Docket:	A.18-07-011 and A.18-07-012
Exhibit Number:	Cal Advocates-
Commissioner:	C. Rechtschaffen
Admin. Law Judge:	K. J. Bemesderfer
Cal Advocates Project Mgr.:	Shelly Lyser
Cal Advocates Expert Witness:	Cameron Reed

PUBLIC ADVOCATES OFFICE

Public Advocates Office

California Public Utilities Commission

Supporting Exhibits to the Public Advocates Office Testimony on Service Quality and Public Safety for the Proposed Transfer of Control of Sprint to T-Mobile

- PUBLIC -

San Francisco, California
January 7, 2019

A.18-07-011 AND **A.18-07-012** THE PUBLIC ADVOCATES OFFICE TESTIMONY EXHIBIT INDEX ON SERVICE QUALITY

Exhibit #	**Document Name**	Public Information	Contains **Confidential** T-Mobile Information	Contains **Confidential** Sprint Information
C-1	Fierce Wireless: Sprint's roaming agreement doesn't impact VoLTE rollout	X		
C-2	Sprint Roaming Agreement FAQ	X		
C-3	Sprint response to Cal Advocates Data Request 2, Question 2-1, 2-2, and 2-3.	X		
C-4	FCC Wireless Appendices	X		
C-5	Sprint Response to Cal Advocates Data Request No. 002 Question 2-9			X
C-6	Sprint Response to Cal Advocates Data Request No. 001 Question 1-24			X
C-7	Sprint and T-Mobile's CFR and CDR		X	X
C-8	Sprint Response to Cal Advocates Data Request No. 001 Question 1-49			X
C-9	T-Mobile Response to Cal Advocates Data Request No. 004 Question 4-10	X		
C-10	Ookla's 2018 Speed Test Report	X		
C-11	T-Mobile Network Reports		X	
C-12	T-Mobile response to Cal Advocates Data Request No. 001 Question 1-24		X	
C-13	Dish Petition to Deny Slide Deck	X		

C-14	Collected T-Mobile Service Outages Available on CD upon request		X	
C-15	Sprint Response to Cal Advocates Data Request No. 001 Question 1-23 Available on CD upon request			X
C-16	Consolidated CAB informal complaint reports, 2015-2017	X		
C-17	Sprint Response to Cal Advocates Data Request No. 001, Question 1-53			X
C-18	T-Mobile Response to Cal Advocates Data Request No. 001, Question 1-53	X		
C-19	Sprint Customer Complaints			X
C-20	T-Mobile Response to Cal Advocates Data Request No. 001 Question 1-68		X	
C-21	Sprint Response to Cal Advocates Data Request No. 001 Question 1-73			X
C-22	Sprint and T-Mobile Response to Cal Advocates Data Request Question 1-22	X		
C-23	Intrado Slide Deck to the FCC	X		
C-24	NENA letter to the FCC	X		
C-25	T-Mobile Response to Cal Advocates Data Request 4 Question 4-7, 4-8, and 4-9.	X		
C-26	Sprint Response to Cal Advocates Data Request 1 Question 1-45			X

C-27	Sprint Response to Cal Advocates Data Request 1 Question 1-47			X
C-28	Sprint Response to Cal Advocates Data Request 2 Question 2-28	X		
C-29	T-Mobile Response to Cal Advocates Data Request 6 Question 6-8		X	
C-30	T-Mobile Response to Cal Advocates Data Request 6 Question 6-9 and 6-10		X	
C-31	Sprint and T-Mobile Responses to Cal Advocates Data Request 2 Question 2-26	X		
C-32	T-Mobile Response to Cal Advocates Data Request 1 Question 1-30	X		
C-33	Ookla 2016 and 2017 Speedtest Reports	X		
C-34	New T-Mobile Model Assumptions		X	

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-1

"Fierce Wireless: Sprint's roaming agreement doesn't impact VoLTE rollout"

Sprint's roaming agreement with T-Mobile doesn't impact VoLTE rollout

T-Mobile's agreement to provide Sprint with LTE roaming for four years does not appear to be slowing Sprint down in its VoLTE rollout.

"We remain on track to begin commercial deployment of VoLTE starting this fall," a Sprint spokesperson told FierceWirelessTech.

For more than a year, Sprint has been testing VoLTE and preseeding its customer base with VoLTE-capable devices. "Our network today offers a great HD Voice experience on a very efficient 1x platform, and our goal with VoLTE is to match this same high-quality experience that our customers have today," the spokesperson added.

RELATED: Sprint expects to deploy VoLTE starting this fall

Included in their presentation drumming up support of their merger, T-Mobile said it would provide Sprint with a roaming agreement for four years, and that agreement will survive in the event the transaction is terminated. Speculation then immediately centered on whether Sprint would suspend its VoLTE investment since it could then rely on T-Mobile's VoLTE, but the spokesperson's answer squashes that idea.

Plus, T-Mobile CTO Neville Ray clarified during T-Mobile's first-quarter earnings call on Tuesday that the roaming agreement is really about data. Sprint's customers' phones in the areas covered by the roaming agreement could do VoIP but not VoLTE at this point, he said. Sprint has underlying voice calling available through CDMA.

"The issue that we're trying to address and work together on is LTE data coverage," Ray said, referring to the roaming agreement.

T-Mobile is proud of its work on VoLTE, laying claim to being the first in the U.S. to deploy VoLTE and having VoLTE on 100% of its LTE network. As of earlier this year, 80% of all voice at T-Mobile was carried over VoLTE.

RELATED: T-Mobile deploys Ericsson data analytics to measure voice quality, detect VoLTE issues

At Mobile World Congress 2018 in February, it was revealed that T-Mobile was part of the Ericsson Expert Analytics solution announcement. The solution is used to gain insights into how customers are experiencing a range of services, including VoLTE, video calling over LTE, rich communication services and mobile broadband, enabling T-Mobile to resolve call-related issues in real time.

VoLTE offers as much as three times more voice and data capacity than 3G technologies, enabling higher-quality connections. According to the GSA, 217 operators are investing in VoLTE in 102 countries, including 134 operators with commercially launched VoLTE-HD voice service in 65 countries.

Verizon has fully deployed VoLTE over its network, so 100% of its LTE sites have the capability, equating to its entire footprint. Rival AT&T touted a milestone in 2015 when its VoLTE reached more than 27 million subscribers; it took a market-by-market approach to rolling it out.

In 2016, Verizon and AT&T started offering interoperable VoLTE to some customers, meaning customers on both networks could place VoLTE calls with each other.

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Public Advocates Office

Exhibit C-2

"Sprint Roaming Agreement FAQ"

FAQs About Domestic Roaming

Sprint helps you keep track of your domestic data roaming use by sending notices as you reach the limit. Once your domestic data roaming limit has been reached, domestic data roaming is suspended.

If you use your device while roaming in the U.S., Puerto Rico, or U.S. Virgin Islands you may use up to the monthly data roaming allowance included in your plan; refer to your plan for roaming usage limitations.

• Sprint will automatically suspend only domestic data roaming once the limit is exceeded. Unless your plan charges for domestic data roaming, there is no charge.

• Sprint will automatically restore domestic data roaming at the beginning of your next bill cycle.

• Sprint will suspend your data roaming service when you exceed your limit. The data roaming suspension only limits access to data while roaming; there is no impact to voice or text while roaming and all service while on the Sprint network will remain available.*

*Check plan details for charges that may apply for data roaming.

You can track your usage online by signing in to My Sprint. When you view your bill, separate line items will be displayed for Sprint Network and domestic roaming for all data plans, with information shown separately for phones and mobile broadband cards. Sprint Network use includes use on the Sprint network, Extended LTE and Extended Coverage networks. Roaming use includes use on roaming networks.

Sprint sends notifications to the account holder via the selected notification preference as you get close to or reach your limit. For domestic data roaming, notifications are sent when you reach 75%, 90% and 100% of your limit.* To update your notification preferences, you can manage your account online by signing in to My Sprint or just contact us.

Note: When updating your online preferences, you must change your default notification to Yes and select either text or email to receive the notifications.

Your data roaming service will be automatically restored at the start of your next billing cycle.

Mobile broadband devices offer additional options that are not available for mobile phones. With mobile broadband devices:

- At 100%, you will have the option to suspend your data roaming service for the month or continue to use it and pay the overage charges.
- If charges are accepted, you will continue to receive text or email notifications at 20% increments.
- Data roaming is 25¢/MB (for plans starting after August 8, 2010) after you hit your plan's monthly data roaming limit.
- If you signed up or changed your plan after August 8, 2010, and you reach your limit, we'll send you to a special web page. Click Restore service to accept any overage charges for the rest of your billing cycle.
- If you have an older plan, contact us to see if you can change to a plan that will accept overage charges.

**Roaming charges could be delayed up to 60 days; notifications may be delayed based on when roaming partners provide usage details. Customers using Static IP or DataLink will not receive notifications and will not be suspended.

Last updated Mon Aug 27 2018

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-3

"Sprint response to Cal Advocates Data Request 2, Question 2-1, 2-2, and 2-3."

Data Request 2-1.

*Please provide the following information on Your plans to maintain, deploy or improve service in **rural areas** of California absent the merger.*

a) Your anticipated annual capital investment in rural areas from 2018 to 2024 absent the merger.

b) Please describe the infrastructure You plan to build out in rural areas of California during 2018 to 2024 absent the merger.

Response to Data Request 2-1.

Sprint objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrases "maintain, deploy or improve service," "rural areas," "capital investment in rural areas," and "infrastructure." Sprint also objects to this Data Request to the extent that it is duplicative of Cal PA DRs 1-24 through 1-28.

Subject to and without waiving its objections, Sprint responds that it does not make capital investment decisions based on whether an area is rural or urban and therefore does not maintain the requested information in the ordinary course of business. Notably, however, Sprint provided information regarding capital investment in its October 10 Response to DRs 1-32 and 1-33.

With respect to Sprint's plans to build out infrastructure, Sprint responds that its plans for infrastructure deployment generally have been developed to implement network plans that were developed on a national basis and do not distinguish between rural and non-rural areas in a given state. Notably, however, Sprint does not anticipate deploying high-speed broadband covering significant portions of rural areas absent the transaction. Sprint provided extensive information regarding its deployment and upgrade plans in its October 10 Response to DRs 1-24 to 1-29, and hereby incorporates these responses by reference. *See also* Wireless Application, Confidential Exhibit I.

Data Request 2-2.

Please identify the rural areas of California that You plan to deploy new service to during 2018 to 2024 absent the merger.

Response to Data Request 2-2.

Sprint objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrases "plan to deploy," "rural areas," and "new service." Sprint also objects to this Data Request to the extent that it is duplicative of Cal PA DRs 1-24 to 1-29.

Subject to and without waiving its objections, Sprint responds that its deployment plans generally have been developed to implement network plans that were developed on a national basis and do not distinguish between rural and non-rural areas in a given state. Notably, however, Sprint does not anticipate deploying high-speed broadband covering significant portions of rural areas absent the transaction. Sprint provided extensive information regarding its deployment and upgrade plans in its October 10 Response to DRs 1-24 through 1-29, and hereby incorporates these responses by reference. *See also* Wireless Application, Confidential Exhibit I.

Data Request 2-3.

When do You expect 5G capable handset devices to become available?

Response to Data Request 2-3.

Sprint objects to this Data Request on the grounds it is vague and ambiguous with respect to geographic scope and the phrase "available."

Subject to and without waiving its objections, Sprint responds that 5G capable handsets are expected to be available in the first half of 2019.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-4

"FCC Wireless Appendices"

Communications Marketplace Report

Collected Appendices

A. Mobile Wireless Market Appendices

APPENDIX A-1: TOTAL MOBILE WIRELESS CONNECTIONS

Appendix Figure II.A.1
***Estimated* Total Mobile Wireless Connections: 2003–2017**

	NRUF			CTIA
Year	Connections (millions)	Increase from previous year (millions)	Connections Per 100 People	Estimated Connections (millions)
2003	160.6	18.8	54	158.7
2004	184.7	24.1	62	182.1
2005	213.0	28.3	71	207.9
2006	241.8	28.8	80	233.0
2007	263.0	21.2	86	255.4
2008	279.6	16.6	91	270.3
2009	290.7	11.1	94	285.6
2010	301.8	11.1	97	296.3
2011	317.3	15.5	101	316.0
2012	329.2	11.9	105	326.5
2013	339.2	10.0	108	335.7
2014	357.1	17.2	114	355.4
2015	378.2	21.1	121	377.9
2016	398.4	20.2	127	395.9
2017	410.7	12.3	126	400.2

Source: NRUF 2003–2017; CTIA Wireless Industry Year-End Indices; Census data.

APPENDIX A-2: PENETRATION RATES BY EA
Appendix Figure II.A.2
PENETRATION RATES BY EA: 2013-2017

2017 Rank	EA	Market Name	2017 Population (est.)	2017	2016	2015	2014
1	82	Biloxi-Gulfport-Pascagoula, MS	436,438	204%	168%	126%	106%
2	102	Davenport-Moline-Rock Island, IA-IL	557,998	186%	158%	117%	103%
3	101	Peoria-Pekin, IL	519,880	178%	161%	126%	108%
4	57	Detroit-Ann Arbor-Flint, MI	6,831,311	177%	174%	161%	150%
5	55	Cleveland-Akron, OH-PA	4,521,868	159%	153%	143%	141%
6	84	Baton Rouge, LA-MS	865,489	143%	142%	131%	118%
7	8	Buffalo-Niagara Falls, NY-PA	1,448,276	139%	131%	120%	111%
8	73	Memphis, TN-AR-MS-KY	2,008,738	139%	131%	118%	113%
9	51	Columbus, OH	2,763,581	137%	135%	128%	126%
10	88	Shreveport-Bossier City, LA-AR	586,915	137%	123%	114%	115%
11	40	Atlanta, GA-AL-NC	7,354,214	136%	130%	122%	114%
12	99	Kansas City, MO-KS	2,814,986	136%	132%	124%	116%
13	50	Dayton-Springfield, OH	1,118,228	136%	133%	127%	121%
14	10	New York-North New Jersey-Long Island, NY-NJ-CT-PA	27,438,740	134%	130%	124%	119%
15	31	Miami-Fort Lauderdale, FL	6,959,355	133%	131%	124%	110%
16	155	Farmington, NM-CO	224,752	133%	138%	127%	117%
17	83	New Orleans, LA-MS	1,720,674	133%	136%	129%	121%
18	3	Boston-Worcester-Lawrence-Lowewell-Brockton, MA-NH	8,566,759	131%	127%	121%	117%
19	160	Los Angeles-Riverside-Orange County, CA-AZ	20,824,439	130%	128%	120%	109%
20	94	Springfield, MO	1,013,648	129%	122%	112%	103%
21	12	Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	7,892,279	129%	125%	119%	113%
22	13	Washington-Baltimore, DC-MD-VA-WV-PA	10,229,209	129%	126%	121%	117%
23	64	Chicago-Gary-Kenosha, IL-IN-WI	10,799,978	129%	126%	119%	115%
24	161	San Diego, CA	3,337,685	128%	126%	121%	111%

2017 Rank	EA	Market Name	2017 Population (est.)	2017	2016	2015	2014
25	85	Lafayette, LA	659,736	128%	124%	121%	119%
26	97	Springfield, IL-MO	508,944	127%	124%	117%	112%
27	142	Scottsbluff, NE-WY	89,593	127%	127%	123%	119%
28	135	Odessa-Midland, TX	481,713	126%	120%	120%	122%
29	87	Beaumont-Port Arthur, TX	469,537	126%	124%	119%	117%
30	116	Sioux Falls, SD-IA-MN-NE	594,401	126%	121%	111%	108%
31	86	Lake Charles, LA	564,006	126%	120%	117%	113%
32	163	San Francisco-Oakland-San Jose, CA	10,515,482	125%	123%	116%	108%
33	78	Birmingham, AL	1,720,001	125%	119%	114%	111%
34	172	Honolulu, HI	1,427,538	125%	120%	114%	111%
35	93	Joplin, MO-KS-OK	280,818	124%	120%	114%	110%
36	44	Knoxville, TN	1,156,968	124%	124%	119%	114%
37	49	Cincinnati-Hamilton, OH-KY-IN	2,376,858	124%	122%	118%	111%
38	53	Pittsburgh, PA-WV	2,887,694	124%	120%	113%	109%
39	89	Monroe, LA	336,404	124%	124%	122%	116%
40	20	Norfolk-Virginia Beach-Newport News, VA-NC	1,878,745	123%	122%	122%	118%
41	22	Fayetteville, NC	587,839	123%	125%	116%	113%
42	69	Evansville-Henderson, IN-KY-IL	879,608	123%	118%	111%	109%
43	17	Roanoke, VA-NC-WV	898,251	123%	120%	119%	113%
44	79	Montgomery, AL	499,729	122%	118%	115%	112%
45	132	Corpus Christi, TX	597,631	122%	117%	115%	111%
46	63	Milwaukee-Racine, WI	2,363,834	122%	120%	113%	108%
47	131	Houston-Galveston-Brazoria, TX	7,974,985	122%	118%	116%	112%
48	90	Little Rock-North Little Rock, AR	1,737,645	122%	121%	117%	115%
49	37	Albany, GA	492,918	122%	121%	113%	111%
50	127	Dallas-Fort Worth, TX-AR-OK	10,169,082	122%	119%	116%	112%
51	107	Minneapolis-St. Paul, MN-WI-IA		122%	119%	114%	109%

2017 Rank	EA	Market Name	2017 Population (est.)	2017	2016	2015	2014
			5,162,587				
52	56	Toledo, OH	1,260,824	122%	120%	112%	111%
53	70	Louisville, KY-IN	1,621,381	121%	118%	113%	109%
54	34	Tampa-St. Petersburg-Clearwater, FL	3,091,399	121%	121%	118%	113%
55	38	Macon, GA	840,416	120%	118%	111%	107%
56	126	Western Oklahoma, OK	141,104	120%	117%	109%	100%
57	115	Rapid City, SD-MT-ND-NE	230,360	120%	113%	105%	95%
58	80	Mobile, AL	749,159	120%	117%	114%	110%
59	96	St. Louis, MO-IL	3,694,893	119%	116%	111%	108%
60	29	Jacksonville, FL-GA	2,407,609	119%	117%	113%	109%
61	5	Albany-Schenectady-Troy, NY	1,228,034	119%	124%	117%	105%
62	74	Huntsville, AL-TN	1,141,428	118%	116%	112%	107%
63	141	Denver-Boulder-Greeley, CO-KS-NE	5,251,183	118%	116%	113%	110%
64	124	Tulsa, OK-KS	1,523,908	118%	116%	112%	110%
65	152	Salt Lake City-Ogden, UT-ID	2,863,934	118%	113%	109%	106%
66	77	Jackson, MS-AL-LA	1,471,367	117%	116%	116%	108%
67	133	McAllen-Edinburg-Mission, TX	1,370,424	117%	114%	111%	104%
68	58	Northern Michigan, MI	260,612	117%	115%	*	*
69	125	Oklahoma City, OK	2,011,327	117%	115%	110%	109%
70	81	Pensacola, FL	759,130	117%	115%	112%	108%
71	170	Seattle-Tacoma-Bremerton, WA	5,203,886	117%	116%	112%	108%
72	45	Johnson City-Kingsport-Bristol, TN-VA	608,176	117%	117%	113%	107%
73	27	Augusta-Aiken, GA-SC	687,551	117%	116%	112%	108%
74	134	San Antonio, TX	3,021,065	117%	113%	111%	107%
75	165	Redding, CA-OR	363,494	116%	112%	103%	97%
76	23	Charlotte-Gastonia-Rock Hill, NC-SC	2,848,436	116%	114%	109%	106%
77	67	Indianapolis, IN-IL	3,488,733	116%	113%	108%	104%

2017 Rank	EA	Market Name	2017 Population (est.)	2017	2016	2015	2014
78	171	Anchorage, AK	731,593	116%	113%	111%	107%
79	100	Des Moines, IA-IL-MO	1,821,507	115%	112%	106%	100%
80	128	Abilene, TX	228,855	115%	114%	111%	108%
81	91	Fort Smith, AR-OK	355,317	115%	113%	108%	107%
82	24	Columbia, SC	1,109,251	115%	112%	106%	104%
83	95	Jonesboro, AR-MO	314,428	115%	112%	106%	102%
84	76	Greenville, MS	194,904	115%	114%	113%	99%
85	157	El Paso, TX-NM	1,158,956	115%	113%	110%	103%
86	15	Richmond-Petersburg, VA	1,730,301	115%	115%	115%	110%
87	117	Sioux City, IA-NE-SD	251,423	115%	109%	102%	95%
88	129	San Angelo, TX	217,503	115%	112%	104%	101%
89	72	Paducah, KY-IL	230,026	114%	111%	107%	102%
90	121	North Platte, NE-CO	59,964	114%	117%	115%	103%
91	60	Appleton-Oshkosh-Neenah, WI	482,134	114%	109%	102%	95%
92	159	Tucson, AZ	1,193,737	114%	114%	114%	111%
93	71	Nashville, TN-KY	3,151,635	114%	117%	113%	111%
94	137	Lubbock, TX	428,609	114%	112%	109%	104%
95	42	Asheville, NC	547,368	114%	112%	106%	102%
96	156	Albuquerque, NM-AZ	1,102,134	114%	109%	104%	99%
97	35	Tallahassee, FL-GA	826,154	114%	115%	112%	105%
98	106	Rochester, MN-IA-WI	351,315	114%	111%	106%	101%
99	7	Rochester, NY-PA	1,494,379	114%	111%	107%	103%
100	153	Las Vegas, NV-AZ-UT	2,695,558	114%	112%	108%	107%
101	118	Omaha, NE-IA-MO	1,193,449	113%	109%	105%	99%
102	28	Savannah, GA-SC	869,672	113%	110%	104%	103%
103	139	Santa Fe, NM	276,170	113%	107%	104%	99%
104	36	Dothan, AL-FL-GA		113%	109%	106%	99%

2017 Rank	EA	Market Name	2017 Population (est.)	2017	2016	2015	2014
			357,859				
105	110	Grand Forks, ND-MN	225,370	112%	110%	104%	98%
106	6	Syracuse, NY-PA	1,883,125	112%	111%	105%	101%
107	30	Orlando, FL	5,190,137	112%	111%	107%	104%
108	39	Columbus, GA-AL	557,562	112%	109%	105%	102%
109	164	Sacramento-Yolo, CA	2,916,196	112%	111%	107%	99%
110	66	Fort Wayne, IN	762,072	112%	110%	104%	100%
111	130	Austin-San Marcos, TX	2,237,703	112%	110%	108%	104%
112	147	Spokane, WA-ID	999,565	112%	108%	103%	99%
113	9	State College, PA	792,309	112%	109%	101%	101%
114	18	Greensboro-Winston-Salem-High Point, NC-VA	2,108,673	111%	110%	106%	103%
115	98	Columbia, MO	422,738	111%	108%	103%	97%
116	59	Green Bay, WI-MI	690,731	111%	107%	103%	99%
117	43	Chattanooga, TN-GA	837,458	111%	111%	106%	103%
118	108	Wausau, WI	491,187	111%	106%	102%	87%
119	61	Traverse City, MI	309,010	111%	107%	*	*
120	148	Idaho Falls, ID-WY	384,240	111%	109%	105%	102%
121	143	Casper, WY-ID-UT	478,994	111%	107%	109%	104%
122	75	Tupelo, MS-AL-TN	633,017	111%	110%	107%	101%
123	140	Pueblo, CO-NM	295,680	111%	106%	104%	100%
124	41	Greenville-Spartanburg-Anderson, SC-NC	1,489,869	111%	109%	105%	103%
125	162	Fresno, CA	1,760,739	111%	110%	103%	94%
126	167	Portland-Salem, OR-WA	3,635,116	111%	108%	105%	101%
127	158	Phoenix-Mesa, AZ-NM	4,893,762	110%	109%	106%	104%
128	109	Duluth-Superior, MN-WI	352,369	110%	108%	104%	99%
129	65	Elkhart-Goshen, IN-MI	962,546	110%	108%	100%	96%
130	16	Staunton, VA-WV	370,434	110%	111%	112%	104%

2017 Rank	EA	Market Name	2017 Population (est.)	2017	2016	2015	2014
131	52	Wheeling, WV-OH	297,682	110%	107%	102%	98%
132	62	Grand Rapids-Muskegon-Holland, MI	2,047,495	110%	107%	103%	99%
133	1	Bangor, ME	534,752	110%	106%	101%	94%
134	166	Eugene-Springfield, OR-CA	902,011	110%	109%	104%	99%
135	136	Hobbs, NM-TX	219,828	110%	104%	103%	99%
136	144	Billings, MT-WY	488,883	110%	107%	105%	101%
137	169	Richland-Kennewick-Pasco, WA	861,578	109%	107%	103%	98%
138	4	Burlington, VT-NY	624,942	109%	107%	103%	98%
139	119	Lincoln, NE	437,943	109%	107%	103%	99%
140	2	Portland, ME	801,155	109%	108%	104%	101%
141	103	Cedar Rapids, IA	457,887	109%	108%	104%	101%
142	68	Champaign-Urbana, IL	637,967	109%	105%	99%	95%
143	149	Twin Falls, ID	196,712	109%	107%	102%	99%
144	11	Harrisburg-Lebanon-Carlisle, PA	1,284,585	109%	107%	102%	98%
145	138	Amarillo, TX-NM	521,079	108%	108%	105%	101%
146	154	Flagstaff, AZ-UT	500,823	108%	102%	101%	101%
147	48	Charleston, WV-KY-OH	1,145,657	108%	110%	107%	100%
148	123	Topeka, KS	476,687	107%	105%	100%	96%
149	54	Erie, PA	497,876	107%	104%	100%	96%
150	19	Raleigh-Durham-Chapel Hill, NC	2,582,353	107%	107%	103%	99%
151	113	Fargo-Moorhead, ND-MN	433,580	107%	104%	101%	98%
152	168	Pendleton, OR-WA	212,494	107%	105%	96%	90%
153	151	Reno, NV-CA	825,446	107%	105%	103%	101%
154	150	Boise City, ID-OR	822,607	106%	105%	101%	95%
155	46	Hickory-Morganton, NC-TN	561,814	105%	98%	94%	90%
156	32	Fort Myers-Cape Coral, FL	1,112,104	104%	102%	98%	95%
157	26	Charleston-North Charleston, SC		104%	103%	100%	98%

2017 Rank	EA	Market Name	2017 Population (est.)	2017	2016	2015	2014
			813,442				
158	104	Madison, WI-IA-IL	1,069,213	104%	102%	99%	94%
159	25	Wilmington, NC-SC	1,168,787	104%	104%	101%	100%
160	21	Greenville, NC	955,192	103%	102%	98%	93%
161	33	Sarasota-Bradenton, FL	1,023,585	101%	100%	98%	96%
162	47	Lexington, KY-TN-VA-WV	1,943,075	101%	99%	96%	93%
163	145	Great Falls, MT	164,950	101%	97%	96%	92%
164	105	La Crosse, WI-MN	263,319	100%	97%	94%	89%
165	92	Fayetteville-Springdale-Rogers, AR-MO-OK	601,974	100%	97%	91%	88%
166	14	Salisbury, MD-DE-VA	450,244	99%	98%	95%	92%
	111	Minot, ND	144,596	*	114%	115%	121%
	112	Bismarck, ND-MT-SD	211,845	*	*	*	101%
	114	Aberdeen, SD	82,331	*	*	*	*
	146	Missoula, MT	474,578	*	*	*	*
	120	Grand Island, NE	291,516	*	*	*	*
	122	Wichita, KS-OK	1,209,412	*	**	192%	151%

Source: Based on NRUF and 2017 Census Population Estimates; EAs as defined in 1995. Asterisks are used to withhold data to maintain firm confidentiality or where there are concerns about data reliability.

APPENDIX A-3: CPI

Appendix Figure II.A.3
Change in CPI, 1997-2017

Year	CPI		Wireless Telephone Services CPI		Telephone Services CPI		Land-line Telephone Services CPI	
	Annual Index Average	Annual Change	Annual Index Average	Annual Change	Annual Index Average	Annual Change	Annual Index Average	Annual Change
1997	100.0		100.0		100.0			
1998	101.6	1.6%	95.1		100.7			
1999	103.8	2.2%	84.9	-10.7%	100.1	-0.6%		
2000	107.3	3.4%	76.0	-10.5%	98.5	-1.6%		
2001	110.3	2.8%	68.1	-10.4%	99.3	0.8%		
2002	112.1	1.6%	67.4	-1.0%	99.7	0.4%		
2003	114.6	2.3%	66.8	-0.9%	98.3	-1.4%		
2004	117.7	2.7%	66.2	-0.9%	95.8	-2.5%		
2005	121.7	3.4%	65.0	-1.8%	94.9	-0.9%		
2006	125.6	3.2%	64.6	-0.6%	95.8	0.9%		
2007	129.2	2.9%	64.4	-0.3%	98.2	2.6%		
2008	134.1	3.8%	64.2	-0.2%	100.5	2.2%		
2009	133.7	-0.4%	64.3	0.0%	102.4	1.9%	100.0	
2010	135.8	1.6%	62.4	-2.9%	102.4	0.0%	101.6	
2011	140.1	3.2%	60.1	-3.6%	101.2	-1.1%	103.3	1.7%
2012	143.0	2.1%	59.7	-0.8%	101.7	0.5%	105.6	2.2%
2013	145.1	1.5%	58.6	-1.8%	101.6	-0.1%	108.1	2.4%
2014	147.5	1.6%	57.4	-2.1%	101.1	-0.4%	111.1	2.7%
2015	147.7	0.1%	55.2	-3.8%	99.3	-1.8%	113.4	2.1%
2016	149.5	1.3%	54.7	-1.0%	98.8	-0.5%	114.5	1.0%
2017	152.1	1.7%	48.8	-10.8%	91.8	-7.1%	116.1	1.4%
1997 to 2017		**52.1%**		**-51.2%**		**-8.2%**		**13.9%**

Source: Data from Bureau of Labor Statistics. All CPI figures were taken from BLS databases. Bureau of Labor Statistics, http://www.bls.gov. 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.[1]

[1] All CPI figures were taken from BLS databases: Bureau of Labor Statistics, http://www.bls.gov. 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, https://www.bls.gov/cpi/questions-and-answers.htm. The CPI category "Telephone Services" has two components: wireless telephone services and landline telephone services. Additional information can be found at Bureau of Labor Statistics, Consumer Price Index: How the Consumer Price Index Measures Price Change for Telephone Services, https://www.bls.gov/cpi/factsheets/telephone-services.htm.

APPENDIX A-4: ARPU

Appendix Figure II.A.4
Annualized Average Revenue Per Reported Subscriber Unit (ARPU): 1993–2017

Year	Total Annual	Percentage	Average Reported	Average Monthly
1993	$10,895,175		11,861,362	$76.55
1994	$14,229,922	30.6%	18,299,487	$64.80
1995	$19,081,239	34.1%	26,757,320	$59.43
1996	$23,634,971	23.9%	35,554,818	$55.40
1997	$27,485,633	16.3%	46,375,849	$49.39
1998	$33,133,175	20.6%	58,455,471	$47.23
1999	$40,018,489	20.8%	71,885,076	$46.39
2000	$52,466,020	31.1%	90,048,320	$48.55
2001	$65,316,235	24.5%	109,318,848	$49.79
2002	$76,508,187	17.1%	125,002,023	$51.00
2003	$87,624,093	14.5%	141,658,059	$51.55
2004	$102,121,210	16.5%	161,980,026	$52.54
2005	$113,538,221	11.2%	186,801,940	$50.65
2006	$125,456,825	10.5%	213,077,033	$49.07
2007	$138,869,304	10.7%	234,921,960	$49.26
2008	$148,084,170	6.6%	252,539,475	$48.87
2009	$152,551,854	3.0%	265,038,212	$47.97
2010	$159,929,648	4.9%	280,392,201	$47.53
2011	$169,767,314	6.2%	306,840,648	$46.11
2012	$185,013,936	9.0%	314,685,754	$48.99
2013	$189,192,812	2.3%	323,133,932	$48.79
2014	$187,848,477	(0.7%)	335,606,098	$46.64
2015	$191,949,025	2.2%	358,228,494	$44.65
2016	$188,524,256	(1.8%)	378,554,642	$41.50
2017	$179,091,135	(5.0%)	386,013,771	$38.66

Source: Based on CTIA Wireless Industry Indices Year-End 2017.

APPENDIX A-5: MOBILE WIRELESS SPEED

In this Appendix, we present information on another speed metric, CalSPEED. Mean and median LTE download and upload speed measurements for the state of California, estimated using CalSPEED data collected from the second half of 2016 through the second half of 2017, are presented in the Appendix Figures below.[2]

Appendix Figure II.A.5
CalSPEED--Estimated LTE Download Speeds by Service Provider, California Only

Service Provider	Fall 2016			Spring 2017			Fall 2017		
	Mean LTE DL Speed (Mbps)	Median LTE DL Speed (Mbps)	Number of Tests	Mean LTE DL Speed (Mbps)	Median LTE DL Speed (Mbps)	Number of Tests	Mean LTE DL Speed (Mbps)	Median LTE DL Speed (Mbps)	Number of Tests
AT&T	14.04	14.40	1,517	14.90	15.49	1,517	15.50	16.75	1,552
Sprint	9.54	8.11	1,045	9.99	7.95	1,172	11.54	10.11	1,219
T-Mobile	11.97	11.27	1,216	13.20	13.01	1,419	13.08	13.00	1,488
Verizon	16.69	18.43	1,626	14.68	15.51	1,714	16.88	18.62	1,722
Total	13.50	13.70	5,404	13.44	13.31	5,822	14.49	15.38	5,981

Source: CalSPEED. Fall 2016 tests were taken between the dates of Sept. 29, 2016 to Nov. 4, 2016. Spring 2017 tests were taken between the dates of May 25, 2017 to June 30, 2017. Fall 2017 tests were taken between the dates of Oct. 5, 2017 to Nov. 15, 2017.

Appendix Figure II.A.6
CalSPEED - Estimated LTE Upload Speeds by Service Provider, California Only

Service Provider	Fall 2016			Spring 2017			Fall 2017		
	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	6.89	6.44	1,516	7.08	6.25	1,517	7.45	6.82	1,552
Sprint	3.95	3.20	1,045	4.02	3.07	1,172	3.37	2.62	1,219
T-Mobile	7.93	8.40	1,216	8.27	7.77	1,419	8.11	7.38	1,488
Verizon	8.16	8.77	1,626	8.52	8.97	1,714	8.59	9.00	1,722

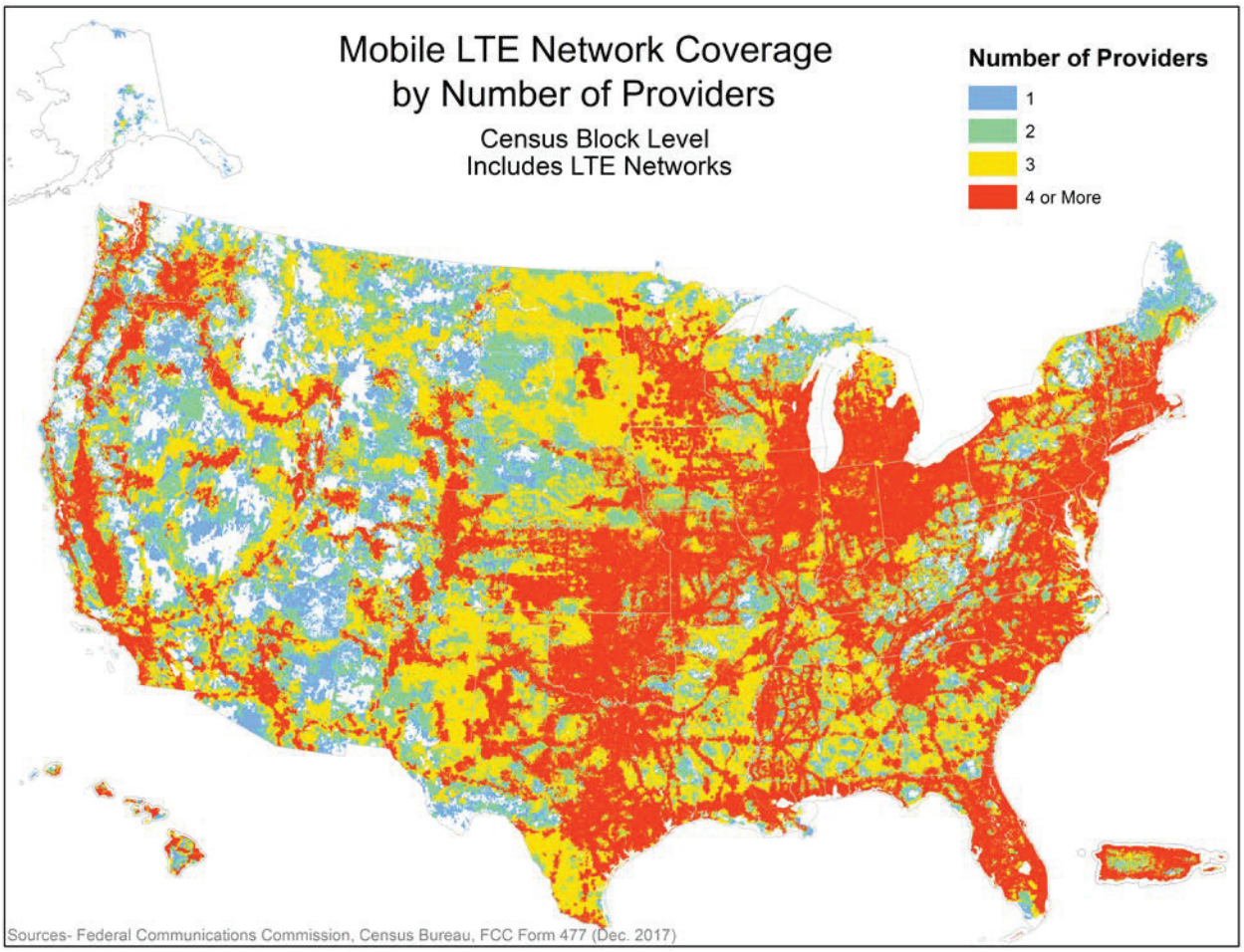
Source: The estimated speeds are based on the CalSPEED data. Fall 2016 tests were taken between the dates of Sept. 29, 2016 and Nov. 4, 2016. Spring 2017 tests were taken between the dates of May 25, 2017 to June 30, 2017. Fall 2017 tests were taken between the dates of Oct. 5, 2017 to Nov. 15, 2017.

[2] 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). The CalSPEED data presented in this *Report* are the result of a structured sampling program of nearly 2,000 locations scattered throughout California. CPUC, Mobile Broadband Testing, http://cpuc.ca.gov/General.aspx?id=1778. For more discussion regarding CalSPEED, *see Seventeenth Report*, 29 FCC Rcd at 15469-70, Appendix VI., paras. 12-16.

APPENDIX A-6: MOBILE WIRELESS COVERAGE MAPS

The maps presented below are based on Commission estimates derived from census block analysis of December 2017 Form 477 coverage maps, using the centroid methodology.[3] These maps will be published in interactive form on the *Communications Marketplace Report*'s website upon release of the *Communications Marketplace Report*.

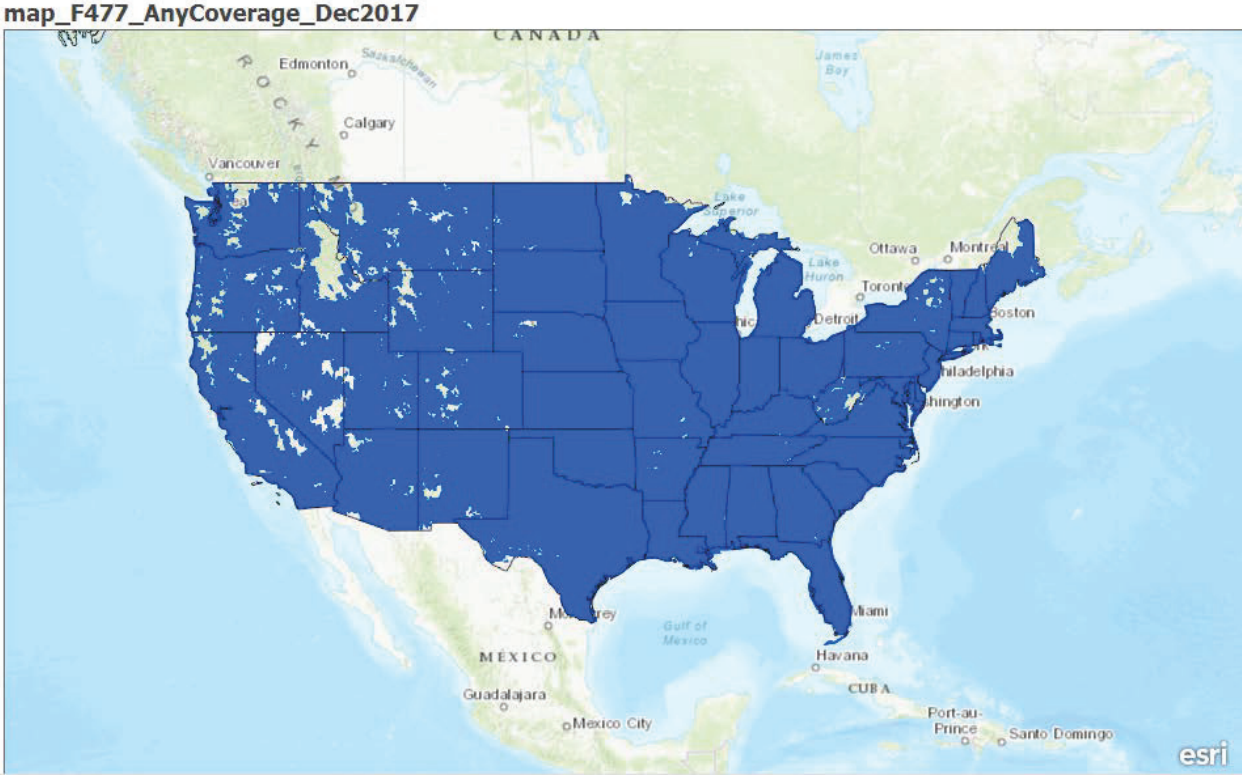
LTE Coverage Nationwide by Number of Service Providers
Form 477, Centroid Method, December 2017



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

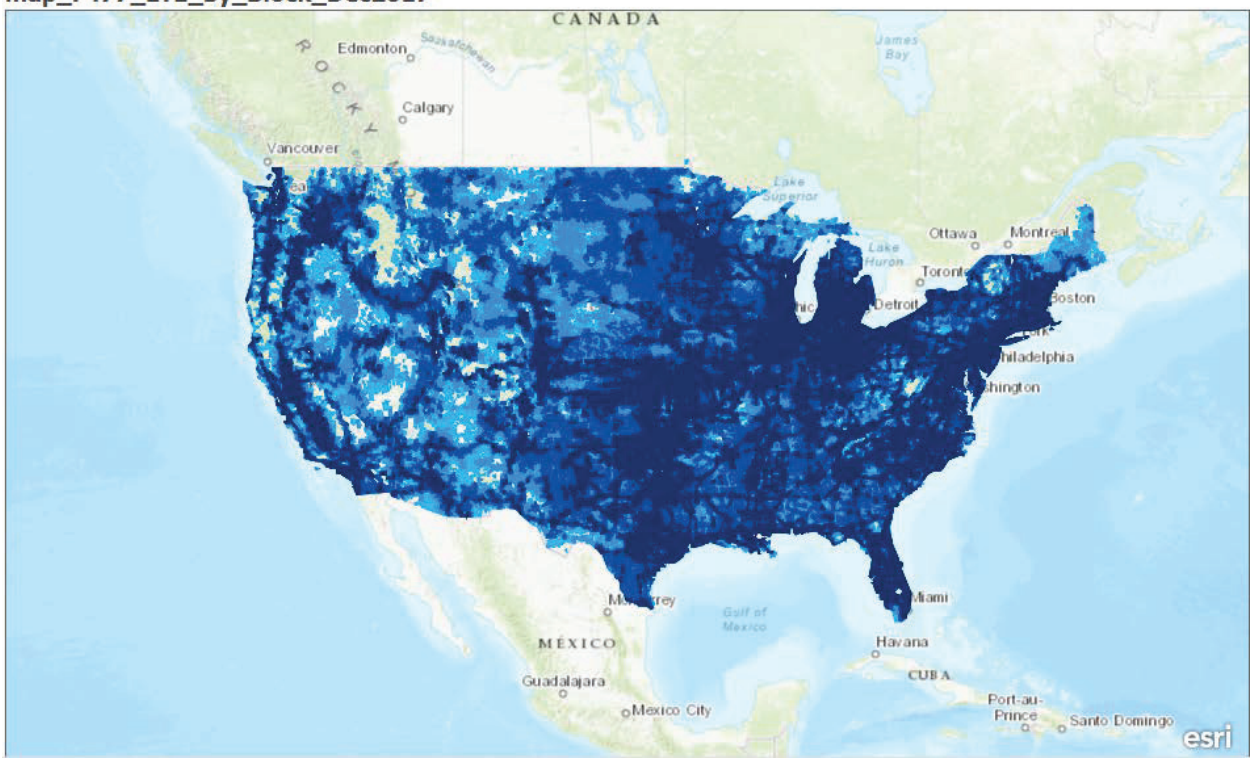
Nationwide Mobile Wireless Coverage, Year-End 2017 (Form 477)

map_F477_AnyCoverage_Dec2017



Nationwide LTE Coverage, Year-End 2017 (Form 477)

map_F477_LTE_by_Block_Dec2017

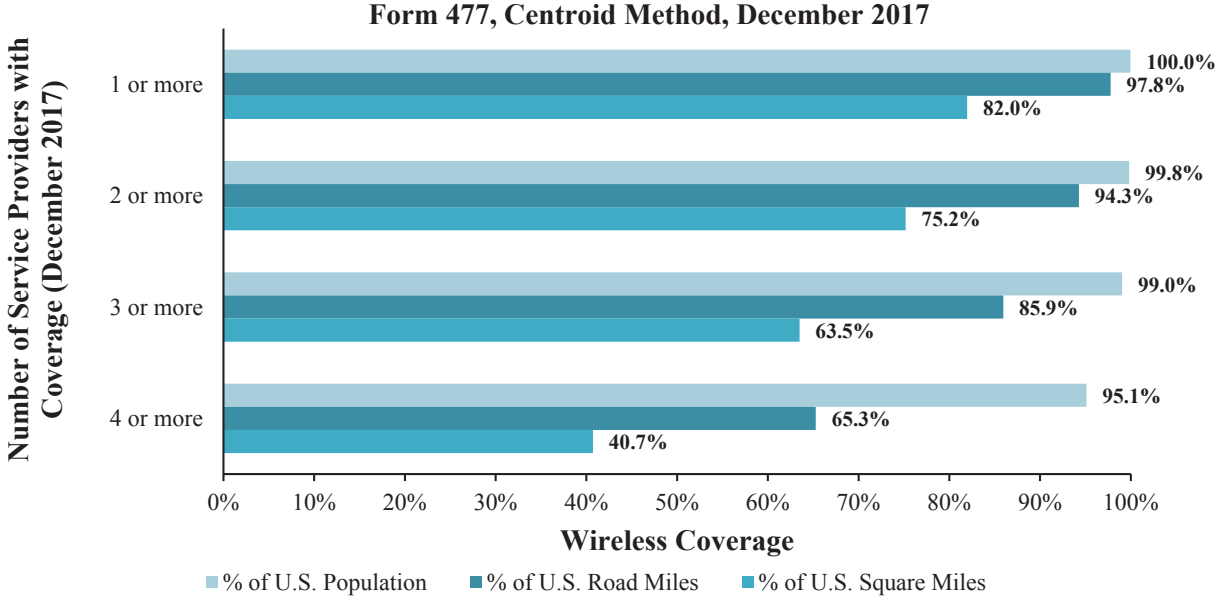


APPENDIX A-7: MOBILE WIRELESS COVERAGE

The figures presented below are based on Commission estimates derived from census block analysis of December 2017 Form 477 coverage maps, using both the centroid and the actual area coverage methodologies.[4] We report those based on the centroid analysis first, before moving on to those associated with the actual area methodology.

Centroid methodology. The centroid methodology is applied to U.S. census blocks overlaid on service provider coverage maps. Under this methodology, if the geometric center point, or centroid, of a census block is within the coverage boundary of a coverage map, then we consider that block to be "covered" by that service provider and/or technology. We then aggregate the population, land area, and road miles of the covered census blocks to generate our total coverage estimates. We note that these coverage estimates represent deployment of mobile networks and do not indicate the extent to which service providers affirmatively offer service to residents in the covered areas. While we recognize that this analysis likely overstates the coverage experienced by some consumers, especially in large or irregularly shaped census blocks, we find that it is nonetheless useful because estimated coverage can be compared across network technologies and service providers.[5]

Appendix Figure II.A.7
Estimated Wireless Coverage by Census Block Including Federal Land
Form 477, Centroid Method, December 2017



Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

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

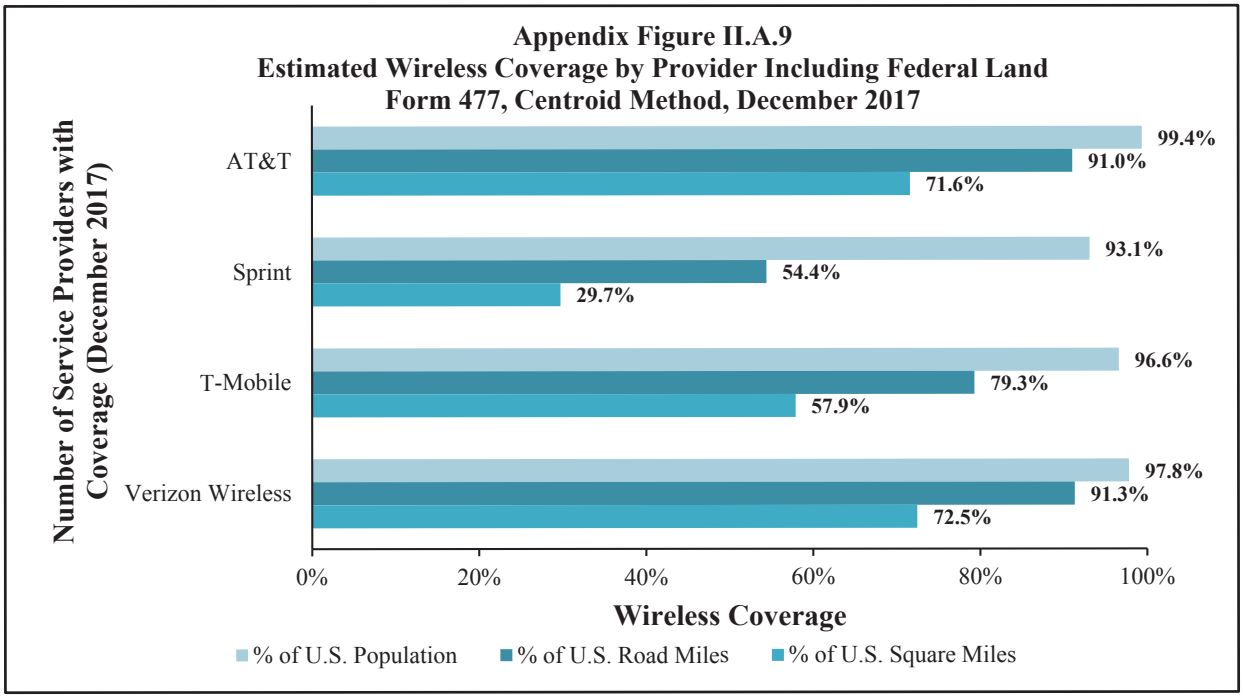
[5] For a more detailed discussion of the centroid methodology, *see Twentieth Report*, 32 FCC Rcd at 9016, para. 71.

Appendix Figure II.A.8
***Estimated* Overall Wireless Coverage by Census Block Including Federal Land**
Form 477, Centroid Method, December 2017

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
US Total	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,523,237	312,366,922	100.0%	2,910,344	82.0%	6,666,052	97.8%
2 or more	10,376,889	311,900,707	99.8%	2,669,667	75.2%	6,427,859	94.3%
3 or more	9,957,038	309,463,821	99.0%	2,254,761	63.5%	5,859,529	85.9%
4 or more	8,607,858	297,226,261	95.1%	1,445,926	40.7%	4,449,977	65.3%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.9
Estimated Wireless Coverage by Provider Including Federal Land
Form 477, Centroid Method, December 2017



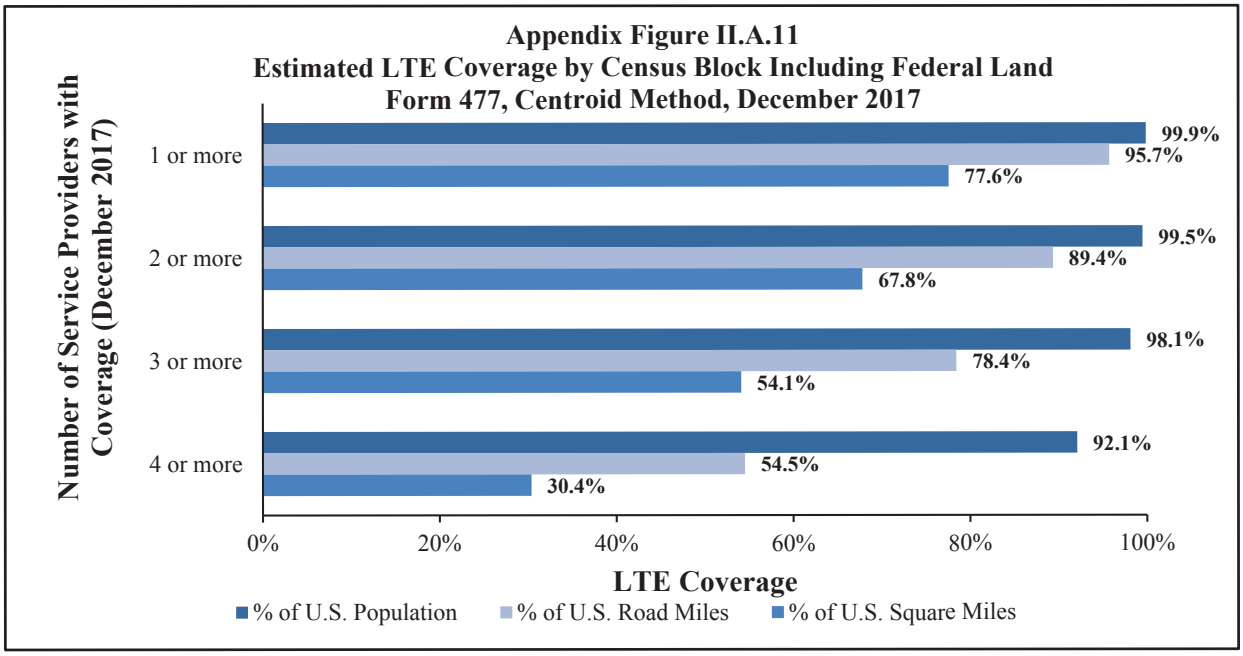
Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.10
***Estimated* Overall Wireless Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2017

Provider	Number of Blocks	POPS in those Blocks	% Total US POPs	Square Miles in those Blocks	% Total US Square Miles	Road Miles in those Blocks	% Total US Road Miles
U.S. Total	*10,609,302*	*312,471,32*	*100.0%*	*3,550,85*	*100.0%*	*6,817,73*	*100.0%*
AT&T	10,158,469	310,402,44	99.3%	2,553,42	71.9%	6,204,98	91.0%
Sprint	7,654,799	287,660,63	92.1%	976,639	27.5%	3,525,82	51.7%
T-Mobile	8,849,655	297,340,33	95.2%	1,690,97	47.6%	4,834,57	70.9%
Verizon	9,859,047	304,313,31	97.4%	2,377,38	67.0%	5,945,34	87.2%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.11
Estimated LTE Coverage by Census Block Including Federal Land
Form 477, Centroid Method, December 2017



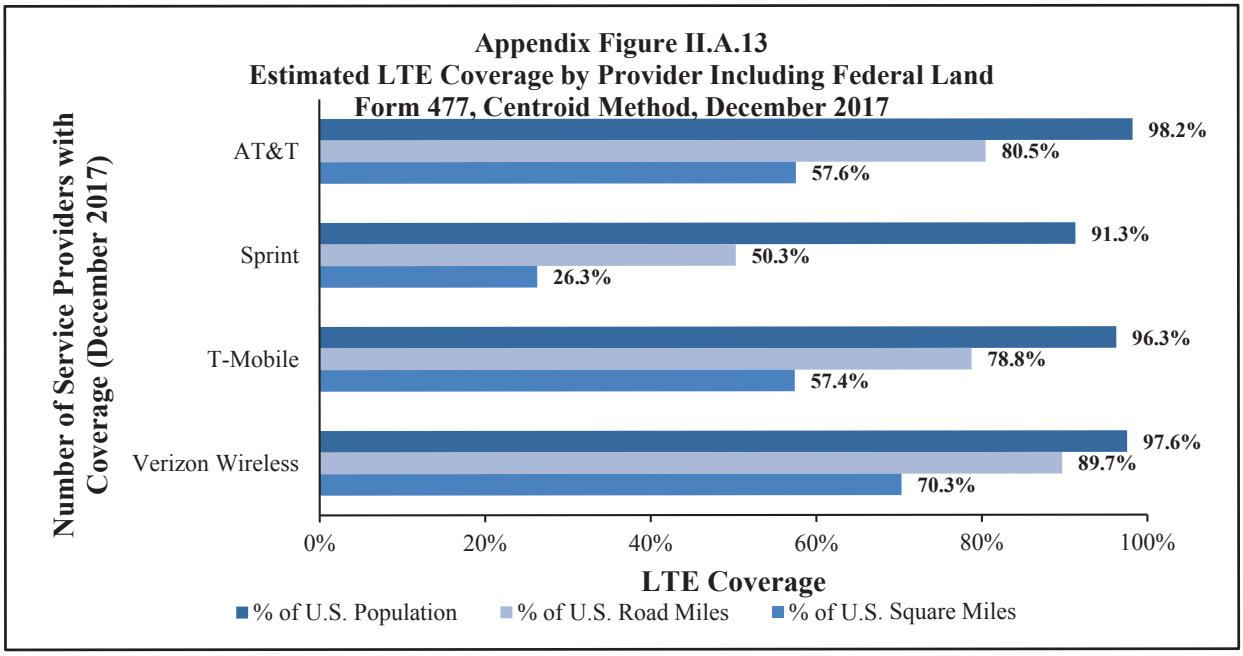
Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.12
***Estimated* LTE Coverage by Census Block Including Federal Land**
Form 477, Centroid Method, December 2017

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
US Total	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,433,138	312,044,388	99.9%	2,754,031	77.6%	6,525,357	95.7%
2 or more	10,147,846	310,840,536	99.5%	2,407,597	67.8%	6,091,677	89.4%
3 or more	9,540,945	306,564,207	98.1%	1,920,661	54.1%	5,345,812	78.4%
4 or more	7,837,391	287,707,338	92.1%	1,078,014	30.4%	3,715,965	54.5%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.13
Estimated LTE Coverage by Provider Including Federal Land
Form 477, Centroid Method, December 2017



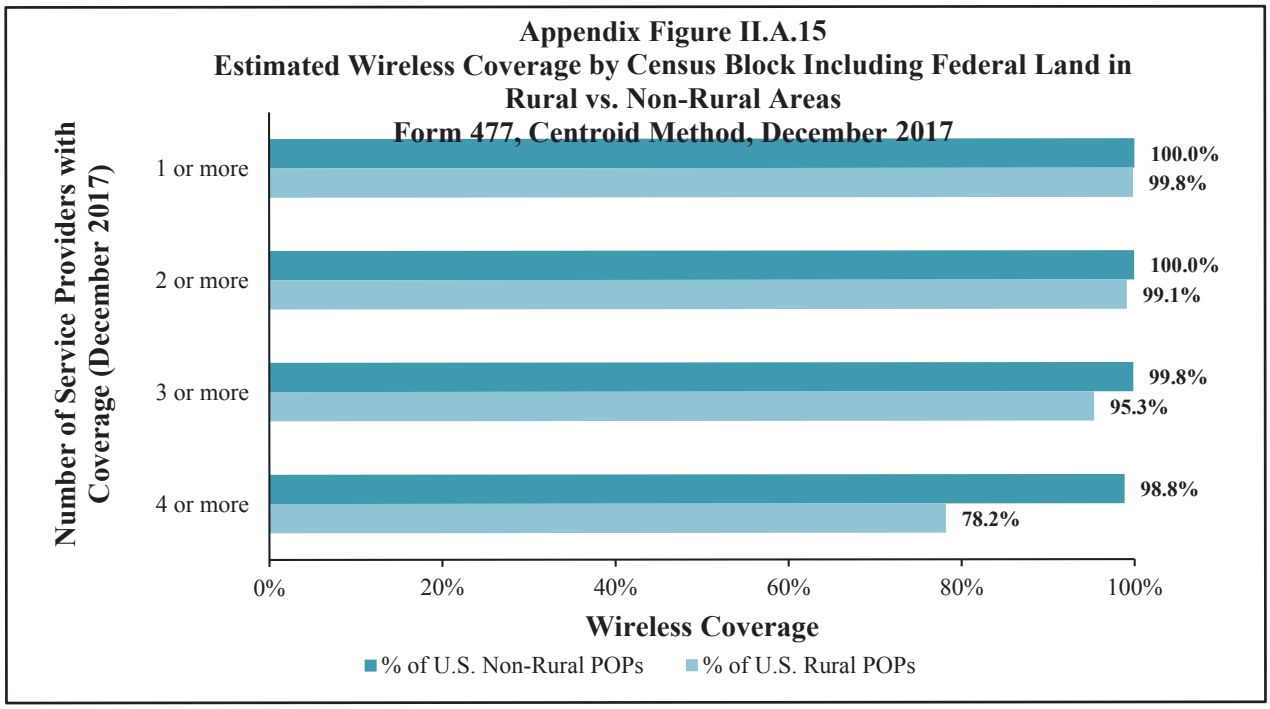
Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.14
***Estimated* LTE Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2017

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	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	9,614,934	307,000,222	98.2%	2,044,185	57.6%	5,487,898	80.5%
Sprint	7,535,705	285,385,219	91.3%	934,117	26.3%	3,428,669	50.3%
T-Mobile	9,292,861	300,756,476	96.3%	2,038,678	57.4%	5,370,112	78.8%
Verizon	9,992,604	304,842,225	97.6%	2,495,691	70.3%	6,116,214	89.7%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.15
Estimated Wireless Coverage by Census Block Including Federal Land in Rural vs. Non-Rural Areas
Form 477, Centroid Method, December 2017



Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.16
***Estimated* Overall Wireless Coverage in Rural Areas by Census Block Including Federal Land**
Form 477, Centroid Method, December 2017

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 Rural Road Miles
US Total	*4,937,330*	*56,094,552*	*100.0%*	*2,987,281*	*100.0%*	*4,518,876*	*100.0%*
1 or more	4,855,542	56,000,060	99.8%	2,352,992	78.8%	4,372,818	96.8%
2 or more	4,720,318	55,601,116	99.1%	2,123,031	71.1%	4,146,973	91.8%
3 or more	4,333,770	53,472,672	95.3%	1,733,764	58.0%	3,615,513	80.0%
4 or more	3,143,515	43,854,700	78.2%	993,559	33.3%	2,337,027	51.7%

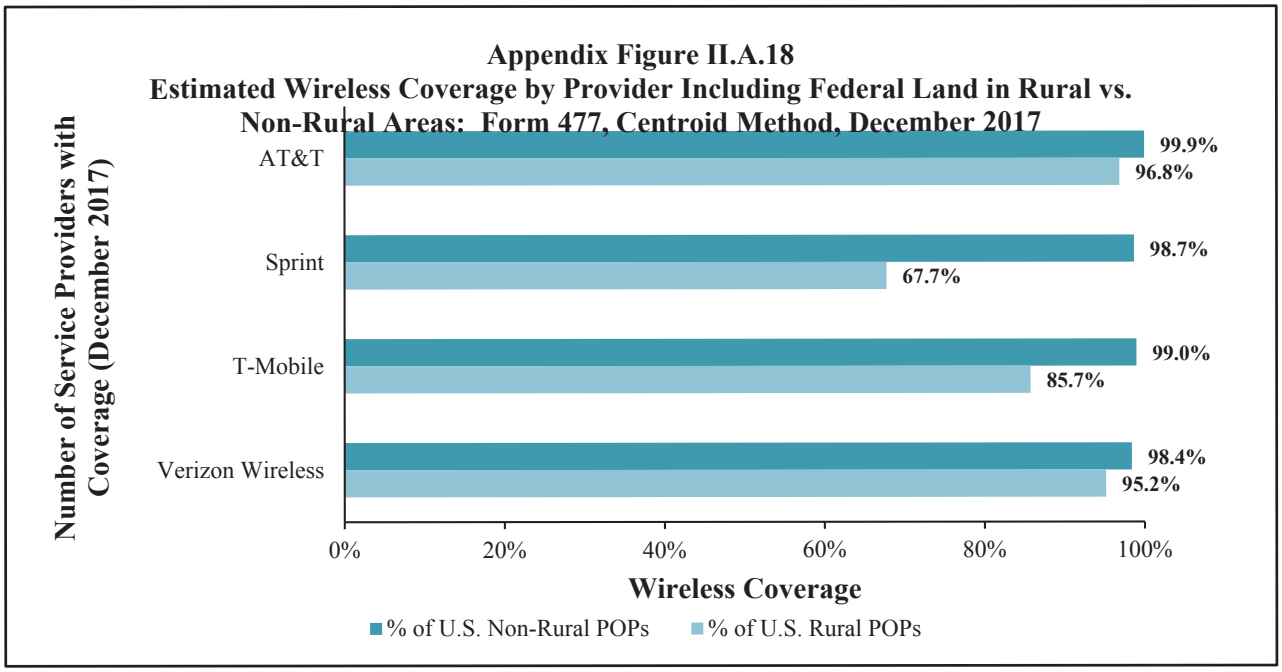
Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.17
***Estimated* Overall Wireless Coverage in Non-Rural Areas by Census Block Including Federal Land**
Form 477, Centroid Method, December 2017

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
US Total	*5,671,972*	*256,376,773*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,667,695	256,366,864	100.0%	557,353	98.9%	2,293,234	99.8%
2 or more	5,656,571	256,299,584	100.0%	546,637	97.0%	2,280,887	99.2%
3 or more	5,623,268	255,991,152	99.8%	520,998	92.4%	2,244,016	97.6%
4 or more	5,464,343	253,371,568	98.8%	452,368	80.3%	2,112,950	91.9%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.18
Estimated Wireless Coverage by Provider Including Federal Land in Rural vs. Non-Rural Areas: Form 477, Centroid Method, December 2017



Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.19
***Estimated* Rural Wireless Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2017

Provider	Number of Blocks	POPS Contained in Those Blocks	% of Total Rural US POPs	Road Miles Contained in Those Blocks	% of Total US Rural Road Miles
US Total	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	4,517,284	54,318,840	96.8%	3,932,114	87.0%
Sprint	2,433,438	37,993,681	67.7%	1,615,636	35.8%
T-Mobile	3,806,863	48,090,252	85.7%	3,212,222	71.1%
Verizon	4,506,266	53,382,645	95.2%	3,980,776	88.1%

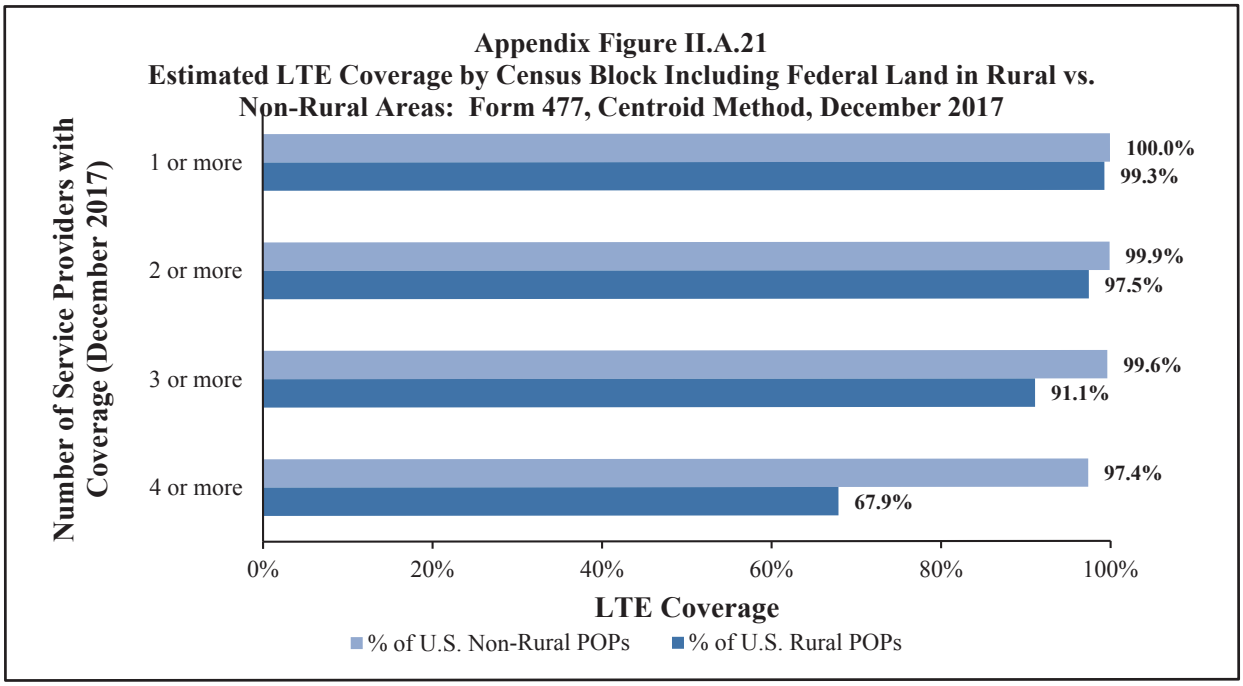
Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.20
***Estimated* Non-Rural Wireless Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2017

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	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,650,652	256,192,975	99.9%	2,274,979	99.0%
Sprint	5,447,986	252,930,917	98.7%	2,094,551	91.1%
T-Mobile	5,533,901	253,718,966	99.0%	2,194,456	95.5%
Verizon	5,564,286	252,234,658	98.4%	2,244,736	97.6%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.21
Estimated LTE Coverage by Census Block Including Federal Land in Rural vs. Non-Rural Areas: Form 477, Centroid Method, December 2017



Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.22
***Estimated* LTE Coverage in Rural Areas by Census Block Including Federal Land**
Form 477, Centroid, December 2017

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
US Total	*5,671,972*	*256,376,773*	*100.0%*	*563,570*	*100.0%*	*2,298,858*	*100.0%*
1 or more	5,662,241	256,336,800	100.0%	550,122	97.6%	2,286,095	99.4%
2 or more	5,637,995	256,163,024	99.9%	527,851	93.7%	2,256,943	98.2%
3 or more	5,578,692	255,463,328	99.6%	494,473	87.7%	2,199,456	95.7%
4 or more	5,301,951	249,623,104	97.4%	407,162	72.2%	1,995,748	86.8%

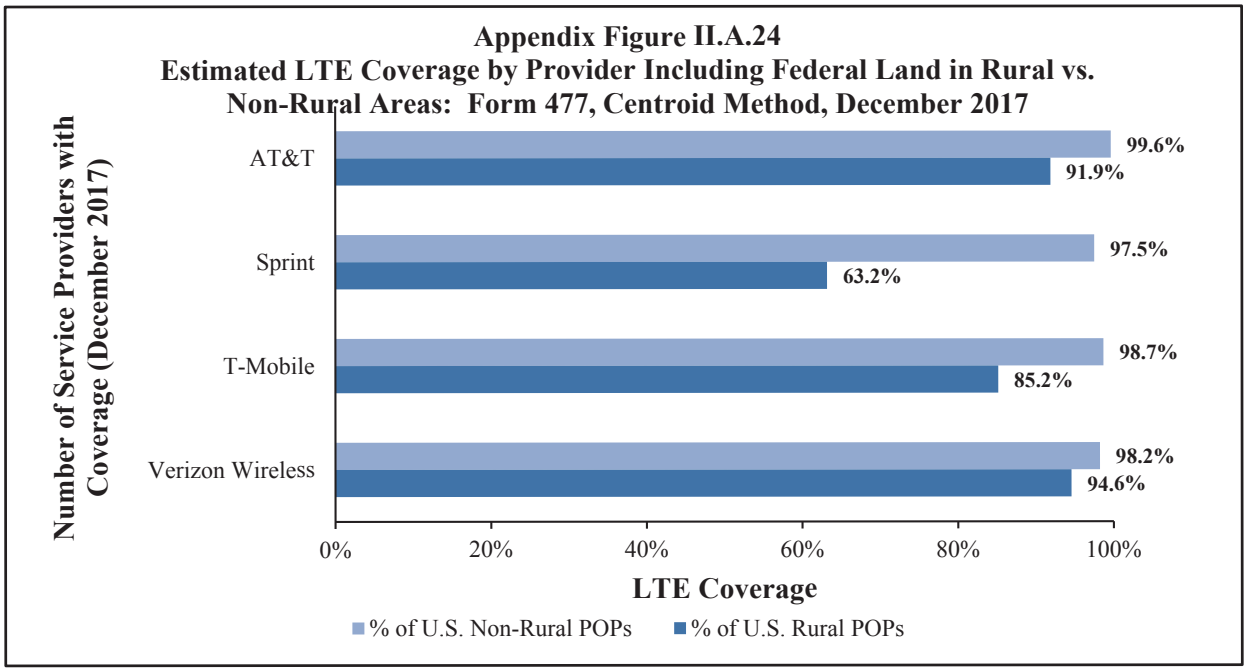
Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.23
***Estimated* LTE Coverage in Non-Rural Areas by Census Block Including Federal Land**
Form 477, Centroid Method, December 2017

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
US Total	*10,609,302*	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	10,433,138	312,044,380	99.9%	2,754,031	77.6%	6,525,357	95.7%
2 or more	10,147,846	310,840,536	99.5%	2,407,597	67.8%	6,091,677	89.4%
3 or more	9,540,945	306,564,200	98.1%	1,920,662	54.1%	5,345,812	78.4%
4 or more	7,837,391	287,707,336	92.1%	1,078,014	30.4%	3,715,965	54.5%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.24
Estimated LTE Coverage by Provider Including Federal Land in Rural vs. Non-Rural Areas: Form 477, Centroid Method, December 2017



Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.25
***Estimated* Rural LTE Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2017

Provider	Number of Blocks	POPS Contained in Those Blocks	% of Total Rural US POPs	Road Miles Contained in Those Blocks	% of Total US Rural Road Miles
US Total	*4,937,330*	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	4,029,157	51,536,845	91.9%	3,280,816	72.6%
Sprint	2,209,889	35,438,910	63.2%	1,418,951	31.4%
T-Mobile	3,781,024	47,768,704	85.2%	3,187,527	70.5%
Verizon	4,445,141	53,042,528	94.6%	3,883,903	85.9%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.26
***Estimated* Non-Rural LTE Coverage in the U.S. by Service Provider**
Form 477, Centroid Method, December 2017

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	*5,671,972*	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	5,585,777	255,463,377	99.6%	2,207,082	96.0%
Sprint	5,325,816	249,946,309	97.5%	2,009,718	87.4%
T-Mobile	5,511,837	252,987,772	98.7%	2,182,585	94.9%
Verizon	5,547,463	251,799,697	98.2%	2,232,311	97.1%

Source: Based on centroid analysis of December 2017 Form 477 and 2010 Census data. Note that the number of service providers in a census block represents network coverage only. Network coverage does not necessarily reflect the number of service providers that actively offer service to individuals located in a given area.

Appendix Figure II.A.27
***Estimated* Overall Wireless Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2017

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	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	310,408,682	99.3%	2,533,825	71.4%	6,188,828	90.8%
Sprint	290,734,898	93.0%	1,054,528	29.7%	3,699,433	54.3%
T-Mobile	301,714,590	96.6%	2,055,223	57.9%	5,400,147	79.2%
Verizon	305,479,257	97.8%	2,551,552	71.9%	6,198,465	90.9%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.28
***Estimated* LTE Coverage by Census Block Including Federal Land**
Form 477, Actual Area Coverage Method, December 2017

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
US Total	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
1 or more	312,008,352	99.9%	2,746,233	77.3%	6,510,130	95.5%
2 or more	310,709,888	99.4%	2,396,544	67.5%	6,071,729	89.1%
3 or more	306,358,944	98.0%	1,912,953	53.9%	5,327,027	78.1%
4 or more	287,446,016	92.0%	1,074,287	30.3%	3,702,785	54.3%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.29
***Estimated* LTE Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2017

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	*312,471,327*	*100.0%*	*3,550,852*	*100.0%*	*6,817,734*	*100.0%*
AT&T	306,808,300	98.2%	2,033,640	57.3%	5,466,237	80.2%
Sprint	285,162,942	91.3%	933,056	26.3%	3,418,661	50.1%
T-Mobile	300,661,495	96.2%	2,039,867	57.4%	5,364,722	78.7%
Verizon	304,719,091	97.5%	2,476,676	69.7%	6,091,236	89.3%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.30
***Estimated* Rural Wireless Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2017

Provider	Covered POPs	% of Total Rural US POPs	Covered Road Miles	% of Total US Rural Road Miles
US Total	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	54,267,818	96.7%	3,915,430	86.6%
Sprint	37,892,940	67.6%	1,608,033	35.6%
T-Mobile	48,043,725	85.6%	3,205,650	70.9%
Verizon	53,305,256	95.0%	3,956,139	87.5%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.31
***Estimated* Non-Rural Wireless Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2017

Provider	Covered POPs	% of Total Non-Rural US POPs	Covered Road Miles	% of Total Non-Rural US Road Miles
US Total	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	256,140,865	99.9%	2,273,398	98.9%
Sprint	252,841,958	98.6%	2,091,400	91.0%
T-Mobile	252,174,001	98.9%	2,194,497	95.5%
Verizon	251,981,080	98.4%	2,242,326	97.5%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.32
***Estimated* LTE Coverage in Rural Areas by Census Block Including Federal Land**
Form 477, Actual Area Coverage Method, December 2017

Number of Providers with Coverage in a Block	Covered POPs	% of Total Rural US POPs	Covered Road Miles	% of Total Rural US Road Miles
US Total	56,094,552	100.0%	4,518,876	100.0%
1 or more	55,676,272	99.3%	4,225,027	93.5%
2 or more	54,603,672	97.3%	3,816,131	84.4%
3 or more	50,992,188	90.9%	3,130,544	69.3%
4 or more	37,989,484	67.7%	1,711,274	37.9%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.33
***Estimated* LTE Coverage in Non-Rural Areas by Census Block Including Federal Land**
Form 477, Actual Area Coverage Method, December 2017

Number of Providers with Coverage in a Block	Covered POPs	% of Total Non-Rural US POPs	Covered Road Miles	% of Total Non-Rural US Road Miles
US Total	256,376,773	100.0%	2,298,858	100.0%
1 or more	256,332,080	100.0%	2,285,103	99.4%
2 or more	256,106,224	99.9%	2,255,598	98.1%
3 or more	255,366,768	99.6%	2,196,483	95.5%
4 or more	249,456,544	97.3%	1,991,511	86.6%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.34
***Estimated* Rural LTE Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2017

Provider	Covered POPs	% of Total Rural US POPs	Covered Road Miles	% of Total US Rural Road Miles
US Total	*56,094,554*	*100.0%*	*4,518,876*	*100.0%*
AT&T	54,267,818	91.7%	3,262,217	72.2%
Sprint	37,892,940	63.0%	1,412,671	31.3%
T-Mobile	48,043,725	85.1%	3,182,022	70.4%
Verizon	53,305,256	94.4%	3,861,668	85.5%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Appendix Figure A.II.35
***Estimated* Non-Rural LTE Coverage in the U.S. by Service Provider**
Form 477, Actual Area Coverage Method, December 2017

Provider	Covered POPs	% of Total Non-Rural US POPs	Covered Road Miles	% of Total Non-Rural US Road Miles
US Total	*256,376,773*	*100.0%*	*2,298,858*	*100.0%*
AT&T	255,377,712	99.6%	2,204,019	95.9%
Sprint	249,811,940	97.4%	2,005,989	87.3%
T-Mobile	252,933,205	98.7%	2,182,700	94.9%
Verizon	251,749,455	98.2%	2,229,568	97.0%

Source: Based on actual area analysis of December 2017 Form 477 and 2010 Census data. Unlike the centroid methodology where each block is either covered or not, the actual area coverage methodology acknowledges that many blocks are only partially covered. Because it is unclear which census blocks should be considered covered or not, we do not report the number of blocks covered in these results.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-5

"Sprint Response to Cal Advocates Data Request No. 002 Question 2-9"

Contains CONFIDENTIAL SPRINT Information

Docket: A.18-07-011 and A.18-07-012

Witness: Cameron Reed

Date: January 7, 2019

Public Advocates Office

Exhibit C-6

"Sprint Response to Cal Advocates Data Request 001 Question 1-24"

Contains CONFIDENTIAL SPRINT Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-7-S

"Sprint CFR and CDR"

Contains CONFIDENTIAL Sprint Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-7-T

"T-Mobile CFR and CDR"

Contains CONFIDENTIAL T-Mobile Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-8

"Sprint Response to Cal Advocates Data Request No. 001 Question 1-49"

Contains CONFIDENTIAL SPRINT Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-9

"T-Mobile Response to Cal Advocates Data Request No. 004 Question 4-10"

Data Request 4-10.

Please fill out the attached spreadsheet Attachment DR004 (Service Quality Measurements) for California for the years 2015, 2016, 2017, through October 2018 with the following information:

a. *Location by which the metric is tracked (Nationwide, Statewide, Market, Zip Code, etc.)*
b. *Month Measurement Was Taken*
c. *Voice Drop Rate (%)*
d. *Voice Access Rate (%)*
e. *Data Drop Rate (%)*
f. *Data Access Rate (%)*
g. *Availability (%)*

Response to Data Request 4-10.

T-Mobile objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrase "Service Quality Measurements," "Voice Drop Rate." "Voice Access Rate," "Data Drop Rate," and "Data Access Rate." T-Mobile also objects to this Data Request on the grounds it seeks information that is neither germane to the pending Wireline or Wireless Applications nor is reasonably calculated to lead to the discovery of relevant information as the metrics used by T-Mobile to monitor its network performance has no reasonable bearing on whether the transfer of Sprint Wireline is adverse to the public interest or to any appropriate review of the Sprint Wireless Transfer Notification. T-Mobile additionally objects to this Data Request on the grounds it seeks information regarding broadband which is an exclusively interstate service that is subject to the FCC's – not the Commission's – jurisdiction. T-Mobile further objects to this Data Request on the grounds that General Order 133-D defines the Commission's service quality obligations applicable to wireless carriers. T-Mobile further objects to this Data Request to the extent it is duplicative of Cal PA DRs 1-49 to 1-52.

Subject to and without waiving its objections, T-Mobile provides the data requested for the period from July 2017 through October 2018. T-Mobile does not retain this network data in the ordinary course of business for extended time periods. See Cal PA DR 004 Production Folder. T-Mobile further refers to its Responses to Cal PA DRs 1-49 and 1-52.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-10

"Ookla's 2018 Speed Test Report"

English TAKE A SPEEDTEST®

Reports > United States

UNITED STATES

Mobile

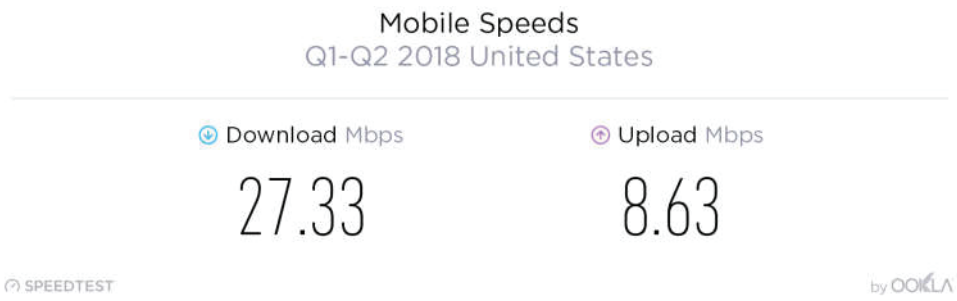
July 18, 2018
Based on Q1-Q2 2018 data

Introduction

5G is on the horizon, but for now LTE is still the name of the game as mobile carriers in the United States continue to invest in and fine-tune their infrastructure to improve speeds and more efficiently use existing spectrum. In Q1-Q2 2018, the U.S. ranked 43rd in the world for mean download speed over mobile, between Hong Kong and Portugal, and 73rd for mean upload speed, between Laos and Panama.

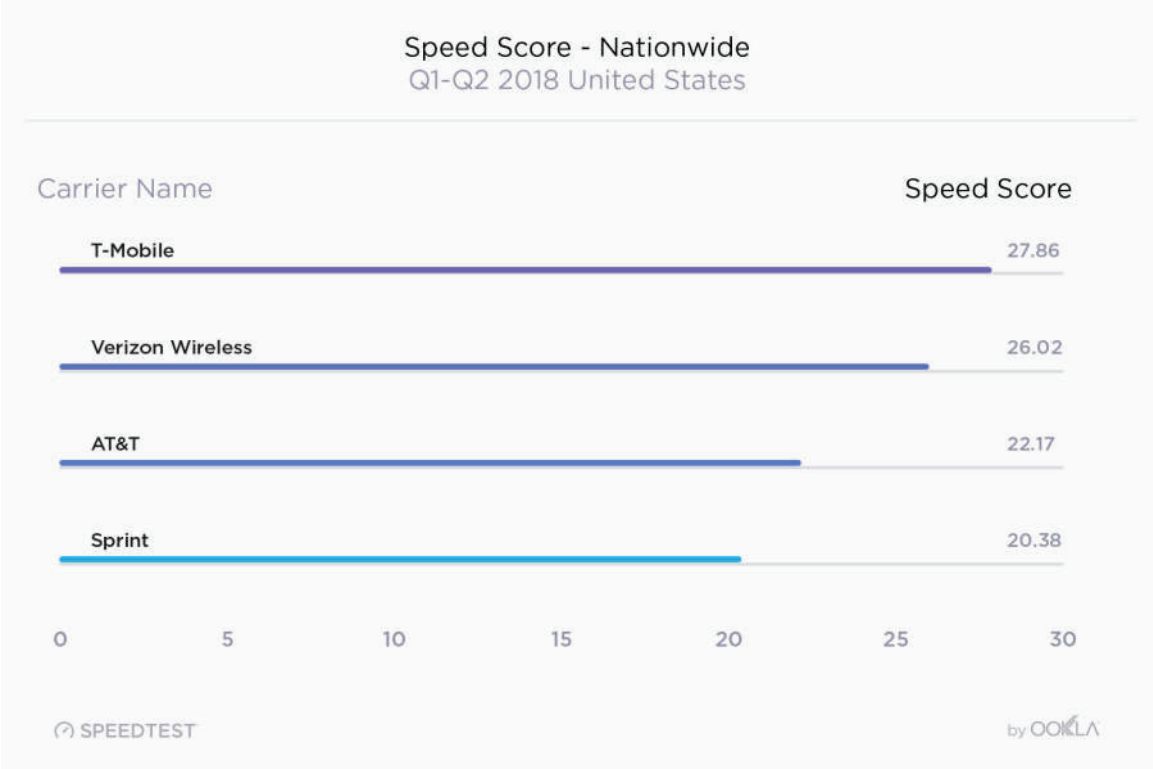
The 2018 Speedtest® U.S. Mobile Performance Report by Ookla® is based entirely on Speedtest Intelligence® data captured during the first half of 2018. During this period, 2,841,471 unique mobile devices were used to perform over 12 million consumer-initiated cellular network tests on Speedtest apps. After analyzing those tests, Ookla is able to determine the carriers with the fastest and most consistent networks across the nation. We are also able to analyze carriers' performance in the 100 largest cities in the country and how speeds in rural areas compare.

Country speeds



Mean download speed over mobile in the U.S. increased 20.4% between Q1-Q2 2017 and Q1-Q2 2018 to 27.33 Mbps. The mean upload speed for mobile was 8.63 Mbps, up 1.4% over Q1-Q2 2017.

Fastest carriers



Data from Speedtest Intelligence reveals T-Mobile was the fastest carrier in the U.S. in Q1-Q2 2018 with a Speed Score™ of 27.86 on modern devices. Verizon Wireless was the second fastest, AT&T the third fastest and Sprint the slowest.

Speed Score

When analyzing fastest carriers, we consider top carriers (all carriers with 3% or more of total test samples in the market for the period). We then determine the fastest carrier using Speed Score which incorporates a measure of each provider's download and upload speed to rank network speed performance (90% of the final Speed Score is attributed to download speed and the remaining 10% to upload speed). The Speed Score uses a modified trimean to demonstrate the download and upload speeds that are available across a provider's network. We take speeds from the 10th percentile, 50th percentile (also known as the median), and 90th percentile, and combine them in a weighted average using a 1:2:1 ratio, respectively. We place the most emphasis on download speeds and median speeds as those represent what most network providers' customers will experience on a day-to-day basis. When considering carrier speeds, we look specifically at tests completed on modern devices, those devices that are capable of connecting to the fastest, broadly-available wireless networks.

How the big four carriers are improving their networks

To better understand why carriers rank as they do, we looked at their infrastructure investments over the past year. While these investments have contributed to improved speeds, they also provide the foundation for strong 5G experiences.

T-Mobile invests in LTE

Using recently acquired 600 MHz spectrum, T-Mobile has been expanding their LTE footprint by adding thousands of sites in over 900 cities and towns, including previously unserved areas. Because this type of spectrum propagates farther, it allows the operator to cover vast geographical areas more efficiently and utilize fewer cell sites in the process. At this point, T-Mobile has dedicated virtually all of its mid-band spectrum portfolio to LTE operations, keeping only the last 10 MHz sliver of spectrum for 3G legacy users and packing the tiny GSM channels into the LTE and UMTS guard bands for those using 2G-only devices.

In order to stay ahead of the curve and prepare for 5G and the predicted surge in data demand, T-Mobile has been deploying License Assisted Access (LAA) and using a technique called Carrier Aggregation. LAA is an advanced LTE technique which combines the existing licensed spectrum with unlicensed spectrum in the 5 GHz band. This strategy provides a significant capacity boost in targeted dense urban areas, creating the possibility of real world speeds approaching 600 Mbps.

Verizon Wireless increases capacity

The breadth of Verizon's LTE network is widely known in the industry, but it can be challenging to offer vast coverage along with fast speeds everywhere. Verizon has been busy addressing capacity demand by adding new cell sites, mostly in urban cores. The process of network densification offers many benefits to end users, such as: faster speeds, better signal quality and improved battery life. Verizon has repurposed all mid-band spectrum assets for LTE in many markets, including the AWS-3 spectrum assets. This leaves

a small section of 850 MHz (cellular) frequency band for CDMA operation. In markets like Los Angeles, a portion of cellular band has already been repurposed for LTE.

To add incremental capacity and improve network efficiency, Verizon has accelerated the implementation of advanced LTE features like 256 QAM and 4x4 MIMO. Although the extent of the implementation appears to be dependent on the infrastructure hardware and software availability. In markets where Verizon has been using Ericsson technology, a minor upgrade to existing hardware is all that is needed to enable these features. However, the process of replacing older legacy Alcatel-Lucent hardware with the newer Nokia Networks equipment has slowed down the rollout of these efficiency-boosting measures in other markets.

AT&T bets on spectrum diversity

AT&T has the most diverse spectrum portfolio delivering LTE experiences across seven frequency bands. This already rich spectrum portfolio is soon to be augmented now that AT&T has been awarded a contract for deploying an LTE network using spectrum reserved for public safety. This low-band 700 MHz spectrum (Band 14) will prioritize first responders, but AT&T subscribers will also have lower priority access which will help ease network congestion.

AT&T customers with the latest flagship devices are able to experience world-class speeds leveraging the unlicensed spectrum in parts of seven metropolitan areas. Additionally, the use of LAA also improves the experience for users with older devices by freeing up resources in the licensed bands to increase speeds for everyone.

Similar to Verizon, AT&T's rollout of advanced LTE features has been slowed down in markets previously served by Alcatel-Lucent infrastructure. This will continue until all the radios and base stations are replaced with newer and more advanced Nokia equipment.

Sprint flexes LTE with TDD

Sprint has delivered the most improved download speeds over the past year. While still the slowest of the four major carriers, the gap between Sprint and AT&T has been closing. In some markets, Sprint customers are experiencing faster download speeds than those on any other carrier. This development is because Sprint committed between 40 MHz and 60 MHz of contiguous 2.5 GHz spectrum to LTE and the company expanded its use of carrier aggregation across a wider footprint.

More significantly, Sprint's increase in download speeds is a result of a change of the frame configuration in the 2.5 GHz frequency band. Being the only Time Division Duplex (TDD) LTE operator in the United States, Sprint's network has the flexibility of adjusting the amount of subframes dedicated to downlink (at the expense of uplink). A shift from TDD LTE Configuration 1 to 2 also allowed for 30% more downlink capacity. However, this reallocation degraded upload speeds which were already in the single digits. The use of uplink 64 QAM could improve upload speeds by up to 50% in good signal conditions and we are already seeing a slow rollout of this feature in a few markets.

Sprint could further improve coverage and capacity in the 2.5 GHz band by rolling out Massive MIMO active antenna solutions and leveraging features like advanced beamforming. While Sprint holds large swaths of spectrum in the 2.5 GHz band (160 MHz on average), providing a consistent LTE experience has been difficult. This has especially been the case in situations where 2.5 GHz doesn't propagate. In those instances, Sprint's LTE network is limited to thin portions of 5 MHz fallback mid- and low-band spectrum and a very limited cell site density. Merging with T-Mobile could offer a solution to both of these pain points.

HD Speed Ratio

The HD Speed Ratio (HDSR) measures what percent of each carrier's test download data samples are HD-capable (equaling or exceeding 5 Mbps). This speed should deliver a strong HD experience at 720p and is generally sufficient to surf the web, connect to social accounts and view most content on a mobile connection. While we think fast speeds are paramount, ensuring a minimum acceptable experience is also a worthy measure of a network's quality. It's important to point out that the ability to stream HD video comes as an upgrade to existing data plans. Whether you end up choosing "One Plus" on T-Mobile, "Unlimited Plus" on Sprint, "Beyond Unlimited" on Verizon, or "Unlimited & More Premium" on AT&T; without these premium plans, streaming video is typically reduced in quality to 480p.

National HD Speed Ratio
Percent of Mobile Download Results ≥ 5 Mbps
Q1-Q2 2018 United States

Carrier Name	HD Speed Ratio
T-Mobile	86.6%
Verizon Wireless	85.8%
AT&T	77.4%
Sprint	75.2%

SPEEDTEST by OOKLA

T-Mobile had the highest HDSR in the U.S. during Q1-Q2 2018 with 86.6% of their Speedtest results showing a download speed of 5 Mbps or higher. Verizon was a close second. AT&T was third. A last place HDSR of 75.2% means that 24.8% of Speedtest results on Sprint are below the 5 Mbps quality threshold.

Comparing performance on two popular devices

To see how carriers stack up on two popular devices, we reviewed Speedtest results from 351,847 Apple iPhone Xs and 20,822 Samsung Galaxy S9s during Q1-Q2 2018.

Speed Score on Popular Mobile Devices
Q1-Q2 2018 United States

Carrier Name	Galaxy S9	iPhone X
T-Mobile	39.48	28.93
Verizon Wireless	35.24	29.36
AT&T	33.25	26.20
Sprint	30.19	21.79

SPEEDTEST by OOKLA

Verizon Wireless's Speed Score jumps slightly ahead of T-Mobile's on the iPhone X, while T-Mobile retains the top spot on the Galaxy S9. The difference in fastest carrier between the two devices can be explained by the fact that the Galaxy S9 has four receive antennas and the iPhone X does not. Without the ability to leverage more than two spatial streams, achievable speeds on the iPhone X are chiefly limited by the aggregate amount of LTE spectrum that each carrier has deployed and the ability of the iPhone X to address up to 60 MHz of spectrum on the downlink by the way of 3X Carrier Aggregation. Because Verizon has on average deployed more wideband (30 MHz and 40 MHz) contiguous Frequency Division Duplex (FDD) LTE spectrum blocks than other carriers, their customers see faster speeds on the iPhone X.

On the other hand, T-Mobile has had an early start with capacity-boosting technologies like 4x4 MIMO and thus likely has this feature enabled on a larger percentage of cell sites across their entire footprint. That means that T-Mobile users with capable devices — like the Galaxy S9 — are able to see faster speeds in more places.

Except for the reversal between T-Mobile and Verizon Wireless on the iPhone X, carrier rankings are the same on both devices as we saw overall at the national level.

This look at flagship phones allows us to see that customers with the latest devices should receive better speeds all around than the carriers' national averages. It also pinpoints that the Samsung Galaxy S9 is significantly faster than the iPhone X. The difference in speed between these two devices seems to come from the fact that the Galaxy S9 is powered by the latest Qualcomm Snapdragon X20 LTE modem, while the iPhone X uses a mix of modified Qualcomm Snapdragon X16 and Intel XMM7480 modems. The real magic happens

for Samsung between the modem and the antenna modules. A combination of Qualcomm's powerful RF front-end solution and Samsung's experience designing smartphones with four receive antennas, explains the 20-40% speed advantage over the iPhone X. With the extra set of "ears" (four receive antennas), the Galaxy S9 is able to collect more energy in challenging radio conditions resulting in improved speeds and signal quality. The device is capable of using two additional data streams by the way of 4x4 MIMO in good signal conditions.

Understanding the urban-rural divide in mobile performance

The large physical size of the U.S. and differing levels of development make for a variety of mobile internet experiences across the country. To better understand that difference, we examined mobile performance in FCC-defined cellular market areas (CMAs). Specifically, we compared performance in the 100 most populous metropolitan statistical areas (MSAs) with that in all rural service areas (RSAs). Note that U.S. territories like American Samoa, Puerto Rico and the U.S. Virgin Islands were excluded from this analysis.

Speeds are slower in rural areas

Our analysis reveals Speed Score increases for all carriers when looking only at the 100 largest MSAs. This is likely because infrastructure is easier and less costly to build and maintain in more densely populated areas; it's also easier to justify the investment when there are more customers in an area. There is a virtual tie between Verizon and T-Mobile based on Speed Score in the largest 100 MSAs. AT&T and Sprint come in third and fourth, respectively.

Urban vs. Rural Weighted Speed Scores on Mobile
Q1-Q2 2018 United States

Carrier Name	Top 100 MSAs	RSAs
Verizon Wireless	28.50	20.21
T-Mobile	28.46	21.72
AT&T	23.81	19.86
Sprint	21.99	15.51

SPEEDTEST by OOKLA

When looking at performance in RSAs, we see across the board Speed Score decreases compared to national averages. The carrier ranking mimics that at the national level with Speedtest results for T-Mobile coming in fastest and Sprint slowest. Note that though we examined 413 RSAs, we only included data for those RSAs in which a given carrier had five or more samples. Using this logic, Verizon was present in 413 RSAs, AT&T in 411, T-Mobile in 397 and Sprint in 379.

The majority of each carrier's tests take place in urban areas because that's where approximately 80% of the U.S. population lives. However, rural areas comprise about 97% of the country's land mass, and some carriers cover that wide area more thoroughly than others. Verizon accounted for 49.0% of all samples we saw in rural areas. AT&T made up 30.5%, T-Mobile 12.1% and Sprint 8.3%. Verizon and AT&T show 29.1% and 20.2% of their total Speedtest results, respectively, occurring in rural areas. For Sprint, 16.9% of their tests are in RSAs and T-Mobile shows 11.3% of their tests in RSAs.

All carriers show lower HD Speed Ratios in rural areas

Urban vs. Rural HD Speed Ratios
Percent of Mobile Speedtest Results ≥ 5 Mbps
Q1-Q2 2018 United States

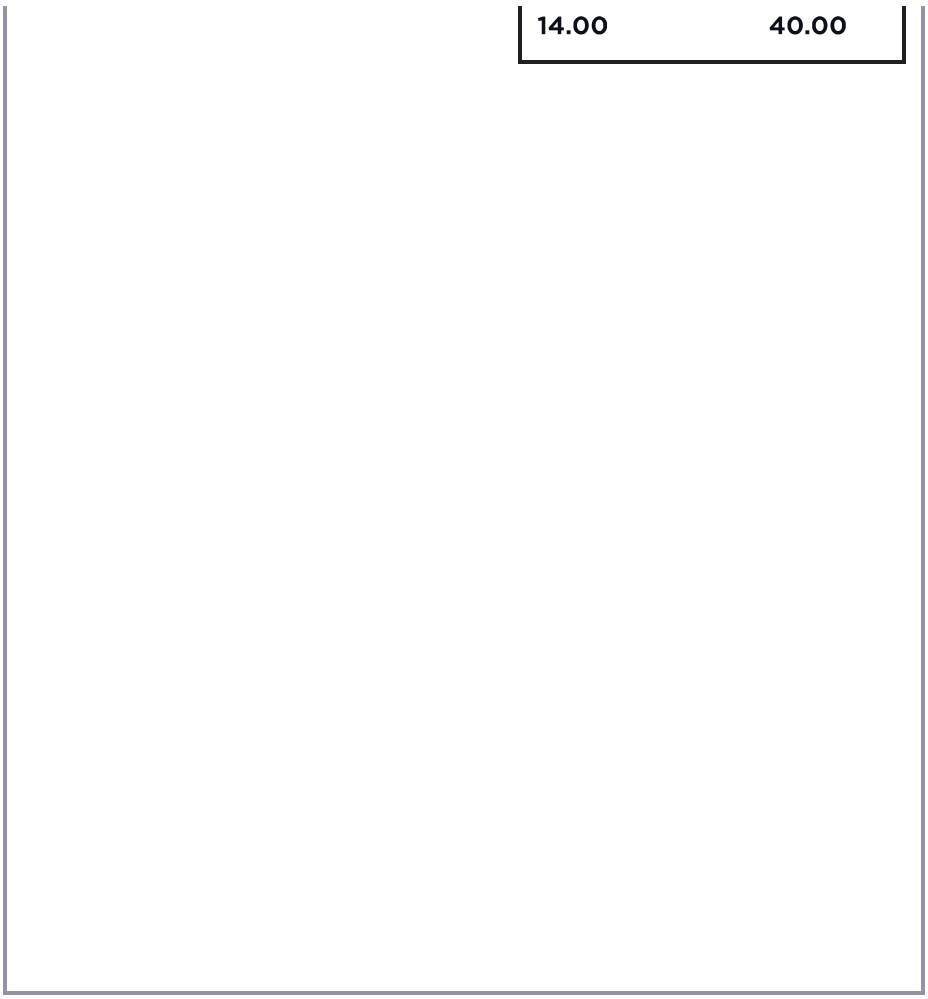
Carrier Name	Top 100 MSAs	RSAs
Verizon Wireless	87.1%	78.8%
T-Mobile	86.5%	82.4%
AT&T	78.2%	74.1%
Sprint	76.4%	68.2%

SPEEDTEST by OOKLA

Using the same 5 Mbps download threshold as we used at the national level, we found that Verizon Wireless virtually tied with T-Mobile for the highest HD Speed Ratio (HDSR) in the 100 largest MSAs, but T-Mobile was first in RSAs and Verizon ranked second in RSAs. Sprint had the lowest HDSR in both MSAs and RSAs.

It's clear from this data that customers in more rural parts of the country have a harder time connecting at minimally acceptable speeds.

Mobile speeds by state



A state-level view of Q1-Q2 2018 mobile speeds offers a closer look at strong and weak spots across the U.S. as well as which carriers won in which states.

With a mean download speed over mobile of 36.80 Mbps, first-place Minnesota outpaced runner-up Michigan by over 4 Mbps. New Jersey, Ohio, Massachusetts and Rhode Island formed a tight group to round out the top six.

Wyoming had the slowest mean download speed over mobile, followed by Alaska, Mississippi, Maine and West Virginia.

T-Mobile was the fastest carrier in 31 states across the country, faring especially well in the Southeast, Southwest and on the West Coast. Verizon Wireless was the fastest carrier in 13 states and the District of Columbia, including much of the northeastern seaboard, the upper Midwest, Alaska and Hawaii. AT&T was fastest in four states including the Carolinas, Nebraska and Nevada. Sprint was fastest only in Colorado. T-Mobile tied with Verizon Wireless in Massachusetts.

Fastest carriers by city

Q1-Q2 2018

City speeds based on average speeds for all results. Carrier speeds based on Speed Score for modern devices.

City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Carrier's Speed Score
Albuquerque, New Mexico	26.17	10.01	AT&T	27.75
Anaheim, California	27.64	10.36	Verizon Wireless	34.77
Anchorage, Alaska	18.90	8.30	Verizon Wireless	25.21
Arlington, Texas	26.76	9.49	Verizon Wireless	32.32
Atlanta, Georgia	33.81	11.96	Verizon Wireless	38.81
Aurora, Colorado	26.02	7.42	Verizon Wireless	25.57
Austin, Texas	29.86	8.46	Sprint	28.40
Bakersfield, California	28.50	9.90	Verizon Wireless	31.53
Baltimore, Maryland	31.75	10.65	Verizon Wireless	40.51
Baton Rouge, Louisiana	27.64	8.01	Verizon Wireless	26.20
Boise, Idaho	31.17	8.99	T-Mobile	35.48
Boston, Massachusetts	30.07	10.90	Verizon Wireless	30.32
Buffalo, New York	26.15	8.71	Verizon Wireless	27.37
Chandler, Arizona	31.74	9.80	T-Mobile	34.44
Charlotte, North Carolina	25.60	8.12	AT&T	27.63
Chesapeake, Virginia	33.84	10.85	T-Mobile	39.36
Chicago, Illinois	29.33	10.34	Verizon Wireless	34.96
Chula Vista, California	29.40	10.76	Verizon Wireless	31.70
Cincinnati, Ohio	33.25	8.76	Verizon Wireless	37.53
Cleveland, Ohio	31.16	9.32	T-Mobile	33.68
Colorado Springs, Colorado	29.01	8.60	T-Mobile	33.12
Columbus, Ohio	32.52	9.07	T-Mobile	36.00
Corpus Christi, Texas	28.83	8.70	Sprint | T-Mobile	29.29 | 29.03
Dallas, Texas	26.16	9.55	Verizon Wireless	30.33
Denver, Colorado	28.51	7.89	Sprint	30.11
Detroit, Michigan	32.27	9.82	Verizon Wireless	35.57
Durham, North Carolina	28.36	8.23	AT&T	32.56
El Paso, Texas	21.18	9.96	T-Mobile	19.95

City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Carrier's Speed Score
Fort Wayne, Indiana	38.36	11.06	Verizon Wireless	44.84
Fort Worth, Texas	25.13	9.06	Verizon Wireless	29.56
Fremont, California	31.21	9.24	T-Mobile	30.33
Fresno, California	22.98	7.85	Verizon Wireless | AT&T	20.89 | 20.89
Garland, Texas	25.69	9.77	Verizon Wireless	29.02
Gilbert, Arizona	29.14	9.40	T-Mobile	31.49
Glendale, Arizona	25.92	9.20	AT&T	29.12
Greensboro, North Carolina	27.13	8.04	T-Mobile	29.40
Henderson, Nevada	25.20	9.07	T-Mobile	25.11
Hialeah, Florida	24.98	9.58	T-Mobile	29.62
Honolulu, Hawaii	23.53	11.24	Verizon Wireless	29.12
Houston, Texas	26.28	9.14	T-Mobile	25.70
Indianapolis, Indiana	33.56	9.29	AT&T	32.87
Irvine, California	34.10	12.01	Verizon Wireless	37.72
Irving, Texas	25.65	9.82	Verizon Wireless	29.89
Jacksonville, Florida	27.90	8.99	T-Mobile	31.45
Jersey City, New Jersey	31.29	12.23	Verizon Wireless	39.86
Kansas City, Missouri	33.90	8.12	Verizon Wireless	36.13
Laredo, Texas	18.52	7.13	T-Mobile	20.05
Las Vegas, Nevada	24.49	9.18	T-Mobile	22.90
Lexington, Kentucky	25.38	8.91	T-Mobile	32.88
Lincoln, Nebraska	24.40	8.67	Sprint	25.97
Long Beach, California	27.10	9.91	Verizon Wireless	28.46
Los Angeles, California	27.40	10.34	Verizon Wireless	31.18
Louisville, Kentucky	28.10	8.54	Sprint | AT&T	26.02 | 25.96
Lubbock, Texas	20.70	8.89	Verizon Wireless	25.95
Madison, Wisconsin	20.29	6.65	Verizon Wireless	25.84
Memphis, Tennessee	23.38	7.70	T-Mobile	24.81
Mesa, Arizona	26.86	9.41	AT&T	26.93
Miami, Florida	22.96	9.58	T-Mobile	25.96
Milwaukee, Wisconsin	26.17	8.30	Verizon Wireless	31.94
Minneapolis, Minnesota	44.92	14.26	Verizon Wireless	44.99
Nashville, Tennessee	27.68	10.90	Verizon Wireless	28.30

City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Carrier's Speed Score
New Orleans, Louisiana	25.84	8.99	Verizon Wireless	25.54
New York, New York	32.74	11.81	Verizon Wireless	41.66
Newark, New Jersey	23.31	10.12	Verizon Wireless	25.20
Norfolk, Virginia	25.67	9.69	T-Mobile	26.94
North Las Vegas, Nevada	22.23	7.86	Sprint	21.32
Oakland, California	30.23	9.96	Verizon Wireless	32.50
Oklahoma City, Oklahoma	22.55	8.86	T-Mobile	24.46
Omaha, Nebraska	23.64	7.73	T-Mobile	39.19
Orlando, Florida	29.35	10.08	Verizon Wireless | T-Mobile	29.20 | 29.11
Philadelphia, Pennsylvania	28.30	9.82	T-Mobile	27.68
Phoenix, Arizona	25.41	9.47	AT&T	27.58
Pittsburgh, Pennsylvania	30.54	11.26	AT&T	31.39
Plano, Texas	30.57	10.02	T-Mobile	35.90
Portland, Oregon	29.45	8.77	T-Mobile	33.32
Raleigh, North Carolina	29.34	8.94	AT&T	35.10
Reno, Nevada	20.32	7.58	Sprint	22.75
Richmond, Virginia	28.92	10.36	Verizon Wireless	31.89
Riverside, California	28.86	10.92	Verizon Wireless	31.25
Sacramento, California	26.50	9.36	Verizon Wireless	25.50
Saint Paul, Minnesota	42.28	12.81	Verizon Wireless | T-Mobile	42.60 | 42.25
Saint Petersburg, Florida	29.97	9.32	T-Mobile	32.96
San Antonio, Texas	25.76	8.76	T-Mobile	26.65
San Bernardino, California	27.95	11.96	Verizon Wireless	38.22
San Diego, California	31.46	11.54	AT&T	30.72
San Francisco, California	34.64	13.27	Verizon Wireless	37.36
San Jose, California	30.38	9.31	Verizon Wireless	30.94
Santa Ana, California	26.25	10.43	Verizon Wireless	34.19
Scottsdale, Arizona	29.39	9.06	T-Mobile	34.32

City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Carrier's Speed Score
Seattle, Washington	**31.77**	**11.21**	T-Mobile	**32.23**
St. Louis, Missouri	**32.80**	**9.63**	AT&T	**34.86**
Stockton, California	**23.85**	**8.51**	Verizon Wireless	**29.31**
Tampa, Florida	**29.11**	**10.29**	T-Mobile	**31.32**
Toledo, Ohio	**33.83**	**9.28**	Verizon Wireless	**38.47**
Tucson, Arizona	**26.88**	**10.39**	Verizon Wireless	**27.42**
Tulsa, Oklahoma	**25.12**	**10.54**	T-Mobile	**29.30**
Virginia Beach, Virginia	**33.05**	**10.77**	T-Mobile	**36.15**
Washington, District of Columbia	**30.08**	**9.74**	Verizon Wireless	**32.71**
Wichita, Kansas	**31.55**	**9.16**	T-Mobile	**33.39**
Winston-Salem, North Carolina	**27.12**	**8.57**	AT&T	**30.93**

See Less

Looking at Q1-Q2 2018 mobile performance in the 100 most populous cities in the U.S., Minneapolis had the fastest mean download speed over mobile. Neighboring St. Paul was second, Fort Wayne third, San Francisco fourth and Irvine fifth. On the other end of the spectrum, Laredo and Anchorage came in last and second to last. Madison was third slowest, followed by Reno and Lubbock.

Verizon Wireless was the fastest carrier in 45 of the 100 cities we examined. T-Mobile won 33, AT&T 12 and Sprint five. Verizon and T-Mobile tied in Orlando and Saint Paul, Verizon tied with AT&T in Fresno, T-Mobile and Sprint tied in Corpus Christi, and Sprint and AT&T tied in Louisville.

Conclusion

As much as mobile download speeds have improved in the past year, the big change will come next year when 5G is a reality. With any luck, 5G will also jumpstart upload speeds which have lagged in recent years. For now, T-Mobile's investment in LTE has made them the fastest carrier in the U.S. and Verizon Wireless is close behind. T-Mobile has the highest HD Speed Ratio at the national level and was the fastest carrier in the majority of states. However, Verizon won in nearly half of the country's largest cities.

In rural areas, T-Mobile outperforms Verizon with faster speeds and a higher HD Speed Ratio in RSAs where they are present. We see that Verizon's rural performance numbers are likely drawn down by the fact that they offer coverage in areas where other carriers do not — especially isolated areas where it's more difficult to offer service at all.

Changes are on the horizon. AT&T and Verizon are committed to deploying 5G in the high millimeter wave (mmWave) frequency bands, which will allow them to deliver speeds over 1 Gbps in a very surgical manner. Sprint will leverage its vast 2.5 GHz mid-band spectrum and existing 64T64R massive MIMO radios operating in mixed mode (LTE + 5G). T-Mobile will continue rolling out 5G-ready 600 MHz equipment nationwide and supplement that rollout with a mmWave 5G layer in several dense urban markets. 2019 may very well see the merger of T-Mobile and Sprint, which could result in a very powerful 5G network built on low-, mid- and high-band fallow spectrum. How will this all affect mobile speeds and coverage? Ookla's recent acquisition of Mosaik puts us in a unique position to bring you in-depth analysis in future reports.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-11

"T-Mobile Network Reports"

Contains CONFIDENTIAL T-MOBILE Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-12

"T-Mobile response to Cal Advocates Data Request No. 001 Question 1-24"

Contains CONFIDENTIAL T-MOBILE Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-13

"Dish Petition to Deny Slide Deck"

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REDACTED—FOR PUBLIC INSPECTION

November 19, 2018

BY ECFS

Marlene Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: **Notice of Ex Parte Meeting, Applications of T-Mobile US, Inc. and Sprint Corporation for Consent to Transfer Control of Licenses and Authorizations, WT Docket No. 18-197**

Dear Ms. Dortch:

On November 15, 2018, representatives of DISH Network Corporation[1] met with members of the FCC Transaction Team listed on Attachment A to discuss the Brattle/Harrington Declarations submitted with DISH's Petition to Deny and Reply in the above-captioned proceeding.[2] DISH's economists discussed the presentation enclosed as Attachment B.

DISH's economists explained that the proposed transaction would lead to substantial price increases in a number of markets, as explained further in Attachment B. The supposed efficiencies and quality improvements claimed by the Applicants are not enough to offset the upward price pressure and are either vastly overstated or simply non-existent.

---

[1] Participating for DISH were Jeffrey Blum, Senior Vice President, Public Policy & Government Affairs, and Alison Minea, Director & Senior Counsel, Regulatory Affairs (for the public portion of the discussion only). Also present were Pantelis Michalopoulos and Andrew Golodny of Steptoe & Johnson, LLP, and William Zarakas, Jeremy Verlinda, and Coleman Bazelon of the Brattle Group. Joseph Harrington of the University of Pennsylvania and David Sappington of the University of Florida participated by phone.

[2] *See* Declaration of Joseph Harrington and The Brattle Group (Exhibit B to DISH Petition to Deny) (Aug. 27, 2018), Reply Declaration of Joseph Harrington and The Brattle Group (Exhibit 1 to DISH Reply) (Oct. 31, 2018).

DISH's economists also explained that the merger would increase the likelihood of post-merger tacit coordination among the remaining three facilities-based providers of mobile voice/broadband service in the United States: AT&T, Verizon and New T-Mobile will have well-aligned incentives to coordinate pricing, causing even further price increases.

DISH has denoted with **{{BEGIN HCI END HCI}}** information that is deemed to be Highly Confidential Information pursuant to the *Protective Order* and denoted with **{{BEGIN NRUF/LNP HCI END NRUF/LNP HCI}}** information that is deemed to be Highly Confidential Information pursuant to the *NRUF/LNP Protective Order*. A public, redacted version of this filing is being filed with the Commission.[3]

Please contact me with any questions.

Respectfully submitted,

/s
Pantelis Michalopoulos
Counsel to DISH Network Corporation

[3] Applications of T-Mobile US, Inc. and Sprint Corporation for Consent to Transfer Control of Licenses and Authorizations, *Protective Order*, WT Docket No. 18-197, DA 18-624 (June 15, 2018) ("*Protective Order*"); Applications of T-Mobile US, Inc. and Sprint Corporation for Consent to Transfer Control of Licenses and Authorizations, *NRUF/LNP Protective Order*, WT Docket No. 18-197, DA 18-777 (July 26, 2018) ("*NRUF/LNP Protective Order*").

Attachment A

Joseph Wyer
Monica Delong
Marcus Maher
Catherine Matraves
David Sibley
David Laurence
Katherine LoPiccalo
Ziad Sleem
Kirk Arner
Chris Smeenk
Aleks Yankelevich
Weiren Wang
Jonathan Campbell
Robert Chen
Patrick Sun
Matthew Collins
Ronald Repasi
Nicholas Copeland
Jim Bird
Joel Rabinovitz
Thuy Tran
Kathy Harris
Charles Mathias
Donald Stockdale
Garnet Hanly
Aalok Mehta
Pramesh Joban Putra

Attachment B

REDACTED—FOR PUBLIC INSPECTION

Economic Analysis of the Proposed Sprint/T-Mobile Merger

PRESENTED TO
Federal Communications Commission

PRESENTED BY
Coleman Bazelon
Jeremy Verlinda
William Zarakas

November 15, 2018

THE Brattle GROUP

Summary of Conclusions

- Upwards pricing pressure in the Compass model is {{BEGIN HCI END HCI}} as calculated in the initial Brattle declaration; it is {{BEGIN HCI END HCI}} when porting data is used as the basis for diversion.

- Compass estimates reflect results on an aggregated level; in their case, "overall" neutral effects on consumer welfare mean that some customers are harmed disproportionately.

- Compass has calculated marginal cost savings by comparing incremental costs of congestion relief for the Sprint and T-Mobile stand-alone networks versus a combined New T-Mobile network, but their network assumptions include material flaws.
  - The Applicants' 5G models are artificially spectrum constrained; modestly relaxing the spectrum constraint significantly reduces the merger related offered capacity increases and also reduces marginal cost savings.
  - Adjustments in spectral efficiency and 5G refarming for stand-alone Sprint, congestion relief, and cost and usage assumptions also reduce claimed marginal cost savings.

Summary of Conclusions

- Correcting the network modeling assumptions:
  - Marginal cost savings are just a fraction of those claimed by the Applicants
  - Prices increase for all Sprint and T-Mobile subscribers
  - Improvements in network quality are insufficient to offset harm from price increases
- The merger will likely cause significant increases in wholesale prices paid by MVNOs and resellers, and marginal cost efficiencies will not offset these.
- The merger increases the likelihood that the three leading firms – AT&T, Verizon and New T-Mobile – will have higher incentives to coordinate pricing than exist absent the merger; New T-Mobile will almost assuredly abandon its maverick strategy.
- The Applicants' revised network model, which underlies Compass' calculated marginal cost savings, indicates that the stand-alone networks will have sufficient capacity to meet customer 5G demand, and that each stand-alone company will not experience almost any congestion.

Retail Market Price Effects

Unilateral Effects - Retail

- Under Compass' model, the retail price effects are {{BEGIN HCI
  END HCI}} than those estimated in the initial Brattle declaration.
  - Relative to the Brattle declaration, where segments are considered independently and market shares were used for some diversion calculations, the combination of all segments into Compass' merger simulations and the use of Harris data causes price effects to {{BEGIN HCI END HCI}}
  - If IKK had used porting data for diversion, the price effects would be {{BEGIN HCI
    END HCI}} than in the Brattle declaration

- Before consideration of efficiencies, the Compass model predicts significant price increases for all of the Applicants' products

- Even including claimed marginal costs efficiencies, the Compass model predicts that Sprint subscribers pay higher prices due to the merger

Retail Price Increases and Compensating Marginal Cost Reductions Based on Porting Data

{{BEGIN NRUF/LNP HCI

END NRUF/LNP HCI}}

Retail Price Increases Under the Compass Model and Inputs

The Compass merger simulation model and inputs predict large price increases *before* consideration of marginal cost efficiencies

{{BEGIN HCI

END HCI}}

Retail Price Increases Under the Compass Model and Inputs, Including Claimed Efficiencies

The Compass model, including *claimed* marginal cost efficiencies, predicts that Sprint subscribers pay higher prices due to merger

{{BEGIN HCI

END HCI}}

Wholesale Market Price Effects

Unilateral Effects - Wholesale

- Salop and Sarafidis' discussion of the vertical upward pricing pressure on wholesale prices mischaracterizes the likely effect on MVNO and reseller input costs as "de minimis," but their own data shows that the merger creates significant upward pricing pressure on the wholesale prices of the Applicants' MVNO and reseller affiliates.

- Furthermore, the Applicants' claimed marginal cost efficiencies are insufficient to offset the vertical upward pricing pressure induced by the merger, indicating that the merger would cause wholesale prices to increase even when efficiencies are accounted for.

Wholesale Prices Increase Under the Compass Model and Inputs

The Compass merger simulation model and inputs predict large wholesale price increases before consideration of marginal cost efficiencies

- Input substitution reflects the ability of an MVNO to switch suppliers in response to a wholesale price increase

{{BEGIN HCI

END HCI}}

- Compass notes that Sprint resellers may not be able to switch wholesale affiliates
  ➔ Sprint & "with input substitution" scenario less relevant

Wholesale Price Increases Under the Compass Model and Inputs, Including Claimed Efficiencies

The Compass model, including claimed marginal cost efficiencies, predicts that MVNO & reseller affiliates will face higher input costs

{{BEGIN HCI

END HCI}}

Coordinated Effects

The Merger Increases Coordination Risk

- The merger will substantially increase the incentive of the three leading firms – AT&T, Verizon and New T-Mobile – to engage in coordinated pricing.
- New T-Mobile would be expected to abandon T-Mobile's historical maverick strategy (to gain market share) and instead exploit the increased market power from the merger to focus on short-term profits (given that it will have a market share in line with AT&T and Verizon).
- The CPPI is a relevant tool for assessing the potential increase in incentives to collude resulting from the merger.
- Even if merger efficiencies were sufficiently large so as to neutralize the (unilateral) upward pricing pressure induced by the merger, the merger would still significantly increase the incentives for collusion in the market for mobile voice/broadband services.

The Merger Increases the Risk of Coordinated Behavior

Even accounting for efficiencies, the CPPI increases by {{BEGIN HCI

END HCI}}

- Conservatively assumes that the merger can achieve Compensating Marginal Cost Reductions (CMCRs) for both brands

{{BEGIN HCI

END HCI}}

Marginal Cost Efficiencies

The Applicants Overstate the Marginal Cost Savings of the Merger

- Compass' calculated marginal cost savings are derived by comparing incremental costs of congestion relief for the Sprint and T-Mobile stand-alone networks versus a combined New T-Mobile network, but their network assumptions include material flaws
  - Most notable is the omission of reasonable amounts of millimeter wave spectrum in the Sprint and T-Mobile networks
  - Other inputs are also misstated (spectral efficiency, 2.5 GHz refarming and the cost of 5G upgrades)

- Compass considers alternative, lower network usage projections vs Ray model. Putting much less pressure on the network than the level it was apparently designed for significantly reduces the networks' marginal cost estimates, and generally boosts marginal cost savings.

- Correcting the network modeling assumptions:
  - Marginal cost savings are just a fraction of those claimed by the Applicants
  - Prices increase for all Sprint and T-Mobile subscribers
  - Improvements in network quality are insufficient to offset harm from price increases

The Compass Analysis Contemplates Cross Subsidies Among Consumers

- Compass' discussion of aggregate welfare neutrality masks underlying price increases for Sprint and certain T-Mobile subscribers

- Even under the hypothetical "welfare neutral" cost efficiencies:
  - Retail prices would increase for all Sprint segments and T-Mobile Prepaid
  - Only T-Mobile post-paid customers are expected to realize a price decrease

Summary of Compass' Sequential Argument for Assessing Merger Harm

1) Diversion x Margin = UPP

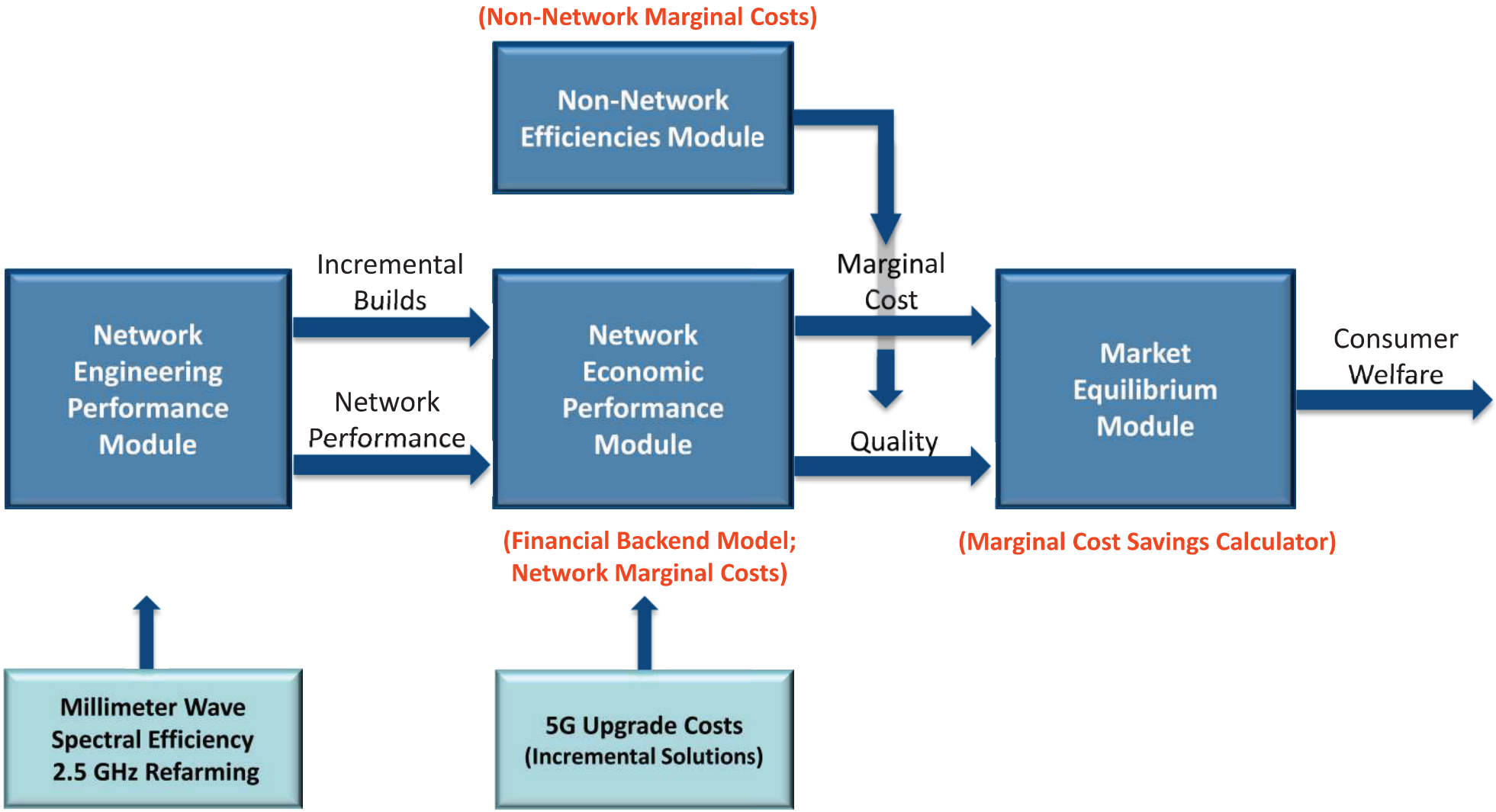
2) If Cost Efficiencies > UPP, then the merger is beneficial

3) If Cost Efficiencies < UPP, then the merger *may* be harmful (higher prices), but

4) Quality Improvements can offset higher prices

5) If Value of Quality Improvements > Harm from Price Increases, then the merger is beneficial

Marginal Cost Savings Schematic



Compensating Marginal Cost Reductions Under the Compass Model and Inputs

The Compass model inputs (margins, diversion) show that large marginal cost efficiencies are required to prevent price increases

{{BEGIN HCI

END HCI}}

Compass Significantly Overstates Marginal Cost Efficiencies

Adjusting the Applicants' network model to account for the stand-alone acquisition of millimeter wave spectrum reduces marginal cost efficiencies to just a fraction of the values claimed by Compass

{{BEGIN HCI

END HCI}}

After Adjusting Compass' Marginal Cost Efficiencies Estimates, Retail Prices Increase for Both Sprint and T-Mobile Subscribers

Adjusting the Applicants' network model to account for the stand-alone acquisition of millimeter wave spectrum means that the merger causes price increases across the board

{{BEGIN HCI

END HCI}}

Network Quality Improvements

Network Quality Improvements are Overstated by the Applicants

- The Applicants' revised network model shows that each stand-alone company will have significantly more capacity than the Applicants had originally estimated, and also shows that neither stand-alone company will experience congestion in any of the years estimated by the model except in a very small percentage of sectors.
- Refarming just an additional 20 MHz of 2.5 GHz spectrum in the standalone Sprint network model reduces the offered capacity increase from combining the networks and reduces marginal cost savings.
- The Applicants' 5G models are artificially spectrum constrained. Modestly relaxing the spectrum constraint significantly reduces the merger-related offered capacity.

The Ray Network Model

{{BEGIN HCI

END HCI}}

The Applicants Overstate the Improvements in Network Quality

The Applicants' own revised network models show that the stand-alone carriers can successfully deploy 5G levels of throughput

{{BEGIN HCI

END HCI}}

The Applicants Overstate New T-Mobile's Rural Coverage

- The Applicants' claims about improved rural coverage are not supported by the incremental sites added to the New T-Mobile network.
  - {{BEGIN HCI
    END HCI}}

{{BEGIN HCI

END HCI}}

The Applicants Overstate the Improvements in Network Quality

The Applicants' estimated increases in offered capacity due to the merger are overstated by nearly {{BEGIN HCI END HCI}} by 2024 after accounting for additional millimeter wave frequencies

{{BEGIN HCI

END HCI}}

Compass Adjustments to Network Models

Compass adjusts New T-Mobile's network model such that the 5G usage per subscriber is roughly half that of the Applicants' network model

{{BEGIN HCI

END HCI}}

Compass Adjustments to Network Models

Compass adjustments result in New T-Mobile having roughly the same carried traffic as the sum of the two standalones.

{{BEGIN HCI

END HCI}}

The Applicants' Claimed Quality Improvements Do Not Offset Harm to Sprint Subscribers from Higher Prices

Even accepting all claimed marginal cost efficiencies and willingness-to-pay for claimed quality improvements, Sprint subscribers are harmed

{{BEGIN HCI

END HCI}}

The Applicants' Claimed Quality Improvements Do Not Offset Harm Higher Prices

After adjusting for overstated marginal cost efficiencies, both Sprint and T-Mobile prices increase – and the claimed quality improvements do not offset the harm from these price increases

{{BEGIN HCI

END HCI}}

Nevo Quality Improvement Willingness to Pay Calculations

How Does Compass Calculate Willingness to Pay for Network Improvements?

Nevo et al. estimates of preferences for speed of wireline customers are the basis of Compass' WTP calculations

{{BEGIN HCI

END HCI}}

REDACTED

The "Adjusted" Results from IKK

{{BEGIN HCI

END HCI}}

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-14

"Collected T-Mobile Service Outages"

Contains CONFIDENTIAL T-MOBILE Information

Available on CD upon request

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-15

"Sprint Response to Cal Advocates Data Request No. 001 Question 1-23"

Contains CONFIDENTIAL SPRINT Information

Available on CD upon request

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-16

"Consolidated CAB informal complaint reports, 2015-2017"

any	Billing	Lifeline	Policy and Practices	Service	Total	Most Common Service Problem	Total w/o Lifeline
	8			3	1	12 Bill Adjustment	12
	7	10			2	19 Bill Adjustment	9
	15	28		1		44 Bill Adjustment	16
	5	15		3	1	24 Abusive Marketing	9
	9	16		5	1	31 Bill Adjustment	15
	7	28		3	3	41 Abusive Marketing	13
	7	14		1	3	25 High Bill	11
	10	14		1	4	29 High Bill	15
	6	24		4		34 High Bill	10
	10	29		1	2	42 High Bill	13
	5	12		2	1	20 Bill Adjustment	8
	8	32		2	3	45 No Single Prevailing Problem	13
bile	10				2	12 Bill Adjustment	12
bile	7			2	2	11 High Bill	11
bile	4			2	1	7 Bill Adjustment	7
bile	2			1		3 Bill Adjustment	3
bile	8			2	1	11 Bill Adjustment	11
bile	9			2	3	14 Other Charges	14
bile	7			1	2	10 High Bill	10
bile	8			1	1	10 Bill Adjustment	10
bile	10			4	5	19 Abusive Marketing	19
bile	12			1	1	14 Bill Adjustment	14
bile	4					4 Slamming	4
bile	5			1	3	9 Bill Adjustment	9
	9	18		5	4	36 Abusive Marketing	18
	8	29		2	1	40 High Bill	11
t	9	14		3	2	28 High Bill	14
t	10	20		3		33 Bill Adjustment	13
	6	21		2	1	30 Bill Adjustment	9
	6	26			1	33 High Bill	7
	6	12			1	19 Other Charges	7
	4	18		2	1	25 Abusive Marketing	7

t	9	9	3	2	23	High Bill	14
t	5	5			10	Other Charges	5
t	5	11	3	1	20	High Bill	9
t	10		1	2	13	High Bill	13
bile	5			2	7	Bill Adjustment	7
bile	14		1	1	16	Bill Adjustment	16
bile	7		1	3	11	Bill Adjustment	11
bile	6			1	7	Other Charges	7
bile	5				5	High Bill	5
bile	10				10	Bill Adjustment	10
bile	9				9	High Bill	9
bile	10			2	12	High Bill	12
bile	11			2	13	High Bill	13
bile	3		2	4	9	Call Quality	9
bile	3			1	4	Call Quality	4
bile	11			1	12	High Bill	12
t	6			2	8	High Bill	8
t	8		2	4	14	Bill Adjustment	14
t	9		1	2	12	High Bill	12
t	7		3	2	12	High Bill	12
t	5			4	9	Bill Adjustment	9
t	3		2	3	8	Call Quality	8
t	8		1		9	High Bill	9
t	8			4	12	High Bill	12
t	4	2	1		7	Abusive Marketing	5
t	5			2	7	Other Charges	7
t	8		4	3	15	Abusive Marketing	15
t	8			2	10	Refusal to Serve	10
bile	7				7	High Bill	7
bile	12		2	2	16	High Bill	16
bile	19		1	1	21	Bill Adjustment	21
bile	10		1	2	13	High Bill	13
bile	14			1	15	Other Charges	15
bile	10			1	11	High Bill	11

bile	7			7	Other Charges	7
bile	7	2		9	High Bill	9
bile	5	1	2	8	High Bill	8
bile	4	3	1	8	Abusive Marketing	8
bile	5			5	Other Charges	5
bile	6			6	Bill Adjustment	6

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-17

"Sprint Response to Cal Advocates Data Request No. 001, Question 1-53"

Contains CONFIDENTIAL SPRINT Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-18

"T-Mobile Response to Cal Advocates Data Request No. 001, Question 1-53"

Data Request 1-53.

Please provide Your current processes and/or procedures for handling customer's complaints and/or dissatisfaction in California for:

a. *Broadband*
b. *Voice over Internet Protocol (VoIP)*
c. *Voice over Long Term Evolution (VoLTE)*
d. *Wireless Voice Service*

Response to Data Request 1-53.

T-Mobile objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrases "complaints" and "dissatisfaction." T-Mobile further objects to this Data Request on the grounds it seeks information that is neither germane to the pending Wireline or Wireless Applications nor reasonably calculated to lead to the discovery of relevant information. T-Mobile also objects to this Data Request on the grounds it seeks information regarding broadband which is an exclusively interstate service that is subject to the FCC's – not the Commission's – jurisdiction.

Subject to and without waiving its objections, T-Mobile responds that T-Mobile customers communicate inquiries to T-Mobile, including customer complaints or customer dissatisfaction, through a wide variety of channels, including in-person, telephone, mail, email, online chat or messaging, the T-Mobile smartphone app, social media, communications directed to T-Mobile executives, and through various third-parties, such as the Better Business Bureau and federal, state, and local governmental agencies. There is no uniform set of processes and procedures for handling customer inquiries received across all of those varied channels, but T-Mobile's handling of such inquiries does not vary or differ based on the customer's state of residence or on any of the categories listed in the Request. In addition, there is no single repository of information within T-Mobile relating to customer inquiries, nor is there a standardized convention for documenting the subject matter of consumer inquiries across the various groups and teams that address and respond to such inquiries.

T-Mobile strives to provide world-class customer service to all of its customers, and to address customer concerns and complaints promptly and effectively. That commitment is reflected in the fact that T-Mobile and MetroPCS were the highest-ranked providers in the most recent J.D. Power U.S. Wireless Customer Care Full-Service and U.S. Wireless Customer Care Non-Contract studies, respectively. Moreover, for postpaid wireless customers, in August 2018 T-Mobile announced the nationwide launch of its innovative "Team of Experts" customer care model, under which customers have a dedicated team of T-Mobile care experts who are assigned to them and who they can connect directly with in a variety of ways, including by calling T-Mobile customer care, scheduling a call, or using messaging through the T-Mobile website or smartphone app.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-19

"Sprint Customer Complaints"

Contains CONFIDENTIAL SPRINT Information

Docket: A.18-07-011 and A.18-07-012

Witness: Cameron Reed

Date: January 7, 2019

Public Advocates Office

Exhibit C-20

"T-Mobile Response to Cal Advocates Data Request No. 001 Question 1-68"

Contains CONFIDENTIAL T-MOBILE Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-21

"Sprint Response to Cal Advocates Data Request No. 001 Question 1-73"

Contains CONFIDENTIAL SPRINT Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-22

"Sprint and T-Mobile Response to Cal Advocates Data Request Question 1-22"

Data Request 1-22.

Please provide processes and procedures regarding how You provision 911 services in California?

Response to Data Request 1-22.

Sprint objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrase "how you provision 911 services." Sprint also objects to this Data Request on the grounds it seeks information that is neither relevant to the pending Wireless Application nor reasonably calculated to lead to the discovery of relevant information, as the provisioning of 911/E911 by wireless carriers is a matter addressed by the FCC which requires ongoing coordination between wireless carriers and Public Safety Answering Points ("PSAPs"). Sprint further objects to this Data Request on the grounds it has no reasonable bearing on whether the transfer of Sprint Wireless is adverse to the public interest or the type of information required to complete the review of the Sprint Wireless Transfer Notification.

Subject to and without waiving its objections, Sprint responds that as a general matter, and consistent with FCC guidelines, emergency calls from mobile devices are connected with the Mobile Positioning Center ("MPC") via a Mobile Switching Center ("MSC"). The MPC determines the appropriate PSAP based on the serving cell site/sector and then returns routing digits in the form of an Emergency Services Routing Key ("ESRK"). The MSC sends a SIP INVITE to a dedicated 911 Session Border Controller ("SBC"). The 911 SBC will direct the INVITE message to a peering partner 911 SBC, which then delivers the call to the appropriate PSAP 911 Service Provider Selective Router based on the ten-digit ESRK value. The Selective Router then delivers the call to the appropriate PSAP. The ESRK can then be used to request location data for the 911 call. The 911 Routing Vendor works directly with 911 Coordinators throughout California for decisions on which cell site/sectors are routed to the California Highway Patrol call centers and PSAPs. Requests for changes to call routing are agreed upon by the involved parties in a collaborative effort to ensure calls are routed to the appropriate PSAP.

With respect to text-to-911, most PSAPs in the State of California have opted to use the HTTPS TCC-to-TCC (TCC = Text Control Center) interconnectivity solution for the PSAPs in California that have requested and/or implemented text-to-911. The PSAP must have public internet connectivity into workstations readily available, workstations must have web browser capability, the PSAP must be responsible for its equipment (upgrades/maintenance/technical support), and the PSAP must provide a point of contact for equipment customer support. Where Text-to-911 Service has not been requested or implemented, the following message will be sent to a wireless device attempting to text 911: "For emergency only. CALL 9-1-1. Text-to-911 not available."

Data Request 1-22.

Please provide processes and procedures regarding how You provision 911 services in California?

Response to Data Request 1-22.

T-Mobile objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrase "how you provision 911 services." T-Mobile also objects to this Data Request on the grounds it seeks information that is neither relevant to the pending Wireline or Wireless Applications nor reasonably calculated to lead to the discovery of relevant information as the provisioning of 911/E-911 by wireless carriers is a matter addressed by the FCC, which requires ongoing coordination between wireless carriers and Public Safety Answering Points. T-Mobile is not aware of any issue with its provisioning of 911 services in California and further objects to this Data Request on the grounds it has no reasonable bearing on whether the transfer of Sprint Wireline is adverse to the public interest or the type of information required to complete the review of the Sprint Wireless Transfer Notification.

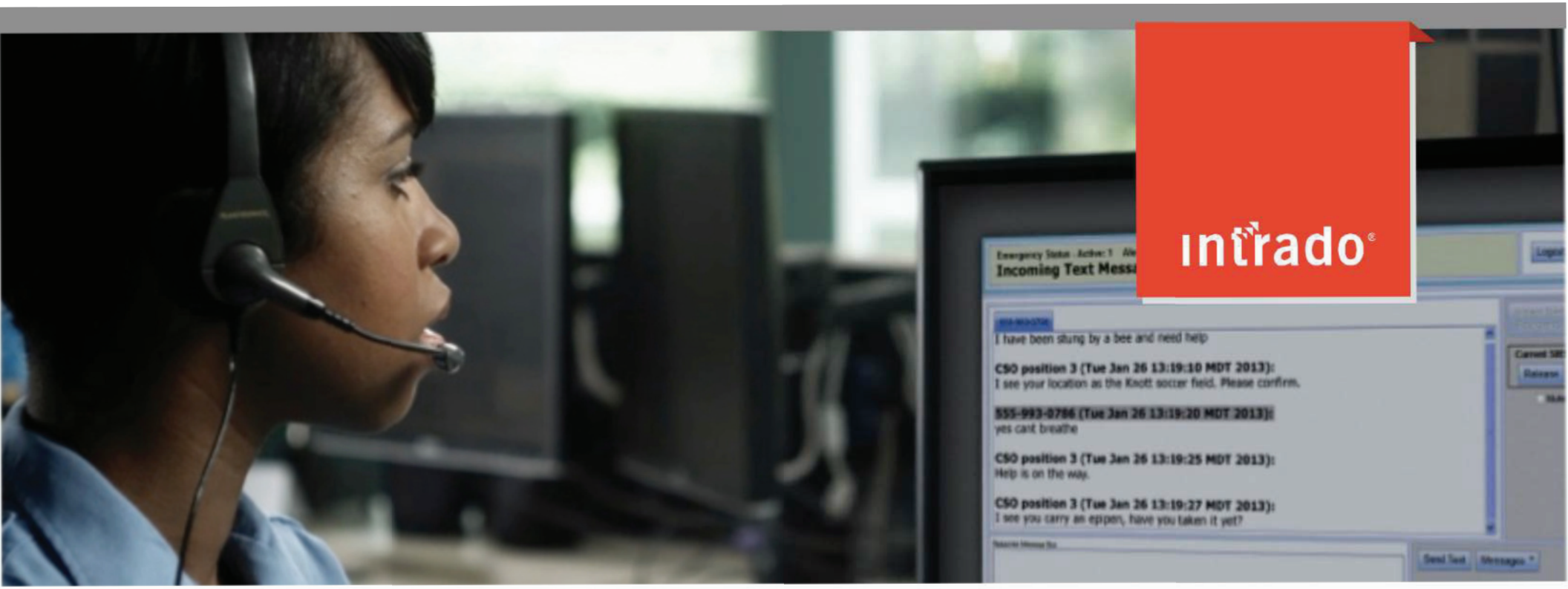
Subject to and without waiving its objections, T-Mobile responds that as a general matter, and consistent with FCC guidelines, T-Mobile implements Phase I/II and text requests within 6 months of receiving a valid request for service from a PSAP. If T-Mobile does not have coverage in an area, it cannot meet that requirement and thus will notify the PSAP and put the request on hold. If T-Mobile expands coverage into an area, it contacts the PSAP and the six-month clock starts to fulfill the request. T-Mobile will request an extension to the original request for service or a new request for service in these cases. In certain situations, PSAP requests are put on hold because alternate routing already exists (*e.g.*, another PSAP in the area already takes calls) or the PSAP is not ready to implement.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-23

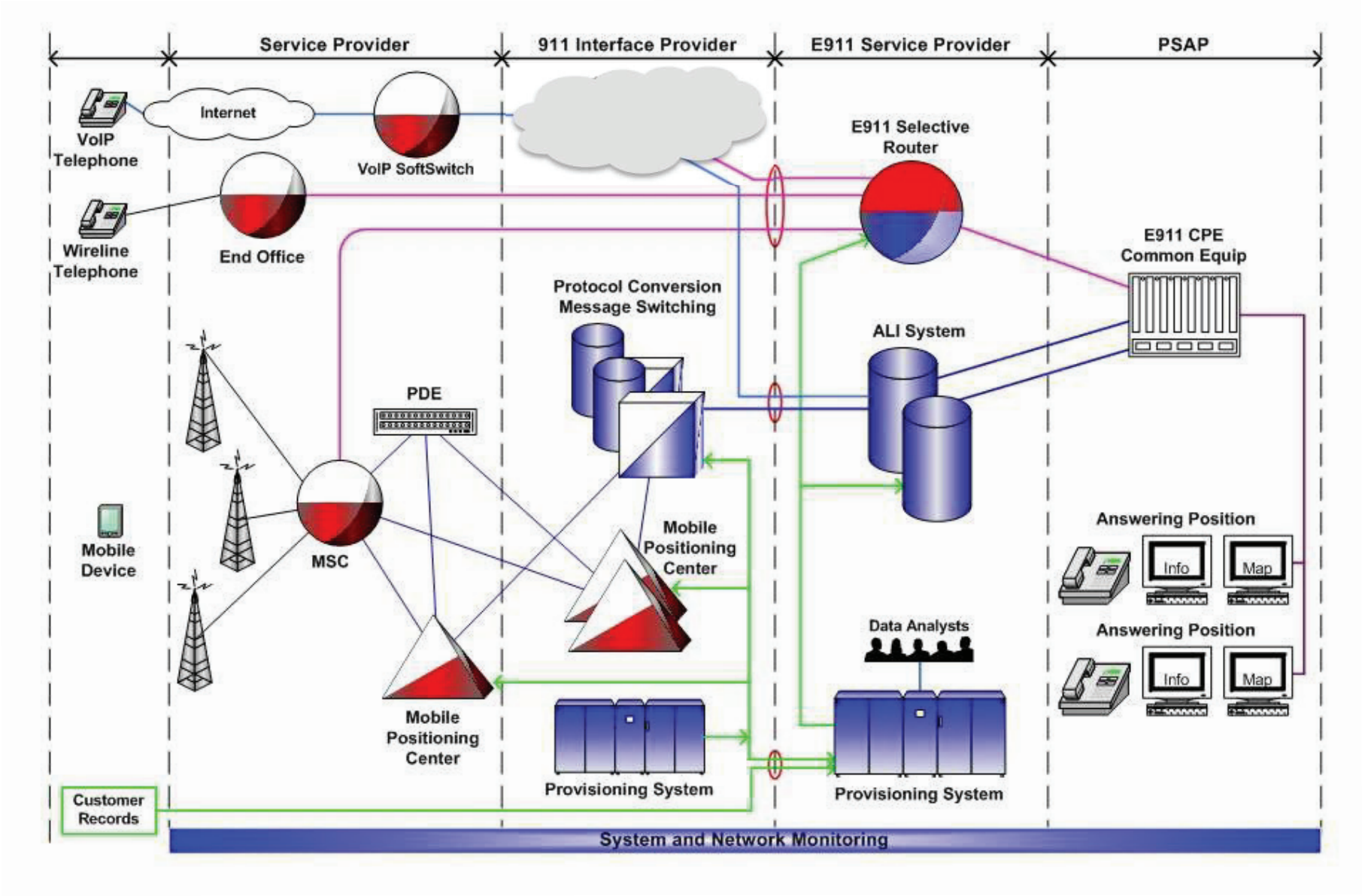
"Intrado Slide Deck to the FCC"



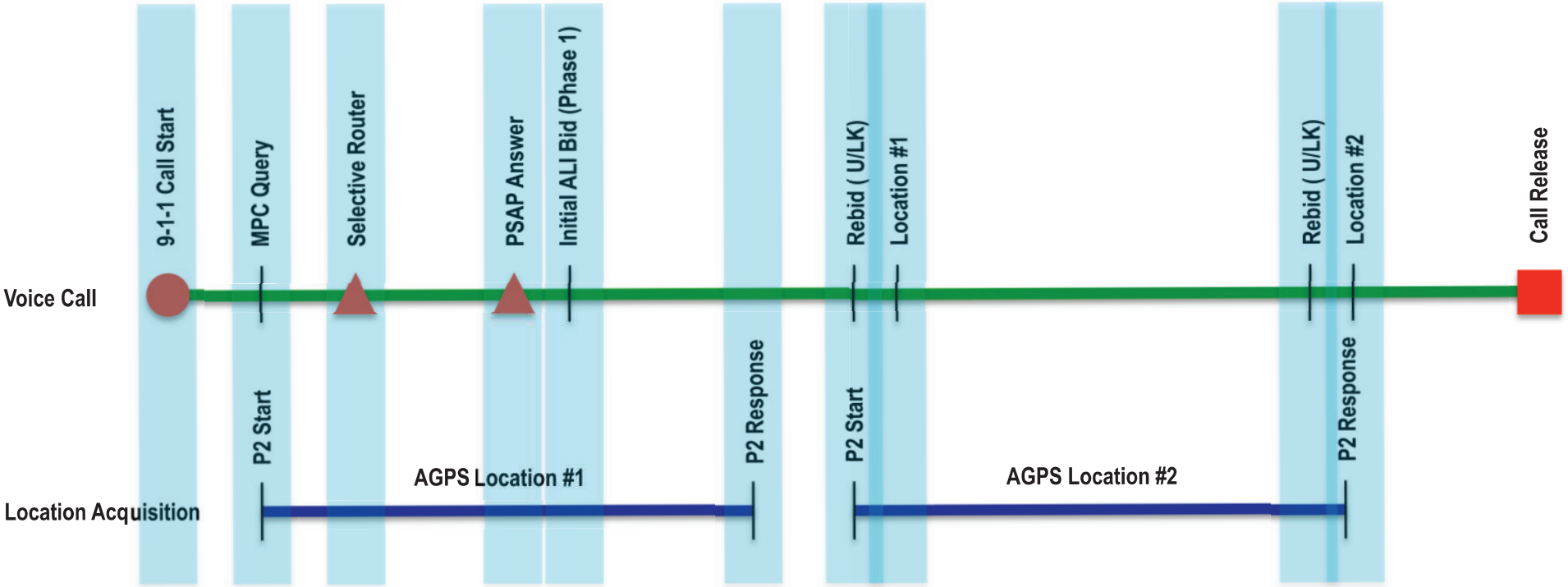
Wireless 9-1-1 Call Flow

John Snapp
Vice President, Senior Technical Officer
John.Snapp@Intrado.com

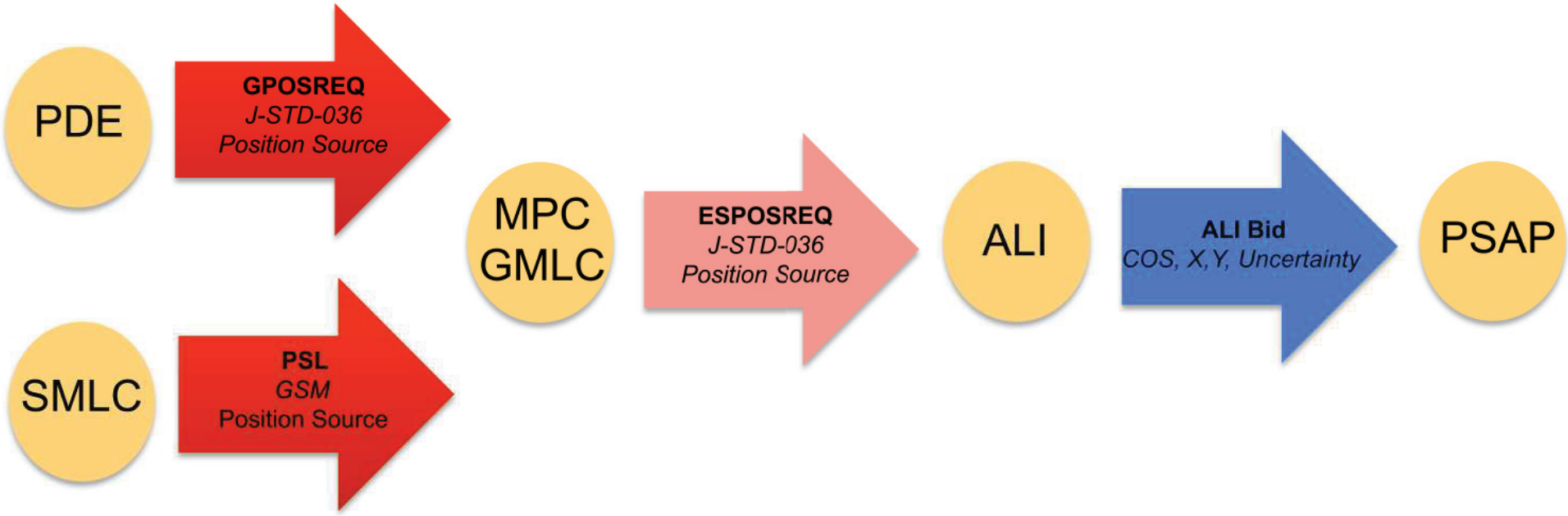
9-1-1 Reference Diagram



Wireless 9-1-1 Call Timeline



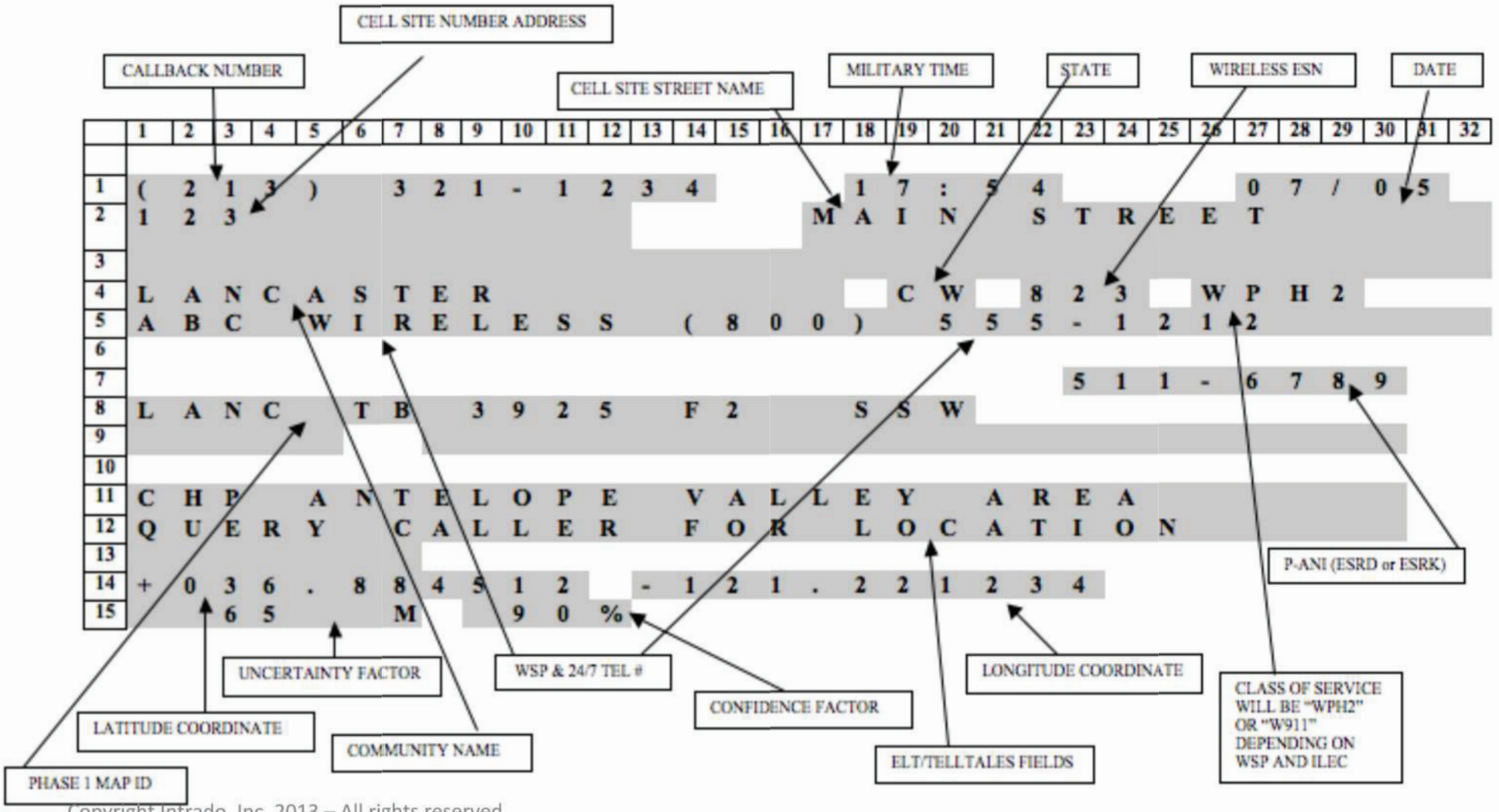
Translation of Location Data



Intrado

California ALI Formats

State of California - Wireless E9-1-1
Typical Wireless ALI Display for Phase II using new ALI Format - known as 92 with PB and Verizon (previously called Option 4)



Looking at Location

- Location is provided as an area not a point
- Uncertainty provides the area the system believes the actual location is within
- Uncertainty is a measure of location quality NOT a measure of accuracy
- Confidence is the measure of how likely the actual location is within the area of uncertainty and should be a fixed value
- X/Y should never be used alone but should ALWAYS be used with uncertainty

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-24

"NENA letter to the FCC"

NENA
The 9-1-1 Association
1700 Diagonal Road | Suite 500 | Alexandria, VA 22314

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Applications of T-Mobile US, Inc. and Sprint Corporation for Consent to Transfer Control of Licenses and Authorizations, WT Docket No. 18-197

Dear Ms. Dortch:

NENA, the National Emergency Number Association, is filing this letter in this important docket highlighting the possible benefits to the new company's subscribers when dialing 9-1-1, should the acquisition be approved. NENA recognizes the diligence of the Commission staff – and ultimately the Commissioners – in reviewing acquisitions and mergers. NENA does not typically comment in such proceedings, but chooses to do so in this proceeding simply because of the work that T-Mobile is doing in the 9-1-1 space. Such work, if carried over to the combined companies, will benefit T-Mobile customers when dialing 9-1-1 from their mobile devices. I would like to highlight some of the demonstrated commitment T-Mobile continues to show to 9-1-1, include the following:

- T-Mobile is an active participant and leader in industry efforts to improve 9-1-1, including the indoor location technology test bed and developing the National Emergency Address Database (NEAD).
- T-Mobile does most of its 9-1-1 work in-house, which provides for flexibility and allows it to implement new and innovative 9-1-1 network designs and solutions in a timely manner. For example, T-Mobile has implemented a unique 9-1-1 network design that provides for increased resiliency and diversity, e.g., three active, geographic, and locally redundant GMLCs sites, each capable of handling 100% traffic load for all services, thus mitigating possible issues with access to emergency services.
- Doing 9-1-1 work in-house has led to innovation in other areas, as well. For example, T-Mobile can provide more precise location for text-to-9-1-1 instead of just a cell sector centroid estimate.

- T-Mobile is also one of the industry-leading companies in implementing native Real-Time Text (RTT). This will allow greater access to 9-1-1, especially for the speech and hearing impaired. Sprint currently does not offer RTT and hence, its customers will be able to leverage this new and innovative technology once they become part of the new T-Mobile.
- Regarding device-based hybrid location technology to improve the location of wireless 9-1-1 callers, T-Mobile was one of, if not the first, mobile carriers to implement Apple's HELO technology for 9-1-1 location in 2015. They have begun incorporating Android's device-based hybrid location services over the control plane for new devices starting in June 2018.
- T-Mobile was among the first wireless carriers to implement OTDOA, a network-based location technology for LTE that requires VoLTE implementation. Currently, Sprint does not offer VoLTE or OTDOA. All customers of the new T-Mobile will be able to leverage both technologies.
- T-Mobile was one of the first carriers to complete first functional testing of dispatchable location in the test bed, proving proper network and handset functionality for this important new indoor-location initiative. On Aug 23rd, T-Mobile entered the test bed for dispatchable location performance testing. Sprint currently is not positioned to leverage the NEAD or provide dispatchable location, but its customers as part of the New T-Mobile will be able to benefit from this new and innovative wireless approach to 9-1-1 location.
- T-Mobile is advancing their Next Generation 9-1-1 readiness. Currently, E9-1-1 traffic is leaving the T-Mobile network over IP connections that could terminate to NG9-1-1 service provider networks once they are ready for true all-IP end state NG9-1-1-over-IP and is actively engaged with and a CMRS leader for several state NG9-1-1/ESINet implementations, such as in Washington and Massachusetts.
- T-Mobile has been the industry leader in Wi-Fi calling and OTT communications platforms, e.g., DIGITS. Wi-Fi calling allows consumers to make 9-1-1 calls when not connected to a wireless macro-network or in areas where there is no macro wireless coverage. Both Wi-Fi calling and DIGITS leverage commercially available device provided location rather than relying solely on customer provided 9-1-1 addresses which may not always be updated or accurate.

I fully respect the Commission's acquisition and merger review process and all that it involves, but I wanted to bring to your attention how this transaction will benefit the new entity's customer base when they dial 9-1-1.

Respectfully,

Brian Fontes, PhD
CEO

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-25

"T-Mobile Response to Cal Advocates Data Request 4 Question 4-7"

Data Request 4-7.

Please provide copies of all current Emergency Preparedness Plans including all relevant documents and maps.

Response to Data Request 4-7.

T-Mobile objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrases "Emergency Preparedness Plans," "documents," and "maps." T-Mobile also objects to this Data Request on the grounds it seeks information that is neither germane to the pending Wireline or Wireless Applications nor is reasonably calculated to lead to the discovery of relevant information. T-Mobile also objects to this Data Request to the extent that it is duplicative of Cal PA DRs 2-34 to 2-36.

Subject to and without waiving its objections, T-Mobile responds as follows:

T-Mobile further responds that it is committed to safeguarding the interest of its customers, employees, and stakeholders in the event of an emergency or other significant business disruption. As a result T-Mobile maintains an enterprise-wide Business Continuity Program that is designed to provide general guidance and maximum flexibility in order to provide effective, and individually tailored, responses to a wide variety of potentially disruptive events such as earthquakes, wildfires and the like. T-Mobile's Business Continuity Program promotes active involvement by all lines of business and is regularly refined to maintain its effectiveness and ensure the flexibility needed to effectively address emergency situations throughout the country and ensure overall business continuity. See Cal PA DR 004 Production Folder for a copy of T-Mobile's most current Emergency Response Plan.

T-Mobile notes that is also draws from industry best practices and governmental guidance to shape its Business Continuity Program. T-Mobile participates in the annual certification program at CTIA, the premiere industry trade association for wireless services provider; the CTIA program requires yearly recertification.

Several key elements of the T-Mobile Business Continuity Program include:

- **Risk Evaluation and Controls.** T-Mobile identifies risks and hazards – both natural and man-made – that may threaten operations, customers, and services. The business continuity team performs assessments annually to identify and prioritize the company's key business interruption risks. The engineering team conducts site assessments and threat and vulnerability assessments (TVA) that identify potential impacts to critical sites and properties. Strategies that incorporate geo-redundant teams, infrastructure and application systems are part of the overall risk mitigation strategy across many teams as a normal course of business.

- **Business Continuity and Disaster Recovery Strategic Direction.** Critical groups within the company such as engineering, customer care, technology, and facilities are structured to be able to respond quickly at both a national and

regional level during emergency situations. Strategies that incorporate geo-redundant teams, infrastructure and application systems are part of the overall risk mitigation strategy across many teams as a normal course of business.

- **Crisis Response, Emergency Response, and Operations.** T-Mobile corporate headquarters has established a Business Operations Center (BOC) that is used 24/7 to monitor the ongoing health of the business. Since the BOC is a 24x7 operations center, there is no formal EOC activation. This center offers a complete view into company operations including but not limited to physical security, social media, software used to monitor any police activity around the country and its proximity to T-Mobile facilities. The BOC Team oversees the center and reports twice a day to all C-Level executives, Vice Presidents, Sr. Directors and others as needed. During significant events interim reports are generated to leadership in addition to the twice daily reports. Separately, the Engineering and Technology groups have dedicated Emergency Operations Centers nationwide to address major event command and controls. Call centers, Data centers and Retail stores have plans to activate processes in response to various events. During a specific event, the BOC activates reporting processes from teams across the enterprise for either preparation actions (pre-impact), impacts, or response status which activates continuous updates from those teams on a frequency of twice or more daily until event stand-down is declared.

- **Business Continuity Plan Development, Maintenance, and Exercising.** T-Mobile maintains training and awareness across the organization to ensure readiness. T-Mobile provides further details in its Response to Cal PA DR 4-8.

- **Coordination with External Agencies.** Various organizations within T-Mobile have established relationships with federal, state and local government agencies and officials to facilitate response to events in affected areas. T-Mobile's Government Affairs function is active in coordinating the Company's response activities with the appropriate government officials. In addition, Engineering has dedicated resources to report on a regular basis, operational outages to the Federal Communications Commission.

In responding to disasters, T-Mobile's emergency response teams have the flexibility and authority to react to the needs of government and community in these types of situations; each of which presents unique – and unpredictable – challenges. For example, in the case of the recent Camp and Woolsey wildfires, the T-Mobile emergency response teams worked closely with local governments, first responders, and community organizations to restore service that was disrupted by the fires and to otherwise assist impacted consumers. Among other things, T-Mobile:

- Used a variety of tools to restore service including the use of Cells on Light Trucks ("COLTs"), Cells on Wheels ("COWs"), generators, and microwave or satellite backhaul to restore service as soon as possible;

- Provided "pre-lit" devices to the community and customers at no cost at evacuation centers, T-Mobile stores, and various related locations in the areas of the fire.
- Delivered car, wall and portable chargers provided at no charge to both the community and customers.
- Distributed N95 masks to the community and employees to address air quality.
- Made Wi-Fi available at various locations including evacuation centers and shelters.
- Provided impacted consumers with various service and billing relief including making unlimited calls and texts were available if a customer did not already have that access, equipment installment plan charges for devices lost in the fire were removed from accounts, and payment extensions were granted. Payment fee waivers automatically applied for affected area codes and collection holds were placed on all impacted accounts.

In addition, T-Mobile provided – and continues to provide – regular updates to the Commission, the California Office of Emergency Services ("OES") and the California Utilities Emergency Association ("CEUA")[1] regarding the status of its network and its efforts to restore service.

T-Mobile further notes that it has leveraged its relationships with national vendors to meet the needs of impacted communities and local governments as well as to support its own recovery efforts. T -Mobile also maintains backup and alternate power sources at mission-critical locations, and has information processing and telecommunications back-up sites that provide redundancy that is important to protecting key business information and services. See Responses to Cal PA DRs 1-46, 1-47, and 2-34 to 2-36.

[1] T-Mobile is an active member of the CUEA, which facilities emergency response and recovery efforts for critical infrastructure, such as telecommunications networks.

Data Request 4-8.

Does T-Mobile conduct any emergency drills or exercises regarding large scale disasters such as fires or earthquakes?

Response to Data Request 4-8.

T-Mobile objects to this Data Request on the grounds it is vague and ambiguous with respect to the temporal scope and the phrase "conduct any emergency drills or exercises" and "large scale." T-Mobile also objects to this Data Request on the grounds it seeks information that is neither germane to the pending Wireline or Wireless Applications nor is reasonably calculated to lead to the discovery of relevant information. T-Mobile also objects to this Data Request to the extent that it is duplicative of Cal PA DRs 2-34 to 2-36.

Subject to and without waiving its objections, T-Mobile responds that its engineering department conducts regular exercises across the enterprise to ensure awareness of appropriate procedures for monitoring its network and responding to emergencies. The emergency management team within engineering has implemented monitoring software that alerts both the field office and headquarters as to the status of critical network infrastructure, *e.g.*, cell sites and generators. This team conducts live, on-site drills once yearly at all field offices, running emergency scenarios for the field office. The team then conducts a second, remote drill to follow up and reinforce procedures.

See also Responses to Cal PA DRs 2-34 to 2-36 and 4-7.

Data Request 4-9.

Does T-Mobile have any Memorandums of Understanding or Mutual Aid Agreements with other organizations to obtain or provide emergency assistance in the event of large scale disasters such as fires or earthquakes?

Response to Data Request 4-9.

T-Mobile objects to this Data Request on the grounds it is vague and ambiguous with respect to the temporal scope and the phrases "Memorandums of Understanding or Mutual Aid Agreements," "emergency assistance," "other organizations," and "large scale." T-Mobile also objects to this Data Request on the grounds it seeks information that is neither germane to the pending Wireline or Wireless Applications nor is reasonably calculated to lead to the discovery of relevant information. T-Mobile also objects to this Data Request to the extent that it is duplicative of Cal PA DRs 2-34 to 2-36.

Subject to and without waiving its objections, T-Mobile responds that it maintains contracts with national vendors to provide logistics support during times of emergency. These vendors rent generators, provide fuel, provide transportation (*i.e.*, barges, planes, and other transportation as needed to ship equipment and staff), provide housing, provide drone inspection for damage, forecast and report weather, provide satellite equipment and services. The contracts are structured to ensure that the national vendor enlists the subcontractors necessary to meet the needs of the emergency event. See also Responses to Cal PA DRs 2-34 to 2-36, 4-7, and 4-8.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-26

"Sprint Response to Cal Advocates Data Request 1 Question 1-45"

Contains CONFIDENTIAL SPRINT Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-27

"Sprint Response to Cal Advocates Data Request 1 Question 1-47"

Contains CONFIDENTIAL SPRINT Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-28

"Sprint Response to Cal Advocates Data Request 2 Question 2-28"

Data Request 2-26.

Please provide a copy of Your Customer Service Agreement and/ other contractual documents, including privacy policies, ("CSAs") that You currently require Your Public Safety Customers in the state of California to accept prior to the initiation of services You currently offer within the state of California.

Response to Data Request 2-26.

Sprint objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrases "Public Service Safety Customers," "Customer Service Agreement," and "require your Public Service Safety Customers …to accept." Sprint also objects to this Data Request to the extent it is duplicative of Cal PA DRs 1-82 through 1-84.

Subject to and without waiving its objections, Sprint responds that the terms and conditions of services are generally governed by contract. State government customers in California, including State Public Safety Customers, are generally required to negotiate under the state's NASPO contract. All other eligible city, counties, and local government entities may choose to use the NASPO contract or, alternatively, to individually negotiate their own contract for products, services, pricing, terms, and conditions. Several cities in California have negotiated their own contracts. *See* documents Bates stamped SPR-CAPAO-00005946 through SPR-CAPAO-00005968. With respect to information not set forth in the NASPO contract or an individually negotiated contract, Sprint also refers to and incorporates by reference its October 10 Response to DRs 1-82 through 1-84 and 1-96.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-29

"T-Mobile Response to Cal Advocates Data Request 6 Question 6-8"

Contains CONFIDENTIAL T-MOBILE Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-30

"T-Mobile Response to Cal Advocates Data Request 6 Question 6-9 and 6-10"

Contains CONFIDENTIAL T-MOBILE Information

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-31

"Sprint and T-Mobile Responses to Cal Advocates Data Request 2 Question 2-26"

Data Request 2-28.

Please describe Your contract terms, agreements, policies, and/or practices in California that apply only during emergencies.

a) Please describe the process that You use to create these contract terms, agreements, policies, and/or practices.

Response to Data Request 2-28.

Sprint objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrases "emergencies" and "process that You use to create these contract terms, agreements, policies and/or practices." Sprint also objects to this Data Request on the ground it seeks information that is neither germane to the pending Wireless Application nor reasonably calculated to lead to the discovery of relevant information. How or whether Sprint defines the term "emergency," and in what context, has no rational bearing on any appropriate review of the Sprint Wireless Transfer Notification. Sprint further objects to this Data Request to the extent it is duplicative of Cal PA DRs 1-82 through 1-84.

Subject to and without waiving its objections, Sprint responds that it is committed to ensuring its customers who play a role in public safety receive the services and support they need during times of emergency. As noted above, the company has a framework in place that actively monitors emergency events and implements actions to support Sprint's entire customer base, including public safety personnel, during such times. This framework is not specific to California.

With respect to emergency response policies and practices generally, as part of Sprint's emergency response plans, Sprint assesses the needs of its customers in the impacted areas of the emergency in order to provide appropriate relief to such customers. Each emergency is unique and is accompanied by its own set of challenges. Thus, having the flexibility to respond in the most appropriate way is vitally important.

As a general matter, however, Sprint's ERT maintains "mobile emergency command centers" during major emergencies, which are fully equipped with large inventories of devices such as cell phones, Push-to-Talk handsets, air cards, hotspots, Wi-Fi access points, small cell equipment, Sprint Magic Boxes, and other specialized gear. Working with Sprint's network teams on the ground, the ERT assists first responders, public safety officials, and government agencies with voice and data services before, during, and after major emergencies. When emergencies can be predicted, Sprint's ERT pre-stages essential resources such as SatCOLTs (satellite cell sites on light truck) and VSATs (portable satellite systems) and recovery resources (such as equipment, fuel, generators, etc.) inside and outside the projected impacted areas to enable rapid deployment and minimize any service disruptions.

While most of these relief items will be implemented for the impacted customer accounts by the emergency response teams, the applicable relief items also are posted on sprint.com and internal customer support resources to aid appropriate account handling for impacted customers.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-32

"T-Mobile Response to Cal Advocates Data Request 1 Question 1-30"

Data Request 1-30.

Please provide Your plans (assuming the proposed transaction occurs) for network investments, upgrades or expansions in California post-transaction, including but not limited to projects that will improve Your Voice or Broadband services in California. Please provide the following information:

a. *Name of project*
b. *Location (Census block or county/city/community name)*
c. *Estimated Start Date*
d. *Description*
e. *Estimated Number of Customers Affected*
f. *Estimated Total Capital Cost*
g. *Estimated Completion Date*
h. *Expected Download Speeds*
i. *Expected Upload Speeds*
j. *Identify any State and/or Federal grant/loans that will be used as sources of funding for the project.*

Response to Data Request 1-30.

T-Mobile objects to this Data Request on the grounds it is vague and ambiguous with respect to the phrases "investments," "upgrades," "expansions," "improve" and "State and/or Federal grants/ loans." T-Mobile also objects to this Data Request on the grounds it vague and ambiguous with respect to temporal scope. T-Mobile further objects to this Data Request on the grounds it seeks information that is dependent on decisions which will not and cannot be finalized until the transaction can be consummated.

Subject to and without waiving its objections, and with the understanding that this Data Request seeks information regarding New T-Mobile's planned 5G deployment, T-Mobile responds that the combination of the two companies will generate enormous cost-savings in the form of approximately $43.6 billion total net present value cost synergies by 2024, allowing New T-Mobile to invest in new network technology, innovation, and operations to rapidly construct and deploy the first true, nationwide 5G network. New T-Mobile will use these synergies to invest nearly $40 billion to bring the combined company into the 5G era over the next three years, or approximately three times the amount that T-Mobile would have invested on its own without the merger.

New T-Mobile will implement natural cell splitting by (1) anchoring on the T-Mobile cell site network, (2) augmenting the density of deployed cell sites by retaining a number of Sprint cell sites (approximately 11,000 retained sites), and (3) deploying both parties' spectrum across New T-Mobile's network, ultimately leading to far more 5G sites being deployed than either standalone company had planned or could practicably deploy. This approach will lead to a multiplicative increase in overall network capacity.

T-Mobile anticipates being able to supplement this Response with additional California-specific information in the near term. See also, Wireless Application at Confidential Exhibit I (California-specific Spectrum Depth maps).

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-33

"Ookla 2016 and 2017 Speedtest Reports"

English TAKE A SPEEDTEST®

Speedtest® Market Report

United States

Published August 3, 2016

The data from the first six months of 2016 is in; the internet in the United States has gotten faster. Fixed broadband customers have seen the biggest jump in performance with download speeds achieving an average of over 50 Mbps for the first time ever. This improvement is more than a 40% increase since July 2015. Overall, the fixed broadband industry has seen consolidation, speed upgrades and, thankfully, growth in fiber optic deployments from upstarts like Google Fiber to industry titans like XFINITY and AT&T to other regional internet service providers.

Mobile internet customers have also seen performance gains, improving by more than 30% since last year with an average download speed of 19.27 Mbps in the first six months of 2016. The four major mobile carriers—Verizon Wireless, T-Mobile, AT&T and Sprint—are in a tight race for fastest download speeds. All four are also aggressively competing on price to attract new subscribers.

Competition is a good thing, and while we're seeing faster performance than ever before, the internet in the U.S. could certainly improve. The U.S. still lags from an international perspective, currently ranking 20th in fixed broadband and 42nd in mobile internet performance globally.

Speedtest by Ookla: Over 9 billion tests and counting...

The Definitive Source for Internet Metrics

Speedtest is the most popular and trusted way to measure internet performance. Using Speedtest, consumers can accurately test their connection speeds from any of their devices at any time, whether in their home, at work, or on the go. Speedtest doesn't rely on background testing that surreptitiously collects data at the wrong times, or use drive testing that only collects data where cars can drive. Insights from Speedtest are always based on actual internet speeds experienced by hundreds of millions of consumers around the world.

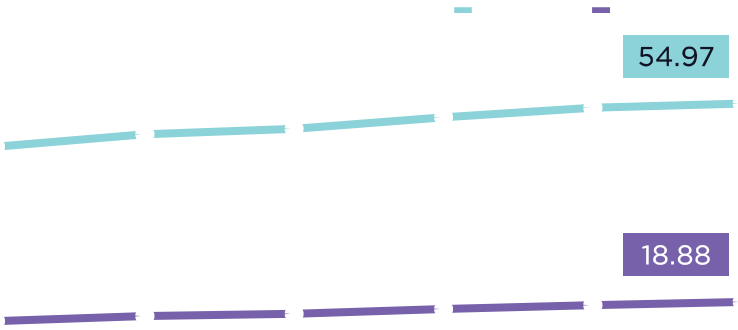
Hundreds of millions of users worldwide

Over 8 million tests every single day

5,000+ geographically distributed servers

Measuring both broadband & mobile

U.S. Fixed Broadband Speeds



TEST COUNT:

59,915,997

1-YEAR CHANGE (DOWNLOAD):

42%

1-YEAR CHANGE (UPLOAD):

51%

FASTER THAN EVER BEFORE

The typical fixed broadband consumer in the U.S. saw average download speeds greater than 50 Mbps for the first time ever during the first six months of 2016, topping out at 54.97 Mbps in June. This laudable milestone is a 42% increase in download speed year-over-year. While this average speed is more than sufficient for typical activities like browsing the web and streaming video content, 50 Mbps is a small fraction of the speed offered from gigabit fiber optic internet. Upload speed saw an even bigger increase, improving by over 50% since last year, with the average consumer receiving an upload speed of 18.88 Mbps.

MARKET CONSOLIDATION

The U.S. telecom sector has seen considerable consolidation over the past two years with AT&T's acquisition of DirecTV and Altice USA's (parent company of Suddenlink) purchase of Cablevision in 2015. However, 2016's merger of Charter Communications, Time Warner Cable (TWC) and Bright House Networks has the largest potential impact on customers.

After Comcast's failed bid to acquire TWC, Charter Communications purchased both TWC and Bright House Networks. The new combined company is known as Spectrum. Spectrum is now the second largest fixed

While the average consumer is doing well enough, not every American is receiving sufficient speeds. In a recent Broadband Progress Report released by the FCC, 10% of Americans lack access to the FCC target speeds of 25 Mbps download and 3 Mbps upload. This number increases to 39% when looking at rural populations. It's important to note, however, that the largest concentration of the U.S. population resides in urban areas and only 4% of urban Americans lack access to those speeds. It is also worth noting that the FCC goals weigh download speed as a much more important metric than upload speed because download speed has the largest impact on how users experience and consume content on the internet. We agree with this approach and place a higher premium on download speed in our analysis as a result.

GROWTH IN FIBER OPTIC

Growth in fiber-to-the-home (FTTH) connectivity continued to increase in the U.S. in 2015. Greater consumer demand for the speeds offered by fiber technology has also pushed providers to offer faster non-fiber speeds. As a result, non-fiber speeds increased in urban and suburban areas. While Verizon, one of the first fiber providers, has been around for years, Google Fiber has undoubtedly been the predominant public face of the rise of fiber in the U.S. Google Fiber initially offered service in Kansas City in September 2012 and has continued to grow its service locations through infrastructure development and acquisition. The fiber trend is also being adopted by municipal and community-owned providers that are able to deliver affordable and extremely high-performing service in urban, suburban and rural areas alike. Smaller ISPs, like Tachus in Houston and PAXIO in the San Francisco Bay Area, are using fiber offerings as a way to differentiate themselves in regional markets.

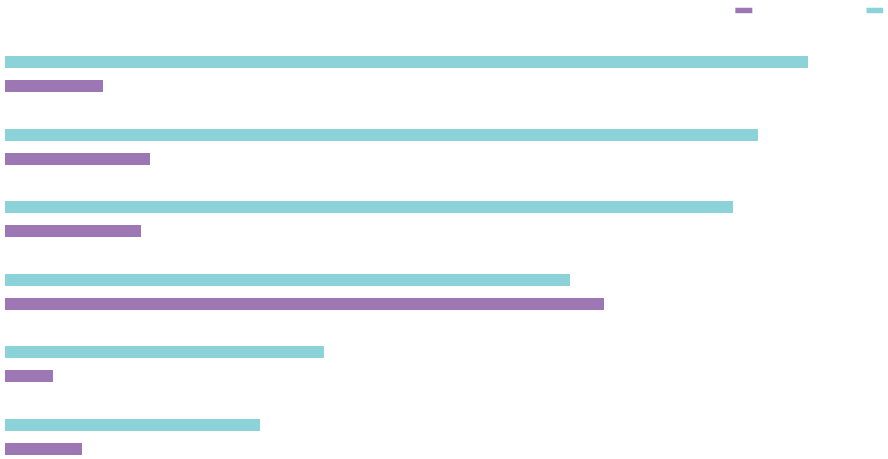
broadband provider in the country (behind Comcast) with control of roughly 30% of the U.S. consumer fixed broadband market. The merger was approved by the FCC and the U.S. Department of Justice after several concessions from Charter to cease overage fees and assure no data caps for 7 years.

Both TWC and Bright House saw marked performance speed increases over the first six months of this year, while Charter showed little to no improvement nationwide. It is currently unclear if Spectrum will push for network performance improvements that follow the model employed by TWC and Bright House, or if it will follow a path more closely aligned to the relatively flat performance employed recently by Charter.

LOOKING AHEAD

Market consolidation by large ISPs doesn't typically bode well for innovation and increased speeds. That said, U.S. consumer appetite for more speed is insatiable. With the growth of municipal and locally-focused fiber deployments, as well as network infrastructure investments from the big ISPs, the U.S. is likely to see continued performance gains in the coming year. Time will tell whether those gains will be incremental or a larger step toward gigabit speeds.

U.S. Fastest ISPs



Download

FASTEST: XFINITY

Comcast's XFINITY made few substantial investments on its network in the past year after delivering faster speeds within each tier in 2015. Instead, their focus has shifted to improving customer service and building their brand to be more customer friendly. They still offer multiple high-level tiers with 105 Mbps, 150 Mbps, 250 Mbps to residential users with speed options in some areas at 505 Mbps and 2Gbps.

Upload

FASTEST: Verizon

A major player in most arenas, Verizon offers fiber optic internet in locations across the country. Many ISPs prioritize download speed over upload speed, but Verizon puts a special emphasis on creating symmetric links, to make the upload just as fast as the download speed.

TOP-END TIERS GET FASTER

During the first half of 2016, U.S. broadband top 10% download performance increased from 99.03 Mbps to 117.91 Mbps. The largest contributions to this increase came in the month of June from XFINITY and Cox

HOW SPEEDTEST MEASURES FIXED BROADBAND

ISPs offering fixed broadband services are ranked based on top 10% performance, which is

Communications with average download speeds of 132.08 Mbps and 162.14 Mbps, respectively. The newly-created Spectrum was also a top-three contributor, ending the same period with a combined 131.97 Mbps.

Verizon, AT&T U-verse and CenturyLink all remained below 100 Mbps download. However, they have all shown modest improvement since the start of 2016. Despite the lower download speed, Verizon continues to shadow other top providers with its fast upload speeds, ending June at 97.71 Mbps. For comparison, Spectrum achieved the second fastest upload speed at the end of June with 23.37 Mbps.

XFINITY IS FASTEST, AGAIN

XFINITY took fastest ISP in the U.S. with a top-tier download speed of 125.53 Mbps. XFINITY's top download speeds have been consistently higher than those of other ISPs over the last year, though in the last couple months that gap has been closing. Despite the fastest download speeds, XFINITY claimed fourth place in upload speed with 15.26 Mbps.

DON'T COUNT OUT COX

Cox Communications came in second place in both download (117.85 Mbps) and upload (22.61 Mbps) speeds. Despite planned network improvements, we've seen relatively minor speed improvements from Cox since July 2015 until download speeds exploded in May and June of 2016. Cox increased download speeds 35% from 119.98 Mbps in April 2016 to 162.14 Mbps by the end of June. With Cox's launch of their new G1GABLAST gigabit service in select areas, this pattern of increasing speed will likely continue and presumably place them in prime position to rise to the number one spot in U.S. download speed by the end of this year.

SPECTRUM, A NEW CONTENDER

Spectrum, the newly formed merger of

> determined using the 90th percentile of the download and upload speeds of each ISP's Speedtest results. While many ISPs offer various service tiers, our aim is to determine who is fastest by showing the performance achieved by each residential ISP's top tier. These speeds represent customers who subscribe to faster service tiers and provide an accurate view of the top-end performance of a given ISP. It is important to note that customers subscribing to higher tiers will generally pay more for their service than the average subscriber. For purposes of this report, only Top Providers in a given location were included in the analysis. Each ISP that accounts for at least 3% of the total sample size in the geographic area is included as a Top Provider. When analyzing the U.S. overall, we use the average speed, as it represents the experience of a typical U.S. consumer. When comparing ISPs individually, we use top 10% performance, as it represents the performance a consumer could reasonably expect to receive if they subscribe to one of the ISP's higher tiers of service.

DSL PROVIDERS INVEST IN FIBER

AT&T U-verse saw fairly stagnant download and upload speeds with an average top download speed of 49.78 Mbps, which only beat out CenturyLink. AT&T U-verse also turned in the worst upload speed among major providers with 7.49 Mbps. AT&T's lower download speed DSL variants (starting at just 6 Mbps in some markets) have been a staple in many locations for years, contributing directly to their low position on the leaderboard.

Charter, TWC and Bright House, has the potential to greatly impact consumer speeds across the nation due to some promising pre-merger trends from TWC and Bright House. Charter was relatively flat between January and April of 2016 with an improvement of only 1.24 Mbps in top-tier speeds. TWC, however, improved its top-tier download speed by 34.54 Mbps from January 2016 to 152.70 Mbps in May 2016 when the merger took place. Bright House's top download speed also increased to 152.16 Mbps, a gain of 21.02 Mbps from January, prior to the merger. Both TWC and Bright House's network improvements helped Spectrum show an initial top download speed of 131.97 Mbps at the end of June 2016. We hope that Spectrum's top-tier download speed continues to improve over the remainder of the year.

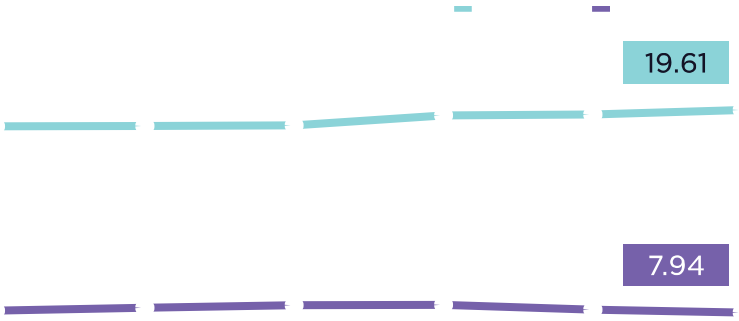
VERIZON HAS THE FASTEST UPLOAD

As mentioned earlier, Verizon's fiber optic services achieved far higher upload speeds than other popular service providers. In 2012, Verizon launched its now retired FiOS Quantum product, which offered speeds of up to 300 Mbps down and 65 Mbps up. They now offer symmetrical internet services with speeds of up to 500 Mbps. Verizon's download speed hovered around 83.91 Mbps at the start of January 2016 and ended June 2016 at 94.98 Mbps. Despite this slight increase, Verizon still falls squarely in the middle of the major U.S. providers for top download speeds.

AT&T is now investing in fiber technology through their new GigaPower brand, which will hopefully provide a much needed boost to their high-speed offerings. AT&T's investments in their fiber network build-outs are the provider's priority right now since they are holding off on further mobile expansion until 5G upgrades are ready to be made.

CenturyLink didn't offer up much competition during the first half of this year. They came last in top-tier download speed with 39.85 Mbps. As of May 2016, CenturyLink is providing more than 1.5 million customers across the U.S. with their fiber "GPON" gigabit service. This offering should help increase their performance in time.

U.S. Mobile Internet Speeds



TEST COUNT:

13,167,061

1-YEAR CHANGE (DOWNLOAD):

33%

1-YEAR CHANGE (UPLOAD):

28%

FASTER MOBILE, BUT FLAT IN 2016

Average mobile internet speeds are indeed faster than they were a year ago, with download speeds up by 33% and upload speeds improved by 28%. However, download speed growth only improved by 5% to reach 19.61 Mbps during the first six months of 2016. Average upload speeds saw a slight drop of -1% to 7.94 Mbps. The slow performance growth rate in 2016 thus far indicates that the major carriers likely weren't able to keep up with the data capacity needs of consumers.

Mobile phones are the most popular way for consumers to connect to the internet in the U.S. According to OECD data, there were almost 3.5 wireless broadband subscribers in the U.S. for every fixed broadband subscriber in June 2015. We suspect this ratio has increased since then, and will continue to do so. Consumers' increased mobile internet usage will continue to put strain on the cellular network infrastructure, which will likely drive carriers to invest in network capacity rather than just investing in coverage alone.

NETWORK IMPROVEMENTS

REGIONAL CARRIERS

While this report focuses on the dominant four carriers in the U.S., there are some regional players with competitive speeds that are worth mentioning. During the first half of 2016, Nsight in Wisconsin achieved the fastest average download speed in the country at 24.26 Mbps (7.76 Mbps upload), but fell short of reaching nationwide recognition because of their regional focus and very low test count. Additional regional carriers with speed results within the results range of the major carriers include: Appalachian Wireless (19.47 Mbps down and 11.58 Mbps up - second only to T-Mobile in upload speeds); United Wireless (14.09 Mbps down, 9.46 Mbps up); and Keystone Wireless (14.01 Mbps down, 4.02 Mbps up).

WHAT ABOUT MVNOS?

Mobile virtual network operators (MVNOs) are another category of mobile providers that play a major role in the U.S. market. MVNOs lease network bandwidth from the four major carriers and resell those services to consumers. In some cases, major providers like T-Mobile and AT&T own their own MVNOs: Metro PCS from T-Mobile and Cricket Wireless

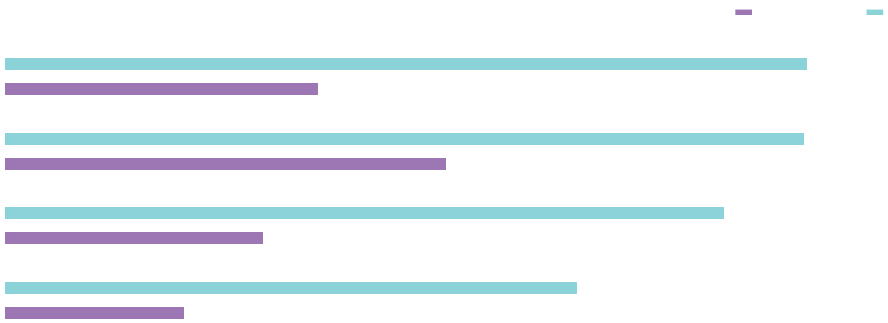
The gain in year-over-year speeds mentioned above can be attributed to an increase in competition by the four major carriers —Verizon Wireless, T-Mobile, AT&T and Sprint—all of which have made investments in their networks. Over the past year, Sprint led the way by increasing their download speeds by an impressive 57%. AT&T followed with a download speed increase of 45%. T-Mobile and Verizon Wireless had more modest increases with 26% and 18%, respectively. Despite AT&T and Sprint's improvement, Verizon Wireless and T-Mobile remain the fastest in the U.S.

from AT&T.

MVNOs are important because they offer prepaid and/or less expensive packages than the standard plans offered through major carriers. These plans tend to be more appealing and accessible to consumers who are unwilling or unable to spend upwards of $50 per month on mobile phone service. By offering a less expensive option, MVNOs enable many people to access the internet who might not otherwise be able to get online.

However, MVNO users often experience slower speeds due to added network complexity and even throttling. Given this issue with MVNO speeds, we have removed MVNO tests from the big four carriers' network results so as to accurately represent what customers of those networks actually received in the first half of 2016.

U.S. Fastest Mobile Carriers



Download

FASTEST: Verizon Wireless & T-Mobile

Upload

FASTEST: T-Mobile

Both Verizon Wireless and T-Mobile achieve download speeds faster than 21 Mbps. The difference between them is so slight, less than 1%, that we consider the two in a dead heat for fastest download in the United States. Performance does vary from state to state, which can be viewed later in the report.

With upload performance, T-Mobile is the fastest with speeds exceeding 11 Mbps, making them a good choice for consumers who are sharing lots of content from their mobile phone.

T-MOBILE, VERIZON WIRELESS ARE FASTEST

During the first half of 2016, Verizon Wireless had an average download speed for modern devices (those capable of achieving 4G LTE speeds) of 21.11 Mbps. T-Mobile achieved a nearly identical download speed at 21.02 Mbps. In fact, less than 1% separated the average download speeds between Verizon Wireless and T-Mobile, a difference so slight that we consider the two carriers tied for fastest download performance. Verizon Wireless and T-Mobile have been highly competitive with each other for quite a while, with less than 5% separating their average download speeds since the beginning of 2015.

When comparing upload performance, T-Mobile has been on top since early 2014 with the fastest speeds among the four major U.S. carriers. T-Mobile's upload speed of 11.59 Mbps during the first half of 2016 was over 40% faster than any of the other major carriers.

LTE is now pervasive across each of the four major carrier networks. When looking strictly at tests conducted over LTE, T-Mobile performed the best with an average download speed of 22.11 Mbps. Verizon Wireless came in second, slightly behind T-Mobile, with an average download speed of 21.32 Mbps. AT&T and Sprint followed with 20.05 Mbps and 15.80 Mbps, respectively. However, LTE network coverage is also important to consider. While T-Mobile has the fastest LTE network, they trail Verizon Wireless in LTE network coverage. Verizon Wireless was the clear coverage winner, with 98% of test

HOW SPEEDTEST MEASURES MOBILE CARRIERS

The top mobile carriers in the U.S. are ranked using the average download speed of "Modern Devices" - those devices that are capable of connecting to the fastest, broadly-available wireless networks. In the U.S., this means devices capable of 4G LTE. This ensures we provide an accurate view of the typical performance a user can achieve using a modern smartphone or tablet on a given mobile network. Each top carrier accounts for at least 3% of the sample size in the geographic area.

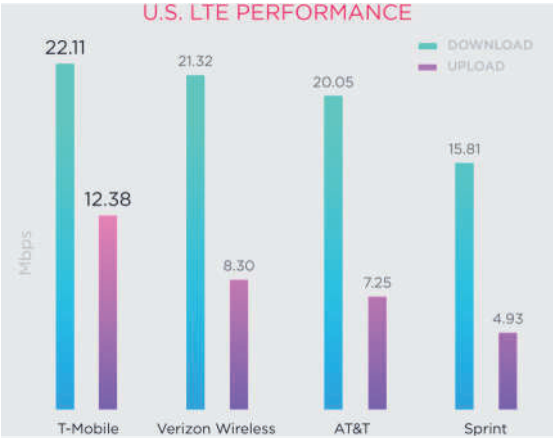
Looking at the U.S. states individually, which you can browse at the bottom of this report, Verizon Wireless was the fastest in 20, while T-Mobile was fastest in 18. AT&T followed with 11 states, and Sprint was fastest in only 2.

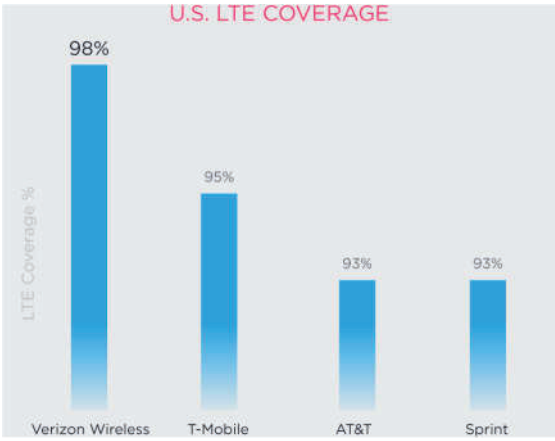
AT&T, SPRINT GETTING FASTER

AT&T and Sprint have ranked lower than Verizon Wireless and T-Mobile over the past two years, though in 2016 they increasingly closed the gap by making great improvements to their download speeds. Over the past year, AT&T had the largest raw improvement of the four major U.S. carriers with an increase of 5.85 Mbps to 19.94 Mbps by the end of June 2016, a 42% improvement. Meanwhile, Sprint

samples from LTE-capable devices taking place on their LTE network. T-Mobile came in second at 95%, followed by AT&T and Sprint tied at 93%. Ultimately, Verizon Wireless' more extensive LTE network bolstered their overall results and created a virtual tie for overall performance with T-Mobile.

had the largest percentage-based performance improvement of the four major U.S. carriers, increasing their speed over the previous year by 54%, going from 9.99 Mbps to 15.42 Mbps. Sprint still trails the other three major U.S. carriers, but they are making a strong push to close the gap.





Speeds by City

Speeds by State

Market Summary

If you're an optimist, you'll see an annual 40% increase in fixed broadband performance and a 30% increase in mobile internet performance as a big step in the right direction. For the skeptics among us, you'll recognize that current speeds in the U.S. are still much slower than what many other countries receive.

In fixed broadband, a slow, steady march toward fiber optic networks has the potential to bring a quantum leap in speeds to many U.S. markets in the coming years. However, while ISPs are competing on speed, many consumers in the U.S. still only have a single high speed choice available in their homes. Additionally, provider consolidation presents a big risk that ISPs won't be motivated to invest in performance gains.

Mobile internet in the U.S. is faster than ever before, but performance growth during the first half of 2016 has been largely flat. Carriers are aggressively focusing on network capacity to combat the insatiable data usage of U.S. mobile consumers; people are using mobile internet more and more. The coming arrival of 5G looms on the horizon with the promise of huge performance gains, but we likely won't see those networks turn up until at least 2020.

Regardless of your disposition, the next several quarters will certainly be interesting.

Editor's note: This report was updated on November 28, 2017 to change Verizon Fios to read as Verizon throughout.

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Speedtest Intelligence

Speedtest Intelligence is a comprehensive business intelligence platform, providing the unparalleled ability to analyze network performance for any location or service provider around the globe. It is trusted as a vital research and analysis tool by businesses and governments worldwide.

Speedtest Intelligence has the data science built-in, taking advantage of Speedtest's expertise in measuring and evaluating internet performance data. Since the work is already done, you can avoid collecting, storing and aggregating Speedtest data.

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UNITED STATES

Mobile Fixed

September 7, 2017
Based on Q1-Q2 2017 data

Introduction

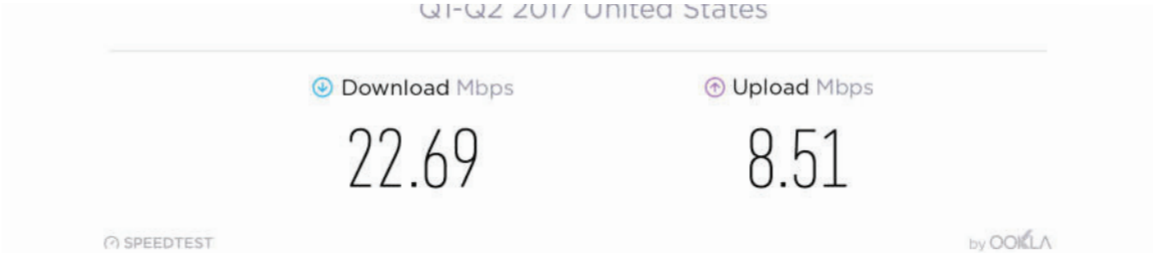
During the past 12 months, improvements in technology and usage of available network spectrum led to a 19% increase in average mobile download speeds in the United States. All four major carriers have boosted download speeds, but not all carriers are improving equally and not all areas of the country are seeing the same benefits. In addition, not all are responding equally to the performance demands of unlimited plans. While progress was made over the last year, the U.S. still lost footing in the global race for fastest mobile internet speeds with a rank slip from 42nd to 44th in the world based on data from Q1-Q2 2017.

The 2017 U.S. Market Report by Ookla is based entirely on Speedtest Intelligence data captured during the first half of 2017. During this period, nearly 3 million unique mobile devices were used to perform over 14 million consumer-initiated cellular network tests. After analyzing these tests we are able to reveal which carrier is the fastest in the nation and in the most populous CMAs, who consistently provides acceptable speeds and how performance in rural areas lags. We also have an unparalleled view into how the speeds at Verizon and AT&T changed for customers after the debut and expansion of the carriers' respective unlimited plans.

This year Ookla also introduced Speed Score to more accurately reflect the full breadth of networking experience on a given network. Speed Score incorporates low-end, median and top-end performance for both download and upload speed. It's a comprehensive metric that combines all factors that matter to a good network experience into a single score.

Country Speeds

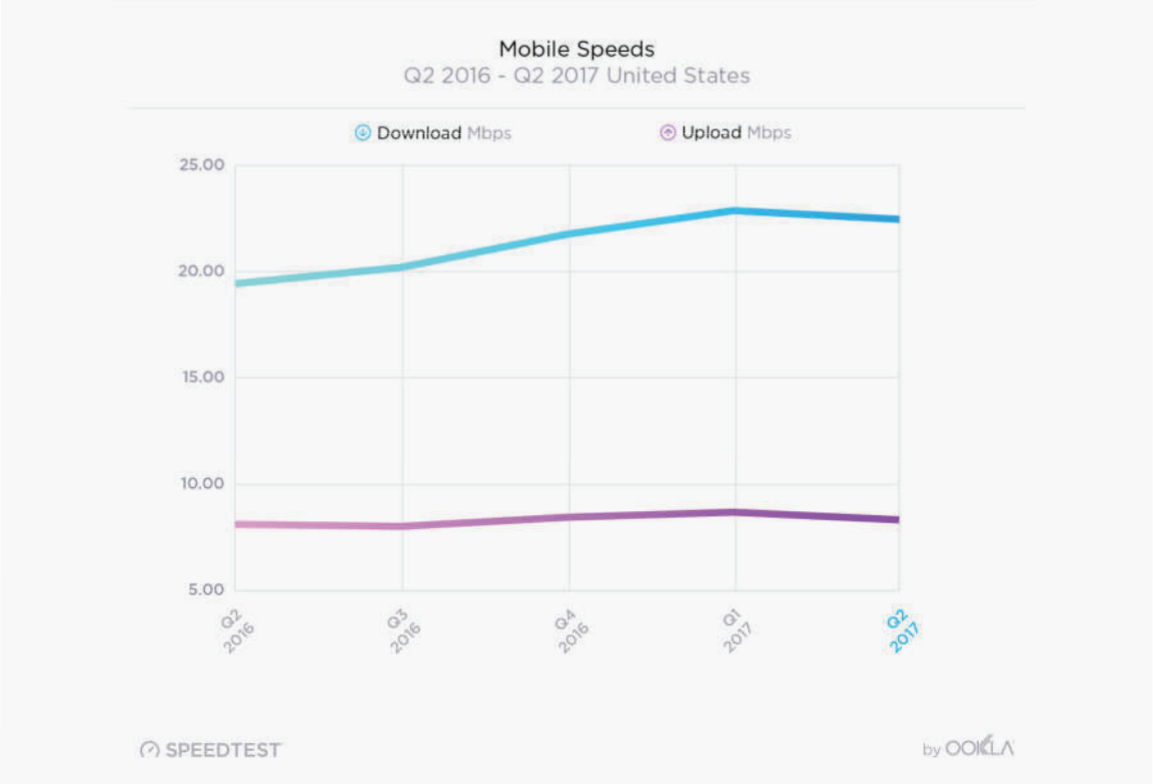
Mobile Speeds



Average mobile download speed in the U.S. increased 19.2% between Q1-Q2 2016 and Q1-Q2 2017 to 22.69 Mbps. That is not as strong as the year-over-year growth of 33% we saw in last year's report. The U.S. still only ranked 44th in the world for download speed, immediately behind Fiji and Germany and just ahead of Oman for Q1-Q2 2017. Of course, the geographic breadth of the U.S. makes it challenging for its cellular speeds to compete with smaller, more densely populated nations.

Average upload speed over mobile improved a very slight 4.0% from the same period the year before to 8.51 Mbps. This is a much slower improvement than the year prior when we saw a 28% improvement between Q1-Q2 2015 and Q1-Q2 2016. The U.S. ranked 65th in the world for upload speed for Q1-Q2 2017, directly behind Mongolia and ahead of Germany.

Overall speeds for both downloads and uploads dipped when comparing Q1 2017 to Q2 2017. This could be due to decreased performance on some networks because of deprioritization on unlimited data plans. This is discussed more specifically in "How Unlimited Data Affects Performance" below.

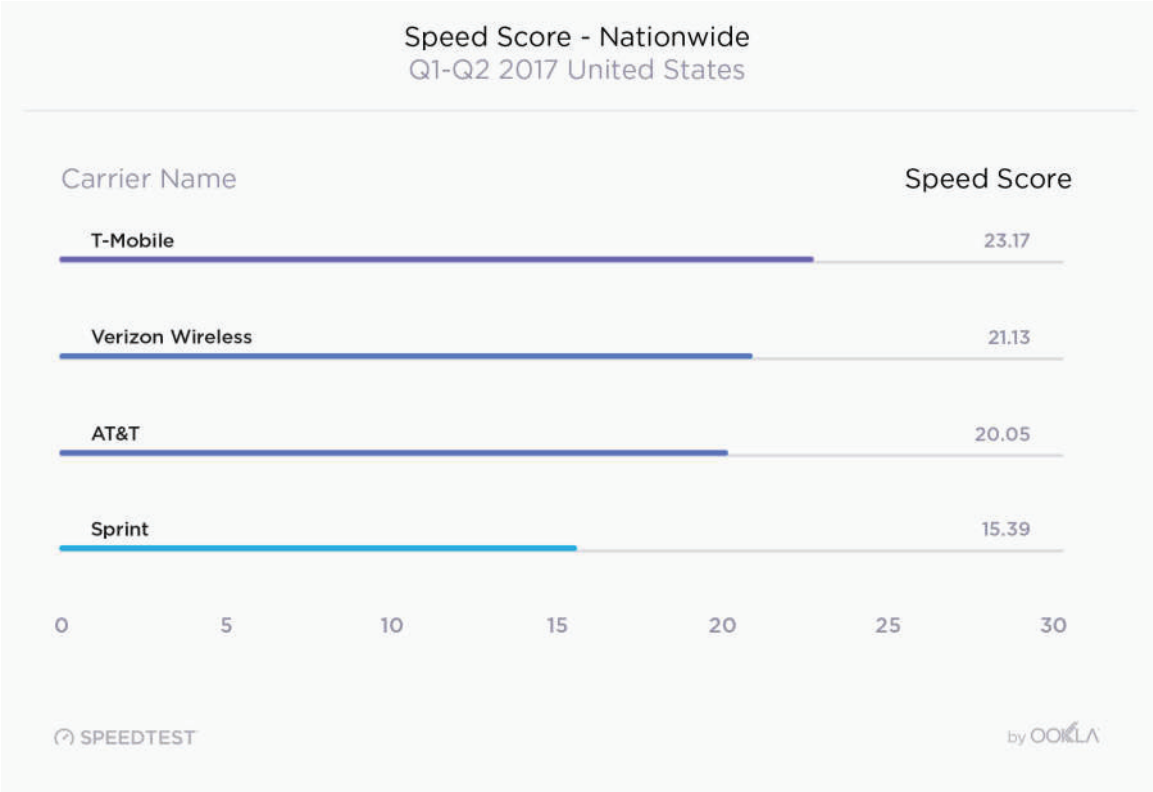


Meanwhile, customers in rural areas saw an average download speed of 17.93 Mbps, 20.9% slower than the nation as a whole. Rural areas are Rural Service Areas (RSAs) as defined by the Federal Communications Commission (FCC).

Country-level speeds are average speeds based on all tests taken during this period, regardless of the device type that was used.

Fastest Carriers

Using the same nationwide lens, Speedtest Intelligence data reveals which carrier is the fastest in the U.S. as a whole. Though this is a country-wide view, carrier rankings remain the same when we limit the analysis to the 100 most populated Cellular Market Areas (CMAs). There are also other important ways to assess networks, including performance in top markets and consistency of acceptable speeds — both of which we explore later in this report.



T-Mobile is the fastest carrier nationwide

T-Mobile has the fastest mobile network in the United States, clocking in with a Speed Score of 23.17 on modern devices during Q1-Q2 2017. The combination of a tightly-spaced cell site grid and a smaller subscriber base than Verizon and AT&T could be the keys to T-Mobile's success in the U.S. market and to their ability to support the exponential growth in mobile data consumption. Leveraging 700MHz spectrum, T-Mobile has been expanding its LTE footprint into new markets. Additionally, T-Mobile has been aggressively refarming their spectrum, previously used for legacy technologies such as GSM and WCDMA, and committing those assets to the more efficient LTE technology.

With the fastest time-to-market when rolling out advanced LTE features such as Wi-Fi Calling, HD Voice, VoLTE using Enhanced Voice Services Codec, various capacity enablers such as Higher Order Multiple-Input Multiple-Output (MIMO), advanced modulation schemes (256QAM), and LTE in the Unlicensed 5GHz band, T-Mobile is in an excellent position to become the first all-LTE mobile carrier in the United States which will allow them to deliver voice and data more efficiently.

Verizon Wireless takes second

Second-place Verizon Wireless, the first LTE carrier in the U.S., has a Speed Score of 21.13 and delivers consistent and reliable performance across its large footprint. Over the past year, Verizon has been doing a lot of work around network densification, installing thousands of small cells in urban and suburban areas, as well as many commercial venues. Utilizing LTE-Advanced technologies like Three Channel Carrier Aggregation, Verizon has been able to maintain solid performance in areas of high traffic, though a drop in performance has been seen since Verizon launched Unlimited.

To fortify network performance, Verizon has started refarming legacy spectrum more aggressively. One example is the New York City market, where Verizon has recently started sunsetting their legacy 3G network in the 1900MHz band and repurposing the entire 1900MHz block for LTE operation. Verizon is already the fastest carrier in New York City and this will only further improve their LTE performance in the months to come.

AT&T comes in third

AT&T was one of the first carriers to adopt LTE in the U.S., but over the past few years the competition has gotten better. Now AT&T ranks third with a Speed Score of 20.05. For the most part, AT&T has managed to keep up with the increased consumption and maintain its performance. But a notable drop in performance coincides with the timing of AT&T's expansion of their Unlimited Plan and the introduction of their Unlimited Choice Plan, which caps subscriber speeds at 3 Mbps with unlimited data usage, the impact of which is discussed later in this report.

That said, AT&T's network performance has started to improve in the last few months, likely due to their deployment of LTE in the 2300MHz band, 700MHz supplemental downlink and refarming of existing spectrum assets after the recent GSM sunset. AT&T still has a lot of room for incremental capacity gain with rollout of 4x4 MIMO, 256QAM, License Assisted Access (LAA) and other LTE Advanced Pro features.

Sprint finishes in fourth

Though coming in fourth on our rankings for Q1-Q2 2017 with a Speed Score of 15.39, Sprint made significant improvements compared to the same period last year. Between December 2016 and June 2017 the company's mean download speed on modern devices increased 23.7%. Sprint is well positioned for even more improvement moving forward given its massive 2.5GHz spectrum portfolio. Significantly lower levels of network budget compared to other carriers, low cell site density and a thin fallback LTE layer in the 800MHz and

1900MHz bands created real challenges for Sprint this year. They responded with an impressive bout of creative problem-solving during the past year leading to the deployment of small cells, mini-macros and relay solutions. These moves did improve Sprint's network performance, but the proliferation of smartphones capable of aggregating multiple component carriers, HPUE (High Performance User Equipment) and 4-branch antenna diversity could be viewed as the forgotten heroes in Sprint's success — adding much needed efficiency. Sprint still has a lot of room for improvement, and a lot of opportunities for tapping into its treasure trove of 2.5GHz spectrum.

Performance on popular devices

Speed Score - Popular Devices
Q1-Q2 2017 United States

Carrier	iPhone 7	Galaxy S7
T-Mobile	25.51	27.36
Verizon Wireless	23.66	23.99
AT&T	23.01	22.62
Sprint	17.09	20.66

SPEEDTEST by OOKLA

Even when comparing the performance on two popular modern phones, our national rankings hold. We received test results from 250,278 Apple iPhone 7 devices and 134,742 Samsung Galaxy S7 devices during Q1-Q2 2017. Carrier rankings remain the same, but the Speed Scores on these newer devices are higher, because they are capable of aggregating three component carriers, which improves peak and average speeds. The performance of the Samsung Galaxy S7 improves even further on T-Mobile's network, as both the device and the network have advanced LTE features enabled such as higher order modulation and 4-Layer MIMO.

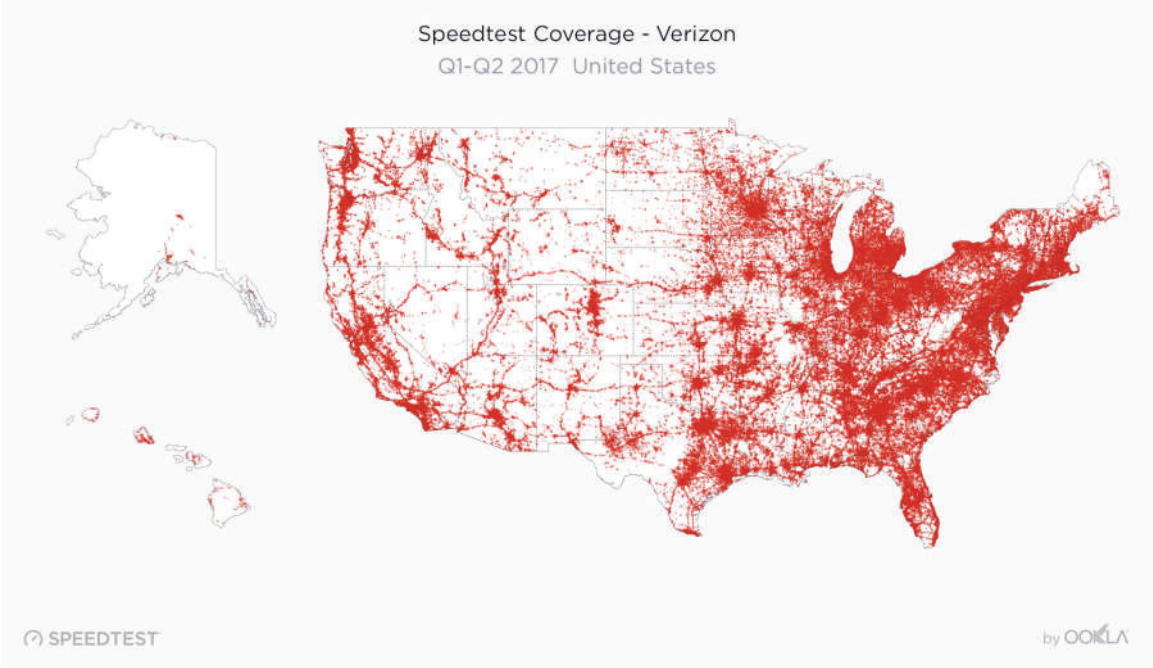
Speed Score

When analyzing fastest carriers, we consider all carriers with 3% or more of total test samples in the market for the period. We then determine the fastest carrier using Speed Score which incorporates a measure of each provider's download and upload speed to rank network speed performance (90% of the final Speed Score is attributed to download speed and the remaining 10% to upload speed). The Speed Score uses a modified trimean to demonstrate the download and upload speeds that are available across a provider's network. We take speeds from the 10th percentile, 50th percentile (also known as the median), and 90th percentile, and combine them in a weighted average using a 1:2:1 ratio, respectively. We place the most emphasis on the download speeds and median speeds as those represent what most network providers' customers will experience on a day-to-day

basis.

Speedtest Coverage

With over 14 million cellular network mobile test results in the U.S. during Q1-Q2 2017, Speedtest is everywhere people live and work. The maps below show the extent of Speedtest results in the U.S. and where we saw tests for each carrier. Comparing these maps to the coverage maps for AT&T, Sprint, T-Mobile and Verizon, we can see that the presence of Speedtest results is a reasonable proxy for mobile coverage in any given area.



Comparing Speeds in Urban Areas

Nationwide aggregates can't fully convey a comparison view of performance because not all carriers are in all markets. For this reason, we've provided a look at urban areas where significant carrier overlap can reveal information that is relevant to consumers when choosing a carrier.

Using the consumer-initiated data available in Speedtest Intelligence, we looked specifically at mobile performance in the 100 most populated Cellular Market Areas (CMAs), a geographic determination used by the FCC to identify urban Metropolitan Statistical Areas (MSAs) and Rural Service Areas (RSAs) within the United States. We calculated a weighted average of each carrier's Speed Score based on data for modern devices, those capable of LTE speeds, in Q1-Q2 2017.

While the ranking of top providers does not change when focusing only on these most populous CMAs, the gap between first and second shrinks considerably and Speed Scores for all four carriers increase compared to their country-wide numbers. T-Mobile sees the smallest bump at 1.5%, AT&T and Sprint are both up around 3.7-3.8% and Verizon is 7% faster in these urban areas than in the country as a whole.

Although the majority of each carrier's tests do take place in urban areas, some carriers have a much larger footprint in rural areas than others. The coverage maps above give a sense of this, but the numbers are even more telling. Verizon accounted for a full 51.6% of all samples we saw in rural areas. AT&T made up 27.3%, T-Mobile 11.5% and Sprint 9.6%. Verizon's rural coverage is laudable. At the same time, their rural market pulls down their nationwide performance numbers because they have that much more market share in areas that are more difficult to serve.

Acceptable Speed Ratio

A mobile download speed of at least 5 Mbps allows a user to do most of the things they expect on their phone. This speed should be fast enough to stream HD movies without buffering, and it's more than enough to surf the web, connect to social accounts and view most content. For this reason, Ookla developed the "Acceptable Speed Ratio" to measure the percentage of each carrier's test data samples that equal or exceed the 5 Mbps threshold. While we think fastest speeds are paramount, ensuring a minimum acceptable experience is also a worthy measure of a network's quality.

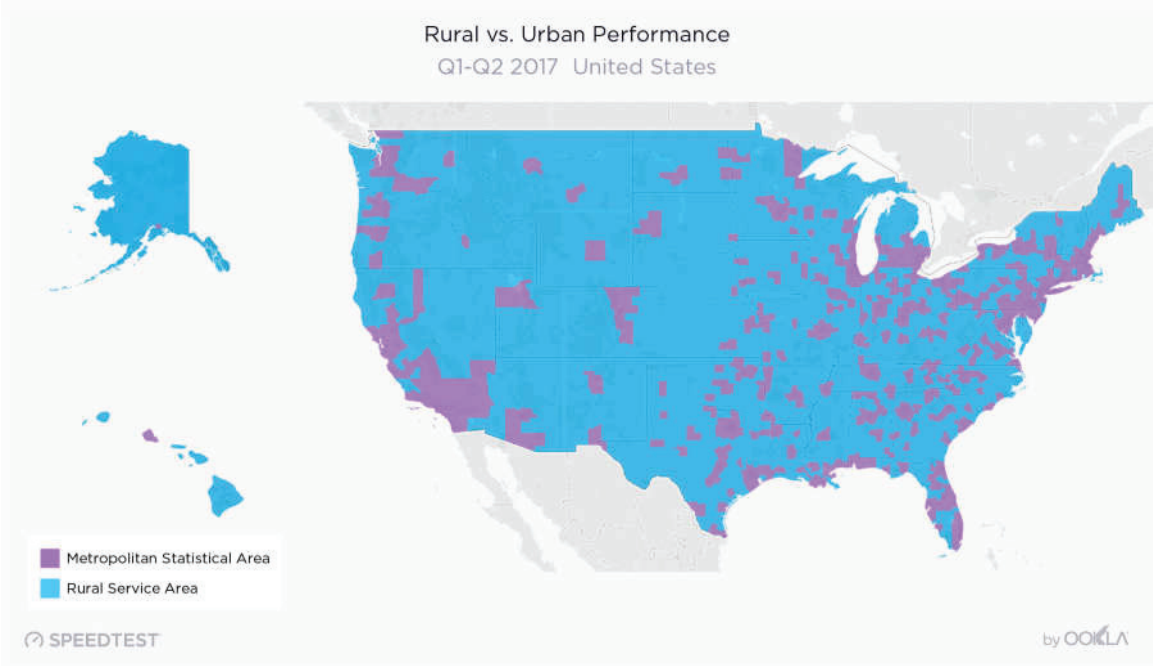
Mobile Acceptable Speed Ratio
Q1-Q2 2017 United States

Carrier	National	Top 100 CMAs
T-Mobile	**78.1%**	77.9%
Verizon Wireless	77.8%	**79.8%**
AT&T	75.9%	76.5%
Sprint	64.9%	66.0%

SPEEDTEST by OOKLA

When it comes to providing mobile broadband service that's adequate on a national scale, T-Mobile (78.1%) is slightly ahead of runner-up Verizon Wireless (77.8%). AT&T is a little further behind at 75.9% and Sprint is in last place with only 64.9% of samples showing connections of 5 Mbps or faster.

Taking an urban view by using the same 100 most populous CMAs we examined earlier, Verizon takes first place at 79.8%. T-Mobile comes in second and their Acceptable Speed Ratio actually decreased to 77.9%. The Acceptable Speed Ratios for AT&T and Sprint increase as expected with results of 76.5% and 66.0%, respectively.

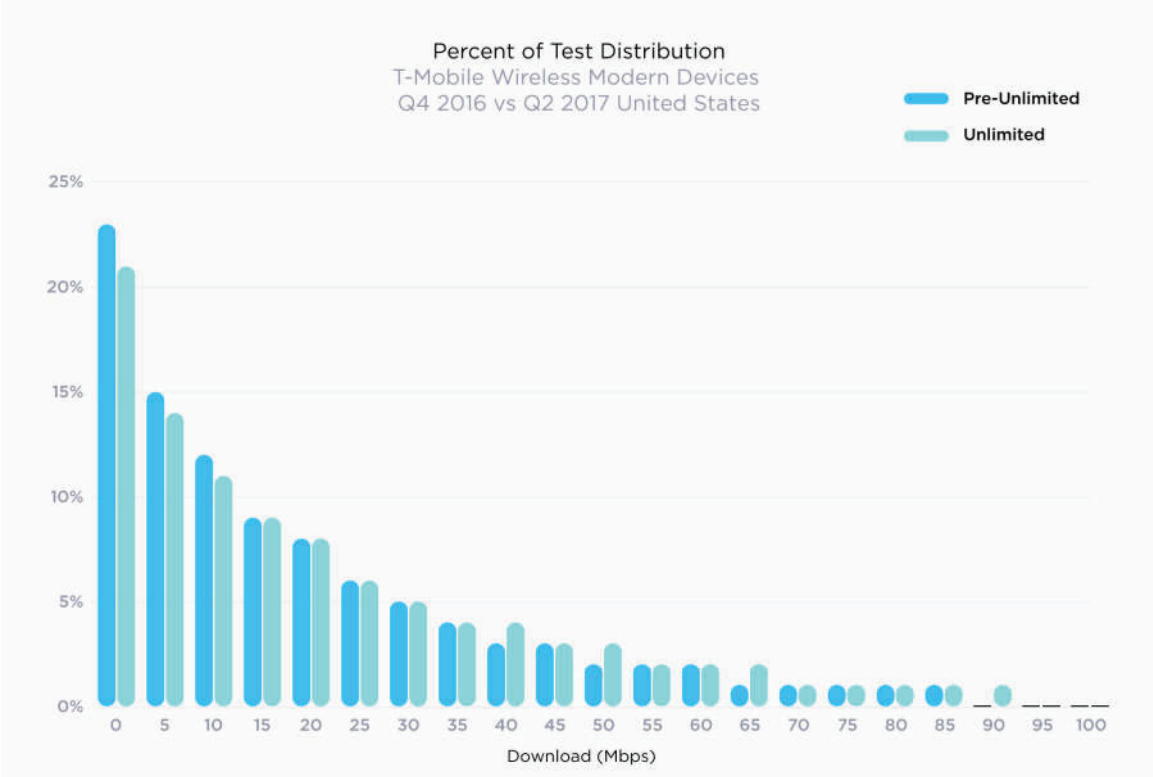


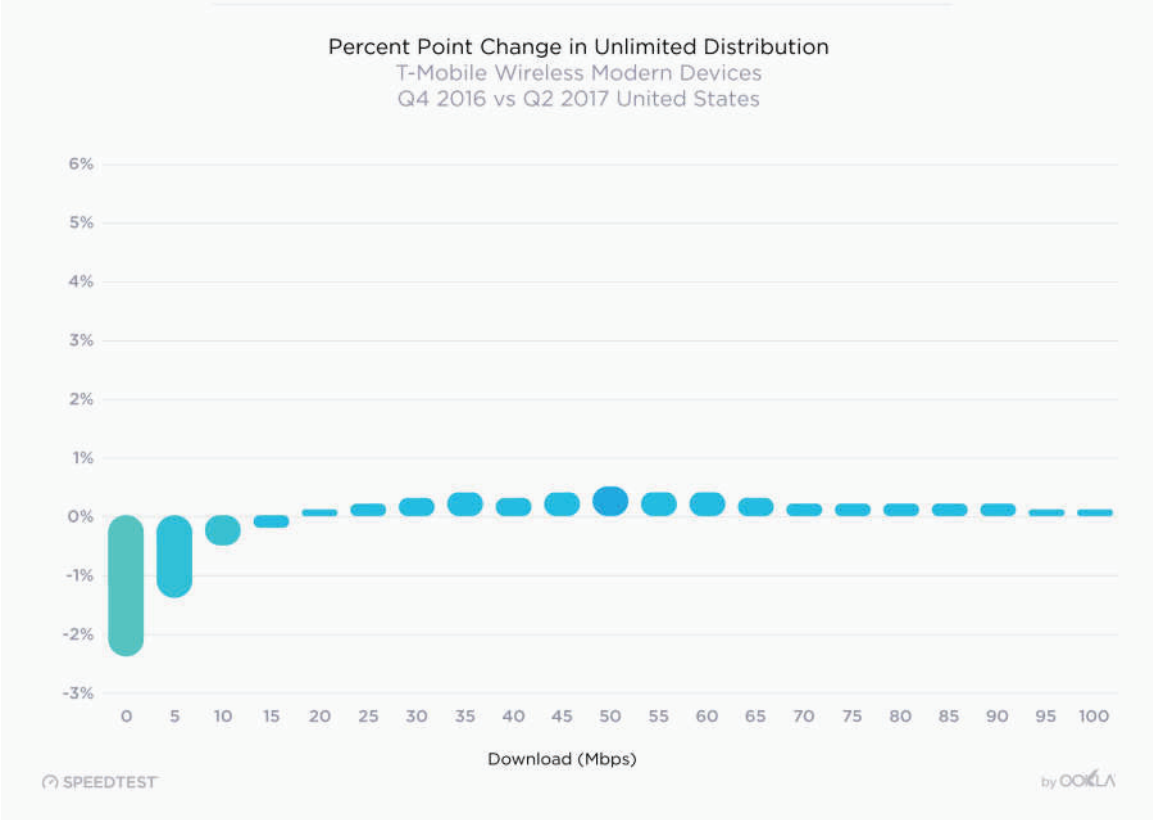
From a rural perspective, it's difficult to accurately compare service among carriers because of the vast difference in rural footprint outlined above. We can, on the other hand, compare the overall national Acceptable Speed Ratio (74.9%) with that in RSAs (69.6%). That means on average all those places in blue on the map above are almost 7% less likely to experience an internet connection that's acceptably fast. Considering the Acceptable Speed Ratio for all MSAs taken together is 76.2%, there's a strict divide in the consistency

customers in more populated areas can expect from their internet experience versus what those in rural areas can.

How Unlimited Data Affects Performance

There's been a lot written about the network impact to AT&T and Verizon Wireless following their respective launches of unlimited data plans in February of 2017. We compared Speedtest data on download speeds from before (Q4 2016) and after (Q2 2017) these unlimited plans were widely released to get a good picture of what speeds were like after both companies had sufficient time to onboard customers to the new plans.





Our data shows that in the case of Verizon and AT&T, the percentage of test results with the lowest-end download speeds (those under 5 Mbps) shot up compared to the period before these unlimited data plans were widely available. For comparison, both T-Mobile and Sprint are seeing the opposite effect in the same time period where fewer results are below

5 Mbps in Q2 2017 than they were in Q4 2016.

Are some heavy data users being deprioritized? Both Verizon and AT&T say unlimited customers may experience reduced speeds if customers exceed 22 GB in a month and the cell site is congested. Just six months later Verizon is reinforcing that policy alongside new video optimization policies. AT&T on the other hand launched their Unlimited Choice plan in March 2017 which sets a maximum data speed of 3 Mbps. Whether these carriers are deprioritizing customers or customers are flocking to slower, more budget-friendly plans, both AT&T and Verizon are seeing an increase of customers experiencing speeds less than 5 Mbps.

Others have argued that these networks may be saturated. However, if they were, we'd expect to see the number of tests at every level of speed decrease. Our data does not bear this out and it seems likely we're seeing reduced performance due to high usage de-prioritization and consumer plan choice.

Fastest Carriers by City

Q1-Q2 2017

City speeds based on average speeds for all results. Carrier speeds based on Speed Score for modern devices.

City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Speed Score
Albuquerque, NM	**25.40**	**10.11**	T-Mobile	**29.98**
Anaheim, CA	**20.33**	**9.46**	Verizon Wireless	**25.69**
Anchorage, AK	**18.31**	**8.04**	AT&T	**19.64**
Arlington, TX	**23.54**	**9.87**	T-Mobile	**24.79**
Atlanta, GA	**29.64**	**11.68**	Sprint	**32.05**
Aurora, CO	**18.29**	**6.17**	T-Mobile	**17.34**
Austin, TX	**25.08**	**7.91**	AT&T	**25.20**
Bakersfield, CA	**24.29**	**9.97**	Verizon Wireless	**25.98**
Baltimore, MD	**21.38**	**7.82**	Verizon Wireless	**29.69**
Baton Rouge, LA	**22.62**	**7.37**	Verizon Wireless	**23.39**
Boise, ID	**20.03**	**6.23**	T-Mobile	**24.29**
Boston, MA	**23.07**	**10.47**	AT&T	**25.44**
Buffalo, NY	**19.47**	**7.85**	T-Mobile	**21.69**
Chandler, AZ	**25.16**	**8.72**	Verizon Wireless	**24.89**

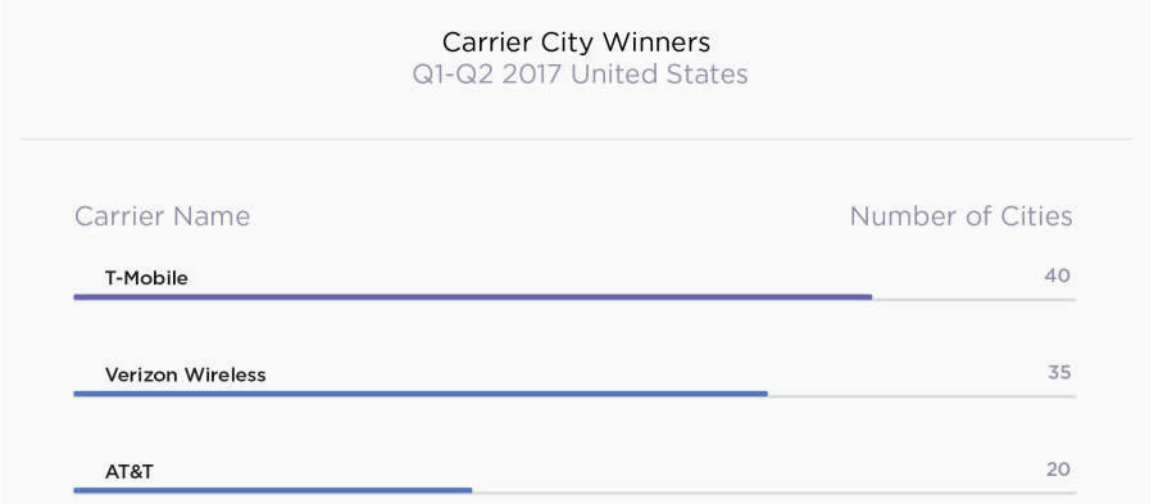
City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Speed Score
Charlotte, NC	19.03	7.38	AT&T	21.00
Chesapeake, VA	24.69	8.50	T-Mobile	29.64
Chicago, IL	24.76	10.66	Verizon Wireless	31.35
Chula Vista, CA	22.49	10.46	Verizon Wireless	31.55
Cincinnati, OH	23.21	7.25	Sprint	23.19
Cleveland, OH	27.25	9.92	T-Mobile	28.01
Colorado Springs, CO	20.96	7.87	T-Mobile	21.18
Columbus, OH	25.30	9.05	T-Mobile	29.35
Corpus Christi, TX	22.94	8.97	T-Mobile	24.16
Dallas, TX	23.27	9.65	T-Mobile	24.93
Denver, CO	18.99	6.46	Sprint	20.18
Detroit, MI	24.47	10.35	Verizon Wireless	26.20
Durham, NC	22.07	7.76	AT&T	24.01
El Paso, TX	19.77	9.85	T-Mobile	21.45
Fort Wayne, IN	36.64	11.53	Verizon Wireless	41.54
Fort Worth, TX	22.56	9.10	T-Mobile	24.97
Fremont, CA	24.95	9.47	Verizon Wireless	27.17
Fresno, CA	19.02	8.06	AT&T	21.26
Garland, TX	22.94	9.49	T-Mobile	25.10
Gilbert, AZ	24.46	8.07	T-Mobile	28.07
Glendale, AZ	21.03	8.46	AT&T	23.29
Greensboro, NC	20.19	7.85	AT&T	22.58
Henderson, NV	20.79	8.50	T-Mobile	20.62
Hialeah, FL	22.94	10.24	T-Mobile	24.22
Honolulu, HI	18.32	11.97	Verizon Wireless	24.40
Houston, TX	22.99	9.40	AT&T	21.77
Indianapolis, IN	27.83	8.80	AT&T	29.29
Irvine, CA	26.27	11.68	Verizon Wireless	28.97
Irving, TX	21.60	9.29	T-Mobile	21.35
Jacksonville, FL	24.15	9.41	T-Mobile	27.44
Jersey City, NJ	22.69	11.57	Verizon Wireless	30.60
Kansas City, MO	25.15	7.79	T-Mobile	26.73
Laredo, TX	16.25	5.67	AT&T	19.06
Las Vegas, NV	17.91	8.14	AT&T	17.87

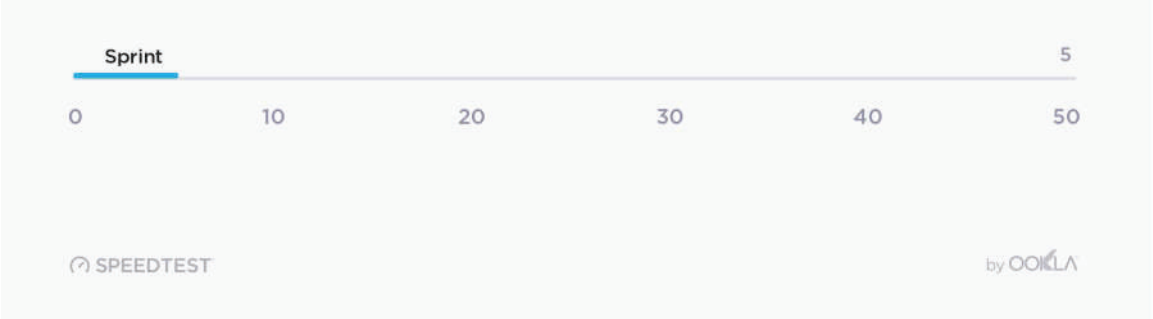
City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Speed Score
Lexington, KY	21.78	8.27	T-Mobile	28.05
Lincoln, NE	24.10	9.13	Verizon Wireless	23.24
Long Beach, CA	21.23	10.27	AT&T	20.88
Los Angeles, CA	21.76	10.31	Verizon Wireless	24.57
Louisville, KY	24.23	7.83	T-Mobile	23.83
Lubbock, TX	19.10	7.60	Verizon Wireless	24.87
Madison, WI	18.36	7.05	AT&T	22.20
Memphis, TN	19.13	6.96	T-Mobile	23.97
Mesa, AZ	22.49	8.21	T-Mobile	23.58
Miami, FL	20.93	9.25	Verizon Wireless	23.58
Milwaukee, WI	22.70	8.47	Verizon Wireless	29.95
Minneapolis, MN	32.66	12.23	T-Mobile	32.49
Nashville, TN	21.27	9.91	Verizon Wireless	23.57
New Orleans, LA	21.88	7.92	Verizon Wireless	22.08
New York, NY	24.32	11.08	Verizon Wireless	28.83
Newark, NJ	17.97	10.11	Verizon Wireless	24.07
Norfolk, VA	19.15	8.01	T-Mobile	24.25
North Las Vegas, NV	15.36	7.16	AT&T	16.84
Oakland, CA	23.23	9.71	Verizon Wireless	27.62
Oklahoma City, OK	19.05	8.03	T-Mobile	21.20
Omaha, NE	20.38	8.32	T-Mobile	27.11
Orlando, FL	25.13	10.04	Verizon Wireless	30.35
Philadelphia, PA	21.50	9.96	T-Mobile	21.12
Phoenix, AZ	20.54	7.90	AT&T	21.21
Pittsburgh, PA	28.42	11.12	Verizon Wireless	28.48
Plano, TX	25.97	9.67	T-Mobile	34.15
Portland, OR	25.57	9.50	T-Mobile	31.43
Raleigh, NC	23.86	8.32	AT&T	24.72
Reno, NV	19.05	8.04	Sprint	20.57
Richmond, VA	23.35	9.09	T-Mobile	26.11
Riverside, CA	24.34	10.89	Verizon Wireless	24.65
Sacramento, CA	20.65	9.83	AT&T	22.93
San Antonio, TX	20.51	8.26	T-Mobile	23.48
San Bernardino, CA	19.49	10.45	Verizon Wireless	26.18

City	Download (Mbps)	Upload (Mbps)	Fastest Carrier	Speed Score
San Diego, CA	23.22	10.90	Verizon Wireless	24.85
San Francisco, CA	26.50	12.18	Verizon Wireless	34.70
San Jose, CA	24.52	9.36	Verizon Wireless	26.46
Santa Ana, CA	20.26	9.75	Verizon Wireless	27.88
Scottsdale, AZ	24.38	7.88	T-Mobile	28.23
Seattle, WA	25.96	11.08	Sprint	27.04
St Paul, MN	32.03	12.10	T-Mobile	33.69
St. Louis, MO	22.48	8.27	Verizon Wireless	25.65
St. Petersburg, FL	23.47	10.34	T-Mobile	24.09
Stockton, CA	19.69	9.06	Verizon Wireless	27.41
Tampa, FL	23.90	11.19	T-Mobile	24.25
Toledo, OH	26.08	8.65	T-Mobile	29.00
Tucson, AZ	19.72	7.67	Verizon Wireless	21.91
Tulsa, OK	20.18	8.58	T-Mobile	26.04
Virginia Beach, VA	26.34	9.17	T-Mobile	33.23
Washington, DC	22.68	9.16	AT&T	22.31
Wichita, KS	24.30	7.11	Verizon Wireless	27.49
Winston-Salem, NC	20.89	8.46	AT&T	22.45

See Less

Based on Speed Score on modern devices, T-Mobile is the fastest carrier in 40 of the 100 most populous cities in the U.S. Verizon Wireless is fastest in 35, AT&T carries 20 and Sprint five.





For overall city averages, we looked at download and upload speeds across all devices.

Fort Wayne, Indiana had the fastest average mobile download speeds on all devices during Q1-Q2 2017. Minneapolis, Saint Paul, Atlanta and Pittsburgh round out the top five fastest cities for mobile downloads. North Las Vegas, Nevada, the city with the slowest download speed on the list, was 32.2% slower than the national average. Laredo, Texas; Las Vegas, Nevada; Newark, New Jersey and Aurora, Colorado were the cities with the second, third, fourth and fifth slowest download speeds, respectively.

The fastest upload speeds we saw were in Minneapolis, San Francisco, St. Paul, Honolulu and Atlanta. With an upload speed that's 33.3% slower than the country as a whole, Laredo, Texas had the slowest upload speeds of all the cities we looked at. Aurora, Colorado; Boise, Idaho; Denver, Colorado and Memphis, Tennessee rounded out the bottom five cities with the slowest upload speeds.

Conclusion

This year we evaluated performance from the standpoint of fastest speeds and also additional angles, because nationwide speed isn't everything. Mobile performance in the U.S. is improving, but not uniformly. T-Mobile comes out on top for overall speeds and acceptable speeds at a national level and provides the fastest service in 40% of the largest cities in the U.S. Verizon Wireless has the fastest service in many of the cities we looked at and comes in first on acceptable speeds in the top 100 CMAs, but we suspect their use of deprioritization on Unlimited could be bringing down their overall performance. AT&T falls near the bottom in consistency of acceptable speeds and also saw a spike in low end speeds in Q2 2017. The slowest carrier, Sprint, struggles with consistently providing acceptable speeds but saw big gains in the first half of the year.

Mobile data consumption is expected to continue to grow over the next year, and carriers will need to find creative ways to increase the spectral efficiency of their networks. In order to deliver more bits per second per hertz, mobile network operators will have to continue densifying their networks by adding more cell sites, enable key features such as 4-Layer MIMO and higher order modulation, and accelerate the use of greenfield licensed and unlicensed bands. In addition, backhaul provisioning and infrastructure vendor rate limiting licenses will likely have to be boosted to support faster data rates.

At the same time, consumers will be looking for features that meet their needs, whether that's T-Mobile's or Sprint's free international roaming or the large LTE footprints of Verizon Wireless and AT&T. Customers will also be looking for straight-forward policies including unlimited data plans that offer accessibility and speed. While all four carriers currently offer unlimited data plans, they all limit users in some way.

Most importantly, smartphones have a key role to play in network efficiency. Highly efficient devices with 4-branch antenna diversity and sophisticated RF Front End will continue to proliferate the marketplace. Existing Gigabit LTE devices not only deliver the fastest possible speeds to the users, but they can significantly increase the overall spectral efficiency of the networks. It will be in the best interest of carriers to foster adoption of as many of these devices as possible.

Updated on September 11, 2017 to correct a typo in the Fastest Carriers by City section.

Docket:	A.18-07-011 and A.18-07-012
Witness:	Cameron Reed
Date:	January 7, 2019

Public Advocates Office

Exhibit C-34

"New T-Mobile Model Assumptions"

Contains CONFIDENTIAL T-MOBILE Information