APPENDIX VI

NON-PRICE RIVALRY

Investment

Table VI.A.i

Quarterly Capital Expenditure by Mobile Wireless Providers (In millions)
1Q2011 – 2Q2014

	1Q11	2Q11	3Q11	4Q11	1Q12	2Q12	3Q12	4Q12	1Q13	2Q13	3Q13	4Q13	1Q14	2Q14
National Operators														
Verizon Wireless	2,735	2,667	1,784	1,787	1,885	2,048	2,133	2,791	1,992	2,278	2,450	2,705	2,554	2,771
AT&T	1,870	2,511	2,520	2,863	2,324	2,345	2,709	3,417	2,296	3,033	3,060	2,802	3,082	3,480
Sprint	449	546	647	774	710	1,012	1,376	1,786	1,706	1,728	1,683	1,716	1,057	1,416
T-Mobile	749	688	741	551	747	539	717	898	1,076	1,050	1,017	882	947	940
Total National	5,803	6,412	5,692	5,975	5,666	5,944	6,935	8,892	7,070	8,089	8,210	8,105	7,640	8,607
Regional Operators														
Cincinnati Bell	5	1	5	7	6	2	4	3	8	2	2	4	6	0.6
Leap	93	93	103	152	146	119	106	63	26	22	90	130		
Metro PCS	187	265	248	190	144	182	262	258						
NTELOS	8	13	14	23	13	19	22	19	17	27	21	16	14	32
US Cellular	96	162	248	276	201	183	199	253	118	169	243	208	90	144
Total Regional	388	534	618	649	511	505	593	595	170	220	356	358	110	177
Total	6,191	6,946	6,310	6,624	6,177	6,449	7,528	9,487	7,240	8,309	8,566	8,462	7,750	8,784

Notes: Based on UBS Wireless 411 Report, Version 51 at 28. Metro PCS data are not available separately after the fourth quarter of 2012 as the T-Mobile and MetroPCS merger was consummated in early 2013. Leap is reported separately from AT&T as the AT&T and Leap merger was not consummated by the fourth quarter of 2013.

Network Coverage and Technology Upgrades

1. Appendix Tables VI.B.i – VI.B.vi contain detailed data on the percentage of the U.S. population, land area, and road miles covered by each of the top four mobile wireless service providers, and top four mobile broadband providers, and also show rural and non-rural breakdown for these categories. All tables are derived from Commission estimates based on census block analysis of Mosaik Coverage Right coverage maps, January 2014. Excludes coverage for Island Areas (Guam, American Samoa, US Virgin Islands, Mariana Islands. Population data are from the 2010 Census. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

Table VI.B.i
Estimated Mobile Wireless Coverage in the U.S. by Provider
January 2014

Provider	Number of Blocks	POPS Contained in Those Blocks	% of Total US POPs	% of Total US Square Miles	% of Total US Road Miles
ATT	10,324,435	308,396,818	98.7	61.8	85.3
VZW	10,164,336	302,838,131	96.9	61.2	84.8
Sprint	7,606,057	280,488,603	89.8	24.9	48.1
T-Mobile	8,286,265	287,702,030	92.1	34.3	58.3

Source: Mosaik January 2014, Census 2010.The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

Table VI.B.ii

Estimated Mobile Wireless Network Coverage, Selected Facilities-Based Providers
***Voice Networks*,**
2009-2014 (Covered POPs, in millions)

Service Provider	Oct. 2009	Oct. 2010	Apr. 2011	Jan. 2012	Oct. 2012	Jan. 2014
AT&T	262.8	281.9	306.3	306.6	307.2	306.9
Verizon Wireless	270.5	284.9	299.5	299.5	300.0	300.6
T-Mobile	246.2	249.5	282.5	284.8	281.4	286.7
Sprint Nextel	258.0	263.2	292.1	291.2	290.3	275.2
MetroPCS	84.6	92.1	105.0	105.4	108.1	-
Leap	80.5	82.7	94.0	93.4	94.2	-
US Cellular	41.7	41.5	44.2	44.0	44.0	314.6

Note: The estimates in this Table are based on our census block analysis of Mosaik CoverageRight coverage maps using the April 2011, January 2012, and October 2012 data. The population data are from the 2010 Census. Estimates for 2009 and 2010 are obtained from the *Fifteenth Report*, 25 FCC Rcd at 9702 ¶ 45. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

Table VI.B.iii
Estimated Mobile Wireless Broadband Coverage in the U.S. by Provider
January 2914

Provider	Number of Blocks	POPS Contained in Those Blocks	% of Total US POPs	% of Total US Square Miles	% of Total US Road Miles
ATT	9,920,357	305,640,460	97.8	55.1	79.2
VZW	10,113,892	302,645,159	96.9	59.5	83.6
Sprint	7,507,299	278,989,810	89.3	24.5	47.4
T-Mobile	5,603,484	246,362,777	78.8	15.0	32.3

. Source: Mosaik January 2014, Census 2010. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

Table VI.B.iv

Estimated Mobile Wireless Network Coverage, Selected Facilities-Based Providers
Broadband Networks,
2009-2014 (Covered POPs, in millions)

Service Provider	Nov. 2009	Aug. 2010	Apr. 2011	Jan. 2012	Oct. 2012	Jan. 2014
AT&T	212.3	228.6	276.1	289.9	296.7	305.7
Verizon Wireless	266.7	270.0	298.0	299.2	300.4	302.6
Sprint Nextel	226.9	239.4	276.4	273.7	275.1	279.1
T-Mobile	133.9	183.8	214.7	227.6	235.4	246.3
MetroPCS	-	-	62.2	72.4	108.3	-
Clearwire	-	-	108.9	105.1	105.3	-
Leap	79.2	81.5	92.6	92.3	93.4	-
US Cellular	26.6	30.0	40.7	41.1	43.2	311.9

Note: For purposes of this, and earlier, *Mobile Wireless Competition Reports*, we include coverage by WCDMA/HSPA, HSPA+, EV-DO, WiMAX, and LTE networks within our estimate of mobile broadband network coverage. Commission estimates based on census block analysis of Mosaik CoverageRight coverage maps, April 2011, January 2012, and October 2012. Population data are from the 2010 Census. Estimates for 2009 and 2010 are obtained from the *Fifteenth Report*. *Fifteenth Report*, 25 FCC Rcd at 9702 ¶ 45. The recent *Broadband Progress Report* did not include WCDMA/HSPA or EV-DO networks in its definition of mobile broadband networks. *2012 Eighth Broadband Progress Report*, WN Docket No. 11-121 (rel. Aug. 21, 2012) ¶ 40. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

Table VI.B.v
Estimated Mobile Wireless Voice Coverage in Rural Areas by Provider
January 2014

	Number of Rural Census Blocks	POPS Contained in Rural Census Blocks	% of Total U.S. POPs	% of Total U.S. Square Miles	% of Total U.S. Road Miles
Total for US	5,387,335	59,151,859	18.9	84.5	67.3
Provider	**Number of Rural Census Blocks**	**POPS Contained in Rural Census Blocks**	**% of Total Rural U.S. POPs**	**% of Total Rural U.S. Square Miles**	**% of Total Rural U.S. Road Miles**
ATT	4,349,508	53,931,208	91.2	49.3	72.1
VZW	4,404,874	52,710,410	89.1	54.1	76.1
Sprint	2,153,983	34,185,221	57.8	15.3	27.7
T-Mobile	2,763,501	38,999,396	65.9	25.3	41.1

Source: Mosaik January 2014, Census 2010. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

Table VI.B.vi
Estimated Mobile Wireless Voice Coverage in Non-Rural Areas by Provider
January 2014

	Number of Non-Rural Census Blocks	POPS Contained in Non-Rural Census Blocks	% of Total U.S. POPs	% of Total U.S. Square Miles	% of Total U.S. Road Miles
Total for US	5,768,151	253,319,468	81.8	15.5	32.7
Provider	**Number of Non-Rural Census Blocks**	**POPS Contained in Non-Rural Census Blocks**	**% of Total Non-Rural U.S. POPs**	**% of Total Non-Rural U.S. Square Miles**	**% of Total Non-Rural U.S. Road Miles**
ATT	5,716,694	252,900,141	99.8	89.4	97.7
VZW	5,582,339	247,913,734	97.9	85.7	95.3
Sprint	5,158,015	240,994,632	95.1	60.6	79.8
T-Mobile	5,425,720	247,797,133	97.8	74.8	89.4

Source: Mosaik January 2014, Census 2010. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

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Table VI.B.vii
Estimated Mobile Broadband Coverage in Rural Areas by Provider
January 2014

	Number of Rural Census Blocks	POPS Contained in Rural Census Blocks	% of Total U.S. POPs	% of Total U.S. Square Miles	% of Total U.S. Road Miles
Total for US	5,387,335	59,151,859	18.9	84.5	67.3
Provider	**Number of Rural Census Blocks**	**POPS Contained in Rural Census Blocks**	**% of Total Rural U.S. POPs**	**% of Total Rural U.S. Square Miles**	**% of Total Rural U.S. Road Miles**
ATT	4,235,577	53,085,491	89.7	49.3	70.8
Verizon	4,503,652	53,936,545	91.2	54.6	77.5
Sprint	2,260,761	35,283,398	59.6	17.0	30.1
T-Mobile	991,184	17,388,659	29.4	8.4	14.1

Source: Mosaik January 2014, Census 2010. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

Table VI.B.viii
Estimated Mobile Broadband Coverage in Non-Rural Areas by Provider
January 2014

	Number of Non-Rural Census Blocks	POPS Contained in Non-Rural Census Blocks	% of Total U.S. POPs	% of Total U.S. Square Miles	% of Total U.S. Road Miles
Total for US	5,768,151	253,319,468	81.8	15.5	32.7
Provider	**Number of Non-Rural Census Blocks**	**POPS Contained in Non-Rural Census Blocks**	**% of Total Non-Rural U.S. POPs**	**% of Total Non-Rural U.S. Square Miles**	**% of Total Non-Rural U.S. Road Miles**
ATT	5,684,780	252,554,969	99.7	86.3	96.4
Verizon	5,610,240	248,708,614	98.2	86.6	96.0
Sprint	5,246,538	243,706,412	96.2	65.5	83.0
T-Mobile	4,612,300	228,974,118	90.4	50.8	69.7

Source: Mosaik January 2014, Census 2010. The data underlying these estimates measure mobile network "coverage," and not the number of network providers affirmatively offering service to any or all residents in those locations. Coverage calculations based on Mosaik data, while useful for measuring developments in mobile wireless coverage, have certain limitations that likely overstate the extent of mobile wireless coverage.

C. Quality of Service

i. Ookla

1. *Description of Ookla Speed Test.* The Ookla speed test is solely crowdsourced and requires users to choose to run each individual test. This app is available free of charge for iOS, Amazon, Android, and Windows Phones. It tests latency, download speed and upload speed. Ookla Net Index mobile app users are able to perform speed tests any time they have a wireless connection.

2. To measure download speed, the tested device first downloads small binary files from the web server to the client, and Ookla measures that download to estimate the connection speed. There are several factors that can affect the speed of individual samples, therefore the fastest 10 percent and slowest 10 percent of the samples are discarded. In addition, because the ramp-up period can take a significant part of the beginning of the test, an additional 20 percent of the bottom samples are trimmed. Overall, the fastest 10 percent and slowest 30 percent of the samples are discarded. The remaining samples are averaged together to determine the final reported result.[1] To measure upload speed, a small amount of random data is first generated in the client device and sent to the web server to estimate the connection speed. Based on this result, an appropriately sized chunk of randomly generated data are selected for upload. The upload test is then performed in chunks of uniform size. The slowest 50 percent of the observations are dropped, and the fastest 50 percent of the observations are averaged to eliminate anomalies and determine the result. [2]

3. The latency test simply sends HTTP requests to the selected server, and measures the time it takes to get a response.[3] The Ookla speed test chooses a server for each test individually, based on which server from a set of possible test servers has the fastest latency. However, the tester also has the ability to choose the server that the test will use.

4. *Presentation of Ookla Speed Test Data*. For this presentation, we use the city-level Net Index speed data, which presents daily mean upload and download speeds by city.[4] The daily, city-level observations can consist of thousands of speed measurements, averaged into one data point.[5] Because this dataset is aggregated at the city level on a daily basis, we cannot identify individual connection speeds.

5. In this *Report*, we present mobile wireless upload and download speeds within the United States for 2013, and for the first half of 2014. We estimate nationwide speeds by service provider. We also estimate California-only speeds by service provider, in order to facilitate comparison with CalSPEEDdata. Not all wireless providers are represented in the Net Index data. For example, there were no observations for US Cellular during this time frame.[6] Similarly, not all states are represented during these years, due to the lack of Ookla mobile app users in certain states. For instance, Alaska, North Dakota, West Virginia, Wyoming, and Vermont are not represented in the 2014 data.

6. We calculate the median[7] and mean upload and download speeds by service provider. The

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[1] From: https://support.speedtest.net/entries/20862782-How-does-the-test-itself-work-How-is-the-result-calculated-

[2] From: https://support.speedtest.net/entries/20862782-How-does-the-test-itself-work-How-is-the-result-calculated-

[3] From: https://support.speedtest.net/entries/20862782-How-does-the-test-itself-work-How-is-the-result-calculated-

[4] Net Index speed data are available at the city level (city_isp_daily_speeds.csv), the state level (region_isp_daily_speeds.csv), and the country level (country_isp_daily_speeds.csv) at http://www.netindex.com/#source ; http://www.ookla.com/support/a39030078/Frequently-Asked-Questions

[5] The free dataset that is publicly available from Ookla consists of anonymous daily index values. The dataset reports the average speed, the number of tests that generate the speed and the date when the tests were done for every geographic location found at NetIndex.com. *See* http://netindex.com/source-data/. There is also available for purchase a more extensive dataset from Ookla that contains every individual speed test measurement.

[6] MetroPCS was dropped from this analysis, as there were only 10 observations for this provider from 2012 until the present. We also drop a few cities due to insufficient observations.

[7] The median speed is actually a median of daily averages, and therefore does not represent a true median speed.

estimated nationwide download speeds by service provider are presented in table VI.C.i, and the estimated nationwide upload speeds by service provider are presented in table VI.C.ii. The estimated California-only upload speeds by service provider are presented in table VI.C.iii, and the estimated California-only download speeds by service provider are presented in table VI.C.iv.

Table VI.C.i
Ookla - Estimated Download Speeds by Service Provider, Nationwide

Service Provider	2013			Jan - June 2014		
	Mean down load speed (Mbps)	Median down load speed (Mbps)	Number of tests ('000s)	Mean down load speed (Mbps)	Median down load speed (Mbps)	Number of tests ('000s)
Verizon	9.13	8.99	30,200	10.81	10.74	12,500
AT&T	9.21	9.04	7,588	9.58	9.79	2,955
Sprint	2.26	1.92	28,800	3.2	2.9	11,700
T-Mobile	6.48	6.16	4,719	9.96	9.89	3,146

Source: Ookla NetIndex data

Table VI.C.ii
Ookla - Estimated Upload Speeds by Service Provider, Nationwide

Service Provider	2013			Jan - June 2014		
	Mean upload speed (Mbps)	Median upload speed (Mbps)	Number of tests ('000s)	Mean upload speed (Mbps)	Median upload speed (Mbps)	Number of tests ('000s)
Verizon	4.22	4.14	30,200	5.41	5.37	12,500
AT&T	3.97	3.86	7,588	4.44	4.55	2,955
Sprint	0.83	0.67	28,800	1.09	0.89	11,700
T-Mobile	2.03	1.76	4,719	4.22	4.16	3,146

Source: Ookla NetIndex data

Table VI.C.iii
Ookla - Estimated Download Speeds by Service Provider, California Only.

Service Provider	2013			Jan - June 2014		
	Mean down load speed (Mbps)	Median down load speed (Mbps)	Number of tests ('000s)	Mean down load speed (Mbps)	Median down load speed (Mbps)	Number of tests ('000s)
Verizon	8.51	8.49	6,973	9.82	9.82	2,822
AT&T	9.56	9.27	1,230	9.71	9.42	6445
Sprint	1.77	1.22	6,888	2.94	2.38	2,069
T-Mobile	7.39	7.03	944	10.49	10.35	886

Source: Ookla NetIndex data

Table VI.C.iv
Ookla - Estimated Upload Speeds by Top 4 Nationwide Service Provider, California only.

Service Provider	2013			Jan - June 2014		
	Mean upload speed (Mbps)	Median upload speed (Mbps)	Number of tests (‘000s)	Mean upload speed (Mbps)	Median upload speed (Mbps)	Number of tests (‘000s)
Verizon	4.47	4.45	6,973	5.60	5.56	2,822
AT&T	4.17	4.04	1,230	4.82	4.58	645
Sprint	0.70	0.55	6,888	1.02	0.67	2,069
T-Mobile	2.54	2.33	944	4.66	4.63	886

Source: Ookla NetIndex data

ii. FCC

7. The FCC Speed Test app is available free of charge for Android phones and for the iPhone. The application measures mobile broadband performance in four active categories: download speed, upload speed, latency and packet loss. Several other passive metrics are also recorded, including signal strength of the connection, and device manufacturer and model.[8] The FCC speed test can be set to automatically run in the background of Android phones, but not iPhone devices, for which the user must execute the speed test manually. No tests are executed if the device is transferring more than 64kbit/s at the time a test is scheduled to execute. Tests that are skipped are rescheduled to execute at a later time. By default the app will limit the total monthly data traffic used for execution of scheduled tests to a maximum of 100MB. Volunteers can adjust the data cap to suit their preference.[9]

8. When starting a measurement cycle, the application runs a brief latency test to measurement servers in the application's configuration. The nearest measurement server with the lowest round-trip latency is selected as the target for all subsequent measurements (throughput, latency and packet loss).[10] In a manner similar to the Ookla test, the FCC test makes an adjustment to account for possible slow TCP startup. If a packet is not received back within three seconds of sending, it is treated as lost.[11]

9. The speed test measures the download and upload speed of the given connection in bits per second by performing multi-connection GET and POST HTTP requests to a target test node. Binary non-zero content, herein referred to as the payload, is hosted on a web server on the target test node. The test operates for either a fixed duration (in seconds) or a fixed volume (in MB). It can also report the recorded average throughput at multiple intervals during the test (e.g. once every five seconds). The client will attempt to download as much of the payload as possible for the duration of the test.[12] The speed test preconditions streams to get past possible slow TCP startup, which can bias the throughput test towards reporting higher throughput.[13] Further details regarding the methodology used in presenting FCC Speed Test app data are provided in the text of this *Report.*

iii. RootMetrics

10. RootMetrics tests data, call, and text performance in all 50 states across the United States. As described by the company, its testing of data performance measures reliability and speed for file uploads and

[8] http://www.fcc.gov/measuring-broadband-america/mobile

[9] http://www.fcc.gov/measuring-broadband-america/mobile

[10] http://www.fcc.gov/measuring-broadband-america/mobile/technical-summary

[11] http://www.fcc.gov/measuring-broadband-america/mobile/technical-summary

[12] http://www.fcc.gov/measuring-broadband-america/mobile/technical-summary

[13] CalSPEED: Measuring California Mobile Broadband - A Comparison of Methodologies

downloads, for downloading email, and for loading lite data files that represent loading typical webpages and apps.[14] Its call testing measures how reliably each network is able to place and maintain calls.[15] Finally, its text testing measures how reliably and quickly consumers can send and receive text messages.[16] RootMetrics uses these measurements to calculate a Reliability Index and a Speed Index, denoted as RootScores, using a proprietary algorithm that it describes as focusing on large-scale patterns of performance and minimizing the effects of isolated, rare events.[17] These RootScores are available for each of the airports and metropolitan areas included in the sample, as well as at the state and national levels.[18] Finally, RootMetrics combines these RootScores using a proprietary method to compute an overall performance score. In this section we discuss only the national Speed Index data for the top four facilities-based providers.

11. The RootMetric Speed Index takes into account the speed measurements of both data and texts. The data speed measurements assess how quickly consumers can connect to the network, as well as how quickly data tasks can be completed online (downloading/uploading files, downloading email, and downloading lite data files that approximate loading a typical webpage or app). The text speed measurements assess how quickly consumers can send and receive text messages.[19] The raw data speed measurements and text speed measurements are then converted by RootMetrics into separate speed indices for data and for text. These separate indices are then combined and converted into overall speed indices using a proprietary algorithm. According to RootMetrics, RootScores (i.e. the indices) 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.[20] Table V.C.v provides the national Speed Index data for the four nationwide providers and their separate data and text components for the second half of 2013 and the first half of 2014.[21] Table V.C.vi provides the same data for California.

[14] During file transfer testing, RootMetrics attempts to open an HTTP connection(s), and then measures network connection success rates, as well as upload and download transfer speeds. The testing measures how reliably and quickly each network is able to: 1) connect to an IMAP server and download a group of 10 emails and 2) establish a network connection and download lite data files to represent typical web and app behaviors. http://www.rootmetrics.com/us/methodology

[15] To measure call performance, RootMetrics places a call from each network's phone and attempts to hold that call open for the duration of the test cycle. The testing shows blocked and dropped outgoing call failure rates. http://www.rootmetrics.com/us/methodology

[16] To analyze texting, RootMetrics measures send failure rates and the speed at which each network can send and receive texts from a phone within its own network and phones within the other networks. http://www.rootmetrics.com/us/methodology

[17] http://www.rootmetrics.com/us/methodology

[18] http://www.rootmetrics.com/us/methodology

[19] http://www.rootmetrics.com/us/methodology

[20] http://www.rootmetrics.com/us/standards. Prior to January 2014, Data RootScores in Metro and Airport RootScore Reports could exceed 100 if performance was extraordinary, http://www.rootmetrics.com/us/methodology.

[21] Source: http://www.rootmetrics.com/us/rsr/united-states/2013/2H and http://www.rootmetrics.com/us/rsr/united-states/2014/1H.

Table VI.C.v
RootMetrics: National Speed Index Data
2nd Half 2013, 1st Half 2014

	2nd Half 2013			1st Half 2014		
	Speed Index	Data Performance	Text Performance	Speed Index	Data Performance	Text Performance
AT&T	88.7	83.9	94.3	71.1	78.1	81.2
Verizon	88.5	87.3	94.7	75.7	81.5	80.4
Sprint	65.8	51.2	92.8	54.2	63.7	78.8
T-Mobile	74.3	48.7	90.1	64.4	67.1	78.4

Source: RootMetrics RootScore Report Data, 2nd half 2013, 1st half 2014.

Table VI.C.vi
RootMetrics: California Speed Index Data
2nd Half 2013, 1st Half 2014

	2nd Half 2013			1st Half 2014		
	Speed Index	Data Performance	Text Performance	Speed Index	Data Performance	Text Performance
AT&T	85.3	80.4	92.2	83.0	89.6	87.9
Verizon	88.5	84.3	92.8	88.9	93.7	88.6
Sprint	62.6	44.7	89.3	62.3	72.0	87.2
T-Mobile	82.5	65.9	90.2	83.0	86.3	87.3

Source: RootMetrics RootScore Report Data, 2nd half 2013, 1st half 2014.

iv. CalSPEED

12. *Description of CalSPEED.* CalSPEED is a structured sampling program of 1,986 locations (originally 1,200) scattered throughout California. The sites are spread across urban (37 percent), rural (56 percent) and tribal (seven percent), lands. These sites are visited every six months and speed tests are run on the latest available Android phone and also on a USB network device on a Windows based netbook, for each of the four major providers (Verizon, AT&T, Sprint, and T-Mobile).[22] Tests are not performed using iPhones. CalSPEED data was collected in five rounds from the spring of 2012 through Spring 2014.[23]

13. Each test in the structured sampling program is run using the same protocol. Tests are performed inside a stationary automobile. First, a valid GPS reading is obtained from the GPS receiver connected to a netbook, and tests are run using the data cards for each provider. Next, the smart phone tests are performed. Results are uploaded to the cloud-based database server at each location. In cases where data cannot be uploaded from the tested location, the test results remained on the netbook or smart phone until the tester reaches a location with sufficient network coverage to upload the data.[24]

14. Although not yet incorporated into CalSPEED's published speed test results, in April 2013 CalSPEED launched a free mobile speed test app that is available for download on Android phones.[25] The smartphone user must manually run this test, as it does not automatically run in the background of the phone. The

[22] From CalSPEED: California Mobile Broadband - An Assessment. Ken Biba Managing Director and CTO Novarum, Inc.

[23] Spring 2013 tests were taken between the dates of 4/4/2013 to 4/29/2013, while Fall 2013 tests were taken between the dates of 10/17/2013 to 12/18/2013. Spring 2014 tests were taken between the dates of 4/10/2014 and 6/05/2014.

[24] California Public Utilities Commission: Spring 2012 Mobile Broadband Field Testing Initial Staff Report. September, 2012. pp. 3.

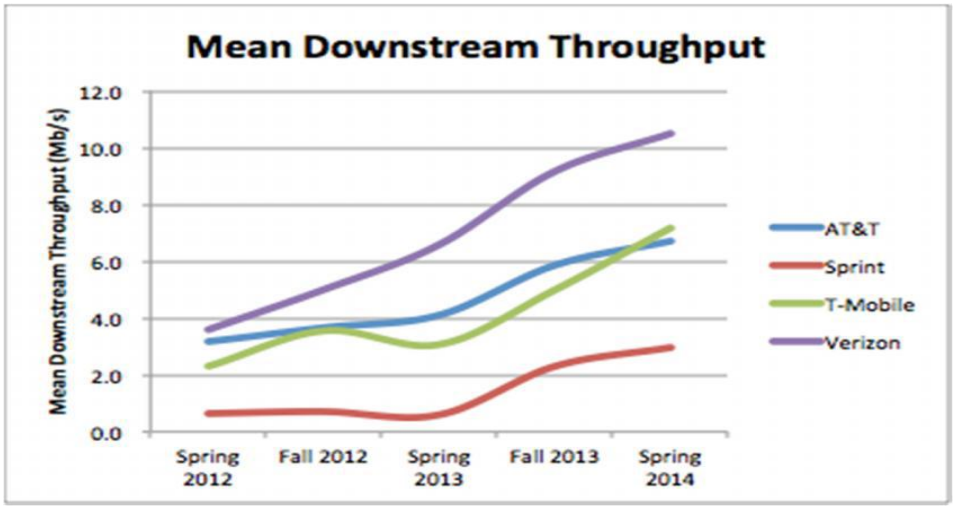
[25] http://calbroadbanddrivetest.blogspot.com/2013/04/calspeed-is-now-available-on-google-play.html

CalSPEED crowdsourced data are not included in our analysis.[26]

15. CalSPEED measures the complete network path, from the client device, through the local access network, through the Internet backbone, to two fixed servers. One server is physically located in Northern California and the other in Northern Virginia - both in the Amazon Web Services cloud.[27] CalSPEED measures network metrics including end-to-end packet latency, upload speed, download speed, packet loss and jitter. These data track three major trends over time: changes in performance (throughput, latency and jitter) due to new technology and capacity deployment, changes in performance due to increases in user load, and changes in coverage as providers deploy their footprint. Observations are not included in the analysis if the measurement was taken outside of the carrier's coverage area, or if the tester did not complete the test. Any other errors are counted as zero throughput. CalSPEED reduces their calculated means by one standard deviation.

16. In this *Report*, we present mobile wireless upload and download speeds and latency within the United States for 2013 through Spring 2014. The estimated download speeds by provider are presented in Chart VI.C.i, and the estimated upload speeds by provider are presented in Chart VI.C.ii. In terms of both median and mean speeds, Verizon has the fastest download and upload speeds in 2013, followed by AT&T, T-Mobile, and then Sprint. For the period spanning fall 2013 and spring 2014, Verizon still has the highest mean and median download and upload speeds. T-Mobile shows significant speed improvements in Spring 2014, surpassing AT&T in both mean and median download speeds.

Chart VI.C.i
CalSPEED Mean Downstream Throughput, 2012-2014

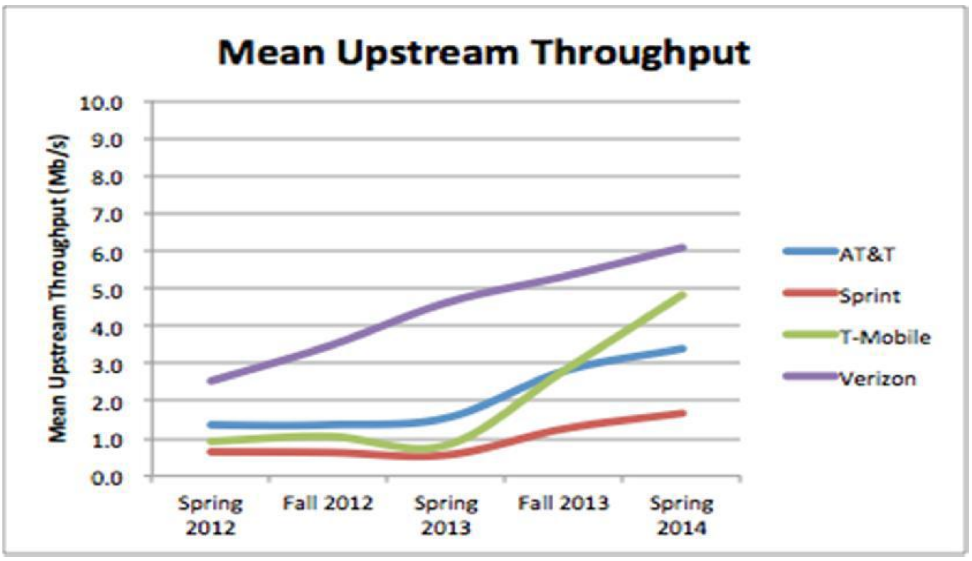


Source: "CALSPEED - California's Mobile Broadband Assessment", November 2014.

Chart VI.C.ii
CalSPEED Mean Upstream Throughput, California, 2012-2014

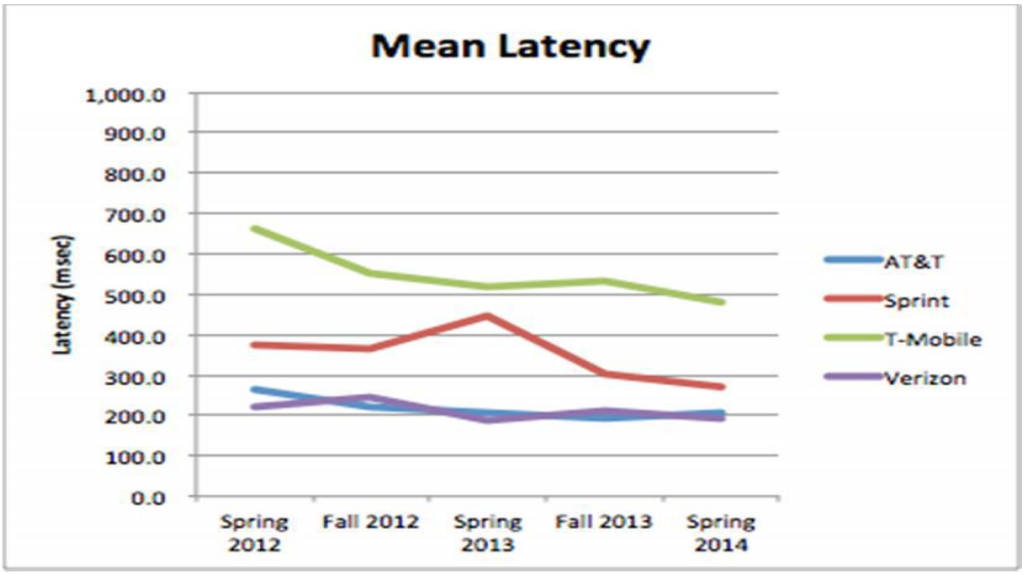
[26] From CalSPEED: California Mobile Broadband - An Assessment. Ken Biba Managing Director and CTO Novarum, Inc.

[27] From CalSPEED: California Mobile Broadband - An Assessment. Ken Biba Managing Director and CTO Novarum, Inc.



Source: "CALSPEED - California's Mobile Broadband Assessment", November 2014.

Chart VI.C.iii
CalSPEED Mean Latency, California, 2012-2014



Source: "CALSpeed - California's Mobile Broadband Assessment", November 2014.