Before the
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Implementation of Section 6002(b) of the Omnibus	)	
Budget Reconciliation Act of 1993	)	WT Docket No. 17-69
	)	
Annual Report and Analysis of Competitive Market	)	
Conditions With Respect to Mobile Wireless,	)	
Including Commercial Mobile Services	)	

TWENTIETH REPORT

Adopted: September 26, 2017 **Released: September 27, 2017**

By the Commission: Chairman Pai and Commissioners O'Rielly and Carr issuing separate statements; Commissioners Clyburn and Rosenworcel dissenting and issuing separate statements.

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I. INTRODUCTION

1. Mobile wireless services are an important and ubiquitous part of Americans' daily lives, and competition in the provision of mobile wireless services drives innovation and investment to the ultimate benefit of the American people and economy. In this Twentieth Mobile Wireless Competition Report (*Twentieth Report* or *Report*), we fulfill our obligation, pursuant to Section 332(c)(1)(C) of the Communications Act (the Act), to report annually to Congress on "competitive market conditions with respect to commercial mobile services."[1] In particular, the Section states: "The Commission shall review competitive market conditions with respect to commercial mobile services and shall include in its annual report an analysis of those conditions. Such analysis shall include an identification of the number of competitors in various commercial mobile services, an analysis of whether or not there is effective competition, an analysis of whether any of such competitors have a dominant share of the market for such services, and a statement of whether additional providers or classes of providers in those services would be likely to enhance competition."[2]

2. This *Twentieth Report* presents and reviews available 2016 data for all mobile wireless services, including voice, messaging, and broadband,[3] and presents certain information, where available, for early 2017.[4] As discussed below, our assessment of various characteristics of the mobile wireless

[1] 47 U.S.C. § 332(c)(1)(C).

[2] 47 U.S.C. § 332(c)(1)(C).

[3] Our analysis in this *Report* is data-centric; it combines short discussions with substantial use of tables and charts in accessible data formats. We also are providing many of the charts and tables in the *Twentieth Report* on a dedicated website that we intend to update before the release of the next *Report* as new data become available. Additional data and maps are also available on this website. FCC, Mobile Wireless Competition Report (20th Annual), www.fcc.gov/reports-research/reports/commercial-mobile-radio-services-competition-reports/mobile-wireless-5.

[4] Some of the data are only published at year-end and are publicly available only in the middle of the following year. Quarterly and annual SEC filings for the public wireless service providers are available soon after the release of

(continued….)

industry described in Section II: Characteristics of the Mobile Wireless Industry and various indicators of how service providers compete as described in Section III: Elements of Inter-Firm Rivalry indicates that there is effective competition in the mobile wireless services marketplace.

3. As an initial matter, we note that Section 332(c)(1)(C) does not define "effective competition" or dictate a way to measure effective competition. In addition, there is no single definition of effective competition that is generally accepted by economists or competition policy authorities.[5] In the *Eighth Report* through the *Twelfth Report*, the Commission, without defining the phrase "effective competition," made a finding that the provision of mobile wireless services was effectively competitive based on an assessment of several "structural and performance measures of competition" over the relevant time periods.[6] Beginning with the *Fourteenth Report* and continuing through the *Sixteenth Report*, the Commission expanded its assessment of competition in the provision of mobile wireless services to analyze a broader "mobile wireless ecosystem" that included "upstream" and "downstream" market segments, such as network equipment, operating systems, and applications.[7] In those three *Reports*, the Commission concluded that, because of the complexity of the mobile wireless ecosystem, it would not be meaningful to try to make a single, all-inclusive finding regarding effective competition, and instead it presented an analysis of the competitive metrics and trends within the ecosystem.[8] The Wireless

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their financial releases; however, aggregate industry data for public and non-public service providers tend only to be available after they have been compiled by analysts and trade associations based on their set releases. For example, all CTIA–The Wireless Association (CTIA) data are now released based on year-end data available in its annual report published after the close of its industry survey. For these CTIA data, we are able to present only annualized numbers with no mid-year updates.

[5] *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*, Nineteenth Report, 31 FCC Rcd 10534, 10537, para. 4 (WTB 2016) (*Nineteenth Report*); *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services*, Sixteenth Report, 28 FCC Rcd 3700, 3733-34, para. 15 (2013) (*Sixteenth Report*); *see also* Letter from Christine A. Varney, Assistant Attorney General, Department of Justice, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 09-51, at 11 (filed Jan. 4, 2010) ("[t]he operative question in competition policy is whether there are policy levers that can be used to produce superior outcomes, not whether the market resembles the textbook model of perfect competition."); Amanda B. Delp and John W. Mayo, *The Evolution of "Competition": Lessons for 21st Century Telecommunications Policy*, Review of Industrial Organization, 50:393-416 (2017) (discussing evolving and varying definitions of "effective competition" and "workable competition").

[6] *See, e.g., Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services*, Eighth Report, 18 FCC Rcd 14783, 14791, 14812, paras. 12, 57 (2003). Prior to the *Eighth Report*, the Commission observed various degrees of evolving competition in the mobile wireless marketplace. *See, e.g.*, *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services*, Fourth Report, 14 FCC Rcd 10145, 10206-207, Section III (1999). The Wireless Telecommunications Bureau adopted a similar approach in the *Thirteenth Report*. *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services*, Thirteenth Report, 24 FCC Rcd 6185, 6242-43, para. 109 (2009).

[7] *See, e.g., 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, 11411, 11433-36, paras. 2, 11-19 (Figure 1) (2010) (*Fourteenth Report*).

[8] *See, e.g., Sixteenth Report*, 28 FCC Rcd at 3733, para. 14; *Fourteenth Report*, 25 FCC Rcd at 11411, paras. 2-3.

Telecommunications Bureau, acting on delegated authority, followed this same approach in the *Seventeenth Report* through the *Nineteenth Report*.[9]

4. In this *Twentieth Report*, we conclude that the better way to fulfill our statutory obligation to report to Congress on competition with respect to "commercial mobile services" and to analyze "whether or not there is effective competition"[10] is to return to the narrower, more well-defined scope of inquiry that the Commission adopted in the *Eighth Report* through the *Twelfth Report*, rather than the broader inquiry that the Commission utilized in the *Fourteenth Report* through the *Sixteenth Report*. Specifically, in this *Twentieth Report*, we focus only on competition in the provision of mobile wireless services, rather than attempting to examine the broader "mobile wireless ecosystem," which the Commission previously found to be too complex to make a meaningful finding regarding effective competition.[11] We do not attempt to do a full market definition or market power analysis, however, as this would involve an extremely detailed analysis of supply and demand factors at the national and local level.[12] Instead, we consider a number of facts and characteristics of the provision of mobile wireless services, which taken together, indicate that there is effective competition. This *Twentieth Report* also addresses other elements that Congress identified in Section 332(c)(1)(C). In particular, we present information on the number of mobile wireless service providers,[13] and we reference data indicating that, at the nationwide level, no single service provider has a dominant market share,[14] for purposes of Section 332(c)(1)(C).[15] In addition, we discuss the Commission's continued efforts to make spectrum available for the deployment of wireless services by existing providers, and for potential new competitors.[16]

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[9] *See, e.g.*, *Nineteenth Report*, 31 FCC Rcd at 10537, para. 4.

[10] 47 U.S.C. § 332(c)(1)(C).

[11] *See, e.g.*, *Fourteenth Report*, 25 FCC Rcd at 11411, 11433-36, paras. 2-3, 11-19 (Figure 1). We note that, in Sections II.E: Facilitating Access to Spectrum and II.F: Wireless Infrastructure, we do focus on access to spectrum and infrastructure because they can be key indicators regarding ease of market entry and are facilitated in part by Commission policies. We also discuss devices in Section III.B: Differentiation in Mobile Wireless Devices/Services and Advertising/Marketing in the context of how mobile wireless service providers differentiate themselves from their rival competitors.

[12] We note that in the context of Competition Report proceedings, we generally have access only to publicly available data, unlike the circumstances in our review of proposed secondary market transactions. As noted in previous Reports, any individual proceeding in which the Commission defines relevant product and geographic markets, such as an application for approval of a license transfer, may lead to narrower or broader market(s) than any used, suggested, or implied in this *Twentieth Report*. *See, e.g.*, *Nineteenth Report*, 31 FCC Rcd at 10537, paras. 3-4; *Sixteenth Report*, 28 FCC Rcd at 3729-30, para. 4. Further, as with previous *Reports*, this *Twentieth Report* does not address the merits of any license transfer applications that are currently pending before the Commission or that may be filed in the future, which will be decided based on the record collected in each proceeding. *See, e.g.*, *Nineteenth Report*, 31 FCC Rcd at 10536, para. 2 & n.4; *Sixteenth Report*, 28 FCC Rcd at 3704, para. 1 & n.4.

[13] *See infra* Section II.A: Service Providers. *See also* Section III.D: Nationwide Network Coverage and Technology Upgrades, which provides information on coverage by number of service providers, as well as by individual service providers.

[14] *See infra* Section II.B: Connections and Subscribers, Table II.B.1; Section II.C: Market Shares and Concentration, Table II.C.1.

[15] 47 U.S.C. § 332(c)(1)(C). The Commission has made a similar finding in certain prior Competition Reports. *See e.g.*, *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services*, Tenth Report, 20 FCC Rcd 15908, 15911, para. 2 (2005); *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services*, Eleventh Report, 21 FCC Rcd 10947, 10950, para. 2 (2006).

[16] *See infra* Section II.E: Facilitating Access to Spectrum.

5. *Rising consumer demand and increased output*. Both the number of wireless connections and average data usage per connection have been rising in recent years.[17] For example, based on CTIA data, the total number of mobile wireless subscriber connections grew by approximately five percent, from approximately 378 million at year-end 2015 to approximately 396 million at year-end 2016.[18] In addition, according to CTIA, reported wireless data volumes totaled 13.7 trillion MB in 2016, an increase of approximately 42 percent from 9.6 trillion MB in 2015, and an increase of approximately 238 percent from the 4.1 trillion MB reported in 2014.[19] Further, CTIA reports that monthly data usage per smartphone subscriber rose to an average of 3.9 GB, an increase of approximately 39 percent from year-end 2015 to year-end 2016.[20] According to preliminary data from the Centers for Disease Control and Prevention (CDC), from December 2013 to December 2016, the percentage of U.S. households that were identified as wireless-only increased from approximately 41 percent to approximately 51 percent, making 2016 the first year in which a majority of U.S. households were wireless-only households.[21] Further, according to comScore, smartphone penetration rates have almost doubled over the past five years, from approximately 42 percent in 2011 to approximately 81 percent in 2016.[22]

6. *Falling prices*. Service providers continue to expand and adjust data plans and pricing, including adding new plans and reintroducing unlimited data plans to the mobile wireless marketplace.[23] Various measures of Average Revenue per User (ARPU) are frequently used as a proxy for price, particularly in industries with multiple pricing plans and complex rate structures.[24] In recent years, both average revenue per connection and average revenue per MB have been falling.[25] According to CTIA, the industry ARPU per subscriber unit fell sharply during 2016 from $44.65 to $41.50, a decline of approximately 7 percent.[26] According to analysis by Recon Analytics, the cost per MB has fallen significantly over the past decade, from $1.37 per MB in 2007 to less than half a cent per MB in 2016.[27]

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[17] *See infra* Section II.B.1: Total Connections and Subscribers; Appendix I: Trends in Consumer Usage, Chart 2.

[18] *See infra* Section II.B.1: Total Connections and Subscribers.

[19] CTIA Wireless Industry Indices Year-End 2016, at 96. Appendix I: Trends in Consumer Usage, Chart 1 shows annual minutes, messages, and megabytes of wireless traffic from 2008 through 2016.

[20] CTIA Wireless Industry Indices Year-End 2016, at 97. Appendix I: Trends in Consumer Usage, Chart 2 shows average data usage per subscriber from 2010 to 2016 for both data-capable devices and smartphones.

[21] CDC, NCHS, Stephen J. Blumberg and Julian V. Luke, Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July-December 2016, National Center for Health Statistics (May 2017), https://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201705.pdf.

[22] comScore, U.S. Smartphone Penetration Surpassed 80 Percent in 2016 (Feb. 3, 2017), https://www.comscore.com/Insights/Blog/US-Smartphone-Penetration-Surpassed-80-Percent-in-2016. Section III.B.1: Differentiation in Mobile Wireless Devices and Services provides information on smartphone penetration rates.

[23] *See infra* Section III.A: Pricing Levels and Trends.

[24] *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, 15328, para. 35 & n.52 (WTB 2014) (*Seventeenth Report*); Patrick McCloughan and Sean Lyons, *Accounting for ARPU: New evidence from international panel data*, Telecommunications Policy 30, 521-32 (2006); Eun-A Park, Krishna Jayakar, *Competition between Standards and the Prices of Mobile Telecommunication Services: Analysis of Panel Data*, TPRC 2015 (Aug. 15, 2015). *See infra* Section III.A.3: Price Indicators for Mobile Wireless Services.

[25] *See infra* Section III.A.3: Price Indicators for Mobile Wireless Services, Charts III.A.3 and III.A.4.

[26] CTIA reported an industry average measure of "Average Revenue per Reported (subscriber) Unit," or ARPU, which is based "upon total revenues divided by the average total reported active units per survey period, divided by the number of months in the survey period," i.e., an annualized monthly ARPU.

[27] FierceWireless, Industry Voices—Entner: Consumer 'Surplus' in Wireless Rises $192B in 2 Years (Aug. 14,

(continued….)

Further, from year-end 2012 through year-end 2016, while the overall CPI increased by 4.5 percent, the annual Wireless Telephone Services CPI decreased by approximately 8 percent and the Telephone Services CPI decreased by approximately 3 percent.[28]

7. *Network investment*. Service providers have made significant investments in their networks, which have resulted in higher broadband speeds, expanded network coverage, and increased network densification. For example, according to CTIA, between 2010 and 2016, U.S. wireless service providers invested $200 billion,[29] and they are expected to invest over $275 billion over the next several years.[30] A substantial majority of American consumers are covered today by four nationwide service providers, and there are numerous smaller providers that play an important role in local and regional markets.[31] As of January 2017, at least four service providers covered approximately 92 percent of the U.S. population with 3G technology or better as compared to 82 percent at the beginning of 2014.[32] Further, as of December 2016, at least four service providers covered approximately 89 percent of American consumers with LTE.[33] While more limited than in non-rural areas, LTE coverage in rural areas has also increased: As of January 2017, at least four service providers covered approximately 55 percent of the population in rural areas, an increase from approximately 41 percent as of July 2015.[34] Finally, service providers have also been densifying their networks: Between 2013 and 2016, almost 4,000 new cell sites were added,[35] and according to CTIA, there has been an approximate 57 percent growth in the number of cell sites over the last ten years.[36]

8. *Service quality and speed.* Network speed is a key characteristic of mobile wireless performance, and these network investments have resulted in improved network quality as measured by download speed. For example, based on Ookla data, the mean LTE download speed increased from 14.4 Mbps for the first half of 2014 to 23.5 Mbps for the first half of 2017, an increase of well over 60 percent,

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2017), http://www.fiercewireless.com/wireless/industry-voices-entner-consumer-surplus-wireless-rises-192b-2-years.

[28] *See infra* Section III.A.3: Price Indicators for Mobile Wireless Services.

[29] CTIA, Wireless Snapshot 2017, https://www.ctia.org/docs/default-source/default-document-library/ctia-wireless-snapshot.pdf.

[30] Letter from Scott K. Bergmann, Vice President, Regulatory Affairs, CTIA, to Marlene H. Dortch, Secretary, FCC, WC Docket No. 17-84, at 1 (filed Apr. 7, 2017). The U.S. Census Bureau estimated total annual capital expenditures by wireless service providers to be around $32.7 billion for 2015 (approximately 37% of all capital expenditures in the telecommunications industry). U.S. Census Bureau, Annual Capital Expenditures Survey, [NAICS code 5172] https://www.census.gov/library/publications/2017/econ/2015-aces-summary.html (last visited Sept. 1, 2017). *See infra* Section III.C: Investment.

[31] *See infra* Section II.A: Service Providers; Section III.D: Nationwide Network Coverage and Technology Upgrades.

[32] Web Appendix III: Elements of Inter-Firm Rivalry, https://www.fcc.gov/20th-mobile-wireless-report-web-appendices; *Seventeenth Report*, 29 FCC Rcd at 15336, Chart III.A.2.

[33] *See infra* Section III.D: Nationwide Network Coverage and Technology Upgrades.

[34] Web Appendix III: Elements of Inter-Firm Rivalry, https://www.fcc.gov/20th-mobile-wireless-report-web-appendices; *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, 14544, Chart III.A.5 (WTB 2015) (*Eighteenth Report*).

[35] *See infra* Appendix II.F: Wireless Infrastructure.

[36] CTIA, Wireless Snapshot 2017, https://www.ctia.org/docs/default-source/default-document-library/ctia-wireless-snapshot.pdf. CTIA asserts that that the number of cell sites will significantly increase as the mobile wireless industry densifies networks and prepares for 5G. *Id.*

while the median LTE download speed increased from 11.0 Mbps to 15.5 Mbps, an increase of approximately 40 percent, over the same time period.[37]

9. *Access to spectrum*. Competition depends critically upon the availability of sufficient suitable spectrum, both for new entrants and for incumbents wishing to expand their coverage and/or increase capacity. While demand for spectrum continues to increase, reflecting increased mobile broadband usage, in recent years the Commission has made available a significant amount of additional spectrum across a range of frequencies.[38] For example, 65 megahertz of AWS-3 spectrum was won at auction in 2015, while 70 megahertz of 600 MHz spectrum was won in the recently concluded broadcast television incentive auction.[39] Also, in 2015, in the *3.5 GHz* proceeding, the Commission made 150 megahertz of spectrum available on a shared basis with incumbent federal and non-federal users of the band.[40] Further, in 2016, the Commission made available an additional 3250 megahertz of millimeter (mmW) spectrum, and is considering additional mmW spectrum bands that might be made available.[41] Last month, the Commission sought input on potential opportunities in spectrum bands between 3.7 GHz and 24 GHz.[42]

10. *Innovation and new technologies.* Finally, service providers compete strongly on the development and implementation of innovative technologies, as evidenced by the rapid deployment of LTE across the nation, and the upgrades made since to LTE. Moreover, the mobile wireless services marketplace is on the brink of a major technological transformation that is likely to be both competitively disruptive and transformative. Although fifth generation (5G) cellular networking standards have yet to be finalized, several wireless service providers already have begun 5G trials.[43]

II. CHARACTERISTICS OF THE MOBILE WIRELESS INDUSTRY

11. In our analysis of the mobile wireless industry, it is important to look at a variety of characteristics, including the number and type of connections; service providers' market shares and industry concentration; industry revenues and profitability; and spectrum holdings and infrastructure.

A. Service Providers

12. Providers of mobile wireless services typically offer an array of mobile voice and data services, such as interconnected mobile voice services, text and multimedia messaging, and mobile

[37] *See infra* Section III.E: Speed of Service, Chart III.E.1.

[38] *See infra* Section II.E: Facilitating Access to Spectrum.

[39] *Auction Of Advanced Wireless Services (AWS-3) Licenses Closes, Winning Bidders Announced For Auction 97, Public Notice,* 30 FCC Rcd 630 (2015); *Incentive Auction Closing and Channel Reassignment Public Notice; The Broadcast Television Incentive Auction Closes; Reverse Auction and Forward Auction Results Announced; Final Television Band Channel Assignments Announced; Post-Auction Deadlines Announced,* Public Notice, 32 FCC Rcd 2786 (MB, WTB 2017) (*Closing and Channel Reassignment Public Notice)*.

[40] *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC Rcd 3959 (2015) (*3.5 GHz Order and 2nd FNPRM*); *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Order on Reconsideration and Second Report and Order, 31 FCC Rcd 5011 (2016) (*3.5 GHz Second Order*).

[41] *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et. al*., Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014 (2016) (*Spectrum Frontiers Order*).

[42] *Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Inquiry, FCC 17-104 (Aug. 3, 2017) (*Mid-Band Spectrum NOI*).

[43] *See infra* Section III.D.4: Coverage and Technology Upgrades by Service Provider.

broadband services.[44] Facilities-based mobile wireless service providers offer services primarily using their own network facilities, although they sometimes rely on roaming agreements to provide service outside their coverage areas. These facilities-based service providers may operate nationwide, multi-regional, regional, or local networks. In this Section, we present information and available data on all mobile wireless service offerings, as well as on individual services and segments where appropriate.

1. Facilities-Based Service Providers

13. *Nationwide Service Providers*. As of year-end 2016, there were four facilities-based mobile wireless service providers in the United States that industry observers typically describe as "nationwide": AT&T, Sprint, T-Mobile, and Verizon Wireless. Although none of these four nationwide service providers has a network that covers the entire land area or population of the United States, all four service providers have networks that cover a significant portion of both. Therefore, this *Report* will refer to these four service providers as "nationwide service providers."[45] Collectively, these four service providers account for over 411 million connections, over 98 percent of the nationwide total.[46]

14. *Multi-Regional, Regional, and Local Service Providers*. U.S. Cellular, currently the fifth largest service provider in the United States, is best characterized as a multi-regional service provider. It has developed wireless networks and customer service operations in portions of 23 states.[47] As of December 31, 2016, U.S. Cellular provided services to its customers with approximately five million connections.[48] C Spire, the sixth largest service provider nationwide, provides service in the Southeastern United States to nearly one million subscribers.[49] There are also dozens of other facilities-based service providers throughout the United States,[50] many of which provide service in a single, often rural,

[44] For purposes of this *Report*, mobile wireless services also include certain machine-to-machine (M2M) connections, in-vehicle connectivity, smart grid devices, home security systems, and other telematics services. We note that fixed wireless services currently are not included in our analysis of mobile wireless services. *Nineteenth Report*, 31 FCC Rcd at 10538, para. 6.

[45] According to AT&T, it covers over 325 million people with its voice and data service, and over 317 million people with its LTE network. AT&T, AT&T Has the Nation's Largest Network to Connect with Friends and Family, https://www.att.com/offers/network.html (last visited Sept. 1, 2017). According to Sprint, its LTE network now covers nearly 300 million people, and it has also deployed its "LTE Plus Network" in 250 markets across the nation. Sprint, Our Network, http://newsroom.sprint.com/about-us/our-network/ (last visited Sept. 1, 2017). According to T-Mobile, its LTE network now covers 311 million people. T-Mobile, the Un-Carrier Fact Sheet (August 2016), https://newsroom.t-mobile.com/doc_download.cfm?doc_id=210 (last visited Sept. 1, 2017). According to Verizon Wireless, it covers approximately 322 million people and 2.4 million square miles with LTE. Verizon Wireless, We Have Coverage Where It Counts, https://www.verizonwireless.com/featured/better-matters/ (last visited Sept. 1, 2017).

[46] *See infra* Section II.B.1: Total Connections and Subscribers, Table II.B.1.

[47] United States Cellular Corp., 2016 SEC Form 10-K, at 1 (filed Feb. 24, 2017), https://www.sec.gov/Archives/edgar/data/821130/000082113017000010/USMform10k.htm. U.S. Cellular is a majority-owned (83%) subsidiary of Telephone and Data Systems, Inc. *Id*.

[48] *Id.* at 1. According to U.S. Cellular, its LTE network reached 99% of its customers. U.S. Cellular, U.S. Cellular Announces 2015 Statewide Investment in Iowa, https://www.uscellular.com/about/press-room/2016/USCELLULAR-ANNOUNCES-2015-STATEWIDE-INVESTMENT-IN-IOWA.html (last visited Sept. 1, 2017).

[49] C Spire, About C Spire, https://www.cspire.com/company_info/about/more_info.jsp (last visited Sept. 1, 2017).

[50] Examples of regional facilities-based service providers include Appalachian Wireless, Bluegrass Cellular, Carolina West Wireless, Cellcom, Choice Wireless, GCI, Nex-Tech Wireless, and Sagebrush Cellular.

geographic area.[51] These non-nationwide service providers increase choice for consumers and help to promote deployment in rural areas.[52]

2. Resellers/Mobile Virtual Network Operators and Other Service Providers

15. *Resellers/MVNOs.* Resellers and mobile virtual network operators (MVNOs) do not own any network facilities, but instead purchase mobile wireless services wholesale from facilities-based service providers and resell these services to consumers.[53] Agreements between an MVNO and a facilities-based service provider may occur when the MVNO has better access to some market segments than the host facilities-based service provider and can better target specific market segments, such as low-income consumers or consumers with lower data-usage needs.[54]

16. In 2016, the largest MVNO, with approximately 26 million subscribers at year-end, was TracFone Wireless (TracFone), an America Movil subsidiary.[55] In 2015, Google launched "Project Fi," an MVNO in partnership with T-Mobile and Sprint. Google Fi subscribers switch between Wi-Fi networks and these two service providers' LTE networks.[56] In 2016, both Comcast[57] and Charter

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[51] Verizon Wireless's LTE in Rural America (LRA) program allows Verizon Wireless to offer its customers 4G LTE coverage in the rural areas of its rural partners, and the program allows customers of participating companies to roam on Verizon Wireless's 4G LTE network throughout the U.S., including Alaska. Verizon, Verizon's LTE in Rural America (LRA) Program Celebrates Five Years of Delivering Advanced Wireless Services to Rural Customers, http://www.verizonwireless.com/news/article/2015/05/verizons-lte-in-rural-america-lra-program-celebrates-five-years-of-delivering-advanced-wireless-services-to-rural-customers.html (last visited Sept. 1, 2017); Verizon, Verizon: All 21 LTE in Rural America Carrier Partners Have Launched Service, http://www.fiercewireless.com/story/verizon-all-21-lte-rural-america-carrier-partners-have-launched-service/2015-10-15 (last visited Sept. 1, 2017).

[52] *Policies Regarding Mobile Spectrum Holdings Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 29 FCC Rcd 6133, 6207, paras. 179-80 (2014) (*Mobile Spectrum Holdings Report and Order*).

[53] *Nineteenth Report*, 31 FCC Rcd at 10540, para. 9; *Sixteenth Report*, 28 FCC Rcd at 3738, para. 29; *see also* Sprint, Launching a Wireless Brand–Seven Things You Need to Know, http://wholesale.sprint.com/docs/default-library/seven-requirements-of-a-successful-mvno.pdf (last visited Sept. 1, 2017) (defining an MVNO and noting that an MVNO is "responsible for its own retail pricing, customer service, billing support systems, marketing and sales personnel").

[54] Philip Kalmus and Lars Wiethaus, *On the Competitive Effects of Mobile Virtual Network Operators*, Telecommunications Policy, Vol. 34 (2010); Aniruddha Banerjee and Christian Dippon, *Voluntary Relationships Among Mobile Network Operators and Mobile Virtual Network Operators: An Economic Explanation*, Information Economics and Policy, Vol. 21 (2009); *see also* The Yankee Group, Jason Armitage, Yankee Group's 2011 Predictions: 4G Fuels the Decade of Disruption, at 7 (stating "[I]t's critical the MVNO does not compete to any meaningful degree with the host.").

[55] TracFone, TracFone Home, http://www.tracfone.com/ (last visited Sept. 1, 2017); Prepaid Phone News, Fourth Quarter 2016 Prepaid Mobile Subscriber Numbers by Operator (Feb. 14, 2017), http://www.prepaidphonenews.com/2017/02/fourth-quarter-2016-prepaid-mobile.html. TracFone currently operates the Straight Talk, NET 10, TracFone, Simple Mobile, Page Plus, Total Wireless, Telcel America, and SafeLink Wireless MVNO brands, http://www.tracfonewirelessinc.com/en/brands/ (last visited Sept. 1, 2017).

[56] FierceWireless, Google Unveils "Project Fi" MVNO with Sprint and T-Mobile as Partners (Apr. 22, 2015), http://www.fiercewireless.com/story/google-unveils-project-fi-mvno-sprint-and-t-mobile-partners/2015-04-22. In June 2016, Google added U.S. Cellular as a partner. FierceWireless, Google's Project Fi to Add U.S. Cellular to Partner Network (June 8, 2016), http://www.fiercewireless.com/story/googles-project-fi-add-us-cellular-partner-network/2016-06-08. Google requires a Google phone (Pixel, Nexus 5X, 6, or 6P for the service). Similar Wi-Fi/Cellular hybrid services such as Republic Wireless, Ting, and RingPlus offer their subscribers a wide range of calling plans that feature both Wi-Fi and cellular calling along with text and data plans. Republic Wireless, Republic Wireless Home, https://republicwireless.com/ (last visited Sept. 1, 2017); Ting, Ting Home,

(continued….)

Communications,[58] the nation's two largest cable providers, activated MVNO options they held with Verizon Wireless. Comcast launched its wireless service in the spring of 2017 as Xfinity Mobile,[59] and Charter anticipates offering its service in 2018.[60]

17. *Mobile Satellite Service Providers.* Mobile Satellite Services (MSS) providers offer satellite-based communications to mobile devices. Traditionally, MSS has involved voice and narrowband data services. MSS services generally are targeted at users who require communications and asset tracking in remote areas, in disaster response situations, or other places where terrestrial mobile wireless network access may be limited. Examples of MSS customers include the oil industry, maritime users, public safety agencies, and other government/military operations. In 2016, the Commission modified its rules so as to allow Globalstar, Inc. (Globalstar) to seek authorization to use some of its MSS spectrum for low-powered terrestrial broadband service,[61] and in 2017, the Commission's International Bureau granted Globalstar's request to modify its authorization pursuant to the new rules.[62]

18. *Narrowband Data Service Providers.* Narrowband data and paging services comprise a specialized market segment within the mobile wireless industry. These services include two-way messaging, as well as machine-to-machine (M2M) and other telemetry communications. They are consumed primarily by businesses, government users, and other institutions.[63]

B. Connections and Subscribers

1. Total Connections and Subscribers

19. This *Report* uses several data sources to estimate the number of mobile wireless subscribers and connections.[64] One such source, Numbering Resource Utilization Forecast (NRUF),

(Continued from previous page)
https://ting.com/ (last visited Sept. 1, 2017); RingPlus, RingPlus Home, https://ringplus.net/ (last visited Sept. 1, 2017).

[57] FierceWireless, Comcast to Launch Wireless Service in 2017 with Verizon MVNO, 15M Wi-Fi Hotpots (Sept. 20, 2016), http://www.fiercewireless.com/wireless/comcast-to-launch-wireless-service-2017-verizon-mvno-15m-wi-fi-hotspots.

[58] FierceCable, Rutledge: Charter Has Asked Verizon to Activate MVNO Agreement (Sept. 21, 2016), http://www.fiercecable.com/cable/rutledge-charter-has-asked-verizon-to-activate-mvno-agreement.

[59] Comcast.com, Comcast Introduces Xfinity Mobile: Combining America's Largest, Most Reliable 4G LTE Network and the Largest Wi-Fi Network (Apr. 6, 2017), http://corporate.comcast.com/news-information/news-feed/comcast-xfinity-mobile; WirelessWeek, Comcast Opens Enrollment For Its Mobile Plans With $45 Unlimited Offer (May 23, 2017), https://www.wirelessweek.com/news/2017/05/comcast-opens-enrollment-its-mobile-plans-45-unlimited-offer.

[60] FierceCable, Charter's Rutledge: T-Mobile Doesn't Understand Our MVNO Deal (Feb. 16, 2017), http://www.fiercecable.com/cable/charter-s-rutledge-t-mobile-doesn-t-understand-our-mvno-deal.

[61] *Terrestrial Use of the 2473.5-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Report and Order, 31 FCC Rcd 13801 (2016).

[62] *FCC Satellite Policy Branch Information, Actions Taken*, Report No. SAT-01260, Public Notice, DA 17-756 (IB Aug. 11, 2017).

[63] There are approximately 7 megahertz of spectrum allocated to narrowband and paging services, and there are hundreds of licensees for these services, including private individuals, firms, and local and state governments.

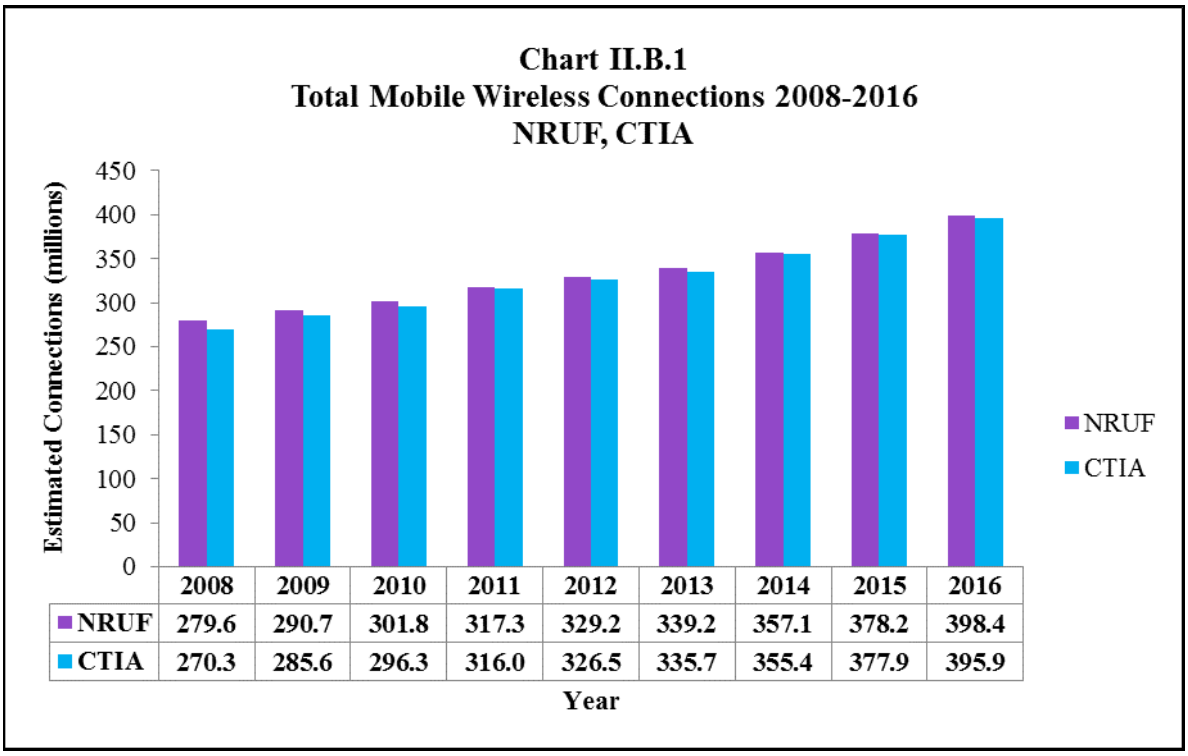
[64] Different sources refer to their data as connections or subscribers, and they may have changed the terminology they use during the periods in which we present their data. When discussing the different data, we will use the terminology most currently used by the source, and where possible, provide a definition of this term. For example, CTIA explains their use of the terms "subscribers" and "connections" as follows: "'Subscribers' is used as a term of art, and reflects the number of revenue-generating units, equally describable as 'wireless connections' – the
(continued….)

tracks the quantity of phone numbers that have been assigned to mobile wireless devices.[65] As shown in Chart II.B.1 below, the number of mobile wireless connections in December 2015, based on NRUF, was approximately 378 million, and during 2016, that number grew by approximately five percent to reach approximately 398 million by year-end 2016, while CTIA and UBS estimates were relatively similar.[66] Chart II.B.2 presents data on total connections by service segment based on UBS data. It shows that, in 2016, the postpaid segment accounted for more than 60 percent of the total connections, the prepaid segment accounted for approximately 20 percent of the total connections, while wholesale connections and connected devices accounted for the remaining approximately 20 percent of total mobile wireless connections.

(Continued from previous page)
equivalent of wireline 'lines.' The terms 'subscriber' and 'subscribership' do not denote unique individual subscribers. Indeed, the growing categories of non-traditional devices and machine-to-machine applications mean that the term 'subscribers' is increasingly less descriptive of a growing share of the universe of active units. Nonetheless, individual users still number in the hundreds of millions." CTIA Wireless Industry Indices Year-End 2016, at 12. Appendix II: Characteristics of the Mobile Wireless Industry, Tables II.B.i-ii provide detailed data on total mobile wireless connections, and total mobile wireless connections by service segment.

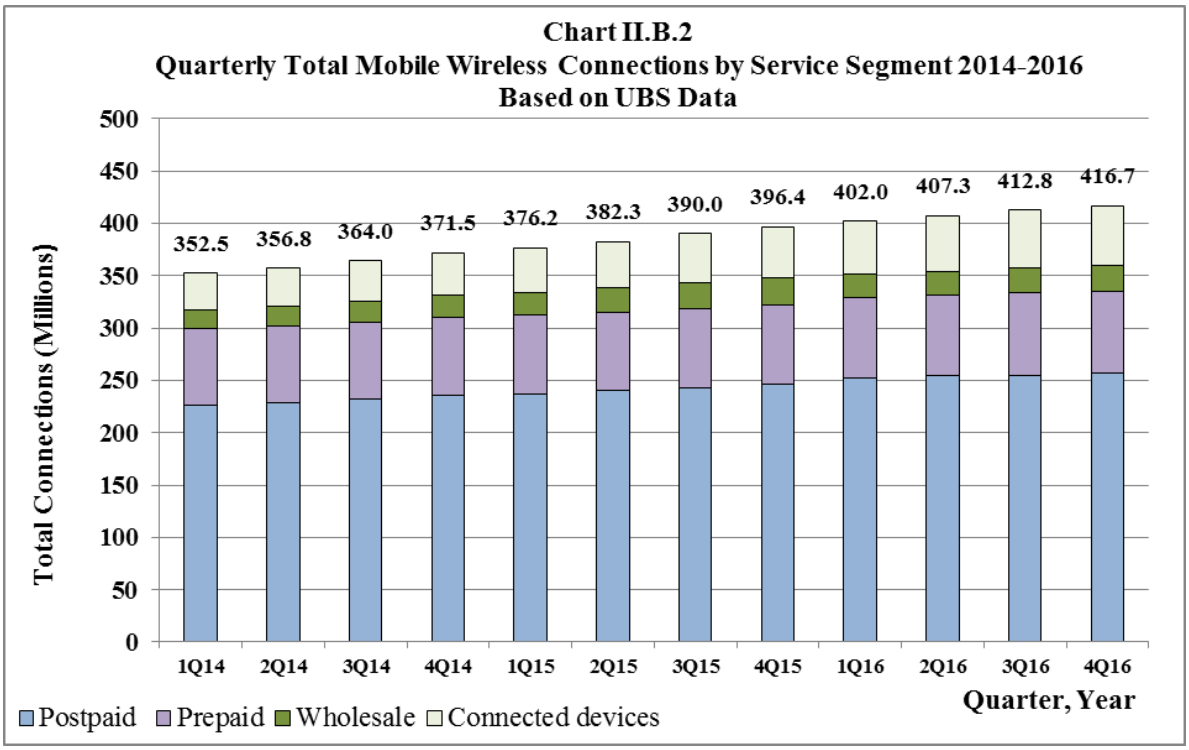
[65] When all mobile wireless devices were assigned telephone numbers and subscribers generally carried one mobile device for making voice calls, NRUF data were a reasonably accurate measure of subscribership. Currently, however, consumers frequently use more than one mobile device that has been assigned a telephone number, particularly non-voice devices, such as Internet access devices (e.g., wireless modem cards and mobile Wi-Fi hotspots), e-readers, tablets, and telematics systems. In addition, certain service providers do not assign telephone numbers to at least some of the devices on their networks. Therefore, rather than measuring the number of individual subscribers, NRUF provides a measure of the number of mobile wireless connections or connected devices that have assigned telephone numbers. As the number of mobile wireless devices that lack telephone numbers increases, the NRUF data will become less accurate.

[66] CTIA estimated that the total number of mobile wireless subscriber connections grew by approximately 5%, from approximately 378 million at year-end 2015 to approximately 396 million at year-end 2016. According to another data source, UBS, the total number of wireless connections rose from approximately 397 million in 4Q2015 to approximately 417 million in 4Q2016, an increase of approximately 5%. UBS US Wireless 411, February 2017, Figure 25.



	2008	2009	2010	2011	2012	2013	2014	2015	2016
NRUF	279.6	290.7	301.8	317.3	329.2	339.2	357.1	378.2	398.4
CTIA	270.3	285.6	296.3	316.0	326.5	335.7	355.4	377.9	395.9

Source: NRUF, CTIA Wireless Industry Indices Year-End 2016.



Source: UBS Investment Research. UBS US Wireless 411, Version 51, Figure 17; UBS US Wireless 411, Version 59, Figure 42; UBS Wireless 411, Feb. 2017, Figure 25.

20. CTIA reports that monthly data usage per smartphone subscriber rose to an average of 3.9 GB per subscriber per month, an increase of approximately 39 percent from year-end 2015 to year-end 2016,[67] while there was a slight drop in total annual minutes of voice use (MOUs).[68] In addition, total messaging traffic amounted to around 1.94 trillion messages for 2016, down from around 2.11 trillion messages in December 2015, a decrease of approximately 8 percent, and attributable to a sharp decrease in SMS/text messaging traffic of approximately 12 percent.[69] Cisco's Visual Networking Index (VNI) reported that as of September 2016, average data usage in North America was approximately 3.2 GB a month for an Android user and approximately 4.8 GB per month for an iOS user.[70] Ericsson, in its November 2016 North American Mobility report, indicated that data traffic per active smartphone user equaled approximately 5.1 GB per month in 2016,[71] while Cisco reported that smartphones in the United States consumed an average of 4.4 GB of mobile data per month in 2016.[72] This trend in increasing data use appears due to multiple factors, including the increased adoption of smartphones and tablets, growth in streaming video, and the development of faster networks.

21. According to Pew's survey, by the end of 2016, smartphone and tablet ownership were 77 percent and 51 percent, respectively, up from 35 percent and 10 percent, in 2011.[73] As of January 2017, Pew reported that just over one in ten American adults are "smartphone-only" Internet users—they own a smartphone, but do not have traditional home broadband service.[74] According to preliminary data from CDC, from December 2013 to December 2016, the percentage of U.S. households that were identified as wireless-only increased from approximately 41 percent to approximately 51 percent, making 2016 the first year in which a majority of U.S. households were wireless-only households.[75]

22. In addition to providing mobile wireless services directly to consumers and businesses, service providers may also provide M2M services.[76] There are limited statistics on M2M

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[67] CTIA Wireless Industry Indices Year-End 2016, at 97. Appendix I: Trends in Consumer Usage, Chart 2 shows average data usage per subscriber from 2010 to 2016 for both data-capable devices and smartphones.

[68] CTIA Wireless Industry Indices Year-End 2016, at 91. Total annual minutes of voice use (MOUs) dropped slightly to 2.75 trillion in 2016, a decrease of approximately 5% compared to year-end 2015. *Id.*

[69] CTIA Wireless Industry Indices Year-End 2016, at 96, 99.

[70] Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021 White Paper, at 29 (Feb. 7, 2017), http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html. Global mobile data traffic is predicted to grow at a Compound Annual Growth Rate (CAGR) of 47% from 2016 to 2021, resulting in 49 exabytes per month by 2021. *Id.* at 3.

[71] Ericsson, Ericsson Mobility Report, On the Pulse of the Networked Society, at 2 (November 2016), https://www.ericsson.com/assets/local/mobility-report/documents/2016/ericsson-mobility-report-november-2016.pdf.

[72] Cisco, VNI Mobile Forecast Highlights 2016-2021, http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/#~Country (last visited Sept. 1, 2017).

[73] Pew Research Center, Mobile Fact Sheet (Jan. 12, 2017), http://www.pewinternet.org/fact-sheet/mobile/ (last visited Sept. 1, 2017).

[74] *Id.*

[75] CDC, NCHS, Stephen J. Blumberg and Julian V. Luke, Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July-December 2016, National Center for Health Statistics (May 2017), https://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201705.pdf.

[76] M2M is a subset of the larger Internet-of-Things (IoT), and due to differing definitions, researchers may be including or excluding connections that are not specifically defined by the industry as M2M. These variations make it difficult to compare data from multiple reported sources. The IoT is seen by some commentators as the next major opportunity for providing advanced connections among devices, and many industries such as healthcare are beginning to use M2M networks to connect their numerous smart devices and machines. The Ericsson Mobility Report predicts that between 2016 and 2022, IoT will rapidly increase at a CAGR of 21%, making up over 18 billion (continued….)

communications.[77] Many research firms forecast that the overall trends for M2M will become more significant as new and existing network service providers continue to deliver connectivity between devices, sensors, monitors, etc., and their networks.[78] 5G networks and services[79] are expected to usher in an era of explosive growth for M2M.[80]

23. Table II.B.1 presents data on total mobile wireless connections for the largest service providers operating in the United States.[81]

(Continued from previous page)
of the total forecast of 29 billion connected devices in 2022. Ericsson, Ericsson Mobility Report, On the Pulse of the Networked Society, at 33 (November 2016), https://www.ericsson.com/assets/local/mobility-report/documents/2016/ericsson-mobility-report-november-2016.pdf.

[77] As of 1Q2017, Chetan Sharma Consulting reports that connected devices for the U.S. accounted for 63% of net subscriber additions. Chetan Sharma, Industry Research (1Q2017), http://www.chetansharma.com/consulting/market-research. For 2016, Cisco reports 109 million U.S. M2M connections, an increase of 58% from 2015. Cisco, VNI Mobile Highlights 2016-2021 (M2M Connections and Traffic), http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/.

[78] *See, e.g.*, McKinsey & Company, McKinsey Global Institute, The Internet of Things: Mapping the Value Beyond the Hype (June 2015), http://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/Unlocking_the_potential_of_the_Internet_of_Things_Executive_summary.ashx; *see generally* Thierer, A. and Castillo, A., Mercatus Center at George Mason University, Projecting the Growth and Economic Impact of the Internet of Things (June 15, 2015), https://www.mercatus.org/system/files/IoT-EP-v3.pdf.

[79] We do not intend to define what qualifies as "5G" in this *Report.* Standard bodies like the Third Generation Partnership Project (3GPP) and the International Telecommunication Union (ITU) plan to develop requirements for 5G by the middle of 2018. 3GPP, 5G-NR Workplan for eMBB (Mar. 9, 2017), http://www.3gpp.org/news-events/3gpp-news/1836-5g_nr_workplan.

[80] *See, e.g.*, Cisco, VNI Mobile Highlights, 2016-2021, http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/. "In the United States, the number of mobile-connected M2M modules will grow 5.4-fold between 2016 and 2021, reaching 587 million in number."

[81] We note that C Spire's total number of connections is not reflected in Table II.B.1. C Spire is the largest privately held service provider in the U.S., and states that it has nearly one million subscribers. C Spire, About C Spire, http://www.cspire.com/company_info/about/more_info.jsp (last visited Sept. 1, 2017).

Table II.B.1
***Estimated* Total Connections for Publicly Traded Facilities–Based Mobile Wireless Service Providers (in thousands): 2013–2016**[82]

Nationwide Service Providers	EOY 2013	EOY 2014	EOY 2015	EOY 2016	EOY 2016 (%)
Verizon Wireless	125,535	134,612	140,924	145,859	35.0
AT&T	110,276	120,620	128,679	134,875	32.4
T-Mobile	46,684	55,018	63,282	71,455	17.1
Sprint	54,622	55,929	58,578	59,515	14.3
Nationwide Service Provider Total	**337,117**	**366,179**	**391,463**	**411,704**	
Regional Service Providers	**EOY 2013**	**EOY 2014**	**EOY 2015**	**EOY 2016**	**EOY 2016 (%)**
U.S. Cellular	4,774	4,760	4,876	5,079	1.2
Leap Wireless	4,551	*	*	*	*
NTELOS	465	449	306	*	*
Cincinnati Bell	340	82	*	*	*
Regional Service Provider Total	**10,130**	**5,291**	**5,182**	**5,079**	**1.2**
Total Estimated Connections	**347,247**	**371,470**	**396,645**	**416,783**	

Source: UBS US Wireless 411, Version 51, Table 21; Version 59, Figure 53; UBS Wireless 411, Feb. 2017, Figure 33. Total estimated connections figure includes data only for the service providers reported in this table.

2. Net Additions

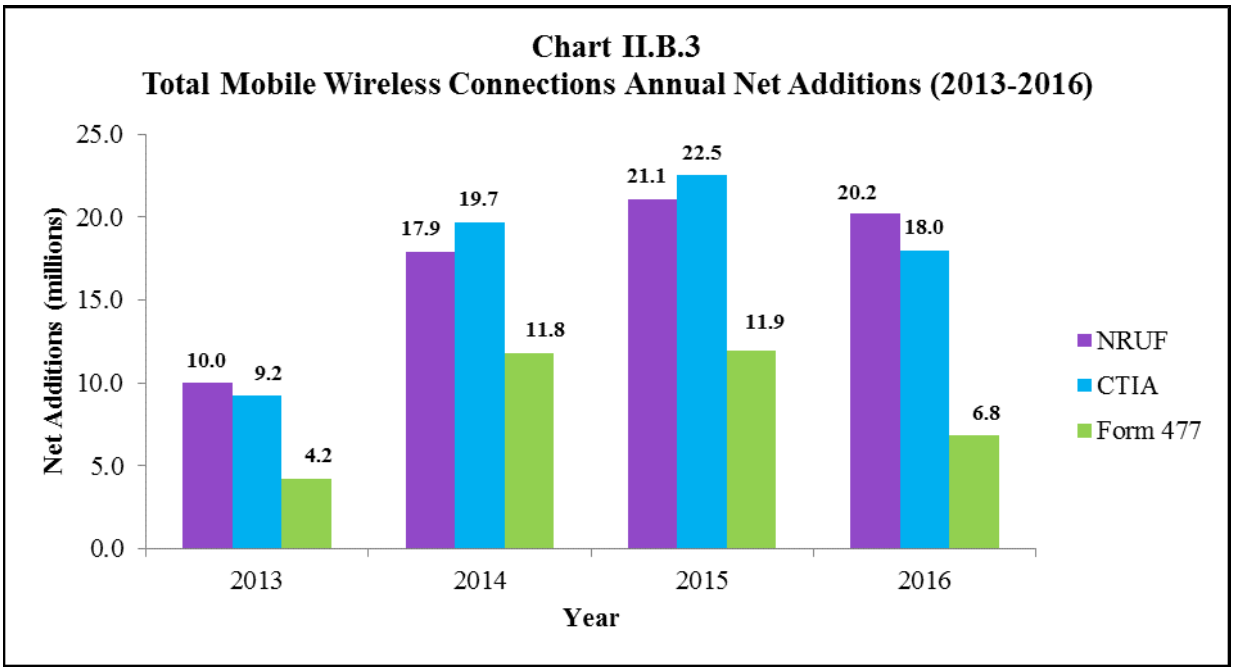
24. As shown in Chart II.B.3 below, for 2016, there were approximately 20 million net additions based on NRUF data, compared with 18 million based on CTIA data.[83] Preliminary mobile voice subscriber data as reported by service providers on Form 477 show that for 2016, net subscriber additions totaled approximately seven million.[84] Chart II.B.4 below shows net additions broken down by service segment: It shows that postpaid net additions peaked during 2014, and have declined through 2016. Chart II.B.4 further shows that the net number of connected device additions was consistently higher than prepaid additions, from 2013 through 2016.[85] Finally, it indicates that, during 2013 through 2016, prepaid additions did not make up a significant percentage of total net additions.

[82] Asterisks (*) indicate that the service provider is no longer separately reporting financial results. Shentel, a Sprint affiliate, acquired nTelos in 2016; AT&T acquired Leap Wireless in 2014; and Cincinnati Bell shut down its mobile operations in February 2015.

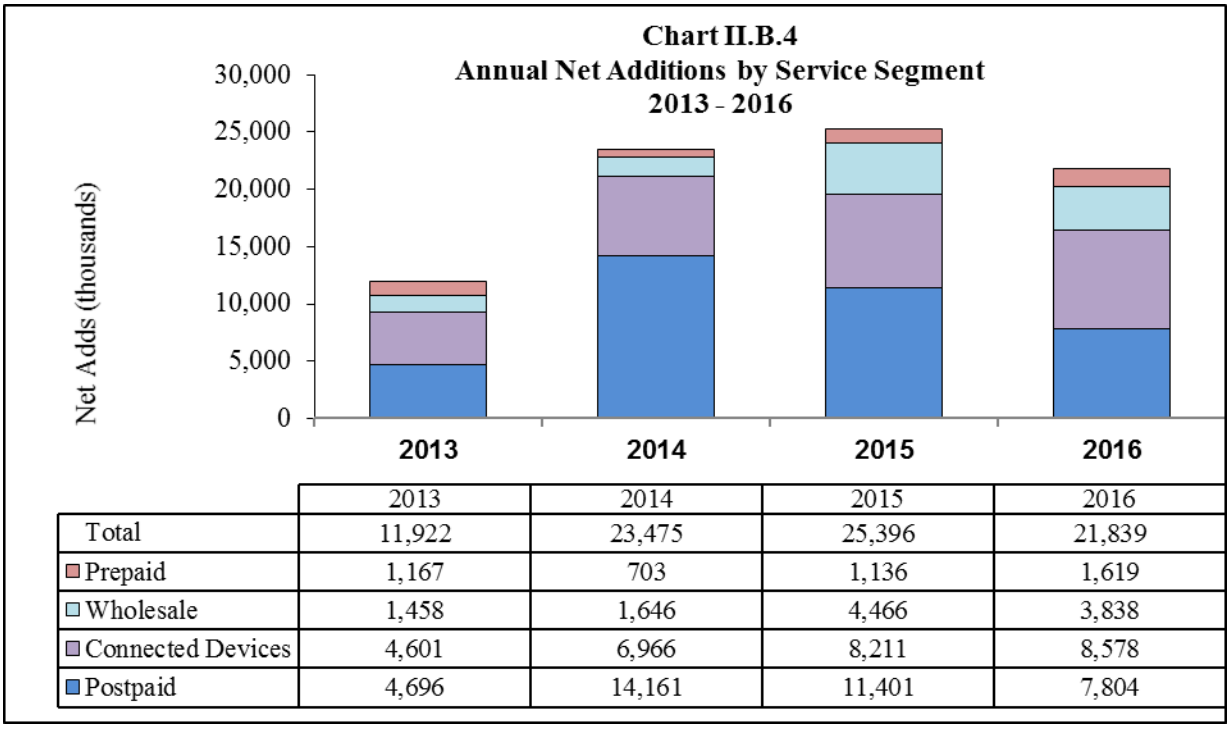
[83] Different data sources refer to their data as connections or subscribers, and methodologies may differ for how the data are collected. *See supra* n.64 and n.65.

[84] Based on Form 477, the preliminary total number of mobile voice telephone subscriptions at year-end 2016 was 341.3 million, as compared to 334.6 million at year-end 2015. We again note that the year-end Form 477 data are preliminary only, and the final data will be published in due course by the agency. *See, e.g.*, FCC, Wireline Competition Bureau, Voice Telephone Services: Status as of December 31, 2015 (November 2016), https://apps.fcc.gov/edocs_public/attachmatch/DOC-342357A1.pdf. These data do not include non-voice devices.

[85] Appendix II: Characteristics of the Mobile Wireless Industry, Table II.B.iii provides detailed data on quarterly net additions by service segment.



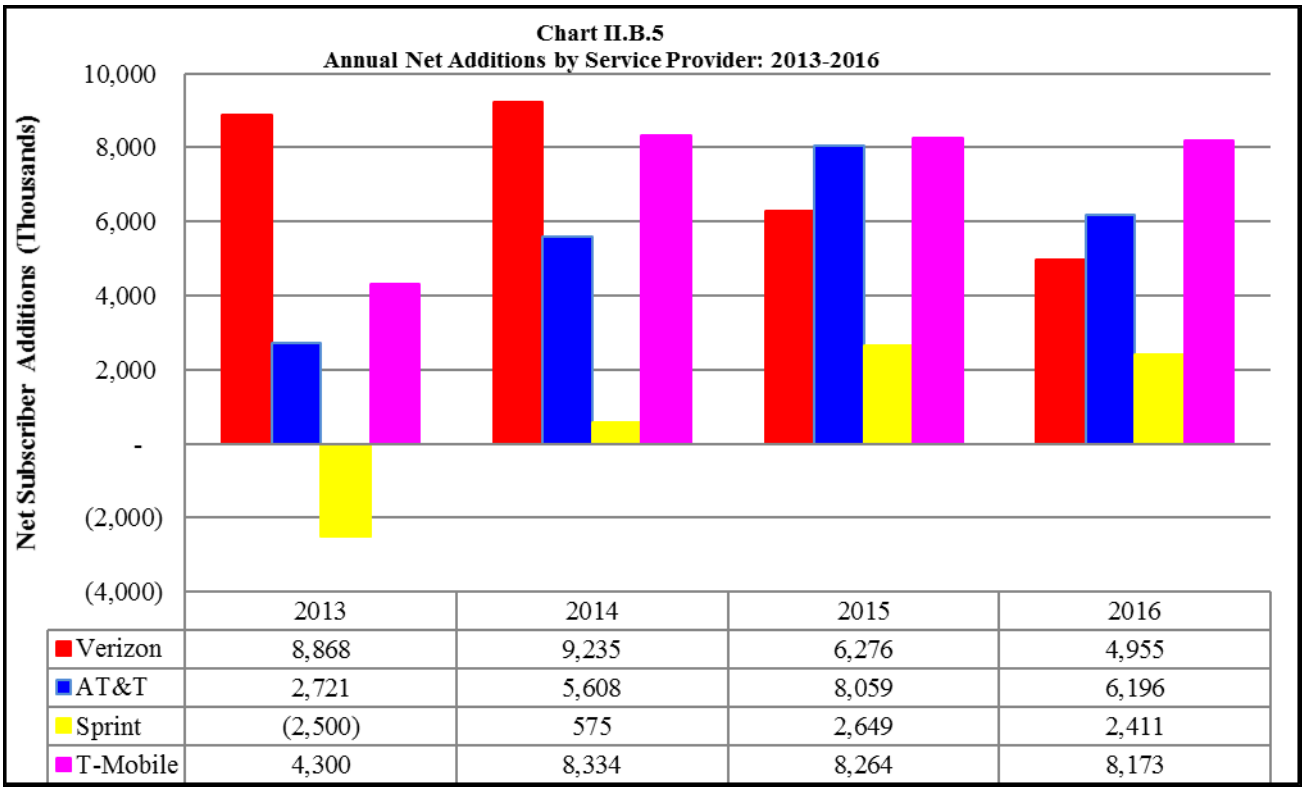
Source: NRUF, CTIA Wireless Industry Indices Year-End 2016, Form 477.



	2013	2014	2015	2016
Total	11,922	23,475	25,396	21,839
Prepaid	1,167	703	1,136	1,619
Wholesale	1,458	1,646	4,466	3,838
Connected Devices	4,601	6,966	8,211	8,578
Postpaid	4,696	14,161	11,401	7,804

Source: UBS Investment Research. UBS US Wireless 411, V. 59, Figure 42; UBS US Wireless 411, Feb. 2017, Figure 25.

25. Chart II.B.5 below shows net subscriber additions by the four nationwide service providers from 2013 through 2016. Throughout this period, AT&T and Verizon Wireless consistently showed strong net additions. T-Mobile, which nearly doubled its net additions between 2013 and 2014, led the industry in this metric for 2015 and 2016. Sprint showed a strong upward trend in 2015, and maintained that growth in 2016.



	2013	2014	2015	2016
Verizon	8,868	9,235	6,276	4,955
AT&T	2,721	5,608	8,059	6,196
Sprint	(2,500)	575	2,649	2,411
T-Mobile	4,300	8,334	8,264	8,173

Source: UBS Investment Research. UBS US Wireless 411, Version 51, Figure 14; UBS US Wireless 411, Version 59, Figure 62; UBS Wireless 411 Feb. 2017, Figure 35.

3. Churn

26. Churn measures the number of connections that are disconnected from mobile wireless service during a given period time period; it is usually expressed as a percentage.[86] A service provider's churn rate depends on many factors, including the distribution of its customers between postpaid and prepaid service plans, customer satisfaction with their service provider, and switching costs.[87] High levels of industry churn can indicate that consumers are not only willing but are also able to readily switch between service providers.

27. According to UBS, the industry weighted average monthly churn rates from the first quarter of 2013 to the fourth quarter of 2016 have ranged from 1.42 percent to 1.85 percent.[88] For 2016, CTIA calculated an annual industry-wide churn rate of 26.3 percent, and a monthly rate of 2.21 percent,[89] while for prepaid services, CTIA reported an annual industry-wide churn rate of 57.5 percent and a

[86] Churn is calculated by dividing the aggregate number of wireless subscriber connections who canceled service during a time period by the total number of wireless subscriber connections at the beginning of that time period. The churn rate for a time period that is longer than a month is equal to the weighted average of the churn rate for each month of that period (e.g., the three months in a quarter or the twelve months for an annual churn rate). Thus, a monthly churn rate of 1% averaged over the three-month reporting period would also be reported as 1%. For an annual calculation, if a service provider has an average monthly churn rate of 2%, the service provider would lose 24% of its subscribers over the course of a year. Service providers publish their monthly churn rate information as part of their quarterly filings with the SEC.

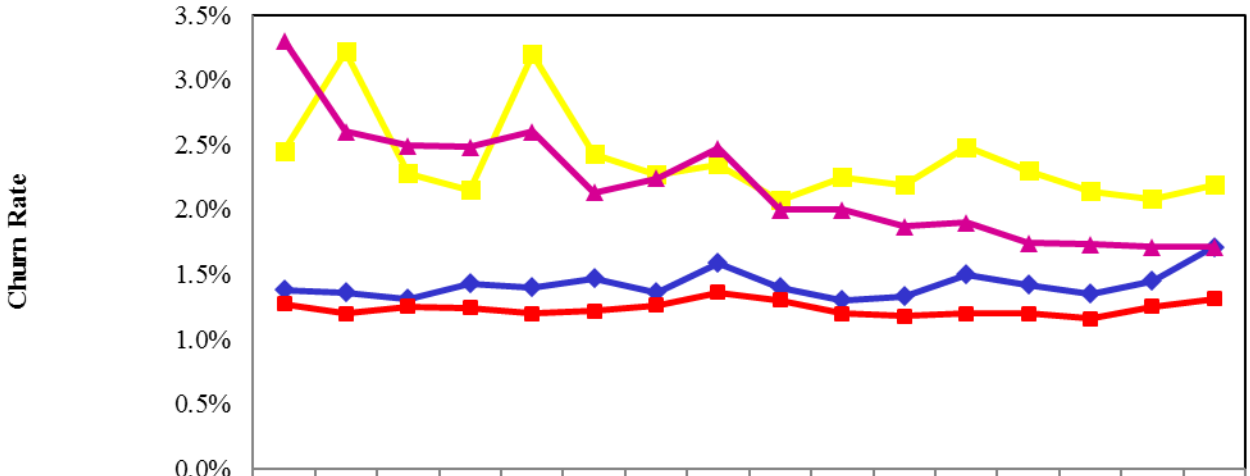
[87] *Nineteenth Report*, 31 FCC Rcd at 10546-47, para. 18; *Sixteenth Report*, 28 FCC Rcd at 3865, para. 260.

[88] UBS Investment Research. UBS US Wireless 411, February 2017, Figure 35.

[89] CTIA Wireless Industry Indices Year-End 2016, at 40.

monthly churn rate of 4.79 percent.[90] For the fourth quarter of 2016, churn rates of the nationwide service providers, as shown in Chart II.B.6 below, were 1.3 percent for Verizon Wireless, 1.7 percent for AT&T and T-Mobile, and 2.2 percent for Sprint. In the fourth quarter of 2016, industry weighted monthly churn was 1.61 percent, its highest in two years.[91]

Chart II.B.6
Quarterly Churn Rate for Nationwide Mobile Wireless Providers
1st Quarter 2013- 4th Quarter 2016



	1Q13	2Q13	3Q13	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15	1Q16	2Q16	3Q16	4Q16
AT&T	1.4%	1.4%	1.3%	1.4%	1.4%	1.5%	1.4%	1.6%	1.4%	1.3%	1.3%	1.5%	1.4%	1.4%	1.5%	1.7%
Verizon Wireless	1.3%	1.2%	1.3%	1.2%	1.2%	1.2%	1.3%	1.4%	1.3%	1.2%	1.2%	1.2%	1.2%	1.2%	1.3%	1.3%
Sprint	2.5%	3.2%	2.3%	2.2%	3.2%	2.4%	2.3%	2.4%	2.1%	2.3%	2.2%	2.5%	2.3%	2.1%	2.1%	2.2%
T-Mobile	3.3%	2.6%	2.5%	2.5%	2.6%	2.1%	2.2%	2.5%	2.0%	2.0%	1.9%	1.9%	1.7%	1.7%	1.7%	1.7%

Source: UBS Investment Research. UBS US Wireless 411, Version 49, Table 16. UBS US Wireless 411, Version 51, Figure 28. UBS US Wireless 411, Version 59, Figure 60; UBS US Wireless 411 Feb. 2017, Figure 35.

4. Penetration Rates by Geographic Area

28. To better understand the number of connections across geographic areas, for this *Report* we have estimated penetration rates (the number of mobile wireless connections per 100 people), using NRUF subscriber/connection data, for the 172 EAs of the United States. Our estimates suggest that 2016 regional penetration rates range from a low of 97 percent in Fayetteville-Springdale-Rogers, AR-MO to a high of 174 percent in Detroit-Ann Arbor-Flint, MI.[92] That NRUF-based penetration rates can exceed 100 percent (including the nationwide penetration rate) is not surprising,[93] since NRUF identifies the

[90] *Id*. at Appendix C, 11.

[91] UBS Investment Research, Wireless Telecommunications Wireless 411: A Difficult Market Asking for Repair?, at 19 (Feb. 2017).

[92] Web Appendix II: Characteristics of the Mobile Wireless Industry (EA Penetration Rates: 2013-2016), https://www.fcc.gov/20th-mobile-wireless-report-web-appendices provides more details.

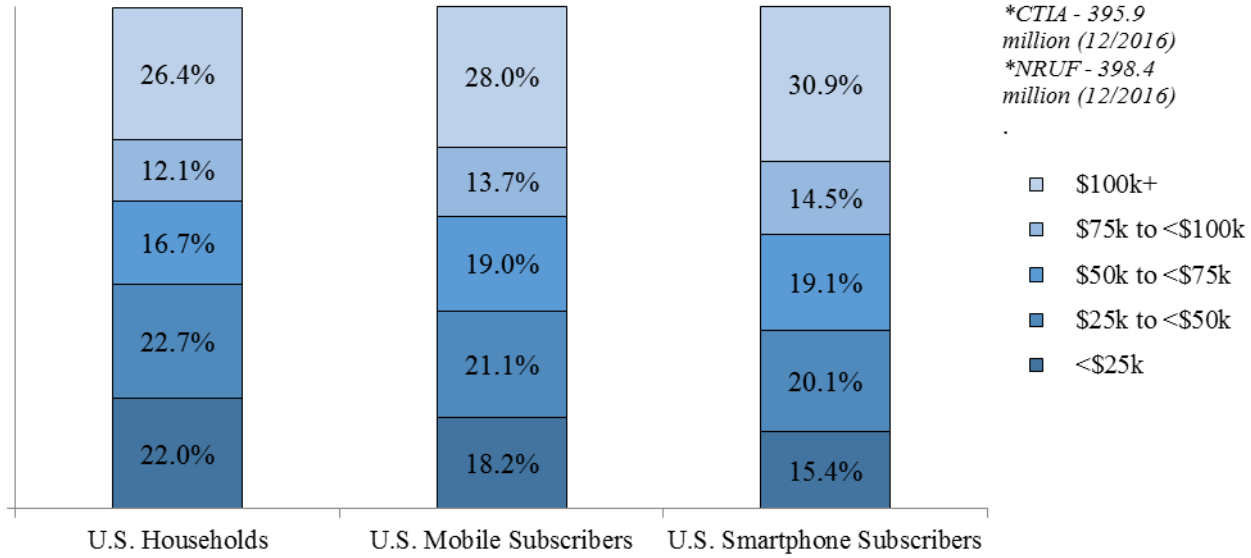
[93] At the end of 2016, the penetration rate was at least 100 percent in 160 of 172 EAs.

number of connected devices that have associated telephone numbers, and a single subscriber may have multiple connected devices.[94]

5. Subscriber Demographics

29. Household income and age are correlated with overall mobile wireless subscription rates as well as smartphone subscription rates. Based on January 2017 survey data from comScore MobiLens,[95] Chart II.B.7 below shows the percentage of mobile wireless subscribers overall, and smartphone subscribers in particular, who fall within various income classes, as well as the overall percentage of U.S. households that fall within the same income range. The chart shows that mobile wireless subscribers and smartphone subscribers are more likely to have higher incomes. For example, approximately 22 percent of the population lives in households with an annual income of less than $25,000, but only approximately 18 percent of mobile wireless users and approximately 15 percent of smartphone users are in this bracket. Conversely, approximately 26 percent of the population live in households with an annual income over $100,000, but approximately 28 percent of mobile wireless subscribers and approximately 31 percent of smartphone subscribers are in this income bracket.

Chart II.B.7
Total U.S. Households, Mobile Subscribers and Smartphone Subscribers by Income Bracket (January 2017)

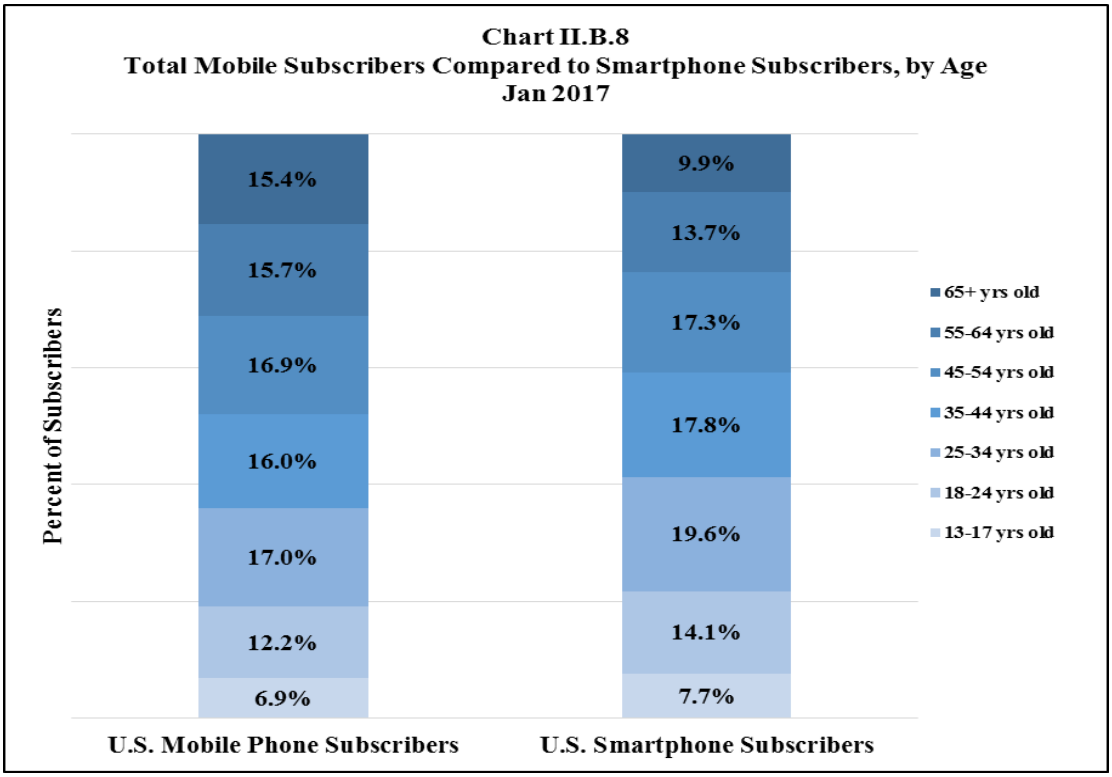


Source: ComScore MobiLens Audience Profile, January 2017, and U.S. Census Bureau.

[94] According to the U.S. Census Bureau, the combined population of the 50 states, the District of Columbia, and Puerto Rico, as of July 1, 2016, was estimated to be 326.5 million. U.S. Census Bureau, American FactFinder, https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2016_PEPANNRES&src=pt (last visited Sept. 1, 2017). We note that, if NRUF is used to calculate a mobile wireless penetration rate (of a population), then that penetration rate is overstated due to the number of individuals who have more than one mobile wireless device.

[95] Survey data based on comScore MobiLens, January 2017. ComScore MobilLens U.S. data are derived from a monthly survey of approximately 30,000 respondents ages 13 and older, who are recruited to represent U.S. Census demographics. The total universe size is estimated from data provided by CTIA and comScore's monthly subscriber studies. Income data are found in Income and Poverty in the United States: 2015 by the U. S. Census Bureau, Table A-1: Households by Total Money Income, Race, and Hispanic Origin of Householder: 1967 to 2015 (Sept. 2016), https://www.census.gov/content/dam/Census/library/publications/2016/demo/p60-256.pdf.

30. Chart II.B.8 below shows the composition of mobile users by age. Although the percentage of mobile devices is evenly distributed across age groups, smartphone ownership is somewhat more concentrated in younger age groups.



Source: ComScore MobiLens, 3-Month Average, January 2017.

C. Market Shares and Concentration

31. Revenues and customers (or in the case of wireless, subscribers and/or connections) are often used to measure the size of an industry and a company. In turn, the size of a company relative to the total size of the industry determines its market share. In general, changes in market share may provide a signal of the relative competitiveness of a company's products or services. In 2016, total wireless service revenues were approximately $189 billion, a year-over-year decrease of $3.4 billion (or approximately two percent).[96] Providers' service revenues and market shares by service revenues are shown in Table II.C.1 below. In addition, Table II.B.1 above shows market shares by connections/subscribers for year-end 2016.

32. By year-end 2016, the four nationwide service providers accounted for approximately 98 percent of the nation's mobile wireless service revenue, up from approximately 96 percent in 2013. As shown in Table II.C.1, AT&T and Verizon Wireless continued to maintain the largest market shares in 2016, while Sprint's market share declined from approximately 15 percent in 2014 to approximately 13

[96] CTIA Wireless Industry Indices Year-End 2016, at 45. Total wireless service providers' revenues, as reported by CTIA, include monthly service fees, usage-related charges, activation charges, vertical services (voicemail, enhanced calling features, and other services), out-collect roaming revenues, and data service revenues. Prepaid revenues increased by approximately 6% to $27.1 billion in 2016, and accounted for slightly more than 14% of total wireless industry revenues. CTIA Wireless Industry Indices Year-End 2016, Appendix C, at 15.

percent in 2016, and T-Mobile's market share increased from approximately 12 percent to approximately 15 percent over that same time period.[97]

Table II.C.1
Service Revenues and Market Shares Based on Service Revenues for Mobile Wireless Service Providers ($ millions), 2013–2016

Service Provider	*2013 Revenue*	*Market Share*	*2014 Revenue*	*Market Share*	*2015 Revenue*	*Market Share*	*2016 Revenue*	*Market Share*
Verizon Wireless	*69,033*	*36.5%*	*72,630*	*38.7%*	*70,396*	*38.1%*	*66,580*	*36.8%*
AT&T	*61,552*	*32.5%*	*61,032*	*32.5%*	*59,837*	*32.4%*	*59,386*	*32.8%*
T-Mobile	*20,535*	*10.9%*	*22,375*	*11.9%*	*24,821*	*13.5%*	*27,844*	*15.4%*
Sprint	*29,263*	*15.5%*	*27,959*	*14.9%*	*25,845*	*14.0%*	*24,215*	*13.4%*
U.S. Cellular	*3,594*	*1.9%*	*3,398*	*1.8%*	*3,350*	*1.8%*	*3,051*	*1.7%*

Source: UBS Investment Research. UBS US Wireless 411, Feb. 2017, Figure 36.

33. *Market Concentration (NRUF Subscriber/Connection Data).* The Commission employs the Herfindahl-Hirschman Index (HHI), a widely-accepted measure of market concentration in competition analysis, to measure mobile wireless concentration. The HHI is calculated by summing the squared market shares of all firms in any given market.[98] In this *Report*, we calculate HHIs based on the NRUF data by Economic Area (EA) to maintain continuity with past *Reports*,[99] and to ensure that we do not compromise the confidential information found in the NRUF data.[100] Although high market concentration levels in a given market may raise some concern that a market is not competitive, this is not

[97] Based on service revenues, the market share for regional service providers fell from close to 5% in 2013 to under 2% by year-end 2016. These estimates are based on UBS US Wireless 411 Reports, which do not provide subscriber numbers for C Spire, a privately held regional service provider that has approximately one million subscribers.

[98] To the extent that this *Report* uses the term "markets," we do not intend it to be interpreted as synonymous with the concept of the "relevant market," which the Commission defines in the context of secondary market transactions review. *See, e.g., Applications of AT&T Inc., Leap Wireless International, Inc., Cricket License Co., LLC and Leap Licenseco, Inc. for Consent To Transfer Control and Assign Licenses and Authorizations*, Memorandum Opinion and Order, 29 FCC Rcd 2735, 2735, para. 27 (WTB, IB 2014) (*AT&T-Leap Order*).

[99] Following widespread industry practices, the Commission generally attributes the subscribers of MVNOs to their host facilities-based service providers, including when it calculates market concentration metrics.

[100] NRUF subscriber data indicate the number of assigned phone numbers that a wireless service provider has in a particular wireline rate center (there are approximately 18,000 rate centers in the country). Rate centers are geographic areas used by local exchange carriers for a variety of reasons, including the determination of toll rates. Harry Newton, Newton's Telecom Dictionary: 19th Expanded & Updated Edition 660 (July 2003). All mobile wireless service providers must report to the Commission the quantity of their phone numbers that have been assigned to end users, thereby permitting the Commission to calculate the total number of mobile wireless subscribers. For purposes of geographical analysis, the rate center data can be associated with a geographic point, and all of those points that fall within a county boundary can be aggregated together and associated with much larger geographic areas based on counties. We note that the aggregation to larger geographic areas reduces the level of inaccuracy inherent in combining non-coterminous areas, such as rate center areas and counties.

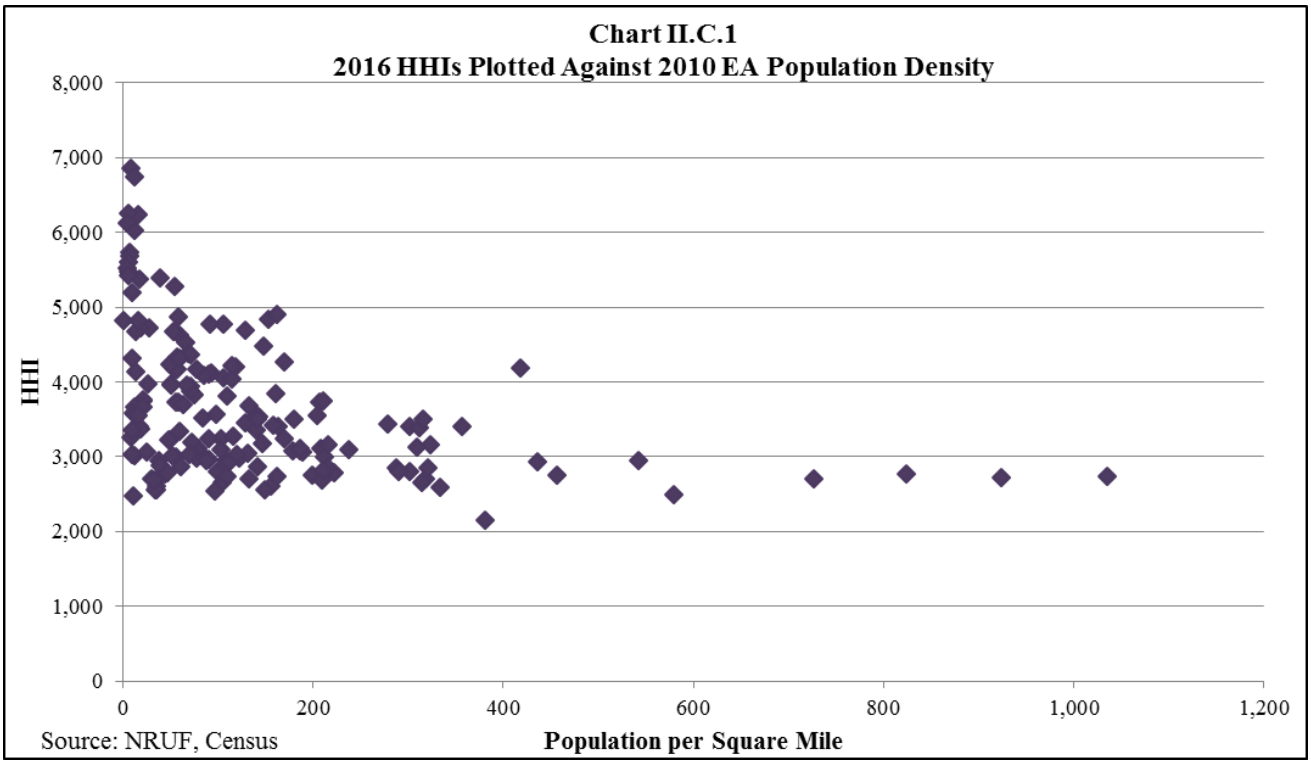
necessarily the case.[101] To evaluate the competitiveness of any market, one must consider multiple factors, including prices and trends in prices, non-price rivalry, investment, innovation, and any barriers to entry.[102] As of year-end 2013, the weighted average HHI (weighted by population across the 172 EAs in the United States) for mobile wireless services was 3,027. As of year-end 2016, the weighted average HHI for mobile wireless services was 3,101.[103] Chart II.C.1 shows the relationship between the HHI by EA and EA population densities. This chart indicates that HHI values tend to decline as the population density increases. The most concentrated EAs tend to be more rural, while major metropolitan areas lie in the least concentrated EAs. This likely reflects greater demand and greater cost efficiencies (per-user mobile wireless network deployment costs tend to decrease with increases in the population density) in more densely-populated areas.[104]

[101] It is well understood that we can observe intense competition even with a small number of firms in the market. *See, e.g.*, Ernest Gellhorn, *Antitrust Law and Economics* (4th ed.), West Publishing, at 117 (1994) (stating "[m]arket shares are not synonymous with market power; they should mark the beginning for careful analysis, not the end of it."); Michael Whinston, Antitrust Policy toward Horizontal Mergers, *Handbook of Industrial Organization*, Vol. 3, ed. Mark Armstrong and Robert Porter, Elsevier (2007); John Sutton, *Sunk Costs and Market Structure*, MIT Press (1991); Joseph Farrell and Carl Shapiro, Antitrust Evaluation of Horizontal Mergers: An Economic Alternative to Market Definition, *The B.E. Journal of Theoretical Economics*, Vol.10, Issue 1, Article 9; Gregory J, Werden and Luke M. Froeb, Unilateral Competitive Effects of Horizontal Mergers in *Handbook of Antitrust Economics*, ed. Paolo Buccirossi, MIT Press (2008).

[102] *Applications of AT&T Inc. and DIRECTV For Consent to Assign or Transfer Control of Licenses and Authorizations*, Memorandum Opinion and Order, 30 FCC Rcd 9131, 9140, paras. 19-20 (2015); *AT&T-Leap Order*, 29 FCC Rcd at 2756-57, para. 49; *Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corporation*, Memorandum Opinion and Order, 19 FCC Rcd 21522, 21544-45, paras. 41-42 (2004).

[103] Antitrust authorities in the United States generally classify markets into three types: Unconcentrated (HHI < 1500), Moderately Concentrated (1500 < HHI < 2500), and Highly Concentrated (HHI > 2500). U.S. Department of Justice and the Federal Trade Commission, Horizontal Merger Guidelines (Aug. 19, 2010), http://www.justice.gov/atr/public/guidelines/hmg-2010.pdf. The Commission's initial HHI screen identifies, for further case-by-case market analysis, those markets in which, post-transaction: (1) the HHI would be greater than 2800 and the change in HHI would be 100 or greater; or (2) the change in HHI would be 250 or greater, regardless of the level of the HHI. *See, e.g., Applications of SprintCom, Inc., Shenandoah Personal Communications, LLC, and NTELOS Holdings Corp. for Consent To Assign Licenses and Spectrum Lease Authorizations and To Transfer Control of Spectrum Lease Authorizations and an International Section 214 Authorization*, Memorandum Opinion and Order, 31 FCC Rcd 3631, 3639, para. 17 & n.50 (WTB, IB 2016) (*Sprint-Shentel-NTELOS Order*); *AT&T-Leap Order*, 29 FCC Rcd at 2753, para. 41 & n.140.

[104] Relatively high fixed costs in relation to the number of customers may limit the number of firms that can enter and survive in a market. *See, e.g.*, John Sutton, *Sunk Costs and Market Structure*, MIT Press (1991); Luis Cabral, *Introduction to Industrial Organization*, MIT Press, Chapter 14 (2000); Dennis W. Carlton and Jeffrey M. Perloff, *Modern Industrial Organization* (4th ed.), Addison, Wesley, Longman, Inc., at 41 (2005); George S. Ford, et al., *Competition After Unbundling: Entry, Industry Structure, and Convergence*, Federal Communications Law Journal, 59:2, at 332, 337 (2007).



D. Profitability

34. In the absence of the data necessary to estimate economic profits,[105] accounting profits can instead be estimated using various metrics available to wireless industry observers,[106] though we note that economists have questioned the use of accounting profits.[107] One such common accounting profits metric, based on company data reported to the Securities and Exchange Commission (SEC), is EBITDA (Earnings before Interest, Taxes, Depreciation, and Amortization). As shown in Table II.D.1 below, for the five largest facilities-based mobile wireless service providers in 2016, EBITDA per subscriber ranged from a low of $11.05 (U.S. Cellular) to a high of $22.71 (Verizon Wireless). A second indicator of mobile wireless profitability is the EBITDA margin, which expresses EBITDA as a percentage of service revenue. Dividing EBITDA by service revenues facilitates cross-provider comparisons. The EBITDA margin of seven publicly reported mobile service providers for the past four years is shown in Chart II.D.1. As of year-end 2016, the EBITDA margins of the four nationwide service providers ranged from approximately 35 percent for T-Mobile to approximately 53 percent for Verizon Wireless.

[105] Economic profit is defined as total revenue minus total costs including opportunity costs. One of the main distinctions between economic profit and accounting profit is capital costs, which reflect a firm's opportunity costs. Dennis Carlton and Jeffrey Perloff, *Modern Industrial Organization*, at 247-52 (2005). A true measure of economic profit, especially in a capital intensive industry such as the mobile wireless industry, would reflect cash flows over a period of time that is long enough to recoup investment costs, and would account for a firm's weighted average cost of capital. Because limitations on data availability make it difficult to measure true economic profit, we consider EBITDA as a crude proxy measure. *Fourteenth Report*, 25 FCC Rcd at 11544, para. 215.

[106] Measures of profitability are widely used by industry observers and analysts, and can provide useful indicators of absolute and relative provider performance. *Fourteenth Report*, 25 FCC Rcd at 11544, para. 214.

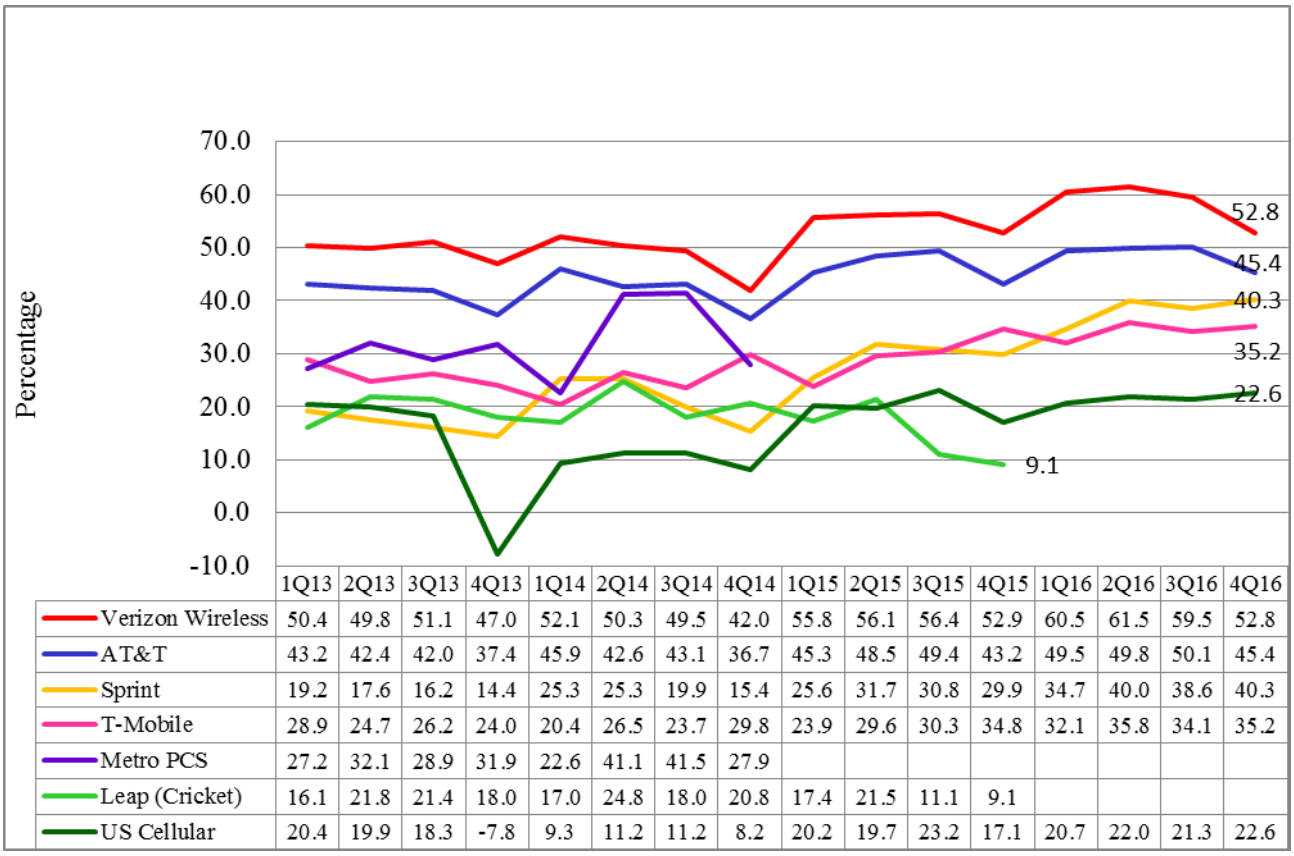
[107] *See e.g.*, Franklin Fisher and John McGowan, *On the Misuse of Accounting Rates of Return to Infer Monopoly Profits*, American Economic Review, Vol. 73, Issue 1, 82-97 (1983) (stating "accounting rates of return, even if properly and consistently measured, provide almost no information about economic rates of return"); Dennis Carlton and Jeffrey Perloff, *Modern Industrial Organization*, 247-52 (2005).

Table II.D.1
Annual EBITDA per Subscriber ($/month), 2013–2016

Mobile Wireless Service Providers	2013	2014	2015	2016
Verizon Wireless	23.56	22.67	23.70	22.71
AT&T	19.55	18.39	18.74	18.30
Sprint	7.53	9.14	11.01	13.00
T-Mobile	10.08	9.20	10.39	11.80
U.S. Cellular	7.34	6.01	11.74	11.05

Source: UBS US Wireless 411, Feb. 22, 2017, Figure 37. Annual figures are calculated by taking the average of each quarter for each year.

Chart II.D.1
Reported EBITDA Margins (%) for Selected Publicly Traded Facilities-Based Wireless Service Providers, 2013–2016



	1Q13	2Q13	3Q13	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15	1Q16	2Q16	3Q16	4Q16
Verizon Wireless	50.4	49.8	51.1	47.0	52.1	50.3	49.5	42.0	55.8	56.1	56.4	52.9	60.5	61.5	59.5	52.8
AT&T	43.2	42.4	42.0	37.4	45.9	42.6	43.1	36.7	45.3	48.5	49.4	43.2	49.5	49.8	50.1	45.4
Sprint	19.2	17.6	16.2	14.4	25.3	25.3	19.9	15.4	25.6	31.7	30.8	29.9	34.7	40.0	38.6	40.3
T-Mobile	28.9	24.7	26.2	24.0	20.4	26.5	23.7	29.8	23.9	29.6	30.3	34.8	32.1	35.8	34.1	35.2
Metro PCS	27.2	32.1	28.9	31.9	22.6	41.1	41.5	27.9								
Leap (Cricket)	16.1	21.8	21.4	18.0	17.0	24.8	18.0	20.8	17.4	21.5	11.1	9.1				
US Cellular	20.4	19.9	18.3	-7.8	9.3	11.2	11.2	8.2	20.2	19.7	23.2	17.1	20.7	22.0	21.3	22.6

Source: UBS US Wireless 411, Feb. 22, 2017, Figure 37.

E. Facilitating Access to Spectrum

35. Spectrum is a critical input in the provision of mobile wireless services.[108] It can affect whether, when, and where existing service providers and potential entrants will be able to expand capacity or deploy networks.[109] Incumbent service providers may need additional spectrum to increase their coverage or capacity, while new entrants need access to spectrum to enter a geographic area.[110] In addition, increasing consumer demand for mobile data is expected to continue increasing service providers' need for spectrum.[111]

36. Spectrum bands vary in their propagation characteristics, and these variations have implications for how spectrum is deployed.[112] Spectrum below 1 GHz (low-band spectrum) has certain propagation advantages for network deployment over long distances, and for penetrating buildings and urban canyons, while spectrum above 1 GHz (mid- or high-band spectrum) allows for the better transmission of large amounts of information.[113] In the *Spectrum Frontiers Order*, the Commission noted that technological advances have made possible the use of ultra-high frequency bands above 24 GHz, or mmW bands, for the provision of mobile broadband.[114] In the *Mid-Band Spectrum NOI*, the Commission observed that bands between 3.7 GHz and 24 GHz could yield a balance of coverage and capacity that could provide a critical input to operators to deploy new and improved wireless services to rural, remote, and underserved areas of the country.[115]

37. Recognizing the importance of spectrum in the provision of mobile wireless services, Congress, under the Communications Act, requires that the Commission implement spectrum policies that promote competition, innovation, and the efficient use of spectrum to serve the public interest, convenience, and necessity.[116] Consistent with this statutory mandate, the Commission has established policies to make spectrum available to existing mobile service providers and potential new entrants through initial licensing, primarily by competitive bidding, and through secondary market transactions.[117]

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[108] Non-spectrum inputs in the provision of mobile wireless services include cellular base stations and towers to carry transmissions and backhaul, which routes voice and data traffic from base stations to mobile switching centers. Backhaul may be provided via wireless spectrum, copper, or fiber, though copper may lack sufficient capacity for current data demands.

[109] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6134, para. 2; *see also Nineteenth Report*, 31 FCC Rcd at 10572, para. 49; *Sixteenth Report*, 28 FCC Rcd at 3769, para. 85.

[110] *Nineteenth Report*, 31 FCC Rcd at 10572, para. 49; *Sixteenth Report*, 28 FCC Rcd at 3769, para. 86.

[111] *Mid-Band Spectrum NOI*, at 3-4, paras. 5-6.

[112] Service providers deploy their spectrum bands differently depending on the nature of the service, geography, density, or other factors in their network build-out. *Nineteenth Report*, 31 FCC Rcd at 10572, para. 50 & n.103; *Sixteenth Report*, 28 FCC Rcd at 3789, para. 119.

[113] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6135, para. 3; *Nineteenth Report*, 31 FCC Rcd at 10572, para. 50. In this sense, low-band spectrum may be thought of as "coverage" spectrum, and higher band spectrum may be thought of as "capacity" spectrum.

[114] *Spectrum Frontiers Order*, 31 FCC Rcd at 8020, paras. 6-7.

[115] *Mid-Band Spectrum NOI*, at 3-4, para. 6.

[116] 47 U.S.C. § 309(j)(3)(B).

[117] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6143-44, 6167-68, 6190, 6193, 6221-22, 6223-24, paras. 17, 67-69, 135, 144, 225-27, 231-32. The Commission generally has adopted "flexible use" policies, thereby allowing licensees to decide which services to offer and what technologies to deploy on spectrum used for the provision of mobile wireless services.

38. On March 30, 2017, for example, bidding concluded in the broadcast television spectrum incentive auction,[118] which made available 70 megahertz of low-band spectrum in the 600 MHz band for commercial use.[119] In the *3.5 GHz* proceeding,[120] the Commission established a three-tiered spectrum authorization framework to facilitate a variety of small cell and other broadband uses of the 3.5 GHz Band on a shared basis with incumbent federal and non-federal users of the band.[121] The innovative spectrum sharing techniques established are currently being implemented by the Commission and other stakeholders, which will allow the introduction of 150 megahertz of contiguous spectrum for the Citizens Broadband Radio Service for the exploration of new technologies and spectrum sharing.[122] The Commission's "Spectrum Frontiers" rulemaking proceeding also took significant steps towards enabling the next generation 5G evolution of wireless technologies. On July 14, 2016, the Commission released a Report and Order and Further Notice of Proposed Rulemaking, which adopted new licensing, service, and technical rules for using three spectrum bands above 24 GHz and sought comment on which additional bands could be made available.[123] The service rules established a framework for flexible services, including mobile services, shared with fixed, satellite, and federal government uses in the mmW bands.[124]

39. Subject to the Commission's approval, licensees may transfer licenses, in whole or in part (through partitioning and/or disaggregation), on the secondary market.[125] In reviewing proposed transfers of control of spectrum, the Commission uses an initial spectrum screen[126] to help identify, for case-by-

[118] The incentive auction was composed of a reverse auction component in which eligible broadcasters voluntarily offered to relinquish some or all of their spectrum usage rights and a forward auction component where mobile wireless providers could bid for new, flexible-use licenses suitable for providing mobile broadband services. *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, 29 FCC Rcd 6567 (2014) (*Incentive Auction Report and Order*).

[119] *Broadcast Auction Scheduled to Begin March 29, 2016; Procedures for Competitive Bidding in Auction 1000, Including Initial Clearing Target Determination, Qualifying to Bid, and Bidding in Auctions 1001 (Reverse) and 1002 (Forward)*, Public Notice, 30 FCC Rcd 8975 (2015). The incentive auction generated approximately $19.8 billion in (gross) bids for 70 megahertz of licensed spectrum nationwide, and as a result of this auction, the 600 MHz Band Plan includes 70 megahertz, or seven paired five megahertz blocks, of licensed spectrum and 14 megahertz of spectrum available for unlicensed use and wireless microphones. *Incentive Auction Closing and Channel Reassignment Public Notice; The Broadcast Television Incentive Auction Closes; Reverse Auction and Forward Auction Results Announced; Final Television Band Channel Assignments Announced; Post-Auction Deadlines Announced*, Public Notice, 32 FCC Rcd 2786, 2793, para. 15 & n.19 (MB, WTB 2017) (*Closing and Channel Reassignment Public Notice*).

[120] The 3.5 GHz Band encompasses 3550-3700 MHz. *3.5 GHz Order and 2nd FNPRM*, 30 FCC Rcd at 3961, para. 1; *see also 3.5 GHz Second Order*, 31 FCC Rcd 5011. CTIA and T-Mobile have petitioned for changes to the rules governing the Citizens Broadband Radio Service. *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on Petitions for Rulemaking Regarding the Citizens Broadband Radio Service*, Public Notice, 32 FCC Rcd 5055 (WTB, OET 2017).

[121] *3.5 GHz Order and 2nd FNPRM*, 30 FCC Rcd at 3962, paras. 4, 6.

[122] *Id.* at 3962, 3975, 3992-93, paras. 4, 44, 98-100.

[123] The *Spectrum Frontiers Order* adopted service and licensing rules for the 24 GHz, 37 GHz, and 39 GHz bands. In addition, it made available the 64-71 GHz band for use by unlicensed devices. *Spectrum Frontiers Order*, at 8018-19, para. 4. In the Spectrum Frontiers' Further Notice of Proposed Rulemaking, comment was sought on making additional bands available. *Id.*

[124] *Id.* at 8018-19, paras. 2-4.

[125] As part of its secondary market policies, the Commission also permits mobile wireless licensees to lease all or a portion of their spectrum usage rights for any length of time within the license term and over any geographic area encompassed by the license.

[126] The Commission, in its initial screen, includes spectrum that it finds is suitable and available for the provision of mobile wireless services. *See, e.g.*, *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6169, para. 71;

(continued….)

case review, local markets where changes in spectrum holdings resulting from the transaction may be of particular concern.[127] As set out in various transaction orders reviewing proposed license transfers, however, the Commission has not limited its consideration of potential competitive harms solely to markets identified by its initial spectrum screen, if it encounters other factors that may bear on the public interest inquiry.[128] In the past decade, in the context of its review of secondary market transactions, the Commission periodically has determined that additional spectrum was suitable and available, and therefore subject to inclusion in the spectrum screen.[129] The current suitable and available spectrum included in the spectrum screen is as follows:

(Continued from previous page)
Sprint-Shentel-NTELOS Order, 31 FCC Rcd at 3638-39, para. 17. In addition, if a proposed transaction involves the transfer of customers, the Commission's initial HHI screen identifies, for further case-by-case market review, those markets in which, post-transaction: (1) the HHI would be greater than 2800 and the change in HHI would be 100 or greater; or (2) the change in HHI would be 250 or greater, regardless of the level of the HHI. *See, e.g.*, *Sprint-Shentel-NTELOS Order*, 31 FCC Rcd at 3639, para. 17 & n.50; *AT&T-Leap Order*, 29 FCC Rcd at 2753, para. 41 & n.140.

[127] *See, e.g.*, *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6221-22, para. 225; *see also AT&T-Leap Order*, 29 FCC Rcd at 2752-53, paras. 39, 41. For transactions that result in the acquisition of wireless business units and customers or change the number of firms in any market, the Commission also applies an initial screen based on the size of the post-transaction HHI and the change in the HHI. *See, e.g.*, *Sprint-Shentel-NTELOS Order*, 31 FCC Rcd at 3638-39, para. 17, n.50. In addition, the Commission determined in the *Mobile Spectrum Holdings Report and Order* that increased aggregation of below-1-GHz spectrum would be treated as an "enhanced factor" under its case-by-case review of license transfers if post-transaction the acquiring entity would hold approximately one-third or more of the currently suitable and available spectrum below 1 GHz. *See, e.g.*, *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6240, paras. 282-88.

[128] *See, e.g.*, *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6221-22, para. 225; *Sprint-Shentel-NTELOS Order*, 31 FCC Rcd at 3635-36, para. 9; *AT&T-Leap Order*, 29 FCC Rcd at 2752, para. 39.

[129] *Incentive Auction Closing and Channel Reassignment*, Public Notice, 32 FCC Rcd 2786 (WTB 2017); *Sprint-Shentel-NTELOS Order*, 31 FCC Rcd at 3637-38, paras. 15-16; *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6172-90, paras. 82-134; *Applications of AT&T Mobility Spectrum LLC, New Cingular Wireless PCS, LLC, Comcast Corporation, Horizon Wi-Com, LLC, NextWave Wireless, Inc., and San Diego Gas & Electric Company for Consent To Assign and Transfer Licenses*, Memorandum Opinion and Order, 27 FCC Rcd 16459, 16470-71, para. 31 (2012); *Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band*, Report and Order, 25 FCC Rcd 11710, 11711, para. 1 (2010); *Applications of Sprint Nextel Corporation and Clearwire Corporation for Consent To Transfer Control of Licenses, Leases, and Authorizations*, Memorandum Opinion and Order, 23 FCC Rcd 17570, 17598-99, paras. 70, 72 (2008); *Applications of AT&T Inc. and Dobson Communications Corporation for Consent To Transfer Control of Licenses and Authorizations*, Memorandum Opinion and Order, 22 FCC Rcd 20295, 20307-08, para. 17 (2007).

Table II.E.1
Spectrum Included in the Spectrum Screen[130]

Spectrum Band	*Megahertz (Amount)*
600 MHz	70
700 MHz[131]	70
Cellular	50
SMR	14
Broadband PCS	130
AWS-1	90
AWS-3	65
AWS-4	40
H Block	10
WCS	20
BRS	67.5
EBS	89
Total Amount of Spectrum	***715.5***

1. Service Providers' Spectrum Holdings

40. Table II.E.2 and Table II.E.3 below present spectrum holdings by service provider. As of May 2017, the four nationwide service providers, Verizon Wireless, AT&T, Sprint, and T-Mobile, together, held approximately 76 percent of all spectrum, measured on a MHz-POPs basis.

[130] We note that we consider AWS-1 and BRS spectrum as available on a nationwide basis. While 15 megahertz of AWS-3 spectrum are available on a nationwide basis (1695-1710 GHz), we will evaluate the availability of the remaining 50 megahertz of AWS-3 spectrum (1755-1780 GHz and 2155-2180 GHz) on a market-by-market basis. Further, while 112.5 megahertz of EBS spectrum are available, we discount this spectrum such that 89 megahertz is included in the screen for review of proposed transactions. *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6177-79, 6184-6187, paras. 100-102, 118-25.

[131] This does not include the 20 megahertz of 700 MHz spectrum allocated to public safety. In March 2017, AT&T was selected by FirstNet to build a nationwide public safety broadband network. AT&T Newsroom, AT&T Selected By FirstNet To Build And Manage America's First Nationwide Public Safety Broadband Network Dedicated To First Responders (Mar. 30, 2017), http://about.att.com/story/firstnet_selects_att_to_build_network_supporting_first_responders.html.

Table II.E.2
Percentage Spectrum Holdings, Measured on a MHz-POPs Basis by Licensee, by Frequency Band*

	600 MHz	700 MHz	Cell.	SMR	PCS	H Block	AWS-1	AWS-3	AWS-4	WCS	BRS	EBS
Spectrum	**70 meg.**	**70 meg.**	**50 meg.**	**14 meg.**	**130 meg.**	**10 meg.**	**90 meg.**	**65 meg.**	**40 meg.**	**20 meg.**	**67.5 meg.**	**112.5 meg.****
AT&T	3.8%	41.6%	44.5%	0.0%	29.3%	0.0%	16.2%	33.6%	0.0%	100.0%	0.0%	0.0%
Sprint	0.0%	0.0%	0.0%	96.5%	28.6%	0.0%	0.0%	0.0%	0.0%	0.0%	86.8%	69.8%
T-Mobile	45.3%	14.2%	0.1%	0.0%	22.0%	0.0%	41.0%	5.6%	0.0%	0.0%	0.0%	0.0%
VZW	0%	31.0%	47.5%	0.0%	16.4%	0.0%	39.1%	18.9%	0.0%	0.0%	0.0%	0.0%
USCC	2.6%	3.6%	4.0%	0.0%	1.1%	0.0%	0.8%	2.6%	0.0%	0.0%	0.0%	0.0%
DISH**	26.2%	6.6%	0.0%	0.0%	0.0%	100.0%	0.0%	35.0%	100.0%	0.0%	0.0%	0.0%
Other	22.0%	3.0%	3.9%	3.5%	2.6%	0.0%	2.9%	4.3%	0.0%	0.0%	13.2%	30.2%

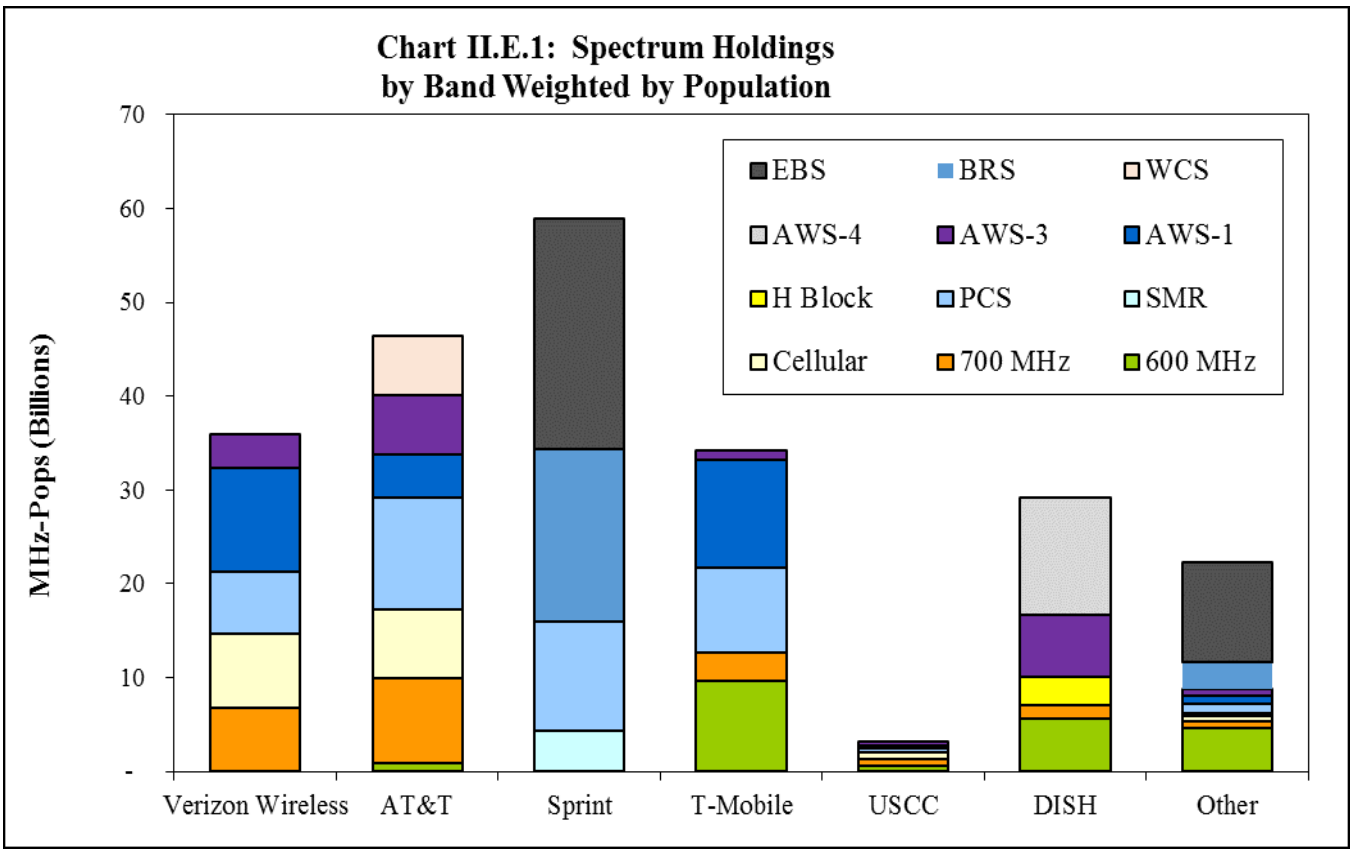
* Staff estimates as of May 2017. Abbreviations for spectrum bands: Cell. (Cellular), SMR (Specialized Mobile Radio Service), PCS (Personal Communications Service), BRS (Broadband Radio Service), and EBS (Educational Broadband Service).
** DISH currently does not provide mobile service.
*** In the application of the spectrum screen in proposed secondary market transactions, EBS spectrum is discounted such that 89 megahertz is included.

Table II.E.3
Population-Weighted Average Megahertz Holdings by Licensee, by Frequency Band*

	600 MHz	700 MHz	Cell.	SMR	PCS	H Block	AWS-1	AWS-3	AWS-4	WCS	BRS	EBS
Spectrum Counted	**70 meg.**	**70 meg.**	**50 meg.**	**14 meg.**	**130 meg.**	**10 meg.**	**90 meg.**	**15 meg.**	**40 meg.**	**20 meg.**	**67.5 meg.**	**112.5 meg.****
AT&T	2.6	29.2	23.6	0.0	38.1	0.0	14.6	20.3	0.0	20.0	0.0	0.0
Sprint	0.0	0.0	0.0	13.9	37.3	0.0	0.0	0.0	0.0	0.0	58.6	78.5
T-Mobile	30.8	9.9	0.0	0.0	28.7	0.0	36.9	3.4	0.0	0.0	0.0	0.0
VZW	0.0	21.7	25.2	0.0	21.4	0.0	35.2	11.4	0.0	0.0	0.0	0.0
USCC	1.8	2.5	2.1	0.0	1.5	0.0	0.7	1.6	0.0	0.0	0.0	0.0
DISH**	17.8	4.6	0.0	0.0	0.0	10.0	0.0	21.1	40.0	0.0	0.0	0.0
Other***	14.9	2.1	2.0	0.5	3.4	0.0	2.6	2.6	0.0	0.0	8.9	34.0

* Staff estimates as of May 2017.
** DISH currently does not provide mobile service.
*** In the application of the spectrum screen in proposed secondary market transactions, EBS spectrum is discounted such that 89 megahertz is included.

41. Chart II.E.1 shows the population-weighted average megahertz spectrum holdings of nationwide wireless service providers by frequency, and provides a side-by-side comparison of each licensee's total spectrum holdings by band, measured by population-weighted average megahertz.[132]



Note: Staff estimates as of May 2017.

F. Wireless Infrastructure

42. Wireless infrastructure facilities constitute another major input in the provision of mobile wireless services. In addition to towers and other tall structures, such as lattice towers, guyed towers, monopoles, rooftops, water towers, and steeples, wireless infrastructure also includes distributed antenna systems (DAS)[133] and small cells,[134] deployed to improve spectrum efficiency for 4G and future 5G

[132] We consider population-weighted spectrum holdings in order to account for customer density in different geographic areas. A spectrum license in Los Angeles or New York City, for example, covers more customers than a spectrum license over the same amount of land area in White Sands, New Mexico.

[133] A DAS network consists of three primary components: (i) a number of remote communications nodes (DAS node(s)), each including at least one antenna for the transmission and reception of a wireless service provider's RF signals; (ii) a high capacity signal transport medium (typically fiber optic cable) connecting each DAS node back to a central communications hub site; and (iii) radio transceivers or other head-end equipment located at the hub site that propagates and/or converts, processes or controls the communications signals transmitted and received through the DAS nodes. The HetNet Forum, Distributed Antenna Systems (DAS) and Small Cell Technologies Distinguished, at 3 (Feb. 2013), http://www.thedasforum.org/resources/send/2-resources/24-das-and-small-cell-technologies-distinguished.

services, and to address coverage and capacity issues indoors, in densely populated areas outdoors, and even underground.[135] For example, small cells and DAS antennas can be placed on utility poles, buildings, or traffic signal poles in areas where constructing towers is not feasible or wireless traffic demands are too great to be met solely with large cells.[136]

43. In order to expand or to improve coverage in existing service areas, and to accommodate newer technologies, mobile service providers historically have deployed additional cell sites. According to CTIA, there were 308,334 cell sites in use at year-end 2016, up from 307,626 as of year-end 2015 (approximately 0.2 percent increase).[137] Mobile service providers increasingly have started to deploy small cells and DAS sites to fill local coverage gaps, to densify networks and to increase local capacity, or to prepare for their 5G network.[138] According to one analyst, between 100,000 and 150,000 small cells could be installed nationwide by the end of 2018.[139] Rather than building their own DAS deployments, some service providers share neutral host systems owned by third-party operators.[140]

(Continued from previous page)

[134] "Small cell" is an umbrella term for operator-controlled, low-powered radio access nodes, including both those that operate in licensed spectrum and those that operate in unlicensed carrier-grade Wi-Fi. Small cells typically have a range from 10 meters to several hundred meters. Small Cell Forum, Small Cell Definition, http://www.smallcellforum.org/about/about-small-cells/small-cell-definition/ (last visited Sept. 1, 2017).

[135] The HetNet Forum, Distributed Antenna Systems (DAS) and Small Cell Technologies Distinguished, at 6 (Feb. 2013), http://www.thedasforum.org/resources/send/2-resources/24-das-and-small-cell-technologies-distinguished; *Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment*, Notice of Proposed Rulemaking and Notice of Inquiry, 32 FCC Rcd 3330, 3343, para. 32 (2017) (*Wireless Infrastructure Notice*). Another component of a wireless service provider's network are backhaul connections that link a mobile wireless service provider's cell sites to the mobile switching centers that provide connections to the provider's core network, the public switched telephone network, or the Internet, carrying wireless voice and data traffic for routing and onward transmission. Backhaul facilities are generally provided by incumbent local exchange carriers (ILECs), competitive local exchange carriers (CLECs), competitive fiber and microwave wholesalers, cable providers, and independent backhaul operators. *Nineteenth Report*, 31 FCC Rcd at 10589, para. 75; *Sixteenth Report*, 28 FCC Rcd at 3912, para. 336.

[136] Because DAS sites are less visible than tower structures, they may be particularly desirable in areas with stringent siting regulations, such as in historic districts.

[137] CTIA Wireless Industry Indices Year-End 2016, at 72. Because multiple cell sites can be co-located in the same "tower" site, the reported cell sites should not be equated with "towers." The reported cell sites include repeaters and other cell-extending devices (e.g., femtocells or distributed antenna systems). *Id.* at 72. Appendix II: Characteristics of the Mobile Wireless Industry, Table II.F.i provides information on year-end cell site counts by service provider.

[138] *See, e.g.*, Sprint Q2 2016 Earnings Call transcript, at 4, http://s21.q4cdn.com/487940486/files/doc_financials/quarterly/2016/Q2/S-US-20161025-1881741-C.pdf; *see also* FierceWireless, Sprint Exec Acknowledges Small Cell 'Misunderstandings,' Promises Expanded Rollout in 2017 (Jan. 19, 2017), http://www.fiercewireless.com/wireless/sprint-exec-acknowledges-small-cell-misunderstandings-promises-expanded-rollout-2017; Verizon 2016 Annual Report, at 39; RCR Wireless, Verizon Claims 'Largest Small Cell Deployment' in the U.S (Mar. 17, 2017), http://www.fiercewireless.com/wireless/verizon-claims-largest-small-cell-deployment-any-u-s-carrier; CTIA Comment, at 38; RCR Wireless, AT&T Explains Small Cell Siting Strategy (Nov. 10, 2016), http://www.rcrwireless.com/20161110/network-infrastructure/att-explains-small-cell-siting-strategy-tag4-tag99; New Network Technologies Coming for Our Customers in 2017, Verizon Blog (Jan. 23, 2017), http://www.verizon.com/about/news/new-network-technologies-coming-our-customers-2017-building-2016-accomplishments; *see also* RCR Wireless, Carrier small cells appear slowly but surely (May 24, 2016), http://www.rcrwireless.com/20160524/carriers/carrier-small-cells-tag4.

[139] S&P Global Market Intelligence, John Fletcher, Small Cell and Tower Projections through 2026, SNL Kagan Wireless Investor (Sept. 27, 2016); *see also* CTIA Comments at 43 ("Charter intends to eventually extend its own network, including densification via small cells"); RCR Wireless, Crown Castle: Small Cell Revenue Could Equal

(continued….)

44. A specialized communications tower industry has developed to provide and manage the support structures for the cell sites. Today, there are more than 120 tower and DAS operators in the United States,[141] and a majority of towers are now owned or operated by independent companies rather than by mobile wireless service providers.[142] Independent tower operators own, operate and lease shared wireless communications and broadcasting towers, manage other tall structure sites (such as rooftops and water towers), and to a lesser extent, own and operate neutral facilities to host small cells and DAS networks for mobile service providers.[143] In most cases, tower operators and property owners lease antenna, rooftop and other site space to multiple wireless service providers.[144]

45. As of December 2016, according to one estimate, the three largest publicly-traded neutral host providers (Crown Castle, American Tower, and SBA Communications) owned or operated approximately 95,000 towers (not including DAS and small cells).[145] At the end of December 2016, the top three tower operators had 1.8 to 2.2 tenants per tower site and had significant capacity available for additional antennas or tenants.[146] Chart II.F.1 shows that, as of April 2017, there were three or more tower operators in 91 percent of counties nationwide, and six or more tower operators in 53 percent of counties based on tower site data collected from 44 tower providers.[147] As shown in Chart II.F.2, tower

(Continued from previous page)
Tower Revenue (Oct. 25, 2016), http://www.rcrwireless.com/20161025/network-infrastructure/crown-castle-small-cell-revenue-could-rival-tower-revenue-tag4.

[140] Wireless Infrastructure Association, Distributed Antenna Systems (DAS) in Mid-Tier Markets, at 4, http://wia.org/wp-content/uploads/Distributed-Antenna-Systems-DAS-in-Mid-Tier-Markets.pdf; RCR Wireless, Sprint network expanding in New England thanks to GNW and ExteNet (July 6, 2016), http://www.rcrwireless.com/20160706/carriers/sprint-network-expanding-in-rural-new-england-thanks-to-gnw-and-extenet-tag4; RCR Wireless, Crown Castle spends more on small cells than on new towers (Dec. 15, 2015), http://www.rcrwireless.com/20151216/network-infrastructure/crown-castle-spends-more-on-small-cells-than-on-new-towers-tag4.

[141] Wireless Estimator, Top 100 Tower Companies in the U.S., http://wirelessestimator.com/top-100-us-tower-companies-list/ (last visited Sept. 1, 2017).

[142] Some major wireless service providers have sold their tower business to third-party tower operators. *See, e.g.*, American Tower, American Tower Corporation Closes Verizon Transaction (Mar. 30, 2015), http://www.americantower.com/corporateus/investor-relations/press-releases/news-item.htm?id=2030383.

[143] American Tower 2016 Annual Report (10-K), at 1 & 27; Crown Castle 2016 Annual Report (10-K), Part 1, at 1 & 4; SBA Communications 2016 Annual Report (10-K), Part 1, at 1; *see also* Crown Castle, Crown Castle Announces Agreement to Acquire Lightower (July 18, 2017), http://investor.crowncastle.com/phoenix.zhtml?c=107530&p=irol-newsArticle&ID=2287220.

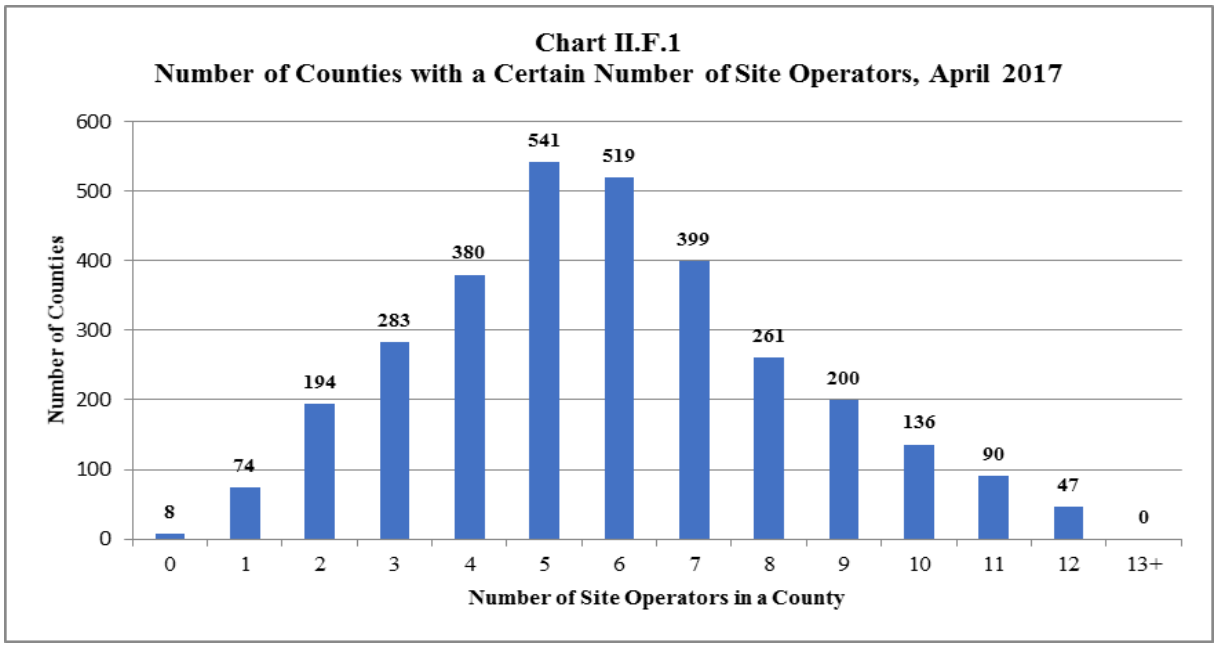
[144] *See, e.g.*, American Tower 2016 Annual Report, at 1, http://www.verizonwireless.com/b2c/realestate/ (last visited Sept. 1, 2017).

[145] Wireless Estimator, Top 100 Tower Companies in the U.S. (Crown Castle at 40,039, American Tower at 39,989, SBA at 14,873, and as of December 2016, not including rooftop sites, DAS and small cells), http://www.wirelessestimator.com/t_content.cfm?pagename=US-Cell-Tower-Companies-Complete-List (last visited Sept. 1, 2017).

[146] American Tower 2016 Annual Report, Part I, at 4 (1.9 tenants per tower), Crown Castle 2016 Annual Report, at 18 (2.2 tenants per tower), and SBA 2016 Annual Report, Item 1, at 4 (1.8 tenants per tower).

[147] Tower site information was downloaded from 44 tower providers' websites in April 2017. Wireless Estimator, Top 100 Tower Companies in the U.S., http://www.wirelessestimator.com/t_content.cfm?pagename=US-Cell-Tower-Companies-Complete-List (last visited Sept. 1, 2017). The 44 tower providers are American Tower Corporation, AT&T, Arcadia Towers, Badger Towers, Branch Communications/Branch Towers, Crown Castle, Communication Enhancement, Clearview Tower Company, Central States Tower Holdings, Day Wireless Systems, ForeSite, Grain Management, Hayes Towers, Heartland Towers, Hemphill Tower, Horizon Tower, Horvath Communications, Industrial Communications, K2 Towers, KGI Wireless, Message Center Management, MidAmerica Towers, Milestone Communications, Municipal Communications, Nsight Tower Holdings,
(continued….)

operators tend to build and operate more towers in more densely populated areas. For example, as of June 2017, the average number of tower sites per county was 45 for counties with a population density between 75 and 100 people per square mile, compared to 781 per county for counties with a population density between 2000 and 4000 people per square mile. Between April 2016 and April 2017, the average number of tower sites per county increased from 584[148] to 815 in the most densely-populated counties, with a population density of over 4000 people per square mile. This likely reflects both network densification efforts by mobile service providers and the inclusion of more tower operators in the sample.



Source: Data collected from 44 tower companies on standalone towers, rooftops, DAS, and small cells (April 2017).

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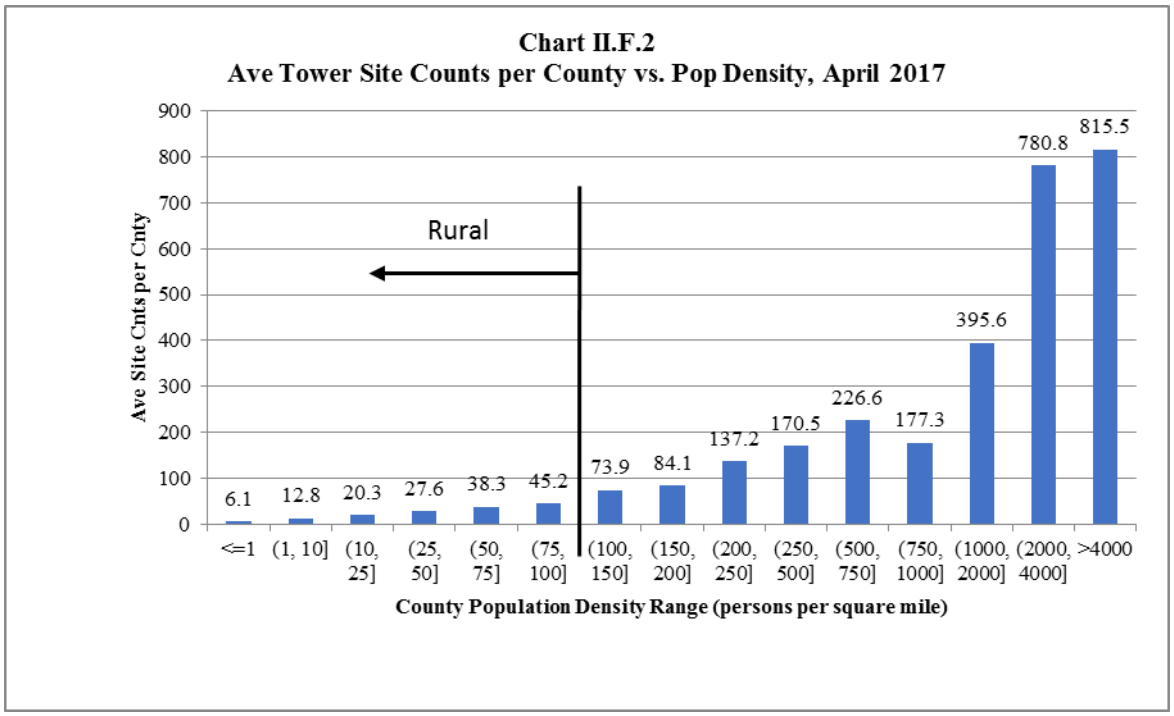
Performance Development Group, Phoenix Tower International, Prime Tower Development, RG Towers, SBA Communications Corporation, Skyway Towers, Sprint, Subcarrier Communications, T-Mobile, Tarpon Towers, Telecom Tower Group, TowerCo, TowerCom, Tower King, Tower Sites Inc., Tower Ventures, Unison Site Management, Vertical Bridge Holdings, and Wireless Access Group.

[148] *Nineteenth Report*, 31 FCC Rcd at 10587, Chart IV.B.2.



Source: Data based on 44 tower companies. Counties considered rural are those with 100 people or less per square mile. Population density is from the 2010 U.S. Census. Tower sites include standalone towers, rooftops, DAS, and small cells.

46. Several factors affect the cost and speed with which towers and DAS sites can be deployed or modified. Three of the most important are: (i) the capital cost of deploying or modifying a site; (ii) the cost and time involved in obtaining the necessary zoning approvals from local authorities; and (iii) the cost and time involved in complying with federal environmental and historic preservation laws, which includes engagement with state and Tribal historic preservation authorities.[149] In terms of capital expenditures, co-locating wireless equipment on existing structures is often the most efficient and least costly solution for mobile wireless service providers that need new cell sites, and co-location reduces the cost of entry or market expansion. Estimates of the average cost of building a new cell site tower range from $150,000 to $300,000,[150] while the average cost of co-location on an existing tower is about 30 percent of the total cost of a new tower.[151] The per-site cost (including both capital and operating costs)

[149] *Nineteenth Report*, 31 FCC Rcd at 10537, para. 74; *Sixteenth Report*, 28 FCC Rcd at 3908, para. 328.

[150] Statistic Brain Research Institute, Cell Phone Tower Statistics (Apr. 24, 2017), http://www.statisticbrain.com/cell-phone-tower-statistics/ (average cost of building a cell phone tower is $150K); *see also* PCIA Comments on the *Seventeenth Report*, at 8 (June 17, 2013) ("on average, a new wireless support structure costs approximately $250,000 to $300,000"); City of Wayzata, Minnesota, SEH, Telecommunications Site Options Analysis Report, Table 1, at 25 (Dec. 5, 2012), http://www.wayzata.org/DocumentCenter/View/402 (estimating the cost of building a new telecommunication tower is between $265K and $277K for three sites in City of Wayzata, Minnesota); RCR Wireless, AT&T Cell Site of the Future Hits a Speed Bump (July 17, 2014), http://www.rcrwireless.com/article/20140717/infrastructure-2/att-cell-site-future-hits-speed-bump/ (last visited Sept. 1, 2017) (stating the cost per site was coming in at $380,000 in the New York metro area).

[151] Statistic Brain Research Institute, Cell Phone Tower Statistics, http://www.statisticbrain.com/cell-phone-tower-statistics/ (last visited Sept. 1, 2017) (average cost of building a cell phone tower is $150K, while the average yearly cell phone tower lease rate is $45K, about 30% of the cost of building a new cell tower).

for small cells is estimated to be less than half of the per-site cost for macro sites.[152] According to CTIA, over the past seven years, mobile wireless providers collectively have invested more than $30 billion annually, on average, in next-generation networks and wireless infrastructure.[153]

III. ELEMENTS OF INTER-FIRM RIVALRY

47. Mobile wireless service providers compete for customers across many dimensions, including on price, service characteristics, service quality, advertising and marketing, investment, network coverage and technology, and speed of service. Such price and non-price rivalry can influence a customer's choice of a service provider and thus impose significant competitive constraints on the ability of individual service providers to raise price or reduce quality or quantity, especially in high technology industries that experience rapid innovation.[154] This Section presents data on various elements of price and non-price rivalry.

A. Pricing Levels and Trends

48. The following discussion of developments in mobile service pricing focuses on pricing changes during the period covered by this *Report*.[155] We note first that mobile service providers offer nationwide pricing plans throughout their service area, with little pricing disparity between rural and non-rural markets.[156] The majority of mobile wireless subscribers in the United States are billed monthly, after service has been provided (postpaid service), while others pay for services in advance of receiving them (prepaid service).

1. Postpaid Service

49. In 2016, we observed two significant trends in post-paid pricing plans as providers sought to distinguish themselves from their rivals: increased pricing pressure as indicated by the return of "unlimited" data plans, and the offering of content (particularly video) that does not count against a customer's data limit.[157] Also, service providers have offered various promotions designed to partially or fully compensate consumers' switching costs.[158]

a. Pricing Trends and "Unlimited" Data Plans

50. Service providers frequently revise their pricing plans to attract customers. For example, in February 2016, Sprint introduced the Sprint Better Choice Plan, which included unlimited voice and text and a choice of six tiers of data, including one plan with unlimited data.[159] In July 2016, Verizon launched the New Verizon Plan, which revised the previously existing five data tiers by adding 30 percent

[152] Senza Fili Consulting, The Economics of Small Cells and Wi-Fi Offload, at 2 (2012), http://www.senzafiliconsulting.com/Portals/0/docs/Reports/SenzaFili_SmallCellWiFiTCO.pdf.

[153] CTIA Comments at 29.

[154] *Nineteenth Report*, 31 FCC Rcd at 10599, para. 94; *Sixteenth Report*, 28 FCC Rcd at 3732, 3796-97, paras. 9, 136.

[155] This renders unnecessary a separate, standalone rate survey authorized in the 2011 Order that modernized the universal service program for awarding support to mobile service providers in high-cost areas. *Connect America Fund*, Report and Order and Further Notice of Proposed Rulemaking, 26 FCC Rcd 17663, 17694, 17708-09, paras. 85, 113, and 114 (2011).

[156] *Nineteenth Report*, 31 FCC Rcd at 10592, para. 81; *Sixteenth Report*, 28 FCC Rcd at 3797, para. 137.

[157] Zero-rating is the exempting of certain data uses or content from counting towards a subscriber's monthly limit. *Fifteenth Report*, 26 FCC Rcd at 10594, para. 85.

[158] *Nineteenth Report*, 31 FCC Rcd at 10595-96, para. 87.

[159] FierceWireless, Sprint Takes Aim at Verizon with Data-heavy 'Better Choice' Family Plans (Feb. 18, 2016), http://www.fiercewireless.com/wireless/sprint-takes-aim-at-verizon-data-heavy-better-choice-family-plans.

to 50 percent more data per tier for only a moderate increase in price.[160] In August 2016, AT&T launched the AT&T Mobile Share Advantage Plan, which started at $30 per month for 1 GB of data–up from $20 a month for 300 MB of data. AT&T further offered a plan with 3 GB of data at $40 per month, while 30 GB of data was $135 per month.[161] In late August 2016, T-Mobile introduced the One+ Plan, which added unlimited tethering, 3G international roaming, and unlimited GOGO in-flight Wi-Fi, to their One Plan for an additional $25 fee.[162] In August 2016, U.S. Cellular launched the Data Shared Connect Plan, which included unlimited talk and text and 2 GB of data for $30 per month, and up to 24 GB for $100 per month.[163] According to analysis by Recon Analytics and CTIA, presented in FierceWireless, the cost per MB has fallen from $1.37 in 2007 to less than half a cent in 2016.[164]

51. One significant trend that has developed recently is the return of "unlimited" data plans.[165] In January 2016, AT&T introduced the AT&T Unlimited Plan for DIRECTV (or U-Verse). While that plan was made available only to DIRECTV subscribers,[166] it signaled a shift towards service providers again offering unlimited data plans. In August 2016, T-Mobile launched the T-Mobile ONE Plan offering unlimited voice, text and high-speed 4G LTE smartphone data.[167] The next day, Sprint introduced its Unlimited Freedom plan, which offered two lines of unlimited talk, text and data for $100 a month.[168] In February 2017, Verizon launched its Unlimited Data Plan offering unlimited data on

[160] PC Mag, Verizon's New Plans Offer Higher Rates But More Data (July 6, 2016), http://www.pcmag.com/news/345869/verizons-new-plans-offer-more-data-higher-rates.

[161] FierceWireless, AT&T Follows Verizon's Lead, Introduces Pricier Plans, More Data and Removes Overage Charges (Aug. 17, 2016), http://www.fiercewireless.com/wireless/at-t-follows-verizon-s-lead-introduces-pricier-plans-and-more-data.

[162] PC Mag, T-Mobile Adds 'One Plus' Plan for 'Power Users' (Aug. 29, 2016), http://www.pcmag.com/news/347392/t-mobile-boosts-one-plan-video-streaming-speeds.

[163] U.S. Cellular, U.S. Cellular Adding Customer Value With New Shared Connect Pricing Plans (Aug. 25, 2016), https://www.uscellular.com/about/press-room/2016/USCELLULAR-ADDING-CUSTOMER-VALUE-WITH-NEW-SHARED-CONNECT-PRICING-PLANS.html.

[164] FierceWireless, Industry Voices—Entner: Consumer 'Surplus' in Wireless Rises $192B in 2 Years (Aug. 14, 2017), http://www.fiercewireless.com/wireless/industry-voices-entner-consumer-surplus-wireless-rises-192b-2-years.

[165] The terms of service of various providers' Unlimited Plans indicate that subscribers who exceed a certain amount (e.g., 22 GB) per month may have their speeds reduced to address network congestion. *See, e.g.*, Verizon Wireless, Verizon Plan, https://www.verizonwireless.com/plans/verizon-plan/ (last visited Sept. 1, 2017); AT&T, Unlimited Data Plans, https://www.att.com/plans/unlimited-data-plans.html (last visited Sept. 1, 2017); T-Mobile, Plans, https://www.t-mobile.com/cell-phone-plans?icid=WMM_TM_Q117TMO1PL_H85BRNKTDO37510 (last visited Sept. 1, 2017); Sprint, Unlimited Cellphone Plans, https://www.sprint.com/en/shop/plans/unlimited-cell-phone-plan.html?INTNAV=TopNav:Shop:UnlimitedPlans (last visited Sept. 1, 2017).

[166] FierceWireless, AT&T Resurrects Unlimited Data Offering at $100/Month, But Only for Its DIRECTV Subscribers, (Jan. 11, 2016), http://www.fiercewireless.com/wireless/at-t-resurrects-unlimited-data-offering-at-100-month-but-only-for-its-directv-subscribers. In addition, AT&T, for a limited time, offered DIRECTV or U-Verse customers, who did not subscribe to its wireless service, $500 if they switched to the AT&T Unlimited Plan with an eligible trade-in, and bought a smartphone on AT&T Next. For those AT&T customers that have the provider's wireless service but not DIRECTV, the provider offered a TV package beginning at $19.99 per month for 12 months, with a 24-month agreement.

[167] T-Mobile, Hello Un-carrier 12 ... R.I.P. Data Plans T-Mobile Goes All In on Unlimited (Aug. 18, 2016), https://newsroom.t-mobile.com/news-and-blogs/rip-data-plans.htm.

[168] BusinessWire, Sprint Launches Unlimited Freedom: Two Lines of Unlimited Talk, Text and Data for Just $100–All on a Great Network–and the Best Price Among All National Carriers (Aug. 18, 2016), http://www.businesswire.com/news/home/20160818005742/en/.

smartphones and tablets for $80 a month.[169] AT&T then introduced the Unlimited Choice plan, which offered unlimited data for $60 per month for a single line ($155 for four lines).[170] In late February 2017, U.S. Cellular introduced its own unlimited data offering.[171]

b. Video Content Not Counted Towards Data Limits

52. T-Mobile introduced its Binge On feature in November 2015, which exempted streaming video from participating content providers from subscribers' monthly data allowance. Other service providers introduced their own offerings throughout 2016.[172] For example, in January 2016, Verizon Wireless introduced FreeBee 360, which allowed content providers to provide some or all of their mobile content to consumers – whether in an app or mobile website–without having the content count against their data plans.[173] In September 2016, AT&T launched the "Data Free TV" feature, which allowed zero-rated streaming of AT&T's U-verse and DIRECTV content via a DIRECTV App.[174] In November 2016, AT&T launched DIRECTV NOW, an over-the-top video product seeded from its existing satellite TV service,[175] and made the content available to its own subscribers without counting against their data limits. In December 2016, T-Mobile offered DIRECTV NOW for 1 year to AT&T customers who switched to T-Mobile's ONE plan.[176] And in March 2017, Verizon Wireless allowed its wireless customers who subscribe to its internet and TV services to watch FiOS programming without incurring data charges by using Verizon Wireless's FiOS Mobile App.[177]

2. Prepaid Service

53. The four nationwide service providers also offer prepaid service under their own prepaid brands, in addition to selling mobile wireless service wholesale to MVNOs, which then resell service on the nationwide networks under a variety of prepaid brands. According to certain analysts, "T-Mobile and AT&T maintained their co-leadership in prepaid, reflecting the expansion and strength of their MetroPCS and Cricket brands, largely at the expense of Sprint."[178] Verizon Wireless has the smallest share of

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[169] Verizon, Get Unlimited Data On the Network You Deserve: Verizon (Feb. 12, 2017), http://www.verizon.com/about/news/get-unlimited-data-network-you-deserve-verizon.

[170] FierceWireless, AT&T Knocks $10 Off Unlimited Service, Adds $60 Unlimited Option with 3 Mbps Speeds (Feb. 27, 2017), http://www.fiercewireless.com/wireless/at-t-knocks-10-off-unlimited-service-adds-60-unlimited-option-3-mbps-speeds.

[171] U.S. Cellular, U.S. Cellular Introduces Unlimited Data Offering Among Its New Total Plans With No Hidden Fees (Feb. 24, 2017), https://www.uscellular.com/about/press-room/2017/USCELLULAR-INTRODUCES-UNLIMITED-DATA-OFFERING-AMONG-ITS-NEW-TOTAL-PLANS-WITH-NO-HIDDEN-FEES.html.

[172] T-Mobile, T-Mobile Makes Netflix, Hulu and Other Streaming Video Data Free with Binge On (Nov. 10, 2015), http://www.fiercewireless.com/wireless/t-mobile-makes-netflix-hulu-and-other-streaming-video-data-free-binge. T-Mobile Unleashes Mobile Video with Binge On (Nov. 10, 2015), https://newsroom.t-mobile.com/media-kits/un-carrier-x.htm.

[173] Verizon, Introducing FreeBee Data: The New Sponsored Data Service from Verizon (Jan. 19, 2016), http://www.verizon.com/about/news/introducing-freebee-data-new-sponsored-data-service-verizon.

[174] AT&T, Watch It Anywhere with AT&T DIRECTV (Sept. 7, 2016), http://about.att.com/story/watch_it_anywhere_with_att_directv.html.

[175] AT&T, The Revolution is Here: AT&T Offers 3 Ways to Stream Premium Video Content (Nov. 28, 2016), http://about.att.com/story/att_offers_three_ways_to_stream_premium_video_content.html.

[176] FierceWireless, T-Mobile Offers Year of DirecTV Now to Users Who Switch from AT&T (Dec. 15, 2016), http://www.fiercewireless.com/wireless/t-mobile-offers-year-directv-now-to-users-who-switch-from-at-t.

[177] FierceWireless, Verizon Extends Zero-rated Mobile Video to Fios Users (Mar. 9, 2017), http://www.fiercewireless.com/wireless/verizon-extends-zero-rated-mobile-video-to-fios-users.

[178] Paul de Sa, Bernstein Research, U.S. Telecom: Eight Takeaways from 1Q16 Retail Mobile (May 13, 2016).

prepaid subscribers among the nationwide service providers, with only one prepaid brand, Verizon Wireless Prepaid. To varying degrees, the other three nationwide service providers pursue a multi-brand prepaid strategy.[179] TracFone, the largest MVNO reseller, also has multiple prepaid brands, including Straight Talk, telcel AMERICA, and SafeLink, which target different market and demographic segments such as premium, Hispanic, or low-income subscribers.[180]

54. As postpaid offerings have shifted away from term contracts and equipment subsidies, service providers have adopted pricing plans and promotions for their high-end prepaid monthly service offerings that are similar to those they have for postpaid offerings. For example, in April 2017, Verizon Wireless introduced an $80-a-month plan for prepaid users that included unlimited talk, text and data, as well as unlimited text to more than 200 international markets and unlimited talk to Mexico and Canada.[181] The move followed the launch of unlimited-data prepaid plans by Verizon Wireless's three main competitors. T-Mobile's MetroPCS updated its $50/month 8 GB plan to include unlimited data. However, hotspot and tethering are not allowed on the $50 plan and videos are degraded to 480p quality.[182] In March 2017, AT&T's Cricket reduced the price of its unlimited plan from $70 to $60 a month,[183] while Sprint's Boost Mobile in February 2017 began offering four lines of unlimited data for $100 a month for users who switch service providers.[184]

55. Generally, prepaid subscribers who reach the limit of their high-speed data allowance in a given month may continue to use their handsets for data service on an unlimited basis, but at reduced speeds. For example, Cricket Wireless reduces data download speeds to a maximum of 128 Kbps after the customer's high speed data allowance is used.[185] In comparison, postpaid subscribers who use up their plan's data allowance in a given month generally experience data deprioritization only during network congestion.[186] In addition, AT&T offers zero overages, as well as "Rollover Data," which allows its postpaid subscribers to roll over their unused data at no additional cost.[187]

56. The prepaid and postpaid versions of a given pricing plan or promotion still differ somewhat,[188] largely because prepaid subscribers may lack the credit background or income necessary to

[179] Sprint prepaid brands include Boost Mobile and Virgin Mobile.

[180] TracFone Wireless Inc., Brands, http://www.tracfonewirelessinc.com/en/brands/ (last visited Sept. 1, 2017).

[181] Verizon, Verizon Introduces Unlimited to Prepaid (Apr. 25, 2017), http://www.verizon.com/about/news/verizon-introduces-unlimited-prepaid.

[182] MetroPCS, $50 Period, https://www.metropcs.com/shop/plans?icid=home%7Chero%7Cplans (last visited Sept. 1, 2017).

[183] Cricket Wireless, Cricket Wireless' Unlimited Plan Now Just $60 Plus Switch to Cricket and Choose from 4 FREE Smartphones (Mar. 1, 2017), http://cricketwireless.mediaroom.com/news-releases?item=122578.

[184] Boost Mobile, 4 Lines for $100/mo., https://www.boostmobile.com/?#!/4for100/ (last visited Sept. 1, 2017).

[185] Cricket Wireless, Mobile Broadband Information, https://www.cricketwireless.com/legal-info/mobile-broadband-information.html (last visited Sept. 1, 2017).

[186] *See, e.g.*, Sprint, Sprint Unlimited Data, Talk and Text Cell Phone Plans, https://www.sprint.com/landings/unlimited-cell-phone-plans/?id16=unlimited%20Freedom%20%7CAll&question_box=unlimited%20Freedom%20%7CAll (last visited Sept. 1, 2017); Verizon Wireless, The New Verizon Plan Unlimited FAQs, https://www.verizonwireless.com/support/new-verizon-plan-unlimited-faqs/ (last visited Sept. 1, 2017).

[187] AT&T, Mobile Share Advantage, https://www.att.com/shop/wireless/data-plans.html (last visited Sept. 1, 2017); AT&T, Rollover Data, https://www.att.com/shop/wireless/rollover-data.html (last visited Sept. 1, 2017).

[188] *Nineteenth Report*, 31 FCC Rcd at 10596, para. 90.

qualify for postpaid service. To prevent credit losses,[189] and mitigate the credit risk associated with the prepaid segment, service providers require advance payment for both prepaid service and handsets.[190]

3. Price Indicators for Mobile Wireless Services

57. As discussed earlier, and in previous *Reports*, it is difficult to compare prices of mobile wireless service plans because providers offer a variety of plans, frequently under multipart pricing schemes, which also vary in non-price terms and features, such as early termination fees and the consequences of reaching usage limits.[191] The many pricing plans offered by mobile wireless service providers vary in several dimensions, and these plans frequently change.[192] Chart III.A.1 below presents monthly postpaid prices for the four nationwide service providers, including discounts for auto-pay, which are now a feature of all major plans.[193] Chart III.A.2 below shows the current monthly prices for major prepaid service providers. As discussed above, plans with "unlimited" LTE data, whether postpaid or prepaid, are now the primary offering of the four nationwide providers (though postpaid users frequently are given priority over prepaid users on a given network during times of peak congestion). Further, the heaviest postpaid users may also experience deprioritized speeds during periods of peak network congestion after they have exceeded certain monthly data thresholds.[194]

[189] Both Sprint and T-Mobile have changed or modified their policies regarding credit checks to subscribers most at risk of defaulting on new purchases of higher end devices. FierceWireless, Sprint Using Progressive Finance to Provide Loans to Customers for Devices Without a Credit Check (Mar. 23, 2016), http://www.fiercewireless.com/story/sprint-using-progressive-finance-provide-loans-customers-devices-without-cr/2016-03-23.

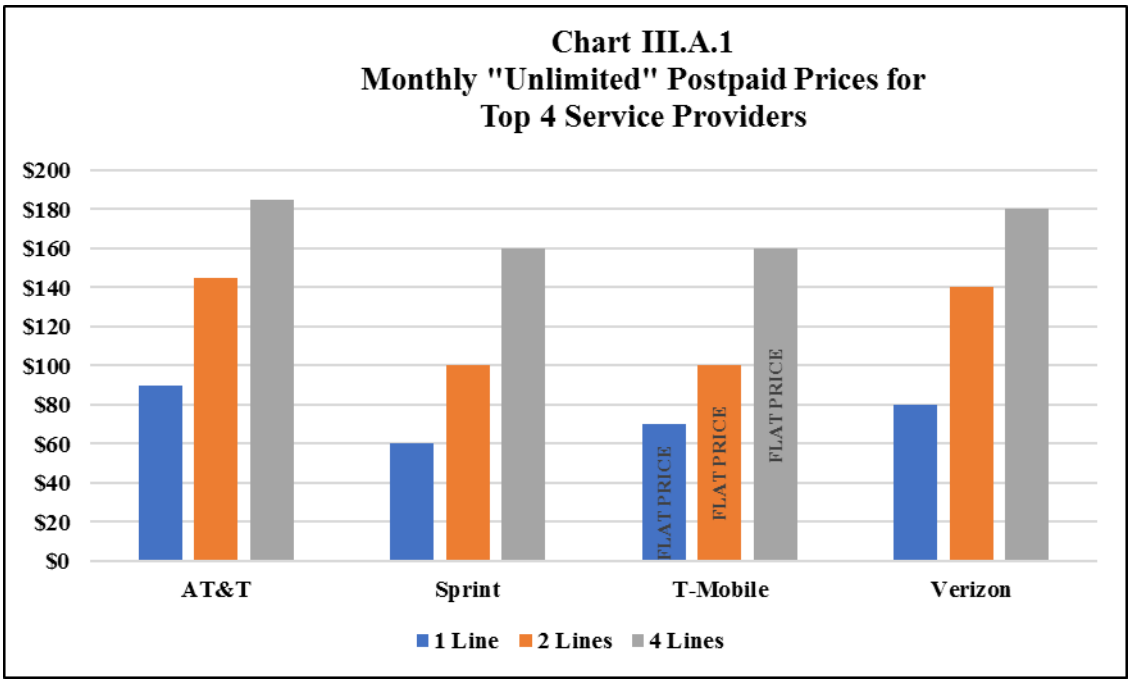
[190] AT&T, AT&T GoPhone, Unlimited Talk, Text, and Data Usage, https://www.att.com/shop/wireless/gophone-plans.html (last visited Sept. 1, 2017); Sprint, More Data, More Data, More Data (July 28, 2015), http://newsroom.sprint.com/news-releases/more-data-more-data-more-dataeveryone-wants-more-high-speed-data-so-boost-mobile-and-virgin-mobile-usa-offer-more-high-speed-data-with-5-and-10-data-pack-add-ons.htm.

[191] As discussed in previous *Reports*, it is therefore difficult to identify sources of information that track mobile wireless service prices in a comprehensive and consistent manner. In addition, data on subscribership is not available at the plan level and any average price comparison implicitly assumes uniform subscribership of all plans. *See, e.g.*, *Nineteenth Report*, 31 FCC Rcd at 10554-55, para. 26; *Sixteenth Report*, 28 FCC Rcd at 3797, para. 137.

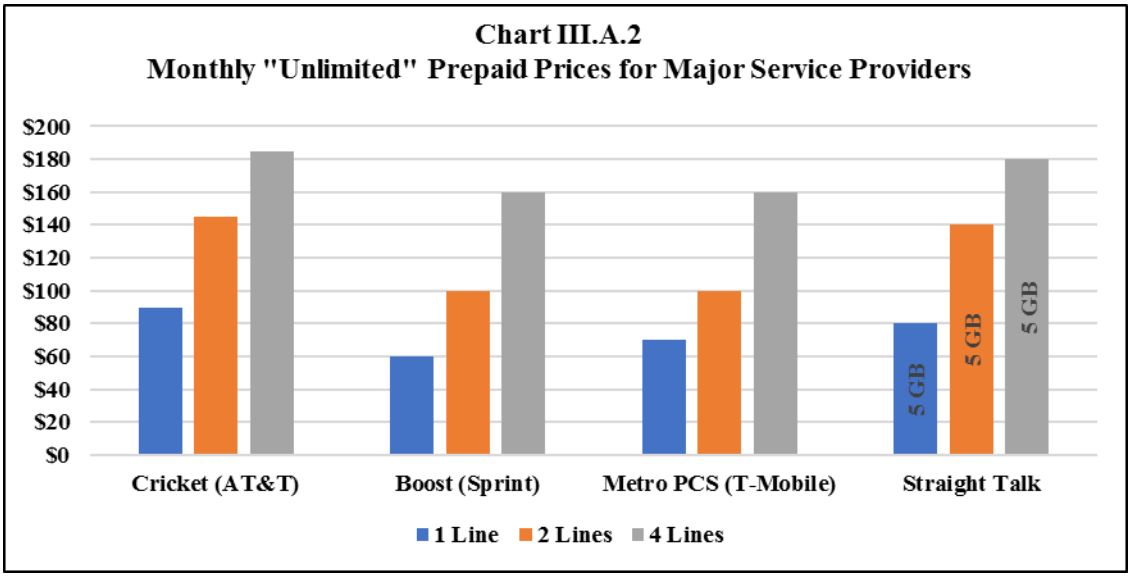
[192] Appendix III: Elements of Inter-Firm Rivalry provides additional information, based on data from RBC Capital Markets, on pricing over the time period covered by this *Report* for the four nationwide service providers.

[193] In addition, T-Mobile incorporates taxes and fees into its advertised prices. As these fees vary by locality, there is no way to fully account for the differences in pricing in Chart III.A.1.

[194] As noted above, the average consumer uses about 4 GB of data per month, and after a certain level of data consumption (around 20 GB or so), data may be deprioritized.



Note: The prices for unlimited data plans were taken from service providers' websites on May 2, 2017. Prices include any per line charges indicated by the service provider. Prices do not include any additional charges such as for equipment installment plans, insurance, international use, or mobile hotspots. If a service provider includes any such feature as part of its unlimited data plan without extra charge, the above price would include this feature. Further, the above prices do not include any one-time charges paid, such as activation fees and termination fees. Prices and the specifics of the plans are subject to change.



Note: The prices were taken from service providers' websites on May 17, 2017. Prices include any per line changes indicated by the service provider. Except where noted, prices are for unlimited data quantities. Prices and the specifics of the plans are subject to change.

58. *CPI.* The Consumer Price Index (CPI) is a measure of the average change over time in the prices paid by consumers for a fixed market basket of consumer goods and services.[195] As documented in previous *Reports*, two different pricing indicators–the Wireless Telephone Services CPI and the per-minute price of voice service–show that mobile wireless prices have declined significantly since the launch of Personal Communications Service (PCS) service in the mid-1990s.[196] The wireless telephone services' component of the CPI (Wireless Telephone Services CPI) is published by the U.S. Department of Labor's Bureau of Labor Statistics (BLS) on a national basis.[197] According to CPI data, the price (in constant dollars) of mobile wireless services has continued to decline. From year-end 2015 to year-end 2016, the annual Wireless Telephone Services CPI decreased by 1.0 percent while the overall CPI increased by 1.3 percent, and the Telephone Services CPI fell by 0.5 percent.[198] Further, from year-end 2012 through year-end 2016, the annual Wireless Telephone Services CPI decreased by approximately 8 percent and the Telephone Services CPI decreased by approximately 3 percent, while the overall CPI increased by 4.5 percent.

59. *Average Revenue Per Unit.* ARPU can be used as a reasonable proxy for understanding pricing changes, particularly where there are multiple pricing plans and/or pricing structures are complicated as is the case for mobile wireless services.[199] As shown in Chart III.A.3 below, according to CTIA, the industry ARPU fell sharply during 2016 from $44.65 to $41.50, a decline of approximately 7 percent.[200] Recent changes by service providers, such as the removal of overage charges, the move toward unlimited data plans, and EIPs have all contributed to the reported decline in ARPU.[201] Chart III.A.3 also shows subscribers/connections and ARPU for the past 20 years.

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[195] The basket of goods includes over 200 categories, such as food and beverages, housing, apparel, transportation, medical care, recreation, education, and communications. The CPI allows consumers to compare the price of the basket of goods and services this month with the price of the same basket a month or a year ago.

[196] *See, e.g.*, *Nineteenth Report*, 31 FCC Rcd at 10557-58, para. 29; *Sixteenth Report*, 28 FCC Rcd at 3875, 3877, para. 265, Table 38.

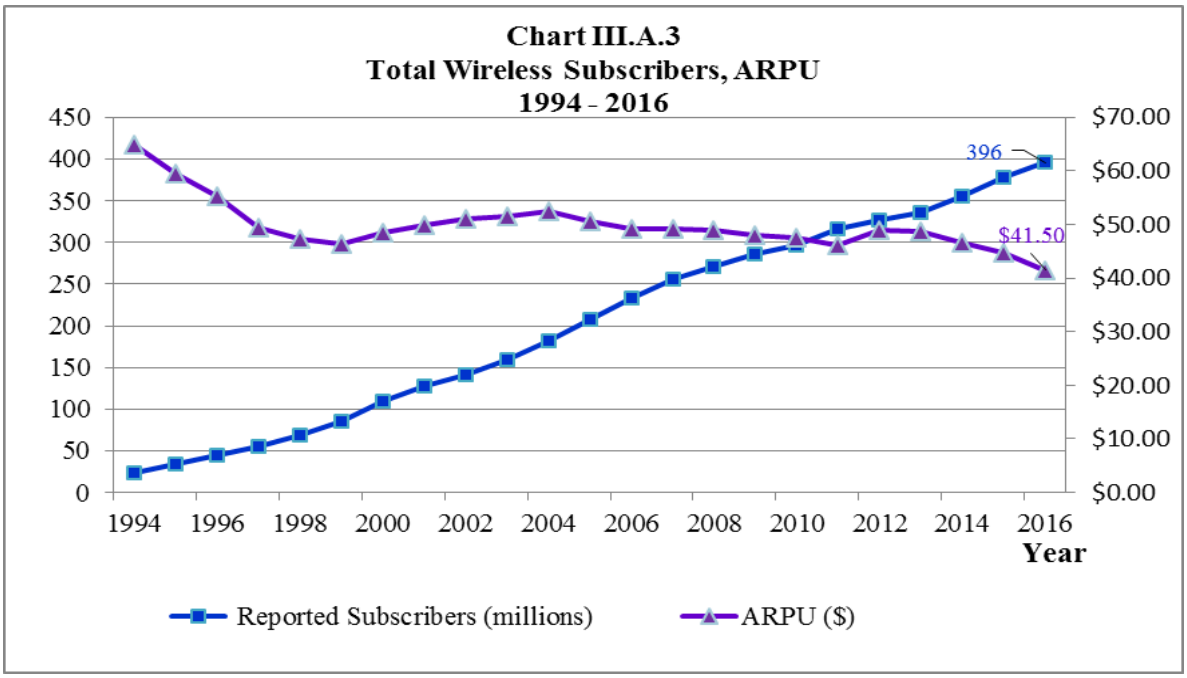
[197] Starting in December 1997, the basket included a category for cellular/wireless telephone services. All CPI figures discussed above were taken from BLS databases: Bureau of Labor Statistics, http://www.bls.gov (last visited Sept. 1, 2017. The index used in this analysis, the CPI for All Urban Consumers (CPI-U), represents about 87% of the total U.S. population. Bureau of Labor Statistics, Consumer Price Index: Frequently Asked Questions, http://www.bls.gov/cpi/cpifaq.htm (last visited Sept. 1, 2017). The CPI category "Telephone Services" has two components: wireless telephone services and landline telephone services. Wireless telephone services include "all service charges, applicable per-plan charges or per-minute call charges, and other charges normally included in a cellular plan are eligible for pricing. Internet access is also eligible." Landline telephone services include "charges for all types of local and long-distance residential services are eligible for collection, including charges for dial tone services, line maintenance and access, 911 services, directory assistance, touch-tone service, and other special features and mandatory charges and installation." Additional information can be found at Bureau of Labor Statistics, Consumer Price Index: How the Consumer Price Index Measures Price Change for Telephone Services, https://www.bls.gov/cpi/factsheet-telephone-services.htm (last visited Sept. 1, 2017).

[198] Appendix III: Elements of Inter-Firm Rivalry, Table III.A.i provides more details.

[199] *Seventeenth Report*, 29 FCC Rcd 15311, 15328, para. 35 & n.52; Patrick McCloughan, Sean Lyons, *Accounting for ARPU: New evidence from international panel data*, Telecommunications Policy 30, 521-32 (2006); Eun-A Park, Krishna Jayakar, *Competition between Standards and the Prices of Mobile Telecommunication Services: Analysis of Panel Data*, TPRC 2015 (Aug. 15, 2015).

[200] CTIA reported an industry average measure of "Average Revenue per Reported (subscriber) Unit," or ARPU, which is based "upon total revenues divided by the average total reported active units per survey period, divided by the number of months in the survey period," i.e., an annualized monthly ARPU.

[201] In 2012, CTIA started reporting an alternative ARPU measure which is calculated on revenue generating devices and replaced the original Average Local Monthly Bill (ALMB). The methodology change contributed to different calculations. CTIA Wireless Industry Indices Year-End 2016, at 85.



Source: Based on CTIA Wireless Industry Indices Year-End 2016. Appendix III: Elements of Inter-Firm Rivalry, Table III.A.ii provides more detail.

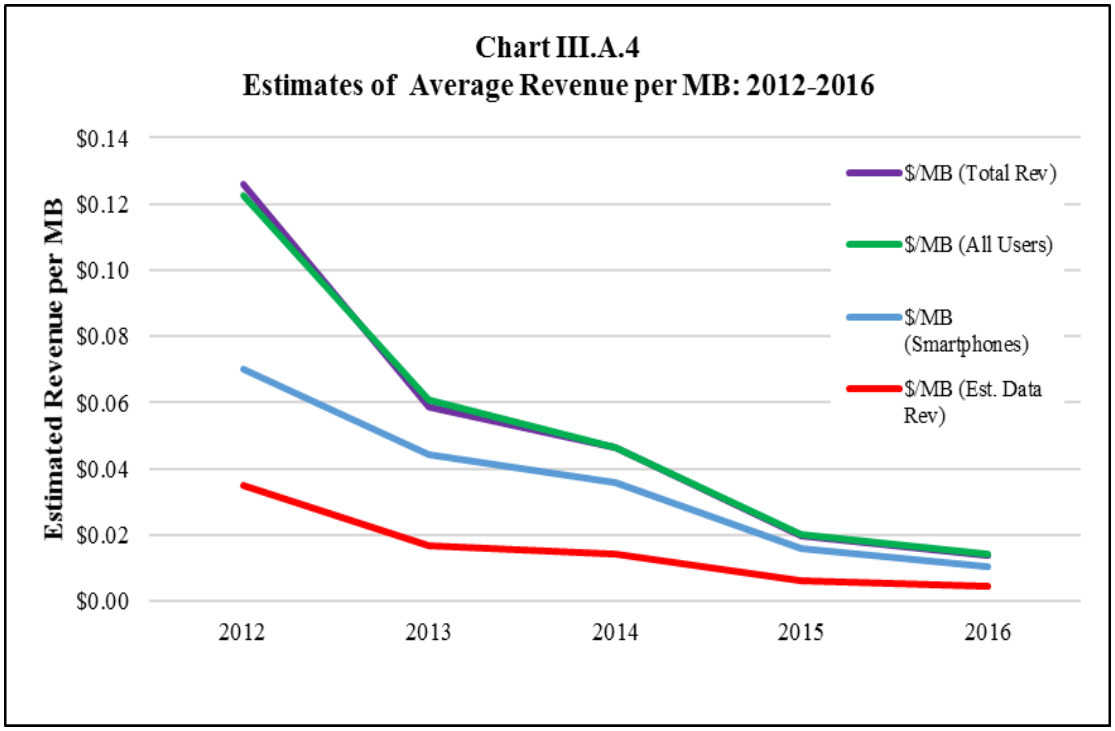
60. *Average Revenue Per Unit by Service Provider.* Based on UBS estimates, as seen in Table III.A.1, from the fourth quarter of 2013 to the fourth quarter of 2016, ARPU declined for all service providers: AT&T's ARPU declined by approximately 23 percent; Sprint's ARPU declined by approximately 29 percent; T-Mobile's ARPU declined by approximately 8 percent; and Verizon Wireless's ARPU declined by approximately 21 percent. Industry ARPU declined by approximately 21 percent over this time period. The move by the Top 4 service providers towards unlimited data plans could drive some ARPU increases for single line users; however, in general, family plans (with two or more lines) are likely to show decreases in ARPU per user, primarily because the relatively small incremental charge for an additional line is averaged across family members.

Table III.A.1
ARPU Estimates of Publicly Traded Facilities-Based Mobile Wireless Service Providers
4th Quarter 2013–4th Quarter 2016

Nationwide Providers	4Q13	4Q14	4Q15	4Q16
AT&T	$47.58	$42.04	$38.78	$36.58
Sprint	$44.83	$40.44	$35.54	$32.03
T-Mobile	$36.91	$35.56	$34.53	$33.80
Verizon Wireless	$47.50	$45.52	$40.99	$37.52
U.S. Cellular	$50.21	$53.58	$49.32	$49.03
Industry ARPU	**$45.63**	**$42.27**	**$38.54**	**$35.93**

Source: UBS US Wireless 411, February 22, 2017, Figure 36.

61. *Estimated Average Revenue per MB.* Given the variation in data plans, including shared plans, the lack of information on how much data users consume across these different plans, and the fact that revenues specific to data consumption are no longer reported by service providers, we lack the necessary information to measure precisely a "true" price per MB. However, by making certain assumptions, we can calculate various industry-wide estimates of the average revenues per MB. Chart III.A.4 below shows four different estimates of the average revenue per MB, based on data from CTIA and the U.S. Census,[202] and all four estimates indicate that average revenue per MB has been declining. Specifically, as of 2016, these estimates show a decrease of approximately 28 to approximately 33 percent compared to 2015, and a decrease of approximately 85 percent to approximately 89 percent compared to 2012.



Source: Based on data from the CTIA Wireless Industry Indices Year-End 2016 and the U.S. Census.

[202] To derive $/MB (Total Rev), we divide the Total Service Revenues by the Total Wireless Data Traffic, assuming that 100% of service revenues are attributable to data. CTIA Wireless Industry Indices Year-End 2016, at 8, 45. To derive $/MB (All Users) and $/MB (Smartphones) we divide ARPU by the monthly average GB data usage, and we calculate this metric both with all users and with smartphone users only. Again, this assumes that 100% of revenues are attributable to data and that average revenue is the same for both smartphone users and non-smartphone users. CTIA Wireless Industry Year-End 2016, at 53, 97. Finally, for $/MB (Est. Data Rev), we estimate the percentage of total revenues that are attributable to data by dividing Internet Access Service Revenues by Total Revenues for NAICS 5172, U.S. Census Bureau, 2015 Annual Service Survey, Table 4: Estimated Sources of Revenue for Employer Firms: 2010 through 2015, https://www.census.gov/services/index.html (last visited Sept. 1, 2017). The 2016 data percentage was estimated based on the average growth rate across 2012 to 2015. We then applied these percentages to the CTIA data (Total Service Revenues/Total Wireless Data Traffic). CTIA Wireless Industry Indices Year-End 2016, at 8, 45. This does not take into account the fraction of revenues that are made up of messaging.

B. Differentiation in Mobile Wireless Devices/Services and Advertising/Marketing

1. Differentiation in Mobile Wireless Devices and Services

62. In addition to competing on price and network quality, service providers compete by offering consumers innovative mobile wireless devices and differentiated services at a variety of prices.[203] Wireless providers increasingly are also offering mobile video and content, virtual reality, wearable devices such as smartwatches,[204] smart home devices, and other connected IoT devices.[205] There has been significant growth in the variety of networked devices over the past year, [206] and there also have been improvements and innovations in device functionality across platforms and technologies. For example, smartphone operating systems such as the Android and Apple iOS are more integrated with other mobile and wireless-enabled devices, including tablets, wearable devices, PCs, and over-the-top (OTT) streaming devices,[207] while handsets may now include features such as touch screens, mobile web browsing capabilities, current-generation operating systems, faster processors, improved cameras, and better battery performance.[208]

63. Smartphone device penetration in the U.S. increased between 2015 and 2016 from 70 percent to 77 percent.[209] According to comScore, smartphone penetration rates have almost doubled over the past five years, from approximately 42 percent in 2011 to approximately 81 percent in 2016.[210] During 2016, the number of active smartphones in the U.S. increased from 228.3 million to 261.9 million.[211] UBS estimates that internet device net adds (including tablets) increased between 2015 and 2016, although growth has slowed in this category. In 2015, there were 8.2 million net adds of internet devices, which increased by four percent in 2016 to 8.6 million.[212] CTIA estimates that, in total, the 309.8 million smartphones and other data-heavy devices amount to roughly 78 percent of all connections.[213] CTIA also estimates that 105.7 million devices were data-only at year-end 2016, up from 85.7 million at

[203] CTIA Comments at vi.

[204] CNET, Wearables Market Expected to Hit 213 Million Units Shipped in 2020 (June 15, 2016), http://www.cnet.com/news/wearables-market-expected-to-hit-213-million-units-shipped-in-2020/.

[205] The large array of IoT products includes both consumer and business devices and applications, such as wearables, connected cars, smart home devices, manufacturing systems, and remote monitoring of products like Verizon Wireless's Hum device, which plugs into a vehicle and offers monitoring, roadside and emergency assistance, and stolen vehicle tracking. Verizon Wireless Comments at 16. It is predicted that the widespread availability of 5G services will fuel the growth of the IoT. *See, e.g.*, Mobile Future Comments at 7.

[206] CTIA Comments at 7. The devices offered include a range of traditional handsets, smartphones, phablets, tablets made by different manufacturers with different operating systems, e-readers, wireless data cards, mobile Wi-Fi hotspots, and netbook computers with embedded modems.

[207] For example, Verizon Wireless claims that to meet the demand for data usage, Wi-Fi is now integrated into nearly all of their devices. Verizon Wireless Comments at 8.

[208] CTIA Comments at vi. In April 2017, Apple introduced the iPhone7 in September 2016, with improvements to the display, processor, stereo speakers, and camera. Samsung introduced the Galaxy S8, with improved camera and processor, and iris scanning security functions. In addition, HTC offered the U Ultra phablet that includes a personal assistant program (the HTC Sense Companion). CTIA Comments at 18-19.

[209] Deloitte, 2016 Global Mobile Consumer Survey: U.S. Edition at 6.

[210] comScore, U.S. Smartphone Penetration Surpassed 80 Percent in 2016 (Feb. 3, 2017), https://www.comscore.com/Insights/Blog/US-Smartphone-Penetration-Surpassed-80-Percent-in-2016.

[211] CTIA Comments at 8.

[212] UBS US Wireless 411: Version 56, at 11 (May 14, 2015); Version 57, at 20 (Aug. 17, 2015); Version 59, at 22 (Mar. 2, 2016); UBS US Wireless 411, at 13, Feb. 2017.

[213] CTIA Comments at 8.

year-end 2015.[214] Although the use of data-only devices with mobile network connectivity has grown, "phablets," a class of mobile device combining the form and technical capabilities of smartphones and tablets, are replacing the use of tablets in some cases.[215] In addition, M2M modules represented approximately 23 percent of device connections in 2016.[216]

64. Examples of mobile providers trying to differentiate their offerings include AT&T's installment plan device charges of $5 per month for an LG K10 device, and $32 per month for an iPhone 7 Plus with 256 GB of storage capacity,[217] and U.S. Cellular's offering of a low-cost LG smartphone for $19.99.[218] In addition, MVNOs may use specialized customer care and content to differentiate their service plan offerings.[219] Another strategy is one of exclusive arrangements with device manufacturers. During the past several years, AT&T has been the exclusive provider of devices ranging from the Lumia 1020 from Nokia to the Amazon Fire phone.[220] Verizon Wireless also has exclusive distribution arrangements for certain Motorola models, and is the exclusive provider of Google's Pixel phone (besides Google itself through its Project Fi mobile wireless plan).[221] Smaller service providers have asserted that exclusive agreements between handset manufacturers and the larger service providers put them at a competitive disadvantage because they are sometimes unable to obtain the newest handsets.[222] The percentage of NTCA survey respondents indicating that handset availability remained a major barrier to their ability to provide wireless service to their customers declined from 42 percent in 2015 to 33 percent in 2016.[223]

65. With respect to OTT video streaming and content, some service providers have offered video-streaming plans that do not count against their monthly data allowance.[224] For example, AT&T offered DIRECTV NOW which allowed data free streaming of video using the DIRECTV application.[225]

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[214] *Id.*

[215] The phablet has been defined as a handset with a screen size of 5.5 to 6.9 inches that can be held while making phone calls, but not necessarily for an extended period of time. CNET, Phablets to Flood Smartphone Market in Coming Years (Jan. 28, 2015), http://www.cnet.com/news/phablets-to-flood-smartphone-market-in-coming-years-report/.

[216] Verizon Wireless Comments at 16 (citing Cisco, VNI Mobile Forecast Highlights 2016-2021).

[217] AT&T, Smartphones, https://www.att.com/shop/wireless/devices/smartphones.html (last visited Sept. 1, 2017).

[218] CTIA Comments at 19.

[219] Verizon Wireless Comments at 22.

[220] FierceWireless, With Shrinking Handset Lineup, AT&T Shifting Focus from Gadgets to Services (Mar. 23, 2017), http://www.fiercewireless.com/wireless/shrinking-handset-lineup-at-t-shifting-focus-from-gadgets-to-services.

[221] FierceWireless, With Shrinking Handset Lineup, AT&T Shifting Focus from Gadgets to Services (Mar. 23, 2017), http://www.fiercewireless.com/wireless/shrinking-handset-lineup-at-t-shifting-focus-from-gadgets-to-services.

[222] *Nineteenth Report*, 31 FCC Rcd at 10615, para. 113.

[223] NTCA 2015 Wireless Survey Report (Jan. 2016); NTCA 2016 Wireless Survey Report (Jan. 2017).

[224] *See supra* Section III.A.1: Pricing Levels and Trends.

[225] FierceWireless, AT&T's Stephenson: DirecTV Now to Offer 100-Plus Channels of Zero-rated Video for Wireless Subs (Sept. 21, 2016), http://www.fiercewireless.com/wireless/at-t-s-stephenson-directv-now-to-offer-100-plus-channels-zero-rated-video-for-wireless. AT&T also offers customers an option called "Stream Saver." This option allows customers to watch more video while using less data by streaming video content at Standard Definition quality, similar to DVD (about 480p). The customer has the option of turning this feature on or off. AT&T, Stream Saver, https://www.att.com/offers/streamsaver.html (last visited Sept. 1, 2017).

AT&T also has offered content such as HBO as part of certain service packages.[226] Verizon Wireless launched an unlimited plan for $80 a month which includes HD video.[227] T-Mobile has also offered HD video with its $70/month unlimited plan.[228]

2. Advertising and Marketing

66. Mobile wireless service providers also compete for customers through advertising and marketing, including by establishing retail distribution networks. Service providers may advertise through television, print, radio, internet and mobile applications, social media, outdoor signage, point-of-sale media promotions, sponsorships and co-branding, and at events.[229] During the period covered by this *Report*, service providers' marketing campaigns continued to focus on the quality, coverage, and reliability of their mobile broadband networks.[230] They also continued to promote the advantages of their particular service plans, including the prices of their plans relative to those of their rivals.[231] For example, Sprint targeted Verizon Wireless customers by claiming that, although there is only a one percent difference in network quality between Verizon Wireless and Sprint (with Verizon Wireless rating one percent higher than Sprint), Sprint's prices are approximately 50 percent lower than Verizon Wireless' prices.[232] AT&T's advertising has focused on its unlimited data offerings and packages with DirecTV that allow video-streaming that does not count against data usage. Verizon Wireless has aired commercials highlighting its unlimited data plan and claiming that its network is unrivaled in quality.[233] T-Mobile also has advertised its unlimited data offerings,[234] and continues to market itself as "the Uncarrier." For example, at the 2017 Consumer Electronics Show, T-Mobile announced its "Uncarrier Next" campaign, including unlimited data plans and plans inclusive of taxes and fees.[235]

67. In 2016, Verizon Wireless spent more than $2.7 billion on advertising;[236] AT&T spent $3.8 billion,[237] T-Mobile spent $1.7 billion,[238] and Sprint spent $1.1 billion.[239] In March of 2017 alone,

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[226] Fortune, How to Get Free HBO With AT&T's Unlimited Mobile Plan (Apr. 5, 2017), http://fortune.com/2017/04/05/hbo-free-att-mobile/.

[227] FierceWireless, T-Mobile Fires Back at Verizon, Adds HD Video to Unlimited (Feb. 13, 2017), http://www.fiercewireless.com/wireless/t-mobile-fires-back-at-verizon-adds-hd-video-to-unlimited.

[228] FierceWireless, T-Mobile Fires Back at Verizon, Adds HD Video to Unlimited (Feb. 13, 2017), http://www.fiercewireless.com/wireless/t-mobile-fires-back-at-verizon-adds-hd-video-to-unlimited.

[229] *See, e.g.*, 2016 SEC Form 10-K for Verizon Wireless.

[230] FierceWireless, The Top 5 Wireless Ads: AT&T Continues to Own a Majority of the Mobile Industry's Spend in April (May 10, 2016), http://www.fiercewireless.com/special-reports/top-5-wireless-ads-att-continues-own-majority-mobile-industrys-spend-april.

[231] FierceWireless, The Top 5 Wireless Ads: AT&T Continues to Own a Majority of the Mobile Industry's Spend in April (May 10, 2016), http://www.fiercewireless.com/special-reports/top-5-wireless-ads-att-continues-own-majority-mobile-industrys-spend-april.

[232] ispot.tv, Sprint TV Commercial, 'The Sprint Way: 50 Percent Off Verizon Rates,' https://www.ispot.tv/ad/A4so/sprint-the-sprint-way-50-percent-off-verizon-rates (last visited Sept. 1, 2017).

[233] YouTube Video, Verizon Commercial 2017 Thomas Middleditch Drop the Mic (Feb. 15, 2017), https://www.youtube.com/watch?v=t3zptG2nVmM.

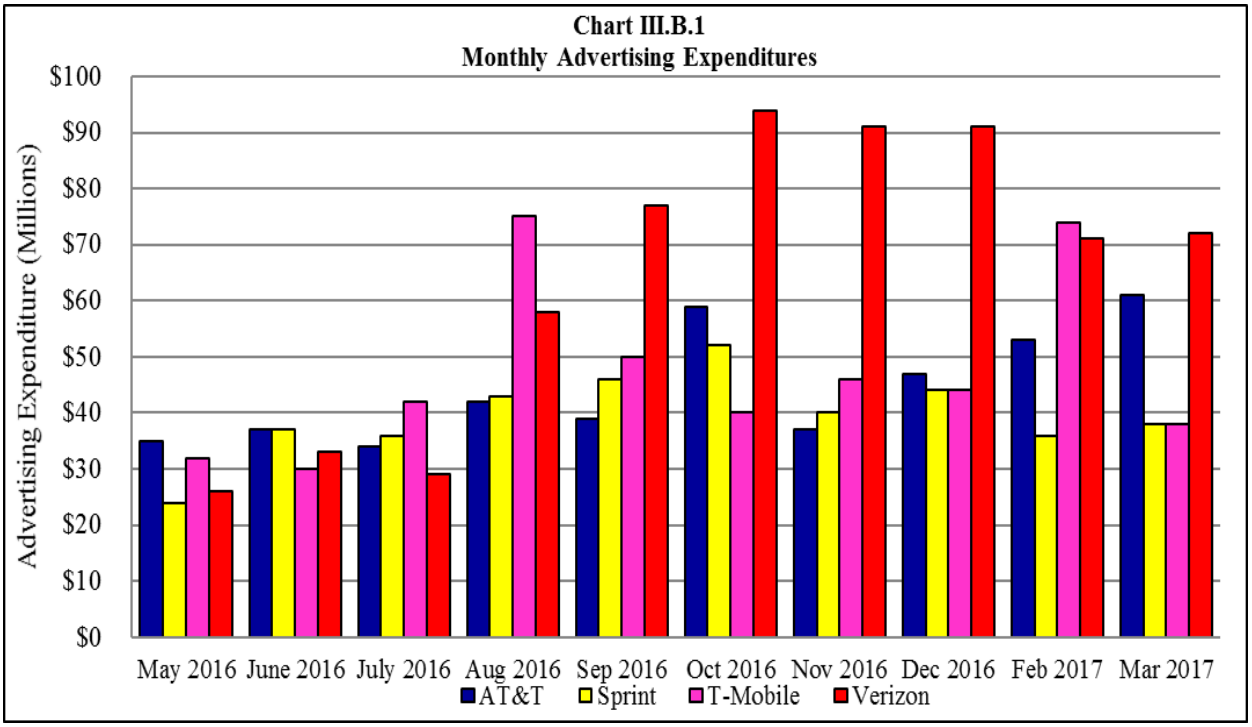
[234] ispot.tv, The Top 5 Wireless Ads: Vote for Your Favorite Spot from Verizon, Cricket and More From March (Apr. 10, 2017), http://www.fiercewireless.com/wireless/top-5-wireless-ads-vote-for-your-favorite-spot-from-t-mobile-verizon-and-more-from-march.

[235] T-Mobile, The Un-carrier Goes 'All In.' T-Mobile ONE Now Includes Taxes & Fees (Jan. 5, 2017), https://newsroom.t-mobile.com/news-and-blogs/un-carrier-next.htm.

[236] Verizon, Annual Report (Form 10-K) at note 14 (Feb. 21, 2017).

[237] AT&T Inc., Annual Report (Form 10-K) at note 18 (Feb. 17, 2017).

the wireless industry spent $280 million on advertising. Chart III.B.1 shows monthly advertising expenditures by the four nationwide service providers for the period May 2016 through March 2017.



Source: iSpot.tv.

C. Investment

68. Over the past seven years, according to CTIA, wireless service providers in the United States have made capital investments of more than $200 billion.[240] According to the UBS Wireless 411 report, in 2016, wireless service providers spent an incremental $28.0 billion, which is a decline of approximately 9 percent from the $30.9 billion invested in 2015.[241] According to UBS, AT&T, Sprint, T-Mobile, and Verizon Wireless spent a combined $27.5 billion in 2016, $30.3 billion in 2015, and $31.2 billion in 2014, accounting for close to 100 percent of total industry capital investment as tracked by UBS in these time periods.[242] AT&T and Verizon Wireless consistently made more capital investments in absolute CAPEX dollars in each quarter than did either Sprint or T-Mobile. In 2016, AT&T, T-Mobile, and Verizon Wireless each had CAPEX of approximately 16 percent to 17 percent of service revenue.[243]

(Continued from previous page)

[238] T-Mobile Annual Report (Form 10-K) at 60 (Feb. 14, 2017).

[239] Sprint, Annual Report (Form 10-K) at F-16 (May 26, 2017).

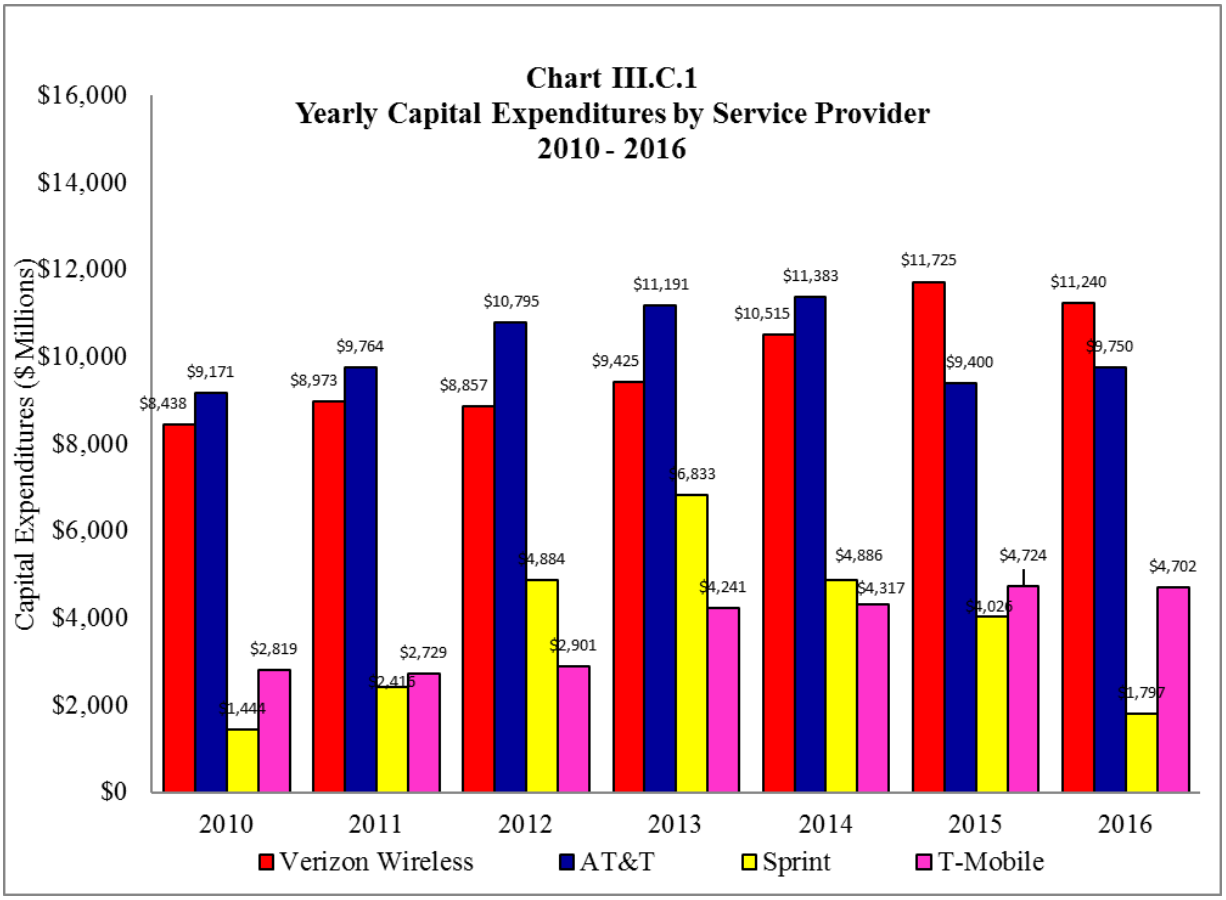
[240] CTIA Wireless Industry Indices Year-End 2016, at 60. CTIA's figure includes incremental investment in currently operational systems, including expenditures for building operating systems, land and capital leases, and all tangible non-system capital investment, but does not include the cost of spectrum licenses purchased at auctions or other acquisition processes or greenfield builds. In 2016, the incremental investment reported to CTIA amounted to $26.4 billion, down approximately 17% from 2015. CTIA Wireless Industry Indices Year-End 2016, at 12. CTIA's Capex for the period consisted of surveyed service providers comprising 97.9% of all estimated wireless subscriber connections in the industry.

[241] UBS US Wireless 411, February 2017, Figure 38.

[242] *Id.*

[243] UBS US Wireless 411, February 2017, Figure 36 and Figure 38.

CAPEX by Sprint, on the other hand, fell considerably in this time period, from approximately 17 percent of service revenue in 2015 to 7.5 percent in 2016.[244] Access to capital may be more constrained for some service providers, including smaller service providers.[245] Chart III.C.1 below shows annual capital expenditures by the four nationwide service providers since 2010.



Source: UBS US Wireless 411, Version 55, Figure 54; UBS US Wireless 411, Version 57, Figure 60; UBS US Wireless 411, Version 59, Figure 72; Wireless 411, February 2017, Figure 38.

D. Nationwide Network Coverage and Technology Upgrades

69. We measure network coverage in this *Report* based on Form 477 data,[246] which contains information on deployment submitted by service providers in the form of polygons representing detailed

[244] UBS US Wireless 411, February 2017, Figure 38.

[245] According to The Rural Broadband Association (NTCA), which consists exclusively of small, rural service providers, 61% of the rural service providers who were surveyed described the process of obtaining financing for their wireless projects as "somewhat difficult" or "very difficult." NTCA 2016 Wireless Survey Report, at 3, 10 (Jan. 2017), https://www.ntca.org/images/stories/Documents/Advocacy/SurveyReports/2016wirelessurveryreport.pdf. *See also* NTCA Comments.

[246] Currently, Form 477 collects data from facilities-based service providers of (1) internet service with information transfer rates exceeding 200 kbps in at least one direction; and (2) mobile service to at least one subscriber. This excludes providers of terrestrial wireless "hot spot" services, like local-area Wi-Fi or Wi-Fi within public places, but includes facilities-based network providers that provide resale of mobile services. Facilities-based service providers of mobile wireless service submitted polygons in an ESRI shapefile format representing geographic coverage

(continued….)

coverage areas.[247] We first apply a centroid methodology to the Form 477 data, and we then analyze the Form 477 data on a sub-census-block level, calculating the percentage of each census block covered by each technology.

70. As the Commission has stated, having accurate and reliable mobile broadband deployment data is critical to policymakers as well as to consumers.[248] We observe that, while the current Form 477 deployment data is an improvement over the deployment data previously available on a national scale, questions have arisen in various contexts regarding the bases for certain filings.[249] For example, in the context of the MF-II proceeding, the Commission determined that a separate, one-time data collection was necessary to ensure that all Form 477 filers were using a consistent standard when reporting their deployment of 5 Mbps 4G LTE services.[250] In addition, the Commission has initiated a rulemaking to consider improvements in the Form 477 data collection process.[251]

71. The centroid methodology is applied to U.S. census blocks overlaid on service provider coverage maps. Under this methodology, if the geometric center point, or centroid,[252] of a census block is

(Continued from previous page)
nationwide (including U.S. territories) for each transmission technology (e.g., EV-DO, WCDMA, HSPA+, LTE, WiMAX) deployed in each frequency band (e.g., 700 MHz, Cellular, AWS, PCS, BRS/EBS). *Modernizing the FCC Form 477 Data Program*, WC Docket No. 11-10, Report and Order, 28 FCC Rcd 9887, 9908, para. 42 (2013) (*Modernizing Form 477 Order*); FCC Form 477, Local Telephone Competition and Broadband Reporting, Instructions 24 (2016) (Form 477 Instructions), https://transition.fcc.gov/form477/477inst.pdf. In addition, service providers submit information on the geographic areas in which users should expect to receive the minimum speed advertised by the service provider for the used spectrum and deployed technologies. *Modernizing Form 477 Order*, 28 FCC Rcd at 9888, 9897, 9908 paras. 3, 20, 42; FCC Form 477, Form 477 Instructions, at 24. Service providers are also required to certify as to the accuracy of the data submitted. *Modernizing Form 477 Order*, 28 FCC Rcd at 9897-98, paras. 23-24 (noting that the certification obligation will help promote complete and accurate data).

[247] In addition, on the *Twentieth Report*'s website, we present overall wireless and LTE coverage information based on data received by the Commission through a contract with Mosaik Solutions. Web Appendix III: Elements of Inter-Firm Rivalry, https://www.fcc.gov/20th-mobile-wireless-report-web-appendices. Mosaik Solutions is an independent consulting firm that tracks coverage footprints of mobile voice and mobile data networks and provides data on facilities-based service providers in the form of coverage boundary maps based on the coverage boundaries provided to them by mobile wireless network operators. Mosaik, About Us, http://www.mosaik.com/about-us/ (last visited Sept. 1, 2017). Mosaik reports advertised coverage as reported to it by service providers, each of which uses a different definition or determination of coverage, which means that its data are not collected under a consistent methodology across geographic areas and service providers, and its coverage estimates likely overstate the coverage actually experienced by consumers. In addition, the data do not expressly account for factors such as signal strength, bit rate, or in-building coverage, and may convey a false sense of consistency across geographic areas and service providers. *Nineteenth Report*, 31 FCC Rcd at 10559-60, para. 33; *Sixteenth Report*, 28 FCC Rcd at 3743-44, para. 42.

[248] *Modernizing the FCC Form 477 Data Program*, Further Notice of Proposed Rulemaking, 32 FCC Rcd 6329, 6331-32, para. 8 (2017) (*Modernizing the FCC Form 477 Data Program*).

[249] *Modernizing the FCC Form 477 Data Program*, 32 FCC Rcd at 6332-33, para. 10.

[250] *Connect America Fund, Universal Service Reform—Mobility Fund*, Order on Reconsideration and Second Report and Order, 32 FCC Rcd 6282, 6286, 6287, 6298, paras. 7, 10, 34 (2017) (the Commission reconsidered its decision to use the Form 477 data given the various challenges with respect to the accuracy of the Form 477 deployment data, and determined that there would be a new one-time data collection).

[251] *See generally Modernizing the FCC Form 477 Data Program*, 32 FCC Rcd 6329.

[252] In this *Report*, we use the term "centroid" to describe what the Census Bureau calls the "internal point," which is at or near the geographic center of the entity (i.e., the internal point latitude/longitude of a census block polygon). For some irregularly-shaped entities (such as those shaped like a crescent), the calculated geographic center may be located outside the boundaries of the entity. In such instances, the internal point is identified as a point inside the entity boundaries nearest to the calculated geographic center and, if possible, within a land polygon. U.S. Census Bureau, Geography, https://www.census.gov/geo/reference/gtc/gtc_area_attr.html (last visited Sept. 1, 2017). The (continued….)

within the coverage boundary of a coverage map,[253] then we consider that block to be "covered" by that service provider and/or technology.[254] We then aggregate the population, land area, and road miles of the covered census blocks to generate our total coverage estimates. We note that these coverage estimates represent deployment of mobile networks and do not indicate the extent to which service providers affirmatively offer service to residents in the covered areas. While we recognize that this analysis likely overstates the coverage experienced by some consumers,[255] especially in large or irregularly shaped census blocks,[256] we find that it is nonetheless useful because estimated coverage can be compared across network technologies and service providers.[257]

72. In addition to the centroid methodology, we also analyze the Form 477 data on a sub-census-block level, by estimating the percentage of each census block covered by each technology. Unlike the centroid methodology where a particular census block is either covered or not, the actual area coverage methodology estimates the area of the census block covered by each service provider by technology.[258] Because we currently do not know the distribution of the population at the sub-census-block level, however, we must approximate the population covered by each technology. To do this, we assume, for purposes of this *Report*, that the population of a census block is uniformly distributed such

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latitude and longitude of the centroid of each block are available in the census block map files. U.S. Census Bureau, 2010 TIGER/Line Shapefiles, https://www.census.gov/cgi-bin/geo/shapefiles2010/main/ (last visited Sept. 1, 2017). In our analysis, we have taken the centroids directly from the U.S. Census bureau website. For use of the centroid methodology, *see, e.g., Connect America Fund; A National Broadband Plan for Our Future; Establishing Just and Reasonable Rates for Local Exchange Carriers; High-Cost Universal Service Support; Developing an Unified Intercarrier Compensation Regime; Federal-State Joint Board on Universal Service; Lifeline and Link-Up; Universal Service Reform –Mobility Fund*, Report and Order and Further Notice of Proposed Rulemaking, 26 FCC Rcd 17663, 17786, n.576 (2011) (*USF/ICC Transformation Order*).

[253] A census block is the smallest geographic unit for which the Census Bureau tabulates decennial census data. There are 11,166,336 blocks designated in the 2010 Census, and they range in population from zero to several hundred. U.S. Census Bureau, 2010 Census Tallies of Census Tracts, Block Groups & Blocks, https://www.census.gov/geo/maps-data/data/tallies/tractblock.html (last visited Sept. 1, 2017).

[254] *Nineteenth Report*, 31 FCC Rcd at 10560-61, para. 34; *Sixteenth Report*, 28 FCC Rcd at 3743-44, para. 42.

[255] "[A]lthough most census blocks are small, some can be large, particularly in low-density rural areas, and … coverage at the centroid might result, incorrectly, in the entirety of those large areas being deemed served." *Connect America Fund, et al.*, Report and Order and Further Notice of Proposed Rulemaking, 26 FCC Rcd 17663, 17787, para. 344 (2011); *see also Nineteenth Report*, 31 FCC Rcd at 10560, n.77; *Sixteenth Report*, 28 FCC Rcd at 3743-44, para. 42.

[256] *Nineteenth Report*, 31 FCC Rcd at 10560-61, para. 34. The centroid methodology may also understate coverage for certain blocks, such as those that have a small partial area coverage, and for which the centroid of the block does not fall within the coverage boundary.

[257] Service providers often offer coverage outside of their network coverage areas through roaming arrangements, which allow their customers to automatically receive service from other service providers' networks when they are in areas that are covered by their roaming partners' networks but not by their own network. In contrast to the purchase of capacity wholesale to provide resale or MVNO services, a provider uses roaming services to market extended coverage to consumers residing within the provider's network coverage area, but not to acquire customers where a service provider does not have network coverage.

[258] This sub-census-block analysis can tell us the unique combination of service providers serving a particular percentage of the area in a census block with a certain technology. As this analysis was done at each technology level, the set of unique combinations that it produces are valid for each individual technology but not across multiple technologies. Essentially, we can distinguish the unique percentages covered by various service providers at the sub-census-block level using a particular technology (e.g., LTE), but we do not currently know how this interplays with other technologies (e.g., with 2G or 3G technologies). Therefore, we can calculate the areas served and not served by all wireless technologies (LTE, non-LTE 4G, 3G, and 2G technologies) only at the national level.

that the fraction of the population covered in a block is proportional to the fraction of the actual area covered. We then sum the estimated covered population across blocks to estimate the total covered population within the United States. Likewise, we assume that the fraction of the road miles covered in a block is proportional to the fraction of the actual area covered. At the aggregate national level, the results should be similar whether the centroid methodology or the actual area coverage methodology is utilized and therefore, at that aggregate level, the centroid approach is a reasonable one. The actual area coverage methodology does yield more precise estimates, however, and differences in the coverage results are expected to show more clearly at the disaggregated geographic level, particularly in rural areas.[259]

73. In this Section, we first present our overall mobile wireless coverage estimates based on any technology of the percentage of the U.S. population, land area, and road miles covered by a certain number of facilities-based service providers.[260] We then present our estimates of overall mobile wireless coverage by individual service provider. Secondly, we present our LTE coverage estimates for the percentage of the U.S. population, land area, and road miles covered, where LTE is now the baseline industry standard for the marketing of mobile broadband service. Again, we consider LTE coverage nationwide by a certain number of service providers, before turning to LTE coverage by individual service providers. Finally, we present our estimates of overall mobile wireless and LTE coverage in rural and non-rural areas, first by a certain number of service providers, and then by individual service providers.

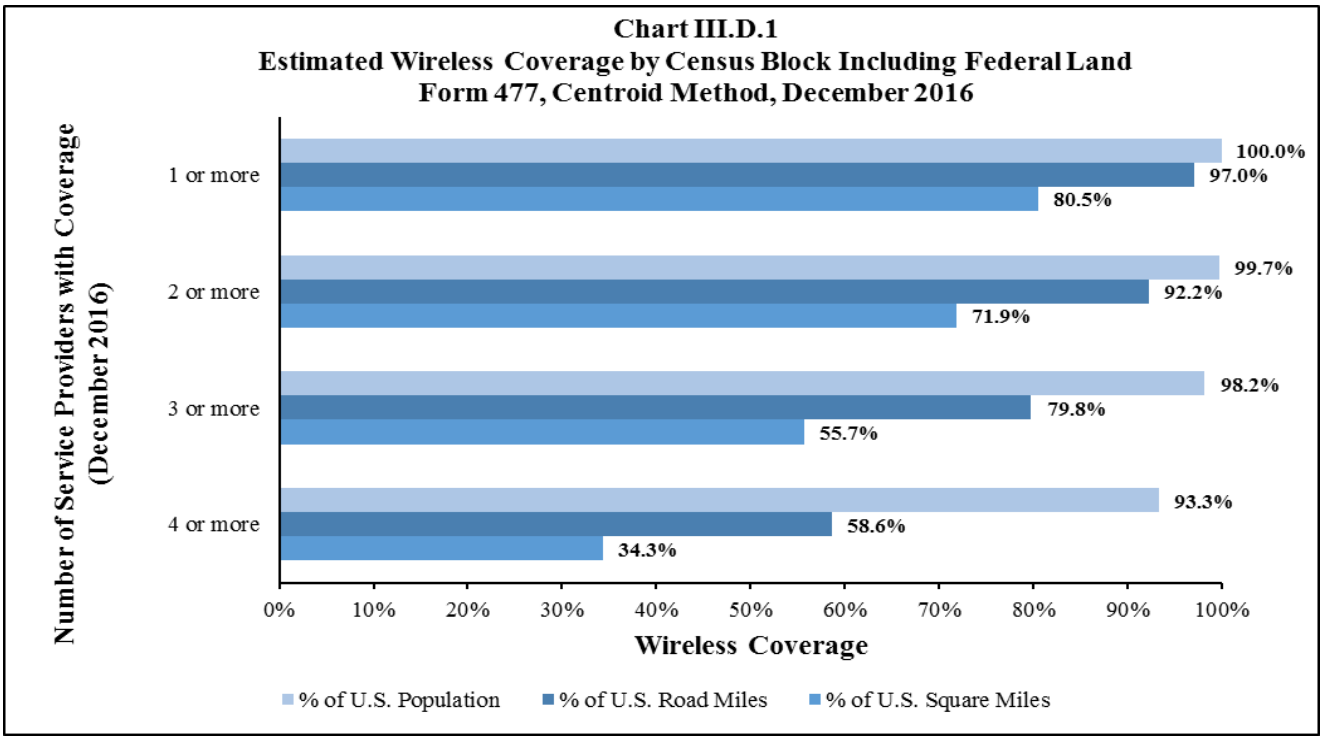
1. Overall Mobile Wireless Network Coverage (Any Technology)

a. Overall Coverage by a Certain Number of Service Providers

74. Chart III.D.1 presents overall mobile wireless coverage (any technology) based on centroid analysis of December 2016 Form 477 data by a certain number of service providers. It shows that approximately 93 percent of the population is covered by at least four service providers, while approximately 34 percent of the total land area of the United States, and approximately 59 percent of total U.S. road miles are covered by at least four service providers.

[259] In order to fully exploit the increase in precision offered by the actual area coverage methodology, spatially accurate representations of population and road miles would be necessary. We do not have access to such information at this point in time for the current *Report*, however.

[260] Appendix III: Elements of Inter-Firm Rivalry, Tables III.D.i-xxi provide more detailed information. In addition, Web Appendix III: Elements of Inter-Firm Rivalry, https://www.fcc.gov/20th-mobile-wireless-report-web-appendices, presents our estimates of overall mobile wireless coverage, 3G or better (EV-DO, EV-DO Rev A, WCDMA/HSPA, HSPA+, LTE, and mobile WiMAX), and LTE coverage based on Mosaik data. Further, it presents our estimates of overall mobile wireless coverage and LTE coverage by census block excluding Federal land based on both Form 477 and Mosaik data.



Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

75. In order to estimate the number of service providers serving a particular CMA, we include a service provider if it has a greater than two percent market share (or alternatively, a five percent market share which provides greater assurance of a meaningful choice for consumers) of mobile wireless connections in the CMA based on NRUF data.[261] Table III.D.1 presents the data for December 2013 and December 2016, and shows that, using either market share threshold, the number of CMAs with three service providers has decreased since 2013 while the number of CMAs with four service providers has increased substantially.[262]

[261] *Nineteenth Report*, 31 FCC Rcd at 10563, para. 38; *Sixteenth Report* 28 FCC Rcd at 3751, para. 50.

[262] Because NRUF includes data on the number of telephone numbers that have been assigned to end-user devices by mobile wireless service providers, this analysis does not include service providers whose data-only devices are not assigned a mobile telephone number.

Table III.D.1
Estimated Mobile Wireless Service Providers Offering Service by CMA, Excluding Territories

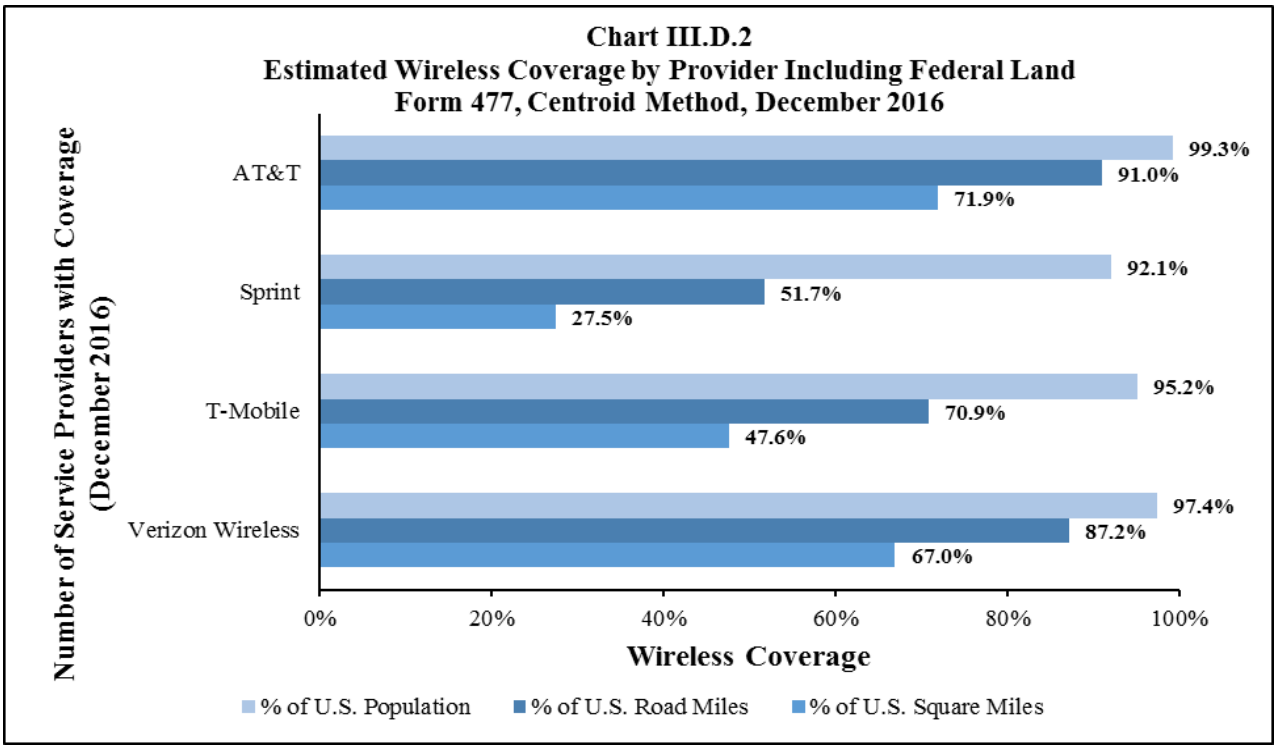
Number of Providers Offering Service Anywhere in a CMA	Two Percent Market Share Threshold				Five Percent Market Share Threshold			
	Number of CMAs		Total CMAs (percent)		Number of CMAs		Total CMAs (percent)	
	2013	2016	2013	2016	2013	2016	2013	2016
Total for U.S., excluding territories	*716*	*716*	*100.0%*	*100.0%*	*716*	*716*	*100.0%*	*100.0%*
1 provider	0	0	0.0%	0.0%	2	1	0.3%	0.1%
2 providers	63	54	8.8%	7.5%	139	104	19.4%	14.5%
3 providers	146	84	20.4%	11.7%	214	156	29.9%	21.8%
4 or more providers	507	578	70.8%	80.7%	361	455	50.4%	63.5%

Source: Based on December 2013 and December 2016 NRUF data.

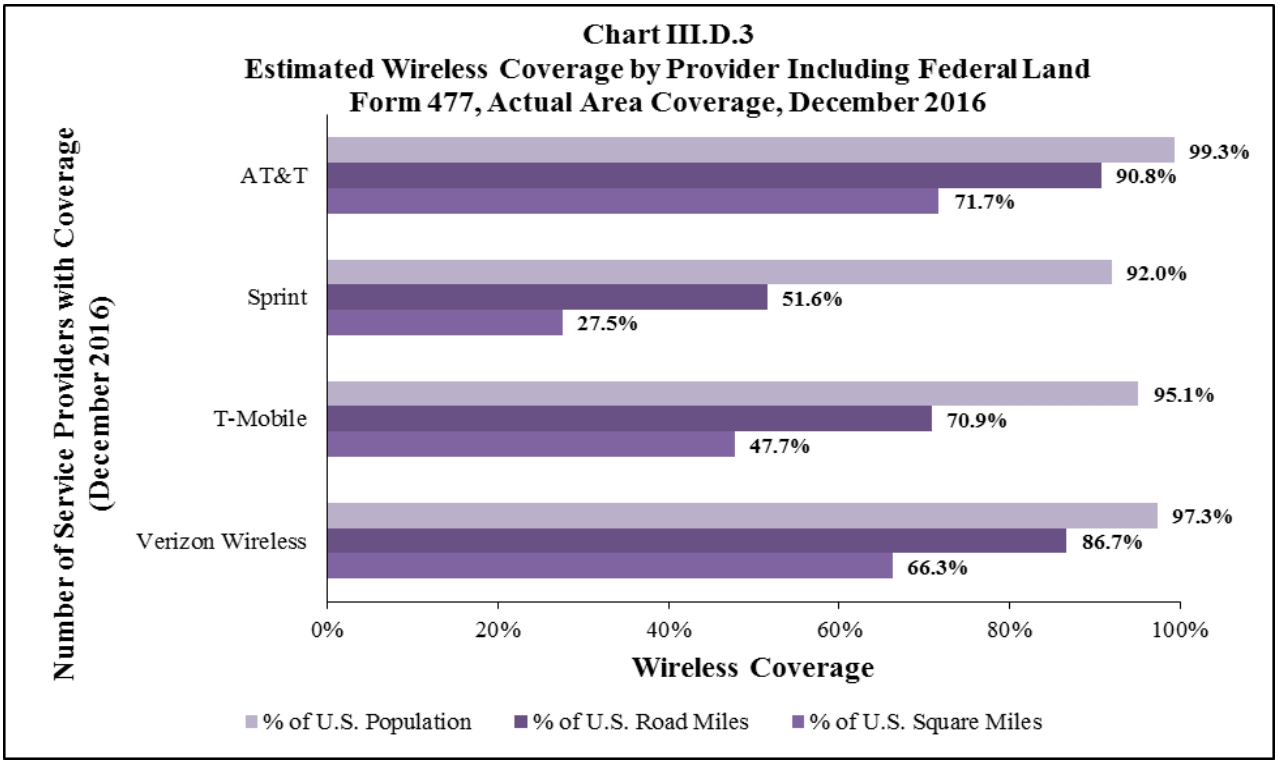
b. Overall Coverage by Individual Service Provider

76. Chart III.D.2 and Chart III.D.3 present estimates of mobile wireless coverage (any technology) by individual service provider, using December 2016 Form 477 data and the centroid and actual area coverage methodologies.[263] According to our analysis, AT&T provided wireless coverage in census blocks containing approximately 99 percent of the population, while the comparable percentages are approximately 97 percent for Verizon Wireless, approximately 95 percent for T-Mobile, and approximately 92 percent for Sprint. Verizon Wireless and AT&T each covered over 65 percent of the land area with their respective mobile wireless networks, while T-Mobile and Sprint each covered less than 50 percent of the land area. In terms of road miles, AT&T covered approximately 91 percent, Verizon Wireless covered approximately 87 percent, T-Mobile covered approximately 71 percent, and Sprint covered approximately 52 percent of road miles.

[263] Since we do not know the distribution of either the population or road miles at the sub-census block level, as noted above, we must approximate the percentage that is covered by each technology. To do this, we assume for purposes of this Report that both population and road miles are distributed uniformly across each census block. The fraction of the population or road miles covered in a census block is assumed to be proportional to the fraction of the actual area covered. We then sum the estimated covered population (road miles) across blocks to estimate the total covered population (road miles) within the United States.



Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.

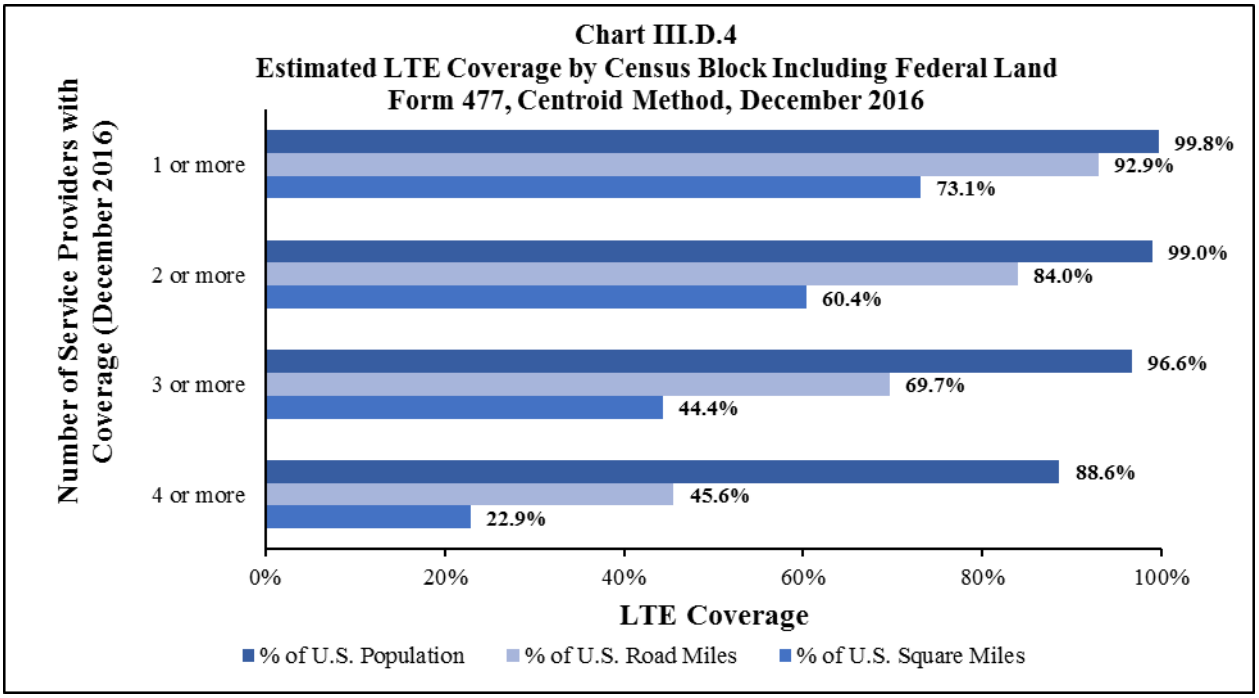


Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block.

2. LTE Mobile Broadband Coverage

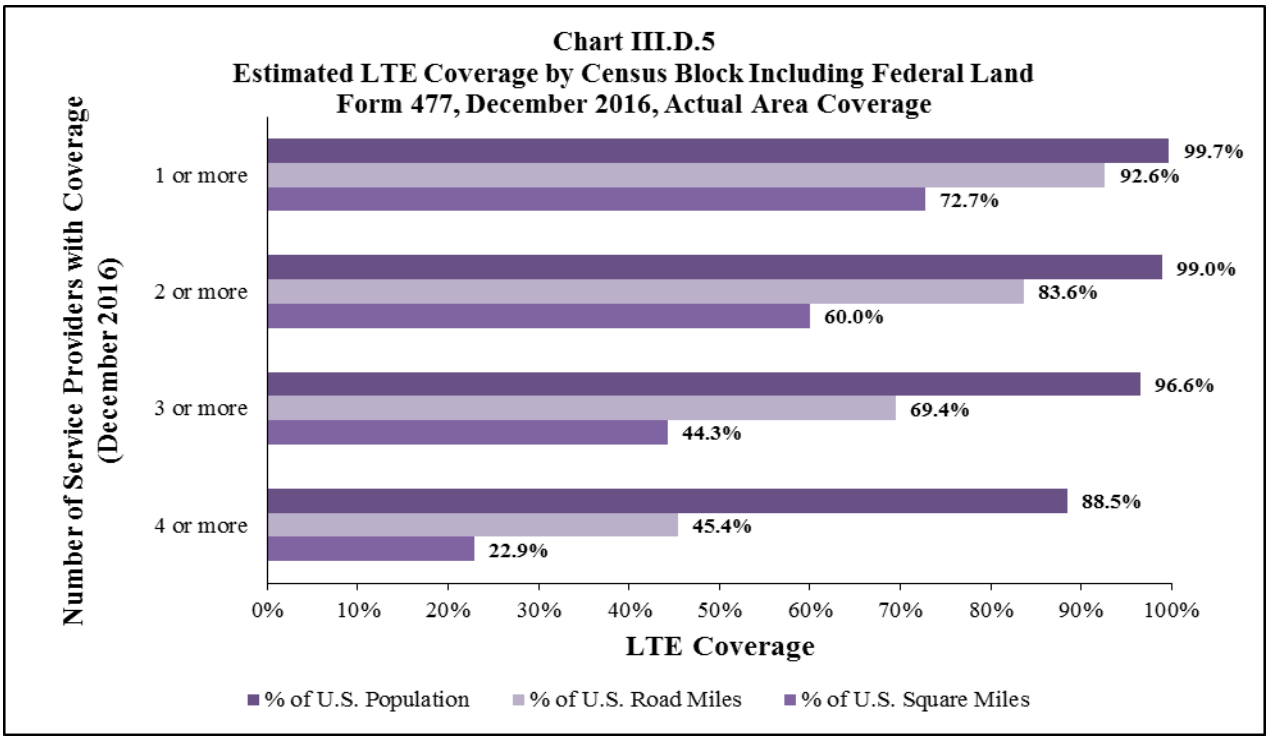
a. LTE Coverage by a Certain Number of Service Providers

77. Chart III.D.4 and Chart III.D.5 present LTE mobile broadband coverage based on Form 477 data as of December 2016 for both the centroid methodology and the actual area coverage methodology by a certain number of service providers. According to the actual area coverage analysis, in December 2016, approximately 89 percent of the U.S. population lived in census blocks with LTE coverage by at least four service providers. These census blocks only accounted for approximately 46 percent of road miles and approximately 23 percent of the total land area of the United States, however. As previously noted, in part in response to criticisms of the existing Form 477 data collection, the Commission has recently initiated a rulemaking proceeding to consider how it could further increase the quality and accuracy of the information collected by the Commission on the Form 477.[264]



Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

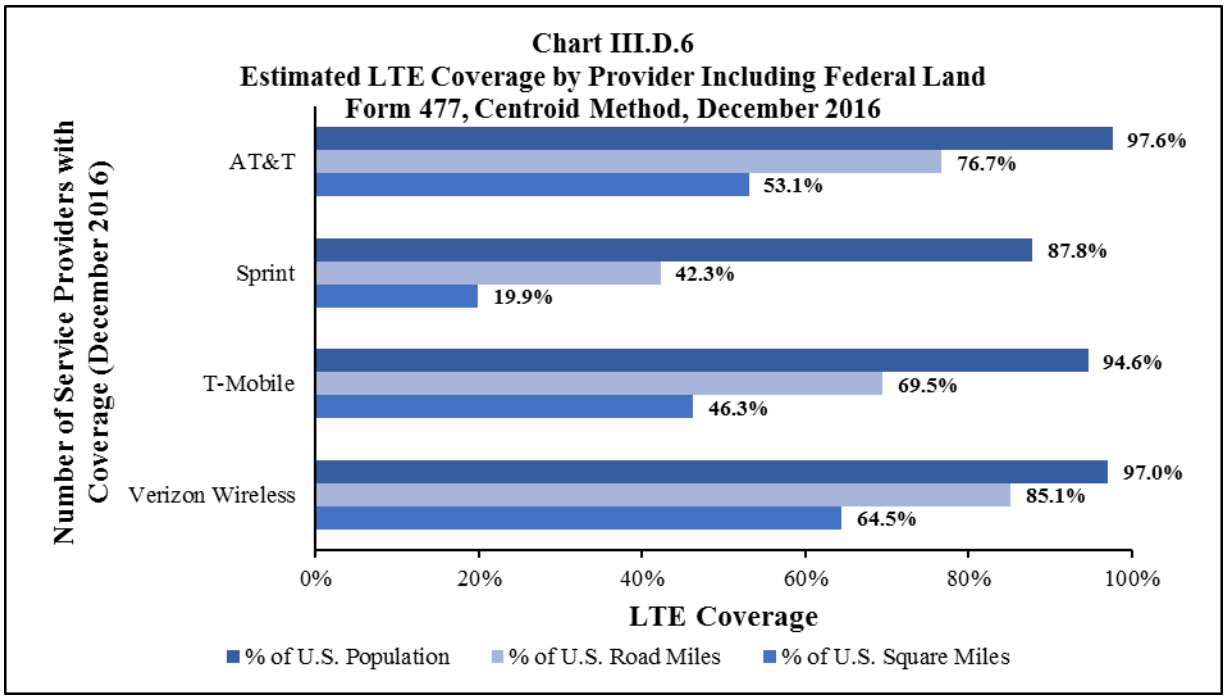
[264] *See generally Modernizing the FCC Form 477 Data Program*, 32 FCC Rcd 6329.



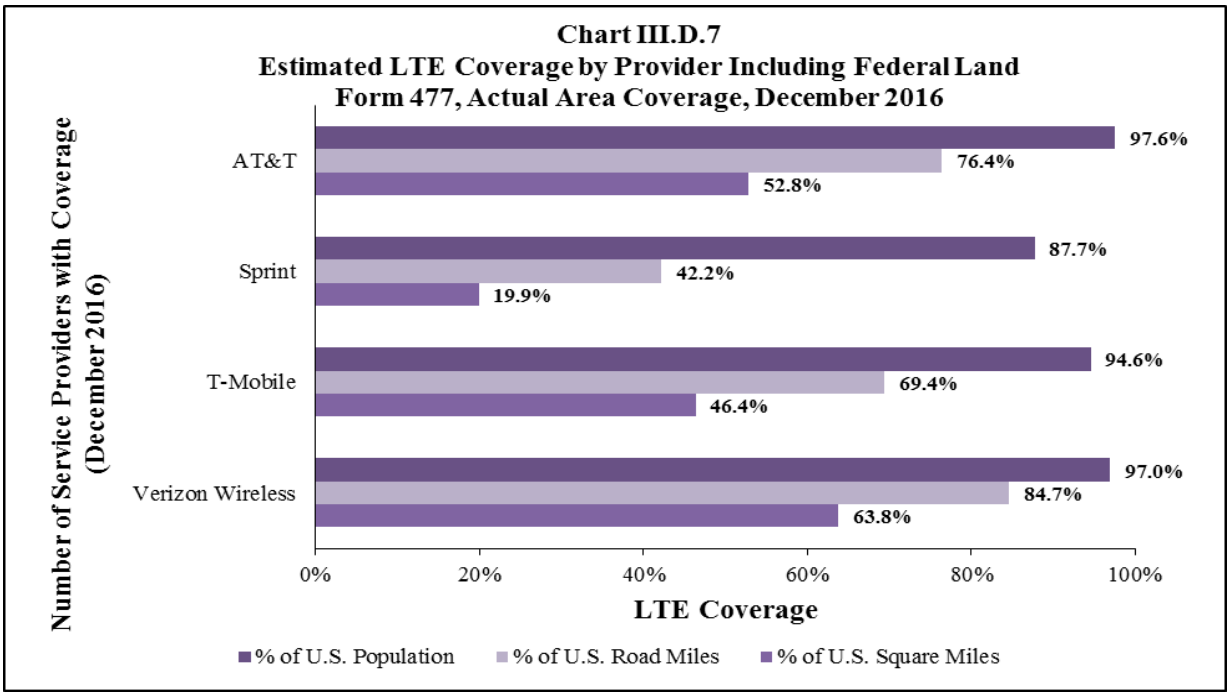
Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

b. LTE Coverage by Individual Service Provider

78. Chart III.D.6 and Chart III.D.7 present estimates of LTE mobile broadband coverage by service provider using December 2016 Form 477 data and the centroid and actual area coverage methodologies. According to our analysis, Verizon Wireless and AT&T each provided LTE coverage to census blocks containing approximately 97 percent of the population, T-Mobile provided LTE coverage to approximately 95 percent of the population, while Sprint provided LTE coverage to approximately 88 percent of the population. In terms of road miles and land area, Verizon Wireless covered approximately 85 percent of road miles and 64 percent of the land area, AT&T covered approximately 77 percent of road miles and 53 percent of the land area, T-Mobile covered approximately 69 percent of road miles and 46 percent of the land area, and Sprint covered approximately 42 percent of road miles and 20 percent of the land area with LTE.



Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.



Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block.

3. Rural/Non-Rural Comparisons

79. Although the Communications Act does not include a statutory definition of what constitutes a rural area, the Commission since 2004 has used a "baseline" definition of a rural county as one with a population density of 100 people per square mile or less.[265] We use this same baseline definition to analyze coverage in rural versus non-rural areas for all our analysis throughout this *Report* (including the Appendices).

80. To determine whether counties are rural or non-rural for our coverage analysis, we first excluded all water-only census blocks within each county.[266] We then divided the county population by the total geographic area of the county (excluding the previously identified water-only blocks) to determine the population density of the county. For those counties with a population density of 100 people per square mile or less, all census blocks within those counties were considered rural. Under this definition and using 2010 U.S. Census data, approximately 56 million people, or approximately 18 percent of the U.S. population, live in rural counties. These counties comprise approximately 3 million square miles, or approximately 84 percent, of the geographic area of the United States.[267]

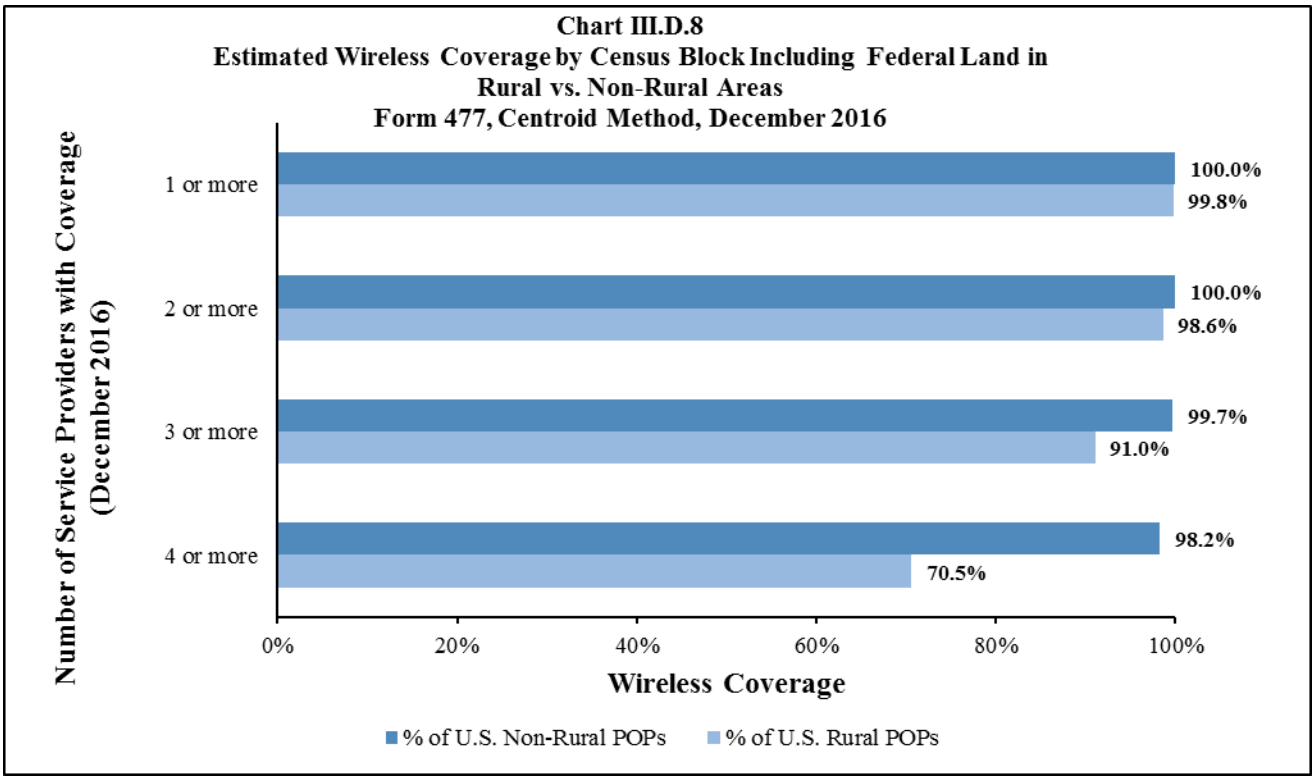
a. Rural and Non-Rural Overall Coverage by a Certain Number of Service Providers

81. Chart III.D.8 below presents mobile wireless coverage (any technology) of both the rural and non-rural U.S. population based on the Form 477 centroid analysis. The chart shows that, as of December 2016, approximately 98 percent of the population living in non-rural areas was covered by at least four service providers, while only approximately 70 percent of the population living in rural areas was covered by at least four service providers.

[265] *Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies To Provide Spectrum-Based Services*, Report and Order and Further Notice of Proposed Rule Making, 19 FCC Rcd 19078, 19086-88, paras. 10-12 (2004) (*2004 Report and Order*).

[266] *Nineteenth Report*, 31 FCC Rcd at 10565, para. 41. Previous *Reports* had used all census blocks, including water-only blocks, to generate the total geographic area of the county. Based on this methodology, approximately 59 million people, or approximately 19% of the U.S. population, live in rural counties based on 2010 U.S. Census data. *See, e.g.*, *Eighteenth Report*, 30 FCC Rcd at 14623-24, Appendix Tables II.A.vi-vii; *Seventeenth Report*, 29 FCC Rcd at 15336-37, 15430, paras. 52-53, Appendix Tables II.A.vi-vii; *Sixteenth Report*, 28 FCC Rcd at 3725, 3939, 3942-43, para. 387, Tables 55-58.

[267] Based on 2010 Census data (includes the population of Puerto Rico). As discussed, water-only census blocks are excluded from our analysis in this *Report*.

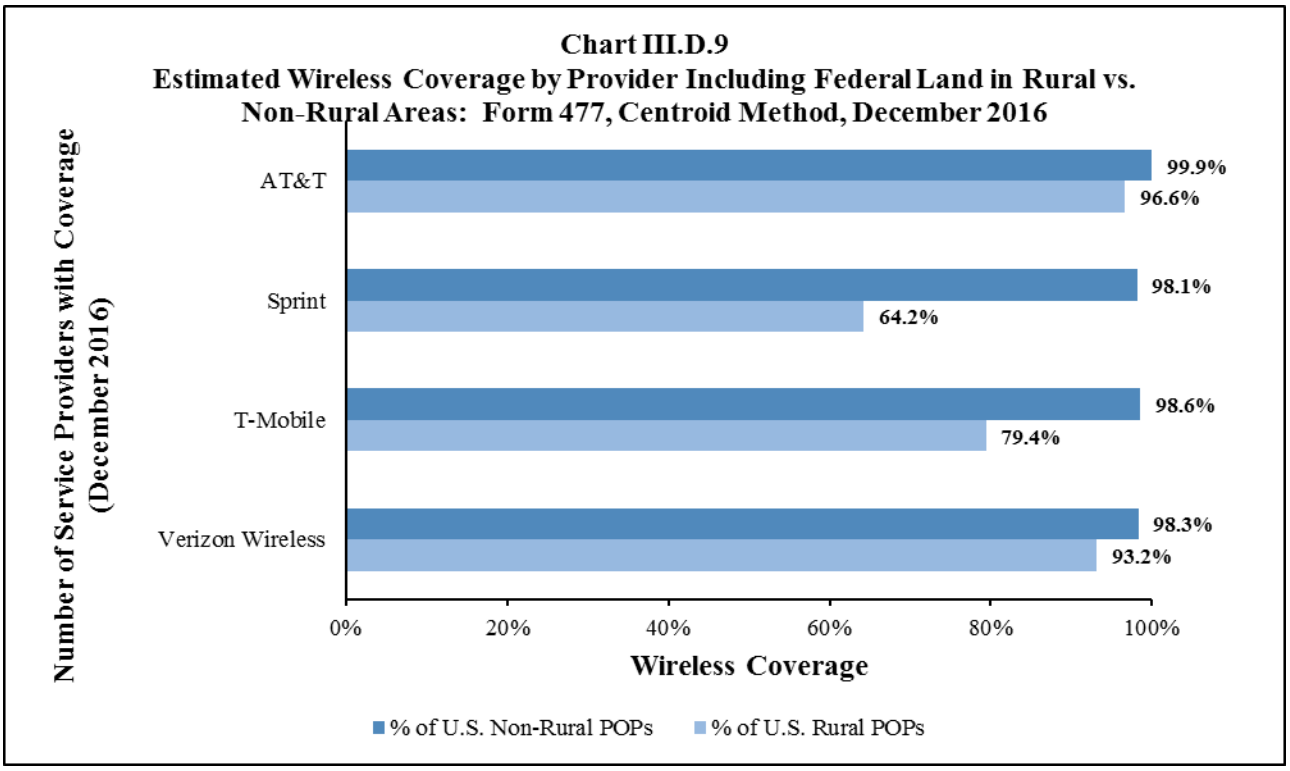


Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

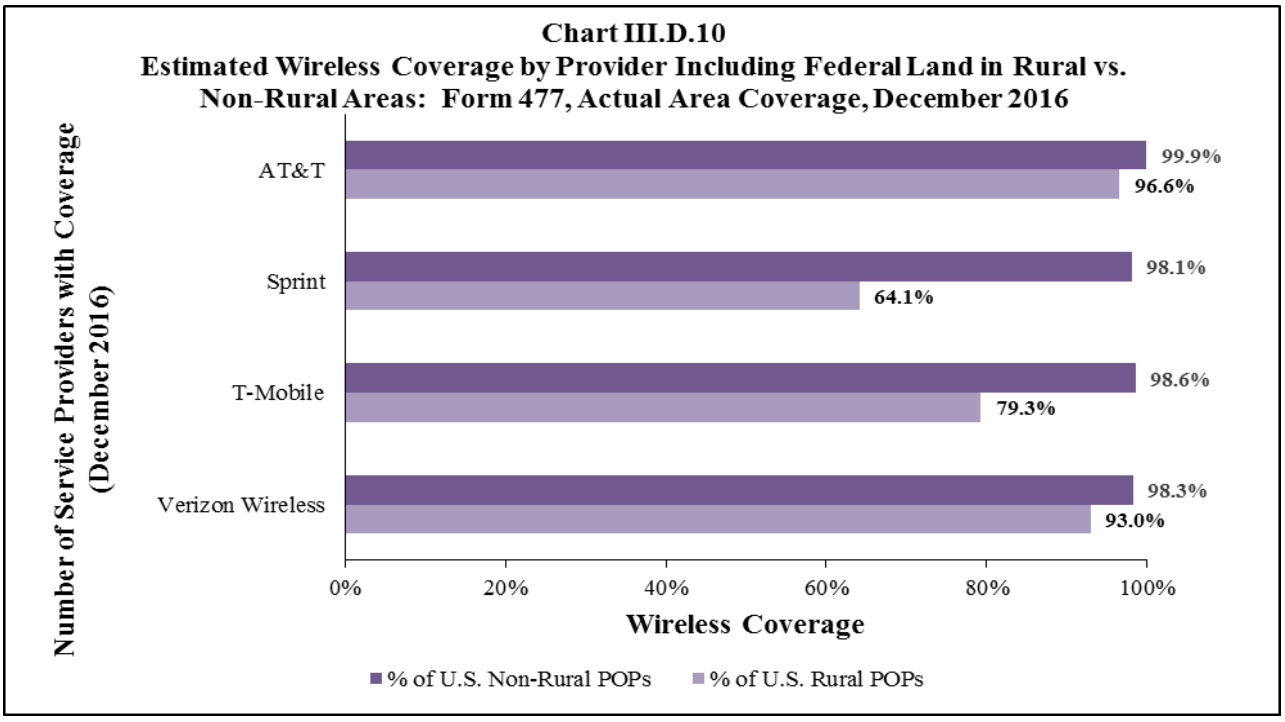
b. Rural and Non-Rural Overall Network Coverage by Individual Service Provider

82. Chart III.D.9 and Chart III.D.10 present mobile wireless coverage (any technology) of the rural and non-rural U.S. population, based on centroid and actual area coverage analysis of December 2016 Form 477 data.[268] Our analysis indicates that all four nationwide service providers covered at least 98 percent of the non-rural population with mobile wireless service. Rural wireless coverage by service provider is more limited: AT&T covered approximately 97 percent, Verizon Wireless covered approximately 93 percent, T-Mobile covered approximately 79 percent, and Sprint covered approximately 64 percent of the rural population with wireless service.

[268] As noted above, the Commission's "baseline" definition of rural is a county with a population density of 100 people or less per square mile. *2004 Report and Order*, 19 FCC Rcd 19078, 19087-88, paras. 11-12.



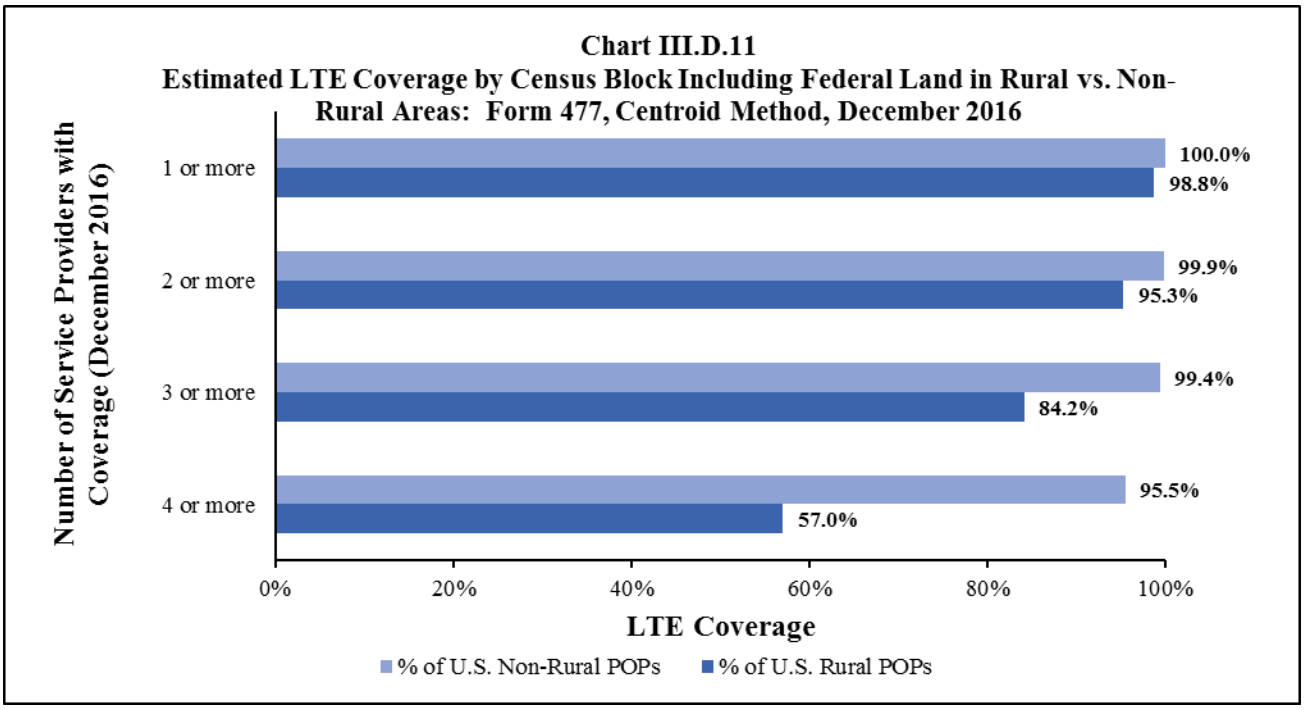
Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.



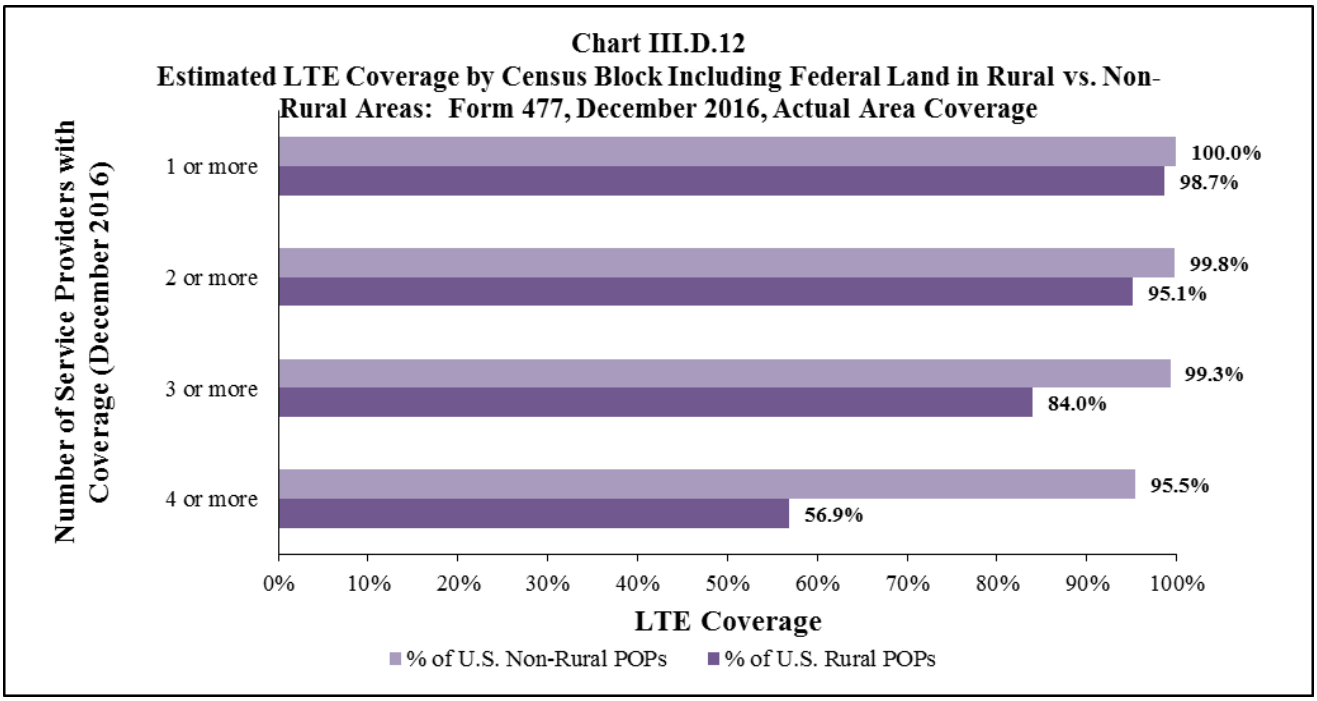
Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block.

c. Rural and Non-Rural LTE Coverage by a Certain Number of Service Providers

83. Chart III.D.11 and Chart III.D.12 present LTE population coverage in rural and non-rural census blocks by a certain number of service providers, based on the Form 477 centroid and actual area methodologies respectively. Similar to overall mobile wireless coverage, the LTE coverage gap between the population living in rural versus non-rural census blocks also increases as the threshold for number of service providers covering the area increases. Our estimates show that approximately 99 percent of the non-rural population was covered by at least three LTE service providers, while approximately 84 percent of the rural population had the same network coverage. Approximately 95 percent of the non-rural American population had LTE coverage from four or more service providers, while only approximately 57 percent of the rural population was covered by at least four LTE service providers.



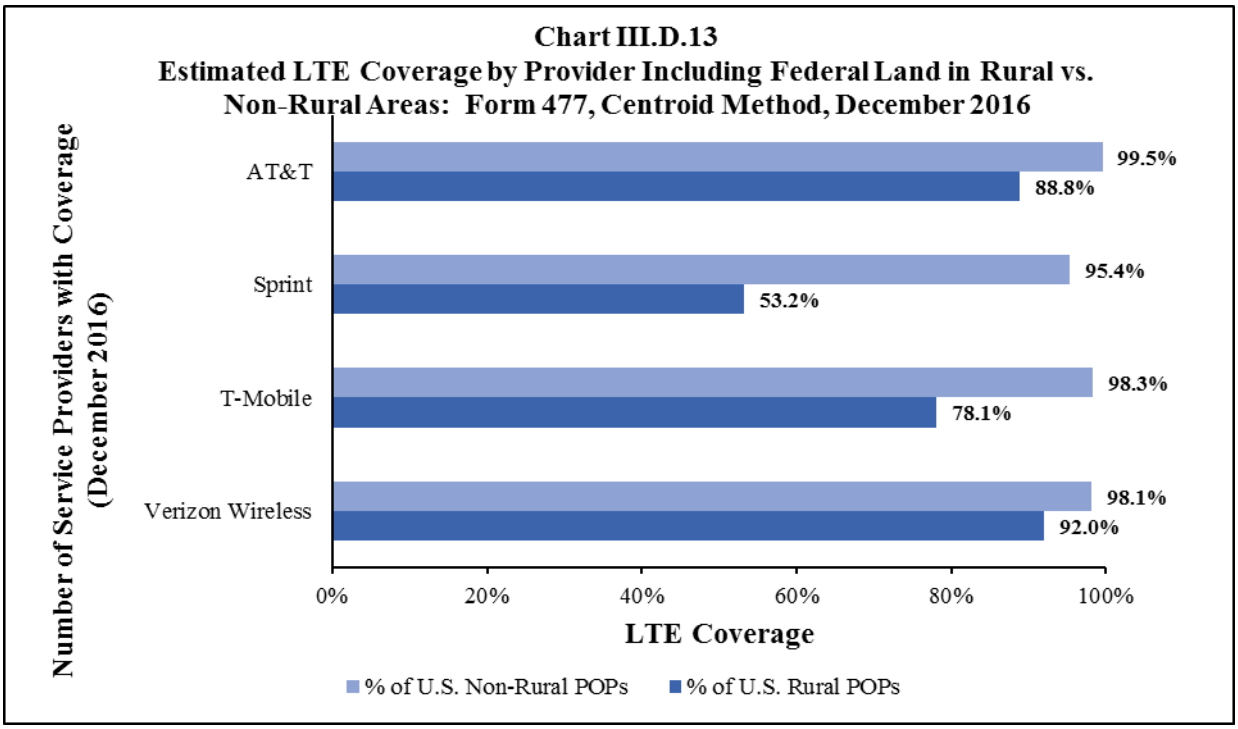
Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.



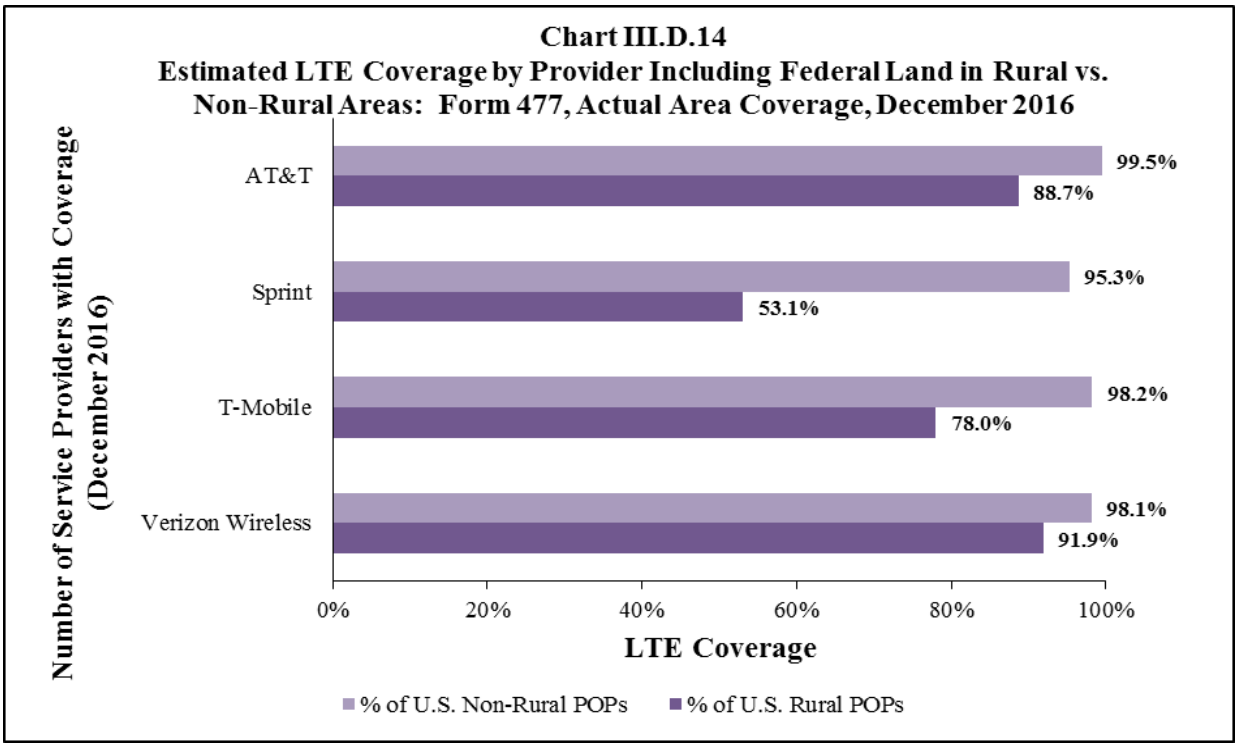
Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

d. Rural and Non-Rural LTE Coverage by Individual Service Provider

84. Chart III.D.13 and Chart III.D.14 present LTE coverage by individual service provider of both the rural and non-rural U.S. population based on centroid and actual area coverage analysis of December 2016 Form 477 data. Our estimates show that the four nationwide service providers cover at least 95 percent of the non-rural population with LTE. Regarding LTE coverage in rural areas, Verizon Wireless covers approximately 92 percent, AT&T covers approximately 89 percent, T-Mobile covers approximately 78 percent, and Sprint covers approximately 53 percent of the rural population with LTE.



Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.



Source: Based on actual area coverage analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block.

4. Coverage and Technology Upgrades by Service Provider

85. LTE is a type of wireless technology–defined by a set of 3GPP standards–that is characterized by fast upload and download data transfer speeds and low latency, with high spectral efficiency as well as flexible spectrum utilization.[269] Service providers have deployed LTE using their differing spectrum portfolios.[270] LTE has evolved beyond standard LTE (Release 8/9) to LTE-Advanced (LTE-A, Release 10/+).[271] LTE-A uses carrier aggregation with up to four bands and enhanced multiple input, multiple output (MIMO) technology to increase the maximum speed and capacity compared to standard LTE.[272] Currently, all four nationwide service providers, Verizon Wireless,[273] Sprint,[274] T-Mobile,[275] and AT&T[276] offer LTE-A in a significant number of markets. While LTE and LTE-A initially were used for data service, providers also are offering Voice over LTE (VoLTE) service which allows high-quality voice calls to be made over their LTE networks, and consumers can access voice and data services simultaneously.[277] Verizon Wireless, T-Mobile, and AT&T currently offer VoLTE service within their LTE footprints, while U.S. Cellular has made it available in limited areas.[278] Sprint has not announced a launch date for VoLTE.[279]

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[269] PCWorld, FAQ: How is LTE-Advanced different from Regular LTE? (Jan. 21, 2004), http://www.pcworld.com/article/2083981/faq-how-is-lte-advanced-different-from-regular-lte.html; 3GPP: LTE, http://www.3gpp.org/technologies/keywords-acronyms/98-lte (last visited Sept. 1, 2017).

[270] Verizon Wireless, XLTE: America's Best Network Gets Even Better (Oct. 20, 2014), http://www.verizon.com/about/news/vzw/2014/05/verizon-wireless-xlte. In 2014, Verizon Wireless launched XLTE on their AWS spectrum, with the goal of faster peak data speeds, increased bandwidth, and more available LTE capacity on their 700 MHz spectrum; Sprint Newsroom, Introducing the Sprint LTE Plus Network—Faster, Stronger, More Reliable Than Ever Before (Nov. 17, 2015), http://newsroom.sprint.com/introducing-the-sprint-lte-plus-network--faster-stronger-more-reliable-than-ever-before.htm. In 2015, Sprint launched LTE Plus (previously Sprint Spark), which employed techniques such as 3/4/5-channel carrier aggregation, higher order MIMO to increase LTE speeds, capacity, and reliability; T-Mobile News, T-Mobile Extended Range LTE Coming to Chicago in the First Half of 2017 (Dec. 1, 2016), http://www.tmonews.com/2016/12/t-mobile-extended-range-lte-chicago-first-half-2017/; T-Mobile, The Fastest, Most Advanced LTE Network, https://www.t-mobile.com/coverage/4g-lte-network (last visited Sept. 1, 2017). T-Mobile offers Extended Range LTE on their 700 MHz band, promising a larger coverage range and better building penetration.

[271] 3GPP: LTE-Advanced, http://www.3gpp.org/technologies/keywords-acronyms/97-lte-advanced (last visited Sept. 1, 2017).

[272] FierceWireless, What's So Great About LTE Advanced? (Lots, Actually), http://www.fiercewireless.com/special-report/what-s-so-great-about-lte-advanced-lots-actually (last visited Sept. 1, 2017); FierceWireless, XLTE, 5G Evolution, Extended Range LTE and LTE Plus: Explaining carriers' network marketing terms (June 20, 2017), http://www.fiercewireless.com/wireless/xlte-5g-evolution-extended-range-lte-and-lte-plus-explaining-carrier-s-network-marketing; 3GPP, 3GPP Release 14 allows up to four bands carrier aggregation, http://www.3gpp.org/release-14 (last visited Sept. 1, 2017).

[273] Verizon Wireless, Verizon LTE Advanced FAQs, https://www.verizonwireless.com/support/verizon-lte-advanced-faqs/ (last visited Sept. 1, 2017).

[274] Wireless Week, Sprint Enables 3-Carrier Aggregation on More Devices (Jan. 31, 2017), https://www.wirelessweek.com/news/2017/01/sprint-enables-3-carrier-aggregation-more-devices?linkId=34065767.

[275] T-Mobile, LTE Advanced is So 2014. We're Already On to the Next Big Thing. Verizon is Now 50% Faster … and Still Slower Than T-Mobile! (Sept. 6, 2016), https://newsroom.t-mobile.com/news-and-blogs/lte-advanced.htm.

[276] AT&T, LTE Advanced Outperforms 4G LTE, https://www.att.com/offers/network.html (last visited Sept. 1, 2017).

[277] AndroidCentral, What are VoLTE and HD Voice, and Why Should You Use Them? (Sep. 25, 2016), https://www.androidcentral.com/volte.

[278] AndroidCentral, What are VoLTE and HD Voice, and Why Should You Use Them? (Sep. 25, 2016); Verizon Wireless, HD Voice and Video Calling, https://www.verizonwireless.com/solutions-and-services/hd-voice/ (last

(continued….)

86. In the future, 5G cellular networking technology is expected to deliver significantly faster download and upload speeds, lower latency, with more carrier aggregations across different types of spectrum, and a flexible platform that will accommodate a large number of connections for multiple purposes, including IoT.[280] The Phase 1 of New Radio (NR) technology standards for 5G, which will provide basic air interface for Enhanced Mobile Broadband (eMBB) and some low latency features for the IoT, are expected to be completed mid- to late-2018.[281] Verizon Wireless is currently testing fixed wireless implementations of 5G with multiple vendors, and its first 5G network was trialed in Ann Arbor in May 2017, with plans to expand to 10 more cities later in 2017.[282] AT&T has also been conducting 5G trials with fixed wireless using mmW spectrum.[283] This year, both AT&T and Verizon Wireless, in applications seeking Commission consent to acquire mmW spectrum licenses, asserted that approval of the proposed transactions would accelerate their 5G deployment.[284] T-Mobile plans to use low-band 600 MHz spectrum in its 5G network,[285] and potentially 3.5 GHz spectrum,[286] while Sprint plans to use mid-band 2.5 GHz spectrum.[287]

(Continued from previous page)
visited Sept. 1, 2017); T-Mobile, Supported T-Mobile Networks, https://support.t-mobile.com/docs/DOC-4988#firstheading (last visited Sept. 1, 2017); AT&T, AT&T HD Voice, https://www.att.com/shop/wireless/features/hd-voice.html (last visited Sept. 1, 2017); AT&T Innovation Blog, AT&T's Voice Over LTE Network Reaches More than 27 Million Subscribers (Dec. 29, 2015), http://about.att.com/innovationblog/122915voiceoverlte; TDS, Second Quarter 2017 Results, at 6 (Aug. 4, 2017).

[279] Wireless Week, Sprint on "Path Toward" VoLTE, Will Leverage SoftBank Tech (Dec. 19, 2016), https://www.wirelessweek.com/news/2016/12/sprint-path-toward-volte-will-leverage-softbank-tech.

[280] Information Technology & Innovation Foundation, 5G and Next Generation Wireless: Implications for Policy and Competition (June 2016); Qualcomm White Paper, Accelerating 5G NR for Enhanced Mobile Broadband (March 2017) https://www.qualcomm.com/documents/accelerating-5g-new-radio-nr-enhanced-mobile-broadband-and-beyond.

[281] 5G-NR Workplan for eMBB (Mar. 9, 2017), http://www.3gpp.org/news-events/3gpp-news/1836-5g_nr_workplan.

[282] ZDNet, Verizon: Multi-Vendor Interoperability Key for 5G (June 27, 2017), http://www.zdnet.com/article/verizon-multi-vendor-interoperability-key-for-5g/; Wireless Week, Verizon Announces 5G Customer Trials in 11 Cities with 5G Forum Partners (Feb. 22, 2017), https://www.wirelessweek.com/news/2017/02/verizon-announces-5g-customer-trials-11-cities-5g-forum-partners.

[283] Wireless Week, AT&T Takes DirecTV Now Into mmWave 5G Trials in Auction (June 27, 2017), https://www.wirelessweek.com/news/2017/06/t-takes-directv-now-mmwave-5g-trials-austin.

[284] AT&T Mobility Spectrum LLC and FiberTower Corporation Seek FCC Consent to the Transfer of Control of 24 GHz and 39 GHz Licenses, Application, Exhibit 1–Description of Transaction and Public Interest Statement, ULS File Nos. 0007652635; 0007652637 (filed Feb. 13, 2017); Verizon Communications and Straight Path Communications Seek FCC Consent to the Transfer of Control of Local Multipoint Distribution Service, 39 GHz, 3650-3700 MHz and Fixed Point-to-Point Microwave Licenses, Application, Exhibit 1–Description of Transaction and Public Interest Statement, ULS File No. 0007783428 (filed June 1, 2017); *see also* Reuters, Verizon Beats AT&T to Buy Spectrum Holder Straight Path (May 11, 2017), http://www.reuters.com/article/us-straight-path-m-a-verizon-idUSKBN1871HT; RCRWireless, AT&T to Buy FiberTower for Millimeter Wave (Feb. 1, 2017), http://www.rcrwireless.com/20170201/carriers/att-to-buy-fibertower-for-millimeter-wave-tag4.

[285] FierceWireless, T-Mobile to roll out 5G over 600 MHz and other spectrum (May 2, 2017), http://www.fiercewireless.com/5g/t-mobile-to-roll-out-5g-over-600-mhz-and-other-spectrum; T-Mobile, T-Mobile Says First 600 MHz Sites Will Go Live in August (July 19, 2017), http://www.tmonews.com/2017/07/t-mobile-600mhz-launch-august/.

[286] FierceWireless, T-Mobile CTO Has "Huge Interest" in 3.5 Ghz (July 20, 2017), http://www.fiercewireless.com/wireless/t-mobile-cto-has-huge-interest-3-5-ghz; T-Mobile, Petition for Rulemaking, GN Docket No. 12-354 (June 19, 2017) (petitioning the Commission for rule changes to the 3.5 GHz band to better facilitate 5G deployment); *see also* CTIA, Petition for Rulemaking, GN Docket No. 12-354, at 1 (June 16, 2017)
(continued….)

E. Speed of Service

87. Network speed is a key characteristic of mobile wireless performance, and the Commission has recognized the importance of accurate and timely data on wireless upload and download speeds.[288] Mobile broadband speeds experienced by consumers may vary greatly with a number of factors, including the service provider's received signal quality, cell traffic loading and network capacity in different locations,[289] as well as the capability of consumers' devices.[290] First, upload and download speeds will vary based on the location of the consumer's receiving device relative to the transmitting device, which is often a cellular tower.[291] Second, the performance of the broadband connection degrades over distance to the tower, even with a clear line of sight.[292] Third, cellular signals are shared by many users–the greater the number of simultaneous users, the lower the potential performance of any one connection.[293]

88. Because the above factors cause variations in mobile network performance, various methodologies are used to measure mobile network speeds. The two most prevalent rely on crowdsourced data or structured sample data. Crowdsourced data are user-generated data produced by consumers who voluntarily download speed test applications on their mobile devices.[294] Generally, crowdsourced data can bring the benefits of generating a large volume of data at a very low cost and of measuring actual consumer experience on a network in a wide variety of locations, indoor and outdoor.

(Continued from previous page)
(stating, "The 3.5 GHz band is a band of growing importance in the 5G portfolio, . . .").

[287] Wireless Week, Sprint Working Toward 2019 Deployments of 5G at 2.5 GHz (May 10, 2017), https://www.wirelessweek.com/blog/2017/05/sprint-working-toward-2019-deployments-5g-25-ghz.

[288] *See generally 2016 Broadband Progress Report*, 31 FCC Rcd 699.

[289] For example, the received signal quality is dependent on the service provider's deployed cell site density, low/high frequency radio wave propagation losses, user locations, indoor obstructions and outdoor foliage or clutter, weather, inter-cell interference conditions, and wireless network optimization parameters. The cell traffic loading or demand is dependent on the overall number of concurrent active mobile broadband users sharing the same cell, which in turn depends on user locations, the day of the week, and the time of the day. The capacity of a service provider's wireless network is dependent on the deployed mobile wireless technology, sites and equipment, available bandwidth, and the capacity of backhaul connections. *Nineteenth Report*, 31 FCC Rcd at 10608, para. 104; *Sixteenth Report*, 28 FCC Rcd at 3895, para. 293.

[290] Differences in consumer devices (e.g., smartphones, tablets, USB dongles, and laptops) also can result in users experiencing different data speeds on the same mobile wireless broadband network. Moreover, differing capabilities within each device category, such as smartphone processing power and memory, can result in different user experiences on the same mobile wireless broadband network. Based on current and past promotions and partnerships, each wireless service provider may have a customer base with a different smartphone age-profile, which can directly affect speed measurements. In addition, for data services, network quality as perceived by the customer may also depend on how, where and/or when the consumer uses their device (e.g., a consumer who solely uses e-mail may view the quality of the network differently than one who streams video regularly).

[291] If the receiving device (and the person using it) is behind a wall, blocked by terrain or otherwise has an impaired connection with the tower, service will be degraded or not available.

[292] Performance at the edge of a tower's coverage is not equal to performance close to the tower.

[293] The FCC Omnibus Broadband Initiative (OBI); Broadband Performance: OBI Technical Paper No. 4, at 19, https://apps.fcc.gov/edocs_public/attachmatch/DOC-300902A1.pdf. Note that "dead zones" and loss of signal reduce wireless effectiveness. Analysts estimate that an available and reliable connection may only be accessed 80% to 95% of the time. *Id.* at 19-20.

[294] These apps commonly collect data on the service provider, location of device, download and upload speeds, latency, and packet loss, which are then transmitted to the company or entity that developed the app. In some cases, the apps automatically schedule these tests to run at certain times during the day, while in others, the user has to choose to run the tests.

Crowdsourced data are not collected pursuant to statistical sampling techniques, and may require adjustments to construct a representative sample from the raw data. In particular, crowdsourced mobile data come from a self-selected group of users, and there often is little control regarding such parameters as when people implement the test, whether the test is performed indoors or outdoors, the geographic location of the tester, and the age or type of the consumer's device.[295] Some of these issues can be mitigated by creating default settings that run the test at random times, and not only when the consumer initiates the test. Structured sample data, by contrast, are generated from tests that control for the location and time of the tests as well as for the devices used in the test. Structured sample data may be collected using stationary indoor or outdoor tests, or drive tests. However, these tests are more expensive to conduct, involve significant judgment about when and where the tests are run, often involve insufficient testing at indoor locations or in many rural areas, and typically produce datasets that are not as rich as crowdsourced data–all of which are likely to have some effects on reported results.

89. Subject to the limitations described above, this *Report* presents, speed data using the Ookla Net Index data (crowdsourced), RootMetrics data (largely based on drive test data across the United States, but which also incorporate results of some crowdsourced data), and the CalSPEED drive-test data gathered by the California Public Utility Commission (CPUC) (structured sample).[296] In addition to the three speed metrics discussed below, speed measurements are also performed by a variety of other entities.[297]

1. Ookla

90. Table III.E.1 presents the nationwide mean and median LTE download speeds based on Ookla data by service provider for the second half of 2015 through the second half of 2016.[298] Chart

[295] Crowdsourced speed test results may also rely on the phone's connection to the server, factors such as congestion, location of the server, proximity and access to a cell tower, and phone quality.

[296] While speed metrics based on the FCC Speed Test (available for both Android phones and the iPhone) were reported in the *Seventeenth Report* through the *Nineteenth Report*, we do not report these metrics in the *Twentieth Report* due to certain anomalies found in the underlying data. An in-depth discussion of the Measuring Broadband America Program's FCC Speed test is available in the *Seventeenth Report*. *Seventeenth Report*, 29 FCC Rcd at 15467, Appendix VI., paras. 7-9; *see also* FCC, Measuring Mobile Broadband Performance, http://www.fcc.gov/measuring-broadband-america/mobile (last visited Sept. 1, 2017).

[297] For example, OpenSignal gathers crowdsourced mobile speed data through the use of its mobile app. This app is available free of charge to Android and iOs users, and it is designed to collect data about cell phone towers and cell phone signal strength. OpenSignal, State of Mobile Networks: USA, https://opensignal.com/reports/2016/08/usa/state-of-the-mobile-network (last visited Sept. 1, 2017). OpenSignal uses these data to generate a publicly available interactive map. OpenSignal, Coverage Maps, https://opensignal.com/networks (last visited Sept. 1, 2017). Another open source application for measuring network performance on mobile platforms is MobiPerf by M-Lab. MobiPerf, About MobiPerf, https://sites.google.com/site/mobiperfdev/ (last visited Sept. 1, 2017). This application is available for Android phones only, and data collected via the application are used to generate a publicly available interactive map. Open Mobile Data, Visualization Map, http://openmobiledata.appspot.com/visualization (last visited Sept. 1, 2017). Anonymized data are also available for download. MobiPerf, For Researchers, https://sites.google.com/site/mobiperfdev/for-researchers (last visited Sept. 1, 2017). Other entities that perform speed tests include Nielsen and Mosaik. Nielson, Mobile, http://www.nielsen.com/us/en/solutions/measurement/mobile.html (last visited Sept. 1, 2017); Mosaik Solutions, Cell Maps, https://www.mosaik.com/network-experience-solutions/cellmaps/ (last visited Sept. 1, 2017).

[298] Ookla gathers crowdsourced mobile speed data through the use of its Speedtest mobile app. Speedtest, Ookla Speedtest Mobile Apps, http://www.speedtest.net/mobile/ (last visited Sept. 1, 2017). This app is available free of charge to smartphone users, and is designed to test the performance of mobile cellular connections. Once the app is downloaded, with access to wireless service, users can measure the speed of their wireless connection whenever and wherever they choose. Ookla LTE upload speeds by service provider for the second half of 2015 through the second half of 2016 can be found in Appendix III: Elements of Inter-Firm Rivalry.

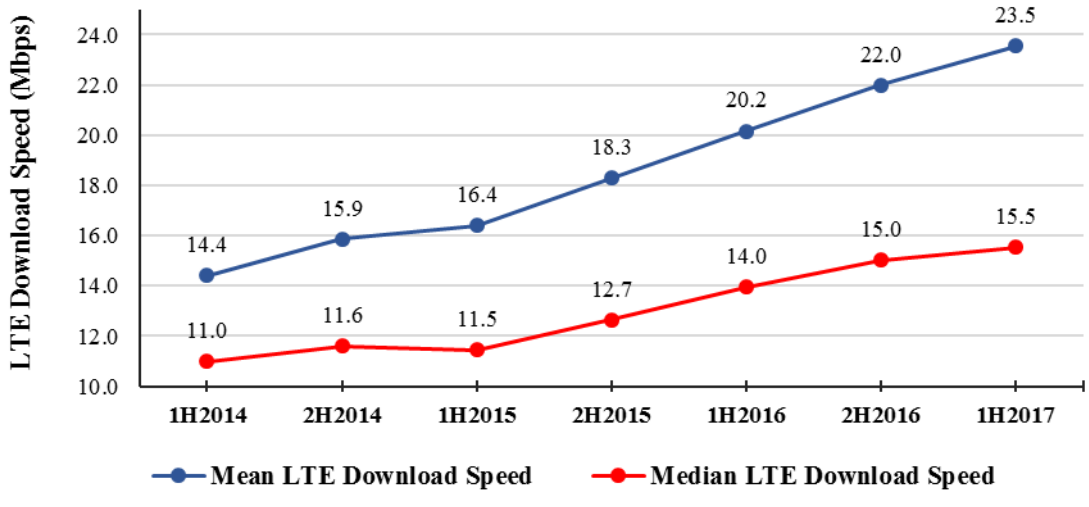
III.E.1 presents the increase over time for mean and median LTE download speeds for all providers, from the first half of 2014 through the first half of 2017.

Table III.E.1
Ookla Speed Test--Estimated LTE Download Speeds by Service Provider, Nationwide

Service Provider	2H2015			1H2016			2H2016		
	Mean Down load Speed (Mbps)	Median Down load Speed (Mbps)	Number of Tests ('000s)	Mean Down load Speed (Mbps)	Median Down load Speed (Mbps)	Number of Tests ('000s)	Mean Down load Speed (Mbps)	Median Down load Speed (Mbps)	Number of Tests ('000s)
AT&T	16.96	11.72	2,720	20.05	14.49	2,630	22.80	16.18	2,526
Sprint	13.65	8.50	2,604	15.80	9.54	2,774	15.54	9.14	2,291
T-Mobile	21.10	15.42	3,990	22.11	15.74	3,755	23.57	16.43	3,756
Verizon Wireless	19.66	14.48	2,899	21.32	15.53	2,792	23.60	17.12	3,066
Total	18.28	12.65	12,735	20.16	13.95	12,199	21.99	15.01	11,905

Source: Ookla SPEEDTEST intelligence data, © 2016 Ookla, LLC. All rights reserved. Published with permission of Ookla. The "Total" mean and median nationwide estimates are based on test results for all service providers included in the Ookla sample dataset.

Chart III.E.1
Ookla Speed Test: Total LTE Download Speeds, Nationwide



Source: Ookla SPEEDTEST intelligence data, © 2017 Ookla, LLC. All rights reserved. Published with permission of Ookla.

2. RootMetrics

91. RootMetrics runs a test program that measures mobile data, call, and text performance in all 50 states across the United States.[299] According to RootMetrics, it performs tests during all hours of the day, every day of the week, and nearly every week of the year, although the testing schedule is weighted more heavily toward typical consumer usage hours. Results are reported at the national, state, and metro levels, and then are combined and converted into scores using a proprietary algorithm. RootScores are meant to reflect a consumer's experience of network performance and are scaled from 0–100, with the lower limit representing network performance that would result in a poor consumer experience and the upper limit reflecting extraordinary performance.[300] RootMetrics has provided the Commission with nationwide median LTE download speeds for the second half of 2015 and the first half of 2016, as presented in Table III.E.2 below.

Table III.E.2
RootMetrics Speed Test–Estimated LTE Download Speeds, Nationwide

Service Provider	2H2015		1H2016	
	Median Download speed (Mbps)	Number of Tests	Median Download speed (Mbps)	Number of Tests
AT&T	12.29	160,752	11.95	153,390
Sprint	8.19	159,870	7.55	153,340
T-Mobile	12.84	160,491	12.77	153,347
Verizon Wireless	17.04	160,642	16.67	153,478

Source: RootMetrics Data, 2016, © RootMetrics. All rights reserved. Published with permission of RootMetrics. In 2H2015, there were 3,851,608 total tests, including 6,607 indoor locations. In 1H2016, there were 3,676,470 total tests, including 4,249 indoor locations.

3. CalSPEED

92. CalSPEED is an open source, non-proprietary, network performance measurement tool and methodology created for the CPUC with the assistance of a grant from the National Telecommunications and Information Administration (NTIA).[301] The CalSPEED data presented in this

[299] Tests are conducted in the 125 most populous metropolitan markets and in each of the 50 U.S. states. RootMetrics take stationary readings at discrete locations, and also test while driving between locations. RootMetrics, Mobile performance in the US part 1: performance across the entire United States, http://rootmetrics.com/en-US/content/mobile-performance-in-the-us-part-1-performance-across-the-entire-united (last visited Sept. 1, 2017). Tests are conducted on the leading Android smartphone available from each service provider. RootMetrics, Testing Methodology, http://rootmetrics.com/en-US/methodology (last visited Sept. 1, 2017). In addition to the performance scores at each location, the RootMetrics Online Coverage Map is available at http://webcoveragemap.rootmetrics.com/us (last visited Sept. 1, 2017). This map incorporates the sample data described above, along with crowdsourced data that are available through consumer use of the free Coverage Map app, available on Android and iOS.

[300] *Id*. RootMetrics LTE upload speeds by service provider, as well as RootMetrics National Speed Index results, are presented in Appendix III: Elements of Inter-Firm Rivalry.

[301] For more discussion regarding CalSPEED, *see Nineteenth Report*, 31 FCC Rcd at 10613, para. 110.

Report are the result of a structured sampling program of nearly 2,000 locations scattered throughout California.[302] Mean and median LTE download speed measurements for the state of California, estimated using CalSPEED data collected from the second half of 2015 through the second half of 2016, are presented in Table III.E.3 below.

Table III.E.3
CalSPEED--Estimated LTE Download Speeds by Service Provider, California Only

Service Provider	Fall 2015			Spring 2016			Fall 2016		
	Mean LTE Down load Speed (Mbps)	Median LTE Down load Speed (Mbps)	Number of Tests	Mean LTE Down load Speed (Mbps)	Median LTE Down load Speed (Mbps)	Number of Tests	Mean LTE Down load Speed (Mbps)	Median LTE Down load Speed (Mbps)	Number of Tests
AT&T	12.26	11.18	3,044	14.01	11.76	1,554	14.04	14.40	1,517
Sprint	9.78	7.87	1,970	9.68	6.74	1,087	9.54	8.11	1,045
T-Mobile	11.84	11.93	2,220	13.11	10.63	1,257	11.97	11.27	1,216
Verizon	14.36	15.49	3,124	16.41	16.09	1,583	16.69	18.43	1,626
Total	12.33	12.17	10,358	13.64	11.47	5,481	13.50	13.70	5,404

Source: The estimated speeds are based on the CalSPEED data. Fall 2015 tests were taken between the dates of Dec. 3, 2015 to Jan. 22, 2016. Spring 2016 tests were taken between the dates of Apr. 14, 2016 through May 25, 2016. Fall 2016 tests were taken between the dates of Sept. 29, 2016 to Nov. 4, 2016.

IV. CONCLUSION

93. Competition continues to play an essential role in the mobile wireless marketplace–leading to lower prices, more innovation, and higher quality service for American consumers. In this *Twentieth Report*, we analyze competition in the mobile wireless marketplace pursuant to Section 332(c)(1)(C) of the Communications Act. Focusing only on competition in the provision of mobile wireless services, rather than attempting to examine the broader mobile wireless ecosystem, our assessment of various generally accepted metrics of competition in this *Twentieth Report* indicates that there is effective competition in the marketplace for mobile wireless services. In addition, we note that, for purposes of Section 332(c)(1)(C), no single service provider has a dominant market share at the nationwide level.

[302] CPUC, Mobile Broadband Testing, http://cpuc.ca.gov/General.aspx?id=1778 (last visited Sept. 1, 2017). These sites are visited twice a year and tests are run on both Android smartphones and tablets, for each of the four nationwide service providers. Data can be downloaded from CPUC Mobile Broadband Testing. FCC staff downloaded the complete raw data set for use in this *Report*. In our presentation of CalSPEED data, we have dropped any observation that was not in the provider's coverage area, or any observation that was terminated by the tester, which corresponds to the method used by CPUC. If the test was terminated for any other reason, we followed CPUC guidance and assumed a download speed of zero Mbps for that particular test. Tests were not included if the testing device was not a smartphone. Finally, results from each site and for each provider were averaged across all east coast and west coast servers, and the top 1% of resulting speed observations were trimmed from the dataset, by provider and separately for each time period. This is a surveyed test and not crowdsourced, and therefore some of the cleaning criteria differ from other speed tests. CPUC LTE upload speeds by service provider for the second half of 2015 through the second half of 2016 can be found in Appendix III: Elements of Inter-Firm Rivalry.

94. This conclusion is supported by the following industry facts and market characteristics, among others. First, consumer demand and output continue to increase. Both the number of wireless connections and average data usage per connection have been rising in recent years. In addition, service providers continue to expand and adjust data plans and pricing, including adding new plans and reintroducing unlimited data plans to the mobile wireless marketplace, and based on various price metrics, average prices have been falling. Further, service providers have made significant investments in their networks over the past several years, which have resulted in higher broadband speeds, expanded network coverage, and increased network densification. In terms of LTE network coverage, a substantial majority of American consumers today are covered by four nationwide service providers, and there are numerous smaller providers that play an important role in local and regional markets. In addition, while demand for spectrum continues to increase, reflecting increased mobile broadband usage, the Commission in recent years has made available a significant amount of additional spectrum across a range of frequencies. Finally, service providers compete strongly in developing and deploying innovative technologies. Overall, these facts and market characteristics, as well as other facts and characteristics presented in this *Twentieth Report*, indicate that competition in the provision of mobile wireless services is effective.

V. PROCEDURAL MATTERS

95. This *Twentieth Report* is issued pursuant to authority contained in Section 332(c)(1)(C) of the Communications Act of 1934, as amended, 47 U.S.C. § 332(c)(1)(C).

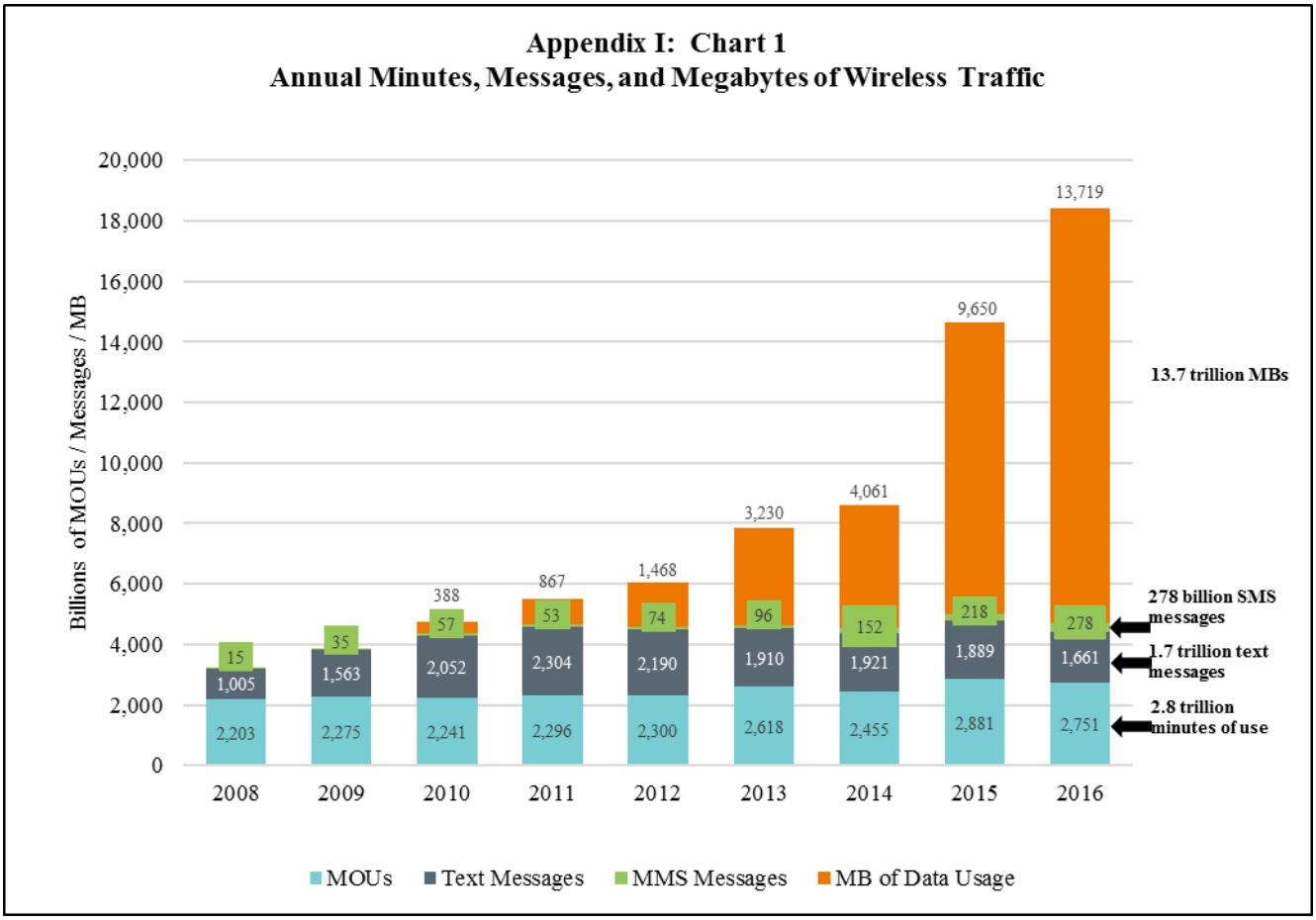
96. It is ORDERED that copies of this *Twentieth Report* be sent to the appropriate committees and subcommittees of the United States House of Representatives and the United States Senate.

97. It is FURTHER ORDERED that the proceeding in WT Docket No. 17-69 IS TERMINATED.

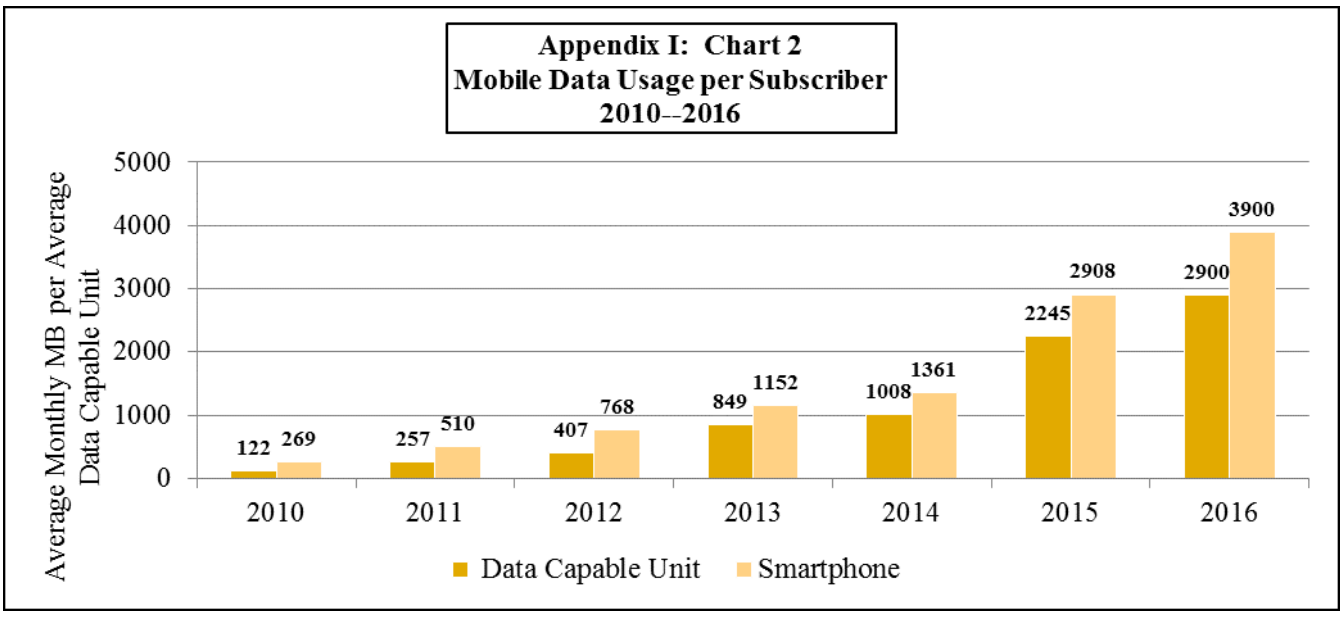
FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary
Federal Communications Commission

APPENDIX I: TRENDS IN CONSUMER USAGE



Source: CTIA Wireless Industry Indices Year-End 2016, Chart 38.



Source: CTIA Wireless Industry Indices Year-End 2016, Chart 32.

APPENDIX II: CHARACTERISTICS OF THE MOBILE WIRELESS INDUSTRY

Section II.B: Connections and Subscribers

Appendix II: Table II.B.i
***Estimated* Total Mobile Wireless Connections: 2003–2016**

	NRUF			CTIA
Year	Connections (millions)	Increase from previous year (millions)	Connections Per 100 People	Estimated Connections (millions)
2003	160.6	18.8	54	158.7
2004	184.7	24.1	62	182.1
2005	213.0	28.3	71	207.9
2006	241.8	28.8	80	233.0
2007	263.0	21.2	86	255.4
2008	279.6	16.6	91	270.3
2009	290.7	11.1	94	285.6
2010	301.8	11.1	97	296.3
2011	317.3	15.5	101	316.0
2012	329.2	11.9	105	326.5
2013	339.2	10.0	108	335.7
2014	357.1	17.2	114	355.4
2015	378.2	21.1	121	377.9
2016	398.4	20.2	127	395.9

Source: NRUF 2003–2016; CTIA Wireless Industry Year-End Indices; Census data.

Appendix II: Table II.B.ii
Quarterly Total Mobile Wireless Connections by Service Segment, 2013-2016

Quarter Year	Postpaid	Prepaid	Wholesale	Connected Devices	Total Connections
1Q13	217,887	73,007	16,847	28,233	335,974
2Q13	218,473	71,687	17,445	29,551	337,156
3Q13	221,142	71,906	17,881	30,932	341,862
4Q13	223,759	72,978	18,683	31,958	347,378
1Q14	225,580	74,827	17,738	33,661	351,807
2Q14	228,348	73,875	18,713	35,234	356,170
3Q14	231,572	73,774	20,210	38,462	364,017
4Q14	235,349	74,484	21,148	40,490	371,471
1Q15	237,409	74,606	22,236	41,961	376,213
2Q15	240,108	74,653	23,575	43,970	382,307
3Q15	242.916	75,488	25,016	46,621	390,042
4Q15	246,361	75,800	25,585	48,701	396,448
1Q16	252,470	76,342	22,182	51,046	402,040
2Q16	254,154	76,952	23,105	53,045	407,257
3Q16	254,624	78,599	24,375	55,179	412,778
4Q16	257,158	77,216	25,031	57,279	416,684

Source: UBS Investment Research. US Wireless 411, Version 51; US Wireless 411, Version 59; UBS Wireless 411, Feb 2017, Figure 25.

Section II.F: Wireless Infrastructure

Appendix II: Table II.F.i
Year-End Cell Site Counts by Service Provider, 2013–2016[1]

Cell Sites	2013	2014	2015	2016
AT&T	61,800	71,768	66,500	67,000
Sprint	55,000	55,000	55,000	50,000
T-Mobile	63,879	61,079	57,971	59,417
Verizon Wireless	46,655	50,065	54,000	58,300
U.S. Cellular	6,975	6,220	6,297	6,415*
Total by Top Wireless Service Providers	**244,753**	**245,585**	**240,735**	**241,091**
CTIA Reported Total Industry-wide Cell Sites	**304,360**	**298,055**	**307,626**	**308,334**

Source: Cell site counts for individual service providers are from UBS Wireless 411, Feb 2017, Figure 39. The total industry-wide cell count is from CTIA Wireless Industry Indices Year-End 2016.

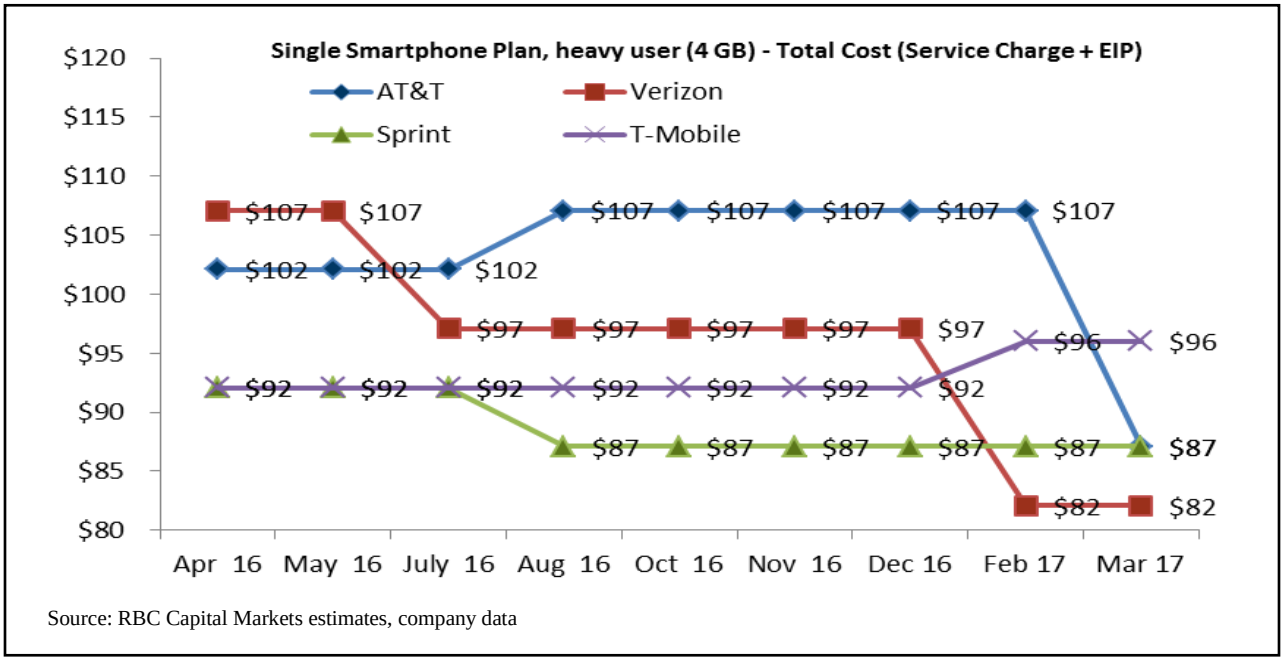
* U.S. Cellular 2016 source: U.S. Cellular Reports Fourth Quarter and Full Year 2016 Results (Feb. 24, 2017), http://investors.uscellular.com/news/news-release-details/2017/US-Cellular-reports-fourth-quarter-and-full-year-2016-results/default.aspx.

[1] Because multiple cell sites can be co-located in the same "tower" site, the reported cell sites should not be equated with "towers." The reported cell sites include repeaters and other cell-extending devices (e.g., femtocells, or distributed antenna systems). CTIA Wireless Industry Indices Year-End 2016 at 72.

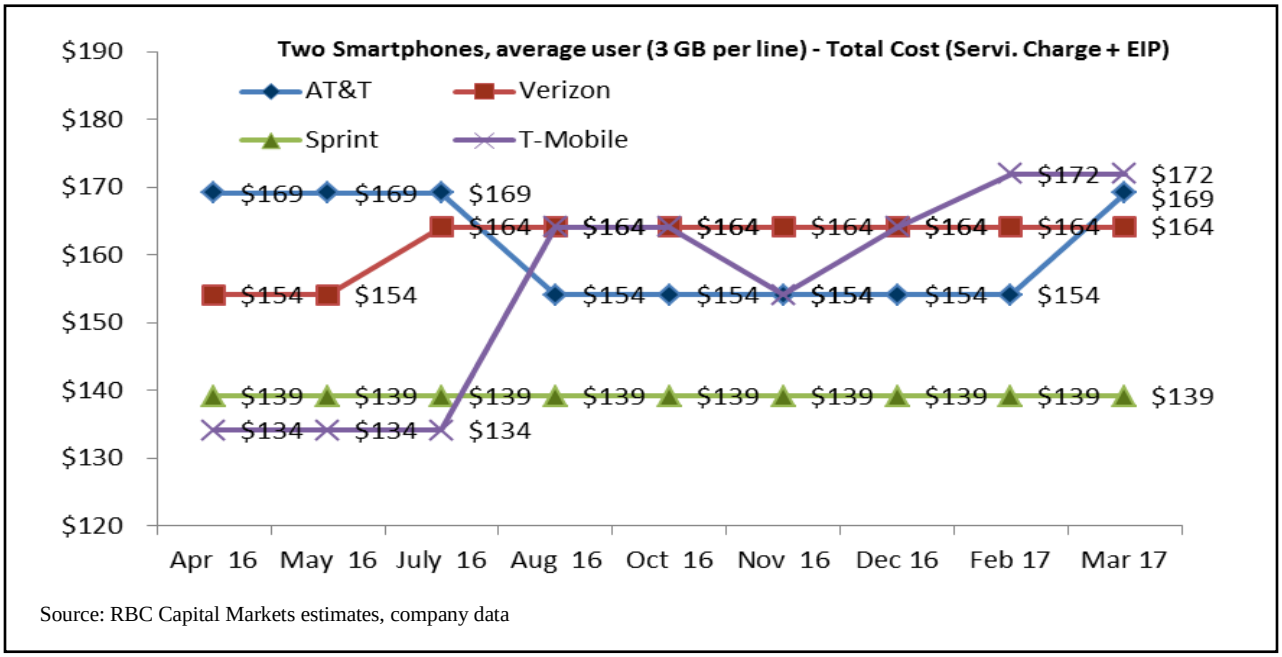
APPENDIX III: ELEMENTS OF INTER-FIRM RIVALRY

Section III.A: Pricing Levels and Trends

The charts below show pricing changes for various plans across the four nationwide service providers, sourced from RBC Capital Markets, for the time period April 2016 through March 2017.[2]

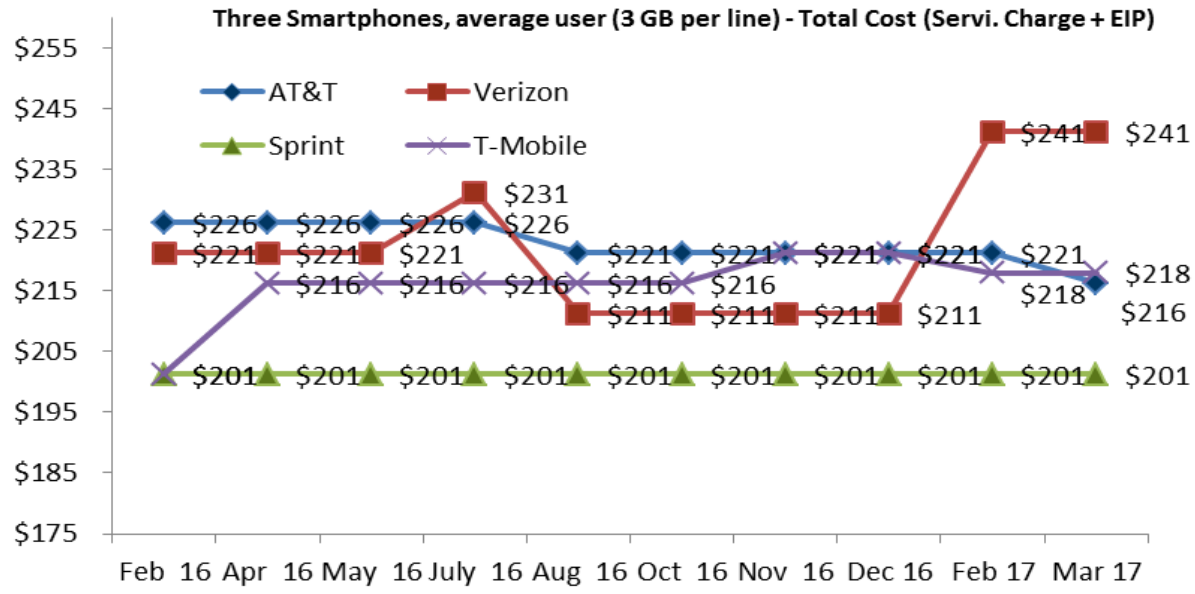


Source: RBC Capital Markets estimates, company data

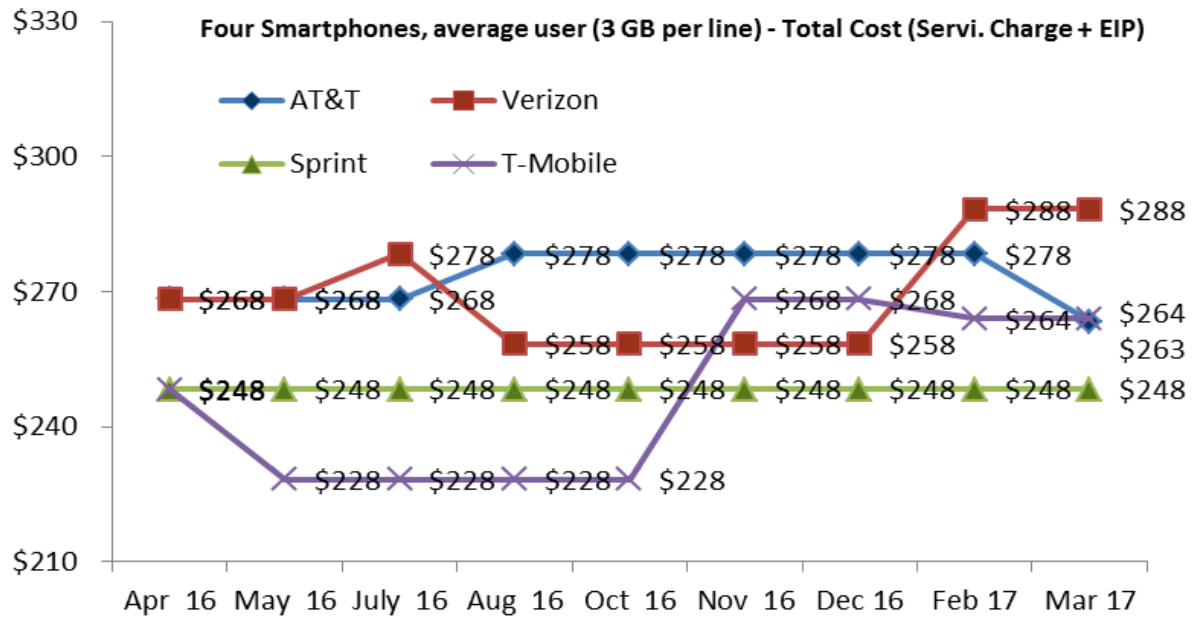


Source: RBC Capital Markets estimates, company data

[2] Jonathan Atkin, Bora Lee, and Brajesh Mishra, RBC Capital Markets, Equity Research, Wireless Telecommunications Services, (Mar. 16, 2017).



Source: RBC Capital Markets estimates, company data



Source: RBC Capital Markets estimates, company data

Appendix III: Table III.A.i
Change in CPI, 1997-2016

Year	CPI		Wireless Telephone Services CPI		Telephone Services CPI		Land-line Telephone Services CPI	
	Annual Index Average	Annual Change	Annual Index Average	Annual Change	Annual Index Average	Annual Change	Annual Index Average	Annual Change
1997	100.0		100.0		100.0			
1998	101.6	1.6%	95.1		100.7			
1999	103.8	2.2%	84.9	-10.7%	100.1	-0.6%		
2000	107.3	3.4%	76.0	-10.5%	98.5	-1.6%		
2001	110.3	2.8%	68.1	-10.4%	99.3	0.8%		
2002	112.1	1.6%	67.4	-1.0%	99.7	0.4%		
2003	114.6	2.3%	66.8	-0.9%	98.3	-1.4%		
2004	117.7	2.7%	66.2	-0.9%	95.8	-2.5%		
2005	121.7	3.4%	65.0	-1.8%	94.9	-0.9%		
2006	125.6	3.2%	64.6	-0.6%	95.8	0.9%		
2007	129.2	2.9%	64.4	-0.3%	98.2	2.6%		
2008	134.1	3.8%	64.2	-0.2%	100.5	2.2%		
2009	133.7	-0.4%	64.3	0.0%	102.4	1.9%	100.0	
2010	135.8	1.6%	62.4	-2.9%	102.4	0.0%	101.6	
2011	140.1	3.2%	60.1	-3.6%	101.2	-1.1%	103.3	1.7%
2012	143.0	2.1%	59.7	-0.8%	101.7	0.5%	105.6	2.2%
2013	145.1	1.5%	58.6	-1.8%	101.6	-0.1%	108.1	2.4%
2014	147.5	1.6%	57.4	-2.1%	101.1	-0.4%	111.1	2.7%
2015	147.7	0.1%	55.2	-3.8%	99.3	-1.8%	113.4	2.1%
2016	149.5	1.3%	54.7	-1.0%	98.8	-0.5%	114.5	1.0%
1997 to 2016		**49.5%**		**-45.3%**		**-1.2%**		**12.7%**

Source: Data from Bureau of Labor Statistics. All CPI figures were taken from BLS databases. Bureau of Labor Statistics, http://www.bls.gov (last visited Sept. 1, 2017). Beginning in January 2010, the CPIs for local telephone service and long-distance telephone service were discontinued and replaced by a new CPI for land-line telephone services.[3]

[3] Starting in December 1997, the basket included a category for cellular/wireless telephone services. The index used in this analysis, the CPI for All Urban Consumers (CPI-U), represents about 87% of the total U.S. population. Bureau of Labor Statistics, Consumer Price Index: Frequently Asked Questions, http://www.bls.gov/cpi/cpifaq.htm (last visited Sept. 1, 2017). The CPI category "Telephone Services" has two components: wireless telephone services and landline telephone services. Wireless telephone services include "all service charges, applicable per-plan charges or per-minute call charges, and other charges normally included in a cellular plan are eligible for pricing. Internet access is also eligible." Landline telephone services include "charges for all types of local and long-distance residential services are eligible for collection, including charges for dial tone services, line maintenance and access, 911 services, directory assistance, touch-tone service, and other special features and mandatory charges and installation." Additional information can be found at Bureau of Labor Statistics, Consumer Price Index: How the Consumer Price Index Measures Price Change for Telephone Services, https://www.bls.gov/cpi/factsheet-telephone-services.htm (last visited Sept. 1, 2017).

Appendix III: Table III.A.ii
Annualized Average Revenue Per Reported Subscriber Unit (ARPU): 1993–2016

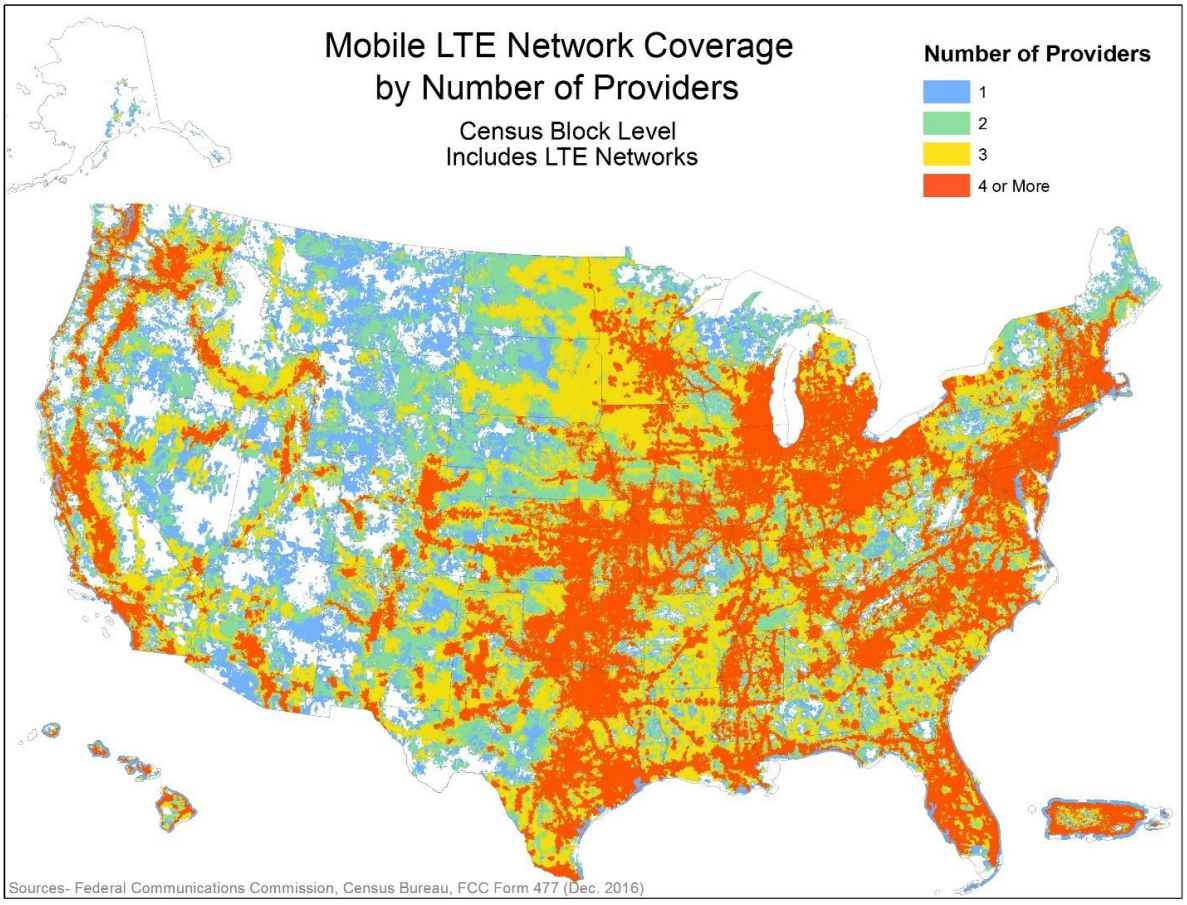
Year	Total Annual Service Revenue (thousands)	Percentage Change	Average Reported Subscribers	Average Monthly Revenue per Active Subscriber Unit
1993	$10,895,175		11,861,362	$76.55
1994	$14,229,922	30.6%	18,299,487	$64.80
1995	$19,081,239	34.1%	26,757,320	$59.43
1996	$23,634,971	23.9%	35,554,818	$55.40
1997	$27,485,633	16.3%	46,375,849	$49.39
1998	$33,133,175	20.6%	58,455,471	$47.23
1999	$40,018,489	20.8%	71,885,076	$46.39
2000	$52,466,020	31.1%	90,048,320	$48.55
2001	$65,316,235	24.5%	109,318,848	$49.79
2002	$76,508,187	17.1%	125,002,023	$51.00
2003	$87,624,093	14.5%	141,658,059	$51.55
2004	$102,121,210	16.5%	161,980,026	$52.54
2005	$113,538,221	11.2%	186,801,940	$50.65
2006	$125,456,825	10.5%	213,077,033	$49.07
2007	$138,869,304	10.7%	234,921,960	$49.26
2008	$148,084,170	6.6%	252,539,475	$48.87
2009	$152,551,854	3.0%	265,038,212	$47.97
2010	$159,929,648	4.9%	280,392,201	$47.53
2011	$169,767,314	6.2%	306,840,648	$46.11
2012	$185,013,936	9.0%	314,685,754	$48.99
2013	$189,192,812	2.3%	323,133,932	$48.79
2014	$187,848,477	(0.7%)	335,606,098	$46.64
2015	$191,949,025	2.2%	358,228,494	$44.65
2016	$188,524,256	(1.8%)	378,554,642	$41.50

Source: Based on CTIA Wireless Industry Indices Year-End 2016.

Section III.D: Nationwide Network Coverage and Technology Upgrades

The maps, tables, and charts presented below are based on Commission estimates derived from census block analysis of December 2016 Form 477 coverage maps, using both the centroid[4] and the actual area coverage methodologies.[5]

LTE Coverage Nationwide by Number of Service Providers
Form 477, Centroid Method, December 2016



Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

[4] The centroid methodology provides estimates of the percentage of the population located in census blocks with a certain number of service providers and represents network coverage. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. In addition, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block. This is likely to be particularly relevant in larger rural census blocks. For both these reasons, the number of service providers in a census block does not necessarily reflect the number of choices available to a particular individual or household.

[5] Since we do not know the distribution of either the population or road miles at the sub-census block level, as noted above, we must approximate the percentage that is covered by each technology. To do this, we assume that both population and road miles are distributed uniformly across each census block. The fraction of the population or road miles covered in a census block is assumed to be proportional to the fraction of the actual area covered. We then sum the estimated covered population (road miles) across blocks to estimate the total covered population (road miles) within the United States.

Appendix III: Table III.D.i
***Estimated* Overall Wireless Coverage by Census Block Including Federal Land**
Form 477, Centroid Method, December 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs in those Blocks	% Total US POPs	Square Miles in those Blocks	% Total US Square Miles	Road Miles in those Blocks	% Total US Road Miles
U.S. Total	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,495,816	312,318,080	100.0%	2,860,209	80.5%	6,616,224	97.0%
2 or more	10,289,924	311,578,912	99.7%	2,552,228	71.9%	6,285,795	92.2%
3 or more	9,610,063	306,733,376	98.2%	1,976,189	55.7%	5,437,258	79.8%
4 or more	8,122,859	291,384,672	93.3%	1,217,636	34.3%	3,997,894	58.6%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix III: Table III.D.ii
***Estimated* Overall Wireless Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2016

Provider	Number of Blocks	POPS in those Blocks	% Total US POPs	Square Miles in those Blocks	% Total US Square Miles	Road Miles in those Blocks	% Total US Road Miles
U.S. Total	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	10,158,469	310,402,440	99.3%	2,553,426	71.9%	6,204,988	91.0%
Sprint	7,654,799	287,660,631	92.1%	976,639	27.5%	3,525,826	51.7%
T-Mobile	8,849,655	297,340,337	95.2%	1,690,976	47.6%	4,834,578	70.9%
Verizon Wireless	9,859,047	304,313,314	97.4%	2,377,385	67.0%	5,945,348	87.2%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.

Appendix III: Table III.D.iii
***Estimated* Overall Wireless Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2016

Provider	Covered POPs	% Total US POPs	Covered Square Miles	% Total US Square Miles	Covered Road Miles	% Total US Road Miles
U.S. Total	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	310,325,279	99.3%	2,546,087	71.7%	6,187,858	90.8%
Sprint	287,524,311	92.0%	977,391	27.5%	3,520,150	51.6%
T-Mobile	297,234,855	95.1%	1,695,206	47.7%	4,830,828	70.9%
Verizon Wireless	304,153,186	97.3%	2,353,257	66.3%	5,913,414	86.7%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.iv
***Estimated* LTE Coverage by Census Block Including Federal Land**
Form 477, Centroid Method, December 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs in those Blocks	% Total US POPs	Square Miles in those Blocks	% Total US Square Miles	Road Miles in those Blocks	% Total US Road Miles
U.S. Total	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,320,856	311,700,096	99.8%	2,594,112	73.1%	6,336,745	92.9%
2 or more	9,892,909	309,443,872	99.0%	2,144,384	60.4%	5,724,591	84.0%
3 or more	9,003,164	301,978,016	96.6%	1,576,584	44.4%	4,749,465	69.7%
4 or more	7,070,546	276,897,216	88.6%	813,451	22.9%	3,105,382	45.5%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix III: Table III.D.v
***Estimated* LTE Coverage by Census Block Including Federal Land**
Form 477, Actual Area Coverage Method, December 2016

Number of Providers with Coverage in a Block	Covered POPs	% Total US POPs	Covered Square Miles	% Total US Square Miles	Covered Road Miles	% Total US Road Miles
U.S. Total	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	311,650,127	99.7%	2,583,240	72.7%	6,316,546	92.6%
2 or more	309,282,273	99.0%	2,131,980	60.0%	5,700,783	83.6%
3 or more	301,756,857	96.6%	1,571,968	44.3%	4,734,886	69.4%
4 or more	276,615,446	88.5%	811,655	22.9%	3,094,882	45.4%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.vi
***Estimated* LTE Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2016

Provider	Number of Blocks	POPS in those Blocks	% Total US POPs	Square Miles in those Blocks	% Total US Square Miles	Road Miles in those Blocks	% Total US Road Miles
U.S. Total	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	9,371,159	305,044,030	97.6%	1,884,170	53.1%	5,227,070	76.7%
Sprint	6,819,732	274,334,994	87.8%	706,872	19.9%	2,881,409	42.3%
T-Mobile	8,744,514	295,725,994	94.6%	1,642,540	46.3%	4,738,782	69.5%
Verizon Wireless	9,747,080	303,246,208	97.0%	2,288,616	64.5%	5,804,749	85.1%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.

Appendix III: Table III.D.vii
***Estimated* LTE Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2016

Provider	Covered POPs	% Total US POPs	Covered Square Miles	% Total US Square Miles	Covered Road Miles	% Total US Road Miles
U.S. Total	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	304,873,426	97.6%	1,874,309	52.8%	5,207,363	76.4%
Sprint	274,121,224	87.7%	707,146	19.9%	2,874,422	42.2%
T-Mobile	295,591,220	94.6%	1,646,823	46.4%	4,734,613	69.4%
Verizon Wireless	303,065,589	97.0%	2,265,590	63.8%	5,772,000	84.7%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.viii
***Estimated* Overall Wireless Coverage in Rural Areas by Census Block Including Federal Land**
Form 477, Centroid Method, December 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs in those Blocks	% Total Rural US POPs	Square Miles in those Blocks	% Total Rural US Square Miles	Road Miles in those Blocks	% Total Rural US Road Miles
U.S. Total	*4,937,330*	*56,094,554*	*100.0%*	*2,987,281*	*100.0%*	*4,518,876*	*100.0%*
1 or more	4,830,115	55,959,148	99.8%	2,305,284	77.2%	4,326,172	95.7%
2 or more	4,639,721	55,317,968	98.6%	2,014,096	67.4%	4,014,109	88.8%
3 or more	4,016,415	51,072,240	91.0%	1,473,807	49.3%	3,221,633	71.3%
4 or more	2,742,692	39,566,248	70.5%	787,800	26.4%	1,943,792	43.0%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix III: Table III.D.ix
***Estimated* Overall Wireless Coverage in Non-Rural Areas by Census Block Including Federal Land**
Form 477, Centroid Method, December 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs in those Blocks	% Total Non-Rural US POPs	Square Miles in those Blocks	% Total Non-Rural US Square Miles	Road Miles in those Blocks	% Total Non-Rural US Road Miles
U.S. Total	*5,671,972*	*256,376,773*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,665,701	256,358,944	100.0%	554,925	98.5%	2,290,052	99.6%
2 or more	5,650,203	256,260,944	100.0%	538,132	95.5%	2,271,686	98.8%
3 or more	5,593,648	255,661,136	99.7%	502,382	89.1%	2,215,625	96.4%
4 or more	5,380,167	251,818,416	98.2%	429,836	76.3%	2,054,102	89.4%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix III: Table III.D.x
Estimated Rural Wireless Coverage in the U.S. by Service Provider
Form 477, Centroid Method, December 2016

Provider	Number of Blocks	POPS in those Blocks	% Total Rural US POPs	Road Miles in those Blocks	% Total US Rural Road Miles
U.S. Total	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	4,507,660	54,201,991	96.6%	3,929,354	87.0%
Sprint	2,269,266	36,032,381	64.2%	1,476,921	32.7%
T-Mobile	3,370,160	44,544,057	79.4%	2,679,681	59.3%
Verizon Wireless	4,313,593	52,264,691	93.2%	3,721,479	82.4%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.

Appendix III: Table III.D.xi
Estimated Non-Rural Wireless Coverage in the U.S. by Service Provider
Form 477, Centroid Method, December 2016

Provider	Number of Blocks	POPS in those Blocks	% Total Non-Rural US POPs	Road Miles in those Blocks	% Total Non-Rural US Road Miles
U.S. Total	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,650,809	256,200,449	99.9%	2,275,633	99.0%
Sprint	5,385,533	251,628,250	98.1%	2,048,905	89.1%
T-Mobile	5,479,495	252,796,280	98.6%	2,154,896	93.7%
Verizon Wireless	5,545,454	252,048,623	98.3%	2,223,869	96.7%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.

Appendix III: Table III.D.xii
Estimated Rural Wireless Coverage in the U.S. by Service Provider
Form 477, Actual Area Coverage Method, December 2016

Provider	Covered POPs	% Total Rural US POPs	Covered Road Miles	% Total US Rural Road Miles
U.S. Total	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	54,161,808	96.6%	3,913,834	86.6%
Sprint	35,980,745	64.1%	1,474,406	32.6%
T-Mobile	44,488,508	79.3%	2,675,963	59.2%
Verizon Wireless	52,172,107	93.0%	3,692,174	81.7%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.xiii
***Estimated* Non-Rural Wireless Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2016

Provider	Covered POPs	% Total Non-Rural US POPs	Covered Road Miles	% Total Non-Rural US Road Miles
U.S. Total	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	256,163,470	99.9%	2,274,025	98.9%
Sprint	251,543,566	98.1%	2,045,744	89.0%
T-Mobile	252,746,348	98.6%	2,154,865	93.7%
Verizon Wireless	251,981,080	98.3%	2,221,240	96.6%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.xiv
***Estimated* LTE Coverage in Rural Areas by Census Block Including Federal Land**
Form 477, Centroid, December 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs in those Blocks	% Total Rural US POPs	Square Miles in those Blocks	% Total Rural US Square Miles	Road Miles in those Blocks	% Total Rural US Road Miles
U.S. Total	*4,937,330*	*56,094,554*	*100.0%*	*2,987,281*	*100.0%*	*4,518,876*	*100.0%*
1 or more	4,665,551	55,399,592	98.8%	2,053,426	68.7%	4,060,830	89.9%
2 or more	4,273,937	53,444,832	95.3%	1,632,801	54.7%	3,488,415	77.2%
3 or more	3,477,248	47,207,160	84.2%	1,105,642	37.0%	2,594,464	57.4%
4 or more	1,983,516	31,975,876	57.0%	457,334	15.3%	1,252,201	27.7%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix III: Table II.D.xv
***Estimated* LTE Coverage in Non-Rural Areas by Census Block Including Federal Land**
Form 477, Centroid Method, December 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs in those Blocks	% Total Non-Rural US POPs	Square Miles in those Blocks	% Total Non-Rural US Square Miles	Road Miles in those Blocks	% Total Non-Rural US Road Miles
U.S. Total	*5,671,972*	*256,376,773*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,655,305	256,300,480	100.0%	540,687	95.9%	2,275,915	99.0%
2 or more	5,618,972	255,999,024	99.9%	511,583	90.8%	2,236,175	97.3%
3 or more	5,525,916	254,770,864	99.4%	470,942	83.6%	2,155,001	93.7%
4 or more	5,087,030	244,921,344	95.5%	356,118	63.2%	1,853,181	80.6%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix III: Table III.D.xvi
Estimated LTE Coverage in Rural Areas by Census Block Including Federal Land
Form 477, Actual Area Coverage Method, December 2016

Number of Providers with Coverage in a Block	Covered POPs	% Total Rural US POPs	Covered Road Miles	% Total Rural US Road Miles
U.S. Total	56,094,554	100.0%	4,518,876	100.0%
1 or more	55,357,360	98.7%	4,041,474	89.4%
2 or more	53,351,473	95.1%	3,466,688	76.7%
3 or more	47,109,619	84.0%	2,583,634	57.2%
4 or more	31,899,472	56.9%	1,246,467	27.6%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.xvii
Estimated LTE Coverage in Non-Rural Areas by Census Block Including Federal Land
Form 477, Actual Area Coverage Method, December 2016

Number of Providers with Coverage in a Block	Covered POPs	% Total Non-Rural US POPs	Covered Road Miles	% Total Non-Rural US Road Miles
US Total (actual)	256,376,773	100.0%	2,298,858	100.0%
1 or more	256,292,768	100.0%	2,275,072	99.0%
2 or more	255,930,800	99.8%	2,234,095	97.2%
3 or more	254,647,238	99.3%	2,151,252	93.6%
4 or more	244,715,974	95.5%	1,848,414	80.4%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.xviii
Estimated Rural LTE Coverage in the U.S. by Service Provider
Form 477, Centroid Method, December 2016

Provider	Number of Blocks	POPS in those Blocks	% Total Rural US POPs	Road Miles in those Blocks	% Total US Rural Road Miles
U.S. Total	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	3,805,464	49,840,011	88.8%	3,032,408	67.1%
Sprint	1,733,600	29,844,941	53.2%	1,035,715	22.9%
T-Mobile	3,296,978	43,831,229	78.1%	2,604,127	57.6%
Verizon Wireless	4,222,673	51,630,610	92.0%	3,599,369	79.7%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.

Appendix III: Table III.D.xix
***Estimated* Non-Rural LTE Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2016

Provider	Number of Blocks	POPS in those Blocks	% Total Non-Rural US POPs	Road Miles in those Blocks	% Total Non-Rural US Road Miles
U.S. Total	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,565,695	255,204,019	99.5%	2,194,662	95.5%
Sprint	5,086,132	244,490,053	95.4%	1,845,693	80.3%
T-Mobile	5,447,536	251,894,765	98.3%	2,134,655	92.9%
Verizon Wireless	5,524,407	251,615,598	98.1%	2,205,380	95.9%

Source: Based on centroid analysis of December 2016 Form 477 and 2010 Census data. That a particular service provider has indicated that it has network coverage in a particular census block does not necessarily mean that it offers service to residents in that census block. Also, the fact that a service provider reports coverage in a particular census block does not mean that it necessarily provides coverage everywhere in the census block.

Appendix III: Table III.D.xx
***Estimated* Rural LTE Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2016

Provider	Covered POPs	% Total Rural US POPs	Covered Road Miles	% Total US Rural Road Miles
U.S. Total	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	49,756,255	88.7%	3,016,392	66.8%
Sprint	29,794,042	53.1%	1,032,547	22.8%
T-Mobile	43,768,877	78.0%	2,600,256	57.5%
Verizon Wireless	51,530,498	91.9%	3,569,677	79.0%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix III: Table III.D.xxi
***Estimated* Non-Rural LTE Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2016

Provider	Covered POPs	% Total Non-Rural US POPs	Covered Road Miles	% Total Non-Rural US Road Miles
U.S. Total	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	255,117,172	99.5%	2,190,971	95.3%
Sprint	244,327,182	95.3%	1,841,875	80.1%
T-Mobile	251,822,343	98.2%	2,134,357	92.8%
Verizon Wireless	251,535,091	98.1%	2,202,323	95.8%

Source: Based on actual area analysis of December 2016 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Section III.E: Speed of Service

***Ookla*:** An in-depth discussion of the Ookla speed test is available in the *Seventeenth Report*.[6] We present here LTE upload speeds within the United States for the second half of 2015 through the second half of 2016.

Appendix III: Table III.E.i
Ookla Speed Test - Estimated LTE Upload Speeds by Service Provider, Nationwide

Service Provider	2H2015			1H2016			2H2016		
	Mean Upload Speed (Mbps)	Median Upload Speed (Mbps)	Number of Tests ('000s)	Mean Upload Speed (Mbps)	Median Upload Speed (Mbps)	Number of Tests ('000s)	Mean Upload Speed (Mbps)	Median Upload Speed (Mbps)	Number of Tests ('000s)
AT&T	6.43	4.75	2,720	7.25	5.37	2,630	7.44	5.23	2,526
Sprint	4.51	3.46	2,604	4.93	3.91	2,774	4.75	3.50	2,291
T-Mobile	11.22	9.23	3,990	12.38	9.79	3,755	11.96	9.24	3,756
Verizon Wireless	7.87	4.89	2,899	8.30	5.10	2,792	8.44	4.99	3,066
Total	7.99	5.50	12,735	8.73	5.87	12,199	8.74	5.67	11,905

Source: Ookla SPEEDTEST intelligence data, © 2016 Ookla, LLC. All rights reserved. Published with permission of Ookla. The "Total" mean and median nationwide estimates are based on test results for all service providers included in the Ookla sample dataset.

RootMetrics. An in-depth discussion of the RootMetrics dataset is available in the *Seventeenth Report*.[7] We present here LTE upload speeds for the second half of 2015 and the first half of 2016, and mobile wireless indices within the United States for the second half of 2015 through the second half of 2016.

Appendix III: Table III.E.ii
RootMetrics Speed Test–Estimated LTE Upload Speeds, Nationwide

Service Provider	2H2015		1H2016	
	Median Upload speed (Mbps)	Number of Tests	Median Upload speed (Mbps)	Number of Tests
AT&T	6.71	161,124	5.81	153,140
Sprint	3.16	160,314	3.00	153,064
T-Mobile	11.30	160,862	11.02	153,095
Verizon Wireless	10.47	161,005	9.05	153,234

Source: RootMetrics Data, 2016, © RootMetrics. All rights reserved. Published with permission of RootMetrics. In 2H2015, there were 3,851,608 total tests, including 6,607 indoor locations. In 1H2016, there were 3,676,470 total tests, including 4,249 indoor locations.

[6] *Seventeenth Report*, 29 FCC Rcd at 15465-66, Appendix VI., paras. 1-6. The upload and download speeds were calculated by Ookla and provided to the Commission for use in this *Report*.

[7] *Seventeenth Report*, 29 FCC Rcd at 15467-68, Appendix VI., paras 10-11.

Appendix III: Table III.E.iii
RootMetrics National Speed Index Data, 2nd Half 2015--2st Half 2016[8]

	2nd Half 2015			1st Half 2016			2nd Half 2016		
Service Provider	Speed Index	Data Index	Text Index	Speed Index	Data Index	Text Index	Speed Index	Data Index	Text Index
AT&T	86.8	93.2	96.5	86.1	92.8	95.6	89.6	94.4	95.3
Sprint	73.1	83.1	95.8	72.2	84.3	94.1	72.3	82.5	95.0
T-Mobile	84.7	87.1	92.2	85.8	89.9	90.8	87.1	90.6	89.1
Verizon Wireless	92.0	95.9	97.0	91.0	95.6	96.9	93.3	96.5	96.5

Source: RootMetrics Data, © RootMetrics. All rights reserved. Published with permission of RootMetrics. In 2H2015, there were 3,851,608 total tests, including 6,607 indoor locations. In 1H2016, there were 3,676,470 total tests, including 4,249 indoor locations. In 2H2016, there were 3,690,123 total tests, including 4,283 indoor locations.

CalSPEED. An in-depth discussion of the CalSPEED dataset is available in the *Seventeenth Report*.[9] We present here LTE upload speeds within California for the fall of 2015 through the fall of 2016.[10]

Appendix III: Table III.E.iv
CalSPEED - Estimated LTE Upload Speeds by Service Provider, California Only

Service Provider	Fall 2015			Spring 2016			Fall 2016		
	Mean LTE Upload Speed (Mbps)	Median LTE Upload Speed (Mbps)	Number of Tests	Mean LTE Upload Speed (Mbps)	Median LTE Upload Speed (Mbps)	Number of Tests	Mean LTE Upload Speed (Mbps)	Median LTE Upload Speed (Mbps)	Number of Tests
AT&T	5.88	5.41	3,044	5.78	5.46	1,554	6.89	6.44	1,516
Sprint	4.14	3.60	1,968	3.65	3.14	1,088	3.95	3.20	1,045
T-Mobile	7.92	9.07	2,220	6.96	7.80	1,257	7.93	8.40	1,216
Verizon Wireless	7.59	8.16	3,124	7.28	7.80	1,583	8.16	8.77	1,626

Source: The estimated speeds are based on the CalSPEED data. Fall 2015 tests were taken between the dates of Dec. 3, 2015 and Jan. 22, 2016. Spring 2016 tests were taken between the dates of Apr. 14, 2016 and May 25, 2016. Fall 2016 tests were taken between the dates of Sept. 29, 2016 and Nov. 4, 2016.

[8] RootMetrics, Methodology, http://rootmetrics.com/en-US/methodology (last visited Sept. 1, 2017). RootMetrics performs drive tests and stationary tests in specific locations, using the leading Android-based smartphone for each network. They measure network reliability and speed performance across a range of activities, like checking email, browsing webpages, using apps, making calls, and sending texts. These tests measure both download and upload speeds. The results are then aggregated by RootMetrics, using a proprietary formula, to calculate the Speed Index.

[9] *Seventeenth Report*, 29 FCC Rcd at 15469-70, Appendix VI., paras. 12-16.

[10] In our presentation of CalSPEED data, we have dropped any observation that was not in the provider's coverage area, or any observation that was terminated by the tester, which corresponds to the method used by CPUC. If the test was terminated for any other reason, we followed CPUC guidance and assumed a download speed of zero Mbps for that particular test. Results from each site and for each provider were averaged across all east coast and west coast servers, and the top 1% of resulting speed observations were trimmed from the dataset, by provider and separately for each time period. This is a surveyed test and not crowdsourced, and therefore some of the cleaning criteria may be different from the other speed tests.

STATEMENT OF
CHAIRMAN AJIT PAI

Re: *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*, WT Docket No. 17-69

The 20th Mobile Wireless Competition Report that we adopt today differs from the last several reports in at least two important ways.

First, we return to giving Commissioners a chance to vote on this annual report. In 2014, 2015, and 2016, the prior leadership of the FCC abandoned long-standing practice and marginalized Commissioners by having the Wireless Telecommunications Bureau issue this report. This was wrong. So today, we return to regular order and bring this important report up for a Commission vote. Whether my colleagues are voting yes or no, I'm pleased that they can vote in the first place.

Second, we return to following the law—and by that, I mean the specific direction set out for us by Congress to include in this report an analysis of whether there is effective competition in the wireless marketplace. Unfortunately, the prior six reports have dodged this question. Indeed, the last time this report included a finding of whether the wireless market was competitive was our 13th Report, way back in 2009. The wireless buzz at the time was over the Apple iPhone 3GS, and the App Store was barely a year old. It's been eight long years since the FCC has done what Congress directed us to do. Today, we are finally getting back on track.

The 20th Report reviews many factors indicating that the wireless marketplace is, indeed, effectively competitive. I won't repeat them here; that's why we have the report. But looking at the bigger picture, most reasonable people see a fiercely competitive marketplace. For example, since the FCC's last report in 2016, all four national carriers have rolled out new or improved unlimited plans. This is strong, incontrovertible evidence.

To be sure, some strenuously resist this conclusion, and have for many years. At its core, it's hard to say that resistance is inspired by a careful review of the facts. Instead, it's all about ideology. To those who want to impose more regulation upon the wireless marketplace, the reality of effective competition is an inconvenient truth that must be discounted or ignored. But today, the Commission begins with the facts, not the conclusion. Those facts are what they are; the FCC will once again do what Congress has told us to do.

Thank you to the staff that worked on this item: Matt Collins, Judith Dempsey, Monica DeLong, Ben Freeman, Garnet Hanly, Leon Jackler, Pramesh Jobanputra, Kate Matraves, Betsy McIntyre, Paroma Sanyal, Dana Shaffer, Don Stockdale, Cecilia Sulhoff, Joel Taubenblatt, Joe Wyer, and Mary Claire York from the Wireless Telecommunications Bureau; Jim Schlichting from the International Bureau; Jerry Ellig, Evan Kwerel, Paul LaFontaine, and Wayne Leighton from the Office of Strategic Planning and Policy Analysis; and David Horowitz, Keith McCrickard, Linda Oliver, Joel Rabinovitz, and Bill Richardson from the Office of General Counsel. As Don noted, I'd also like to give a shout out to the teams in the Wireline Competition Bureau, Media Bureau, and Enforcement Bureau which helped review this item.

DISSENTING STATEMENT OF
COMMISSIONER MIGNON L. CLYBURN

Re: *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*, WT Docket No. 17-69

This summer I received a letter from Pat of Athens County, Ohio, a rural community located not far from the West Virginia border. To illustrate just how bad the cell phone coverage is in that area, she wrote: "A few years ago, my son was travelling State Route 550 between Amesville and Bartlett on a motorcycle and hit a deer. He had no cell phone signal to call for help. He's very fortunate to be alive…" When she worked in the Village of Amesville, there was no Internet or cell phone coverage at all.

Not a week passes in Washington, and various parts of our nation, where the buzz about the promise of 5G is not heard. The reality, however, is that far too many in this country do not have reliable and affordable 3G service. In fact, our recent Mobility Fund Phase II proceeding is designed to bring ubiquitous mobile wireless service to millions: yes, I said *millions* of Americans who are still waiting for mobile wireless service with the download speeds others enjoy.

Consider this: if one of our nationwide wireless carriers covers only 64% of the rural population, that means it is probable that 20.5 million people in these areas do not have access to all four of our nationwide wireless providers. So, my question is a simple one: How then can this Commission conclude that the mobile wireless market is effectively competitive? I have been struggling with its conclusion from the very first day this Report was circulated, and weeks later I find myself in the same place: unable to support the ultimate finding that there is effective competition in the provision of mobile wireless services.

I can neither understand nor condone why the majority used a truncated analysis to reach this conclusion. For one, the discussion of investment in the mobile wireless services industry is fundamentally flawed. By highlighting a decrease in investment between 2015 and 2016, this section was clearly written to support the false narrative that the *2015 Open Internet Order* deterred wireless carriers from investing in their networks.

Despite my office's request, this Report does not include data from the 19th, 18th, and 16th Competition Reports, which showed investment from all commercial wireless companies declined from $33.1 billion in 2013 to $30.9 billion in 2015. In case you missed it, those reports predated the 2015 Order. Also, despite my request, this report does not include CTIA's investment data indicating that investment per consumer measurements declined from 2006 to 2009. Just in case you missed it again, that predates the 2015 and 2010 Open Internet Orders. These statistics demonstrate that there must be other factors, other than the Open Internet Orders, that account for why wireless carriers decreased their investment in their networks.

More broadly, and for the past six years, the Commission has approached this annual review with a focus on assessing competition in the entire mobile wireless ecosystem, including key input markets, such as towers, backhaul, and transport facilities, as well as the output markets for products that rely on mobile wireless services, such as mobile applications and content. By providing detailed analyses on the costs of backhaul, availability of data roaming agreements, and other key factors that determine the barriers to entering the wireless services market, the six previous competition reports were useful in identifying areas where communications policy could promote deployment of competitive options for wireless service in rural areas.

Those prior reports encouraged me, as Acting Chairwoman, to seek a voluntary solution to restore interoperability in the 700 MHz band. They led me to support the 2014 Mobile Spectrum Holdings Order, that showed consistent consolidation in the commercial mobile wireless market between 2003 and 2013, and set spectrum limits in the incentive auction to promote competition. They also supported the Commission's decision, in 2015, to reform our competitive bidding rules, so small companies could gain licenses in the incentive auction and provide services in underserved rural areas.

This Twentieth Report, however, takes a decidedly myopic view of the ecosystem, and instead focuses only on "competition in the provision of mobile wireless services." This is like a doctor looking at one organ and pronouncing a patient fit as a fiddle. I am grateful, at least, that this item is being voted by the full Commission so that I can vociferously declare my dissent and express my profound disappointment in the findings expressed therein.

While unable to support this Report or its conclusions, I do appreciate the hard work of the Wireless Telecommunications Bureau in drafting this Report and researching a number of questions my office had for them.

STATEMENT OF
COMMISSIONER MICHAEL O'RIELLY

Re: *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*, WT Docket No. 17-69

For the first time in eight years, the Commission has found correctly that there is effective competition in the provision of commercial mobile services. I am pleased that, after all of this time, we have returned to complying with the requirements of the law, under section 332(c)(1)(C), by drawing a simple conclusion.

On a purely evidentiary standard, it is clear that the mobile sector is competitive. There are four nationwide and numerous regional providers that are investing in spectrum and infrastructure, innovating and providing new services, and fiercely competing for customers. In fact, you can simply turn on your television or look at the Internet to watch the various marketing campaigns of providers vigorously fighting it out for market share. These entities banter back and forth about who has better coverage, faster speeds, cooler offerings, the latest phones and which plans are the best bang for your buck. But, for those of us involved in the policy side of the equation, we can also look at the statistics in this report and the important picture it presents.

Providers are actively improving their products to meet consumer expectations and to differentiate themselves in the marketplace to attract and retain customers. Each year, more and more devices are connected to wireless networks, which are delivering exponential increases in data and faster speeds. For instance, in one year, wireless connections grew eight percent, data usage per smartphone subscriber increased 39 percent, and the average LTE download speed went from 14.4 to 23.5 Mbps. Further, because of the competitive situation, consumers have the choice of several unlimited plans, pre- and post-paid options, offers for free video services, and special promotions to change carriers. And, in the midst of all this competition-driven innovation, prices, as measured by average revenue per user, have decreased by seven percent and the cost per megabyte has fallen from $1.37 to less than half a cent over the last ten years.

This price decrease is particularly remarkable because we are entering an era of tremendous network investment. The report details that, over the past six years, providers invested $200 billion, and that is despite the – let's say – less than friendly regulatory environment that existed during that time period. It is expected that another $275 billion will be invested over the next several years. In fact, this amount may be understated when you consider the auctions we have had over the past few years and those yet to be scheduled. The race amongst our largest providers to deploy, trial and market next generation, or 5G, offerings may incur investment levels that we have never seen before.

While this report focuses on competition between commercial mobile providers, it provides a glimpse into industry trends and the competitive pressures from outside sources. For instance, while data usage is increasing, the annual voice minutes and the use of traditional SMS text messaging are decreasing. Many of the legacy wireless cellphone functions are being overtaken by Internet apps, such as Skype, FaceTime, WhatsApp and Facebook messenger. In the future, the traditional mobile sector is likely to experience more, not less, competition from new 5G services, next generation satellites and other innovations we don't even know about yet.

Then, there are the actual coverage numbers. More than 98 percent of Americans have a choice of three or more providers and almost 97 percent have a choice of three or more LTE options. And, in rural America, 91 percent of the population has the choice of three or more providers, and more than 95 percent have at least two LTE options. While urban consumers still have more choice than their rural

counterparts, these numbers are impressive because rural and remote areas, with far fewer consumers, cannot support the same number of competitors as Washington, D.C., Los Angeles, or even Buffalo, New York.

For these reasons, the Commission rightfully concludes that the mobile sector is competitive, but what exactly does this finding mean? While these statistics show the current state of competitiveness of our wireless industry, the situation can be even better and there is room for improvement. We will leave this meeting and continue our mission to create an environment that promotes innovation and investment, so that consumers will benefit not only from network improvements, next generation technologies and new service offerings, but hopefully future new entrants. We will return to the Spectrum Frontiers and infrastructure proceedings, and we will continue our efforts to ensure that rural service offerings are improved and, most importantly, that service gets to the unserved.

This is why I am dismayed that some have expressed concerns that the FCC would no longer have any impetus to promote further wireless network expansion or broadband deployment, if it finds that mobile services are competitive or, in the context of the annual section 706 report, that broadband is being deployed in a reasonable and timely manner. Just because a report finds there is competition or that industry participants are doing a good job does not mean we all get to go home. I see no risk that we would halt our Mobility Fund efforts or other broadband infrastructure initiatives based on the findings in any of the Commission's competition-related reports. Instead, our job is to conduct the review as required by Congress and issue this report, and then we will be right back at it to improve the situation even further.

Finally, I thank the Chairman for righting a procedural wrong and putting this report before the Commission, as opposed to following recent precedent of releasing the item on delegated authority. While we may disagree about the findings, hopefully we all can agree that such issues should be reviewed and debated by the Commissioners.

STATEMENT OF
COMMISSIONER BRENDAN CARR

Re: *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*, WT Docket No. 17-69

Even though I am the only Commissioner that is participating in their first open meeting today, this item highlights one thing that I have not missed out on. For the past couple of years, none of my colleagues have been given the opportunity to do what we are doing today, which is simply to cast a vote on the agency's annual wireless competition report. The Commission's prior leadership broke from precedent by pressing consecutive reports out at the Bureau level over the objection of two Commissioners. And it was not just the process that had gone awry. In those reports, the agency refused to determine whether there is effective competition in the wireless market, even though the statute requires us to do so.

I am glad that this Commission is correcting both of those errors today. As the report details, wireless prices are falling. Speeds are increasing. Network coverage and capacity are expanding. Providers are competing vigorously with each other through innovative technologies and service plans. And for the first time ever, the majority of American households are wireless-only. The facts make it abundantly clear that this is a competitive market and consumers are the beneficiaries.

Now, this is not to say that there is no additional progress to be made. The wireless industry is in the middle of a transition from 4G to 5G technologies. This could introduce even greater competition into the market. But to get there, the FCC has to do its part. That means driving down the regulatory costs associated with deploying fiber, small cells, and other network infrastructure. And it means finding ways to streamline and expedite the deployment process. Getting those reforms across the finish line is going to be one of my top priorities at the agency, and I look forward to working with my colleagues on that effort.

DISSENTING STATEMENT OF
COMMISSIONER JESSICA ROSENWORCEL

Re: *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*, WT Docket No. 17-69

There is a lot to celebrate in the way that wireless ubiquity has changed our lives and our world. After all, there are few aspects of civic and commercial life that remain untouched by the power of wireless service. But the truth is, we're just getting started. Hard as it may be to imagine, our connections in the future will multiply, expanding beyond the devices in our palms to anything and everything that can be connected around us. The endless data these connections supply have the capacity to make our world more efficient, our choices more just, and our lives more safe. They will play no small role in helping us address global challenges in future—from energy to agriculture to governance and human rights.

Rewind, however, because this report is firmly rooted in the present, with a singular focus on the mobile voice and data services available today. To this end, it highlights changes in consumer service plans, improvement to network speeds, and alleged trends in capital investment. But it has a fatal flaw—and for that reason I dissent.

In the Communications Act, Congress charged the Commission with reporting annually on the state of commercial mobile service markets. As part of this assessment, the agency is tasked with an analysis of whether or not there is "effective competition." Simple enough. But to make this determination in the affirmative—as this report does—requires that the Commission define "effective competition." On this account it fails. Instead of a definition of this essential threshold, we have all manner of apologies and admissions. We are told there is no single definition used by economists or policy authorities. We are told that upstream and downstream market segments involving network equipment, operating systems, and applications are outside the scope, and yet the core of what is "effective competition" remains undefined. In short, it's hard. Well, tough. Congress creates new terms in legislation all the time and it's up to expert agencies like this one to define them. But our failure to do so is inexcusable if the Commission wants desperately to conclude, as it does here, that "effective competition" exists.

If you add this up, this Commission is making a determination about the state of competition in one of the most vital sectors of the new economy using a standard that calls to mind Potter Stewart's famous "I know it when I see it." That's not good enough. The bottom line is this: If you find it, you must define it. And on that account, this report fails.

One further thing: Like everyone else, I read reports of mergers waiting in the wings. So while this report celebrates the presence of four nationwide wireless providers, let's be mindful that a transaction may soon be announced that seeks to combine two of these four. While the Commission should not prejudge what is not yet before us, I think this agency sticks its collective head in the sand by issuing this report and implying move along, there is nothing to see here. For my part, any transaction before us will require someone to explain how consumers will benefit, how prices will not rise, and how innovation will not dissipate in the face of so much more industry concentration. Someone will also need to explain how having fewer potential big bidders in upcoming spectrum auctions will not render our most potent distribution mechanism substantially less powerful. Those are hard questions that hover over this report—and we should not ignore them.