LTE. It also flagged the fact that prices vary according to whether the subscriber signs up for autopay and noted differences in potential costs or discounts related to the phone, warranties and activation fees. Even this list is incomplete. The plans also differ with respect to bundled video services (e.g., Hulu, HBO, Netflix, Go90).

75. The 2017 FCC Report also explains this differentiation and complexity.

> [I]t is difficult to compare prices of mobile wireless service plans because providers offer a variety of plans, frequently under multipart pricing schemes, which also vary in non-price terms and features, such as early termination fees and the consequences of reaching usage limits. The many pricing plans

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99 *Guidelines*, *supra* note 3, at 26.

100 *Id.*

101 Patrick Holland, ***Verizon, T-Mobile, AT&T, and Sprint Unlimited Plans Compared***, CNET (Apr. 27, 2018), https://www.cnet.com/news/how-does-verizon-unlimited-plan-stack-up-against-the-others/.

102 *Id.* The article noted that the T-Mobile prices included taxes, surcharges and additional fees, but the other carriers' plans do not.

offered by mobile wireless service providers vary in several dimensions, and these plans frequently change.[103]

76. In light of the large number of product dimensions and the differentiation among these dimensions, reaching a common understanding on price and monitoring defections or engaging in coordinated parallel accommodating conduct after the merger would be very difficult, despite the transparency of posted nominal prices. A common understanding would require a significant number of dimensions. The same complexity would deter coordinated parallel accommodating conduct. A potential defector could choose to deviate along a dimension where it would be more difficult for rivals to efficiently and rapidly respond.[104]

2. Market Asymmetries

77. While not discussed in the Guidelines, another possible checklist factor is the similarity or differences among the firms in the market. Asymmetric incentives make it more difficult for firms to reach a common understanding of the preferred coordinated outcome.[105] For example, firms with lower costs of expansion may prefer lower prices than firms with higher costs. Firms also may differ in the characteristics of their products and the characteristics of their customers. These and other asymmetries also may make it harder to deter firms from deviating from a coordinated outcome. For these reasons, asymmetries tend to make successful coordination less likely.

78. The degree of structural symmetry might be considered as a proxy for the similarity in the competitive incentives of the various firms. The merger of Sprint and T-Mobile will make the nationwide all-wireless subscriber shares of the remaining three firms more similar.

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[103] *FCC 2017 Report*, *supra* note 16 ¶ 57.

[104] Economic theory suggests two conflicting ways in which product differentiation generally can affect defection incentives. On the one hand, a given price deviation would gain for the defector fewer new customers, which would decrease the incentives to defect. On the other hand, a smaller gap between the monopoly price and the non-coordinated price reduces the harm to the defector from a breakdown in coordination, which would increase the incentive to defect. Without more evidence regarding the structure of demand, it cannot be determined in general which of these factors would dominate. *See, e.g.*, Marc Ivaldi et al., *The Economics of Tacit Collusion*, Final Report for DG Competition, European Commission - IDEI (2003), http://ec.europa.eu/competition/mergers/studies_reports/the_economics_of_tacit_collusion_en.pdf. However, in this matter, the differentiation would make it difficult to reach a common understanding to begin with, and Newco's incentives to defect would be increased because of the efficiencies and dynamic demand.

[105] *Id.*

However, national subscriber shares are not a good indicator of more similar incentives. There are other indicia that suggest significant asymmetries in the incentives of the three competitors.

79. For example, the three carriers will be quite asymmetric in terms of their respective shares of total industry profits. In the first quarter of 2018, a combined Sprint and T-Mobile accounted for about 25 percent of industry EBITDA (approximately 12 percent each), lagging behind AT&T and Verizon, which accounted for about 30 percent and 45 percent, respectively.[106] These differences would undermine the carriers' ability to reach a coordinated outcome that maintains status quo market shares. A coordinated outcome that would reallocate market shares also would be too complicated to reach, given the differences in profitability and other asymmetries. A coordinated outcome that would reallocate profit shares would be impossible without large side payments.

80. In addition, there also will be continued asymmetry in the product offerings resulting from differences in the product portfolios and the degree of vertical integration among the carriers. AT&T and Verizon will have the ability to bundle wireline cable and broadband. AT&T also will have the ability to bundle DirecTV video and the DirecTV Now virtual MVPD. Following its Time Warner merger, AT&T also will have the ability to bundle this content and may have the incentive to disadvantage rivals' access to it. Verizon may have a still different path for video. The ability to offer multiple services from this vertical integration makes it harder to reach a common understanding or monitor and deter defections. As a small video provider, Newco will face higher content costs from its smaller size, which will incentivize it to try to grow its market share faster.[107]

[106] *See* quarterly reports from the first quarter of 2018. Sprint, ***Financial & Operating Information – Excel***, http://investors.sprint.com/financials/default.aspx; T-Mobile, ***Financial Results, Supplemental Data, Non-GAAP Reconciliations, and Reconciliation of Operating Measures – Excel***, http://investor.t-mobile.com/QuarterlyResults; AT&T, ***Financial and Operational Trends***, https://investors.att.com/financial-reports/quarterly-earnings/2018; Verizon, ***Financial & Operating Information***, https://www.verizon.com/about/investors/quarterly-reports/1q-2018-quarter-earnings-conference-call-webcast; US Cellular, ***U.S. Cellular Reports First Quarter 2018 Earnings Press Release***, http://s1.q4cdn.com/183458318/files/doc_financials/quarterly/2018/USM-1Q-2018-final.pdf.

[107] T-Mobile recently purchased Layer3 TV, which will give it a foothold in the video market.

3. Retail Buyer Size, Infrequency of Purchases and Switching Costs

81. Two other checklist factors are buyer size and frequency of purchases. The Guidelines explain that a "firm is more likely to be deterred from making competitive initiatives by whatever responses occur if sales are small and frequent rather than via occasional large and long-term contracts."[108] In this case, retail buyers are typically small, except for larger enterprise customers. Long-term contracts are no longer the norm. But, as discussed previously,[109] carriers face customer stickiness from a variety of switching costs, which makes sales infrequent. Thus, these two factors—small retail buyers and infrequent sales—work in opposite directions. However, as discussed previously, infrequency of purchases from consumer stickiness also leads to dynamic demand, which has a significant and negative effect on Newco's coordination incentives, when coupled with the future efficiencies. This effect becomes stronger as result of the merger.

82. While the impact of switching costs on coordination incentives involves a general tension between two opposing effects, switching costs reduce the likelihood of successful coordination for this merger.[110] On the one hand, switching costs in principle reduces the profitability of defection by reducing the number of subscribers obtained by the defector when it cuts price. But, on the other hand, the existence of switching costs makes coordination less likely because it reduces the impact of retaliation on the profits of a defector. The existence of switching costs implies that incremental subscribers obtained by a defector from the lower prices are likely to be retained by the defector even if competitors cut prices or increase network investments in

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108 *Guidelines*, *supra* note 3, at 26.

109 *Supra*, section IV.A.3.

110 The presence of consumer switching costs in a market complicates the economic analysis. *See*, e.g., Joseph Farrell & Paul Klemperer, *Coordination and Lock-In: Competition with Switching Costs and Network Effects*, HANDBOOK OF INDUSTRIAL ORGANIZATION 1967 (Mark Armstrong & Robert Porter eds., 2007). There are ex ante and ex post effects. Switching costs can reduce the price sensitivity of a firm's customers. By itself, this factor may incentivize a firm to raise prices (ex post) to existing customers, though the analysis actually is more complicated. The switching costs also can create the incentive for a firm to give introductory (ex ante) discounts to new customers. These ex ante introductory discounts reflect increased competition for new customers and can mitigate or even totally offset the effect of the ex post higher prices. Firms also might take other actions to mitigate switching costs. For example, as discussed earlier, T-Mobile paid the early termination fees for new subscribers and eliminated two-year contracts. Of course, the Commission's number portability policy also reduced switching costs.

retaliation.[111] This is a key effect. As explained in the Guidelines, a firm "is more likely to anticipate strong responses . . . if customers find it relatively easy to switch between suppliers."[112] By contrast, switching costs make customers *less likely* to switch away from the defector after rivals respond. Applied here, if Newco were to deviate from a hypothetical coordinated outcome with AT&T and Verizon, it would retain many of the incremental subscribers it gained when deviating, even if AT&T and Verizon subsequently cut prices or increased network capacity investments. This effect implies that Newco's post-merger incentive to deviate would be enhanced, which reduces the likelihood of successful coordination.

83. Comparing these two opposing effects, the switching costs in this matter on balance likely reduce the likelihood of successful coordination. This is because the switching costs contribute to dynamic demand. Coupled with very large anticipated future efficiencies, Newco's incentives to build its share in advance by defecting from a hypothetical coordinated outcome significantly increase, even aside from the other checklist factors. Thus, even though switching costs reduce the number of subscribers attracted from a given price decrease, this imperative to build its subscriber base means that Newco will cut price by more if necessary. As a result, the combination of this merger, its efficiencies and the switching costs likely reduces the risk of successful coordination.

4. MVNO and Cable Competition

84. In contrast to retail buyers, MVNOs are large wholesale buyers. Coordination also would be complicated by the existence of competition from MVNOs and the emerging competition from cable providers.

85. MVNOs purchase capacity at wholesale from their hosts and, for that reason, sometimes are said not to provide direct competition to the host network.[113] However, the MVNOs do compete with the service provided by both the host and non-host carriers. The facilities-based

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111 A similar analysis would apply to coordinated parallel accommodating conduct. If one firm leads a price increase and another rival does not follow, that rival will retain the customers who leave the leader and switch to the rival even if the leader rescinds the price increase.

112 *See Guidelines, supra* note 3, at 26.

113 *See, e.g.,* YANKEE GROUP, *Yankee Group's 2011 Predictions: 4G Fuels the Decade of Disruption* (Dec. 10, 2010), (cited by *FCC 2017 Report, supra* note 16 ¶ 15 n.54).

carriers also do not control the MVNOs' retail prices or output decisions. As the Ewens Declaration explains, "MVNOs typically have long-term contracts at wholesale prices and provide sufficient capacity to permit the MVNO to expand."[114] Thus, the potential for MVNO expansion could divert a significant number of subscribers from the coordinating carriers, making coordination less likely to succeed during this immediate transition period.

86. MVNOs also facilitate competition among their hosts by acting as powerful wholesale buyers. This wholesale competition leads to more retail competition too. The Guidelines recognize that powerful buyers may undermine harmful competitive effects.[115] MVNOs can induce wholesale competition among the facilities-based carriers. For example, TracFone divides its business among multiple carriers and can alter its wholesale purchase shares. In theory, the facilities-based carriers might try to coordinate by refusing to sell to MVNOs or agreeing to charge higher wholesale prices. But, because the MVNOs are large buyers, their ability to move significant purchases would make such attempted coordination less likely to succeed. Each facilities-based carrier would have strong incentives to defect and gain significant business from the MVNOs. Cutting off the MVNOs also would be very costly because the MVNOs have marketing advantages in promoting to particular segments that would be lost.[116]

87. Cable MVPDs currently operate as MVNOs and have several assets that make them an entry threat. First, cable MVPDs can leverage their Wi-Fi hotspots to offload traffic and so reduce their costs of purchasing capacity from the facilities-based carriers. Comcast's wireless service has an MVNO contract with Verizon, but relies on Comcast's 18 million Wi-Fi hotspots as a "Wi-Fi First" plan.[117] Charter plans to launch a similar "Wi-Fi First" wireless service this summer, also supported by an MVNO agreement with Verizon.[118, 119] Additionally, Comcast

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114 Ewens Decl. ¶ 28.

115 *Guidelines*, *supra* note 3, at 27.

116 Ewens Decl. ¶ 28.

117 Xfinity, *What are Xfinity WiFi Hotspots and how do I connect?* (May 22, 2018), https://www.xfinity.com/mobile/support/article/221762167/what-are-xfinity-wifi-hotspots-and-how-do-i-connect, ("Xfinity Mobile has over 18 million WiFi hotspots, areas where you can save on data by accessing free WiFi.").

118 *See* Bevin Fletcher, *Report Says Charter Plans June 30 Launch for Spectrum Mobile*, WIRELESSWEEK (May 4, 2018), https://www.wirelessweek.com/news/2018/05/report-says-charter-plans-june-30-launch-spectrum-mobile ("Charter is planning to debut its Spectrum Mobile wireless service on June 30, according to DSLReports.").

and Charter have entered into a partnership for the development and design of backend systems, which will support their wireless products.[120] Second, by targeting their own cable subscribers, cable MVPDs have lower (wireless) subscriber acquisition costs. Third, cable MVPDs also have countervailing bargaining power in dealing with the facilities-based carriers over MVNO wholesale rates. Their control over backhaul, small cell sites and video content can be used as bargaining chips to obtain more favorable wholesale rates. Given these advantages, cable MVPDs are longer term threats to wireless carriers, and coordination even in the short-term could accelerate their growth. While Comcast currently has a very low market share, it entered only in May 2017,[121] and its growth trajectory indicates significant potential. Comcast added almost 600 thousand wireless customers in its first year[122] and analysts predict it could add as many as two million new customers per year in the near future.[123]

88. Taken together, these checklist factors do not indicate that Newco would have the incentive to soften or eliminate its disruptive maverick conduct in the period immediately after the merger is consummated. Analysis of key checklist factors thus helps to rebut a conclusion that the merger would render the market significantly more vulnerable to successful coordination.

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119 Altice intends to enter in 2019 with an MVNO contract with Sprint. Altice's plans to purchase spectrum are unclear. *See* Mike Dano, ***Cable company Altice won't launch its wireless service until 2019***, FIERCEWIRELESS (February 28, 2018), https://www.fiercewireless.com/wireless/cable-company-altice-won-t-launch-its-wireless-service-until-2019.

120 *See* Jeff Baumgartner, ***Comcast, Charter Form Mobile Platform Partnership***, MULTICHANNELNEWS (Apr. 20, 2018), https://www.multichannel.com/news/comcast-charter-form-mobile-platform-partnership.

121 *See* Diana Goovaerts, ***Comcast Opens Enrollment for Its Mobile Plans With $45 Unlimited Offer***, WIRELESSWEEK (May 18, 2017), https://www.wirelessweek.com/news/2017/05/comcast-opens-enrollment-its-mobile-plans-45-unlimited-offer.

122 *See* Jeff Baumgartner, ***Comcast Adds 197K Xfinity Mobile Customer Lines in Q1***, MULTICHANNELNEWS (Apr. 25, 2018), https://www.multichannel.com/news/comcast-adds-197k-xfinity-mobile-customer-lines-q1.

123 *See* Michelle Caffrey, ***This Week in Comcast: Xfinity Mobile poised for significant growth***, PHILADELPHIA BUSINESS JOURNAL (Apr. 10, 2018), https://www.bizjournals.com/philadelphia/news/2018/04/10/cmcsa-comcast-xfinity-mobile-wireless-davidlcohen.html.

V. Conclusion

89. Our understanding of the facts and the economic analysis set out in this declaration suggest that the Commission would lack a credible basis to conclude that the merger would increase the risk of successful coordination or encourage attempts to coordinate.

Steven C. Salop

Y Sarafidis

Yianis Sarafidis

Exhibit 1
Curricula Vitae of Professor Steven C. Salop and Dr. Yianis Sarafidis

CURRICULUM VITAE
STEVEN C. SALOP

ADDRESS Georgetown University Law Center
600 New Jersey Ave., N.W.
Washington, D.C. 20001

Telephone: (202) 662-9095 (office); (202)253-5431(cell)
Email: salop@law.georgetown.edu

PERSONAL Born, December 23, 1946; Married to Judith R. Gelman, three children; U.S. Citizen

FIELDS OF SPECIALIZATION

Industrial Organization, Competition and Antitrust Policy, Economics of Information, Economic Analysis of Law.

DEGREES

Ph.D.	Economics, Yale University, 1972
M. Phil.	Economics, Yale University, 1972
B.A.	University of Pennsylvania, 1968

AWARDS AAI Antitrust Achievement Award (2010)
Summa Cum Laude, with Honors in Economics, University of Pennsylvania, 1968; Schoenbaum Prize in Economics, University of Pennsylvania, 1968; NSF Graduate Fellowship, 1968-72; Phi Beta Kappa, 1968.

EMPLOYMENT EXPERIENCE

Current Position: Professor of Economics and Law, Georgetown University Law Center (at GULC since August, 1981).

Guest Scholar, Brookings Institution, 1990-1991.

Visiting Professor, Massachusetts Institute of Technology, Spring 1986.

Visiting Interdisciplinary Professor, Georgetown University Law Center, July 1981-June 1982.

Associate Director for Special Projects, Bureau of Economics, Federal Trade Commission, January 1980-June 1981.

Assistant Director for Industry Analysis, Bureau of Economics, Federal Trade Commission, September 1979-January 1980.

Deputy Assistant Director for Consumer Protection, Bureau of Economics, Federal Trade Commission, December 1978-September 1979.

Economist, Division of Consumer Protection, Bureau of Economics, Federal Trade Commission. July 1978-December 1978.

Economist, Office of Economic Analysis, Civil Aeronautics Board, September 1977-July 1978.

Economist, Federal Reserve Board, July 1972-September 1977.

Adjunct Professor, Department of Economics, University of Pennsylvania, September 1977-June 1978.

Adjunct Professor, Department of Economics, George Washington University, September 1975-January 1978.

PUBLICATIONS

Books and Reports

Strategy, Predation and Antitrust Analysis. Editor. Federal Trade Commission, 1981.

Consumer Post-Purchase Remedies. With H. Beales et al. Federal Trade Commission Staff Report, 1980.

Consumer Information Remedies. With L. Kantor et al. Federal Trade Commission Staff Report, 1979.

Articles

"Reinvigorating Vertical Merger Enforcement," *Yale L. J.* (2018).

"Whither Antitrust Enforcement in the Trump Administration?" *Antitrust Source* (2017)

"The Raising Rivals' Cost Foreclosure Paradigm, Conditional Pricing Practices and the Flawed Incremental Price-Cost Test," *Antitrust Law Journal* (2017)

"Market Definition and Multi-Product Firms in Merger Analysis," in *Antitrust Economics for Lawyers §§ 1.01-1.05 (LexisNexis 2017 ed.)* (with Serge Moresi & John R. Woodbury.

"Revising the Vertical Merger Guidelines: Policy Issues and an Interim Guide for Practitioners," *Journal of Antitrust Enforcement* (2016) (with Daniel P. Culley)

"Modifying Merger Consent Decrees: An Economist Plot to Improve Merger Enforcement Policy," *Antitrust* (2016)

"Evaluating Joint Ventures: An Economic Analysis Checklist," *Antitrust* (2016)

"The Evolution and Vitality of Merger Presumptions: A Decision-Theoretic Approach," *Antitrust Law Journal* (2015)

"Antitrust, Competition Policy, and Inequality," *Georgetown Law Review Online* (2015) (with Jonathan Baker)

"Jean Tirole's Nobel Prize in Economics: The Rigorous Foundations of Post-Chicago Antitrust Economics," *Antitrust* (Spring 2015) (with Carl Shapiro)

"What Consensus: Why Ideology and Elections Still Matter for Antirust," *Antitrust Law Journal (2014)*

"vGUPPI: Scoring Unilateral Pricing Incentives in Vertical Mergers," *Antitrust Law Journal* (2013) (with Serge Moresi)

"Merger Settlement and Enforcement Policy for Optimal Deterrence and Maximum Welfare," *Fordham Law Review* (2013)

"Developing an Administrable MFN Enforcement Policy, "*Antitrust* (April 2013) (with Fiona Scott-Morton)

Economic Analysis of the AT&T/T-Mobile Wireless Merger, *Journal of Competition Law and Economics* (2013) (with Stan Besen et. al.)

The Sirius/XM Satellite Radio Merger, in J. Kwoka and L. White, *The Antitrust Revolution* (with Serge Moresi)

"Refusals to Deal and Price Squeezes by an Unregulated Vertically Integrated Monopolist," *Antitrust Law Journal* (2010).

"Question: What is the Real and Proper Antitrust Welfare Standard? Answer: The *True* Consumer Welfare Standard," *Loyola Consumer Law Review* (2010)

"Economic Analysis of Exclusionary Vertical Conduct: Where Chicago Has Overshot the Mark," in Robert Pitofsky (ed), *Where the Chicago School Overshot the Mark: Effect of Conservative Economic Analysis on U.S. Antitrust* (2008).

“Implementing the Hypothetical Monopolist SSNIP Test with Multi-Product Firms,” *Antitrust Source* (Feb. 2008) (with Serge X. Moresi & John R. Woodbury). (http://www.abanet.org/antitrust/at-source/08/02/Feb08-Moresi.pdf)

“The Controversy over the Proper Antitrust Standard for Anticompetitive Exclusionary Conduct,” Barry Hawk (ed), *Fordham Competition Law Institute 33rd Annual Conference on International Antitrust Law and Policy* (2006).

“Exclusionary Conduct, Effect on Consumers, and the Flawed Profit-Sacrifice Standard,” *Antitrust Law Journal* (2006).

“Anticompetitive Overbuying by Power Buyers,” *Antitrust Law Journal* (2005)

“A Few Righteous Men: Imperfect Information, Quit-for-Tat, and Critical Mass in the Dynamics of Cooperation,” *Joseph E. Stiglitz Feschrift Volume 2003* (with S. Moresi)

“Should Concentration be Dropped from the Merger Guidelines?” With Jonathan Baker. *University of West Los Angeles Law Review* (2001)

“The Flawed Fragmentation Critique of Structural Remedies in the *Microsoft* Case,” *Antitrust Bulletin* (2001)

“Analysis of Foreclosure In The EC Guidelines On Vertical Restraints,” *Fordham University Law Institute 28th Annual Conference on International Antitrust Law and Policy* (2001)

“The First Principles Approach, *Kodak*, and Antitrust at the Millennium,” *Antitrust Law Journal* (2000).

“Competitive Analysis of Partial Ownership Interests.” With Daniel O’Brien, *Antitrust Law Journal* (1999).

“The Competitive Effects of Passive Minority Equity Interests: Reply.” With Daniel O’Brien. *Antitrust Law Journal*, 2001.

“Preserving Monopoly: Economic Analysis, Legal Standards and Microsoft,” With R. Craig Romaine, *George Mason University Law Review*, 1999.

“Decision Theory and Antitrust Rules,” With C. Frederick Beckner, III, *Antitrust Law Journal*, 1999

“Analyzing Vertical and Horizontal Cross Ownership in Cable Television: The Time Warner-Turner Merger.” With S. Besen, J. Murdoch, D. O’Brien, and J. Woodbury. In J. Kwoka and L. White (eds.), *The Antitrust Revolution* 1998.

“You Keep On Knocking But You Can’t Come In: Evaluating Restrictions on Access Rules to Input Joint Ventures.” With D. Carlton. *Harvard Journal of Law and Technology* (1996).

"Evaluating Vertical Mergers: A Post-Chicago Approach." With M. Riordan. *Antitrust Law Journal* (1995).

"An Economic Analysis of Copyright Collectives." With S. Besen and S. Kirby. *Virginia Law Review* (1991).

"Competition Among Complements, and Intra-Network Competition." With N. Economides. *Journal of Industrial Economics* (1992).

"Rowing Against the Tidewater: A Theory of Voting by Multi-Judge Panels." With D. Post. *Georgetown University of Law Review* (1992).

"Evaluating Network Pricing Self-Regulation." In *Electronic Services Networks: A Business and Public Policy Challenge of Electronic Shared Networks*, edited by Guerin-Calvert and Wildman, (1991).

"Equilibrium Vertical Foreclosure." With J. Ordover and G. Saloner. *American Economic Review* (1990).

"Vertical Foreclosure Without Commitment: Reply to Reiffen." With J. Ordover and G. Saloner. *American Economic Review* (1992).

"Deregulating Self-Regulated Shared ATM Networks." *Economics of Innovation and New Technology* (1990).

"Monopoly Power and Market Power in Antitrust Law." With T. Krattenmaker and R. Lande. *Georgetown University Law Review* (1987).

"Analyzing Anticompetitive Exclusion." With T. Krattenmaker. *Antitrust Law Journal* (1987).

"Cost-Raising Strategies." With D. Scheffman. *Journal of Industrial Economics* (1987).

"Information, Welfare and Product Diversity." With J. Stiglitz. In *Arrow and the Foundations of the Theory of Economic Policy*, edited by Feiwel et al., (1987).

"Antitrust Analysis of Exclusionary Rights: Raising Rivals' Costs to Gain Power Over Price." With T. Krattenmaker. *Yale Law Journal* (December 1986).

"Private Antitrust Litigation: Introduction and Framework." With L. White. *Georgetown University Law Review* (1986).

"Economics of Private Antitrust Litigation." With L. White. *Antitrust Law Journal* (1986). Reprinted by the Senate Judiciary Committee.

"Quantifying the Competitive Effects of Production Joint Ventures." With T. Bresnahan. *International Journal of Industrial Organization* (1986).

"Measuring Ease of Entry." *Antitrust Bulletin* (1986).

"Firm-Specific Information, Product Differentiation and Industry Equilibrium." With J. Perloff. In *Strategic Behavior and Industrial Competition*, edited by Morris et al., (1986).

"Practices that (Credibly) Facilitate Oligopoly Coordination." In *New Developments in the Analysis of Market Structure*, edited by Stiglitz et al., (1986).

"Equilibrium with Product Differentiation." With J. Perloff. *Review of Economic Studies* (January 1985).

"A Practical Guide to Merger Analysis." With J. Simons. *Antitrust Bulletin* (Winter 1984).

"A Bidding Model of Special Interest Regulation: Raising Rivals' Costs in a Rent-Seeking Society." With D. Scheffman and W. Schwartz. In *The Political Economy of Regulation: Private Interests in the Regulatory Process,* (1984).

"Judo Economics: Capacity Limitations and Coupon Competition." With J. Gelman. *Bell Journal of Economics* (Autumn 1983).

"Raising Rivals' Cost." With D. Scheffman. *American Economic Review* (May 1983).

"Defects in Disneyland: Quality Control as a Two-Part Tariff." With A. Braverman and J.L. Guasch. *Review of Economic Studies* (January 1983).

"The Theory of Sales: A Simple Model of Equilibrium Price Dispersion with Identical Agents." With J. Stiglitz. *American Economic Review* (December 1982).

"A Framework for Evaluating Consumer Information Regulation." With H. Beales, M. Mazis, and R. Staelin. *Journal of Marketing* (Winter 1981).

"Efficient Regulation of Consumer Information." With H. Beales and R. Craswell. *Journal of Law and Economics* (December 1981).

"Consumer Search and Public Policy." With H. Beales, M. Mazis, and R. Staelin. *Journal of Consumer Research* (June 1981).

"Information Remedies for Consumer Protection." With H. Beales and R. Craswell. *American Economic Review*, Papers and Proceedings (May 1981).

"Introduction." In *Strategy, Predation and Antitrust Analysis,* edited by S.C. Salop. Federal Trade Commission, 1981.

“Strategic Entry Deterrence.” *American Economic Review*, Papers and Proceedings (May 1979).

“Monopolistic Competition with Outside Goods.” *Bell Journal* (Spring 1979).

“A Model of the Natural Rate of Unemployment.” *American Economic Review* (March 1979).

“Alternative Reservations Contracts.” Civil Aeronautics Board, 1978.

“Parables of Information Transmission in Markets.” In *The Effect of Information on Consumer and Market Behavior*, edited by Mitchell, (1978).

“The Noisy Monopolist: Information, Price Dispersion and Price Discrimination.” *Review of Economic Studies* (October 1977).

“Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion.” With J. Stiglitz. *Review of Economic Studies* (October 1977).

“Self-Selection and Turnover in the Labor Market.” With J. Salop. *Quarterly Journal of Economics* (November 1976).

“Information and Monopolistic Competition.” *American Economic Review*, Papers and Proceedings (May 1976).

“Wage Differentials in a Dynamic Theory of the Firm.” *Journal of Economic Theory* (August 1973).

“Systematic Job Search and Unemployment.” *Review of Economic Studies* (April 1973).

Reviews/Comments/Congressional and AMC Testimony/Etc.

AT&T’s Flawed Arbitration Proposal (April 10, 2018) (with Gene Kimmelman); https://medium.com/@PublicKnowledge/at-ts-flawed-arbitration-proposal-d020e66b2985

“Blocking the AT&T/Time Warner Merger is Good Antitrust Economics and Law” (November 21, 2007); https://medium.com/@PublicKnowledge/blocking-the-at-t-time-warner-merger-is-good-antitrust-economics-and-law-1845f07ed586

“Proposed Legal Rule for Unilateral Refusals to Deal;” “Avoiding Error in Antitrust Analysis of Refusals to Deal;” “Opening Statement;” AMC Hearings on Section 2 (September 29, 2005)

“Slap Their Wrists? Tie Their Hands? Slice Them Into Pieces? Alternative Remedies for Monopolization in the Microsoft Case,” *Antitrust*, 1999

"Using Leverage to Preserve Monopoly: Discussion of Katz and Shapiro Paper," in Eisenach and Lenard (eds), Competition Innovation and the Microsoft Monopoly: Antitrust in the Digital Marketplace (1999)

"Vertical Mergers and Leverage, " in *The New Palgrave Dictionary of Law and Economics*, 1998.

"Efficiencies in Dynamic Merger Analysis." Testimony at FTC Hearings on Global and Innovation-Based Competition (November 1995). A slightly revised version has been published as "Efficiencies in Dynamic Merger Analysis: Summary." With G. Roberts. *World Competition* (June 1996).

"Exclusionary Access Rules in Standards and Network Joint Ventures." Testimony at FTC Hearings on Global and Innovation-Based Competition (December 1995).

"Evaluating Vertical Mergers: Reply to Reiffen and Vita Comment." With M. Riordan. *Antitrust Law Journal* (1995).

"More Value for the Legal Dollar: A New Look at Attorney-Client Fees and Relationships." With R. Litan. *Judicature* (1994).

"*Kodak* as Post-Chicago Law and Economics," *CRA Perspectives*, April 1993. Reprinted in Texas Bar Association, *Antitrust and Business Litigation Bulletin* (November 1993).

"Exclusionary Vertical Restraints: Has Economics Mattered?" *American Economic Review* (May 1992).

"Antitrust Goes to College." With L. White. *Journal of Economic Perspectives* (Summer 1991).

"Analysis of Entry in the New Merger Guidelines." Brookings Papers on Economic Activity (1991).

"Mergers and Antitrust." *Journal of Economic Perspectives* (1987).

"Competition and Cooperation in the Market for Exclusionary Rights." With T. Krattenmaker. *American Economic Review* (May 1986).

"Comment on Golbe and White, 'Time Series Analysis of Mergers.'" In Auerbach et al., *Mergers and Acquisitions*, NBER.

"Policy Implications of Conference Papers." In Auerbach et al., *Mergers and Acquisitions*, NBER.

"Evaluating Uncertain Evidence with Sir Thomas Bayes." *Journal of Economic Perspectives* (Summer 1987).

"Implications of the Georgetown Project for Treble Damages Reform." Senate Judiciary Committee, March 21, 1986.

"Policing Deceptive Advertising." Serial No. 97-134, 97th Congress.

"Entry Barriers, Consumer Welfare and Antitrust Reform." In Bock et al., *Antitrust and New Views of Microeconomics*. Conference Board, 1986.

"Buy American, Save Your Job?" In J. Tobin et al., *Macroeconomics, Prices and Quantities*. Brookings Institution, 1983.

"Selling Consumer Information." With H. Beales. In J. Olson et al., *Advances in Consumer Research*, Vol. VII. 1980.

"Comment on R. Schmalensee, 'On the Use of Economic Models in Antitrust.'" In O. Williamson et al., *Antitrust Law and Economics*, 1980.

"Review of K. Lancaster, 'Variety, Equity and Efficiency,'" *Journal of Economic Literature*, 1980.

UNPUBLISHED PAPERS AND TEACHING MATERIALS

"Understanding Richard Posner on Exclusionary Conduct" (February 2018)

"An Enquiry Meet for the Case: Decision Theory, Presumptions, and Evidentiary Burdens in Formulating Antitrust Legal Standards" (January 2018)

"The Appropriate Legal Standard and Sufficient Economic Evidence for Exclusive Dealing under Section 2: the FTC's *McWane* Case," (with Sharis Pozen and John Seward) (August 2014)

"Economic Reasoning for Lawyers: Cases and Materials" (2010)

SELECTED PROFESSIONAL ACTIVITIES

ABA Antitrust Masters Course (2014, 2012, 2010)

American Antitrust Institute (AAI) Advisory Board

ABA Antitrust Presidential Transition Taskforce (2012)

Associate Editor, Litigation Economics Review

Associate Editor, Journal of Industrial Economics (1997-2000)

Advisory Committee, FTC Hearings on Global and Innovation-Based Competition (1996).

Associate Editor (Industrial Organization), *Journal of Economic Perspectives* (1987-1993).

ABA Antitrust Task Force on Second Requests (1990).

Advisory Board, Georgetown Project on Treble Damages (1986-1987).

Associate Editor, *Journal of Industrial Economics* (1983-1988).

Associate Editor, *International Journal of Industrial Organization* (1984-1989).

Secretary, Antitrust Section, American Association of Law Schools (1983-1984).

Memberships: American Economic Association, American Bar Association, Phi Beta Kappa.

Nominating Committee: American Economic Association, 1982.

Economics Editorial Advisor, *Journal of Consumer Research*, 1982.

OTHER ACTIVITIES

Senior Consultant, Charles River Associates

President, Salop Economics Inc.

Board of Directors, Charles River Associates (1998-2008)

Board of Trustees, The Lowell School (1989-1995)

Yianis Sarafidis

Vice President

PhD, Economics
Yale University

BA, Economics and Mathematics
Grinnell College

Yianis Sarafidis specializes in antitrust economics. He has appeared as the lead economics expert for merger investigations in front of government agencies and is recognized for his specialized skills in economic modeling and econometrics, which he has applied on topics such as merger simulation, market definition, bargaining theories, vertical arithmetic, and parallel accommodating conduct. He maintains an active profile in the antitrust community through speaking engagements and publishing, including a well-regarded article in the Antitrust Law Journal on the competitive analysis of cross-market hospital mergers.

Prior to joining Charles River Associates, Dr. Sarafidis served on the faculty at INSEAD and Yale University. His academic research on behavioral economics seeks to make sense of seemingly irrational behavior, such as the behavior of contestants on the popular game show Deal or No Deal.

A native of Greece, Dr. Sarafidis earned a BA in Economics and Mathematics from Grinnell College. He holds a PhD and MA in Economics from Yale University.

Professional history

2006–Present	***Vice President***, Charles River Associates, Washington, DC (previously ***Associate Principal***, and ***Principal***)
2005–2006	***Visiting Assistant Professor of Economics***, Yale University, New Haven, CT
2001–2005	***Assistant Professor of Economics***, INSEAD, Fontainebleau, France

Selected consulting experience

In the context of a merger review in the mobile telephony industry: Spoke at a state public utility commission proceeding on the competitive effects arising from the proposed merger; developed a merger simulation model to evaluate unilateral effects concerns.

In the context of a merger review in the media/communications industry: Developed a game-theoretic model of pricing in the presence of word-of-mouth effects and conducted merger simulations with it.

In the context of a merger review in the rock aggregates industry: Led economist team in support of the merger; gave presentations in front of Agency; submitted white papers; developed affirmative arguments regarding the importance of distance and power buyers.

In the context of a merger review in the chemicals industry: Led economist team in support of the merger; gave presentations in front of Agency; submitted white paper; developed affirmative arguments, including by implementing a delivered cost analysis and a merger simulation model with capacity constraints.

In the context of a merger review in the cement industry: Co-led economist team in support of the merger; developed affirmative arguments, including by implementing a delivered cost analysis and analyzing a natural experiment; helped the parties navigate the Second Request process.

In the context of a divestiture remedy proposal as a condition to approve a merger in the cement industry: Gave presentations in front of Agency on behalf of an interested third party.

In the context of a merger review involving medical devices: Authored submissions; helped the merging parties develop affirmative arguments and navigate the Second Request process.

In the context of a merger review involving aircraft engines and parts: Developed a vertical arithmetic model to analyze vertical foreclosure concerns.

In the context of a merger review in the rental car industry: Developed economic models to evaluate unilateral and coordinated effects concerns; developed empirical tests to evaluate alternative theories of how firms compete (price vs. capacity competition).

In the context of a merger review involving parking lots: Developed a novel methodology for calculating diversion ratios in industries with geographic product differentiation.

In the context of an antitrust investigation involving consumer personal care products: Developed an economic model to analyze the competitive effects of discount practices used by a major manufacturer.

In the context of regulatory proceedings conducted by the Federal Reserve Board: Authored a submission to the Board analyzing the economics of debit card regulation.

In the context of a merger review in the e-commerce and integration services industry: Conducted a statistical analysis of diversion ratios using win/loss and sales data and authored a white paper describing the techniques and the results; oversaw the data production associated with the Second Request.

In the context of a merger review involving biological products: Authored a white paper on merger efficiencies; helped the merging parties develop affirmative arguments; developed merger simulation models.

In the context of an investigation of a JV agreement in internet commerce: Developed techniques for estimating the increase in advertisers' welfare due to the proposed JV agreement; authored a white paper describing these techniques and the results.

In the context of a merger review in the chemicals industry: Helped the parties develop affirmative arguments and oversaw the data production associated with the Second Request and the Form CO.

In the context of a DOJ litigation against a national association of professionals: Worked on a joint CRA/DOJ team supporting the economic expert witness; managed a large CRA team supporting three major expert reports; designed and executed econometric analyses of labor productivity.

In the context of a merger review involving natural gas providers: Authored a white paper evaluating the merger effects on consumers.

In the context of a private litigation in the financial services industry: Developed an economic model based on bargaining theory to estimate damages.

Publications

"What Have You Done for Me Lately? Release of Information and Strategic Manipulation of Memories," ***Economic Journal***, 117 (518), 307–326, March 2007.

"Managers as Administrators: Reputation and Incentives." With Amil Dasgupta. ***Journal of Economic Behavior and Organization***, 70 (1–2), 155–163, May 2009.

"Decision Making under Risk in Deal or No Deal." With Nick de Roos. ***Journal of Applied Econometrics***, 25 (6), 987–1027, September/October 2010.

"Cross-Market Hospital Mergers: A Holistic Approach." With Gregory Vistnes, ***Antitrust Law Journal***, 79 (1), 253-293, January 2014.

"Momentum in Dynamic Contests." With Nick de Roos. ***Economic Modelling***, Volume 70, 401-416, April 2018.

Working papers

"cGUPPI: Scoring Incentives to Engage in Parallel Accommodating Conduct" With Serge Moresi, David Reitman, and Steven Salop.

"Advice from an Expert with Unknown Motives." With Vassilis Dimitrakas. Revise-and-resubmit at ***Games and Economic Behavior.***

"Inter-temporal Price Discrimination with Time Inconsistent Consumers," awarded the ***EARIE 2004 Young Economist Award.***

"Solution Concepts for Games with Time Inconsistent Players," presented at the Summer Meetings of the Econometric Society (2007, Durham, NC).

"A Model of Ordered Bargaining with Applications." With Serge Moresi and Steven Salop. Presented at the Summer Meetings of the Econometric Society (2009, Boston, MA).

Presentations

Departments Seminars

DOJ Antitrust Division (EAG); Harvard (HBS), HEC-Montreal, Heidelberg, Iowa, Maryland (Smith), McGill, Paris I, Penn State, Stony Brook, Toronto, Washington (Olin), Yale

Academic conferences

EARIE (2004, Berlin), Econometric Society World Congress (2005, London), Society for Economic Design (2004, Mallorca), Summer Meetings of the Econometric Society (2009, Boston, MA; 2007, Durham, NC; 2004, Providence, RI)

Teaching experience

Undergraduate (Yale)

Introduction to Economic Analysis (introductory microeconomics): fall 2005

Microeconomics with Environmental Applications (introductory microeconomics for environmental studies majors): fall 2005

Firms, Markets, and Competition (undergraduate industrial organization): spring 2006

MBA (INSEAD, Georgetown University, and the University of Maryland)

Microeconomics (Georgetown, MBA core course): fall 2010

Game Theory for Managerial Decisions (University of Maryland, MBA elective course): spring 2010, spring 2011

Prices and Markets (INSEAD, MBA core microeconomics course): spring 2002, fall 2002, fall 2003, spring 2003, fall 2004

Advanced Game Theory (INSEAD, MBA elective course): fall 2003, fall 2004, spring 2005

PhD (INSEAD)

Game Theory (first-year PhD course): spring 2002, spring 2003, spring 2005

Microeconomics (first-year PhD course): fall 2003

APPENDIX I: DECLARATION OF JEFFREY A. EISENACH, PH.D.
Managing Director, NERA Economic Consulting, and
Co-Chair, NERA Communications, Media, and Internet Practice

DECLARATION OF JEFFREY A. EISENACH, PH.D.
Managing Director, NERA Economic Consulting, and
Co-Chair, NERA Communications, Media, and Internet Practice

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I. Introduction and Summary of Opinions

1. My name is Jeffrey A. Eisenach. I am a Managing Director at NERA Economic Consulting and Co-Chair of NERA's Communications, Media, and Internet Practice. I am also an Adjunct Professor at the Antonin Scalia Law School at George Mason University, where I teach Regulated Industries, and a Visiting Scholar at the American Enterprise Institute, where I focus on policies affecting the information technology sector. Previously, I served in senior policy positions at the U.S. Federal Trade Commission and the White House Office of Management and Budget and taught at Harvard University's Kennedy School of Government and Virginia Polytechnic Institute and State University.

2. My practice focuses on the economic analysis of competition, intellectual property, regulatory, and consumer protection issues. I have submitted expert reports and testified in litigation matters, as well as in regulatory proceedings before the U.S. Federal Communications Commission (FCC or Commission), the U.S. Federal Trade Commission (FTC), the U.S. Copyright Royalty Board, several state public utility commissions, and courts and regulatory bodies in Australia, Canada, the Caribbean, the European Union, and South America. I have also testified before the U.S. Congress on multiple occasions. The focus of much of my work has been on assessing competition in the inter-related markets for communications, content, software, and devices that together constitute the modern mobile broadband ecosystem. I have written numerous academic papers and expert reports on the economics of mobile broadband markets and the factors that affect mobile broadband competition and market performance.

3. I am the author or co-author of several books and monographs, including *Broadband Competition in the Internet Ecosystem,* The Digital Economy Fact Book, and The Telecom

Revolution: An American Opportunity, and I have edited or co-edited five books, including Communications Deregulation and FCC Reform: What Comes Next? and Competition, Innovation and the Microsoft Monopoly: Antitrust in the Digital Marketplace. My articles have appeared in peer-reviewed journals such as *Communications and Strategies*, *Review of Network Economics*, and *Telecommunications Policy*, as well as in such popular outlets as Forbes, Investor's Business Daily, and the Wall Street Journal.

4. Before joining NERA, I was a managing director and principal at Navigant Economics. Before that, I served as Chairman of Empiris LLC, Criterion Economics LLC, and CapAnalysis, LLC. Among my other previous affiliations, I served as President and Senior Fellow at The Progress & Freedom Foundation and a scholar at the Heritage Foundation and the Hudson Institute. I received my Ph.D. in economics from the University of Virginia and my Bachelor of Arts in economics from Claremont McKenna College. Exhibit A of this report contains my curriculum vitae, including my prior publications and testimony.

5. I prepared this report at the request of T-Mobile US, Inc. (T-Mobile). T-Mobile asked me to assess the employment-related effects of T-Mobile's proposed merger with Sprint Corporation (Sprint) (the Transaction), including specifically the impact of the Transaction on employment in the United States. The Commission has consistently recognized that increased employment may constitute a public interest benefit of a transaction in the context of its statutory assessment of whether license transfers benefit the public interest, convenience and necessity.

6. My empirical analysis considers both the immediate and medium-term effects of the Transaction, including direct, indirect and induced effects on employment associated with changes in capital and operating expenditures and increases in economic activity associated

with New T-Mobile's ability to provide new and enhanced services. I also consider the employment effects of accelerated deployment of advanced mobile communications infrastructure (i.e., "5G") which the Transaction would make possible, which are likely to be significant, especially in the "out-years." In all cases, my analysis focuses on effects that are merger-specific – i.e., which would not occur but for the Transaction.[1]

7. To model the employment effects of the Transaction, I apply a methodology called Input-Output (I/O) analysis. Economists use I/O models to estimate how specific changes in economic activity affect economic performance as measured (for example) by total output and total employment. I/O models categorize the productive sector of the economy into specific sub-sectors and capture the interdependencies between sub-sectors through multipliers, which quantify the effects of a change in final demand on each sub-sector and on economic performance overall. To estimate the impact of the Transaction on job creation, I apply employment "multipliers" (coefficients that relate changes in final demand to changes in employment) derived from the IMPLAN (IMpacts for PLANning) model. IMPLAN is a widely used I/O model of the U.S. economy developed through collaboration between the U.S. Forest Service and the University of Minnesota.

8. Changes in final demand can be created both by changes in expenditures for investment or business operations and by changes in output associated with new business activity. T-Mobile has provided me with data based on its *pro forma* financial model of the Transaction which estimates changes (including both increases and decreases) in capital expenditures (capex), operating expenditures (opex) and revenue from new business growth opportunities for the combined firm ("New T-Mobile") compared with the plans of the standalone

[1] *See e.g.*, Federal Communications Commission, *In the Matter of Applications of Deutsche Telekom AG, T-Mobile USA, Inc., and MetroPCS Communications, Inc. for Consent to Transfer Control of Licenses and Authorizations, Memorandum Opinion and Order and Declaratory Ruling,* WT Docket No. 12-301 (Mar. 12, 2013) at ¶56.

companies. I use these data to identify Transaction-specific changes in expenditures and output enabled by the Transaction, which are the necessary inputs for the IMPLAN model. I assign each type of expenditure and output change to one or more of the approximately 500 industry sectors for which the IMPLAN model provides sector-specific multipliers based on documents provided by T-Mobile, interviews with company executives, reference to the North American Industrial Classification System (NAICS) and my experience and knowledge of the wireless telecommunications industry.

9. The IMPLAN model provides estimates, by year, of the direct, indirect and induced effects of the Transaction on U.S. employment.[2] Direct effects represent employment within the sectors that experience a change in final demand as a direct result of Transaction-driven changes in expenditures and output, such as New T-Mobile employees and vendors (e.g., construction contractors), which are accounted for in Tahoe's *pro forma* financial model.[3] Indirect effects represent employment associated with production of intermediate goods needed to satisfy the initial change in demand, such as jobs needed to manufacture construction equipment used to build New T-Mobile's 5G network. Induced effects refer to employment in sectors that experience increased demand as a result of higher labor incomes, such as auto manufacturers, retailers and restaurants.

10. The IMPLAN model is subject to several important limitations. Because the model assumes no factor or product substitution and fixed prices, the model's estimates are most reliable in the short- to medium-run,[4] before wages and prices have fully adjusted to changes in

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[2] As I explain below, the IMPLAN model estimates the effects of economic changes on "job-years," where a job-year is defined as one person employed for one year.

[3] My estimates represent net effects on U.S. employment throughout the economy and are distinct from the effects of the Transaction on employment by the merging firms *per se*.

[4] United States Department of Agriculture, *Guidelines for Economic Impact Analysis with IMPLAN*, Technical Notes 200-ECN-2 (December 5, 2014) at 2; Harry W. Richardson, "Input-Output and Economic Base Multipliers: Looking Backward and Forward," *Journal of Regional Science* 25;4 (1985) 607-661 at 635; Peter McGregor, J. Kim

economic activity. As the economic impact of an event is projected further into the future, the estimated employment effects become less certain.[5] Thus, I limit my projections to the first five years following consummation of the Transaction, which I treat as calendar years 2019 through 2023, and my quantitative estimates therefore do not account for employment effects attributable to the Transaction in subsequent years.

11. My I/O analysis of the employment effects of the Transaction shows that it will contribute a cumulative total of approximately 51,200 job-years to the U.S. economy in the five years following consummation (2019-2023). This increase represents the net effect of three sets of changes identified in T-Mobile's *pro forma* financial model:

- *Capital and Operating Expenditures.* To integrate the two firms and capture potential synergies from the Transaction, New T-Mobile will make significant investments (capital expenditures) and incur significant increases in operating costs. These increased expenditures are concentrated in the first three years following consummation (2019-2021), and result in significant employment gains.

- *Synergies.* Partially as a result of these expenditures, T-Mobile will realize synergies which will result in net savings in operating costs (and to a lesser extent in capital expenditures) beginning in 2022. While these efficiencies are beneficial for the economy and will result in lower prices and higher quality services for consumers, they offset a portion of the employment gains created by increased capex and operating costs in the first three years after consummation.

- *New Business Opportunities.* The Transaction will allow New T-Mobile to enter or significantly expand its enterprise, Internet of Things (IoT), home broadband replacement and video service offerings, and to increase its presence in rural markets, resulting in increased output in the market for mobile wireless services and generating additional economic growth and employment. These effects begin in 2019 and grow throughout the period.

12. As I explain further below, the I/O model does not account for changes in employment associated with the broader economic effects of accelerated 5G deployment from the

Swales and Ya Ping Yin, "A Long-Run Interpretation of Regional Input-Output Analysis," *Journal of Regional Science* 36;3 (1996) 479-501 at 479, 496 (noting that "[t]he conventional interpretation of I-O is that it applies in the short run (impact period) in an imperfectly competitive setting characterized by general excess supplies of capital and labor" and showing that a long-term interpretation requires fixed prices and capacity constraints).

[5] United States Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System* (RIMS II), 3d. ed. (United States Government Printing Office, 1997).

Transaction. Thus, I separately estimate the employment effects of accelerated 5G deployment. My analysis indicates that accelerated 5G deployment will contribute an additional 73,600 job-years from 2021 through 2023, bringing total job creation to approximately 124,800 job-years. As a result, the Transaction can reliably be expected to contribute net new jobs each year for the foreseeable future.

13. My conclusions are based on the information currently available to me at the time this declaration was prepared. As the companies' integration plans are further refined, some of this information may change, and I reserve the right to adjust my analysis accordingly.

14. The remainder of this declaration is organized as follows. Section II describes the Transaction, including the merging parties and the *pro forma* business plan from which I derive the necessary inputs for my employment estimates. Section III presents my estimates of the direct, indirect and induced effects of changes in expenditures caused by the Transaction on U.S. employment. Section IV discusses the effect of accelerated 5G deployment on employment. Section V presents a brief summary.

II. The Transaction

15. This section briefly describes the merging firms and then details the information from their going-forward *pro forma* business plan which I have relied upon to perform my I/O analysis.

A. The Merging Firms

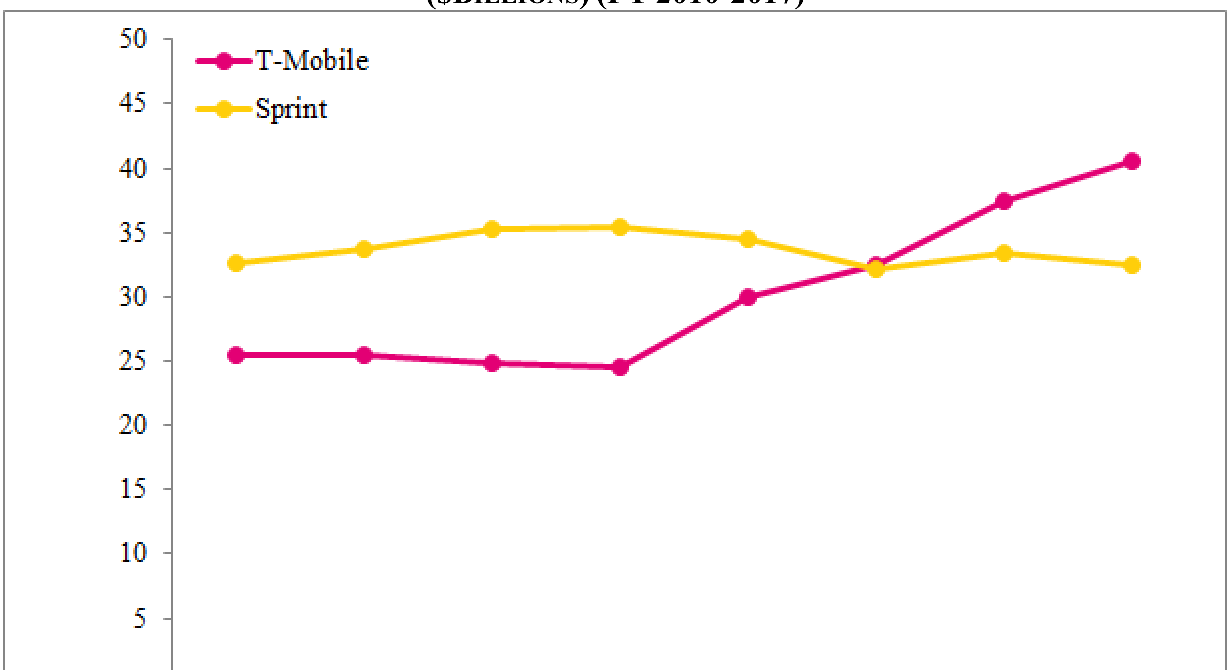
16. T-Mobile is a publicly-traded Delaware corporation headquartered in Bellevue, Washington. T-Mobile offers nationwide wireless voice and data services to consumer and enterprise customers. It is the third largest mobile wireless operator in the U.S. in terms of subscribers and has been growing rapidly in recent years.

17. Sprint is a publicly-traded Kansas corporation with headquarters in Overland Park, Kansas. Sprint offers a range of wireless and wireline voice and data products and services to

consumers, businesses, government subscribers and resellers nationwide. It is the fourth largest mobile wireless operator in the U.S. by subscribers. Sprint's revenues have been flat since 2010, and its employment has been declining since 2005.

18. As shown in Figure 1, Sprint's revenue declined from a 2013 peak of $35.5 billion to $32.4 billion in 2017, while T-Mobile's revenue increased 65 percent over the same period, from $24.6 billion to $40.6 billion.

FIGURE 1:
SPRINT AND T-MOBILE REVENUES
($BILLIONS) (FY 2010-2017)



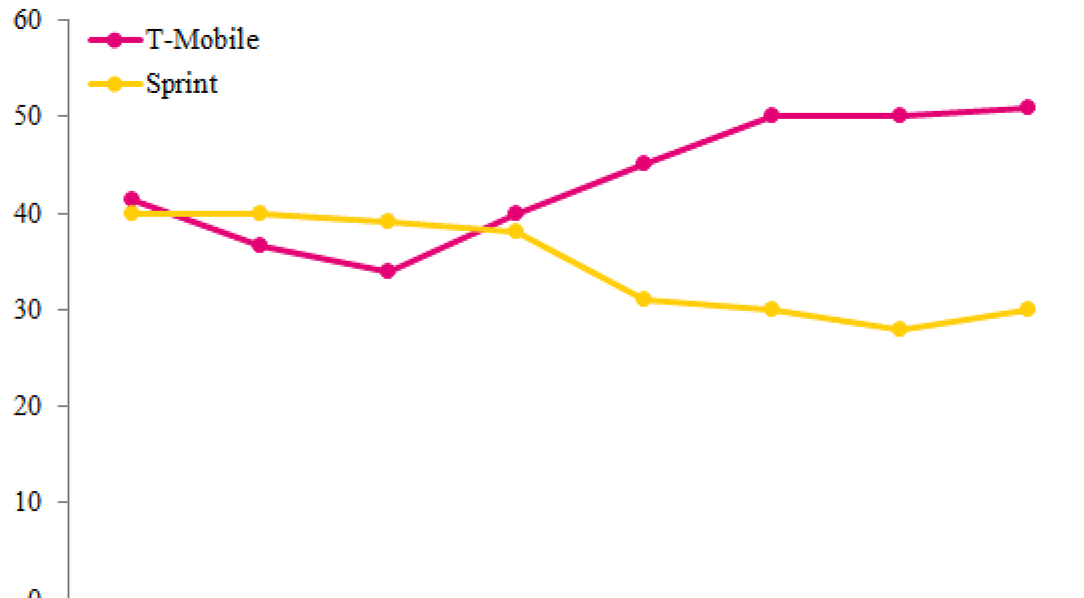
	2010	2011	2012	2013	2014	2015	2016	2017
T-Mobile	25.4	25.5	24.8	24.6	29.9	32.5	37.5	40.6
Sprint	32.6	33.7	35.3	35.5	34.5	32.2	33.3	32.4

Sources: Form 10-Ks. Notes: [1] Sprint figures for 2010 through 2013 are for the year ended December 31, while figures for 2014 through 2017 are for the year ended March 31. [2] The Sprint figure for 2013 includes amounts from before and after the SoftBank Merger, which closed on July 10, 2013 ($18,602,000,000 from the 191 days ended July 10, 2013 and $16,891,000,000 for the remaining part of the year ended December 31, 2013. [3] T-Mobile figures for 2010 through 2012 include MetroPCS revenues.

19. Figure 2 shows the number of Sprint and T-Mobile employees for fiscal years 2010 to 2017. Sprint's headcount has fallen from 40,000 in 2011 to 30,000 in 2017, a 25 percent decrease.

T-Mobile's headcount fell from 41,400 in 2010 to 34,000 in 2012, but grew to 51,000 in 2017, a net increase of 23 percent.

FIGURE 2:
SPRINT AND T-MOBILE EMPLOYEE WORKFORCE
(THOUSANDS) (FY 2010-2017)



	2010	2011	2012	2013	2014	2015	2016	2017
T-Mobile	41.4	36.6	34.0	40.0	45.0	50.0	50.0	51.0
Sprint	40.0	40.0	39.0	38.0	31.0	30.0	28.0	30.0

Sources: Form 10-Ks. Notes: [1] Sprint figures for 2010 through 2013 are as of December 31, while figures for 2014 through 2017 are as of March 31 of the following calendar year. [2] T-Mobile figures for 2010 through 2012 include MetroPCS employees.

20. In March 2018, Sprint announced it was laying off an additional 500 employees from its Overland Park, Kansas headquarters.[6]

B. Effect of the Transaction on Expenditures and Output of the Merging Firms

21. As is commonplace in significant mergers, the merging firms are engaging in pre-Transaction integration planning, which includes developing a *pro forma* business plan for New T-Mobile. The business plan projects synergies and cost savings from the merger, expenditures that will be required to integrate the operations of the two firms, and going-

[6] Mark Davis, "Sprint to Lay Off 500 from Overland Park Headquarters in Cost-cutting Push," *Kansas City Star* (March 9, 2018) (available at http://www.kansascity.com/news/business/technology/article204415764.html).

forward business opportunities that will be available to the merged firm which would not have been available to the standalone entities.[7] New T-Mobile has shared with me outputs from its *pro forma* business plan, from which I have derived inputs for the IMPLAN model I use to estimate the employment effects of the merger. In this section, I describe the effects of the Transaction on capital expenditures, operating expenditures and revenues from new growth opportunities as compared with the standalone entities.

1. Changes in Capital Expenditures

22. Table 1 below shows T-Mobile's estimates of changes in capital expenditures due to the Transaction. As the table shows, New T-Mobile expects to undertake approximately [redacted] in incremental capital expenditures between 2019 and 2023, above what would have been spent by the standalone firms. The largest changes are for network integration, integration of back office operations (e.g., IT systems and billing), and capex required to engage in new and expanded business opportunities such as IoT services and an expanded video offering based on T-Mobile's recent acquisition of Layer 3.[8]

[7] *See* Declaration of G. Michael Sievert; Declaration of Peter Ewens.

[8] T-Mobile, "T-Mobile Closes Layer3 TV Acquisition, Prepares to Take on Cable & Satellite TV" (January 23, 2018) (available at https://newsroom.t-mobile.com/news-and-blogs/uncarrier-tv-close.htm).

TABLE 1:
TRANSACTION-SPECIFIC CHANGES IN CAPEX
($BILLIONS) (2019-2023)

Category	2019	2020	2021	2022	2023	2019-2023
Network	[redacted]					
Sales, Service & Marketing						
Back Office						
Customers						
Rural						
Enterprise						
IoT						
Home Broadband Replacement						
Video						
Capex Total						

Source: T-Mobile. Note: Some figures do not sum to totals due to rounding.

2. Opex Synergies

23. Table 2 shows T-Mobile's estimates of changes in operating expenditures resulting from the merger. These changes take two main forms, "synergies" and "costs to achieve." Synergies represent ongoing savings (or, in some cases, costs – "dis-synergies") associated with the Transaction, including lower network operating costs, savings in sales, service and marketing, and reduced back office expenses. Synergies over the five-year period total approximately $[redacted]. Costs to achieve represent temporary increases in operating expenses required to integrate the two firms, such as costs related to refreshing and rebranding Sprint stores, operating costs associated with network upgrades, and costs related to installing and integrating new IT systems. Operating costs to achieve total approximately $[redacted] over the five-year period. Thus, the net effect of the Transaction is to reduce total opex from 2019 through 2023 by approximately $[redacted].

TABLE 2:
TRANSACTION-SPECIFIC CHANGES IN OPEX
($BILLIONS) (2019-2023)

Category	2019	2020	2021	2022	2023	2019-2023
Synergies	[redacted]					
Network						
Sales, Service & Marketing						
Store Consolidation						
Lease						
Labor						
Dealer Opportunity						
Advertising						
Customer Care						
Equipment Expense						
Repair & Logistics						
Back Office						
Customers						
Opex Synergies Total						
Cost to Achieve						
Network						
Sales, Service & Marketing						
Back Office						
IT & Billing						
Other Fixed G&A						
Customers						
Opex CTA Total						
Opex Total						

Source: T-Mobile. Note: Some figures do not sum to totals due to rounding.

3. Revenues from New and Expanded Business Opportunities

24. As a result of the Transaction, New T-Mobile will enter new markets and expand in others, beyond what would have been possible for the standalone firms. Table 3 shows T-Mobile's estimate of the revenue effects of these Transaction-specific changes. The primary sources of additional revenues are increased rural sales, increased sales to enterprises, new services to support IoT, home broadband replacement and the expansion of the Layer3-based video service. Over the five-year period from 2019 to 2023, growth opportunities are projected to contribute $[redacted] in new revenues to the combined firm.

TABLE 3:
TRANSACTION-SPECIFIC REVENUE GROWTH
($BILLIONS) (2019-2023)

Categories	2019	2020	2021	2022	2023	2019-2023
Rural	[redacted]					
Enterprise						
IoT						
Home Broadband Replacement						
Video						
Growth Total						

Source: T-Mobile. Note: Some figures do not sum to totals due to rounding.

III. Direct, Indirect and Induced Effects of the Transaction on Employment

25. As explained above, I use an I/O analysis to estimate the effect of changes in expenditures and output resulting from the Transaction on employment. The model I implement yields estimates of the Transaction's direct, indirect and induced effects on employment. The first section below explains the economic framework I apply. The second section presents the results of my analysis.

A. Use of Multiplier-Based I/O Models to Estimate Employment Effects

26. Governments, academics, researchers and policy-makers often rely on multiplier-based I/O models to estimate how specific changes in economic activity affect the broader economy in terms of variables like total output and total employment. I/O models capture the interdependencies between the goods-producing sectors in an economy and quantify the extent to which output from each sector is used as an input in other sectors.[9] These

[9] Ronald E. Miller and Peter D. Blair, *Input-Output Analysis*, 2d. ed. (Cambridge University Press, 2009) at 1-2 (hereafter *Input-Output Analysis*). The creator of the I/O model, Wassily Leontief, won the 1973 Nobel Prize in Economics "for the development of the input-output method and for its application to important economic problems." See The Royal Swedish Academy of Sciences, "The Prize in Economic Sciences in Memory of Alfred Nobel to the Father of Input-Output Analysis" (October 18, 1973) (available at https://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1973/press.html) ("This important innovation [the input-output technique] has given to economic sciences an empirically-useful method to highlight the general interdependence in the production system of a society. In particular, the method provides tools for a systematic analysis of the complicated interindustry transactions in an economy.").

interdependencies are expressed as multipliers that specify how changes in economic activity in a given sector or sectors translate into broader economic effects.[10]

27. I/O multipliers relate changes in final demand to changes in measures of economic performance, such as total output or employment. Employment multipliers relate changes in final demand to the number of jobs required to produce the output necessary to satisfy that demand.[11] The IMPLAN model distinguishes between three types of multiplier effects: direct, indirect and induced. As I explained above, direct effects refer to the jobs created in an industry by a direct change in final demand occurring in that industry; indirect effects refer to the employment effects created by the consecutive rounds of spending across industries necessary to supply the intermediate goods needed to satisfy the change in final demand; induced effects refer to the employment effects from demand stimulated by the labor-income generated by the change in final demand.[12] The use of multiplier-based I/O models to estimate the relationship between telecommunications sector expenditures and employment is generally accepted and has been employed in a number of previous studies, as briefly summarized in Exhibit B.

28. In implementing I/O models, it is important to ensure that the inputs reflect net changes in economic activity, as opposed to firm-specific changes that are balanced out elsewhere in the marketplace (e.g., shifts in market share), as only the former affect overall economic performance. It is also important to assign changes in expenditures to the appropriate sectors within the model, since the employment effects of changes in expenditures vary depending on the economic sectors affected. (For example, an increase in construction spending, which

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[10] IMPLAN, *General Information About Multipliers* (available at https://implanhelp.zendesk.com/hc/en-us/articles/115009505707-General-Information-About-Multipliers).
[11] *Input-Output Analysis* at 250.
[12] Frances Day, *Principles of Impact Analysis and IMPLAN Applications*, 1d. ed. (IMPLAN) at 17.

is both labor intensive and heavily weighted towards domestic spending, has a larger effect on U.S. employment than an equal increase in spending on telecommunications equipment, which is less labor intensive and significantly weighted towards imports which do not directly affect U.S. employment). Some changes in final demand, such as lease payments to existing resources like land or existing capital stock, are transfer payments which lie outside the productive sector of the economy and have no multiplier effect,[13] and thus do not result in changes in employment. As I explain below, my methodology accounts fully for these considerations.[14]

B. Estimated Effect of Changes in Expenditures and Output on Employment

29. To estimate the contribution of the Transaction to employment, I apply the IMPLAN I/O model, which was developed by the U.S. Forest Service and the University of Minnesota.[15] Because the most recent IMPLAN model year is 2016, all expenditures are deflated to 2016 dollars before applying the multiplier.[16] IMPLAN assumes no factor or product substitution

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[13] *Input-Output Analysis* at 13-15; William J. Baumol and Edward N. Wolff, "A Key Role for Input-Output Analysis in Policy Design," *Regional Science and Urban Economics* 24 (1994) 93-113 at 97; Hollis B. Chenery and Tsunehiko Watanabe, "International Comparisons of the Structure of Production," *Econometrica* 26;4 (1958) 487-521 at 504; Thijs ten Raa, *Input-Output Economics: Theory and Applications*, 1d. ed. (World Scientific Publishing, 2010) at 7-8.

[14] The employment effects estimated by I/O models generally assume the economy is not at full employment. While the officially-reported unemployment rate is low by historical standards, the labor force participation rate remains at its lowest levels since the mid-1970s, 62 percent, about five points below the mid-1990s peak. Recent evidence suggests that the workers are reentering the workforce in significant numbers, and the Council of Economic Advisers has found specifically that further increases are both possible and desirable. See Exhibit F and Council of Economic Advisers, *Economic Report of the President Together with the Annual Report of the Council of Economic Advisers* (February 2018) (available at https://www.whitehouse.gov/wp-content/uploads/2018/02/ERP_2018_Final-FINAL.pdf).

[15] Frances Day, *Principles of Impact Analysis and IMPLAN Applications*, 1d. ed. (IMPLAN) at 27. The two primary alternatives to IMPLAN are the REMI model and the RIMS II model. The three models have advantages and disadvantages for particular applications. I chose IMPLAN because of its finely detailed sectoring scheme for the entire U.S. economy and its transparent and flexible model structure. I have no reason to believe the choice of model materially affects my results.

[16] *Id.* at 88 ("Because all the relationships in a Model are created based on the year of the IMPLAN data set, to conduct an accurate analysis it is necessary to convert sales from the year in which they are occurring to the base year of the data used to create the Model.").

and fixed prices,[17] and its estimates are therefore most reliable in the short- to medium-run, before wages and prices have fully adjusted to changes in economic activity.[18] Thus, my model focuses on the first five years following consummation of the Transaction, which I assume to be calendar years 2019-2023.

30. As discussed above, the data provided to me by T-Mobile in its *pro forma* business model show expected changes in capex, opex and revenues resulting from the Transaction relative to the but-for world in which the two firms continue as standalone enterprises. I allocate Transaction-specific changes in expenditures and revenues to the appropriate IMPLAN sectors based on an in-depth examination of each category of business activity represented in the *pro forma* model. Specifically, my assessment is based on extensive discussions with T-Mobile executives, materials provided by T-Mobile, comparison of IMPLAN industry codes to North American Industry Classification System (NAICS) codes and my many years of experience studying the wireless telecommunications sector.[19] Exhibit C provides a detailed discussion of the data and the assumptions made in classifying the expenditures used as inputs in the model.

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[17] United States Department of Agriculture, *Guidelines for Economic Impact Analysis with IMPLAN*, Technical Notes 200-ECN-2 (December 5, 2014) at 2.

[18] United States Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System* (RIMS II), 3d. ed. (United States Government Printing Office, 1997); see also Harry W. Richardson, "Input-Output and Economic Base Multipliers: Looking Backward and Forward," *Journal of Regional Science* 25;4 (1985) 607-661 at 635; Peter McGregor, J. Kim Swales and Ya Ping Yin, "A Long-Run Interpretation of Regional Input-Output Analysis," *Journal of Regional Science* 36;3 (1996) 479-501 at 479, 496 (noting that "[t]he conventional interpretation of I-O is that it applies in the short run (impact period) in an imperfectly competitive setting characterized by general excess supplies of capital and labor" and showing that a long-term interpretation requires fixed prices and capacity constraints).

[19] As explained by the U.S. Census Bureau, "The North American Industry Classification System (NAICS) is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was developed under the auspices of the Office of Management and Budget (OMB), and adopted in 1997 to replace the Standard Industrial Classification (SIC) system." See U.S. Census Bureau, "North American Industry Classification System" (available at https://www.census.gov/eos/www/naics/).

31. For merger-specific changes in capex and opex, employment effects are calculated by multiplying the expenditures allocated to each IMPLAN sector by the appropriate IMPLAN multiplier for that sector. For example, T-Mobile's financial model indicates that the Transaction will generate $[redacted] (in 2016 dollars) in increased "back office" capital expenditures related to software development required to integrate New T-Mobile's IT systems in 2019, which I assign to the IMPLAN industry "computer systems design services." The IMPLAN multiplier for "computer systems design services" is [redacted]. Thus, I estimate the employment effect of this increase in capital expenditures to be approximately [redacted] job-years in 2019.[20]

32. For changes in economic activity associated with New T-Mobile's expanded output in sectors such as IoT and home broadband replacement, a further step is required to distinguish between output that represents new economic activity and output that represents a shift in market share to New T-Mobile and away from its competitors.[21] My analysis of this issue begins with the fact that wireless communications services are highly differentiated. Firms compete on a variety of quality dimensions, ranging from the locations of retail stores to network quality and speed.[22] In differentiated products, the introduction of new products or

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[20] Unadjusted capital expenditures are found in Table 1, showing $[redacted] for the back office category in 2019. Unrounded, this amount is $[redacted]. Because the IMPLAN model is based on 2016 data, this expenditure is deflated to $[redacted] in 2016 dollars (shown as $[redacted] in Table C-1). The IMPLAN multiplier for "computer systems design services" is [redacted] (shown as [redacted] in Exhibit D). IMPLAN multipliers represent thousands of jobs per billion dollars of expenditure. The IMPLAN multiplier for "computer systems design services" indicates that for every billion dollars of expenditure in the "computer systems design services" sector, 19,162 jobs are added to the economy. Thus, the employment effect of $[redacted] million in capital expenditures on "computer systems design services" is [redacted] × [redacted] × 1,000 = [redacted] jobs (shown as [redacted] in Exhibit E).

[21] United States Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System* (RIMS II), 3d. ed. (United States Government Printing Office, 1997) at 9 ("When the activity of a new project competes with the existing regional activity, estimating the change in final demand is more difficult, because it is necessary to estimate how much of the new project's output replaces the existing output.").

[22] Federal Communications Commission, *In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993: Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile*

product varieties increases total demand by attracting customers whose tastes were not met by the existing array of options.[23] Empirical studies have demonstrated that the introduction of new, differentiated products creates significant increases in economic welfare with a large proportion of the gains being realized by consumers.[24]

33. The growth opportunities identified in the New T-Mobile *pro forma* business plan fall into five categories: rural, enterprise, IoT, home broadband replacement and video. Based on my conversations with T-Mobile executives and my knowledge of mobile wireless markets, I estimated the share of increased output attributable to each growth opportunity that is incremental to final demand. The variation in the share of demand that is incremental is a function of the relative differentiation of each offering and the degree of market saturation. For home broadband and IoT, where there are many potential new customers and where New T-Mobile's unique multi-band spectrum strategy is likely to be particularly attractive relative to other competitors, a substantial share of these growth opportunities is incremental. However, the rural retail, enterprise and video markets are more developed and, thus, the ability of New T-Mobile to increase demand through product differentiation is more limited. Overall, I estimate that about [redacted] percent of the new revenues projected in the New T-Mobile business plan represent incremental growth.[25]

34. Applying the IMPLAN multipliers in Exhibit D to the expenditures in Table C-1, I calculate employment effects for each expenditure category, shown in Exhibit E. Table 4 provides a

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Wireless, Including Commercial Mobile Services, Twentieth Report, WT Docket No. 17-69 (September 27, 2017) at ¶¶62-67.

[23] Amil Petrin, "Quantifying the Benefits of New Products: The Case of the Minivan," *Journal of Political Economy* 110;4 (2002) 705-729.

[24] *Id.*; *see also* Jerry A. Hausman, "Valuation of New Goods Under Perfect and Imperfect Competition," *The Economics of New Goods* ed. Timothy F. Bresnahan and Robert J. Gordon (University of Chicago Press, 1996) 207-248; Jerry A. Hausman, "Valuing the Effect of Regulation on New Services in Telecommunications," *Brookings Papers on Economic Activity: Microeconomics* (1997) 1-36.

[25] Specifically, I estimate that 5 percent of rural, 5 percent of enterprise, 25 percent of home broadband replacement, 50 percent of IoT and 5 percent of video output is incremental to final demand.

summary of these employment effects. As the table shows, the net employment effect of the Transaction over the five-year period is to contribute approximately 51,200 jobs-years to the U.S. economy.[26]

35. Of these 51,200 job-years, approximately 7,100 are contributed by the net effect of capex and opex specific to the Transaction. This positive employment is primarily due to increased expenditures on network infrastructure and customer care, which outweigh expenditure reductions from the closing of retail stores and reduced administrative employment. Incremental output due to growth opportunities contributes an additional 44,100 job-years on net over the five-year period. Stated differently, I estimate the Transaction will result in a direct employment effect of 8,300 job-years in the sectors of the economy directly affected by merger-related expenditures; an indirect employment effect of approximately 18,500 job-years as a result of supplying intermediate goods to satisfy the increase in final demand; and, an induced employment effect of approximately 24,400 job-years to meet the demand induced by increased labor income.

[26] A job-year is the "equivalent of one job for one year" and is commonly used in economics to measure employment effects over time, which is more relevant to policymakers than the employment level at a single point in time. Council of Economic Advisers, *Economic Report of the President* (January 2017) at 41 (available at https://www.govinfo.gov/features/ERP-2017); see also Executive Office of the President and Council of Economic Advisers, *Estimates of Job Creation from the American Recovery and Reinvestment Act of 2009* (May 2009) at 3 (available at https://obamawhitehouse.archives.gov/sites/default/files/microsites/Estimate-of-Job-Creation.pdf) ("For some purposes, looking at the effects at a single point in time is not the most useful approach. Since the economy is likely to be operating below capacity for several years, job creation any time over the next several years is valuable. Thus, a second way to look at the employment effects of the program is to estimate the number of *job-years* the program will create over the President's first term.").

TABLE 4:
EMPLOYMENT EFFECTS OF TRANSACTION-SPECIFIC CHANGES IN SPENDING AND REVENUES (THOUSAND JOB-YEARS) (2019-2023)

	2019	2020	2021	2022	2023	2019-2023
Direct Capex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Indirect Capex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Induced Capex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Capex Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Direct Opex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Indirect Opex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Induced Opex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Opex Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Opex + Capex Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Direct Growth Opportunities	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Indirect Growth Opportunities	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Induced Growth Opportunities	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Growth Opportunities Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total Direct	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total Indirect	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total Induced	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Sources: Exhibits C-E. Note: [1] Estimates exclude employment effects enabled by accelerated 5G deployment. [2] Some figures do not sum to totals due to rounding.

IV. Effect of Accelerated 5G Deployment on Employment

36. I understand from T-Mobile's *pro forma* business plan and other information made available to me that the Transaction will cause the merging firms to deploy a significantly more capable wireless network than the separate firms would have achieved independently and do so on an accelerated schedule. New T-Mobile's accelerated deployment of multi-band 5G network technology – which seems likely to be the first of its kind in the United States – will affect the economy, and hence employment, in three primary ways. First, the accelerated availability of multi-band 5G from New T-Mobile will create direct benefits for New T-Mobile customers. Second, New T-Mobile's deployment will in and of itself kick-start the "virtuous circle" associated with advances in general-purpose technologies, which promises to lead to more rapid development and deployment of innovative wireless applications, content and devices than would otherwise have been the case. Third, New T-Mobile's accelerated deployment will prompt a competitive response from other wireless operators,

including accelerated deployment by the major incumbents and potentially new or expanded entry by others. Thus, the Transaction will result in the availability of advanced 5G services more quickly and at higher levels of quality to U.S. wireless broadband consumers than would otherwise be the case.

37. As with prior transitions to more advanced wireless standards, the transition from 4G to 5G will enable the development of new services and applications, increasing productivity and economic output. By accelerating that transition, the Transaction will allow these benefits to be realized sooner, generating incremental output and employment. My IMPLAN analysis – which is explicitly premised on constant prices and input mixes – does not capture these broader effects on economic activity and job creation.[27] This section presents my analysis of the incremental effects of the Transaction attributable to accelerated 5G deployment.

38. In the first section below, I describe the general economic benefits of 5G technology and its deployment and explain why 5G deployment will have a transformative effect on the economy. In the second section, I describe my understanding of the impact of the Transaction on deployment of 5G infrastructure by the merging firms and their competitors. The third section is my analysis of the impact of accelerated 5G deployment resulting from the Transaction on employment.

C. Economic Benefits of 5G Deployment

39. There is broad consensus among economists, policy makers and industry experts that 5G will accelerate economic growth, increase productivity and promote job creation. These economic benefits will be driven by the advanced features of 5G networks, including faster transmission speeds, greater network capacity and lower latencies. As a result of these

[27] My IMPLAN analysis captures the merger-specific effects of the Transaction on the output of the merging firms. By contrast, as I explain further below, my 5G analysis captures the incremental economy-wide effects of the transition to a new generation of mobile wireless technology.

features, 5G technology will enable consumer, commercial and industrial use cases not feasible with previous generations of wireless technology.

40. A growing literature projects that 5G will result in substantial economic growth. A recent study by the consulting firm IHS projects that by 2035, 5G will enable $12.3 trillion in economic activity globally.[28] Another study by the consulting firm Accenture estimates that 5G will increase U.S. GDP by $500 billion in the seven years following initial deployment.[29] The FCC has also recognized the economic benefits of 5G, citing evidence that investment in 5G is expected to reach $275 billion.[30]

41. The economic benefits of 5G result in part from the fact that it, like previous generations of mobile wireless standards, will function as a General Purpose Technology (GPT) that will have "pervasive adoption across multiple industries."[31] 5G is expected to affect more than just the wireless and communications sector, enabling use cases throughout the economy including sectors such as healthcare, manufacturing, finance and transportation.[32] Ericsson estimates revenues for the 5G addressable manufacturing market at $113 billion in 2026, a seven percent increase from current service revenue forecasts.[33] Accenture projects that 5G-

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[28] See Karen Campbell *et al*, *The 5G Economy: How 5G Technology Will Contribute to the Global Economy*, IHS Economics & IHS Technology (January 2017) at 19 (hereafter *The 5G Economy*). IHS attributes about 12 percent of the economic activity enabled by 5G to the information and communications sectors, with the remainder attributable to other economic sectors.

[29] Majed Al Amine *et al*, *Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities,* Accenture Strategy (2017) (available at https://www.ctia.org/docs/default-source/default-document-library/how-5g-can-help-municipalities-become-vibrant-smart-cities-accenture.pdf). See also Federal Communications Commission, *In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment, Notice of Proposed Rulemaking and Notice of Inquiry*, WT Docket No. 17-79 (April 21, 2017) at ¶1.

[30] Federal Communications Commission, *In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment, Second Report and Order,* WT Docket No. 17-79 (March 30, 2018) at ¶2.

[31] *The 5G Economy* at 1.

[32] Ericsson, *The Industry Impact of 5G* (January 2018) at 6-7 (available at https://www.ericsson.com/assets/local/.../report-bnew-18000486-rev-a-uen.pdf); see also Ericsson, *The 5G Consumer Business Case: An Economic Study of Enhanced Mobile Broadband* (2018), (available at https://www.ericsson.com/assets/local/narratives/networks/documents/gfmc-18000020-rev-a-uen.pdf.).

[33] Ericsson, *5G for Manufacturing: A Robust Opportunity for Operators* (available at https://www.ericsson.com/en/networks/trending/insights-and-reports/5g-for-manufacturing).

enabled solutions "could produce $160 billion in benefits and savings through reductions in energy usage, traffic congestion and fuel costs."[34]

42. As a result of increased economic activity, 5G is widely projected to serve as a major source of job creation over the next decade and beyond. IHS estimates that the 5G value chain will support 22 million jobs globally in 2035, and Accenture finds that the process of deploying 5G will create three million new jobs within the United States.[35] A recent study by Singer *et al* estimates the potential impact of the FCC's attempt to reduce barriers to investing in 5G and finds that proposed rule changes could generate up to 358,000 jobs.[36] To be clear, I do not attribute these overall effects to the Transaction, and they do not enter directly into my analysis of its effects on employment. Rather, I cite these analyses to demonstrate that the economic effect of accelerating 5G deployment – which is a Transaction-specific effect – is likely to be significant.

D. Accelerated 5G Deployment by New T-Mobile and its Competitors

43. I understand from materials provided to me by T-Mobile and from interviews with T-Mobile executives that the merged company will deploy a significantly more capable and extensive 5G network than the companies would deploy separately absent the Transaction. As explained by T-Mobile Chief Technology Officer Neville Ray in his declaration, the New T-Mobile 5G network will have approximately three times the capacity, 3.9 to 5.8 times the

[34] Majed Al Amine *et al*, *Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities,* Accenture Strategy (2017) at 1 (available at https://www.ctia.org/docs/default-source/default-document-library/how-5g-can-help-municipalities-become-vibrant-smart-cities-accenture.pdf).

[35] *The 5G Economy* at 4, 18-19; Majed Al Amine *et al*, *Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities,* Accenture Strategy (2017) at 1 (available at https://www.ctia.org/docs/default-source/default-document-library/how-5g-can-help-municipalities-become-vibrant-smart-cities-accenture.pdf). A recent study by Deloitte estimates that 5G will require between $130-150 billion in fiber investment alone. See Dan Littmann *et al*, *Communications Infrastructure Upgrade: The Need for Deep Fiber*, Deloitte (July 2017) at 4.

[36] Hal Singer, Ed Naef and Alex King, *Assessing the Impact of Removing Regulatory Barriers on Next Generation Wireless and Wireline Broadband Infrastructure Investment*, Economists Incorporated (June 2017) (available at http://ei.com/wp-content/uploads/2017/06/SingerAssessingImpact6.17.pdf). Singer *et al* also found significant positive job effects from rule changes that accelerate FTTP deployment.

average throughput (and 1.5 to 5.8 times the peak throughput) and provide 100 Mbps or higher coverage to 1.6 to 2.8 times as many Americans as the networks that would be built by the standalone companies in the absence of the Transaction.[37] The difference in network performance from the perspective of consumers will be significant. For example, average speeds on the New T-Mobile network in 2021 will be about four times faster than on the standalone T-Mobile network and more than twice as fast as on the standalone Sprint network; peak data rates will also be substantially higher.[38]

44. As with prior transitions to new generations of wireless technology, T-Mobile's "first mover" deployment of 5G will prompt a competitive response by other mobile wireless carriers. The long history of mobile wireless carriers competing to deploy the fastest, most advanced networks is chronicled in detail in the Commission's annual wireless competition reports. For example:

- In the network upgrade from 2G to 3G, Verizon announced that it would begin launching EV-DO, its chosen 3G technology, in March 2003.[39] In response, Sprint altered its previous strategy in June 2004 and announced plans to deploy EV-DO to compete with Verizon and meet customer demand for faster wireless data speeds. Sprint had originally been considering CDMA 1XEV-DV for its next network upgrade.[40]

- Similarly, in December 2005, Cingular upgraded its network to WCDMA/HSDPA instead of the slower, interim WCDMA technology to compete with Verizon's EV-DO network.[41]

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[37] *See* Declaration of Ray Neville at ¶51, Figure 5.
[38] *Id*.
[39] Verizon Wireless, "Verizon Wireless Makes Strides with Planned BroadbandAccess 3G Network Expansion" (March 22, 2004) (available at http://www.verizon.com/about/news/vzw/2004/03/pr2004-03-22c).
[40] Federal Communications Commission, *In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993: Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile Wireless, Including Commercial Mobile Services, Ninth Report*, WT Docket No. 04-111 (September 28, 2004) at ¶134 ("Sprint's change in strategy with regard to deployment of technologies on the CDMA migration path can be seen as a competitive response to Verizon's EV-DO offering, and thus provides a clear-cut example of non-price rivalry.").
[41] Federal Communications Commission*, In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993: Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile Wireless, Including Commercial Mobile Services, Tenth Report,* WT Docket No. 05-71 (September 30, 2005) at

- In the next upgrade from 3G to 4G, Verizon launched LTE during 2009 and 2010, while Sprint was still offering WiMAX, and T-Mobile and AT&T deployed different versions of HSPA+ technology.[42] To compete with other firms' network speeds, AT&T accelerated its deployment of LTE by a year.[43]

45. Given this history, and considering the heavy marketing and public relations emphasis AT&T and Verizon have placed on leading in the deployment of 5G networks,[44] I believe it is a virtual certainty that they would respond to New T-Mobile's accelerated multi-band deployment by accelerating their own efforts.[45] Thus, while New T-Mobile is likely to lead in the deployment of multi-band 5G, the Transaction will serve as a catalyst for more rapid deployment by all carriers, including new competitors such as the cable operators.[46] As I explain below, faster network deployment will be accompanied by more rapid and extensive adoption of 5G devices.

¶116 ("It has been reported that this upgrade as (*sic*) an effort to compete with Verizon Wireless's EV-DO network, which offers speeds similar to or slightly below HSDPA and faster than UMTS.").

[42] Federal Communications Commission, *In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993: Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile Wireless, Including Commercial Mobile Services, Sixteenth Report,* WT Docket No. 11-186 (March 21, 2013) at ¶185.

[43] *Id.* at ¶189 ("AT&T has stated that it expedited its rollout of LTE by a year in order to compete with other firms on the basis of network speeds and because LTE is a more spectrally efficient technology than those on the UMTS/HSPA migration path.").

[44] *See e.g*., AT&T, "AT&T to Launch Mobile 5G in 2018" (January 4, 2018) (available at http://about.att.com/story/att_to_launch_mobile_5g_in_2018.html); Verizon, "Verizon Chairman & CEO Lowell McAdam Names Los Angeles as 2018 5G Market" (May 15, 2018) (available at http://www.verizon.com/about/news/verizon-chairman-ceo-lowell-mcadam-names-los-angeles-2018-5g-market).

[45] According to industry analysts the Transaction could lead to new entry, resulting in further increases in capital expenditures. See Craig Moffett, *T-Mobile and Sprint, and the Towers: It's Hammer Time,* Moffett-Nathanson (April 30, 2018) at 14-15 ("Having a wireless industry with three players rather than four would increase the odds that a new fourth player might enter the market. Dish Network, or Dish with some partner, would be the most obvious candidate given Dish already has the significant spectrum holdings required to construct a network…The construction of a greenfield national network in the wake of this transaction would ultimately more than offset the losses [to tower companies] associated with a T-Mobile/Sprint transaction.").

[46] The current 5G deployment schedules of New T-Mobile's primary competitors reflect their lack of unused spectrum (especially low- and mid-band) and the desire to avoid or delay the costs of spectrum re-purposing. However, both firms have the ability to accelerate spectrum re-purposing if they choose to do so, and additional spectrum is likely to become available in the near future, including mid-band spectrum in the CBRS band and the C-Band. The competitive threat of New T-Mobile's multi-band 5G deployment will give them strong incentives to employ these or other options in order to accelerate 5G deployment.

E. Effect of Accelerated 5G Deployment on Employment

46. I base my quantitative assessment of the employment effects of accelerated 5G deployment driven by the Transaction on an econometric analysis conducted by Dr. Robert J. Shapiro and Dr. Kevin A. Hassett, which quantified the employment effects of the transition from 2G to 3G wireless technology.[47] Specifically, Shapiro and Hassett estimated the relationship between 3G adoption and employment using an econometric technique known as the Granger causality test.[48] The Granger causality test identifies the extent to which changes in one variable at a point in time lead to changes in another variable at a future point in time, accounting for possible feedback interactions between the two variables.[49]

47. To measure 3G penetration, Shapiro and Hassett used state-level data derived from a Nielsen mobile phone ownership survey that collected information on the wireless technology used by respondents' mobile devices to estimate a lagged linear regression model that related the changes in 3G device penetration to employment. Their results identified a robust and statistically significant relationship between the rate of adoption of new mobile wireless technology and employment.

48. Shapiro and Hassett's coefficient estimates provide an empirical basis for assessing the employment effects of the accelerated 5G deployment which I understand will result from the Transaction. In preparing its *pro forma* business model, T-Mobile has projected the

[47] Robert J. Shapiro and Kevin A. Hassett, *The Impact of Broadband and Related Information and Communications Technologies on the American Economy,* Internet Innovation Alliance (March 23, 2016) (hereafter *Shapiro and Hassett*). Shapiro formerly served as Undersecretary of Commerce for Economic Affairs. Dr. Hassett is the current Chairman of the White House Council of Economic Advisers.
[48] *Id.* at 17.
[49] Clive Granger, "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica* 37;3 (1969) 424-438; the primary insight behind the Granger causality test is that by including a sufficient number of lags of both variables against the current value of the dependent variable of interest (here, the change in employment), causality can be established through a linear regression. In this context, the test allows the researcher to determine whether an increase in 3G wireless penetration leads directly to an increase in employment or if any observed correlation between the two is merely the result of higher employment inducing consumers to spend more on wireless. See *Shapiro and Hassett* at 18.

impact of the Transaction on both overall subscribership and on the adoption of 5G devices by New T-Mobile subscribers. Those projections are shown in Table 5. As the table indicates, T-Mobile projects that the Transaction will increase T-Mobile/Sprint 5G penetration by 3.6 percentage points in 2021, 4.2 percentage points in 2022 and 4.6 percentage points in 2023.[50]

TABLE 5:
5G PENETRATION: STANDALONE VS. NEW T-MOBILE
(SUBSCRIBERS, MILLIONS) (FORECAST 2021-2023)

	2021	2022	2023
Standalone			
T-Mobile 5G	22.5	32.6	48.3
Sprint 5G	17.1	24.6	36.4
Total 5G	39.6	57.2	84.7
Total 4G + 5G	112.7	116.3	119.1
Standalone 5G Penetration	35.1%	49.2%	71.1%
New T-Mobile			
5G	44.0	63.6	94.1
4G + 5G	113.5	119.1	124.3
New T-Mobile 5G Penetration	38.8%	53.4%	75.7%
Δ5G Penetration	3.6%	4.2%	4.6%

Source: T-Mobile.

49. Applying the Shapiro and Hassett methodology to estimate the increase in employment enabled by 5G using the data above requires three additional steps: estimating 5G penetration for the wireless market as a whole; converting the annual change in 5G penetration to quarterly changes; and, estimating the baseline level of employment in each quarter from 2021 to 2023. I now discuss each of these steps in more detail.

50. The Shapiro and Hassett penetration variable applies to wireless penetration as a whole, rather than just the penetration associated with a single wireless provider. However, as discussed above, both economic theory and evidence from prior transitions in wireless

[50] See also Strategy Analytics, "US Wireless Outlook: T-Mobile/Sprint Merger Accelerates 5G with 17% Uplift" (May 29, 2018) (available at https://www.strategyanalytics.com/access-services/service-providers/service-providers-strategies/reports/report-detail/us-wireless-outlook-t-mobile-sprint-merger-accelerates-5g-with-17-uplift#.WxBfN0gvzDc) (projecting 17 percent increase in 5G adoption as a result of the Transaction).

technology suggest that in response to New T-Mobile's more aggressive 5G deployment and improved service, AT&T and Verizon will respond by improving their own 5G offerings. Thus, I assume that 5G adoption will increase for AT&T and Verizon in the same proportion as the increase for New T-Mobile – that is, I assume that the increases in 5G penetration indicated in Table 5 above are representative of the market as a whole.

51. The Shapiro and Hassett model is estimated on quarterly data, and, for a given change in 5G penetration in a quarter, the model predicts increased employment in the next three quarters. Specifically, a one-percentage point increase in penetration results in a 0.007 percentage point increase in employment growth in the following quarter, a 0.00581 percentage point increase in the subsequent quarter, and a 0.00483 percentage point increase in the third quarter.[51] To convert the annual changes in 5G penetration shown in Table 5 into quarterly increments, I assume that the increase in penetration indicated in the final row of Table 5 above is evenly distributed across the quarters within a given year.

52. Finally, because the Shapiro and Hassett model relates changes in penetration to percentage changes in employment, projecting the increase in employment requires an estimate of the level of employment in each quarter. Every two years, the Bureau of Labor Statistics (BLS) estimates the level of employment ten years into the future.[52] The most recent estimate used 2016 employment data to project employment in 2026.[53] To estimate the level of employment in each quarter, I assume the incremental change in employment is distributed evenly across quarters, and use the predicted values from 2021 to 2023.

[51] *Shapiro and Hassett* at 18.
[52] Bureau of Labor Statistics, "Employment Projections: 2016-2026 Technical Note" (January 30, 2018) (available at https://www.bls.gov/news.release/ecopro.tn.htm).
[53] Bureau of Labor Statistics, "Employment Projections: 2016-2026 Summary" (January 30, 2018) (available at https://www.bls.gov/news.release/ecopro.nr0.htm).

53. Table 6 shows my calculations of the quarterly increase in employment using the Shapiro and Hassett methodology.

TABLE 6:
TRANSACTION-SPECIFIC QUARTERLY INCREASE IN EMPLOYMENT ENABLED BY 5G (THOUSANDS) (2021-2023)

	2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Employment	[redacted]											
Δ5G Penetration												
5G Employment Effects												
Shock t-1												
Shock t-2												
Shock t-3												
Total												

Source: Shapiro and Hassett at 19.

54. The first increase in 5G penetration modeled in the table above is a [redacted] percent increase in Q1 2021. The cumulative effect of this shock is a projected increase in employment of approximately [redacted] jobs in Q2 2021,[54] approximately [redacted] jobs in Q3 2021[55] and approximately [redacted] jobs in Q4 2021.[56] However, because penetration shocks are assumed to occur every quarter, the total effect in any given quarter is the sum of the effect from the shocks in each of the previous three quarters.

55. The employment effects shown in Table 6 represent changes in the level of employment in each quarter, e.g., the model predicts that there will be approximately 33,200 more people employed during the fourth quarter of 2023 than if the Transaction had not occurred. To convert those quarterly figures to job-years, I take the average of the quarterly figures for each year as an estimate of the number of additional job-years in that year. For example, the average of the quarterly employment increases for 2021 is approximately 13,600, which is the increase in job-years I attribute to 2021.

[54] Specifically, [redacted] jobs, where 0.007 is the coefficient estimate from Shapiro and Hassett of the job effect one quarter into the future.
[55] Specifically, [redacted] jobs, where 0.00581 is the coefficient estimate from Shapiro and Hassett of the job effect two quarters into the future.
[56] Specifically, [redacted] jobs, where 0.00483 is the coefficient estimate from Shapiro and Hassett of the job effect three quarters into the future.

56. Table 7 shows the employment effects of the Transaction due to accelerated 5G deployment alongside the effects from changes in capex, opex and revenues from growth opportunities. Accelerated 5G deployment resulting from the Transaction will contribute approximately 73,600 job-years from 2021 to 2023. In total, the Transaction will add approximately 124,800 job-years to the economy from 2019 to 2023.

TABLE 7:
EMPLOYMENT EFFECTS OF THE TRANSACTION
(THOUSAND JOB-YEARS) (2019-2023)

	2019	2020	2021	2022	2023	2019-2023
Capex	[redacted]					
Opex						
Growth Opportunities						
Accelerated 5G Deployment						
Total	**40.0**	**10.0**	**26.9**	**20.3**	**27.6**	**124.8**

Sources: See Table 4 sources; Shapiro and Hassett; Bureau of Labor, "Employment Projections" (available at https://data.bls.gov/projections/occupationProj). Note: Some figures do not sum to totals due to rounding.

V. Conclusions

57. For the reasons set forth in this declaration, the proposed Transaction will result in a significant increase in U.S. employment compared to the but-for world in which T-Mobile and Sprint continue to operate as separate entities.

Jeffrey A. Eisenach

EXHIBIT A
CURRICULUM VITAE OF JEFFREY A. EISENACH

Jeffrey A. Eisenach, Ph.D.
Managing Director
Co-Chair Communications, Media and Internet Practice

Dr. Eisenach is a Managing Director and Co-Chair of NERA's Communications, Media, and Internet Practice, and also serves on the firm's Board of Directors. He is also an Adjunct Professor at George Mason University Law School, where he teaches Regulated Industries, and a Visiting Scholar at the American Enterprise Institute. Previously, Dr. Eisenach has served in senior policy positions at the US Federal Trade Commission and the White House Office of Management and Budget, and taught at Harvard University's Kennedy School of Government and Virginia Polytechnic Institute and State University.

Dr. Eisenach's consulting practice focuses on economic analysis of competition, regulatory, intellectual property and consumer protection issues. He has submitted expert reports and testified in US federal court as well before the Antitrust Division of the U.S. Department of Justice, the Federal Trade Commission, the Copyright Royalty Board, the Federal Communications Commission, US Tax Court, several state public utility commissions, and courts and regulatory bodies in Australia, Canada, the United Kingdom, the Caribbean, and South America. He has also advised clients in some of the world's largest information technology sector mergers.

He has written or edited 19 books and monographs, including *Broadband Competition in the Internet Ecosystem* and *Competition, Innovation and the Microsoft Monopoly: Antitrust in the Digital Marketplace*. His writings have also appeared in scholarly journals such as *The Review of Network Economics*, as well as in popular outlets like *Forbes*, *The New York Times*, and *The Wall Street Journal*.

Prior to joining NERA, Dr. Eisenach was a managing director and principal at Navigant Economics, and before that he served as Chairman of Empiris LLC, Criterion Economics, and CapAnalysis, LLC. Among his other previous affiliations, Dr. Eisenach has served as President and Senior Fellow at The Progress & Freedom Foundation; as a scholar the Heritage Foundation, and the Hudson Institute; as a member of the 1980-81 Reagan-Bush Transition Team on the Federal Trade Commission, the 2000-2001 Bush-Cheney Transition Team on the Federal Communications Commission, the Virginia Governor's Commission on E-Communities, and the Virginia Attorney General's Task Force on Identity Theft. In 2016-2017 he led the Trump-Pence Transition Team for the Federal Communications Commission.

Dr. Eisenach received his PhD in economics from the University of Virginia and his BA in economics from Claremont McKenna College.

Education

1985	Ph.D. in Economics, University of Virginia
1979	B.A. in Economics, Claremont McKenna College

Professional Experience

Jan 2014-present	Managing Director/Senior Vice President NERA Economic Consulting
Jan 2010-Jan 2014	Managing Director and Principal, Navigant Economics
Sept 2008-Jan 2010	Chairman and Managing Partner, Empiris LLC
June 2006-Sept 2008	Chairman, Criterion Economics, LLC
July 2005-May 2006	Chairman, The CapAnalysis Group, LLC
Feb 2003-July 2005	Executive Vice Chairman, The CapAnalysis Group, LLC
June 1993-Jan 2003	President, The Progress & Freedom Foundation
July 1991-May 1993	Executive Director, GOPAC
Mar 1988-June 1991	President, Washington Policy Group, Inc.
Sept 1986-Feb 1988	Director of Research, Pete du Pont for President, Inc.
1985-1986	Executive Assistant to the Director, Office of Management and Budget
1984-1985	Special Advisor for Economic Policy and Operations, Office of the Chairman, Federal Trade Commission
1983-1984	Economist, Bureau of Economics, Federal Trade Commission
1981	Special Assistant to James C. Miller III, Office of Management and Budget/Presidential Task Force on Regulatory Relief
1979-1981	Research Associate, American Enterprise Institute
1980	Consultant, Economic Impact Analysts, Inc.
1978	Research Assistant, Potomac International Corporation

Teaching Experience

2000-present	Adjunct Professor, George Mason University School of Law, (Courses Taught: Regulated Industries; Perspectives on Government Regulation; The Law and Economics of the Digital Revolution)
1995-1999	Adjunct Lecturer, Harvard University, John F. Kennedy School of Government, (Course Taught: The Role of Government in the 21st Century)
1989	Adjunct Professor, George Mason University, (Course Taught: Principles of Economics)

1985, 1988	Adjunct Professor, Virginia Polytechnic Institute and State University, (Courses Taught: Graduate Industrial Organization, Principles of Economics)
1983-1984	Instructor, University of Virginia, (Courses Taught: Value Theory, Antitrust Policy)
1982-1983	Teaching Assistant, University of Virginia, (Courses Taught: Graduate Microeconomics, Undergraduate Macroeconomics)

Honors & Professional Activities

2018-present	Member, Board of Directors, NERA Economic Consulting
2016-2017	Leader, Trump-Pence Presidential Transition Team on the Federal Communications Commission
2012-present	Visiting Scholar, American Enterprise Institute
2011-present	Member, Board of Directors, Information Technology & Innovation Foundation
2011-present	Member of the Board of Directors, Economic Club of Washington (Vice President for Education, 2012-2017)
2010-2011	Member, World Bank ICT Broadband Strategies Toolkit Advisory Group
2009-present	Member, Economic Club of Washington
2008-2009	Member, Board of Directors, PowerGrid Communications
2008-2012	Member, Board of Advisors, Washington Mutual Investors Fund
2002-2014	Member, Board of Advisors, Pew Project on the Internet and American Life
1993-2009	Member, Board of Directors, The Progress & Freedom Foundation
2002	Member, Attorney General's Identity Theft Task Force, Virginia
2002-2003	Member of the Board of Directors, Privacilla.com
2001-2004	Member, Executive Board of Advisors, George Mason University Tech Center
2001-2002	Contributing Editor, *American Spectator*
2001	Member, Transition Advisory Committee on the FCC
2000-2001	Member, Governor's Task Force on E-Communities, State of Virginia
1999-2001	Member, 2000-2001 Networked Economy Summit Advisory Committee
1998-2003	Member, Board of Directors, Internet Education Foundation
1998-2003	Member, Internet Caucus Advisory Committee
1996-2002	Member, American Assembly Leadership Advisory Committee
1995-2000	Member, Commission on America's National Interests

1988-1991	Adjunct Scholar, Hudson Institute
1988-1991	Visiting Fellow, Heritage Foundation
1981-1984	President's Fellowship, University of Virginia
1981-1983	Earhart Foundation Fellowship, University of Virginia
1981	Member, Presidential Transition Team on the Federal Trade Commission
1979	Henry Salvatori Award, Claremont Men's College
1978	Frank W. Taussig Award, Omicron Delta Epsilon

Testimony, Declarations and Expert Reports

U.S. Department of Justice, Antitrust Division Roundtable Series on Competition and Deregulation, Roundtable on Consent Decrees, Prepared Statement of Jeffrey A. Eisenach (April 26, 2018)

In the Matter of Certain Mobile Electronic Devices and Radio Frequency and Processing Components Thereof, International Trade Commission Inv. No. 337-TA-1065, Rebuttal Report on Behalf of Apple Inc. (March 30, 2018)

In the Matter of Certain Mobile Electronic Devices and Radio Frequency and Processing Components Thereof, International Trade Commission Inv. No. 337-TA-1065, Expert Report on Behalf of Apple Inc. (March 16, 2018)

Reconsideration of Telecom Decision 2017-56 Regarding Final Terms and Conditions for Wholesale Mobile Wireless Roaming Service, Canadian Radio-Television and Telecommunications Commission, CRTC 2017-259, Expert Report on Behalf of TELUS Communications Company (September 8, 2017)

Testimony on Addressing the Risk of Waste, Fraud, and Abuse in the Federal Communications Commission's Lifeline Program, Before the Committee on Commerce, Science and Transportation, United States Senate (September 6, 2017)

Effects of the AT&T-Time Warner Transaction on Competition in the Premium Channels Industry, Expert Report (with T. Watts) on behalf of Starz, Inc. (July 2017)

In Re: Determination of Royalty Rates and Terms of Making and Distributing Phonorecords (Phonorecords III), United States Copyright Royalty Judges, Written Supplemental Report of Jeffrey A. Eisenach on behalf of National Music Publishers Association and National Songwriters Association International (March 1, 2017)

In Re: Determination of Royalty Rates and Terms of Making and Distributing Phonorecords (Phonorecords III), United States Copyright Royalty Judges, Written Rebuttal Report of Jeffrey A. Eisenach on behalf of National Music Publishers Association and National Songwriters Association International (February 13, 2017)

SESAC Inc., SESAC LLC, and SESAC Holdings, Inc. Claimants vs. Radio Music Licensing Committee, Arbitration Before the Hon. Vaughn R. Walker, Kenneth R. Feinberg, Esq. and Lee A. Freeman, Esq., Expert Rebuttal Report of Jeffrey A. Eisenach on Behalf of SESAC (January 23, 2017)

SESAC Inc., SESAC LLC, and SESAC Holdings, Inc. Claimants vs. Radio Music Licensing Committee, Arbitration Before the Hon. Vaughn R. Walker, Kenneth R. Feinberg, Esq. and Lee A. Freeman, Esq., Expert Report of Jeffrey A. Eisenach on Behalf of SESAC (December 23, 2016)

In Re: Determination of Royalty Rates and Terms of Making and Distributing Phonorecords (Phonorecords III), United States Copyright Royalty Judges, Written Direct Report of Jeffrey A. Eisenach on behalf of National Music Publishers Association and National Songwriters Association International (October 31, 2016)

Examination of Differential Pricing Practices Related to Internet Data Plans, Canadian Radio-Television and Telecommunications Commission, CRTC 2016-192, Supplemental Expert Report on Behalf of TELUS Communications Company (September 21, 2016)

Balancing Efficient Pricing and Investment Incentives in the Migration from Copper to Fibre Networks: Assessing the Feasibility of a Temporary Copper Wedge, Expert Report on Behalf of Vodaphone (July 13, 2016)

Examination of Differential Pricing Practices Related to Internet Data Plans, Canadian Radio-Television and Telecommunications Commission, CRTC 2016-192, Expert Report on Behalf of TELUS Communications Company (June 28, 2016)

The Canadian Market for Wireless: Understanding the Bell-MTS Transaction, Expert Report on Behalf of Bell Canada (June 2, 2016)

Analysis of Online Music Copyright Issues; Copyright Tribunal of Australia CT 3 of 2013 – Reference by Phonographic Performance Company of Australia Limited (ACN 000 680 704) Under section 154 (1) of the Copyright Act of 1968, Fifth Expert Report on Behalf of Phonographic Performance Company of Australia Ltd. (March 9, 2016)

Analysis of Online Music Copyright Issues; Copyright Tribunal of Australia CT 3 of 2013 – Reference by Phonographic Performance Company of Australia Limited (ACN 000 680 704) Under section 154 (1) of the Copyright Act of 1968, Fourth Expert Report on Behalf of Phonographic Performance Company of Australia Ltd. (February 8, 2016)

Review of the Consultation Paper on Differential Pricing for Data Services (Consultation Paper No. 8/2015), Telecom Regulatory Authority of India, Expert Declaration on Behalf of Facebook, Inc. (December 30, 2015)

In the Matter of the Joint Application of Frontier Communications Corporation, Verizon California Inc. (U 1002 C), Verizon Long Distance, LLC (U 5732 C), and Newco West Holdings LLC for Approval of Transfer of Control Over Verizon California Inc. and Related Approval of Transfer of Assets and Certifications, *California Public Service Commission*, Expert Declaration on Behalf of Verizon Communications (August 24, 2015)

Broadband Market Performance in Canada: Implications for Policy, Canadian Radio-Television and Telecommunications Commission Notice of Consultation 15-134, Expert Report on Behalf of Bell Canada (July 2015)

Analysis of Online Music Copyright Issues; Copyright Tribunal Proceeding CT 3 of 2013 – Reference by Phonographic Performance Company of Australia Ltd. Under s 154 of the Copyright Act of 1968, Third Expert Report on Behalf of Phonographic Performance Company of Australia Ltd. (February 26, 2015)

Analysis of Online Music Copyright Issues; Copyright Tribunal Proceeding CT 3 of 2013 – Reference by Phonographic Performance Company of Australia Ltd. Under s 154 of the Copyright Act of 1968, Second Expert Report on Behalf of Phonographic Performance Company of Australia Ltd. (December 9, 2014)

Testimony on Open Internet Rules, Before the Committee on the Judiciary, United States Senate (September 17, 2014)

Review of Wholesale Mobile Wireless Services, Canadian Radio-Television and Telecommunications Commission Notice of Consultation CRTC 2014-76, Supplemental Expert Report on Behalf of TELUS Communications Company (August 20, 2014)

Analysis of Online Music Copyright Issues; Copyright Tribunal Proceeding CT 3 of 2013 – Reference by Phonographic Performance Company of Australia Ltd. Under s 154 of the Copyright Act of 1968, Expert Report on Behalf of Phonographic Performance Company of Australia Ltd. (August 5, 2014)

The Economics of Pick-and-Pay, Canadian Radio-Television and Telecommunications Commission Broadcasting Notice of Consultation CRTC 2014-190, Expert Report on Behalf of Bell Canada (June 27, 2014)

Review of Wholesale Mobile Wireless Services, Canadian Radio-Television and Telecommunications Commission Notice of Consultation CRTC 2014-76, Expert Report on Behalf of TELUS Communications Company (May 15, 2014)

In the Matter of Special Access for Price Cap Local Exchange Carriers, AT&T Corporation Petition for Rulemaking to Reform Regulation of Incumbent Local Exchange Carrier Rates for Interstate Special Access Services, Federal Communications Commission, WC Docket No. 05-25, RM-10593 Expert Declaration (with Kevin W. Caves) on Behalf of Verizon Communications and Verizon Wireless (March 12, 2013)

In the Matter of Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, Federal Communications Commission, Docket No. 12-268, Expert Reply Declaration on Behalf of the Expanding Opportunities for Broadcasters Coalition (March 10, 2013)

In the Matter of Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, Federal Communications Commission, Docket No. 12-268, Expert Declaration on Behalf of the Expanding Opportunities for Broadcasters Coalition (January 24, 2013)

Testimony on the Digital Sound Performance Right, Before the Subcommittee on Intellectual Property, Competition and the Internet, Committee on the Judiciary, United States House of Representatives (November 28, 2012)

Response to Pre-Consultation Document PC12/03: Comments on Market Review Process (Part B), Before the Bermuda Telecommunications Regulatory Authority, Expert Report of Jeffrey A. Eisenach on Behalf of Bermuda Digital Communications Ltd. (November 21, 2012)

Order Instituting Rulemaking to Evaluate Telecommunications Corporations Service Quality Performance and Consider Modification to Service Quality Rules, Before the California Public Service Commission, Rulemaking 11-12-001, Reply Declaration of Jeffrey A. Eisenach on Behalf of Verizon Communications (March 1, 2012)

Order Instituting Rulemaking to Evaluate Telecommunications Corporations Service Quality Performance and Consider Modification to Service Quality Rules, Before the California Public Service Commission, Rulemaking 11-12-001, Expert Declaration of Jeffrey A. Eisenach on Behalf of Verizon Communications (January 31, 2012)

In the Matter of Howard Ferrer et al vs. Puerto Rico Telephone Company, Before the Telecommunications Regulatory Board of Puerto Rico, Case No. JRT: 2009-Q-0014, Expert Declaration of Jeffrey A. Eisenach on Behalf of the Puerto Rico Telephone Company (December 1, 2011)

Joint Declaration of Jeffrey A. Eisenach and Wayne A. Leighton before the Tribunal de Defensa de la Libre Competencia, Santiago, Chile, on behalf of Telefónica Chile S.A. (July 22, 2011)

In the Matter of Amendment of the Commission's Rules Related to Retransmission Consent, Federal Communications Commission, MB Docket No. 10-71, Expert Reply Declaration (with Kevin W. Caves) on Behalf of the National Association of Broadcasters (June 27, 2011)

In the Matter of an Application by Way of a Reference to the Federal Court of Appeal Pursuant to Sections 18.3(1) and 28(2) of the Federal Courts Act, R.S.C. 1985, C.F-7, Between: Cogeco Cable Inc. et al Applicants and Bell Canada et al Respondents, In the Supreme Court of Canada (on appeal from the Federal Court of Appeal), Affidavit and Expert Report on Behalf of Bell Media Inc. and V Interactions Inc. (May 27, 2011)

In the Matter of Amendment of the Commission's Rules Related to Retransmission Consent, Federal Communications Commission, MB Docket No. 10-71, Expert Declaration (with Kevin W. Caves) on Behalf of the National Association of Broadcasters (May 27, 2011)

In the Matter of Section 36 of the Public Utilities Commission Act, Proposal to Establish a New Interconnection Agreement Between Digicel and GT&T, Expert Oral Testimony on Behalf of Guyana Telephone and Telegraph Company, Guyana Public Utilities Commission (July 13, 2010)

In the Matter of International Comparison and Consumer Survey Requirements in the Broadband Data Improvement Act, Federal Communications Commission GN Docket No. 09-47, Supplemental Declaration Regarding the Berkman Center Study (NBP Public Notice 13) (with R. Crandall, E. Ehrlich and A. Ingraham), on Behalf of Verizon Communications (May 10, 2010)

Testimony on Deployment of Broadband Communications Networks, Before the Subcommittee on Communications, Technology and the Internet, Committee on Energy and Commerce, United States House of Representatives (April 21, 2010)

Net Neutrality: The Economic Evidence, Expert Declaration in the Matters of Preserving the Open Internet and Broadband Industry Practices, GN Docket No. 09-191 and WC Docket No. 07-52 (with Brito et al) (April 12, 2010)

In the Matter of the Constitution of the Co-Operative Republic of Guyana and In the Matter of the Application for Redress Under Article 153 for the Contravention of the Applicant's Fundamental Rights Guaranteed by Articles 20, 146, and 149D of the Constitution of the Republic of Guyana and In the Matter of the Telecommunications Act No. 27 of 1990, U-Mobile (Cellular) Inc., v. The Attorney General of Guyana, "International Exclusivity and the Guyanese Telecommunications Market: A Further Response to DotEcon," Expert Report on Behalf of Guyana Telephone and Telegraph Company (March 9, 2010)

Universal Service Subsidies to Areas Served by Cable Telephony: Supplemental Report, Expert Report Submitted to the Federal Communications Commission, on Behalf of the National Cable and Telecommunications Association (January 2010)

Policy Proceeding on a Group-Based Approach to the Licensing of Television Services and on Certain Issues Relating to Conventional Television, Canadian Radio-Television and Telecommunications Commission, Broadcasting Notice of Consultation CRTC 2009-411, Oral Testimony on Behalf of CTVgm (November 16, 2009)

In the Matter of International Comparison and Consumer Survey Requirements in the Broadband Data Improvement Act, Federal Communications Commission GN Docket No. 09-47, Declaration Regarding the Berkman Center Study (NBP Public Notice 13) (with R. Crandall and E. Ehrlich) on behalf of the National Cable and Telecommunications Association and the United States Telecom Association (November 16, 2009)

Universal Service Subsidies to Areas Served by Cable Telephony, Expert Report Submitted to the Federal Communications Commission, on behalf of the National Cable and Telecommunications Association (November 2009)

Policy Proceeding on a Group-based Approach to the Licensing of Television Services and on Certain Issues relating to Conventional Television, Canadian Radio-Television and Telecommunications Commission Broadcasting Notice of Consultation CRTC 2009-411, Expert Report on the Economics of Retransmission Consent Negotiations in the U.S. and Canada, (with S. Armstrong) on Behalf of CTVgm (September 19, 2009)

Virginia State Corporation Commission, Second Order for Notice and Hearing In Re: Revisions of Rules for Local Exchange Telecommunications Company Service Quality Standards, Comments on Behalf of Verizon Virginia (March 13, 2009)

In the Matter of Review of the Commission's Program Access Rules and Examination of Programming Tying Arrangements, Federal Communications Commission Docket MB 07-198, Supplemental Report on Behalf of the Walt Disney Company (December 11, 2008)

In re: Investigation of Rates of Virgin Islands Telephone Corporation d/b/a Innovative Communications, PSC Docket 578, Rebuttal Testimony on Behalf of Virgin Islands Telephone Corporation (October 31, 2008)

Evidence Relating to the ACCC's Draft Decision Denying Telstra's Exemption Application for the Optus HFC Footprint, Australian Consumer and Competition Commission, Expert Report on Behalf of Telstra Corporation Ltd. (October 13, 2008)

In re: Investigation of Rates of Virgin Islands Telephone Corporation d/b/a Innovative Communications, PSC Docket 578, Direct Testimony on Behalf of Virgin Islands Telephone Corporation (September 26, 2008)

In the Matter of the Appropriate Forms of Regulating Telephone Companies, Maryland Public Service Commission, Case No. 9133, Rebuttal Testimony on Behalf of Verizon Maryland (September 24, 2008)

Virginia State Corporation Commission, Proposed Service Quality Rules for Traditional Landline Telecommunications, Comments on Behalf of Verizon Virginia (August 21, 2008)

In re: Complaint and Request for Emergency Relief against Verizon Florida, LLC for Anticompetitive Behavior in Violation of Sections 364.01(4), 364.3381, and 364.10, F.S., and for Failure to Facilitate Transfer of Customers' Numbers to Bright House Networks Information Services (Florida), LLC, and its Affiliate, Bright House Networks, LLC, Florida Public Service Commission, Docket No. 070691-TP, Rebuttal Testimony on Behalf of Verizon Florida LLC (July 25, 2008)

In the Matter of the Appropriate Forms of Regulating Telephone Companies, Maryland Public Service Commission, Case No. 9133, Direct Testimony on Behalf of Verizon Maryland (July 8, 2008)

Comparative Analysis of Communications Markets as it Relates to the Economic Viability of Optus' HFC Network and Telstra's Proposed HFC Exemption, Australian Consumer and Competition Commission, Expert Report on Behalf of Telstra Corporation Ltd. (June 23, 2008)

In the Matter of the Constitution of the Co-Operative Republic of Guyana and In the Matter of the application for redress under Article 153 for the contravention of the Applicant's fundamental rights guaranteed by Articles 20, 146, and 149D of the Constitution of the Republic of Guyana and In the Matter of the Telecommunications Act No. 27 of 1990, U-Mobile (Cellular) Inc., v. The Attorney General of Guyana, Expert Report on Behalf of Guyana Telephone and Telegraph Company (June 19, 2008)

In the Matter of Bright House Networks LLC et al v. Verizon California et al, Federal Communications Commission File No. EB-08-MD-002, Expert Declaration on Behalf of Verizon Communications (February 29, 2008)

In the Matter of Review of the Commission's Program Access Rules and Examination of Programming Tying Arrangements, Federal Communications Commission Docket MB 07-198, Reply Report on Behalf of the Walt Disney Company (February 12, 2008)

In the Matter of Verizon's 2007 Price Cap Plan for the Provision of Local Telecommunications Services in the District Of Columbia, District of Columbia Public Service Commission, Formal Case No. 1057, Rebuttal Testimony on Behalf of Verizon (January 31, 2008)

In the Matter of Review of the Commission's Program Access Rules and Examination of Programming Tying Arrangements, Federal Communications Commission Docket MB 07-198, Expert Report on Behalf of the Walt Disney Company (January 4, 2008)

In the Matter of Verizon's 2007 Price Cap Plan for the Provision of Local Telecommunications Services in the District Of Columbia, District of Columbia Public Service Commission, Formal Case No. 1057, Direct Testimony on Behalf of Verizon (December 7, 2007)

In the Matter of the Commission's Investigation Into Verizon Maryland, Inc.'s Affiliate Relationships, Maryland Public Service Commission, Case No. 9120, Rebuttal Testimony on Behalf of Verizon (November 19, 2007)

On Petition for a Writ of Certiorari to the United States Court of Appeals for the Ninth Circuit, Pacific Bell Telephone Company d/b/a AT&T California, et al., Petitioners, v. Linkline Communications, Inc., et al., Respondents, Brief of Amici Curiae Professors and Scholars in Law and Economics in Support of the Petitioners (with R. Bork, G. Sidak, et al) (November 16, 2007)

In the Matter of the Commission's Investigation Into Verizon Maryland, Inc.'s Affiliate Relationships, Maryland Public Service Commission, Case No. 9120, Direct Testimony on Behalf of Verizon (October 29, 2007)

Application of Verizon Virginia, Inc. and Verizon South for a Determination that Retail Services Are Competitive and Deregulating and Detariffing of the Same, State Corporation Commission of Virginia, Case No. PUC-2007-00008, Rebuttal Report on Behalf of Verizon (July 16, 2007)

Testimony on Single Firm Conduct, "Understanding Single-Firm Behavior: Conduct as Related to Competition," United States Department of Justice and United States Federal Trade Commission, Sherman Act Section 2 Joint Hearing (May 8, 2007)

Testimony on Communications, Broadband and U.S. Competitiveness, Before the Committee on Commerce, Science and Transportation, United State Senate (April 24, 2007)

Application of Verizon Virginia, Inc. and Verizon South for a Determination that Retail Services Are Competitive and Deregulating and Detariffing of the Same, State Corporation Commission of Virginia, Case No. PUC-2007-00008, Expert Testimony and Report on Behalf of Verizon (January 17, 2007)

In re: ACLU v. Gonzales, Civil Action No. 98-CV-5591, E.D. Pa., Rebuttal Report on Behalf of the U.S. Department of Justice (July 6, 2006)

In re: ACLU v. Gonzales, Civil Action No. 98-CV-5591, E.D. Pa., Expert Report on Behalf of the U.S. Department of Justice (May 8, 2006)

In re: Emerging Communications Shareholder Litigation, "The Valuation of Emerging Communications: An Independent Assessment" (with J. Mrozek and L. Robinson), Court of Chancery for the State of Delaware (August 2, 2004)

In the Matter of Review of the Commission's Rules Regarding the Pricing of Unbundled Network Elements and the Resale of Service by Incumbent Local Exchange Carriers, WC Docket No. 03-173, Declaration of Jeffrey A. Eisenach and Janusz R. Mrozek, Federal Communications Commission (December 2003)

In the Matter of Disposition of Down Payments and Pending Applications Won During Auction No. 35 for Spectrum Formerly Licensed to NextWave Personal Communications, Inc., NextWave Power Partners, Inc. and Urban Comm – North Carolina, Inc., Federal Communications Commission, (October 11, 2002)

In the Matter of Echostar Communications Corporation, General Motors Corporation, and Hughes Electronics Corporation, Federal Communications Commission (February 4, 2002)

In the Matter of United States v. Microsoft Corp. and New York State v. Microsoft Corp., Proposed Final Judgment and Competitive Impact Statement (with T. Lenard), U.S. Department of Justice, Civil Action No. 98-1232 and 98-1233 (January 28, 2002)

In the Matter of Implementation of Section 11 of the Cable Television Consumer Protection and Competition Act of 1992 (with R. May), Federal Communications Commission (January 4, 2002)

In the Matter of Request for Comments on Deployment of Broadband Networks and Advanced Telecommunications (with R. May), National Telecommunications and Information Administration (December 19, 2001)

In the Matter of Implementation of the Telecommunications Act of 1996, Telecommunications Carriers' Use of Customer Proprietary Network Information and Other Consumer Information; Implementation of the Non-Accounting Safeguards of Sections 271 and 272 of the Communications Act of 1934, As Amended (with T. Lenard and J. Harper), Federal Communications Commission (November 16, 2001)

In the Matter of Flexibility for Delivery of Communications by Mobile Satellite Service Providers (with W. Adkinson), Federal Communications Commission (October 22, 2001)

In the Matter of Deployment of Advanced Telecommunications Capability (with R. May), Federal Communications Commission (October 5, 2001)

In the Matter of Deployment of Advanced Telecommunications Capability (with R. May), Federal Communications Commission (September 24, 2001)

In the Matter of Nondiscrimination in Distribution of Interactive Television Services Over Cable (with R. May), Federal Communications Commission (March 19, 2001)

In the Matter of High-Speed Access to the Internet Over Cable and Other Facilities, Reply Comments (with R. May), Federal Communications Commission (December 1, 2000)

Testimony on Federal Communications Commission Reform, Before the Committee on Government Reform, Subcommittee on Government Management, Information and Technology, United States House of Representatives (October 6, 2000)

In the Matter of Public Interest Obligations of TV Broadcast Licensees (with R. May), Federal Communications Commission (March 27, 2000)

Testimony on Truth in Billing Legislation, Before the Subcommittee on Telecommunications, Trade and Consumer Protection, Committee on Commerce, United States House of Representatives (March 9, 2000)

In the Matter of GTE Corporation, Transferor and Bell Atlantic, Transferee for Consent to Transfer of Control, (with R. May), Federal Communications Commission (February 15, 2000)

Testimony on Reforming Telecommunications Taxes in Virginia, Governor's Commission on Information Technology (October 26, 1999)

Testimony on Telecommunications Taxes, Advisory Commission on Electronic Commerce (September 14, 1999)

In the Matter of GTE Corporation, Transferor and Bell Atlantic, Transferee for Consent to Transfer of Control, Federal Communications Commission (December 23, 1998)

In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996 (with C. Eldering), Federal Communications Commission (September 14, 1998)

Testimony on Section 706 of the Telecommunications Act of 1996 and Related Bandwidth Issues, Before the Subcommittee on Communications Committee on Commerce, Science, and Transportation, United States Senate (April 22, 1998)

Testimony on the Impact of the Information Revolution on the Legislative Process and the Structure of Congress, Before the Subcommittee on Rules and Organization of the House of the Committee on Rules, United States House of Representatives (May 24, 1996)

Testimony on Efforts to Restructure the Federal Government, Before the Committee on Governmental Affairs, United States Senate (May 18, 1995)

Testimony on the Role of the Department of Housing and Urban Development and the Crisis in America's Cities, Before the Committee on Banking and Financial Services, United States House of Representatives (April 6, 1995)

Academic Publications and White Papers

Right-to-Work Laws: The Economic Evidence (Update), NERA Economic Consulting, May 2018

"Do State Reviews of Communications Mergers Serve the Public Interest?" (with Robert Kulick) *Federal Communications Law Journal*, forthcoming 2018

Do State Reviews of Communications Mergers Serve the Public Interest? (with Robert Kulick) NERA Economic Consulting, October 2017

Impacts of Potential Aluminum Tariffs on the U.S. Economy (with David Harrison), NERA Economic Consulting for Emirates Group Aluminium, June 2017

Balancing Incentives for the Migration to Fibre Networks (with B. Soria), NERA Economic Consulting for Vodafone Group PLC, March 2017

"US Merger Enforcement in the Information Technology Sector," *Handbook of Antitrust, Intellectual Property and High Tech* (Roger Blair and Daniel Sokol, eds.) Cambridge University Press, 2017

Making America Rich Again: The Latino Effect on Economic Growth, NERA Economic Consulting, December 2016

"The Economics of Zero Rating," in *Net Neutrality Reloaded: Zero Rating, Specialised Service, Ad Blocking and Traffic Management* (L. Belli, ed.) Annual Report of the UN IGF Dynamic Coalition on Net Neutrality, December 2016

The Long-Run Effects of Employment Regulation on California's Economy, U.S. Chamber of Commerce, July 2016

A New Regulatory Framework for the Digital Ecosystem (with B. Soria), GSMA and NERA Economic Consulting, February 10, 2016

Broadband Market Performance in Canada: Implications for Policy, NERA Economic Consulting, October 2015

"Looking Ahead: The FTC's Role in Information Technology Markets" (with I.K. Gotts), *George Washington University Law Review* 83;6, November 2015

Right-to-Work Laws: The Economic Evidence, NERA Economic Consulting, June 18, 2015

The Economics of Zero Rating, NERA Economic Consulting, March 2015

"In Search of a Competition Doctrine for Information Technology Markets: Recent Antitrust Developments in the Online Sector" (with I. K. Gotts), in *Competition and Communications Law: Key Issues in the Telecoms, Media and Technology Sectors*, Kluwer Law International, 2014

Economic Effects of Imposing Third-Party Liability on Payment Processors, NERA Economic Consulting, July 2014

Delivering for Television Viewers: Retransmission Consent and the U.S. Market for Video Content, NERA Economic Consulting, July 2014

The ABCs of "Pick-and-Pay," NERA Economic Consulting, June 2014

"Mobile Wireless Performance in the EU and the US: Implications for Policy" (with E. Bohlin and C. Caves), *Communications and Strategies* 93, 2014

"The Sound Recording Performance Right at a Crossroads: Will Market Rates Prevail?" *Commlaw Conspectus* 22, 2013–2014

An Empirical Analysis of the Value of Information Sharing in the Market for Online Content (with H. Beales), Navigant Economics, February 2014

The Equities and Economics of Property Interests in TV Spectrum Licenses, Navigant Economics, January 2014

Mobile Wireless Market Performance in Canada: Lessons from the EU and the US (with E. Bohlin and C. Caves), Navigant Economics, September 2013

"Avoiding Rent-Seeking in Secondary Market Spectrum Transactions," (with H. Singer), *Federal Communications Law Journal* 65;3, June 2013

Understanding Webcaster Royalties, Navigant Economics, June 2013

Mobile Wireless Performance in the EU and the US (with E. Bohlin and C. Caves), GSMA and Navigant Economics, May 2013

"The Long-Run Effects of Copper-Loop Unbundling and the Implications for Fiber" (with R. Crandall and A. Ingraham), *Telecommunications Policy* 37, 2013

Putting Consumers First: A Functionality-Based Approach to Online Privacy (with H. Beales), Navigant Economics, January 2013

"What Happens When Local Phone Service is Deregulated?" (with K. Caves), *Regulation*, September 2012

"Economic and Legal Aspects of FLSA Exemptions: A Case Study of Companion Care" (with K. Caves), *Labor Law Journal*, September 2012

The Long-Run Impact of Copper Unbundling and the Implications for Fiber (with R. Crandall and A. Ingraham), Navigant Economics, March 2012

Estimating the Economic Impact of Repealing the FLSA Companion Care Exemption (with K. Caves), Navigant Economics, March 2012

The Impact of Liberalizing Price Controls on Local Telephone Service: An Empirical Analysis (with K. Caves), Navigant Economics, February 2012

"Spectrum Reallocation and the National Broadband Plan," *Federal Communications Law Journal* 64;1, December 2011

The Rural Utilities Service Should Reassess its Reliance on Universal Service High-Cost Support to Leverage Broadband Loans, Navigant Economics, September 2011

The Effects of Regulation on Economies of Scale and Scope in TV Broadcasting, Navigant Economics, June 2011

Evaluating the Cost-Effectiveness of RUS Broadband Subsidies: Three Case Studies, Navigant Economics, April 2011

Revenues from a Possible Spectrum Incentive Auction: Why the CTIA/CEA Estimate is Not Reliable, Navigant Economics, April 2011

Competition in the New Jersey Communications Market: Implications for Reform, Navigant Economics, March 2011

The Role of Independent Contractors in the U.S. Economy, Navigant Economics, December 2010

"Vertical Separation of Telecommunications Networks: Evidence from Five Countries" (with R. Crandall and R. Litan), *Federal Communications Law Journal* 62;3, June 2010

Video Programming Costs and Cable TV Prices: A Reply to CRA, (with K. Caves), Navigant Economics, June 2010

Video Programming Costs and Cable TV Prices, Navigant Economics, April 2010

Retransmission Consent and Economic Welfare: A Reply to Compass Lexecon, Navigant Economics, April 2010

The Benefits and Costs of Implementing 'Return-Free' Tax Filing In the U.S. (with R. Litan and C. Caves), Navigant Economics, March 2010

"The Impact of Regulation on Innovation and Choice in Wireless Communications" (with E. Ehrlich and W. Leighton), *Review of Network Economics* 9;1, 2010

Uncollected Sales Taxes on Electronic Commerce (with R. Litan), Empiris LLC, February 2010

The Economics of ESPN360.com, Empiris LLC, November 2009

"Net Neutrality versus Consumer Welfare," in *The Consequences of Net Neutrality Regulations on Broadband Investment and Consumer Welfare: A Collection of Essays,* American Consumer Institute, November 2009

The Economics of Retransmission Consent, Empiris LLC, March 2009

Economic Effects of Tax Incentives for Broadband Infrastructure Deployment (with H. Singer and J. West), Empiris LLC, January 5, 2009

"An Event Analysis Study of the Economic Implications of the FCC's UNE Decision: Backdrop For Current Network Sharing Proposals," (with P. Lowengrub and J.C. Miller III), *Commlaw Conspectus* 17;1, 2008

"Broadband Policy: Does the U.S. Have It Right After All?" in *Telecommunications Policy & Regulation*, Practicing Law Institute, December 2008

"Broadband in the U.S. – Myths and Facts," in *Australia's Broadband Future: Four Doors to Greater Competition,* Committee for Economic Development of Australia, 2008

The Benefits and Costs of I-File, (with R. Litan and K. Caves), Criterion Economics, LLC, April 14, 2008

"Irrational Expectations: Can a Regulator Credibly Commit to Removing an Unbundling Obligation?" (with Hal J. Singer), *AEI-Brookings Joint Center Related Publication 07-28*, December 2007

Due Diligence: Risk Factors in the Frontline Proposal, Criterion Economics, LLC, June 28, 2007

The Effects of Providing Universal Service Subsidies to Wireless Carriers (with K. Caves), Criterion Economics, LLC, June 13, 2007

Assessing the Costs of the Family and Medical Leave Act, Criterion Economics, LLC, February 16, 2007

Improving Public Safety Communications: An Analysis of Alternative Approaches (with P. Cramton, T. Dombrowsky, A. Ingraham, H. Singer) Criterion Economics, LLC, February 6, 2007

Economic and Regulatory Implications of Unregulated Entry in the Canadian Mortgage Insurance Market, Criterion Economics, LLC, June 20, 2006

The FCC's Further Report on A La Carte Pricing of Cable Television (with R. Ludwick) The CapAnalysis Group, LLC, March 6, 2006

The EX-IM Bank's Proposal to Subsidize the Sale of Semiconductor Manufacturing Equipment to China: Updated Economic Impact Analysis (with J.C. Miller III, R. Ludwick), The CapAnalysis Group, LLC, November 2005

Retransmission Consent and Cable Television Prices (with D. Trueheart), The CapAnalysis Group, LLC, March 2005

The EX-IM Bank's Proposal to Subsidize the Sale of Semiconductor Manufacturing Equipment to China: An Economic Impact Analysis (with J.C. Miller III, R. Ludwick, O. Grawe), The CapAnalysis Group, LLC, January 2005.

Peer-to-Peer Software Providers' Liability under Section 5 of the FTC Act (with J.C. Miller III, L. Fales, C. Webb), The CapAnalysis Group, LLC and Howrey LLP, April 2004

Mandatory Unbundling: Bad Policy for Prison Payphones (with D. Trueheart, J. Mrozek), The CapAnalysis Group, LLC, March 2004

UNE Rates Do Not Reflect Underlying Costs: A Rebuttal to Ekelund and Ford (with J. Mrozek), The CapAnalysis Group, LLC, January 30, 2004

Do UNE Rates Reflect Underlying Costs? (with J. Mrozek), The CapAnalysis Group, LLC, December 2003

Rising Cable TV Rates: Are Programming Costs the Villain? (with D. Trueheart), The CapAnalysis Group, LLC, October 2003

Economic Implications of the FCC's UNE Decision: An Event Analysis Study (with J.C. Miller III, P. Lowengrub, The CapAnalysis Group, LLC, April 2003

"Telecom Deregulation and the Economy: The Impact of 'UNE-P' on Jobs, Investment and Growth" (with T. Lenard), *Progress on Point 10.3,* The Progress & Freedom Foundation, January 2003.

"The CLEC Experiment: Anatomy of a Meltdown" (with L. Darby and J. Kraemer) *Progress on Point 9.23,* The Progress & Freedom Foundation, September 2002

"The Debate Over Digital Online Content: Understanding the Issues" (with W. Adkinson, Jr.) *Progress on Point 9.14,* The Progress & Freedom Foundation, April 2002

"Electricity Deregulation after Enron," *Progress on Point 9.11,* The Progress & Freedom Foundation, April 2002

"Political Privacy: Is Less Information Really Better?" *Progress on Point 9.2,* The Progress & Freedom Foundation, January 2002

"Communications Deregulation and FCC Reform: Finishing the Job" (with R. May), in *Communications Deregulation and FCC Reform: What Comes Next?* (ed., with R. May) Kluwer Academic Publishers, 2001

"Does Government Belong in the Telecom Business?" *Progress on Point 8.1,* The Progress & Freedom Foundation, January 2001

"Critics Fear Surveillance of Web Surfers Compromising Personal Privacy," *Progress on Point 7.11,* The Progress & Freedom Foundation, July 2000

"Access Charges and The Internet: A Primer," *Progress on Point 7.9*, The Progress & Freedom Foundation, June 2000

"The Need for a Practical Theory of Modern Governance," *Progress on Point 7.7*, The Progress & Freedom Foundation, May 2000

"The Microsoft Monopoly: The Facts, the Law and the Remedy" (with T. Lenard) *Progress on Point 7.4*, The Progress & Freedom Foundation, April 2000

"Regulatory Overkill: Pennsylvania's Proposal to Breakup Bell Atlantic" (with C. Eldering, R. May) *Progress on Point 6.13,* The Progress & Freedom Foundation, December 1999

"Is There a Moore's Law for Bandwidth?" (with C. Eldering, M. Sylla), *IEEE Communications Magazine,* October 1999

"The High Cost of Taxing Telecom," *Progress on Point 6.6,* The Progress & Freedom Foundation, September 1999

"Creating the Digital State: A Four Point Program," *Progress on Point 6.4,* The Progress & Freedom Foundation, August 1999

"How to Recognize a Regulatory Wolf in Free Market Clothing: An Electricity Deregulation Scorecard," (with T. Lenard) *Progress on Point 6.3,* The Progress & Freedom Foundation, July 1999

"Into the Fray: The Computer Industry Flexes Its Muscle on Bandwidth," *Progress on Point 5.9,* The Progress & Freedom Foundation, December 1998

"Surprise: Even in Electricity, the Market Works," The Progress & Freedom Foundation, Nov. 1998

"Finally! An 'Electricity Deregulation' Bill That Deregulates," *Progress on Point 5.7,* The Progress & Freedom Foundation, October 1998

"Time to Walk the Walk on Telecom Policy," *Progress on Point 4.3,* The Progress & Freedom Foundation, July 1997

"The FCC and the Telecommunications Act of 1996: Putting Competition on Hold?" (with G. Keyworth), *Progress on Point 2.1,* The Progress & Freedom Foundation, October 1996

"Forebearance, Self-Certification and Privatization" (with J. Gattuso, et al) *Future Insight No. 3.2,* The Progress & Freedom Foundation, May 1996

"Privatizing the Electromagnetic Spectrum" (with R. Crandall, et al) *Future Insight No. 3.1,* The Progress & Freedom Foundation, April 1996

"Broadcast Spectrum: Putting Principles First" (with R. Crandall et al) *Progress on Point 1.9,* The Progress & Freedom Foundation, January 1996

"How (Not) to Solve the Liability Crisis," in P. McGuigan, ed., *Law, Economics & Civil Justice Reform: A Reform Agenda for the 1990's,* Free Congress Foundation, 1995

"The Future of Progress," *Future Insight 2.3,* The Progress & Freedom Foundation, May 1995

"American Civilization and the Idea of Progress," in D. Eberly, ed., *Building a Community of Citizens: Civil Society in the 21st Century,* University Press of America, 1994

"Fighting Drugs in Four Countries: Lessons for America?" *Backgrounder* 790, The Heritage Foundation, Washington, DC, September 24, 1990

"Drug Legalization: Myths vs. Reality," *Heritage Backgrounder 122*, The Heritage Foundation, January 1990

"How to Ensure A Drug-Free Congressional Office," The Heritage Foundation, January 1990

"A White House Strategy for Deregulation," in *Mandate for Leadership III,* The Heritage Foundation, 1989

"From George Bush, A Convincing Declaration of War on Drugs," *Executive Memorandum* No. 250, The Heritage Foundation, September 14, 1989

"Winning the Drug War: What the States Can Do," *Heritage Backgrounder* 715/S, July 7, 1989

"Why America is Losing the Drug War," *Heritage Backgrounder* 656, June 9, 1988

"Selectivity Bias and the Determinants of SAT Scores," (with A. Behrendt and W. Johnson) *Economics of Education Review* 5;4, 1986

"Review of Banking Deregulation and the New Competition in the Financial Services Industry," *Southern Economic Journal* 52;3, January 1986

"Warranties, Tie-ins, and Efficient Insurance Contracts: A Theory and Three Case Studies," (with R. Higgins and W. Shughart II), *Research in Law and Economics* 6, 1984

"Regulatory Relief under Ronald Reagan," (with James C. Miller III), in Wayne Valis, ed., *The Future Under President Reagan*, Arlington House, 1981

Books and Monographs

An American Strategy for Cyberspace: Advancing Freedom, Security, and Prosperity, (with C. Barfield, et al) American Enterprise Institute for Public Policy Research, June 2016

Broadband Competition in the Internet Ecosystem, AEI Economic Studies, American Enterprise Institute for Public Policy Research, October 2012

The Impact of State Employment Policies on Job Growth: A 50-State Review (with David S. Baffa, et al), U.S. Chamber of Commerce, March 2011

The Digital Economy Fact Book 2002, (with W. Adkinson Jr. and T. Lenard) The Progress & Freedom Foundation, August 2002

Privacy Online: A Report on the Information Practices and Policies of Commercial Web Sites, (with W. Adkinson, Jr., T. Lenard) The Progress & Freedom Foundation, March 2002

The Digital Economy Fact Book 2001, (with T. Lenard, S. McGonegal) The Progress & Freedom Foundation, August 2001

Communications Deregulation and FCC Reform: What Comes Next? (ed., with R. May) Kluwer Academic Publishers, 2001

The Digital Economy Fact Book 2000, (with T. Lenard, S. McGonegal) The Progress & Freedom Foundation, August 2000

Digital New Hampshire: An Economic Factbook, (with R. Frommer, T. Lenard) The Progress & Freedom Foundation, December 1999

The Digital Economy Fact Book, (with A. Carmel and T. Lenard), The Progress & Freedom Foundation, August 1999

Competition, Innovation and the Microsoft Monopoly: Antitrust in the Digital Marketplace, (ed., with T. Lenard), Kluwer Academic Publishers, 1999

The People's Budget, (with E. Dale, et al), Regnery Publishing, 1995

The Telecom Revolution: An American Opportunity, (with G. Keyworth, et al) The Progress & Freedom Foundation, 1995

Readings in Renewing American Civilization, (ed. with S. Hanser) McGraw-Hill, Inc., 1993

America's Fiscal Future 1991: The Federal Budget's Brave New World, Hudson Institute, 1991

Winning the Drug War: New Challenges for the 1990's, (ed.) The Heritage Foundation, Washington, DC, 1991

Drug-Free Workplace Policies for Congressional Offices, (ed.) The Heritage Foundation, Washington, DC, 1991

America's Fiscal Future: Controlling the Federal Deficit in the 1990's, Hudson Institute, 1990

The Five-Year Budget Outlook, Hudson Institute, 1988

The Role of Collective Pricing in Auto Insurance, Federal Trade Commission, Bureau of Economics Staff Study, 1985

Selected Short Articles and Op-Eds

"Spectrum Favoritism is Bad Economics," *Forbes*, April 28, 2015

"Competition is the Only Way to Preserve an Open Internet," *Real Clear Markets*, December 18, 2014

"End the Internet Blackout on Airplanes," *The Hill*, December 12, 2013

"Trolling for a Patent Policy Fix," *Roll Call*, September 19, 2013

"A Good News Story: The Internet," *AEIdeas*, May 31, 2013

"Should You Let the IRS Do Your Taxes for You?" *The Daily Caller*, May 1, 2013

"Net Neutrality as 'Crony Capitalism,'" *AEIdeas*, November 2, 2012

"Broadband Competition in the Internet Ecosystem: A Conflict of Visions," *AEIdeas*, October 18, 2012

"The Internet Doesn't Need More Regulation," *The American: The Journal of the American Enterprise Institute*, September 25, 2012

"Follow Obama's Lead on Wireless," *The Australian*, February 7, 2011

"The Radicalism of Net Neutrality," *The Hill*, September 2, 2010

"Net Neutrality Rules Threaten Telecom Détente," *Law360.com*, August 10, 2010

"Don't Drag Broadband Into the Net Neutrality Morass," *The Daily Caller,* July 13, 2010

"Coase vs. the Neo-Progressives," (with A. Thierer), *The American: The Journal of the American Enterprise Institute* (October 28, 2009)

"The U.S. Abandons the Internet," (with J. Rabkin), *The Wall Street Journal*, October 3, 2009

"A La Carte Regulation of Pay TV: Good Intentions vs. Bad Economics," (with A. Thierer) *Engage,* June 2008

"A New Takings Challenge to Access Regulation," American Bar Association, Section on Antitrust Law, *Communications Industry Committee Newsletter*, Spring 2007

"Reagan's Economic Policy Legacy," (with J.C. Miller III), *The Washington Times*, August 8, 2004

"Do Right by Minority Farmers," *The Washington Times*, July 17, 2003

"Pruning the Telecom Deadwood," *The Washington Times*, November 1, 2002

"The Real Telecom Scandal," *The Wall Street Journal*, September 30, 2002

"Ensuring Privacy's Post-Attack Survival," (with Peter P. Swire) *CNET News.com*, September 11, 2002

"One Step Closer to 3G Nirvana," *CNET News.com*, August 6, 2002

"Reviving the Tech Sector," *The Washington Times*, July 10, 2002

"Broadband Chickens in Age of the Internet," *The Washington Times*, March 11, 2002

"Watching the Detectives," *The American Spectator,* January/February 2002

"Can Civil Liberties Survive in a Society Under Surveillance?" *Norfolk Virginian-Pilot*, November 18, 2001

"Microsoft Case: There Are Still Antitrust Laws," *Newport News Daily Press,* July 6, 2001

"Dear Diary: There's Still an Antitrust Law," *Los Angeles Times*, June 29, 2001

"Lost in Cyberspace? Does the Bush Administration Get the New Economy?" *The American Spectator,* June 2001

"Local Loop: NASDAQ Noose, Al Gore's Internet Socialism is Choking the Technology Sector," *The American Spectator*, April 2001

"Local Loop, High-Tech Noose," *The American Spectator,* March 2001

"Rescue Opportunity at the FCC," *The Washington Times,* February 4, 2001

"Economic Anxieties in High-Tech Sector," *The Washington Times*, December 12, 2000

"Nation's Conservatives Should Support a Breakup of Microsoft," *The Union Leader & New Hampshire Sunday News*, February 22, 2000

"Benefits Riding on a Breakup," *The Washington Times*, November 14, 1999

"Still Wondering What Cyberspace is All About?" *Insight on the News*, Vol. 15, No. 11, March 22, 1999

"Computer Industry Flexes Its Muscle," *Intellectual Capital.com*, January 28, 1999

"Ira Magaziner Targets the Internet," *The Washington Times,* March 26, 1997

"Revolution – or Kakumei" *Forbes ASAP,* December 1996

"Digital Charity," *Intellectual Capital.com*, November 28, 1996

"Time to Junk the Telecom Act," *Investor's Business Daily,* July 23, 1998

"Consumers Win in Mergers," *Denver Post,* July 5, 1998

"Microsoft's Morality Play," *News.com,* March 11, 1998

"California Will Soon Be Eating Dust," *Forbes Magazine*, August 1997

"Watch Out for Internet Regulation," *The Washington Times*, July 9, 1997

"Those GOP Blockheads Just Don't Get It; Block Grants are Merely another Bogus Solution," *The Washington Post*, September 3, 1995

"Replace, Don't Reinvent, HUD," *The Wall Street Journal,* May 11, 1995

"Poor Substitute," (with P. du Pont), *National Review,* December 31, 1994

"Just Say No to More Drug Clinics," *St. Louis Post-Dispatch*, June 14, 1991

"Drug Rehab Funding is No Panacea," *Chicago Tribune*, June 7, 1991

"The Vision Thing, Conservatives Take Aim at the '90's," *Policy Review* 52, Spring 1990

"What States Can Do To Fight the Drug War," *The Washington Times*, September 4, 1989

"Congress: Reform or Transform," (with P. McGuigan), *Washington Times,* June 12, 1989

"How to Win the War on Drugs: Target the Users," *USA Today*, January 1989

"Invest Social Security Surplus in Local Project Bonds," *Wall Street Journal,* January 4, 1989

"The Government Juggernaut Rolls On," *Wall Street Journal,* May 23, 1988

"Is Regulatory Relief Enough?" (with M. Kosters), *Regulation* 6, March/April 1982

"Price Competition on the NYSE," (with J.C. Miller III), *Regulation* 4, Jan./Feb. 1981

Selected Presentations

"Regulating the New Digital," Carnegie India Global Technology Summit (Bangalore, India) December 8, 2017

"A New Regulatory Framework for the Internet Ecosystem," GSMA Mobile World Congress, Ministerial Program (Barcelona, Spain) February 22, 2016

"Regulatory Benefit-Cost Analysis: Applications Under Dodd/Frank," Second Annual Attorney General Public Policy Institute Conference on Financial Services Regulation, Law & Economics Center, George Mason University School of Law, June 4, 2012

"Exploring Developments in the Communications Sector," National Regulatory Conference, May 17, 2012

"Platform Competition in the Internet Ecosystem: Implications for Regulation," Mercatus Institute, November 8, 2011

"Competition in the Internet Ecosystem," American Consumer Institute, June 30, 2011

"The Future of Mobile Broadband: Platform Competition in the Internet Ecosystem," Informa Telecoms and Media North America Broadband Traffic Management Conference, June 21, 2011

"The Communications Sector and Economic Growth," Innovation Policy Institute, March 2, 2011

"The Benefits and Costs of I-File," Council for Electronic Revenue Communications Advancement, May 2008

"Sell Globally, Sue Locally: The Growing Perils of Global 'Dominance,'" Antitrust Section, Ohio State Bar Association, October 27, 2006

"The Growing Global Perils of 'Dominance,'" Aspen Summit Conference, August 21, 2006

"Telecoms in Turmoil: What We Know and (Mostly) Don't Know About the Telecom Marketplace in 2006," National Regulatory Conference, May 11, 2006

"Mandatory Unbundling in the U.S.: Lessons Learned the Hard Way," Telstra Corporation, November 25, 2005

"The Fourth 'S': Digital Content and the Future of the IT Sector," Federal Communications Bar Association, May 2, 2003

"Restoring IT Sector Growth: The Role of Spectrum Policy in Re-Invigorating 'The Virtuous Circle,'" National Telecommunications and Information Administration Spectrum Summit, April 2, 2002

"Restoring IT Sector Growth-Why Broadband, Intellectual Property and Other E-Commerce Issues Are Key to a Robust Economy," August 2001

"Remarks at the 2000 *Global Internet Summit*," March 14, 2000

"The Digital State: Remarks on Telecommunications Taxes," Address Before the Winter Meeting of the National Governors Association, February 21, 1999

"The Digital Economy," Address at the George Mason University Conference on *The Old Dominion and the New Economy,* November 1998

"A Convergence Strategy for Telecommunications Deregulation," Remarks at the United States Telephone Association's *Large Company Meeting*, September 1998

EXHIBIT B:
EXISTING LITERATURE ON TELECOM EMPLOYMENT MULTIPLIERS

The use of I/O based multiplier models to estimate the employment effects of changes in telecommunications sector investment and expenditures is generally accepted. At least nine studies have utilized this methodology since 2009.[1] The results of those studies are summarized in Table B-1 below. The existing literature includes studies covering a variety of investment mixes and models. Six of the studies focus on wireless capex specifically, including Sosa and Audenrode (2011), Eisenach, Singer and West (2009), Al Amine *et al* (2017), Crandall and Singer (2010), Singer *et al* (2017) and Davidson and Swanson (2010), though the last three of these simply adopt the Eisenach-Singer-West multiplier of 14.7 thousand jobs per billion dollars in expenditures.

[1] See Robert Atkinson *et al*, *The Digital Road to Recovery: A Stimulus Plan to Create Jobs, Boost Productivity and Revitalize America,* The Information Technology & Innovation Foundation (January 2009) (available at https://www.itif.org/files/roadtorecovery.pdf); Jeffrey A. Eisenach, Hal J. Singer, and Jeffrey D. West, *Economic Effects of Tax Incentives for Broadband Infrastructure Deployment,* Empiris (2009) (available at https://www.fiberbroadband.org/d/do/800); Raul Katz and Stephan Suter*, Estimating the Economic Impact of the Broadband Stimulus Plan,* CITI (February 2009) at 13 (available at https://www.researchgate.net/publication/237285765_ESTIMATING_THE_ECONOMIC_IMPACT_OF_THE_BROADBAND_STIMULUS_PLAN); Robert Crandall and Hal Singer, *The Economic Impact of Broadband Investment,* Broadband for America (2010) (available at http://internetinnovation.org/files/special-reports/Economic_Impact_of_Broadband_Investment_Broadband_for_America_.pdf); Charles Davidson and Bret Swanson, "Net Neutrality, Investment & Jobs: Assessing the Potential Impacts of the FCC's Proposed Net Neutrality Rules on the Broadband Ecosystem," *The Advanced Communications Law & Policy Institute at New York Law School* (June 2010) 1-63 (available at http://www.nyls.edu/wp-content/uploads/sites/169/2013/08/Davidson-Swanson-NN-Economic-Impact-Paper-FINAL.pdf); David W. Sosa and Marc Van Audenrode, *Private Sector Investment and Employment Impacts of Reassigning Spectrum to Mobile Broadband in the United States,* Analysis Group (August 2011) (available at http://www.analysisgroup.com/uploadedfiles/content/news_and_events/news/sosa_audenrode_spectrumimpactstudy_aug2011.pdf); Majed Al Amine *et al*, *Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities,* Accenture Strategy (2017) at 1 (available at https://www.ctia.org/docs/default-source/default-document-library/how-5g-can-help-municipalities-become-vibrant-smart-cities-accenture.pdf); Coleman Bazelon and Pallavi Seth, *REIT Supported Wireless Infrastructure: Foundation of the Mobile Economy*, The Brattle Group (May 2017) at 19 (available at http://www.brattle.com/system/publications/pdfs/000/005/469/original/REIT_Supported_Wireless_Infrastructure_Foundation_of_the_Mobile_Economy.pdf?1499802857); Hal Singer, Ed Naef and Alex King, *Assessing the Impact of Removing Regulatory Barriers on Next Generation Wireless and Wireline Broadband Infrastructure Investment*, Economists Incorporated (June 2017) (available at http://ei.com/wp-content/uploads/2017/06/SingerAssessingImpact6.17.pdf).

TABLE B-1:
SUMMARY EMPLOYMENT RESULTS OF PREVIOUS MULTIPLIER-BASED I/O STUDIES OF TELECOMMUNICATIONS EXPENDITURES

Study	Sector	Model	Capex ($Billions)	Employment Effect (Thousands)	Employment Multiplier (Thousand Jobs / $Billion of Expenditure)
Atkinson *et al* (2009)	Broadband	RIMS	$10.0	229	22.9
Eisenach, Singer and West (2009)	Wireless	RIMS	n/a	n/a	14.7
Katz and Suter (2009)	Wireless/Wireline	RIMS	$6.4	128	20.0
Crandall and Singer (2010)	Wireless	RIMS	$14.0	206	14.7
Davidson and Swanson (2010)	Wireless	RIMS	$17.2	251	14.7
Sosa and Audenrode (2011)	Wireless	RIMS	$15.1	308	20.4
Al Amine *et al* (2017)	Wireless (5G)	IMPLAN	$275.0	3,000	10.9
Bazelon and Seth (2017)	Wireless Towers	IMPLAN	$0.8	12	15.2
Singer *et al* (2017)	Wireless	RIMS	$4.8	70	14.7

Source: See infra at n. 1. Note: Eisenach, Singer and West (2009) estimate the job creation effects of fiber-to-the-home. The wireless multiplier is provided for the purpose of comparison. Thus, capex and employment effects are labeled "n/a."

The three studies which independently apply wireless multipliers use estimates ranging from 20.4 to 10.9. Specifically:

- Eisenach, Singer and West (2009) calculate a RIMS-based multiplier for wireless capex of 14.7 based on a mix of 93 percent for equipment and seven percent for construction.

- Sosa and Audenrode (2011) estimate job creation by applying wireless capex multipliers from the RIMS model based on a capex mix of 56 percent for construction and 44 percent for communication equipment, yielding a multiplier of 20.4.

- Al Amine *et al* (2017) use IMPLAN multipliers to estimate that $275 billion in investment in 5G infrastructure would create three million jobs, implying a capex multiplier of 10.9.

EXHIBIT C:
ASSIGNMENT OF EXPENDITURE AND REVENUE CHANGES TO IMPLAN MODEL INDUSTRY SECTORS

This section provides an in-depth description of the process used to assign the Transaction-specific changes in expenditures and output detailed in T-Mobile's financial model and presented in Tables 1, 2 and 3 above to the economic sub-sectors that comprise IMPLAN's model of the productive sector of the economy. The financial model identifies three overall categories of changes in final demand that serve as inputs into the IMPLAN model: capital expenditures (capex), operating expenditures (opex) and revenue from new growth opportunities (output). Within opex, the financial model distinguishes between "synergies" and "cost to achieve," where synergies represent on-going outlays or savings attributable to the Transaction and cost to achieve represents non-repeated outlays or savings related to integration of the two firms.[1] As described below, each general category is subdivided into more granular categories within the financial model, which facilitate linking the changes in economic activity associated with the Transaction to the appropriate IMPLAN sectors.

Capex

Network Capex: This category represents expenditures relating to the integration and build-out of New T-Mobile's network. The expenditures associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. Of these expenditures, T-Mobile estimates that [redacted] percent are related to wireless equipment and [redacted] percent are related to labor associated with network construction. These expenditures are assigned to the IMPLAN sectors for "broadcast and wireless communications equipment manufacturing" and "construction of new power and communications structures," respectively.[2]

Sales, Service and Marketing Capex: This category primarily represents expenditures related to the renovation and refurbishing of Sprint retail stores that will be converted after the merger. The

[1] Although as a matter of form T-Mobile's *pro forma* financial model distinguishes between cost to achieve and synergies for capex, there is no substantive difference in the nature of the expenditures and capex cost to achieve and synergies are treated identically in specifying the IMPLAN model.

[2] Each industrial sector in the IMPLAN model matches to one or more NAICS sector. The assignment of wireless equipment expenditures to the IMPLAN industry "broadcast and wireless communications equipment manufacturing" is based on NAICS sector 334220, "radio and television broadcasting and wireless communications equipment manufacturing." According to the U.S. Census Bureau: "This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 334220" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=334220&naicslevel=6#). The assignment of network construction to the IMPLAN industry "construction of new power and communication structures" is based on NAICS sector 237130, "power and communication line and related structures construction." According to the U.S. Census Bureau: "This industry comprises establishments primarily engaged in the construction of power lines and towers, power plants, and radio, television, and telecommunications transmitting/receiving towers. The work performed may include new work, reconstruction, rehabilitation, and repairs." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 237130" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=237130&naicslevel=6#).

expenditures associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. Of these expenditures, [redacted] percent are related to the purchase of materials necessary to refurbish the stores while [redacted] percent are related to labor associated with renovations. These expenditures are assigned to the IMPLAN sectors for "wholesale trade" and "construction of new commercial structures," respectively.[3]

Back Office Capex: This category primarily represents expenditures related to the development of software to integrate T-Mobile's and Sprint's IT Systems. The expenditures associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. These expenditures are assigned to the IMPLAN sector for "computer systems design services."[4]

Customers Capex: This category is an offset in the financial model related to reduced prices and decreasing customer churn. These synergies represent a transfer rather than a change in final demand and do not interact with the productive sector of the economy.[5] Synergies associated with this category are excluded from the IMPLAN model for the purposes of estimating employment effects.

Rural and Enterprise Capex: Rural and Enterprise Capex represent a number of different sources of expenditure. The expenditures associated with the buyout of a rural affiliate are transfers with no employment multiplier effect and are excluded from the employment model.[6] The remaining expenditures constitute changes in final demand that interact with the productive sector of the

[3] The assignment of store refurbishing expenditures to the IMPLAN industry "wholesale trade" is based on NAICS sector 425120, "wholesale trade agents and brokers." According to the U.S. Census Bureau: "This industry comprises Wholesale Trade agents and brokers acting on behalf of buyers or sellers in the wholesale distribution of goods. Agents and brokers do not take title to the goods being sold but rather receive a commission or fee for their service. Agents and brokers for all durable and nondurable goods are included in this industry." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 425120" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=425120&naicslevel=6#). The assignment of labor associated with renovations to the IMPLAN industry "construction of new commercial structures" is based on NAICS sector 236220, "commercial and institutional building construction." According to the U.S. Census Bureau: "This industry comprises establishments primarily responsible for the construction (including new work, additions, alterations, maintenance, and repairs) of commercial and institutional buildings and related structures, such as stadiums, grain elevators, and indoor swimming facilities. This industry includes establishments responsible for the on-site assembly of modular or prefabricated commercial and institutional buildings." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 236220" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=236220&naicslevel=6#).

[4] The assignment of expenditures related to software development to the IMPLAN industry "computer systems design services" is based on NAICS sector 541512, "computer systems design services." According to the U.S. Census Bureau: "This U.S. industry comprises establishments primarily engaged in planning and designing computer systems that integrate computer hardware, software, and communication technologies. The hardware and software components of the system may be provided by this establishment or company as part of integrated services or may be provided by third parties or vendors. These establishments often install the system and train and support users of the system." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 541512" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=541512&naicslevel=6#).

[5] As discussed above, in I/O analyses, only changes in final demand that require intermediate inputs to satisfy the initial demand shock create multiplier effects. Thus, transfer payments to existing resources lie outside the productive sector of the economy and have no multiplier effect.

[6] The buyout of a rural affiliate accounts for $[redacted] of Rural Capex Costs to Achieve in 2019.

economy and thus create employment multiplier effects. Expenditures categorized as costs to achieve are associated with opening new storefronts. Of these [redacted] to achieve, [redacted] percent are related to labor associated primarily with building construction and 50 percent are related to the purchase of materials for the new stores. These expenditures are assigned to the IMPLAN sectors for "construction of new commercial structures" and "wholesale trade," respectively.[7] Expenditures categorized as dis-synergies are associated with building out New T-Mobile's network to keep up with the growth from new rural and enterprise opportunities. Therefore, these expenditures are treated in the same way as Network Capex, for which T-Mobile estimates that [redacted] percent are related to wireless equipment and [redacted] percent are related to labor associated with network construction. These expenditures are assigned to the IMPLAN sectors for "broadcast and wireless communications equipment manufacturing" and "construction of new power and communications structures," respectively.[8]

<u>IoT Capex</u>: IoT Capex primarily represents expenditures related to New T-Mobile's development of software to support new IoT connectivity services, which are expected to grow rapidly as a result of 5G. The expenditures associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. These expenditures are assigned to the IMPLAN sector for "custom computer programming services."[9]

<u>Home Broadband Replacement Capex</u>: Home Broadband Replacement Capex primarily represents expenditures related to the purchase of wireless equipment. The expenditures associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. These expenditures are assigned to the IMPLAN sector for "broadcast and wireless communications equipment manufacturing."[10]

<u>Video Capex</u>: Video Capex represents expenditures related to New T-Mobile's expansion of video offerings designed to compete with cable television. The expenditures associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. These expenditures are assigned to the IMPLAN sector for "wired telecommunications carriers."[11]

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[7] For a detailed explanation of the expenditures assigned to IMPLAN industries "construction of new commercial structures" and "wholesale trade," see *infra* at n. 3.

[8] For a detailed explanation of the expenditures assigned to IMPLAN industries "broadcast and wireless communications equipment manufacturing" and "construction of new power and communications structures," see *infra* at n. 2.

[9] The assignment of expenditures related to development of software to the IMPLAN industry "custom computer programming services" is based on NAICS sector 541511, "custom computer programming services." According to the U.S. Census Bureau: "This U.S. industry comprises establishments primarily engaged in writing, modifying, testing, and supporting software to meet the needs of a particular customer." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 541511" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=541511&naicslevel=6#).

[10] For a detailed explanation of the expenditures assigned to IMPLAN industries "broadcast and wireless communications equipment manufacturing," see *infra* at n. 2.

[11] The assignment of expenditures related to the expansion of video offerings to the IMPLAN industry "wired telecommunications carriers" is based on NAICS sector 517110, "wired telecommunications carriers." According to the U.S. Census Bureau: "This industry comprises establishments primarily engaged in operating and/or providing

Opex

Network Opex Synergies: Network Opex Synergies represent savings achieved as a result of the Transaction in operating New T-Mobile's network. As explained above, synergies related to lease payments for wireless towers and backhaul and taxes have no multiplier effect because they do not interact with the productive sector of the economy. Of the remaining synergies, [redacted] percent are related to savings on payments to utilities, [redacted] percent are related to savings on network maintenance and [redacted] percent are related to reduced spending on wireless equipment. These expenditures are assigned to IMPLAN sectors for "electric power generation – fossil fuel," "construction of new power and communications structures" and "broadcast and wireless communications equipment manufacturing," respectively.[12]

Store Consolidation and Dealer Opportunity Opex Synergies: These categories represent savings achieved by the closing of duplicative branded stores and stores operated by third-party dealers. Of the store consolidation synergies, [redacted] percent represent savings from leases, which are transfer payments that do not interact with the productive sector of the economy. The remaining synergies constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. Nearly all of the expenditures associated with these categories are associated with a reduction in retail services and are assigned to the IMPLAN category for "retail – electronics and appliance stores."[13]

access to transmission facilities and infrastructure that they own and/or lease for the transmission of voice, data, text, sound, and video using wired telecommunications networks. Transmission facilities may be based on a single technology or a combination of technologies. Establishments in this industry use the wired telecommunications network facilities that they operate to provide a variety of services, such as wired telephony services, including VoIP services; wired (cable) audio and video programming distribution; and wired broadband Internet services. By exception, establishments providing satellite television distribution services using facilities and infrastructure that they operate are included in this industry." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 517110" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=517110&naicslevel=6#).

[12] The assignment of expenditures related to utilities to the IMPLAN industry "electric power generation — fossil fuel" is based on NAICS sector 221112, "fossil fuel electric power generation." According to the U.S. Census Bureau: "This U.S. industry comprises establishments primarily engaged in operating fossil fuel powered electric power generation facilities. These facilities use fossil fuels, such as coal, oil, or gas, in internal combustion or combustion turbine conventional steam process to produce electric energy. The electric energy produced in these establishments is provided to electric power transmission systems or to electric power distribution systems." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 221112" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=221112&naicslevel=6#). For a detailed explanation of the other expenditures assigned to IMPLAN industries "construction of new power and communications structures" and "broadcast and wireless communications equipment manufacturing," see *infra* at n. 2.

[13] The assignment of expenditures related to a reduction in retail services to the IMPLAN industry "retail – electronics and appliance stores" is based on NAICS sectors 443142 and 443141, "electronics stores" and "household appliance stores." According to the U.S. Census Bureau, the former industry "comprises: (1) establishments known as consumer electronics stores primarily engaged in retailing a general line of new consumer-type electronic products such as televisions, computers, and cameras; (2) establishments specializing in retailing a single line of consumer-type electronic products; (3) establishments primarily engaged in retailing these new electronic products in combination with repair and support services; (4) establishments primarily engaged in retailing new prepackaged computer software; and/or (5) establishments primarily engaged in retailing prerecorded audio and video media, such as CDs, DVDs, and tapes." The latter industry "comprises establishments known as appliance stores primarily engaged in retailing an array of new household appliances, such as refrigerators, dishwashers, ovens, irons, coffeemakers, hair dryers, electric razors, room air-conditioners, microwave ovens, sewing machines, and vacuum cleaners, or retailing new appliances in combination with appliance repair services."

Lease Opex Synergies: This category represents dis-synergies due to the increased expenditures associated with lease payments required to expand retail operations at remaining retail stores. Lease payments are transfers with no employment multiplier effect and are excluded from the employment model.

Labor Opex Synergies: This category represents dis-synergies due to the increased expenditures associated with labor required to expand retail operations at remaining retail stores. These expenditures involve the deployment of resources to expand the capacity of the existing retail stores and thus interact with the productive sector of the economy. Nearly all of the expenditures associated with this category are associated with an increase in retail services and are assigned to the IMPLAN category for "retail – electronics and appliance stores."[14]

Advertising Opex Synergies: This category represents savings achieved by reducing duplicative marketing overhead. The synergies associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. These expenditures are assigned to the IMPLAN sector for "advertising."[15]

Customer Care Opex Synergies: This category represents dis-synergies associated with increased customer care service as a result of the Transaction. The synergies associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. The increased expenditures associated with this category are assigned to the IMPLAN sector for "business support services."[16]

See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 443142" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=443142&naicslevel=6#); see also U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 443141" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=443141&naicslevel=6).

[14] For a detailed explanation of the expenditures assigned to IMPLAN industry "retail – electronics and appliance stores," see *infra* at n. 13.

[15] The assignment of expenditures to the IMPLAN industry "advertising" is based on NAICS sectors 541890, 541870, 541860, 541850, 541840, 541830, 541820 and 541810: "other services related to advertising," "advertising material distribution services," "direct mail advertising," "outdoor advertising," "media representatives," "media buying agencies," "public relations agencies" and "advertising agencies." According to the U.S. Census Bureau, the NAICS code 5418 "comprises establishments primarily engaged in (1) offering advertising agency services; (2) public relations agency services; (3) media buying agency services; (4) outdoor advertising; (5) direct mail advertising services; (6) advertising material distribution services; and (7) all other services related to advertising, such as sign lettering and painting, mannequin decorating services, welcoming services, and merchandise demonstration services." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 5418" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=5418&naicslevel=4#).

[16] The assignment of expenditures to the IMPLAN industry "business support services" is based on NAICS sectors 561410, 561421, 561422, 561431, 561439, 561440, 561450, 561491, 561492 and 561499: "document preparation services," "telephone answering services," "telemarketing bureaus and other contact centers," "private mail centers," "other business service centers (including copy shops)," "collection agencies," "credit bureaus," "repossession services," "court reporting and stenotype services" and "all other business support services." According to the U.S. Census Bureau, the NAICS code 5614 "comprises establishments engaged in performing activities that are ongoing routine business support functions that businesses and organizations traditionally do for themselves." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 5614" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=5614&naicslevel=4#).

Equipment Expense and Repair and Logistics Opex Synergies: This category represents volume discounts from third-party suppliers due to increased scale. As these discounts do not affect output, they are treated as transfers and do not have an employment multiplier effect.

Back Office Opex Synergies: This category represents savings associated with eliminating duplicative administrative functions. The synergies associated with this category constitute changes in final demand that interact with the productive sector of the economy and thus create employment multiplier effects. Of these synergies, [redacted] percent are related to corporate management, [redacted] percent are related to reduced purchase of furniture and fixtures and [redacted] percent are related to rationalization of third-party services such as legal. These savings are assigned to the IMPLAN sectors for "management of companies and enterprises," "wholesale trade" and "legal services," respectively.[17]

Customers Opex Synergies: This category is an offset in the financial model related to reduced average revenue per user due to price decreases. These dis-synergies represent a transfer rather than a change in final demand and do not interact with the productive sector the economy. Dis-synergies associated with this category are excluded from the IMPLAN model for the purposes of estimating employment effects.

Network Opex Costs to Achieve: This category represents payments required to terminate leases on wireless towers and backhaul no longer needed as a result of the Transaction and demolition of extraneous sites. Payments to terminate leases are transfers with no employment multiplier effect and are excluded from the employment model. The remaining demolition expenditures represent labor and are assigned to the IMPLAN sector for "construction of new power and communications equipment."[18]

Sales, Service and Marketing Opex Costs to Achieve: This category represents payments to terminate leases associated with closing stores. Payments to terminate leases are transfers with

[17] The assignment of expenditures to the IMPLAN industry "management of companies and enterprises" is based on the NAICS sector 55111: "offices of other holding companies," "offices of bank holding companies" and "corporate, subsidiary, and regional managing offices." According to the U.S. Census Bureau, the NAICS code 55111 "comprises (1) establishments primarily engaged in holding the securities of (or other equity interests in) companies and enterprises for the purpose of owning a controlling interest or influencing the management decisions or (2) establishments (except government establishments) that administer, oversee, and manage other establishments of the company or enterprise and that normally undertake the strategic or organizational planning and decision making role of the company or enterprise." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 55111" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=55111&naicslevel=5#). For a detailed explanation of the expenditures assigned to IMPLAN industry "wholesale trade," see *infra* at n. 3. The assignment of expenditures to the IMPLAN industry "legal services" is based on the NAICS sector 5411 "legal services." According to the U.S. Census Bureau: "This industry group comprises establishments primarily engaged in offering legal services such as offices of lawyers, notaries, title abstract and settlement offices, and all other legal services such as patent agent services, paralegal services, and process serving services." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 5411" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=5411&naicslevel=4#). The professional services included in this category extend beyond legal and include additional savings on payments to third-party warehousing services and payments processors, etc. Because IMPLAN's legal services sector has an employment multiplier that is high relative to the other third-party services associated with this category, this classification is conservative as it likely overestimates job reductions attributable to this category of synergies.

[18] For a detailed explanation of the expenditures assigned to IMPLAN industry "construction of new power and communications equipment," see *infra* at n. 2.

no employment multiplier effect and are excluded from the employment model. Thus, none of the outlays associated with this category result in employment effects.

Back Office Opex Costs to Achieve: This category represents spending on new IT systems directly related to consummating the merger. Expenditures associated with incentive payments such as bonuses and retention payments are excluded as transfers. Expenditures on merger-specific legal and professional services projected in 2018 are conservatively assumed to take place in 2019 instead and are assigned to the "legal services" category.[19] Nearly all of the remaining expenditures are associated with integration and implementation of new IT systems and are assigned the IMPLAN sector for "computer systems design services."[20]

Customers Opex Costs to Achieve: This category represents the cost of substituting handsets that are compatible with the New T-Mobile's network for handsets that will become incompatible as a result of the Transaction. While accelerated handset replacement may cause some increase in final demand, these expenditures are excluded from the IMPLAN model and do not affect the employment estimates.

Growth Opportunities

For growth opportunities, because deflated revenue is a measure of output from new business activities, the appropriately deflated projected revenues can be used directly as inputs into the IMPLAN model. The assignment of these revenues for use in the IMPLAN model is described below.

Rural Growth Opportunities: This category represents new retail sales related to the expansion of New T-Mobile's rural footprint. The revenues for this category are assigned to the IMPLAN sector, for "wireless telecommunications carriers (except satellite)."[21]

Enterprise Growth Opportunities: This category represents new sales to enterprise customers which New T-Mobile will be able to achieve as a result of the Transaction. The revenues for this category are assigned to the IMPLAN sector is "satellite, telecommunications resellers, and all other telecommunications," as telecommunications resellers typically maintain large enterprise salesforces and T-Mobile's business operations in this area will most closely resemble the activities of a telecommunications reseller.[22]

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[19] For a detailed explanation of the expenditures assigned to IMPLAN industry "legal services," see *infra* at n. 17.

[20] For a detailed explanation of the expenditures assigned to IMPLAN industry "computer systems design services," see *infra* at n. 4.

[21] The assignment of expenditures to the IMPLAN industry "wireless telecommunications carriers (except satellite)" is based on the NAICS sector 517210, "wireless telecommunications carriers (except satellite)." According to the U.S. Census Bureau: "This industry comprises establishments engaged in operating and maintaining switching and transmission facilities to provide communications via the airwaves. Establishments in this industry have spectrum licenses and provide services using that spectrum, such as cellular phone services, paging services, wireless Internet access, and wireless video services." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 517210" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=517210&naicslevel=6#).

[22] The assignment of expenditures to the IMPLAN industry "satellite, telecommunications resellers, and all other telecommunications" is based on the NAICS sectors 517410, 517911 and 517919: "satellite telecommunications," "telecommunications resellers" and "all other telecommunications." According to the U.S. Census Bureau, the

IoT Growth Opportunities: This category represents revenues derived from New T-Mobile's entry into the IoT connectivity business. Because New T-Mobile plans to offer services alongside its connectivity business, [redacted] percent of the revenues for the category are allocated to the IMPLAN sector for "wireless telecommunications carriers (except satellite)" and [redacted] percent are allocated to the IMPLAN sector for "computer systems design services."[23]

Home Broadband Replacement Growth Opportunities: This category represents revenues derived from T-Mobile's entry in the provision of retail home broadband replacement service. The revenues for this category are assigned to the IMPLAN sector for "wired telecommunications carriers."[24]

Video Growth Opportunities: This category represents revenues related to New T-Mobile's expansion of video offerings designed to compete with traditional cable offerings. The revenues for this category are assigned to the IMPLAN sector for "data processing, hosting, and related services."[25]

NAICS sector 517410 "comprises establishments primarily engaged in providing telecommunications services to other establishments in the telecommunications and broadcasting industries by forwarding and receiving communications signals via a system of satellites or reselling satellite telecommunications." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 517410" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=517410&naicslevel=6#). According to the U.S. Census Bureau, the NAICS sector 517911 "comprises establishments engaged in purchasing access and network capacity from owners and operators of telecommunications networks and reselling wired and wireless telecommunications services (except satellite) to businesses and households. Establishments in this industry resell telecommunications; they do not operate transmission facilities and infrastructure. Mobile virtual network operators (MVNOs) are included in this industry." U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 517911" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=517911&naicslevel=6#). According to the U.S. Census Bureau, the NAICS sector 517919 "comprises establishments primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation. This industry also includes establishments primarily engaged in providing satellite terminal stations and associated facilities connected with one or more terrestrial systems and capable of transmitting telecommunications to, and receiving telecommunications from, satellite systems. Establishments providing Internet services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry." U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 517919" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=517919&naicslevel=6#).

[23] For a detailed explanation of the expenditures assigned to IMPLAN industry "wireless telecommunications carriers (except satellite)," see *infra* at n. 21. For a detailed explanation of the expenditures assigned to IMPLAN industry "computer systems design services," see *infra* at n. 4.

[24] For a detailed explanation of the expenditures assigned to IMPLAN industry "wired telecommunications carriers," see *infra* at n. 11.

[25] The assignment of expenditures to the IMPLAN industry "data processing, hosting, and related services" is based on the NAICS sector 518210, "data processing, hosting, and related services." According to the U.S. Census Bureau: "This industry comprises establishments primarily engaged in providing infrastructure for hosting or data processing services. These establishments may provide specialized hosting activities, such as web hosting, streaming services or application hosting; provide application service provisioning; or may provide general time-share mainframe facilities to clients. Data processing establishments provide complete processing and specialized reports from data supplied by clients or provide automated data processing and data entry services." See U.S. Census Bureau, "Industry Statistics Portal 2012 NAICS: 518210" (available at https://www.census.gov/econ/isp/sampler.php?naicscode=518210&naicslevel=6#).

TABLE C-1:
EMPLOYMENT-RELATED CHANGES IN EXPENDITURES AND REVENUES
($2016 BILLIONS) (2019-2023)

	2019	2020	2021	2022	2023	2019-2023
Capex	[redacted]					
Network & Rural/Enterprise Synergies	[redacted]					
Sales, Service & Marketing	[redacted]					
Back Office	[redacted]					
Rural Costs to Achieve	[redacted]					
IoT	[redacted]					
Home Broadband Replacement	[redacted]					
Video	[redacted]					
Capex Total	[redacted]					
Opex	[redacted]					
Synergies	[redacted]					
Network	[redacted]					
Sales, Service & Marketing	[redacted]					
Store Consolidation	[redacted]					
Labor	[redacted]					
Dealer Opportunity	[redacted]					
Advertising	[redacted]					
Customer Care	[redacted]					
Back Office	[redacted]					
Costs to Achieve	[redacted]					
Network	[redacted]					
Back Office IT	[redacted]					
Back Office Merger	[redacted]					
Opex Total	[redacted]					
Growth Opportunities	[redacted]					
Rural	[redacted]					
Enterprise	[redacted]					
IoT	[redacted]					
Home Broadband Replacement	[redacted]					
Video	[redacted]					
Growth Opportunities Total	[redacted]					
Total	[redacted]					

Sources: Table 1; Table 2; Table 3; Bureau of Labor Statistics, Consumer Price Index (CPI) All Urban Consumers (Current Series) (Series ID CUUR0000SA0) (available at https://www.bls.gov/data/). Note: [1] The adjustments to each category are described above. [2] Expenditures are deflated to 2016 dollars assuming CPI increases at the same annual rate as the increase from 2016 to 2017.

EXHIBIT D:
EMPLOYMENT MULTIPLIERS BY EXPENDITURE CATEGORY

Category	Sector Description	Weight	Direct	Indirect	Induced	Total
Capex		[redacted]				
Network & Rural/Enterprise Synergies		[redacted]				
	Wireless Equipment	[redacted]				
	Network Construction	[redacted]				
Sales, Service & Marketing		[redacted]				
	Building Construction	[redacted]				
	Wholesale Trade	[redacted]				
Back Office	IT Services	[redacted]				
Rural Costs to Achieve		[redacted]				
	Building Construction	[redacted]				
	Wholesale Trade	[redacted]				
IoT	Custom Software Development	[redacted]				
Home Broadband Replacement	Wireless Equipment	[redacted]				
Video	Wired Telecommunications	[redacted]				
Opex		[redacted]				
Synergies		[redacted]				
Network		[redacted]				
	Utilities	[redacted]				
	Network Maintenance	[redacted]				
	Wireless Equipment	[redacted]				
Sales, Service & Marketing		[redacted]				
Store Consolidation	Retail	[redacted]				
Labor	Retail	[redacted]				
Dealer Opportunity	Retail	[redacted]				
Advertising	Advertising	[redacted]				
Customer Care	Customer Care	[redacted]				
Back Office		[redacted]				
	Corporate Management	[redacted]				
	Wholesale Trade	[redacted]				
	Legal Services	[redacted]				
Costs to Achieve		[redacted]				
Network	Network Construction	[redacted]				
Back Office IT	IT Services	[redacted]				
Back Office Merger	Legal Services	[redacted]				
Growth Opportunities		[redacted]				
Rural	Wireless	[redacted]				
Enterprise	Telecom Resellers	[redacted]				
IoT		[redacted]				
	Wireless	[redacted]				
	IT Services	[redacted]				
Home Broadband Replacement	Wired Telecommunications	[redacted]				
Video	Video Streaming	[redacted]				

Sources: Exhibit C; IMPLAN (Model Year 2016). Note: Sector descriptions correspond to the following IMPLAN industry sectors (sector description: IMPLAN sector): Advertising: 457 Advertising, public relations, and related services; Building Construction: 57 Construction of new commercial structures; Corporate Management: 461 Management of Companies and Enterprises; Customer Care: 465 Business support services; Custom Software Development: 451 Custom computer programming services; IT Services: 452 Computer systems design services; Legal Services: 447 Legal Services; Network Construction/Maintenance: 54 Construction of new power and communications structures; Retail: 398 Retail - Electronics and Appliance Stores; Telecom Resellers: 429 Satellite, Telecommunications Resellers, and All Other Telecommunications; Utilities: 42 Electric Power Generation - Fossil Fuel; Video Streaming: 430 Data Processing, Hosting, and Related Services; Wholesale Trade: 395 Wholesale Trade; Wired Telecommunications: 427 Wired Telecommunications Carriers; Wireless: 428 Wireless Telecommunications Carriers (except Satellite); Wireless Equipment: 305 Broadcast and Wireless Communications Equipment Manufacturing.

EXHIBIT E:
TOTAL EMPLOYMENT EFFECTS OF THE TRANSACTION BY EXPENDITURE CATEGORY (THOUSAND JOB-YEARS) (2019-2023)

	2019	2020	2021	2022	2023	2019-2023
Capex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Network & Rural/Enterprise Synergies	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Sales, Service & Marketing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Back Office	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Rural Costs to Achieve	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
IoT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Home Broadband Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Video	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Capex Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Opex	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Synergies	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Network	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Sales, Service & Marketing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Store Consolidation	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Labor	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Dealer Opportunity	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Advertising	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customer Care	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Back Office	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Costs to Achieve	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Network	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Back Office IT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Back Office Merger	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Opex Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Growth Opportunities	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Rural	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Enterprise	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
IoT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Home Broadband Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Video	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Growth Opportunities Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Sources: Exhibit C; Exhibit D. Note: Estimates exclude employment effects enabled by accelerated 5G deployment.

EXHIBIT F:
LABOR FORCE PARTICIPATION

The IMPLAN job creation estimates in this declaration are premised on the availability of additional workers.

According to the 2018 *Economic Report of the President*, the overall "labor force participation rate of the U.S. noninstitutional civilian population in 2017 was 62.8 percent, the culmination of a multiyear decline beginning in roughly 1990."[83] While the ratio of employment to population eventually returned to parity for the 1980 and 1990 business cycles, the 2001-2007 business cycle "never recovered from its initial decline, and the employment declines during the Great Recession simply layered on to these still-depressed rates. As a result, not only is the ratio of employment to population in 2017:Q4 below the value in 2007:Q4, it also remains below the ratio at the beginning of the 2001 recession."[84]

For prime-age workers, participation rates have fallen almost continuously between 1970 and 2017 and "were at 91.6 percent of their 1970 level for men age 45–54, 93.6 percent for men age 35–44 and 92.1 percent for men age 25–34."[85] Until roughly 2000, the labor force participation of women approximately offset the decline in labor participation for men, but "since then all age/sex labor force participation groups are below their 2000 levels, producing a fall in the prime-age participation rate over the past 17 years."[86]

Increasing the labor participation rate would have significant economic benefits. As the 2018 *Economic Report of the President* explains, "a return of the prime-age participation rate to the rate apparent in 2007 (still well below the rate apparent in 2000) would return about 1.7 million U.S. workers to the labor force over 10 years and raise the overall participation rate by 0.065 percentage point a year, resulting in an increase of 0.1 percentage point a year in the rate of GDP growth."[87]

The *Report* specifically notes that policies that successfully "encourage business formation and capital spending" could "drive up the demand for labor and wages and increase labor force participation"[88] and would thus have a "material impact on long-run economic growth."[89] The report further asserts that policies that increase the labor supply are "necessary to set the United States on a path of higher employment growth."[90]

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[83] Council of Economic Advisers, *Economic Report of the President Together with the Annual Report of the Council of Economic Advisers* (February 2018) at 129 (available at https://www.whitehouse.gov/wp-content/uploads/2018/02/ERP_2018_Final-FINAL.pdf).
[84] *Id.* at 125.
[85] *Id.* at 144.
[86] *Ibid.*
[87] *Id.* at 156.
[88] *Id.* at 155.
[89] *Id.* at 110.
[90] *Id.* at 156.

The *Report* also specifically notes that increasing infrastructure spending could cause a rise in labor demand for infrastructure construction and design occupations and related fields.[91] Compared to the overall U.S. labor force, "the current stock of infrastructure workers in the labor force is disproportionately drawn from the population with a high school degree or less, indicating that enhanced labor demand would disproportionately benefit those with fewer years of formal education, precisely the segment of the population where there is the most excess supply.[92] The report further estimates "an excess supply of nearly 350,000 infrastructure workers relative to the unemployment rate for workers in non-infrastructure occupations."[93]

FIGURE F-1:
LABOR FORCE PARTICIPATION BY QUARTER
(1965-2018)

Source: Bureau of Labor Statistics, "Labor Force Statistics from the Current Population Survey: (Seas) Labor Force Participation Rate (Series ID LNS11300000)" (available at https://beta.bls.gov/dataViewer/view/timeseries/LNS11300000;jsessionid=5E399B790A95B2FC668FA8796728E9A1). Notes: [1] Data include all civilians aged 16 years and over. [2] The labor participation rate in 2018 is calculated as the average rate for the months of January through April.

[91] *Id.* at 163.
[92] *Ibid.*
[93] *Id.* at 175.

APPENDIX J: LOW-BAND SPECTRUM AGGREGATION

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In the *Mobile Spectrum Holdings Report and Order*, the Commission found that it is in the public interest to continue to use its spectrum screen and case-by-case review and, in addition, "to require that any increase in spectrum holdings of below 1 GHz be treated as an 'enhanced factor' in its review if post-transaction the acquiring entity would hold approximately one-third or more (*i.e*., more than 68.5 MHz) of such spectrum."[1] As explained by the Commission, the low-band enhanced review was necessary because "low-band spectrum is less costly to deploy and provides higher quality coverage than higher-band spectrum, and *the two leading nationwide providers hold most of the low-band spectrum available today*."[2] The Commission further opined that if AT&T and Verizon "were to acquire all, or substantially all, of the remaining low-band spectrum, they would benefit, independently of any deployment, to the extent that rival service providers are denied its use."[3] Thus, enhanced review was initially a tool to provide extra scrutiny to transactions involving "*the two leading nationwide providers*," not companies like Sprint or T-Mobile.

Nonetheless, the "enhanced factor" analysis is not explicitly confined to review of transactions involving AT&T and Verizon and, accordingly, T-Mobile and Sprint have provided additional details in this attachment to conform to the enhanced factor review policies. In such

[1] *Application of AT&T Mobility Spectrum LLC and North Dakota Network Co. For Consent To Assign License,* 32 FCC Rcd 163, 166 (2017) ("*AT&T-NDN Order*") (*citing Policies Regarding Mobile Spectrum Holdings*, 29 FCC Rcd 6133, 6223-24 (2014) ("*Mobile Spectrum Holdings Report and Order*")).

[2] *Application of AT&T Mobility Spectrum LLC and Kaplan Telephone Company, Inc. For Consent To Assign Licenses*, 30 FCC Rcd 8502, 8508 (2015) ("*AT&T-Kaplan Order*"); *see also Applications of AT&T Mobility Spectrum LLC and KanOkla Telephone Association For Consent To Assign* Licenses, 30 FCC Rcd 8555, 8559 (2015)("*AT&T-KanOkla Order*"); *Application of AT&T Mobility Puerto Rico Inc. and Worldcall Inc. For Consent To Assign Licenses*, 30 FCC Rcd 9763, 9767-68 (2015) ("*AT&T-Worldcall Order*"); *Application of AT&T Mobility Spectrum LLC and Consolidated Telephone Company For Consent To Assign Licenses*, 30 FCC Rcd 9797, 9801 (2015) ("*AT&T-Consolidated Order*"); *Application of Hardy Cellular Telephone Company and McBride Spectrum Partners, LLC For Consent To Assign License*, 30 FCC Rcd 9899, 9903 (2015) ("*Hardy-McBride Order*"); *Application of AT&T Mobility Spectrum LLC and Club 42CM Limited Partnership For Consent To Assign Licenses*, 30 FCC Rcd 13055, 13061-62 (2015) ("*AT&T-Club 42 Order*"); *AT&T-NDN Order* at 166.

[3] *Id*.

regards, "[w]hen considering the potential competitive effects of increased spectrum aggregation as a result of a proposed transaction," the factors the FCC will consider include: "whether there would be an increased likelihood that rival service providers or potential entrants would be foreclosed from expanding capacity, deploying mobile broadband technologies, or entering the market, and also whether rivals' costs would be increased to the extent that they would be less likely to be able to compete robustly."[4] In undertaking this analysis, the FCC examines "competitive variables" that include, but are not limited to: "the total number of rival service providers; the number of rival firms that can offer competitive service plans; the coverage by technology of the firms' respective networks; the rival firms' market shares; the combined entity's post-transaction market share and how that share changes as a result of the transaction; the amount of spectrum suitable for the provision of mobile telephony/broadband services controlled by the combined entity; and the spectrum holdings of each of the rival service providers."[5] Importantly, a factor the FCC has found important in a number of decisions has been whether "other rival service providers were provided with the opportunity to acquire [the] below-1-GHz spectrum . . ., but did not choose to do so."[6]

If potential competitive harms are identified, the FCC applies several criteria in determining whether a claimed benefit to the transaction should be considered and weighed against potential harms. In prior transactions, the FCC has recognized benefits that include

[4] *AT&T-Kaplan Order*, 30 FCC Rcd at 8509; *see also AT&T-KanOkla Order*, 30 FCC Rcd at 8559-60; *AT&T-Worldcall Order*, 30 FCC Rcd at 9768; *AT&T-Consolidated Order*, 30 FCC Rcd at 9801-02; *Hardy-McBride Order*, 30 FCC Rcd at 9903; *AT&T-Club 42 Order*, 30 FCC Rcd at 13062-63; *AT&T-NDN Order*, 32 FCC Rcd at 167.

[5] *AT&T-Kaplan Order*, 30 FCC Rcd at 8512; *see also AT&T-KanOkla Order*, 30 FCC Rcd at 8562; *AT&T-Worldcall Order*, 30 FCC Rcd at 9770; *AT&T-Consolidated Order*, 30 FCC Rcd at 9803-04; *Hardy-McBride Order*, 30 FCC Rcd at 9905; *AT&T-Club 42 Order*, 30 FCC Rcd at 13071; *AT&T-NDN Order*, 32 FCC Rcd at 169.

[6] *AT&T-Kaplan Order*, 30 FCC Rcd at 8514; *see also AT&T-KanOkla Order*, 30 FCC Rcd at 8563; *AT&T-Club 42 Order*, 30 FCC Rcd at 13068, 73 (noting "the spectrum was offered openly, through a broker, and that other service providers had the same opportunity as AT&T to purchase Club 42's licenses"); *AT&T-NDN Order*, 30 FCC Rcd at 170.

increases in “system capacity to enhance existing services, better accommodate its overall growth, and facilitate the provision of additional products and services.”[7] And, in particular, the FCC has recognized the ability to deploy larger LTE carriers, stating, for example, that “that the relative gain in capacity from a 10×10 megahertz block is greater than the total capacity of two separate 5×5 megahertz blocks, and that wider bandwidth results in noticeably better performance for users.”[8] Notably, the FCC has recognized an Applicant’s argument that “additional spectrum is ‘essential’ to improving its system throughput speeds, such that it can provide an LTE experience comparable to its competitors, and thus bolster its long-term competitive position.”[9] The FCC has also recognized the benefits of continuity/seamlessness of services enabled through commonality of spectrum with adjacent markets.[10] The FCC also cited Applicants’ market-specific claims that low-band has superior characteristics within their service areas, noting that “the superior propagation characteristics of the proposed Lower 700 MHz spectrum are preferable for expanding LTE capacity in the rural, mountainous areas”[11] involved in the transaction and, in another case, that “the better in-building signal penetration of below-1-GHz spectrum is of particular use” in serving an area where “most structures use steel-reinforced concrete.”[12]

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[7] *AT&T-KanOkla Order*, 30 FCC Rcd at 8563-64; *AT&T-Kaplan Order*, 30 FCC Rcd at 8515; *AT&T-Worldcall Order*, 30 FCC Rcd at 9772; *AT&T-Consolidated Order*, 30 FCC Rcd at 9805; *Hardy-McBride Order*, 30 FCC Rcd at 9908; *AT&T-Club 42 Order*, 30 FCC Rcd at 13075; *AT&T-NDN Order*, 32 FCC Rcd at 170.

[8] *Id*.

[9] *Hardy-McBride Order*, 30 FCC Rcd at 9908.

[10] *AT&T-KanOkla Order*, 30 FCC Rcd at 8563-64; *AT&T-Kaplan Order*, 30 FCC Rcd at 8515; *AT&T-Worldcall Order*, 30 FCC Rcd at 9772; *AT&T-Consolidated Order*, 30 FCC Rcd at 9805; *Hardy-McBride Order*, 30 FCC Rcd at 9908; *AT&T-Club 42 Order*, 30 FCC Rcd at 13075; *AT&T-NDN Order*, 32 FCC Rcd at 170.

[11] *Hardy-McBride Order*, 30 FCC Rcd at 9908.

[12] *Application of TeleGuam Holdings, LLC and Club 42 CM Limited Partnership For Consent To Assign Licenses*, 30 FCC Rcd 10213 at ¶21 (2015).

As explained in the Public Interest Statement, this Transaction has not been undertaken for spectrum foreclosure purposes. While the New T-Mobile may end up with low-band spectrum in excess of the screen, the competitive situation in these markets demonstrates that the New T-Mobile is still likely to operate at a disadvantage, and that existing carriers have had adequate opportunities to acquire low-band spectrum if that was a competitive imperative. First, the New T-Mobile will generally compete with the two established 800 MHz cellular carriers, which have had decades to develop their low-band networks. The incumbent 800 MHz carriers are AT&T and Verizon, except in Puerto Rico, where the established 800 MHz cellular carriers are AT&T and Puerto Rico Telephone Company ("PRT"), the wireline telephone company, and Wyoming 3 – Lincoln, where the cellular operators are Verizon and Union Telephone Company. Notably, neither Verizon nor AT&T participated in the most recent low-band spectrum auction—the 600 MHz broadcast television incentive auction—in any meaningful way, and low-band 600 MHz spectrum remains unassigned in many of these markets. As the Applicants have shown, the coverage of the 800 MHz cellular incumbent's networks in these markets—for both 3G and 4G services—is typically more extensive than either T-Mobile or Sprint network in the region, and likely to have greater coverage than a combined network upon consummation.[13] As a final matter, the Public Interest Statement details how the New T-Mobile will apportion the use of its spectrum for 5G services—which includes the majority of its low-band 600 MHz assets. While the New T-Mobile will also use 2.5 GHz spectrum for 5G capacity builds, T-Mobile generally has no millimeter wave ("mmW") spectrum in these markets. A more rational

[13] The Applicants have based their coverage calculations upon the FCC's mapping data provided as of the end of the year 2016. While coverage may have improved since that time, any increased coverage by the incumbent cellular providers would reinforce the Applicant's argument that existing competitors are not disadvantaged. Increased deployment by T-Mobile and Sprint would demonstrate that the spectrum is not be used for foreclosure, but rather to compete.

spectrum comparison, therefore, would measure the New T-Mobile's 5G spectrum assets against the mmW holdings of other carriers in the market.

I. THE PUERTO RICO MARKETS

Applicants are addressing the Puerto Rico CMAs in a single analysis, since there is a great deal of uniformity with respect to spectrum holdings across the territory. The Puerto Rico market consists of San Juan-Caguas (CMA091), Ponce (CMA147), Mayaguez (CMA169), Arecibo (CMA202), Aguadilla (CMA204), Puerto Rico 1 – Rincon (CMA723), Puerto Rico 2 – Adjuntas (CMA724), Puerto Rico 3 – Ciales (CMA725), Puerto Rico 4 – Aibonito (CMA726), Puerto Rico 5 – Ceiba (CMA727), Puerto Rico 6 – Vieques (CMA728), and Puerto Rico 7 – Culebra (CMA729). As discussed below, with only minor variation, the spectrum situation in these markets plays out similarly.

The combined company will hold 76.85 MHz of low-band spectrum, exceeding the low-band screen, but the combination will not be anticompetitive. T-Mobile and its affiliates hold 50 MHz of low-band spectrum, including the 600 MHz C, D, E, F and G Blocks (10 MHz ea.) and Sprint and its affiliates hold 26.85 MHz of low-band spectrum, including the Upper 700 MHz C Block (22 MHz) and 800 MHz ESMR spectrum (4.85 MHz). As an initial matter, AT&T and PRT are the legacy cellular providers in the market, holding licenses that were granted in the early 1980s, and each has extensive coverage of the island. AT&T also holds the majority of the Lower 700 MHz C Block (12 MHz) and the D Block (6 MHz),[14] and PRT holds the Lower 700 MHz A and most of the B Blocks (12 MHz ea.).[15] DISH and its affiliates hold 26 MHz of low-

[14] In Rincón, Vieques and Culebra where it does not hold C Block 700 MHz spectrum, it holds the B Block. It holds both the B and C Block in Aibonito, Arroyo, Barranquitas, Coamo, Comerío, Guayama, Maunabo, Patillas, Santa Isabel, Yabucoa, Ceiba, and Naguabo.

[15] PRT does not hold the B Block in Rincón, Aibonito, Arroyo, Barranquitas, Coamo, Comerío, Guayama, Maunabo, Patillas, Santa Isabel, Yabucoa, Ceiba, and Naguabo.

band spectrum, including the 600 MHz A and B Blocks (10 MHz ea.) and the Lower 700 MHz E Block (6 MHz). In addition:

- AT&T and its affiliates hold 163 MHz or 175 MHz in aggregate in all but two counties,[16] including the AWS-1 A Block (20 MHz),[17] the AWS-1 C Block (10 MHz) and AWS-3 J Block (20 MHz), 20 MHz of 2 GHz PCS A Block, the 2 GHz PCS B Block (30 MHz), and the WCS A, B, C and D Blocks (20 MHz attributable total).

- PRT generally holds 99 MHz in aggregate, including the AWS-1 B Block (20 MHz), the AWS-3 G and H Blocks (10 MHz ea.), and the 2 GHz PCS E Block (10 MHz).

- DISH and its affiliates hold 91 MHz in aggregate, including the AWS-3 A1 Block (5 MHz), the AWS-3 I Block (10 MHz), the 2 GHz PCS H Block (10 MHz), and the AWS-4 A and B Blocks (20 MHz ea.).

- T-Mobile and its affiliates hold 115 MHz in aggregate, including the AWS-1 D, E and F Blocks (10, 10 and 20 MHz), 15 MHz of 2 GHz PCS C Block, and the 2 GHz PCS F Block (10 MHz).

- Sprint and its affiliates hold 157-210.5 MHz in aggregate, 10 MHz of 2 GHz PCS A Block, 15 MHz of 2 GHz PCS C Block, the 2 GHz D and G Blocks (10 MHz ea.), as well as variable amounts of BRS and EBS spectrum.

Notably, the overwhelming majority of the Applicants' low-band spectrum—62 MHz of the 76.85 MHz, including the 600 MHz blocks and the assignment of the 22 MHz Upper 700 MHz C Block—occurred after 2016. Thus, the Applicants' significant aggregation of low-band spectrum is relatively recent.

The FCC's recent 600 MHz auction conclusively demonstrates that the Applicants' acquisition of low-band spectrum is not anti-competitive. Specifically, according to the FCC's own bidding data, only five entities bid for PEA412, which encompassed all of Puerto Rico—T-Mobile, DISH, AT&T, PRT and Comcast. AT&T, for its part, zeroed its bidding in Round 25 when, apparently, it made the decision to exit the auction for reasons that seemingly have

[16] In Vieques and Culebra, AT&T holds 143 MHz.

[17] AT&T does not hold the A Block in Vieques and Culebra.

nothing to do with the Puerto Rican market.[18] PRT and Comcast ceased to bid at under $2.25/MHz-POP for licenses that ultimately sold for $2.75/MHz-POP. There is absolutely no reason to posit that PRT—the incumbent landline and wireless carrier in Puerto Rico—and Comcast—one of the largest communications companies in the world with a market capitalization of over $172B and annual revenues of more than $80B—were foreclosed from participation in the auction at those prices. Indeed, DISH was able to acquire several licenses in the auction, so it should be self-evident that the auction prices were not some premium intended to shut out new entry—ironically, given that AT&T and PRT are the longstanding incumbents in the market, it is those companies—not T-Mobile—who would have the incentive to foreclose further competition.

As a final matter, Applicants have provided coverage maps illustrating the positions of the carriers operating in Puerto Rico. As shown in Figs. 1-3, the coverage of T-Mobile, along with the networks of Joint Venture partners Sprint and Open Mobile, have the weakest coverage of the carriers operating in Puerto Rico. Unsurprisingly, the carriers with 800 MHz cellular—AT&T and PRT—have had years to develop rural coverage maximizing the benefits of low-band spectrum. The proposed transaction will enable further rural expansion, thus promoting competition in new areas.

[18] AT&T began sloughing off demand at the end of Stage 1, and reduced its desired volume to zero in virtually every market by the middle of Stage 3.

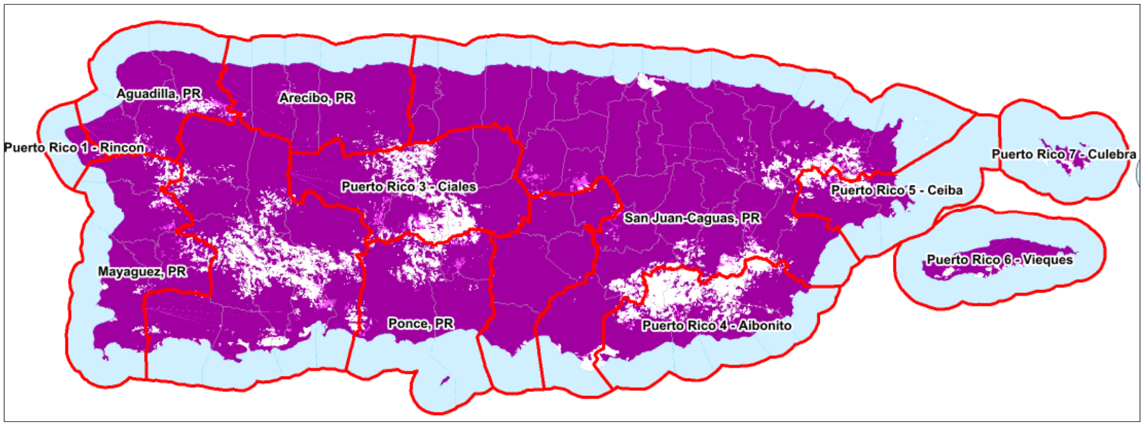

Figure 1: T-Mobile 3G (light) and 4G (dark) Coverage

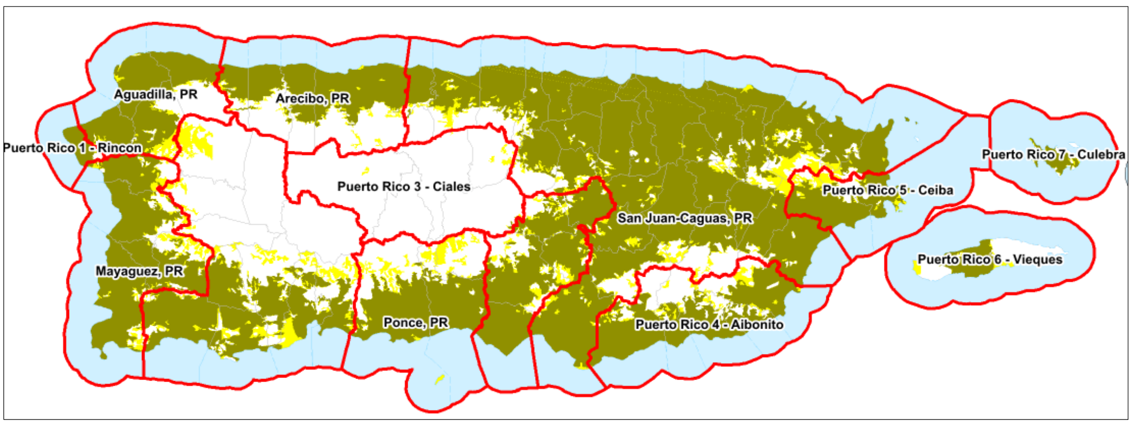

Figure 2: Sprint 3G (light) and 4G (dark) Coverage

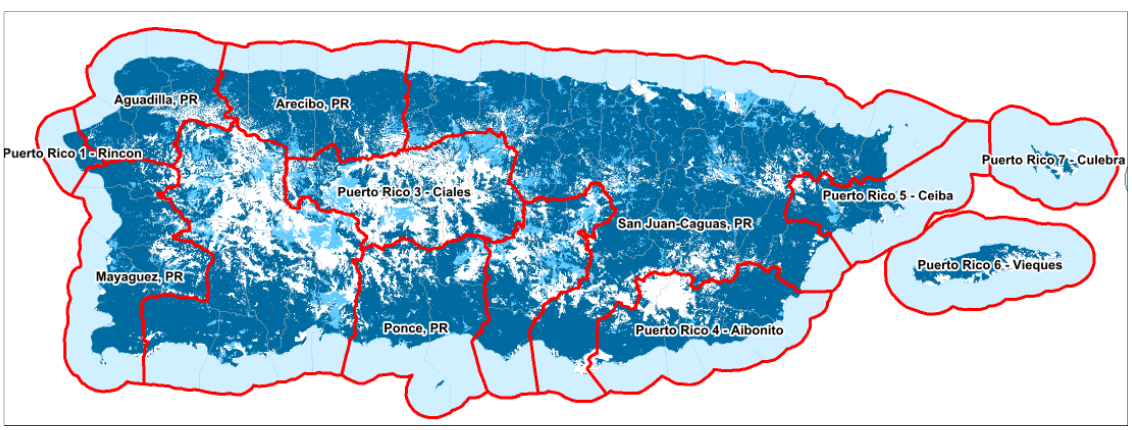

Figure 3: Open Mobile 3G (light) and 4G (dark) Coverage

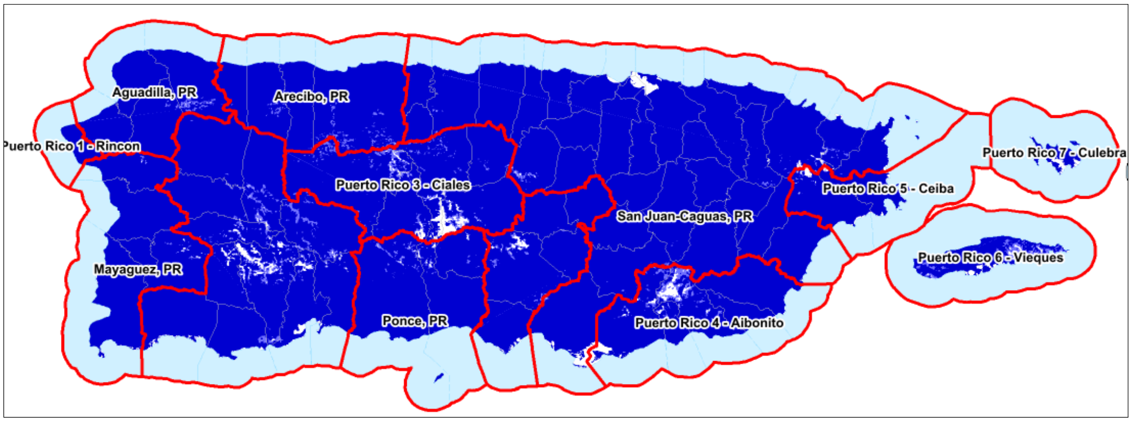

Figure 4: AT&T 3G (light) and 4G (dark) Coverage

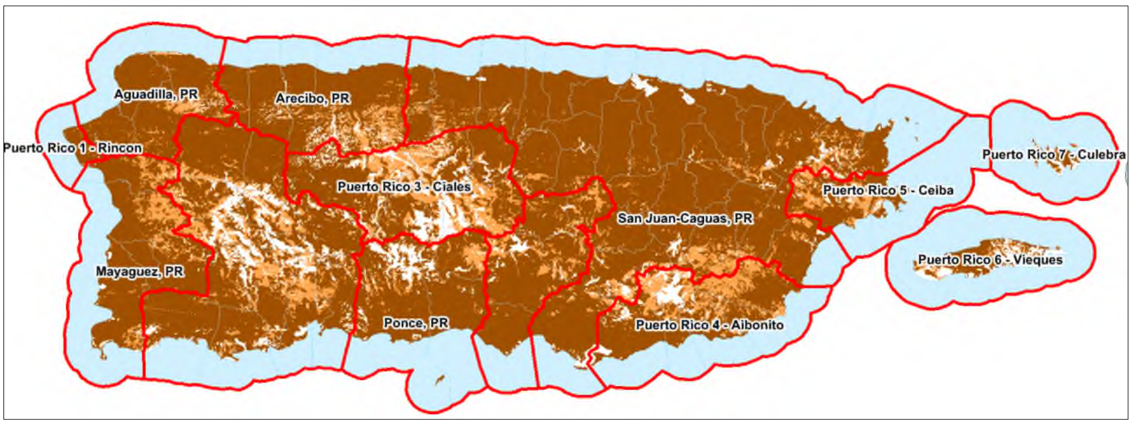

Figure 5: Puerto Rico Tel. Co. 3G (light) and 4G (dark) Coverage

It should also be noted that AT&T and Verizon both hold substantial mmW assets in Puerto Rico—Verizon holds 600 MHz of 39 GHz spectrum, and AT&T holds 200 MHz in the major population centers and a minimum of 100 MHz throughout the island. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. Still, that leaves New T-Mobile behind both AT&T and Verizon in 5G-specific spectrum. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

II. COLORADO SPRINGS, CO (CMA 117)

Applicants will hold a total of 76 MHz of attributable low-band spectrum in the Colorado Springs, CO CMA (CMA147). T-Mobile holds the B, C, D, E, and F Blocks in the 600 MHz band (10 MHz ea.), as well as the Lower 700 MHz A Block (12 MHz).[19] Sprint holds 14 MHz of 800 MHz ESMR spectrum.[20] The aggregation in this market, however, cannot be anticompetitive. As an initial matter, there is one unsold 10 MHz A Block license in the 600 MHz band. And, after the Final Stage Rule in the 600 MHz auction, the only competitors for the unrestricted blocks were T-Mobile, Comcast and DISH. But both of those competitors, who are hardly capital-constrained, dropped out of the market during the course of Stage 4. Indeed, T-Mobile was able to add a fourth unrestricted block at the very end of bidding. Clearly, if low-band spectrum were a barrier to competition in the market, competitors could have bid in the auction, but did not.

The lack of any competitive effects is also underscored in this market by the network coverage and spectrum holdings of existing competitors in the market. Once again, T-Mobile and Sprint arguably have the least market coverage, which, again, is unsurprising given that AT&T and Verizon hold the longstanding 800 MHz A and B Block licenses respectively. AT&T also holds 30 MHz of Lower 700 MHz spectrum in the low-band (B, C, and D Blocks) and Verizon holds the 22 MHz Upper 700 MHz C Block, so these carriers hold, respectively, 55 MHz and 47 MHz of low-band spectrum. DISH also acquired the 10 MHz G Block in the 600 MHz band and the 6 MHz E Block Lower 700 MHz license, and all of these entities also hold substantial mid-band spectrum:

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[19] T-Mobile also holds 10 MHz of the AWS-1 A Block, the 10 MHz AWS-1 E Block, the 20 MHz AWS-1 F Block, and the 30 MHz PCS B Block.

[20] Sprint also holds the 30 MHz PCS C Block, 10 MHz PCS G Block, 89 MHz of attributable EBS spectrum, and 61.5 MHz of attributable BRS spectrum.

- AT&T also holds 40 MHz of AWS-1/3 spectrum (C, D, H, and I Blocks) and 20-50 MHz of 2 GHz PCS spectrum (A, D, and F Block); and 20 MHz of attributable WCS spectrum (A, B, C, and D Blocks).

- Verizon also holds 50 MHz of AWS-1/3 spectrum (10 MHz of the A Block, and the B and J Blocks) and 10 MHz of 2 GHz PCS spectrum (E Block).

- DISH also holds the AWS-3 A1, B1, the 10 MHz H Block, as well as the 40 MHz of AWS-4 spectrum (A and B Block).

As shown in Fig. 6-9, AT&T has superior coverage to both T-Mobile and Sprint, and Verizon's coverage is at least on par with T-Mobile's. As a result, it would defy logic to suggest that T-Mobile would be the one attempting to foreclose competitors from acquiring low-band spectrum in this market.

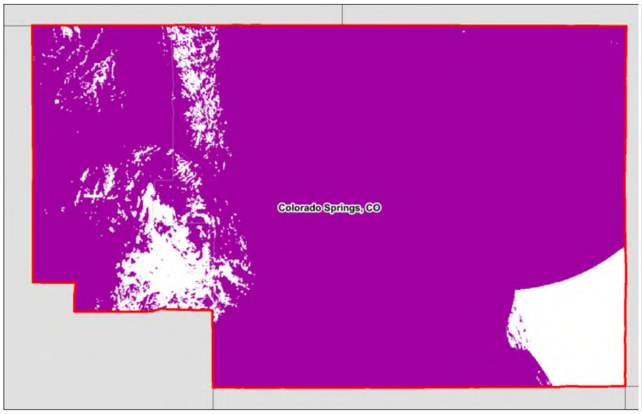

Figure 6: T-Mobile 3G and 4G Coverage

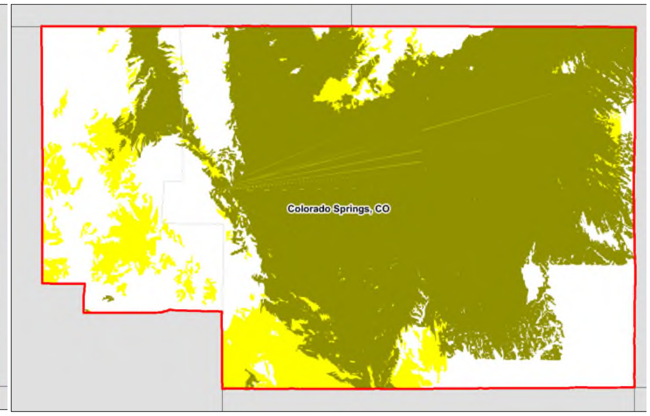

Figure 7: Sprint 3G and 4G Coverage

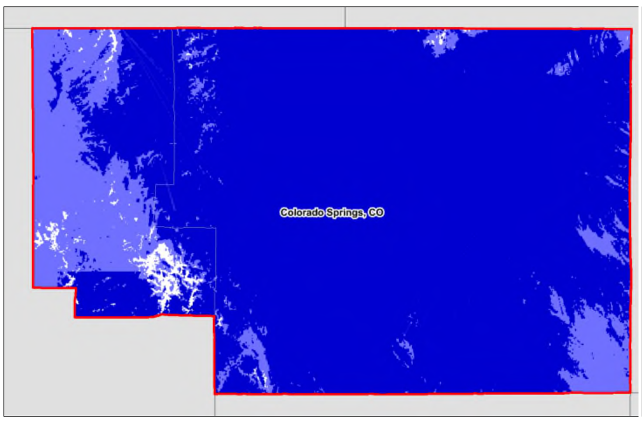

Figure 8: AT&T 3G and 4G Coverage

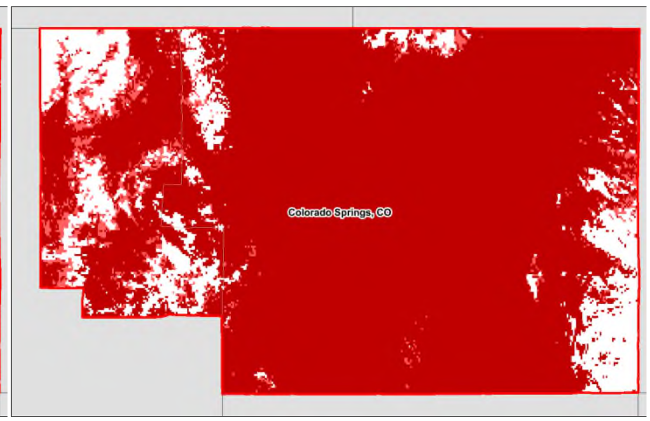

Figure 9: Verizon 3G and 4G Coverage

In addition, AT&T and Verizon each hold over 500 MHz of mmW spectrum in this market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted] Still, that leaves New T-Mobile well behind both AT&T and Verizon in 5G-specific spectrum. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

III. IDAHO 5 – BUTTE (CMA392)

The Applicants trigger the ID 5 – Butte low-band screen because of a single county—Butte, ID—the one county of the CMA that is in the Salmon, ID PEA (PEA407) rather than the Twin Falls, ID PEA (PEA274). While the Applicants low-band holdings are generally consistent in across both PEAs, with T-Mobile holding the B, C, D, and E Blocks in the 600 MHz band (10 MHz ea.) and the Lower 700 MHz A Block (12 MHz), and Sprint holding 14 MHz of 800 MHz ESMR spectrum, in the one PEA274 overlap county T-Mobile also holds the 600 MHz A Block, and therefore triggers the low-band screen with a total of 76 MHz of low-band attributable spectrum.[21] As discussed below, however, the aggregation should not be viewed as anti-competitive.

As an initial matter, the Applicants note that there is at least one unsold 600 MHz block—the G Block—across the CMA, and in all counties except Butte, the F Block is also unsold. In the county causing the trigger, T-Mobile further notes that the two winning bidders—DISH and T-Mobile—were the only bidders in the market until the 54th round of Stage 4, when SAL Spectrum, LLC tendered a series of bids lasting 3 rounds. That type of activity seems more opportunistic than strategic, so it should be clear that no other competitors, or potential entrants in the market, were denied an opportunity to secure low-band spectrum during the auction. Under the circumstances, there is no possible claim that the Applicants are engaged in anticompetitive warehousing.

The coverage and spectrum positions of competitors in the market also underscore the lack of any anticompetitive potential from the proposed transaction. Both AT&T and Verizon have superior coverage to either T-Mobile or Sprint. Verizon, in fact, has 72 MHz of low-band

[21] T-Mobile also holds 50 MHz of AWS-1/3 (E, F, G and H Blocks) and 30 MHz of PCS everywhere except Butte county, where it only holds 20 MHz (A Block). Sprint also holds 40 MHz of PCS (B and G Blocks), but does not hold any EBS or BRS.

spectrum in the market, including both 800 MHz cellular licenses and the 22 MHz Upper 700 MHz C Block license. Verizon also 40 MHz of AWS-1 spectrum (A and B Blocks) and 25 MHz of PCS (15 MHz of C Block and 10 MHz E Block). AT&T, for its part, holds 30 MHz of low-band spectrum—the Lower 700 MHz Blocks B, C and D—as well as 40 MHz of AWS-1/3 (C, D and J Blocks)[22] and 45 MHz of PCS (15 MHz of C Block and the D and F Blocks),[23] as well as 20 MHz of attributable WCS spectrum (A, B, C, and D Blocks). DISH has 10 MHz of 600 MHz spectrum (either A or F Block), the 6 MHz Lower 700 MHz E Block, 15 MHz of AWS-1/3 (A1 and B1 Blocks), and 40 MHz of AWS-4 (A and B Blocks).

[22] AT&T does not hold the 10 MHz C Block in Butte county—that license is held by Union Telephone Company.

[23] AT&T also holds 10 MHz of PCS A Block spectrum in Butte county, but does not hold the PCS F Block in Union county.

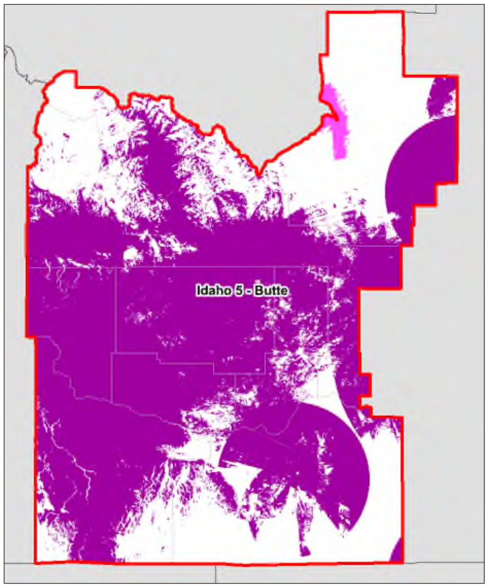

Figure 10: T-Mobile 3G and 4G Coverage

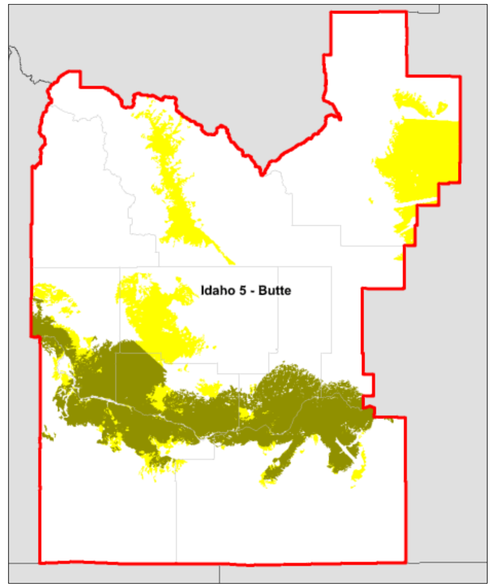

Figure 11: Sprint 3G and 4G Coverage

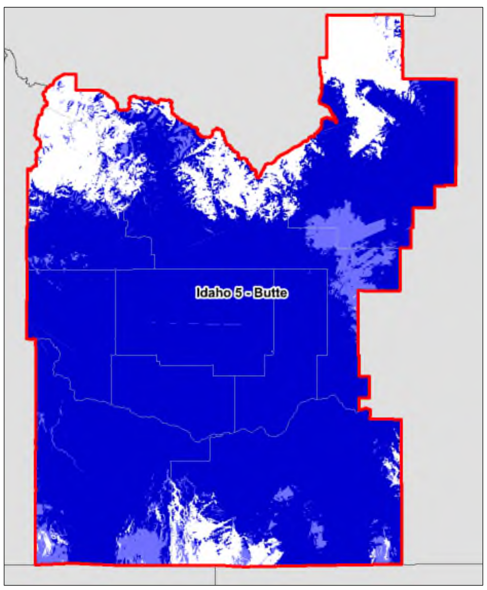

Figure 12: AT&T 3G and 4G Coverage

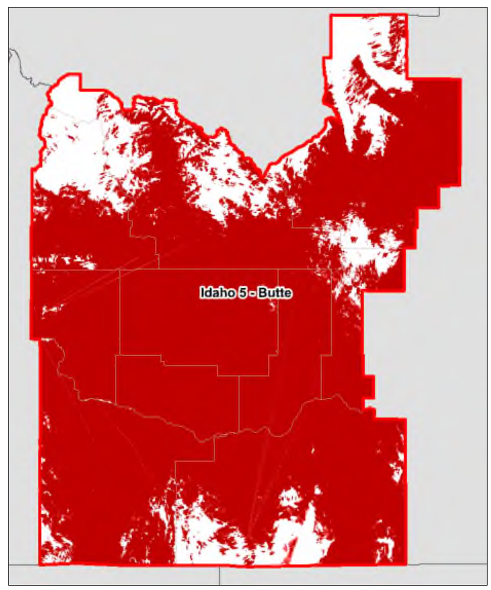

Figure 13: Verizon 3G and 4G Coverage

In addition, Verizon holds 300 MHz of mmW spectrum in this market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted] Still, that leaves New T-Mobile well behind Verizon in 5G-specific spectrum. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

IV. MONTANA 5 – MINERAL (CMA527)

The Applicants trigger the MT 5 – Mineral CMA because T-Mobile holds the B, C, D and E Blocks in the 600 MHz band and the A and B Blocks in the Lower 700 MHz band, and Sprint holds 14 MHz of 800 MHz ESMR.[24] However, as discussed below, this aggregation of 76 MHz does not present any competitive issues—the Applicants are well under the CMRS spectrum screen, for example. Moreover, there is 20 MHz of low-band spectrum (Blocks F and G) that remain unsold from the 600 MHz auction.

As shown in Figs. 14-16 by the coverage of their networks, AT&T and Verizon's mature low-band networks eclipse T-Mobile's coverage. Sprint has no coverage in the market. AT&T and Verizon both hold 800 MHz cellular authorizations—AT&T holds 43 MHz of low-band spectrum (800 MHz Cellular Block A and Lower 700 MHz Blocks C and D) and Verizon holds 47 MHz of low-band spectrum (800 MHz Cellular Block B and Upper 700 MHz Block C). AT&T also holds 50 MHz of AWS-1/3 (A, D and J Blocks); generally holds 50 MHz of PCS (10 MHz of Block B and Blocks C, E and F);[25] and holds 20 MHz of WCS (Blocks A, B, C, and D). Verizon also holds 40 MHz of AWS-1 (B, C and I Blocks) and 40 MHz of PCS (A Block and either D or E Block). DISH holds 16 MHz of low-band spectrum (600 MHz Block A and Lower 700 MHz Block E), as well as 15 MHz of AWS-1 (A1 and B1 Blocks), 10 MHz of PCS (H Block), and 40 MHz of AWS-4 (A and B Blocks).

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[24] T-Mobile also holds 40 MHz of AWS-1/3 (Blocks E, F and H) and 10 MHz of PCS (Block D), and Sprint also holds 30 MHz of PCS (20 MHz of B Block and G Block). T-Mobile also holds 10 MHz of PCS B Block in Powell, MT, but does not hold the PCS D Block in that county or in Lewis and Clark county. Sprint does not hold BRS or EBS in this market.

[25] AT&T does not hold the 10 MHz of PCS B Block and holds only 20 MHz of PCS C Block in Powell, MT, and does not hold the 10 MHz of PCS E Block in Mineral, Missoula and Ravalli, MT.

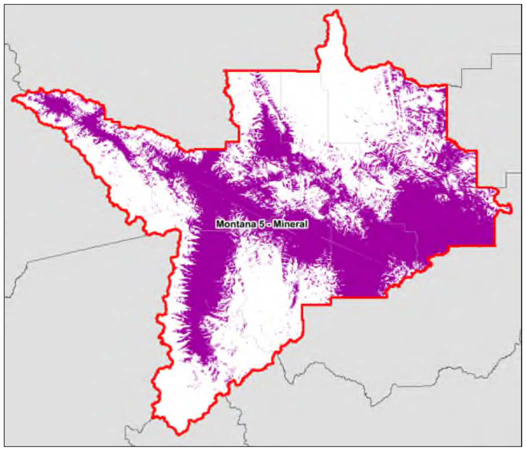

Figure 14: T-Mobile 3G and 4G Coverage

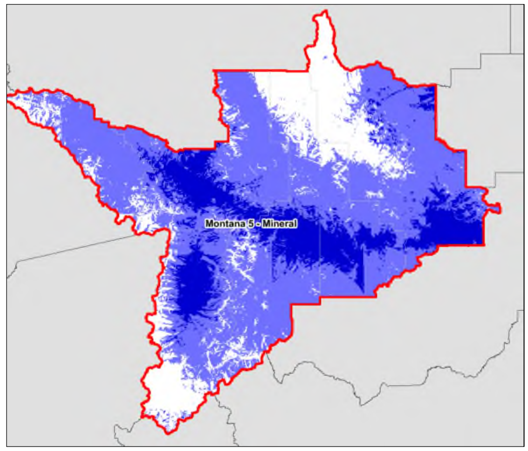

Figure 15: AT&T 3G and 4G Coverage

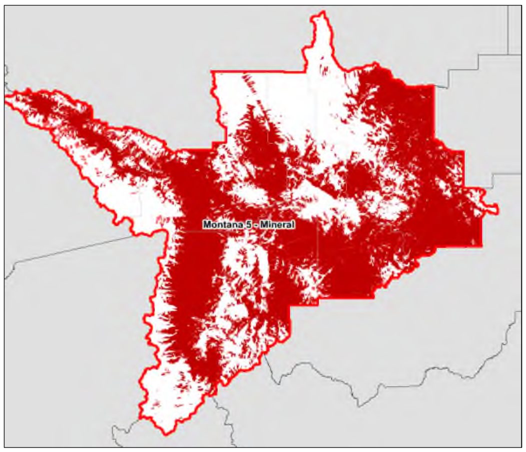

Figure 16: Verizon 3G and 4G Coverage

In addition, Verizon holds 600 MHz of mmW spectrum in this market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. Still, that leaves New T-Mobile well behind Verizon in 5G-specific spectrum. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

V. NORTH CAROLINA 15 – CABARRUS (CMA579)

The Applicants trigger the low-band screen in NC 15 – Cabarrus due to a single county—Davie, NC. Throughout the market, T-Mobile holds 40 MHz of 600 MHz spectrum (B, C, D and E Blocks) and the Lower 700 MHz A Block while Sprint holds 14 MHz of 800 MHz ESMR spectrum; but in Davie, T-Mobile also holds the 600 MHz A Block license, so it has a total of 76 MHz of attributable low-band spectrum.[26] As discussed below, however, this level of aggregation in this market is not a competitive issue and Applicants do not exceed the CMRS spectrum screen in Davie county.

As an initial matter, all of the entities that submitted bids in the 600 MHz auction for PEA234, which includes Davie county, were successful in obtaining spectrum in the auction. T-Mobile won five licenses, but DISH and Carolina West (CWW Consortium) each obtained 10 MHz of spectrum. There are also existing carriers with substantial low-band holdings—Verizon holds 72 MHz of low-band spectrum including both 800 MHz cellular licenses and the 22 MHz Upper 700 MHz C Block, as well as 60 MHz of mid-band spectrum.[27] AT&T holds 30 MHz of low-band spectrum (Lower 700 MHz B, C and D Blocks) and 110 MHz of mid-band spectrum.[28] DISH acquired 10 MHz in the 600 MHz auction, but also already held the 6 MHz Lower 700 MHz E Block.[29] And, as shown in Figs. 17-20, AT&T and Verizon both have footprints that

[26] T-Mobile also holds 20-30 MHz of AWS-1/3 (D and E Blocks, with I Block in Davie county) and 30 MHz of PCS (20 MHz of A Block and 10 MHz of C Block). Sprint holds 30-40 MHz of PCS (10 MHz of A Block, D and G Blocks, and E Block everywhere except Davie county) and varying amounts of EBS/BRS spectrum—notably, Sprint holds only 48.8 MHz of attributable EBS and 6 MHz of attributable BRS in Davie county.

[27] Verizon also holds 40 MHz of AWS-1/3 (B and F Blocks) and 20 MHz of PCS (20 MHz of C Block or 10 MHz of C Block with 10 MHz F Block).

[28] AT&T also holds 50 MHz of AWS-1/3 (A, C, and H and I or J Blocks); 40 MHz of PCS (B Block and E or F Block); and 20 MHz of attributable WCS (A, B, C, and D Blocks).

[29] DISH also holds 15 MHz of AWS-1/3 (A1 and B1 Blocks); the 10 MHz PCS H Block; and 40 MHz of AWS-4 (A and B Blocks).

exceed the coverage of either of the Applicants. Under the circumstances, it defies logic to suggest Applicants would be engaged in foreclosure.

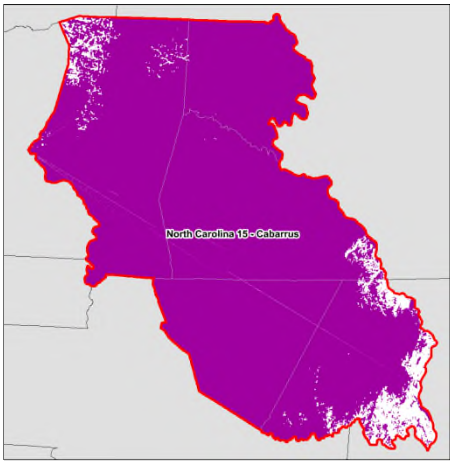

Figure 17: T-Mobile 3G and 4G Coverage

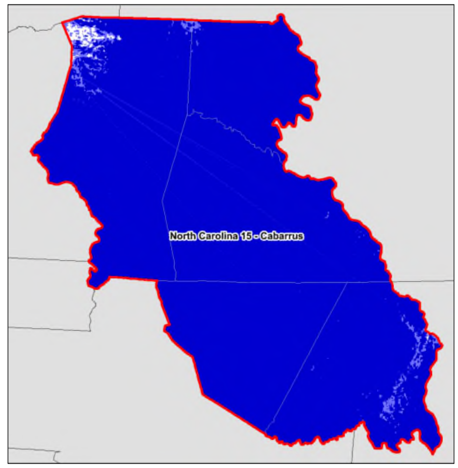

Figure 18: AT&T 3G and 4G Coverage

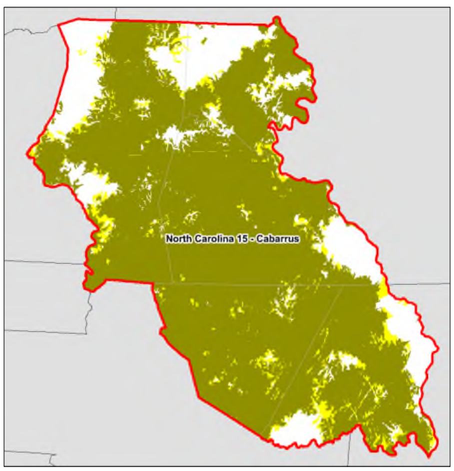

Figure 19: Sprint 3G and 4G Coverage

Figure 20: Verizon 3G and 4G Coverage

In addition, AT&T holds 300-400 MHz of mmW spectrum and Verizon holds 600 MHz of mmW spectrum in this market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. Still, that leaves New T-Mobile well behind both AT&T and Verizon in 5G-specific spectrum. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

VI. NORTH DAKOTA: BISMARCK (CMA298) AND ND – 5 KIDDER (CMA584)

The Applicants trigger the low-band screen in both counties in Bismarck, ND (CMA298) and in four of nine counties in ND 5 – Kidder (CMA584). In both cases, T-Mobile acquired the B, C, D and E Blocks in the recent 600 MHz auction. In Bismarck, T-Mobile already held the Lower 700 MHz A and C Block licenses, and in the four triggered counties of ND 5 - Kidder, T-Mobile held the A, B and C Blocks in the Lower 700 MHz band. Sprint, for its part, holds 14 MHz of 800 MHz SMR spectrum. Thus, the low-band screen in Bismarck is triggered with aggregate holdings of 78 MHz and, in the four counties of the RSA, with 90 MHz. As discussed below, however, there is no argument that low-band spectrum is a competitive issue in these RSAs.

As an initial matter, there was at least 10 MHz of unsold low-band spectrum in both Bismarck and in ND 5 – Kidder. In the latter case, in fact, there was 20 MHz of unsold low-band spectrum in the four counties of PEA395 in the market. There are also a substantial number of entities in these markets that hold low-band spectrum already—Verizon holds 49 MHz of low-band spectrum, including both the 22 MHz Upper 700 MHz C Block and the 800 MHz Cellular Block B license (25 MHz); AT&T holds 43 MHz of low-band spectrum, including the 800 MHz Cellular Block A license (25 MHz), and the Lower 700 MHz Block B (12 MHz) and Block D (6 MHz) licenses; DISH has 16 MHz of low-band spectrum, including 10 MHz of either the 600 MHz A or E Blocks and the 6 MHz Lower 700 MHz E Block; Spotlight Media Corporation holds the 600 MHz E Block (10 MHz) in the Bismarck CMA and 10 MHz of A Block 600 MHz spectrum in the four counties of ND 5 – Kidder that are triggered by the Applicants; and, Dakota Central Telecommunications Cooperative holds the Lower 700 MHz B and C Blocks the areas of ND 5 – Kidder where T-Mobile is not licensed. Notably, all of the entities tendering bids for PEA351—which includes the four counties of ND 5 – Kidder triggered by the Applicants—were able to obtain spectrum in the 600 MHz auction. It should therefore be self-evident that low-band spectrum is not a competitive issue in the North Dakota markets.

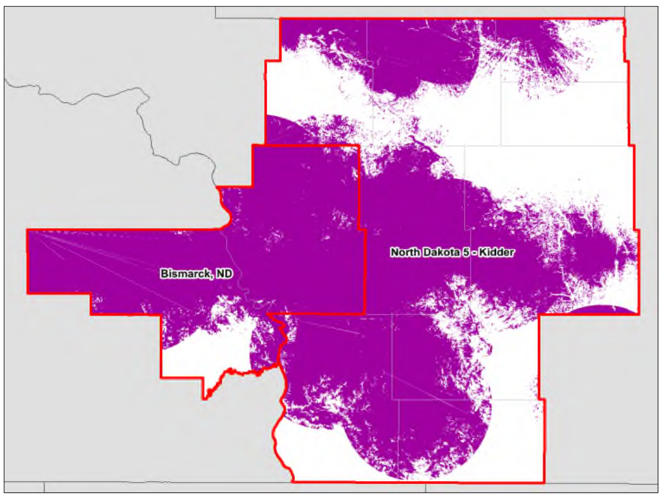

Figure 21: T-Mobile 3G and 4G Coverage

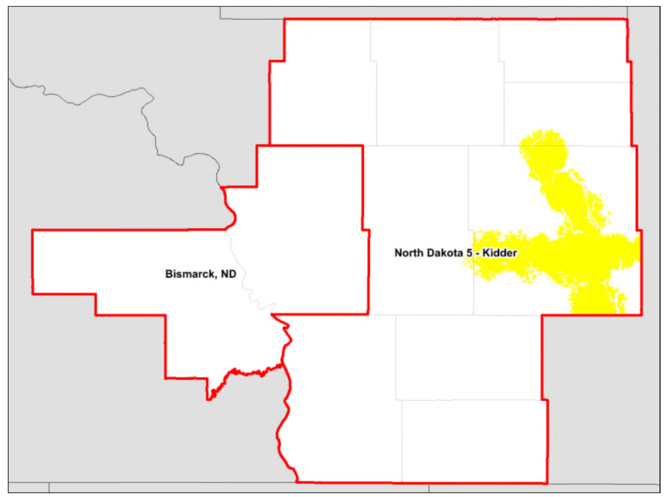

Figure 22: Sprint 3G Coverage

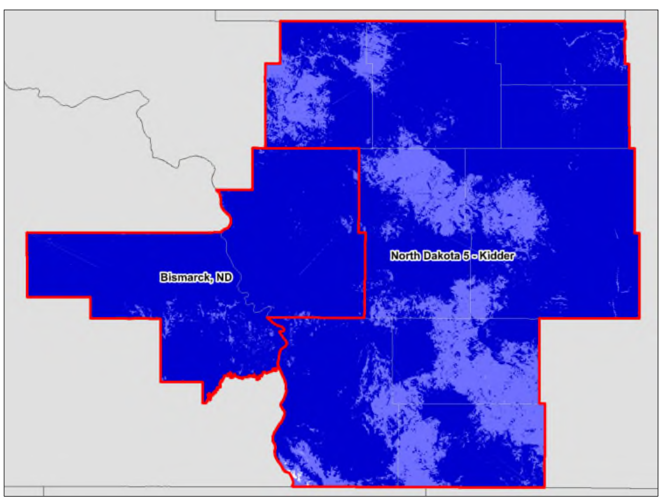

Figure 23: AT&T 3G and 4G Coverage

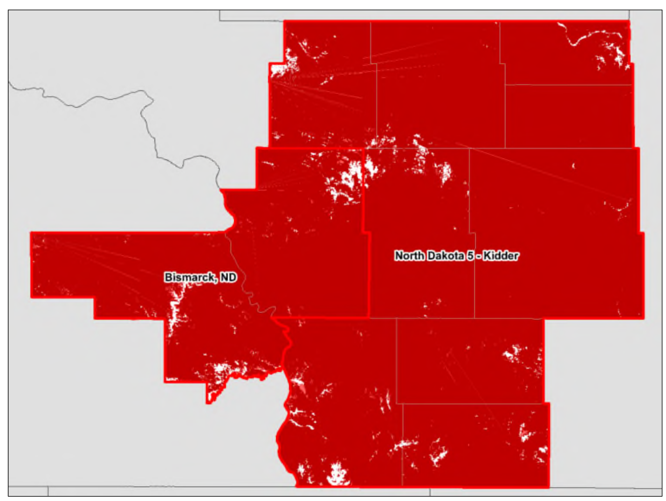

Figure 24: Verizon 3G and 4G Coverage

Moreover, as shown in Figs. 26-29, both of the incumbent 800 MHz cellular carriers—AT&T and Verizon, have coverage that far exceeds that of T-Mobile, and overwhelms that of Sprint.

In addition, AT&T holds 300-400 MHz of 39 GHz mmW spectrum and Verizon holds a staggering 1450 MHz—850 MHz of 28 GHz mmW spectrum and 600 MHz of 39 GHz mmW spectrum—in this market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. Still, that leaves New T-Mobile well behind both AT&T and Verizon in 5G-specific spectrum.

VII. OHIO 2 – SANDUSKY (CMA586)

The Applicants trigger the low-band screen in Ohio 2 – Sandusky (CMA586) in a single county because T-Mobile has the B, C, D, and E Blocks in the 600 MHz band, T-Mobile holds the 700 MHz A Block license, Sprint holds 14 MHz of 800 MHz ESMR, and T-Mobile has just filed to acquire the 700 MHz B Block license in that county—and aggregate of 78 MHz of low band spectrum.[30] T-Mobile also holds 20-30 MHz of AWS-1/3 (A and B Blocks and H Block in Erie and Huron counties); 20-30 MHz of PCS (20 MHz of C Block in Erie and Huron counties, 10 MHz of D Block in Sandusky and Seneca counties, 10 MHz of E or F Block). Sprint holds 40-60 MHz of PCS (10 MHz of A Block except in Seneca county, 10 MHz of C Block in Erie and Huron counties and 30 MHz of C Block in Sandusky and Seneca counties, D Block in Erie and Huron counties, E Block in Sandusky, and G Block); and varying amounts of EBS and BRS. As discussed below, however, the aggregation of 78 MHz of low-band spectrum in one county in this market by the Applicants is not anticompetitive.

[30] *See* ULS File No. 0008229173 (partitioned assignment of WQIZ361 from Bascom Advanced Services, Inc. dba Bascom Long Distance ("Bascom")). In two counties of the CMA (Erie and Huron), T-Mobile does not have the 600 MHz E B Block, and in the fourth (Seneca), T-Mobile is not acquiring the 700 MHz B Block from Bascom.

As an initial matter, the Applicants note that very few entities bid on these markets in the recent 600 MHz auction, and the only entity that did not win licenses was Omega Wireless, LLC, an entity that appears, based on its ownership, to have been formed for the purpose of investment in licenses. There are also incumbents with coverage footprints equal to, or superior, to that of T-Mobile or Sprint, companies that also possess significant low-band assets. Verizon, for example, holds the A Block 800 MHz cellular license as well as 22 MHz of Upper 700 MHz (the C Block). Verizon also holds 30 MHz of AWS-1/3 (D, E, and F Blocks) and 10-20 MHz of PCS (20 MHz of B Block in Sandusky county and 10 MHz F Block elsewhere). AT&T holds 18 MHz of 700 MHz low-band spectrum (C and D Blocks) and the 25 MHz B Block 800 MHz Cellular license. AT&T also hold 30 MHz of AWS-1/3 (C Block with either the H and I Blocks or the J Block); 30-60 MHz of PCS (A Block, 20 MHz of B Block in Erie and Huron counties and 30 MHz of B Block in Seneca county). As a final matter, DISH holds 16-26 MHz of low-band spectrum (600 MHz G Block, Lower 700 MHz E Block, and 600 MHz F Block in Erie and Huron counties), as well as 15-25 MHz of AWS-1/3 (A1 Block and I or J Block); 10 MHz of PCS (H Block) and 40 MHz of AWS-4 (A and B Blocks). Under the circumstances, there is no reason to believe the aggregation proposed by Applicants is anticompetitive in any way.

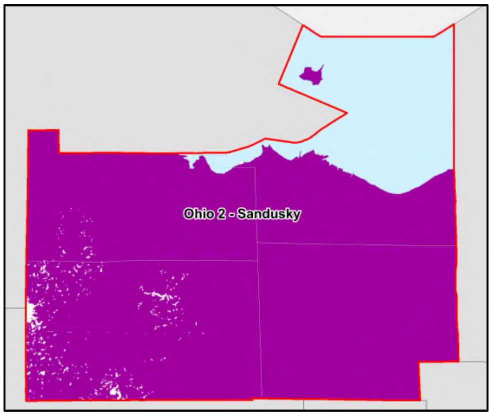

Figure 25: T-Mobile 3G and 4G Coverage

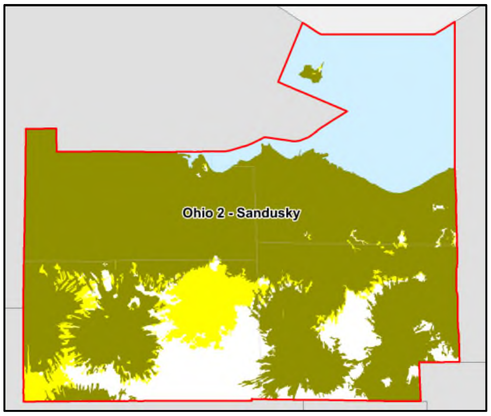

Figure 26: Sprint 3G and 4G Coverage

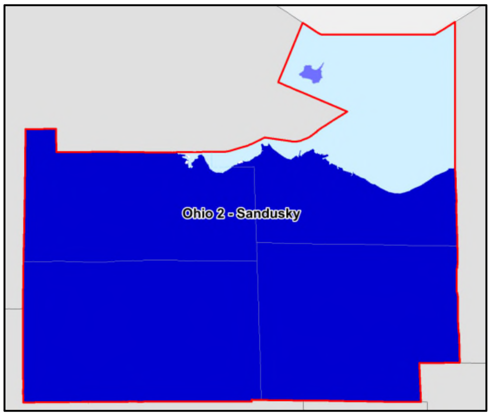

Figure 27: AT&T 3G and 4G Coverage

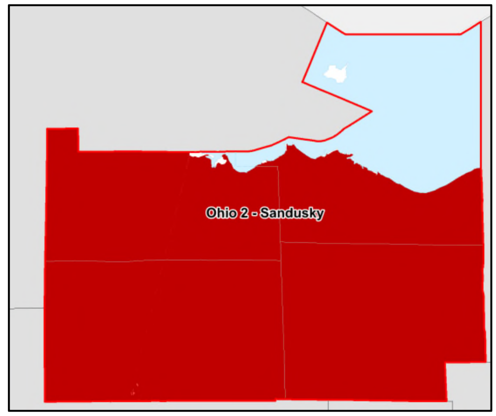

Figure 28: Verizon 3G and 4G Coverage

In addition, AT&T holds 300-400 MHz of mmW spectrum throughout the market, and Verizon holds 600-700 MHz throughout the market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

VIII. SOUTH CAROLINA 5 – GEORGETOWN (CMA629)

The Applicants trigger the low-band screen in South Carolina 5 – Georgetown (CMA629) because T-Mobile has the B, C, D, and E Blocks in the 600 MHz band, T-Mobile holds the 800 MHz Cellular A Block license, and Sprint holds 14 MHz of 800 MHz ESMR. T-Mobile also holds 30 MHz of AWS-1/3 (D, E and G Blocks); 20-30 MHz of PCS (20 MHz of A Block and an additional 10 MHz of A Block in Marion). Sprint holds 20-30 MHz of PCS (10 MHz of C Block except in Marion and D and G Blocks); and varying amounts of EBS and BRS. As discussed below, however, the aggregation of 79 MHz of low-band spectrum in these markets by the Applicants is not anticompetitive.

As an initial matter, the Applicants note that there were two blocks—20 MHz of spectrum—that were unsold in the 600 MHz auction (F and G Blocks). There are also incumbents with coverage footprints equal to, or superior, to that of T-Mobile or Sprint, companies that also possess significant low-band assets. Verizon, for example, holds the B Block 800 MHz cellular license as well as 22 MHz of Upper 700 MHz (the C Block). Verizon also holds 40 MHz of AWS-1/3 (B and F Blocks) and 30 MHz of PCS (20 MHz of C Block and E Block). AT&T holds 30 MHz of 700 MHz low-band spectrum (B, C, and D Blocks) and its partner,[31] Horry Telephone Cooperative, Inc. ("HTC"), holds an additional 12 MHz (Lower 700 MHz A Block). AT&T (and HTC) also hold 60 MHz of AWS-1/3 (A, C, I and J Blocks); 40-50 MHz of PCS (10 MHz of A Block except in Marion, B Block, 10 MHz of C Block in Marion, and the F Block in Georgetown). As a final matter, DISH holds 16 MHz of low-band spectrum (600 MHz A Block and Lower 700 MHz E Block), as well as 15 MHz of AWS-1/3 (A1 and B1 Blocks); 10 MHz of PCS (H Block) and 40 MHz of AWS-4 (A and B Blocks). Under the circumstances, there is no reason to believe the aggregation proposed by Applicants is anticompetitive in any way.

[31] Wikipedia indicates "Through a partnership with Cingular, now AT&T Mobility, HTC offers mobile phone service under the HTC Horizon brand." See https://en.wikipedia.org/wiki/Horry_Telephone_Cooperative (last visited Oct. 30, 2017).

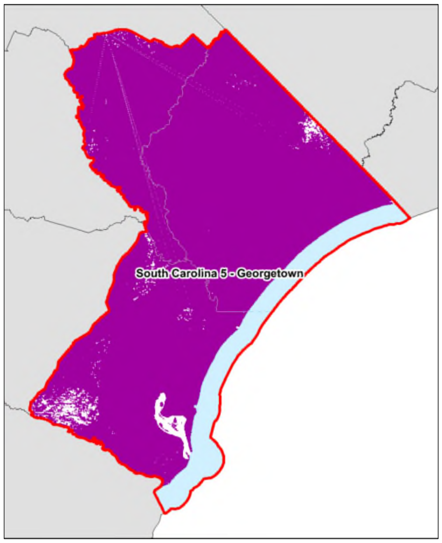

Figure 29: T-Mobile 3G and 4G Coverage

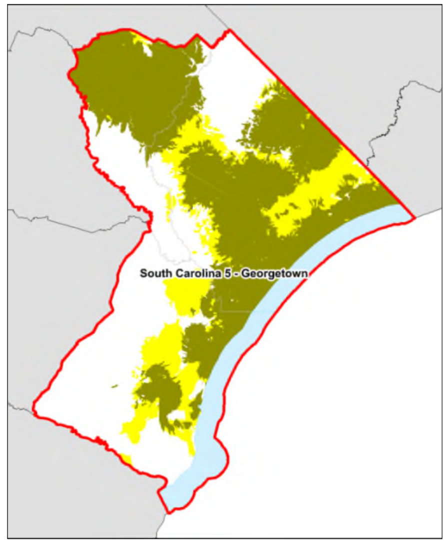

Figure 30: Sprint 3G and 4G Coverage

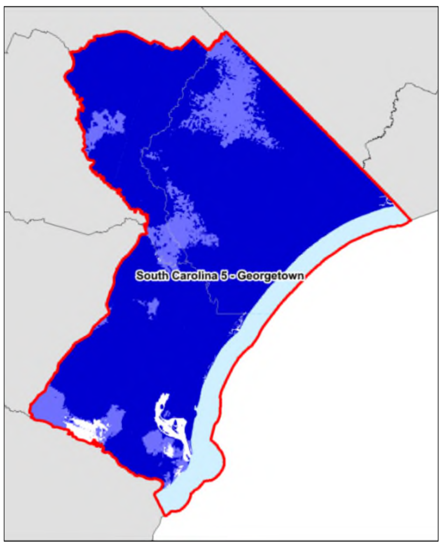

Figure 31: AT&T 3G and 4G Coverage

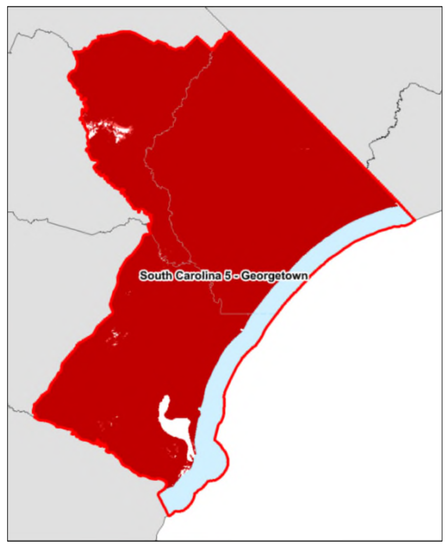

Figure 32: Verizon 3G and 4G Coverage

In addition, AT&T (and HTC) hold over 1 GHz of mmW spectrum in Horry county, which represents almost 75 percent of the population in the market, and 200 MHz of mmW spectrum elsewhere. Verizon also holds 400 MHz throughout the market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. Still, that leaves New T-Mobile well behind both AT&T (and

HTC) and Verizon in 5G-specific spectrum. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

IX. TEXAS 19 – ATASCOCA (CMA670)

In Texas 19 – Atascosa (CMA670), Applicants trigger the low-band screen because T-Mobile holds between 30-40 MHz of 600 MHz (Blocks B, C, D and, except in Atascosa county, E Block); 24 MHz of Lower 700 MHz (A and B Blocks); and 11-14 MHz of 800 MHz ESMR.[32] As discussed below, however, the aggregation of 68-78 MHz of low band spectrum in these markets should not be considered anticompetitive.

As an initial matter, there is 10-20 MHz of spectrum left unpurchased as a result of the 600 MHz Auction—Blocks A and E in Atacosa county, Block G in Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak and McMullen, and Blocks F and G in the remaining counties of Jim Hogg, Starr, Willacy and Zapata. During the auction, the San Antonio PEA (PEA028) received a significant number of competing bids, but that is the market where the overlap in TX 19 is Atascosa county, where T-Mobile won only three 600 MHz licenses. In the Brownsville PEA (PEA047), which overlaps TX 19 in Starr and Willacy counties, the only bidders after Stage 1 were T-Mobile and DISH, and both won licenses. In the Laredo PEA (PEA221), T-Mobile was the only bidder in the market during all of Stage 1, and the only other bidder to enter was DISH—both T-Mobile and DISH secured licenses in the auction. In the Kingsville PEA (PEA329), there were a number of active bidders initially, but the market settled when Spectrum Financial Partners, LLC exited at $107,000. The other three bidders—T-Mobile, DISH and

[32] T-Mobile also holds 40-50 MHz of AWS-1/3 (F, G, H except in Atascosa, Jim Hogg and Zapata, and I except in Starr and Willacy) and 30 MHz of PCS (E and F Block and 10 MHz of A or D Block). Sprint holds 14 MHz of 800 MHz spectrum except in Jim Hogg, Starr, Willacy and Zapata counties, where it holds only 11 MHz. Sprint also holds 30-40 MHz of PCS (20-30 MHz of A Block and G Block) as well as varying amounts of EBS and BRS.

Omega Wireless, LLC—all won licenses. If low-band spectrum access was a competitive issue, the auction outcome should have been considerably different.

Furthermore, as shown in the coverage maps, T-Mobile and Sprint have coverage that falls short of the coverage of the incumbent providers, who also have substantial low-band and other spectrum resources. AT&T holds 56 MHz of low-band spectrum in the market—both the A and B Block 800 MHz cellular licenses, as well as the 6 MHz Lower 700 MHz D Block license. AT&T also holds 30-40 MHz of AWS-1/3 (Blocks D and E, Block C in all counties except Atascosa, Jim Hogg, and Zapata, and Block J in Atascosa, Jim Hogg, and Zapata); 20-30 MHz of PCS (30 MHz of C Block, except Starr county where it holds 20 MHz of C Block); and 20 MHz of attributable WCS (Blocks A, B, C, and D). Verizon holds 22 MHz of Upper 700 MHz C Block, as well as 20-40 MHz of AWS-1/3 (Block B everywhere except Starr and Willacy, Block H in Duval, Jim Hogg and Zapata, and Block J everywhere except Atascosa, Jim Hogg, and Zapata) and 30-40 MHz of PCS (B Block and D Block everywhere except Atascosa, Jim Hogg, McMullen, Starr, Willacy, and Zapata). DISH secured 10-20 MHz in the 600 MHz auction (A or F Block and G Block in Atascosa), and previously held the 6 MHz Lower 700 MHz E Block, 15 MHz of AWS-1/3 (A1 and B1 Blocks), 10 MHz of PCS (H Block) and 40 MHz of AWS-4 (A and B Blocks). Under the circumstances, the aggregation of spectrum proposed herein cannot be anticompetitive.

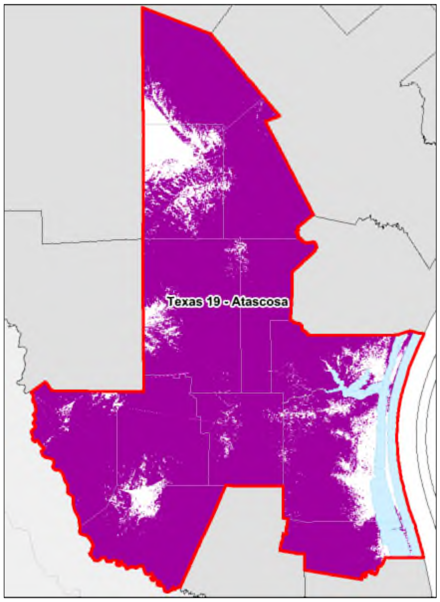

Figure 33: T-Mobile 3G and 4G Coverage

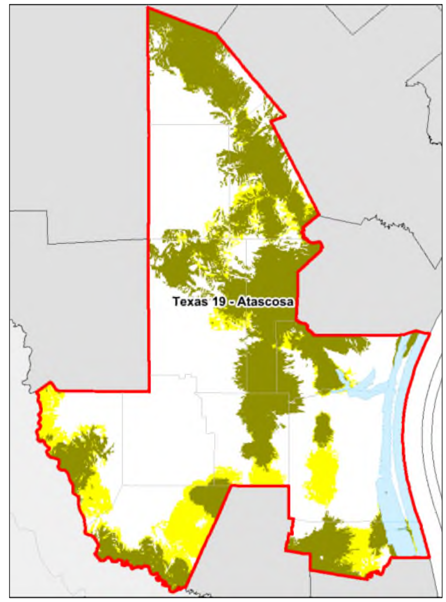

Figure 34: Sprint 3G and 4G Coverage

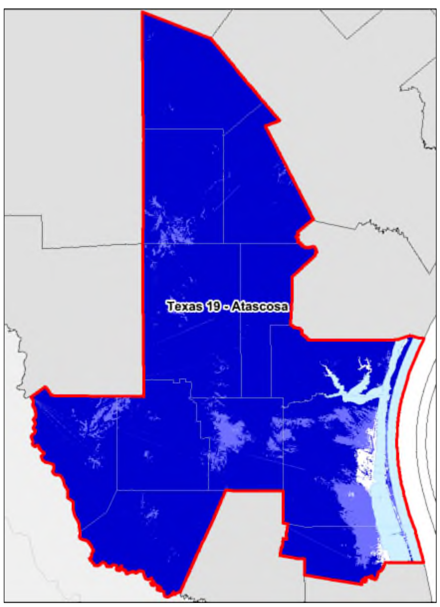

Figure 35: AT&T 3G and 4G Coverage

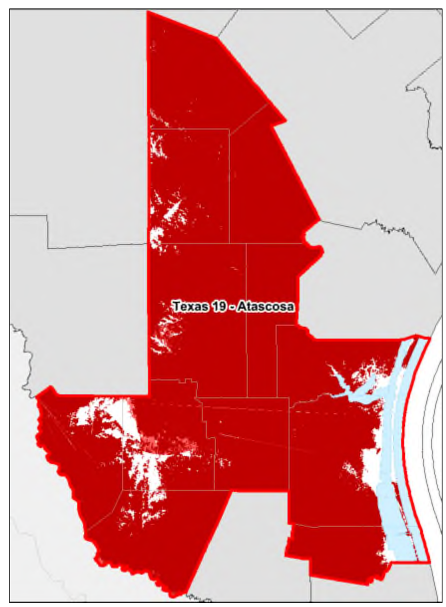

Figure 36: Verizon 3G and 4G Coverage

In addition, AT&T holds 200-400 MHz of 39 GHz mmW spectrum and Verizon's vary between 200 MHz to up to 1450 MHz—850 MHz of 28 GHz mmW spectrum in Atacosa and McMullen counties and between 200 MHz and 600 MHz of 39 GHz mmW spectrum—in this market. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. Still, that leaves New T-Mobile well behind both AT&T and Verizon in 5G-specific spectrum. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.

X. WYOMING 3 – LINCOLN (CMA720)

The Applicants trigger the low-band screen in Wyoming 3 – Lincoln (CMA720) in a single county—Teton, in the northwest corner of the market—because T-Mobile has the B, C, D, and E Blocks in the 600 MHz band, T-Mobile holds the 700 MHz A and B Block license, and Sprint holds 14 MHz of 800 MHz ESMR—and aggregate of 78 MHz of low band spectrum.[33] T-Mobile also holds 20-30 MHz of AWS-1/3 (F Block); 20-30 MHz of PCS (30 MHz of A or B Block, but only 20 MHz in Teton county). Sprint holds 30-40 MHz of PCS (G Block and 30 MHz of A or B Block, except in Uinta, where it holds only 20 MHz); and 67.5 MHz of EBS and BRS. As discussed below, however, the aggregation of 78 MHz of low-band spectrum in one county in this market by the Applicants is not anticompetitive.

As an initial matter, in the 600 MHz auction, there were two unsold licenses in PEA316, Rock Springs, WY; an applicant who could not withdraw demand in PEA382, Riverton, WY without creating excess capacity; and, the only parties who bid in PEA405, Jackon, WY, were Omega Wireless, LLC, an investor, and Nova Wireless LLC, which may have been merely parking eligibility. There are also incumbents with coverage footprints equal to, or superior, to that of T-Mobile or Sprint, companies that also possess significant low-band assets. Verizon, for example, holds the A Block 800 MHz cellular license as well as 22 MHz of Upper 700 MHz (the

[33] T-Mobile holds the 700 MHz A Block only in Teton county, and holds the 700 MHz B Block everywhere except Lincoln county.

C Block). Verizon also holds 40-70 MHz of AWS-1/3 (B and G Blocks throughout, E Block everywhere except Teton county, A Block in Fremont, Sublette and Teton counties, and H Block everywhere except Sublette and Teton counties and the E and F Blocks in Carbon county). Union Telephone Company holds the 25 MHz B Block 800 MHz cellular license, as well as the 12 MHz 700 MHz C Block, the 10 MHz AWS-1/3 C Block, and up to 50 MHz of PCS (30 MHz of C Block in Carbon and Fremont counties, 15 MHz of C Block in Sublette and Sweetwater counties, 10 MHz of D Block everywhere except Carbon and Teton counties, and . AT&T holds 6 MHz of 700 MHz low-band spectrum (D Block), although that license is being assigned to RigNet Satcom.[34] AT&T also hold 30 MHz of AWS-1/3 (J Block and D or E Block); up to 40 MHz of PCS (15 MHz of C Block in Lincoln, 10 MHz of A Block and D Block and 15 MHz of C Block in Teton, and 30 MHz of C Block and 10 MHz of F Block in Uinta county). As a final matter, DISH holds 16 MHz of low-band spectrum (600 MHz A or F Block, Lower 700 MHz E Block), as well as 10 MHz of AWS-1/3 (B1 Block); 10 MHz of PCS (H Block) and 40 MHz of AWS-4 (A and B Blocks). Under the circumstances, there is no reason to believe the aggregation proposed by Applicants is anticompetitive in any way.

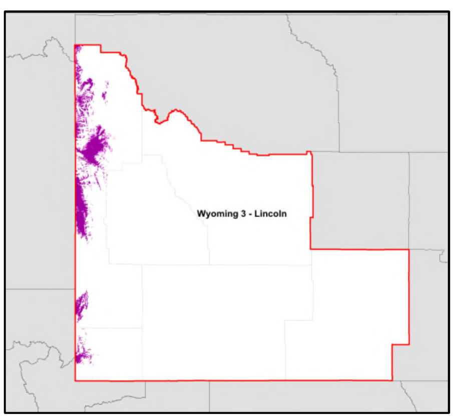

Figure 37: T-Mobile 3G and 4G Coverage

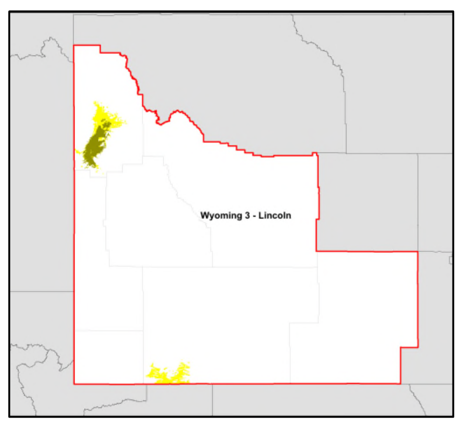

Figure 38: Sprint 3G and 4G Coverage

[34] *See* ULS File No. 0008158761.

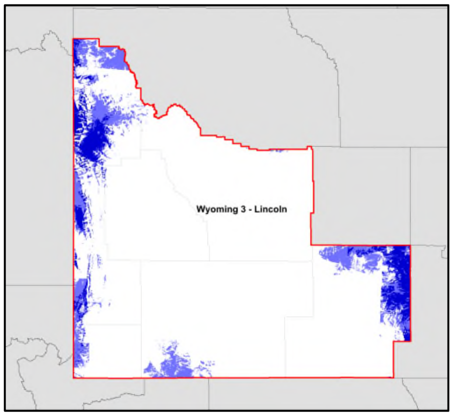

Figure 39: AT&T 3G and 4G Coverage

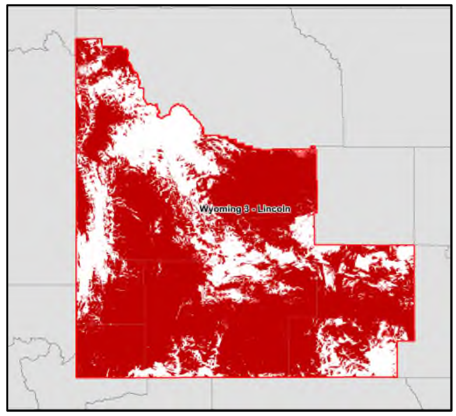

Figure 40: Verizon 3G and 4G Coverage

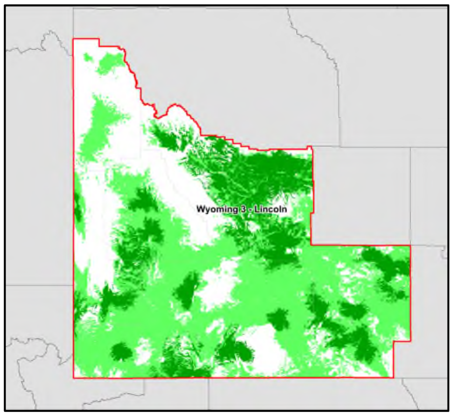

Figure 41: Union Tel. Co. 3G and 4G Coverage

In addition, Verizon holds 300 MHz of mmW spectrum throughout the market, with an additional 850 MHz in Uinta county. As discussed in the Public Interest Statement, by 2022, New T-Mobile would expect to devote [redacted]. If 5G spectrum were appropriately separated into a different category, the aggregate low-band spectrum would not trigger enhanced review.