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. 16-137
	)	
Annual Report and Analysis of Competitive Market	)	
Conditions With Respect to Mobile Wireless,	)	
Including Commercial Mobile Services	)	

NINETEENTH REPORT

Adopted: September 23, 2016 **Released: September 23, 2016**

TABLE OF CONTENTS

Heading Paragraph #

I. INTRODUCTION

1. Mobile wireless services are an essential and ubiquitous part of Americans' daily lives. Preserving and promoting competition in the provision of mobile wireless services is central to the Commission's mission and is critical for driving innovation and investment to the ultimate benefit of the American people and economy. In this Nineteenth Mobile Wireless Competition Report (*Nineteenth Report* or *Report*), the Federal Communications Commission (Commission or FCC) fulfills its obligation, pursuant to Section 332(c)(1)(C) of the Communications Act (the Act), to report annually to Congress on the state of competition in mobile services. Following on from the *Eighteenth Report,* released in December 2015, which provided an analysis of market conditions and developments during the second half of 2014 and the first half of 2015,[1] this *Report* presents data and analysis covering the second half of 2015.[2] The analysis focuses on "competitive market conditions with respect to commercial mobile services," as required by the Act.[3] This *Report* provides a valuable resource for the Commission and other policy makers, industry and other stakeholders, and consumers seeking to make informed decisions in the mobile marketplace.

2. In its presentation of a multitude of industry data on various aspects of mobile wireless competition,[4] this *Report* continues to employ the model first adopted by the *Seventeenth Report,* which is data-centric, combining a concise analysis with a substantial use of tables and charts in accessible data formats.[5] This *Report* therefore follows our practice of undertaking an analysis of all mobile wireless services, including voice, messaging, and broadband from a consumer-oriented perspective. Consumers view various mobile voice, messaging, and data services as interchangeable with one another, and as a result, it is important to consider potential substitutes when analyzing the competitive landscape for these services, and to evaluate the mobile wireless industry as a whole, rather than just focusing on the provision of services classified as commercial mobile radio services (CMRS).[6] Thus, this *Report* analyzes competition across the entire mobile wireless marketplace, including key market segments such as spectrum and infrastructure.

---

[1] *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. 15-125, Eighteenth Report, 30 FCC Rcd 14515 (WTB 2015) (*Eighteenth Report*).

[2] For instance, 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 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.

[3] 47 U.S.C. § 332(c)(1)(C).

[4] 47 U.S.C. § 332(c)(1)(C). As with previous *Reports,* this *Nineteenth 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.

[5] Following that practice, we are providing the charts and tables in the *Nineteenth Report* and its Appendices, as well as much of the underlying data, on a dedicated website that we intend to update before the release of the next report as new data become available. FCC, Commercial Mobile Radio Services Competition Reports, https://www.fcc.gov/reports-research/reports/commercial-mobile-radio-services-competition-reports (last visited Sept. 14, 2016).

[6] *See, e.g., Eighteenth Report*, 30 FCC Rcd at 14517, para. 3; *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services*, Sixteenth Report, 28 FCC Rcd 3700, 3734, para. 20 (2014) (*Sixteenth Report*). We note that *Reports* prior to the *Eighteenth Report* have therefore included in their analysis a consideration of mobile broadband service before the reclassification of that service in the *2015 Open Internet Order*. *Protecting and Promoting the Open Internet*, Report and Order on Remand, Declaratory Ruling, and Order, 30 FCC Rcd 5601, 5715, para. 388 (2015) (*2015 Open Internet Order*).

3. Congress enacted the requirement in 1993 that the Commission report annually on "competitive market conditions with respect to commercial mobile services."[7] At the same time, it created the statutory classification of "commercial mobile services" to promote the consistent regulation of mobile radio services that are similar in nature,[8] and established the promotion of competition as a fundamental goal for CMRS policy formation and regulation.[9] In particular, the statute requiring the annual report on CMRS competition 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.[10]

4. This *Report* complies with the statutory requirements for analyzing competitive market conditions with respect to commercial mobile services. This *Report* analyzes competition in the mobile wireless services marketplace, as well as examining competition across the entire mobile wireless ecosystem. We analyze the competitive rivalry between service providers in the mobile wireless marketplace and how that competitive rivalry, innovation, and investment benefit American consumers. Consistent with the Commission's first seven *Reports*, and the *Fourteenth Report* and subsequent *Reports*, this *Nineteenth Report* does not reach an overall conclusion or formal finding regarding whether or not the CMRS marketplace was effectively competitive, but rather this *Report* provides an analysis and description of the CMRS industry's competitive metrics and trends.[11] Given the complexity of the various inter-related segments and services within the mobile wireless ecosystem, any single conclusion regarding the effectiveness of competition would be incomplete and possibly misleading in light of the complexities that we observe.[12] This *Report* instead focuses on presenting the best data available on various aspects of competition throughout the mobile wireless ecosystem while also highlighting several key trends.

5. First, this *Report* provides an analysis of the overall competitive dynamics of the industry, describing the various operating entities and their relative positions using indices such as market share, subscribership (totals, additions, and churn), as well as various financial indicators.[13] The *Report* then presents a broad overview of industry trends and developments in the mobile marketplace that have taken place since the *Eighteenth Report*. The *Report* then turns to an analysis of key inputs necessary for provision of mobile service,

---

[7] 47 U.S.C. § 332(c)(1)(C). 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 *Nineteenth Report*. *See, e.g., Seventeenth Report*, 29 FCC Rcd at 15360, para. 100.

[8] Omnibus Budget Reconciliation Act of 1993, Pub. L. No. 103-66, Title VI, § 6002(b), amending the Communications Act of 1934 and codified at 47 U.S.C. § 332(c).

[9] 47 U.S.C. § 332 (a)(3).

[10] 47 U.S.C. § 332 (c)(1)(C).

[11] This is in contrast to the *Eighth Report* through the *Thirteenth Report*, which included a specific finding that there was effective competition in the provision of CMRS service without defining the term "effective competition." *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*, Thirteenth Report, 24 FCC Rcd 6185, 6310, para. 274 (WTB 2009) (*Thirteenth Report*).

[12] We note that there is no definition of "effective competition" widely accepted by economists or competition policy authorities such as the U.S. Department of Justice (DOJ). *Eighteenth Report*, 30 FCC Rcd at 15315, para. 5.

[13] Unless stated otherwise, dollar figures stated in this *Nineteenth Report* are nominal (have not been adjusted for inflation).

such as spectrum and network infrastructure. Spectrum, in particular, is a critical input that wireless service providers need for the provision of mobile wireless services, and this *Report* examines the distribution of spectrum in the various bands. Next, the *Report* analyzes recent developments in the ways service providers compete for and attract subscribers through pricing innovations, such as the decreased reliance on traditional handset subsidies and term contracts. The *Report* then analyzes competitive rivalry in non-price factors, such as coverage, service quality, and speed. Finally, the *Report* considers developments in the downstream mobile wireless ecosystem as well as issues such as consumer access to information and intermodal developments.

II. COMPETITIVE DYNAMICS WITHIN THE MOBILE WIRELESS INDUSTRY

6. In this Section, we discuss various competitive dynamics within the mobile wireless industry.[14] We begin by noting that providers of mobile wireless services typically offer an array of mobile voice and data services, including services such as interconnected mobile voice services, text and multimedia messaging, and mobile broadband services.[15] Facilities-based mobile wireless service providers offer such services primarily using their own network facilities, although coverage areas often are supplemented through roaming agreements, and may operate nationwide, multi-regional, regional, or local networks.[16] In this Section, we present information and data on all mobile wireless services as well as on individual services and segments where appropriate, and where the data are available.

A. Service Providers

1. Facilities-Based Service Providers

7. *Nationwide Service Providers*. As of year-end 2015, 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.[17] Although none of these four service providers has a network that

[14] Sections V. and VI. below consider additional aspects in the competitive dynamics of the industry in discussing elements of price and non-price rivalry.

[15] 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. *See, e.g.*, CTIA Comments at 6, 18-19, 23. We note that fixed wireless services currently are not included in our analysis of mobile wireless services.

[16] Some data and messaging services offered by facilities-based providers rely only on Internet Protocol (IP)-based, packet-switched networks, but most mobile voice services continue to connect to the Public Switched Telephone Network (PSTN) and rely on North American Numbering Plan (NANP) telephone numbers.

[17] AT&T Mobility began operations in October 2000 as a joint venture between AT&T and BellSouth and, in 2004, acquired AT&T Wireless Services, Inc. Upon AT&T's acquisition of BellSouth in 2006, AT&T Mobility became a wholly-owned subsidiary. AT&T Inc., SEC 2015 Form 10-K, at 2 (filed Feb. 18, 2016), http://www.sec.gov/Archives/edgar/data/732717/000073271716000147/ye15_10k.htm.

Sprint Nextel was created by the merger in 2005 of Sprint Corp. and Nextel Communications, Inc. On July 5, 2013, the Commission released an order approving the acquisition of Sprint by SoftBank Corp., and Sprint's acquisition of 100% of Clearwire's stock. *Applications of Sprint Nextel Corp. and SoftBank Corp. and Starburst II, Inc. for Consent To Transfer Control of Licenses and Authorizations*, Memorandum Opinion and Order, Declaratory Ruling, and Order on Reconsideration, 28 FCC Rcd 9642, 9643-44, paras. 1-4 (2013) (*Softbank-Sprint-Clearwire Order*).

T-Mobile traces its roots to May 2001, when Deutsche Telekom AG acquired VoiceStream Wireless and Powertel. In September 2002, they were re-branded as T-Mobile. T-Mobile USA Inc., SEC 2002 Form 10-K, at 2 (filed Mar. 10, 2003), http://www.sec.gov/Archives/edgar/data/1097609/000089102003000720/v88048ore10vk.htm. On March 12, 2013, the application of Deutsche Telekom, T-Mobile, and MetroPCS was approved, which resulted in the creation of T-Mobile USA as a wholly-owned subsidiary of Deutsche Telekom. *Applications of Deutsche Telekom AG, T-Mobile USA, Inc., and MetroPCS Communications, Inc. for Consent To Transfer of Control of Licenses and Authorizations*, Memorandum Opinion and Order and Declaratory Ruling, 28 FCC Rcd 2322, 2323-24, paras. 1-2 (WTB, IB 2013) (*T-Mobile-MetroPCS Order*).

covers the entire land area or population of the United States, each has a network that covers a significant portion of both and therefore these four service providers will be referred to as "nationwide service providers" throughout this *Report*.[18]

8. *Multi-Regional, Regional, and Local Service Providers.* U.S. Cellular, currently the fifth largest service provider in the United States, is best characterized as multi-regional, and has developed wireless networks and customer service operations in portions of 23 states.[19] As of December 31, 2015, U.S. Cellular provided services to approximately 4.9 million customers.[20] C Spire and NTELOS are two other regional service providers that had substantial market presence in certain parts of the country during 2015. C Spire provided service in the Southeastern United States to nearly one million subscribers,[21] while NTELOS, in its last full year as an independent entity, had approximately 300,000 subscribers.[22] There are also dozens of regional and local facilities-based service providers[23] throughout the United States that typically provide service in a single geographical area, many of them rural areas.[24] As the Commission noted in the *Mobile Spectrum Holdings Report*

As of December 31, 2013, Verizon owned a controlling 55% interest in Verizon Wireless and Vodafone owned the remaining 45%. On September 2, 2013, Verizon entered into a stock purchase agreement with Vodafone and Vodafone 4 Limited, pursuant to which Verizon agreed to acquire Vodafone's indirect 45% interest in Cellco Partnership d/b/a Verizon Wireless. Verizon completed the transaction on February 21, 2014 and acquired 100% ownership of Verizon Wireless. Verizon Communications, Inc., 2015 SEC Form 10-K, at 3 (filed Feb. 23, 2016), https://www.sec.gov/Archives/edgar/data/732712/000119312516473367/d35513d10k.htm.

[18] 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, Connecting the Things You Care About Most, https://www.att.com/network/en/index.html (last visited Sept. 14, 2016). According to Verizon Wireless, it covers approximately 312 million people in over 450 U.S. markets with LTE. Verizon Wireless, The Verizon Wireless 4G LTE Network, http://www.verizonwireless.com/news/LTE/Overview.html (last visited Sept. 14, 2016); Verizon Wireless, Our Technology, https://www.verizonwireless.com/aboutus/technology/network.html (last visited Sept. 14, 2016). According to T-Mobile, its LTE network now covers 311 million people. T-Mobile, Compare Networks, https://explore.t-mobile.com/4g-lte-network (last visited Sept. 14, 2016). According to Sprint, its LTE network now covers nearly 300 million people, and it has also deployed its "LTE Plus Network" in 204 markets across the nation. Sprint News Release, May 3, 2016, http://newsroom.sprint.com/news-releases/sprint-finishes-fiscal-year-2015-by-generating-positive-annual-operating-income-for-the-first-time-in-nine-years-and-delivering-more-postpaid-phone-net-additions-than-verizon-and-att-for-the-first-time-on-record-in-the-fiscal-fourth-quarter.htm (last visited Sept. 14, 2016).

[19] United States Cellular Corp., 2015 SEC Form 10-K, at 1 (filed Feb. 24, 2016), https://www.sec.gov/Archives/edgar/data/821130/000082113016000050/usmform10k.htm. U.S. Cellular is a majority-owned (84%) subsidiary of Telephone and Data Systems, Inc. *Id.*

[20] *Id.* at 1. According to U.S. Cellular, its LTE network reached 99 percent of its customers. 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.

[21] C Spire, About C Spire, https://www.cspire.com/company_info/about/more_info.jsp (last visited Sept. 14, 2016).

[22] On April 15, 2016, the Commission consented to the Sprint-Shentel-NTELOS transaction, pursuant to which NTELOS would become a wholly-owned subsidiary of Shenandoah, and all of NTELOS's spectrum licenses would be assigned to Sprint. *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, 3637, para. 13 (WTB, IB 2016) (*Sprint-Shentel-NTELOS Order*).

[23] Some regional facilities-based service providers include, but are not limited to, Alaska Wireless, Bluegrass Cellular, Carolina West Wireless, Cellcom, Choice Wireless, Nex-Tech Wireless, Pioneer, and Sagebrush Cellular.

[24] Verizon Wireless's LTE in Rural America 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,

and Order, non-nationwide service providers are important sources of competition in rural areas, enhancing competitive choices for consumers in the mobile wireless marketplace, and helping to promote deployment in rural areas.[25]

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

9. *Resellers/MVNOs.* Resellers and mobile virtual network operators (MVNOs) do not own any network facilities, but instead they purchase mobile wireless services wholesale from facilities-based providers and resell these services to consumers.[26] An agreement between an MVNO and a facilities-based service provider may be more likely to occur when the MVNO has better access to some market segments than the host facilities-based service provider, and can potentially target specific market segments such as low-income consumers or consumers with low-usage needs.[27] Unlike facilities-based service providers, MVNOs do not engage in non-price rivalry by creating capacity through network investments, network upgrades, or network coverage. In 2015, the largest MVNO, with approximately 26 million subscribers at year-end, was America Movil's subsidiary, TracFone Wireless (TracFone).[28] In 2015, Google launched "Project Fi," an MVNO in partnership with two service providers—T-Mobile and Sprint—which allows Google Fi subscribers to dynamically switch between Wi-Fi networks and the two service providers' LTE networks.[29]

---

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. 14, 2016); 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. 14, 2016).

Sprint has partnered with the Competitive Carriers Association (CCA) and Net America to launch the Net America alliance, which allows Sprint customers to obtain 4G LTE service via roaming in rural areas and customers of participating companies to roam on Sprint's 4G LTE network throughout the U.S. Net America Alliance, SMART Delivers the Future to Rural America, http://www.netamericaalliance.com/smart (last visited Sept. 14, 2016).

[25] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6207, paras. 179-80.

[26] According to Verizon Wireless, "MVNOs execute a contract with [the facilities-based provider] to buy wireless service from [the facilities-based provider] to resell under their own brand to customers and perform all marketing, billing, collections and customer service for the customers they activate. MVNOs establish and maintain the relationship with its customers. MVNOs own the relationship with their customers and establish their own calling plans and pricing." Verizon Wireless, Authorized Retailers and MVNOs, http://www.verizonwireless.com/b2c/aboutUs/reseller/authorizedAgentIndex.jsp (last visited Sept. 14, 2016).

[27] P. Kalmus and L. Wiethaus, On the Competitive Effects of Mobile Virtual Network Operators, Telecommunications Policy, Vol. 34, 2010, at 263, 266, 268; A. Banerjee and C. Dippon, Voluntary Relationships Among Mobile Network Operators and Mobile Virtual Network Operators: An Economic Explanation, Information Economics and Policy, Vol. 21, 2009, at 72; *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.").

[28] TracFone, http://www.tracfone.com/ (last visited Sept. 14, 2016); Prepaid Phone News, Fourth Quarter 2015 Prepaid Mobile Subscriber Numbers by Operator (Feb. 17, 2016), http://www.prepaidphonenews.com/2016/02/fourth-quarter-2015-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.

[29] 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 (Nexus 5X, 6, or 6P for the service). In addition, Google Fi offers multiple different plans based on subscriber needs such as a $10 per GB data only, with no annual contract. Google, One Plan, Simple Pricing, Savings Made Easy, https://fi.google.com/about/plan/ (last visited Sept. 14, 2016). 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

10. *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 are generally targeted at users who require service 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.

11. *Narrowband Data Service Providers.* Narrowband data and paging services comprise a specialized market segment of the mobile wireless industry. These services include two-way messaging, as well as M2M and other telemetry communications, and are consumed primarily by businesses, government users, and other institutions.[30]

B. Connections, Net Additions, and Churn

1. Subscribers, Total Connections, and Net Additions

12. This *Report* uses several data sources to estimate the number of mobile wireless subscribers and connections. One such source, Numbering Resource Utilization Forecast (NRUF), tracks the quantity of phone numbers that have been assigned to mobile wireless devices.[31] As shown in Chart II.B.1 below, in the time period since the *Eighteenth Report*, the total number of connections continued to grow strongly. Based on NRUF, the number of mobile wireless connections in December 2014 were approximately 357 million, and connections grew by approximately five percent during 2015 to reach approximately 374 million by year-end 2015. CTIA also estimated the total number of mobile wireless connections,[32] and found that the number of connections grew by approximately six percent during that same period, from approximately 355 million at year-end 2014 to approximately 378 million at year-end 2015.[33] Chart II.B.2 presents data on total connections by service segment. It shows that in 2015, 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, and wholesale connections and connected devices are a small but growing part of total mobile wireless connections.

13. As well as providing mobile wireless services directly to consumers and businesses, we note that service providers may also provide M2M services.[34] Later in this *Report*, detailed information is provided on

along with text and data plans. Republic Wireless, https://republicwireless.com/ (last visited Sept. 14, 2016); Ting, https://ting.com/ (last visited Sept. 14, 2016); RingPlus, https://ringplus.net/ (last visited Sept. 14, 2016).

[30] There is 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.

[31] 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 are more likely to use more than one mobile device that have been assigned telephone numbers–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, NRUF is becoming less useful in measuring the number of individual subscribers. Instead, it provides a measure of the number of mobile wireless connections or connected devices, although we note that it will become a less accurate measure of connected devices to the extent that more are sold that do not use telephone numbers.

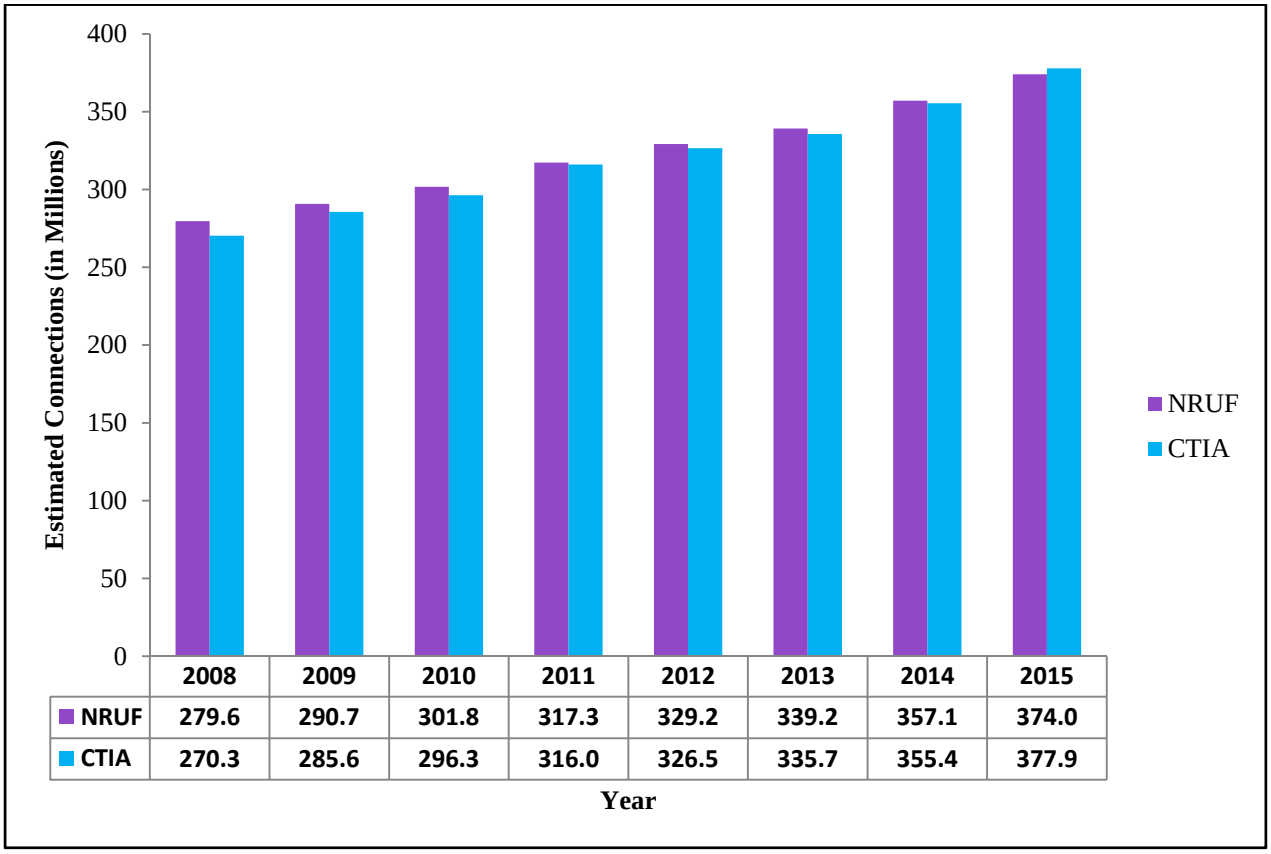
[32] CTIA states that "the terms subscriber, subscriptions, and connections are being used interchangeably." CTIA Wireless Indices Year-End 2015, at 14.

[33] Appendix Table II.B.i provides detailed data on total mobile wireless connections, and Appendix Table II.B.ii provides detailed data on total mobile wireless connections by service segment.

[34] M2M is a subset of the larger Internet of Things (IoT), and aside from 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 transform to use M2M networks to connect their numerous smart devices and machines. The Ericsson Mobility Report predicts that between 2015 and 2021, IoT will increase at a compounded annual growth rate (CAGR) of 23%, making up close to 16 billion of the

retail voice and broadband services; however, there are limited statistics on M2M communications.[35] 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. Fifth Generation (5G) networks and services[36] are expected to usher in an era of explosive growth for M2M.[37]

Chart II.B.1
Total Mobile Wireless Connections: 2008–2015



	2008	2009	2010	2011	2012	2013	2014	2015
NRUF	279.6	290.7	301.8	317.3	329.2	339.2	357.1	374.0
CTIA	270.3	285.6	296.3	316.0	326.5	335.7	355.4	377.9

Source: NRUF, CTIA Wireless Industry Indices Year-End 2015.

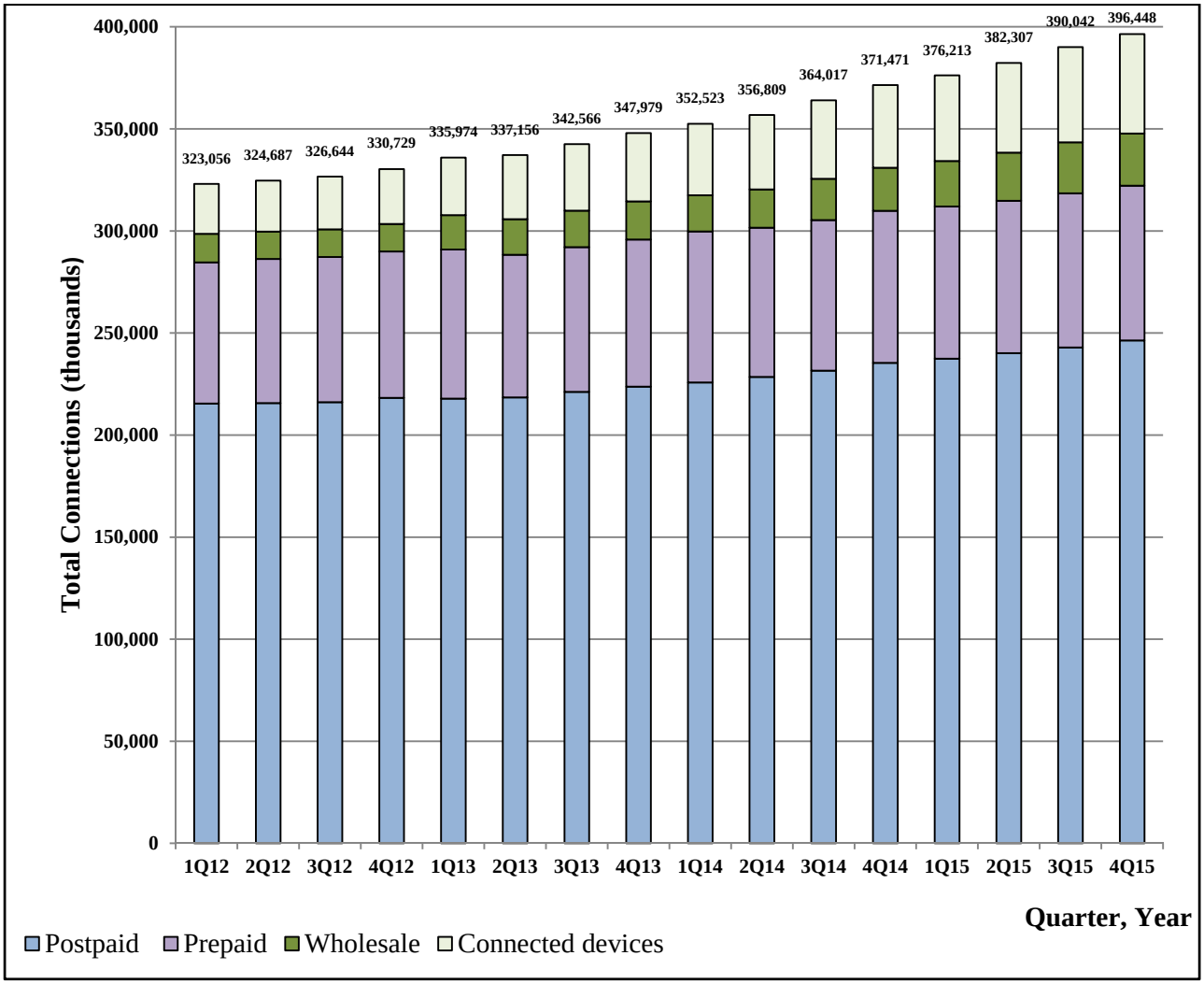
total forecast of 28 billion connected devices in 2021. Ericsson, Ericsson Mobility Report, On the Pulse of the Networked Society, at 3, 10 (June 2016), https://www.ericsson.com/res/docs/2016/ericsson-mobility-report-2016.pdf.

[35] As of 1Q 2016, Chetan Sharma Consulting reports that total connected devices for the U.S. were 63.5 million, of which tablets accounted for 27.7 million, and M2M connections accounted for 35.8 million (connected cars accounted for approximately 25% of that sub-total). Chetan Sharma, Industry Research (Q1 2016), http://www.chetansharma.com/research.htm. For 2015, Cisco reports 75 million U.S. M2M connections, an increase of 68% from 2014. Cisco, VNI Mobile Highlights 2015-2020 (Potential M2M Connections), http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/index.html.

[36] We note that we do not intend to define what qualifies as "5G." Standard bodies like 3GPP and the International Telecommunication Union (ITU) plan to develop the requirements by early 2017. 3rd Generation Partnership Project (3GPP), Tentative 3GPP Timeline for 5G (Mar. 17, 2015), http://www.3gpp.org/news-events/3gpp-news/1674-timeline_5g.

[37] *See, e.g.*, Cisco, VNI Mobile Highlights, 2015-2020, http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/index.html. "In the United States, the number of mobile-connected M2M modules will grow 6.8-fold between 2015 and 2020, reaching 513 million in number."

Chart II.B.2
Quarterly Total Mobile Wireless Connections by Service Segment: 2012–2015



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

14. Table II.B.1 presents data on total mobile wireless connections of the larger service providers operating in the United States. This Table shows that as of year-end 2015, Verizon Wireless and AT&T together accounted for approximately two-thirds of the estimated connections, while T-Mobile and Sprint together accounted for slightly less than one-third of the estimated connections. As of year-end 2015, T-Mobile had approximately 63 million connections, compared to approximately 59 million for Sprint. By year-end 2015, regional service providers accounted for well under two percent of total connections.[38]

[38] We note that C Spire, the largest privately held service provider in the U.S., whose total number of connections are not reflected in Table II.B.1, states that it has nearly 1 million subscribers, with its primary service area in the southeastern U.S. C Spire, About C Spire, http://www.cspire.com/company_info/about/more_info.jsp (last visited Sept. 14, 2016).

Table II.B.1
Estimated Total Connections for Publicly Traded Facilities–Based Mobile Wireless Service Providers (in thousands): 2012–2015

Nationwide Service Providers	EOY 2012	EOY 2013	EOY 2014	EOY 2015
Verizon Wireless	116,570	125,535	134,612	140,924
AT&T	106,965	110,276	120,620	128,679
T-Mobile	30,299	46,684	55,018	63,282
Sprint	55,626	54,622	55,929	58,578
Nationwide Service Provider Total	**309,460**	**337,117**	**366,179**	**391,463**
Regional Service Providers	**EOY 2012**	**EOY 2013**	**EOY 2014**	**EOY 2015**
U.S. Cellular	5,798	4,774	4,760	4,876
Metro PCS	8,887	*	*	*
Leap Wireless	5,297	4,551	*	*
NTELOS	440	465	449	306
Cincinnati Bell	398	340	82	*
Regional Service Provider Total	**20,820**	**10,130**	**5,291**	**5,182**
Total Estimated Connections	**330,279**	**347,247**	**371,470**	**396,645**

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

2. Subscribers and Net Additions

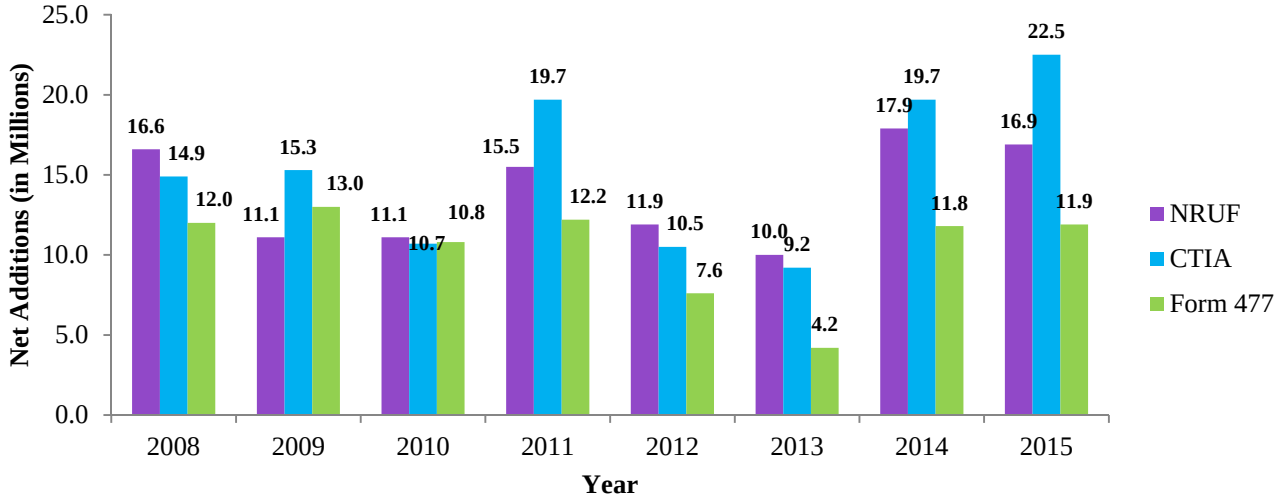
15. As shown in Chart II.B.3 below, net additions for 2015 totaled approximately 17 million based on NRUF data, and approximately 23 million based on CTIA data. In addition, we include the preliminary subscriber data as reported by service providers on Form 477 which show that for 2015 net subscriber additions totaled approximately 12 million.[39]

16. Chart II.B.4 below shows that postpaid net additions showed significant growth during 2014, and while there was a slight dip in the first quarter of 2015, postpaid net additions grew through the end of 2015. In addition, the net number of connected device additions was consistently higher than prepaid additions beginning the first half of 2014 and continuing through year-end 2015.[40] Chart II.B.4 also shows that through 2014 and 2015, prepaid additions did not make up a significant percentage of total quarterly net additions.

[39] Based on Form 477, the preliminary total number of mobile voice telephone subscriptions at year-end 2015 was 334.5 million, as compared to 322.5 million at year-end 2014. 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 Wireline Competition Bureau. *See, e.g.*, FCC, Wireline Competition Bureau, Voice Telephone Services: Status as of December 31, 2014 (March 2016), https://apps.fcc.gov/edocs_public/attachmatch/DOC-338629A1.pdf.

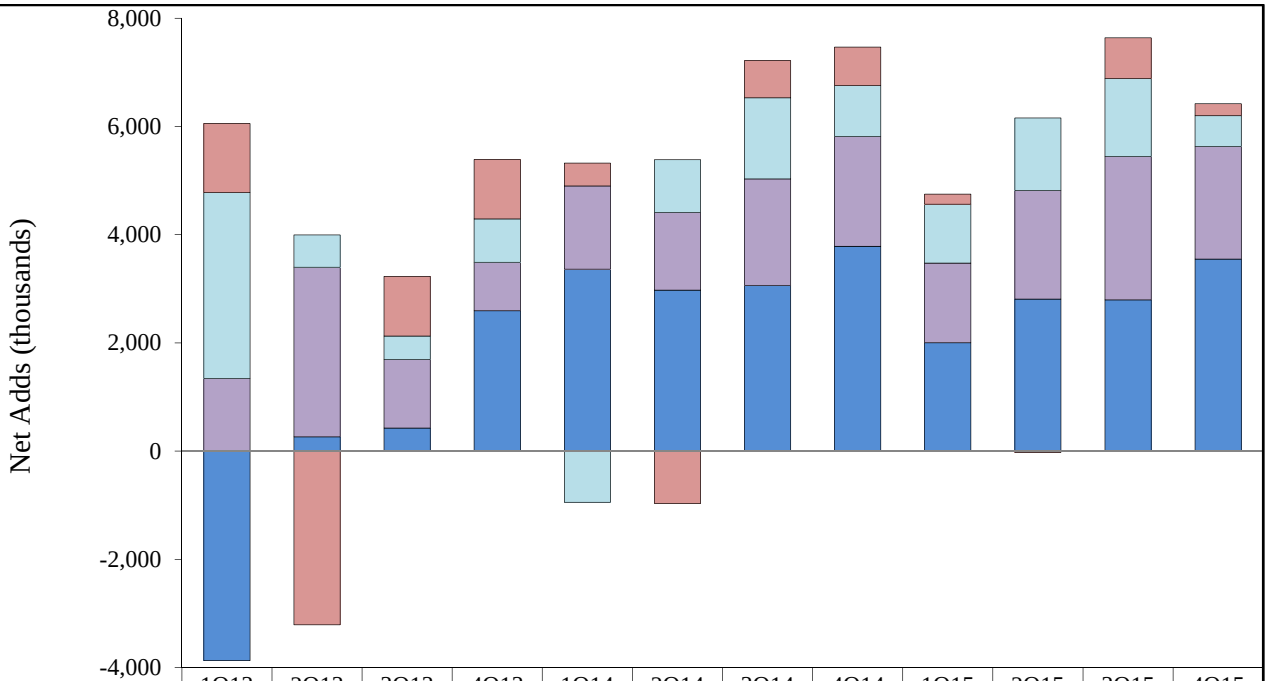
[40] Appendix Table II.B.iii provides detailed data on quarterly net additions by service segment.

Chart II.B.3
Total Mobile Wireless Connections
Annual Net Additions (2008-2015)



Source: NRUF, CTIA Wireless Industry Indices Year-End 2015, Form 477.

Chart II.B.4
Quarterly Net Additions by Service Segment: 2013–2015

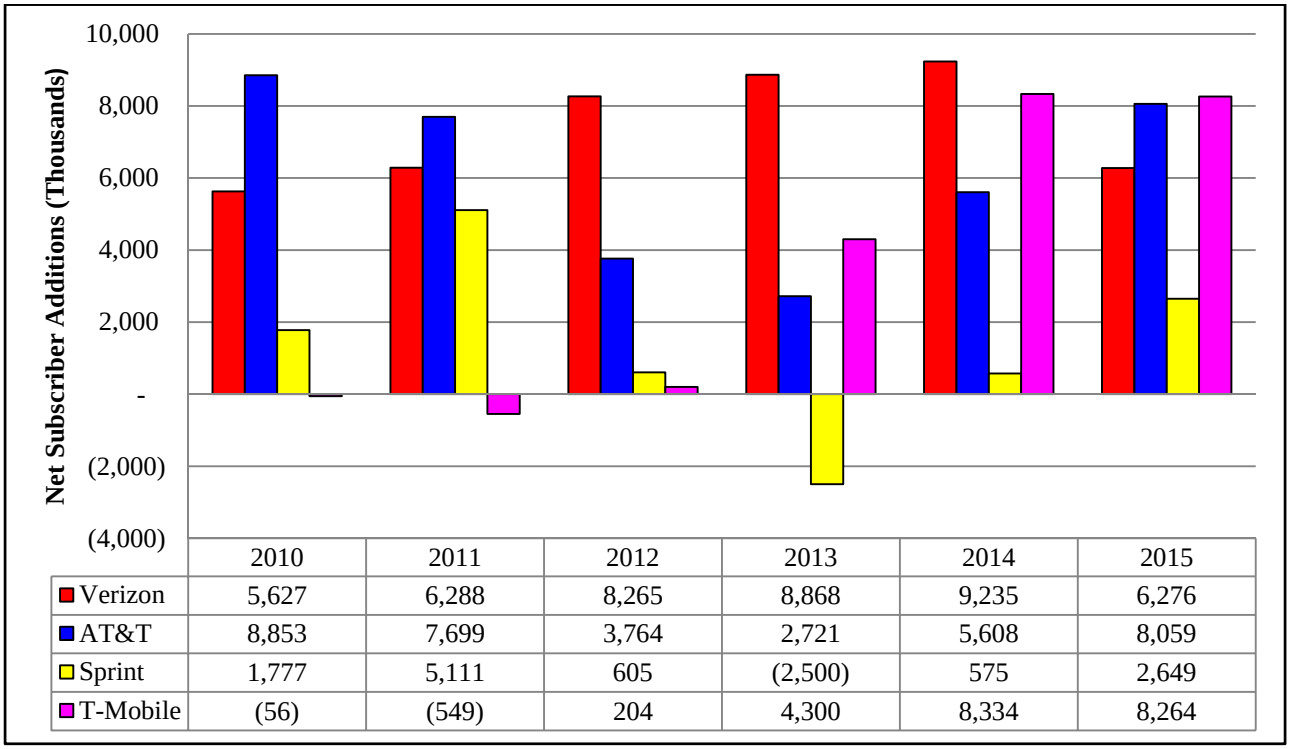


	1Q13	2Q13	3Q13	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
Total	2,181	788	3,229	5,389	4,378	4,418	7,214	7,465	4,748	6,136	7,637	6,418
Prepaid	1,278	-3,208	1,102	1,098	421	-966	686	712	187	-21	751	221
Wholesale	3,431	598	436	802	-945	975	1,497	938	1,088	1,339	1,441	569
Connected Devices	1,344	3,134	1,264	894	1,537	1,434	1,967	2,028	1,471	2,009	2,651	2,080
Postpaid	-3,872	264	427	2,595	3,364	2,976	3,064	3,787	2,003	2,809	2,794	3,549

Source: UBS Investment Research. UBS US Wireless 411, Version 59, Figure 42.

17. Chart II.B.5 below shows net subscriber additions by the four nationwide service providers from 2010 through 2105. While Chart II.B.5 shows that AT&T and Verizon Wireless continue to show strong net additions, of particular note is T-Mobile, which nearly doubled its net additions between 2013 and 2014, and continued to add in 2015. Further, Sprint showed a strong upward trend in 2015.

Chart II.B.5
Annual Net Additions by Service Provider: 2010–2015



	2010	2011	2012	2013	2014	2015
Verizon	5,627	6,288	8,265	8,868	9,235	6,276
AT&T	8,853	7,699	3,764	2,721	5,608	8,059
Sprint	1,777	5,111	605	(2,500)	575	2,649
T-Mobile	(56)	(549)	204	4,300	8,334	8,264

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

3. Churn

18. Churn measures the number of connections that are disconnected from mobile wireless service during a given period time period, and is usually expressed as a percentage.[41] Service providers publish their monthly churn rate information as part of their quarterly filings with the SEC. 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, service provider switching costs, and competition. According to UBS, the industry weighted average monthly churn rates from the first quarter of 2012 to the fourth quarter of 2015 have ranged from 1.44 percent to 1.86 percent.[42] For 2015, CTIA calculated an annual industry-wide churn rate of 23.6 percent, and a monthly rate of 1.96 percent,[43] while for prepaid services, CTIA reported a monthly

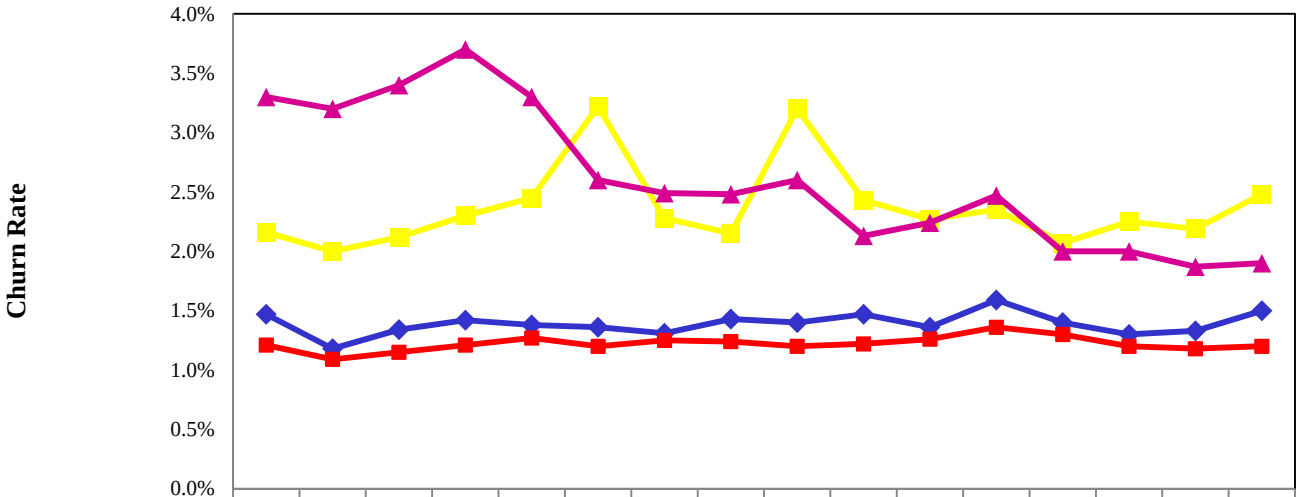
[41] Churn is calculated by dividing the aggregate number of wireless subscriber connections who canceled service during a period by the total number of wireless subscriber connections at the beginning of that period. The churn rate for the period is equal to the weighted average of the churn rate for 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%.

[42] UBS Investment Research. UBS US Wireless 411, Version 59, Figure 60.

[43] CTIA Wireless Industry Indices Year-End 2015, at 40.

churn rate of 4.92 percent.[44] Churn rates of the nationwide facilities-based service providers, as shown in Chart II.B.6 below, ranged from approximately 1 percent for Verizon Wireless to approximately 1.5 percent for AT&T, approximately 2 percent for T-Mobile, and approximately 2.5 percent for Sprint for the fourth quarter of 2015.

Chart II.B.6
Quarterly Churn Rate for Nationwide Mobile Wireless Providers
1st Quarter 2012-4th Quarter 2015



	1Q12	2Q12	3Q12	4Q12	1Q13	2Q13	3Q13	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
AT&T	1.5%	1.2%	1.3%	1.4%	1.4%	1.4%	1.3%	1.4%	1.4%	1.5%	1.4%	1.6%	1.4%	1.3%	1.3%	1.5%
Verizon Wireless	1.2%	1.1%	1.2%	1.2%	1.3%	1.2%	1.3%	1.2%	1.2%	1.2%	1.3%	1.4%	1.3%	1.2%	1.2%	1.2%
Sprint	2.2%	2.0%	2.1%	2.3%	2.5%	3.2%	2.3%	2.2%	3.2%	2.4%	2.3%	2.4%	2.1%	2.3%	2.2%	2.5%
T-Mobile	3.3%	3.2%	3.4%	3.7%	3.3%	2.6%	2.5%	2.5%	2.6%	2.1%	2.2%	2.5%	2.0%	2.0%	1.9%	1.9%

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.

C. Market Shares and Concentration

19. Revenues and connections/subscribers are key metrics that are 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 market share, which is generally calculated as the percentage of an industry or market's total revenues earned (or number of customers served) by a particular company over a specified time period. In general, changes in market share may provide a signal of the relative competitiveness of a company's products or services. Nationwide (and regional) service providers' service revenues and market shares by service revenues are shown in Tables II.C.1 and II.C.2 below. Over the last several years, we have seen further increased consolidation, and by 2015, the four nationwide service providers accounted for approximately 98 percent of the nation's mobile wireless service revenue, up from approximately 93 percent in 2012. The service revenues of AT&T and Verizon Wireless together accounted for approximately 71 percent of total service revenue in 2015. Of the four nationwide facilities-based service providers, AT&T and Verizon Wireless continued to maintain the largest market shares throughout 2015, as shown in Table II.C.2. Sprint's market share declined by approximately one percent between 2014 and 2015, while T-Mobile's market share increased by approximately 1.5 percent. While T-Mobile continues to narrow the gap against Sprint, as of year-end 2015, Sprint remained the third largest service provider in the mobile wireless marketplace in terms of service revenues.

[44] CTIA Wireless Industry Indices Year-End 2015, at Appendix C, 11.

Table II.C.1
Service Revenues for Mobile Wireless Service Providers ($ millions), 2007–2015

National	2007	2008	2009	2010	2011	2012	2013	2014	2015
Verizon Wireless	*38,016*	*49,717*	*52,046*	*55,629*	*59,157*	*63,733*	*69,033*	*72,630*	*70,396*
AT&T	*38,678*	*44,249*	*48,563*	*53,510*	*56,726*	*59,186*	*61,552*	*61,032*	*59,837*
Sprint	*32,106*	*28,435*	*25,832*	*25,894*	*27,390*	*29,086*	*29,263*	*27,959*	*25,845*
T-Mobile	*16,891*	*19,242*	*18,926*	*18,689*	*18,481*	*17,213*	*20,535*	*22,375*	*24,821*
Regional	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S. Cellular	*3,679*	*3,940*	*3,926*	*3,913*	*4,054*	*4,099*	*3,595*	*3,398*	*3,350*
NTELOS	*357*	*392*	*400*	*383*	*395*	*424*	*467*	*445*	*367*
Cincinnati Bell	*267*	*291*	*284*	*269*	*252*	*225*	*185*	*126*	
Leap Wireless	*1,396*	*1,709*	*2,171*	*2,413*	*2,829*	*2,947*	*2,631*		
Metro PCS	*1,919*	*2,437*	*3,130*	*3,690*	*4,428*	*4,540*			
Centennial	*484*	*524*	*408*						
CentennialPCS	*294*	*320*	*236*						
Rural Cellular	*608*	*327*							
Alltel	*7,984*								
Dobson	*1,030*								
SunCom	*649*								

Source: UBS Investment Research. UBS US Wireless 411, Version 51, Table 31. UBS US Wireless 411, Version 59, Figure 63.

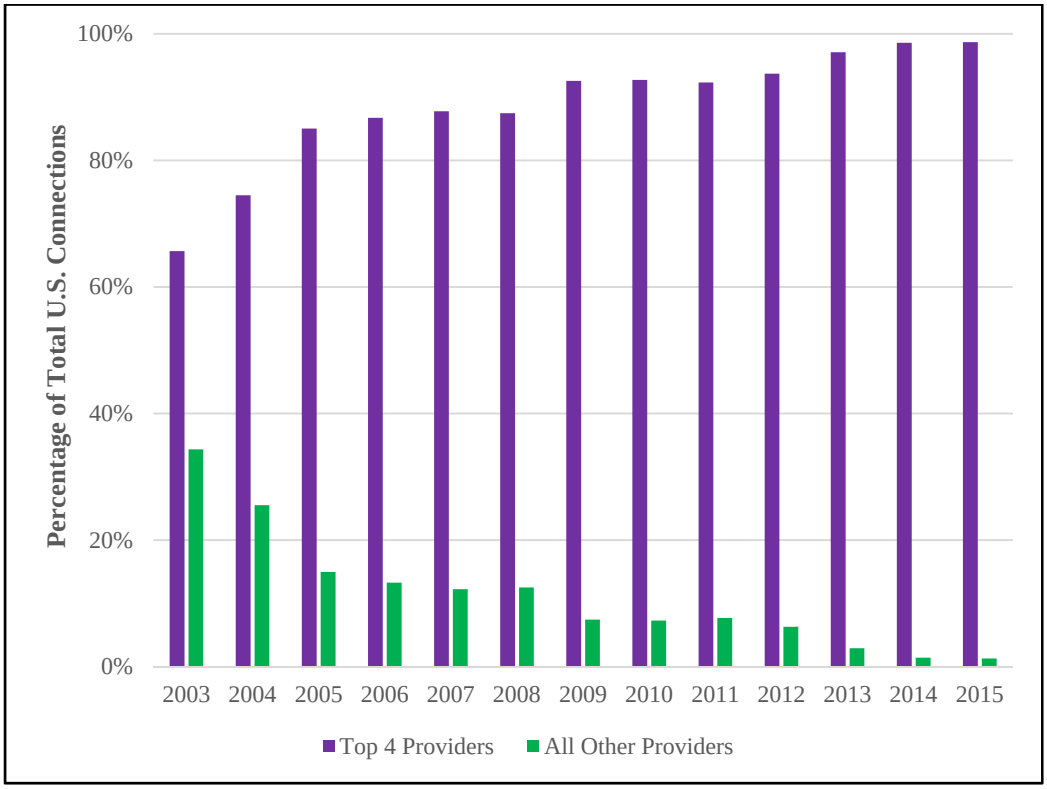
Table II.C.2
Market Shares for Mobile Wireless Service Providers Based on Service Revenues, 2012–2015

Nationwide Service Providers	2012	2013	2014	2015
Verizon Wireless	34.4%	36.5%	38.7%	38.1%
AT&T	32.0%	32.5%	32.5%	32.4%
Sprint	15.7%	15.5%	14.9%	14.0%
T-Mobile	9.3%	10.9%	11.9%	13.5%
Total Nationwide Service Provider Market Share	**91.5%**	**95.3%**	**97.9%**	**98.0%**
Regional Service Providers	**2012**	**2013**	**2014**	**2015**
U.S. Cellular	2.2%	1.9%	1.8%	1.8%
Metro PCS	2.5%			
Leap Wireless	1.6%	1.4%		
NTELOS	0.2%	0.2%	0.2%	0.2%
Cincinnati Bell	0.1%	0.1%	0.1%	
Other	1.9%	1.0%		
Total Regional Service Provider Market Share	**8.5%**	**4.7%**	**2.1%**	**2.0%**

Source: UBS US Wireless 411, Version 51 2014 Q1, Table 31, 19; UBS US Wireless 411, Version 57, Figure 51, UBS US Wireless 411, Version 59, Figure 63*; see also Seventeenth Report*, Table II.C.2 for pre-2014 data.

20. Tables II.C.1 and II.C.2 above also show that over time, regional service providers have accounted for an increasingly small share of overall industry revenues. Based on service revenues, the market share for regional service providers fell from close to 10 percent in 2012 to just 2 percent by year-end 2015.[45] In addition, Chart II.C.1 below measures market shares using the number of subscribers/connections as a percentage of overall industry subscribers/connections. It shows that the Top 4 service providers have increased their share of overall industry subscribers/connections from around 66 percent in 2003 to nearly 99 percent by year-end 2015,[46] meaning that the share of regional and local service providers has declined from around 34 percent to a little over 1 percent during the same time period.[47]

Chart II.C.1
U.S. Mobile Wireless Connections: 2003–2015



Source: 9th Report, Appendix A-8, Table 4; 11th Report, p. 93, Appendix Table 4; 12th Report, p. 132, Appendix Table 4; 14th Report, p. 223, Appendix Table C-4; 15th Report, p. 34, Table 3; 16th Report, p. 55, Table 13; 17th Report, p. 10, Table II.B.1; UBS US Wireless 411, Version 59, Figure 53.

[45] We note that these estimates are based on UBS US Wireless 411 Reports, which do not provide a break out number for C Spire, a privately held regional service provider.

[46] For purposes of Chart II.C.2, a Top 4 service provider is defined as a service provider that is one of the leading four service providers in any given year as measured by its subscribers/connections over total industry subscribers/connections.

[47] As noted above, the Commission consented to the Sprint-Shentel-NTELOS transaction on April 15, 2016. NTELOS's subscribers will be attributed to Sprint moving forward.

21. Market concentration can be measured by the number of competitors in the marketplace or by the sum of the share of subscribers and sales/revenues attributable to each competitor. Although high market concentration levels in a given market may raise some concern that the market is not competitive, an analysis of other factors, such as prices, non-price rivalry, and entry conditions, may find that a market with high concentration levels is competitive. The Herfindahl-Hirschman Index (HHI), which is employed by the Commission to measure market concentration, is a widely-accepted measure of concentration in competition analysis. The HHI is calculated by summing the squared market shares of all firms in any given market.[48] In this *Report*, we calculate HHIs by Economic Area (EA) to maintain continuity with past *Reports* and to ensure that we do not compromise the confidential information found in the NRUF data.[49]

22. As shown in Chart II.C.2, the weighted average HHI (weighted by population across the 172 EAs in the United States) for mobile wireless services at year-end 2015 was 3,111, a slight decrease of 27 points from 3,138 at year-end 2014.[50] Chart II.C.3 below shows the relationship between the HHI by EA and EA population densities, indicating that HHI values, or market concentration, 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.[51]

[48] 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.

[49] 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.

As discussed in this *Report*, "markets" are independent of the relevant market determined 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*).

[50] 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., 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.

Web Appendix II: Competitive Dynamics Within the Industry (Market Concentration by EA, 2012-2015), http://wireless.fcc.gov/competition-reports/mobile-wireless/mw-19/report-assets/index/html provides detailed data on the HHI by EA.

[51] Apart from differences in population, EAs also vary with regard to other likely determinants of market demand such as per-capita income and the age distribution of the population, and facilities-based service provider costs.

Chart II.C.2
Average Population-Weighted HHI Across EAs: 2004–2015

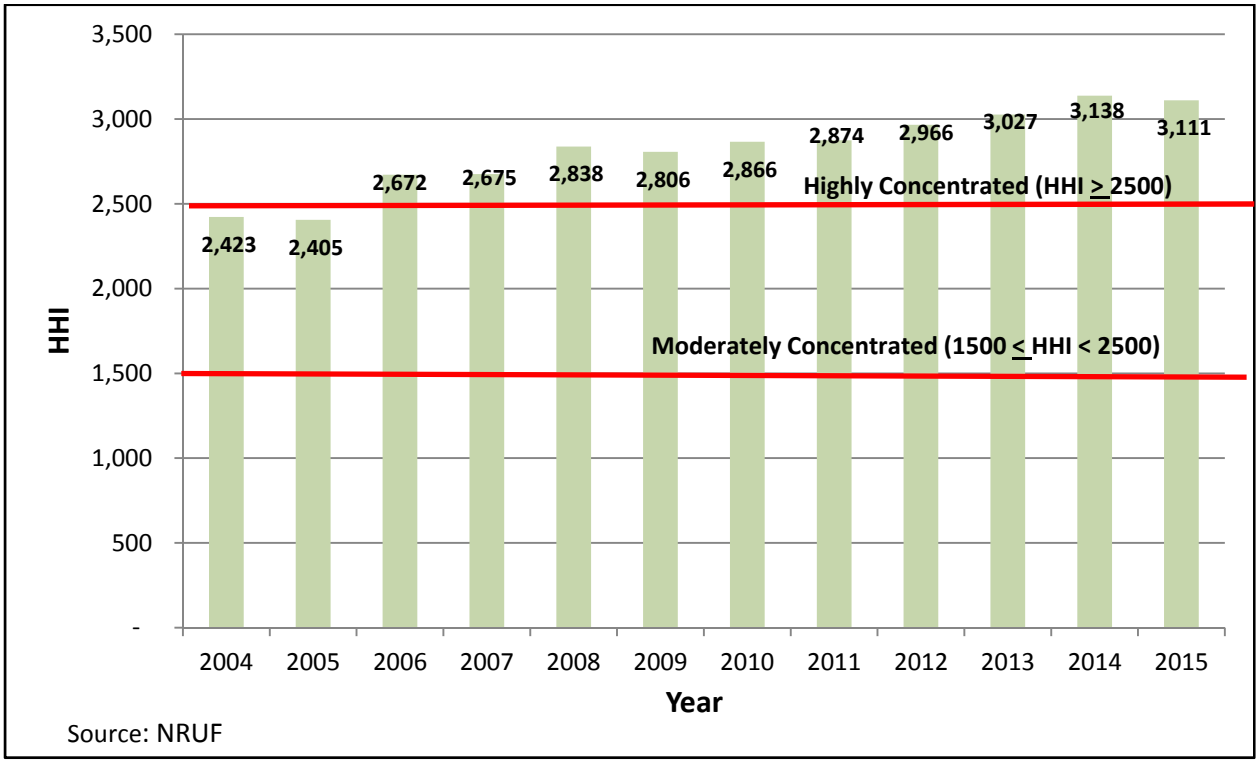
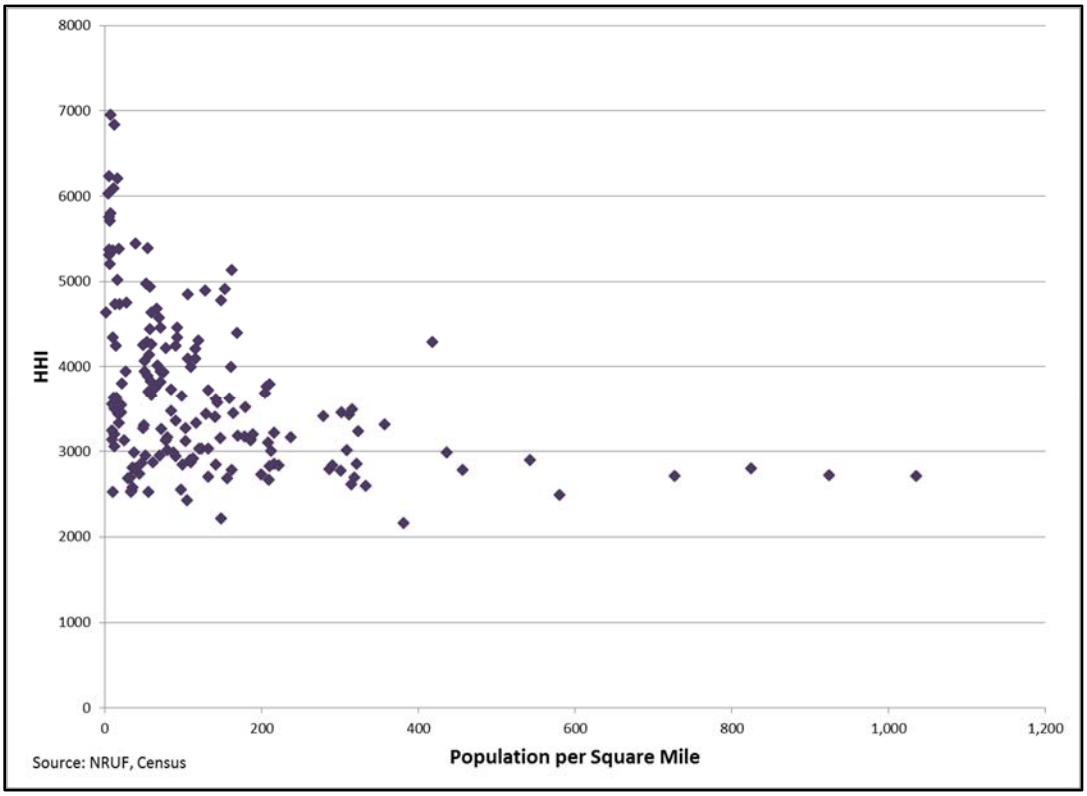


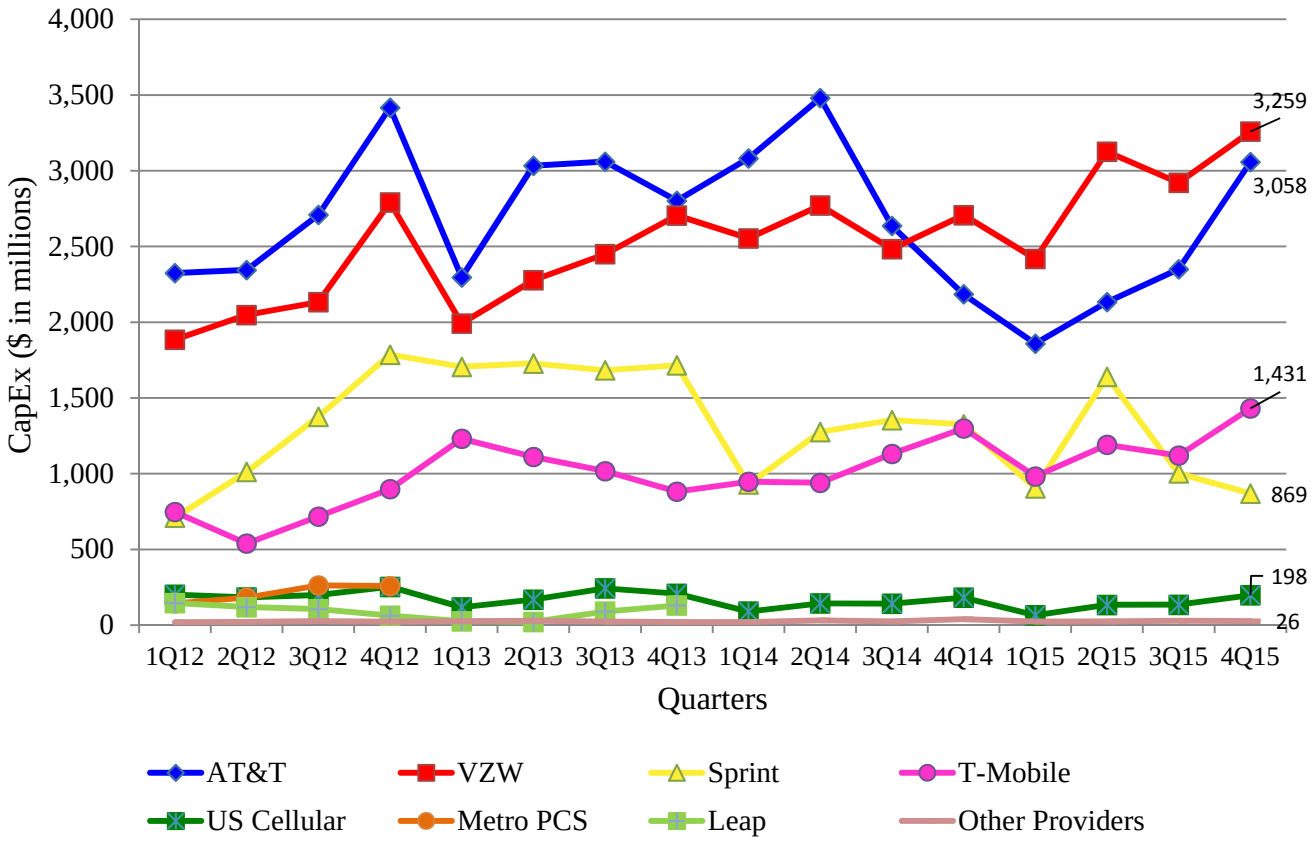
Chart II.C.3
2015 HHIs Plotted Against 2010 EA Population Density



D. Investment

23. Service providers can expand their network coverage and capacity through increased investment in, and expansion of, their existing assets and infrastructure.[52] Service providers may make such strategic capital expenditure (CAPEX) decisions to differentiate their service offerings from those of their rivals by becoming the first to deploy a particular upgrade or new network technology. Over the past six years, wireless service providers in the United States have made capital investments of approximately $177 billion.[53]

Chart II.D.1
Capital Expenditure by U.S. Mobile Wireless Providers
1Q12-4Q15



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. T-Mobile and MetroPCS merged in 2013; AT&T acquired Leap in 2014.

[52] Importantly, service providers also expand into new geographic areas and/or upgrade networks in existing markets after adding to their spectrum portfolios through participation in spectrum auctions and secondary market transactions, as discussed above.

[53] CTIA Wireless Industry Indices Year-End 2015, 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.

24. As shown in Chart II.D.1 above, wireless service providers spent an incremental $30.9 billion in 2015, which is a decline of approximately 3.2 percent from the $31.9 billion invested in 2014.[54] Based on UBS data, AT&T, Sprint, T-Mobile, and Verizon Wireless spent a combined $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. Chart II.D.1 shows that AT&T and Verizon Wireless consistently made more capital investments in absolute CAPEX dollars in each quarter than did either Sprint or T-Mobile. However, if calculated as a percentage of service revenues, as of the end of 2015, for example, Sprint and T-Mobile each invested approximately 18 percent to 19 percent of their total service revenues, as compared to approximately 16 percent for AT&T,[55] and approximately 17 percent for Verizon Wireless.[56] In addition, one should not place too much emphasis on absolute capital expenditures at any given point in time, as that will not provide the full picture of a service provider's investment strategy given the cyclical nature of such investments.[57]

25. Looking beyond the quarterly data in Chart II.D.1, we see the variation in capital expenditures by the four nationwide service providers during the last six years. Chart II.D.2 below presents annual capital expenditures for the four nationwide service providers from 2010 through the end of 2015. From 2010 through the end of 2014, AT&T and Verizon Wireless increased their nominal investment (with the exception of a dip in investment in 2012 for Verizon Wireless). In 2015, Verizon Wireless increased its capital investment, while AT&T's investment decreased. Sprint increased its capital investment from 2010 to 2013, but decreased its capital investment in 2014 and 2015, while T-Mobile's capital expenditures decreased between 2010 and 2011, and subsequently increased, with a sharp spike from 2012 to 2015. Variations in CAPEX may change across service providers for several reasons. First, service providers follow different technological migration paths, which may be on different timeframes. Recently, the industry has followed several technological migration paths for LTE upgrades, with each service provider implementing its own sequence of upgrades. According to analyst William Ho, T-Mobile, for example, had put into place an accelerated schedule on buildout and deploying LTE on its Lower 700 MHz A Block spectrum, whereas Sprint specifically targeted network congestion issues versus broad geographic coverage.[58] Second, service providers often base their investment decisions on an assessment of how network deployments and upgrades may affect future earnings. Third, the timing of network investments often has a strategic component vis-à-vis rivals, as noted above. Finally, access to capital may be more constrained for some service providers, and this may require reallocation of their investment.[59]

[54] UBS US Wireless 411, Version 59, Figure 72.

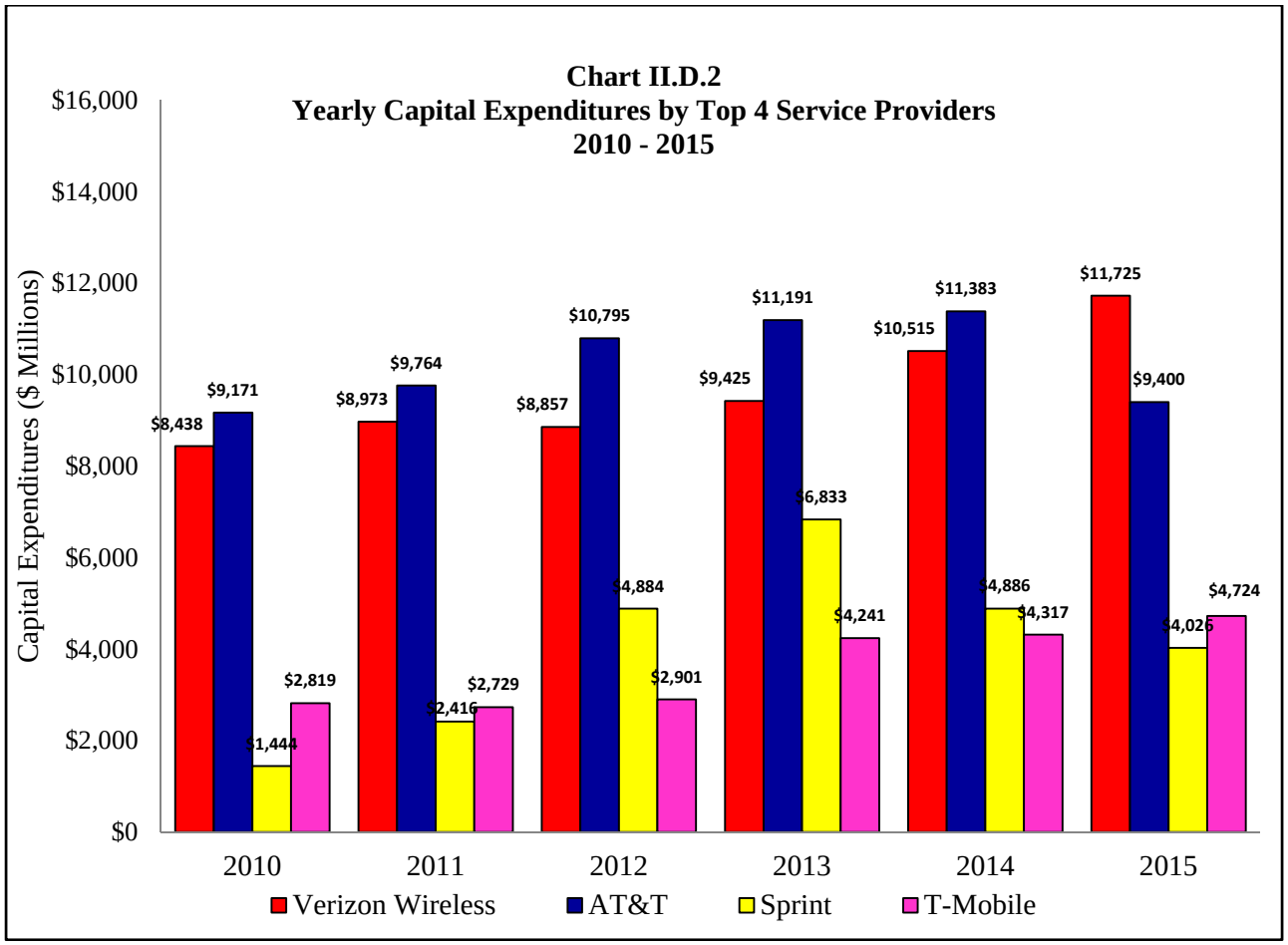
[55] Note that AT&T's financials now report data for DIRECTV in their business segments, and the change from "Wireless" into "Business and Consumer Mobility" means that one cannot make a direct comparison against previously reported data.

[56] UBS US Wireless 411, Version 59, Figure 72.

[57] The *Sixteenth Report* noted that CAPEX in system/network assets may be cyclical or "lumpy" because technological change in the mobile wireless service industry is commercially implemented in successive generations of technologies. Consequently, CAPEX may vary between periods and fluctuations in measures of CAPEX are consistent with the cyclical nature of technological adoption in the mobile wireless service industry. *Sixteenth Report*, 28 FCC Rcd at 3842, para. 215.

[58] FierceWireless, Ho's Perspective: As T-Mobile and Sprint Catch Up to Verizon and AT&T on LTE Coverage, Capacity Comes Into Focus (May 19, 2015), http://www.fiercewireless.com/story/hos-perspective-t-mobile-and-sprint-catch-verizon-and-att-lte-coverage-capa/2015-05-19.

[59] According to The Rural Broadband Association (NTCA), which consists exclusively of small, rural service providers, 70% of the rural service providers who were surveyed described the process of obtaining financing for their wireless projects as "somewhat difficult" or "very difficult," while another 3% found it "virtually impossible." NTCA 2015 Wireless Survey Report, at p. 10 (Dec. 2015), https://www.ntca.org/images/stories/Documents/Advocacy/SurveyReports/2015ntcawirelesssurvey.pdf.



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.

E. Financial Indicators

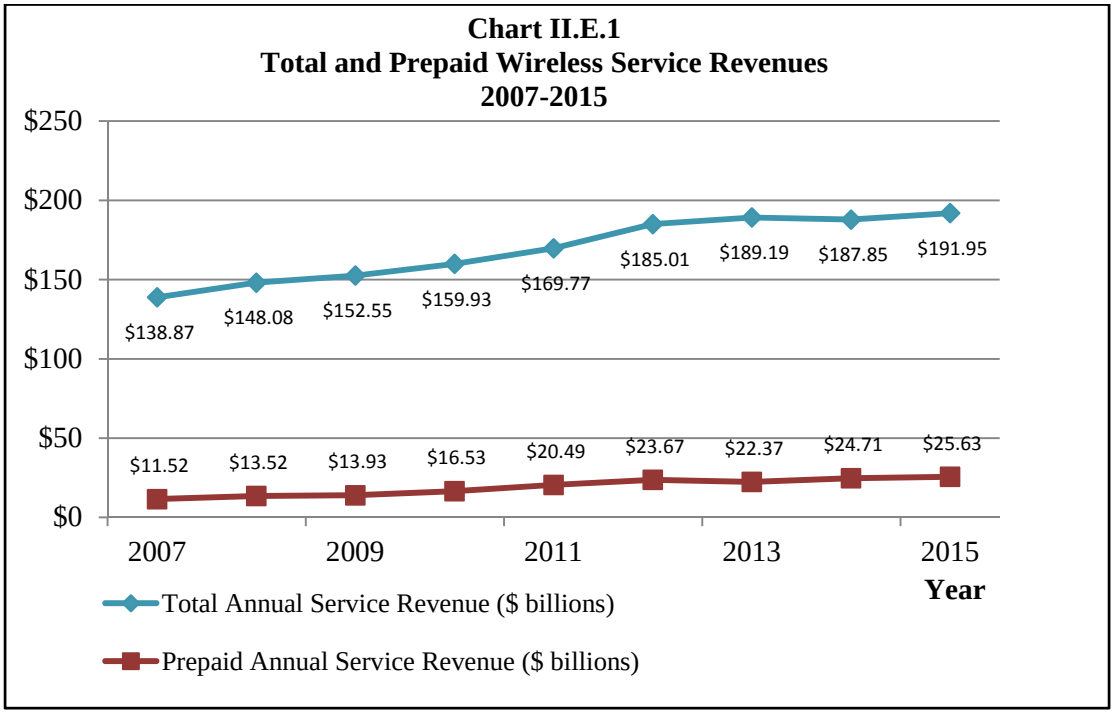
1. Revenue and Average Revenue Per Unit

26. Average price metrics have been necessary and useful tools to compare broad trends in pricing in this industry, even though average metrics have always had their limitations given the longstanding variation in terms of plan characteristics and pricing for mobile voice and data.[60] In 2015, total wireless service revenue was $191.9 billion, a year-over-year increase of 2.2 percent.[61] This increase was in contrast to the revenue decrease

[60] Different service providers have offered a variety of pricing plans for their voice and data services, with service often offered under multi-part pricing schemes and with differing non-price terms and features, such as early termination fees and the consequences of reaching usage limits. 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. Also, data on subscribership is not available at the plan level and any average price comparison implicitly assumes uniform subscribership of all plans.

[61] CTIA Wireless Industry Indices Year-End 2015, at 47. Total wireless service providers' revenues, as reported by CTIA, include monthly service fees, usage-related charges, activation charges, vertical services (voice mail, enhanced calling features, and other services), out-collect roaming revenues, and data service revenues

experienced in 2014, which was the only such year-over-year decrease since 1985.[62] Prepaid revenues increased approximately 4 percent to $25.6 billion in 2015, and accounted for approximately 13 percent of total wireless industry revenues.[63] Chart II.E.1 compares total and prepaid wireless revenues since 2007.



Source: Based on CTIA Wireless Industry Indices Year-End 2015.

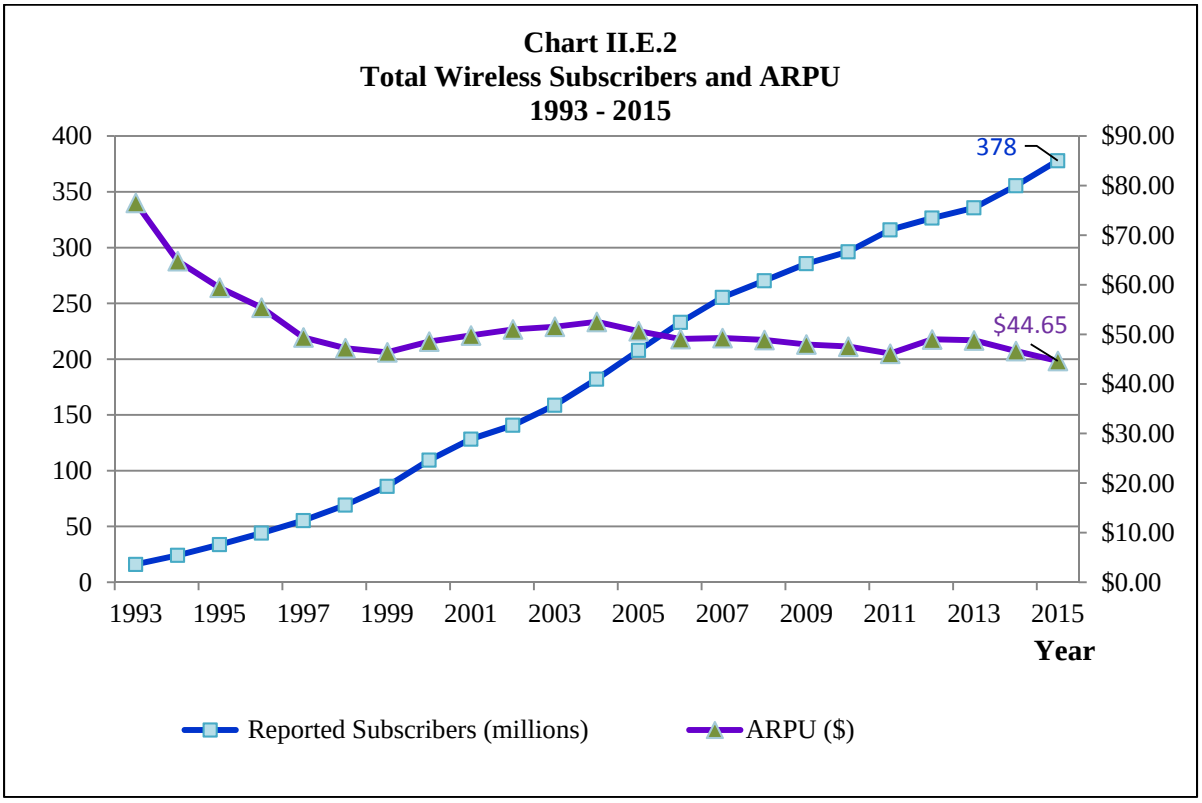
27. CTIA reported an industry average measure of "Average Revenue per Reported (subscriber) Unit," or ARPU, which is based "upon total revenues divided by the average total reported active units per survey period, divided by the number of months in the survey period," i.e., an annualized monthly ARPU.[64] As shown in Chart II.E.1 below, according to CTIA, from December 2014 to December 2015, the industry ARPU was $44.65, a 4.3 percent decline since year-end 2014. Chart II.E.2 also shows subscribers/connections and ARPU for the past 20 years. The chart indicates (in nominal dollars) that the ARPU has slightly declined, for the most part, over the last 10 years, while connections have increased. We note that for the last two reports, the separation of equipment revenues makes it difficult to determine if the decline in the ARPU is likely due to the changes in the

[62] Revenue increased by 4.9%, 6.2%, 9.0%, and 2.3% in 2010, 2011, 2012, and 2013, respectively, and decreased by 0.7% in 2014. Appendix II, Table II.E.i provides further information. Total reported prepaid revenues for 2015 equaled $25.6 billion, up approximately 4% from $24.7 billion reported for 2014. CTIA Wireless Industry Indices Year-End 2015, at 47.

[63] CTIA Wireless Industry Indices Year-End 2015, Appendix C, at 15.

[64] This ARPU is not equal to the "average bill" for a household or consumer as it is not equal to the bill for an "account," which may cover several different devices, such as multiple phones (under a family plan) or multiple devices (including phones, tablets, wireless broadband modems, or other adjunct devices covered by a customer's service plan). It assigns overall service revenue across all revenue generating devices. The total service revenues used include roaming revenues, usage fees, access, and other connection fees. CTIA Wireless Indices Year-End 2015, at 1, 53.

reporting and/or the calculation of the metric.[65] In 2015, the ARPU based on service and equipment revenues was $54.62, according to CTIA, down approximately 2 percent from $55.65 in 2014.[66]



Source: Based on CTIA Wireless Industry Indices Year-End 2015.

2. Average Revenue Per Unit by Service Provider

28. We now present UBS estimates of ARPU and the unit price of mobile wireless broadband services. As seen in Table II.E.1, there is some variation in ARPU amongst the various national and regional wireless service providers, despite the relative stability at the industry level. Table II.E.1 below shows that between the fourth quarter of 2012 and the fourth quarter of 2015, all four nationwide service providers experienced a decline in ARPU. AT&T's ARPU declined by approximately 17 percent, Verizon Wireless's

[65] Under Equipment Installment Plan (EIP) accounting, the revenue associated with the sale of a handset is fully recognized at the time of sale–regardless of whether the handset is paid for upfront or financed–accelerating revenue and therefore EBITDA (Earnings before Interest, Taxes, Debt, and Amortization). At the same time, future service revenues are reduced, lowering service ARPU and EBITDA back to pre-EIP adoption levels. By contrast, in traditional subsidy plans, the full cost of the handset is recognized at the time of sale (just as in EIP accounting), but the bulk of the handset's revenues (less the upfront price paid for the device) are recognized over a period of years, in the form of higher service revenues. The result is a near-term reduction in revenues, EBITDA, and margins, offset by higher service revenue in the future. *Eighteenth Report*, 30 FCC Rcd at 14533, n.57.

[66] CTIA Wireless Industry Indices Year-End 2015 at 57. As discussed in the last two reports, while the ARPU metric remains the best such measure currently used by industry and financial analysts, its consistent estimation has become more difficult. Industry and financial analysts have had to make additional assumptions and begun to estimate a new, normalized version of ARPU, dividing overall reported service revenues by the average number of connections for the time period. *Seventeenth Report*, 29 FCC Rcd at 15328-29, para. 36; *Eighteenth Report*, 30 FCC Rcd at 14534, n.60.

ARPU declined by approximately 14 percent, Sprint's ARPU declined by approximately 18 percent, and T-Mobile's ARPU declined by approximately 14 percent. The overall declines in ARPU are likely attributable to the more widespread use of EIPs, as discussed in Section V. below, which enable subscribers to pay for equipment via installment payments.[67] Regional service providers, such as U.S. Cellular and NTELOS, also experienced a decrease in ARPU during this time.

Table II.E.1
ARPU Estimates of Publicly Traded Facilities-Based Mobile Wireless Service Providers
4th Quarter 2012–4th Quarter 2015

Nationwide Providers	4Q12	4Q13	4Q14	4Q15
AT&T	$46.94	$47.58	$42.04	$38.78
Verizon Wireless	$47.57	$47.50	$45.52	$40.99
Sprint	$43.37	$44.83	$40.44	$35.54
T-Mobile	$40.24	$36.91	$35.56	$34.53
Regional/Rural Providers	4Q12	4Q13	4Q14	4Q15
U.S. Cellular	$50.89	$50.21	$53.58	$49.32
MetroPCS	$40.86	*	*	*
Leap Wireless	$40.69	$45.55	*	*
NTELOS	$52.78	$54.11	$52.35	$49.14
Cincinnati Bell	$43.28	$41.35	$39.87	*

Source: UBS US Wireless 411, Version 59, Figure 65.

3. Wireless Telephone Services Consumer Price Index

29. 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.[68] 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.[69] 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.[70] According to CPI data, the price (in constant dollars) of mobile wireless services has continued

[67] UBS US Wireless 411, Version 59, at 12.

[68] 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.

[69] *See, e.g., Eighteenth Report*, 30 FCC Rcd at 14535, para. 29.

[70] 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. 14, 2016). 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,

to decline. From 2014 to 2015, the annual Wireless Telephone Services CPI decreased by 3.8 percent while the overall CPI increased by 0.1 percent and the Telephone Services CPI fell by 1.8 percent.[71]

4. Profitability Metrics

30. One measure of competition in the mobile wireless marketplace is the relative profitability of competitors. In the absence of the data necessary to estimate economic profits, accounting profits can instead be estimated using various metrics available to wireless industry observers. One such accounting profits metric, based on company data reported to the Securities and Exchange Commission (SEC), is EBITDA (Earnings before Interest, Taxes, Debt, and Amortization), which equals accounting profits before deducting interest expenses, corporate income taxes, depreciation, and amortization. In 2015, as shown in Table II.E.2 below, out of the nationwide facilities-based service providers, EBITDA per subscriber ranged from a low of $10.39 (T-Mobile) to a high of $23.70 (Verizon Wireless).

Table II.E.2
Annual EBITDA per Subscriber ($/month), 2012–2015

Top 5 Mobile Wireless Service Providers	2012	2013	2014	2015
Verizon Wireless	22.21	23.56	22.67	23.70
AT&T	18.64	19.55	18.39	18.74
Sprint	6.11	7.53	9.14	11.01
T-Mobile	12.09	10.08	9.20	10.39
U.S. Cellular	11.51	7.34	6.01	11.74

Source: UBS US Wireless 411, Version 59, Figure 71. Annual figures are calculated by taking the average of each quarter for each year.

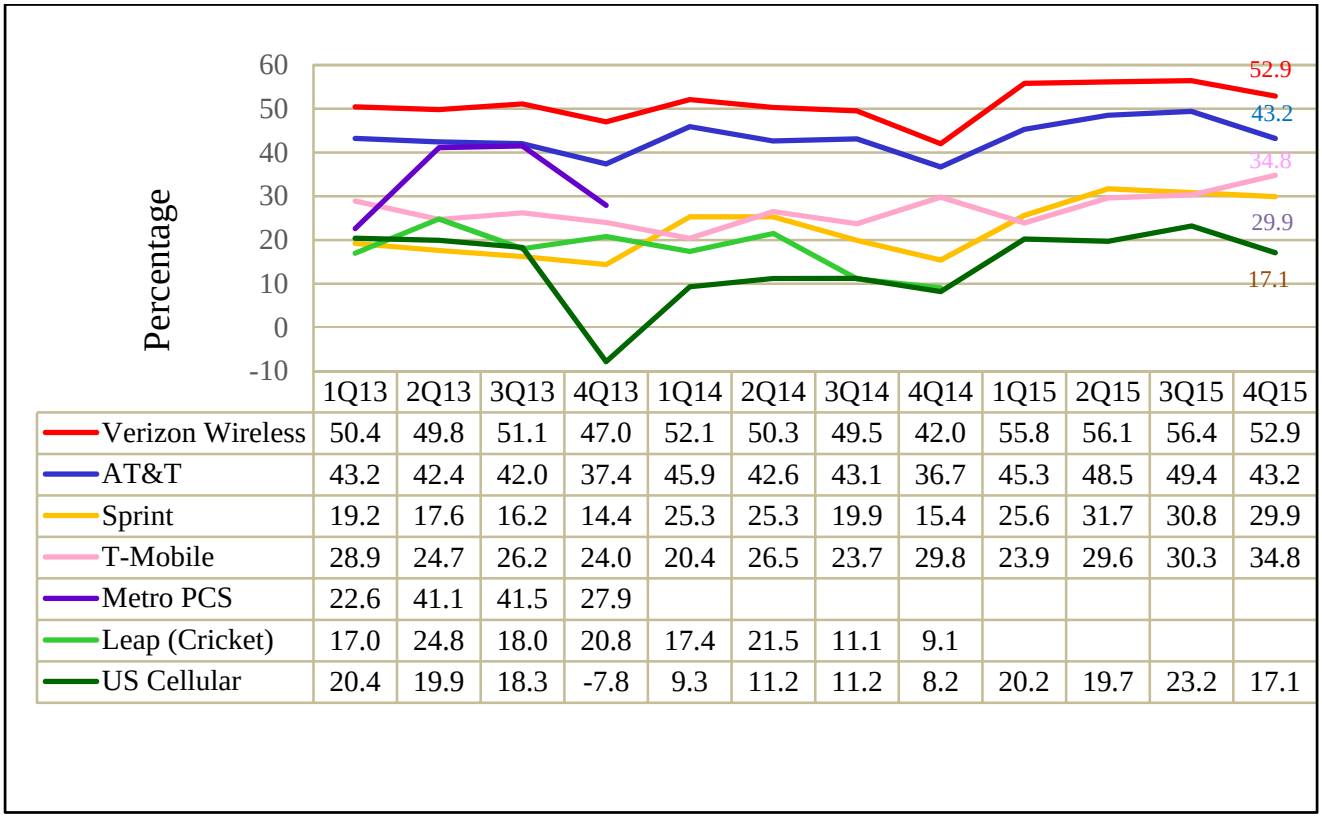
31. A second indicator of mobile wireless segment profitability is the EBITDA margin, which expresses EBITDA as a percentage of service revenue.[72] Standardizing EBITDA by service revenues facilitates cross-provider comparisons. The EBITDA margin of a number of the publicly reported mobile service providers for the past three years is shown in Chart II.E.3. At year-end 2015, the EBITDA margins of the top four nationwide service providers ranged from approximately 30 percent for Sprint to approximately 53 percent for Verizon Wireless.

http://www.bls.gov/cpi/cpifaq.htm (last visited Sept. 14, 2016). The Cellular CPI includes charges from all telephone companies that supply "cellular telephone services," which are defined as "domestic personal consumer phone services where the telephone instrument is portable and it sends/receives signals for calls by wireless transmission." This measure does not include business calls, telephone equipment rentals, portable radios, and pagers. While the CPI-U is urban-oriented, it does include expenditure patterns of some of the rural population. Information submitted by companies for the CPI is provided on a voluntary basis.

[71] Appendix II, Table II.E.ii provides more details.

[72] The EBITDA margin is equal to EBITDA divided by total revenue. Because EBITDA excludes depreciation and amortization, the EBITDA margin may provide a cleaner view of a company's core profitability.

Chart II.E.3
Reported EBITDA Margins (%) for Selected Publicly Traded Facilities-Based Wireless Service Providers, 2012–2015



	1Q13	2Q13	3Q13	4Q13	1Q14	2Q14	3Q14	4Q14	1Q15	2Q15	3Q15	4Q15
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
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
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
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
Metro PCS	22.6	41.1	41.5	27.9								
Leap (Cricket)	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

Source: UBS US Wireless 411, Version 59, Figure 70.

III. OVERALL MOBILE WIRELESS INDUSTRY METRICS

32. In this Section, we discuss the current market trends in the mobile wireless marketplace and provide additional analysis highlighting specific changes that have occurred since the last *Report*. Specifically, this Section examines various indices such as the number of connections and distribution of subscribers by geography and by demographics. Further, it analyzes the extent of mobile wireless and LTE broadband coverage, including by number of available service providers, and provides a comparison of rural versus non-rural markets.

A. Network Coverage

33. We measure network coverage based on two sets of service provider coverage maps. The first set of maps is provided to the Commission through a contract with Mosaik Solutions.[73] The second set of maps is

[73] Mosaik Solutions is an independent consulting firm that tracks coverage footprints of mobile voice and mobile data networks and provides data under contract to the Commission 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. 14, 2016). 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. Further, we note that an analysis of coverage at the nationwide level will mask regional disparities in coverage. *Eighteenth Report*, 30 FCC Rcd at 14537-38, para. 34.

based on Form 477 data, which contains information on deployment at a detailed geographic level.[74] We first apply a centroid methodology to both the Mosaik data and the Form 477 data, as we have done in previous *Reports*. Second, we analyze the Form 477 data on a sub-census-block level, calculating the percentage of each census block covered by each technology.

34. The centroid methodology is applied to U.S. census blocks overlaid on service provider coverage maps, whereby if the geometric center point, or centroid,[75] of a census block is within the coverage boundary of a coverage map,[76] then we consider that block to be "covered" by that service provider and/or technology.[77] We then aggregate the population, land area, and road miles of the covered census blocks to generate our total

[74] 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 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. Providers are also required to certify as to the accuracy of the data submitted. *Id.*, 28 FCC Rcd at 9897-98, paras. 23-24 (noting that the certification obligation will help promote complete and accurate data).

The scope and nature of the Form 477 data on mobile services coverage is an improvement over earlier data sources in certain key respects, such as the uniformity of data reporting. *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act*, 2016 Broadband Progress Report, 31 FCC Rcd 699, 708-09, para. 22 (2016) (*2016 Broadband Progress Report*) ("[D]ata from the Form 477 . . . help us better analyze mobile broadband deployment than in years past.").

[75] 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. 14, 2016).

The 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. 14, 2016). 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*).

[76] 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. 14, 2016).

[77] We note that "although 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 Eighteenth Report*, 30 FCC Rcd at 14537-38, para. 34.

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 recognizing therefore that this analysis likely overstates the coverage experienced by some consumers,[78] especially in large or irregularly shaped blocks, we find that this analysis is useful because estimated coverage can be compared across network technologies and service providers.[79]

35. In addition to the centroid method, we also analyze the Form 477 data on a sub-census-block level, calculating 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 calculates the exact area of the block covered by each service provider by technology.[80] However, as we do not currently know the distribution of the population at the sub-census-block level, we must approximate the population covered by each technology. To do this, we assume for purposes of this *Report,* that the fraction of the population covered in a block is proportional to the fraction of the actual area covered and then we sum the estimated covered population across blocks to estimate the total covered population within the United States. The same methodology is also used to estimate total road miles covered. It is important to note that at the aggregate national level, the results will 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 approach to take. However, the actual area coverage methodology does yield more precise estimates, and differences in the coverage results are expected to show more clearly at the disaggregated geographic level, particularly in the rural areas of the United States.[81]

36. We first present our overall mobile wireless coverage estimates of the percentage of the U.S. population, land area, and road miles covered by a certain number of facilities-based service providers.[82] We then present estimated LTE mobile broadband coverage, which is now the baseline industry standard for the marketing of mobile broadband service, using the same categories. We then turn to overall mobile wireless and LTE coverage in rural and non-rural areas. We note that LTE deployment does not necessarily result in specific guaranteed speeds for consumers. In addition, we note that moving forward, and as also indicated in Section VI.

[78] *Eighteenth Report*, 30 FCC Rcd at 14537-38, para. 34.

[79] *Id.* at 14537-38, para. 34. We note that the centroid methodology may 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.

[80] 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, we note that the set of unique combinations that it produces are valid for each individual technology but not across multiple technologies. Essentially, while currently we can distinguish the unique percentages covered by various service providers at the sub-census-block level using LTE say, we do not currently know how this interplays with 2G or 3G technologies. Therefore, for the U.S. overall, we can calculate the areas served and not served by LTE, non-LTE 4G, 3G, and 2G technologies.

[81] The actual area coverage methodology is more precise than the centroid methodology for understanding the exact land area covered by a given technology because it uses sub-census-block level coverage reported directly by service providers on their Form 477 submissions to get an accurate representation of coverage by providers, rather than using analysis based on proxies for coverage within census blocks.

In our current estimations, to calculate population and road mile coverage, we assume that both population and road miles are distributed evenly across each census block. 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, but we do not have access to that information at this point in time for the current *Report*.

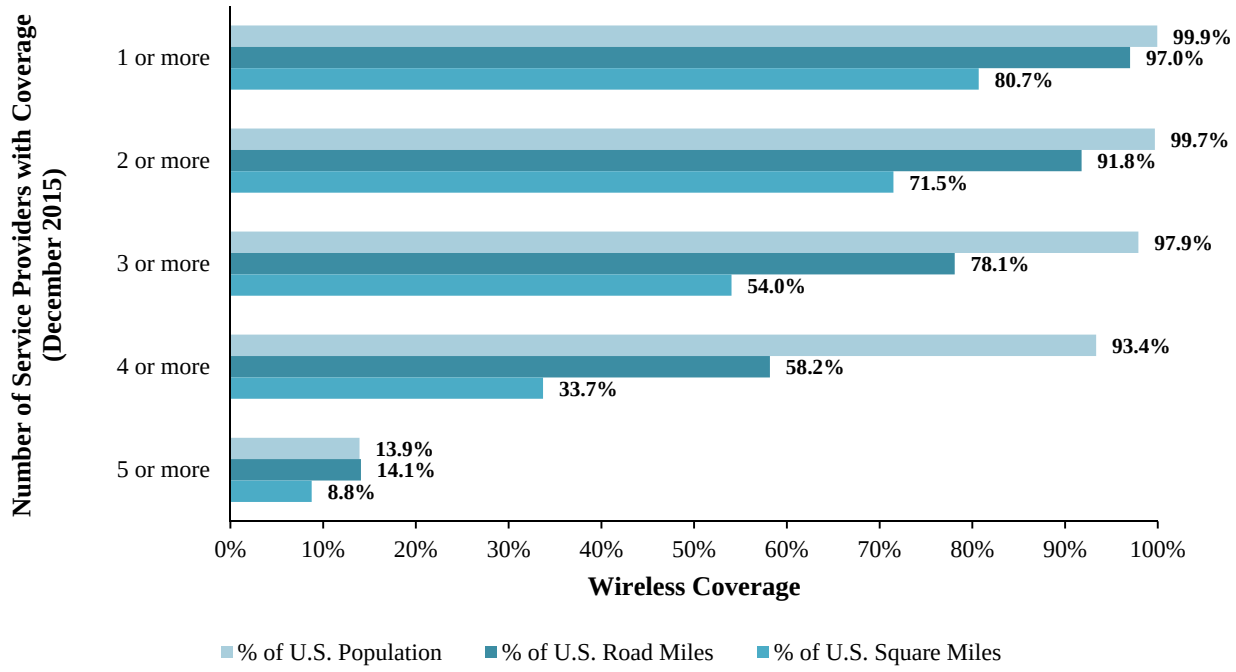
[82] We note that service providers often offer coverage outside of their network coverage areas through roaming arrangements which allow their customers to automatically receive service from other service providers' networks when they are in areas that are covered by their roaming partners' networks 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.

below, we anticipate that Form 477 data will become our primary source for the analysis of overall mobile wireless coverage as well as coverage by individual service providers in the mobile wireless marketplace.[83]

1. Overall Mobile Wireless Network Coverage

37. Subject to the limitations just described, the available data suggest quite extensive mobile wireless coverage. Chart III.A.1 presents overall mobile wireless coverage based on centroid analysis of December 2015 Form 477 data,[84] and shows that more than 90 percent of the population is covered by at least four service providers. However, these census blocks accounted for only approximately 34 percent of the total land area of the United States, and approximately 58 percent of total U.S. road miles.

Chart III.A.1
Estimated Wireless Coverage by Census Block Including Federal Land
Form 477, Centroid Method, December 2015



Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

[83] Web Appendix III: Overall Mobile Wireless Industry Metrics (Overall, 3G or Better, and LTE Coverage by Number of Service Providers), http://wireless.fcc.gov/competition-reports/mobile-wireless/mw-19/report-assets/index/html presents our estimates of mobile service provided using any of the following 3G or 4G technologies: EVDO, EVDO Rev A, WCDMA/HSPA, HSPA+, LTE, and mobile WiMAX. Further, Web Appendix III: Overall Mobile Wireless Industry Metrics (Overall, 3G or Better, and LTE Coverage by Number of Service Providers), http://wireless.fcc.gov/competition-reports/mobile-wireless/mw-19/report-assets/index/html present our estimates of overall mobile wireless coverage and LTE coverage by census block excluding Federal land.

[84] In addition, Appendix Chart III.A.i and Table III.A.i present the results based on the centroid analysis of January 2016 Mosaik data, while Appendix Table III.A.ii provides more details based on Form 477 data.

38. In this *Report*, we have included a service provider if it has a market share above a particular threshold, and we have made estimates based on two alternative thresholds. Specifically, to estimate the number of service providers serving a 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 based on NRUF data. Table III.A.1 presents the data for December 2012 and December 2015, and shows that since 2012, based on the five percent market share threshold, the number of CMAs with three service providers has decreased, while the number of CMAs with four service providers has substantially increased.[85] There has been a decrease in the number of CMAs with at least five service providers based on the five percent market share threshold primarily due to increased industry consolidation over the past several years.

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

	Two Percent Market Share Threshold				Five Percent Market Share Threshold			
Number of Providers Offering Service Anywhere in a CMA	Number of CMAs		Total CMAs (percent)		Number of CMAs		Total CMAs (percent)	
	2012	2015	2012	2015	2012	2015	2012	2015
Total for U.S., excluding territories	*716*	*716*	*100.0%*	*100.0%*	*716*	*716*	*100.0%*	*100.0%*
1 provider	1	0	0.1%	0.0%	1	1	0.1%	0.1%
2 providers	55	73	7.7%	10.2%	128	158	7.7%	22.1%
3 providers	157	113	21.9%	15.8%	221	166	21.9%	23.2%
4 providers	205	389	28.6%	54.3%	247	332	28.6%	46.4%
5 or more providers	298	141	41.6%	19.7%	119	59	41.6%	8.2%

Source: Based on December 2012 and December 2015 NRUF data.

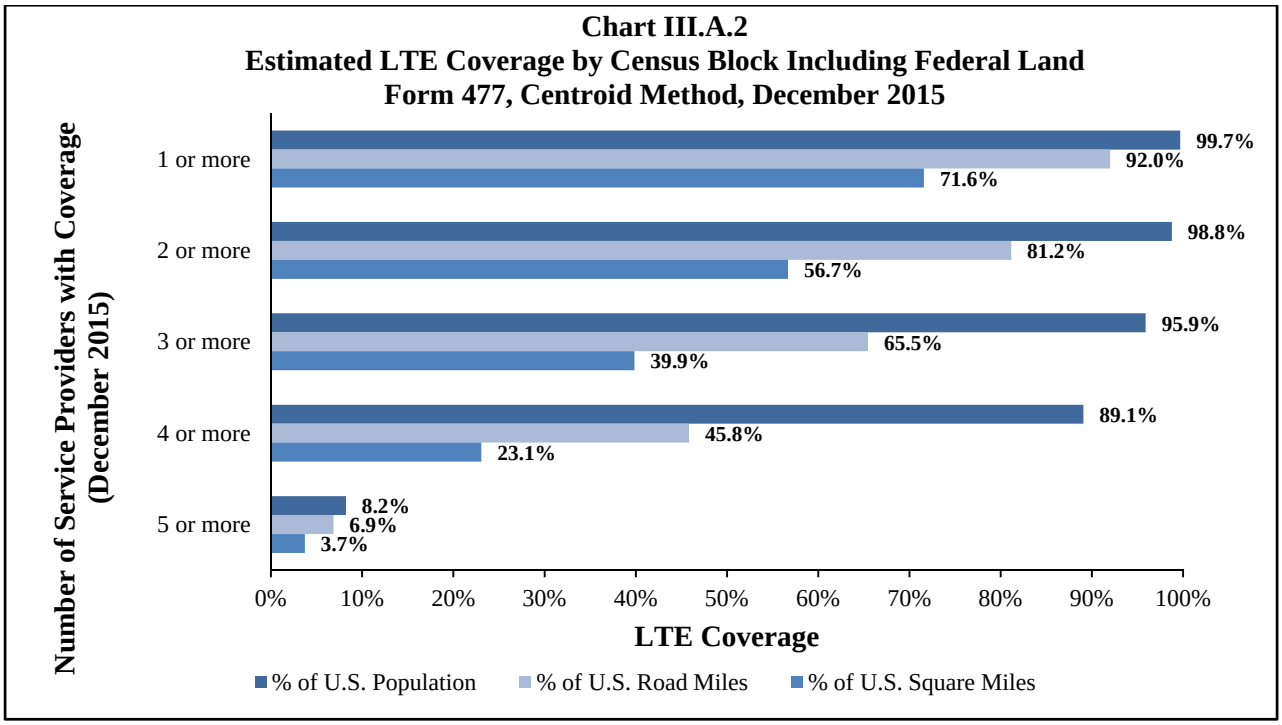
2. LTE Mobile Broadband Coverage

39. Charts III.A.2 and III.A.3 present LTE mobile broadband coverage based on the centroid methodology and the actual area coverage methodology as of December 2015 for the Form 477 data.[86] According to our analysis, approximately 89 percent of the U.S. population lived in census blocks with LTE coverage by at least four service providers at the end of 2015. However, 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. We note that at the national level, the aggregate results are similar for both methodologies. However, the actual area coverage methodology is more precise exactly because it provides us with the actual geographic area covered by a given technology. In addition, we note that differences in the results between the two methodologies are expected to show more clearly at the disaggregated geographic level.[87]

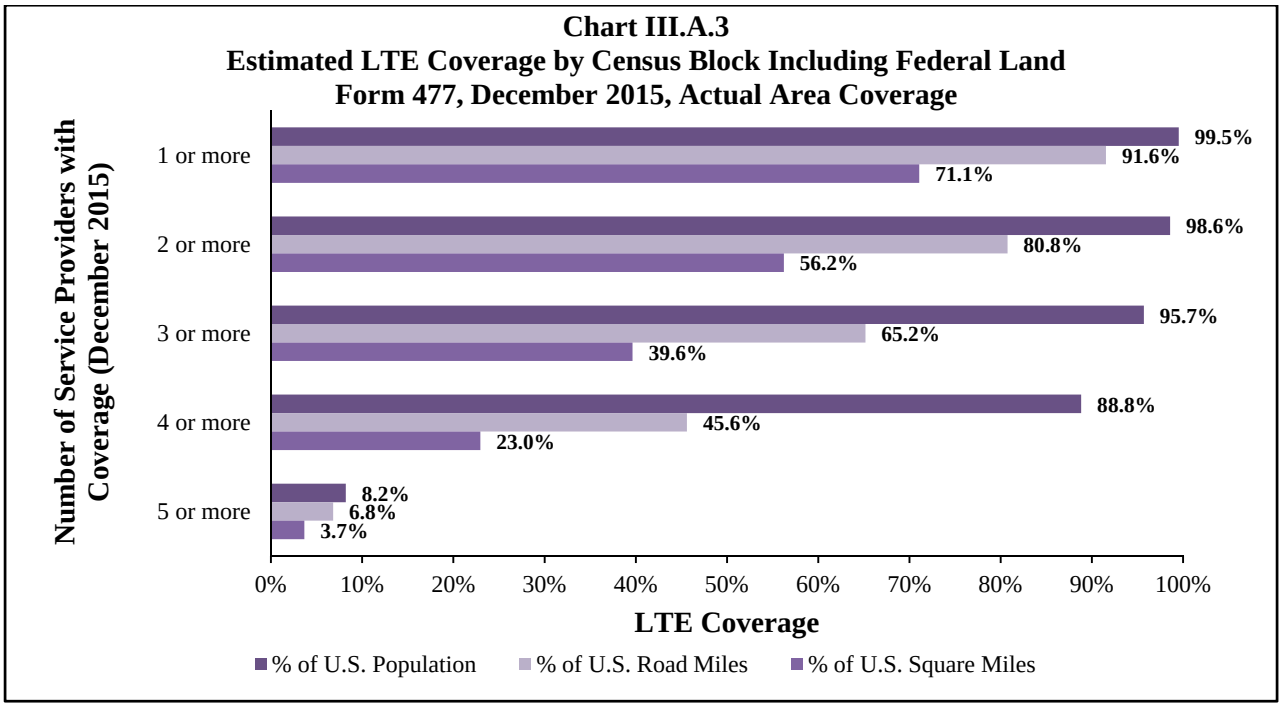
[85] Because NRUF includes data on the number of telephone numbers that have been assigned to end-user devices by mobile wireless service providers, this analysis does not include service providers whose data-only devices are not assigned a mobile telephone number.

[86] Appendix Tables III.A.iii-v and Chart III.A.ii provide more details of estimated LTE coverage, including January 2016 data from Mosaik. As noted above, LTE deployment does not necessarily result in a guaranteed speed for consumers.

[87] As noted above, the actual area coverage methodology is more precise than the centroid methodology for understanding the exact land area covered by a given technology. In our current estimations, we assume that both population and road miles are distributed evenly across each census block. In order to fully exploit the increase in precision offered by the actual area



Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.



Source: Based on the actual area coverage analysis of December 2015 Form 477 and 2010 Census data.

coverage methodology, spatially accurate representations of population and road miles would be necessary, but we do not have access to that information at this point in time for this *Report*.

3. Rural/Non-Rural Comparisons

40. While the Communications Act does not include a statutory definition of what constitutes a rural area, since its *2004 Report and Order* concerning the deployment of wireless services in less populated areas, the Commission has used a "baseline" definition of rural as a county with a population density of 100 people per square mile or less.[88] We use this same baseline definition of "rural" to analyze coverage in rural versus non-rural areas for all of our analysis throughout this *Report* (including the Appendices).

41. In order to determine whether the counties are rural or non-rural for our coverage analysis throughout this *Report*,[89] we first excluded all water-only census blocks within each county. We then divided the county population by the total geographic area of the county (excluding the previously identified water-only blocks) to determine the county population density. For those counties with a population density of 100 people per square mile or less, all census blocks within those counties were considered rural. By this definition, approximately 56 million people, or approximately 18 percent of the U.S. population, live in rural counties based on 2010 U.S. Census data.[90] In addition, these counties comprise approximately 3 million square miles, or approximately 84 percent of the geographic area of the United States.[91]

a. Rural and Non-Rural Mobile Wireless Network Coverage

42. Chart III.A.4 below presents mobile wireless coverage of both the rural and non-rural U.S. population based on the Form 477 centroid analysis.[92] Chart III.A.4 shows that as of December 2015, 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. Overall, the difference in coverage becomes more pronounced with the number of service providers.

[88] *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*) ("We recognize, however, that the application of a single, comprehensive definition for 'rural area' may not be appropriate for all purposes. . . Rather than establish the 100 persons per square mile or less designation as a uniform definition to be applied in all cases, we instead believe that it is more appropriate to treat this definition as a presumption that will apply for current or future Commission wireless radio service rules, policies and analyzes for which the term 'rural area' has not been expressly defined. By doing so, we maintain continuity with respect to existing definitions of 'rural' that have been tailored to apply to specific policies, while also providing a practical guideline"). *Id.* at 19087-88, para. 12.

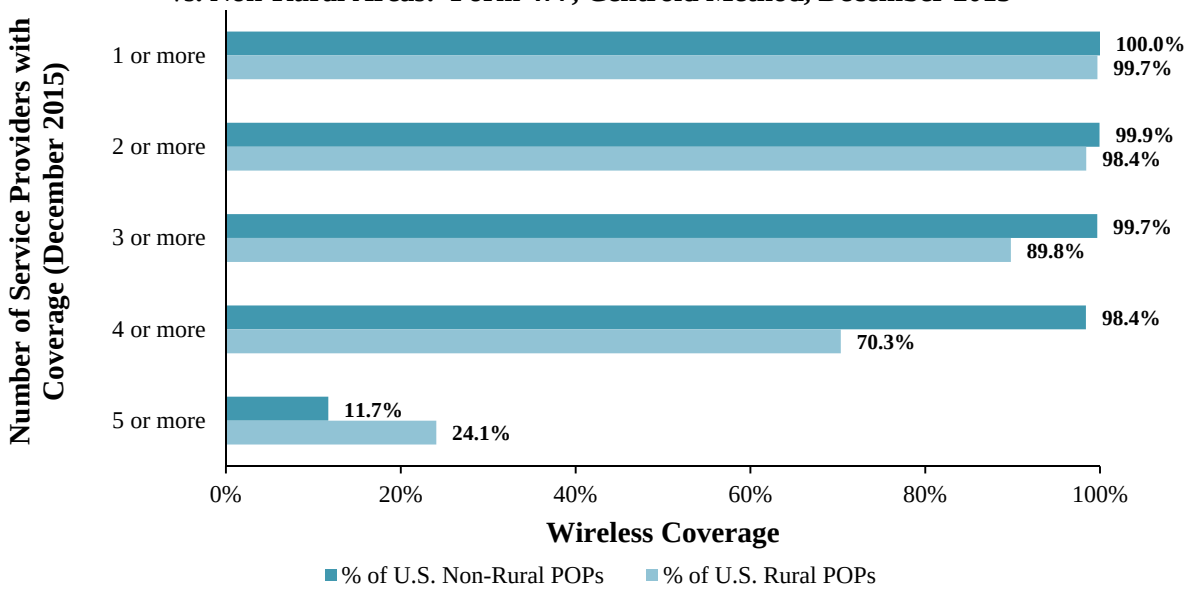
[89] This same identification of rural versus non-rural counties is also used for all analysis presented in the relevant Tables and Charts included in the Web Appendices.

[90] We note that in previous *Reports*, all census blocks, including water-only blocks, have been used to generate the total geographic area of the county. Based on this methodology, approximately 59 million people, or approximately 19 percent 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 III.A.vi-vii; *Seventeenth Report*, 29 FCC Rcd at 15336-37, 15430, paras. 52-53, Appendix Tables III.A.vi-vii; *Sixteenth Report*, 28 FCC Rcd at 3725, 3939, 3942-43, para. 387, Tables 55-58.

[91] 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*.

[92] Appendix Charts III.A.iii-iv and Tables III.A.vi-xiii provide more detailed information on rural and non-rural coverage (overall mobile wireless coverage as well as LTE coverage).

Chart III.A.4
Estimated Wireless Coverage by Census Block Including Federal Land in Rural vs. Non-Rural Areas: Form 477, Centroid Method, December 2015

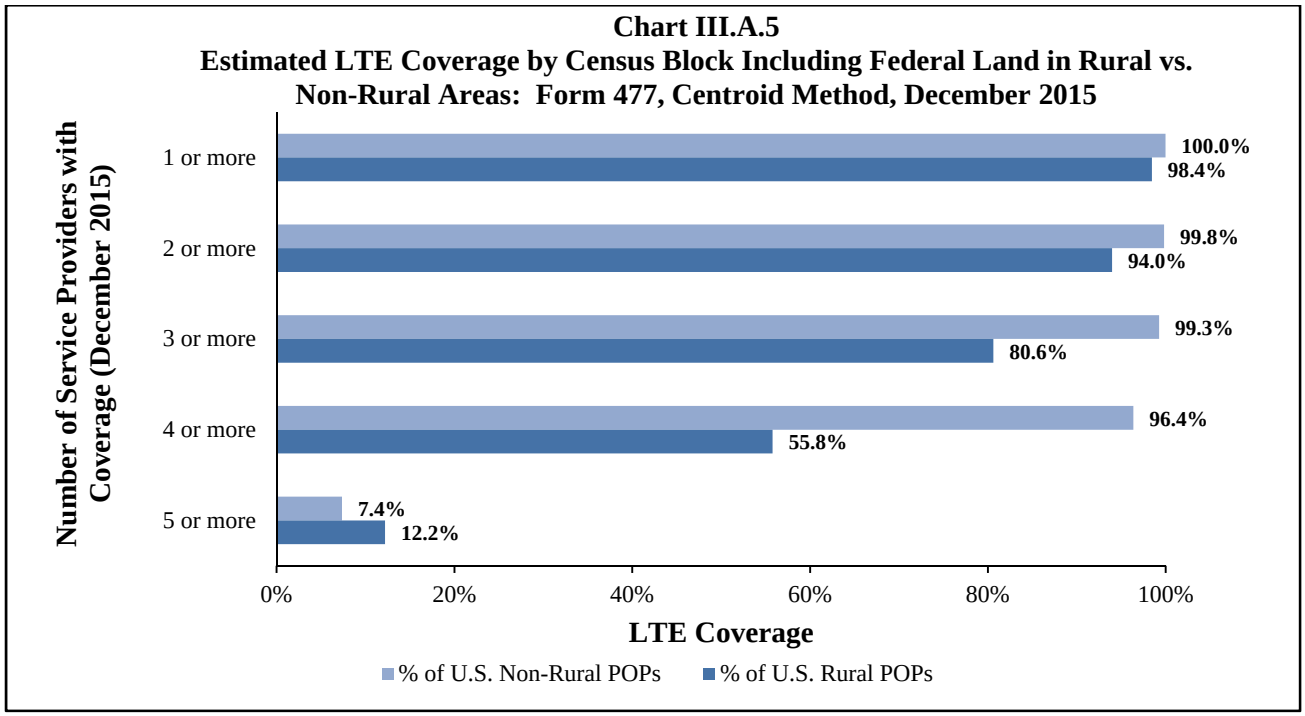


Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

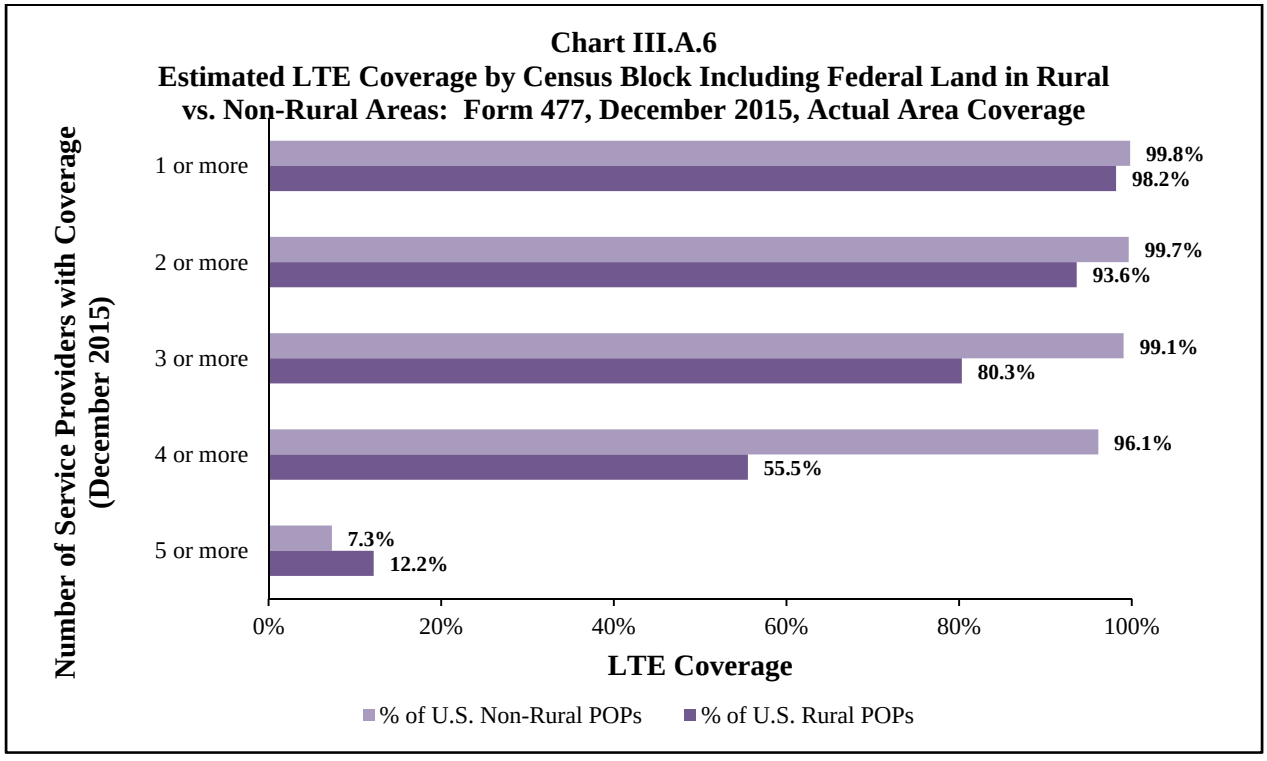
b. Mobile LTE Network Coverage

43. Similar to overall mobile wireless coverage, the LTE coverage gap between the populations living in rural versus non-rural census blocks also increases as the number of service providers increases. Charts III.A.5 and III.A.6 present LTE population coverage in rural and non-rural census blocks by number of service providers, based on the Form 477 centroid and actual area methodologies. We note that at the national level, the aggregate results are similar for both methodologies. However, as discussed above, the actual area coverage methodology is more precise exactly because it provides us with the actual geographic area covered by a given technology. In addition, as noted above, differences in the results between the two methodologies are expected to show more clearly at the disaggregated geographic level.[93] Our estimates show that approximately 99 percent of the non-rural population was covered by at least three LTE service providers, while approximately 80 percent of the rural population had the same network coverage. Considering coverage by four or more service providers, approximately 96 percent of the non-rural American population had LTE coverage, while only approximately 56 percent of the rural population was covered by at least four LTE service providers.

[93] As noted above, the actual area coverage methodology is more precise than the centroid methodology for understanding the exact land area covered by a given technology. In our current estimations, we assume that both population and road miles are distributed evenly across each census block. 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, but we do not have access to that information at this point in time for this *Report*.



Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

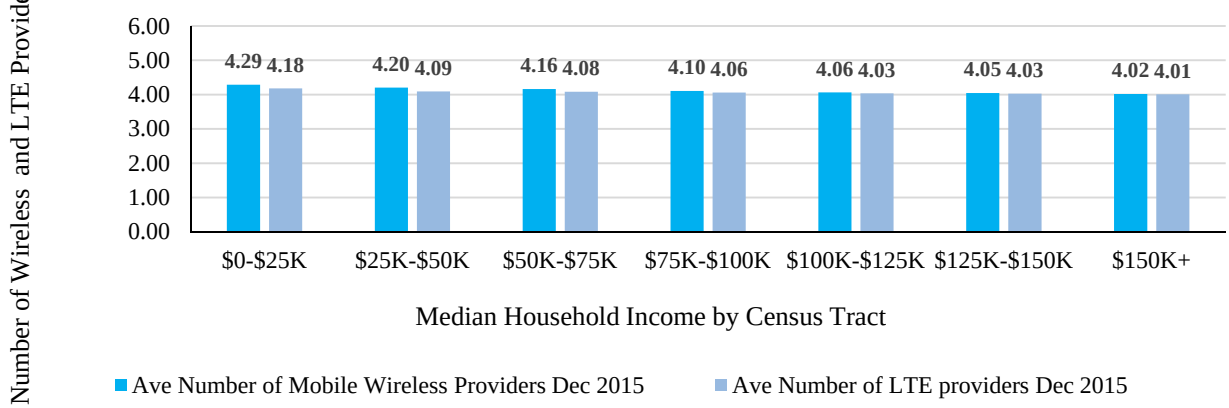


Source: Based on the actual area coverage analysis of December 2015 Form 477 and 2010 Census data.

4. Mobile Wireless and LTE Broadband Coverage by Income Levels

44. Charts III.A.7a–c below show, based on the Form 477 centroid methodology,[94] how the number of facilities-based mobile wireless service providers that have mobile wireless and LTE coverage in a census tract varies by median household income levels.[95] The charts show that the average number of mobile wireless providers with coverage in census tracts was at least four, no matter the ruralness of the census tract, nor the median income level. The charts reveal a different picture for the number of service providers with LTE coverage by census tract. For households with a median income of less than $25,000, the average number of service providers with LTE coverage in non-rural areas was 4.18, as compared to 3.45 in extremely rural areas, whereas for households with a median income of $25,000 to $50,000, the average numbers were 4.09 and 3.71, respectively.

Chart III.A.7.a
Average Number of Mobile Wireless and LTE Providers in Census Tracts by Median Household Income in Non-Rural Areas with Population Density Greater Than 100 People per Square Mile. Form 477, Centroid Method, December 2015



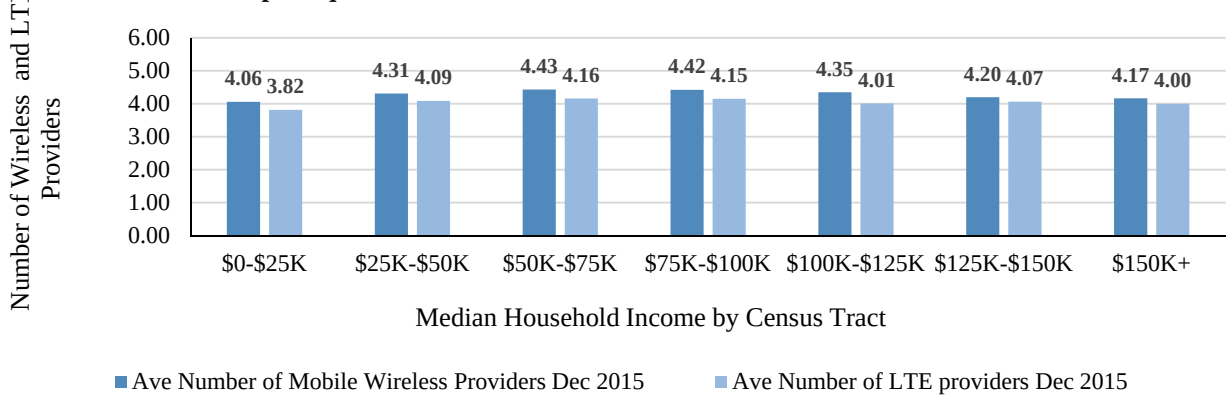
Source: Data on median household income by census tract are based on the U.S. Census Bureau's American Community Survey (ACS) 2009-2013. Data on the number of service providers are based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. Therefore the coverage calculation methodology has certain limitations that likely result in an overstatement of the extent of mobile wireless coverage.

[94] Analyses relying upon the centroid method using the Mosaik dataset can be found in the Appendix at Charts III.A.v.a-c.

[95] The percentages of population located in census tracts with a certain number of mobile wireless or mobile LTE broadband providers represent network coverage, which does not necessarily mean that they offered service to residents in the census block. In addition, we emphasize that a service provider reporting mobile wireless or LTE broadband coverage in a particular census tract may not provide coverage everywhere in the census tract. For both these reasons, the number of service providers in a census tract, or by income level does not necessarily reflect the number of choices available to a particular individual or household at a certain income level, and does not purport to measure competition. In addition, coverage calculations, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely result in an overstatement of the extent of mobile wireless and mobile LTE broadband coverage.

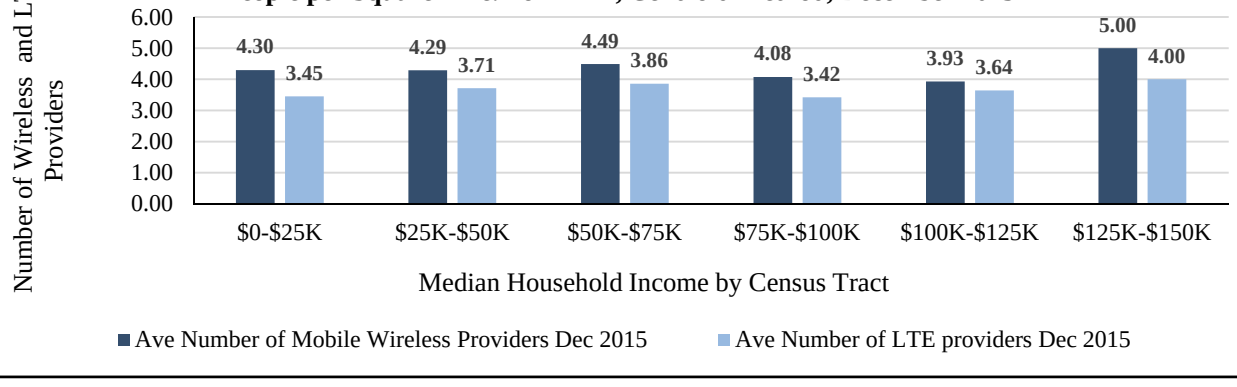
Data on median household income are based on the U.S. Census Bureau's American Community Survey (ACS) 2009-2013. The analysis is done on a census tract, rather than census block, basis because the smallest geographic area for which median household income data is available is census tracts. These data do not allow for an analysis of adoption rates for mobile wireless or mobile LTE broadband services.

Chart III.A.7.b
Average Number of Mobile Wireless and LTE Providers in Census Tracts by Median Household Income in Rural Areas with Population Density Between 20 and 100 People per Square Mile. Form 477, Centroid Method, December 2015



Source: Data on median household income by census tract are based on the U.S. Census Bureau's American Community Survey (ACS) 2009-2013. Data on the number of service providers are based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. Therefore the coverage calculation methodology has certain limitations that likely result in an overstatement of the extent of mobile wireless coverage.

Chart III.A.7.c
Average Number of Mobile Wireless and LTE Providers in Census Tracts by Median Household Income in Extremely Rural Areas with Population Density Less Than 20 People per Square Mile. Form 477, Centroid Method, December 2015



Source: Data on median household income by census tract are based on the U.S. Census Bureau's American Community Survey (ACS) 2009-2013. Data on the number of service providers are based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. Therefore the coverage calculation methodology has certain limitations that likely result in an overstatement of the extent of mobile wireless coverage.

B. Connections and Subscribers

1. Connections and Subscribers by Geography

45. 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 data, for the 172 EAs of the United States. As discussed above, we use EAs as the geographic unit for measuring

the level of concentration in the mobile wireless services marketplace in order to maintain continuity with past *Reports* and to ensure that we do not compromise the confidential information contained in the NRUF data.[96] Our estimates indicate that regional 2015 penetration rates for the 172 EAs range from 91 percent in Fayetteville-Springdale-Rogers, AR-MO-OK to 192 percent in Wichita, KS-OK.[97] The nationwide penetration rate based on NRUF data now exceeds 100 percent, meaning that the number of connected devices exceeds the total population of the United States, and the penetration rate was at least 100 percent in 152 EAs of the 172 EAs at the end of 2015.[98]

2. Connections and Subscribers by Demographics

46. Several socio-economic and demographic factors such as household income and age are correlated with overall mobile wireless subscription rates as well as smartphone subscription rates. Based on May 2016 survey data from ComScore MobiLens,[99] Chart III.B.1 below shows that mobile wireless subscribers overall, and smartphone subscribers in particular, are in higher income brackets. For example, approximately 25 percent of the population live 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 22 percent of the population live in households with an annual income over $100,000, but approximately 29 percent of mobile wireless subscribers and approximately 32 percent of smartphone subscribers are in this income bracket. Further, we note that more postpaid users are in a higher income bracket, while the converse is true for prepaid subscribers.

47. As shown in Chart III.B.2 below, the ComScore data also allow the presentation of the composition of mobile users by age. While the general adoption of mobile wireless devices is fairly evenly distributed among various age groups, smartphone adoption is more concentrated in younger age groups. For example, as of May 2016, adults ages 18 to 44 comprise approximately 46 percent of all mobile wireless subscribers, but make up approximately 53 percent of smartphone subscribers, while adults 55 or over represent approximately 29 percent of all mobile wireless subscribers, but only approximately 22 percent of smartphone subscribers.

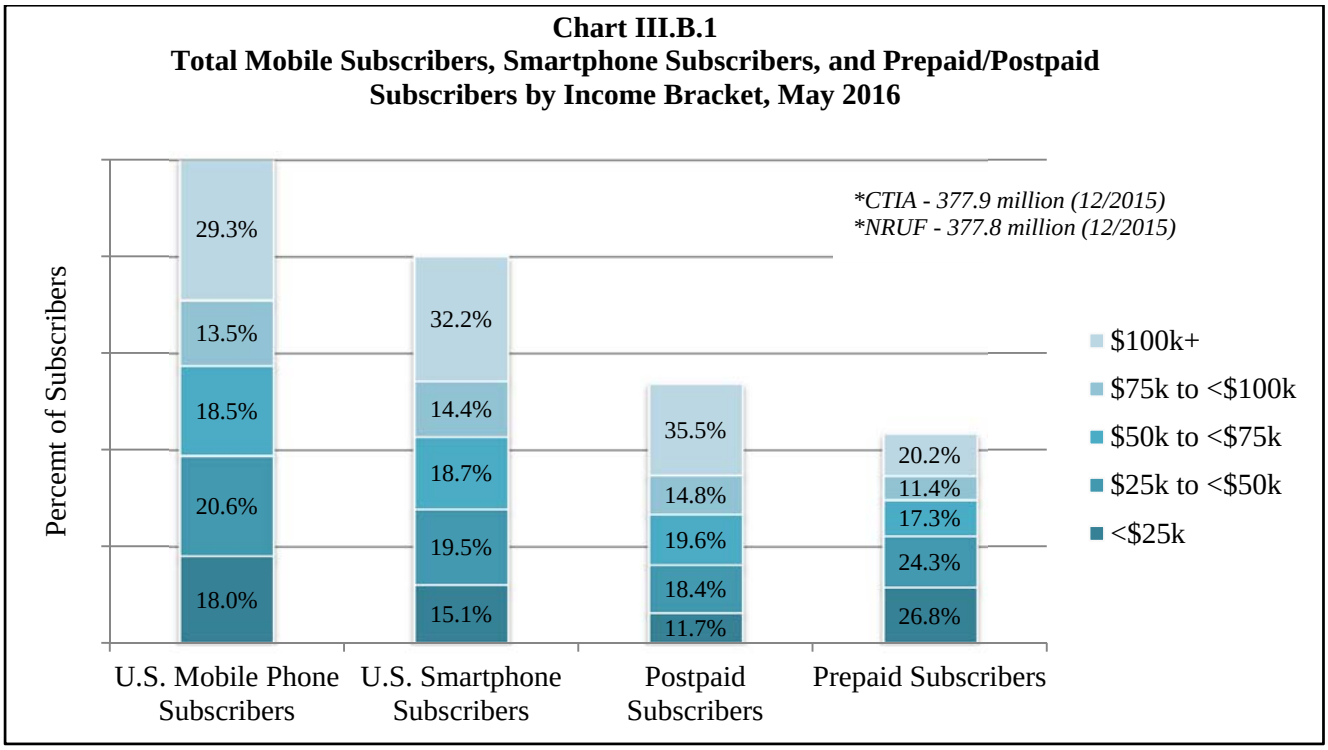
[96] *See supra* Section II.D.

[97] Web Appendix III: Overall Mobile Wireless Industry Metrics (EA Penetration Rates: 2012-2015), http://wireless.fcc.gov/competition-reports/mobile-wireless/mw-19/report-assets/index/html provides more details.

[98] 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, 2015, was estimated to be 324.9 million. U.S. Census Bureau, American FactFinder, http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2014_PEPANNRES&src=pt (last visited Sept. 14, 2016). 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.

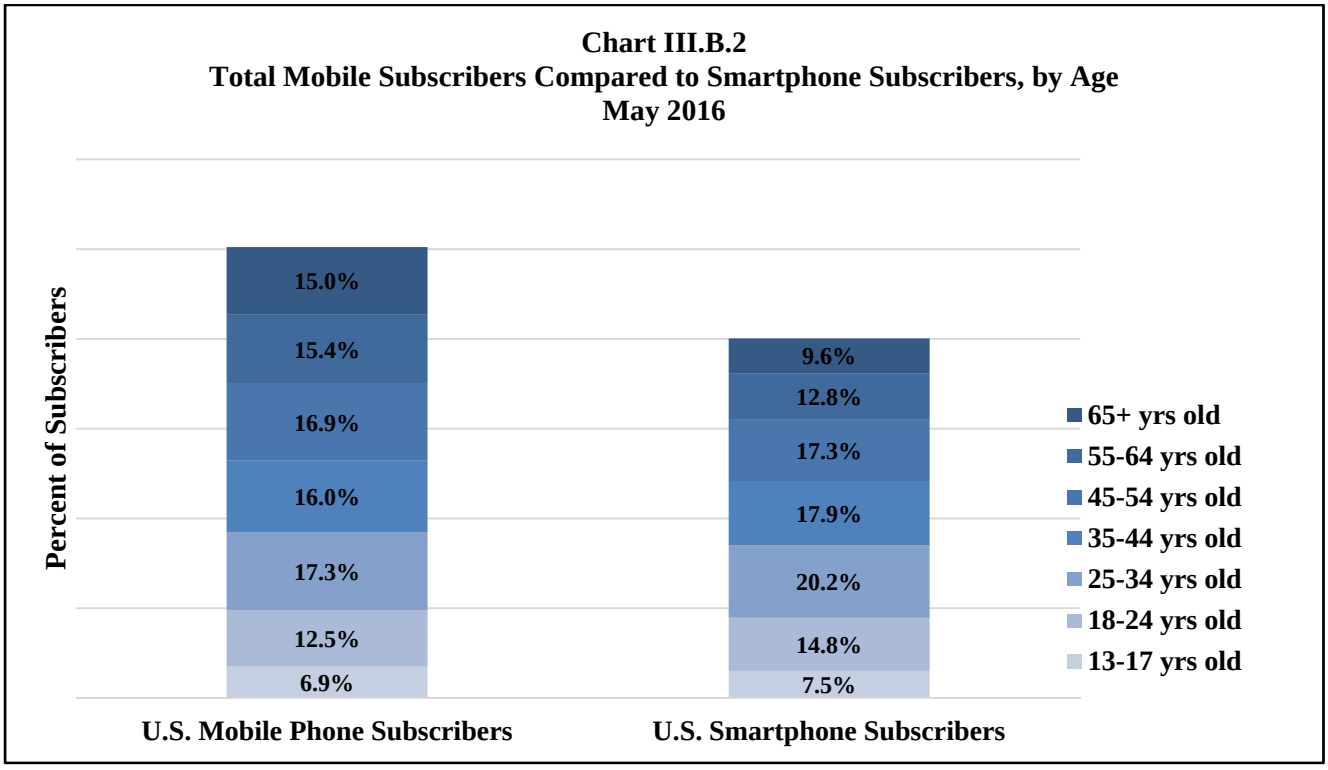
[99] Survey data based on ComScore MobiLens, May 2016. ComScore MobilLens U.S. data are derived from a monthly survey of over 13,000 respondents ages 13 and older who are recruited to represent U.S. Census demographics. The total universe size is estimated from data provided by CTIA and comScore's monthly subscriber studies. Race data are found at the U.S. Census Bureau, State and County Quick Facts 2013, http://quickfacts.census.gov/qfd/states/00000.html (last visited Sept. 14, 2016). Income data are found in the Income, Poverty, and Health Insurance Coverage in the United States: 2012, Current Population Reports by the U. S. Census Bureau, Table A-1: Households by Total Money Income, Race, and Hispanic Origin of Householder (Sept. 2013), http://www.census.gov/prod/2013pubs/p60-245.pdf.

Chart III.B.1
Total Mobile Subscribers, Smartphone Subscribers, and Prepaid/Postpaid Subscribers by Income Bracket, May 2016



Source: ComScore, MobiLens Audience Profile May 2016, and U.S. Census Bureau.

Chart III.B.2
Total Mobile Subscribers Compared to Smartphone Subscribers, by Age May 2016



Source: ComScore MobiLens, 3-Month Average, May 2016.

IV. INPUT MARKETS

48. Mobile wireless service providers employ a combination of inputs to provide mobile wireless services to their customers. These inputs include electromagnetic spectrum to transmit signals between base stations and end users' devices, as well as non-spectrum inputs such as cellular base stations and towers to carry transmissions. Further, backhaul, which routes voice and data traffic from base stations for onward transmission and may use spectrum or wireline resources, is an additional input required for the provision of mobile service. In this Section, we first discuss the critical role of spectrum as an input in the provision of mobile wireless services. Next, we summarize the Commission's policies to facilitate the use of spectrum and then provide information on service providers' current spectrum holdings. Lastly, we provide an analysis of non-spectrum inputs.

A. Spectrum

1. Importance of Spectrum for the Provision of Mobile Wireless Services

49. As the Commission has found, spectrum is a critical input in the provision of mobile wireless services and affects if and when existing service providers and potential entrants will be able to expand capacity or deploy networks.[100] 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.[101] In addition, increasing consumer demand for mobile broadband is increasing service providers' need for spectrum at an unprecedented rate and this is projected to grow further.[102]

50. Spectrum bands vary in their propagation characteristics, which has implications for how spectrum is deployed.[103] Spectrum below 1 GHz (low-band spectrum) has certain propagation advantages for network deployment over long distances, while also reaching deep into buildings and urban canyons, while spectrum above 1 GHz (mid- or high-band spectrum) allows for the better transmission of large amounts of information.[104] In the recent *Spectrum Frontiers Order*, the Commission noted that technological advances have made possible the use of ultra-high frequency bands above 24 GHz, or millimeter wave (mmW) bands, for the provision of mobile broadband.[105]

51. Competition in the mobile wireless marketplace will be better promoted by multiple service providers having the opportunity to access both low-band spectrum that can provide coverage and in-building penetration, as well as higher band spectrum that can provide the increased throughput for mobile broadband applications.[106] Service providers holding a mix of spectrum licenses have greater flexibility and are better able to

---

[100] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6134, para. 2; *see also Eighteenth Report*, 30 FCC Rcd at 14549, para. 47.

[101] *Eighteenth Report*, 30 FCC Rcd at 14549, para. 47.

[102] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6134, para. 2.

[103] Service providers deploy their spectrum bands differently depending on the nature of the service, geography, density, or other factors in their network build-out. *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6149-54, paras. 31-40; *Eighteenth Report*, 30 FCC Rcd at 14549, para. 47 & n.94.

[104] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6135, para. 3; *Eighteenth Report*, 30 FCC Rcd at 15356, para. 47. In this sense, low-band spectrum may be thought of as "coverage" spectrum, and higher band spectrum may be thought of as "capacity" spectrum. We note that there is significantly less low-band spectrum than higher band spectrum that is suitable and available for the provision of mobile telephony/broadband services. *Eighteenth Report*, 30 FCC Rcd at 14549, para. 47 & n.95.

[105] *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, 8020, 8082, paras. 6-7, 185 (2016) (*Spectrum Frontiers Order*).

[106] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6157, para. 47; *Eighteenth Report*, 30 FCC Rcd at 14549-50, para. 48.

optimize network costs for a given quality level.[107] Service providers without access to low-band spectrum would have to rely on less efficient and cost-effective methods to increase rural and in-building coverage to serve additional customers, such as adding towers, splitting cells, or acquiring roaming rights on other networks.[108]

2. Facilitating Access to Spectrum

52. Recognizing the importance of spectrum in the provision of mobile wireless services, Congress, through the Communications Act, requires the Commission to implement spectrum policies that promote competition, innovation, and the efficient use of spectrum to serve the public interest, convenience, and necessity.[109] Further, policies which promote and preserve competition, in turn, enable consumers to make choices among multiple service providers and lead to lower prices, improved quality, and increased innovation.[110] 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.[111] 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.

a. Auctions and Additional Spectrum Initiatives

53. Since 1994, the Commission has conducted various auctions of spectrum licenses.[112] These auctions are open to any eligible entity that submits an application and upfront payment and is found to be a qualified bidder by the Commission.[113] In addition, the Commission generally provides a bidding credit—or discount—to promote participation by small businesses and rural service providers, including businesses owned by members of minority groups and/or women (collectively, designated entities).[114] Further, the Commission's auction website provides detailed information regarding completed, ongoing, and planned auctions.[115] In the *Mobile Spectrum Holdings Report and Order*, the Commission concluded that, in lieu of a post-auction application of the spectrum screen to the initial licensing of spectrum to winning bidders, the Commission would determine whether a band-specific mobile spectrum holding limit is necessary, and if so, would establish an *ex ante* application of that limit to the competitive bidding for that band.[116]

---

[107] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6163-64, para. 59; *Eighteenth Report*, 30 FCC Rcd at 14549-50, para. 48.

[108] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6164, para. 60. While other cost-related factors exist, ensuring that multiple service providers are able to access a sufficient amount of low-band spectrum is a threshold requirement for extending and improving service in both rural and urban areas. *Id.* at 14549-50, para. 48 & n.99.

[109] 47 U.S.C. § 309(j)(3)(B).

[110] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6143-44, para. 17.

[111] *Id.* at 6143-44, 6167-68, 6190, 6193, 6221-22, 6223-24, paras. 17, 67-69, 135, 144, 225-27, 231-32.

[112] FCC, Auctions Home, http://wireless.fcc.gov/auctions/default.htm?job=auctions_home (last visited Sept. 14, 2016).

[113] FCC, About Auctions, http://wireless.fcc.gov/auctions/default.htm?job=about_auctions (last visited Sept. 14, 2016).

[114] 47 U.S.C. § 309(j)(3)(B), 309(j)(4)(D); *see also* 47 C.F.R. § 1.2110. *Updating Part 1 Competitive Bidding Rules; Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions; Petition of DIRECTV Group, Inc. and EchoStar LLC for Expedited Rulemaking to Amend Section 1.2105(a)(2)(xi) and 1.2106(a) of the Commission's Rules and/or for Interim Conditional Waiver; Implementation of the Commercial Spectrum Enhancement Act and Modernization of the Commission's Competitive Bidding Rules and Procedures*, Report and Order, Order on Reconsideration of the First Report and Order, Third Order on Reconsideration of the Second Report and Order, and Third Report and Order, 30 FCC Rcd 7493 (2015) (modified by Erratum 2015) (*Part 1 Report and Order*).

[115] FCC, Auctions Home, http://wireless.fcc.gov/auctions/default.htm?job=auctions_home (last visited Sept. 14, 2016).

[116] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6192, para. 139. For example, the Commission declined to adopt band-specific mobile spectrum holding limits for the AWS-3 auction, emphasizing the availability of a substantial

54. To provide service providers with the opportunities to better meet the rising consumer demand discussed above, the Commission has made, and is continuing to make, substantially more spectrum available for the provision of mobile wireless services. For example, in January 2015, the Commission auctioned 65 megahertz of high-band spectrum in the Advanced Wireless Services-3 (AWS-3) auction, generating approximately $45 billion in (gross) bids.[117] A total of 31 bidding entities won spectrum in the auction, and the spectrum sold for an average of $2.71 per MHz-POP for paired spectrum and $0.52 per MHz-POP for unpaired spectrum.[118] The incentive auction, as described in more detail below, will make available significant amounts of low-band spectrum currently used for over-the-air television broadcasting.[119] And in the *Spectrum Frontiers Order*, the Commission made available 3250 megahertz of ultra-high-band spectrum for flexible use.[120]

55. The incentive auction is composed of a reverse auction (Auction 1001) in which eligible broadcasters will offer to voluntarily relinquish some or all of their spectrum usage rights and a forward auction (Auction 1002) of new, flexible-use licenses suitable for providing mobile broadband services.[121] The Commission established procedures necessary to carry out the incentive auction in the *Auction 1000 Bidding Procedures Public Notice*,[122] and the *Auction 1000 Application Procedures Public Notice*.[123] *The Auction 1000 Bidding Procedures Public Notice* adopted, among other things, procedures for: the initial clearing target, allowing market forces to determine the highest and best use of spectrum on a near-nationwide basis; improved transparency for reverse and forward auction bidders; two categories of generic spectrum blocks for bidding in the clock phase of the forward auction; and the market-based spectrum reserve in the forward auction.[124] Among the

amount of comparable spectrum and the significant existing holdings of multiple service providers of comparable spectrum. *Id.* at 6220-21, paras. 222-24. Regarding the 600 MHz Incentive Auction (incentive auction), however, the Commission established a market-based spectrum reserve of up to 30 megahertz in each geographic license area (Partial Economic Area) (PEA). *Id.* at 6135, 6193, 6210-11, paras. 4, 146, 189-94. Further, in the *Spectrum Frontiers Order*, the Commission established an *ex ante* spectrum aggregation limit of 1250 megahertz that will apply to licensees acquiring spectrum in the 28 GHz, 37 GHz, and/or 39 GHz bands, through competitive bidding. *Spectrum Frontiers Order*, at 8081, 8082-83, paras. 184, 187.

[117] *Auction Of Advanced Wireless Services (AWS-3) Licenses Closes, Winning Bidders Announced For Auction 97, Public Notice*, 30 FCC Rcd 630 (2015); *see also Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands*, Report and Order, 29 FCC Rcd 4610 (2014) (*AWS-3 Report and Order*).

[118] FierceWireless, AWS-3 Auction Results: AT&T leads with $18.2B, Verizon at $10.4B, Dish at $10B and T-Mobile at $1.8B, http://www.fiercewireless.com/story/aws-3-auction-results-att-leads-182b-verizon-104b-dish-10b-and-t-mobile-18b/2015-01-30 (last visited Sept. 14, 2016).

[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).

[120] *See generally Spectrum Frontiers Order*, 31 FCC Rcd 8014.

[121] *See generally Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, 29 FCC Rcd 6567 (2014) (*Incentive Auctions Report and Order*). As part of the auction process, the broadcast television bands will be reorganized or "repacked" so that the television stations that remain on the air after the incentive auction occupy a smaller portion of the ultra-high frequency (UHF) band, thereby clearing contiguous spectrum that will be repurposed as the 600 MHz Band. *Id.* at 6570, para. 3.

[122] *See generally 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) (*Auction 1000 Bidding Procedures Public Notice*).

[123] *Application Procedures for Broadcast Incentive Auction Scheduled to Begin on March 29, 2016; Technical Formulas for Competitive Bidding*, Public Notice, 30 FCC Rcd 11034 (2015) (*Auction 1000 Application Procedures Public Notice*).

[124] *Auction 1000 Bidding Procedures Public Notice*, 30 FCC Rcd at 8979, para. 2.

spectrum reserve procedures adopted, the *Auction 1000 Bidding Procedures Public Notice* adopted the Commission's proposed average price and spectrum benchmarks to help ensure that winning bids for the licenses in the forward auction reflect competitive prices and return a portion of the value of the spectrum to taxpayers without reducing the amount of spectrum repurposed for new, flexible-use licenses.[125] In addition, the *Auction 1000 Applications Procedures Public Notice* addressed implementation issues related to qualification to bid on reserved spectrum, including a preliminary list of reserve-eligible nationwide providers in each PEA, the methodology for calculating below-1-GHz spectrum holdings in a PEA, and logistical details regarding required certification by applicants of their reserve-eligible qualification in particular PEAs.[126] To promote participation by designated entities, the Commission adopted bidding credits for small businesses[127] and, for the first time, a bidding credit for eligible rural service providers.[128] The Commission also capped the total amount of bidding credits that any eligible entity may receive.[129]

56. The incentive auction began in March 2016. Based on the initial commitments made by broadcast applicants seeking to bid in the clock phase of Auction 1001, an initial clearing target of 126 megahertz has been set for the incentive auction.[130] Under the band plan associated with this spectrum clearing target, 100 megahertz, or 10 paired blocks, of licensed spectrum will be offered in the forward auction on a near-nationwide basis, with around 97 percent of the blocks containing a relatively low level of impairments.[131] The Commission stated that by offering only paired blocks in a single band, and by licensing on a PEA basis, the 600 MHz Band Plan will promote participation by both larger and smaller wireless service providers, including rural service providers, and encourage new entrants, and further will promote interoperability and international harmonization.[132] The Wireless Telecommunications Bureau (Bureau) announced that 62 applicants are qualified to bid in the forward auction.[133]

57. The Commission's "Spectrum Frontiers" proceeding took significant steps towards enabling the next generational 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 explored new opportunities to make additional bands

[125] *Id.*

[126] *Auction 1000 Application Procedures Public Notice*, 30 FCC Rcd at 11066-71. The Bureau subsequently released an updated list of reserve-eligible nationwide providers in advance of the deadline for filing applications to participate in the forward auction. *Wireless Telecommunications Bureau Releases Updated List of Reserve-Eligible Nationwide Service Providers In Each PEA for the Broadcast Incentive Auction*, Public Notice, 31 FCC Rcd 876 (WTB 2016).

[127] *Incentive Auction Report and Order* at 6762-6764, para. 474-478; *Part 1 Report and Order*, 30 FCC Rcd at 7522-28, paras. 69-85; 47 CFR §§ 1.2110(f)(2)(i), 27.1301(a), (c)(1).

[128] *Part 1 Report and Order*, 30 FCC Rcd at 7529-38, paras. 86-108; 47 CFR §§ 1.2110(f)(4)(i), 27.1301(b), (c)(2).

[129] *Part 1 Report and Order*, 30 FCC Rcd at 7544-48, paras. 122-30; 47 CFR §§ 1.2110(f)(2)(ii), (4)(ii).

[130] *Initial Clearing Target of 126 Megahertz Set for the Broadcast Television Spectrum Incentive Auction; Bidding in the Clock Phase of the Reverse Auction (Auction 1001) will Start on May 31, 2016*, Public Notice, 31 FCC Rcd 3863 (2016) (*Initial Clearing Target Public Notice*).

[131] Specifically, about 97% of the blocks offered in the forward auction will be "Category 1" blocks (zero to 15% impairment), and about 99% of the "Category 1" blocks will be zero percent impaired. *Initial Clearing Target Public Notice*, 31 FCC Rcd at 3864, para. 4. The initial clearing target announced is the highest possible clearing target; if a subsequent stage is necessary, the clearing target determination procedure will be applied to select a new clearing target and corresponding band plan. *Id.* at 3863-65, paras. 3-5.

[132] *Incentive Auctions Report and Order*, 29 FCC Rcd at 6585-86, para. 44.

[133] *62 Applicants Qualified to Bid in the Forward Auction (Auction 1002) of the Broadcast Television Incentive Auction; Clock Phase Bidding to Begin on August 16, 2016*, Public Notice, DA 16-796 (WTB July 15, 2016).

available.[134] The service rules adopted establish a framework for flexible services, including mobile services, shared with fixed, satellite, and federal government uses in the mmW bands.[135] As noted above, mmW bands historically have been considered unsuitable for mobile applications because of propagation losses at such high frequencies and the inability of mmW signals to propagate around obstacles.[136] However, given technological advances, the mmW bands could potentially be deployed for mobile broadband in conjunction with lower-band spectrum.[137]

58. Consistent with prior rulemakings, in the *Spectrum Frontiers Order*, the Commission explained that it is essential to establish clear and transparent mobile spectrum holdings policies that will promote competition in the future, including competition in the development of 5G services, as well as promote the efficient use of mmW spectrum, and avoid an excessive concentration of licenses.[138] To further these objectives, the Commission adopted an *ex ante* spectrum aggregation limit of 1250 megahertz that will apply to licensees acquiring spectrum in the 28 GHz, 37 GHz, and/or 39 GHz bands, through competitive bidding in auction, as well as a spectrum threshold of 1250 megahertz for proposed secondary market transactions in these bands.[139] While it is not certain at this time how this spectrum will be used, the Commission determined that its anticipated value to the future of 5G makes it critical that multiple service providers have access to it and concluded that these spectrum aggregation policies will help to ensure its optimal use to the benefit of all American consumers.[140]

59. In exploring other technologies,[141] the 3.5 GHz Band proceeding is a Commission initiative that will make more spectrum available to facilitate the provision of mobile wireless service.[142] On April 17, 2015, the Commission adopted a Report and Order that will advance the use of this band.[143] This Report and Order established a three-tiered spectrum authorization framework to facilitate a variety of small cell and other broadband uses of the 3.5 GHz Band[144] on a shared basis with incumbent federal and non-federal users of the band.[145] The three tiers of users, in order of priority, are: Incumbent Access, Priority Access, and General

[134] 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, as well as appropriate mobile spectrum holdings policies. *Id.*

[135] *Id.* at 8018-19, para. 2-4.

[136] *Id.* at 8020, 8082, paras. 6, 185.

[137] *Id.* at 8082, para. 185.

[138] *Id.* at 8081, para. 183.

[139] *Id.* at 8081, para. 184.

[140] *Id.* at 8084, para. 190.

[141] We note that in May, 2015, the Commission released a Public Notice seeking more information on Long Term Evolution –Unlicensed (LTE-U). The Commission plans to continue to monitor the development of unlicensed technologies, including LTE-U. *Office of Engineering and Technology and Wireless Telecommunications Bureau Seek Information on Current Trends in LTE-U and LAA Technology*, Public Notice, 30 FCC Rcd 4457 (2015) (*LTE-U Public Notice*).

[142] The 3.5 GHz Band encompasses 3550-3700 MHz. *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, 3961, para. 1 (2015) (*3.5 GHz Order and 2nd FNPRM*).

[143] *Id.* at 3959.

[144] Priority Access Licenses will not be available in the 3650-3700 MHz portion of the band, which is reserved for GAA and Grandfathered Wireless Broadband Licensees. *Id.* at 3978, para. 54.

[145] *Id.* at 3967, 3978, paras. 24, 54.

Authorized Access (GAA).[146] Incumbent Access users include: (1) military radar systems; (2) non-federal fixed satellite service (FSS) earth stations; and (3) for a finite period, grandfathered terrestrial wireless broadband service licensees in the 3650-3700 MHz portion of the band.[147] These users will be protected from harmful interference from Priority Access and GAA users. Priority Access licensees[148] will receive protection from interference from GAA users[149] based on an engineering approach where Priority Access licensees report their actual network deployments and the spectrum access system (SAS) applies a consistent model of potential signal propagation defines the maximum protection area.[150] Access and operations will be coordinated by the SAS,[151] which can act dynamically and is conceptually similar to—but more technologically advanced than—the databases used to manage Television White Spaces devices.[152] The innovative spectrum sharing techniques adopted in this Order will allow the introduction of 150 megahertz of contiguous spectrum for the Citizens Broadband Radio Service, while protecting critical federal uses, which will enable the exploration of new technologies and spectrum sharing with a focus on relatively low-powered applications.

b. Secondary Markets

60. Subject to the Commission's approval, licensees may assign and exchange licenses, in whole or in part (through partitioning and/or disaggregation), on the secondary market.[153] In reviewing proposed acquisitions of spectrum through secondary market transactions, the Commission uses an initial screen to help identify for case-by-case review local markets where changes in spectrum holdings resulting from the transaction may be of particular concern.[154] As set out in various transactions orders, however, the Commission has not limited its consideration of potential competitive harms solely to markets identified by its initial screen, if it

[146] *Id.* at 3967, 3978, paras. 24, 54.

[147] *Id.* at 3967, 3978, paras. 24, 54; *see also id*. at 3961-62, 4035-40, 4042-48, paras. 3-4, 247-68, 276-96; *see also Wireless Telecommunications Bureau Seeks Comment On An Appropriate Method for Determining The Protected Contours For Grandfathered 3650-3700 MHz Band Licensees*, Public Notice, 30 FCC Rcd 11557 (WTB 2015).

[148] A Priority Access License (PAL) is defined as a non-renewable authorization to use a 10 megahertz channel in a single census tract for three years. PALs will be assigned via competitive bidding in up to seventy megahertz of the 3550-3650 MHz portion of the band. *3.5 GHz Order and 2nd FNPRM*, 30 FCC Rcd at 3961, para. 4. One licensee may hold up to 40 megahertz of PALs in any given census tract at any given time. *Id.* at 3998, para. 117.

[149] GAA users could be a diverse group of stakeholders, including consumers, enterprises, and service providers. *Id.* at 4009, para. 156. GAA users would be permitted opportunistic use of all spectrum from 3550-3700 MHz that is not being used at the time by PAL holders or incumbents. *Id.* at 3983, paras. 72-73.

[150] *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, 5060, para. 174 (2016) (*3.5 GHz Order on Recon. and Second Report and Order*). The Commission expects this model to be refined over time to better accommodate non-interfering uses by GAA users. *Id*. at 5060, para. 175.

[151] *3.5 GHz Order and 2nd FNPRM*, 30 FCC Rcd at 3962, 3984-87, paras. 4, 75-86, Section III.H.

[152] *Id.* at 4035, 4069-71, paras. 247, 379-86.

[153] 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.

[154] *See, e.g., Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6221-22, para. 225; *Applications of AT&T Inc., E.N.M.R Telephone Cooperative, Plateau Telecommunications, Inc., New Mexico RSA 4 East Limited Partnership, and Texas RSA 3 Limited Partnership for Consent To Assign Licenses and Authorizations*, Memorandum Opinion and Order, 30 FCC Rcd 5107, 5113, 5118, paras. 12-13, 24 (2015) (*AT&T-Plateau Wireless Order*); *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., AT&T-Plateau Wireless Order*, 30 FCC Rcd at 5118, para. 24 & n.82.

encounters other factors that may bear on the public interest inquiry.[155] 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, or 45 megahertz or more, of the currently suitable and available spectrum below 1 GHz.[156] Further, in the recently released *Spectrum Frontiers Order*, the Commission established a mmW spectrum threshold as noted above of 1250 megahertz for proposed secondary market transactions.[157]

61. The Commission includes in its initial screen spectrum that it finds is suitable and available for the provision of mobile telephony/broadband services. Suitability is based upon whether the spectrum band at issue is capable of supporting mobile service given its physical properties and the state of equipment technology, whether the spectrum is licensed with a mobile allocation and corresponding service rules, and whether the spectrum is committed to another use that effectively precludes its uses for the relevant mobile services.[158] With respect to availability, the Commission considers particular spectrum to be a relevant input if it is fairly certain that it will meet the criteria for suitability in the near term.[159]

62. In the past decade, in the context of its review of secondary market transactions, the Commission periodically determined that additional spectrum was suitable and available, and therefore subject to inclusion in the spectrum screen—including 700 MHz,[160] Advanced Wireless Service-1 (AWS-1),[161] Broadband Radio Service (BRS),[162] and Wireless Communications Service (WCS).[163] The Commission updated the spectrum screen in the *Mobile Spectrum Holdings Report and Order* by adding 151 megahertz of spectrum in total from the AWS-4 (2.0/2.2 GHz), H Block (1.9 GHz), and BRS and Educational Broadcast Service (EBS) (2.5 GHz) bands.[164] It also designated for future inclusion in the spectrum screen, the amount of 600 MHz Band spectrum that would be made available through the incentive auction, and the 65 megahertz of AWS-3 spectrum as it becomes available

[155] *See, e.g., Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6221-22, para. 225; *AT&T-Plateau Wireless Order*, 30 FCC Rcd at 5113, para. 12; *see also AT&T-Leap Order*, 29 FCC Rcd at 2752, para. 39.

[156] *See, e.g., Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6240, paras. 282-88.

[157] *Spectrum Frontiers Order*, at 8081, para. 184.

[158] *See, e.g., Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6169, para. 71; *AT&T-Plateau Wireless Order*, 30 FCC Rcd at 5116-17, para. 21.

[159] *See, e.g., Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6169, para. 71; *AT&T-Plateau Wireless Order*, 30 FCC Rcd at 5116-17, para. 21.

[160] *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).

[161] *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, 17599, para. 72 (2008) (*Sprint Nextel-Clearwire Order*).

[162] Most BRS spectrum is considered available in those markets where the transition of BRS spectrum to the new band plan has been completed. *Sprint Nextel-Clearwire Order*, 23 FCC Rcd at 17598-99, para. 70; *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).

[163] *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) (*AT&T WCS Order*).

[164] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6172-87, paras. 82-125.

on a market-by-market basis.[165] Earlier this year, in the *Sprint-Shentel-NTELOS Order*, the Bureau found that the AWS-3 1695-1710 MHz band satisfies the standard adopted by the Commission in the *Mobile Spectrum Holdings Report and Order* and "should now be considered available, as well as suitable, on a nationwide basis."[166] Accordingly, the current suitable and available spectrum included in the screen is as follows:

Table IV.A.1
Spectrum Included in the Spectrum Screen

Spectrum Band	***Megahertz (Amount)***
700 MHz	70
Cellular	50
SMR	14
Broadband PCS	130
AWS-1[a]	90
AWS-3	15
AWS-4	40
H Block	10
WCS	20
BRS[b]	67.5
EBS	89
Total Amount of Spectrum	***595.5***

[a] AWS-1 is not attributable in markets where federal government users have not been relocated.
[b] BRS is not attributable in markets where previous BRS licensees have not been transitioned.

63. In proposed secondary market transactions, for those markets identified by the spectrum screen, or that implicate enhanced factor review,[167] or where the Commission encounters other factors that may bear on the public interest inquiry,[168] the Commission generally conducts further competitive review to determine whether

[165] *Id.* at 6171-72, 6176-79, paras. 76-81, 94-102. The Commission also subtracted 12.5 megahertz of Specialized Mobile Radio Service (SMR) and 10 megahertz that was the Upper 700 MHz D Block. *Id.* at 6187-90, paras. 126-34.

[166] *Sprint-Shentel-NTELOS Order*, 31 FCC Rcd at 3637-38, para. 15. After the inclusion of this 15 megahertz of the AWS-3 spectrum in the input market for spectrum, the total amount of spectrum suitable and available for the provision of mobile telephony/broadband services is now 595.5 megahertz, approximately one-third of which is 199 megahertz. *Id*. Certain of the granted AWS-3 spectrum licenses (1755-1780 MHz and 2155-2180 MHz) are not currently included, but as these bands become available, that spectrum also will be included in the spectrum screen on a market-by-market basis. *Id.* at 3638, para. 16.

[167] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6233, 6240, paras. 267, 286-88.

[168] For example, the Commission also considered whether harms in numerous local markets may result in nationwide harms and has considered potential harms from concentration in a particular band with an important ecosystem. *See, e.g., Applications of Cellco Partnership d/b/a Verizon Wireless and SpectrumCo LLC and Cox TMI, LLC for Consent To Assign AWS-1 Licenses*, Memorandum Opinion and Order, 27 FCC Rcd 10698, 10721-22, 10727, paras. 64, 76 (2012) (*Verizon Wireless-SpectrumCo Order*).

the proposed transaction would result in an increased incentive or ability for the assignee or transferee to behave in an anticompetitive manner. The case-by-case review that the Commission undertakes considers factors that are important in predicting the incentives and ability of service providers to successfully reduce competition on price or non-price terms, and evaluates transaction-specific public interest benefits that may mitigate or outweigh any public interest harms that might arise.[169] The Commission can condition approval of a transaction on the divestiture of licenses or certain other commitments in markets where necessary to find an application serves the public interest.[170]

64. Since the *Eighteenth Report*, in addition to the Sprint-Shentel-NTELOS transaction,[171] a number of smaller transactions involving the transfer of spectrum licenses,[172] as well as, in certain cases, network infrastructure and other assets, have been filed with the Commission.[173] Among the smaller transactions that have

[169] These competitive variables include, but are not limited to: the total number of rival service providers; the number of rival firms that can offer competitive service plans; the coverage by technology of the firms' respective networks; the rival firms' market shares; the combined entity's post-transaction market share and how that share changes as a result of the transaction; the amount of spectrum suitable for the provision of mobile telephony/broadband services controlled by the combined entity; and the spectrum holdings of each of the rival service providers. *See, e.g., AT&T-Club 42 Order*, 30 FCC Rcd at 13071, para. 34; *AT&T-Plateau Wireless Order*, 30 FCC Rcd at 5120, para. 29; *AT&T-Leap Order*, 29 FCC Rcd at 2745-46, para. 21.

[170] *See, e.g*., *Sprint-Shentel-NTELOS Order*, 31 FCC Rcd at 3651-53, paras. 45-49; *AT&T-Leap Order*, 29 FCC Rcd at 2743-44, para. 16; *Verizon Wireless-SpectrumCo Order*, 27 FCC Rcd at 10711, para. 30.

[171] *Sprint-Shentel-NTELOS Order*, 31 FCC Rcd 3631.

[172] *See, e.g., Applications of T-Mobile License LLC for Consent to Assign Licenses and Transfer of Control of Lower 700 MHz A Block Licenses*, ULS File Nos. 0007141032 (lead), 0007143962 (lead), 0007140898 (lead) (filed Feb. 19, 2016). These applications are related to three separate transactions involving: Cellular South Licenses, LLC d/b/a C Spire Wireless; subsidiaries of Cavalier License Group, LLC; and wholly-owned subsidiaries of Continuum 700 LLC.

Regarding our review of mmW spectrum band transactions, we note that the Bureau recently consented to Verizon Wireless's long-term *de facto* transfer spectrum leasing arrangement of Nextlink's LMDS (28 GHz) and 39 GHz spectrum licenses, and was guided at the time by the decisions made in the *Spectrum Frontiers Order*. *Application of Cellco Partnership d/b/a Verizon Wireless and Nextlink Wireless, LLC for Consent to Long-Term De Facto Transfer Spectrum Leasing Arrangement*, Memorandum Opinion and Order, ULS File No. 0007162285 (WTB July 25, 2016).

[173] Since the *Eighteenth Report* was released, we consented to the following transactions involving the transfer of spectrum licenses and certain other assets, which implicated our enhanced factor review of below-1-GHz spectrum holdings. *See, e.g*., *Application of AT&T Mobility Spectrum LLC and West Carolina Communications, LLC for Consent To Assign Licenses*, Memorandum Opinion and Order, DA 16-873 (WTB Aug. 1, 2016); *Applications of AT&T Mobility Spectrum LLC, Tampnet Inc., Tampnet Licensee LLC, Broadpoint License Co., LLC, and Broadpoint Wireless License Col, LLC, for Consent To Assign Licenses and Approval of Long-Term De Facto Transfer Spectrum Leasing Arrangements*, et al., Memorandum Opinion and Order and Declaratory Ruling, DA 16-857 (WTB/IB July 28, 2016); *Application of The Alaska Wireless Network, LLC, and T-Mobile License LLC for Consent To Assign License*, Memorandum Opinion and Order, 31 FCC Rcd 4447 (WTB 2016); *Application of USCOC of Central Illinois, LLC, and Adams Telcom, Inc. for Consent To Assign Licenses*, Memorandum Opinion and Order, 31 FCC Rcd 3404 (WTB 2016); *Application of New Cingular Wireless PCS, LLC, and Farmers Telecommunications Corporation for Consent To Assign License*, Memorandum Opinion and Order, 31 FCC Rcd 2207 (WTB 2016); *Application of Cellular South Licenses, LLC d/b/a C Spire Wireless and Waller Wireless, Inc. for Consent To Assign Licenses*, Memorandum Opinion and Order, 31 FCC Rcd 1311 (WTB 2016); *Applications of New Cingular Wireless PCS, LLC, Bluegrass Cellular, Inc. and Bluegrass Wireless LLC for Consent To Assign Licenses*, Memorandum Opinion and Order, 31 FCC Rcd 378 (WTB 2016); *Applications of AT&T Mobility Spectrum LLC and East Kentucky Network, LLC for Consent To Assign Licenses*, Memorandum Opinion and Order, 31 FCC Rcd 361 (WTB 2016); *Applications of AT&T Inc. and Cellular Properties, Inc. for Consent To Assign Authorizations*, Memorandum Opinion and Order, 31 FCC Rcd 318 (WTB 2016); *Notification of Triangle Communication System, Inc. and Cellco Partnership d/b/a Verizon Wireless for a Long-Term Spectrum Manager Leasing*, Memorandum Opinion and Order, 31 FCC Rcd 301 (WTB 2016); *Application of AT&T Mobility Spectrum LLC and Agri-Valley Communications, Inc. for Consent To Assign Licenses*, Memorandum Opinion and Order, 30 FCC Rcd 15691 (WTB 2015). In addition to other Bureau-level Orders, two such

occurred in the past couple of years are a number in which a nationwide service provider acquired spectrum or other assets from a small or regional licensee. Not including intra-market spectrum swaps of equal amounts of spectrum or transactions involving increased aggregation of low-band spectrum that implicate enhanced factor review, from June 2015 through December 2015, the Commission approved approximately fifteen applications in total filed by the four nationwide service providers to acquire PCS, AWS-1, Cellular, and/or 700 MHz licenses from a non-nationwide licensee or lease additional BRS/EBS spectrum from a non-nationwide licensee.

3. Analysis of Spectrum Holdings

65. Table IV.A.2 (Percentage Spectrum Holdings, by Provider, by Frequency Band) and Table IV.A.3 (Population-Weighted Average Megahertz Holdings by Provider, by Frequency Band) below present spectrum holdings by service provider including all spectrum bands currently considered suitable and available. As of April 2016, Verizon Wireless, AT&T, Sprint, and T-Mobile, together, held approximately 80 percent of all spectrum suitable and available for the provision of mobile wireless services, measured on a MHz-POPs basis.

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

	700 MHz	Cell.	SMR	PCS	H Block	AWS-1	AWS-3	AWS-4	WCS	BRS	EBS
Spectrum	**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	42.0%	44.5%	0.0%	29.2%	0.0%	16.1%	0.0%	0.0%	100.0%	0.0%	0.0%
Sprint	0.0%	0.0%	96.5%	28.1%	0.0%	0.0%	0.0%	0.0%	0.0%	86.8%	69.8%
T-Mobile	10.5%	0.1%	0.0%	22.0%	0.0%	41.1%	0.0%	0.0%	0.0%	0.0%	0.0%
VZW	31.0%	47.5%	0.0%	16.3%	0.0%	38.9%	0.0%	0.0%	0.0%	0.0%	0.0%
USCC	3.6%	4.0%	0.0%	1.3%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%
DISH**	6.6%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%
Other***	6.3%	3.9%	3.5%	3.0%	0.0%	3.3%	0.0%	0.0%	0.0%	13.2%	30.2%

* Staff estimates as of April 2016. 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 secondary market transactions, 89 megahertz of EBS spectrum is included.

Commission-level Orders were released prior to the *Eighteenth Report*: *AT&T-Club 42 Order*, 30 FCC Rcd 13055; *AT&T-Plateau Wireless Order*, 30 FCC Rcd 5107.

Table IV.A.3
Population-Weighted Average Megahertz Holdings by Licensee, by Frequency Band*

	700 MHz	Cell.	SMR	PCS	H Block	AWS-1	AWS-3	AWS-4	WCS	BRS	EBS
Spectrum Counted	**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	29.4	23.6	0.0	38.1	0.0	14.5	0.0	0.0	20.0	0.0	0.0
Sprint	0.0	0.0	13.9	36.6	0.0	0.0	0.0	0.0	0.0	58.6	78.5
T-Mobile	7.4	0.0	0.0	28.7	0.0	36.9	0.0	0.0	0.0	0.0	0.0
VZW	21.7	25.2	0.0	21.3	0.0	35.0	0.0	0.0	0.0	0.0	0.0
USCC	2.5	2.1	0.0	1.7	0.0	0.6	0.0	0.0	0.0	0.0	0.0
DISH**	4.6	0.0	0.0	0.0	10.0	0.0	12.7	40.0	0.0	0.0	0.0
Other***	4.4	2.0	0.5	4.0	0.0	3.0	0.0	0.0	0.0	8.9	34.0

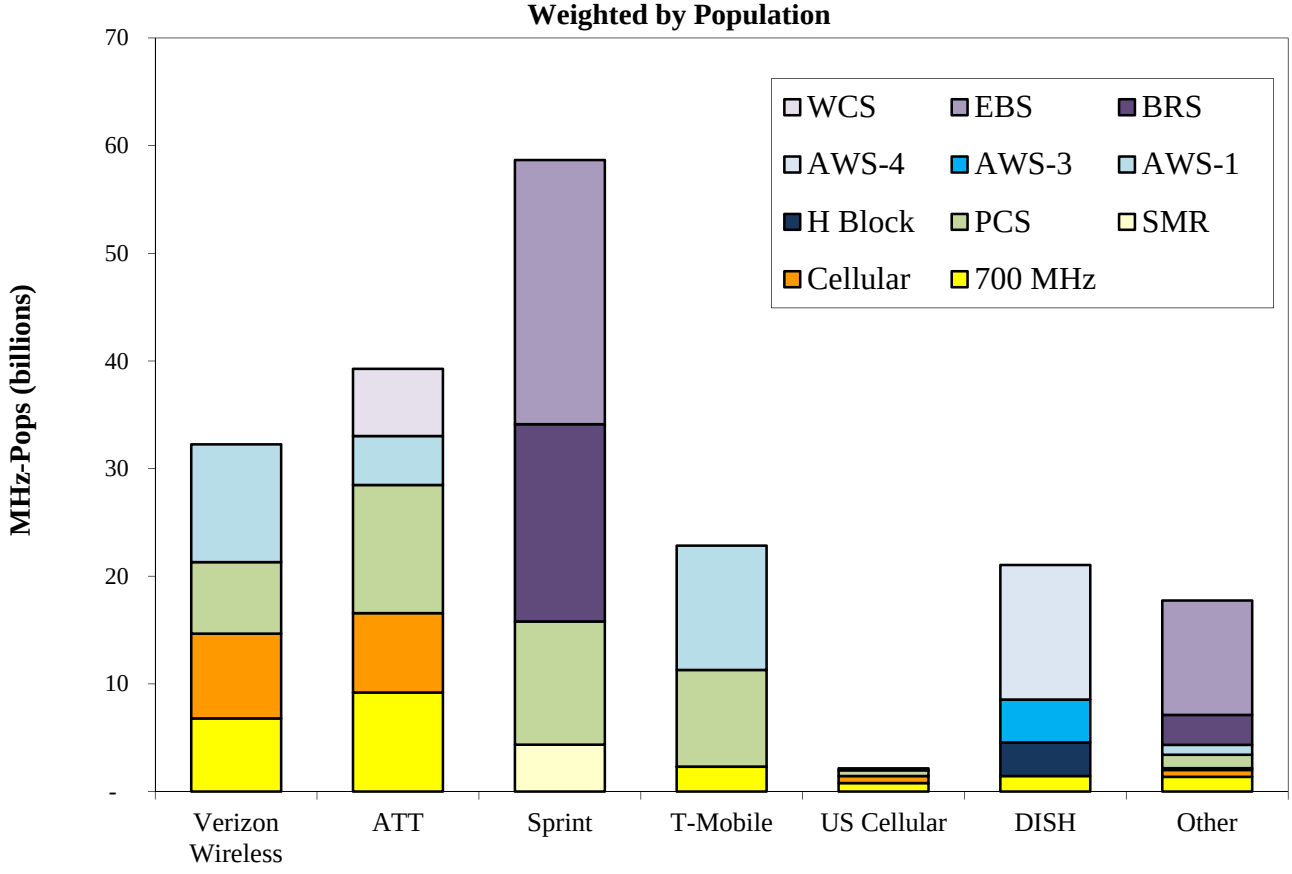
* Staff estimates as of April 2016.
** DISH currently does not provide mobile service.
*** In the application of the spectrum screen in secondary market transactions, 89 megahertz of EBS spectrum is included.

66. Chart IV.A.1 shows the population-weighted spectrum holdings of nationwide wireless service providers by frequency. It provides a side-by-side comparison of each licensee's total spectrum holdings by band, measured by population-weighted average megahertz.[174] All four nationwide service providers hold substantial amounts of above-1-GHz spectrum. Verizon Wireless, AT&T, and T-Mobile each hold a substantial number of PCS and AWS-1 spectrum licenses, while Sprint holds significant amounts of PCS spectrum. Verizon Wireless holds approximately 26 percent of the licensed MHz-POPs of the combined PCS and AWS-1 band spectrum, while the comparable percentages are approximately 24 percent for AT&T, approximately 17 percent for Sprint, and approximately 30 percent for T-Mobile. Regional service provider, U.S. Cellular, holds approximately one percent of the combined PCS and AWS-1 band spectrum, while other smaller service providers hold the remainder. In addition to its PCS and AWS-1 holdings, AT&T holds all 20 megahertz of the licensed WCS spectrum, while Sprint holds a predominant amount of 2.5 GHz spectrum, comprised of the BRS and EBS bands, the highest frequencies currently included in the spectrum screen.[175]

[174] 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.

[175] While certain of the granted AWS-3 (1755-1780 GHz and 2155-2180 GHz) spectrum licenses are not currently included in the spectrum screen (i.e., AWS-3 excluding A1/B1 Blocks), we note that AT&T holds approximately 46% of the licensed MHz-POPs, while Verizon Wireless, T-Mobile, and DISH each hold approximately 26%, 8%, and 19%, respectively, and other smaller service providers hold the remaining 2%.

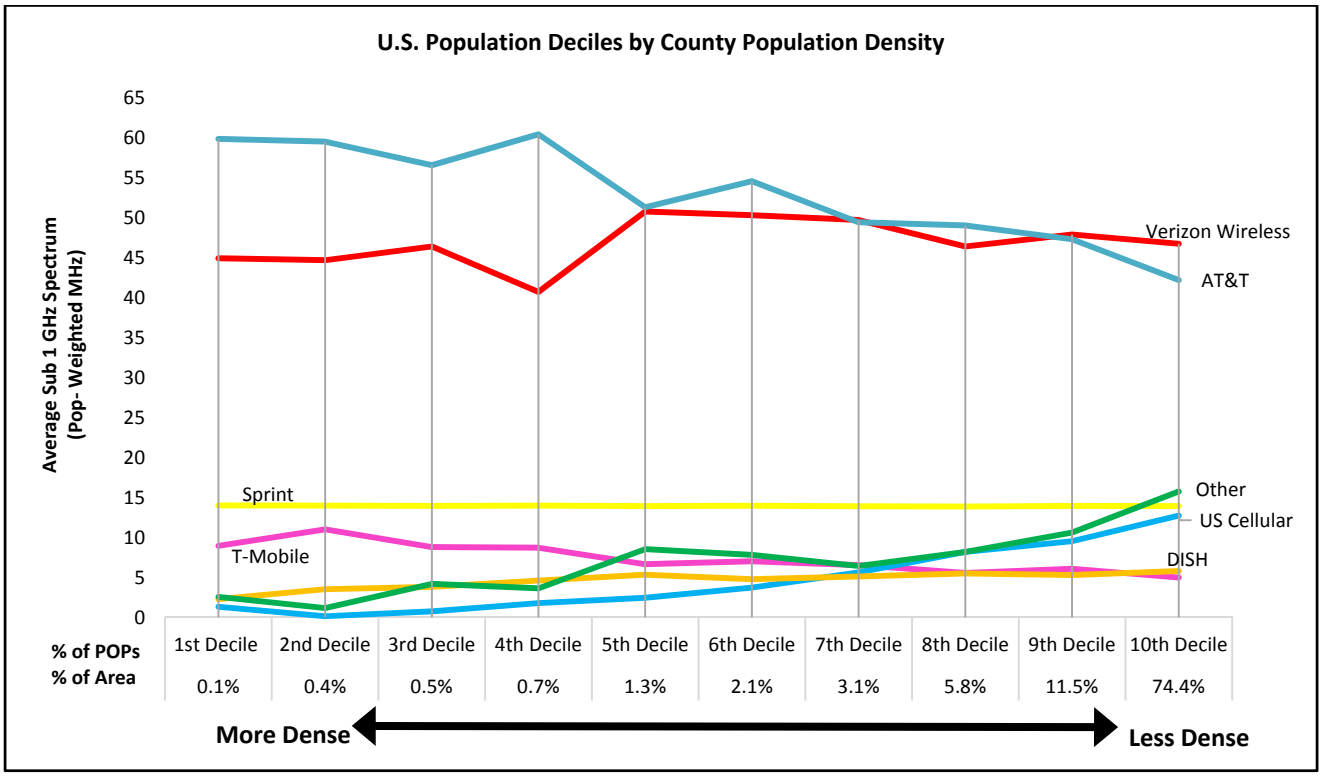
Chart IV.A.1
Mobile Wireless Provider Spectrum Holdings by Band
Weighted by Population



Note: Staff estimates as of April 2016.

67. Below-1-GHz spectrum currently includes the 700 MHz band, SMR (800 MHz), and Cellular (850 MHz) spectrum. The two largest nationwide service providers, AT&T and Verizon Wireless, each hold a significant amount of the available low-band spectrum. In particular, when measured on a licensed MHz-POP basis, AT&T holds approximately 38 percent, while Verizon Wireless holds approximately 35 percent. In addition, Sprint holds approximately 10 percent, T-Mobile holds approximately five percent, and a number of other smaller licensees, combined, hold the remaining approximately 12 percent. Service providers also vary with respect to their below-1-GHz spectrum holdings according to population density, as seen in Chart IV.A.2 below. Specifically, AT&T and T-Mobile hold relatively more of their low-band spectrum in urban areas, Sprint's and Verizon Wireless's low-band spectrum covers both urban and rural areas, and the other smaller licensees hold more low-band spectrum in rural areas than in urban areas.

Chart IV.A.2
Average Below-1-GHz Spectrum by Population Density Deciles, April 2016



Note: Staff estimates as of April 2016.

B. Non-Spectrum Input Segments

1. Wireless Infrastructure

68. Wireless infrastructure facilities are one of the major inputs in the provision of mobile wireless services.[176] In addition to the use of towers and other tall structures, wireless infrastructure also includes distributed antenna systems (DAS),[177] and facilities for small cell technologies,[178] that are generally deployed to address coverage and capacity issues indoors, in densely populated areas outdoors, and even underground.[179] For

[176] These facilities include towers and other tall structures for macro sites, such as lattice towers, guyed towers, monopoles, rooftops, water towers, and steeples.

[177] 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 DAS 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.

[178] "Small cells" is an umbrella term for operator-controlled, low-powered radio access nodes, including those that operate in licensed spectrum and 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. 14, 2016).

[179] The DAS 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.

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 fewer large cells.[180]

69. In order to expand or to improve coverage in existing service areas, and to accommodate newer technologies, mobile service providers have historically deployed more cell sites. After a slight drop in 2014, the number of cell sites in use by mobile service providers increased in 2015. According to CTIA, there were 307,626 cell sites in use at year-end 2015, which is up approximately 3 percent from 298,055 as of year-end 2014.[181] In addition to macro cell sites, mobile service providers, in recent years, increasingly have started to deploy small cells and DAS sites to fill local coverage gaps or to increase local capacity.[182] Rather than building their own DAS deployments, some service providers share neutral host systems owned by third-party operators.[183]

70. A specialized communications tower industry has developed to provide and manage the support structures for the cell sites, and leases space to mobile wireless service providers. Today, there are more than 120 tower and DAS operators in the United States,[184] and a majority of towers are now owned or operated by independent companies rather than by mobile wireless service providers.[185] Independent tower operators own,

[180] 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.

[181] CTIA Wireless Industry Indices Year-End 2015 at 72, 74. 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.

[182] *See, e.g.*, Sprint 2015 Annual Report, at 27 ("We plan to densify the network through the use of small cell technology, femto cells, in-building solutions and repeaters as well as continuing to use traditional macro sites"); *see also* RCR Wireless, Sprint Execs "Extremely Bullish" in Analyst Meeting (June 28, 2016) ("Sprint is in the process of a massive nationwide small cell rollout"), http://www.rcrwireless.com/20160628/carriers/sprint-execs-extremely-bullish-tag17; Verizon 2015 Annual Report, at 11 ("We are investing in the densification of our network by utilizing small cell technology, in-building solutions and distributed antenna solutions"); Verizon Q1 2016 earning conference transcript, at 18 ("We are still deploying a lot of small cells"); RCR Wireless, AT&T Network Focused on Spectrum 5G, Small Cells; Plans for IoT (May 13, 2016) (stating that AT&T is set to have thousands of cell sites hosting its 2.3 GHz spectrum by the end of 2016), http://www.rcrwireless.com/20160513/carriers/at-plans-for-iot-tag2; RCR Wireless, Can Verizon and AT&T Deploy 100,000 New Small Cells (Oct. 29, 2015) (stating that all four nationwide providers are set to invest in small cells and DAS next year), http://www.rcrwireless.com/20151029/carriers/can-verizon-and-att-deploy-100000-new-small-cells-tag4. Antennas Systems & Technology, 16 Million DAS Nodes to be Deployed Through 2018 (Sept. 26, 2013) (predicting that wireless service providers will deploy more than 16 million DAS notes by 2018), http://www.antennasonline.com/main/news/16-million-das-nodes-to-be-deployed-through-2018/.

[183] 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; Sprint network expanding in New England thanks to GNW and ExteNet (ExteNet platform and Nokia radios enable shared infrastructure), July 6, 2016, http://www.rcrwireless.com/20160706/carriers/sprint-network-expanding-in-rural-new-england-thanks-to-gnw-and-extenet-tag4 (last visited Sept. 14, 2016).

[184] Wireless Estimator, Top 100 Tower Companies in the U.S., http://wirelessestimator.com/top-100-us-tower-companies-list/ (last visited Sept. 14, 2016).

[185] 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; U.S. Cellular Announces Sale of Towers in Divested Markets (Dec. 11, 2014), http://investors.uscellular.com/news/news-release-details/2014/US-Cellular-Announces-Sale-of-Towers-in-Divested-Markets/default.aspx; AT&T, AT&T and Crown Castle Close $4.83 Billion Tower Transaction (Dec. 16, 2013), http://about.att.com/newsroom/att_and_crown_castle_close_4_83_billion_tower_transaction_dec.html; Crown Castle, Crown Castle Completes Tower Transaction With T-Mobile USA (Nov. 30, 2012), http://psc.apcointl.org/2012/12/05/crown-castle-completes-tower-transaction-with-t-mobile-usa/; Sprint Nextel, Sprint Nextel Completes Tower Sale to TowerCo for

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, build and operate DAS networks and small cell facilities for mobile service providers.[186] In most cases, tower operators and property owners lease antenna, rooftop and other site space to multiple wireless service providers.[187]

71. One estimate indicates that the three largest publicly traded neutral host providers (Crown Castle, American Tower, and SBA Communications) own or operate more than 94,840 towers (not including DAS and small cells) as of May 2016.[188] At the end of December 2015, the top three tower operators had only 1.8 or 2.2 tenants per tower site and have significant capacity available for additional antennas or tenants.[189] In recent years, tower operators have also built or purchased neutral small cell facilities to host small cells or DAS for mobile service providers.[190] The availability of leased space on existing towers for mobile wireless service providers may eliminate the need to build new towers, reduce the capital requirements for network deployment and capacity expansion, and facilitate the entry of new wireless service providers.

72. As of April 2016, Chart IV.B.1 shows that there were three or more tower operators in 90 percent of counties nationwide, and six or more tower operators in 45 percent of counties.[191] As shown in Chart IV.B.2, tower operators tend to build and operate more towers in more densely populated areas. For example, as of June 2016, the average number of tower sites per county is 42 for counties with a population density between 75 and

Approximately $670 Million in Cash (Sept. 24, 2008), http://newsroom.sprint.com/news-releases/sprint-nextel-completes-tower-sale-to-towerco-for-approximately-670-million-in-cash.htm.

[186] American Tower 2015 Annual Report (10-K) at 1; Crown Castle 2015 Annual Report (10-K), Part 1, at 1; SBA Communications 2015 Annual Report (10-K), Part 1, at 1.

[187] American Tower, 2015 Annual Report at 1 ("Our primary business is leasing antenna space on multiple-tenant communications sites to wireless service providers, radio and television broadcast companies, wireless data providers, government agencies and municipalities and tenants in a number of other industries"); *see also* Verizon Wireless, Network Real Estate Inquires) ("Verizon Wireless receives thousands of inquiries each year from property owners, property managers and customers who offer property on which our communications facilities can be located"), http://www.verizonwireless.com/b2c/realestate/ (last visited Sept. 14, 2016).

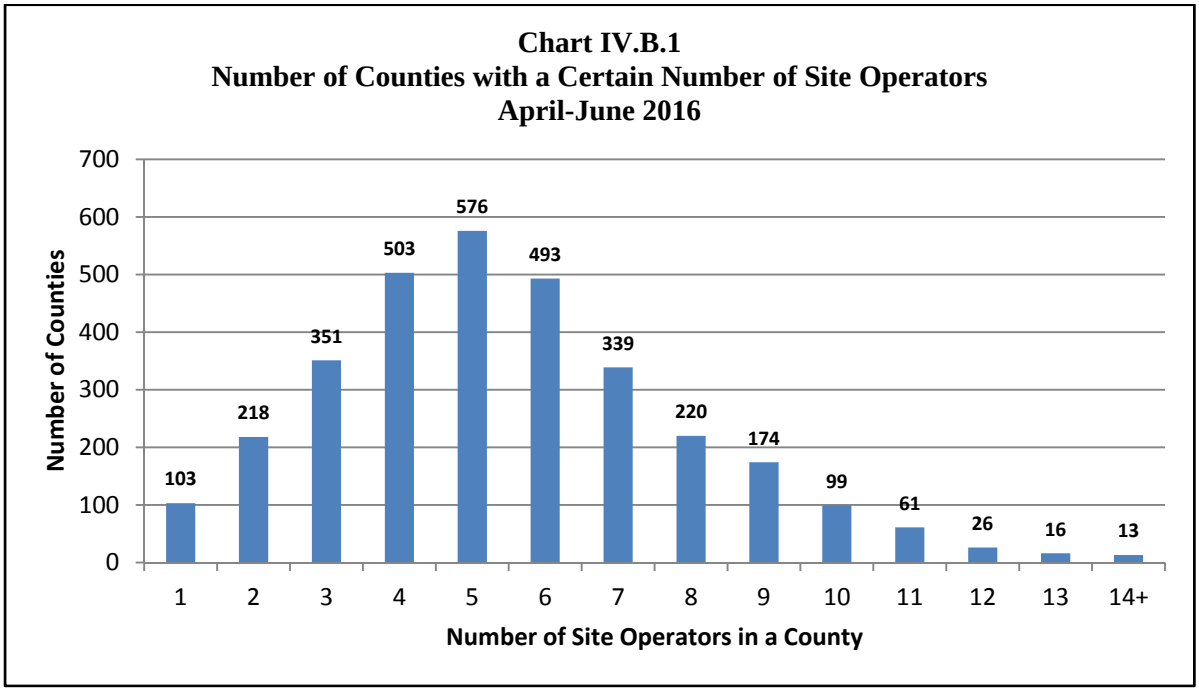
[188] Wireless Estimator, Top 100 Tower Companies in the U.S., (Crown Castle at 40,039, American Tower at 39,928, SBA at 14,873, and as of May 2016, not including rooftop sites, DAS and small cells), http://www.wirelessestimator.com/t_content.cfm?pagename=US-Cell-Tower-Companies-Complete-List (last visited Sept. 14, 2016).

[189] American Tower 2015 Annual Report, Part I, at 4 (1.8 tenants per tower), Crown Castle 2015 Annual Report, at 17 (2.2 tenants per tower), and SBA 2015 Annual Report, at 3 (1.8 tenants per tower); *see also* Wireless Infrastructure Association (WIA) Comments at 9 (claiming that towers currently host on average two to three tenants per tower depending on the provider, although many are capable of accommodating as many as five or six tenants).

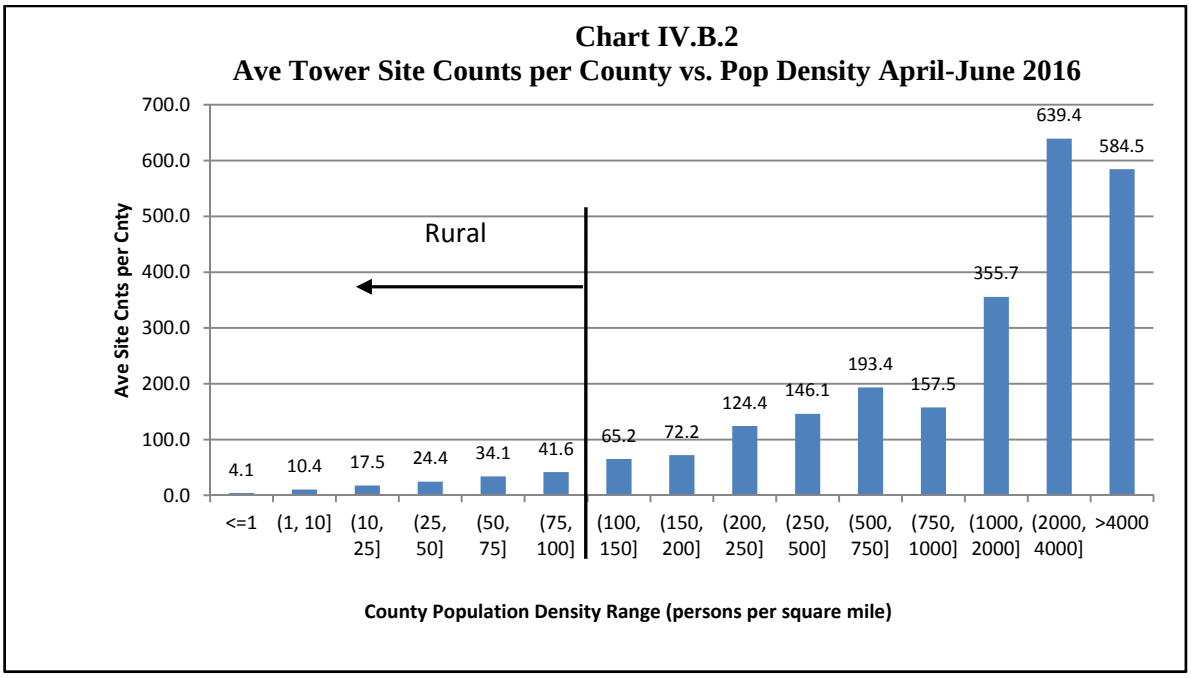
[190] Crown Castle 2015 Annual Report (10-K), Part 1, at 3 (Crown Castle acquired small cell assets from NextG Networks and Sunesys).

[191] Tower site information was downloaded from the tower provider's website in April and June, 2016. 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. 14, 2016). The 27 tower providers listed in this *Report* are Airwave Strategies, American Tower Corporation, AT&T, Badger Towers, Branch Communications/Branch Towers, Crown Castle, Communication Enhancement, Clearview Tower Company, Central States Tower Holdings, Com Sites West, CTI Towers, Day Wireless Systems, ERS Antenna Site Management, ForeSite, Hemphill Tower, Horizon Tower, Horvath Communications, Industrial Communications, K2 Towers KGI Wireless, Message Center Management, Milestone Communications, Municipal Communications, Nsight Tower Holdings, Performance Development Group, SBA Communications Corporation, Skyway Towers, Sprint, Subcarrier Communications, T-Mobile, Tower Ventures, Unison Site Management, and Vertical Bridge Holdings.

100 people per square mile, compared to 639 per county for counties with a population density between 2000 and 4000 people per square mile.[192]



Source: Data collected from 32 tower companies on towers, rooftops, DAS and small cells (April-June 2016).

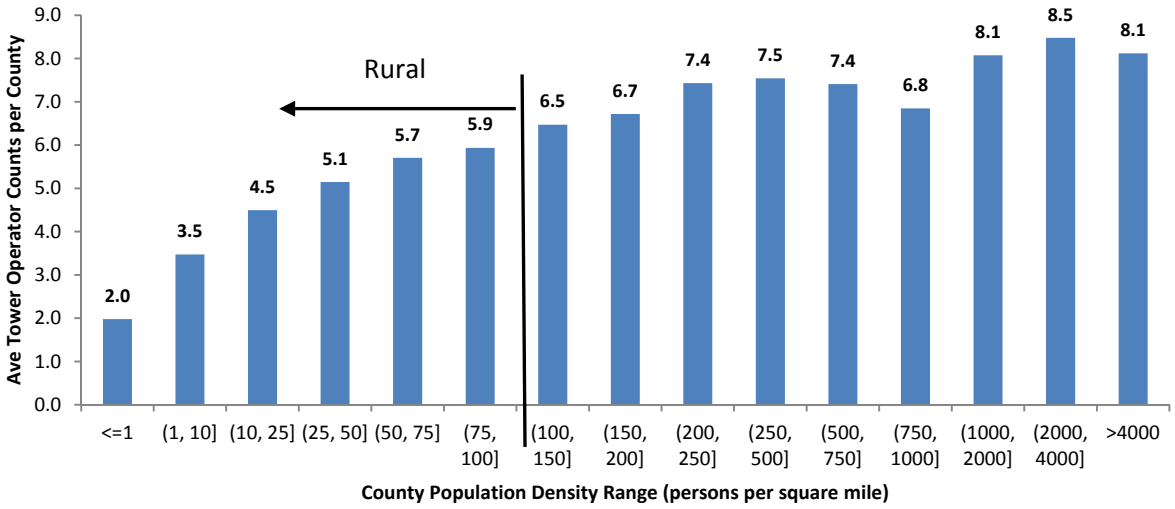


Source: Data based on 32 tower companies referenced above. Counties considered rural are those with 100 people or less per square mile. Population density is from the 2010 U.S. Census. Tower sites include towers, rooftops, DAS, and small cells.

[192] The average tower site counts per county increased mainly due to the inclusion of rooftop sites in our data set. The *Eighteenth Report* did not include rooftop sites.

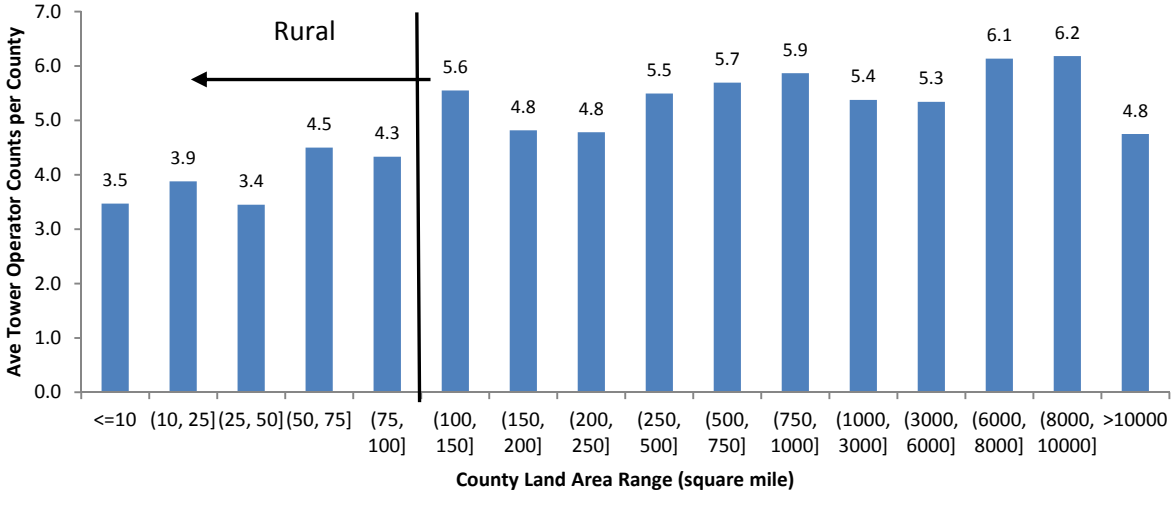
73. In addition, as shown in Chart IV.B.3.a below, there are more tower operators in densely populated counties than in less densely populated counties. The number of tower site operators per county ranges from two site operators per county in the least densely populated counties to eight site operators in the most densely populated counties. Chart IV.B.3.b below indicates that counties with larger land areas generally have more tower operators than counties with smaller land areas.

Chart IV.B.3.a
Ave Tower Operator Counts per County vs. Pop Density April-June 2016



Source: Data are based on the 32 tower companies referenced above. Counties considered rural are those with 100 people or less per square mile. Population density and land area are from the 2010 U.S. Census. Tower sites include towers, rooftops, DAS and small cells.

Chart IV.B.3.b
Ave Tower Operator Counts per County vs. County Land Area
April-June 2016



Source: Data are based on the 32 tower companies referenced above. Counties considered rural are those with 100 people or less per square mile. Population density and land area are from the 2010 U.S. Census. Tower sites include standalone towers, rooftop, and DAS sites.

74. There are three factors that have a significant effect on the deployment or modification of tower and DAS sites: (i) capital expenditure; (ii) obtaining the necessary zoning approvals from local authorities; and (iii) federal regulatory approval, which includes required engagement with state and Tribal authorities.[193] In terms of capital expenditure, co-locating wireless equipment on existing structures is often the most efficient and economical solution for mobile wireless service providers that need new cell sites, either to expand their existing coverage area, increase their capacity, or deploy a new generation of mobile broadband technology. There exist various estimates of the average cost of building a new cell site tower, ranging from as low as $150,000 to as high as $300,000,[194] while the average cost of co-location on an existing tower is about 30 percent of the total cost of a new tower.[195] The per-site cost (including both capital and operating costs) for small cells is estimated to be less than half of the per-site cost for macro sites.[196] The three largest publicly-traded tower operators alone invested more than $2 billion in building new sites and upgrading existing sites in 2015,[197] which is up from $1.6 billion in 2014.[198]

2. Backhaul

75. Backhaul facilities 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 connections are an integral component of a wireless service provider's network, and the cost of backhaul is a significant percentage of the cost of operating a base station.[199] Backhaul services 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.[200]

76. As mobile data traffic has grown rapidly in recent years, the leading mobile wireless service providers have deployed or are in the process of deploying Ethernet backhaul either over fiber or microwave to their cell sites, including both macro sites and small cells. For example, as of November 2015, over 90 percent of

[193] *See Eighteenth Report*, 30 FCC Rcd at 14564, para. 68; *see also infra* Section IV.B.3.

[194] Statistic Brain Research Institute, Cell Phone Tower Statistics (June 12, 2016) (average cost of building a cell phone tower is $150K), http://www.statisticbrain.com/cell-phone-tower-statistics/; *see also* PCIA Comments to 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) (estimating the cost of building a new telecommunication tower is between $265K and $277K for three sites in City of Wayzata, Minnesota), http://www.wayzata.org/DocumentCenter/View/402; RCR Wireless, AT&T Cell Site of the Future Hits a Speed Bump (July 17, 2014) (stating the cost per site was coming in at $380,000 in New York metro area), http://www.rcrwireless.com/article/20140717/infrastructure-2/att-cell-site-future-hits-speed-bump/.

[195] Statistic Brain Research Institute, Cell Phone Tower Statistics (June 12, 2016) (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), http://www.statisticbrain.com/cell-phone-tower-statistics/.

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

[197] WIA Comments at i, 7.

[198] *Eighteenth Report*, 30 FCC Rcd at 14564, para. 68.

[199] Sprint Comments at 6, n.25.

[200] *Eighteenth Report*, 30 FCC Rcd at 14564, para. 69. Service providers of backhaul services include ILECs such as AT&T, Verizon, and CenturyLink; CLECs such as Level 3 and Birch; competitive fiber and microwave wholesalers such as Level 3, Ceragon Networks, FiberNet, and Zayo; cable providers such as Charter Communications, Comcast Business, and Cox Carrier Services; independent backhaul operators, including backhaul specialists such as Telecom Transport Management, and Tower Cloud.

AT&T's mobile data traffic is carried over enhanced backhaul.[201] As of October 2015, T-Mobile's backhaul is substantially all fiber.[202] Sprint is planning on using a hybrid approach of dark fiber and microwave for its backhaul.[203] Verizon Wireless also deployed fiber backhaul facilities for its 4G LTE sites,[204] and its LTE network carried approximately 91 percent of its mobile data traffic as of December 2015.[205] Some mobile wireless service providers also plan to use dark (or unlit) fiber for small cell backhaul connections in their network densification effort.[206] As wireless service providers increase their effort to deploy their small cells in the coming years, backhaul operators, cable companies, fiber providers, and tower operators are building out fiber networks to provide backhaul connectivity.[207]

3. Recent Commission Initiatives

77. In November 2015, the Commission modified its pole attachment rules to encourage infrastructure deployment by "keeping pole attachment rates unified and low."[208] On October 21, 2014, the Commission released an order that implemented section 6409(a) of the Middle Class Tax Relief and Job Creation Act of 2012, which provides that a state or local government "may not deny, and shall approve" any request for co-location, removal, or replacement of transmission equipment on an existing wireless tower or base station, provided this action does not substantially change the physical dimensions of the tower or base station.[209] The October 2014 order also took other actions to eliminate unnecessary reviews, and therefore reduce costs and delays, for wireless facilities siting.[210]

---

[201] AT&T, Network Reliability, at 3 (Nov. 2015), http://about.att.com/content/csr/home/issue-brief-builder/technology/network-reliability.html.

[202] RCR Wireless, T-Mobile US talks Small Cells, Spectrum Portfolio (Oct. 1, 2015), http://www.rcrwireless.com/20151001/network-infrastructure/t-mobile-us-talks-small-cells-spectrum-portfolio-tag17.

[203] Sprint Q3 2015 Earning Call transcript at 11, http://investors.sprint.com/financials/default.aspx (last visited Sept. 14, 2016).

[204] Verizon, Transcript for Verizon at Oppenheimer Holdings Inc. Technology, Internet & Communications Conference, at 7 (Aug. 15, 2012), http://www.verizon.com/about/investors/oppenheimers-15th-annual-technology-internet-communications-conference.

[205] Verizon 2015 Annual Report, at 11.

[206] *See, e.g.*, RCR Wireless, Verizon Looks to Dark Fiber, Small Cells for Densification (Dec. 10, 2015), http://www.rcrwireless.com/20150910/carriers/verizon-looks-to-dark-fiber-small-cells-for-densification-tag17; FierceWireless, Small Cell Push by Verizon, Sprint and Others Draws FairPoint into Dark Fiber Market for Backhaul (Mar. 14, 2016), http://www.fiercewireless.com/story/small-cell-push-verizon-sprint-and-others-draws-fairpoint-dark-fiber-market/2016-03-14; FierceTelecom, Sprint's Thirst for Dark Fiber-based Small Cell Backhaul Spells Opportunity for Zayo, Level 3 (Jan. 28, 2016), http://www.fiercetelecom.com/story/sprints-thirst-dark-fiber-based-small-cell-backhaul-spells-opportunity-zayo/2016-01-28; FierceWireless, Sprint Will Use 2.5 GHz Spectrum, Dark Fiber for Backhaul to Small Cells (Jan. 26, 2016), http://www.fiercewireless.com/story/sprint-will-use-25-ghz-spectrum-dark-fiber-backhaul-small-cells/2016-01-26; *see also* Crown Castle 2015 Annual Report (10-K), Part 1, at 3 ("To a lesser extent, we offer fiber solutions including dark fiber and lit fiber").

[207] FierceTelecom, AT&T Deploys Fiber Out of Region to Satisfy Business, Wireless Backhaul Demand (May 13, 2016), http://www.fiercetelecom.com/story/att-deploys-fiber-out-region-satisfy-business-wireless-backhaul-demand/2016-05-13.

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

[209] Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6409(a) (2012), codified at 47 U.S.C. § 1455(a).

[210] *Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies; Acceleration of Broadband Deployment: Expanding the Reach and Reducing the Cost of Broadband Deployment by Improving Policies Regarding*

78. The Commission has also entered into two Nationwide Programmatic Agreements (NPAs) with the Advisory Council on Historic Preservation (ACHP) and the National Conference of State Historic Preservation Officers (NCSHPOs) to clarify the National Historic Preservation Act (NHPA) Section 106 process for (1) new tower construction, and (2) collocations of communications equipment on existing towers and other structures.[211] On May 12, 2016, the Bureau sought comment on proposed amendments to the NPA governing collocations to exclude from Section 106 review additional DAS and small cell facilities that are unlikely to adversely affect historic properties.[212] In addition, the Commission has taken steps with relevant government and non-governmental stakeholders to develop a process for "clearing" existing towers that did not complete Section 106 historic preservation review prior to construction, including "twilight towers" that were constructed prior to the specification of detailed Section 106 review procedures in the 2005 NHPA,[213] while respecting historic preservation values. This effort will potentially make thousands of additional towers available for co-location.[214] In August 2014, the Commission adopted a Report and Order to streamline and eliminate outdated provisions of the Part 17 Rules governing the construction, marking, and lighting of antenna structures.[215]

79. The Commission has also examined issues related to backhaul including special access services and the use of microwave spectrum for backhaul services in the past few years.[216] On September 15, 2014, the Commission's Wireline Competition Bureau issued an Order on Reconsideration that set a deadline of December 15, 2014 for service providers to submit data on networks, prices, and terms for special access in order to enable the Commission to assess the state of competition.[217] Although the Wireline Competition Bureau kept the December 15, 2014 deadline for streamlined certifications, it extended this deadline to January 29, 2015 for large businesses with more than 1500 employees, and to February 27, 2015 for small businesses with less than 1500 employees.[218] Comments on the data submissions were submitted on January 22, 2016, and replies submitted on February 19, 2016.[219] In addition, on October 16, 2015, the Wireline Competition Bureau initiated an investigation into the terms and conditions of certain ILEC tariff pricing plans of AT&T, CenturyLink, Frontier,

---

Public Rights of Way and Wireless Facilities Siting; 2012 Biennial Review of Telecommunications Regulations, Report and Order, 29 FCC Rcd 12865 (2014) (*Wireless Infrastructure Report and Order*).

[211] 47 C.F.R. Pt. 1, Apps. B and C; *see also* Section 106 of the National Historic Preservation Act, 54 U.S.C. § 306108.

[212] *Wireless Telecommunications Bureau Seeks Comment on Proposed Amended Nationwide Programmatic Agreement for the Collocation of Wireless Antennas*, Public Notice, 31 FCC Rcd 4617 (WTB 2016).

[213] Specifically, "twilight towers" are non-compliant towers built between March 16, 2001 and March 7, 2005.

[214] *Wireless Infrastructure Report and Order*, 29 FCC Rcd at 12867, para. 4.

[215] *2004 and 2006 Biennial Regulatory Reviews–Streamlining and Other Revisions of Parts 1 and 17 of the Commission's Rules Governing Construction, Marking and Lighting of Antenna Structures*, Report and Order, 29 FCC Rcd 9787 (2014).

[216] *Eighteenth Report*, 30 FCC Rcd at 14566, para. 72.

[217] *Special Access for Price Cap Local Exchange Carriers; AT&T Corporation Petition for Rulemaking to Reform Regulation of Incumbent Local Exchange Carrier Rates for Interstate Special Access Services*, Order on Reconsideration, 29 FCC Rcd 10899 (WCB 2014) (*Order on Reconsideration*). On August 22, 2012, the Commission had adopted a Report and Order that suspended, on an interim basis, rules that allowed for automatic grants of pricing flexibility for special access services in light of evidence in the record the rules failed to accurately reflect the state of competition in the market for special access. *Special Access for Price Cap Local Exchange Carriers; AT&T Corporation Petition for Rulemaking to Reform Regulation of Incumbent Local Exchange Carrier Rates for Interstate Special Access Services*, Report and Order, 27 FCC Rcd 10557 (2012).

[218] *Special Access for Price Cap Local Exchange Carriers; AT&T Corporation Petition for Rulemaking to Reform Regulation of Incumbent Local Exchange Carrier Rates for Interstate Special Access Services*, Order, 29 FCC Rcd 14346 (WCB 2014) (*Extension Order*).

[219] *Special Access for Price Cap Local Exchange Carriers; AT&T Corporation Petition for Rulemaking to Reform Regulation of Incumbent Local Exchange Carrier Rates for Interstate Special Access Services*, Order, 30 FCC Rcd 14467 (WCB 2015).

and Verizon for special access services.[220] On April 28, 2016, the Commission adopted the Tariff Investigation Order and Further Notice of Proposed Rulemaking (FNPRM).[221] The Order concluded that certain terms and conditions of these tariffs were unjust and unreasonable, and had the effect of decreasing facilities based competition and inhibiting the transition to new technologies and required the ILECs to make appropriate tariff revisions.[222] In the FNPRM, the Commission seeks comment on a new regulatory framework for the provision of business data services or special access services.[223]

80. In April 2015, the Commission adopted rules for commercial use of 150 megahertz in the 3550-3700 MHz band (3.5 GHz Band), enabling innovative use cases such as wireless backhaul.[224] On April 28, 2016, the Commission finalized the rules for the 3.5 GHz band, reaffirming the innovative and shared use of the band.[225] On October 22, 2015, the Commission proposed new rules to make spectrum bands above 24 GHz available for mobile and other services (including backhaul).[226]

V. PRICING LEVELS AND TRENDS

81. The following discussion of developments in mobile service pricing is divided into two sections–postpaid and prepaid–and focuses on pricing changes during the period covered by this *Report*.[227] As discussed in the *Eighteenth Report*, 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 (prepaid service).[228]

A. Postpaid Service

82. We have continued to see a range of postpaid pricing changes and promotions through the end of 2015. These changes include, but are not limited to, new pricing plans, additional data, equipment promotions, Early Termination Fee (ETF) payoffs, free international roaming, and changes in the pricing of video. The following discussion highlights some of the pricing changes and promotions that have been introduced in postpaid service during the period covered by this *Report*. In addition, and without being comprehensive in our discussion of all the changes in service providers' pricing plans that have been introduced since the beginning of 2016, we note that in recent months, there have been some quite marked changes in how service providers are pricing their offerings. For example, T-Mobile and Sprint have recently reintroduced unlimited plans to differentiate their

[220] *Investigation of Certain Price Cap Local Exchange Carrier Business Data Services Tariff Pricing Plans*, Order Initiating Investigation and Designating Issues for Investigation, 30 FCC Rcd 11417 (WCB 2015).

[221] *Business Data Services in an Internet Protocol Environment; Investigation of Certain Price Cap Local Exchange Carrier Business Data Services Tariff Pricing Plans; Special Access for Price Cap Local Exchange Carriers*, Tariff Investigation Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 4723 (2016).

[222] *Id*. at 4727-28, para. 11.

[223] *Id*. at 4790-91, para. 159.

[224] *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, 4024, para. 207 (2015).

[225] *See generally 3.5 GHz Order on Recon. and Second Report and Order*, 31 FCC Rcd 5011.

[226] *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Notice of Proposed Rulemaking, 30 FCC Rcd 11878, 11880-81, para. 1 (2015).

[227] The pricing analysis included in this Section shows that mobile service providers offer nationwide pricing plans availabile throughout their service area, with no pricing disparity between rural and urban markets, rendering 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. *See 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).

[228] *Eighteenth Report*, 30 FCC Rcd at 14566-67, para. 73.

products, while continuing to battle each other for customers seeking lower priced plans.[229] And furthermore, in response to earlier moves by T-Mobile and Sprint, both AT&T and Verizon Wireless have recently introduced simplified new plans that utilize speed reductions in lieu of overage charges.[230]

1. Promotional Pricing Offers

83. Service providers continued to compete for customers by increasing the monthly data allowances on certain tiers of shared data plans while leaving unchanged the existing monthly data charges. Some of these pricing changes were limited-time promotional offers. For example, in August 2015, Verizon Wireless streamlined individual plans offering Small (1 GB/$30), Medium (3 GB/$45), Large (6 GB/$60), and X-Large (12 GB/$80).[231] AT&T raised the data allowance on its $100 data plan from 10 GB to 15 GB.[232] AT&T also brought its pricing down closer to that of T-Mobile and Sprint for lower data tier plans.[233] In September 2015, Sprint announced that it would be raising the price of its unlimited data plan from $60 to $70 the following month and encouraged subscribers to sign up in advance of the increase.[234] After discontinuing new unlimited data plans, AT&T announced in September 2015 that it would begin slowing data speeds for legacy unlimited subscribers after a subscriber had used 22 GB in a month, and in November 2015 it announced that it would be raising the price for those legacy plans.[235] In January 2016, AT&T made new unlimited data plans available to DIRECTV subscribers.[236] In November 2015, Sprint offered plans to customers who switched from other service providers that would be half-off the rate plans from their previous service provider.[237]

---

[229] FierceWireless, Unlimited plans from T-Mobile and Sprint are compelling, but analysts say network concerns remain (Aug. 18, 2016), http://www.fiercewireless.com/wireless/unlimited-plans-from-t-mobile-and-sprint-are-compelling-but-analysts-say-network-concerns.

[230] *See, e.g.*, Verizon Wireless, Myth v. Reality: New My Verizon app and new Verizon Plans (July 7, 2016) http://www.verizonwireless.com/news/article/2016/007/myth-v-reality-new-my-verizon-app-and-new-verizon-plans.html. AT&T, Zero Overages, https://www.att.com/shop/wireless/data-plans.html (last visited Sept. 14, 2016).

[231] The effect of Verizon Wireless's shared data plan on customers' monthly bills depends on the size of their data allowance and the number of smartphone lines used. Customers on data tiers with less than 6 GB of data will see a price cut as a result of reductions in monthly data and smartphone access charges. The price will remained unchanged for customers on the 6 GB data tier with two smartphones. Customers on data tiers with a monthly data allowance greater than 6 GB and with more than two lines may end up paying slightly higher prices than they had been previously. Droid-Life, Verizon Tries to Simplify Plans with S-M-L-XL Data Plans (Aug. 7, 2015), http://www.droid-life.com/2015/08/07/verizon-tries-to-simplify-plans-with-s-m-l-xl-data-plans/.

[232] PR Newswire, AT&T Introduces New AT&T Mobile Share Value Plans (Aug. 14, 2015), http://www.prnewswire.com/news-releases/att-introduces-new-att-mobile-share-value-plans-300128462.html.

[233] J.P. Morgan, North America Equity Research, Philip Cusick, et al., Verizon Simplifies Pricing and Drops Subsidy Option; AT&T Also Reshuffles Its Pricing, at 1, 3 (Aug. 18, 2015).

[234] Sprint, Sprint Says: Hurry In Before It's Too Late! Last Two Weeks To Get Unlimited High-Speed Data, Talk And Text For Just $60/Month! (Sept. 30, 2015), http://newsroom.sprint.com/news-releases/sprint-says-hurry-in-before-its-too-late-last-two-weeks-to-get-unlimited-high-speed-data-talk-and-text-for-just-60month.htm.

[235] AT&T, Info For Smartphone Customers with Legacy Unlimited Data Plans (Nov. 30, 2015), https://www.att.com/esupport/datausage.jsp?source=IZDUel1160000000U; CNN, AT&T raises price for grandfathered unlimited data plans (Nov. 30, 2015), http://money.cnn.com/2015/11/30/technology/att-unlimited-data-plan-price-increase/index.html.

[236] AT&T, AT&T Introduces New Unlimited Plan For AT&T Wireless and DIRECTV Subscribers (Jan. 11, 2016), http://about.att.com/story/unlimited_plan_for_wireless_and_directv_subscribers.html.

[237] Sprint, Sprint Celebrates Launch of LTE Plus Network; Introduces Biggest Wireless Offer in U.S. History–50% Off Verizon, AT&T and T-Mobile Rate Plans (Nov. 18, 2015), http://newsroom.sprint.com/news-releases/sprint-celebrates-launch-of-lte-plus-network-introduces-biggest-wireless-offer-in-us-history-50-off-verizon-att-and-t-mobile-rate-plans.htm.

84. Price rivalry in the fall of 2015 also took the form of limited-time promotional pricing offers on selected large data plans, focusing on the multi-line family plans. The pricing models of the four nationwide service providers continued to be differentiated in this segment of the market. Verizon Wireless, AT&T, and Sprint offered shared data plans in which a single bucket of data can be shared among multiple (up to ten) persons or devices. In contrast, T-Mobile's version of a family plan offered a dedicated LTE data bucket for each person or device to use on an exclusive basis, gave subscribers the option of adding additional lines at reduced prices.[238] As noted in the *Eighteenth Report*, in July 2015, T-Mobile launched a limited-time promotional offer that gave each customer 10 GB of LTE data per month, with the first two lines priced at $100 per month and each additional line thereafter $20 per month.[239] Subscribers who signed up by September 7, 2015 were offered an additional promotion allowing customers to add a fourth line free of charge. Sprint quickly countered with two limited-time promotional pricing offers of 10 GB of shared data for $100 per month and 40 GB of shared data for $120 per month.[240] As mentioned above, in August 2015, AT&T increased the data bucket for its shared plans from 10 GB to 15 GB.[241] In October 2015, U.S. Cellular, the largest regional service provider, cut its prices on its shared data plans.[242] In February 2016, T-Mobile announced a promotional plan with four lines with unlimited LTE for $150 per month,[243] and Sprint again countered.[244] In February 2016, Verizon Wireless announced a limited-time promotion in which existing and switching subscribers would receive a bonus of 24 GB of sharable data per year for each device they activate.[245]

85. In November 2015, T-Mobile announced that customers on qualifying rate plans would be able to stream unlimited video from participating video streaming services without using their data allowance.[246] Binge-On covered a broad range of popular free and subscription streaming video services and shared certain characteristics with T-Mobile's earlier Music-Freedom promotion, in which T-Mobile allowed customers

---

This promotion applied to pre-paid subscribers of Cricket and MetroPCS, using the rate plans of the parent providers to determine the discounted rate.

[238] FierceWireless, T-Mobile Launches New Family Plan with 10GB of Data, But Drops Existing Unlimited Option (July 15, 2015), http://www.fiercewireless.com/story/t-mobile-launches-new-family-plan-10-gb-data-drops-existing-unlimited-offer/2015-07-14.

[239] T-Mobile, T-Mobile Amps Up its Family Plan; Family Members get 10GB Each–for Just $30 a Line (July 14, 2015), https://newsroom.t-mobile.com/media-kits/simple-choice-family-10gb.htm.

[240] FierceWireless, Sprint Targets T-Mobile With New 10 GB/$100, 40 GB/$120 Shared Family Plan (July 30, 2015), http://www.fiercewireless.com/story/sprint-targets-t-mobile-new-10-gb100-40-gb120-shared-family-plan/2015-07-30.

[241] FierceWireless, AT&T Shakes Up Mobile Share Value Plan Pricing, Increases $100/10 GB Plan to 15 GB (Aug. 14, 2015), http://www.fiercewireless.com/story/att-shakes-mobile-share-value-plan-pricing-increases-10010-gb-plan-15-gb/2015-08-14.

[242] FierceWireless, U.S. Cellular Slashes Prices On Its Shared Data Plans, Undercutting Verizon And AT&T (Oct. 6 2015), http://www.fiercewireless.com/story/us-cellular-slashes-prices-its-shared-data-plans-undercutting-verizon-and-a/2015-10-06.

[243] T-Mobile, T-Mobile Launches Unbeatable Deals for Data-Hungry Families (Feb. 3, 2016), https://newsroom.t-mobile.com/news-and-blogs/unlimited-lte-promotion.htm.

[244] FierceWireless, Sprint Matches T-Mobile: $150/month Gives 4 Lines of Service Unlimited Everything (Feb. 11, 2016), http://www.fiercewireless.com/story/sprint-matches-t-mobile-150month-gives-4-lines-service-unlimited-everything/2016-02-11.

[245] Verizon Wireless, It's Back! 24 Free GB of Data Every Year for Life (Feb 16, 2016), http://www.verizonwireless.com/news/article/2016/02/24-free-gb-of-data-every-year-for-life.html.

[246] T-Mobile, T-Mobile Unleashes Mobile Video with Binge On (Nov. 10, 2015), https://newsroom.t-mobile.com/media-kits/un-carrier-x.htm. At the same time, T-Mobile announced that, as part of Binge On, it was reducing the speed of video services delivered over its network to 1.5 Mbps, which it said delivered DVD quality video, http://www.t-mobile.com/company/company-info/consumer/internet-services.html (last visited Sept. 14, 2016).

unlimited access to music streaming services without using their data allowance.[247] In November 2015, Sprint announced an offer giving customers who purchased a new Samsung phone, an Amazon Prime membership for one year,[248] and in December 2015, T-Mobile offered a one year Hulu membership to customers switching from Verizon Wireless.[249] Following the closing of the AT&T-DIRECTV transaction,[250] AT&T began offering incentives in the form of credits, up to $500, for DIRECTV (and U-verse) subscribers who switch their mobile service to AT&T.[251] In addition, subscribers of both AT&T and DIRECTV with combined bills were given a $10 monthly discount in their combined bill.[252]

2. Continued Phase-Out of Contract Service Plans

86. Starting in 2013, as previously reported in the last two *Reports*, service providers have been promoting service plans without term contracts and equipment subsidies in favor of Equipment Installment Plans (EIPs). That trend has continued, and in conjunction with the August 2015 pricing promotion discussed above, Verizon Wireless announced that it was also discontinuing annual service contracts.[253] That same month, Sprint announced that it would eliminate term contracts by the end of 2015 and move to a handset leasing model.[254] In December 2015, AT&T announced the end of its term contracts and equipment subsidies.[255]

3. Early Termination Fee Buyouts and Other Switching Incentives

87. One of the ways that service providers attract subscribers of rivals to switch is with ETF buyouts. ETF buyouts typically include a cash payment or credit to reimburse ETFs for customers on traditional contract plans, or alternatively, to pay off the remaining balance of an EIP, in addition to a separate device credit for trading in a customer's current handset.[256] For example, Verizon Wireless announced a $650 per line buyout along with 2 GB per month of additional data.[257] Similarly, T-Mobile offered customers switching from AT&T a

[247] *Eighteenth Report*, 30 FCC Rcd at 14569, para. 78; *Seventeenth Report*, 29 FCC Rcd at 15386, para. 152.

[248] Sprint, Sprint Kicks off Holiday Shopping Season with an Exclusive Wireless Offer: A Year of Amazon Prime Included with Sprint Activation on a Qualifying Samsung Device (Nov. 6, 2015), http://newsroom.sprint.com/news-releases/sprint-kicks-off-holiday-shopping-season-with-an-exclusive-wireless-offer-a-year-of-amazon-prime-included-with-sprint-activation-on-a-qualifying-samsung-device.htm.

[249] T-Mobile, T-Mobile Unwraps a Full Year of Hulu & Half-Off the Hottest Holiday Gifts for Verizon Customers (Dec. 10, 2015), https://newsroom.t-mobile.com/news-and-blogs/verizon-holiday-offer.htm.

[250] *Applications of AT&T and DIRECTV for Consent To Assign or Transfer Control of Licenses and Authorizations*, Memorandum Opinion and Order, 29 FCC Rcd 9131 (2015) (*AT&T-DIRECTV Order*).

[251] AT&T, DIRECTV Customers Now Get $500 in Credits for Each Line They Switch to AT&T (Aug. 10, 2015), http://about.att.com/story/dtv_customers_now_get_credits_for_each_line_they_switch_to_att.html.

[252] *Id*.

[253] ArsTechnica, Verizon Wireless Moving Away From Contracts and Phone Subsidies (Aug. 7, 2015), http://arstechnica.com/business/2015/08/verizon-wireless-moving-away-from-contracts-and-phone-subsidies.

[254] FierceWireless, Sprint to Abandon 2-year Contracts by Year-end, Embrace Leasing Exclusively (Aug. 17, 2015), http://www.fiercewireless.com/story/sprint-abandon-2-year-contracts-year-end-embrace-leasing-exclusively/2015-08-17. After discontinuing term contracts in early January 2016, however, Sprint reinstated them as an option for new subscribers the following month. Fierce Wireless, Sprint Resurrects Two-year Wireless Service Contracts to Give Customers More Choices (Feb. 26, 2016), http://www.fiercewireless.com/story/sprint-resurrects-two-year-wireless-service-contracts-give-customers-more-c/2016-02-26.

[255] FierceWireless, AT&T to Kill Contracts for All New Phones (Dec. 30, 2015), http://www.fiercewireless.com/story/att-kill-contracts-all-new-phones/2015-12-30.

[256] *Eighteenth Report*, 30 FCC Rcd at 14574, para. 90.

[257] Verizon Wireless, No Regrets: Switch to the Better Network and Receive Up to $650 (Dec. 28, 2015), http://www.verizonwireless.com/news/article/2015/12/no-regrets-switch-to-the-better-network-and-receive-up-to-650.html/.

discount on new iPhones, in addition to $650 per line.[258] In January 2016, Sprint announced a continuation of a previous $650 per line switching promotion in conjunction with their "50% off" competitors' rate plans promotion.[259] To address hesitancy to switch due to coverage concerns, in September 2015, T-Mobile introduced a lifetime coverage guarantee that provided for refunds of the previous month's service cost, and allowed for returns or unlocking of handsets under certain circumstances.[260] Similarly, in March 2016, Sprint brought back a 30-day guarantee to enable an extended trial of its service to attract switchers concerned with service quality.[261]

4. International Roaming Promotions

88. Another way that service providers used pricing to differentiate themselves was by offering discounted or free roaming while traveling abroad. For example, in July 2015, T-Mobile announced "Mobile Without Borders" adding voice and data roaming (including LTE) in Canada and Mexico at no extra charge to new and existing postpaid plans.[262] In November 2015, AT&T announced free roaming of up to 1 GB in Mexico.[263]

B. Prepaid Service

89. The four nationwide service providers 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 and that T-Mobile was also helped by the closing of three of its MVNOs serviced by its network."[264] As discussed in the *Eighteenth Report*, T-Mobile acquired MetroPCS and AT&T acquired Leap thereby expanding their prepaid offerings.[265] Verizon Wireless has the smallest share of prepaid subscribers among the nationwide service providers. It has only one prepaid brand, which is marketed as Verizon Wireless Prepaid. To varying degrees, the other three nationwide service providers pursue a multi-brand prepaid strategy.[266] TracFone, the largest MVNO reseller, has multiple prepaid brands, such as Straight Talk, telcel AMERICA, and SafeLink, which target different market and demographic segments such as premium, Hispanic, or low-income subscribers.[267]

90. As postpaid offerings have shifted away from term contracts and equipment subsidies, service providers have adopted the same or similar types of pricing changes and promotions for their high-end prepaid

---

[258] T-Mobile, T-Mobile Unleashes Mobile Video with Binge On (Nov. 10, 2015), https://newsroom.t-mobile.com/media-kits/un-carrier-x.htm.

[259] Sprint, Switching Mania Continues: Sprint Extends Biggest Wireless Offer in U.S. History–50% Off AT&T, T-Mobile and Verizon Rate Plans (Jan. 6, 2016), http://newsroom.sprint.com/news-releases/switching-mania-continues-sprint-extends-biggest-wireless-offer-in-us-history-50-off-att-t-mobile-and-verizon-rate-plans.htm.

[260] T-Mobile, Lifetime Coverage Guarantee™ Fact Sheet (Sept. 2015), https://newsroom.t-mobile.com/news-and-blogs/t-mobile-links/lifetime-coverage-guarantee.htm.

[261] FierceWireless, Sprint Re-Introduces 30-day Guarantee to Lure Users (Mar. 28, 2016), http://www.fiercewireless.com/story/sprint-re-introduces-30-day-guarantee-lure-users/2016-03-28.

[262] T-Mobile, T-Mobile Introduces 'Mobile without Borders': Extends Coverage & Calling Across North America at No Extra Charge (July 9, 2015), https://newsroom.t-mobile.com/media-kits/mobile-without-borders.htm.

[263] AT&T, Free Roaming in Mexico Available Friday to Add to Your AT&T Mobile Share Value® Plan (Nov. 11, 2015), http://about.att.com/story/data_in_mexico_at_no_cost.html.

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

[265] *Eighteenth Report*, 30 FCC Rcd at 14576, para. 95.

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

[267] TracFone Wireless Inc., Brands, http://www.tracfonewirelessinc.com/en/brands/ (last visited Sept. 14, 2016).

monthly service offerings as they have for their postpaid offerings. However, the prepaid and postpaid versions of a given pricing change or promotion still often differ due to the remaining differences between postpaid and prepaid service,[268] which largely reflect the fact that prepaid subscribers often lack the credit background or income in order to qualify for postpaid service. To prevent credit losses,[269] and mitigate the credit risk associated with the prepaid segment, service providers require advance payment for both prepaid service and handsets, and as explained below, most prepaid service providers impose speed reductions for data usage in excess of monthly data allowances, rather than the overage charges that are typical of postpaid data plans.

91. 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.[270] For example, Cricket Wireless reduces data download speeds to a maximum of 128 Kbps after the high speed data allowance is used.[271] In contrast, postpaid subscribers who use up their plan's data allowance in a given month generally incur overage charges if they exceed the allowance.[272] We note that T-Mobile has eliminated overage charges as part of its "uncarrier" strategy and generally uses speed reductions to control the data usage of both postpaid and prepaid subscribers.[273] In addition, AT&T has introduced "Rollover Data," which allows its subscribers to roll over their unused data at no addition cost.[274]

92. In many cases the prepaid pricing and promotions are similar to, or variations on, what is seen with postpaid. For example, in November 2015, Verizon Wireless introduced "simple prepaid" service plans, including $60 for 3 GB of data with unlimited minutes and texts, and $45 for 1 GB, with an additional GB for subscribers who sign up to have payments made automatically.[275] T-Mobile's MetroPCS allows roaming in Canada and Mexico, albeit for an additional $5 monthly charge that is not imposed on postpaid subscribers.[276] MetroPCS subscribers can also stream music from certain services without using their data allowance, similar to T-Mobile's postpaid subscribers.[277] Sprint's Boost Mobile brand responded by instituting a similar promotion in

[268] *Eighteenth Report*, 30 FCC Rcd at 14576, para. 96.

[269] 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.

[270] AT&T, AT&T GoPhone, Unlimited Talk, Text, and Data Usage, https://www.att.com/shop/wireless/gophone-plans.html (last visited Sept. 14, 2016); 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.

[271] Cricket Wireless, Important Data Speed, Usage and Pricing Information and Terms, https://www.cricketwireless.com/support/plans-and-features/cricket-plans-and-features/customer/plans.html (last visited Sept. 14, 2016).

[272] AT&T, What You Get With Mobile Share Value, https://www.att.com/shop/wireless/data-plans.html (last visited Sept. 14, 2016); Sprint, Terms and Conditions, https://shop2.sprint.com/en/legal/legal_terms_privacy_popup.shtml (last visited Sept. 14, 2016).

[273] T-Mobile, Simple Choice Plan, https://support.t-mobile.com/docs/DOC-24314 (last visited Sept. 14, 2016).

[274] AT&T, Rollover Data, https://www.att.com/shop/wireless/rollover-data.html (last visited Sept. 14, 2016).

[275] Verizon Wireless, Verizon Introduces Simple Prepaid Service Plans (Nov. 19, 2015), http://www.verizonwireless.com/news/article/2015/11/verizon-introduces-simple-prepaid-service-plans.html/.

[276] MetroPCS, Media Alert: MetroPCS Launches North America Unlimited–Use Your Phone in Mexico or Canada Like at Home, https://www.metropcs.com/press/news-releases/2015/north-america-unlimited-metropcs.html (last visited Sept. 14, 2016).

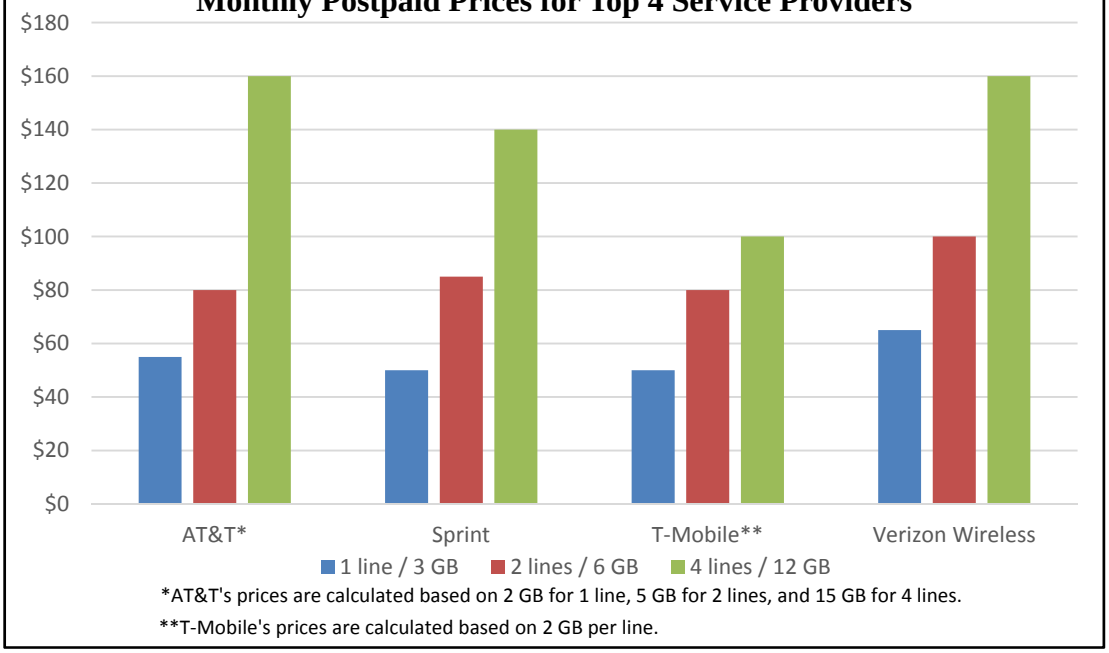
[277] T-Mobile, MetroPCS Customers Get Their 'Music Unlimited' & More Data That Lasts Even Longer (Nov. 16, 2015), https://newsroom.t-mobile.com/news-and-blogs/metropcs-more-data.htm.

December 2015.[278] Boost Mobile also introduced a promotion in October 2015, which added 500 MB to a customer's data allowance for every three payments made on-time.[279] In February 2016, Verizon Wireless increased the amount of data to 2 GB for $45 and 5 GB for $60.[280]

C. Price Indicators for Mobile Wireless Services

93. As the discussion above indicates, there is a wide variety of pricing plans offered by the different mobile wireless service providers that vary in several dimensions, which may frequently change.[281] As discussed earlier,[282] and in previous *Reports*, it is difficult to identify sources of information that track actual mobile wireless service prices in a comprehensive and consistent manner. Chart V.C.1 below presents monthly postpaid prices for the four nationwide service providers. Table V.C.1 below shows the current monthly prepaid prices for major service providers. As reflected in these two charts, sharing data among different lines in an account is a common feature of postpaid pricing plans, but it is not an option for prepaid plans.

Chart V.C.1
Monthly Postpaid Prices for Top 4 Service Providers



Note: The above prices were taken from service providers' websites on June 16, 2016. Prices include any per line charges indicated by the service provider. Prices do not include any additional charges such as equipment installment plans, insurance, international use, or data overage; however, if a service provider includes any such feature in its basic plan, 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.

[278] Boost Mobile, Boost Mobile Adds Unlimited Music Streaming (Dec. 9, 2015), http://newsroom.boostmobile.com/press-release/products-offers/boost-mobile-adds-unlimited-music-streaming.

[279] Boost Mobile, Boost Mobile Launches First and Only Plans With "Growing Data" Starting at $30/Month (Oct. 1, 2015), http://newsroom.boostmobile.com/press-release/boost-mobile-launches-first-and-only-plans-growing-data-starting-30month.

[280] Verizon Wireless, Now Get More Value With Extra Data On Prepaid (Feb. 4, 2016), http://www.verizonwireless.com/news/article/2016/02/now-get-more-value-with-extra-data-on-prepaid.html.

[281] Appendix V. provides additional information, based on data from RBC Capital Markets, on pricing over time for the four nationwide service providers.

[282] *See supra* Section II.E.1.

Table V.C.1
Monthly Prepaid Prices for Major Service Providers

Service Provider	GB per line	1 line	2 lines	4 lines
Cricket (AT&T)	2.5	$40	$70	$100
Boost (Sprint)	2	$35	$60	$100
Metro (T-Mobile)	3	$40	$80	$160
Straight Talk	5	$45	$90	$180

Note: The above prices were taken from service providers' websites on June 16, 2016. Prices include any per line charges indicated by the service provider. Prices and the specifics of the plans are subject to change.

VI. NON-PRICE RIVALRY

94. Mobile wireless service providers also compete for customers on dimensions other than price, including capacity and investment, network coverage and technology, service quality, and advertising and marketing. Service providers take these actions in an attempt to differentiate themselves from competitors, as well as to adopt certain initiatives of their competitors that have been successful in attracting customers. Such non-price rivalry can influence a customer's choice of a service provider and impose significant competitive constraints, especially in high technology industries that experience rapid innovation.[283] This Section presents data in three broad categories reflecting various elements of non-price rivalry among mobile wireless service providers. We first consider network coverage, including recent Commission initiatives, then we turn to our analysis of service quality, and finally, we discuss differentiation in handsets/devices and advertising/marketing.

A. Network Coverage

1. Coverage by Service Provider

95. This Section of the *Report* presents mobile wireless coverage and LTE broadband coverage.[284] Similar to the analysis of nationwide coverage in Section III, we apply a centroid methodology to both the Mosaik data and the Form 477 data.[285] We note that these coverage estimates represent deployment of mobile networks and do not indicate the extent to which providers affirmatively offer service to residents in the covered areas. While recognizing therefore that this analysis likely overstates the coverage experienced by some consumers, as discussed above, we find that this analysis is useful because estimated coverage can be compared across network technologies and service providers. In addition to the centroid method, we also analyze the Form 477 data on a sub-census-block level, calculating the percentage of each census block covered by each technology. Unlike the centroid methodology, where a given census block is either covered or not, the actual area coverage methodology calculates the exact geographical area of the block covered by each service provider by technology.[286]

[283] *Eighteenth Report*, 30 FCC Rcd at 14581, para. 105.

[284] Web Appendix VI: Non-Price Rivalry (3G or Better Coverage by Provider), http://wireless.fcc.gov/competition-reports/mobile-wireless/mw-19/report-assets/index/html presents our estimates of mobile service provided using any of the following 3G or 4G technologies: EVDO, EVDO Rev A, WCDMA/HSPA, HSPA+, LTE, and mobile WiMAX.

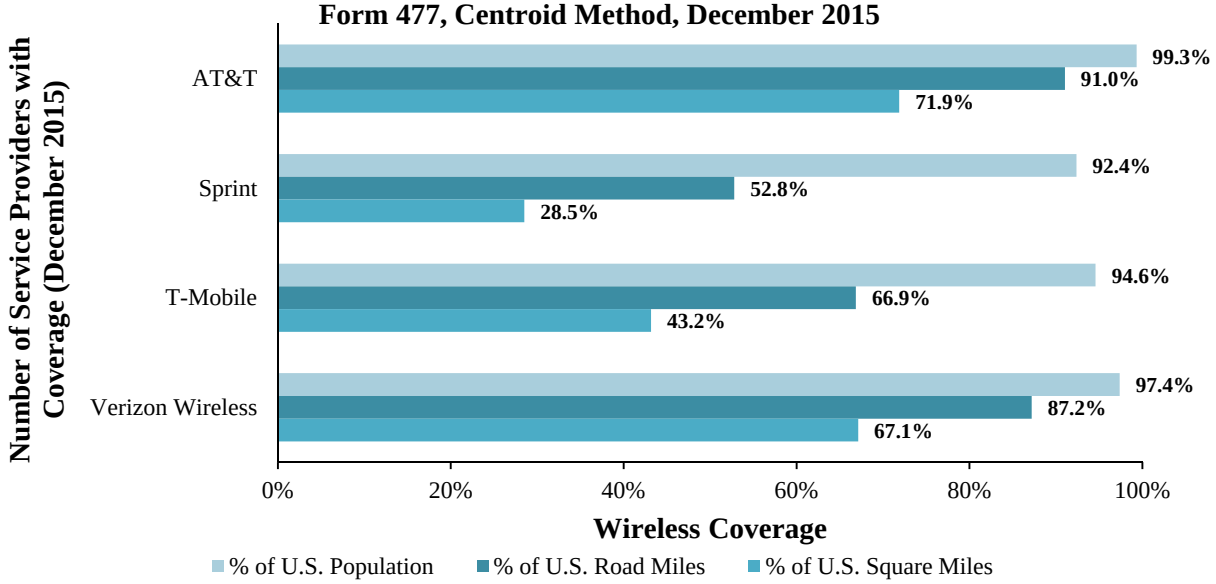
[285] We note that moving forward, and as also indicated in Section III above, we anticipate that the Form 477 data will become our primary source for the analysis of coverage in the mobile wireless marketplace. Coverage by service provider, based on centroid analysis of the Mosaik data, is presented in Appendix VI.

[286] As discussed in Section III, 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. In addition, as we do not know the distribution of the population at the sub-census block level, we must approximate the population covered by each technology.

a. Nationwide Mobile Wireless Network Coverage by Service Provider

96. Charts VI.A.1 and VI.A.2 present mobile wireless coverage by service provider based on centroid and actual area coverage analysis of December 2015 Form 477 data. We note that at the national level, the aggregate results are similar for both methodologies. However, as discussed above, the actual area coverage methodology is more precise exactly because it provides us with the actual geographic area covered by a given technology. In addition, as noted above, differences in the results between the two methodologies are expected to show more clearly at the disaggregated geographic level.[287] 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.[288] In terms of road miles, AT&T covered approximately 91 percent, Verizon Wireless covered approximately 87 percent, T-Mobile covered approximately 67 percent, and Sprint covered approximately 53 percent of road miles.

Chart VI.A.1
Estimated Wireless Coverage by Provider Including Federal Land
Form 477, Centroid Method, December 2015

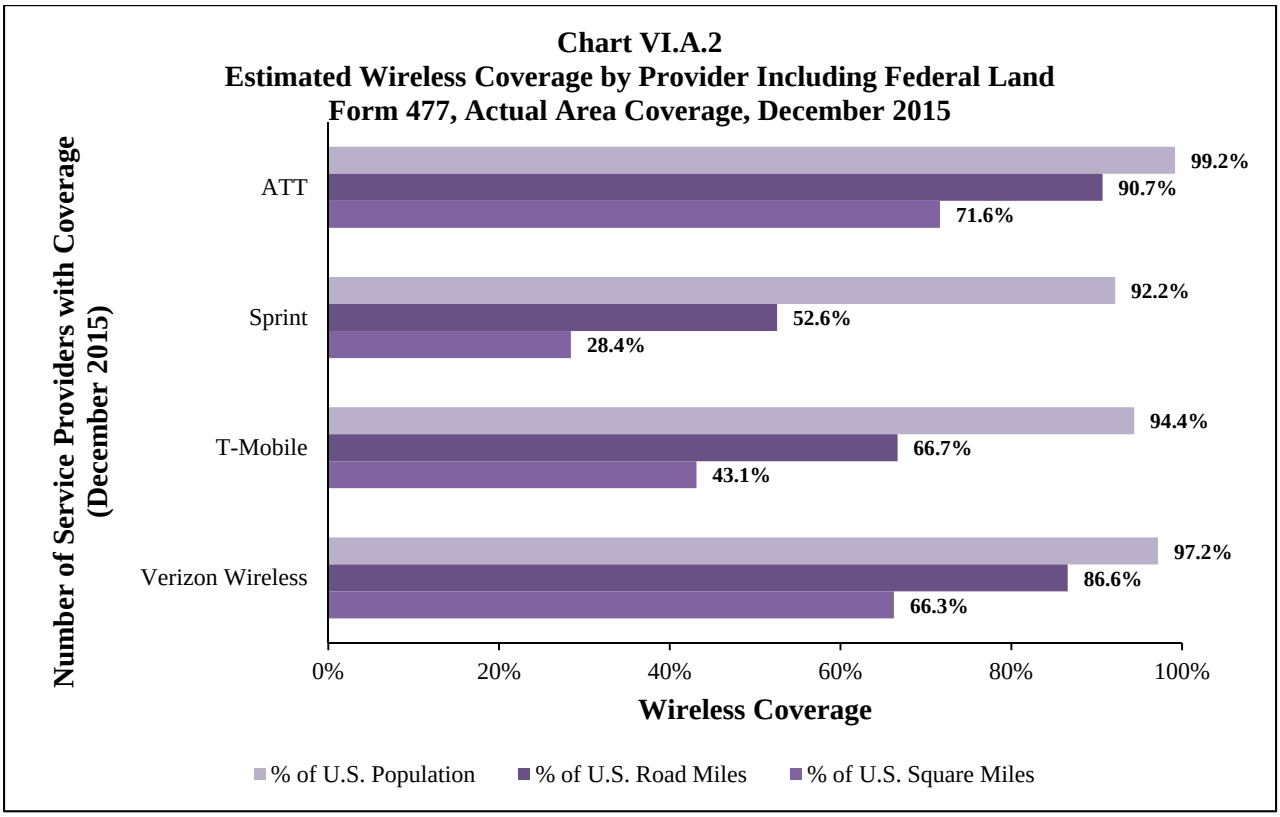


Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

To do this, we assume for purposes of this *Report* that the fraction of the population covered in a census block is proportional to the fraction of the actual area covered, and then sum the estimated covered population across blocks to estimate the total covered population within the United States. The same methodology is also used to estimate total road miles covered.

[287] As noted above, the actual area coverage methodology is more precise than the centroid methodology for understanding the exact land area covered by a given technology. In our current estimations, we assume that both population and road miles are distributed evenly across each census block. 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, but we do not have access to that information at this point in time for this *Report*.

[288] Appendix Tables VI.A.i.-iii and Chart VI.A.i provide more details of estimated mobile wireless coverage, including estimates based on January 2016 Mosaik data.



Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data.

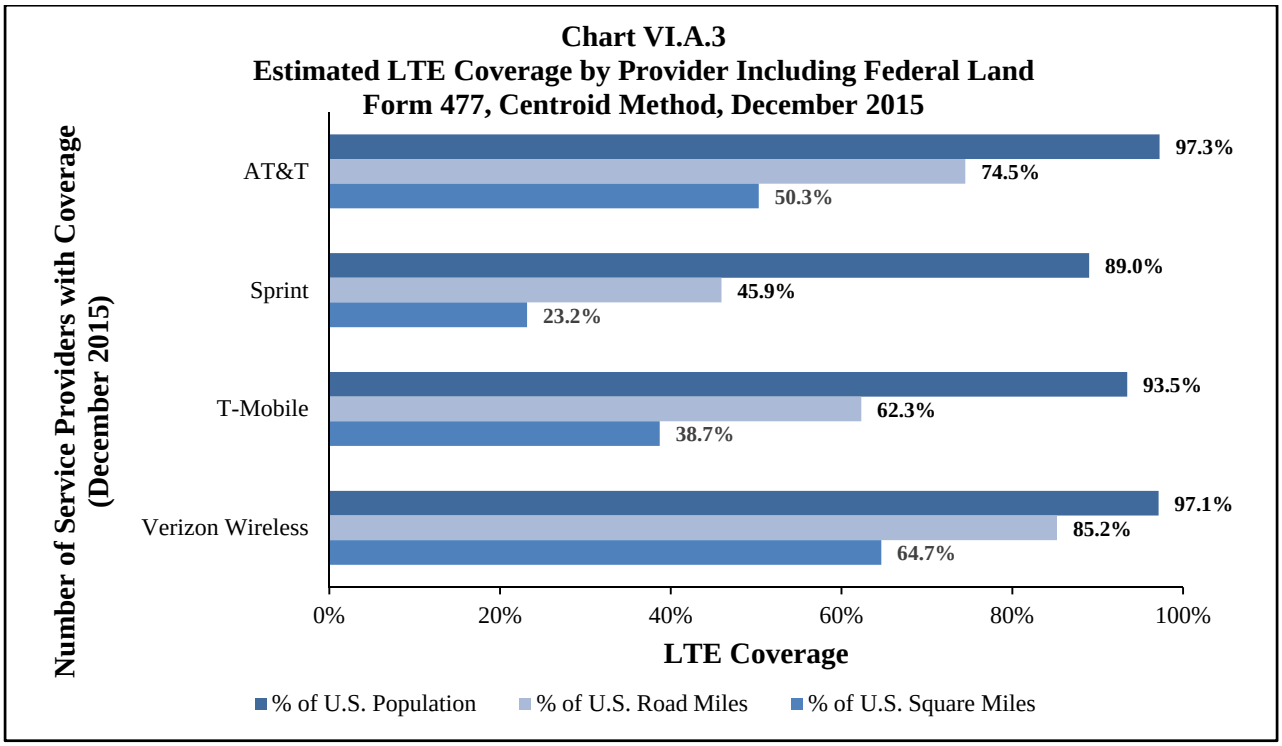
b. Nationwide LTE Broadband Coverage by Service Provider

97. Charts VI.A.3 and VI.A.4 present LTE mobile broadband coverage, by service provider, based on centroid and actual area coverage analysis of December 2015 Form 477 data.[289] We note that at the national level, the aggregate results are similar for both methodologies. However, as discussed above, the actual area coverage methodology is more precise exactly because it provides us with the actual geographic area covered by a given technology. In addition, as noted above, differences in the results between the two methodologies are expected to show more clearly at the disaggregated geographic level.[290] 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 94 percent of the population, and Sprint provided LTE coverage to approximately 89 percent of the population. In terms of road miles and land area, Verizon Wireless covered at approximately 85 percent of road miles and 65 percent of the land area, AT&T covered approximately 75 percent of road miles and 50 percent of the land area, T-Mobile covered approximately 62 percent of road miles and 39 percent of the land area, and Sprint covered approximately 46 percent of road miles and 23 percent of the land area with LTE.

[289] Appendix Tables VI.A.iv-vi and Chart VI.A.ii provide more details of estimated LTE coverage, including estimates based on January 2016 Mosaik data. As noted above, LTE deployment does not necessarily result in a guaranteed speed for consumers.

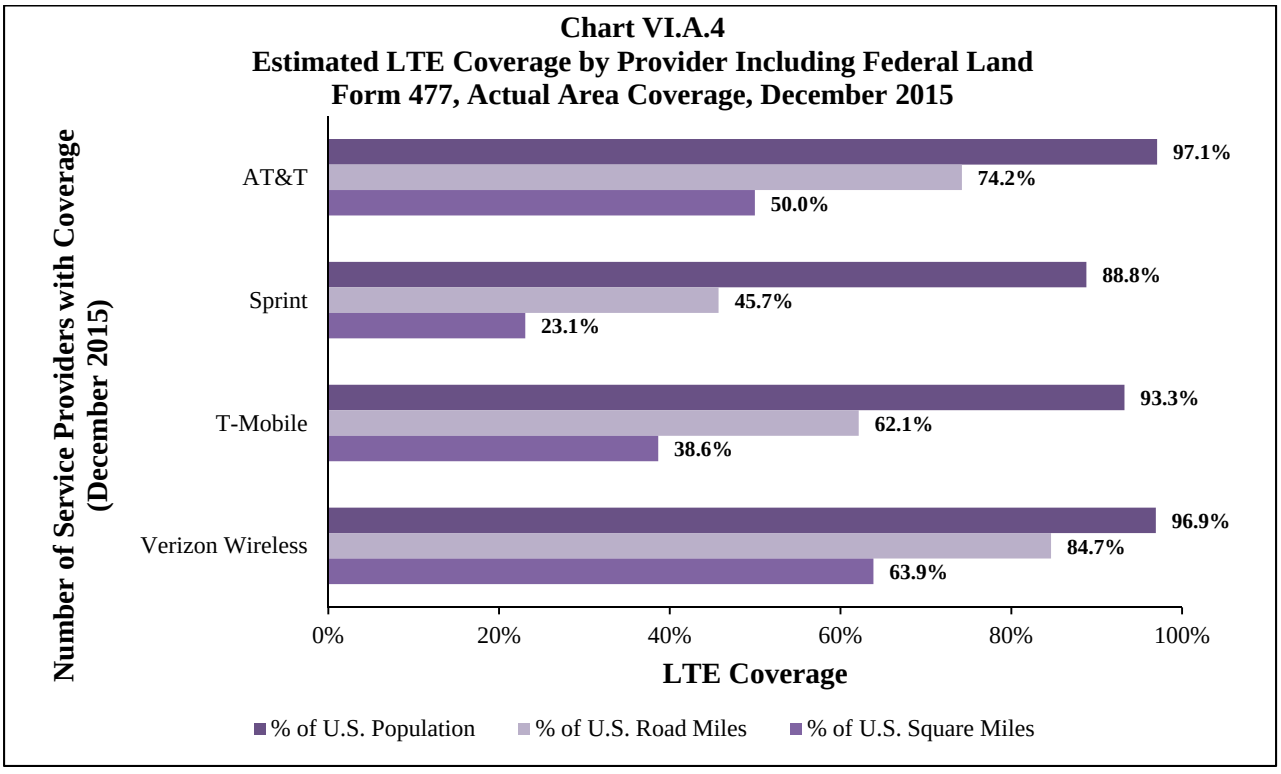
[290] As noted above, the actual area coverage methodology is more precise than the centroid methodology for understanding the exact land area covered by a given technology. In our current estimations, we assume that both population and road miles are distributed evenly across each census block. In order 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, but we do not have access to that information at this point in time for this *Report*.

Chart VI.A.3
Estimated LTE Coverage by Provider Including Federal Land
Form 477, Centroid Method, December 2015



Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart VI.A.4
Estimated LTE Coverage by Provider Including Federal Land
Form 477, Actual Area Coverage, December 2015



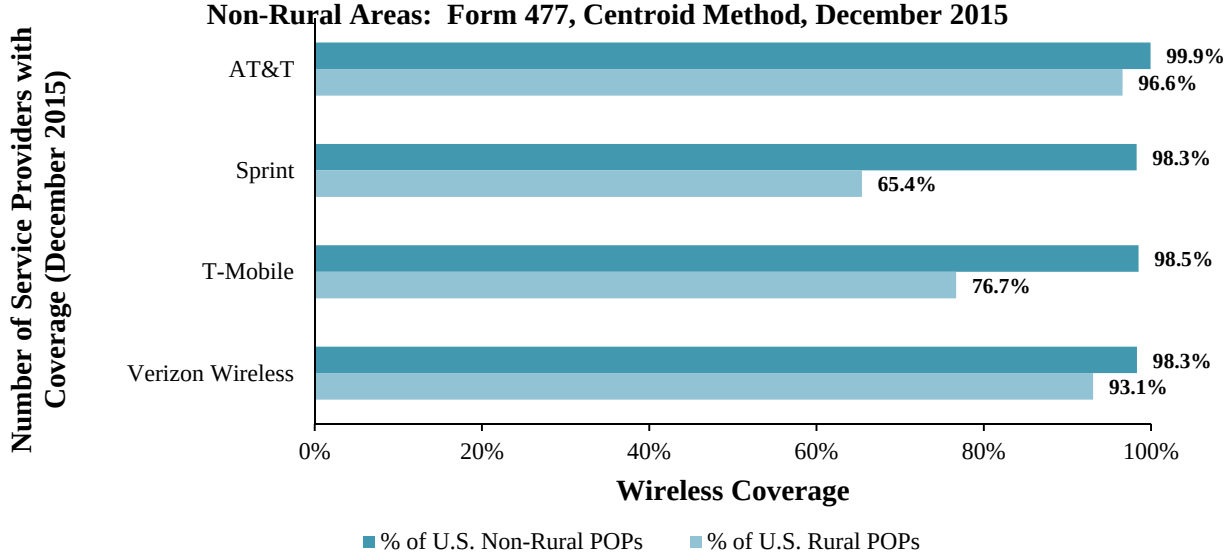
Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data.

2. Rural/Non-Rural Comparisons

a. Mobile Wireless Network Coverage in Rural and Non-Rural Areas

98. Charts VI.A.5 and VI.A.6 present mobile wireless coverage of the rural and non-rural U.S. population, based on centroid and actual area coverage analysis of December 2015 Form 477 data.[291] We note that at the national level, the aggregate results are similar for both methodologies. However, as discussed above, the actual area coverage methodology is more precise exactly because it provides us with the actual geographic area covered by a given technology. In addition, as noted above, differences in the results between the two methodologies are expected to show more clearly at the disaggregated geographic level.[292] Our analysis indicates that all four nationwide service providers covered at least 96 percent of the *non-rural* population with mobile wireless service. However, *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 77 percent, and Sprint covered approximately 65 percent of the rural population with wireless service.[293]

Chart VI.A.5
Estimated Wireless Coverage by Provider Including Federal Land in Rural vs. Non-Rural Areas: Form 477, Centroid Method, December 2015

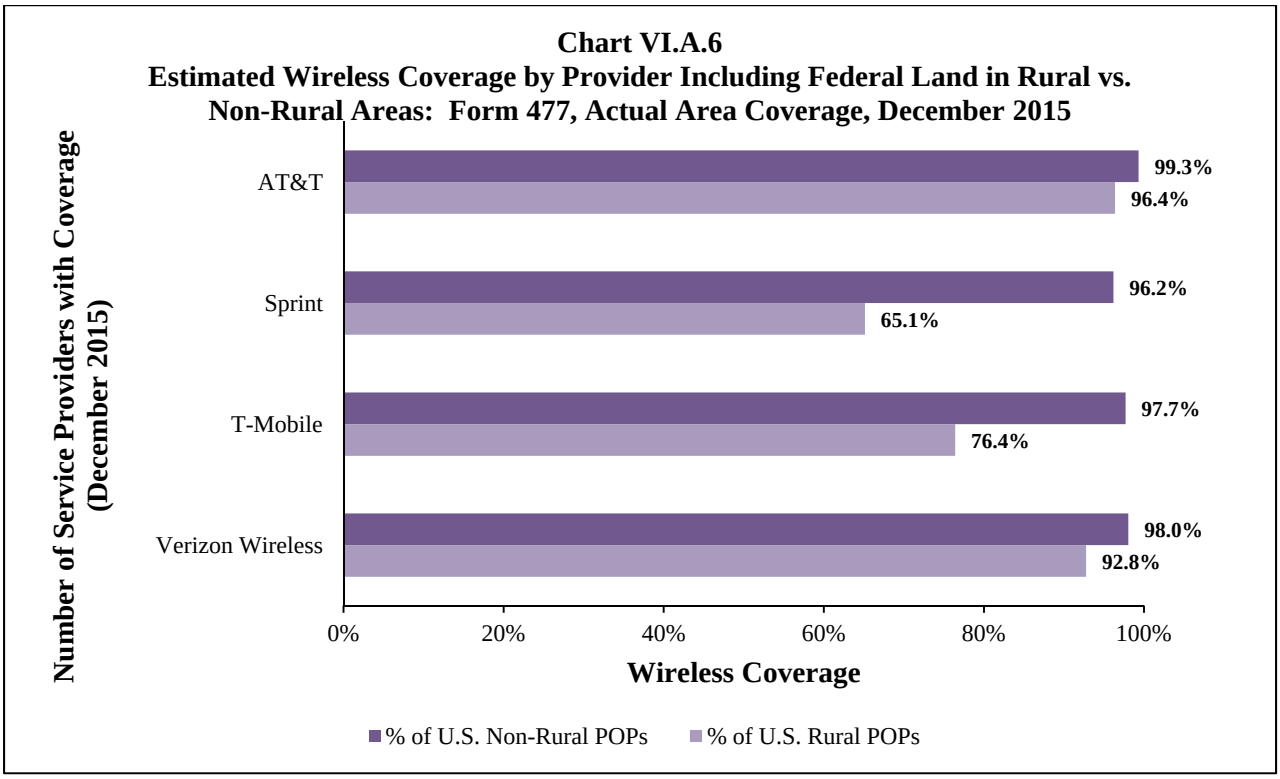


Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

[291] As noted above, while the Communications Act does not include a statutory definition of what constitutes a rural area, since its *2004 Report and Order* concerning the deployment of wireless services in less populated areas, the Commission has used a "baseline" definition of rural as a county with a population density of less than 100 people per square mile. *2004 Report and Order*, 19 FCC Rcd 19078, 19087-88, paras. 11-12.

[292] As noted above, the actual area coverage methodology is more precise than the centroid methodology for understanding the exact land area covered by a given technology. In our current estimations, we assume that both population and road miles are distributed evenly across each census block. 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, but we do not have access to that information at this point in time for this *Report*.

[293] Appendix Tables VI.A.vii-xii and Chart VI.A.iii provide more detail on estimated mobile wireless coverage by providers in rural and non-rural areas, respectively. These Appendix Tables includes estimates based on January 2016 Mosaik data.



Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data.

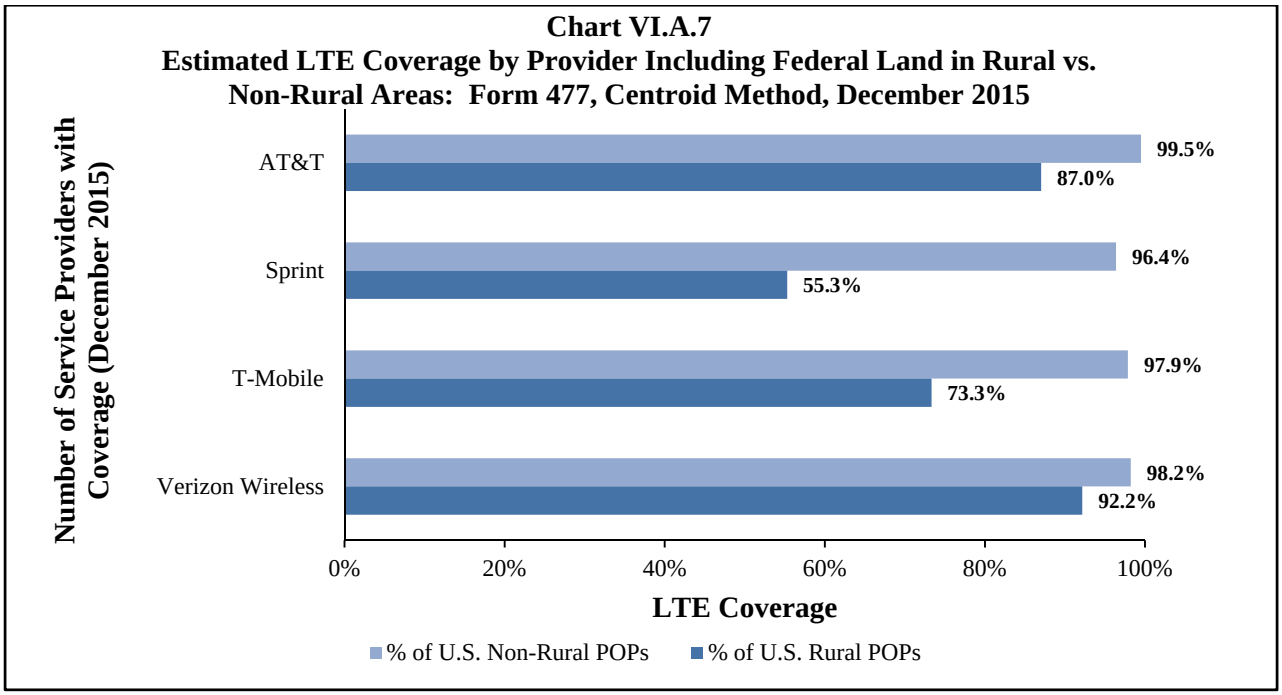
b. LTE Broadband Coverage in Rural and Non-Rural Areas

99. Charts VI.A.7 and VI.A.8 present LTE coverage of both the rural and non-rural U.S. population based on centroid and actual area coverage analysis of December 2015 Form 477 data.[294] We note that at the national level, the aggregate results are similar for both methodologies. However, as discussed above, the actual area coverage methodology is more precise exactly because it provides us with the actual geographic area covered by a given technology. In addition, as noted above, differences in the results between the two methodologies are expected to show more clearly at the disaggregated geographic level.[295] Our estimates show that the four nationwide service providers cover at least 96 percent of the non-rural population with LTE. Regarding LTE coverage in rural areas, Verizon Wireless covers approximately 92 percent, AT&T covers approximately 87 percent, T-Mobile covers approximately 73 percent, and Sprint covers approximately 55 percent of the rural population with LTE.

[294] Appendix Tables VII.A.xiii-xviii and Chart VI.A.iv provide more detail on estimated LTE broadband coverage by service provider in rural areas and non-rural areas, respectively. This includes estimates based on January 2016 Mosaik data. As noted above, LTE deployment does not necessarily result in a guaranteed speed for consumers.

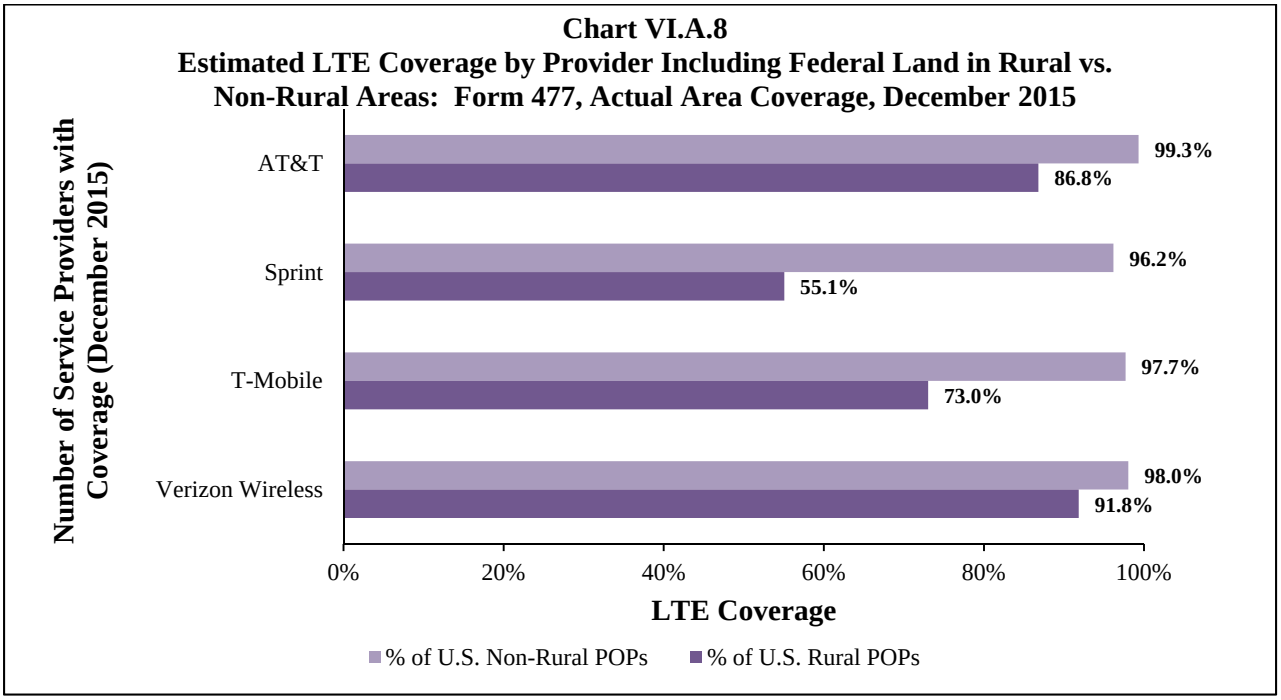
[295] As noted above, the actual area coverage methodology is more precise than the centroid methodology for understanding the exact land area covered by a given technology. In our current estimations, we assume that both population and road miles are distributed evenly across each census block. In order 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, but we do not have access to that information at this point in time for this *Report*.

Chart VI.A.7
Estimated LTE Coverage by Provider Including Federal Land in Rural vs. Non-Rural Areas: Form 477, Centroid Method, December 2015



Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart VI.A.8
Estimated LTE Coverage by Provider Including Federal Land in Rural vs. Non-Rural Areas: Form 477, Actual Area Coverage, December 2015



Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data.

3. Recent Commission Initiatives

100. When competing mobile wireless service providers deploy compatible network technologies, greater economies of scale in the production of both end-user devices and network infrastructure equipment can result, lowering the unit cost of handsets, chipsets, and other network equipment. This, in turn, may promote more rapid adoption of mobile wireless services, a greater variety of handsets, and more price competition. On October 25, 2013, the Commission adopted the *700 MHz Interoperability Report and Order and Order of Proposed Modification* to implement a voluntary industry solution that is designed to establish interoperable LTE devices in the Lower 700 MHz band.[296] Since the Order was adopted, service providers have progressively deployed the Lower 700 MHz A Block spectrum and are continuing to offer more Band Class 12 devices, facilitating the creation of a robust Band Class 12 devices ecosystem.[297] In addition, the Commission has also adopted specific interoperability requirements for the AWS-3 band, as well as for the 600 MHz Band.[298]

101. In order to encourage mobile network deployment into unserved or underserved areas, the Commission adopted rules creating the Mobility Fund in November 2011.[299] The Mobility Fund uses Universal Service Fund reserves to support the deployment of current-generation or future-generation mobile network technologies that provide mobile voice and Internet services.[300] For Mobility Fund Phase I, the Commission is providing up to $300 million in one-time support payments, plus up to $50 million dedicated to Tribal lands, which were awarded through reverse auctions.[301] The Commission is currently exploring whether to retarget Mobility Fund Phase II ongoing support to ensure the continued deployment and preservation of voice and mobile broadband service in areas that otherwise would not have such services.[302]

---

[296] *Promoting Interoperability in the 700 MHz Commercial Spectrum, Requests for Waiver and Extension of Lower 700 MHz Band Interim Construction Benchmark Deadlines*, Report and Order and Order of Proposed Modification, 28 FCC Rcd 15122 (2013) (*700 MHz Interoperability Report and Order and Order of Proposed Modification*).

[297] Band Class 12 devices support the Lower 700 MHz A, B, and C Blocks whereas Band Class 17 devices only support the Lower 700 MHz B and C Blocks. T-Mobile has deployed LTE in 300 markets, using its Lower 700 MHz A Block spectrum. In addition, USCC has also deployed LTE using its Lower 700 MHz spectrum in "over 100 markets." AT&T states that it has "fully deployed" the Multiple Frequency Band Indicator (MFBI) feature to support both Band Class 12 and Band Class 17 devices throughout its network, 64% of the devices operating on AT&T's paired Lower 700 MHz spectrum are Band 12 capable. *Promoting Interoperability in the 700 MHz Commercial Spectrum*, Fourth Progress Report on AT&T Commitments, WT Docket No. 12-69, Attachment 1 (filed Mar. 1, 2016).

[298] *AWS-3 Report and Order*, 29 FCC Rcd at 4694-4700, paras. 225-31; *Incentive Auctions Report and Order*, 29 FCC Rcd at 6866-69, paras. 731-37.

[299] *See generally 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 (2011).

[300] *Id.*

[301] *Mobility Fund Phase I Auction Closes; Winning Bidders Announced for Auction 901*, Public Notice, 27 FCC Rcd 12031 (WTB 2012) (*Auction 901 Closing Public Notice*). Mobility Fund Phase I disbursements were authorized beginning April 2013 and are anticipated to continue through 2016. *Mobility Fund Phase I Support Authorized for Seven Winning Bidders; Defaults on Two Auction 901 Winning Bids Determined*, Public Notice, 28 FCC Rcd 5599 (WTB, WCB 2013); *Tribal Mobility Fund Phase I Auction Closes Winning Bidders Announced for Auction 902*, Public Notice, 29 FCC Rcd 1974 (WTB 2014).

[302] *Connect America Fund; Universal Service Reform – Mobility Fund; ETC Annual Reports and Certifications; Establishing Just and Reasonable Rates for Local Exchange Carriers; Developing an Unified Intercarrier Compensation Regime*, Report and Order, Declaratory Ruling, Order, Memorandum and Order, Seventh Order on Reconsideration, and Further Notice of Proposed Rulemaking, 29 FCC Rcd 7051 (2014).

102. No facilities-based service provider–including the four nationwide providers–has built out its entire licensed service area, and consequently all employ roaming to some extent to fill gaps in their coverage.[303] Many non-nationwide service providers are able to offer their customers coverage that is national in scope through roaming agreements, and accordingly, roaming remains particularly important for small and regional service providers.[304] The Commission has taken a number of actions to facilitate roaming agreements. In 2007, for instance, it clarified that automatic voice roaming is a common carrier obligation for CMRS providers.[305] In April 2010, the Commission adopted the *Roaming Order on Reconsideration*, which eliminated the home roaming exclusion and established the same general obligation to provide automatic voice roaming, regardless of whether the provider requesting roaming holds spectrum in an area.[306] In April 2011, the Commission issued the *Data Roaming Order*,[307] which requires facilities-based service providers of commercial mobile data services, whether or not such service providers also offer CMRS, to offer data roaming arrangements to other mobile data service providers on commercially reasonable terms and conditions, subject to certain limitations.[308]

103. In May 2014, T-Mobile filed a petition for expedited declaratory ruling asking the Commission to provide guidance for determining whether the terms of a data roaming agreement meet the "commercially reasonable" standard adopted in the *Data Roaming Order*.[309] In December 2014, the Bureau released a declaratory ruling granting T-Mobile's petition.[310] The Declaratory Ruling found that the data roaming rule was

[303] *Eighteenth Report*, 30 FCC Rcd at 14593, para. 123.

[304] *Id.*; *see also* CCA Comments at 18-19; NTCA Comments at 3-4 (arguing that regional and local service providers offer a small footprint and need to partner with other service providers through roaming agreement to offer their subscribers competitive expanded coverage).

By definition, MVNOs and resellers rely on using the networks of one or several facilities-based service providers to compete. Depending on the particular arrangement, customers of MVNOs and resellers may have limited or no access to networks other than that of the underlying wholesale provider. For example, the coverage experienced by customers of TracFone's Straight Talk varies depending on the underlying wholesale provider. A Straight Talk customer obtaining service on an underlying CDMA network, for instance, will not have access to voice and SMS service when outside the coverage of that network, but a Straight Talk customer whose service is provided on an underlying GSM network, by contrast, may have voice and SMS service when outside that network's coverage area. Straight Talk, About Straight Talk, http://www.straighttalk.com/wps/portal/home/h/about (last visited Sept. 14, 2016); Straight Talk, Terms and Conditions: Straight Talk Wireless, http://www.straighttalk.com/wps/portal/home/h/legal/terms-and-conditions (last visited Sept. 14, 2016).

[305] *Reexamination of Roaming Obligations of Commercial Mobile Radio Service Providers*, Report and Order and Further Notice of Proposed Rulemaking, 22 FCC Rcd 15817, 15828, para. 27 (2007) (*2007 Roaming Order and FNPRM*) ("[W]e recognize that automatic roaming benefits mobile telephony subscribers by promoting seamless CMRS service around the country, and reducing inconsistent coverage and service qualities.").

[306] *Reexamination of Roaming Obligations of Commercial Mobile Radio Service Providers and Other Providers of Mobile Data Services*, Order on Reconsideration and Second Further Notice of Proposed Rulemaking, 25 FCC Rcd 4181, 4182, para. 2 (2010) (*Roaming Order on Reconsideration*).

[307] *Reexamination of Roaming Obligations of Commercial Mobile Radio Service Providers and Other Providers of Mobile Data Services*, Second Report and Order, 26 FCC Rcd 5411 (2011) (*Data Roaming Order*).

[308] *Id.* at 5418-28, paras. 13-31.

[309] T-Mobile USA, Inc., Petition for Expedited Declaratory Ruling Regarding Reexamination of Roaming Obligations of Commercial Mobile Radio Service Providers and Other Providers of Mobile Data Services, WT Docket No. 05-265 (filed May 27, 2014) (T-Mobile Petition); *Wireless Telecommunications Bureau Seeks Comment on Petition for Expedited Declaratory Ruling by T-Mobile USA, Inc. Regarding Data Roaming Obligations*, Public Notice, 29 FCC Rcd 6035 (WTB 2014). The petition proposed four benchmarks for assessing commercial reasonableness: (i) retail rates; (ii) international roaming rates; (iii) MVNO/resale rates; and (iv) other domestic roaming rates. *See generally* T-Mobile Petition.

[310] *Reexamination of Roaming Obligations of Commercial Mobile Radio Service Providers and Other Providers of Mobile Data Services*, Declaratory Ruling, 29 FCC Rcd 15483 (WTB 2014) (*Data Roaming Declaratory Ruling*). We note that

intended to permit consideration of the totality of the facts, and therefore to permit a complaining party to adduce evidence in any individual case as to whether proffered roaming rates are substantially in excess of retail rates, international rates, and MVNO/resale rates, as well as a comparison of proffered roaming rates to domestic roaming rates as charged by other service providers.[311] The Declaratory Ruling noted that the probative value of these other rates as reference points will depend on the facts and circumstances of any particular case, including all of the factors set forth in the *Data Roaming Order*.[312] In the *2015 Open Internet Order*, the Commission granted limited forbearance from application of the CMRS roaming requirements to mobile broadband Internet access service (MBIAS) providers, conditioned on such providers continuing to be subject to the data roaming rule, and the Commission indicated that it would commence a separate proceeding to revisit the data roaming obligations of MBIAS providers.[313]

B. Quality of Service

104. Key characteristics for mobile wireless performance include network speeds, latency,[314] and consistency of service. The Commission has recognized the importance of accurate and timely data on these characteristics.[315] Mobile broadband network service quality experienced by consumers may vary greatly with a number of real world factors such as the service provider's received signal quality, cell traffic loading and network capacity in different locations, as well as the capability of consumers' devices.[316] First, mobile connection quality will vary based on the location of the receiving device in reference to the transmitting device, which is often a cellular tower.[317] Second, the performance of the broadband connection degrades over distance to the tower, even with a clear line of sight.[318] Third, cellular signals are shared by many users–the more

AT&T and Verizon Wireless filed applications for review of the declaratory ruling, and those applications for review remain pending.

[311] *Id.* at 15486, para. 9.

[312] In addition, the Declaratory Ruling provided guidance with respect to the presumption regarding existing agreements and consideration of the build-out factor in determining commercial reasonableness. *Id.* at 15491, 15492, paras. 25, 28. There have been a number of confidential staff-level mediations, and certain complaints were filed and remain pending.

[313] *2015 Open Internet Order*, 30 FCC Rcd at 5857-58, paras. 523-26.

[314] Latency refers to several types of delays typically incurred during network data processing, and is typically measured in milliseconds (ms). One common measure is round-trip latency, which measures the amount of time it takes a data packet to travel from a source to a destination and back. Latency is often affected by factors such as the specifics of the cellular network architecture or processing delays that may occur when the packets need to pass through proxy servers.

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

[316] 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 enhanced backhaul connections. *Sixteenth Report*, 28 FCC Rcd at 3894, para. 293.

The capability of consumer devices (e.g., smartphones, tablets, USB dongles, and laptops) could result in users experiencing different data speeds on the same mobile wireless broadband network. Even differing capabilities within each device category, such as smartphone processing power and memory, could result in better user experiences on 4G networks.

[317] 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.

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

simultaneous usage, the lower the potential performance of any one connection.[319] It is also important to note that for all mobile technologies, speed and performance measurements are only valid when a wireless connection can be accessed: "Dead zones" and loss of signal reduce wireless effectiveness.[320] Moreover, from the customer's perspective, overall network performance is the product of more than network quality alone.[321]

105. In recognition of the effects of these different parameters on mobile network performance, various methodologies are used in evaluating 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.[322] 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. We note, however, that crowdsourced data are often not collected pursuant to statistical sampling techniques, and may require adjustments to construct a representative sample from the raw data. For instance, 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 vintage of the consumer's device.[323] These issues can be reduced 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. 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 do not involve significant testing indoors 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.

106. This *Report* will primarily present, subject to the limitations described above, speed data using the Ookla Net Index data (crowdsourced), the FCC Speed Test App data, RootMetrics data (largely based on drive test data across the United States, but which also incorporate results of some crowdsourced data),[324] and the CalSPEED drive-test data gathered by the California Public Utility Commission (CPUC).[325] We discuss our analysis of all four speed metrics below.[326]

---

[319] 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.

[320] *Id.* at 19-20.

[321] For data services, network quality as perceived by the customer may also be use-, case-, or application-dependent (e.g., a consumer who solely uses e-mail may view the quality of the network differently than one who streams video regularly). Further, consumers may place more weight on one particular aspect of network quality than another–such as coverage or peak data speeds–when choosing their mobile wireless services.

[322] 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.

[323] By contrast, crowdsourced fixed broadband speed data, such as those collected by the Commission through SamKnows, can be gathered with more control. The SamKnows whiteboxes are able to measure actual fixed network speed and are not dependent on the vintage of the client hardware or software. In addition, the testers are chosen according to a structured sampling technique.

[324] RootMetrics, http://www.rootmetrics.com/us (last visited Sept. 14, 2016).

[325] CalSPEED recently introduced a mobile app, which collects crowdsourced speed data measurements. However, this crowdsourced data is not included in the dataset that was used in this report. CPUC, http://cpuc.ca.gov/General.aspx?id=1778 (last visited Sept. 14, 2016).

[326] In addition to the four speed metrics discussed, speed measurements are also performed by other entities such as by OpenSignal and M-Lab. For example, OpenSignal gathers crowdsourced mobile speed data through the use of their mobile

1. Ookla

107. Table VI.B.1 presents the nationwide mean and median LTE download (and upload–*see* Appendix VI.) speeds by service provider for the second half of 2015.[327] Table VI.B.1 presents Ookla's nationwide median LTE download speed measurements for the second half of 2015,[328] and shows that download speeds vary by service provider.[329] The trends in median download speeds from the first half of 2014 through the second half of 2015 are presented below in Table VI.B.2.[330]

Table VI.B.1
Ookla Speed Test--Estimated LTE Download Speeds by Service Provider, Nationwide[331]

Service Provider	LTE Download Speed 2H2015		
	Mean (Mbps)	Median (Mbps)	Number of Tests ('000s)
AT&T	16.96	11.72	2,720
Sprint	13.65	8.50	2,604
T-Mobile	21.10	15.42	3,990
Verizon Wireless	19.66	14.48	2,899

Source: Ookla SPEEDTEST intelligence data, © 2015 Ookla, LLC. All rights reserved. Published with permission of Ookla.

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 uses these data to generate a publicly available interactive map. OpenSignal, https://opensignal.com/app/ (last visited Sept. 14, 2016). Another open source application for measuring network performance on mobile platforms is MobiPerf by M-Lab. MobiPerf, https://sites.google.com/site/mobiperfdev/ (last visited Sept. 14, 2016). 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, http://openmobiledata.appspot.com/visualization (last visited Sept. 14, 2016). Anonymized data are also available for download. MobiPerf, For Researchers, https://sites.google.com/site/mobiperfdev/for-researchers (last visited Sept. 14, 2016).

[327] Ookla gathers crowdsourced mobile speed data through the use of their Speedtest mobile app. Ookla Speedtest Mobile Apps, http://www.speedtest.net/mobile/ (last visited Sept. 14, 2016). 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, the user can periodically measure the speed of their wireless connection. These data are then used to produce Ookla's Net Index dataset. Because the speed tests 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 can affect the result. Therefore, the Ookla data show significant variation in different geographies, as well as among service providers.

[328] More details can be found in Appendix Tables VI.B.i–ii. These tables include data from the second half of 2014, the first half of 2015, and the second half of 2015.

[329] One factor that may lead to speed differences between wireless service providers is the composition of currently used smartphones. The Ookla Speedtest application is available for download on iOS, Android, or Windows Phones. Each of these operating systems has evolved over time. Vintage smartphones, which do not support 4G, or possibly even 3G service, are still in use. Based on current and past promotions and partnerships, each wireless service provider may have a customer base with a different smartphone profile, which can directly affect speed measurements.

[330] The upload and download speeds were calculated by Ookla and provided to the Commission for use in this *Report*.

[331] Total mean and median download speeds are calculated using aggregated regional data for the four nationwide providers, as well as any other wireless service providers that appear in the Ookla dataset. Only tests with identifiable regions (states) are included. In addition to the current table, this is applicable to Table VI.B.2 and Appendix Tables VI.B.i-ii.

Table VI.B.2
Ookla Median Download Speed by Service Provider, 1H2014–2H2015

	Median Download Speed (Mbps)			
Service Provider	1H2014	2H2014	1H2015	2H2015
AT&T	6.97	7.85	8.26	9.68
Sprint	4.07	4.98	5.64	7.46
T-Mobile	10.52	12.16	11.72	12.70
Verizon Wireless	11.14	12.04	13.00	14.11

Source: Ookla SPEEDTEST intelligence data, © 2015 Ookla, LLC. All rights reserved. Published with permission of Ookla.

2. FCC

108. In September 2012, the Commission announced that it was expanding its Measuring Broadband America program to include information on mobile broadband service performance in the United States using a crowdsourced approach.[332] The program uses the FCC Speed Test app for Android and iPhone devices to test the speed and performance of customers' smartphone mobile broadband services.[333] The FCC Speed Test app is available free of charge for Android phones and for the iPhone.[334] The FCC Speed Test app provides the benefits, and has the limitations, described above for crowdsourced mobile data. Nationwide median LTE download and upload speed measurements for 2015, estimated using data collected with the FCC Speed Test App, are presented in Table VI.B.3 and Table VI.B.4 below.[335]

[332] FCC, Measuring Mobile Broadband Performance, http://www.fcc.gov/measuring-broadband-america/mobile (last visited Sept. 14, 2016).

[333] FCC Speed Test, https://play.google.com/store/apps/details?id=com.samknows.fcc&hl=en (last visited Sept. 14, 2016); FCC Speed Test App, https://itunes.apple.com/us/app/fcc-speed-test/id794322383?mt=8 (last visited Sept. 14, 2016). The data collected include speed, latency, and packet loss for both upload and download. 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.

[334] The FCC speed test can be set to run automatically in the background on Android phones, but iPhone users must execute the speed test manually. This app allows users to measure their mobile broadband performance and voluntarily report these data to the FCC. Collected data include upload and download speed, latency and packet loss, as well as the wireless performance characteristics of the broadband connection and the kind of handsets and versions of operating systems tested. Several other passive metrics are also recorded, including signal strength of the connection, and device manufacturer and model. FCC, Measuring Mobile Broadband Performance, http://www.fcc.gov/measuring-broadband-america/mobile (last visited Sept. 14, 2016).

[335] The data collected by the Measuring Broadband America Program's FCC Speed Test App for Android and iOS Speed data that were used in this *Report* included the test results for download and upload, as well as information about the handset and cellular environment such as the location of the test, operating system of the handset, the Wi-Fi or 3G/4G cellular technology used for the test, the bearer channels, and certain other parameters helpful for the characterization of mobile performance. Data extracts for the time period reviewed in this *Report* were culled from the main database collection selecting only observations that included valid GPS location data in the United States and were executed on the smartphone's cellular connection. The results reported here do not incorporate all attempted tests reported to the Commission. Each individual test report includes information on whether the test completed successfully, whether it timed out due to connection problems, and whether any data from the test are missing. Missing data from a test reflect issues in the operation of the app for that particular test, so that particular test observation is dropped from the dataset. Any observation with a download or upload speed equal to or less than zero was dropped from the calculations. In addition, the top 1% of download and upload speed

Table VI.B.3
FCC Speed Test--Estimated LTE Download Speeds by Service Provider's Flagship Brand, Nationwide

Service Provider	2H2015		
	Mean Download Speed (Mbps)	Median Download Speed (Mbps)	Number of tests
AT&T	13.92	9.32	30,001
Sprint	13.27	6.73	18,225
T-Mobile	19.51	14.39	34,763
Verizon	17.51	12.61	55,288

Source: Data from FCC Measuring Mobile Broadband America data. Observations do not include failed tests, or those with a download speed equal to or less than zero.

Table VI.B.4
FCC Speed Test--Estimated LTE Upload Speeds by Service Provider's Flagship Brand, Nationwide

Service Provider	2H2015		
	Mean Upload Speed (Mbps)	Median Upload Speed (Mbps)	Number of tests
AT&T	5.34	3.93	26,271
Sprint	3.96	2.81	16,232
T-Mobile	10.38	8.50	30,860
Verizon	6.79	4.09	53,496

Source: Data from FCC Measuring Mobile Broadband America data Observations do not include failed tests, or those with an upload speed equal to or less than zero.

observations were dropped, to account for outliers. Tests where the user was on a Wi-Fi network, or if it was a roaming observation, were also filtered out. Based on the remaining data, we calculated the overall mean and median download and upload speeds by service provider. Throughput speeds were converted from bytes/sec to Mbps using a conversion of [1 Mbps=8*(10^-6) bytes/sec]. More details can be found in Appendix Tables VI.B.iii-iv. These tables include data from the first and second half of 2015.

3. RootMetrics

109. RootMetrics runs a test program that measures mobile data, call, and text performance in all 50 states across the United States.[336] According to RootMetrics, tests are performed during all hours of the day, every day of the week, and nearly every week of the year, but the testing schedule is weighted more heavily toward typical consumer usage hours. Performance is measured indoors and outdoors at the same randomly chosen locations, and drive testing takes place during travel between locations. The RootMetrics Speed Index takes into account speed measurements of both data and texts.[337] 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.[338] In addition, RootMetrics has provided the Commission with nationwide median LTE download speeds, as presented in Table VI.B.5 below.

Table VI.B.5
RootMetrics Speed Test–Estimated LTE Download Speeds, Nationwide

Service Provider	2H2015	
	Median Download speed (Mbps)	Number of Tests
AT&T	12.29	160,752
Sprint	8.19	159,870
T-Mobile	12.84	160,491
Verizon Wireless	17.04	160,642

Source: RootMetrics Data, 2015, © RootMetrics. All rights reserved. Published with permission of RootMetrics. In 2H2015, there were 3,851,608 total tests, including 6,607 indoor locations.

4. CalSPEED

110. 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).[339] The CalSPEED data presented in this *Report* are the result of a structured

[336] Tests are conducted in the 125 most populous metropolitan markets and in each of the 50 U.S. states. Tests are conducted on the latest Android smartphone available from each service provider. All tests, which are conducted solely on the networks of the four nationwide service providers, are performed identically across all operators' devices. RootMetrics, Testing Methodology, http://rootmetrics.com/en-US/methodology (last visited Sept. 14, 2016). 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. 14, 2016). This map incorporates the sample data described above, along with crowdsourced data that are available through consumer use of the free CoverageMap app, available on Android and iOS.

[337] RootMetrics, Methodology, http://rootmetrics.com/en-US/methodology (last visited Sept. 14, 2016).

[338] *Id*. RootMetrics National Speed Index results are presented in Appendix Tables VI.B.v-vi.

[339] We present additional CalSPEED results in Appendix Tables VI.B.vii-viii; *see also Eighteenth Report*, 30 FCC Rcd at 14600, para. 132.

sampling program of nearly 2,000 locations scattered throughout California.[340] 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. Any other errors are counted as zero throughput. Median LTE download speed measurements for the state of California, estimated using CalSPEED data collected during the second half of 2015, are presented in Table VI.B.6 below.[341]

Table VI.B.6
CalSPEED--Estimated LTE Download Speeds by Service Provider, California Only

Service Provider	Fall 2015		
	Mean LTE Download Speed (Mbps)	Median LTE Download Speed (Mbps)	Number of Tests
AT&T	12.26	11.18	3,044
Sprint	9.78	7.87	1,970
T-Mobile	11.84	11.93	2,220
Verizon Wireless	14.36	15.49	3,124

Source: The estimated speeds are based on the CalSPEED data. The top 1% of speed values were dropped, by service provider and time period. Fall 2015 tests were taken between the dates of December 3, 2015 through January 22, 2016.

C. Differentiation in Mobile Wireless Devices and Advertising/Marketing

1. Differentiation in Mobile Wireless Devices

111. In addition to competing on price and network quality, service providers also compete by offering consumers a variety of different mobile wireless devices with innovative features. These devices include a range of data-centric smartphones,[342] tablets made by different manufacturers with different operating systems, and wearable devices such as smartwatches,[343] smart home devices, and other connected devices. The first significant differentiation in mobile device offerings occurred with the introduction of Apple's iPhone in June 2007, pursuant to an exclusive arrangement at that time with AT&T. Following that introduction, handset manufacturers have

[340] CPUC, Mobile Broadband Testing, http://cpuc.ca.gov/General.aspx?id=1778 (last visited Sept. 14, 2016).

[341] These sites are visited twice a year and tests are run on both the latest Android phones tablets, for each of the four nationwide service providers. CalSPEED has now had nine rounds of sampling in California. Data can be downloaded from CPUC Mobile Broadband Testing. *Id*.

[342] While there is no industry standard definition of a smartphone, for purposes of this *Report* we continue to consider the distinguishing features of a smartphone to be: an HTML browser that allows easy access to the full, open Internet; an operating system that provides a standardized interface and platform for application developers; and a larger screen size than a traditional, voice-centric handset. Many smartphones run an operating system that offers a standard platform for application developers to create and sell device software through an application store. *Eighteenth Report*, 30 FCC Rcd at 14602, para. 136. By contrast, the basic handset category includes voice-centric handsets that do not allow or are not designed for easy web browsing. In addition to smartphones and basic handsets, a third category of devices consists of data-centric devices that have no inherent voice capability, such as USB wireless modem laptop cards, mobile Wi-Fi devices, e-readers, and laptops and netbooks with embedded mobile wireless modems, wearable devices, and home security and automation systems.

[343] 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/.

continued to introduce competing products with features such as touch screens, mobile web browsing capabilities, and current-generation operating systems. All four nationwide service providers, as well as many regional and smaller service providers, currently offer the most recent iPhone models.

112. As wireless service providers continue to seek a wide range of wireless devices to differentiate their services, manufacturers have responded by increasing the choices, price points, and design within a broad range of devices.[344] Today, smartphone operating systems such as the Android and the Apple iOS are available from multiple service providers, permitting consumers to pair their preferred operating systems with various service providers. In addition, the wireless industry is continuing to provide options for handset users who rely on non-smartphones and are targeting budget-minded consumers with a wider variety of lower-cost prepaid devices.[345] Wireless service providers also offer products for people with disabilities, such as screen readers, captioning software, and hearing aid compatible devices.[346]

113. Certain smartphones and other devices may be introduced by a single provider, however the wide variety of similar models, as well as the ability to unlock devices purchased from other providers, has made it more difficult for the nationwide service providers to differentiate their services based upon differences in device offerings alone. That being said, service providers may attempt to differentiate their brands by promoting and marketing specific devices, and the devices promoted may vary across service providers. While all of the nationwide service providers offer many of the same handsets, smaller providers have complained that exclusive agreements between handset manufacturers and the larger providers put them at a competitive disadvantage, because they are often unable to obtain the newest handsets.[347] Although the number of exclusive agreements may be declining, a survey by NTCA reported that 42 percent of survey respondents still indicated that handset availability remained a major barrier to their ability to provide wireless service to their customers.[348]

114. In addition to smartphones, all of the national service providers offer tablets. Internet device net adds (including tablets) were 2.0 million in the second quarter of 2015, 2.0 million in the third quarter of 2015, and 2.3 million in the fourth quarter of 2015, compared to 2.7 million in the fourth quarter of 2014.[349] AT&T increased its net internet device adds from 449,000 in the first quarter of 2014 to 711,000 in the first quarter of 2015, and saw a decline in the fourth quarter of 2015 to 696,000 net adds.[350] Verizon Wireless increased its net internet device adds from 621,000 in the first quarter of 2014 to 667,000 in the first quarter of 2015, to 803,000 in the second quarter of 2015, to 1.1 million in the fourth quarter of 2015.[351] Sprint saw a decrease in its net internet device adds from 414,000 in the first quarter of 2014 to 379,000 in the first quarter of 2015 to 322,000 in the second quarter of 2015, and an even larger decrease to 135,000 in the fourth quarter of 2015.[352] T-Mobile had the

[344] CTIA Comments at 40.

[345] *Id.* at 43. For example, Apple, which had traditionally focused on a single screen size and a consistent price bracket, now offers three different screen sizes, including the iPhone 6 Plus with a 5.5 inch screen, and price points ranging from $399 to $949, depending on model, screen size, and storage. Samsung, similarly, offers a range of screen sizes at a wide variety of price points, including pre-paid options. *Id.* at 44.

[346] *Id.* at 46.

[347] NTCA Comments at 3.

[348] *Id.* at 3; NTCA 2015 Wireless Survey Report (Jan. 2016).

[349] UBS US Wireless 411: Version 56, at 11 (May 14, 2015); Version 59, at 22-23 (Mar. 2, 2016).

[350] 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).

[351] 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).

[352] 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).

fewest internet device net adds (134,000 in the first quarter of 2015, and 248,000 in the second quarter of 2015) as it entered the tablet market later than the other service providers, although by the fourth quarter of 2015, T-Mobile had increased its internet device adds to 375,000.[353]

115. Although the use of data-only devices with mobile network connectivity has grown in recent years, "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.[354] In 2015, 20 percent of handsets shipped were phablets.[355] In part due to the popularity of phablets, Apple launched the iPhone 6 Plus last year to reclaim customers lost to Android vendors.[356] In the first quarter of 2015, 44 percent of all U.S. phablet sales were the iPhone 6 Plus.[357] 27 percent of all mobile device activations over the 2015 holidays were phablets, more than twice that of the 2014 holiday season, and nearly seven times as many as two years ago.[358]

116. In addition to offering a variety of smartphones, traditional handsets, and phablets, mobile wireless service providers also sell or provide connectivity for other data-only devices such as tablets, e-readers, wireless data cards, mobile Wi-Fi hotspots,[359] netbook computers with embedded modems, and wearable gadgets such as smartwatches. Smartwatches such as Android watches have been available for several years, but they have become more popular since Apple introduced its Apple Watch in April 2015. Mobile wireless service providers also offer wireless data cards and mobile Wi-Fi hotspots to consumers seeking mobile Internet connections for laptop computers and other Wi-Fi enabled devices and may offer products for the interconnected home, such as security systems. In addition, smartphone operating systems are converging with other mobile and wireless-enabled devices, including tablets, wearable devices, PCs, and OTT streaming devices.[360]

2. Advertising and Marketing

117. Mobile wireless service providers also compete for customers through advertising and marketing, including by establishing retail and distribution networks. Service providers may engage in advertising and marketing either to inform consumers about available products or services or to try to increase sales by influencing consumer preferences.[361] Service providers may advertise through television, print, radio, outdoor

[353] 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).

[354] 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/. CNET, How to Buy a New Phone: The CNET Smartphone Buying Guide (Nov. 20, 2015), http://www.cnet.com/topics/phones/buying-guide/.

[355] International Data Corporation, Smartphone Growth Expected to Drop to Single Digits in 2016, Led by China's Transition from Developing to Mature Market, According to IDC (Mar. 3, 2016), http://www.idc.com/getdoc.jsp?containerId=prUS41061616.

[356] *Id.*

[357] CNET, iPhone 6 Plus Leads Phablet Sales in U.S. (May 6, 2015), http://www.cnet.com/news/iphone-6-plus-leads-phablet-sales-in-us/.

[358] The Motley Fool, Phablets Are No Joke, and Apple Inc Is Laughing Its Way to Record Profits (Jan. 14, 2016), http://www.fool.com/investing/general/2016/01/14/phablets-are-no-joke-and-apple-inc-is-laughing-its.aspx.

[359] Mobile Wi-Fi, or "Mi-Fi," devices are credit card-sized, mobile Wi-Fi routers with mobile broadband wide-area connections that allow a certain number of Wi-Fi-enabled devices in short range to connect to the Internet via a Wi-Fi connection. Many smartphones are now sold with built-in Wi-Fi hotspot capabilities, allowing them to serve as mobile Wi-Fi hotspots for an additional charge.

[360] CTIA Comments at 50.

[361] *Eighteenth Report*, 30 FCC Rcd at 14604, para. 141.

signage, internet and mobile applications, social media, point-of-sale media promotions, sponsorships and co-branding, and at events.[362]

118. In 2015, wireless service providers increased advertising spending to $22.5 billion, focusing on network speeds, coverage, and plan offerings.[363] In 2015, 35 wireless brands were advertised on U.S. television, adding up to a total estimated media value of $1.89 billion.[364] This is an increase of approximately 11 percent from 2014, when 53 brands were advertised, spending an estimated $1.7 billion.[365] In 2015, AT&T was the biggest spender, making up 26 percent of the wireless spending on TV ads,[366] while Verizon Wireless made up 20 percent, T-Mobile made up 17 percent, Sprint made up 14 percent, Cricket (which is owned by AT&T) made up 7 percent, and other smaller service providers totaling 17 percent.[367] Of the four nationwide providers, only Sprint decreased its advertising spending from 2014 to 2015.[368]

119. 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.[369] They also continued to promote the advantages of their particular service plans relative to those of rivals.[370] For example, in the first half of 2016, AT&T aired an ad emphasizing their unlimited data offering which would allow customers to stream movies.[371] During the same timeframe, T-Mobile also advertised data plans allowing customers to stream movies.[372] Verizon Wireless emphasized the strength of its network,[373] while Sprint also emphasized its unlimited data plans, in addition to the reliability and good coverage of its network.[374]

[362] *See, e.g.*, 2015 SEC Form 10-K for Verizon Wireless.

[363] CTIA Comments at 3.

[364] iSpot.tv, Year 2015 Industry Report Wireless, at 2.

[365] *Id.*

[366] *Id.*

[367] *Id.*

[368] *Id.* In the month of November 2015 alone, the wireless industry spent $189.3 million on TV advertising. Of this amount, Verizon Wireless and AT&T each accounted for 21%, T-Mobile accounted for 16%, AT&T's Cricket brand accounted for 13%, and Sprint accounted for 12%. FierceWireless, The Top 5 Wireless Ads: Verizon Overtakes AT&T As Top Spender in November (Dec. 7, 2015), http://www.fiercewireless.com/special-reports/top-5-wireless-ads-verizon-overtakes-att-top-spender-november. In the month of March, 2016, the wireless industry spent $268.8 million on TV advertising. Of this amount, Verizon Wireless accounted for 14%, AT&T accounted for 34%, T-Mobile accounted for 15%, Straight Talk Wireless accounted for 8%, and Sprint accounted for 14%. FierceWireless, The Top 5 Wireless Ads: AT&T Owns 34% of the Mobile Industry's Spend in March (Apr. 13, 2016), http://www.fiercewireless.com/special-reports/top-5-wireless-ads-att-owns-34-mobile-industrys-spend-march.

[369] 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.

[370] *Id.*

[371] *Id.*

[372] *Id.*

[373] *Id.*

[374] *Id.*

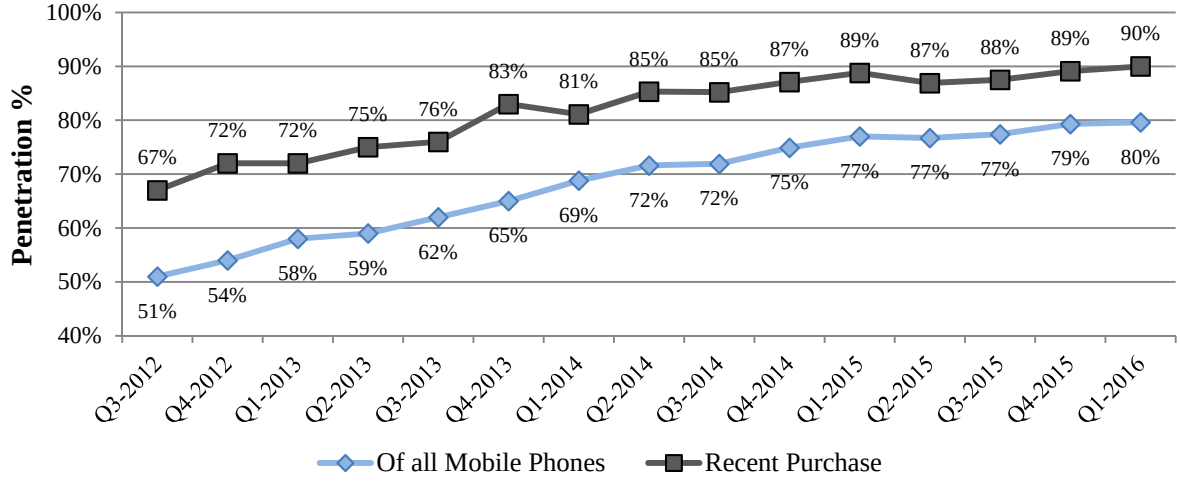
VII. CONSUMERS AND TRENDS IN THE MOBILE WIRELESS ECOSYSTEM

120. In today's connected world, consumers are faced with a wide variety of choices in mobile service plans, devices, and applications.[375] In this Section, we first report on trends in handsets and smartphone penetration, considering the handset operating system, and application (apps) dimensions of the mobile wireless ecosystem. Next, we consider trends in consumers' use of mobile wireless services. The handsets offered by, or compatible with a particular service provider, as well as the available apps, will affect consumers' decisions since each greatly affects the user experience, as discussed below. This Section then discusses consumers' access to information, and lastly, we report on trends in American consumers' use of mobile versus non-mobile services.

A. Handsets and Downstream Mobile Applications

121. *Smartphone Penetration*. Smartphone use has continued to increase over the last three years, as Chart VII.A.1 shows, although smartphone use flattened out slightly in 2015. According to ComScore, approximately 80 percent of all mobile subscribers had a smartphone in the first quarter of 2016, compared to approximately 51 percent in the third quarter of 2012.[376] The smartphone penetration rate among new mobile phone purchases over the same period stood at approximately 90 percent in the first quarter of 2016, up from approximately 67 percent in the third quarter of 2012. Among the top four mobile wireless service providers, the penetration rates for postpaid smartphone subscribers are approximately 97 percent, 91 percent, 87 percent, and 83 percent for T-Mobile, Sprint, AT&T, and Verizon Wireless, respectively, in the first quarter of 2016.[377]

Chart VII.A.1
Smartphone Penetration Rates in the US (3-Month Average)
3Q 2012 - Q1 2016



Source: ComScore, MobiLens Audience Profile, 3-month averages from Q3 2012 to Q1 2016.

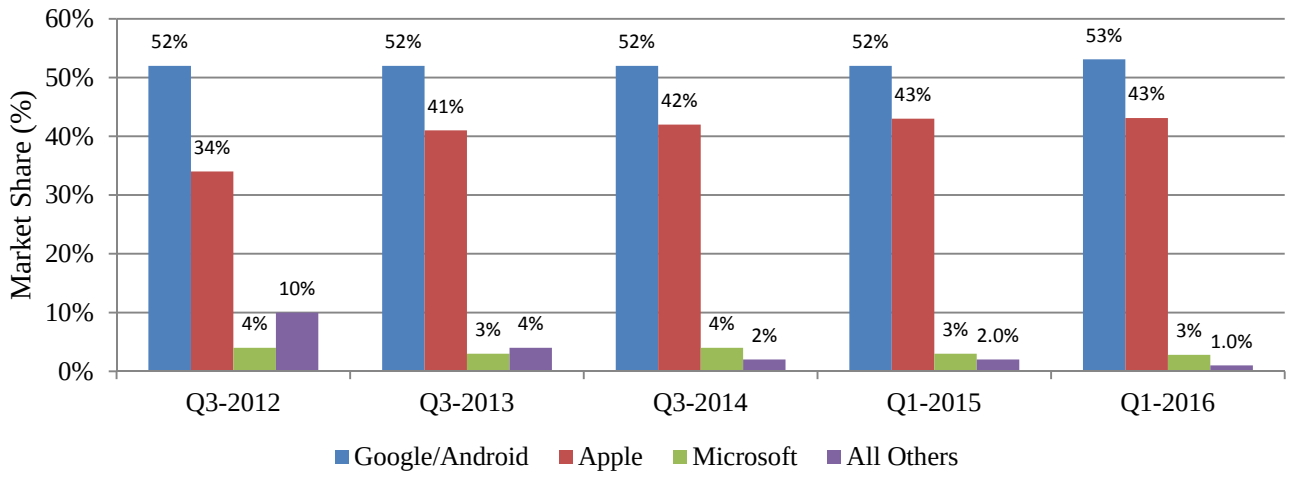
[375] Consumers choose a service provider or switch between providers for varying reasons, including price, availability of family plans, network quality, free/unlimited in-network calling, billing/payment options/credit, reputation/recommendation, previous experience with the service provider, customer service, mobile data services, specific phone offerings, bundling mobile phone services with other services or other unspecified reasons. In the past, contract length, handset exclusivity, and lack of interoperability were some factors that were highlighted as barriers to switching. Consumers may incur some switching costs, even in today's mobile wireless marketplace, including search costs, handset purchases, and implicit costs such as brand loyalty. *Eighteenth Report*, 30 FCC Rcd at 14605-06, para. 143 & n.430.

[376] ComScore, MobiLens Trend, 3-month averages from August 2012 to March 2016.

[377] UBS US Wireless 411, May 24, 2016, at 20, Figure 28.

122. *Share of Smartphones by Operating System*. The operating system (OS) of a smartphone is a major determining factor of the smartphone's ability to support mobile applications and Internet-based services. As seen in Chart VII.A.2, Apple's iOS and Google's Android continued to lead the market for mobile operating systems. In the first quarter of 2016, Android's operating system accounted for approximately 53 percent of the smartphone OS market, while Apple's iOS accounted for approximately 43 percent. Both Android and Apple's market shares have been fairly constant since the third quarter of 2013. Microsoft and other operating systems (e.g., Blackberry) have seen their combined market share dropped from approximately seven percent to approximately four percent since late 2013.[378]

Chart VII.A.2
Market Share by Smartphone Model (2012-2016)



Note: Based on ComScore MobiLens 3-month survey data averages, 2012-2016.

123. *Smartphones and Consumer Satisfaction*. According to an April 2016 JD Power study, consumer satisfaction with smartphone brands differs by wireless service provider.[379] For example, Apple smartphones rank highest in satisfaction among customers of Sprint, T-Mobile, and Verizon Wireless, while Samsung smartphones rank highest among customers of AT&T.[380] Overall satisfaction with smart phone devices is highest among Sprint customers, according to the survey, followed by AT&T, T-Mobile, and Verizon Wireless customers.[381] In

[378] Data from 2012 to 2015 are from the *Eighteenth Report*, 30 FCC Rcd at 14606-07, para. 145. Data for Q1 2016 are from comScore, comScore Report February 2016 U.S. Smartphone Subscriber Market Share, https://www.comscore.com/Insights/Rankings/comScore-Reports-February-2016-US-Smartphone-Subscriber-Market-Share (last visited Sept. 14, 2016).

[379] J.D. Power, Wireless Charging and Fingerprint Scanner Technology Amp Up Smartphone User Satisfaction (Apr. 21, 2016), http://www.jdpower.com/press-releases/2016-us-wireless-smartphone-satisfaction-study-volume-1. The Wireless Smartphone Satisfaction Study measures customer satisfaction based on five factors: performance, ease of operation, battery, physical design and features. In addition, a JD Power 2015 report indicates that the primary reasons for purchasing a smartphone device differ by service provider. For example, Verizon Wireless customers are more likely to buy their device based on the smartphone's features (approximately 34 percent), while T-Mobile customers are more likely to buy based on price (approximately 30 percent). JD Power, Smartphone Device Launches Propel High Satisfaction with Apple, HTC, and Samsung (Apr. 23, 2015), http://www.jdpower.com/press-releases/2015-us-wireless-smartphone-satisfaction-study%E2%80%94volume-1#.

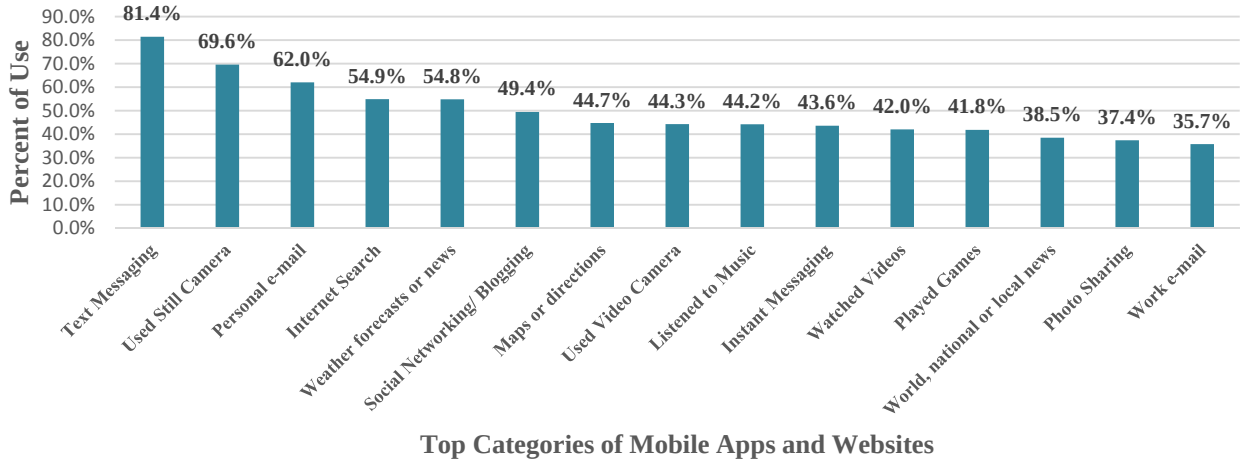
[380] *Id.*

[381] *Id.*

addition, the American Customer Satisfaction Index (ACSI) Telecom Report indicates that T-Mobile has the highest score among the four nationwide providers.[382] Further, the ACSI data indicate that with respect to smartphones, customers are most satisfied with the Samsung Galaxy Note5, and then the Apple iPhone 6S Plus.[383]

124. *Downstream Mobile Applications.* Mobile technology has changed when, where, and how consumers access information and entertainment.[384] Consumers are increasingly using smartphones for getting directions, listening to online music services such as Pandora or Spotify, and watching movies or participating in video calls.[385] Smartphone users generally interact with their devices through specific apps and the increasing use of smartphones has spawned a large and growing mobile app ecosystem. Two app stores dominate the United States marketplace–Google Play and Apple App Store. Google Play offered approximately 2.2 million apps, and Apple App Store offered approximately 2 million apps as of June 2016.[386] Chart VII.A.3 shows the Top 15 types of mobile apps and websites accessed by smartphone users as of April 2016.

Chart VII.A.3
Top 15 Types of Mobile Apps and Websites Accessed by Smartphone Users
April 2016



Source: Based on ComScore MobiLens 3-month survey data averages.

[382] ACSI, ACSI Telecom Report Shows Competitive Industries Have Higher Customer Satisfaction, https://www.theacsi.org/news-and-resources/press-releases/press-2016/press-release-telecommunications-2016 (last visited Sept. 14, 2016). The Report states that T-Mobile posts a 6% increase to 74 for the highest score among the four nationwide service providers, while Sprint is most improved after increasing 8% to 70, and AT&T and Verizon Wireless tie at 71. ACSI is a national cross-industry measure of customer satisfaction in the United States and each year, roughly 70,000 customers are surveyed about the products and services they use the most in around 43 industries, including several hundred in the mobile wireless industry. ACSI, Benchmarks by Industry,http://theacsi.org/index.php?option=com_content&view=article&id=147&catid=&Itemid=212&i=Wireless+Telephone+Service (last visited Sept. 14, 2016).

[383] ACSI, ACSI Telecom Report Shows Competitive Industries Have Higher Customer Satisfaction, https://www.theacsi.org/news-and-resources/press-releases/press-2016/press-release-telecommunications-2016 (last visited Sept. 14, 2016).

[384] Pew Research Center, More American Using Smartphones For Getting Directions, Streaming TV, http://www.pewresearch.org/fact-tank/2016/01/29/us-smartphone-use/ (last visited Sept. 14, 2016).

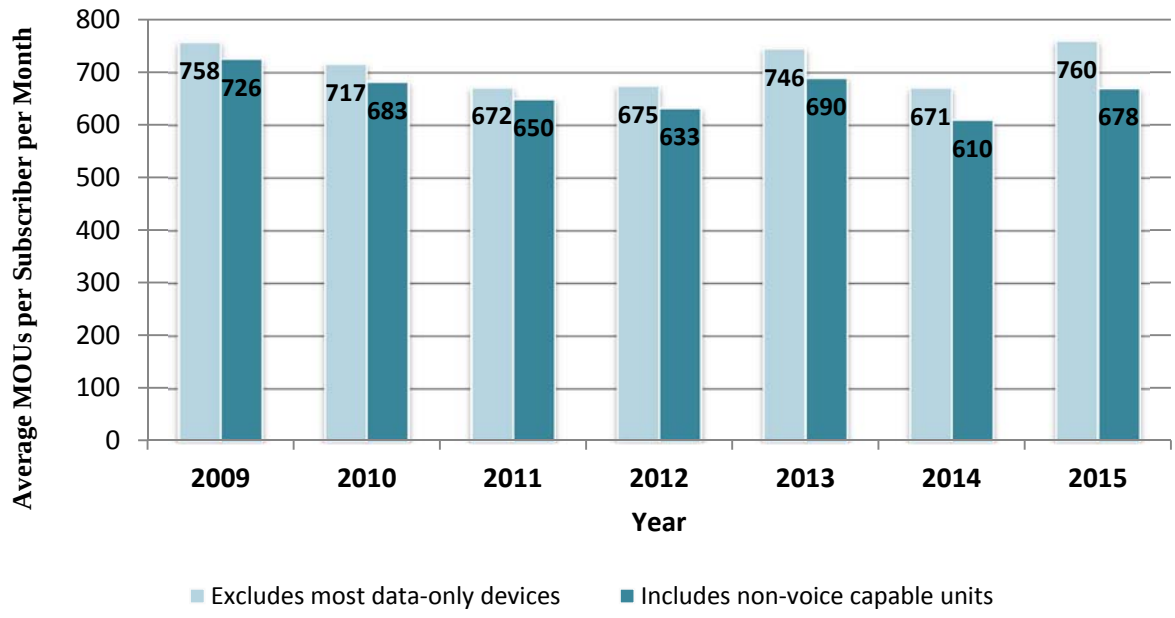
[385] *Id.*

[386] Statista, Number of apps available in leading app stores as of June 2016, http://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ (last visited Sept. 14, 2016).

B. Usage

125. According to CTIA, reported annual minutes of voice use (MOUs) in 2015 reached over 2.88 trillion, an increase of approximately 17 percent compared to year-end 2014, while average billable minutes of use, as shown in Chart VII.B.1, increased by approximately 10 percent.[387] As noted in previous *Reports*,[388] when considering the variation in MOUs, we must take into account changes in how service providers report, the participation of service providers, possible reported volume increases/decreases in usage, as well as the inclusion (and increasing importance of) non-voice-oriented connected devices. As service providers have continued to introduce new all-inclusive voice calling and data plans, as well as modifications on their legacy plans, the reporting of specific breakout data has become more complicated and difficult to analyze.[389] Further, consistent reporting of MOUs across all service providers is likely to become more difficult with the Internet of Things (IoT)–including connected cars, telematics, and M2M–as many of these service providers may not be able to separate out traditional voice usage, which may be included within their total data usage metrics.

Chart VII.B.1
Average MOU per Subscriber per Month, 2009-2015



Source: CTIA Wireless Industry Indices Year-End 2015, at 95.

126. CTIA reported that total messaging traffic (combining SMS and MMS) amounted to around 2.107 trillion messages for 2015, up from around 2.073 trillion in December 2014, an increase of 1.7 percent from the prior year.[390] The growth in messaging was attributable solely due to a sharp increase in MMS traffic. While traditional SMS/text messaging traffic showed a decrease of 1.7 percent, from 1.921 trillion to 1.889 trillion messaging, MMS traffic increased 43.4 percent, from 152 billion messages in 2014 to 218 billion messages in

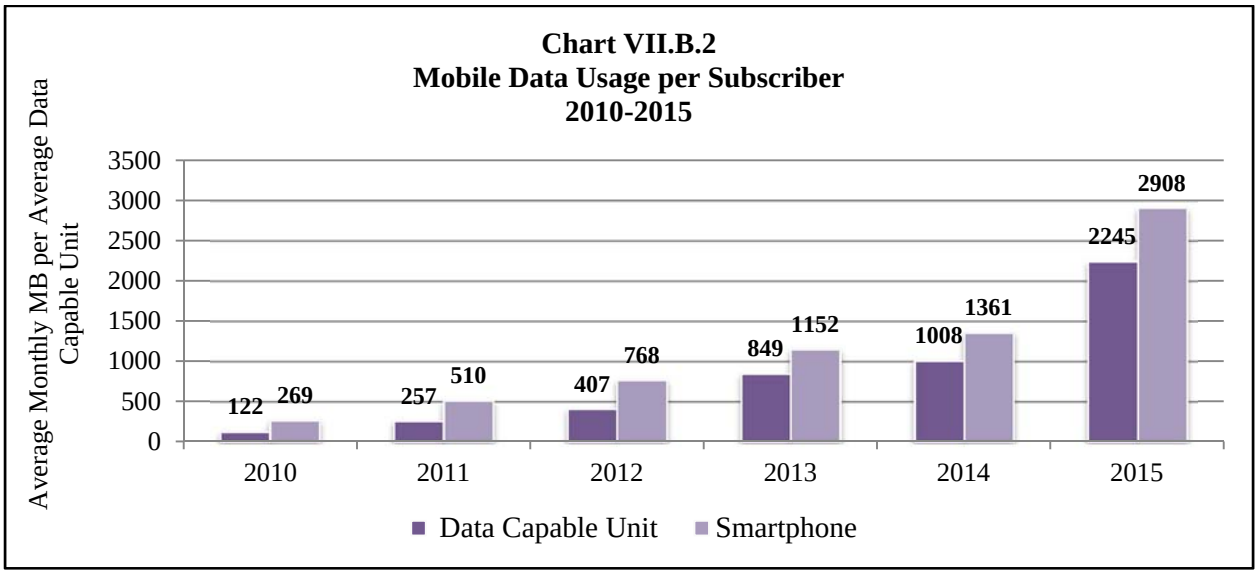
[387] CTIA Wireless Industry Indices Year-End 2015, at 91.

[388] *Eighteenth Report*, 30 FCC Rcd at 14608, para. 148.

[389] CTIA Wireless Industry Indices Year-End 2014, at 131-32 (describing understatement of MOUs).

[390] *Id.* at 97.

2015.[391] Monthly data usage per smartphone subscriber in 2015 averaged 2.9 GB per month, increasing approximately 114 percent since year-end 2014.[392] Total wireless data traffic reported by the service providers to CTIA amounted to 9.65 trillion MB for 2015 increasing approximately 138 percent from 4.06 trillion MB in 2014.[393] Chart VII.B.2 provides average data usage per subscriber for 2010 to 2015 comparing the amount of data usage between data-capable devices and smartphones.



Source: CTIA Wireless Industry Indices Year-End 2015.

127. Further, Cisco's Visual Networking Index reported that as of November 2015, average data usage in North America was approximately 3.1 GB a month for an Android user and approximately 3.8 GB per month for an iOS user.[394] Ericsson, in its June 2016 North American Mobility report, indicated that data traffic per active smartphone user equaled approximately 3.7 GB per month,[395] while according to GSMA's 2016 Report, the average North American user consumed around 4.4 GB per month.[396] This trend in increasing data use is due to multiple factors, including the increased adoption of smartphones and tablets, growth in streaming video, and the development of faster networks. According to the Pew Research Internet Project, 97 percent of cellphone users use their cellphone to send or receive text messages; 89 percent access the Internet; 88 percent send or receive email; 90 percent get directions, recommendations, or other location-based information; 87 percent of younger

[391] *Id.* at 100.

[392] *Id.* at 97.

[393] *Id.*

[394] Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015-2020 White Paper, at 33 (Feb. 3, 2016), 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 CAGR of 53% from 2015 to 2020 to 30.6 exabytes per month. *Id.* at 3.

[395] Ericsson, Ericsson Mobility Report, On the Pulse of the Networked Society, at 2 (June 2016), https://www.ericsson.com/res/docs/2016/ericsson-mobility-report-2016.pdf.

[396] GSMA, GSMA Report, The Mobile Economy 2016, at 15 https://www.gsmaintelligence.com/research/?file=97928efe09cdba2864cdcf1ad1a2f58c&download. The Report predicts that data traffic is forecast to grow at a CAGR of approximately 50% over the next five years, and it will approach a global average of 7 GB per subscriber per month by 2020, with the North American subscriber predicted to consume around 22 GB of mobile data. *Id.* at 15-16.

smartphone users listen to music; and 91 percent of users between 18 and 29 years of age used social networking compared to 55 percent of those age 50 and older.[397]

C. Consumer Access to Information

128. Through the "Consumer Code for Wireless Service," CTIA and the service providers voluntarily commit to providing consumers with information to assist them in the selection of a mobile wireless service provider.[398] Signatories to CTIA's Consumer Code commit to disclose rates, additional taxes, fees, surcharges, and terms of service; provide coverage maps; and make customer service readily accessible. Since its creation, the Consumer Code has been updated to require service providers to ensure disclosure of data allowances offered in a service plan, whether there are any prohibitions on data service usage, and whether there are network management practices that will have a material impact on the customer's wireless data experience.

129. In December 2013, CTIA added a section enhancing transparency and disclosure of mobile wireless providers' device unlocking policies.[399] The ability to unlock a handset in order to activate it on another service provider's network enables consumers to exercise greater choice in choosing or switching service providers and lowers switching costs. These requirements include notifying customers when their postpaid device is eligible for unlocking if the device is not automatically unlocked. In addition, participating service providers are required to post on their websites a clear, concise, and easily found policy on mobile device unlocking.[400] The member service providers were required to implement all of the unlocking disclosure policies by February 11, 2015, and all of the major service providers have fulfilled this commitment.[401] The member service providers agreeing to CTIA's Consumer Code account for service to approximately 97 percent of U.S. wireless customers.[402] All of these customers must be sent alerts regarding data, voice, text, international roaming, and device unlocking eligibility, unless they decide to opt out. In order to further facilitate the adoption of such alerts, the Commission has established a website where consumers can determine which service providers are implementing the voluntary commitments.[403]

130. *Open Internet Rules*. The rules on Internet openness adopted by the Commission in February 2015 require both fixed and mobile broadband Internet service providers to "publicly disclose accurate information regarding the network management practices, performance, and commercial terms of its broadband Internet access services sufficient for consumers to make informed choices regarding use of such services."[404] The *2015 Open Internet Order* reaffirms and enhances transparency rules that were originally adopted in 2010.[405] In 2014, the U.S. Court of Appeals for the D.C. Circuit (D.C. Circuit Court) rejected a challenge by Verizon to the

[397] Pew Research Center, U.S. Smartphone Use in 2015 (Apr. 1, 2015), http://www.pewinternet.org/files/2015/03/PI_Smartphones_0401151.pdf; Pew Research Center, More Americans Using Smartphones For Getting Directions, Streaming TV (Jan. 29, 2016), http://www.pewresearch.org/fact-tank/2016/01/29/us-smartphone-use/.

[398] CTIA, Consumer Code for Wireless Service, http://www.ctia.org/policy-initiatives/voluntary-guidelines/consumer-code-for-wireless-service (last visited Sept. 14, 2016).

[399] *Id.*

[400] FCC, Official FCC Blog, Wireless Providers Fulfill Commitment to Let Consumers Unlock Mobile Phones, (Sept. 14, 2015), https://www.fcc.gov/blog/wireless-providers-fulfill-commitment-let-consumers-unlock-mobile-phones.

[401] CTIA, Consumer Code for Wireless Service, http://www.ctia.org/policy-initiatives/voluntary-guidelines/consumer-code-for-wireless-service (last visited Sept. 14, 2016).

[402] *Id.*

[403] FCC, Helping Consumers Avoid Bill Shock, https://www.fcc.gov/bill-shock-alerts (last visited Sept. 14, 2016).

[404] *2015 Open Internet Order*, 30 FCC Rcd at 5609, para. 23.

[405] *Id.*; *Preserving the Open Internet*, Report and Order, 25 FCC Rcd 17905, 17938-39, para. 56 (2010) (*2010 Open Internet Order*).

2010 transparency rule, although it did invalidate anti-blocking and anti-discrimination rules.[406] Subsequently, in 2015, the Commission adopted new rules against blocking, throttling, and paid prioritization for fixed and mobile service providers.[407] Telecom, cable, and wireless industry associations filed petitions in the D.C. Circuit Court challenging the 2015 Order. These petitions were subsequently denied by the D.C. Circuit Court on June 14, 2016.[408]

131. In providing guidance regarding effective disclosure models in the 2010 and 2015 Open Internet Orders, the Commission indicated that among the types of information that might be included in an effective disclosure are pricing terms such as monthly prices, usage-based fees, and fees for early termination or additional network services.[409] The 2015 Order enhanced the transparency rules adopted in 2010 by adopting a requirement that broadband service providers always must disclose promotional rates, all fees and/or surcharges, and all data caps or data allowances.[410] In addition, the 2015 Order requires that packet loss as a measure of network performance must be disclosed and requires specific notification to consumers that a "network practice" is likely to significantly affect their use of the service.[411]

132. *Consumer Broadband Labels*. On April 4, 2016, the Commission approved, with modifications, the consumer broadband labels proposed by the Commission's Consumer Advisory Committee (CAC).[412] The CAC labels will provide consumers of mobile and fixed broadband Internet service with easy-to-understand information about price and performance.[413] Broadband Internet access service providers will be required to disclose this information to consumers in an accurate, understandable, and easy-to-find manner.[414] More specifically, information required include price points, including various charges that seem confusing to consumers like overage, equipment, early termination and administrative fees, data allowances and broadband speed and other performance metrics.[415] The consumer broadband labels, while not mandated, are recommended by the Commission and will serve as a "safe harbor" to meet the Commission's Open Internet transparency

[406] *Verizon v. Federal Communications Commission*, 740 F.3d 623 (D.C. Cir. 2014).

[407] *2015 Open Internet Order*, 30 FCC Rcd at 5607-08, paras. 15-19.

[408] *United States Telecom Ass'n, et al. v. FCC*, 825 F.3d 674 (D.C. Cir. 2016), *pets. for reh'g pending*.

[409] *2015 Open Internet Order*, 30 FCC Rcd at 5609, para. 23; *2010 Open Internet Order*, 25 FCC Rcd at 17938-39, para. 56. On July 23, 2014, the Enforcement Bureau of the FCC announced that, "Providers of broadband Internet access services must disclose accurate information about their service offerings and make this information accessible to the public." Open Internet Transparent Rule, DA 14-1039, Enforcement Advisory No. 2014-03 (July 23, 2014), https://transition.fcc.gov/eb/Public_Notices/DA-14-1039A1.html. The Commission charged its Consumer Advisory Committee with making recommendations regarding proposed consumer facing disclosure format, based on input from a broad range of stakeholders, accessible to persons with disabilities, and to consider whether different formats should be used for fixed and mobile service providers. *2015 Open Internet Order*, 30 FCC Rcd at 5680-81, para. 180. The recommendations were submitted on October 26, 2015, and are available on the FCC website. FCC, Consumer Advisory Committee Recommendations 2014 thru 2016, https://www.fcc.gov/consumer-advisory-committee-recommendations-2014-thru-2016 (last visited Sept. 14, 2016).

[410] *2015 Open Internet Order*, 30 FCC Rcd at 5609, para. 23.

[411] *Id.*

[412] *Consumer and Governmental Affairs, Wireline Competition, and Wireless Telecommunications Bureaus Approve Open Internet Broadband Consumer Labels*, Public Notice, 31 FCC Rcd 3358 (WTB 2016). The Commission has begun the process of obtaining OMB approval for the enhancements and will publish a notice in the Federal Register announcing that approval and the effective date.

[413] FCC, FCC Unveils Consumer Broadband Labels to Provide Greater Transparency to Consumers (Apr. 4, 2016), https://apps.fcc.gov/edocs_public/attachmatch/DOC-338708A1.pdf.

[414] *Id.*

[415] *Id.*

rules.[416] The consumer broadband labels will provide consumers with more information on service speed and reliability, and greater clarity regarding the costs of broadband service, including fees and other add-on charges that may appear on their bills.

D. Intermodal Developments

133. Advances in technologies and functionalities have made mobile broadband services more versatile and useful to consumers. However, while fixed and mobile broadband services may provide some overlapping capabilities, each service also has unique capabilities. It is also sometimes the case that mobile services and fixed services enhance the quality of one another. In fact, residential and business consumers alike often use mobile and fixed services in concert to, for example, off load reliance from cellular networks to Wi-Fi systems that are connected to the internet via a fixed service.[417] In addition, the increasingly dynamic nature of residential and business communication requires a mix of fixed and mobile broadband access to provide sufficient functionality for families and businesses whose members often simultaneously rely on data-capacity intensive applications at fixed locations and mobile applications on the go.[418]

134. For voice services, we here provide the latest information from the Centers for Disease Control and Prevention's (CDC) National Health Interview Survey on wireless substitution, which we emphasize only pertains to voice services and therefore no inferences regarding broadband services can, or should, be drawn based upon it. The survey includes information about household telephones and whether anyone in the household has a wireless telephone. Preliminary results from the CDC's June to December 2015 National Health Interview Survey indicate that the number of American homes with only wireless telephones continues to grow. As shown in Chart VII.D.1 and Chart VII.D.2, the percentage of U.S. adults and children living in households with landlines, with or without wireless, has fallen steadily over the past several years.[419] The percentage of wireless-only households has continued to increase for both groups, and the percentage of households without phones has decreased slightly.[420] A significant percentage of homes with both landline and wireless phone access received all or almost all calls on wireless telephones despite also having a landline telephone.[421]

---

[416] *Id.*

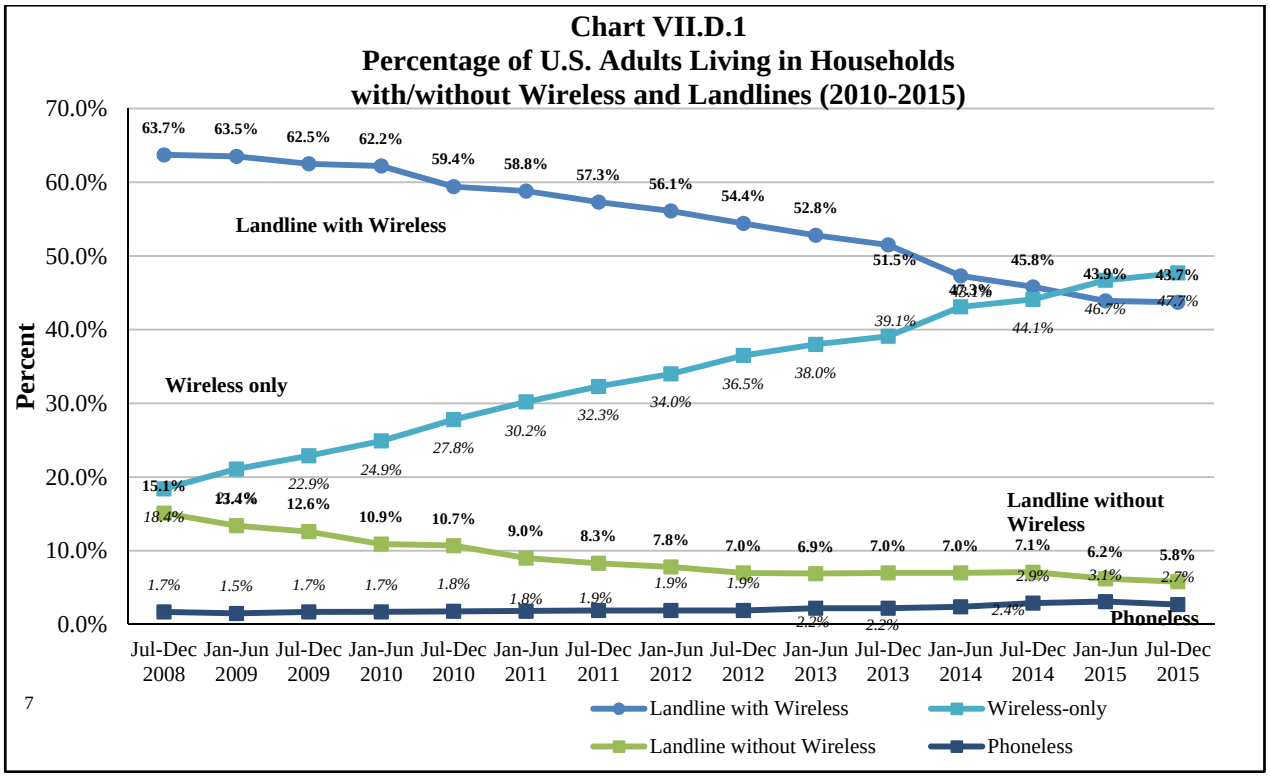
[417] According to Cisco VNI Mobile, "By 2015, more than half of all traffic from mobile-connected devices will be offloaded to the fixed network by means of Wi-Fi devices and femtocells each month." Cisco VNI Mobile, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2015-2020 White Paper, at 4 http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html. As of 2015, 51% of total mobile data traffic from all mobile-connected devices was offloaded. *Id.* at 1. According to a Juniper Research forecast, Wi-Fi offloading will account for nearly 60 percent of mobile data traffic by 2019. Information Week, Wi-Fi Offloading To Skyrocket (June 24, 2015), http://www.networkcomputing.com/wireless/wifi-offloading-skyrocket/1733513641.

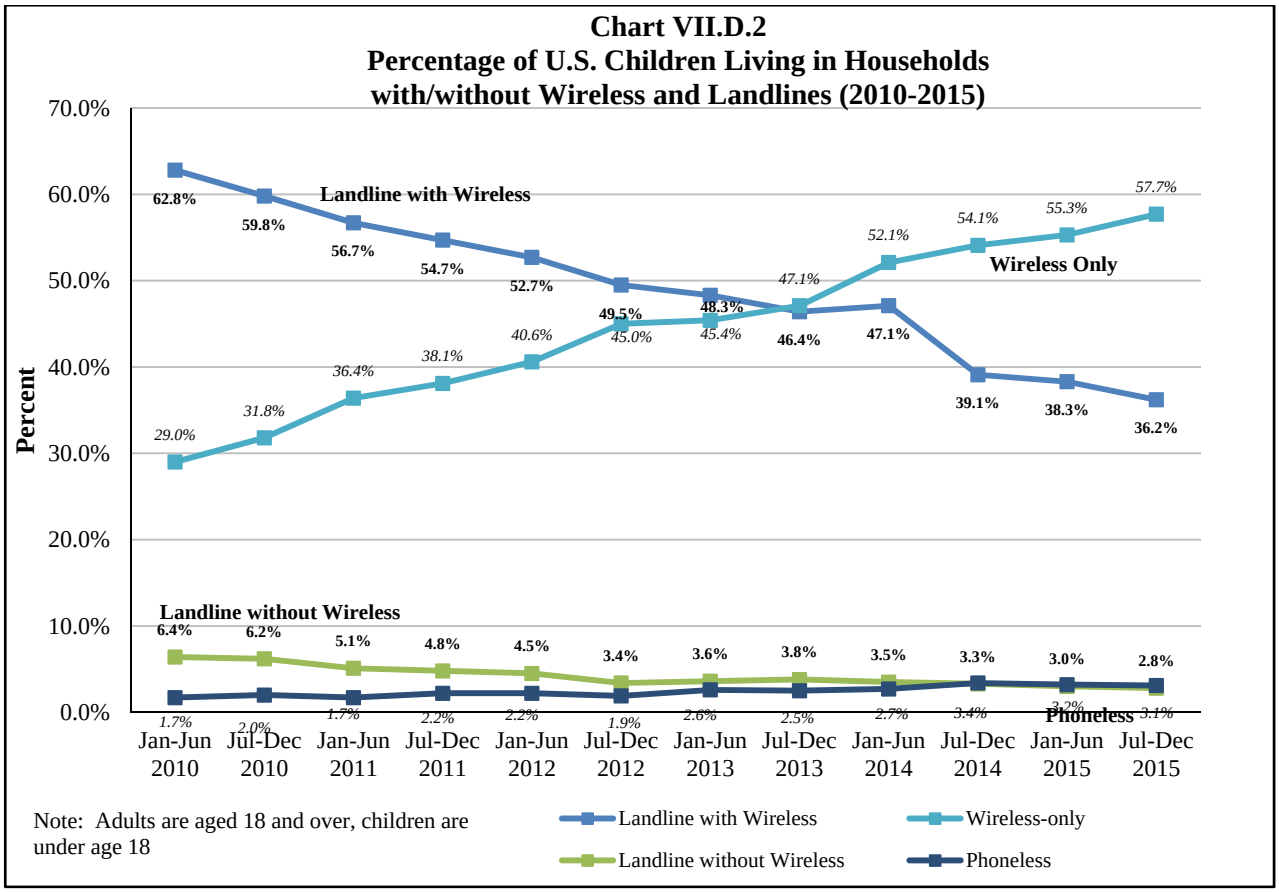
[418] *See generally 2016 Broadband Progress Report*, 31 FCC Rcd 699. The *2016 Broadband Progress Report* concluded that fixed and mobile broadband are often used in conjunction with one another and, as such, are not functional substitutes: each service offers different capabilities to consumers, the services are marketed differently, and most consumers with the financial means choose to purchase both. *Id*. at 710, para. 4.

[419] Appendix Tables VII.C.i and VII.C.ii provide detailed information.

[420] CDC, NCHS, Stephen J. Blumberg and Julian V. Luke, Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July-December 2015, National Center for Health Statistics, Centers for Disease Control (May 2016), http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201605.pdf.

[421] *Id.*





Source: CDC National Health Interview Survey, June–December 2015.

VIII. CONCLUSION

135. Promoting competition is a fundamental goal of the Commission's policymaking. Competition has played and must continue to play an essential role in the mobile wireless industry–leading to lower prices and higher quality for American consumers, and producing innovation and investment in wireless networks, devices, and services. This *Nineteenth Report* analyzes competition in the mobile wireless industry pursuant to Section 332(c)(1)(C) of the Communications Act and highlights several key trends. As with past *Reports*, this *Nineteenth Report* examines various facets of the mobile wireless industry, including market concentration, the conduct and rivalry of service providers, and competition in other segments of the mobile wireless ecosystem, including spectrum, backhaul, and handsets/devices, as well as consumer behavior.

IX. PROCEDURAL MATTERS

136. This *Nineteenth 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), and authority delegated to the Wireless Telecommunications Bureau under Section 0.331 of the Commission's rules, 47 C.F.R. § 0.331.

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

138. It is FURTHER ORDERED, pursuant to the authority delegated to the Wireless Telecommunications Bureau under Section 0.331 of the Commission's rules, 47 C.F.R. § 0.331, that the proceeding in WT Docket No. 16-137 IS TERMINATED.

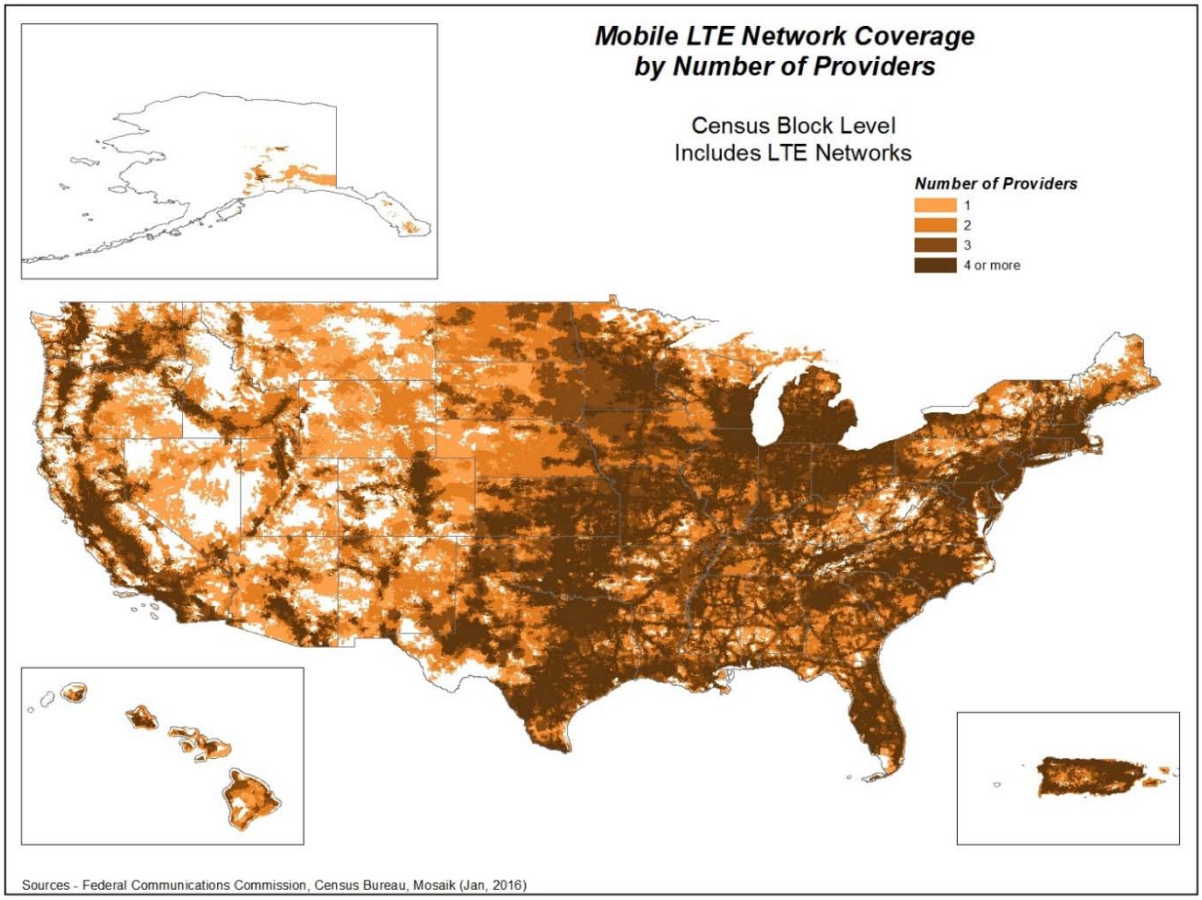
FEDERAL COMMUNICATIONS COMMISSION

Jon Wilkins
Chief, Wireless Telecommunications Bureau

APPENDIX I: LTE COVERAGE NATIONWIDE BY NUMBER OF PROVIDERS[422]

The two maps presented in this Appendix are based on Commission estimates derived from census block analysis of January 2016 Mosaik CoverageRight coverage maps and of December 2015 Form 477 coverage maps. The centroid methodology is used to analyze both data sets. We note that the centroid methodology provides estimates of the percentage of the population located in census blocks with a certain number of service providers represents network coverage, which does not necessarily mean service is offered to residents in the census block. In addition, we emphasize that a service provider reporting coverage in a particular census block may not provide 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, and does not purport to measure competition.

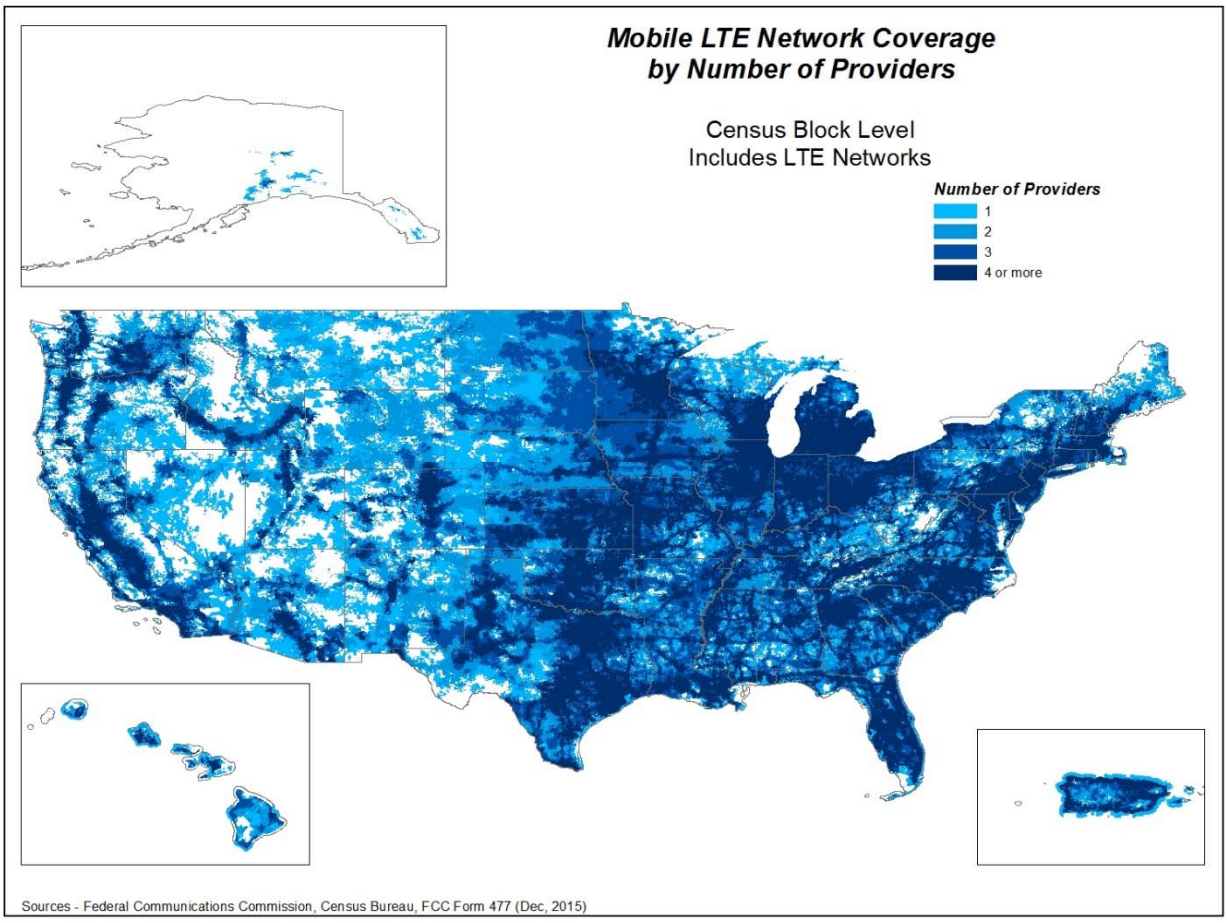
LTE Coverage Nationwide by Number of Service Providers
Mosaik, Centroid Method, Jan. 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

[422] We note that additional coverage maps are provided in Web Appendix I: Maps (Nationwide LTE Coverage, Year-End 2015), http://wireless.fcc.gov/competition-reports/mobile-wireless/mw-19/report-assets/index/html.

LTE Coverage Nationwide by Number of Service Providers
Form 477, Centroid Method, Dec. 2015



Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

APPENDIX II: COMPETITIVE DYNAMICS WITHIN THE INDUSTRY

Connections, Net Adds, and Churn

Table II.B.i
Estimated Total Mobile Wireless Connections: 2002–2015

	NRUF			CTIA
Year	Connections (millions)	Increase from previous year (millions)	Connections Per 100 People	Estimated Connections (millions)
2002	141.8	13.3	49	140.8
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	374.0	16.9	120	377.9

Source: CTIA Wireless Industry Year-End Indices; NRUF 2002–2015; Census data.

Table II.B.ii
Quarterly Total Mobile Wireless Connections by Service Segment
2012–2015

Quarter Year	Postpaid	Prepaid	Wholesale	Connected Devices	Total Connections
1Q12	215,466	69,133	13,955	24,502	323,056
2Q12	215,633	70,649	13,423	24,982	324,687
3Q12	216,129	71,112	13,567	25,836	326,644
4Q12	218,246	71,728	13,416	26,889	330,279
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

Source: UBS Investment Research. US Wireless 411, Version 51; US Wireless 411, Version 59.

Table II.B.iii
Quarterly Net Adds in Mobile Wireless Connections by Service Segment (in thousands)
2010–2015

Quarter Year	Postpaid	Prepaid	Wholesale	Connected Devices	Total Net Adds
1Q10	(6)	2,464	671	1,237	4,366
2Q10	813	749	483	1,421	3,466
3Q10	823	1,565	607	1,634	4,629
4Q10	895	2,633	39	1,831	5,398
1Q11	196	2,661	1,210	1,725	5,791
2Q11	787	1,093	1,017	1,452	4,349
3Q11	583	1,730	1,119	1,446	4,878
4Q11	1,304	1,998	1,506	76	4,884
1Q12	(147)	1,891	1,296	493	3,533
2Q12	784	414	568	480	2,246
3Q12	(405)	462	1,244	854	2,156
4Q12	2,177	603	(151)	1,053	3,682
1Q13	(3,872)	1,278	3,431	1,344	2,181
2Q13	263	(1,391)	598	1,318	788
3Q13	1,132	280	436	1,381	3,229
4Q13	2,492	1,069	802	1,026	5,389
1Q14	3,147	472	-945	1,703	4,378
2Q14	2,899	(1,029)	975	1,574	4,418
3Q14	3,064	686	1,497	1,967	7,214
4Q14	3,787	712	938	2,028	7,465
1Q15	2,003	187	1,088	1,471	4,748
2Q15	2,809	(21)	1,339	2,009	6,136
3Q15	2,794	751	1,441	2,651	7,637
4Q15	3,549	221	569	2,080	6,418

Source: 2010 data from the *Sixteenth Competition Report*, 28 FCC Rcd at 3836; UBS US Wireless 411, 4Q11, at 10, UBS US Wireless 411, Version 54, 1Q12-2Q14; UBS US Wireless 411, Version 59.

Financial Indicators

Table II.E.i
Annualized Average Revenue Per Reported Subscriber Unit (ARPU): 1993–2015

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

Source: Based on CTIA Wireless Industry Indices Year-End 2015.

Table II.E.ii
Change in CPI, 1997-2015

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	-4.9%	100.7	0.7%		
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	1.6%
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%
1997 to 2015		**47.7%**		**-44.8%**		**-0.7%**		**11.8%**

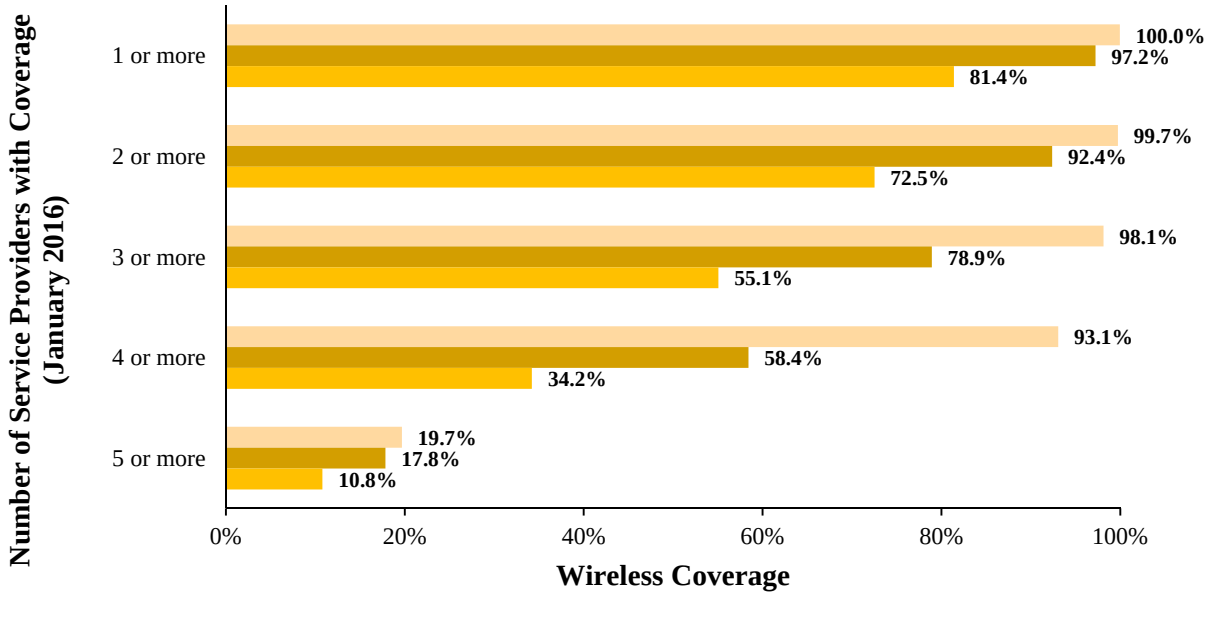
Source: Data from Bureau of Labor Statistics. All CPI figures were taken from BLS databases. Bureau of Labor Statistics, http://www.bls.gov (last visited Sept. 14, 2016). Beginning in January 2010, the CPIs for local telephone service and long-distance telephone service were discontinued and replaced by a new CPI for land-line telephone services.

APPENDIX III: OVERALL WIRELESS INDUSTRY METRICS

The tables and charts presented in this Appendix are based on Commission estimates derived from census block analysis of January 2016 Mosaik CoverageRight coverage maps and of December 2015 Form 477 coverage maps.[423] The centroid methodology is used to analyze both data sets. We note that the centroid methodology provides estimates of the percentage of the population located in census blocks with a certain number of service providers represents network coverage, which does not necessarily mean service is offered to residents in the census block. In addition, we emphasize that a service provider reporting coverage in a particular census block may not provide 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, and does not purport to measure competition.

The Form 477 coverage maps are also analyzed using the actual area coverage methodology (with the assumption of proportionality made as discussed above to generate population and road mile coverage).

Chart III.A.i
Estimated Wireless Coverage by Census Block Including Federal Land: Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

[423] Population data are from the 2010 Census, and include the United States and Puerto Rico. Square miles also include the United States and Puerto Rico.

Table III.A.i
***Estimated* Overall Wireless Coverage by Census Block Including Federal Land**
Mosaik, Centroid Method, January 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
U.S. Total (actual)	*10,609,302*	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,500,747	312,315,488	100.0%	2,889,915	81.4%	6,628,825	97.2%
2 or more	10,296,165	311,615,904	99.7%	2,575,181	72.5%	6,297,656	92.4%
3 or more	9,571,180	306,600,832	98.1%	1,954,875	55.1%	5,381,026	78.9%
4 or more	8,119,361	290,773,312	93.1%	1,214,572	34.2%	3,982,783	58.4%
5 or more	2,321,946	61,465,100	19.7%	383,015	10.8%	1,216,070	17.8%

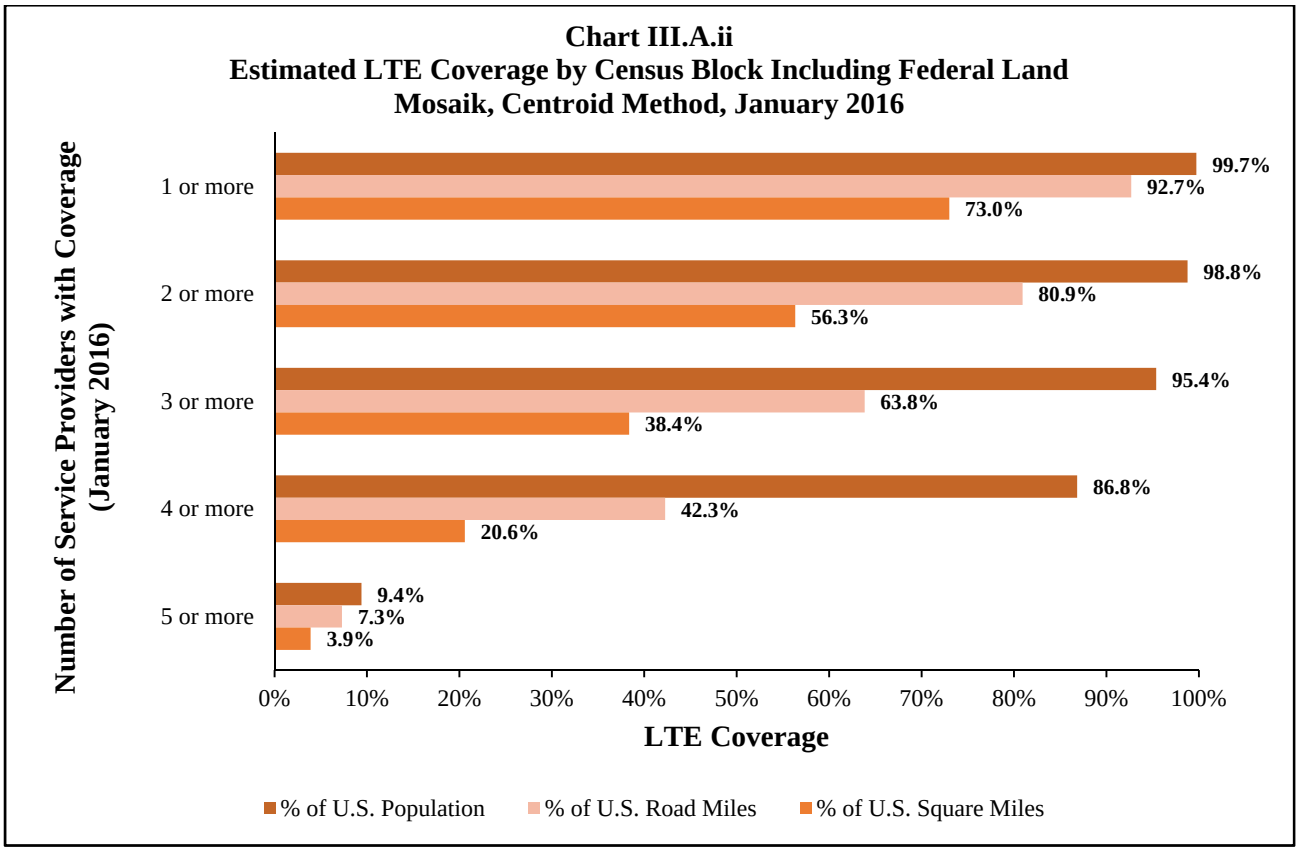
Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.ii
***Estimated* Overall Wireless Coverage by Census Block Including Federal Land**
Form 477, Centroid Method, December 2015

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
U.S. Total (actual)	*10,609,302*	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,493,985	312,289,312	99.9%	2,865,222	80.7%	6,614,200	97.0%
2 or more	10,267,331	311,457,824	99.7%	2,538,457	71.5%	6,257,117	91.8%
3 or more	9,513,882	305,941,952	97.9%	1,918,690	54.0%	5,324,949	78.1%
4 or more	8,115,709	291,706,464	93.4%	1,196,950	33.7%	3,966,275	58.2%
5 or more	1,785,149	43,515,572	13.9%	310,891	8.8%	959,153	14.1%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart III.A.ii
Estimated LTE Coverage by Census Block Including Federal Land
Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.iii
***Estimated* LTE Coverage by Census Block Including Federal Land**
Mosaik, Centroid Method, January 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
U.S .Total (actual)	*10,609,302*	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,311,795	311,639,008	99.7%	2,592,355	73.0%	6,318,737	92.7%
2 or more	9,747,906	308,664,288	98.8%	2,000,114	56.3%	5,518,173	80.9%
3 or more	8,582,888	298,056,608	95.4%	1,362,259	38.4%	4,352,391	63.8%
4 or more	6,711,291	271,303,744	86.8%	730,961	20.6%	2,881,275	42.3%
5 or more	1,039,603	29,372,808	9.4%	138,756	3.9%	497,524	7.3%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.iv
***Estimated* LTE Coverage by Census Block Including Federal Land**
Form 477, Centroid Method, December 2015

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
U.S. Total (actual)	*10,609,302*	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,275,189	311,514,080	99.7%	2,541,982	71.6%	6,272,730	92.0%
2 or more	9,747,441	308,624,864	98.8%	2,012,758	56.7%	5,533,537	81.2%
3 or more	8,727,402	299,678,464	95.9%	1,415,132	39.9%	4,462,928	65.5%
4 or more	7,077,788	278,331,776	89.1%	819,036	23.1%	3,124,573	45.8%
5 or more	966,224	25,707,056	8.2%	131,551	3.7%	467,746	6.9%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.v
***Estimated* LTE Coverage by Census Block Including Federal Land**
Form 477, December 2015, Actual Area Coverage Method

Number of Providers with Coverage in a Block	Covered POPs	% of Total US POPs	Covered Square Miles	% of Total US Square Miles	Covered Road Miles	% of Total US Road Miles
U.S. Total (actual)	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	311,005,856	99.5%	2,524,010	71.1%	6,241,696	91.6%
2 or more	308,022,912	98.6%	1,996,703	56.2%	5,505,579	80.8%
3 or more	299,048,096	95.7%	1,407,657	39.6%	4,443,722	65.2%
4 or more	277,588,352	88.8%	814,965	23.0%	3,109,515	45.6%
5 or more	25,644,906	8.2%	130,087	3.7%	464,338	6.8%

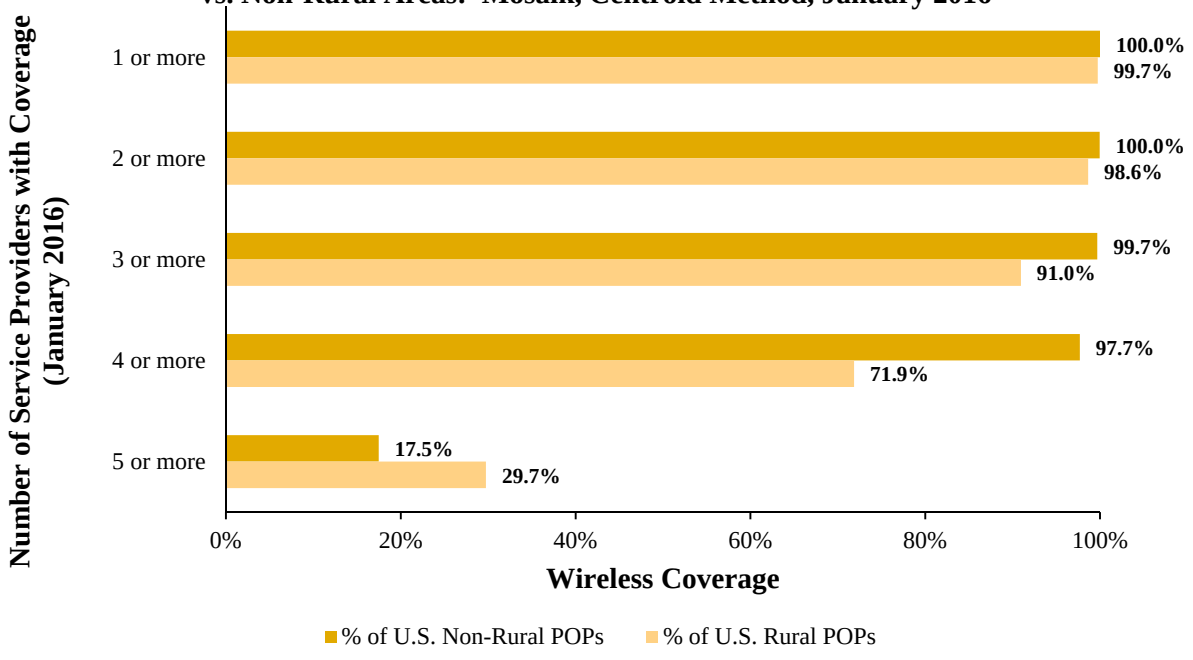
Source: Based on actual area analysis of December 2015 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges many blocks are only partially covered. As it is unclear which of these blocks should be considered covered or not, we decline from reporting the number of blocks covered in these results.

Table III.A.vi
***Estimated* Wireless Coverage in Rural Areas by Census Block Including Federal Land Mosaik, Centroid Method, January 2016**

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Rural US POPs	Square Miles Contained in Those Blocks	% of Total Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total Rural US Road Miles
U.S. Total (actual)	*4,937,330*	*56,094,552*	*100.0%*	*2,987,281*	*100.0%*	*4,518,876*	*100.0%*
1 or more	4,834,491	55,953,972	99.7%	2,334,779	78.2%	4,337,860	96.0%
2 or more	4,643,687	55,327,944	98.6%	2,035,172	68.1%	4,024,241	89.1%
3 or more	3,982,741	51,019,456	91.0%	1,456,181	48.7%	3,171,100	70.2%
4 or more	2,790,150	40,315,084	71.9%	799,403	26.8%	1,964,143	43.5%
5 or more	1,115,723	16,685,835	29.7%	269,935	9.0%	716,205	15.8%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart III.A.iii
Estimated Wireless Coverage by Census Block Including Federal Land in Rural vs. Non-Rural Areas: Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.vii
***Estimated* Wireless Coverage in Rural Areas by Census Block Including Federal Land**
Form 477, Centroid Method, December 2015

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Rural US POPs	Square Miles Contained in Those Blocks	% of Total Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total Rural US Road Miles
U.S. Total (actual)	*4,937,330*	*56,094,552*	*100.0%*	*2,987,281*	*100.0%*	*4,518,876*	*100.0%*
1 or more	4,827,919	55,930,024	99.7%	2,309,699	77.3%	4,323,637	95.7%
2 or more	4,618,686	55,213,676	98.4%	1,999,563	66.9%	3,986,071	88.2%
3 or more	3,927,343	50,370,300	89.8%	1,418,399	47.5%	3,114,673	68.9%
4 or more	2,716,352	39,453,848	70.3%	764,114	25.6%	1,902,037	42.1%
5 or more	934,772	13,497,505	24.1%	227,709	7.6%	604,206	13.4%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.viii
***Estimated* Wireless Coverage in Non-Rural Areas by Census Block Including Federal Land**
Mosaik, Centroid Method, January 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Non-Rural US POPs	Square Miles Contained in Those Blocks	% of Total Non-Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total Non-Rural US Road Miles
U.S. Total (actual)	*5,671,972*	*256,376,768*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,666,256	256,361,504	100.0%	555,136	98.5%	2,290,965	99.7%
2 or more	5,652,478	256,287,968	100.0%	540,009	95.8%	2,273,415	98.9%
3 or more	5,588,439	255,581,376	99.7%	498,695	88.5%	2,209,926	96.1%
4 or more	5,329,211	250,458,224	97.7%	415,169	73.7%	2,018,640	87.8%
5 or more	1,206,223	44,779,264	17.5%	113,080	20.1%	499,865	21.7%

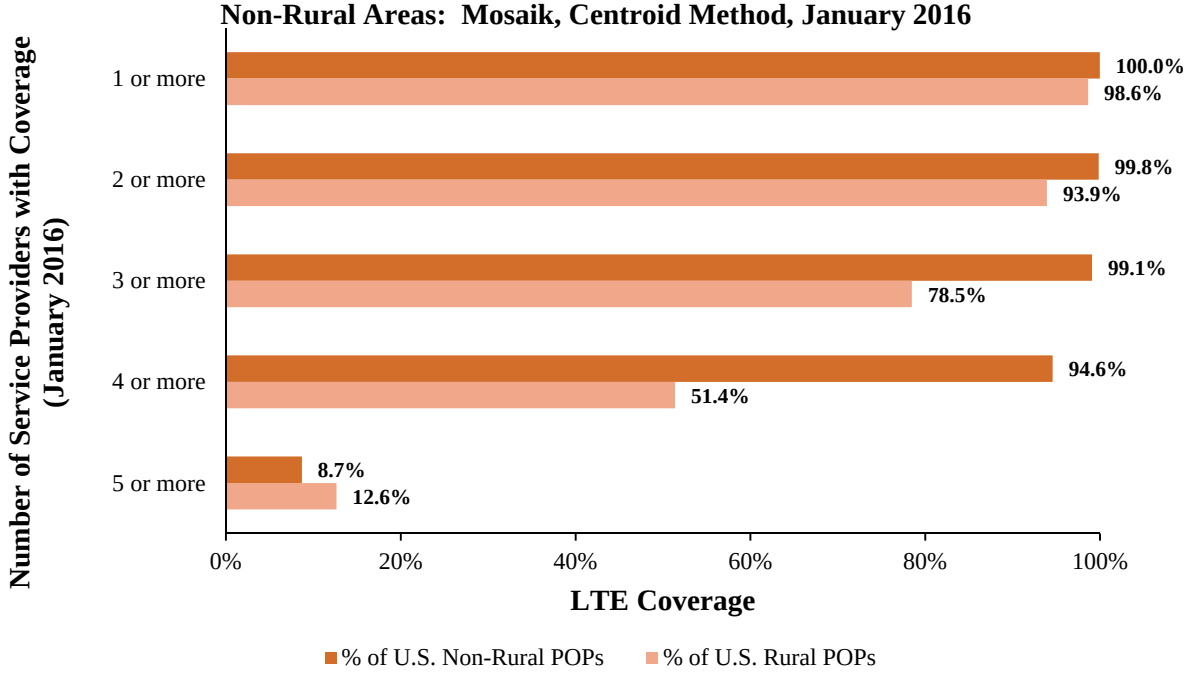
Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.ix
***Estimated* Wireless Coverage in Non-Rural Areas by Census Block Including Federal Land Form 477, Centroid Method, December 2015**

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Non-Rural US POPs	Square Miles Contained in Those Blocks	% of Total Non-Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total Non-Rural US Road Miles
U.S. Total (actual)	*5,671,972*	*256,376,768*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,666,066	256,359,280	100.0%	555,523	98.6%	2,290,563	99.6%
2 or more	5,648,645	256,244,160	99.9%	538,894	95.6%	2,271,047	98.8%
3 or more	5,586,539	255,571,648	99.7%	500,291	88.8%	2,210,276	96.1%
4 or more	5,399,357	252,252,624	98.4%	432,835	76.8%	2,064,238	89.8%
5 or more	850,377	30,018,066	11.7%	83,182	14.8%	354,948	15.4%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart III.A.iv
Estimated LTE Coverage by Census Block Including Federal Land in Rural vs. Non-Rural Areas: Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.x
***Estimated* LTE Coverage in Rural Areas by Census Block Including Federal Land**
Mosaik, Centroid Method, January 2016

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Rural US POPs	Square Miles Contained in Those Blocks	% of Total Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total Rural US Road Miles
U.S. Total (actual)	*4,937,330*	*56,094,552*	*100.0%*	*2,987,281*	*100.0%*	*4,518,876*	*100.0%*
1 or more	4,656,395	55,330,704	98.6%	2,049,643	68.6%	4,041,733	89.4%
2 or more	4,132,555	52,686,888	93.9%	1,491,880	49.9%	3,288,290	72.8%
3 or more	3,097,172	44,019,244	78.5%	905,534	30.3%	2,228,295	49.3%
4 or more	1,724,079	28,817,800	51.4%	389,445	13.0%	1,079,214	23.9%
5 or more	440,245	7,094,075	12.6%	88,473	3.0%	262,173	5.8%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.xi
***Estimated* LTE Coverage in Rural Areas by Census Block Including Federal Land**
Form 477, Centroid, December 2015

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Rural US POPs	Square Miles Contained in Those Blocks	% of Total Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total Rural US Road Miles
U.S. Total (actual)	*4,937,330*	*56,094,552*	*100.0%*	*2,987,281*	*100.0%*	*4,518,876*	*100.0%*
1 or more	4,621,821	55,219,508	98.4%	2,001,911	67.0%	3,998,338	88.5%
2 or more	4,136,326	52,707,712	94.0%	1,505,672	50.4%	3,305,971	73.2%
3 or more	3,221,651	45,224,176	80.6%	951,740	31.9%	2,323,536	51.4%
4 or more	1,916,139	31,289,656	55.8%	442,784	14.8%	1,216,001	26.9%
5 or more	428,370	6,845,744	12.2%	83,751	2.8%	250,812	5.6%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.xii
***Estimated* LTE Coverage in Non-Rural Areas by Census Block Including Federal Land Mosaik, Centroid Method, January 2016**

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Non-Rural US. POPs	Square Miles Contained in Those Blocks	% of Total Non-Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total US Non-Rural Road Miles
U.S. Total (actual)	*5,671,972*	*256,376,768*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,655,400	256,308,304	100.0%	542,712	96.3%	2,277,004	99.0%
2 or more	5,615,351	255,977,408	99.8%	508,233	90.2%	2,229,884	97.0%
3 or more	5,485,716	254,037,376	99.1%	456,725	81.0%	2,124,097	92.4%
4 or more	4,987,212	242,485,936	94.6%	341,515	60.6%	1,802,061	78.4%
5 or more	599,358	22,278,732	8.7%	50,283	8.9%	235,351	10.2%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table III.A.xiii
***Estimated* LTE Coverage in Non-Rural Areas by Census Block Including Federal Land Form 477, Centroid Method, December 2015**

Number of Providers with Coverage in a Block	Number of Blocks	POPs Contained in Those Blocks	% of Total Non-Rural US POPs	Square Miles Contained in Those Blocks	% of Total Non-Rural US Square Miles	Road Miles Contained in Those Blocks	% of Total Non-Rural US Road Miles
U.S. Total (actual)	*5,671,972*	*256,376,768*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,653,368	256,294,560	100.0%	540,070	95.8%	2,274,393	98.9%
2 or more	5,611,115	255,917,152	99.8%	507,086	90.0%	2,227,566	96.9%
3 or more	5,505,751	254,454,272	99.3%	463,392	82.2%	2,139,392	93.1%
4 or more	5,161,649	247,042,128	96.4%	376,252	66.8%	1,908,572	83.0%
5 or more	537,854	18,861,312	7.4%	47,801	8.5%	216,934	9.4%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart III.A.v.a
Average Number of Mobile Wireless and LTE Providers in Census Tracts by Median Household Income in Non-Rural Areas with Population Density Greater Than 100 People per Square Mile, Mosaik, Centroid Method, January 2016

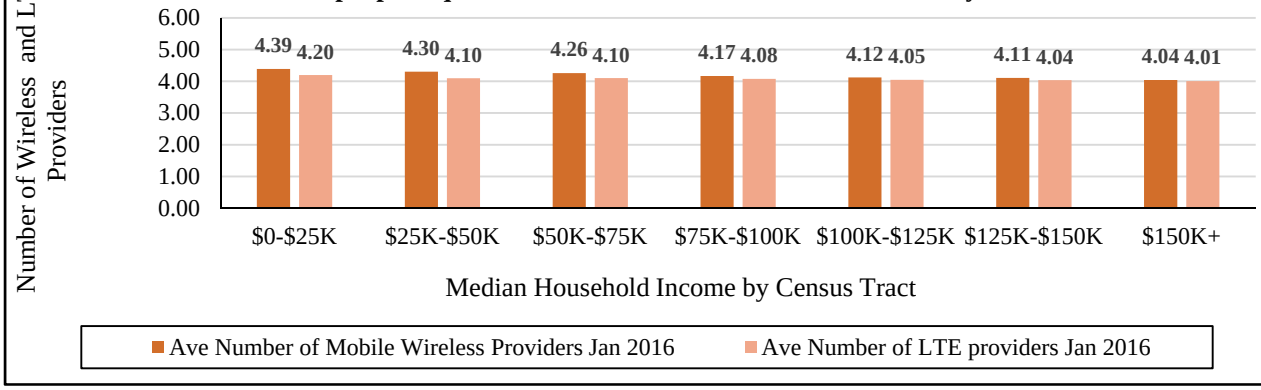


Chart III.A.v.b
Average Number of Mobile Wireless and LTE Providers in Census Tracts by Median Household Income in Rural Areas with Population Density Between 20 and 100 People per Square Mile, Mosaik, Centroid Method, January 2016

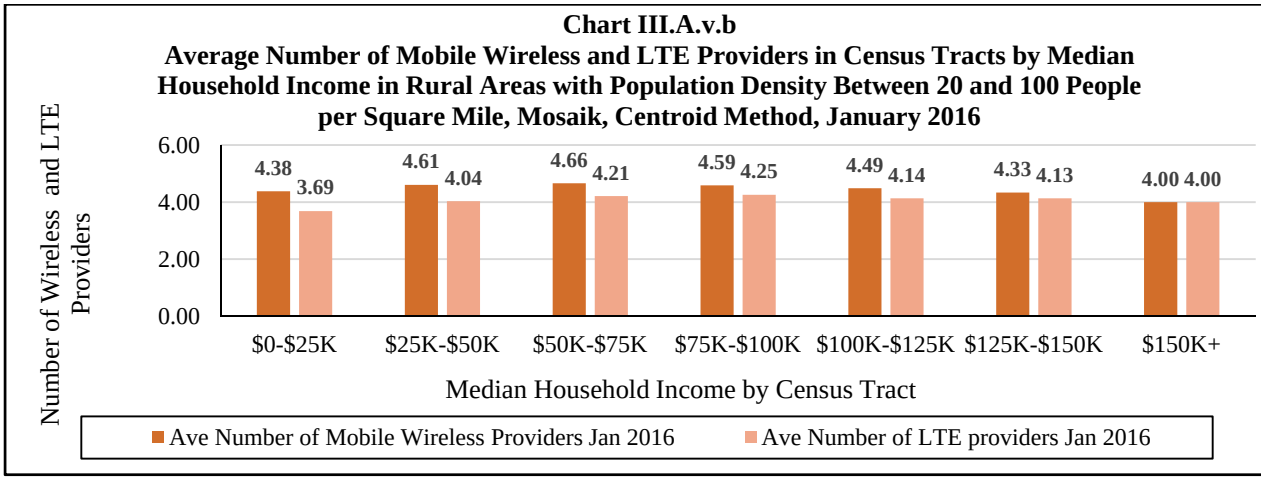
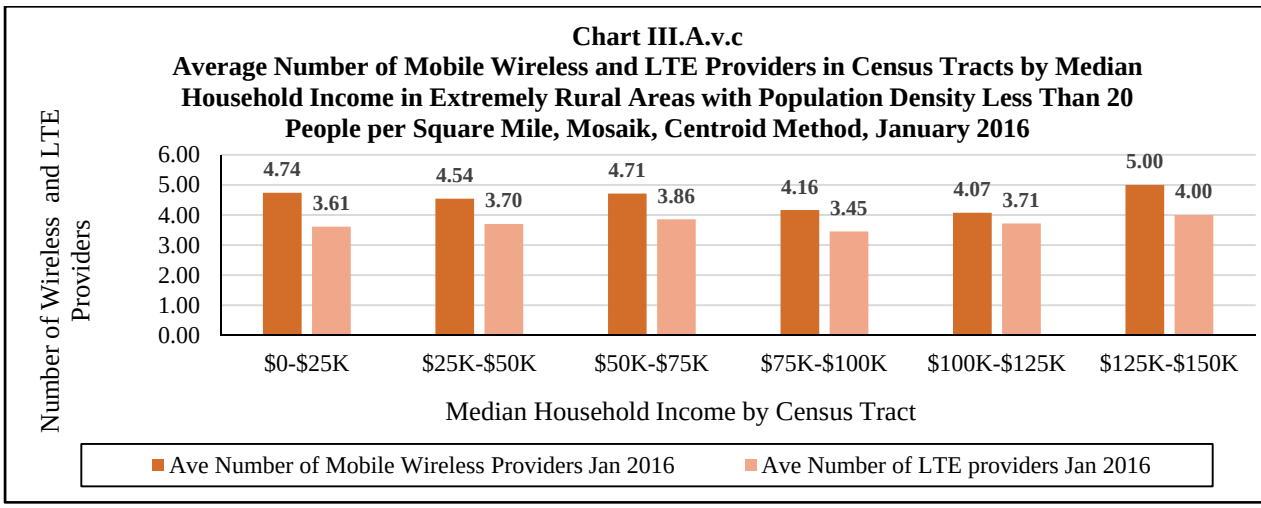


Chart III.A.v.c
Average Number of Mobile Wireless and LTE Providers in Census Tracts by Median Household Income in Extremely Rural Areas with Population Density Less Than 20 People per Square Mile, Mosaik, Centroid Method, January 2016



Source: Data on median household income by census tract are based on the U.S. Census Bureau's American Community Survey (ACS) 2009-2013. Data on the number of service providers are based on centroid analysis of Mosaik, January 2016 data. It is important to note that the number of mobile wireless or mobile LTE broadband service providers in a census tract represents network coverage, which does not necessarily mean that they offered service to any or all the residents in the census tract. In addition, we emphasize that a service provider reporting mobile wireless or LTE broadband coverage in a particular census tract may not provide coverage everywhere in the tract.

APPENDIX IV: INPUT MARKETS

Table IV.B.i
Year End Cell Site Counts by Service Provider, 2012–2015[424]

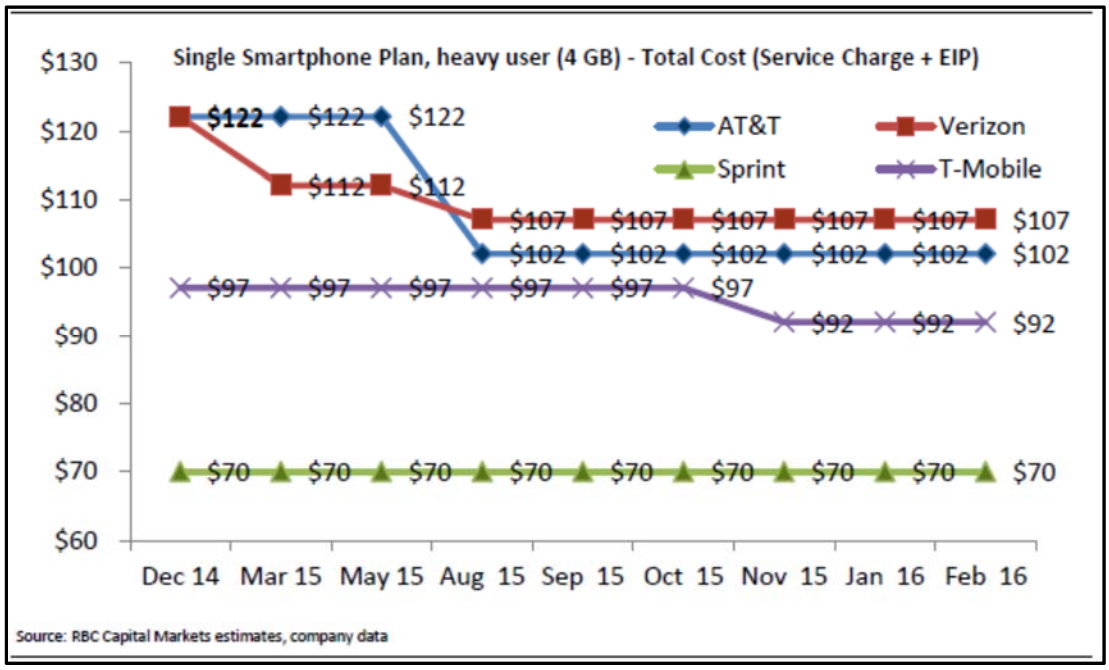
Cell Sites	2012	2013	2014	2015
Verizon Wireless	44,590	46,655	50,065	54,000
AT&T	56,900	61,800	71,768	66,500
Sprint	57,900	55,000	55,000	55,000
T-Mobile	51,104	63,879	61,079	57,971
NTELOS	1,429	1,444	1,453	967
U.S. Cellular	8,028	6,975	6,220	6,297
Total by Top Seven Reported Service Providers	**228,951**	**244,753**	**245,585**	**240,735**
CTIA Reported Total Industry-wide Cell Sites	**301,779**	**304,360**	**298,055**	**307,626**

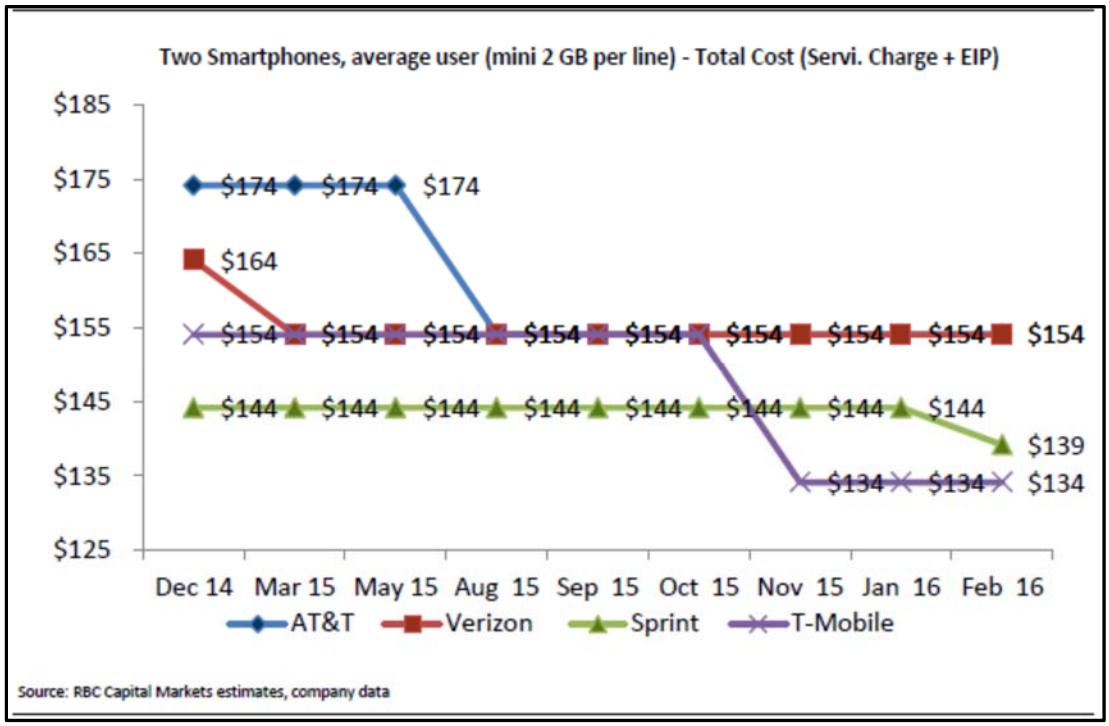
Source: Cell site counts for service providers are from UBS US Wireless 411, Version 59, Figure 75. The total industry-wide cell count is from CTIA Wireless Industry Indices Year-End 2015, at 72, 74.

[424] CTIA Wireless Industry Indices Year-End 2015 at 72, 74. 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.

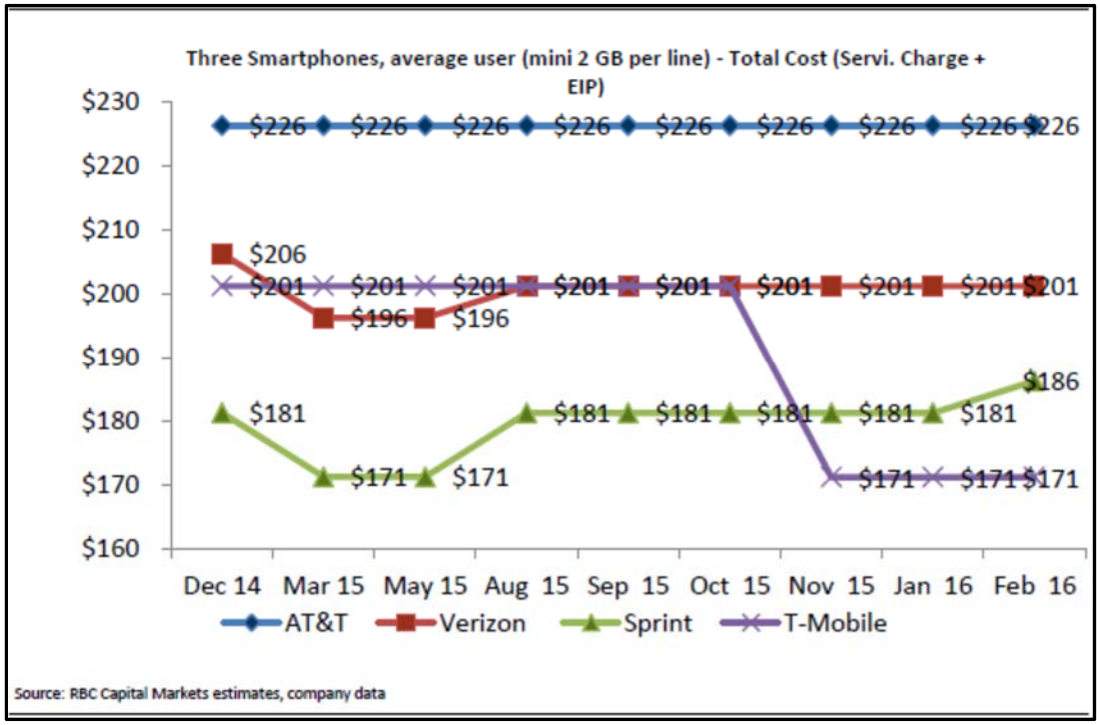
APPENDIX V: PRICING

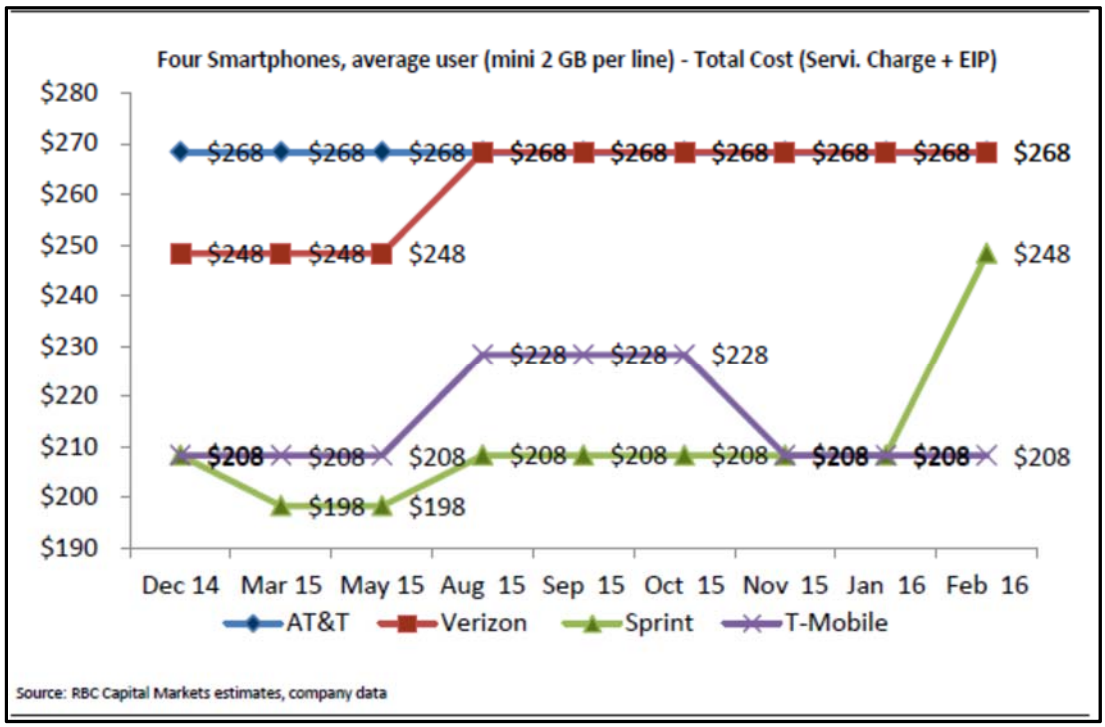
The charts below show pricing changes for various plans across the four nationwide service providers, sourced from RBC Capital Markets, for the time period December 2014 through February 2016.[425]





[425] Jonathan Atkin, Brian Hyun and Bora Lee, RBC Capital Markets, Equity Research, Wireless Telecommunications Services, (Feb. 23, 2016).


Three Smartphones, average user (mini 2 GB per line) - Total Cost (Servi. Charge + EIP)
$230
$220
$210
$200
$190
$180
$170
$160
$226 $226 $226 $226 $226 $226 $226 $226 $226
$206
$201 $201 $201 $201 $201 $201 $201 $201 $201
$196 $196
$186
$181
$181 $181 $181 $181 $181
$171 $171
$171 $171 $171
Dec 14 Mar 15 May 15 Aug 15 Sep 15 Oct 15 Nov 15 Jan 16 Feb 16
AT&T
Verizon
Sprint
T-Mobile
Source: RBC Capital Markets estimates, company data


Four Smartphones, average user (mini 2 GB per line) - Total Cost (Servi. Charge + EIP)
$280
$270
$260
$250
$240
$230
$220
$210
$200
$190
$268 $268 $268 $268 $268 $268 $268 $268 $268
$248 $248 $248
$248
$228 $228 $228
$208 $208 $208 $208 $208 $208 $208 $208 $208
$198 $198
Dec 14 Mar 15 May 15 Aug 15 Sep 15 Oct 15 Nov 15 Jan 16 Feb 16
AT&T
Verizon
Sprint
T-Mobile
Source: RBC Capital Markets estimates, company data

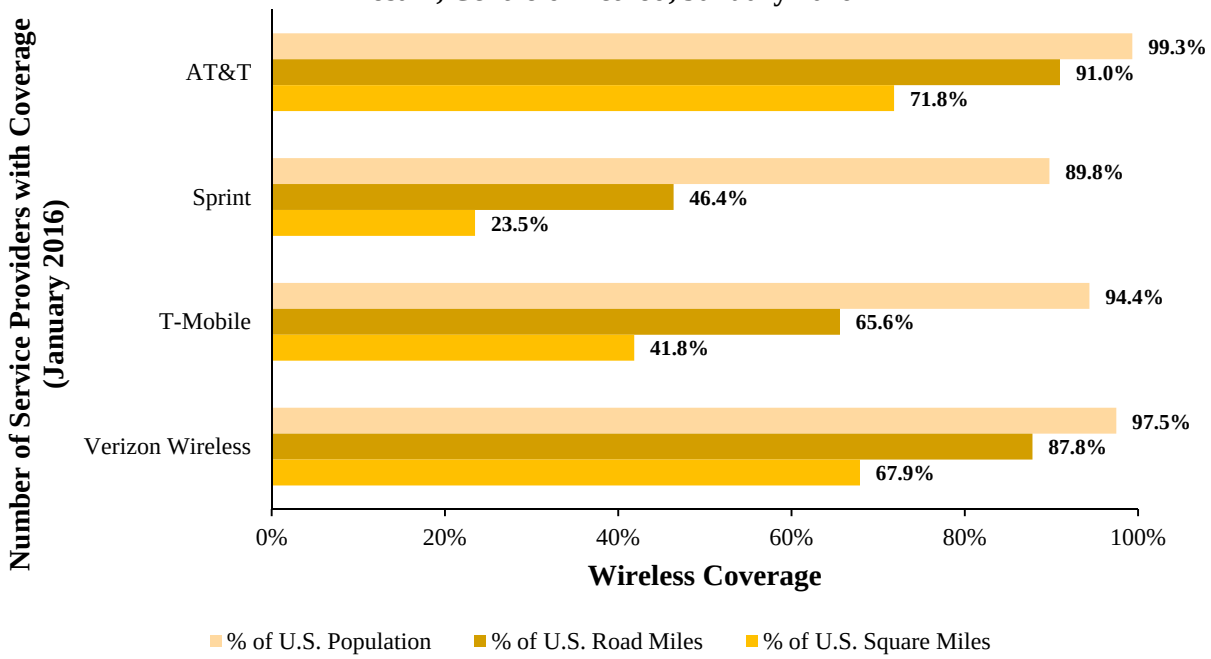
APPENDIX VI: NON-PRICE RIVALRY

Network Coverage

The tables and charts below are based on Commission estimates derived from census block analysis of January 2016 Mosaik CoverageRight coverage maps, and of December 2015 Form 477 coverage maps.[426] The centroid methodology is used to analyze both data sets. We note that the centroid methodology provides estimates of the percentage of the population located in census blocks with a certain number of service providers represents network coverage, which does not necessarily mean service is offered to residents in the census block. In addition, we emphasize that a service provider reporting coverage in a particular census block may not provide 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, and does not purport to measure competition.

The Form 477 coverage maps are also analyzed using the actual area coverage methodology (with the assumption of proportionality made as discussed above to generate population and road mile coverage).

Chart VI.A.i
Estimated Wireless Coverage by Provider Including Federal Land
Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

[426] Population data are from the 2010 Census, and include the United States and Puerto Rico. Square miles also include the United States and Puerto Rico.

Table VI.A.i
***Estimated* Wireless Coverage in the U.S. by Provider**
Mosaik, Centroid Method, January 2016

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
U.S. Total (actual)	*10,609,302*	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	10,164,000	310,414,237	99.3%	2,551,001	71.8%	6,203,234	91.0%
Sprint	7,191,701	280,490,010	89.8%	833,583	23.5%	3,162,984	46.4%
T-Mobile	8,528,090	294,917,583	94.4%	1,485,820	41.8%	4,472,563	65.6%
Verizon Wireless	9,897,265	304,609,818	97.5%	2,411,071	67.9%	5,987,063	87.8%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.ii
***Estimated* Wireless Coverage in the U.S. by Provider**
Form 477, Centroid Method, December 2015

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
U.S. Total (actual)	*10,609,302*	*312,471,32*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	10,162,425	310,397,72	99.3%	2,552,337	71.9%	6,206,628	91.0%
Sprint	7,733,234	288,642,24	92.4%	1,012,594	28.5%	3,599,457	52.8%
T-Mobile	8,615,379	295,563,67	94.6%	1,532,497	43.2%	4,558,616	66.9%
Verizon Wireless	9,851,397	304,250,34	97.4%	2,383,851	67.1%	5,944,300	87.2%

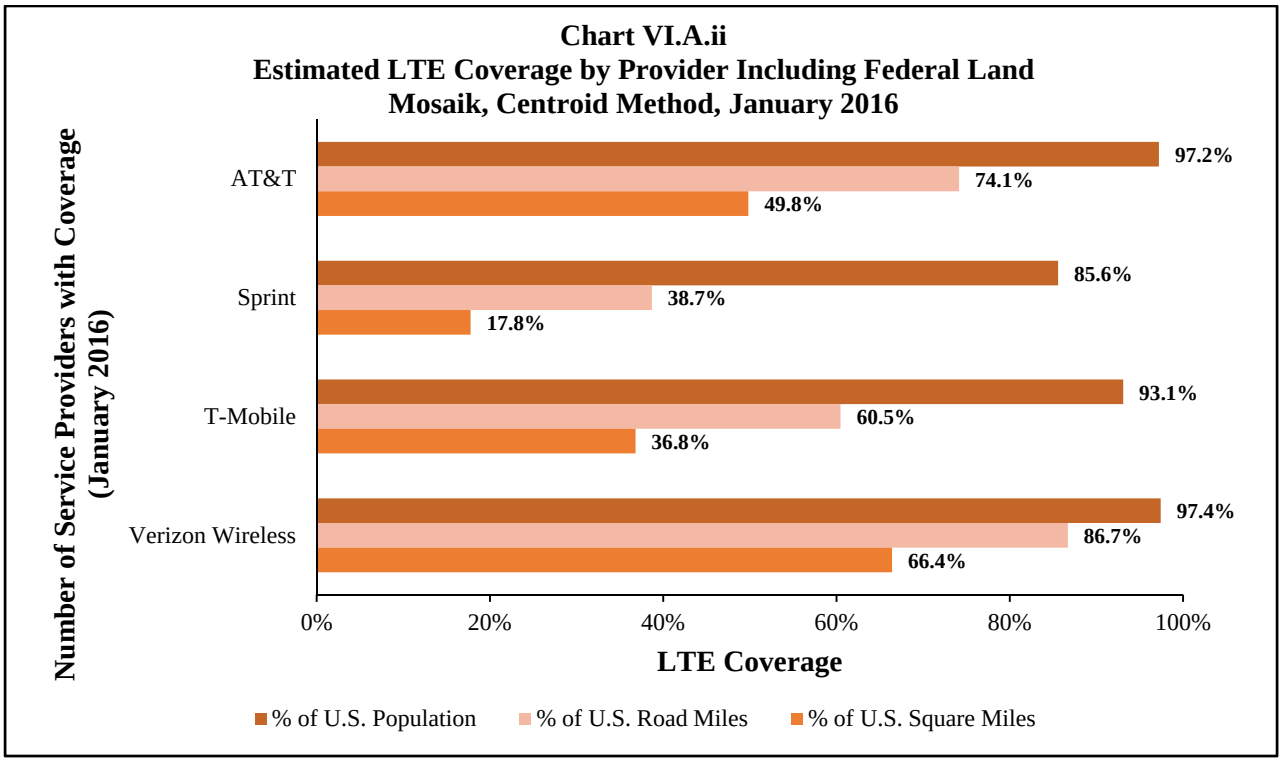
Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.iii
Estimated Wireless Coverage in the U.S. by Provider
Form 477, Actual Area Coverage, December 2015

Provider	Covered POPs	% of Total US POPs	Covered Square Miles	% of Total US Square Miles	Covered Road Miles	% of Total US Road Miles
US Total (actual)	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	309,877,510	99.2%	2,543,856	71.6%	6,182,862	90.7%
Sprint	288,001,752	92.2%	1,009,097	28.4%	3,583,663	52.6%
T-Mobile	294,974,652	94.4%	1,531,158	43.1%	4,545,616	66.7%
Verizon Wireless	303,648,526	97.2%	2,352,611	66.3%	5,904,465	86.6%

Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges many blocks are only partially covered. As it is unclear which of these blocks should be considered covered or not, we decline from reporting the number of blocks covered in these results.

Chart VI.A.ii
Estimated LTE Coverage by Provider Including Federal Land
Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.iv
***Estimated* LTE Coverage in the U.S. by Provider**
Mosaik, Centroid Method, January 2016

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
US Total *(actual)*	*10,609,302*	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	9,225,139	303,793,314	97.2%	1,769,528	49.8%	5,055,230	74.1%
Sprint	6,420,771	267,388,944	85.6%	631,164	17.8%	2,638,153	38.7%
T-Mobile	8,179,456	290,907,605	93.1%	1,307,170	36.8%	4,122,707	60.5%
Verizon Wireless	9,848,821	304,379,420	97.4%	2,358,410	66.4%	5,911,143	86.7%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.v
***Estimated* LTE Coverage in the U.S. by Provider**
Form 477, Centroid Method, December 2015

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Square Miles Contained in Those Blocks	% of Total US Square Miles	Road Miles Contained in Those Blocks	% of Total US Road Miles
US Total (actual)	*10,609,302*	*312,471,328*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	9,238,920	303,885,645	97.3%	1,785,993	50.3%	5,079,633	74.5%
Sprint	7,064,653	278,126,690	89.0%	822,843	23.2%	3,131,898	45.9%
T-Mobile	8,310,724	292,029,945	93.5%	1,373,994	38.7%	4,248,666	62.3%
Verizon Wireless	9,750,726	303,519,787	97.1%	2,295,953	64.7%	5,811,469	85.2%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.vi
***Estimated* LTE Coverage in the U.S. by Provider**
Form 477, Actual Area Coverage, December 2015

Provider	Covered POPs	% of Total US POPs	Covered Square Miles	% of Total US Square Miles	Covered Road Miles	% of Total US Road Miles
US Total (actual)	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	303,336,789	97.1%	1,774,189	50.0%	5,059,433	74.2%
Sprint	277,451,976	88.8%	819,151	23.1%	3,116,684	45.7%
T-Mobile	291,425,017	93.3%	1,372,014	38.6%	4,235,647	62.1%
Verizon Wireless	302,881,610	96.9%	2,267,275	63.9%	5,771,296	84.7%

Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges many blocks are only partially covered. As it is unclear which of these blocks should be considered covered or not, we decline from reporting the number of blocks covered in these results.

Table VI.A.vii
***Estimated* Rural Wireless Coverage in the U.S. by Provider**
Mosaik, Centroid Method, January 2016

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total Rural US POPs	Road Miles Contained in Those Blocks	% of Total Rural US Road Miles
US Total (actual)	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	4,508,842	54,167,810	96.6%	3,925,552	86.9%
Sprint	1,983,893	33,020,380	58.9%	1,224,564	27.1%
T-Mobile	3,066,450	42,353,025	75.5%	2,333,444	51.6%
Verizon Wireless	4,341,445	52,463,962	93.5%	3,755,926	83.1%

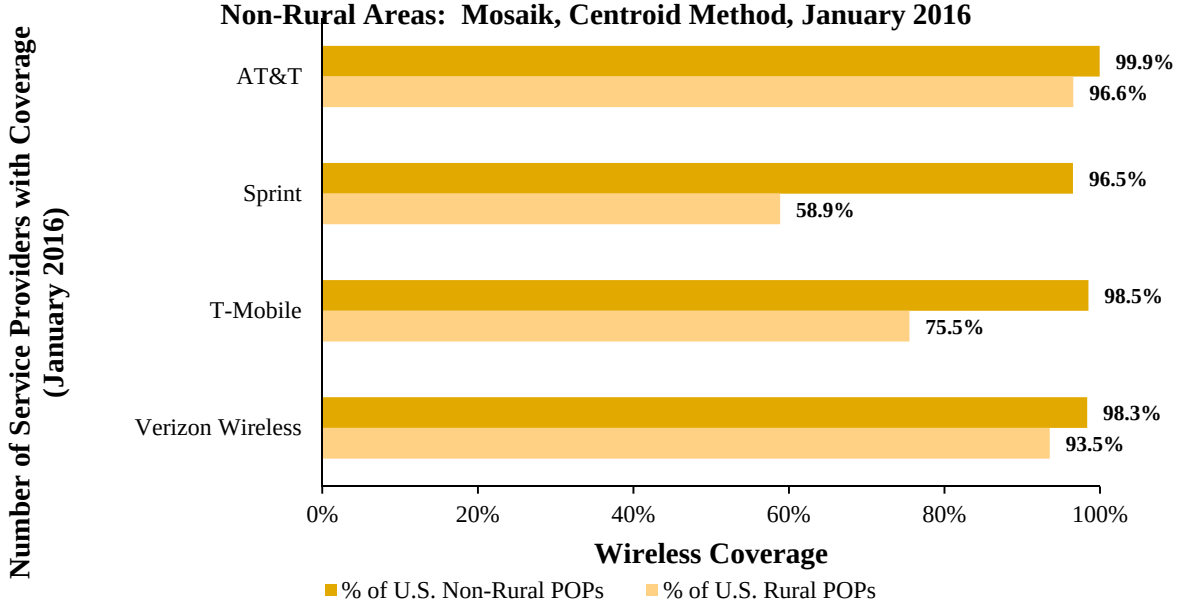
Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.viii
***Estimated* Non-Rural Wireless Coverage in the U.S. by Provider**
Mosaik, Centroid Method, January 2016

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total Non-Rural US POPs	Road Miles Contained in Those Blocks	% of Total Non-Rural US Road Miles
US Total (actual)	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,655,158	256,246,427	99.9%	2,277,682	99.1%
Sprint	5,207,808	247,469,630	96.5%	1,938,421	84.3%
T-Mobile	5,461,640	252,564,558	98.5%	2,139,119	93.1%
Verizon Wireless	5,555,820	252,145,856	98.3%	2,231,136	97.1%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart VI.A.iii
Estimated Wireless Coverage by Provider Including Federal Land in Rural vs. Non-Rural Areas: Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.ix
***Estimated* Rural Wireless Coverage in the U.S. by Provider**
Form 477, Centroid Method, December 2015

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Road Miles Contained in Those Blocks	% of Total US Road Miles
US Total (actual)	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	4,509,514	54,188,565	96.6%	3,929,550	87.0%
Sprint	2,335,609	36,703,213	65.4%	1,538,603	34.0%
T-Mobile	3,153,259	43,025,200	76.7%	2,417,467	53.5%
Verizon Wireless	4,305,415	52,206,365	93.1%	3,718,122	82.3%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.x
***Estimated* Non-Rural Wireless Coverage in the U.S. by Provider**
Form 477, Centroid Method, December 2015

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total US POPs	Road Miles Contained in Those Blocks	% of Total US Road Miles
US Total (actual)	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,652,911	256,209,155	99.9%	2,277,078	99.1%
Sprint	5,397,625	251,939,034	98.3%	2,060,854	89.6%
T-Mobile	5,462,120	252,538,471	98.5%	2,141,150	93.1%
Verizon Wireless	5,545,982	252,043,978	98.3%	2,226,179	96.8%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.xi
***Estimated* Rural Wireless Coverage in the U.S. by Provider**
Form 477, Actual Area Coverage, December 2015

Provider	Covered POPs	% of Total Rural US POPs	Covered Road Miles	% of Total US Rural Road Miles
US Total (actual)	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	54,064,622	96.4%	3,909,453	86.5%
Sprint	36,541,010	65.1%	1,529,046	33.8%
T-Mobile	42,859,748	76.4%	2,407,396	53.3%
Verizon Wireless	52,033,882	92.8%	3,683,561	81.5%

Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges many blocks are only partially covered. As it is unclear which of these blocks should be considered covered or not, we decline from reporting the number of blocks covered in these results.

Table VI.A.xii
***Estimated* Non-Rural Wireless Coverage in the U.S. by Provider**
Form 477, Actual Area Coverage, December 2015

Provider	Covered POPs	% of Total Non-Rural US POPs	Covered Road Miles	% of Total Non-Rural US Road Miles
US Total (actual)	*256,096,198*	*100.0%*	*2,298,858*	*100.0%*
AT&T	255,812,888	99.9%	2,273,409	98.9%
Sprint	251,460,741	98.2%	2,054,617	89.4%
T-Mobile	252,114,904	98.4%	2,138,220	93.0%
Verizon Wireless	251,614,644	98.3%	2,220,904	96.6%

Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges many blocks are only partially covered. As it is unclear which of these blocks should be considered covered or not, we decline from reporting the number of blocks covered in these results.

Table VI.A.xiii
***Estimated* Rural LTE Coverage in the U.S. by Provider**
Mosaik, Centroid Method, January 2016

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total Rural US POPs	Road Miles Contained in Those Blocks	% of Total Rural US Road Miles
US Total (actual)	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	3,667,621	48,699,117	86.8%	2,871,263	63.5%
Sprint	1,487,816	26,639,365	47.5%	862,756	19.1%
T-Mobile	2,795,015	40,127,548	71.5%	2,039,020	45.1%
Verizon Wireless	4,297,238	52,278,577	93.2%	3,684,220	81.5%

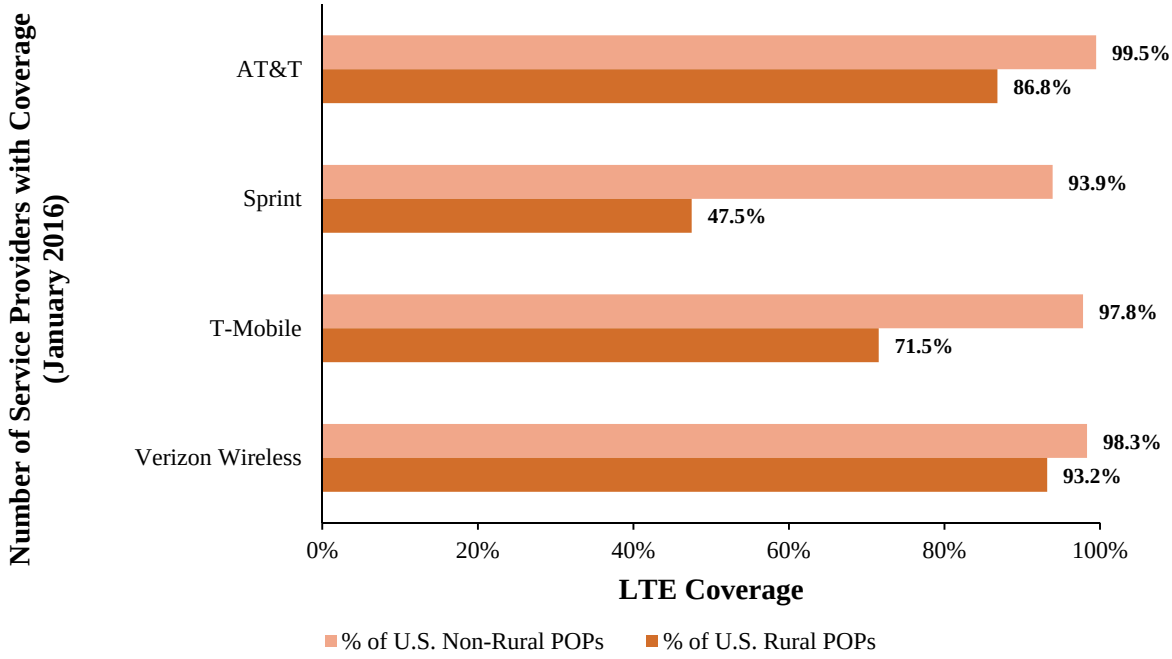
Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.xiv
***Estimated* Non-Rural LTE Coverage in the U.S. by Provider**
Mosaik, Centroid Method, January 2016

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total Non-Rural US POPs	Road Miles Contained in Those Blocks	% of Total Non-Rural US Road Miles
US Total (actual)	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,557,518	255,094,197	99.5%	2,183,967	95.0%
Sprint	4,932,955	240,749,579	93.9%	1,775,397	77.2%
T-Mobile	5,384,441	250,780,057	97.8%	2,083,687	90.6%
Verizon Wireless	5,551,583	252,100,843	98.3%	2,226,923	96.9%

Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Chart VI.A.iv
Estimated LTE Coverage by Provider Including Federal Land in Rural vs. Non-Rural Areas: Mosaik, Centroid Method, January 2016



Source: Based on centroid analysis of January 2016 Mosaik and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.xv
***Estimated* Rural LTE Coverage in the U.S. by Provider**
Form 477, Centroid Method, December 2015

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total Rural US POPs	Road Miles Contained in Those Blocks	% of Total Rural US Road Miles
US Total (actual)	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	3,682,424	48,817,626	87.0%	2,894,383	64.1%
Sprint	1,882,246	31,023,382	55.3%	1,202,010	26.6%
T-Mobile	2,920,377	41,133,354	73.3%	2,159,195	47.8%
Verizon Wireless	4,220,890	51,703,279	92.2%	3,600,068	79.7%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.xvi
***Estimated* Non-Rural LTE Coverage in the U.S. by Provider**
Form 477, Centroid Method, December 2015

Provider	Number of Blocks	POPs Contained in Those Blocks	% of Total Non-Rural US POPs	Road Miles Contained in Those Blocks	% of Total US Non-Rural Road Miles
US Total (actual)	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,556,496	255,068,019	99.5%	2,185,250	95.1%
Sprint	5,182,407	247,103,308	96.4%	1,929,888	83.9%
T-Mobile	5,390,347	250,896,591	97.9%	2,089,471	90.9%
Verizon Wireless	5,529,836	251,816,508	98.2%	2,211,402	96.2%

Source: Based on centroid analysis of December 2015 Form 477 and 2010 Census data. It is important to note that the number of service providers in a census block represent network coverage only. Network coverage does not necessarily reflect the number of service providers from which any particular individual or household in a given area may choose. These coverage calculations, while useful for measuring developments in mobile coverage, have certain limitations that likely result in an overstatement of the extent of mobile coverage.

Table VI.A.xvii
***Estimated* Rural LTE Coverage in the U.S. by Provider**
Form 477, Actual Area Coverage, December 2015

Provider	Covered POPs	% of Total Rural US POPs	Covered Road Miles	% of Total US Rural Road Miles
US Total (actual)	*56,094,554*	*100.0%*	*4,406,356*	*100.0%*
AT&T	48,689,265	86.8%	2,878,685	63.7%
Sprint	30,885,864	55.1%	1,193,595	26.4%
T-Mobile	40,969,032	73.0%	2,149,968	47.6%
Verizon Wireless	51,516,164	91.8%	3,565,664	78.9%

Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges many blocks are only partially covered. As it is unclear which of these blocks should be considered covered or not, we decline from reporting the number of blocks covered in these results.

Table VI.A.xviii
***Estimated* Non-Rural LTE Coverage in the U.S. by Provider**
Form 477, Actual Area Coverage, December 2015

Provider	Covered POPs	% of Total Non-Rural US POPs	Covered Road Miles	% of Total US Non-Rural Road Miles
US Total (actual)	*256,376,773*	*100.0%*	*2,296,063*	*100.0%*
AT&T	254,647,524	99.3%	2,180,748	94.9%
Sprint	246,566,112	96.2%	1,923,089	83.7%
T-Mobile	250,455,985	97.7%	2,085,679	90.7%
Verizon Wireless	251,365,445	98.0%	2,205,632	95.9%

Source: Based on actual area coverage analysis of December 2015 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges many blocks are only partially covered. As it is unclear which of these blocks should be considered covered or not, we decline from reporting the number of blocks covered in these results.

Quality of Service

***Ookla*:** An in-depth discussion of the Ookla speed test is available in the *Seventeenth Report*.[427] In this *Report*, we present LTE upload and download speeds within the United States for the second half of 2014 through the second half of 2015.[428]

Table VI.B.i
Ookla Speed Test - Estimated LTE Download Speeds by Service Provider, Nationwide

Service Provider	2H2014			1H2015			2H2015		
	Mean Download Speed (Mbps)	Median Download Speed (Mbps)	Number of Tests ('000s)	Mean Download Speed (Mbps)	Median Download Speed (Mbps)	Number of Tests ('000s)	Mean Download Speed (Mbps)	Median Download Speed (Mbps)	Number of Tests ('000s)
AT&T	14.51	10.49	3,362	14.66	10.04	2,969	16.96	11.72	2,720
Sprint	9.40	6.69	2,360	10.42	6.90	2,113	13.65	8.50	2,604
T-Mobile	19.80	16.62	3,529	19.64	15.07	3,806	21.10	15.42	3,990
Verizon Wireless	17.67	12.82	3,314	18.55	13.55	2,879	19.66	14.48	2,899

Source: Ookla SPEEDTEST intelligence data, © 2015 Ookla, LLC. All rights reserved. Published with permission of Ookla.

Table VI.B.ii
Ookla Speed Test - Estimated LTE Upload Speeds by Service Provider, Nationwide

Service Provider	2H2014			1H2015			2H2015		
	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	6.12	4.69	3,362	6.07	4.61	2,969	6.43	4.75	2,720
Sprint	3.86	3.18	2,360	4.12	3.20	2,113	4.51	3.46	2,604
T-Mobile	9.64	8.47	3,529	9.92	8.66	3,806	11.22	9.23	3,990
Verizon Wireless	6.97	4.90	3,314	7.29	4.84	2,879	7.87	4.89	2,899

Source: Ookla SPEEDTEST intelligence data, © 2015 Ookla, LLC. All rights reserved. Published with permission of Ookla.

[427] *Seventeenth Report*, 29 FCC Rcd at 15465-66, Appendix VI., paras. 1-6.

[428] The upload and download speeds were calculated by Ookla and provided to the Commission for use in this *Report*.

***FCC*:** An in-depth discussion of the FCC Speed Test is available in the *Seventeenth Report*.[429] In this *Report*, we present LTE upload and download speeds within the United States for 2015.[430]

Table VI.B.iii
FCC Speed Test - Estimated LTE Download Speeds by Service Provider's Flagship Brand, Nationwide

Service Provider	1H2015			2H2015		
	Mean Down load Speed (Mbps)	Median Down load Speed (Mbps)	Number of tests	Mean Down load Speed (Mbps)	Median Down load Speed (Mbps)	Number of tests
AT&T	12.34	8.17	34,185	13.92	9.32	30,001
Sprint	8.60	5.56	17,162	13.27	6.73	18,225
T-Mobile	19.09	14.49	39,004	19.51	14.39	34,763
Verizon	17.44	12.48	60,575	17.51	12.61	55,288

Source: Data from FCC Measuring Mobile Broadband America data. Observations do not include failed tests, or those with a download speed equal to or less than zero. Estimated download speed data excludes any discount brands offered by a service provider.

Table VI.B.iv
FCC Speed Test - Estimated LTE Upload Speeds by Service Provider's Flagship Brand, Nationwide

Service Provider	1H2015			2H2015		
	Mean Upload Speed (Mbps)	Median Upload Speed (Mbps)	Number of tests	Mean Upload Speed (Mbps)	Median Upload Speed (Mbps)	Number of tests
AT&T	5.22	3.93	30,113	5.34	3.93	26,271
Sprint	3.65	2.73	15,452	3.96	2.81	16,232
T-Mobile	9.95	8.20	35,375	10.38	8.50	30,860
Verizon	6.76	4.32	58,702	6.79	4.09	53,496

Source: Data from FCC Measuring Mobile Broadband America data. Observations do not include failed tests, or those with an upload speed equal to or less than zero. Estimated upload speed data excludes any discount brands offered by a service provider.

[429] *Seventeenth Report*, 29 FCC Rcd at 15467, Appendix VI., paras. 7-9.

[430] Throughput speeds were converted from bytes/sec to Mbps using a conversion of [1 Mbps=8*(10^-6) bytes/sec]. Any observation with a download or upload speed equal to or less than zero was dropped from the calculations. In addition, the top 1% of speed observations were trimmed from the dataset, by service provider and separately for each time period. Roaming observations were not included in the calculations. Only observations within the United States were included in the analysis. All tests performed over Wi-Fi were dropped, and only mobile observations were included in the analysis.

RootMetrics. An in-depth discussion of the RootMetrics dataset is available in the *Seventeenth Report*.[431] In this *Report*, we present mobile wireless upload and download speeds for the second half of 2015, and mobile wireless indices within the United States for the second half of 2014 through the second half of 2015.

Table VI.B.v
RootMetrics Speed Test–Estimated LTE Upload Speeds, Nationwide

Service Provider	2H2015	
	Median Upload speed (Mbps)	Number of Tests
AT&T	6.71	161,124
Sprint	3.16	160,314
T-Mobile	11.30	160,862
Verizon Wireless	10.47	161,005

Source: RootMetrics Data, 2015, © RootMetrics. All rights reserved. Published with permission of RootMetrics.

Table VI.B.vi
RootMetrics National Speed Index Data, 2nd Half 2014--2st Half 2015

	2nd Half 2014			1st Half 2015			2nd Half 2015		
Service Provider	Speed Index	Data Index	Text Index	Speed Index	Data Index	Text Index	Speed Index	Data Index	Text Index
AT&T	85.5	91.5	93.2	88.5	94.1	95.5	86.8	93.2	96.5
Sprint	71.0	81.4	92.7	75.8	85.0	95.0	73.1	83.1	95.8
T-Mobile	79.1	81.9	89.7	85.1	87.0	90.5	84.7	87.1	92.2
Verizon Wireless	89.0	94.5	92.4	91.9	96.6	95.2	92.0	95.9	97.0

Source: RootMetrics Data, © RootMetrics. All rights reserved. Published with permission of RootMetrics.

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

CalSPEED. An in-depth discussion of the CalSPEED dataset is available in the *Seventeenth Report*.[432] In this *Report*, we present LTE upload and download speeds within California for the fall of 2014 through the fall of 2015.[433]

Table VI.B.vii
CalSPEED - Estimated LTE Download Speeds by Service Provider, California Only

Service Provider	Fall 2014			Spring 2015			Fall 2015		
	Mean LTE Download Speed (Mbps)	Median LTE Download Speed (Mbps)	Number of Tests	Mean LTE Download Speed (Mbps)	Median LTE Download Speed (Mbps)	Number of Tests	Mean LTE Download Speed (Mbps)	Median LTE Download Speed (Mbps)	Number of Tests
AT&T	10.86	8.93	1,241	9.04	7.55	1,296	12.26	11.18	3,044
Sprint	5.21	3.32	538	5.16	3.30	740	9.78	7.87	1,970
T-Mobile	10.52	9.49	878	9.81	9.56	687	11.84	11.93	2,220
Verizon Wireless	13.79	12.64	1,592	11.94	11.75	1,388	14.36	15.49	3,124

Source: The estimated speeds are based on the CalSPEED data. The top 1% of speed values were dropped, by provider and time period. Round 6 (Fall 2014) observations were measured between 9/25/2014 to 11/21/2014. Round 7 (Spring 2015) observations were measured between 4/30/2015 to 6/15/2015. Round 8 (Fall 2015) observations were measured between 12/3/2015 to 1/22/2016.

Table VI.B.viii
CalSPEED - Estimated LTE Upload Speeds by Service Provider, California Only

Service Provider	Fall 2014			Spring 2015			Fall 2015		
	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	5.68	5.90	1,243	5.55	5.57	1,296	5.88	5.41	3,044
Sprint	2.79	2.04	536	2.68	1.35	740	4.14	3.60	1,968
T-Mobile	6.02	6.92	878	6.70	7.99	687	7.92	9.07	2,220
Verizon Wireless	5.91	5.85	1,592	6.57	6.37	1,388	7.59	8.16	3,124

Source: The estimated speeds are based on the CalSPEED data. The top 1% of speed values were dropped, by provider and time period. Round 6 (Fall 2014) observations were measured between 9/25/2014 to 11/21/2014. Round 7 (Spring 2015) observations were measured between 4/30/2015 to 6/15/2015. Round 8 (Fall 2015) observations were measured between 12/3/2015 to 1/22/2016.

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

[433] The throughput speed was replaced with a value of zero for certain test errors, which correspond to the method used by CPUC. Tests were not included if they were quit by the user, if the test was outside of the service area, or 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 may be different from the other speed tests.

APPENDIX VII: CONSUMERS AND TRENDS IN THE MOBILE WIRELESS ECOSYSTEM

Table VII.C.i
Percentage of U.S. Adults Living in Households with/without Wireless and Landlines (2010-2015)

	Percent of Adults in Households with:			
Date of interview	Landline with Wireless	Landline without Wireless	Wireless-only	Phoneless
Jan-Jun 2009	63.5%	13.4%	21.1%	1.5%
Jul-Dec 2009	62.5%	12.6%	22.9%	1.7%
Jan-Jun 2010	62.2%	10.9%	24.9%	1.7%
Jul-Dec 2010	59.4%	10.7%	27.8%	1.8%
Jan-Jun 2011	58.8%	9.0%	30.2%	1.8%
Jul-Dec 2011	57.3%	8.3%	32.3%	1.9%
Jan-Jun 2012	56.1%	7.8%	34.0%	1.9%
Jul-Dec 2012	54.4%	7.0%	36.5%	1.9%
Jan-Jun 2013	52.8%	6.9%	38.0%	2.2%
Jul-Dec 2013	51.5%	7.0%	39.1%	2.2%
Jan-Jun 2014	47.3%	7.0%	43.1%	2.4%
Jul-Dec 2014	45.8%	7.1%	44.1%	2.9%
Jul-Dec 2015	43.9%	6.2%	46.7%	3.1%
Jul-Dec 2015	43.7%	5.8%	47.7%	2.7%

Note: Adults are aged 18 and over, children are under age 18. Source: CDC/NCHS National Health Interview Survey.

Table VII.C.ii
Percentage of U.S. Children Living in Households with/without Wireless and Landlines (2010-2015)

	Percent of Children in Households with:			
Date of interview	Landline with Wireless	Landline without Wireless	Wireless-only	Phoneless
Jan-Jun 2009	67.6%	9.1%	21.3%	1.7%
Jul-Dec 2009	63.4%	8.5%	25.9%	1.9%
Jan-Jun 2010	62.8%	6.4%	29.0%	1.7%
Jul-Dec 2010	59.8%	6.2%	31.8%	2.0%
Jan-Jun 2011	56.7%	5.1%	36.4%	1.7%
Jul-Dec 2011	54.7%	4.8%	38.1%	2.2%
Jan-Jun 2012	52.7%	4.5%	40.6%	2.2%
Jul-Dec 2012	49.5%	3.4%	45.0%	1.9%
Jan-Jun 2013	48.3%	3.6%	45.4%	2.6%
Jul-Dec 2013	46.4%	3.8%	47.1%	2.5%
Jan-Jun 2014	47.1%	3.5%	52.1%	2.7%
Jul-Dec 2014	39.1%	3.3%	54.1%	3.4%
Jan-Jun 2015	38.3%	3.0%	55.3%	3.2%
Jul-Dec 2015	36.2%	2.8%	57.7%	3.1%

Note: Adults are aged 18 and over, children are under age 18. Source: CDC/NCHS National Health Interview Survey.