

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

In the Matter of)	
)	
Wireless Telecommunications Bureau)	WT Docket No. 16-137
Seeks Comment on the State of Mobile)	
Wireless Competition)	

COMMENTS OF CTIA

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EXECUTIVE SUMMARY

The United States is the epicenter of wireless innovation and competition, even more so in the months since the FCC's most recent mobile wireless competition report was released. The FCC's previous report confirmed that vibrant competition exists within the mobile wireless marketplace, with sharp growth in wireless adoption, data consumption, network performance, and investment, all while prices continue to decline. Those trends have continued and, indeed, have accelerated. Consumers today enjoy unparalleled choice among wireless providers, service plans, and devices. Wireless carriers have continued to invest heavily in their networks to provide performance and reliability. And the development of 5G technologies is already beginning to serve as a catalyst for accelerated innovation and competition. American consumers have demonstrated their desire to communicate wherever and whenever they want, and the U.S. wireless industry is providing the connectivity and performance to meet those growing communications needs.

The U.S. continues to lead the world in wireless deployment and innovation. More than 99 percent of Americans have access to 4G LTE service from at least one provider, and more than 82 percent of the U.S. population can choose from *four or more* providers for 4G LTE service. With more wireless in more places, wireless users in North America consumed more data per subscriber in 2015 than in any other geographic region in the world. To meet this burgeoning consumer demand, wireless operators have continued to invest at extraordinary levels in their networks—providing more investment per person than operators in Asia or the European Union. It is thus not surprising that the U.S. continues to be the source of most of the world's leading technology companies and innovators. Indeed, 74 percent of the companies that comprise the \$120 billion app economy are based in the U.S.

The U.S. wireless market continues to experience growth along every relevant metric. The number of wireless connections in the U.S. grew six percent in 2015, from 355.4 million to 377.9 million. Additionally, by the end of 2015 there were 291 million active Internet-capable wireless devices in the U.S., up from 270 million at the end of 2014. Data use on these devices has continued its inexorable growth, tripling between 2013 and 2015, to reach 749 petabytes per month.

Carriers also are investing vigorously to grow and improve their wireless networks to meet this ever-rising demand. Cumulative capital expenditures by wireless providers grew 7.4 percent from 2014 to more than \$462 billion in 2015. Carriers are also leveraging technologies like distributed antenna systems, small cells, and carrier aggregation to boost network capacity, increase data rates, and improve user experience. Nationwide, carriers added more than a million square miles of coverage to their networks in 2015, including in rural areas, to offer more wireless connectivity in more places. Carriers are also leveraging new spectrum bands to expand their 4G LTE networks, including the WCS and AWS-3 bands. The FCC has done much to facilitate these achievements, including by making spectrum available for auction and promoting expeditious and streamlined processes for infrastructure deployment. The Commission should continue its efforts to facilitate the access to and expeditious deployment of more spectrum bands for wireless service to ensure that these networks can continue to provide the highest quality services to U.S. consumers.

Innovation also continues to flourish throughout the wireless market. Competition among carriers has prompted notable innovations in service plans, with many wireless carriers eliminating two-year contracts, giving customers the flexibility to choose new devices or new carriers without penalty and on their own timeline. In addition, several carriers recently

launched data plans offering targeted bundles of unlimited content. With programs such as T-Mobile's BingeOn or Verizon's go90, consumers can stream video content or listen to music without using any of their data allotment. These pro-consumer developments embody the benefits of permissionless innovation and competition, and should be supported by the FCC.

Also in 2015, the U.S. saw continued growth and innovation in the variety and structure of service plans and wireless providers, including hybrid cellular/Wi-Fi networks, mobile satellite service providers, and Mobile Virtual Network Operators. This growth and expansion of wireless connectivity gives consumers more choices among carriers. In yet another signal of a highly competitive marketplace, wireless carriers spent \$22.5 billion in 2015 on advertising—much of it on television ads—touting their network speeds, coverage, and plan offerings, in an effort to differentiate themselves.

Device manufacturers also continue to innovate and improve on smartphones, tablets, and other mobile devices. More than 20 device manufacturers offer consumers the choice of more than 1,353 different handsets and devices. Each year manufacturers improve the performance, cameras, security features, and design of these devices, not to mention the overall functionality. Consumers now can use wireless devices to make payments, listen to music, chat, text, stream video, and monitor their health. The wearables industry is also expanding the functionality of wireless connections with smartwatches, fitness trackers, and virtual reality devices. The Internet of Things, too, is encompassing almost every major market, including smart grid technology for energy, smart homes, connected cars, and healthcare.

Finally, 5G is a paradigm-shifting technology that is already acting as a catalyst for innovation and competition in the wireless market. This technology also will serve as the foundation for future Internet of Things innovations by providing the network capacity necessary

for billions of connected devices. The low latency and high speed of 5G networks will support time-critical applications, including for automobiles and medical services. Many more innovative uses for 5G are likely still to come as the technology is developed and deployed. But 5G is not just about the future; it is spurring competitive decision-making and innovation across the industry today. This year, wireless carriers and equipment manufacturers—including all four national carriers—are conducting trials of 5G, and some carriers are predicting 5G will be available to consumers by the end of 2017. The race for 5G is a major driver of activity in the wireless market as incumbent players and new start-ups rush to standardize, develop, and test 5G services.

All of these facts compel the conclusion that there is effective competition—indeed, vibrant competition—in the mobile wireless market. The FCC documents this reality every year in its annual report; it is now time for the FCC to expressly acknowledge it. A finding of effective competition would be consistent with the FCC’s recent similar finding in the video distribution market. As discussed below, the mobile wireless market is, if anything, more competitive than the video distribution market. And with the sharp increase in mobile wireless video consumption and distribution, it is especially important for the FCC to take a consistent approach between the wireless market and the traditional MVPD market. As such, the FCC should affirmatively find that the mobile wireless market is characterized by effective competition.

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COMMENTS OF CTIA

I. INTRODUCTION.

CTIA¹ respectfully submits these comments in response to the Public Notice released by the Wireless Telecommunications Bureau (“Bureau”) of the Federal Communications Commission (“FCC” or “Commission”) in the above-captioned proceeding.² In the *Public Notice*, the Bureau seeks comment on the state of mobile wireless competition in the U.S. to inform the 19th Mobile Competition Report. These comments will demonstrate a vibrant, competitive wireless industry. Competition among wireless carriers to meet soaring consumer demand is driving lower prices, better networks, and more functionality for wireless connections. The U.S. wireless market continues to lead the world in the deployment and use of high-speed wireless networks. As Chairman Wheeler has said: “The mobile industry has proven that competition drives capital investment. Equally important, [it has] shown that competition and

¹ CTIA[®] represents the U.S. wireless communications industry. With members from wireless carriers and their suppliers to providers and manufacturers of wireless data services and products, the association brings together a dynamic group of companies that enable consumers to lead a 21st century connected life. CTIA members benefit from its vigorous advocacy at all levels of government for policies that foster the continued innovation, investment and economic impact of America’s competitive and world-leading mobile ecosystem. The association also coordinates the industry’s voluntary best practices and initiatives and convenes the industry’s leading wireless tradeshow. CTIA was founded in 1984 and is based in Washington, D.C.

² *Wireless Telecommunications Bureau Seeks Comment on the State of Mobile Wireless Competition*, Public Notice, DA 16-450 (rel. Apr. 29, 2016) (“*Public Notice*”).

investment are not mutually exclusive . . . [It is] living proof that profit and progress go hand-in-hand.”³

The U.S. is also poised to lead the world in the deployment of fifth generation (“5G”) technology. This will support billions of interconnected devices encompassing the Internet of Things (“IoT”) and offer even higher-speed networks to consumers. Meanwhile, the demand for and use of 4G LTE networks, wireless devices, and wireless functionality continues to grow unabated in the U.S. This demand is driving decreasing prices for devices and plans, and it brings with it innovation by wireless carriers around plan offerings and data use. The wearables, apps, and IoT industries are contributing to the use of wireless connections and driving competition among carriers. The growth in these markets shows no signs of slowing. Customers are also benefiting from the growth of options for wireless service, including from mobile satellite service providers, Mobile Virtual Network Operators (“MVNOs”), and providers offering service on hybrid cellular/Wi-Fi networks.

While the wireless industry continues to invest vigorously in their networks and spectrum holdings to meet consumer demand, there are specific policy actions the FCC can take to ensure that the U.S. continues to lead the world in mobile wireless services, including:

- Reducing barriers to deploying infrastructure that is crucial to the development of wireless networks;
- Facilitating the auction and timely deployment of low-, mid-, and high-band spectrum for use by 4G LTE and 5G technologies;
- Fulfilling the commitment to offer at least \$500 million to support the availability of mobile wireless services in rural areas through a Mobility Fund; and
- Supporting the wireless industry’s development of technologies to offer LTE over unlicensed spectrum.

³ Tom Wheeler, FCC Chairman, Prepared Remarks at 2014 CTIA Show (Sept. 9, 2014) (transcript available at https://apps.fcc.gov/edocs_public/attachmatch/DOC-329271A1.pdf).

As these comments demonstrate, the U.S. wireless market is growing, innovating, and competing vigorously, and CTIA believes the FCC must find that the wireless market is effectively competitive.

II. COMPETITION HAS FUELED U.S. LEADERSHIP IN 4G LTE AND IS DRIVING DEVELOPMENT OF TRANSFORMATIVE 5G TECHNOLOGIES AND SERVICES.

The U.S. is a world leader in the deployment and usage of 4G LTE networks. A larger percentage of U.S. consumers subscribe to 4G LTE networks than in any other region in the world,⁴ and U.S. consumers enjoy unparalleled 4G LTE network coverage. Subscribers in the U.S. have embraced smartphones and consume more mobile data per person, per month than subscribers in almost every other country. The U.S. accordingly has become the primary headquarters for companies that want to build a new app or create a new mobile service. All of this is possible because of mobile wireless carriers' significant investments in building out and maintaining robust, state-of-the-art networks.

The market forces that have created U.S. leadership in 4G LTE deployment are now producing a new wave of innovation and development in the form of 5G technology and services. 5G networks hold the promise of unlocking the true potential of a fully-connected, mobile broadband society. 5G networks will feature super-high speeds, ultra-low latency, and enough bandwidth to support the burgeoning Internet of Things. U.S. wireless carriers are leading the way toward 5G by developing standards for, and trialing deployments of, 5G service. This race to 5G is spurring new competition in the U.S. wireless market.

⁴ See *Mobile Technology Statistics – Global*, 5G AMERICAS, <http://www.4gamericas.org/en/resources/statistics/statistics-global/> (last visited May 6, 2016).

A. By Any Metric—Deployment, Adoption, Data Usage, Network Investment, App Development, or Functionality—Mobile Wireless Competition in the U.S. is Delivering for Consumers.

1. Deployment.

By virtually every available metric, the U.S. has maintained its place of leadership in 4G LTE network deployment. The Commission’s most recent mobile competition report confirmed that, as of July 2015, 99.6 percent of Americans had access to LTE service from at least one provider.⁵ Nearly 98 percent of the population had a choice of two or more LTE-based providers and, significantly, 82.2 percent of the U.S. population could choose from among four or more providers.⁶ While work still remains to be done to deploy 4G LTE to rural parts of the country, America’s mobile wireless service providers have invested unprecedented time, money, and effort deploying 4G LTE service to the vast majority of consumers. The chart below compares the deployment of Mobile Network Operators in the U.S. to that of the rest of the world, showing that the U.S. leads the world in the number of market competitors.

⁵ See *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*, Eighteenth Report, 30 FCC Rcd 14515 ¶ 38 (WTB 2015) (“*Eighteenth Report*”).

⁶ *Id.* Likewise, the *Eighteenth Report* noted that nationwide coverage by 3G or better technology amounted to more than 99 percent of the population having two or more providers, versus 95.5 percent having a choice of three or more providers and 88 percent having a choice of four or more providers of 3G service. See *id.* at 14621 (Chart III.A.i).

Number of Mobile Network Operators Worldwide	
Five or More Mobile Network Operators	
United States Israel Canada	
Four Mobile Network Operators	
Chile Denmark Finland France Iceland Italy Luxembourg	Netherlands Poland Slovak Republic Slovenia Spain Sweden United Kingdom
Three Mobile Network Operators	
Australia Austria Belgium Czech Republic Estonia Germany Greece Hungary Ireland	Japan Korea Mexico New Zealand Norway Portugal Switzerland Turkey

Sources: Budde Research, CTIA Research, OECD, TeleGeography, et al.

Since the release of the last report, nationwide and non-nationwide carriers have continued to deploy 4G LTE and other advanced networks. For example, T-Mobile completed its 2015 goal of covering 300 million POPs with 4G LTE, ahead of schedule.⁷ U.S. Cellular has completed its footprint-wide 4G LTE network build-out.⁸ Twenty-one rural service provider members of Verizon Wireless’s LTE in Rural America program, covering more than 2.7 million

⁷ See Marguerite Reardon, *T-Mobile Doubles 4G Coverage to Take on AT&T and Verizon*, CNET (Oct. 28, 2015), <http://www.cnet.com/news/t-mobile-doubles-4g-coverage-to-take-on-at-t-and-verizon/>.

⁸ See Press Release, U.S. Cellular Corp., U.S. Cellular Reports Fourth Quarter and Full Year 2015 Results (Feb. 19, 2016), <http://investors.uscellular.com/news/news-release-details/2016/US-Cellular-reports-fourth-quarter-and-full-year-2015-results/>.

people, have launched 4G LTE service,⁹ and companies like Bluegrass Cellular have continued to expand their 4G LTE networks.¹⁰ Dozens more rural providers participate in Sprint's Rural Roaming Preferred Provider program, through which 38 million Americans are covered with 4G LTE.¹¹ And AT&T, whose 4G LTE network covers more than 317 million people, expanded its 4G LTE network coverage in parts of Indiana, Kentucky, and Virginia.¹²

Not only is the coverage of 4G LTE networks continuing to expand, but so are the speed and capacity of these networks. In particular, carriers are leveraging multiple spectrum bands to deliver unprecedented performance for consumers. Sprint recently announced the launch of its tri-band "LTE Plus" network in 191 markets, including New York City, Chicago, Dallas, Houston, Denver, and Los Angeles, over which Sprint can deliver speeds in excess of 100 megabits per second ("Mbps").¹³ AT&T announced in September 2015 that it would start

⁹ See *Verizon: All 21 LTE in Rural America Carrier Partners Have Launched Service*, FIERCEWIRELESS (Oct. 15, 2015), <http://www.fiercewireless.com/story/verizon-all-21-lte-rural-america-carrier-partners-have-launched-service/2015-10-15>.

¹⁰ See Press Release, Bluegrass Cellular, *Bluegrass Cellular Continues to Expand 4G LTE Network in Hardin County* (Sept. 30, 2015), <https://bluegrasscellular.com/about/news/bluegrass-cellular-continues-to-expand-4g-lte-network-in-hardin-county>; *Bluegrass Cellular Completes 4G LTE Network*, INSIDE TOWERS (Dec. 1, 2015), <https://insidetowers.com/bluegrass-cellular-completes-4g-lte-network/>.

¹¹ See *Sprint: 16 of 30 Rural LTE Roaming Partners Have Now Launched LTE Service*, FIERCEWIRELESS (May 20, 2015), <http://www.fiercewireless.com/story/sprint-16-30-rural-lte-roaming-partners-have-now-launched-lte-service/2015-05-20>; *Sprint Adds 15 Rural Carriers to LTE Roaming Program*, FIERCEWIRELESS (Sept. 5, 2014), <http://www.fiercewireless.com/story/sprint-adds-15-rural-carriers-lte-roaming-program/2014-09-05>.

¹² See Travis Thayer, *AT&T Upgrades, Enhances 4G LTE Service in Batesville*, EagleCountryOnline.com, <http://eaglecountryonline.com/local-article/att-upgrades-enhances-4g-lte-service-batesville/> (last visited May 19, 2016); *AT&T Expands 4G LTE Service in Brown County*, WBIW.COM (Feb. 16, 2016), <http://www.wbiw.com/local/archive/2016/02/att-expands-4g-lte-service-in-brown-county.php>; *AT&T Expands High Speed Internet at More than 200 Locations in KY; Governor Lauds Expanded Access*, NKYTRIBUNE (Oct. 1, 2015), <http://www.nkytribune.com/2015/10/at-governor-lauds-expanded-accessibility/>; *AT&T Expands 4G Network in Waynesboro, Staunton, Augusta County*, AUGUSTA FREE PRESS (June 4, 2015), <http://augustafreepress.com/att-expands-4g-network-in-waynesboro-staunton-augusta-county/>.

¹³ Colin Gibbs, *Sprint's 'LTE Plus' Network Now Reaches 191 Markets Including New York*, FIERCEWIRELESS (Apr. 15, 2016), <http://www.fiercewireless.com/story/sprints-lte-plus-network-now-reaches-191-markets-including-new-york/2016-04-15>; Dan Meyer, *Sprint LTE Plus Advances Hit 77*

deploying 2.3 GHz WCS Band spectrum for LTE in a number of markets.¹⁴ And Verizon Wireless has deployed “XLTE,” its combined AWS and 700 MHz LTE network, which delivers faster peak data speeds and doubles the bandwidth to 4G LTE customers, in more than 400 markets.¹⁵

Internationally, North America remained the regional leader in total 4G connections in 2015.¹⁶ Fifty-four percent of all mobile subscriptions in North America—or 237 million connections—are on LTE networks.¹⁷ HSPA and HSPA+ still hold a 21 percent market share in North America, bringing the combined market share for LTE and HSPA mobile broadband in the region to 75 percent.¹⁸ In contrast, LTE connections in Western Europe and the Asia Pacific region represented only 24 percent of total connections in each of those regions.¹⁹

2. Adoption.

Wireless subscribership in the U.S. continues an incredible pace of growth. As of the end of 2015, the 326 million people in the U.S. boasted 377.9 million wireless connections.²⁰ This is

Markets, RCR WIRELESS NEWS (Nov. 17, 2015), <http://www.rcrwireless.com/20151117/carriers/sprint-lte-plus-advances-hit-77-markets-tag2>.

¹⁴ See *AT&T Begins Deploying 2.3 GHz WCS Spectrum for LTE*, FIERCEWIRELESS (Sept. 9, 2015), <http://www.fiercewireless.com/story/att-begins-deploying-23-ghz-wcs-spectrum-lte/2015-09-09>.

¹⁵ Paul Macchia, *XLTE by the Numbers*, VERIZON (July 28, 2015), <http://www.verizonwireless.com/news/article/2014/05/xlte-by-the-numbers-infographic.html>.

¹⁶ David George et al., *The Mobile Economy 2016*, GSMA INTELLIGENCE 12 (Feb. 22, 2016), <https://www.gsmainelligence.com/research/2016/02/the-mobile-economy-2016/541/> (“2016 GSMA Report”).

¹⁷ *Mobile Technology Statistics – Global*, 5G AMERICAS, <http://www.4gamericas.org/en/resources/statistics/statistics-global/> (last visited May 19, 2016).

¹⁸ *Id.*

¹⁹ *Id.*

²⁰ *CTIA Annual Survey Report*, CTIA (May, 23 2016), <http://www.ctia.org/resource-library/press-releases/archive/americans-data-usage-more-than-doubled-in-2015> (“CTIA Annual Survey”). A summary of the findings is attached hereto as Appendix A.

an increase of more than 6 percent over the prior year, and the number of wireless connections is continuing to outpace the population of the country.

Contributing to this trend, households increasingly are cutting the cord and going wireless-only, especially among millennial and low-income populations. The percentage of U.S. households with only mobile phones grew to 48.3 percent in the second half of 2015, an increase of nearly 3 percent from the same period in 2014, according to a survey by the Centers for Disease Control and Prevention.²¹ This phenomenon is especially pronounced among adults aged 25-34, two-thirds of whom live in wireless-only households.²² Moreover, 79 percent of adults living with unrelated adult roommates live in households with only mobile phones.²³ Adults living in poverty are also more likely than higher income adults to live in households with wireless telephones only.²⁴ And even those households with both landline and wireless telephones receive more than a third of their calls on the wireless telephones.²⁵ These numbers are indicative of a dynamic, growing wireless industry.

With the availability of 4G LTE networks in the U.S., consumer use and reliance on wireless devices has continued to grow exponentially. According to the CTIA Annual Survey, by the end of 2015, there were 291 million active Internet-capable devices in the U.S., up from 270 million at the end of 2014.²⁶ There were 228 million smartphones in use in the U.S. at the

²¹ Stephen J. Blumberg & Julian V. Luke, *Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July-December 2015*, NAT'L CTR. FOR HEALTH STATISTICS (May 2016), <http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201605.pdf>.

²² *Id.*

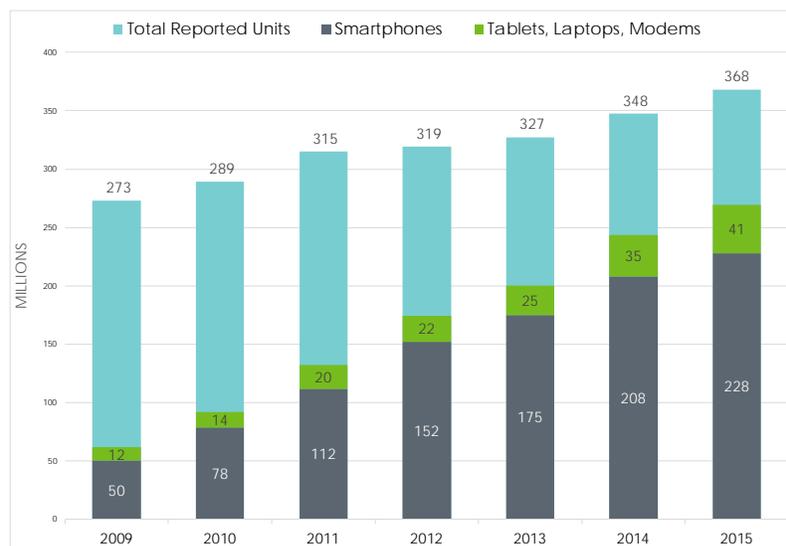
²³ *Id.*

²⁴ *Id.*

²⁵ *Id.*

²⁶ *CTIA Annual Survey*.

end of 2015, up from 208 million at the end of 2014.²⁷ Smartphone penetration in North America reached 74 percent at the end of 2015, compared to 59 percent in Western Europe,²⁸ and compared to a global median of reported smartphone ownership of just 43 percent.²⁹ South Korea, Australia, and Israel—each with a substantially smaller population—are the only countries with a larger smartphone adoption rate than the U.S.³⁰ And customer use of wireless devices does not end with smartphones: six million tablets, laptops, and wireless broadband modems were added to wireless networks in 2015, bringing the total to 41 million at the end of 2015.³¹



Source: Background on CTIA's Wireless Industry Survey (May 2016).

²⁷ *Id.*

²⁸ 2016 GSMA Report at 14.

²⁹ *Smartphone Ownership and Internet Usage Continues to Climb in Emerging Economies*, PEW RESEARCH CTR. (Feb. 22, 2016), <http://www.pewglobal.org/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/> (Smartphone ownership rates skyrocket in many emerging economies, but digital divide remains).

³⁰ 2016 GSMA Report at 18.

³¹ *CTIA Annual Survey* (finding that the number of active wireless-enabled tablets, laptops, netbooks, and wireless broadband modems reported on carriers' networks at year-end 2015 was 41 million, up from 35.4 million in 2014).

The U.S. also is expected to lead in smartphone adoption in the future. North America is projected to have the largest smartphone saturation rate between now and 2020,³² and by the end of 2020, North America is expected to have 95 percent of its installed base converted to smart devices and connections.³³ Western Europe, meanwhile, will have only 86 percent of its mobile subscriber base converted to smartphones.³⁴

3. Data Usage.

The scope of 4G LTE coverage in the U.S., combined with Americans' near-ubiquitous adoption of smartphones, has meant that the U.S. leads the world in the amount of data consumed over mobile networks. Mobile wireless data traffic continues a torrid pace of growth as more consumers use mobile wireless broadband devices. According to the CTIA Annual Survey, annual data traffic grew threefold from 2013 to the end of 2015.³⁵ In 2015, U.S. mobile data traffic was 749 petabytes per month, a 137 percent increase over 2014's reported traffic.³⁶

In 2015, North American users consumed more data traffic per subscriber per month than any other geographic area in the world.³⁷ One study estimated that the average North American user consumed 3.8 gigabytes of data per month in 2015.³⁸ Another study for the same year estimated North Americans' data usage as 4.4 gigabytes per person each month.³⁹

³² White Paper, *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015-2020*, CISCO 10 (Feb. 3, 2016), <http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.pdf> (“Cisco White Paper”).

³³ *Id.*

³⁴ *Id.*

³⁵ *CTIA Annual Survey*.

³⁶ *Id.*

³⁷ *2016 GSMA Report* at 15.

³⁸ White Paper, *Ericsson Mobility Report: On the Pulse of the Networked Society*, ERICSSON 2 (Nov. 2015), <http://www.ericsson.com/res/docs/2015/mobility-report/ericsson-mobility-report-nov-2015.pdf> (“2015 Ericsson White Paper”).

³⁹ *2016 GSMA Report* at 15.

Americans' high rate of consumption of mobile data is expected to continue into the future. Estimates show that by 2020, the average subscriber in North America will consume approximately 22 gigabytes of mobile data per month.⁴⁰ By comparison, the average subscriber in Europe is estimated to consume approximately 12 gigabytes of mobile data per month.⁴¹

After many years of frequent customer movement from wireless provider to wireless provider, 2015 saw a historically low rate of churn. In fact in the second quarter of 2015, despite huge marketing and promotional campaigns, churn was slightly under 1.2 percent for the four nationwide providers.⁴² Nevertheless, a consumer remaining with their provider is not a negative outcome or a reflection of supposedly high switching costs.⁴³ To the contrary, with all the enticements and incentives to switch carriers, a consumer remaining with their provider demonstrates the value and retention efforts of wireless operators.⁴⁴ Given the degree of competition, it is not surprising that wireless consumer satisfaction continues to track at a very high level.⁴⁵

⁴⁰ *Id.* at 16; see also White Paper, *Ericsson Mobility Report: Regional Report – North America* (Nov. 2015), <http://www.ericsson.com/mobility-report>.

⁴¹ *2016 GSMA Report* at 15; see also White Paper, *Ericsson Mobility Report: Regional Report – Europe*, (Nov. 2015), <http://www.ericsson.com/mobility-report>.

⁴² *Analysts: Despite Promotions, Verizon, AT&T, T-Mobile, and Sprint Posted Record-low Churn in Q2*, FIERCEWIRELESS (Aug. 19, 2015), <http://www.fiercewireless.com/story/analysts-despite-promotions-verizon-att-t-mobile-and-sprint-posted-record-1/2015-08-19>.

⁴³ See, e.g., Krista Witanowski, *Open Internet Order: Switching Realities*, CTIA BLOG (Mar. 18, 2015), <http://www.ctialatest.org/2015/03/18/open-internet-switching-realities/>.

⁴⁴ As discussed in more detail below, most wireless carriers today will cover the cost of early termination fees and device or lease buyout costs when consumers decide to switch from one wireless provider to another. See *infra*, Section III.A. These offers make it easy and affordable for consumers to switch providers. *Id.*

⁴⁵ See, e.g., *2014 National Consumer Survey*, ACTwireless, <http://www.actwireless.org/media-center/data-center/2014-national-consumer-survey/>.

4. Network Investment.

The U.S.'s leadership in each of the competitive metrics described above has been possible only because of the significant capital investments that U.S. mobile wireless carriers make in their networks, which the FCC has recognized is an important metric in understanding the marketplace's competitiveness.⁴⁶ Historically, domestic mobile capital expenditures grew significantly in the U.S. between 2008 and 2014.⁴⁷ U.S. operators invested almost \$90 per person in 2014, more than the per-person mobile CAPEX invested by operators in South Korea and the EU5 (France, Germany, Italy, Spain, and United Kingdom).⁴⁸

Mobile wireless carriers continued to invest in their networks in 2015 and 2016. Indeed, as discussed in more detail below, wireless providers' cumulative capital investment exceeded \$462 billion at the end of 2015 and incremental CAPEX totaled almost \$32 billion.⁴⁹ For example, Verizon Wireless invested \$11.7 billion in its network in 2015, up 11.5 percent from 2014,⁵⁰ and AT&T reported full-year capital investment of \$20.7 billion.⁵¹ Sprint invested over \$4.5 billion in its network during fiscal year 2015 (ending March 31, 2016).⁵² More recently,

⁴⁶ *Eighteenth Report* ¶ 105 ("Mobile wireless service providers also compete for customers on dimensions other than price, including investment, capacity, network coverage and technology, service quality, and advertising and marketing.").

⁴⁷ White Paper, *Mobile Operators' Investments: Europe Needs a Pro-Investment Mobile Regulatory Framework*, IDATE CONSULTING 7 (Nov. 2015), <https://www.ericsson.com/res/docs/2015/mobile-operators-investments-whitepaper.pdf>.

⁴⁸ *Id.*

⁴⁹ *See infra*, Section VI.A.1.

⁵⁰ *Verizon caps transformational year with strong, balanced 4Q results*, FIERCETELECOM (Jan. 21, 2016), <http://www.fiercetelecom.com/press-releases/verizon-caps-transformational-year-strong-balanced-4q-results>.

⁵¹ Press Release, AT&T, AT&T Caps Strong Year with 2.8 Million Wireless Net Adds and Double-Digit Growth in Revenues, Adjusted Operating Margin, Adjusted EPS and Free Cash Flow in Fourth Quarter (Jan. 26, 2016), http://about.att.com/story/att_fourth_quarter_earnings_2015.html.

⁵² Press Release, Sprint, Sprint Finishes Fiscal Year 2015 by Generating Positive Annual Operating Income for the First Time in Nine Years and Delivering More Postpaid Phone Net Additions Than

regional wireless operator Shenandoah Telecommunications announced that it would invest \$350 million to build-out 4G LTE in seven states.⁵³ Verizon reported wireless capital expenditures of \$2.2 billion in the first quarter of 2016,⁵⁴ and T-Mobile is on track to invest \$5 billion in capital expenditures in 2016 building out 4G LTE.⁵⁵

5. App Development.

The U.S. is at the epicenter of the flourishing app economy—the product of advanced mobile data networks, Americans’ high adoption rates, and mobile wireless carriers’ significant investment in network infrastructure. Seventy-four percent of companies that make up the \$120 billion app economy are based in the U.S., and 82 percent of these companies are small businesses.⁵⁶ As one analyst recently noted, “the world’s largest tech companies today are mainly U.S.-based. Like the more established internet companies such as Google and Facebook, the U.S. market has recently seen a number of new apps and services scale rapidly, both domestically and internationally, particularly those based on the new ‘sharing economy,’ such as

Verizon and AT&T for the First Time on Record in the Fiscal Fourth Quarter (May 3, 2016), <http://investors.sprint.com/news-and-events/press-releases/press-release-details/2016/Sprint-Finishes-Fiscal-Year-2015-by-Generating-Positive-Annual-Operating-Income-for-the-First-Time-in-Nine-Years-and-Delivering-More-Postpaid-Phone-Net-Additions-Than-Verizon-and-ATT-for-the-First-Time-on-Record-in-the-Fiscal-Fourth-Quarter/default.aspx>.

⁵³ See Colin Gibbs, *Shentel Closes \$640M nTelos Acquisition, Commits \$350M to Upgrade to LTE*, FIERCEWIRELESS, May 9, 2016, <http://www.fiercewireless.com/story/shentel-closes-640m-ntelos-acquisition-commits-350m-upgrade-lte/2016-05-09>.

⁵⁴ Verizon Communications, *Investor Quarterly IQ 2016*, 6 (Apr. 21, 2016).

⁵⁵ See Colin Gibbs, *T-Mobile, AT&T and Verizon Maintain Capex Spending Despite Incentive Auction*, FIERCEWIRELESS (Apr. 27, 2016), <http://www.fiercewireless.com/story/t-mobile-att-and-verizon-maintain-capex-spending-despite-incentive-auction/2016-04-27>.

⁵⁶ See Jonathan Godfrey et al., ACT THE APP ASSOCIATION, *State of the App Economy* 4-5 (4th ed. 2016), http://actonline.org/wp-content/uploads/2016_State_of_App_Economy.pdf.

Uber and Lyft.”⁵⁷ Another analyst recently estimated that the app economy employs 1.66 million Americans, up from approximately 750,000 jobs in 2013.⁵⁸

The explosion in the app economy likely would not have occurred but for the robust competition among wireless service providers to make high quality, advanced data networks available to consumers at low prices.⁵⁹

6. Functionality.

Given the level of competition and investment throughout the wireless industry, consumers can do more with wireless than ever before—on-demand video, real-time communications, location-based services, mobile banking, mobile health, and more. And the deployment of 5G technologies is poised to add even more functionality to wireless connectivity.

The use of smartphones to watch video content continues to skyrocket. The percentage of smartphone users that watched movies or television content on their smartphones through a subscription service like Netflix, Amazon Prime, or Hulu more than doubled, from 15 percent in 2012 to 33 percent in 2015.⁶⁰ More and more people are also using wireless devices for real-

⁵⁷ *The Mobile Economy Europe 2015*, GSMA INTELLIGENCE, 3 (Dec. 2015), <https://www.gsmainelligence.com/research/2015/12/the-mobile-economy-europe-2015/533/>.

⁵⁸ App Economy Jobs in the United States (Part 1), PPI'S THE PROGRESSIVE FIX BLOG (Jan. 6, 2016), <http://www.progressivepolicy.org/slider/app-economy-jobs-part-1/>.

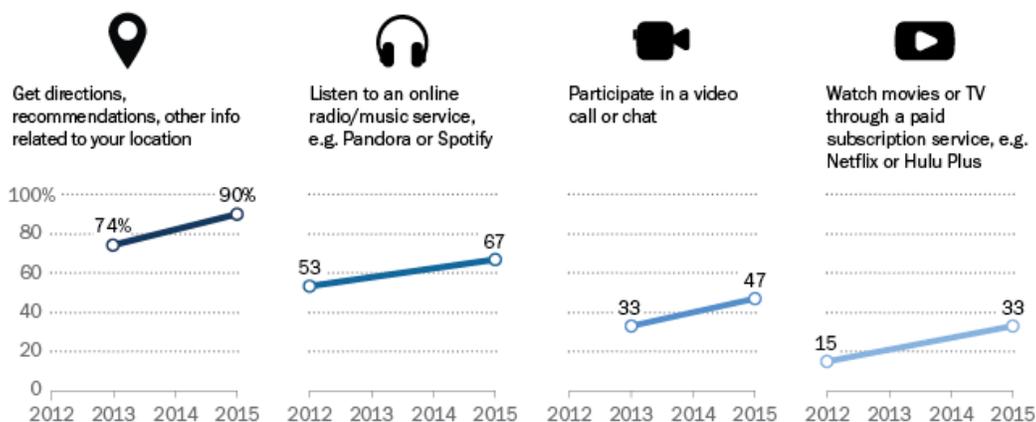
⁵⁹ ROGER ENTNER, RECON ANALYTICS, *The Wireless Industry: Revisiting Spectrum, The Essential Engine of US Economic Growth 2* (Apr. 2016) (“Apps, which were a \$10 billion phenomenon in 2011, became a \$36 billion juggernaut in 2014. But apps haven’t gotten there entirely by themselves. Wireless operators are more indispensable than ever because without the connectivity they provide none of this would be possible.”); *Removing Barriers to Wireless Broadband Deployment: Hearing before the S. Comm. on Commerce, Science and Transportation*, 114th Cong. 2 (2015) (testimony of Jonathan Adelstein, President and CEO, PCIA – The Wireless Infrastructure Association) (“Wireless infrastructure enables the economic growth and technological innovation that accompanies wireless broadband, including the Internet of Things, the app economy, and many future efficiencies and commercial opportunities that wireless broadband enables.”).

⁶⁰ *Americans Increasingly Use Smartphones for More Than Voice Calls, Texting*, PEW RESEARCH CTR. (Jan. 29, 2016), http://www.pewresearch.org/fact-tank/2016/01/29/us-smartphone-use/ft_01-27-16_smartphoneactivities_640/ (“*Americans Use Smartphones for More Than Voice Calls*”).

time applications such as streaming radio, video or voice chat, and live gaming. The percentage of smartphone users over the age of 18 who used their smartphone for a video call or chat increased from 33 percent in 2013 to 47 percent in 2015.⁶¹ Use of wireless connections for streaming music on applications like Pandora or Spotify also increased, from 53 percent of smartphone users over 18 years old in 2012, to 67 percent of smartphone users over 18 in 2015.⁶²

Americans increasingly use smartphones for more than voice calls, texting

% of U.S. smartphone owners ages 18 and over who have ever used their phone to ...



Note: In 2012, the survey question was asked of cellphone owners who use the internet or email on their cellphone or download apps to their cellphone. In 2013, item wording was "Get directions, recommendations, or other information related to a location where you happen to be."

Source: Survey conducted June 10-July 12, 2015. Trend data is from previous Pew Research Center surveys.

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Mobile payment options also are continuing to grow in number and use. The total value of mobile payment transactions is expected to grow by 210 percent in 2016, from \$8.71 billion to \$27.05 billion.⁶³ In addition to the current options in the market, including Samsung Pay and Google Wallet, 2015 saw the emergence of new partnerships and the launch of new options for mobile payments. At the end of 2015, for example, Apple Pay and American Express announced

⁶¹ *Id.*

⁶² *Id.*

⁶³ Sarah Silbert, *How Mobile Payments Will Grow in 2016*, FORTUNE (Oct. 29, 2015), <http://fortune.com/2015/10/29/mobile-payments-grow-2016/>.

a partnership allowing Apple Pay’s footprint to expand internationally.⁶⁴ A Gartner study at the end of 2015 predicted that by 2018 half of adults in mature markets will use smartphones or wearable devices to make mobile payments.⁶⁵

Like mobile payment options, the number and diversity of messaging applications for wireless devices continues to increase. Users can message over their wireless connections using applications like Google’s Hangouts or WhatsApp. Businesses, too, are adopting wireless messaging systems in place of traditional e-mail or messaging systems. For instance, Slack, a business-focused hybrid e-mail and messaging application that launched in 2014, rapidly gained 2.3 million active users and, as of March 2016, was valued at \$2.8 billion.⁶⁶ These over-the-top (“OTT”) messaging services are fast outpacing traditional SMS messaging and fostering more competition in the messaging space. Nevertheless, while the use of traditional SMS messaging has declined since 2012,⁶⁷ consumers are using their mobile devices more than ever, and messaging (whether traditional SMS, MMS, or OTT) remains a large piece of that equation.

B. The Next Generation of Wireless Networks—5G—Will Enable U.S. Wireless Carriers to Continue Global Leadership that Benefits Wireless Consumers.

The U.S. mobile wireless industry has taken remarkable steps towards implementation of 5G since the Commission released its last Mobile Wireless Competition Report. Consumers stand to benefit immensely from U.S. carriers’ deployment of 5G networks. Unlike its 3G and

⁶⁴ Leena Rao, *Apple Pay Partners With AmEx to Expand Internationally*, FORTUNE (Oct. 27, 2015), <http://fortune.com/2015/10/27/apple-pay-amex-international/>.

⁶⁵ Press Release, Gartner, *Gartner Says by 2018, 50 Percent of Consumers in Mature Markets Will Use Smartphones or Wearables for Mobile Payments* (Dec. 15, 2015), <http://www.gartner.com/newsroom/id/3178217>.

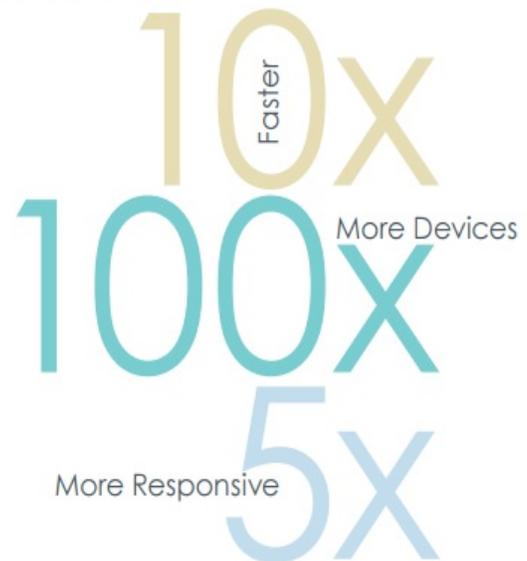
⁶⁶ Sean Captain, *Slacklash: Group Messaging Apps Are Stressing Some People Out*, FAST COMPANY (March 17, 2016), <http://www.fastcompany.com/3057730/slacklash-group-messaging-apps-are-stressing-some-people-out>.

⁶⁷ See, e.g., Brian X. Chen, *Text Messaging Declines in U.S. for First Time, Report Says*, N.Y. TIMES (Nov. 12, 2012), http://bits.blogs.nytimes.com/2012/11/12/text-messaging-declines-united-states/?_r=0.

4G predecessors, 5G networks will build upon the success of previous network iterations while allowing for new and innovative use cases.

The headlines from reports on 5G focus on the gigabit speeds that millimeter wave (“mmW”) networks will facilitate,⁶⁸ but 5G is about much more than fast data rates. 5G networks will serve as the foundation for the growing Internet of Things by providing the network capacity to allow billions of devices to connect and communicate with one another. 5G networks also will experience much lower latency rates than 4G networks, supporting time-critical applications like collision avoidance systems in automobiles and remote medical services. The U.S. wireless ecosystem is competing internally and externally for the opportunities that will flow from deployment of 5G networks. As Commissioner Rosenworcel has stated, “The race to 5G is on. . . . This is a race we want to win. We can do this if we get creative – and get going.”⁶⁹

Consumer Benefits of 5G
By the Numbers



⁶⁸ See, e.g., James Geddes, *Samsung Testing 5G Network with Lightning Speed Standards of 20 GB Per Second*, TECH TIMES (July 14, 2015), <http://www.techtimes.com/articles/68237/20150714/samsung-testing-5g-network-with-lightning-speed-standards-of-20-gb-per-second.htm>; Staff Reports, *AT&T Joins Verizon in Race to Develop Faster Wireless Networks with Austin Trials of 5G*, DALLAS MORNING NEWS, (Feb. 12, 2016), <http://www.dallasnews.com/business/technology/headlines/20160212-att-joins-verizon-in-race-to-develop-faster-wireless-networks-with-5g.ece>.

⁶⁹ Jessica Rosenworcel, Commissioner, Remarks at Leadership Forum on 5G: The Next Generation of Wireless, “Five Ideas for the Road to 5G,” (Feb. 9, 2016), transcript available at https://apps.fcc.gov/edocs_public/attachmatch/DOC-337655A1.pdf.

1. Millimeter wave (“mmW”) networks will deliver high data speeds to consumers, even with high consumer use of bandwidth-intensive applications and services.

The 5G use case that is perhaps the most accepted in the industry and familiar to the public is ultra-high speed networks. Technology leaders such as Samsung,⁷⁰ Ericsson,⁷¹ Nokia,⁷² Intel,⁷³ and QUALCOMM⁷⁴ are demonstrating and testing mmW 5G network deployments, which have seen speeds in excess of one gigabit per second (1 Gbps) in initial testing. High-speed data rates will allow consumers to rapidly download music and videos or stream content directly to mobile devices. Nokia, for example, promises speeds fast enough to download a 3-D movie in seconds, compared to several minutes over 4G LTE or more than an hour over 3G networks.⁷⁵

5G standards are being developed with mobile wireless connectivity in mind, but 5G also will be suitable for fixed wireless connectivity, providing businesses and residences with very high speed wireless broadband. Verizon Wireless, for example, will begin its initial 5G testing

⁷⁰ Geddes, *supra* note 68.

⁷¹ White Paper, *5G Radio Access*, ERICSSON, at 3 (Apr. 2016), <http://www.ericsson.com/res/docs/whitepapers/wp-5g.pdf>; see also Joe Lorio, *Volvo and Ericsson Partner on the Real Killer App for Autonomous Cars: Streaming HD Video*, CAR & DRIVER (Jan. 4, 2016), <http://blog.caranddriver.com/volvo-and-ericsson-partner-on-the-real-killer-app-for-autonomous-cars-streaming-hd-video/>.

⁷² See Nokia Press Release, *Nokia is First to Run 5G on a Commercially Available Base Station #MWC16* (Feb. 22, 2016), <http://networks.nokia.com/news-events/press-room/press-releases/nokia-is-first-to-run-5g-on-a-commercially-available-base-station-mwc16> (“Nokia’s 5G access system covers a broad range of spectrum allocations that are able to deliver more than 20 Gbps, unlocking the potential of new frequencies for multi-Gpbs wireless access.”).

⁷³ Deb Miller Landau, *How 5G Will Power the Future Internet of Things*, INTEL: IQ (Aug. 14, 2015), <http://iq.intel.com/how-5g-will-power-the-future-internet-of-things/>.

⁷⁴ See *Leading the World to 5G*, QUALCOMM TECHS., INC. 2-4 (Feb. 2016), <https://www.qualcomm.com/documents/qualcomm-5g-vision-presentation>.

⁷⁵ David Goldman, *5G Will Cost You A Bundle*, CNN MONEY (May 19, 2015), <http://money.cnn.com/2015/05/18/technology/5G-cost-wireless-data>.

as a fixed wireless pilot.⁷⁶ AT&T's pilot projects will feature fixed and mobile service.⁷⁷ Multi-gigabit service over 5G wireless networks will bring the benefits of high-speed broadband to areas where fiber or other high-speed wireline service cannot be economically deployed.

2. 5G will connect everything, supporting the Internet of Things.

In addition to multi-gigabit speeds, 5G networks will allow for connected homes, connected cars, connected cities, and connected lives. Ericsson estimates that nearly 28 billion IoT devices, including 1.5 billion machine-to-machine and consumer connected wireless (cellular) devices, will exist globally by 2021.⁷⁸ Other use cases—such as mobile health and telemedicine products, smart grids, enhanced public safety services, and smart agriculture—are also in development.

Today's 4G LTE networks alone are unlikely to be able to accommodate the sheer volume of traffic that IoT devices will create in the coming years.⁷⁹ A key feature of 5G networks will be to provide the capacity necessary to allow these billions of devices to communicate with one another. Some IoT devices may connect and communicate over mmW spectrum, but others may connect via lower-band spectrum—particularly devices deployed in more rural areas, such as smart agriculture devices.

⁷⁶ Monica Allevan, *Verizon's Shammo: 5G Pilot in 2017 is All About Fixed Wireless, Not Mobility*, FIERCEWIRELESSTECH (Apr. 21, 2016), <http://www.fiercewireless.com/tech/story/verizons-shammo-5g-pilot-2017-all-about-fixed-wireless-not-mobility/2016-04-21>.

⁷⁷ Stephen Lawson, *5G Might Be Your Next Home Broadband Service*, PCWORLD (Feb. 8, 2016), <http://www.pcworld.com/article/3031008/5g-might-be-your-next-home-broadband-service.html>.

⁷⁸ 2015 Ericsson White Paper at 10.

⁷⁹ See Larry Greenemeier, *Will Millimeter Waves Maximize 5G Wireless?*, SCIENTIFIC AMERICAN (June 23, 2015), <http://www.scientificamerican.com/article/will-millimeter-waves-maximize-5g-wireless/> (“The motivation behind [5G] is the exponential growth in wireless. We’re talking about billions of users, billions of devices and billions of connections. That’s something that a new standard has to address, because 4G is not going to be efficient enough to handle this much growth.”).

3. 5G will be real-time, minimizing delays in network response and enabling entirely new services and applications.

Another identified feature of 5G networks is super-low latency rates. 5G is expected to reduce latency rates by as much as ten times compared to the latency rates currently experienced over 4G LTE networks.⁸⁰ Reduced latency will support several real-world use cases, such as vehicle safety and collision avoidance, augmented and virtual reality, and real-time video conferencing. For example, the reduced latency of a fully optimized 5G network will allow a self-driving car traveling at roughly 60 miles-per-hour to move only one inch between the time it identifies an obstacle and executes a braking command.⁸¹ In contrast, a car would travel 4.6 feet under the same conditions before executing a braking command over a 4G network.⁸² 5G's reduced latency rates will be critical to achieving an autonomous (self-driving) vehicle environment.

Reduced latency will also allow for expanded remote medical services. Samsung recently demonstrated how ultra-low latency 5G technology can allow a robotic arm to react almost instantly to stimulus.⁸³ Eventually, doctors may be able to perform remote surgery in rural hospitals using virtual reality technology connected over ultra-low latency 5G networks.⁸⁴

⁸⁰ White Paper, *LTE and 5G Innovation: Igniting Mobile Broadband*, 4G AMERICAS 20 (Aug. 2015), http://www.4gamericas.org/files/9214/3991/2167/4G_Americas_Rysavy_Research_LTE_and_5G_Innovation_white_paper.pdf.

⁸¹ *5G Vision: 100 Billion Connections, 1 ms Latency, and 10 Gbps Throughput*, HUAWEI, <http://www.huawei.com/minisite/5g/en/defining-5g.html> (last visited May 19, 2016).

⁸² *Id.*

⁸³ Devindra Hardawar, *Samsung Proves Why 5G is Necessary With A Robot Arm*, ENGADGET (Feb. 25, 2016), <http://www.engadget.com/2016/02/25/samsung-proves-why-5g-is-necessary-with-a-robot-arm/>.

⁸⁴ *See 5G Use Cases*, ERICSSON 13-14 (July 8, 2015), <https://www.ericsson.com/res/docs/2015/5g-use-cases.pdf>.

4. 5G will enable other applications and services, including use cases that are not yet imagined.

While high speeds, increased network capacity, and low latency are shaping up to become the hallmarks of 5G networks, there are other applications and services that will rely on this new technology. For example, 5G network planning includes designs for providing additional security beyond the node-to-node and end-to-end security available in today's mobile systems.⁸⁵ Energy efficiency is also a central design principle of 5G.⁸⁶ As standards for the technology are developed and more test pilots are launched, new use cases are likely to emerge that will produce additional consumer surplus, many of which cannot even be imagined today.

C. U.S. Carriers are Increasingly Focused on Ensuring that the U.S. is the World Leader in 5G Development.

1. Several U.S. carriers will begin mmW 5G service trials in 2016.

AT&T has announced plans to begin 5G field trials in Austin, Texas in the second half of 2016.⁸⁷ AT&T's trials "will help guide [AT&T's] 5G standards contributions, and set the stage for widespread commercial and mobile availability once technology standards for 5G are established."⁸⁸ Verizon Wireless also is conducting field trials in a number of states, including Texas, California, Massachusetts, and New Jersey, and reportedly demonstrated a peak data rate of 3.77 Gbps in February 2016.⁸⁹ Verizon has stated that customers will be able to try out the

⁸⁵ See White Paper, *A Deliverable by the NGMN Alliance*, NGMN 32 (Feb. 17, 2015), https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.pdf ("NGMN White Paper").

⁸⁶ See *id.* ("5G should support a 1,000 times traffic increase in the next 10 years timeframe, with an energy consumption by the whole network of only half that typically consumed by today's networks.")

⁸⁷ See Mariella Moon, *AT&T Gets Ready to Test 5G Technologies in 2016*, ENGADGET (Feb. 12, 2016), <http://www.engadget.com/2016/02/12/att-5g-field-testing/>.

⁸⁸ Press Release, AT&T, *AT&T Unveils 5G Roadmap Including Trials in 2016* (Feb. 12, 2016), http://about.att.com/story/unveils_5g_roadmap_including_trials.html.

⁸⁹ Roger Cheng, *Inside Verizon's Vision of Smokin' 5G Speeds*, CNET (Feb. 21, 2016), <http://www.cnet.com/news/verizon-5g-inside-field-test-smokin-super-fast-speeds/>; Colin Gibbs,

service with commercial-grade equipment by next year.⁹⁰ And AT&T has indicated that it will have pre-standards 5G equipment available for consumer use by the end of 2017.⁹¹

Meanwhile, T-Mobile has received a new experimental license to utilize 28 GHz and 39 GHz band spectrum to conduct indoor and outdoor testing of 5G equipment, and reportedly expects to start tests in the second half of 2016.⁹² Sprint is working with both Nokia and Ericsson to test 5G video streaming capabilities over mmW spectrum at two soccer stadiums in the U.S.⁹³ Several U.S. carriers, including AT&T, Sprint, T-Mobile, Verizon, and U.S. Cellular, have also joined the Next Generation Mobile Networks (“NGMN”) Alliance, which is focused on developing end-to-end operator requirements for 5G.⁹⁴ Large and small carriers’ continued investment of research and development dollars into 5G is a positive indication of the level of competition amongst providers to retain customers through improved network technology.

2. The race to 5G is spurring new competition in the U.S. wireless market.

The planning for 5G that is taking place today is already producing competitive effects among incumbent mobile broadband service providers. As one financial report notes, “[t]he U.S. telecom industry has lately emerged as an intensely contested space where success thrives largely on technical superiority, quality of services and scalability,” which in part is driving U.S.

Verizon’s 5G plans a factor in decision to deploy FiOS in Boston, FIERCEWIRELESS (Apr. 13, 2015), <http://www.fiercewireless.com/story/verizons-5g-plans-factor-decision-deploy-fios-boston/2016-04-13>.

⁹⁰ *Id.*

⁹¹ Monica Allevan, *AT&T’s Mair: Like Verizon, AT&T Will Have Pre-Standards 5G Gear By End of 2017*, FIERCEWIRELESSTECH, (May 12, 2016), <http://www.fiercewireless.com/tech/story/atts-mair-verizon-att-will-have-pre-standards-5g-gear-end-2017/2016-05-12>.

⁹² Dan Jones, *T-Mobile Seeks FCC License for 5G Tests*, LIGHTREADING (Mar. 28, 2016), <http://www.lightreading.com/mobile/5g/t-mobile-seeks-fcc-license-for-5g-tests/d/d-id/722209>.

⁹³ Diana Goovaerts, *Sprint Hops on 5G Trial Train With Tests at Soccer Events in Philly, Santa Clara*, WIRELESS WEEK (May 5, 2016), <http://www.wirelessweek.com/news/2016/05/sprint-hops-5g-trial-train-tests-soccer-events-philly-santa-clara>.

⁹⁴ *NGMN White Paper; see also Our Partners*, NGMN, <https://www.ngmn.org/about-us/our-partners/members.html> (last visited May 19, 2016).

carriers' race towards 5G.⁹⁵ But interest in deploying 5G is expanding beyond current 4G LTE network operators. Other tech companies, consisting of both household names and new startups, are also entering the 5G space.

At this year's Mobile World Congress, for example, Facebook's CEO Mark Zuckerberg unveiled its Telecommunications Infrastructure Project, a partnership with Deutsche Telekom, SK Telecom and Nokia Networks that will allow Facebook to help build wireless radios and other equipment and then share the designs for this equipment with other wireless carriers.⁹⁶ Google reportedly is testing 5G service through its "Project SkyBender," a Google Access program through which solar-powered drones beam 5G service down to Internet users.⁹⁷ SkyBender could eventually result in "thousands of high altitude 'self-flying aircraft' delivering internet access around the world" over mmW frequencies.⁹⁸

Meanwhile, Internet startup Starry, Inc. is also testing mmW broadband service. In July 2016, "beta testers in Boston will get a gadget, a little larger than a soda can" that will provide service "expected to be much faster than cable service . . . with upload speeds that match download speeds."⁹⁹ As MIT Technology Review notes, Starry's cost could be as little as \$25

⁹⁵ See Zacks Equity Research, *T-Mobile US: Latest to Jump on the 5G Wireless Bandwagon* (Mar. 29, 2016), <http://finance.yahoo.com/news/t-mobile-us-latest-jump-181506544.html>.

⁹⁶ See Cade Metz, *Facebook Will Open Source Wireless Gear to Forge a 5G World*, WIRED (Feb. 22, 2016), <http://www.wired.com/2016/02/facebook-open-source-wireless-gear-forge-5g-world/>.

⁹⁷ See Nick Statt, *Google's Project SkyBender Aims to Beam 5G Internet from Solar-Powered Drones*, THE VERGE (Jan. 29, 2016), <http://www.theverge.com/2016/1/29/10873676/google-project-skybender-drones-5g-internet>.

⁹⁸ See Mark Harris, *Project SkyBender: Google's Secretive 5G Internet Drone Tests Revealed*, THE GUARDIAN (Jan. 29, 2016), <https://www.theguardian.com/technology/2016/jan/29/project-skybender-google-drone-tests-internet-spaceport-virgin-galactic>.

⁹⁹ See David Talbot, *Wireless, Super-Fast Internet Access is Coming to Your Home*, MIT TECH. REVIEW (May 16, 2016), <https://www.technologyreview.com/s/601442/wireless-super-fast-internet-access-is-coming-to-your-home/>.

per customer, or one one-hundredth of the cost of deploying fiber to customers in urban locations.¹⁰⁰

5G mobile broadband Internet service will deliver significant service improvements to consumers and open the doors to new products and applications (some of which we cannot even contemplate today). It is no wonder then that incumbent providers and new players are all rushing to standardize, develop, and test 5G services. As the Commission evaluates the state of competition in the mobile marketplace, it should take heed of the current market realities around 5G, and the innovation that 5G is already stimulating.

III. SERVICE PLANS CONTINUE TO EVOLVE AND OFFER MORE AS CARRIERS COMPETE TO WIN CUSTOMERS.

A. Increasing Consumer Data Use Has Been a Catalyst for Data Plan Innovation.

As the demand for data increases, wireless carriers have been innovating around the use of data and data plan offerings to maintain a competitive edge in the market, while ensuring high performance of their networks. As the then-Assistant Attorney General for the Department of Justice William Baer stated, “Experience teaches us that the market is thriving and consumers are benefiting from the current competitive dynamic.”¹⁰¹

For example, a significant trend in the last year has been the introduction of consumer friendly free data plans. These programs offer access to targeted bundles of content that do not count against a customer’s allocation of data. T-Mobile’s BingeOn and Verizon’s go90 offer a wide array of video content that customers can watch without any deduction from their data

¹⁰⁰ *Id.*

¹⁰¹ Edward Wyatt, *Wireless Mergers Will Draw Scrutiny, Antitrust Chief Says*, N.Y. TIMES (Jan. 30, 2014), http://dealbook.nytimes.com/2014/01/30/wireless-mergers-will-draw-scrutiny-antitrust-chief-says/?_r=0.

allotment.¹⁰² Consumers have embraced the opportunity to watch videos or listen to music without impacting their allotment of data. For example, consumers with BingeOn have watched more than 377 million hours of video through free data in just six months, and are watching more than twice the amount of streaming video as they did before.¹⁰³ Moreover, 89 percent of U.S. wireless customers said BingeOn would be appealing to have as part of their own service and 94 percent said they would try a new online service if it was a part of a free data program.¹⁰⁴ Millennials, or those 18-34 years of age, were nearly unanimous in their support for innovative free data offerings:



The broader adult population is similarly enthusiastic. About 84 percent of all adults are likely to try a new online service that is a part of a free data program and 85 percent of all adults are likely to use more data when it is free.¹⁰⁵ In addition, free data helps low-income consumers

¹⁰² *BingeOn*, T-MOBILE, <http://www.t-mobile.com/offer/binge-on-streaming-video.html> (last visited May 19, 2016); *Go90*, VERIZON, <http://www.verizonwireless.com/landingpages/go90/> (last visited May 19, 2016).

¹⁰³ T-Mobile Press Release, T-Mobile's BingeOn Brings More Cowbell: Now Over 80 Video Services Stream Free Without Using Your Data (May 17, 2016), <https://newsroom.t-mobile.com/news-and-blogs/binge-on-adds-more-cowbell.htm>.

¹⁰⁴ *Id.*

¹⁰⁵ Dr. Robert Roche, *Americans Love #FreeData*, CTIA BLOG (Apr. 7, 2016), <http://www.ctialatest.org/2016/04/07/americans-love-freedata/>.

who rely on mobile wireless. More than 31.5 million American adults are smartphone-only and, for a full 15 percent of all Americans, smartphones are their primary option for getting online.¹⁰⁶ Free data services provide more mobile wireless data that low-income Americans can use for occupational, community engagement, and educational opportunities. What's more, 12 percent of all African Americans and 13 percent of Latinos are "smartphone-dependent," compared with only 4 percent of whites.¹⁰⁷ The number of all Hispanic adults who rely on smartphone-only connectivity for home Internet increased by 7 percent (increasing from 16 percent to 23 percent) from 2013 to 2015; for African American adults, that number nearly doubled (jumping from 10 percent to 19 percent).¹⁰⁸ As the Multicultural Media, Telecom and Internet Council recently found, "free data can and should play a key role in finally making progress toward universal first-class digital citizenship for every American."¹⁰⁹ The rapid innovation in this area and strong consumer response should be signals to the FCC that such offerings are strongly in the public interest.

Recent Commission inquiries into free data plans threaten this vibrant source of competition.¹¹⁰ Wireless carriers have been forced to divert scarce resources away from network investment and research and development to deal with the inquiries. Permissionless innovation

¹⁰⁶ *U.S. Smartphone Use in 2015*, PEW RESEARCH CTR. (Apr. 1, 2015), http://pewinternet.org/files/2015/03/PI_Smartphones_0401151.pdf.

¹⁰⁷ John B. Horrigan and Maeve Duggan, *Home Broadband 2015: The share of Americans with broadband at home has plateaued, and more rely on their smartphones for online access*, PEW RESEARCH CTR. (Dec. 21, 2015), <http://pewinternet.org/files/2015/12/Broadband-adoption-full.pdf>.

¹⁰⁸ *Id.*

¹⁰⁹ *Understanding and Appreciating Zero-Rating: The Use and Impact of Free Data in the Mobile Broadband Sector*, Multicultural Media, Telecom and Internet Council (MMTC) (May 9, 2016), http://mmtconline.org/WhitePapers/MMTC_Zero_Rating_Impact_on_Consumers_May2016.pdf.

¹¹⁰ See Jim Puzzanghera, *FCC asking if free data plans from T-Mobile, AT&T and Comcast break Internet rules*, L.A. TIMES (Dec. 17, 2015), <http://www.latimes.com/business/la-fi-fcc-tmobile-free-video-20151217-story.html>.

is a driver of competition, but the current regulatory uncertainty in this area will only diminish carrier incentives for offering new products and services.

In addition to free targeted bundles of data, carriers also are providing increased flexibility in their plan offerings, shared data plans, and plans with rollover policies for customer data use.¹¹¹ Unlimited data plans are also reentering the wireless marketplace as carriers are finding creative ways to manage network capacity constraints. For example in January, AT&T announced an unlimited cellphone data plan for customers who subscribe to DirecTV or AT&T's IPTV service, U-verse.¹¹² Sprint and T-Mobile also offer plans with unlimited data use for customers.¹¹³ And while unlimited voice and text plans long ago became a key feature for many wireless plans, carriers are also expanding data-only plan offerings.¹¹⁴ Data-only plans have historically been marketed to deaf and hearing-impaired customers that do not want or need voice service on their devices.¹¹⁵ But these plans also offer additional choices and more flexibility for any data-hungry consumer who may not want traditional voice and text service on his or her wireless device.¹¹⁶ The high speeds and low latency promised by 5G will only

¹¹¹ See 2015 Ericsson White Paper.

¹¹² Tali Arbel, *Are Unlimited Data Cellphone Plans on Their Way Back?*, PHYS ORG (Jan. 11, 2016), <http://phys.org/news/2016-01-unlimited-cellphone.html>.

¹¹³ Lisa Eadicicco, *Unlimited Smartphone Data Plans Are Back From the Dead*, TIME (Jan. 11, 2016), <http://time.com/4174985/att-unlimited-data-plan-2016/>.

¹¹⁴ Christine Torralba, *T-Mobile Quietly Introduces Data-only Wireless Plans Without Voice Call Inclusions*, TMONNEWS (Mar. 30, 2016), <http://www.tmonews.com/2016/03/t-mobile-quietly-introduces-data-only-wireless-plans-without-voice-call-inclusions/>.

¹¹⁵ See *Information for Customers Who Are Deaf or Hard of Hearing*, SPRINT, <https://www.sprint.com/landings/accessibility/hearing.html> (last visited May 24, 2016); Lance Whitney, *A Phone Plan Without Phone Calls? T-Mobile's Got One*, CNET (March 29, 2016), <http://www.cnet.com/news/a-phone-plan-without-phone-calls-t-mobiles-got-one/>.

¹¹⁶ See, e.g., Dan Seifert, *Charge adds voice and text options to its data-only plans*, THE VERGE (May 11, 2016), <http://www.theverge.com/2016/5/11/11653864/charge-voice-text-smartphone-plans>; Diana Goovaerts, *Could Millennials Bring Cord Cutting to Wireless?*, WIRELESS WEEK (May 3, 2016), <http://www.wirelessweek.com/blog/2016/05/could-millennials-bring-cord-cutting-wireless>.

increase the emphasis on and demand for data. Such demands will put a premium on continued innovation from wireless carriers around data plan offerings to simultaneously manage network capacity constraints while providing optimal experiences for consumers.

Carrier flexibility in plan offerings extends to customers switching between wireless carriers. Most wireless carriers will cover the cost of early termination fees, as well as device or lease buyout costs from the prior wireless provider for customers that switch providers.¹¹⁷ For example, Verizon will cover up to \$650 in fees or costs—per line—for customers that switch from another carrier. T-Mobile offers the same amount per line to cover device payments and contractual early termination fees.¹¹⁸ These offers make switching providers easier and more affordable, and demonstrate yet another benefit of competition in the marketplace for consumers.¹¹⁹ As the Commission stated in the *Eighteenth Report*, “[w]ith the shift away from handset subsidies, marketing tactics have increasingly focused on [ETF] buyouts to encourage customers to switch from rivals.”¹²⁰ The increasingly flexible service plan offers described above and provider practices like the move away from term-contracts with cancellation penalties

¹¹⁷ Chris Welch, *Verizon will give you up to \$650 to switch from another carrier*, THE VERGE (Dec. 28, 2015), <http://www.theverge.com/2015/12/28/10674048/verizon-will-pay-you-to-switch-networks>.

¹¹⁸ *Get Up to \$650 Per Line*, T-MOBILE, http://www.t-mobile.com/offer/switch-carriers-no-early-termination-fee.html?clickid=wXwQD-V%3AA0lixIUSogxuixfZUkSQOW1NzUj3SU0&iradid=189313&cmpid=WTR_AF_189313&irpid=10078&irgwc=1 (last visited May 24, 2016).

¹¹⁹ See, e.g., Chris Smith, *How to switch cell phone carriers the easy way*, BGR (Dec. 8, 2015), <http://bgr.com/2015/12/08/switch-carriers-att-sprint-t-mobile-verizon/> (noting that “you can easily switch carriers if you want and some of them will be prepared to take care of those extra costs for you”).

¹²⁰ *Eighteenth Report* ¶ 90; see also *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*, Seventeenth Report, 29 FCC Rcd 15311 ¶ 145 (2014) (“*Seventeenth Report*”). (noting that “[t]he purpose of ETF buyouts is to encourage customers to switch from rivals by reducing switching costs”); ANDRES V. LERNER AND JANUSZ A. ORDOVER, THE “TERMINATING ACCESS MONOPOLY” THEORY AND THE PROVISION OF BROADBAND INTERNET ACCESS 13-14 (Jan. 14, 2015) (“Lerner/Ordover Paper”) (noting that factors like ETFs “reduce switching costs during the term of any wireless subscriber contract” (emphasis original)).

and ETF buyouts are all serving to drive down the cost to consumers of switching providers in this competitive environment.

B. Greater Ease of Entry and Continued Innovation by MVNO and Mobile Satellite Service Providers Highlight the Dynamic Nature of the Wireless Market.

1. Decreased barriers to entry and increased consumer demand for niche wireless plans are fostering growth and innovation in the MVNO marketplace.

The MVNO marketplace continues to grow and innovate, in particular as barriers to entry decrease. The cost to launch an MVNO has decreased dramatically in recent years, allowing more and smaller entities to join the marketplace.¹²¹ Consumers are also increasingly demanding niche wireless plans, also contributing to the growth of the MVNO market.

The MVNO emphasis on personalized, contract-free, innovative plans has long appealed to consumers. And MVNOs, like the larger wireless providers, are innovating around data plan offerings. For example, Charge Wireless is offering a new data-only plan for customers that do not use traditional voice or SMS text offerings.¹²² And in late 2015, Republic Wireless rolled out a plan that refunds customers for data that they pre-purchase and then do not use.¹²³ Ting Wireless is now offering a pay-as-you-go plan where customers pay for only the voice, text, and data services that they use each month.¹²⁴ MVNOs also are trying to differentiate themselves in other ways. For example, earlier this year Mast Mobile launched an MVNO in the U.S. that

¹²¹ David John, *Why MVNOs in the US Now Poised to Thrive*, LINKEDIN (Feb. 20, 2016), <https://www.linkedin.com/pulse/why-mvnos-us-now-poised-thrive-david-j-fondots>.

¹²² Dan Seifert, *Charge Mobile Data Dumps Your Phone's Voice Plan for Pure Data*, THE VERGE (Mar. 14, 2016), <http://www.theverge.com/2016/3/14/11219052/charge-mobile-data-only-plan-price-sim>.

¹²³ *Lose the Killer Phone Bill. Keep the Killer Phone*, REPUBLIC WIRELESS, <https://republicwireless.com/> (last visited May 19, 2016).

¹²⁴ *We Are on a Mission to Make Mobile Sense*, TING WIRELESS, <https://ting.com/> (last visited May 19, 2016).

allows customers to use two numbers on a single phone.¹²⁵ Customer ratings for these niche and personalized MVNO data plans are reportedly very favorable.¹²⁶

2. Hybrid cellular/Wi-Fi networks continue to expand as wireless carriers look to offload data traffic and other companies look to capitalize on the technology.

Hybrid cellular/Wi-Fi networks are continuing to expand the choices for consumers choosing wireless providers and plans. Providers of wireless networks are looking to both offload data traffic and capitalize on new technologies with the use of hybrid cellular/Wi-Fi networks. The largest wireless carriers offer Wi-Fi offloading, by which consumers can connect seamlessly to Wi-Fi networks offered by the carrier, rather than using their data over licensed CMRS spectrum.¹²⁷ Cable operators like Comcast, too, are joining this trend, entering partnerships with wireless carriers that would allow wireless devices to leverage high-speed wireless and Wi-Fi networks.¹²⁸

MVNOs that leverage hybrid cellular/Wi-Fi networks also continue to grow and innovate. Google's Project Fi, released to the public in early 2016, automatically and seamlessly connects its users to the fastest available network, whether Wi-Fi or 4G LTE.¹²⁹ Existing MVNOs using hybrid networks also are expanding their reach. Republic Wireless this year will

¹²⁵ *MVNO Monday: A Guide to the Week's Virtual Operator Developments*, TELEGEOGRAPHY (Feb. 8, 2016), <https://www.telegeography.com/products/commsupdate/articles/2016/02/08/mvno-monday-a-guide-to-the-weeks-virtual-operator-developments/>.

¹²⁶ See, e.g., Dan Meyer, *Carrier Wrap: MVNOs top Consumer Reports survey; T-Mobile US adds more music*, RCR WIRELESS (Nov. 24, 2014), <http://www.rcrwireless.com/20141124/carriers/carrier-wrap-mvnos-top-consumer-reports-survey-t-mobile-us-adds-tag2>.

¹²⁷ *Cisco White Paper* at 10.

¹²⁸ Mike Farrell, *Comcast Talking to Sprint, Others About Wireless*, MULTICHANNEL NEWS (Dec. 8, 2015), <http://www.multichannel.com/news/cable-operators/comcast-talking-sprint-others-about-wireless/395811>.

¹²⁹ *A New Way to Say Hello*, GOOGLE PROJECT FI, <https://fi.google.com/about/> (last visited May 19, 2016).

roll out a wider slate of smartphones that customers will be able to use to connect to the Republic Wireless network.¹³⁰

Even with these developments, 4G LTE will continue to be the gold standard for wireless connectivity. Customers continue to prefer the speeds and utility of 4G LTE service. Carriers are expanding and improving their 4G LTE networks, as described in more detail in Section VI. As a result of this investment, carriers are seeing customers come back to 4G LTE, even during times of extremely high traffic on the networks. For example, Super Bowl stadium traffic offloaded to Wi-Fi has dropped over the last three years. During Super Bowl 48, 53 percent of mobile wireless traffic was offloaded to the Wi-Fi network. But during Super Bowl 50, just 39 percent of mobile wireless traffic was offloaded to the Wi-Fi network.¹³¹

3. Mobile Satellite Service providers are poised to provide additional competition.

Although the Mobile Satellite Service (“MSS”) market traditionally has involved satellite-based voice and narrowband data services, a number of MSS providers are taking steps to provide terrestrial broadband services using their licensed satellite spectrum. Other MSS providers, through their next-generation satellites, have either expanded existing broadband service capabilities or expect to do so soon. All of these factors support the conclusion that the FCC should consider MSS providers as potential competitors to facilities-based carriers, resellers, and MVNOs.

DISH Network Corporation. Most notable among the MSS providers is DISH Network Corporation (“DISH”). DISH (through subsidiaries) holds MSS licenses for all 40 megahertz of

¹³⁰ Marguerite Reardon, *Republic Wireless Snags More Phones for Cheap Wi-Fi Calling*, CNET (May 11, 2016), <http://www.cnet.com/news/republic-wireless-gets-more-phones-for-its-cheap-wi-fi-mobile-service/>.

¹³¹ Kyung Mun, *Mun: Wi-Fi Offloading isn't as Popular as it Used to be in Stadiums*, FIERCEWIRELESS (May 9, 2016), <http://www.fiercewireless.com/story/mun-wi-fi-offloading-isnt-popular-it-used-be-stadiums/2016-05-09>.

spectrum in the 2 GHz MSS band.¹³² In 2012, the FCC adopted flexible terrestrial use rules for this spectrum, referred to as the AWS-4 band with respect to terrestrial service.¹³³ Further, in 2013, DISH received a waiver of the FCC's rules to allow DISH the option to select by June 20, 2016 whether to use the lower portion of the AWS-4 band for downlink or uplink operations, which substantially enhances the technical flexibility of the AWS-4 band.¹³⁴

In addition to this MSS spectrum, in 2014 DISH won all the licenses for the 10 megahertz of H-block spectrum, which is adjacent to the AWS-4 band, at a cost of \$1.564 billion.¹³⁵ In 2015, two separate entities, which the FCC concluded are controlled by DISH, won a combined \$13.327 billion in licenses for AWS-3 spectrum, representing approximately 27.73 megahertz of AWS-3 spectrum nationwide.¹³⁶ DISH also holds 4.6 megahertz of 700 MHz spectrum on a nationwide basis.¹³⁷ Therefore, in total, DISH has available approximately 82.33 megahertz of spectrum nationwide. DISH also has applied to participate in the Broadcast Incentive Auction and, thus, could acquire even more spectrum.¹³⁸ DISH's spectrum holdings

¹³² See *New DBSD Satellite Service G.P., Debtor-in-Possession, and TerreStar Licensee Inc., Debtor-In-Possession, Request for Rule Waivers and Modified Ancillary Terrestrial Component Authority*, Order, 27 FCC Rcd 2250 (2012).

¹³³ See *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands et al.*, Report and Order and Order of Proposed Modification, 27 FCC Rcd 16102 ¶ 162 (2012); see also *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands et al.*, Order of Modification, 28 FCC Rcd 1276 (2013).

¹³⁴ *DISH Network Corporation, Petition for Waiver of Sections 27.5(j) and 27.53(h)(2)(ii) and Request for Extension of Time*, Memorandum Opinion and Order, 28 FCC Rcd 16787 (2013).

¹³⁵ See *Auction of H Block Licenses in the 1915 - 1920 MHz and 1995 2000 MHz Bands Closes; Winning Bidder Announced for Auction 96*, Public Notice, 29 FCC Rcd 2044 (2014).

¹³⁶ See *Northstar Wireless, LLC, SNR Wireless LicenseCo, LLC*, Memorandum Opinion and Order, 30 FCC Rcd 8887 (2015).

¹³⁷ See *Seventeenth Report* ¶ 104.

¹³⁸ See Form 175 Application, ParkerB.com Wireless L.L.C, Auction Number 1002, File No. 0007134225 (filed Feb. 10, 2016).

are comparable to those of existing nationwide mobile carriers and could be used to introduce additional facilities-based competition in the terrestrial mobile wireless industry.

Ligado Networks LLC. Ligado Networks LLC (“Ligado”), formerly LightSquared, is another MSS operator that could offer terrestrial or a hybrid terrestrial/MSS service. Ligado was granted authority in 2004 to deploy a hybrid service in the 1.5 GHz and 1.6 GHz bands.¹³⁹ While Ligado’s terrestrial deployment efforts have been delayed, Ligado has stated that it has resolved concerns raised by the Global Positioning System (“GPS”) community through proposed operating conditions and voluntary agreements with major GPS companies.¹⁴⁰ In December 2015, Ligado submitted license modification applications, which included, as part of the negotiated solution, a proposal to relinquish the right to use the 1545-1555 MHz band for terrestrial downlinks in exchange for authority to operate terrestrial downlinks in the 1670-1680 MHz band.¹⁴¹ In April 2016, the FCC issued public notices requesting comments on the license modification applications and the proposal regarding the use of the 1670-1680 MHz band for Ligado’s terrestrial downlinks.¹⁴² If Ligado’s plan is approved, its spectrum holdings could be used to introduce additional facilities-based competition in the terrestrial mobile wireless industry.

Other Satellite Service Providers. Historically, MSS providers have served niche markets or remote areas where terrestrial networks were limited or unavailable. Recent advances in

¹³⁹ See *Mobile Satellite Ventures Subsidiary LLC, Application for Minor Modification of Space Station License for AMSC-1*, Order and Authorization, 19 FCC Rcd 22144 (2004).

¹⁴⁰ See, e.g., *Comment Sought on Ligado’s Modification Applications*, Public Notice, DA 16-442 (April 22, 2016); *Comment Sought to Update the Record on Ligado’s Request That the Commission Initiate a Rulemaking to Allocate the 1675-1680 MHz Band For Terrestrial Mobile Use Shared With Federal Use*, Public Notice, DA 16-443 (April 22, 2016).

¹⁴¹ See Applications of LightSquared Subsidiary LLC, Narrative, IBFS File Nos. SAT-MOD-20151231-00090, SAT-MOD-20151231-00091, and SES-MOD-20151231-00981 (filed Dec. 31, 2015).

¹⁴² See *id.*

satellite and antenna technology, however, have allowed for the introduction of more sophisticated devices and faster broadband services at lower costs. For example, Iridium is scheduled to launch its next-generation Iridium NEXT constellation beginning in the summer of 2016 with full system deployment by 2017.¹⁴³ The company predicts that Iridium NEXT will dramatically enhance its ability to meet the growing demand for global mobile communications, including support for more bandwidth and higher speeds for new products.

Other operators are also deploying non-MSS satellite networks capable of providing high-speed broadband capability. Inmarsat, for example, has launched three fixed-satellite service satellites, as part of its Global Xpress system, providing high-speed voice and data services with global coverage.¹⁴⁴ And a fourth satellite will be launched later this year.¹⁴⁵

Similarly, World Vu Satellites Limited, doing business as OneWeb, recently submitted a request for U.S. market access for a low-Earth orbit system comprised of approximately 720 non-geostationary orbit satellites capable of providing data at speeds of up to 50 Mbps with round-trip latency of less than 50 milliseconds.¹⁴⁶ The service offerings of both Inmarsat and OneWeb can provide competition in the provision of mobile voice and data, especially for large corporate and government customers.

C. Competition is Driving Innovation in Unlicensed Spectrum Bands.

Competition in the wireless industry is causing wireless providers to look for fresh ways to make efficient use of spectrum resources. This includes the use of both licensed and

¹⁴³ See *IridiumNEXT: Changes the Future of Satellite Communications NOW*, IRIDIUM (Mar. 2016), <https://www.iridium.com/network/iridiumnext>.

¹⁴⁴ See Global Xpress, INMARSAT, <http://www.inmarsat.com/service/global-xpress/> (last visited May 12, 2016).

¹⁴⁵ See *id.*

¹⁴⁶ See WorldVu Satellites Limited, Petition for Declaratory Ruling, File No. SAT-LOI-20160428-00041 (filed April 28, 2016).

unlicensed frequency bands for LTE. The wireless industry has devoted significant time and many resources over the last several years to offer 4G LTE service on unlicensed spectrum, pursuant to Part 15 of the FCC’s rules. Two technologies, LTE-Unlicensed (“LTE-U”) and Licensed Assisted Access (“LAA”), are nearly ready for deployment.¹⁴⁷ LTE-U and LAA technologies will leverage unlicensed spectrum to benefit consumers by enhancing the capacity and performance of 4G LTE networks, all without negatively impacting existing Wi-Fi operations.¹⁴⁸ Indeed, “[m]ultiple tests have shown that LTE-U can harmoniously share the unlicensed platform with other existing technologies such as Wi-Fi. In fact, it actually improves Wi-Fi performance – it works better alongside Wi-Fi than Wi-Fi does with itself.”¹⁴⁹

For decades, the FCC wisely applied a light touch and avoided unnecessary regulation of unlicensed technologies. Those policies have been eroded under this Commission, stalling the deployment of innovative, spectrum-efficient, consumer-friendly services that have heretofore been the hallmark of unlicensed spectrum. Going forward, the FCC should return to its practice of allowing permissionless innovation in the unlicensed bands by allowing the wireless industry to manage the coexistence of unlicensed LTE, Wi-Fi, and other Part 15 operations. This will ensure continued growth and innovation in this area, to the ultimate benefit of consumers.

¹⁴⁷ Comments of CTIA – The Wireless Association®, ET Docket No. 15-105 (June 11, 2015).

¹⁴⁸ *Id.* at 3.

¹⁴⁹ Shawn Chang, *Shawn Chang on the Role of Unlicensed Spectrum in Driving Mobile Innovation*, EVOLVE (May 18, 2016), <http://evolvemobile.org/shawn-chang-on-the-role-of-unlicensed-spectrum-in-driving-mobile-innovation/>.

IV. COMPETITION IN THE WIRELESS MARKET CONTINUES TO PRODUCE NEW AND BETTER DEVICES, APPLICATIONS, AND OPERATING SYSTEMS.

A. Competition in the Wireless Marketplace is Driving the Development of a Broad Range of Wireless Devices at Multiple Price Points, Spurring Further Competition Between Mobile Carriers.

1. There is robust competition in the wireless device market.

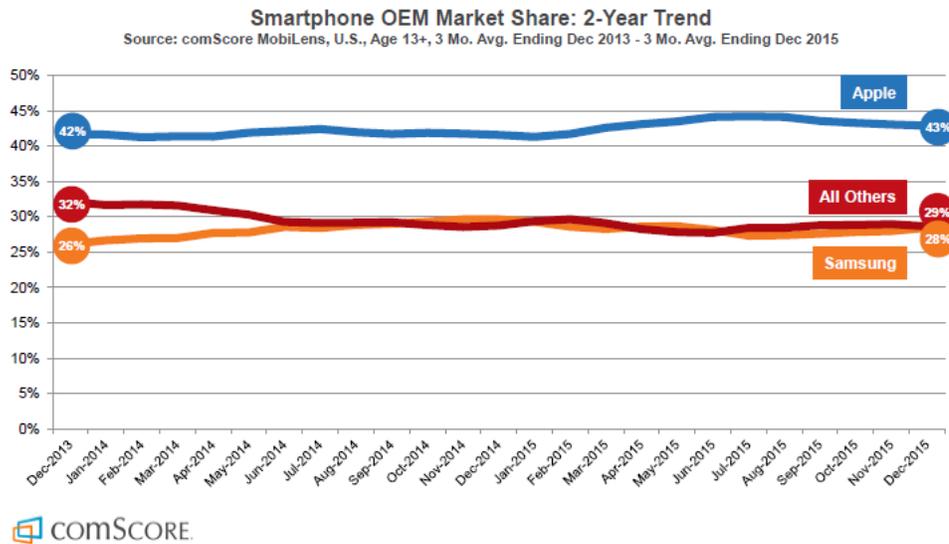
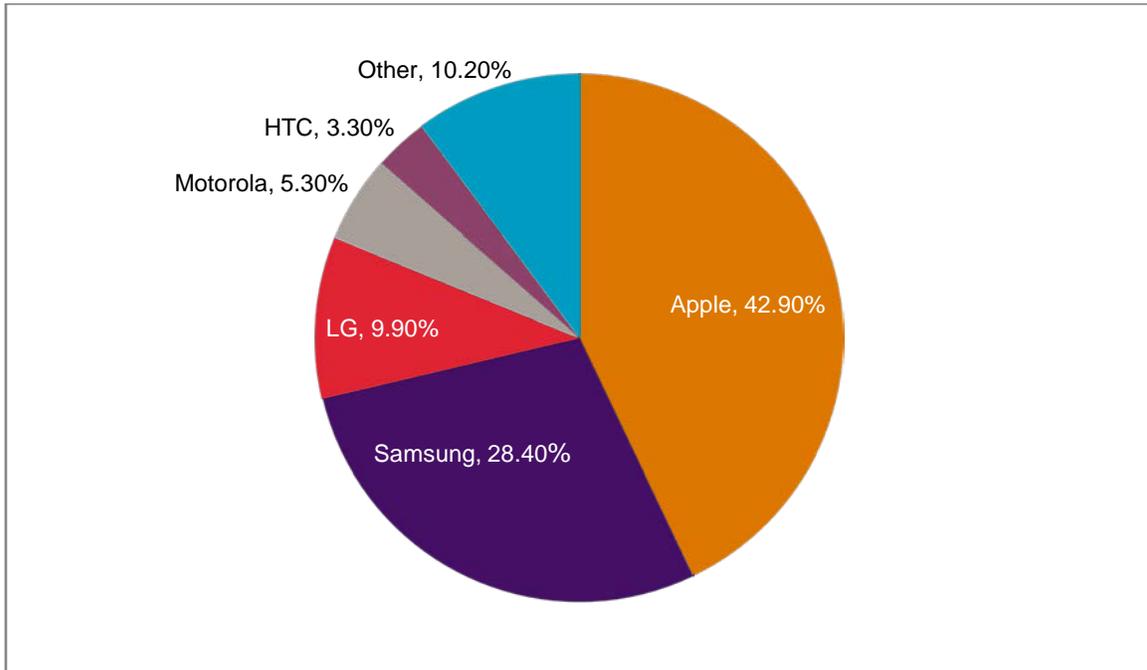
Wireless service providers continue to seek a wide range of wireless devices to differentiate their services in the competitive wireless broadband market. Manufacturers have responded by offering consumers a broad range of devices beyond smartphones and tablets, and have increased the choices, price points, and design within any given category of device. Moreover, platform convergence has opened new frontiers for competition among device manufacturers. Original equipment manufacturers (“OEMs”) now compete to offer a complete ecosystem of wireless devices that complement, or even aim to replace smartphones, laptops, or PCs.

There are currently at least 20 device manufacturers offering more than 1,353 different models of handsets and devices.¹⁵⁰ The OEMs with the higher overall mobile device market shares in 2015 are shown in the chart below. The relative OEM market shares over the past several years continue to shift due to competitive fluctuations, changing consumer preferences, the fast pace of the wireless device life cycle, new device payment and upgrade options and the presence—or potential entrance—of numerous new and well-funded OEMs seeking to carve out market share from the established OEMs in both the high-end and entry-level smartphone market segments.¹⁵¹

¹⁵⁰ *Device Manufacturers Handset Totals by Manufacturer Reporting Period: July 1, 2014-June 30, 2015*, FCC, https://apps.fcc.gov/edocs_public/attachmatch/DOC-334866A1.pdf.

¹⁵¹ Dawn Chmielewski, *Xiaomi’s Bin Lin Says Chinese Smartphone Maker May Enter the US*, CNBC (Oct. 21, 2015), <http://www.cnbc.com/2015/10/21/xiaomis-bin-lin-says-chinese-smartphone-maker-may-enter-the-us.html>; Juro Osawa, *China’s Huawei Hopes to Connect With U.S. Smartphone Market*, THE

Top Smartphone OEMs: 3 Month Avg. Ending Dec. 2015 vs. 3 Month Avg. Ending Sep. 2015 (Total U.S. Smartphone Subscribers Age 13+)¹⁵²



WALL STREET JOURNAL (Dec. 16, 2015), <http://www.wsj.com/articles/chinas-huawei-hopes-to-connect-with-u-s-smartphone-market-1450294200>.

¹⁵² comScore Reports December 2015 U.S. Smartphone Subscriber Market Share, COMSCORE (Feb. 4, 2016), <https://www.comscore.com/Insights/Rankings/comScore-Reports-December-2015-US-Smartphone-Subscriber-Market-Share>.

Major new smartphone product launches in the last year, across size and price points, fueled intense competition in the smartphone market. For example, in the fall of 2015, Apple released the iPhone 6s and 6s Plus, which are refreshed versions of its flagship smartphone with upgraded performance and cameras, including the ability to record 4K video. In early 2016, Apple released the iPhone SE, an upgraded version of its smaller iPhone 5s with an off-contract price starting at \$250 less than the starting price of the iPhone 6s.¹⁵³ Samsung released the Galaxy S6 and S6 Edge in 2015, which offered a fingerprint scanner security feature, and then the Galaxy S7 and S7 Edge in 2015, which reintroduced Samsung's water resistance feature.¹⁵⁴ Meanwhile, HTC unveiled the One H9 in early 2015 and the HTC 10 in 2016, both of which featured an industrial unibody aluminum design with a signature speaker system.¹⁵⁵ Microsoft introduced the Lumia 950 and Lumia 950 XL in late 2015, both of which run Windows 10 and can replace a PC when connected to a monitor.¹⁵⁶ Then in 2016, Microsoft launched a new entry-level smartphone, the Lumia 650, which features an aluminum frame and retails for

¹⁵³ Gordon Kelly, *iPhone SE Vs iPhone 6S: What's The Difference?*, FORBES (Apr. 14, 2016), <http://www.forbes.com/sites/gordonkelly/2016/04/14/iphone-se-vs-iphone-6s-whats-the-difference/#3a7ef0616179>.

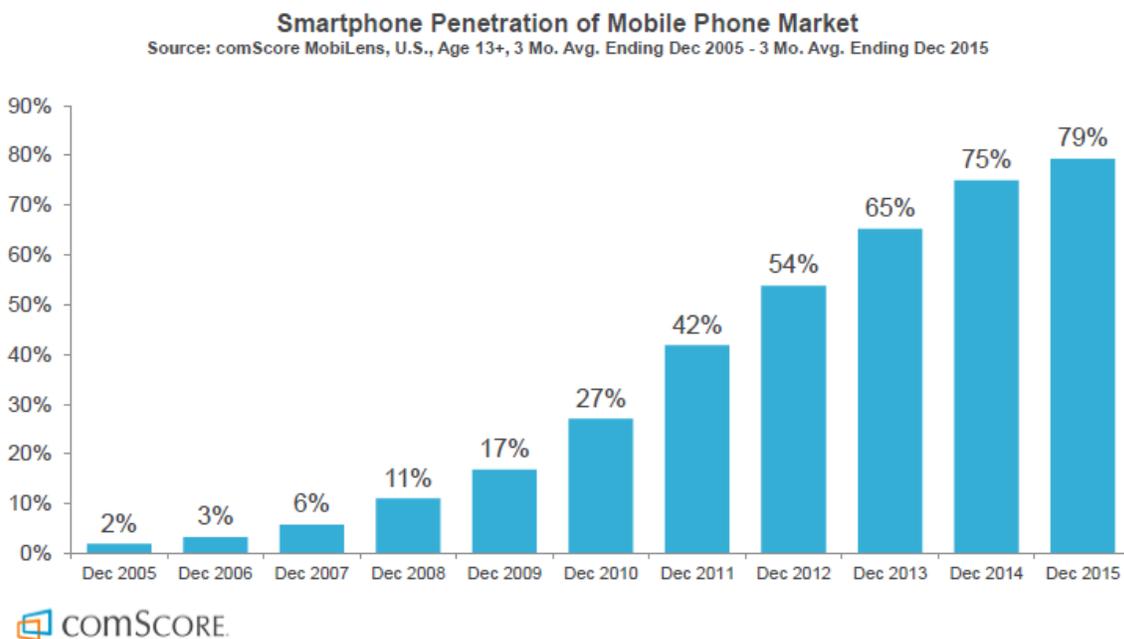
¹⁵⁴ Zach Epstein, *Samsung Galaxy S6 Hands-on: Meet The Smartphone to Beat in 2015*, BGR (Mar. 1, 2015), <http://bgr.com/2015/03/01/samsung-galaxy-s6-review-pt-1-hands-on/>; Dan Seifert, *Samsung's Galaxy S7 and S7 Edge Bring Refinement to a Proven Design*, THE VERGE (Feb. 21, 2016), <http://www.theverge.com/2016/2/21/11077956/samsung-galaxy-s7-edge-smartphone-announced-specs-mwc-2016>.

¹⁵⁵ Aaron Souppouris, *This Is the HTC One M9*, ENGADGET (Mar. 1, 2015), <http://www.engadget.com/2015/03/01/htc-one-m9-announcement/>; Dan Seifert, *HTC 10 Announced: A Modern Phone with Familiar Design*, THE VERGE (Apr. 12, 2016), <http://www.theverge.com/2016/4/12/11402828/htc-10-announced-smartphone-specs-camera-android>.

¹⁵⁶ Dan Seifert, *Microsoft Lumia 950 Review*, THE VERGE (Nov. 20, 2015), <http://www.theverge.com/2015/11/20/9767266/microsoft-lumia-950-review-windows-10-continuum>.

\$199.99.¹⁵⁷ Google also released several iterations of its signature smartphone in September 2015: the Nexus 6P, manufactured by Huawei and the Nexus 5X, manufactured by LG.¹⁵⁸

Smartphones have continued to dominate the wireless handset market over Feature Phones. According to a Pew Research Center study released in February 2016, 72 percent of all U.S. adults owned a smartphone.¹⁵⁹ The total reported smartphones numbered more than 228 million at the end of last year, up 9.6 percent from 208 million in 2014.¹⁶⁰



Still, 21 percent of handset users continue to rely on non-smartphones, and the wireless industry is continuing to provide options for these consumers.¹⁶¹ The OEM market share

¹⁵⁷ *The Cheap Lumia 650 Has More Metal Than the Pricier Lumia 950 (Hands-on)*, CNET (Feb. 23, 2016), <http://www.cnet.com/products/microsoft-lumia-650/>.

¹⁵⁸ Robert Hackett, *Read This Before Buying One of Google's New Phones*, FORTUNE (Oct. 20, 2015), <http://fortune.com/2015/10/20/google-nexus-phone-reviews/>.

¹⁵⁹ *Emerging Economies Study*.

¹⁶⁰ *CTIA Annual Survey*.

¹⁶¹ *Id.*; see also Monica Anderson, *Technology Device Ownership: 2015*, PEW RESEARCH CTR. (Oct. 29, 2015), <http://www.pewinternet.org/2015/10/29/technology-device-ownership-2015/>.

positions for non-smartphones are highly fluid as new entrants seek to leverage success in international markets and target budget-minded consumers with lower-cost prepaid device options. For example, ZTE began ramping up its entry into the U.S. prepaid market in late 2014 and, by April 2015, claimed 21 percent of the prepaid smartphone market.¹⁶² Carriers continue to focus on prepaid phones and are moving to compete more vigorously with more prepaid smartphone options from a wider variety of OEMs.¹⁶³ For instance, the ZTE Maven has a screen, speakers, and a processor with capabilities somewhere between the iPhone 5 and 6 and costs just \$60.¹⁶⁴

2. Wireless device functions are improving rapidly while prices are dropping.

Competition among device manufacturers is driving innovative advances in device quality at the same time prices have fallen due to the wider range of device price points and innovative device financing options.

Wireless device performance has continued to improve across all technical parameters. For example, a comparison of the Samsung Galaxy S5, released in 2014, to the Samsung S7, launched in 2016, shows enhanced capabilities on virtually every metric, including display resolution, battery life, processor capabilities, system memory, hard drive size, and camera

¹⁶² See Evelyn Cheng, *The Chinese Smartphone That's Ramping Up in the US*, CNBC (Nov. 13, 2014), <http://www.cnbc.com/2014/11/13/chinese-smartphone-tracking-ztes-growth-in-us-mobile-market.html>; Kishalaya Kundu, *ZTE Claims 21% U.S. Market Share in Pre-Paid Handsets*, ANDROID HEADLINES (Apr. 24, 2015), <http://www.androidheadlines.com/2015/04/zte-claims-21-u-s-market-share-pre-paid-handsets.html>.

¹⁶³ See, e.g., Kundu, *supra* note 162; Bruce Einhorn, *The Cheap Phones Quietly Winning the U.S.*, BLOOMBERG (Sept. 3, 2015), <http://www.bloomberg.com/news/articles/2015-09-03/zte-s-cheap-phones-quietly-winning-the-u-s->.

¹⁶⁴ *Id.*

quality.¹⁶⁵ 4G LTE-capable phones, which can take advantage of the 4G LTE networks deployed by most wireless broadband carriers, are now the market standard.¹⁶⁶

Given the increased sophistication of devices as well as consumer demand for lower-priced devices, OEMs have emphasized design, device variations, and a variety of price points to entice consumers to choose their devices.¹⁶⁷ Lower income consumers are increasingly participating in the smartphone market and OEMs are reacting with a wider variety of low-cost devices.¹⁶⁸ For example, Apple, which had traditionally focused on a single screen size and a consistent price bracket, now offers three different screen sizes, including the iPhone 6 Plus with a 5.5 inch screen, and price points ranging from \$399 to \$949, depending on model, screen size, and storage.¹⁶⁹ Samsung, similarly, offers a range of screen sizes at a wide variety of price points, including pre-paid options.¹⁷⁰

¹⁶⁵ Compare Samsung Galaxy S7, S6, and S5, GSM ARENA, <http://www.gsmarena.com/compare.php3?idPhone1=7821&idPhone2=6849&idPhone3=6033> (last visited May 16, 2016).

¹⁶⁶ Coleman Bazelon & Giulia McHenry, *Substantial Licensed Spectrum Deficit (2015-2019): Updating the FCC's Mobile Data Demand Projections*, THE BRATTLE GROUP 4 (June 23, 2015), http://www.ctia.org/docs/default-source/default-document-library/brattle_350MHz_licensed_spectrum.pdf (“June 2015 Brattle Report”).

¹⁶⁷ Press Release, NPD Group, U.S. Smartphone Sales among Consumers Earning Less than \$30,000 Grow More Than 50 Percent, According to The NPD Group (Apr. 21, 2015), <https://www.npd.com/wps/portal/npd/us/news/press-releases/2015/us-smartphone-sales-among-consumers-earning-less-than-30000-grow-more-than-50-percent-according-to-the-npd-group/> (“We are seeing Apple react with increased distribution, lower priced products, and more device choices in order to appeal to a wider audience. Samsung continues to provide a wide range of choices for its customer and channel base, which continues to be broader in scope than its main competitor. Samsung hopes to deliver increased penetration into the more affluent demographics with its updated and more premium Galaxy S6 line.”).

¹⁶⁸ *Id.*

¹⁶⁹ See *Compare iPhone Models*, APPLE, <http://store.apple.com/us/iphone/compare> (last visited May 16, 2016).

¹⁷⁰ See *Compare Samsung Smartphone Models*, SAMSUNG, <http://www.samsung.com/us/mobile/cell-phones/all-products> (last visited May 16, 2016).

Meanwhile, the wireless industry continues to develop innovative solutions for consumers that require enhanced accessibility features. Wireless service providers continue to offer a wide range of service plans that offer people with disabilities choice and value among voice, text, and data services and are showcasing these products and services on their websites. Wireless OEMs are focused on achieving accessibility, including the development of innovative feature phones, smartphones, and tablets with built-in accessibility solutions such as screen readers, captioning software, hearing aid compatibility and, increasingly, personal assistant programs that ease everyday tasks and operations of mobile devices for all consumers, including those with hearing-, vision-, cognitive-, and dexterity-related disabilities. Accessibility support is also being addressed throughout the wireless ecosystem, including by ensuring compatibility with assistive technologies and developing innovative applications to meet the needs of people with disabilities. With the many software enhancements that OEMs have developed in mind, manufacturers are bridging the final gap between hardware and software capabilities. For instance, OEMs are taking steps to make sure that consumers are aware of wireless accessory products that are compatible with their mobile devices such as Braille display technology and Bluetooth devices.¹⁷¹ Meanwhile, companies with services that are primarily accessed via wireless devices are innovating to ensure that their content is accessible to as many users as possible on mobile platforms.¹⁷²

¹⁷¹ See, e.g., *Apple Accessibility Accessory Sales Reach Out to Users of All Needs*, PHONEARENA.COM (May 5, 2016), http://www.phonearena.com/news/Apple-accessibility-accessory-sales-reach-out-to-users-of-all-needs_id80825.

¹⁷² See, e.g., Casey Newton, *Facebook begins using artificial intelligence to describe photos to blind users*, THE VERGE (Apr. 5, 2016), <http://www.theverge.com/2016/4/5/11364914/facebook-automatic-alt-tags-blind-visually-impaired>; Todd Kloots, *Accessible images for everyone*, TWITTER BLOG (Mar. 29, 2016), <https://blog.twitter.com/2016/accessible-images-for-everyone>.

3. Contract-free device payment plans provide consumers with more flexibility and increase competition.

New wireless device leasing and installment payment plans have increased competition among wireless carriers by enabling consumers to switch more easily. The four largest wireless carriers are phasing out mandatory two-year service contracts and instead offering a variety of device leasing and installment payment plans.¹⁷³ The shift away from two-year contracts has lowered prices for consumers,¹⁷⁴ as well as provided them with more flexibility and choice in wireless devices and carriers.¹⁷⁵ Wireless carriers and at least one OEM offer various payment plans and lease options that enable consumers to buy wireless devices without signing a contract to receive device subsidies.¹⁷⁶ Additionally, wireless carriers now unlock wireless devices at users' request.¹⁷⁷ OEM device financing options give consumers more options to buy devices independently of wireless carriers. The availability of device unlocking, combined with the near-elimination of two-year contracts and the availability of wireless carrier and OEM payment plans, allows consumers to readily switch service providers. This has spurred intense price competition among the major nationwide wireless carriers for subscribers.¹⁷⁸ For example,

¹⁷³ Jon Brodtkin, *Apple's iPhone Upgrade Program vs. the Big Four Carriers' Payment Plans*, ARS TECHNICA (Sept. 10, 2015), <http://arstechnica.com/apple/2015/09/apples-iphone-upgrade-program-vs-the-big-four-carriers-payment-plans/>; Jacob Kastrenakes, *Two-year phone contracts are now dead at all major US Carriers*, THE VERGE (Jan. 11, 2016), <http://www.theverge.com/2016/1/11/10749160/sprint-kills-two-year-phone-contracts>.

¹⁷⁴ Philip Michaels, *Two-Year Phone Contracts Are Going Away – And That's Good For You*, TOM'S GUIDE (Aug. 17, 2015), <http://www.tomsguide.com/us/sprint-ends-contracts,news-21478.html>.

¹⁷⁵ Victor Luckerson, *How to Buy a Phone Now That 2-Year Contracts Are Dead*, TIME (Jan. 8, 2016), <http://time.com/4171314/cell-phone-two-year-contracts-upgrade-iphone/>.

¹⁷⁶ *Id.*

¹⁷⁷ Kif Leswing, *Now That It's Legal, Here's How to Unlock Your Phone on All Four U.S. Carriers*, GIGAOM (July 28, 2014), <https://gigaom.com/2014/07/28/unlock-phone-att-verizon-tmobile-sprint/>.

¹⁷⁸ Fionna Agomuah, *Wireless Price Wars: Consumers Win As Verizon, T-Mobile, Sprint And AT&T Battle For Subscribers*, INTERNATIONAL BUSINESS TIMES (Dec. 13, 2014), <http://www.ibtimes.com/wireless-price-wars-consumers-win-verizon-t-mobile-sprint-att-battle-subscribers-1749969>.

Verizon cut prices for its data plans by \$10 a month in February 2015, and then cut prices again in August 2015, in addition to decreasing access line charges for devices.¹⁷⁹ Likewise, as a result of price wars among carriers, in August 2015 AT&T cut the prices for some of its plans, and offered more data for the current prices of other plans.¹⁸⁰ Consumers are the beneficiaries of these shrinking prices and growing data offerings.

4. OEMs continue to develop and launch complementary wearable devices, which are poised to become indispensable add-ons to smartphones.

The wireless device market has begun to expand beyond smartphones and tablets as OEMs launch complementary wearable wireless devices, a market that is expected to see 750 million units shipped during the period from 2013 to 2020.¹⁸¹ For example, in 2015, Apple, Motorola, LG, Sony, Samsung, and other OEMs each launched smartwatches that offer integration with smartphones and increased functionality, such as biometric monitoring.¹⁸² Biometric monitoring features allow a wearer to track his or her heart rate during intense exercise to maximize training, and could one day offer sophisticated monitoring that warns the

¹⁷⁹ See Amit Chowdhry, *Verizon Drops Prices on Most Data Plans By \$10*, FORBES (Feb. 5, 2015), <http://www.forbes.com/sites/amitchowdhry/2015/02/05/verizon-drops-prices-on-most-data-plans-by-10/#3f92b7fd1919>; *Verizon Cuts Prices on Shared Data Plans and Smartphone Access Charges*, FIERCEWIRELESS (Aug. 7, 2015), <http://www.fiercewireless.com/story/verizon-cuts-prices-shared-data-plans-and-smartphone-access-charges/2015-08-07>.

¹⁸⁰ Nicole Arce, *Price Wars Force AT&T To Introduce New Plans With More Data For the Same Price Or Less*, TECH TIMES (Aug. 15, 2015), <http://www.techtimes.com/articles/76892/20150815/price-wars-force-at-t-to-introduce-new-plans-with-more-data-for-the-same-price-or-less.htm>.

¹⁸¹ *Cumulative Wearable Device Shipments to Surpass 750 Million Units by 2020, According to Tractica*, BUSINESS WIRE (June 22, 2015), <http://www.businesswire.com/news/home/20150622005210/en/Cumulative-Wearable-Device-Shipments-Surpass-750-Million#.VYwn7mfJC71>.

¹⁸² See John McCann and Lily Prasuethsut, *Best Smartwatch for 2016*, TECHRADAR (June 4, 2015), <http://www.techradar.com/us/news/wearables/best-smart-watches-what-s-the-best-wearable-tech-for-you-1154074>.

wearer of heart issues.¹⁸³ Smartwatches also allow consumers to play music, send messages or drawings to friends, and receive up-to-the-minute news and weather alerts.¹⁸⁴ Samsung launched a 3G-enabled smartwatch that gives users mobile connectivity without requiring a smartphone.¹⁸⁵ These devices increase connectivity and flexibility for consumers, allowing them to receive calls and messages untethered from their smartphones or other devices.¹⁸⁶ Meanwhile, LG, Samsung, HTC, and other OEMs have released virtual reality devices that either use or connect to smartphones and mobile device platforms.¹⁸⁷

5. Wireless device operating systems continue to compete for the lead in market share while expanding into new platforms and devices.

Apple's iOS and Google's Android operating systems continue to compete for the lead in market share, with Google Android capturing 53 percent and Apple's iOS capturing 43 percent.¹⁸⁸ Other entrants—including Windows Phone, Blackberry, and variations of Android (including Amazon FireOS)—have invested or are investing significant resources in developing competing operating systems.¹⁸⁹ Current smartphone operating system market shares are below.

¹⁸³ See Christina Farr, *Can a Smartwatch Help Prevent a Heart Attack?*, KQED SCIENCE (May 6, 2015), <http://ww2.kqed.org/futureofyou/2015/03/18/can-a-smartwatch-help-prevent-a-heart-attack/>.

¹⁸⁴ Michael Fuchs, *8 Ways Smartwatches Will Knock Your Socks Off*, VERIZON WIRELESS, <http://www.verizonwireless.com/archive/mobile-living/tech-smarts/android-smartwatch-features/> (last visited May 24, 2016).

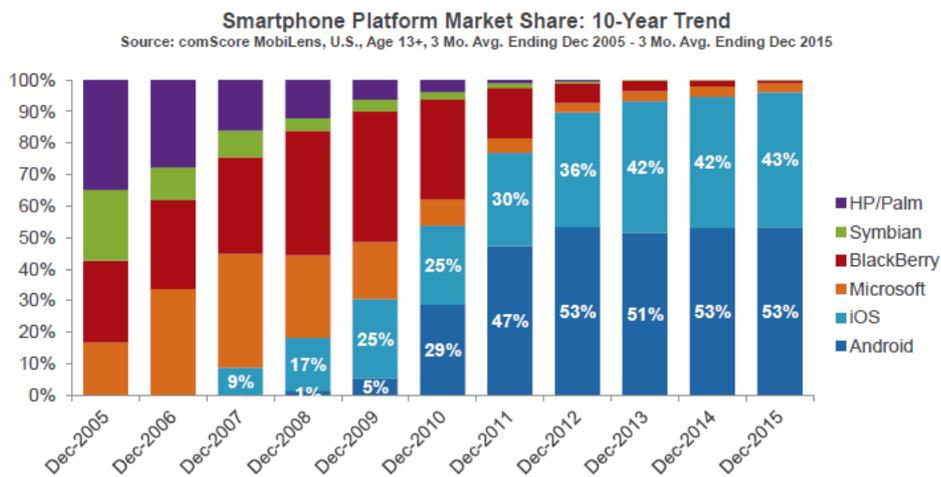
¹⁸⁵ James Peckham, *Samsung's New 3G Smartwatch Puts Another Nail in the SIM Card's Coffin*, TECHRADAR (Feb. 18, 2016), <http://www.techradar.com/us/news/wearables/samsung-s-new-3g-smartwatch-puts-another-nail-in-the-sim-card-s-coffin-1315214>.

¹⁸⁶ *Id.*

¹⁸⁷ Paul Lamkin, *The Best VR Headsets: The Virtual Reality Race Is On*, WAREABLE (Apr. 12, 2016), <http://www.wareable.com/headgear/the-best-ar-and-vr-headsets>.

¹⁸⁸ White Paper, *2016 U.S. Cross-Platform Future in Focus*, COMSCORE 24 (Mar. 30, 2016), <https://www.comscore.com/Insights/Presentations-and-Whitepapers/2016/2016-US-Cross-Platform-Future-in-Focus>.

¹⁸⁹ See e.g., Devindra Hardawar, *Amazon Launches Fire OS 5 Dev Preview, Based on Android Lollipop*, ENGADGET (June 19, 2015), <http://www.engadget.com/2015/06/19/amazon-fire-os-5-dev/>.



Platform integration has continued to create new opportunities for competition in the mobile operating system space. Consumers remain enthusiastic purchasers of wireless-enabled tablets, which are spurring further platform integration across devices.¹⁹⁰ As of October 2015, 45 percent of American adults own a tablet computer.¹⁹¹ Likewise, smartphone operating systems continue to converge with other mobile and wireless-enabled devices, including tablets, wearable devices, PCs, and OTT streaming devices.

B. Mobile Applications are Becoming A Primary Portal for Consumers’ Access to Digital Information and Content in the Competitive Wireless Marketplace.

Growth in demand for wireless services has also driven growth in the applications market, which supports hundreds of thousands of jobs and generates more competition among carriers and developers. More than 3.7 million apps were available from just three of the major app in 2015.¹⁹² The Google Play app store offers more than 1.8 million apps, while Apple’s

¹⁹⁰ Anderson, *supra* note 161.

¹⁹¹ *Id.*

¹⁹² Artyom Dogtiev, *App Store Statistics Roundup*, BUSINESSOFAPPS (Feb. 29, 2016), <http://www.businessofapps.com/app-store-statistics-roundup/>.

iTunes store offers 1.5 million apps.¹⁹³ Additionally, the open source nature of Google's Android OS has led other OEMs to design competing app stores, including the Amazon App Store and Blackberry's implementation of the Android app store.¹⁹⁴ The Amazon App Store offers more than 400,000 apps.¹⁹⁵

These applications for mobile devices support three-quarters of a million jobs. For instance, in 2015, 388,000 developers worked on the Google platform, 282,000 developers worked on the Apple platform, and 48,000 developers worked on the Amazon platform.¹⁹⁶ Moreover, consumers spend more and more time using apps, currently 198 minutes a day, on average, compared with 168 minutes a day watching TV.¹⁹⁷ Programmers are expected to speed development of apps in future months and years to meet the rapidly increasing demand from consumers for more apps, as well as to beat competition in the app marketplace.¹⁹⁸ App developers are also creating apps for new platforms including OTT streaming devices and smartwatches.¹⁹⁹

Consumers continue to benefit from a plethora of free apps, which allow companies to achieve broad penetration while earning additional revenue from in-app purchases. Even with

¹⁹³ Greg Sterling, *Report: Google Play Finally Passes iOS App Store In Number of Apps, Developers*, MARKETING LAND (Jan. 13, 2015), <http://marketingland.com/report-google-play-finally-passes-ios-app-store-number-apps-developers-114115>.

¹⁹⁴ See e.g., Hardawar, *supra* note 189; *Amazon Appstore Now Available for Your BlackBerry 10 Smartphone*, BLACKBERRY, <http://us.blackberry.com/apps/amazon-appstore.html> (last visited May 19, 2016).

¹⁹⁵ Dogtiev, *supra* note 192.

¹⁹⁶ Sterling, *supra* note 193.

¹⁹⁷ Sarah Perez, *U.S. Consumers Now Spend More Time in Apps Than Watching TV*, TECHCRUNCH (Sept. 10, 2015), <http://techcrunch.com/2015/09/10/u-s-consumers-now-spend-more-time-in-apps-than-watching-tv/>.

¹⁹⁸ *15 Mobile App Development Trends to Look Out for In 2015*, JULY RAPID, <http://julyrapid.com/15-mobile-app-development-trends-look-2015/> (last visited May 19, 2016).

¹⁹⁹ See, e.g., *Apple wants developers to make native apps*, BUSINESS INSIDER (Apr. 27, 2016), <http://www.businessinsider.com/apple-wants-developers-to-make-native-apps-2016-4>.

the majority of apps being free, consumers will nonetheless spend an estimated \$50 billion on mobile apps in 2016 and \$100 billion in 2020, demonstrating the sheer volume of app use and purchases predicted to occur.²⁰⁰ The U.S. market is transitioning from a phase characterized by sharp growth in downloads to a phase characterized by strong growth in app usage and resulting revenue expansion.²⁰¹

Because of these vibrant and growing application offerings, applications have become a primary portal for consumer access to information and content. Through applications providing travel information and directions, such as Waze, consumers are able to leverage real-time data to determine the fastest routes for travel.²⁰² Applications for services such as Netflix, Hulu, and Amazon Prime allow customers to stream video anywhere, and Kindle and other e-reader applications offer consumers a catalog of books and magazines to read on the go.²⁰³ Health- and fitness-related applications like Apple Health, MyFitnessPal, or Sworkit also benefit consumers by tracking steps, suggesting workouts, or tracking calories eaten and burned.²⁰⁴

C. Mobile Advertising Spending Continues to Increase at a Rapid Rate, Demonstrating Continued Competition for Wireless Consumers.

Facing competitive pressures from within the dynamic wireless marketplace, wireless carriers continue to increase spending on advertising to attract new customers and differentiate themselves from their competitors. With this information, consumers can evaluate their

²⁰⁰ *App Annie Mobile App Forecast: The Path to \$100 Billion*, APP ANNIE (2016), <https://barbanouille.files.wordpress.com/2016/02/app-annie-02-2016-forecast-en.pdf>.

²⁰¹ *Id.*

²⁰² White Paper, *The Next Generation of Wireless: 5G Leadership in the U.S.*, CTIA (Feb. 9, 2016), http://www.ctia.org/docs/default-source/default-document-library/5g_white-paper-web.pdf.

²⁰³ *See Americans Use Smartphones for More Than Voice Calls.*

²⁰⁴ *See, e.g.*, Jeff Cattel & Zach Watson, *The 39 Best Health and Fitness Apps of 2016*, GREATIST (Apr. 19, 2016), <http://greatist.com/fitness/best-health-fitness-apps>; Jill Duffy, *The 25 Best Fitness Apps for 2016*, PC MAG (Jan. 6, 2016), <http://www.pcmag.com/article2/0,2817,2485287,00.asp>.

competitive choices and select the best provider, plan, and device for their particular needs. Consumers can also use information about both pricing and quality attributes of a particular competitive choice when deciding whether to switch wireless devices or providers.²⁰⁵

In 2015, billions of dollars of wireless advertising spending went to television ads. According to a report from FierceWireless and iSpot.tv, in 2015, 35 wireless brands placed 466 television spots 440,000 times for a total ad value of \$1.89 billion.²⁰⁶ This represents an increase of \$100 million over 2014.²⁰⁷ In reaction to the fierce competition that has resulted in lower prices and increased flexibility for customers, carriers are using advertising in an effort to stand out from each other in the market. For example, T-Mobile has focused for years on branding itself as the “un-carrier.” And last year, Sprint spent more than \$254 million on marketing, with \$37 million going to variations of an advertisement that showed customers literally cutting their phone bills in half.²⁰⁸ Meanwhile, AT&T spent \$487.9 million on television advertisements in 2015, while Verizon spent \$377.9 million on television ads that focused on the speed and reliability of the Verizon 4G LTE network, in some instances using colorful balls as demonstration tools.²⁰⁹ These examples reflect the variety of ways that mobile providers seek to

²⁰⁵ Lerner/Ordo Paper at 2-3 (“Wireless consumers switch not only because of price differences, but also due to data download speeds, data coverage, reliability, and other quality attributes.”); *see also Seventeenth Report* ¶ 69 (“Consumers choose a service provider or switch between providers for varying reasons, including price, availability of family plans, network quality, free/unlimited in-network calling, billing/payment options/credit, reputation/recommendation, previous experience with the provider, customer service, mobile data services, specific phone offerings, and bundling mobile phone services with other services or other unspecified reasons.”).

²⁰⁶ *The top 10 advertisers in wireless in 2015: From AT&T to Straight Talk*, FIERCEWIRELESS (Jan. 25, 2016), <http://www.fiercewireless.com/special-reports/top-10-advertisers-wireless-2015-att-straight-talk>.

²⁰⁷ *Id.*

²⁰⁸ *Id.*

²⁰⁹ *Id.*; *see also Verizon: A Better Network as Explained by Colorful Balls*, <https://www.youtube.com/watch?v=785YQKmgITo> (last visited May 17, 2016).

differentiate themselves – such as service plans, price points, and network performance – in the increasingly competitive marketplace.

Mobile devices are also becoming an increasingly valuable medium for hosting advertisements. Of the more than \$22 billion expected to be spent in 2016 on digital display advertisements such as banners and sponsorships, 77.5 percent, or \$17.5 billion, “will be spent to reach individuals on mobile devices like smartphones and tablets.”²¹⁰ The advertising industry is recognizing the enormous reach of the wireless market, with the hundreds of millions of wireless connections in use today.

Given the tremendous value and competitiveness of the wireless advertising marketplace, the FCC should be careful not to enact regulations that could negatively affect the rapidly evolving online advertising ecosystem.²¹¹ The Commission’s proposed rules in the recently released broadband privacy notice of proposed rulemaking have the potential to restrict the ability of broadband providers—including mobile broadband providers—to advertise effectively.²¹² The proposed rules are a sharp departure from the Federal Trade Commission (“FTC”) framework that has governed Internet service providers (“ISPs”) for decades and that provides uniform protection for consumer data under a coherent regulatory regime. The FCC’s proposed framework would limit the ability of companies to cross-promote and compete effectively by applying an entirely different set of rules to ISPs than is applied to edge providers like search engines, ad networks, and social media platforms, which have access to the same information—if not more information—than ISPs. Moreover, the proposed rules will result in

²¹⁰ *US Digital Display Ad Spending to Surpass Search Ad Spending in 2016*, EMARKETER (Jan. 11, 2016), <http://www.emarketer.com/Article/US-Digital-Display-Ad-Spending-Surpass-Search-Ad-Spending-2016/1013442>.

²¹¹ See Comments of CTIA, WC Docket No. 16-106 (filed May 26, 2016).

²¹² See *Protecting the Privacy of Consumers of Broadband and Other Telecommunications Services*, Notice of Proposed Rulemaking, 31 FCC Rcd 2500 (2016).

substantial public interest harms. Most important, consumers will be confused about what information is being protected and the fact that ISPs are subject to different rules than edge providers that use the same information for the same commercial purposes. Consumers will also be frustrated by the proposal to require frequent and intrusive notice and opt-in mechanisms for the use of their personal information. Finally, the FCC's proposals would jeopardize data security, undermine the goal of broadband investment and deployment, and harm the ability of ISPs to provide competition in the online advertising market. Accordingly, CTIA joins with others in asking the FCC to instead create a framework that mirrors the rational FTC model for protecting consumer privacy and reflects the reality of today's Internet economy.²¹³

V. COMPETITION AND CONNECTIVITY ARE CREATING MASSIVE GROWTH IN THE INTERNET OF THINGS.

A. IoT Is a Pervasive Evolution Affecting the Broader Mobile Ecosystem.

Today, the IoT ecosystem has eclipsed the "vision of the future" moniker and is actively improving lives and enhancing our nation's productivity. According to Gartner, IoT will grow to encompass 21 billion devices and become a \$3 trillion a year industry by 2020.²¹⁴ Cisco goes even further, estimating 50 billion devices and \$8 trillion in value by 2020.²¹⁵ A large percentage of these devices will be connected via wireless networks, which will bring continued

²¹³ Letter to Chairman Jess Flake and Ranking Member Al Franken, Subcommittee on Privacy, Technology and the Law, from American Cable Association, CTIA, Internet Commerce Coalition, National Cable & Telecommunications Association, and USTelecom (May 10, 2016), <http://sf8.colorado.ctia.org/docs/default-source/Legislative-Activity/subcommittee-privacy-letter.pdf?sfvrsn=2>.

²¹⁴ Press Release, Gartner, Gartner Says 6.4 Billion Connected "Things" Will Be in Use in 2016, Up 30 Percent From 2015 (Nov. 10, 2015), <http://www.gartner.com/newsroom/id/3165317>.

²¹⁵ Press Release, Cisco, Internet of Things Will Deliver \$1.9 Trillion Boost to Supply Chain and Logistics Operations (Apr. 15, 2015), <https://newsroom.cisco.com/press-release-content?articleId=1621819>.

competition and innovation in the wireless sector for many years to come.²¹⁶ As detailed below, the continued, aggressive deployment of high-speed wireless networks has produced tremendous benefits for a wide range of critical U.S. industry sectors, encompassing such diverse industries as automotive, healthcare, wearables, smart homes, agriculture, and energy.

B. The IoT Landscape is Growing to Encompass Nearly Every Major Industry.

1. Automotive.

Gartner predicts a “huge increase” in connected automobiles over the next five years, stating that by 2020 there will be approximately 250 million connected vehicles on the road, enabling new in-vehicle services and automated driving capabilities.²¹⁷ 4G Americas predicts that by 2018, one in five cars on the road will be “self-aware” and able to discern and share information on their mechanical health, location, and status of their surroundings.²¹⁸

A wide range of transportation-related services are now being provided over wireless networks, and the rollout of 5G networks will only increase the capabilities of connected vehicles. Currently, the IoT Automotive industry provides connected vehicle telematics, safety and entertainment services, traffic management and emergency alert services, ticketing services, mobile parking management applications, and roadside assistance. Examples of wireless carrier involvement in the automotive IoT sector include:

²¹⁶ See White Paper, *Cellular Technologies Enabling the Internet of Things*, 4G AMERICAS, 2 (Nov. 2015), http://www.4gamericas.org/files/6014/4683/4670/4G_Americas_Cellular_Technologies_Enabling_the_IoT_White_Paper_-_November_2015.pdf (“4G Americas IoT White Paper”) (stating that GSM Association predicts that cellular IoT communications will account for over 10% of the global market by 2020).

²¹⁷ Press Release, Gartner, Gartner Says By 2020, a Quarter Billion Connected Vehicles Will Enable New In-Vehicle Services and Automated Driving Capabilities (Jan. 26, 2015), <http://www.gartner.com/newsroom/id/2970017>.

²¹⁸ 4G Americas IoT White Paper at 15.

- The AT&T Drive platform, which allows automakers to pick and choose the apps, services, and capabilities that help differentiate their products in the marketplace.²¹⁹
- Verizon's Hum Service, which provides drivers with up-to-date information about their car's health, contacts roadside assistance in the case of a breakdown, and dispatches emergency services if it detects an accident.²²⁰

2. Healthcare.

The healthcare IoT market segment is poised to hit \$136.8 billion by 2021.²²¹ McKinsey Global Institute estimates that the economic impact of IoT deployments through healthcare applications could be as much as \$1.6 trillion by 2025.²²² IoT healthcare products include blood pressure monitors, glucose monitoring, electrocardiogram monitoring, hearing aids, defibrillators, insulin pumps, and pulse oximetry. These developments are occurring because of significant improvements in computing power and storage, widespread availability of cloud services, more advanced data analytics, less expensive and lower-power wireless sensors, and the development of a peripheral device ecosystem.

The growth of the IoT healthcare industry allows individuals to play a more active role in their care with IoT wearables (discussed below), and has the potential to profoundly impact multiple areas of healthcare, including remote patient monitoring, medication adherence, and intelligent hospital rooms. According to PwC Health Research Institutes' annual report, mobility

²¹⁹ See Chris Penrose, *AT&T Introduces Three New Applications to the AT&T Drive Connected Car Platform*, AT&T CONSUMER BLOG (Mar. 2, 2015), <http://blogs.att.net/consumerblog/story/a7797754>.

²²⁰ See HUM BY VERIZON, <https://www.hum.com/> (last visited May 16, 2016).

²²¹ See Mohammed Adnan Malik, *World Internet of Things in Healthcare Market - Opportunities and Forecasts, 2014 -2021*, ALLIED MARKET RESEARCH (Feb. 2016), <https://www.alliedmarketresearch.com/iot-healthcare-market>.

²²² James Manyika et al., *Unlocking the Potential of the Internet of Things*, MCKINSEY GLOBAL INSTITUTE (June 2015), <http://www.mckinsey.com/business-functions/business-technology/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world>.

will be one of the top three trends reshaping the healthcare industry in 2016.²²³ The report found that 32 percent of U.S. consumers have at least one health app on their mobile devices (up 16 percent since 2013). Makovsky/Kelton’s “Pulse of Online Health” survey found that two-thirds of consumers would use mobile healthcare apps to prevent and manage disease by: tracking diet/nutrition (47 percent); receiving medication reminders (46 percent); tracking symptoms (45 percent); and tracking physical activity (44 percent).²²⁴

Innovations like digital fitness trackers can provide a number of consumer benefits. Research suggests that wearing a device that tracks and measures physical activity can increase motivation, accuracy, and accountability for users.²²⁵ Similarly, primary care physicians are engaging patients in self-monitoring and goal-setting via such technologies.²²⁶ As Commissioner Clyburn has stated, wearable devices and personal health technologies “demonstrate the power of spectrum to unlock opportunities for consumers to take control of their personal health. From the most basic devices that monitor daily steps and vitals, to more complex technologies like glucose reading and heart monitoring, these innovations in the mobile ecosystem, have the potential to significantly impact the health and safety of individuals.”²²⁷

²²³ See *Top Health Industry Issues of 2016*, PwC (2016), <http://www.pwc.com/us/en/health-industries/top-health-industry-issues.html>.

²²⁴ See *Two-Thirds of Americans in Favor of Digital Personal Health Management*, IMAGING TECHNOLOGY NEWS (Feb. 24, 2015), <http://www.itnonline.com/content/two-thirds-americans-favor-digital-personal-health-management>.

²²⁵ See Heidi Godman, *Can digital fitness trackers get you moving?*, HARVARD HEALTH BLOG (Aug. 27, 2015), <http://www.health.harvard.edu/blog/can-digital-fitness-trackers-get-you-moving-201508278214>.

²²⁶ See Doug Klein, *Electronic activity trackers encourage family fun and fitness*, NATIONAL INSTITUTES OF HEALTH (June 30, 2015), <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4496722/>.

²²⁷ Remarks of FCC Commissioner Mignon L. Clyburn, 2016 California Telehealth Network Annual Summit, San Diego, CA, at 3 (Apr. 18, 2016), https://apps.fcc.gov/edocs_public/attachmatch/DOC-338901A1.pdf.

Examples of the revolutionary changes taking place in the way healthcare is being delivered via mobile technology include:

- AT&T Virtual Care, which delivers end-to-end telehealth solutions (including the necessary hardware, software, and network infrastructure) to allow for the evaluation, diagnosis and treatment of patients in remote locations by specialists.²²⁸
- HealthID, a product of Sprint’s Accelerator powered by Techstars program, is a wristband that allows first responders to access important medical information during an emergency, by touching/holding their near field communication (NFC) enabled smartphone over the “Star of Life” symbol.²²⁹ HealthID helps startups build the future of mobile technology in areas such as wearables, mobile applications, enterprise solutions, education, gaming, entertainment, health, security and government.²³⁰

3. Wearables.

Wearables are defined as “the computing devices that are always-on, always accessible and easily worn on the body.”²³¹ Cisco forecasts that wearables will grow to 601 million devices in use worldwide by 2020.²³² Ownership of wearable devices has doubled since 2014.²³³ The categories of products and applications that currently define the wearable landscape include fitness, healthcare, industrial, infotainment, augmented reality, smart clothing, authentication,

²²⁸ See White Paper, *Telehealth: Breaking Down Barriers for More Connected Healthcare*, AT&T, http://www.corp.att.com/healthcare/docs/connected_hc.pdf (last visited May 16, 2016).

²²⁹ See HealthID Bands, HealthID, <https://healthid.myshopify.com/collections/frontpage/products/healthid-band> (last visited May 16, 2016).

²³⁰ See *Sprint Mobile Accelerator*, SPRINT, <http://sprintaccel.com/> (last visited May 16, 2016).

²³¹ *4G Americas IoT White Paper* at 19.

²³² See *Cisco White Paper*.

²³³ Steven Musil, *Ownership of Wearable Devices Has Doubled Since 2014, Study Finds*, CNET (May 12, 2016), <http://www.cnet.com/news/ownership-of-wearable-devices-has-doubled-since-2014-study-finds/>.

and gaming headsets. The number of wearable use cases is continually growing, driving consumer data usage far beyond the smartphone.

4. Smart Homes.

Gartner predicts that a typical family home could contain more than 500 smart devices by 2022.²³⁴ According to *The Economic Times*, the majority of home devices shipped will be connected to the Internet by 2030.²³⁵ Smart home technologies can create both individual and societal benefits in different ways. They can provide financial savings, enhance convenience for consumers, contribute to more ecological and sustainable living, and reinforce the homeowner's sense of safety and security. A recent report by VisionMobile found that out of the 4.5 million people identified as IoT developers in 2015, 1.4 million were focused on smart home applications.²³⁶ Examples of innovative mobile apps that allow consumers to monitor and control their home devices remotely include Samsung's SmartThings,²³⁷ Philips Hue,²³⁸ IFTTT,²³⁹ and Honeywell's Lyric.²⁴⁰ These apps allow a user to connect and control various "smart" household devices—including thermostats, lights, alarm systems, and even coffee makers—directly from their smartphone.

²³⁴ Press Release, Gartner, Gartner Says a Typical Family Home Could Contain More Than 500 Smart Devices by 2022 (Sept. 8, 2014), <http://www.gartner.com/newsroom/id/2839717>.

²³⁵ *Internet of Things Report 2015: When Things Talk Back*, THE ECONOMIC TIMES (Nov. 9, 2015), http://articles.economictimes.indiatimes.com/2015-11-09/news/68134239_1_food-services-devices-lot.

²³⁶ See David Bolton, *1.4 Million App Developers Are Building for the Smart Home*, ARC FROM APPLAUSE (Feb. 9, 2016), <https://arc.applause.com/2016/02/09/smart-homes-app-development/>.

²³⁷ *Samsung Smart Things*, SAMSUNG, <http://www.samsung.com/uk/smarthings/> (last visited May 20, 2016).

²³⁸ *Hue: Personal Wireless Lighting*, PHILIPS, <http://www2.meethue.com/en-us/> (last visited May 20, 2016).

²³⁹ *Connect Your Home*, IFTTT, <https://ifttt.com/categories/connect-your-home> (last visited May 20, 2016).

²⁴⁰ *Lyric Mobile App*, HONEYWELL, <http://yourhome.honeywell.com/en/products/apps/lyric-mobile-app> (last visited May 20, 2016).

The Alexa voice service and app, in tandem with the Amazon Echo device, is also expanding the universe of connected home technology. In 2015 Amazon released Echo, a wireless-enabled, voice-activated device that, among other things, plays music, reads audiobooks, and provides news and weather reports.²⁴¹ The Echo can also control lights, switches, and thermostats by connecting wirelessly to smart home devices like the Hue, WeMo, Nest, and others.²⁴² In April 2016, Amazon opened the Echo's application programming interface to allow developers to further increase the capabilities of the Echo device.²⁴³

5. Agriculture.

The agriculture industry is also taking advantage of the innovative IoT marketplace, deploying wireless sensors and weather stations to gather real-time data, including how much water different plants need and whether they require pest management or fertilizer.²⁴⁴ According to Accenture, the total market size for digital precision agriculture services (the practice of sensing and responding to variables such as weather and soil conditions) is expected to grow “at a compound annual growth rate of 12.2 percent between 2014 and 2020, to reach \$4.55

²⁴¹ *Amazon Echo*, AMAZON, <http://www.amazon.com/Amazon-Echo-Bluetooth-Speaker-with-WiFi-Alexa/dp/B00X4WHP5E> (last visited May 30, 2016).

²⁴² *Id.*

²⁴³ *Amazon releases API to add more smart home capabilities to Alexa*, BUSINESS INSIDER (Apr. 7, 2016), <http://www.businessinsider.com/amazon-releases-api-to-add-more-smart-home-capabilities-to-alexa-2016-4>.

²⁴⁴ *State of the Market: Internet of Things 2016*, VERIZON, 15 (Apr. 2016), <http://www.verizon.com/about/our-company/state-of-the-market-internet-of-things> (“*Verizon 2016 State of the Market IoT Report*”).

billion.”²⁴⁵ The use of IoT in the agriculture industry will not only help improve efficiency, but will also play a vital role in conserving precious natural resources.²⁴⁶

6. Energy.

The availability of high-speed wireless networks to most consumers has ushered in a wide array of applications and services focused on the energy sector. Smart grids (electrical grids that incorporate communications technology) allow energy distribution to be managed in real time based on immediate data rather than historic patterns of energy, energy consumption can be controlled more efficiently and dependably. New energy-related applications and services enabled by wireless networks such as Nest,²⁴⁷ Hive,²⁴⁸ and Tado,²⁴⁹ allow homeowners to adjust their temperature and hot water settings from a smartphone, some even learning the user’s specific habits and gradually adjusting their settings to fit the users’ preferences. Other energy-related IoT initiatives include: AT&T’s Smart Grid solutions²⁵⁰ and Verizon Wireless BigBelly Solar smart trash and recycling receptacles.²⁵¹ In addition, companies like Sprint, T-Mobile, and U.S. Cellular have adopted handset recycling programs, which provide “big change

²⁴⁵ *Digital Agriculture: Improving Profitability*, ACCENTURE, 3 (2015), https://www.accenture.com/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Digital_3/Accenture-Digital-Agriculture-Point-of-View.pdf.

²⁴⁶ See Press Release, Report Shows American Farmers Rely on Wireless Technology to Increase Productivity and Conserve Water, CTIA Wireless Foundation (Apr. 22, 2016), <http://www.wirelessfoundation.org/about-us/news/2016/04/22/report-shows-american-farmers-rely-on-wireless-technology-to-increase-productivity-and-conserve-water>.

²⁴⁷ See NEST, <https://nest.com/> (last visited May 20, 2016).

²⁴⁸ See Help, HIVE, <https://www.hivehome.com/user-guides/> (last visited May 20, 2016).

²⁴⁹ See TADO, <https://www.tado.com/us/> (last visited May 20, 2016).

²⁵⁰ See *AT&T Smart Grid Solutions*, AT&T, <https://www.business.att.com/enterprise/Service/internet-of-things/smart-cities/iot-smart-grid/> (last visited May 16, 2016).

²⁵¹ See *Applying Innovative Technology to Energy Management*, VERIZON, <http://www.verizon.com/about/sites/default/files/Energy-Management.pdf> (last visited May 20, 2016).

... one small device at a time.”²⁵² Going forward, IoT will likely continue to have a substantial impact on the energy sector. As Verizon points out, “[w]ith an addressable market of more than 300 million electric, water and gas meters in service in the US today, the opportunity for intelligent solutions and services in the utilities market is massive.”²⁵³

VI. WIRELESS CARRIER INVESTMENT IN THE EXPANSION AND IMPROVEMENT OF NETWORKS IS EXCEPTIONAL.

Consistent with their past efforts, wireless carriers continue to invest vigorously in their networks and deploy more advanced and efficient technologies across the nation, including in rural areas. However, this new infrastructure deployment depends on wireless carriers’ ability to site and maintain physical facilities. The Commission has taken several actions recently that have reduced barriers to such deployment, but there are additional steps that both it and other federal agencies can take to give wireless carriers the tools they need to deploy more robust and more advanced networks, such as 5G networks.

A. Competition is Increasing Capital Investment in Infrastructure, But There is Still More the Commission Can Do to Support Deployment of Infrastructure.

1. Since the FCC’s last report on competition in the mobile marketplace, U.S. wireless carriers have continued to invest vigorously in their networks.

Along with adoption and usage rates, one of the best indicators of the wireless industry’s vibrancy and competitiveness continues to be its capital investment record. The FCC has recognized that “[n]etwork investment remains a centerpiece of service providers’ efforts to improve their customers’ mobile wireless service experience.”²⁵⁴ Since the FCC’s last mobile

²⁵² *Device Recycling*, SPRINT, <http://goodworks.sprint.com/product/device-recycling/> (last visited May 20, 2016); *About T-Mobile: Community & Sponsorships*, T-MOBILE, http://www.t-mobile.com/company/community.aspx?tp=Abt_Tab_PhoneRecyclingProgram (last visited May 20, 2016); *Trade-In & Recycling Programs*, U.S. CELLULAR, <http://www.uscellular.com/tradein/index.html> (last visited May 20, 2016).

²⁵³ *Verizon 2016 State of the Market IoT Report* at 21.

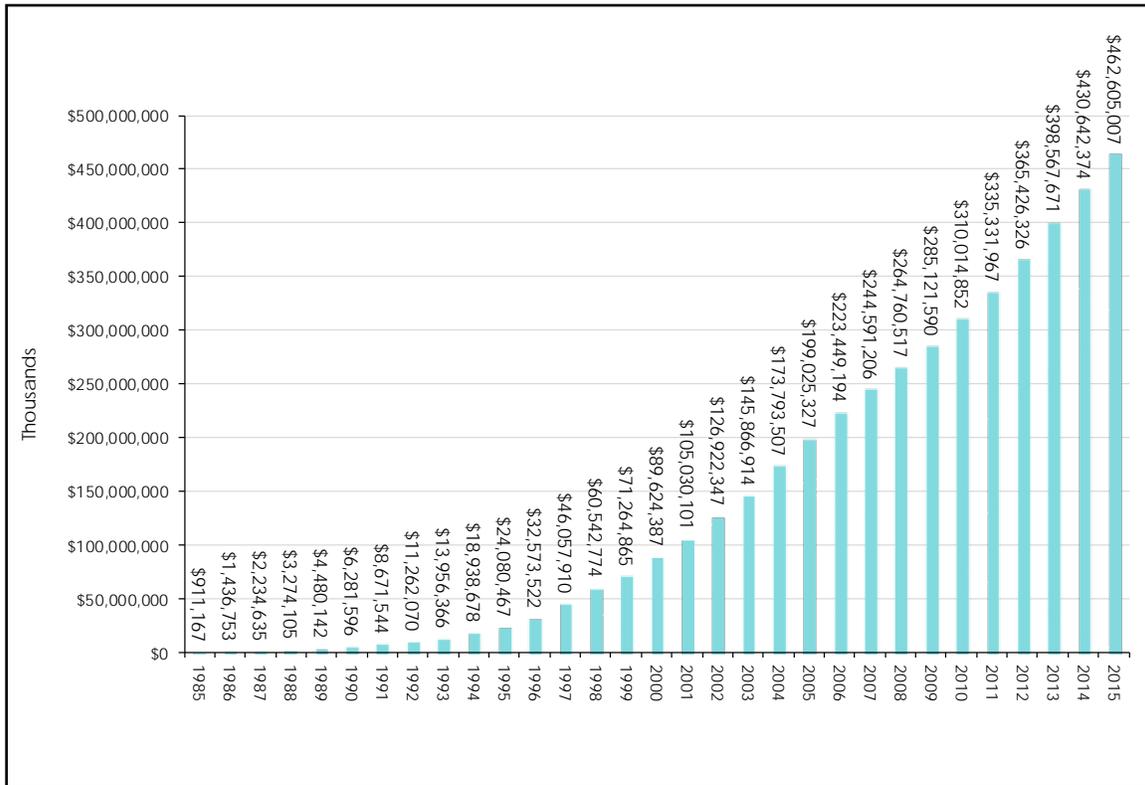
²⁵⁴ *Eighteenth Report* ¶ 115.

wireless competition report, U.S. wireless carriers have continued to make substantial investments in their networks. The ongoing level of investment demonstrates wireless carriers' commitment to improving and expanding the quality and capacity of their networks to accommodate new technologies and meet consumers' needs in light of increased use of wireless data applications, ever-widening smartphone penetration, and the adoption of other emerging and embedded wireless devices.

As shown in the graph below, capital expenditures by wireless providers continue to escalate, with cumulative capital investment at the end of 2015 totaling more than \$462 billion, up 7.4 percent from 2014.²⁵⁵

²⁵⁵ See *CTIA Annual Survey* at 11.

Reported Cumulative Capital Investment Exceeds \$462 Billion, Rises 7.4% Year-Over-Year; Incremental Capex Totals Almost \$32 Billion in 2015



Source: Background on CTIA’s Wireless Industry Survey (May 2016).

Over just the last seven years, wireless carriers invested over \$197 billion into the U.S. GDP.²⁵⁶ And in 2015 alone, wireless carriers invested \$32 billion in their networks.²⁵⁷ This represents over a 28 percent increase in annual investment from 2010.²⁵⁸ Additionally, the wireless industry as a whole generated \$282 billion in U.S. GDP in 2014 (up 44 percent from

²⁵⁶ See *id.*

²⁵⁷ See *CTIA Annual Survey* at 11.

²⁵⁸ See *id.*

\$195 billion in 2011), making it larger than the car manufacturing, hotel, movie, and music industries.²⁵⁹

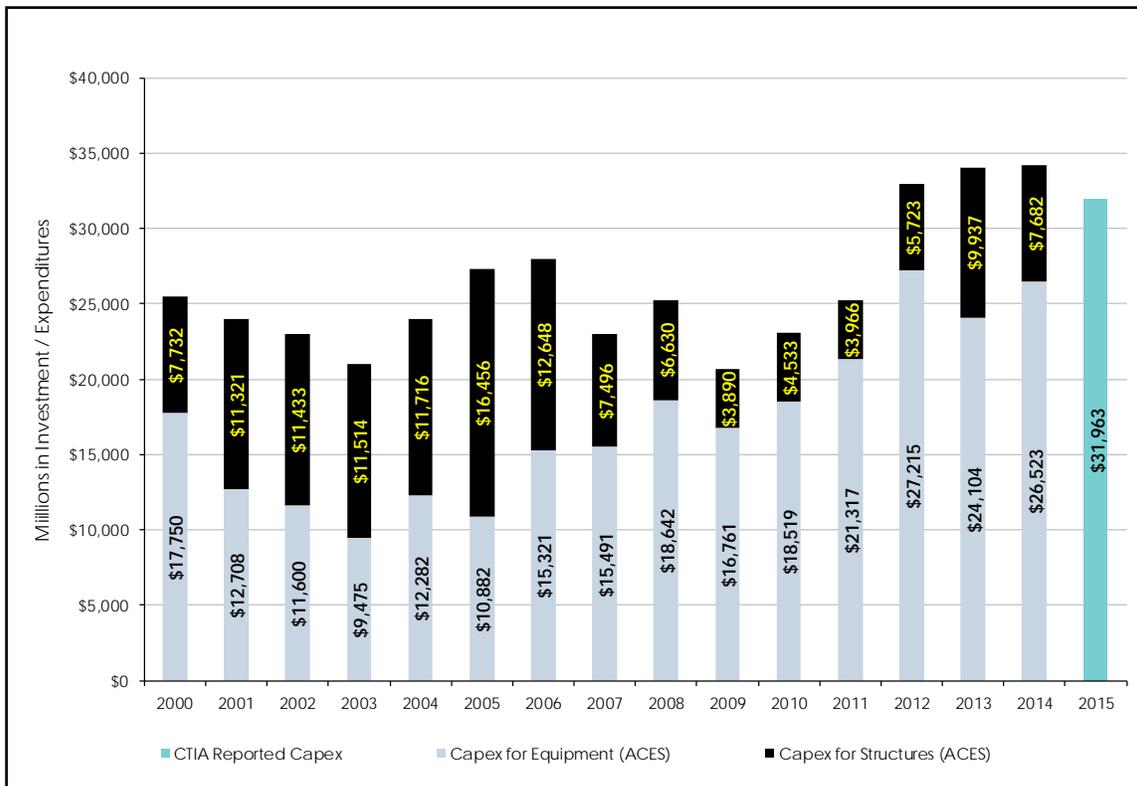
Moreover, as reported by the U.S. Census Bureau's Annual Capital Expenditures Survey, and as demonstrated in the chart below, in 2014 wireless telecommunications carriers spent \$34.2 billion on structures and equipment, including \$7.68 billion on deploying network structures.²⁶⁰ (Investment in related equipment totaled \$26.52 billion, of which all but \$9 million was spent on new equipment).²⁶¹ The steady growth in demand for network improvements by the wireless industry also causes other industries to invest in infrastructure used by wireless providers. For example, the tower company Crown Castle reports that its site rental revenues increased 9 percent from 2015 to 2016.²⁶²

²⁵⁹ See Roger Entner, *The Wireless Industry: Revisiting Spectrum, the Essential Engine of US Economic Growth 2*, CTIA, 17-18, 30 (Apr. 2016), <http://www.ctia.org/docs/default-source/default-document-library/entner-revisiting-spectrum-final.pdf>; see also Press Release, CTIA, America's Wireless Industry Generated Almost \$195 Billion of Domestic Economic Value and More Than \$282 Billion in US GDP in 2014 (Apr. 11, 2016), <http://www.ctia.org/resource-library/press-releases/archive/america-wireless-industry-economic-value>.

²⁶⁰ U.S. Census Bureau, *2014 Annual Capital Expenditures Survey* (Feb. 24, 2016), at Table 4a, <https://www2.census.gov/programs-surveys/aces/tables/2014/table4a.xlsx>.

²⁶¹ See *id.*

²⁶² *Crown Castle Quarterly Report (Form 10-Q)*, at 18 (May 9, 2016) (“*Crown Castle 10-Q*”), <http://bit.ly/1OQCjXs>; see also *American Tower Corp. Quarterly Report (Form 10-Q)*, at 24 (Apr. 29, 2016), <http://bit.ly/1OEhc5a> (“We continue to believe that our site leasing revenue is likely to increase due to the growing use of wireless [communications services] and our ability to meet the corresponding incremental demand for wireless real estate.”).



Source: U.S. Census Annual Capital Expenditures Survey (“ACES”), and Background on CTIA’s Wireless Industry Survey (May 2016).

These robust investment figures represent a true success story for the U.S. wireless market and for the U.S. economy. For example, in 2014, U.S. telecom companies invested 62 percent more in infrastructure than their EU counterparts.²⁶³ Statistics regarding capital investment by Asian carriers tell a similar story. In 2014, U.S. carriers spent \$10.70 in capital expenditures per subscriber per month.²⁶⁴ That was more than twice the monthly spending in China and more than six times the spending in Indonesia.²⁶⁵ These figures, moreover, do not even tell the entire story, as they do not include the more than \$41 billion spent at the

²⁶³ *The Wireless Ecosystem: US v. EU*, STRAND CONSULT, 4 (Apr. 2016) (reporting \$78 billion versus \$48 billion and \$75 billion versus \$48 billion), <https://morningconsult.com/wp-content/uploads/2016/04/Strand-Consulting-Net-Neutrality-Paper.pdf>.

²⁶⁴ *Analysis: Closing the Coverage Gap – A View from Asia*, GSMA INTELLIGENCE 8 (June 2015), <https://www.gsmaintelligence.com/research/?file=e245c423854fcfd38eeae0a918cc91c8&download>.

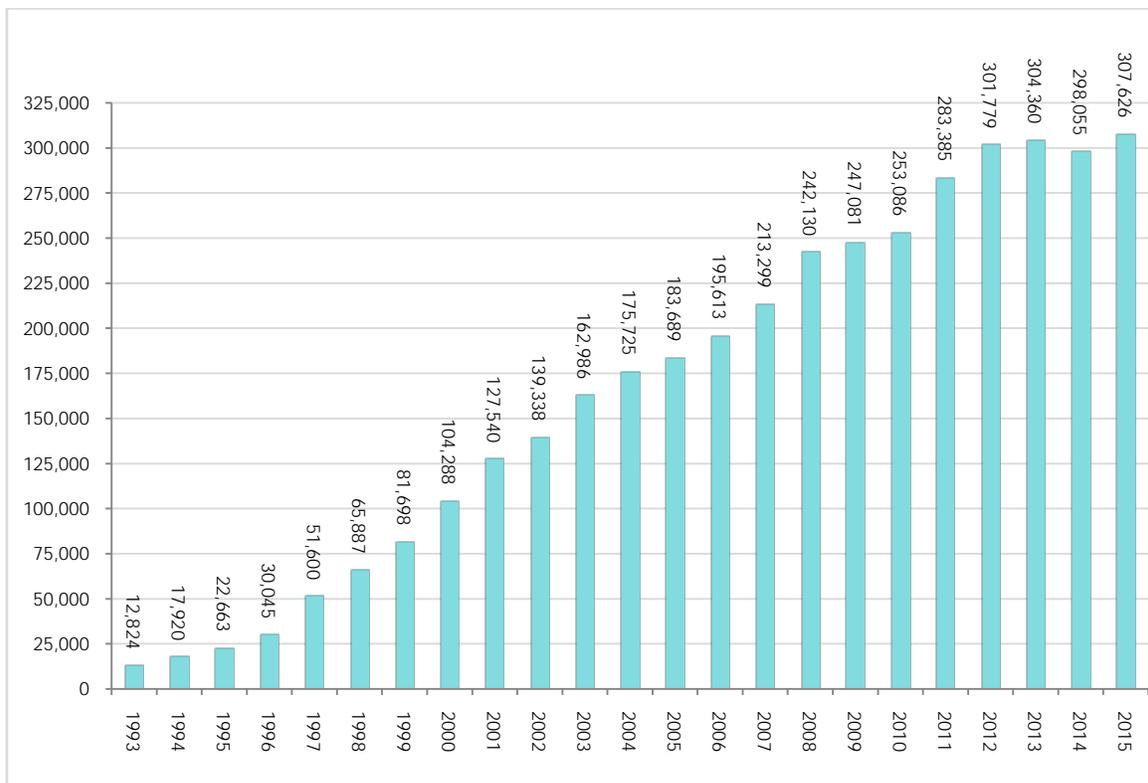
²⁶⁵ See *id.*

Commission’s AWS-3 spectrum auction²⁶⁶ or the additional sums spent acquiring spectrum resources in subsequent secondary market transactions.

2. Wireless carriers are continuing to find network efficiencies and expand cell site deployment.

This ongoing investment has allowed wireless carriers to both add new sites and deploy more advanced and efficient network technologies. In fact, there was a 3.2 percent increase in the aggregate number of cell sites deployed nationwide as of year-end 2015, which rose to 307,626, compared to 298,055 as of year-end 2014.²⁶⁷ The chart below illustrates the trend in operational cell sites over time.

Cell Sites in Service Rise 3.2% Year-to-Year



Source: Background on CTIA’s Wireless Industry Survey (May 2016).

²⁶⁶ See, e.g., Auction of Advanced Wireless Services (AWS-3) Licenses Closes; Winning Bidders Announced for Auction 97, Public Notice, 30 FCC Rcd 630 (WTB 2015).

²⁶⁷ See CTIA Annual Survey at 10.

These figures demonstrate a vibrant industry that is competing to improve network capacity, quality, and performance. Wireless providers are aggressively competing to offer existing and potential customers new capabilities, and they continue to deploy additional infrastructure to make their networks sufficiently robust to support the ever-increasing demands of consumers for anytime, anywhere high-speed and high-capacity connectivity. In fact, a recent report predicts the inventory of U.S. cell sites will rise to about 362,269 cell sites in 2019.²⁶⁸

Meanwhile, wireless carriers have begun to rely on an array of wireless infrastructure technologies to densify their networks and meet consumers' growing need for connectivity. In particular, wireless carriers are increasingly deploying smaller antennas—distributed antenna systems (“DAS”) and small cells—to boost capacity for the next generation of high speed, low latency services, especially in areas where macro cells are difficult to site.²⁶⁹ Industry analysts predict that wireless carriers will deploy more than 16 million DAS nodes by 2018,²⁷⁰ and that the number of microcells will grow from 2.5 million to 54.5 million sites during the next five years.²⁷¹

3. The Commission can continue to reduce barriers to the deployment of infrastructure and backhaul.

The deployment of mobile broadband networks depends on mobile providers' ability to site and maintain the physical facilities, including the deployment of dense DAS and small cell

²⁶⁸ *June 2015 Brattle Report* at 12-13.

²⁶⁹ See, e.g., *Enabling the Wireless Networks of Tomorrow: Rules of the Road for Pole Attachments in States Across America*, CTIA 2 (Apr. 2016), <http://www.ctia.org/docs/default-source/default-document-library/enabling-the-wireless-networks-of-tomorrow.pdf>. (“*Rules of the Road*”).

²⁷⁰ See *16 Million DAS Nodes to be Deployed Through 2018*, ANTENNAS SYSTEMS & TECHNOLOGY (Sept. 26, 2013), <http://www.antennasonline.com/main/news/16-million-das-nodes-to-be-deployed-through-2018/>.

²⁷¹ See *id.*

facilities, which have a lower impact and are more easily collocated.²⁷² As Commissioner O’Rielly has correctly pointed out, “To realize the promise of 5G, companies will need to expeditiously deploy facilities in a cost effective manner. Unnecessary siting expenditures substantially risk slowing 5G and broadband deployment.”²⁷³

CTIA commends the FCC for several recent actions the agency has taken that have made it easier for carriers to repurpose existing infrastructure through collocation, as well as to deploy DAS and small cells, thereby avoiding the need to build expensive new towers. For example, in November 2015, the FCC modified its pole attachment rules to encourage infrastructure deployment by “keeping pole attachment rates unified and low.”²⁷⁴ In October 2014, the FCC adopted new wireless infrastructure rules that streamline the environmental and historic preservation review process for collocations and DAS/small cell infrastructure, while preserving the ability of states, local jurisdictions, and Tribal Nations to protect their land-use priorities and safety interests.²⁷⁵ And in August 2014, the FCC streamlined its antenna structure construction, marking, and lighting rules in ways that will further assist wireless providers with their efforts to

²⁷² See Comments of CTIA – The Wireless Association®, GN Docket No. 14-126, at 10 (filed Mar. 6, 2015).

²⁷³ Statement of Michael O’Rielly, FCC Commissioner, Before the Senate Committee on Commerce, Science, and Transportation, “Oversight of the Federal Communications Commission,” at 2 (Mar. 2, 2016), https://apps.fcc.gov/edocs_public/attachmatch/DOC-338047A1.pdf; see also Remarks of Michael O’Rielly, FCC Commissioner, Before Hogan Lovells’ Technology Forum, “The 5G Triangle,” at 2 (May 25, 2016) (“There is little dispute that 5G wireless networks will require expansive buildout efforts by providers.”).

²⁷⁴ *Implementation of Section 224 of the Act; A National Broadband Plan for Our Future*, Order on Reconsideration, 30 FCC Rcd 13731 ¶ 4 (2015).

²⁷⁵ See *Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies; Acceleration of Broadband Deployment: Expanding the Reach and Reducing the Cost of Broadband Deployment by Improving Policies Regarding Public Rights of Way and Wireless Facilities Siting; 2012 Biennial Review of Telecommunications Regulations*, Report and Order, 29 FCC Rcd 12865 (2014).

keep pace with consumer demand and continue the economic growth made possible through the expanding mobile ecosystem.²⁷⁶ CTIA applauds these efforts.

The FCC should continue to reduce barriers to deploying infrastructure to ensure that consumers' present and future connectivity needs are met. As one example, CTIA encourages the FCC to quickly finalize the Programmatic Agreement to provide a comprehensive program alternative for the historic preservation review of DAS/small cell technologies.²⁷⁷ The Commission, and the Bureau specifically, have worked diligently to streamline siting of DAS and small cell systems in order to account for the limited potential for such facilities to adversely affect historic properties. The Commission should expeditiously move forward with finalizing the additional exclusions in order to facilitate the deployment of these important systems for 5G deployment and IoT. The FCC should also look for ways to streamline the environmental and historic preservation review of conventional towers. One positive step would be to adopt timeframes governing the review of Environmental Assessments, particularly in situations where no challenges are filed.²⁷⁸ Adopting clear, specific timetables for completing review will expedite antenna siting on federal, Tribal, and private properties and will help eliminate delays associated with the failure to act promptly on uncontested applications.

²⁷⁶ *2004 and 2006 Biennial Regulatory Reviews—Streamlining and Other Revisions of Parts 1 and 17 of the Commission's Rules Governing Construction, Marking and Lighting of Antenna Structure*, Report and Order, 29 FCC Rcd 9787 (2014).

²⁷⁷ See *Wireless Telecommunications Bureau Seeks Comment on Proposed Amended Nationwide Programmatic Agreement for the Collocation of Wireless Antennas*, Public Notice, DA 16-519 (WTB rel. May 12, 2016); *Wireless Telecommunications Bureau Seeks Comment on Revising the Historic Preservation Review Process for Small Facility Deployments*, Public Notice, 30 FCC Rcd 8160 (WTB 2015); Comments of CTIA – The Wireless Association®, WT Docket No. 15-180 (filed Sept. 28, 2015).

²⁷⁸ Comments of CTIA – The Wireless Association®, Department of Agriculture and Department of Commerce, *Broadband Opportunity Council Request for Comment*, Docket No. 150414365-5365-01, at 26 (filed June 10, 2015) (“*June 2015 Comments of CTIA*”).

4. Other agencies should also work to streamline deployments on federal lands.

The FCC should also encourage and coordinate with other federal agencies to streamline the deployment of wireless infrastructure on lands and buildings that they control. The dense 5G networks that are on the horizon must be widespread and close to consumers to achieve optimal performance.²⁷⁹ Additional sites, however, can be difficult to find.²⁸⁰ The federal government controls nearly 30 percent of all land in the U.S. and owns thousands of buildings. Federal agencies should—as directed by President Obama—work to streamline wireless infrastructure deployments on these lands and buildings.²⁸¹

For example, federal agencies should adopt a uniform rate schedule that would apply to all federal lands, including those managed by the Department of Defense.²⁸² Agencies should also streamline their processes for reviewing wireless applications, which can be considerably more time-consuming than those associated with deployments on private lands.²⁸³ Adoption and use of standardized processes and fees for siting wireless facilities could resolve many of the delays faced by wireless carriers when deploying facilities on federal lands.²⁸⁴

²⁷⁹ See, e.g., *Rules of the Road* at 3.

²⁸⁰ *Id.*

²⁸¹ See Exec. Order No. 13616, 77 Fed. Reg. 36,903 (June 20, 2012) (“2012 Executive Order”), <https://www.gpo.gov/fdsys/pkg/FR-2012-06-20/pdf/2012-15183.pdf>; see also Press Release, *Presidential Memorandum – Expanding Broadband Deployment and Adoption by Addressing Regulatory Barriers and Encouraging Investment and Training*, THE WHITE HOUSE (Mar. 23, 2015), <https://www.whitehouse.gov/the-press-office/2015/03/23/presidential-memorandum-expanding-broadband-deployment-and-adoption-addr>.

²⁸² See *June 2015 Comments of CTIA* at 11 (CTIA’s members report that some of the most expensive lease terms are imposed by the Department of Defense.).

²⁸³ See *id.* at 11-12, 16-17.

²⁸⁴ See *id.* at 20-21.

B. Wireless Technology Continues to Evolve, and Carriers Continue to Introduce Network Advancements.

1. Operators are continuing to aggressively deploy and expand their 4G LTE networks.

As the proliferation of 4G LTE wireless devices and consumer appetite for mobile broadband data accelerates, 4G LTE networks continue to expand. This growth corresponds with a migration of traffic away from less efficient 2G and 3G networks, as limited spectrum resources are refarmed for 4G LTE.²⁸⁵ In addition to the spectrum bands in which 4G LTE had been deployed (*e.g.*, the 700 MHz, Cellular/SMR, PCS, AWS-1, and BRS bands), 4G LTE is also expanding into the WCS band.²⁸⁶ Throughout the industry carriers are working to further expand 4G LTE into the recently auctioned AWS-3 band and the AWS-4 band. Band Class 66, which supports frequencies covered by AWS-1, AWS-3, and the AWS-4 downlink, was approved in the 3GPP standards-setting process last December and deployments are expected to begin in late 2017.²⁸⁷

Carriers have also rapidly expanded their 4G LTE coverage. For example, in late 2015, T-Mobile announced that its 4G LTE network now covers 304 million Americans, up from 265 million at the end of 2014 and 209 million at the end of 2013.²⁸⁸ Meanwhile, Sprint has doubled

²⁸⁵ See, *e.g.*, *AT&T Begins Deploying 2.3 GHz WCS Spectrum for LTE*, FIERCEWIRELESS (Sept. 9, 2015), <http://www.fiercewireless.com/story/att-begins-deploying-23-ghz-wcs-spectrum-lte/2015-09-09> (stating that “AT&T is also refarming its 1900 MHz PCS spectrum for LTE service in some markets”).

²⁸⁶ See *Id.*; Dan Meyer, *AT&T Network Focused on Spectrum 5G, Small Cells; Plans for IoT*, RCR WIRELESS NEWS (May 13, 2016), <http://www.rcrwireless.com/20160513/carriers/at-plans-for-iot-tag2> (“Mair said AT&T was also set to have ‘thousands’ of cell sites hosting the carrier’s 2.3 GHz spectrum resources by the end of this year, moving on work the carrier began last year. Mair said the spectrum would initially be used in dense urban and suburban environments where the carrier sees the greatest need for additional capacity.”).

²⁸⁷ *Id.* (“Moving forward, AT&T is looking in late 2017 to add support from the 1.7/2.1 GHz spectrum band the carrier purchased in last year’s AWS-3 auction, with volume deployments set for 2018.”)

²⁸⁸ See Ray Sheffer, *T-Mobile’s 4G LTE Coverage: Very Close to Verizon’s and AT&T’s*, MARKET REALIST (Dec. 1, 2015), <http://marketrealist.com/2015/12/t-mobiles-4g-lte-coverage-close-verizons-atts/>.

its number of LTE Plus markets and now offers this ultra-fast LTE service in more than 150 markets.²⁸⁹ AT&T's 4G LTE network now covers more than 355 million people in North America²⁹⁰ and Verizon reports that its 4G LTE network covers 312 million people across the U.S.²⁹¹ The 21 regional companies that have partnered with Verizon continue to help deliver 4G LTE to the nation's smallest towns and rural counties through the LTE in Rural America program, which now covers about 2.7 million people in areas totaling more than 100,000 square miles,²⁹² as do other providers that are participating in the Rural Independent Network Alliance, Sprint's Rural Roaming Preferred Provider program, and other next generation technology efforts.²⁹³

2. Investment in 4G LTE Advanced is unleashing the power of high bandwidth and increased data rates resulting from carrier aggregation.

In advance of 5G, U.S. operators are harnessing the power of carrier aggregation to increase data rates and improve the user experience. Carrier aggregation is a technology that allows multiple 4G LTE channels from the same or different spectrum bands to be combined into the equivalent of a single wideband channel, enabling increased data rates. For carrier aggregation to work, operators need to upgrade their networks to a 4G LTE Advanced release (LTE Releases 10, 11, or 12) and configure their base stations to aggregate available 4G LTE

²⁸⁹ See Press Release, Sprint, Sprint's LTE Plus Network Delivers Faster Download Speeds than Verizon, AT&T and T-Mobile and Costs 50% Less (Jan. 25, 2016), <http://investors.sprint.com/news-and-events/press-releases/press-release-details/2016/Sprints-LTE-Plus-Network-Delivers-Faster-Download-Speeds-than-Verizon-ATT-and-T-Mobile-and-Costs-50-Less/default.aspx>.

²⁹⁰ See *About AT&T*, AT&T, <http://about.att.com/news/wireless-network.html> (last visited May 18, 2016).

²⁹¹ See *A Leader in 4G LTE*, VERIZON, <http://www.verizonwireless.com/news/LTE/Overview.html> (last visited May 26, 2016).

²⁹² See *Verizon: All 21 LTE in Rural America Carrier Partners Have Launched Service*, FIERCEWIRELESS (Oct. 15, 2015), <http://www.fiercewireless.com/story/verizon-all-21-lte-rural-america-carrier-partners-have-launched-service/2015-10-15>.

²⁹³ See *infra* Section VI.C.

channels. But of equal importance, operators need to ensure that subscribers have devices capable of supporting 4G LTE-Advanced technology. All of these upgrades currently are taking place, and in the past year carrier aggregation has become prevalent. Carrier aggregation is quickly increasing data rates and improving 4G LTE service despite increasing traffic loads on 4G LTE networks.

For example, Verizon now supports carrier aggregation (“XLTE”) in more than 400 markets nationwide.²⁹⁴ T-Mobile claims to have “America’s *Most Advanced* LTE Network” and cites carrier aggregation of its 700 MHz spectrum and its mid-band spectrum as one of the reasons.²⁹⁵ And Sprint, which supports carrier aggregation (“LTE Plus”) in 103 major markets,²⁹⁶ recently announced that it had reached speeds of 300 Mbps on a Samsung Galaxy S7 using three-channel carrier aggregation.²⁹⁷

But carrier aggregation has little utility without devices to support it. Fortunately, most recently-released smartphones and tablets provide this support. For example, 3GPP specifications define multiple “categories” of devices depending on their capabilities. Support of 4G LTE Advanced begins with Category 6 (“Cat6”) devices, which support aggregation of two 20 MHz 4G LTE channels for peak data rates up to 300 Mbps.²⁹⁸ In the past twelve months,

²⁹⁴ See Paul Macchia, *XLTE by the Numbers*, VERIZON (July 28, 2015), <http://www.verizonwireless.com/news/article/2014/05/xlte-by-the-numbers-infographic.html>.

²⁹⁵ See Neville Ray, *Taking America’s Fastest 4G LTE Even Further*, T-MOBILE (Dec. 23, 2015), <https://newsroom.t-mobile.com/news-and-blogs/2015-end-of-year-network-recap.htm>.

²⁹⁶ See John Saw, *Introducing the Sprint LTE Plus Network – Faster, Stronger, More Reliable Than Ever Before*, SPRINT (Nov. 17, 2015), <http://newsroom.sprint.com/blogs/sprint-perspectives/introducing-the-sprint-lte-plus-network--faster-stronger-more-reliable-than-ever-before.htm>.

²⁹⁷ See Colin Gibbs, *Sprint Achieves 300 Mbps on Samsung Galaxy S7 with 3-Channel Carrier Aggregation*, FIERCEWIRELESS (Mar. 15, 2016), <http://www.fiercewireless.com/story/sprint-achieves-300-mbps-samsung-galaxy-s7-3-channel-carrier-aggregation/2016-03-15>.

²⁹⁸ See Zahid Ghadialy, *New LTE UE Categories: 11, 12, 13 and 14 in 3GPP Rel-12*, THE 3G4G BLOG (May 4, 2015), <http://blog.3g4g.co.uk/2015/05/new-lte-ue-categories-11-12-13-and-14.html>.

smartphones and tablets that support Cat6 or higher have become commonplace, because the chipsets powering the latest devices support the features of 4G LTE Advanced.²⁹⁹ As a result, many of the most popular phones from Samsung, Apple, HTC, LG, Motorola, and others support 4G LTE Advanced Cat6 carrier aggregation.³⁰⁰ A few devices released recently also support Cat9 or Cat12, both of which support the aggregation of three 20 MHz 4G LTE channels and download speeds of up to 450 Mbps for Cat9 and 600 Mbps for Cat12.³⁰¹

As operators are deploying two- and three-channel carrier aggregation in their networks, 3GPP has been working to expand the future capabilities of the feature. The original vision for carrier aggregation was to combine up to five 20 MHz “component carriers” for a total bandwidth of 100 MHz. In Releases 10 and 11 these component carriers are required to use the same frame structure (*i.e.*, all five are Frequency Division Duplex (“FDD”) or all five are Time Division Duplex (“TDD”) with the same uplink/downlink ratio). However, Release 12 allows aggregation of FDD and TDD carriers as well as aggregation of TDD carriers with different uplink/downlink ratios, which adds enormous flexibility to the current carrier aggregation framework.³⁰² This is an important development that helps to create a clear path toward 5G. Since deployments in frequency bands such as the 3.5 GHz band and those that will eventually be used for 5G will likely be TDD, the features in Release 12 will allow operators to leverage

²⁹⁹ See, e.g., *Processors Comparison*, QUALCOMM, <https://www.qualcomm.com/products/snapdragon/processors/comparison> (last visited May 20, 2016).

³⁰⁰ See *Apple iPhone 6s Specifications*, UBERGIZMO, http://www.ubergizmo.com/products/lang/en_us/devices/iphone-6s/ (last visited May 17, 2016); *LG G3 Cat. 6 vs Samsung Galaxy S6*, PHONEARENA.COM, <http://www.phonearena.com/phones/compare/LG-G3-Cat.-6,Samsung-Galaxy-S6/phones/8778,8997> (last visited May 17, 2016).

³⁰¹ See, e.g., *Processors Comparison*, *supra* note 301 (showing Qualcomm’s Snapdragon 820 chipset support for Category 12; several phones such as the LG G5 and the HTC 10 use this processor).

³⁰² See *Overview of 3GPP Release 12 V0.2.0 (2015-09)*, 3GPP160 http://www.3gpp.org/ftp/Information/WORK_PLAN/Description_Releases/Rel-12_description_20150909.zip (last visited May 20, 2016).

current and future spectrum assets to the benefit of consumers. This flexibility also facilitates the use of 4G LTE in unlicensed spectrum by operators that otherwise use FDD in their licensed spectrum holdings. Finally, Release 13, which is now commonly called “LTE Advanced Pro,” will increase the number of carriers that can be aggregated from five to 32, allowing a significant increase in data rates even before 5G is ready.³⁰³ At Mobile World Congress in Barcelona this year, LTE Advanced Pro capabilities demonstrated throughputs of approximately 1 Gbps.

3. Voice over LTE (“VoLTE”) is improving voice quality and will facilitate evolution to all-IP wireless networks.

Until recently, 4G LTE deployments supported packet data only, with voice support provided by 3G or 2G circuit-switched technology through a feature called circuit-switched fallback. However, the long term vision for 4G LTE has always been to support packet-switched voice, and U.S. wireless operators are investing heavily in a standard IMS-based implementation called Voice over LTE, or VoLTE. Indeed, implementation of VoLTE is a focus of operators worldwide. As Alan Hadden, VP of Research at the Global Mobile Suppliers Association points out, “the VoLTE market is advancing strongly and continues in 2015 as a main industry trend.”³⁰⁴

VoLTE provides several benefits for both mobile operators and consumers. It reduces call set up times and enables High Definition (“HD”) Voice by utilizing a wideband codec, which makes voice calls sound noticeably richer for mobile-to-mobile calls compared to typical circuit-switched voice calls. It also enables a suite of enhanced services known collectively as Rich Communication Services. Rich Communication Services includes standardized

³⁰³ See Dino Flore, *Evolution of LTE in Release 13*, 3GPP (Feb. 18, 2015), <http://www.3gpp.org/news-events/3gpp-news/1628-rel13>.

³⁰⁴ See Anne Morris, *GSA: VoLTE Deployments Reach 40 Worldwide*, FIERCEWIRELESSEUROPE (Dec. 16, 2015), <http://www.fiercewireless.com/europe/story/gsa-volte-deployments-reach-40-worldwide/2015-12-16>.

interoperable features such as video calling, conferencing, file transfer, real-time language translation, video voicemail and instant messaging. Most of the services enabled by Rich Communication Services are available as third-party applications to consumers, but Rich Communication Services simplifies use by allowing a user to launch these services from the phone's native dialer, instead of opening a separate application for each.

Like carrier aggregation, devices that support VoLTE are much more commonplace now than they were twelve months ago. However, VoLTE requires devices at both ends of the call to support the technology; collaborative work is well underway and progress is being made.³⁰⁵

At the end of 2015, AT&T had 27 million VoLTE subscribers,³⁰⁶ and according to T-Mobile, more than half of calls made on its network are VoLTE calls.³⁰⁷ T-Mobile also recently announced that it is upgrading its VoLTE network to Enhanced Voice Services,³⁰⁸ which, according to the carrier, offers improved call reliability, higher fidelity than HD Voice, and Wi-Fi calling support.³⁰⁹ And Verizon recently enabled VoLTE on late-model iPhones, which significantly increased the number of Verizon customers that can take advantage of the technology.³¹⁰ As a result of the investment and operator collaboration toward deploying VoLTE calling capabilities, the U.S. mobile industry is even closer to all-IP wireless networks.

³⁰⁵ See Bill Smith, *AT&T's Voice Over LTE Network Reaches More Than 27 Million Subscribers*, AT&T INNOVATION SPACE BLOG (Dec. 29, 2015), <http://about.att.com/innovationblog/122915voiceoverlte>.

³⁰⁶ *Id.*

³⁰⁷ See Martha Degrasse, *T-Mobile: Most of Our Calls Are on VoLTE*, RCR WIRELESS NEWS (Mar. 3, 2016), <http://www.rcrwireless.com/20160303/carriers/t-mobile-volte-tag4>.

³⁰⁸ See White Paper, *Evolved HD Voice for LTE*, ERICSSON (Oct. 2014), <http://www.ericsson.com/res/docs/whitepapers/wp-evolved-hd-voice-for-lte.pdf>.

³⁰⁹ See Neville Ray, *Patent-Pending: T-Mobile's Next Network Upgrade With Enhanced Voice Services*, T-MOBILE (Apr. 6, 2016), <https://newsroom.t-mobile.com/news-and-blogs/volte-enhanced-voice-services.htm>.

³¹⁰ See *It's Automatic: Better Sound Quality on iPhone 6 and Newer Models With Verizon HD Voice; iOS 9.3 Includes Wi-Fi Calling for Those Who Need It*, VERIZON (Mar. 21, 2016),

4. Small cells and heterogeneous networks are helping to add capacity and represent an important step toward 5G.

Operators realize that technical improvements in spectral efficiency, additional spectrum, and spectrum refarming will not be enough to satisfy the rapidly increasing demand for mobile broadband services, so densifying their networks with small cells is necessary to meet the needs of customers and to remain competitive. The required throughput per square kilometer is already taxing networks in dense urban areas and demand is continuing to increase, but small cells represent a viable solution by providing greater capacity and will provide the added benefit of paving the way for 5G.³¹¹ In addition, small cells and DAS can vastly improve indoor coverage and offload the outdoor macrocell layer of the network, improving the user experience in multiple ways. Small cell deployments for 4G LTE are leveraging outdoor DAS deployments and in-building deployments to carry traffic in dense urban areas.

A macrocell network, in which the majority of cells are of similar height and size, can be considered generally homogeneous. Traffic management for a homogeneous network, while challenging to provide capacity relief, is generally manageable using proven engineering traffic techniques. But the addition of various sizes of small cells, together with different bands of spectrum, creates a heterogeneous network, presents more technical challenges from an interference and traffic management perspective. The trend toward heterogeneous networks requires network features to allow the different sized cells to work efficiently together, particularly with multiple bands of spectrum being used across both macrocells and small cells. Fortunately, the 4G LTE standard includes several features to help mitigate the potential

<http://www.verizonwireless.com/news/article/2016/030/its-automatic-better-sound-quality-on-iphone-6-and-newer-models-with-verizon-hd-voice-ios-93-includes-wi-fi-calling-for-those-who-need-it.html>.

³¹¹ See Meyer, *supra* note 286 (“For small cells, Mair said [AT&T] sees the dense urban and suburban environments as making the most sense for the carrier, similar to where it views the use case for millimeter wave spectrum.”).

challenges that heterogeneous networks may introduce, including enhanced Inter-cell Interference Coordination, Carrier Aggregation with cross-carrier scheduling, and Coordinated Multi Point.³¹² U.S. operators are upgrading their 4G LTE networks to support these features as they continue to roll out more small cells.

The small cell trend has also created a vibrant market for neutral host multi-operator DAS and small cell solutions, which can leverage existing fiber assets, reduce costs, and accelerate network densification to improve broadband capacity for all operators in crowded public spaces like dense urban areas, stadiums, shopping malls, transportation hubs, and other areas where a high concentration of mobile broadband users congregate.³¹³

Providing backhaul to small cells is another challenge for which wireless operators are making significant investments to solve. In preparation for extensive small cell deployments, operators, cable companies, and fiber providers are building out fiber networks to provide backhaul connectivity.³¹⁴ The market for small cell backhaul solutions has expanded as a result, including the markets for both dark fiber and wireless backhaul, and growth is expected to increase dramatically as the industry edges closer to 5G.³¹⁵

U.S. operators are embracing small cells as a cost effective method for increasing capacity and providing indoor coverage. For example, Sprint recently announced that it

³¹² See Jeanette Wannstrom & Keith Mallinson, *HetNet/Small Cells*, 3GPP <http://www.3gpp.org/hetnet> (last visited May 20, 2016).

³¹³ See *Neutral Host Small Cell Networks*, WIRELESS 20/20 (Feb. 25, 2016), <http://www.slideshare.net/SmallCellForum1/neutral-host-small-networks>.

³¹⁴ See Sean Buckley, *AT&T Deploys Fiber Out of Region to Satisfy Business, Wireless Backhaul Demand*, FIERCETELECOM (May 13, 2016), <http://www.fiercetelecom.com/story/att-deploys-fiber-out-region-satisfy-business-wireless-backhaul-demand/2016-05-13>.

³¹⁵ See David Chambers, *Small Cell Backhaul Industry Update*, THINKSMALLCELL (Oct. 22, 2015), <http://www.thinksmallcell.com/Backhaul/small-cell-backhaul-industry-update.html>; Mike Dano, *Small Cell Backhaul Remains a Hot Topic Among Fiber Providers Like Zayo and Lumos*, FIERCEWIRELESS (May 6, 2016), <http://www.fiercewireless.com/story/small-cell-backhaul-remains-hot-topic-among-fiber-providers-zayo-and-lumos/2016-05-06>.

contracted with CommScope for an “extensive deployment” of small cells, which will include both LTE and 802.11ac Wi-Fi capabilities.³¹⁶

5. Network functions virtualization, software defined networking, and advances in 4G LTE machine type communications are paving the way toward 5G.

Advances in computing power and software design have obviated the need to deploy the dedicated or specialized hardware that have traditionally powered wireless networks. In short, computing resources have become a commodity and network operators now have the option to run the software that powers their networks on standard shared computing platforms at lower cost, with less power, and with better scalability.³¹⁷ This is known as Network Functions Virtualization (“NFV”).

According to one analyst, “2016 is the year all operators will start doing something about NFV... Operators are citing ‘competition’ as a big driver for NFV.”³¹⁸ An important benefit of NFV is that it allows network operators to accelerate the deployment of new network services that will provide additional revenue streams and growth. With traditional proprietary hardware, launching a new service often requires another specialized box that must be developed, powered, and connected to the existing network. This requires time, expertise, power, and most of all, capital expense. Further, hardware lifecycles are short and becoming shorter as technology advances, so all of this complex hardware needs to be upgraded periodically. With NFV, the functions provided by proprietary hardware are “virtualized” in software running on standard computing platforms, which facilitates innovation, reduces provisioning time of new capabilities

³¹⁶ See Diana Goovaerts, *Sprint Kicks Small Cell Deployment Into Gear With CommScope Deal*, WIRELESS WEEK (May 4, 2016), <http://www.wirelessweek.com/news/2016/05/sprint-kicks-small-cell-deployment-gear-commscope-deal>.

³¹⁷ See *Network Virtualization*, OSS TRANSFORMATION, <http://www.osstransformation.com/Network-Virtualization> (last visited May 20, 2016).

³¹⁸ See Steve Saunders, *NFV: Coming, Ready or Not!*, LIGHTREADING (Apr. 19, 2016), <http://www.lightreading.com/nfv-strategies/nfv-coming-ready-or-not!/a/d-id/722690>.

and services, and allows rapid scaling up or down as required.³¹⁹ Many operators realize that NFV represents a capability that they must have to compete in the new wireless era as the industry migrates to 5G.

Software Defined Networking (“SDN”) is a synergistic but independently separate approach in which a telecommunications network is transformed by separating the network control functions from the data forwarding functions.³²⁰ In effect, SDN is an open-standard, centralized switching architecture that provides programmable central control of all switches and routers in the network, and thus central control of network traffic. SDN increases operational agility by allowing real-time traffic shaping and dynamic resource allocation, but also provides operational efficiencies by enabling service creation and near-real-time service delivery across the entire network.³²¹

Some U.S. operators are making major investments in both NFV and SDN and working closely with other companies in the wireless and IT industries to migrate their networks toward software-based architectures quickly, which is a step toward 5G. For example, Verizon recently released its SDN-NFV Reference Architecture³²² and their website states that “Verizon is working closely with a number of its key technology partners [...] to transform our network by implementing an SDN architecture and laying the groundwork for new innovative services and applications.” John Donovan of AT&T announced its SDN and NFV plans at Mobile World

³¹⁹ See White Paper, Margaret Chiosi et al., *Network Functions Virtualization: An Introduction, Benefits, Enablers, Challenges & Call for Action* (Oct. 22-24, 2012), https://portal.etsi.org/nfv/nfv_white_paper.pdf.

³²⁰ See Kanika, *What Is Software Defined Networking*, SDN Tutorials, <http://sdntutorials.com/what-is-software-defined-networking/> (last visited May 17, 2016).

³²¹ See *id.*

³²² See *Verizon Network Infrastructure Planning: SDN-NFV Reference Architecture*, VERIZON, (Feb. 2016), http://innovation.verizon.com/content/dam/vic/PDF/Verizon_SDN-NFV_Reference_Architecture.pdf.

Congress last year and the company’s website describes “AT&T’s Network of the Future” as “emulat[ing] the functions of those complex pieces of hardware with software, and run that software on standard, off-the-shelf hardware. You can add capacity faster and push out upgrades at the speed of the Internet.”³²³

Although other operators are at various stages of network transformation,³²⁴ it appears certain that all operators are currently exploring the benefits and risks of SDN and virtualization because it represents a major element of the future of mobile wireless broadband service delivery.³²⁵

C. Rural Consumers Have Increased Choices as Carriers Continue to Expand Coverage in Rural Markets.

Wireless carriers, including national and regional providers, have also expanded coverage in rural and remote areas. While vigorous investment in mobile wireless networks has ensured that nearly all Americans have access to LTE service from at least one provider,³²⁶ it is generally acknowledged that continuously serving rural Americans with innovative wireless technologies is a capital-intensive effort. For this reason, the Commission should re-affirm its commitment to establish a permanent and robust Mobility Fund of at least \$500 million, which will be necessary to support the availability of mobile wireless broadband networks in rural and remote areas.

³²³ See John Donovan, *How Do You Keep Pace With a 100,000 Percent Increase in Wireless Data Traffic? Software*, AT&T INNOVATION SPACE BLOG (Mar. 2, 2015), <http://about.att.com/innovationblog/3215howdoyoukeeppace>.

³²⁴ See Dan Meyer, *Sprint and C Spire Remain Cautious on NFV and SDN Moves*, RCR WIRELESS NEWS (Apr. 13, 2016), <http://www.rcrwireless.com/20160413/carriers/sprint-c-spire-remain-cautious-nfv-sdn-moves-tag2>.

³²⁵ See Monica Allevan, *SK Telecom SVP: Future of SDN, NFV is Mobile*, FIERCEWIRELESSTECH (Mar. 16, 2016), <http://www.fiercewireless.com/tech/story/sk-telecom-svp-future-sdn-nfv-mobile/2016-03-16>.

³²⁶ *Eighteenth Report* at Chart III.A.5, Estimated Mobile LTE Coverage in Non-Rural and Rural Areas by Census Block; Mosaik, July 2015.

Regional providers are building out coverage in the rural areas they serve, and national providers have adopted programs to expand access to all consumers. For example, U.S. Cellular reported in February 2016 that it had “largely finished its LTE network buildout, and . . . now covers roughly 99 percent of its postpaid customers with LTE service.”³²⁷ Additionally, Verizon’s LTE in Rural America Program, launched in 2010, now covers more than 2.7 million people in rural communities, more than 225,000 square miles, and more than 1,000 cell sites with live 4G LTE networks.³²⁸ All 21 original participants in Verizon’s LTE in Rural America Program have launched 4G LTE service.³²⁹ Bluegrass Cellular, one participant in Verizon’s LTE in Rural America Program, completed construction of an LTE build-out that serves 10,300 square miles, employs 115 LTE cell sites, and covers 732,000 POPs.³³⁰ T-Mobile is expanding into new rural areas, in addition to continuing its program to provide rural and regional carriers with spectrum resources to build out 4G LTE networks.³³¹ Finally, Sprint’s Rural Roaming

³²⁷ See Mike Dano, *U.S. Cellular completes LTE buildout and begins LTE roaming, but Q4 performance below some expectations*, FIERCE WIRELESS (Feb. 19, 2016), <http://www.fiercewireless.com/story/us-cellular-completes-lte-buildout-and-begins-lte-roaming-q4-performance-be/2016-02-19>. U.S. Cellular is also reportedly entering into LTE roaming agreements with multiple partners. *Id.*

³²⁸ Joan Engebretson, *Bluegrass LTE Network Completion Shows Power of Verizon Rural LTE Program*, TELECOMPETITOR (Dec. 2, 2015), <http://www.telecompetitor.com/bluegrass-lte-network-completion-shows-power-of-verizon-rural-lte-program/>; Robin Nicol, *LTE in Rural America Continues to Grow*, VERIZON (May 30, 2014), <http://www.verizonwireless.com/news/article/2014/05/lte-rural-america-continues-to-grow.html>; *T-Mobile Confirms It Has Leased Spectrum to Other Carriers to Expand LTE Network Coverage*, FIERCEWIRELESS (May 15, 2015), <http://www.fiercewireless.com/story/t-mobile-confirms-it-has-leased-spectrum-other-carriers-expand-lte-network/2015-05-15> (“*T-Mobile Confirms*”).

³²⁹ Engebretson, *supra* note 333; *Verizon: All 21 LTE in Rural America Carrier Partners Have Launched Service*, FIERCEWIRELESS (OCT. 15, 2015), <http://www.fiercewireless.com/story/verizon-all-21-lte-rural-america-carrier-partners-have-launched-service/2015-10-15>.

³³⁰ Engebretson, *supra* note 333.

³³¹ Reardon, *supra* note 7 (T-Mobile is “putting LTE into and onto rural ground and turf in brand new markets.”); Kirsten Silven, *T-Mobile Strives to Improve Coverage Among Smaller and Rural Carriers*, INQUISITR (Aug. 29, 2015), <http://www.inquisitr.com/2377295/t-mobile-strives-to-improve-coverage-among-smaller-and-rural-carriers/> (T-Mobile joined the Competitive Carrier Association Data Services Hub to work with 12 other rural and regional carriers in order to “expand data and voice roaming capabilities across each other’s regions.”); *T-Mobile Confirms*, *supra* note 333.

Preferred Providers program includes 30 carriers, 16 of which are serving a population of more than 38 million people.³³² Additionally, for more than two years, Sprint has shared spectrum and other resources with rural providers to enable them to build out 4G LTE to rural populations as part of the Small Market Alliance for Rural Transformation.³³³

Low-powered technologies (such as DAS and small cells) provide carriers with lower-cost options for increased deployments in rural areas, which in turn increases competition in rural markets.³³⁴ Carriers are transitioning small cell deployments from *ad hoc* rollouts intended to fill in service and coverage gaps to large scale deployments to densify carrier networks.³³⁵ Outdoor carrier small cell deployments are expected to top 667,000 worldwide in 2020.³³⁶ Low-powered technologies offer more flexible siting options than macro cells for both national and regional carriers that are deploying mobile broadband in rural and remote areas, which can reduce deployment costs and increase scalability.³³⁷ Increased low-powered deployments in

³³² *Sprint: 16 of 30*, *supra* note 11; Eric M. Zeman, *Sprint Partners Making Headway in Rural LTE Push*, PHONE SCOOP (May 21, 2015), <http://www.phonescoop.com/articles/article.php?a=15828>; *Sprint Reaches 4G LTE Roaming Agreements With 15 Additional Rural Carriers*, SPRINT (Sept. 5, 2014), <http://newsroom.sprint.com/news-releases/sprint-reaches-4g-lte-roaming-agreements-with-15-additional-rural-carriers.htm>.

³³³ *NetAmerica Alliance Adds Partners As SMART Forges Ahead*, NETAMERICA ALLIANCE (Sep. 8, 2014), <http://www.netamericaalliance.com/news-events/press-releases/103-netamerica-alliance-adds-partners-as-smart-forges-ahead>.

³³⁴ White Paper, *Crossing the Chasm: Small Cells Industry*, SMALL CELL FORUM (Nov. 2015), http://www.scf.io/en/white_papers/Crossing_the_Chasm_Small_Cells_Industry_2015.php (“*Small Cell Report*”).

³³⁵ *Id.* at 4; *see also, e.g.*, Martha DeGrasse, *Sprint Looks to Wireless Backhaul to Cut Costs*, RCR WIRELESS (Mar. 13, 2016), <http://www.rcrwireless.com/20160313/carriers/sprint-wireless-backhaul-tag4>; Sean Kinney, *Sprint CFO: ‘We’re Building a 5G Network for the Future’*, INDUSTRIAL IOT 5G (Apr. 15, 2016), <http://industrialiot5g.com/sprint-cfo-building-5g-network-future/>.

³³⁶ *Id.*

³³⁷ Sarah Murray, *Greg Fischer in Wireless Week: “Small Cells Play a Vital Role in Giving Operators and Their Subscribers Seamless Data Services,”* BROADCOM (Oct. 14, 2015), <http://www.broadcom.com/blog/network-infrastructure/greg-fischer-in-wireless-week-small-cells-play-a-vital-role-in-giving-operators-and-their-subscribers-seamless-data-services/>; *Small Cells in Emerging Markets*, DEVELOPING TELECOMS at 10 (Nov. 2015),

rural areas could open up access to 650 million new cellular users around the world and could be worth an estimated \$163 billion.³³⁸

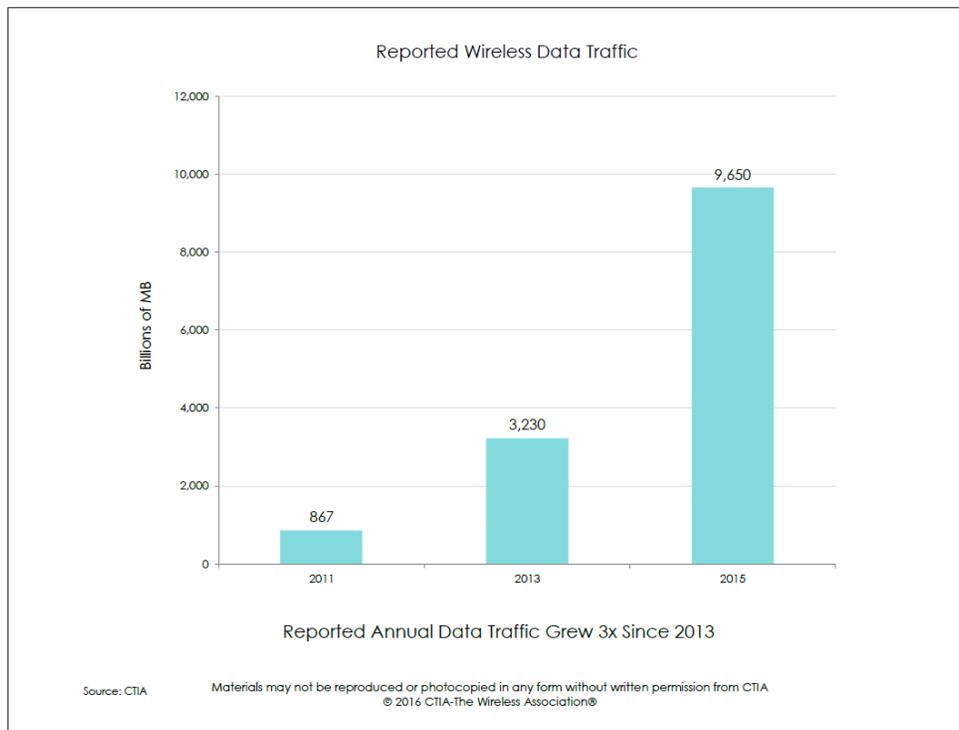
VII. THE COMMISSION MUST FACILITATE ACCESS TO THE SPECTRUM NEEDED FOR MOBILE BROADBAND AND 5G TO ENSURE CONTINUED INNOVATION AND COMPETITION IN THE WIRELESS MARKETPLACE.

A. Demand is Increasing Exponentially and Continues to Outpace Spectrum Supply, Emphasizing the Need for Low-, Mid-, and High-Band Spectrum to Meet Consumer Demand.

Once again, demand for mobile broadband data increased significantly in 2015 compared to previous years, and this demand is not showing any signs of waning. CTIA's Year-End 2015 Survey results show that wireless data traffic has grown roughly three times since 2013 and more than 11 times since 2011. In fact, wireless data traffic has grown *25 times* since CTIA first reported 388 billion MB of wireless data traffic in 2010:

<http://www.developingtelecoms.com/images/reports/developingtelecoms-smallcellsinem-2015.pdf> (“*Developing Telecoms Report*”).

³³⁸ *Developing Telecoms Report* at 9; Dan Meyer, #CCAExpo: *Small Cells Remain Challenge for Smaller Operators*, RCR WIRELESS (Mar. 25, 2015), <http://www.rcrwireless.com/20150325/carriers/cca-global-expo-15-small-cells-remain-challenge-for-smaller-operators-tag2>.



Cisco’s latest Visual Networking Index report predicted that mobile data traffic in the U.S. will grow six times from 2015 to 2020.³³⁹ Ericsson’s North America regional Mobility reports smartphone traffic growth of six times over the next five years, while Ericsson’s Traffic Exploration tool projects mobile data traffic growth of eight times by 2021.³⁴⁰ These figures demonstrate that, despite the AWS-3 auction and upcoming broadcast incentive auction, spectrum supply faces challenges in keeping up with demand. As discussed above, operators are leveraging new technologies and investing in network densification in an attempt to keep up, but the critical “third leg of the stool” is spectrum. As the Commission stated in last year’s Mobile Competition Report, “increasing consumer demand for mobile broadband is increasing service

³³⁹ See VNI Mobile Forecast Highlights, 2015-2020, CISCO, http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/index.html#~Country (select “United States” and “2020 Forecast Highlights”) (last visited May 20, 2016).

³⁴⁰ See White Paper, *Ericsson Mobility Report: Regional Report – North America*, (Nov. 2015), <http://www.ericsson.com/mobility-report>, and Ericsson Traffic Exploration, at <http://www.ericsson.com/TET/trafficView/loadBasicEditor.ericsson> (selecting North America, Data Traffic, Smartphone and Mobile PC/Router/Tablet) (last visited May 21, 2016).

providers' need for spectrum at an unprecedented rate and this is projected to grow further."³⁴¹

However, given the long timeframes associated with freeing spectrum for mobile services, action is required now to ensure the pipeline does not become depleted.

B. The FCC Should Act Quickly to Identify and Facilitate Access to the Spectrum Needed for 5G by This Summer and Identify Additional High-Band Spectrum for Future Use.

The U.S. wireless industry's leadership in 4G LTE has had an enormous impact on the U.S. economy. This positive impact was made possible in large part by the FCC making available spectrum for 4G LTE via spectrum auctions that took place years before 4G LTE technology was ready for commercial deployment. For the U.S. to carry its 4G leadership position into the 5G era, the FCC must make high-band spectrum required for 5G available as quickly as possible. To that end, CTIA supports the Commission's efforts in the Spectrum Frontiers proceeding to allocate additional spectrum for mobile broadband, and urges an expeditious completion of the proceeding this summer.

Specifically, the FCC should act this summer to make spectrum available in the 28 GHz, 37 GHz, 39 GHz, and 64-71 GHz bands.³⁴² As discussed in more detail above, U.S. wireless operators are launching 5G trials this year, and access to appropriate spectrum is a critical input to ensure success and rapid development of 5G technologies. As Commissioner Pai has stated, it is therefore imperative that the Commission "put a framework in place that will allow 5G to develop in the United States as quickly as the technology and consumer demand allow."³⁴³

³⁴¹ *Eighteenth Report* ¶ 47.

³⁴² See Reply Comments of CTIA, GN Docket No. 14-177, IB Docket No. 15-256, RM-11664, WT Docket No. 10-112, IB Docket No. 97-95 (filed Feb. 26, 2016).

³⁴³ *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al.*, Notice of Proposed Rulemaking, 30 FCC Rcd 11878 (2015) ("*Spectrum Frontiers NPRM*"), Statement of Commissioner Ajit Pai Approving in Part and Dissenting in Part, at 1-2, https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-138A5.pdf.

In addition, the FCC should continue to examine opportunities to make additional high-band spectrum available, including bands with less than 500 megahertz of continuous spectrum and bands that are not uniformly and internationally harmonized. Such bands may be ideally suited for 5G services and should not be excluded from future consideration. Although CTIA has long supported international harmonization of mobile spectrum bands, it also recognizes that if a candidate spectrum band is well-suited for mobile services in all other respects, international harmonization should not serve as a barrier to deployment.³⁴⁴ Such was the case with the 28 GHz band, where the Commission thoughtfully determined to move forward with exploring the band for mobile allocation despite it not being included for exploration by the World Radiocommunication Conference in 2019.³⁴⁵ CTIA continues to fully support the Commission's efforts to prioritize the 28 GHz band for mobile services in the United States, and encourages the Commission to continue to explore in the future other bands that may not be internationally harmonized or may encompass smaller contiguous blocks but which may be ideally suited for 5G innovations.³⁴⁶

C. The FCC Should Work Expeditiously to Conclude a Successful Incentive Auction.

As the last major spectrum auction of the foreseeable future, the 600 MHz incentive auction represents an exciting opportunity for wireless operators or new entrants to acquire prime

³⁴⁴ See Comments of CTIA, GN Docket No. 14-177, IB Docket Nos. 15-256, 97-95, RM-11664, WT Docket No. 10-112, at 10-11 (filed Jan. 28, 2016) ("CTIA Spectrum Frontiers Comments").

³⁴⁵ See *Spectrum Frontiers NPRM* ¶ 32; see also FCC Chairman Tom Wheeler's Statement on World Radiocommunication Conference 2015 (Dec. 17, 2015), https://apps.fcc.gov/edocs_public/attachmatch/DOC-336917A1.pdf; Commissioner Jessica Rosenworcel's Statement on World Radiocommunication Conference 2015 (Dec. 17, 2015), https://apps.fcc.gov/edocs_public/attachmatch/DOC-336912A1.pdf; FCC Commissioner Michael O'Rielly, 2015 World Radiocommunication Conference: A Troubling Direction, FCC BLOG (Jan. 15, 2016), <https://www.fcc.gov/news-events/blog/2016/01/15/2015-world-radiocommunication-conference-troubling-direction>.

³⁴⁶ See CTIA Spectrum Frontiers Comments at 11.

“beachfront” spectrum for mobile broadband. With the possibility of auctioning up to 100 megahertz (or 10 paired blocks) of nearly contiguous spectrum, the 600 MHz band has the potential to benefit consumers and stimulate economic growth by increasing mobile broadband capacity and coverage for several operators per market. The auction is the culmination of more than six years of hard work and bipartisan support from Congress, the Administration, and the FCC, under the leadership of both Chairman Genachowski—who initiated the concept—and Chairman Wheeler—who has seen to its implementation. The FCC should continue to work toward a successful conclusion to the auction, and then work to ensure a smooth, well-coordinated, and expeditious repacking transition. Detailed evidence on the record suggests that the tower work and repacking can be accomplished on time and on budget,³⁴⁷ and the FCC must take action to ensure this complex exercise is executed efficiently.

D. The FCC Should Act Quickly to Initiate a Rulemaking to Investigate the Use of the 1675-1680 MHz Band for Shared Commercial Use.

As discussed above, in 2012, Ligado Networks (formerly known as LightSquared) submitted a petition to allocate the 1675-1680 MHz band to terrestrial non-federal use on a shared basis with federal users. More recently, Ligado Networks submitted studies and filings that support and partially modify the 2012 petition, and requested that the 1675-1680 MHz band be made available via auction. The five megahertz of spectrum at issue has the potential to

³⁴⁷ See T-Mobile USA, Inc., Broadcast Tower Technologies, Inc. and Hammett & Edison, Inc., *On Time and On Budget: Completing the 600 MHz Incentive Auction Repacking Process Within the FCC’s 39-Month Relocation Deadline and the Budget Established By Congress* (Feb. 17, 2016), attached to Ex Parte Letter from Steve Sharkey, Vice President, Government Affairs Technology and Engineering Policy, T-Mobile USA, Inc. to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 and AU Docket No. 14-252 (filed Feb. 17, 2016); T-Mobile USA, Inc., Broadcast Tower Technologies, Inc. and Hammett & Edison, Inc., *On Time and On Budget: A Response to Digital Tech Consulting, Inc.’s March 2016 Presentation on the State of Broadcaster Relocation Resources* (May 11, 2016), attached to Ex Parte Letter from Trey Hanbury, Counsel, T-Mobile USA, Inc. to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 and AU Docket No. 14-252 (filed May 11, 2016).

create an additional 35 megahertz of spectrum for mobile broadband—40 megahertz in total³⁴⁸—that will spur additional investment, innovation, and competition in the mobile broadband market. CTIA therefore supports the Commission initiating a rulemaking that seeks comment on repurposing the 1675-1680 MHz band and making it available via auction for commercial use either on an exclusive basis or on a shared basis with government operations.³⁴⁹

E. The FCC Should Work with NTIA to Identify Other Candidate Sub-6 GHz Bands for Mobile Broadband.

Despite the exciting benefits to consumers and the economy that 5G promises, the FCC should not shift its focus exclusively to new spectrum bands with millimeter wave frequencies. The traditional frequencies used today for 3G, 4G, and Wi-Fi will be utilized by 5G in the future, and demand for services on these frequencies will continue to grow. Although the enhanced mobile broadband aspects of 5G will leverage the very wide bandwidths available in millimeter wave bands, other aspects of 5G, including machine-to-machine and ultra-reliable, low-latency communications, will leverage traditional sub-6 GHz frequencies. In addition, signaling for millimeter wave wireless communications will likely be implemented within this traditional range. Therefore, it is imperative that the FCC continue to work with NTIA to identify candidate bands in the sub-6 GHz range to repurpose for mobile broadband.

³⁴⁸ Note that 30 megahertz of this spectrum was MSS spectrum identified in the National Broadband Plan for terrestrial deployment.

³⁴⁹ See Letter from Scott K. Bergmann, Vice President, Regulatory Affairs, CTIA, to Marlene H. Dortch, Secretary, FCC, IB Docket Nos. 12-340, 11-109 (filed Mar. 7, 2016) (further noting that “[o]f course, there are other issues directly relevant to Ligado’s plans, including issues concerning interference to GPS, and as part of the Commission’s inquiry it should seek public comment on whether those interference concerns have been adequately addressed”).

VIII. CONSUMER DEMAND IS CREATING INCREASED CARRIER TRANSPARENCY AROUND WIRELESS PRODUCTS AND SERVICES.

Myriad resources help consumers understand their options in the wireless market and determine which carriers, devices, and plans will meet their needs. This information is not only useful when consumers are making initial purchasing decisions, but also when they are deciding whether to switch carriers or devices. That is because “[s]ubscriber switching is enhanced by the fact that wireless broadband consumers have access to information on competitive offers from various sources, including extensive comparative advertising by wireless providers themselves, from industry groups and publications, and consumer groups.”³⁵⁰ In other words, in today’s competitive wireless environment, consumers have access to the information they need to evaluate competing offers and choose the best devices and service plans for their price range, data requirements, and other needs.³⁵¹

Under the FCC’s transparency rules, adopted as part of the Open Internet proceeding, providers must make detailed disclosures to consumers, including information on plans, speeds, latency, network management practices, fees, and promotional rates.³⁵² Carriers typically provide examples of suitable uses for each of their plan offerings, such as e-mail and Internet surfing on slower-speed plans, or HD video streaming on higher-speed plans. These disclosures are designed to ensure customers can make informed decisions about wireless service offerings. Additionally, signatories to the CTIA Consumer Code have committed to providing consumers with information including rates, additional taxes, fees, surcharges, terms of service, and coverage maps. The CTIA Consumer Code is also designed “to help consumers make informed

³⁵⁰ Lerner/Ordovery Paper at 2-3.

³⁵¹ *Id.* at 10.

³⁵² See *Open Internet Transparency Rule*, FCC (Nov. 3, 2015), <https://www.fcc.gov/consumers/guides/open-internet-transparency-rule>.

choices when selecting their wireless service.”³⁵³ CTIA reviews the Consumer Code periodically to “ensure it reflects the industry’s innovations and consumers’ needs and expectations.”³⁵⁴

Consumers can also consult third-party sources for information about wireless plans. MyRatePlan, Mountain Wireless, CNET, Best Buy, Consumer Reports, Phonescoop, and other resources online and in retail stores rate and disclose information about plans and devices.³⁵⁵ And consumers have access to information regarding mobile broadband deployment and the scope of carrier networks, including an extensive collection of wireless carriers’ own data. As CTIA has previously argued, given the availability of this information, the Commission should continue to rely on commercial data sources about mobile coverage, including Mosaik’s extensive and frequently updated mobile coverage datasets.³⁵⁶ With the availability of third-party services and datasets that enable more comprehensive analyses about mobile network coverage, infrastructure and performance, there is no reason for the Commission to require additional coverage information from carriers to make a finding of effective competition in this proceeding.

IX. THE FCC SHOULD FIND THAT THE MOBILE MARKET IS SUBJECT TO EFFECTIVE COMPETITION.

As part of its assessment of competition in the wireless market, the FCC is required to provide an analysis of “whether or not there is effective competition.”³⁵⁷ The time is ripe for the

³⁵³ *Consumer Code for Wireless Service*, CTIA, <http://www.ctia.org/policy-initiatives/voluntary-guidelines/consumer-code-for-wireless-service> (last visited May 19, 2016).

³⁵⁴ *Id.*

³⁵⁵ *See, e.g.*, CNET, <http://www.cnet.com/> (last visited May 20, 2016); MYRATEPLAN, <http://www.myrateplan.com/> (last visited May 20, 2016).

³⁵⁶ Mosaik, <http://www.mosaik.com/> (last visited May 19, 2016).

³⁵⁷ 47 U.S.C. § 332(c)(1)(C).

Commission to affirmatively find that the mobile wireless marketplace is subject to effective competition. At a minimum, the FCC should reaffirm its previous determination that the core CMRS market is competitive.

A. The Facts Described Above Permit No Other Conclusion Than That the Mobile Wireless Market is Characterized by Effective Competition.

The FCC has elected in recent years not to reach an overall conclusion regarding whether the mobile wireless market is effectively competitive, noting challenges in making such a determination across the segments, services, and geographic areas served by the mobile wireless industry.³⁵⁸ That approach is not consistent with the FCC's statutory duty to analyze *whether* the market is subject to effective competition. It is also not an accurate reflection of marketplace realities.

The mobile wireless marketplace is highly competitive, and becoming more competitive with each passing day. The facts and data discussed above establish that the U.S. market is witnessing continued growth along virtually every metric, from wireless adoption and usage, to investment in infrastructure and new technologies, to the proliferation of devices, to innovations in services and service plans, to advertising expenditures. There are four nationwide providers, as well as dozens of regional and local providers, giving consumers across the country multiple choices for wireless service. MVNO providers offer additional competitive alternatives in many markets. These providers all compete fiercely on a day-to-day basis, and consumers are benefitting from the rivalry. The facts described above permit no other conclusion than that the mobile wireless market is indeed subject to effective competition.

A finding of effective competition in the wireless market would be consistent with the approach that the FCC recently took in finding effective competition in the video distribution

³⁵⁸ See *Eighteenth Report* ¶ 5.

market. In the *Effective Competition Order*,³⁵⁹ the FCC reversed its longstanding presumption that the MVPD market was not subject to effective competition. The FCC did so based on its recognition that, for the most part, each geographic market has at least three competing providers: the incumbent cable operator, plus two nationwide direct broadcast satellite (“DBS”) operators.³⁶⁰ Thus, even leaving aside additional over-builders such as Verizon FiOS, AT&T U-Verse, and Google Fiber, the FCC concluded that the presence of three competitors in most markets was sufficient to justify a finding of effective competition. The FCC pointed to the “widespread availability of DBS video service” and the fact that “approximately 99.7 percent of homes in the U.S. have access to at least three MVPDs, and nearly 35 percent have access to at least four MVPDs.”³⁶¹ The FCC accordingly recognized that broad competitiveness of the market on a nationwide basis, in particular the widespread availability of at least three MVPD providers in nearly all markets, justified a finding of effective competition, even while recognizing that a small number of geographic markets might face fewer competitors.³⁶²

The mobile wireless market is at least as competitive, and arguably more competitive, than the MVPD market. Indeed, more than 91.5 percent of American consumers have the ability to choose from among three or more mobile broadband providers, while an impressive 82.2 percent of consumers can choose from four or more mobile broadband providers. And the coming transition to 5G will only accelerate the competitiveness of the mobile wireless market along virtually all dimensions, from networks to services to devices. Especially in the wake of

³⁵⁹ *Amendment to the Commission’s Rules Concerning Effective Competition; Implementation of Section 111 of the STELA Reauthorization Act*, Report and Order, 30 FCC Rcd 6574 (2015) (“*Effective Competition Order*”).

³⁶⁰ *Id.* ¶ 8.

³⁶¹ *Id.* ¶ 4.

³⁶² *Id.* ¶ 11.

the *Effective Competition Order*, it is time for the FCC to affirmatively make a finding of effective competition in the mobile wireless market.

B. At a Minimum, the FCC Should Reaffirm its Previous Finding That the Core CMRS Market is Competitive.

If the FCC continues to resist making a statutorily mandated finding of effective competition regarding the entire wireless market (including various market inputs or non-CMRS segments such as spectrum, infrastructure, and wholesale services), at a minimum it should conclude that the core CMRS market (*i.e.*, the market for terrestrial mobile voice, messaging, and data services provided to consumers) is effectively competitive.

In the *Thirteenth Competition Report*, the FCC analyzed the mobile wireless market and determined that there was competition in the core CMRS market, based on an analysis of market structure, provider conduct, consumer behavior, and market performance.³⁶³ After the *Thirteenth Competition Report*, the FCC expanded its analysis to include CMRS as one component of the broader universe of mobile wireless services, including upstream and downstream market segments such as infrastructure and devices.³⁶⁴ But there can be no serious question that the core CMRS market has, if anything, grown more competitive since 2009, when the FCC last concluded that the CMRS market was subject to effective competition.

Since 2009, vigorous competition has continued in the core CMRS market and mobile wireless service has played an increasingly significant role in the lives of American consumers.

³⁶³ See *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*, Thirteenth Report, 24 FCC Rcd 6185 ¶ 1 (2009) (“*Thirteenth Competition Report*”) (concluding “that there is effective competition in the CMRS market and demonstrate the increasingly significant role that wireless services play in the lives of American consumers”).

³⁶⁴ See *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*, Fourteenth Report, 25 FCC Rcd 11407 ¶ 2 (2010).

As outlined in detail above, the available data demonstrate that the mobile wireless market is continuing to experience considerable growth.

In the *Thirteenth Competition Report*, the FCC stated that “lower prices, higher quality and greater choice of services” are “the ultimate test of effective competition.”³⁶⁵ Since 2009, wireless voice and data prices have steadily decreased, consumers continue to have multiple choices of providers, demand continues to grow explosively, and service quality is higher than ever. The FCC accordingly should, at a minimum, reaffirm that the core CMRS market is effectively competitive.

X. CONCLUSION.

The vibrant, robust U.S. wireless market is a global leader in 4G LTE deployment and is rapidly working to develop and deploy 5G technology. The deployment of 5G is expected to infuse even greater competition into the U.S. wireless marketplace. Demand for wireless connections, innovative service offerings, and high quality devices continues to increase. Under this consumer pressure, wireless carriers are competing to offer more flexibility, more functionality, and more choice. And to meet this demand carriers continue to invest vigorously in their networks. These facts and the data provided in CTIA’s comments permit no other conclusion than that the mobile wireless market is characterized by effective competition.

The FCC can take important steps to support the continued competitiveness of the wireless marketplace. In particular, the FCC can continue to reduce barriers to the deployment of critical wireless infrastructure, re-affirm its support for mobile wireless services in rural areas, and facilitate the auction and deployment of new spectrum to meet growing consumer demand. As the imminent deployment of 5G adds even more competitive fervor to the wireless

³⁶⁵ *Thirteenth Competition Report* ¶ 187.

marketplace, CTIA believes the information it has provided in these comments compels an FCC finding that the mobile wireless market is subject to effective competition.

Respectfully submitted,

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APPENDIX A

Background on CTIA's Wireless Industry Survey

CTIA's wireless industry survey develops industry-wide information drawn from operational member and non-member wireless service providers. It has been conducted since January 1985, originally as a cellular-only survey instrument, and now including the community of CMRS licensees (e.g., PCS, ESMR, AWS, BRS and 700 MHz license holders). No break-out of results specific to spectrum bands or licenses is performed. From January 1985 through December 2012, it was conducted as a semi-annual survey, and it is now being conducted on an annual basis.

The information determined based on the survey includes: direct employment, number of cell sites, total service revenues, the average revenue per unit (ARPU), and various measures of usage (e.g., minutes and megabytes). The ARPU figure is not equal to the average monthly bill, which may reflect provision of service to multiple devices on a single account.

CTIA's survey develops information on the number of reported wireless service subscribers or "connections" for the responding systems, and an estimated total connections figure (taking into account non-responding systems). Because CTIA's survey is a voluntary survey, it cannot compel responses from wireless carriers. However, the survey has an excellent response rate. For the December 31, 2015, installment of the survey, CTIA aggregated data from companies serving 97.8 percent of all estimated wireless subscriber connections (excluding some machine-to-machine and other units not treated as "subscriber connections" for reporting purposes by some carriers).

Because not all systems do respond, CTIA develops an estimate of total wireless connections. The estimate is developed by determining the identity and character of non-respondents and their markets (e.g., RSA/MSA or equivalent-market designation, age of system, market population), and using surrogate penetration and growth rates applicable to similar, known systems to derive probable subscribership. These numbers are then summed with the reported subscriber connection numbers to reach the total estimated figures. No carrier-specific or market-specific information is maintained as a result of the survey. All such information is aggregated by an independent accounting firm to a nationwide level. The underlying source material for the survey is then destroyed per confidentiality agreements.

The following tables and charts reflect selected top-of-the-line data. Complete results of CTIA's survey will be available for purchase in the comprehensive report, *CTIA's Wireless Industry Indices: 1985 – 2015*, including data on revenues, subscriber usage, investment, and other operational indicators and ratios. The report is available for a member price of \$850 and a non-member price of \$1,075. Subsequent copies are available to members at \$475 each and to non-members at \$535 each. Annual subscriptions are available at a member price of \$1,445 and non-member price of \$1,825. The report may be ordered by contacting research@ctia.org or by ordering directly from CTIA's online Store at <http://store.ctia.org/>. Order forms are also available on CTIA's web site, at http://files.ctia.org/pdf/Indices_Order_Form1.pdf.

CTIA ANNUALIZED WIRELESS INDUSTRY SURVEY RESULTS - DECEMBER 1985 TO DECEMBER 2015

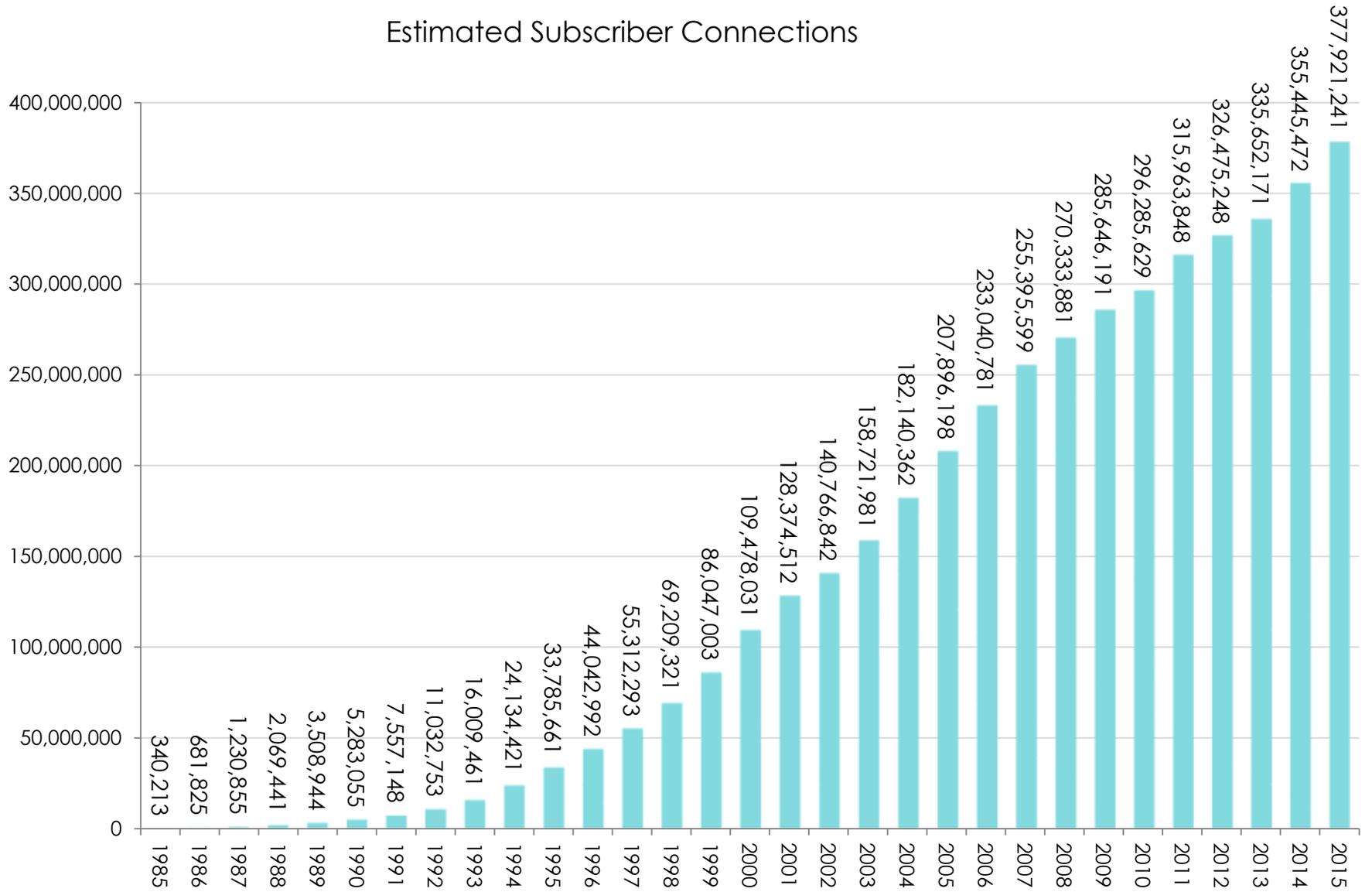
Date	Estimated Total Subscriber Connections	Annual Service Revenues (\$000s)	Cumulative CapEx (\$000)	Cell Sites	Direct Carrier Employees	Monthly Average Revenue per Unit
1985	340,213	\$482,428	\$911,167	913	2,727	N/A
1986	681,825	\$823,052	\$1,436,753	1,531	4,334	N/A
1987	1,230,855	\$1,151,519	\$2,234,635	2,305	7,147	N/A
1988	2,069,441	\$1,959,548	\$3,274,105	3,209	11,400	N/A
1989	3,508,944	\$3,340,595	\$4,480,142	4,169	15,927	N/A
1990	5,283,055	\$4,548,820	\$6,281,596	5,616	21,382	N/A
1991	7,557,148	\$5,708,522	\$8,671,544	7,847	26,327	N/A
1992	11,032,753	\$7,822,726	\$11,262,070	10,307	34,348	N/A
1993	16,009,461	\$10,892,175	\$13,956,366	12,824	39,810	\$76.55
1994	24,134,421	\$14,229,922	\$18,938,678	17,920	53,902	\$64.80
1995	33,785,661	\$19,081,239	\$24,080,467	22,663	68,165	\$59.43
1996	44,042,992	\$23,634,971	\$32,573,522	30,045	84,161	\$55.40
1997	55,312,293	\$27,485,633	\$46,057,910	51,600	109,387	\$49.39
1998	69,209,321	\$33,133,175	\$60,542,774	65,887	134,754	\$47.23
1999	86,047,003	\$40,018,489	\$71,264,865	81,698	155,817	\$46.39
2000	109,478,031	\$52,466,020	\$89,624,387	104,288	184,449	\$48.55
2001	128,374,512	\$65,316,235	\$105,030,101	127,540	203,580	\$49.79
2002	140,766,842	\$76,508,187	\$126,922,347	139,338	192,410	\$51.00
2003	158,721,981	\$87,624,093	\$145,866,914	162,986	205,629	\$51.55
2004	182,140,362	\$102,121,210	\$173,793,507	175,725	226,016	\$52.54
2005	207,896,198	\$113,538,221	\$199,025,327	183,689	233,067	\$50.65
2006	233,040,781	\$125,456,825	\$223,449,194	195,613	253,793	\$49.07
2007	255,395,599	\$138,869,304	\$244,591,206	213,299	266,782	\$49.26
2008	270,333,881	\$148,084,170	\$264,760,517	242,130	268,528	\$48.87
2009	285,646,191*	\$152,551,854	\$285,121,591	247,081	249,247	\$47.97
2010	296,285,629*	\$159,929,648	\$310,014,852	253,086	250,393	\$47.53
2011	315,963,848*	\$169,767,314	\$335,331,968	283,385	238,071	\$46.11
2012	326,475,248	\$185,013,936	\$365,426,327	301,779	230,101	\$48.99
2013	335,652,171	\$189,192,812	\$398,567,671	304,360	230,409	\$48.79
2014	355,445,472	\$187,848,447	\$430,642,374	298,055	232,169	\$46.64
2015	377,921,241	\$191,949,025	\$462,605,007	307,626	235,818	\$44.65

*Previously Restated

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Estimated Subscriber Connections



Year-End Estimated Connections Near 378 Million

Source: CTIA

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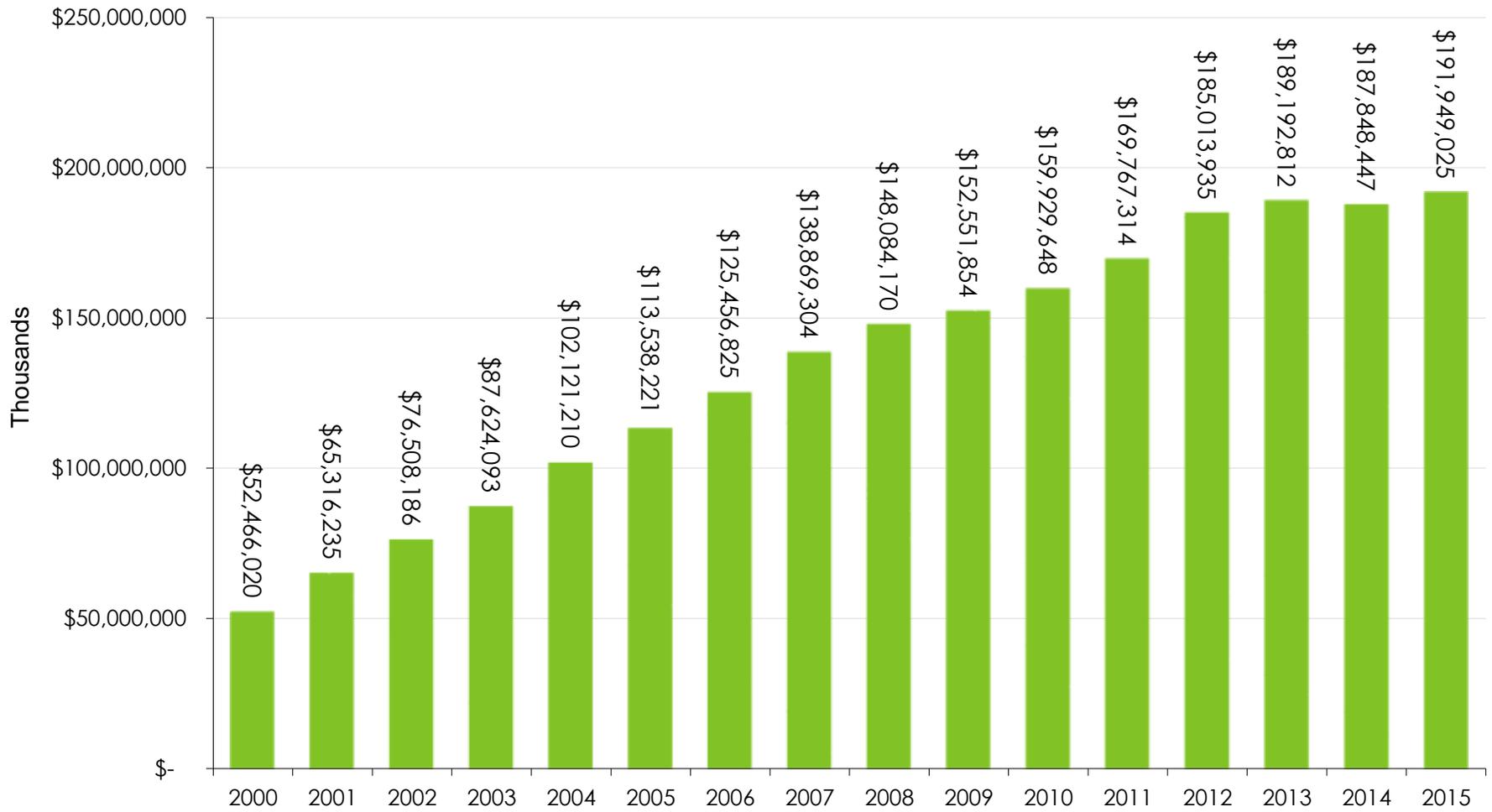
Reported Smartphones, Tablets & Other Devices v. All Units



Source: CTIA

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Annual Total Wireless Service Revenues (000s)

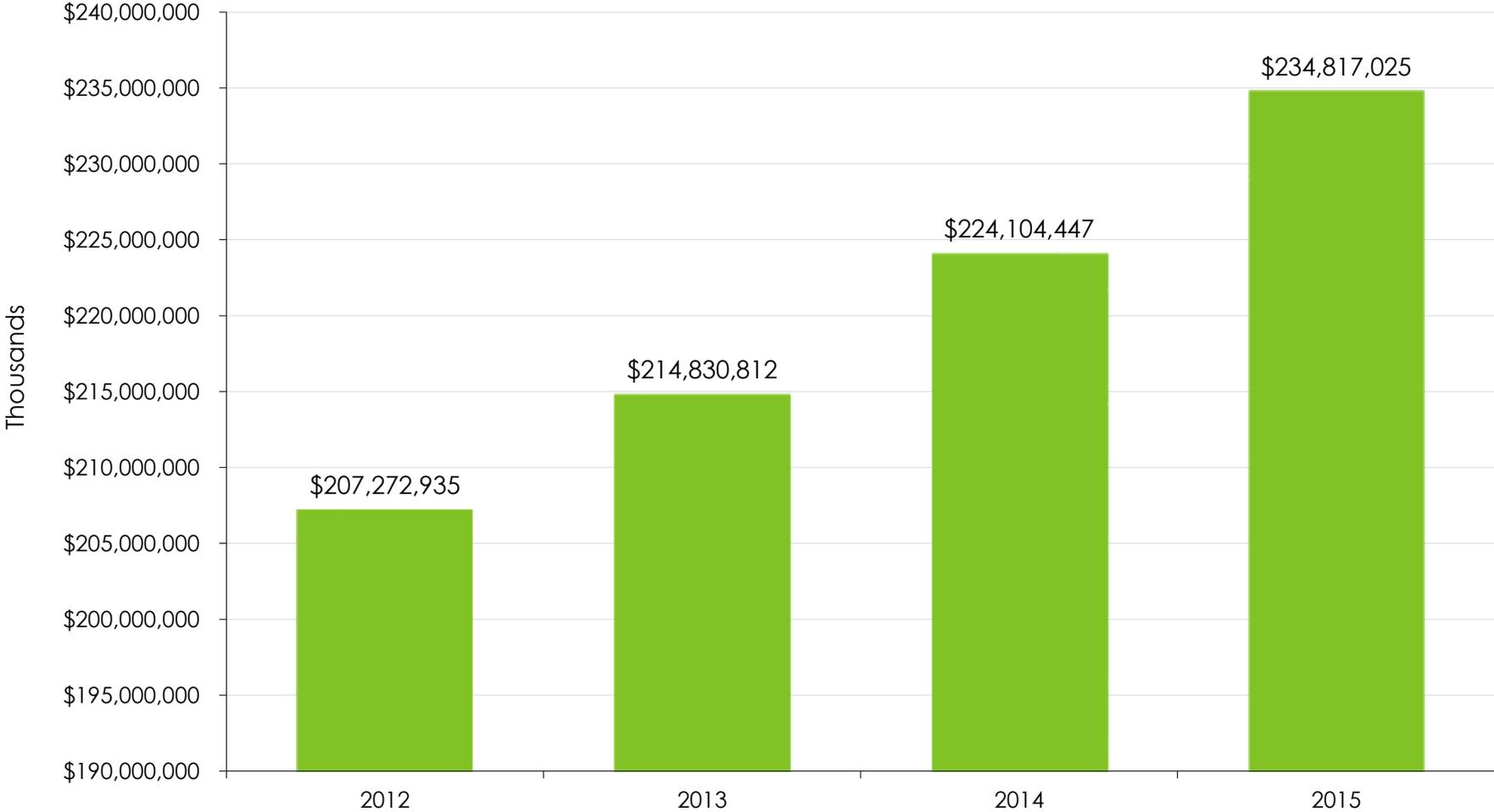


Source: CTIA

Total Reported Service Revenues Rise 2.2% Year-to-Year

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Combined Wireless Service and Equipment Revenues (000s)

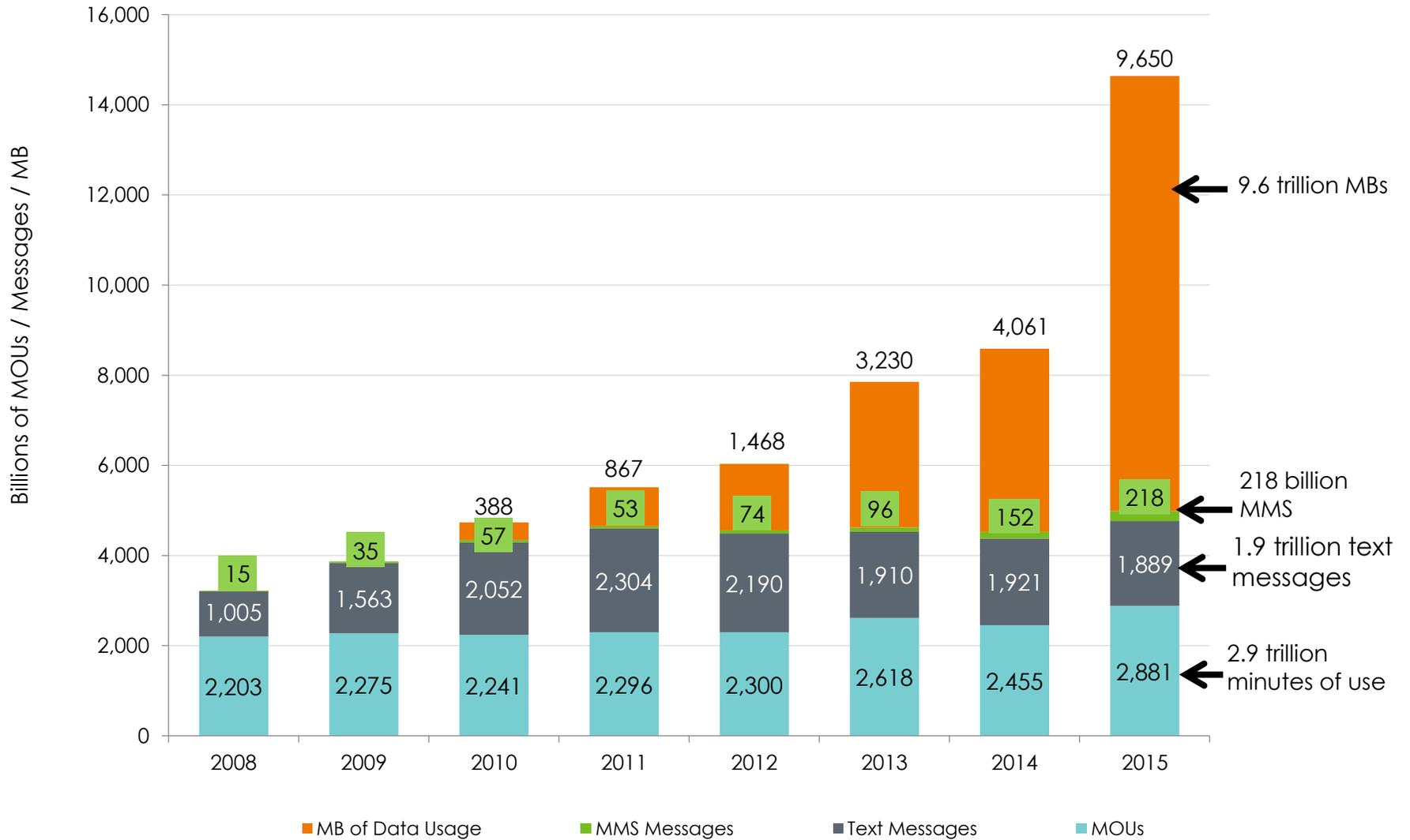


Combined Service and Equipment Revenues Rose 4.8% Year-to-Year

Source: CTIA

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Annual Minutes, Messages and Megabytes of Wireless Traffic

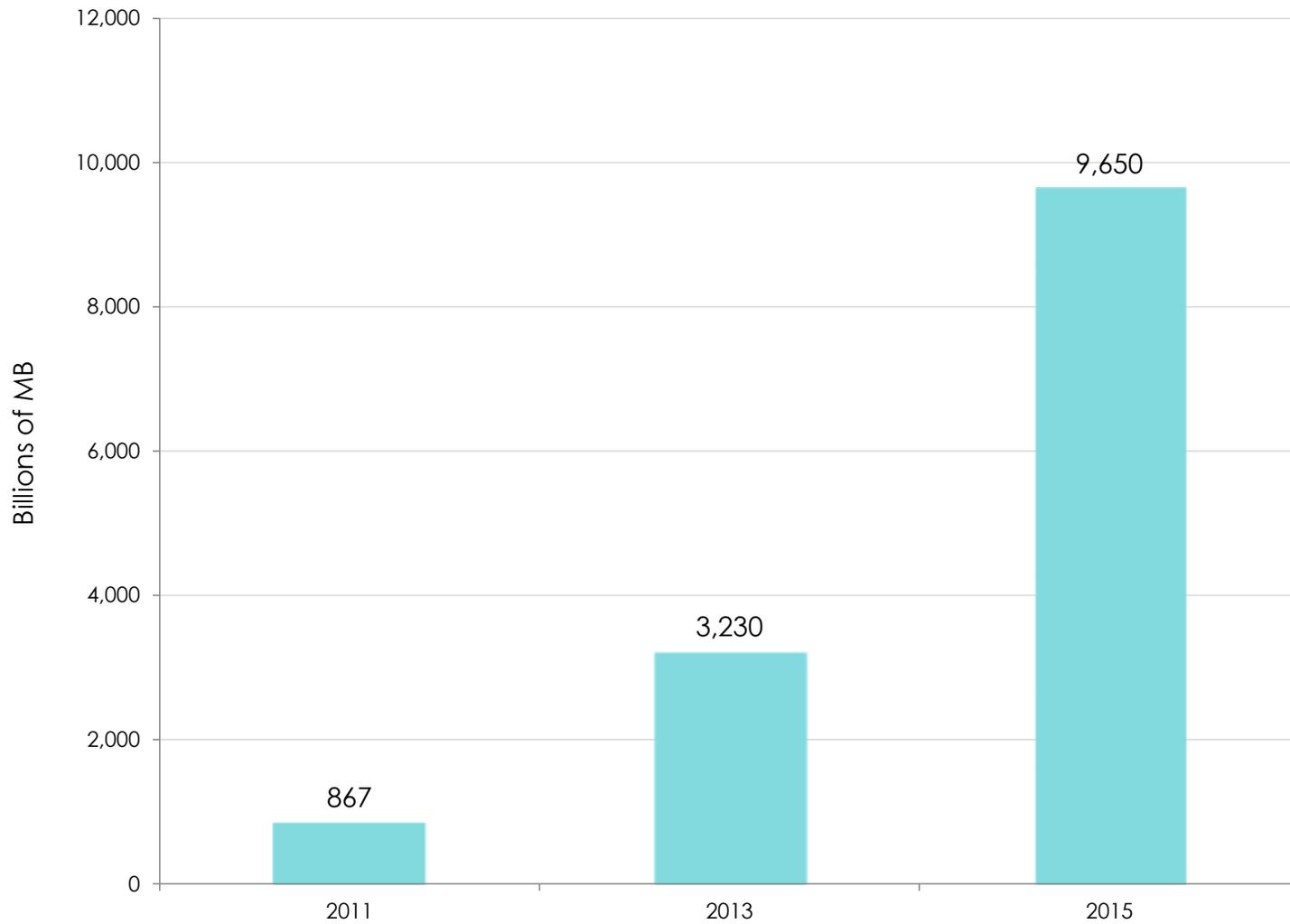


The Mix of Minutes, Messages and MBs Changes

Source: CTIA

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Reported Wireless Data Traffic



Reported Annual Data Traffic Grew 3x Since 2013

Source: CTIA

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Monthly Service Average Revenue per Unit (ARPU)

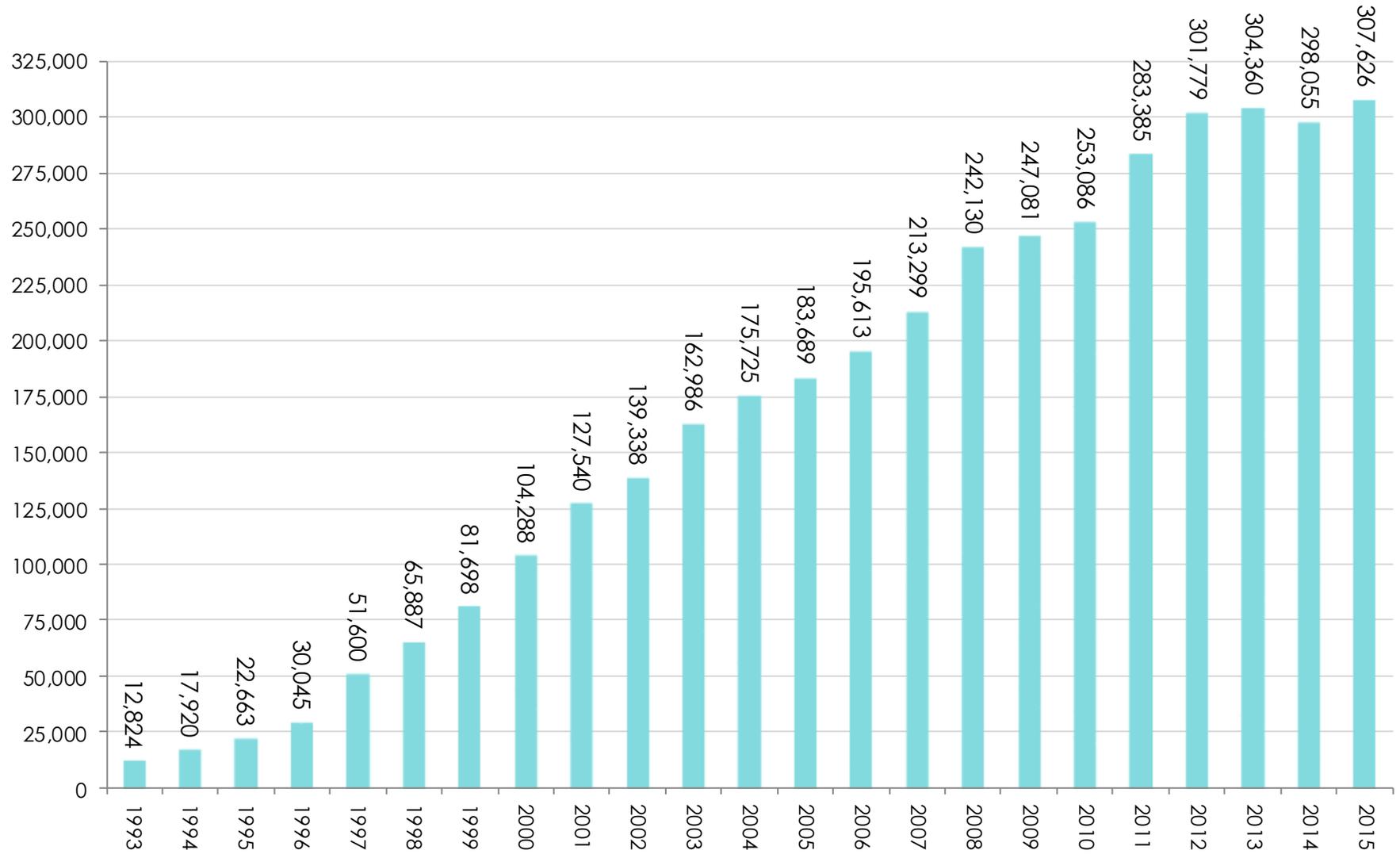


Monthly Average Service Revenue per Unit Falls 4% Year-to-Year

Source: CTIA

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Cell Sites in Service



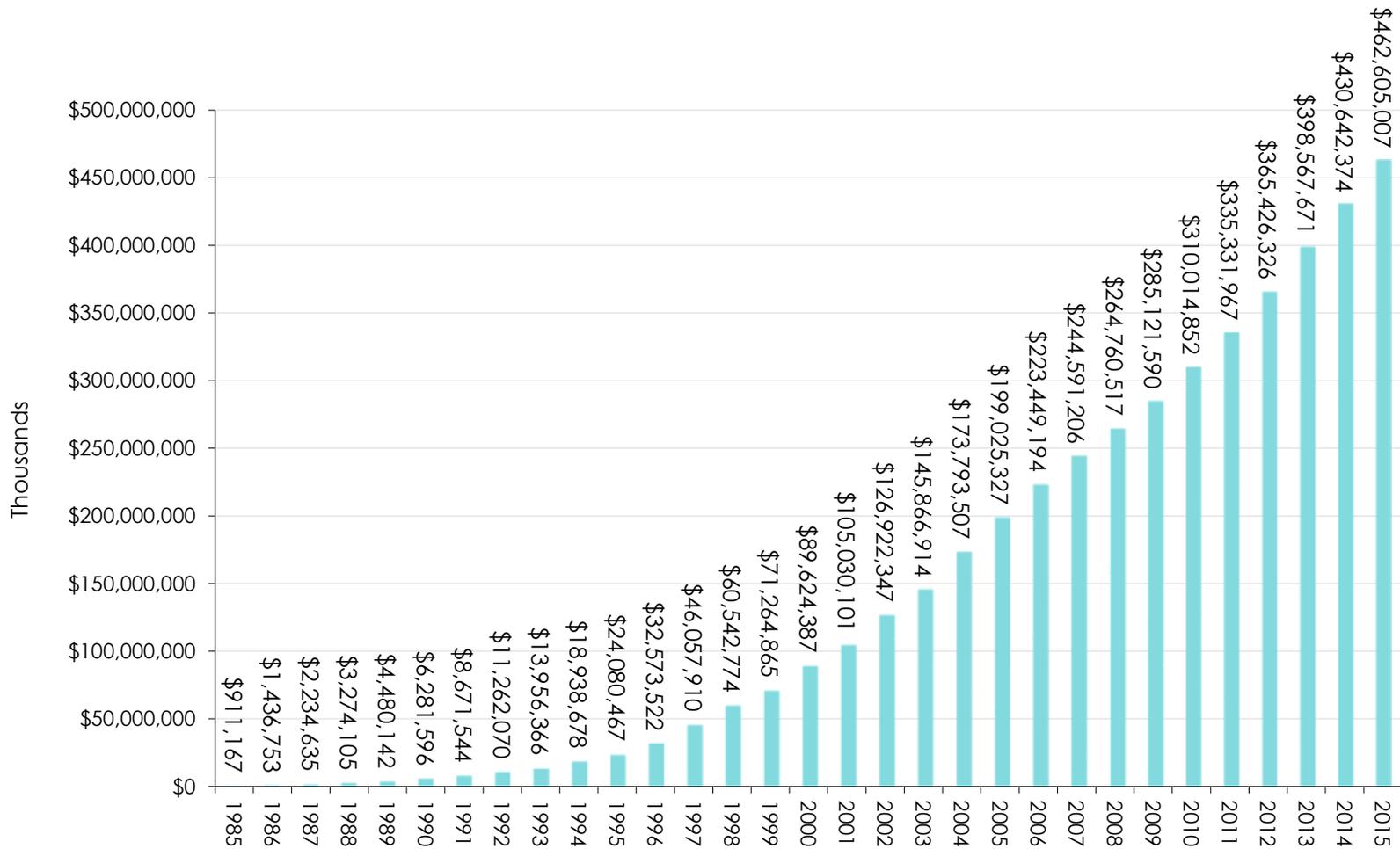
Cell Sites Rise 3.2% Year-to-Year

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Source: CTIA

Reported Cumulative Capital Investment Exceeds \$462 Billion



Reported Cumulative Capex Rises 7.4% Year-Over-Year,
Incremental Capex Totals Almost \$32 billion in 2015

Source: CTIA

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